AEROSCENE LAND LOGIC
Ranch Management \ Rangeland Health

7600 Shedhorn Drive, Bozeman, MT 59718
406.585.3407 Phone | 307.851.5033 Cell
todd@aerosceneland.com

MERLIN RANCH

2009 RANGELAND HEALTH MONITORING

Prepared for Merlin Ranch

Prepared by Aeroscene Land Logic

Todd Graham

TABLE OF CONTENTS

INTRODUCTION

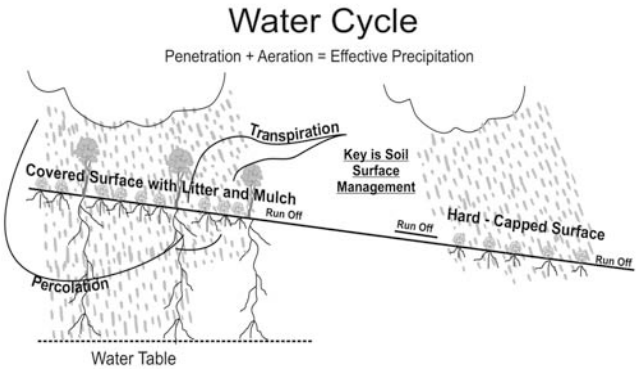
This document presents the findings of two rangeland health monitoring transects examined on Merlin Ranch in August 2009. Merlin began a monitoring effort in 2006 to better guide its management decision making and simultaneously track changes in rangeland health. These sites were the Hall Homestead and the Tipperary Pastures. This represents the third reading of the Hall Homestead site and the second reading of the Tipperary site. Changes in land health will be discussed, overall trend will be examined, and management recommendations will be presented. Merlin Ranch will use these findings for directing management action, improving rangeland health, improving wildlife habitat, and increasing profitability.

Since 2006, study sites have been added at Merlin. They are as follows:

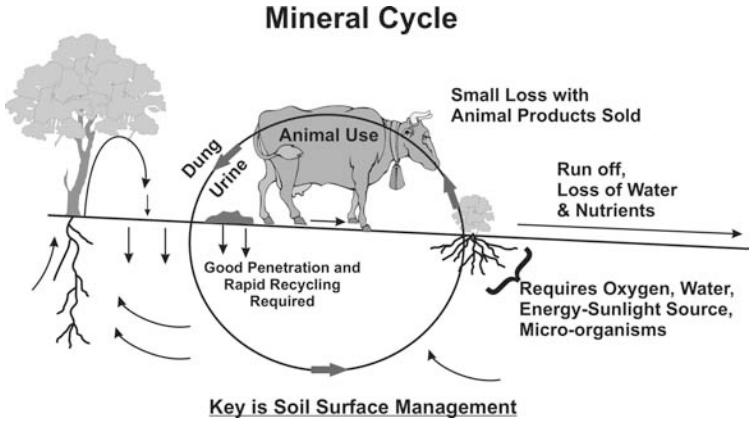
2006: Hall Pasture, Hall Homestead;
2007: Three Section, Tipperary; and
2008: Pigpen, Lower, and M&M#1.

Findings will be presented with a combination of qualitative rangeland health indicators and quantitative data. Quantitative data will be used to track changes on the land as they occur through time. Qualitative indicators will provide a snapshot of land health on the day the site was sampled. Both will be used to provide the management recommendations contained herein.

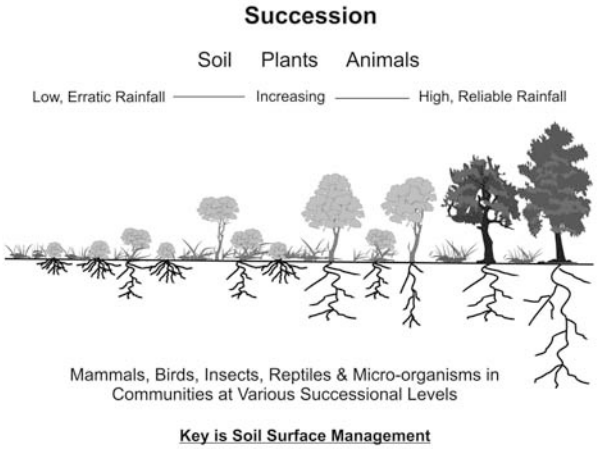
Much discussion will be made concerning the function of four fundamental ecosystem processes. These are the water cycle, mineral cycle, energy flow, and successional process. These are reviewed graphically on the following pages.



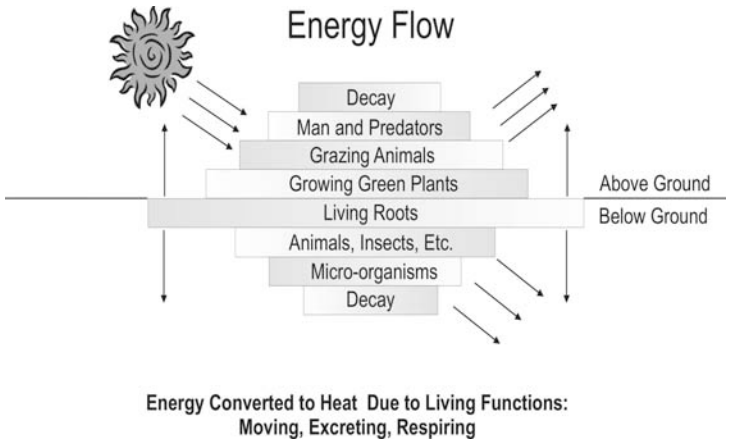
An effective water cycle requires covered soil and high biodiversity. When effective, most water soaks in quickly where it falls. Later, it's released slowly through plants that transpire it, or through rivers, springs, and aquifers that collect through seepage what the plants don't take. When biodiversity is reduced and soil exposed, much water runs off as floods. What little soaks in is released rapidly from evaporation which draws moisture back up through the soil surface (Savory, 1993).



Like the water cycle, an effective and rapid mineral cycle requires covered soil and high biodiversity. When effective, many nutrients cycle between living plants and living soil continually. When soil is exposed and biodiversity low, nutrients become trapped at various points in the cycle, or are lost to wind and water erosion (Savory, 1993).



With few exceptions, communities strive to develop toward ever-greater complexity, and thus stability. From unstable bare ground, where biodiversity is low, stable complex range or forest communities, high in biodiversity develop over time (Savory, 1993). This is succession.



Almost all life requires energy that flows daily from the sun. The basic conversion of this solar energy to useable form takes place through plant material on land and in water. Energy passes from plants to whatever eats them, and in turn eats the consumers of plants. Energy doesn't cycle, but flows through the ecosystem until it's consumed (Savory, 1993).

Data from the Hall Homestead site will be displayed on the following pages. Indicators of rangeland health will first be discussed. Next, both photo and data comparisons will be made between the two sample years. Finally, a discussion of data between the two years will ensue, trend determination made, and management recommendations discussed.

SUMMARY OF FINDINGS AND MANAGEMENT RECOMMENDATIONS CONTAINED IN THIS REPORT

Hall Homestead

This site has now been sampled three times. Range trend here was upward. The amount of bare soil fell between sample years, and live cover increased. Both are positive signs. The big sagebrush community appeared to be replacing itself with many decadent plants and young plants found. Production continued to be well below the desired level for this site. Basal plant spacing by species showed mixed signs of improvement. Less desired species such as threadleaf sedge and blue grama reduced in presence, while the highly desired species green needlegrass increased. These signs suggest that the new management of practice of increasing recovery periods between grazings is already bearing fruit. With the rapid change in the big sage in this area, management has an opportunity to drive this plant community in the direction of more desired plants with continued good grazing management.

Tipperary

This was the second time this site had been sampled. Like Hall Homestead, big sagebrush plants at Tipperary were replacing themselves in the community. Several young and decadent plants were found. Plant productivity was well below the desired levels, but improvement was observed. A strong reduction in bare soil along with increased live plant cover were measured. These were both positive changes. The most abundant plant species on the soil surface also showed change. The less desired species of blue grama and threadleaf sedge decreased in abundance between the two sample years. These species were replaced by mid-seral plants such as prairie junegrass and Sandberg bluegrass. In time, more desired species such as bluebunch wheatgrass and green needlegrass must move into this community. New pastures were added here that should help with improvement of the site. With more pastures, management may better control the grazing duration, plant recovery periods, and utilization rate. Management should use this new infrastructure to study plant recovery periods between grazings and to ensure that utilization rates are at moderate levels (harvest roughly 30 – 50% of available plants).

Nutrient analysis

Vegetation samples at both sites showed that a sample lactating cow would not meet her crude protein, total digestible nutrient, and trace mineral needs. This is likely due to the seasonality of sample collection when plants were preparing for dormancy. Management may consider several actions in response, including early weaning of a calf, moving pairs onto greener areas such as hay meadows in the fall, and mineral supplementation of dry cows in winter to replace lost nutrient reserves.

Additional comments on grazing management

Based upon findings contained in this report and conversations with Merlin management over the past two years, the following discussion is offered on changes in management.

First, management should examine use of a planned recovery period for plants between grazings. Determining this number is critical for promoting good grazing management. Previously, management was using a "year over year" versus a "year to year" protocol. Plants were grazed relative to the last time they were grazed, rather than being grazed relative to full recovery of the plant based on growth. Previously, management set a recovery period of 90 days. With 365 days in the year and a 90-day recovery period, this meant that some pastures were grazed four times per year. This is too much. Instead, management should calculate a recovery period, for example, of 250 days. Examine grazing durations based on this number. This may mean that some pastures are grazed twice (growing and dormant seasons), and some pastures are only grazed once. Further, this may allow pastures to be grazed early some years and late in others, thus altering the timing of grazings on a regular basis. 250 may not be the correct number, but management should consider multiple recovery figures in its analysis.

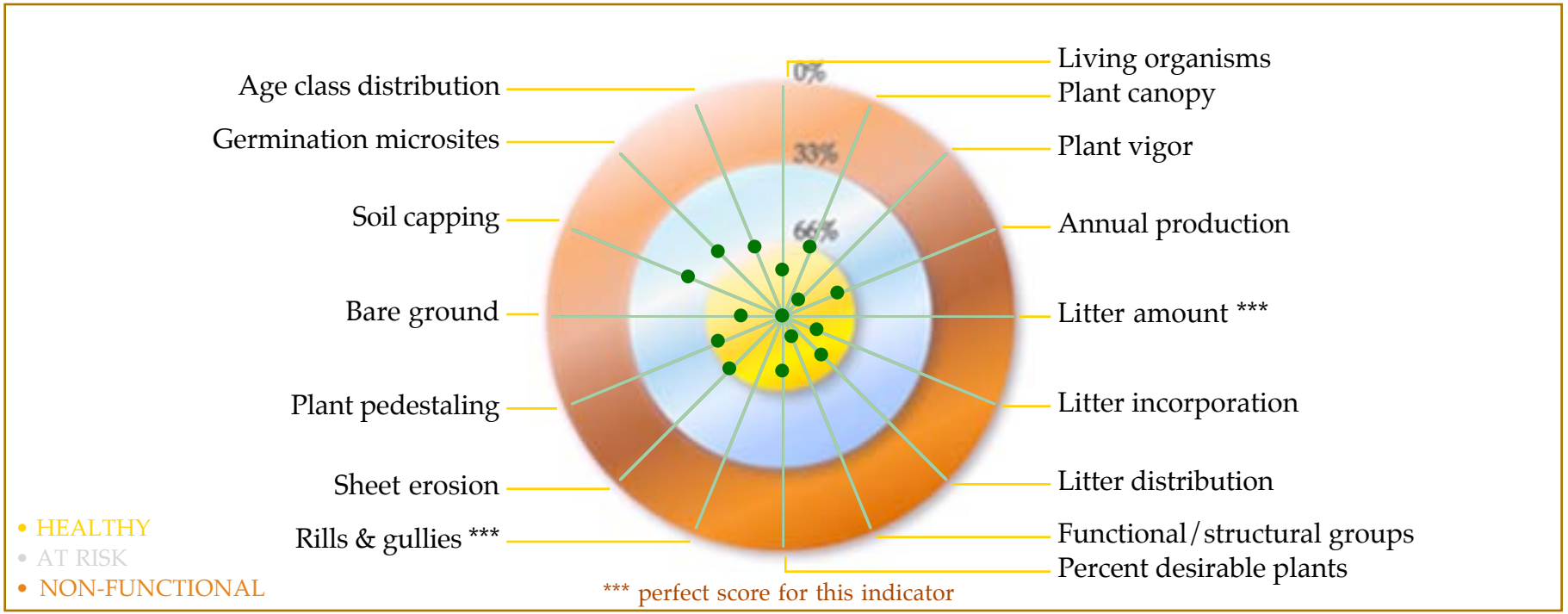
Second, management should revisit the use of fast growth and slow growth recovery periods. In northeast Wyoming, fast growth is likely to last only a few days, making that time window almost not worth considering. Better planning figures would be found in slow growth and no growth calculations. Pastures on Merlin tend to green up in spring slowly and receive a short spurt of fast growth as soil temperatures rise. Then, as seed onset occurs, plants grow much more slowly into June and July. As August arrives, plants may still be green, but are growing so slowly as to have almost no growth at all. Planning recovery times would be analogous to using slow growth and dormant season (or no growth) figures. The result of such an analysis is that management could effectively ignore a 30-day recovery period intended for fast growth on rangelands. Management could experiment with slow growth recovery times of 100 days and 250 days for no growth periods. Place those in the grazing duration spreadsheet and determine how the new grazing moves look.

Third, management should supplement its existing observation of ADAs available in a pasture with an average of ADAs harvested from the same pasture through time. Use both as planning figures for gaining confidence in planning stocking rates.

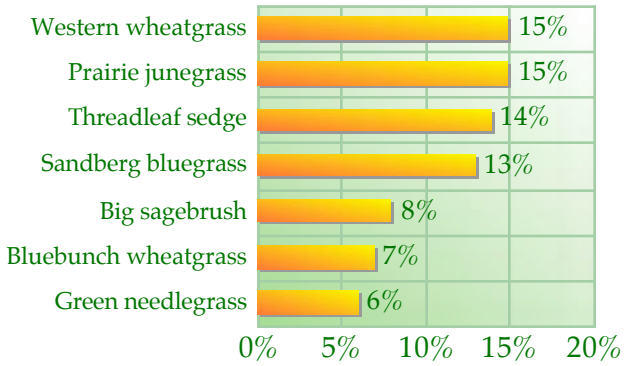
Fourth, management should consider an additional planning tool for evaluating future stocking rates. Divide the total animal days harvested by the inches of precipitation received. This figure would provide stock days per ADA. By using a four-year trailing average of

harvest's relationship to precipitation, management may gain another gauge on setting future stocking rates.

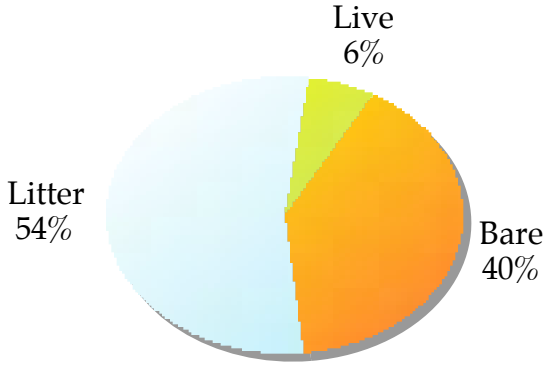
In recent years, management altered plant recovery times. From data displayed in the pages that follow, this was a good move. Dividends were being earned from that decision. The comments above seek to supplement this planning effort by providing increased confidence in tracking the past.



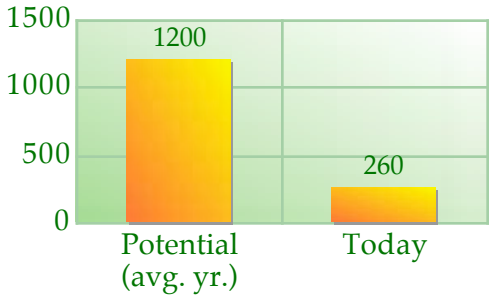
Basal Cover by Species - Top 7 Species



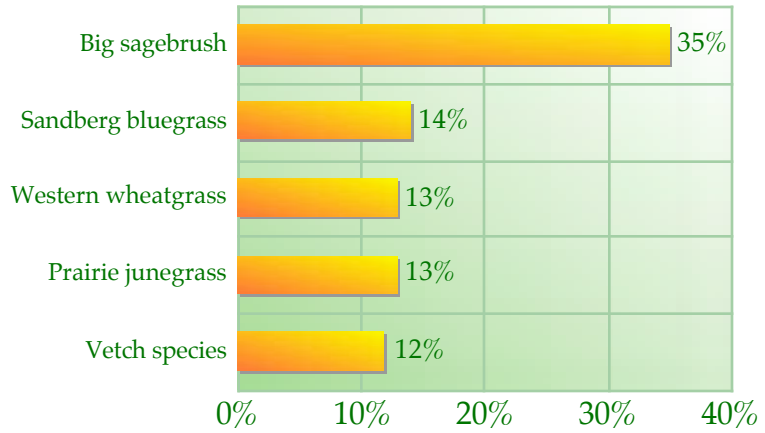
2009 Basal Cover



Forage Production



Predominant Species: Composition by Weight



Additional Info: Overall Site Score: **78**

Apparent range trend:

Site sampled August 26, 2009.

UTM coordinates: (NAD 83) 13T 376148 4913808

Big sagebrush data:
29 plants intercepted along transect line for 15% canopy cover.
Age class distribution: 8% seedling, 79% mature, 13% decadent.
Average plant height = 9.1 inches.
Belt transect: 206 plants growing in 1000 square feet.

Average distance to nearest perennial plant: 1.3 inches.

32 plants encountered at transect site.

Plant species encountered at site:

Western wheatgrass
Sandberg bluegrass
Prairie junegrass
Japanese brome
Cheatgrass
Bluebunch wheatgrass
Green needlegrass
Threadleaf sedge
Needleandthread
Blue grama
Big sagebrush
Fringed sage
Broom snakeweed
Silver sagebrush
Rubber rabbitbrush
Western yarrow
Salsify
Curlycup gumweed
Hood's phlox
Astragalus species 1
Astragalus species 2
Astragalus species 3
Clover species
Showy fleabane
Vagrant lichen
Pricklypear cactus
White alyssum
Scarlet globemallow
Sego lily
2 unknown perennial forbs

Hall Homestead (Transect MRT06)

This site was chosen in 2005 as an area to be treated by the Lawson Renovator. It also served as an area of concern, for plants that year did not display the strong vigor that was expected of them. Unfortunately, the Lawson Renovator missed this site during its mechanical treatment of area pastures.

The first plot studied at the Hall Homestead site.

We first studied **living organisms** at this site where either the following species were observed, or signs of their presence was observed: sage grouse, snake, pronghorn, grasshoppers, various song birds, flies, and ants. This indicator received a 80 for its score.

The **plant canopy** at the site was minimal. Much sunlight energy struck the soil surface rather then being intercepted by living plant leaves. Some study plots contained large sagebrush plants growing in them, and had a correspondingly high plant canopy. Those plots lacking a large sage plant, contained a minor canopy. The big sage canopy had also been browsed during this growing season. This indicator received a 68.

Plant vigor was high. Those ungrazed sagebrush plants had leaders appraoching 10 inches. Green needlegrass and needleandthread plants had achieved tall stature, produced seed, and appeared to be green and growing in late August. This indicator received a 90.

The Wyoming State Range Site Guide suggests potential production for this site should be 1200 pounds per acre (USDA, 1990). The clipped plot revealed 260 pounds per acre, or 22% of the potential. Further, production within the plots varied widely from this potential figure. Those plots containing a big sagebrush plant produced growth well beyond the potential. Those lacking a big sage plant produced well below the potential. Overall, this indicator received a 74 for its score.

The **litter amount** in the plots was high. This indicator received a perfect score. The point intercept method revealed the 54% of the soil was covered by litter. Additional litter was needed at the site to help cover some of the bare soil found here.

Litter incorporation received an 84. Litter was contacting the soil surface, but was not mixing well with soil. It appeared to be idly lying on the soil and oxidizing, rather than breaking down.

In some of the study plots, litter was not well **distributed** over the soil surface. These were the plots that lacked big sage plants. Where big sage grew in a plot, litter distribution was uniform. It appeared as if wind-blown litter had accumulated near big sage plants, leaving the interspaces bare of cover. This indicator received a 76.

The **functional and structural groups** indicator looks for different plant forms (grass, forb, shrub) as well as the total number of plant species found in a study plot. Different plant forms with their varied canopies may trap wind-driven snow and serve as shade for the soil surface. Their root structures reach different soil depths as well and elevate nutrients stored in different parts of the soil profile. A higher number of plant species found suggests greater diversity and complexity of the plant community. To summarize this indicator, the greater the number of plant forms and species, the higher the score. The Hall Homestead site produced high diversity of species at each sample plot. In the study plots, five to nine species were present. This indicator received a high score at 90.

The **percent desirable plants** indicator received a mid-range score at 76. The desired plants were present, but not in the abundance desired. Mid-seral plants such as prairie junegrass and Sandberg bluegrass were abundant at the site. HIghly desired plants, such as green needlegrass and needleandthread, were present, but their numbers needed to be greater. A high number of forbs was found, including the desired curlycup gumweed, which is a favorite of the sage grouse. Only cheatgrass and Japanese brome were found as undesired species. These two species had a minor presence at the site.

No signs of water erosion in the form of **rills and gullies** were observed on this slope. This indicator received a perfect score.

Some signs of wind erosion in the form of **scouring and sheet erosion** were observed. Some desert pavement had formed on the surface, where wind removed finer soil particles, leaving coarser materials behind. This indicator received a 68. **Plant pedestals** were also observed. They were not so evident as to expose roots. This indicator received a 70.

Too much **bare soil** was found in the study plots for this site. Agin, litter tended to be clumped around big sage plants, leaving the interspaces exposed. These spaces should be filled with both litter and living plants. The bare soil indicator received a 82.

A one-inch thick **soil cap** was found at the site. This crust made the soil hard underfoot and required a knife to chip. The crust would inhibit the movement of water into the soil. Thus, the water cycle was less effective at this site since recent rainfall would have a harder time entering the soil surface. This indicator receivd a 56.

Germination microsites are those areas on the soil surface where a new plant may find a start on life. They are areas where litter is not too deep, the soil crust is not too thick, where exposure to the elements and herbivory are not excessive. At Hall Homestead, the thick crust would be the limiting factor for germination success. This indicator received a 60.

Standing in contrast to the statement above, different **age classes** were evident, particularly in big sagebrush plants. These appeared in all four classes: seedling, young, mature, and decadent. Numerous seedling and young sagebrush plants were observed while performing the belt transect. Further, some green needlegrass plants appeared in young and mature classes. This suggests these two species are replacing themselves at the site. Ironically, however, none of the big sage or green needlegrass seedlings fell in a study plot that was scored. These plants fell outside the plots. This indicator received a 68.

Additional comments:
Energy flow was moderate here, where much sunlight energy was intercepted by plants, but much also struck the soil surface. The thick soil crust prevented the water cycle from being effective. Excess bare ground was also found here. The mineral cycle was moderately rapid. The soil crust was affecting litter breakdown, and wind was blowing litter away from interspaces between big sage plants. Within community dynamics, the desired species were present, but were not in the abundance desired.

Hall Homestead

Photopoint Summaries

Transect view at the Hall Homestead. Photo taken September 3, 2005.

Transect view at Hall Homestead. Photo taken September 16, 2006.

Hall Homestead transect view. Photo taken August 26, 2009.

The first plot studied at the Hall Homestead site. Photo taken September 3, 2005.

The first plot studied at the Hall Homestead site. Photo taken September 16, 2006.

The first plot studied at the Hall Homestead site. Photo taken August 26, 2009

BIG SAGEBRUSH DATA

2005	2006	2009	
			Line intercept:
38	32	29	*Number encountered*
			Line Intercept: Age Class
0%	0%	0%	seedling
18%	3%	8%	young
82%	81%	79%	mature
0%	16%	13%	decadent
11.5	12.5	9.1	*Avg plant height - inches*
16%	9%	15%	*Percent canopy cover*
186	211	206	*Density per 1000 square feet*

PRODUCTION: Pounds per acre

2005	2006	2009
760	230	260

ADDITIONAL INFORMATION

Site sampled September 3, 2006.
Site sampled September 16, 2006.
Site sampled August 26, 2009.

RELATIVE PLANT SPECIES COMP. BY WEIGHT RANKING (TOP 5 SPECIES)

2005		2006		2009	
Big sagebrush	30%	Big sagebrush	22%	Big sagebrush	35%
Bluebunch wheat	17%	Western wheatgrass	20%	Sandberg bluegrass	14%
Fringed sage	11%	Sandberg bluegrass	17%	Western wheatgrass	13%
Prairie junegrass	9%	Bluebunch wheat	16%	Prairie junegrass	13%
Broom snakeweeed	8%	Prairie junegrass	8%	Vetch species	12%

BASAL COVER

2005	2006	2009	
49%	44%	40%	Bare
43%	49%	54%	Litter
8%	7%	6%	Live

RELATIVE BASAL PLANT SPACING

2005	2006	2009
1.1 inches	1.6 inches	1.3 inches

RELATIVE BASAL PLANT SPACING BY SPECIES (Top 7 species)

2005		2006		2009	
Threadleaf sedge	22%	Sandberg bluegrass	36%	Western wheatgrass	15%
Western wheatgrass	16%	Western wheatgrass	23%	Prairie junegrass	15%
Needleandthread	14%	Prairie junegrass	12%	Threadleaf sedge	14%
Prairie junegrass	11%	Big sagebrush	12%	Sandberg bluegrass	13%
Big sagebrush	11%	Hood's phlox	7%	Big sagebrush	8%
Bluebunch wheat	9%	Fringed sage	4%	Bluebunch wheat	7%
Blue grama	6%	Bluebunch wheat	3%	Green needlegrass	6%

PLANT SPECIES FOUND IN TRANSECT AREA

2005	2006	2009	
23	*19*	*29*	***Total count***
X	X	X	Bluebunch wheatgrass
X	X	X	Western wheatgrass
X	X	X	Prairie junegrass
X		X	Japanese brome
X	X	X	Blue grama
X		X	Green needlegrass
X	X	X	Threadleaf sedge
X		X	Needleandthread
X	X	X	Big sagebrush
X	X	X	Fringed sage
X	X	X	Silver sagebrush
X	X	X	Broom snakeweed
X	X	X	Rubber rabbitbrush
X	X	X	Western yarrow
X		X	Vetch species
X	X	X	Hood's phlox
X	X	X	Pricklypear cactus
X		X	Curlycup gumweed
X		X	Lepidium (white alyssum)
X	X	X	Vagrant lichen
X			Plains daisy
X			Musk thistle
	X	X	Sandberg bluegrass
	X		Smooth brome
	X		Sixweeksgrass
	X		Moss species
	X		Longleaf phlox
1	1	2	Unknown perennial forb
		X	Cheatgrass
		X	Salsify

2005	2006	2009	
		X	Clover species
		X	Showy fleabane
		X	Scarlet globemallow
		X	Sego lily
		2	Additional vetch species

DISCUSSION OF HALL HOMESTEAD PASTURE DATA BETWEEN 2007 AND 2009

Photos

The photos shown above reveal how the land at Hall Homestead responds to different levels of precipitation. 2005, the year the first transect was established here was wet, 2006 was dry, and 2009 contained a wet spring. The 2006 photos above show plants of much lower vigor than the other two sample years. Leader growth on big sagebrush plants was minimal. Note particularly the plot photos and that lone big sage plant in 2006. In 2005 and 2009, years with better moisture, leader growth on the big sage plants appears to be quite long. Grass plants from 2006 also appear to have gone dormant long before sample day, but many appear to be still growing in 2005 and 2009. Much bare soil is evident on this site in all three sample years.

Sagebrush data

This site was selected to be treated by the Lawson Renovator machine in 2005, but the treatment missed the transect site. That treatment was intended to open the sagebrush canopy and promote age-class distribution within the species. As can be seen on the data table above, the sagebrush community appeared to be turning over on its own. A steady decline in the number of big sage plants encountered along the transect line was observed. Further, these plants were increasingly seen in different age classes, including seedlings and decadent classes. This suggests further turnover within the big sage community is to be expected into the future.

Production

The Wyoming State Range Site Guides suggest production should be 1200 pounds per acre in an average year. As can be seen in the data set, productivity was well below this mark all three sample years. Even in the wetter year of 2009, overall productivity was well below the desired level. No utilization of plants was observed in 2009.

Composition by weight

As an expression of aboveground biomass by weight, the top five plants found at Hall Homestead have changed much through the years. Big sagebrush remained the most productive plant. The desired bluebunch wheatgrass fell in percent composition relative to the other species in each year sampled. It was not among the top five producers in 2009 (but was the sixth most common plant by weigh, a position that did not allow it to appear on the table containing the top 5). Prairie junegrass had a good year in 2009, likely aided by the wet spring that year. Vetch (a forb in the genus *Astragalus*) also had a good year in 2009. From the perspective of land health, livestock performance, and wildlife habitat, the list of species contained in all three years is not bad. Ideally, additional perennial bunchgrasses such as green needlegrass, needleandthread, and bluebunch wheatgrass would all be found with greater productivity. Big sage should remain as the most productive plant in the community, vetch's presence as a forb is desired, but these grasses would ideally be replaced by others.

Basal cover

Too much bare ground existed in each year on this site. Ideally, the amount of bare soil would be less than 15%

here. The slow, steady decline in bare soil amount was encouraging and heading in the right direction.

Relative basal plant spacing
When gathering data for the basal cover data set described above, a steel rod is lowered to the soil surface at specific intervals along the transect's tape measure. When the basal cover data is collected, the distance to the nearest perennial plant is also measured. Averaged over 100 data points, this measurement shows the relative basal plant spacing figure in the table. If this average distance declines through time, then additional plants may be found growing on the soil surface and/or the crown of the plants may be growing larger (a sign of increased plant vigor). At Hall Homestead, this distance first became larger (a negative sign) between 2005 and 2006, and then shrunk (a positive sign) between 2006 and 2009. Over a few short years, this is a fairly dramatic change in this measurement. It suggests that changes in the plant community have been occurring and continue to occur. The change from 1.6 inches in 2006 to 1.3 inches in 2009 is highly desired, but 1.3 is still much higher than the starting figure of 1.1. Ideally, this figure would drop below the starting measurement of 1.1.

Relative basal spacing by species
When measuring the distance to the nearest perennial plant as described above, that nearest plant's species is also recorded. Tallying plant species that were the most commonly marked as the nearest perennial plant provides the relative basal plant spacing by species data set. Like the plant spacing measurement itself, the actual plants encountered at Hall Homestead changed in the three sample years. Threadleaf sedge had a strong presence in 2005. It fell from the list in 2006, but then was seen in 2009, but with reduced abundance. At Hall Homestead, threadleaf sedge is a less desired plant. Ideally, it would continue to have reduced presence in the community. Blue grama is a similar species that should be replaced here. It was on the list in 2005, but has not made the list of top seven since then. This was a positive sign. The desired species bluebunch wheatgrass was found in 2005 at nearly the same composition as in 2009. Through time, this plant is desired at greater levels. On a positive note, the highly desired green needlegrass came onto the list of the top seven in 2009. In time, plants like bluebunch wheat and green needlegrass should compose much of this community, and displace the mid-seral plants such as Sandberg bluegrass and prairie junegrass.

Plant species list
The plant species list again shows the importance of precipitation to this area. Several forbs and grasses were not found during the dry year of 2006, but were present in 2009. Conversely, undesired species such as sixweeksgrass and smooth brome were found in 2006 that were not observed in the two wetter years. Importantly, some highly desired forbs such as salsify, clover, fleabane, scarlet globemallow, and sego lily were found in 2009. Management should continue to look for these desired forbs in coming years, further signs that more moisture is entering the soil surface.

Range trend
Trend here was upward. This plant community was in transition with the dominant plant big sagebrush replacing itself in the community. As this single species changes, other plants have the opportunity to propagate. Signs of success include increased presence of green

needlegrass and reduced presence of threadleaf sedge and blue grama. Simultaneously, the amount of bare soil continues to drop, while live cover increased.

Management recommendations

The Hall Homestead transect site was missed by the Lawson Renovator treatment. It was intended to disturb the sagebrush canopy of the area, which was appearing as a single-aged crop. The big sage community appeared to be replacing itself in 2009, providing multiple opportunities for other plants to find a place on the soil surface to grow.

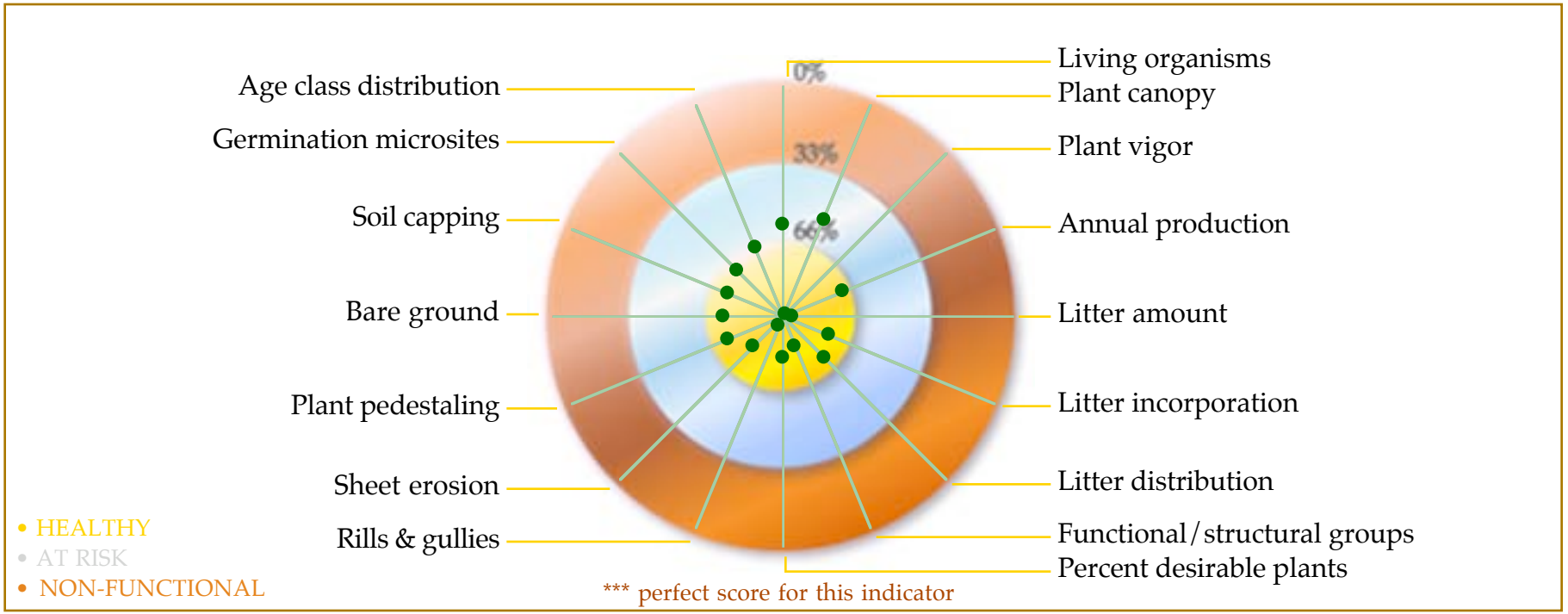
This site appeared to be improving in land health. Indicators suggest that past grazing management included utilization rates that were too high and plant recovery periods that were too short. The high bare ground amount help support the notion that utilization rates were too high, and the presence of less-desired species such as threadlaf sedge and blue grama suggest that recovery periods were too short. Management has since reversed these practices and greatly lengthened the recovery period between grazings. Signs of improvement include reduced bare ground, reduced spacing between plants, and encouraging signs of new species entering the community. Although the transect data do not show it, green needlegrass seedlings and young plants appeared in the transect area. This was a highly encouraging sign for this site.

Management should continue to practice grazing management with longer recovery periods in place. This change appeared to bear fruit on the soil surface. With turnover in the big sagebrush community, management has a tremendous opportunity to promote the growth of highly desired bunchgrasses and perennial forbs. Their growth is promoted through managing for moderate utilization rates (harvest 30 – 50% of the crop by height and weight) and for lengthy recovery periods between grazings.

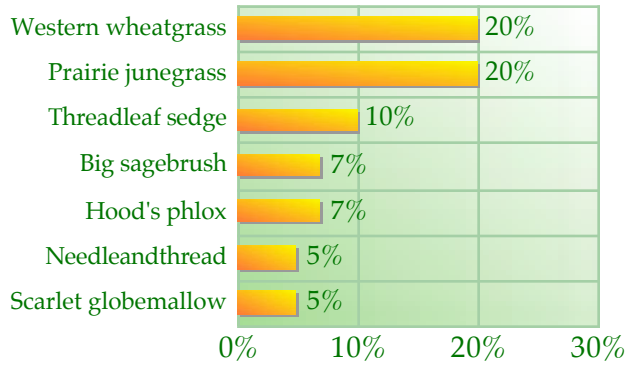
Early-warning indicators

If management actions are improperly applied here, look first for decreased plant vigor and increased signs of a soil cap. These would suggest that the water cycle is becoming less effective. Look to reduce the utilization rate further and promote increased litter amount to cover the soil surface and prevent formation of a soil cap. If the site continues to decline in health, look for increased presence of undesired threadleaf sedge and blue grama. Likewise, the desired species of green needlegrass and bluebunch wheatgrass will decline.

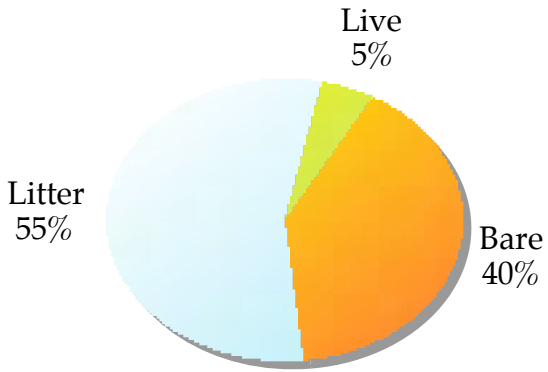
If management actions are properly applied here, look first for increased plant vigor, even in dry years. This suggests that the water cycle is effective and that precipitation is entering the soil. Then look for increases in productivity and decreases in bare ground. Finally, look for increased presence of the desired perennial bunchgrasses in the plant community.



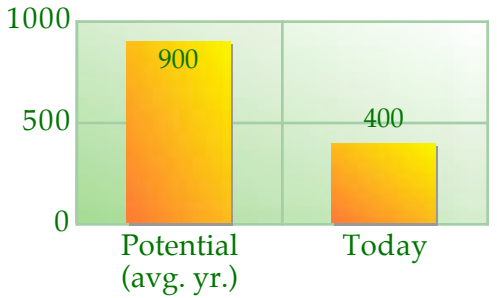
Basal Cover by Species - Top 7 Species



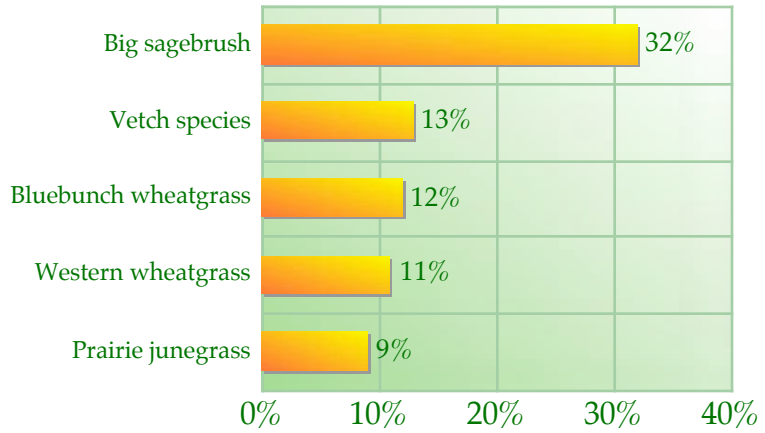
2009 Basal Cover



Forage Production



Predominant Species: Composition by Weight



Additional Info: Overall Site Score: **78**

Apparent range trend:

Site sampled August 27, 2009.

UTM Coordinates: (NAD 83) 13T 379313 4917960

Big sagebrush data:
36 plants intercepted along transect line for 20% canopy cover.
Age class distribution: 3% young, 89% mature, 8% decadent.
Average plant height was 12.9 inches.
Belt transect: 106 plants growing in 1000 square feet.

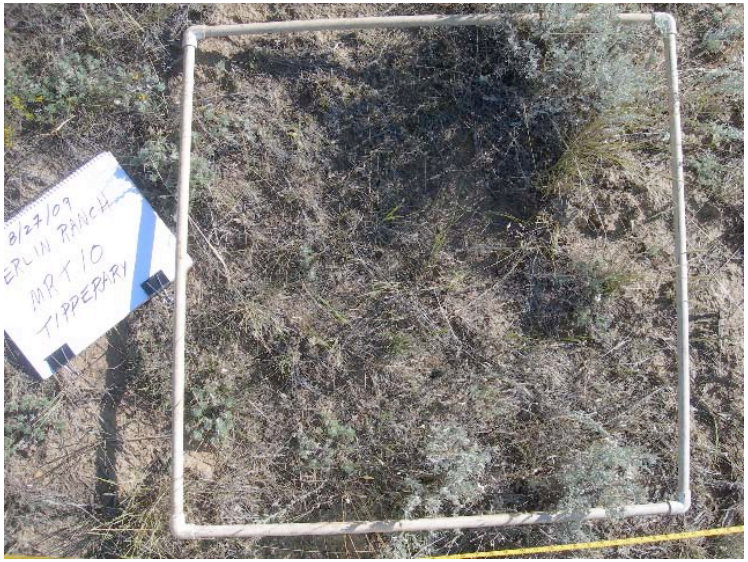
Average distance to nearest perennial plant: 1.6 inches

Plant species encountered at site:

Needleandthread
Bluebunch wheatgrass
Japanese brome
Western wheatgrass
Cheatgrass
Threadleaf sedge
Prairie junegrass
Green needlegrass
Blue grama
Big sagebrush
Broom snakeweed
Fringed sage
Rubber rabbitbrush
Salsify
Scarlet globemallow
Hood's phlox
Astragalus species 1
Astragalus species 2
Astragalus species 3
Penstemon species
Povertyweed
Vagrant lichen
White alyssum
Sunflower species
Pricklypear cactus
Curlycup gumweed

Tipperary (Transect MRT10)

This site was chosen in 2007 to be representative of the Tipperary pasture. The site lies on the shoulder of a slope that best represents the mix of hills, slopes, and bottoms found in the area. Since the site was established, additional fencing was added in the area that broke the pasture into smaller units.



The first plot studied at the Tipperary site.

The first indicator studied at this site was **living organisms** where the following species were seen, or signs of their presence were observed: sage grouse, mice, pronghorn, ants, flies, grasshoppers, and various songbirds. This indicator received a 60.

The **plant canopy** was highly varied at the Tipperary site. Where big sagebrush plants were encountered in a plot, the canopy was large. Where big sage plants were lacking, the canopy was minimal. Grasses and forbs also tended to be found in the vicinity of big sage plants, with fewer plants found in the big sage interspaces. This indicator received a 54.

Plant vigor on area grasses and forbs was high. Desired species such as needleandthread, green needlegrass, and bluebunch wheatgrass had produced seed, reached tall stature in the growing season, and were green at the end of August. Some big sagebrush plants displayed high vigor, with leader growth reaching 5 inches. Other plants appeared as if they had been eaten. Still others were dead and dying. Of all plants found at Tipperary, big sage appeared to be of the lowest vigor. Overall, this indicator recived a 98.

The Wyoming State Range Site Guides suggest that potential **production** should be 900 pounds per acre in an average year (USDA, 1990). A clipped plot at Tipperary revealed 400 pounds per acre production, or less than half the potential. The plots displayed wide ranges of production, based upon presence of big sage plants. Where a big sagebrush plant grew in a study plot, productivity was high. Where a big sage plant was not found in a study plot, productivity was much lower. If a perennial bunchgrass happened to grow in that same plot, production became much higher again. The community was highly influenced by the presence or absence of big sage plants that grew nearby. This indicator received a 72.

The **litter amount** was adequate in most study plots. Additional litter was desired in some to help cover the bare soil found. This indicator received a 96.

In some plots, litter was **incorporating** well into the soil. It appeared to be breaking down and was mixing with soil. In other plots litter was lying idly on the soil surface and oxidizing. This indicator received a 78.

Litter was well **distributed** across many of the study plots. In others, litter amount was becoming light, resulting in a more patchy litter distribution. Again, better distribution was associated with prominent big sage plants. This indicator received a 74.

The **functional and structural groups** indicator examines both plant form (grass, forb, shrub) and the number of plant species present in a plot. Ideally, a mix of plant forms would be present, combined with several plant species. This was the case in most plots at Tipperary. Grasses, forbs, and shrubs were found in most plots, and five to ten species were found in each plot. This indicator received a high score at 86.

The **percent desirable plants** was high in most plots. Desired species consisted of big sage, perennial bunchgrasses such as needleandthread, green needlegrass, and bluebunch wheatgrass. These were found in most plots. Note that species such as Sandberg bluegrass and prairie junegrass were considered intermediary species (neither desired, nor undesired). These plants grew well in 2009 and were highly prominent on the soil surface. These were found in each study plot, and often in abundance. The only undesired species in the area were Japanese brome and cheatgrass. These plants were not found in abundance. This indicator received a 82.

Within two of the study plots, some signs of water erosion were observed in the form of **rills and gullies**. These small areas where water traveled were barely evident on this slope. This indicator received a 96.

Signs of wind erosion were prominent. **Scouring and sheet erosion** appeared to have removed many of the finer sol particles in the area, leaving coarser materials behind. Formation of desert pavement was evident. This indicator received an 82. **Plant pedestals** were also common. This indicator received a 74. Pedestaling was not so prominent that roots were exposed.

Too much **bare soil** existed in the study plots. Around big sage plants, bare soil was almost nonexistent. In plots where big sage was lacking, bare soil tended to be higher. This indicator received a 74.

A **soil crust** reaching depth of roughly one-half inch had formed in some of the plots. This appeared to be a more recent crust, likely produced by recent rains. The crust was prominent in some of the plots that contained more bare soil. This indicator received a 74.

Germination microsites are those areas on the soil surface where a new plants may find a start on life. They are areas where litter is not too deep, where the soil crust is not too thick, where competition from other plants is not intrusive, and where exposure to the elements and herbivory is not excessive. At Tipperary, germination success would have been limited by the soil crust and competition with other plants such as threadleaf sedge. Where the crust was absent and the sedge lacking, germination sites were evident. This indicator received 72.

Exmaining **age class distribution** involves looking for seedlings, young, mature, and decadent plants on the soil surface. As already stated, big sagebrus plants occurred in all these classes. Many of the big sage plants looked decadent, while numerous seedlings and young plants were evident. Perennial bunchgrasses did not appear in different age classes. The mature class was only observed. This indicator received a 68.

Additional comments:
Energy flow was moderate here where much sunllight energy struck the soil surface, but much was also intercepted by living plant leaves. The water cycle was moderately effective. Plant vigor was high as if moisture was entering the soil, but the soil crust and signs of erosion were problematic. The mineral cycle was moderately rapid. Litter was breaking down well in some areas, but was lying idly on the soil surface in others. Within community dynamics, the desired plant species were present on the site. Ideally, different age classes of the desired perennial bunchgrasses would be observed, indicating these species were replacing themselves in the community.

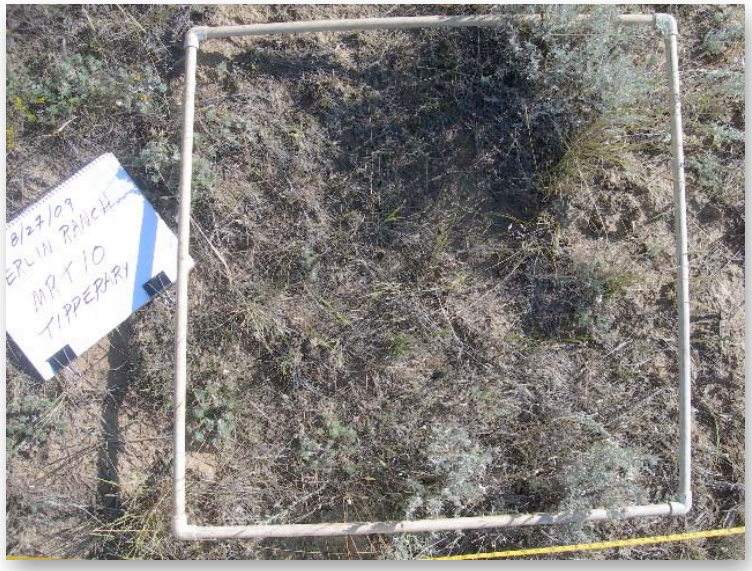
Tipparary

Photopoint Summaries

Transect view at the Tipperary site. Photo taken August 16, 2007.

Transect view at the Tipperary site. Photo taken August 27, 2009.

The first plot studied at the Tipperary site. Photo taken August 16, 2007.



The first plot studied at the Tipperary site. Photo taken August 27, 2009.

BIG SAGEBRUSH DATA

2007	2009	
		Line intercept:
35	36	*Number of big sage plants encountered*
		Line Intercept: Age Class Distribution
0%	0%	seedling
0%	3%	young
100%	89%	mature
0%	8%	decadent
15.2 inches	12.9 inches	*Average plant height*
19%	20%	*Percent canopy cover*
127	106	*Density per 1000 square feet*

PRODUCTION: Pounds per acre

2007	2009
320	400

ADDITIONAL INFORMATION

Site sampled August 16, 2007.
Site sampled August 27, 2009.

RELATIVE PLANT SPECIES COMP. BY WEIGHT RANKING (TOP 5 SPECIES)

2007		2009	
Big sagebrush	33%	Big sagebrush	32%
Bluebunch wheat	20%	Vetch species	13%
Threadleaf sedge	15%	Bluebunch wheatgrass	12%
Japnese brome	8%	Western wheatgrass	11%
Western wheatgrass	7%	Prairie junegrass	9%

BASAL COVER

2007	2009	
52%	40%	Bare
44%	55%	Litter
4%	5%	Live

RELATIVE BASAL PLANT SPACING

2007	2009
1.8 inches	1.6 inches

RELATIVE BASAL PLANT SPACING BY SPECIES (Top 7 species)

2007		2009	
Bluebunch wheat	28%	Western wheatgrass	20%
Threadleaf sedge	18%	Prairie junegrass	20%
Western wheatgrass	14%	Bluebunch wheatgrass	10%
Blue grama	11%	Threadleaf sedge	10%
Needleandthread	6%	Big sagebrush	7%
Scarlet globemallow	5%	Hood's phlox	7%
Big sagebrush	5%	Needleandthread	5%

PLANT SPECIES FOUND IN TRANSECT AREA

2007	2009	
30	***26***	***Total count***
X	X	Cheatgrass
X	X	Japanese brome
X	X	Bluebunch wheatgrass
X	X	Threadleaf sedge
X	X	Western wheatgrass
X	X	Blue grama
X		Sandberg bluegrass
X		Kentucky bluegrass
X	X	Needleandthread
X	X	Prairie junegrass
X	X	Scarlet globemallow
X	X	Pricklypear cactus
X		Stickseed
X	X	Lepidium (White alyssum)
X	X	Hood's phlox
X	X	Vetch species
X		Woolly plantain
X		Clover species
X		Senecio species
X		Aster species
X		Mustard species
X		Nailwort
X	X	Vagrant lichen
X	X	Salsify
X	X	Broom snakeweed
X	X	Big sagebrush
X	X	Fringed sage
X	X	Douglas rabbitbrush
	X	Green needlegrass
	X	Penstemon species
	X	Povertyweed
	X	Sunflower species
	X	Curlycup gumweed
	2	Other vetch species
2	0	Unknown perennial forbs

DISCUSSION OF TIPPERARY PASTURE DATA BETWEEN 2007 AND 2009

Photos

In both years this site was sampled, ample spring moisture was received, meaning high plant vigor should be expected. The photos reveal high vigor on visible plants, particularly on big sagebrush in 2007. Leader growth in both years was strong. Many standing grass plants are visible in photos from both sample years, and the 2007 transect view photos show a bit more standing grass than do the 2009 photos. Conversely, the plot photos show more standing grass in 2009 than 2007. Further, several new big sagebrush plants appear in the 2009 plot photo along the bottom edge of the plot. The sagebrush data tables to be described below also support the notion that recruitment of new sagebrush plants occurred. The amount of bare soil was high in both sample years, and it is evident in all these photos.

Sagebrush data

Note first the minimal change in the number of plants encountered along the transect line (35 in 2007 and 36 in 2009). Though the number of plants intercepted changed little, the age classes showed signs of change. The sagebrush community appeared to be replacing itself at Tipperary. 100% mature age classes were found in 2007, and some younger plants were found in 2009. As referred to in the photo discussion above, numerous seedlings were visible in the photos and throughout the area. The overall canopy changed slightly, but the density of big sage plants fell. This suggests that some of the plants encountered in 2007 died. The seedlings observed in the area will mature and be counted on the density transect in the future.

Production

The Wyoming State Range Site Guides suggest potential production on this shallow loamy range site should be around 900 pounds per acre in an average year. As can be seen from the production table, clippings from both sample years were well below this mark. The improvement from 320 to 400 pounds per acre between the two years was noteworthy, but overall productivity was well below where it should be for this site. This suggests the water cycle was less effective. No signs of utilization were observed in 2009.

Composition by weight

Those plants producing the most biomass as measured by weight changed during the two years. Big sage continued to be the most abundant plant in the community. A vetch had a productive year in 2009. This forb was likely aided by the wet spring of '09. The composition of the highly desired bluebunch wheatgrass fell, likely due to the presence of the vetch. Japanese brome also fell from the list of the top five plants in 2009, which should be viewed as a positive sign.

Basal cover

Too much bare ground existed here in both sample years. Ideally, a site like Tipperary would have under 15% bare ground. The 12 percentage point drop in bare ground, corresponding with an increase in live cover should be taken as significant progress. However, much room for improvement still exists.

Relative basal plant spacing
These data are gathered as an addition to the ground cover data set. When dropping a steel rod to the soil at specified points along the transect's tape measure, the distance to the nearest perennial plant from that steel rod is measured. Over 100 data points, an average distance to the nearest perennial plant is achieved. At Tipperary, this average distance dropped by 0.2 inches. A reduction in this distance (a positive sign) suggests that more plants were growing on the soil surface and/or that the diameter of the plant crown had increased (an indicator of higher plant vigor). This change was not large, but it was in the desired direction.

Relative basal spacing by species
These data are gathered using that same steel rod described above. When measuring the distance to the nearest perennial plant, that plant's species is also recorded. When tallying data over 100 data points along the tape measure, the list of most abundant perennial plants can be created. The greatest change seen here is the reduction in presence of bluebunch wheatgrass. This important plant was still in the community, but it had lost its place atop the most abundant plants. As can be seen by looking at the 2009 figures, both Western wheatgrass and prairie junegrass produced well in 2009. Their abundant growth likely led to the reduction in composition bluebunch wheat. Two positive changes were seen within this list. These were the reductions in presence of threadleaf sedge and blue grama. At Tipperary, these plants would be favored if recovery periods between grazings were too short. With a recent change in management and longer recovery periods between grazings, the growth of perennial bunchgrasses is favored. This was occurring at Tipperary.

Plant species list
The plant species list revealed four fewer plant species in 2009 than 2007. Ideally, more plant species would be found in time. It is worth reviewing which plants left the list between the two sample years, and which plants were added. Two grasses fell from the list: Sandberg bluegrass and Kentucky bluegrass, both mid-seral species (meaning neither desired, nor undesired). Sandberg is surprising, since it grows well in years with wet springs. Several forbs fell from the list, including the showy flowers of senecio and aster. Conversely, desired species such as green needlegrass, penstemon, and curlycup gumweed, which is favored forage of sage grouse, were observed in 2009. Each of these changes suggests that the community was in transition. Further changes in community composition should be expected here in time.

Range trend
Trend here was upward. The strong reduction in bare ground, increase in live cover, and reduction in distance to the nearest perennial plant all provide evidence for this. These data are trending in a good direction. Further, the relative basal plant spacing by species table shows reductions in the presence of threadleaf sedge and blue grama. This again is evidence of positive change.

Management recommendations
The recovery time between grazings at Tipperary appears to have been too short in the past. Plants were grazed, but then lacked sufficient recovery time between grazings to fully recover from that earlier bite. Perennial bunchgrasses do not propagate well under such circumstances. The less desired plants of blue grama and threadleaf sedge, which both grow quite near the soil

surface with little standing crop, may thrive. Management altered course recently and lengthened recovery periods. The positive aspects of this change were seen at Tipperary in 2009.

The additional fencing that was added to Tipperary in recent years will speed the healing of this site. Grazing and plant recovery times can be better managed with establishment of new pastures. Animal impact may also be utilized more effectively with increased stock densities. A soil cap was found here, meaning that movement of moisture into the soil would be inhibited. Animal impact should help disturb this cap and speed the water cycle. Further, extra animal impact should help the mineral cycle. Some litter was lying idly on the soil surface without decomposing. Hoof action will help speed decomposition by ensuring greater contact of litter with soil where microorganisms of decay can go to work. More rapid cycling of nutrients in the system should increase productivity and invite the growth of additional plant species in time.

Early-warning indicators

If management actions are improperly applied on this site, look first for increased signs of erosion. Then look for a more well armored soil crust and reduced plant vigor as the water cycle becomes less effective. These would be signs that utilization rates have been excessive and that not enough plant material is remaining behind to fall to the soil surface as litter. Lastly, look for shifts in species composition away from the more desired plants.

If management actions are properly applied on this site, look first for reductions in bare soil amounts. Then look for a reduced soil crust. These would be signs that the water cycle is more effective. Next, the mineral cycle would become more rapid as litter mixes with soil and is broken down more readily. Watch next for increased plant vigor, even in drier years. Finally, look for increased presence of desired plants as species composition shifts in a favorable direction.

NUTRIENT ANALYSIS

At each of the sampled sites, a single plot was clipped to determine above-ground productivity. The plant matter taken from this clipping was saved and used to determine nutrient content of the plants. The sample is first sorted to remove plant species like sagebrush that livestock would not graze. The remaining sample, mostly grasses, is sent to Midwest Labs in Omaha, NE for nutrient analysis. The following table displays the dry-matter nutrient content of each of the sites sampled in 2009.

	Hall Home	Tipperary
Crude Protein (%)	7.67	6.35
Acid Detergent Fiber (%)	43.2	47.8
Total Digestible Nutrients (%)	53.3	48
Net energy-lactation (Mcal/lb)	0.54	0.48
Net energy-maintenance (Mcal/lb	0.51	0.45
Net energy-gain (Mcal/lb)	0.29	0.24
Sulfur (%)	0.14	0.11
Phosphorus (%)	0.12	0.15
Potassium (%)	1.13	0.52
Magnesium (%)	0.13	0.08
Calcium (%)	0.46	0.48
Sodium (%)	0.01	0.02
Iron (ppm)	227	473
Manganese (ppm)	46	26
Copper (ppm)	4	8
Zinc (ppm)	24	23

A glance at the composition by weight tables for each of these sites reveals those species contained in the sample. The Hall Homestead site was composed mainly of Sandberg bluegrass, Western wheatgrass, and prairie junegrass. Each of these species is an intermediate plant (called "mid-seral" in the jargon), meaning it is neither desired, nor undesired. Ideally, for overall rangeland health, these species would be replaced by more desired species such as bluebunch wheatgrass and green needlegrass. These two plants are large producers of above-ground plant material and will have a corresponding level of root mass below the soil surface. They may be expected to have a higher trace mineral content as a result.

That being said, bluebunch wheat was the most predominant plant in the sample at Tipperary. Other plants at Tipperary included Western wheatgrass and prairie junegrass. Conversely, at Hall Homestead, Sandberg bluegrass (one of those "mid-serals") was the dominant plant. Should then the sample at Tipperary be superior to Hall Homestead because of the presence of bluebunch wheatgrass? A glance at the table to the left reveals that the Tipperary sample with its bluebunch component was not superior. Look primarily at the crude protein, TDN, calcium, phosphorus, and the trace minerals.

The major variables of crude protein and TDN were lower at Tipperary than at Hall Homestead. It appears that the desired bluebunch wheatgrass did not provide additional crude protein and TDN that is highly desired on rangeland

soils. Conversely, some of the trace minerals were higher (calcium, phosphorus, and copper being important on the list). Perhaps the larger root mass of bluebunch at Tipperary did indeed reach different nutrients than did the Sandberg bluegrass at Hall Homestead.

While plants such as bluebunch wheatgrass may be highly desired from a rangeland health perspective, they may not provide an anticipated extra level of nutrient to livestock. These data suggest that having multiple plant species present at a site are best for rangeland health and livestock production. Cattle may choose their forage, and with the rotation through pastures designed by managers, livestock may enjoy a high plane of nutrition throughout the growing season.

Switching areas of focus, the nutrient table above reveals that none of the nutrients featured was at toxic levels. Iron was higher than desired at Tipperary (over 1000 ppm reaches toxic levels), which may tie up copper in the cow's system. Copper is important for strong immune system function. Should management view signs of poor herd health, the iron levels may provide a signal as to the cause. That being said, however, a glance at past Merlin Ranch grass samples has shown wide variations in iron levels of sampled plants. These range from the 50s to the 400s. Iron levels reached 483 ppm in the 2007 Tipperary sample, suggesting iron levels may be high in this particular area. These figures do not require cause for alarm, for cattle graze forage across multiple pastures, but observation of herd health in Tipperary is warranted.

As done in previous years, the nutrients provided by the two samples will be compared against the needs of an 1100-pound lactating cow. The plants were collected in August as they were going dormant for the year. Using the Nutrient Requirements of Beef Cattle tables (NRC, 1984), the requirements of an 1100-pound lactating cow of average milking ability are stated as follows:

Dry Matter	Crude Protein	TDN	Ca	P
21.6#	2#	12.1#	27g	22g

Assuming our sample cow meets her dry matter requirements, the **Hall Homestead** sample will return the following to her:

Dry Matter	Crude Protein	TDN	Ca	P
21.6#	1.7#	10.4#	44g	12g

As can be seen, the sample is short on meeting this cow's needs during this window of the growing season. She is short 0.3# crude protein, 1.7# TDN, and 10g of phosphorus. The calcium to phosphorus ratio was 3.7 to 1, which was well below the recommended limit of 7:1. These figures should not be surprising, given impending dormancy of plants. It is worth management's attention to note that the cow will be drawing from reserves to meet her own

requirements. It is also worth noting that the requirements of a dry cow would be met with this sample of forage.

Moving to the **Tipperary** sample, and assuming our sample cow meets her dry matter requirements, the forage will return the following:

Dry Matter	Crude Protein	TDN	Ca	P
21.6#	1.4#	10.4#	47g	15g

Like the Hall Homestead sample, plants at Tipperary will not meet all the needs of our lactating cow. She will be short 0.6# crude protein, 1.7# of TDN and 7 grams of phosphorus per day. Of these, the low TDN figure presents the greatest deficiency. The calcium to phosphorus ratio was roughly 3 to 1, well below the recommended limit of 7:1. Again, the deficiency is due to the impending dormancy of the plants. During the active growing season, these plants likely met the needs of our cow.

Management recommendations from nutrient analyses

Analysis of the sample nutrients on the preceding pages serves as a guide for management when considering nutritional factors as they relate to livestock performance. It is intended to be a "shotgun" approach to examining livestock performance, rather than serving as a precise science. As an example of this, note that livestock have access to forage throughout a pasture, rather than just the forage at the sample site. Some of their nutrient deficiencies may be made up with different forage in the same pasture. Should the sample cow graze forage along a riparian area with its complement of green and growing forage, many minerals may be added to the cow's diet.

When taking management action with these nutrient data, the first item to consider is early weaning of the calf. If cow longevity is an issue across Merlin's herd, calves may be weaned earlier in the fall than they previously were. Removal of the calf that limits lactation would reduce the cow's bodily requirements. She would likely gain in body condition as plants continued dormancy.

Next, management may place the herd on former hay meadows as fall advances. These meadows that had been irrigated and hayed through the summer would have ample forage that was green and still growing. This would help replenish lost nutrients for a short time.

Lastly, management may seek to provide a trace mineral supplement to these cows. During winter, this supplement would be fed alongside normal hay or forage. Nutrients could be stored in the cow's body and be ready when nutrient content of the plants decline in fall.

MONITORING METHODS

On August 26, 2009, Mark Gordon of Merlin Ranch and Todd Graham of Aeroscene toured Merlin Ranch, examining potential study sites. They selected three study sites on each ranch to be sampled in 2009.

Todd Graham read those transects over the next few days. He laid out a 200-foot tape measure along the soil surface that served as the basis of the monitoring protocol. A variety of methods were then conducted from this tape measure (Figures 1 and 2).

Figure 1: five-gallon bucket lids used to mark transect locations

Each location was photographed and described. This description included a list of plants, activities of animals, and type of soil and terrain. A background field form was used to record the following information:

1. Site name;
2. Date;
3. Investigators;
4. Location description;
5. Details of transect layout and orientation;
6. Production characteristics (from area soil survey);
7. Current weather conditions;
8. History of pasture use;
9. Wildlife observations;
10. Soil characteristics;
11. Vegetation characteristics; and
12. Reasons for site choice.

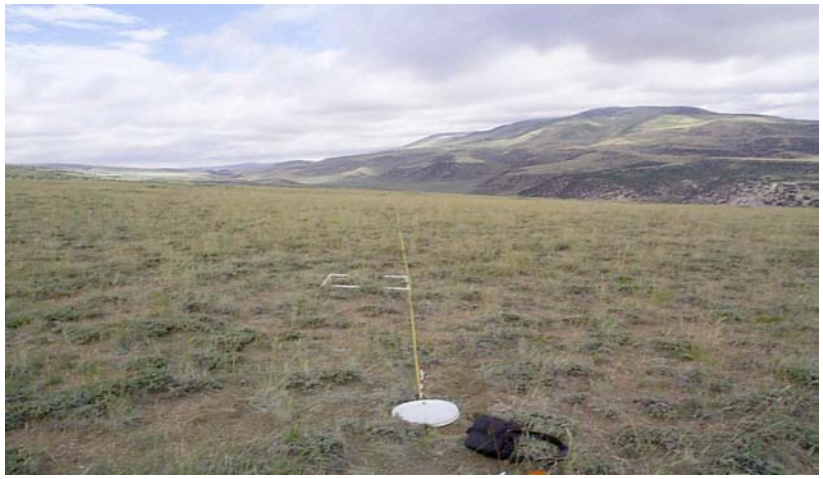


***Figure 2: Permanent transects were 200 feet long and were permanently marked* on each end.**

Ten plots along the transect line were examined and 16 indicators of rangeland health were evaluated (Figure 3). The first plot lay at the 10-foot mark on the tape measure, and each successive plot was read at 20-foot intervals (10,

30, 50, 70 feet, etc.) Ocular utilization estimates were also recorded.

A rangeland health qualitative scoring guide accompanies this document that portrays how each of the 16 indicators was evaluated. Each indicator is assigned a score from one to five, with five being the score that best reflects achievement of the landscape goals for that site. As an example, consider the "litter distribution" indicator. If it was found that litter displayed "mostly uniform, slightly patchy" appearance, this indicator would be assigned a score of "4." Each of the 16 indicators was scored in this way at each of the 10 plots.

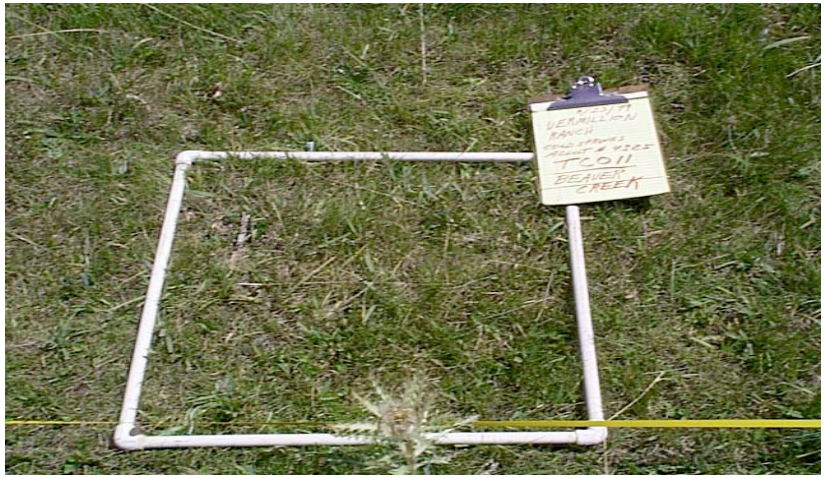


Figure 3: The first plot on a transect. [This plot lies in Colorado.]

When all 10 plots have been evaluated, the scores for each indicator are tallied. Using the litter distribution indicator example, the scores may read 4, 3, 5, 2, 4, etc. up to ten plots. Assume that this indicator's score totaled 36. (If all plots received a "5", a perfect score would be achieved at 50 points.) Then, multiply this score by two. This allows the indicator's score to be plotted on the target (Figure 4) for visual portrayal on a 100 point scale. In the example, litter distribution would receive a 72 for its score. This indicator would be plotted on the Web at the 72 mark, which lies in the silver target zone. Using the colors of the Olympics, gold is preferred, silver in the mid range, and bronze is least desired.

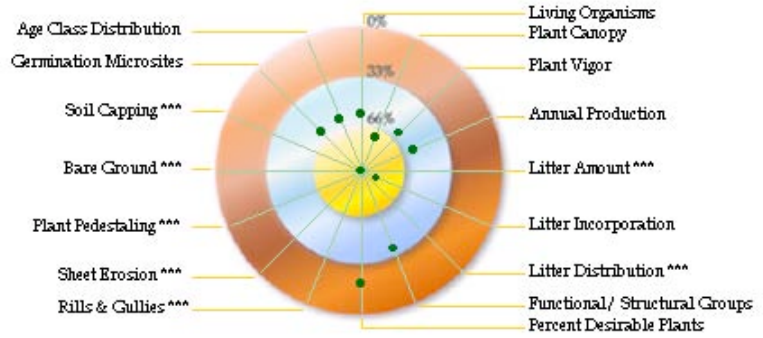


Figure 4: The target portrays results of each of the 16 indicators studied based on field scores.

An overall site score is then sought. This score is calculated by averaging the total score for each of the 16 indicators. For example, adding the scores for all 16 indicators together may produce a total of 1456. By

dividing this figure by 16, an overall site score of 91 is achieved. The overall site score will be displayed in the "Additional Information" box. This figure will change through time, and progress toward the stated landscape description goal can be tracked.

Additionally, the 16 indicators of rangeland health provide information for making management decisions. This report provides a brief narrative on how each indicator was evaluated and what management recommendations arose through their evaluation.

The Wyoming State Range Site Guide suggests potential production for each site. The site's average-year production figure was used to produce the bar graph featured in Figure 5 below. A single plot was clipped at each site. The clipped plants were dried, and then weighed. The resulting weight in pounds per acre is displayed as the "today" figure.

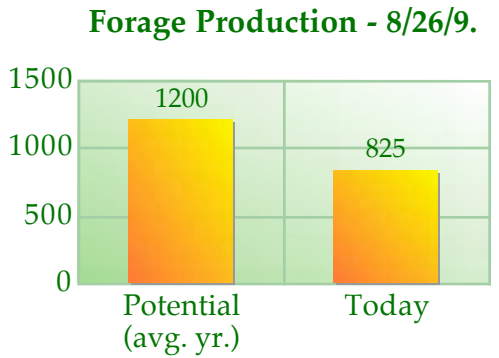


Figure 5: Plant production on sample day as compared with the site's potential from the soil survey.

While looking in each study plot, that species estimated to be most abundant by weight is evaluated. A value of "5" is then assigned for that species. The next most abundant by weight received a "4" and so on until the five most abundant species by weight have been recorded. The procedure is repeated for all 10 study plots. The percentage composition of each species is calculated based on its scoring versus other species encountered in the plots. The most abundant will have the highest scores and the highest percentage composition. A chart with the five heaviest species is then generated like the one featured in Figure 6 below.

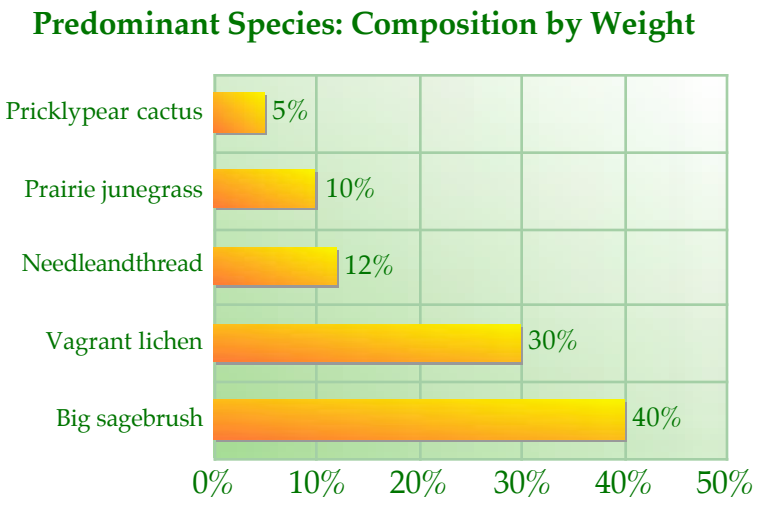


Figure 6: The most abundant species as composition by weight.

A sample of forage plants most likely to be selected by cattle is sent to Midwest Labs, Inc. in Omaha, Nebraska. The nutrient analysis returned is presented in the body of this report.

The procedure also uses the 200-foot tape measure as a base for collecting information such as ground cover and plant density. Using the point intercept method, a steel rod is lowered to the soil surface using a point frame (Figure 7).

Figure 7: The point frame used in point intercept sampling for gathering ground cover and plant density data.

The rod is lowered to the soil surface every other foot along the 200-foot tape measure. At each point, ground cover is classed as bare soil, litter, or live plant cover. After examining all 100 points, the percentage of each class is calculated. A pie chart is generated portraying the results (Figure 8).

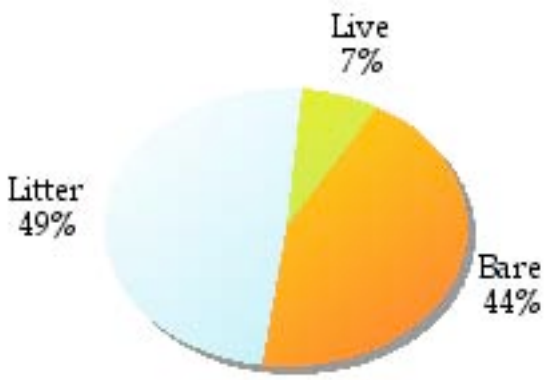


Figure 8: The ground cover chart generated by using the point intercept method.

At each point ground cover data was collected, data on basal cover by plant species was gathered. When the point intercept rod was lowered to the soil surface, the distance to the nearest perennial plant was measured. The average distance for all 100 points is calculated and the average distance to nearest perennial figure is found and displayed in the "Additional Information" box. Simultaneously, this nearest plant's species was recorded. The seven species representing the closest perennial plants (the most dense) are portrayed in the "Basal Cover by Species" bar graph (Figure 9).

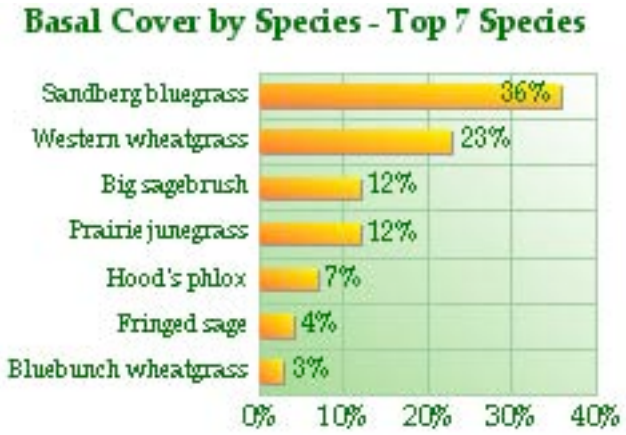


Figure 9: Basal cover by species bar graph created by measuring the distance to the nearest perennial plant using the point intercept method. The seven most numerous species are displayed here.

This means of collecting plant density data was developed by the Holistic Management International in Albuquerque, NM.

Rangeland Health Indicators Scoring Guide

Side One

Indicator	5	4	3	2	1
Living Organisms	Abundant signs of non-plant life. Many different life forms.	Several signs of non-plant life; different life forms.	Moderate signs of non-plant life. Some different life forms.	Few signs of non-plant life and different life forms.	Little, if any, sign of non-plant species.
Plant Canopy	Canopy: 81 -100% of plot. Best photosynthetic activity.	Canopy: 61-80% of plot. Good photosynthetic activity.	Canopy: 41-60% of plot. Moderate photosynthetic activity.	Canopy: 21-40% of plot. Photosynthetic area low.	Canopy 0-20% of plot. Photosynthetic area very low.
Plant vigor	Capability to produce seed or vegetative tillers is not limited relative to recent climatic conditions.	Capability to produce seed or veg. tillers is only slightly limited relative to recent climatic conditions.	Capability to produce seed or vegetative tillers is somewhat limited relative to recent climatic conditions.	Capability to produce seed or vegetative tiller is greatly reduced relative to recent climatic conditions.	Capability to produce seed or vegetative tillers is severely reduced relative to recent climatic conditions.
Annual Production	Exceeds 80% of potential production.	60-80% of potential production.	40-60% of potential production.	20-40% of potential production.	Less than 20% of potential production.

Indicator	5	4	3	2	1
Litter Cover	30-70% of soil surface in plot covered with litter.	20-30% of soil surface in plot covered with litter.	10-20% of soil surface in plot covered with litter.	1-10% of soil surface in plot covered with litter.	No litter present on soil surface in plot.
Litter Incorporation	Litter mixing well with soil, resulting in more rapid mineral cycle.	Litter partially mixing with soil. Litter contacting soil.	Some mixing of litter with soil. Some elevated litter.	Reduced mixing of litter with soil; elevated litter; lesser litter amount.	Litter amount is light, resulting in slow cycling.
Litter distribution	Uniform across plot.	Less uniformity of litter cover in plots.	Litter becoming associated with prominent plants or other obstructions.	Plot showing general lack of litter, with patches around prominent plants.	Litter largely absent.
Functional/ Structural Groups	F/S groups and number of species in each group closely match that expected for site.	Number of F/S groups slightly reduced and/or number of species slightly reduced.	Number of F/S groups moderately reduced and/or number of species moderately reduced.	Number of F/S groups reduced and/or number of species significantly reduced.	Number of F/S groups greatly reduced and/or number of species dramatically reduced.
Percent Desirable Plants	Desirable species exceed 80% of plant community. Scattered intermediates.	community are desirable species. Remainder mostly intermediates and/or a few undesirables present.	40-60% desirable plant species. And/or some presence of undesirable species.	20-40% of desirable plant species in plot. And/or strong presence of undesirable species.	Less than 20% of plants are desirable species. And/or undesirable species dominate plot.

Rangeland Health Indicators Scoring Guide

Side Two

Indicator	5	4	3	2	1
Rills and Gullies	Rills or gullies absent.	Rills or gullies with blunted and muted features.	Rills or gullies small and embryonic, and not connected into a dendritic pattern.	Rills and gullies connected with dendritic pattern.	Well defined and actively expanding dendritic pattern.
Scouring or sheet erosion	No visible scouring or sheet erosion	Small patches of bare soil or scours. No desert pavement.	Patches of bare soil or scours developing. Formation of desert pavement.	Patches of bare areas or scours are larger. Desert pavement more widespread.	Bare areas and scours well developed and contiguous. Abundant desert pavement.
Plant pedestaling	No pedestals present.	Active pedestaling or terecette formation is rare.	Slight active pedestaling.	Moderate active pedestaling. Occasional exposed roots.	Abundant active pedestaling. Exposed plant roots are common.
Bare ground	Amount and size of bare areas nearly to totally match that expected for the site.	Slightly to moderately higher than expected for the site. Bare areas are small and rarely connected.	Moderately higher than expected for the site. Bare areas are of moderate size and sporadically connected.	Moderately to much higher than expected for the site. Bare areas are large and occasionally connected.	Much higher than expected for the stie. Bare areas are large and generally connected.

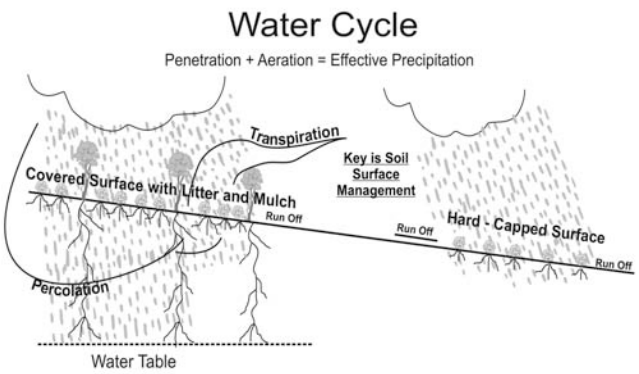
Indicator	5	4	3	2	1
Soil Crusting	No physical crusting present.	Recently formed physical crust seen over some of plot.	Recently formed physical crust seen over much of plot.	Older physical crust formed over much of plot.	Plot dominated by older physical crust.
Germination Microsites	Microsites present and distributed across the site.	Some formation of crust, soil movement, litter that would degrade microsites.	Developing crusts, soil movement, and/or litter degrading microsites; developing crusts are fragile.	Soil movement, crusting, litter, lack of protection sufficient to inhibit some germination and seedling establishment.	Soil movement, crusting, litter, lack of protection sufficient to inhibit most germination and seedling establishment.
Age class distribution	Variety of age classes seen in plot.	Some sign of seedlings and young plants.	Seedlings and young plants missing.	Some deteriorating plants present.	Primarily old or deteriorating plants present.

RANGELAND HEALTH

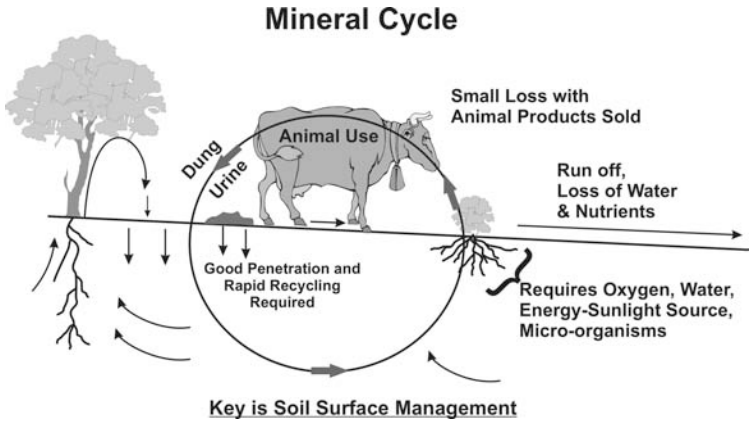
In its 1994 report Rangeland Health, the National Research Council defined rangeland health as the degree to which the integrity of the soil and the ecological processes of rangeland ecosystems are sustained. Range in good health produces more forage and better wildlife habitat, while watershed condition is improved, resulting in more stable stream flows and higher water quality (NRC, 1994). Healthy range generally supports more plant and animal diversity and provides greater ecological stability in terms of productivity and population flux.

The monitoring methods used here were intended to observe changes in rangeland health through time. Both qualitative observations and quantitative methods were employed. Both are intended to provide decision-making information to land managers. Methods used in generation of this report are aligned with the findings with the Rangeland Health document.

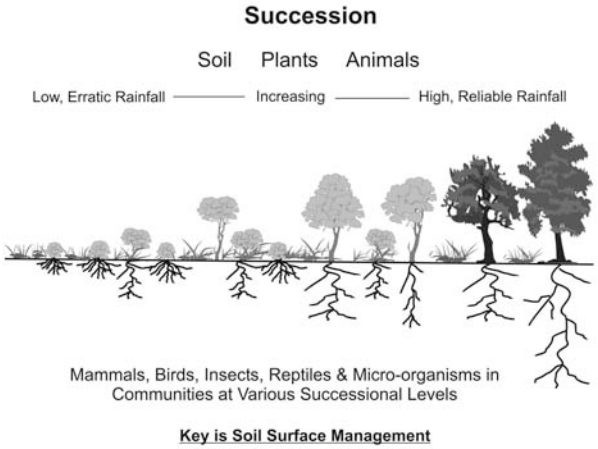
The following pages visually describe the ecosystem process described in this report. They are the water cycle, mineral cycle, community dynamics (succession) and energy flow.



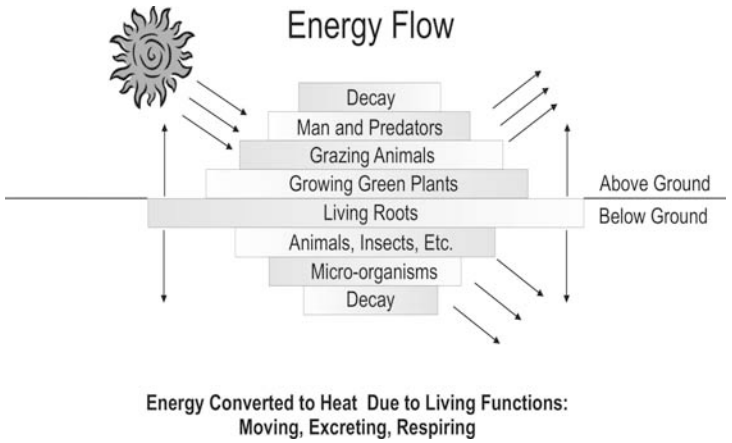
An effective water cycle requires covered soil and high biodiversity. When effective, most water soaks in quickly where it falls. Later, it's released slowly through plants that transpire it, or through rivers, springs, and aquifers that collect through seepage what the plants don't take. When biodiversity is reduced and soil exposed, much water runs off as floods. What little soaks in is released rapidly from evaporation which draws moisture back up through the soil surface (Savory, 1993).



Like the water cycle, an effective and rapid mineral cycle requires covered soil and high biodiversity. When effective, many nutrients cycle between living plants and living soil continually. When soil is exposed and biodiversity low, nutrients become trapped at various points in the cycle, or are lost to wind and water erosion (Savory, 1993).



With few exceptions, communities strive to develop toward ever-greater complexity, and thus stability. From unstable bare ground, where biodiversity is low, stable complex range or forest communities, high in biodiversity develop over time (Savory, 1993). This is succession.



Almost all life requires energy that flows daily from the sun. The basic conversion of this solar energy to useable form takes place through plant material on land and in water. Energy passes from plants to whatever eats them, and in turn eats the consumers of plants. Energy doesn't cycle, but flows through the ecosystem until it's consumed (Savory, 1993).

LITERATURE CITED

National Research Council. 1984. Nutrient Requirements of Beef Cattle. National Academy Press, Washington. 90 p.

National Research Council. 1994. Rangeland Health- New methods to classify, inventory, and monitor rangelands. National Academy Press, Washington. 180 p.

Savory, A. 1993. The ecosystem that sustains us. Holistic resource management quarterly. Number 40.

United States Department of Agriculture, Natural Resources Conservation Service. 1990. Wyoming State Range Site Guide.