Merlin Ranch:

2010 Rangeland Health Monitoring Report for Hall Pasture, Three Section, and Lower Hepp Pastures

Prepared for Merlin Ranch Management

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INTRODUCTION

This document presents the findings of three rangeland health monitoring transects examined on Merlin Ranch in August 2010. These sites were located in the Hall Pasture, Three Section, and Lower Hepp Pastures. The Hall Pasture and Three Section sites were established previously, and data from past readings will be displayed side-by-side with 2010 data, and range trend will be determined. The Lower Hepp Pasture site was established in 2010.

Merlin began a monitoring effort in 2006 to track changes in land health through time. Using permanently marked study sites within pastures, data gathered through the years provides a permanent record of changes on the land. Data presented will show how the land has responded to changes in management, changes in precipitation, and natural phenomena such as grasshopper outbreaks. The data will also be the basis for making management recommendations to improve land health and overall performance of pastures.

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 in the Methods section. Management may influence the function of these processes by altering such variables as stocking rate, stock density, grazing duration, recovery times between grazings, utilization rate, and timing of grazings. Data presented in this report will show how these variables interact with function of ecosystem processes, and how management may improve their interaction for the improvement of pasture performance, wildlife habitat, and profitability.

Since 2006, the pastures that have been studied at Merlin Ranch are as follows:

2006: Hall Pasture, Hall Homestead;
2007: Three Section, Tipperary;
2008: Pigpen, Lower, and M&M#1; and
2009: Hall Homestead, Tipperary.

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.

SUMMARY OF FINDINGS AND MANAGEMENT RECOMMENDATIONS CONTAINED IN THIS DOCUMENT

This portion of the report briefly reviews the results of the land health investigations conducted at each of the three sample sites. Management recommendations from the sites are also presented. For greater detail and discussion, see the individual transect summaries themselves.

Hall Pasture – MRT07

This site was read for the third time in 2010, and data from 2010 and the prior years' readings will be displayed side-by-side. This site was initially chosen to track changes in the even-aged stand of big sagebrush that seemed to dominate the pasture. That big sage community displayed slow signs of decay in the data sets, with a 30% decline in big sage plants encountered along the transect line and a 27% reduction in overall sagebrush density. No evidence points to the reason for the sagebrush decline. Photos will show this gradual decline in the sagebrush community. Where big sage plants have died on the transect line, the void has been filled by undesired plants like cheatgrass and Japanese brome and desired plants like Western wheatgrass. The amount of bare soil declined, and live cover percentage slowly climbed, both of which were positive signs. Highly desired species like needleandthread and green needlegrass were present in the area, but not in abundance. These plants were slow to propagate in the area, a finding that suggests corrective management action must be taken.

The pasture should be deferred from spring grazing for the next two to three years to allow propagation of desired bunchgrasses as big sage plants continue to falter. Graze the pasture later in the growing season once the bunchgrasses have had a chance to produce seed. Two years should allow plenty of time for establishment, and then the pasture may also be used at other times of the year.

Three Section Pasture

This site was first established in 2007 to be representative of the flat portion of the Three Section Pasture. In spring 2009, the site was partially treated with a Lawson Renovator that crossed the transect line in two large swaths. The treatment dramatically altered the site's plant canopy, particularly for big sagebrush, and increased litter cover while reducing bare ground. Surprisingly, the number of big sagebrush plants on the transect line changed little. This is due to the fact that many young big sage plants grew in untreated areas. Had the treatment not occurred, the site would likely have displayed many new big sage plants. The desired plant needleandthread increased it basal abundance, but mid-seral species continued to dominate this site.

The site in 2010 appeared to still be responding from the Lawson treatment. Management must help promote growth of desired perennial bunchgrasses that will compete with the abundant cheatgrass, Japanese brome, and mid-seral plants so prevalent on the site. This is best accomplished by, first, deferring the pasture to later-season grazing for the next two years (to help the bunchgrasses grow), second, ensuring that adequate recovery times exist between grazings, and, third, by ensuring that utilization rates are at moderate levels.

Lower Hepp Pasture

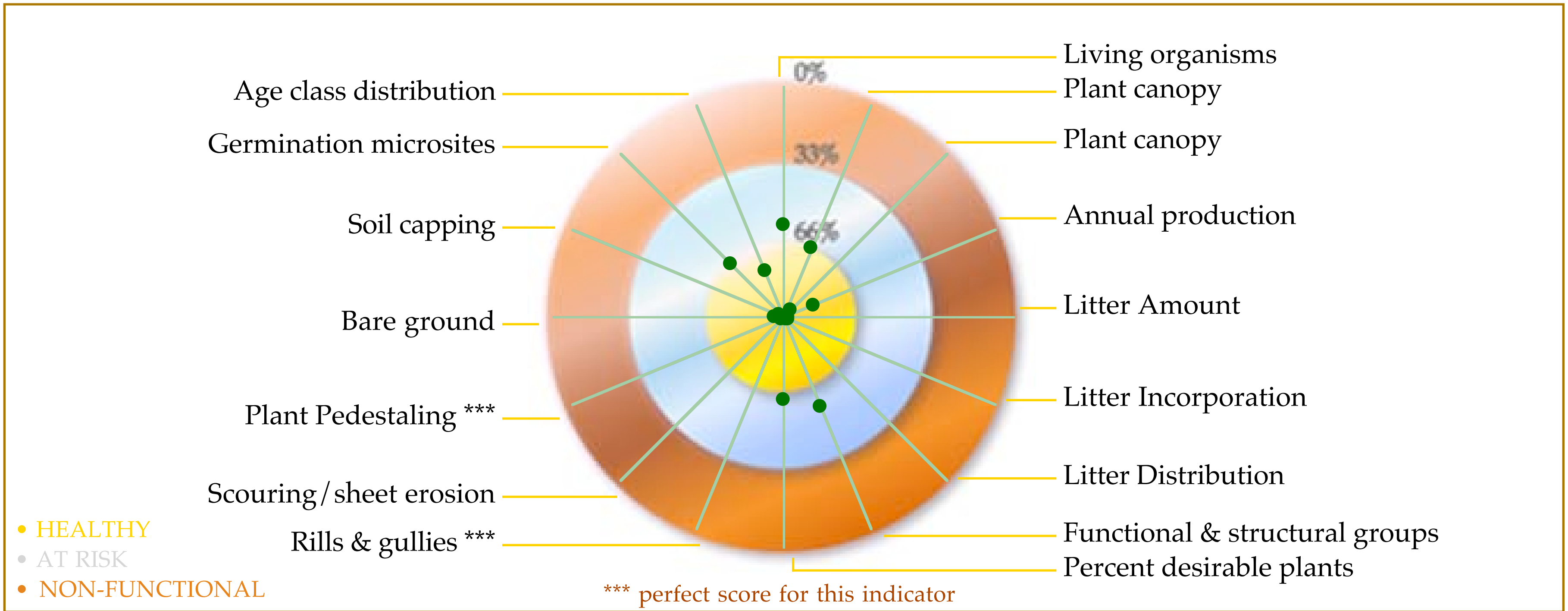
This site was established in 2010 in an area that had not received much livestock use in quite some time. Management had recently established a new stockwater tank nearby and had constructed new fences. The water and fences will dramatically increase the stock density and overall use of this area, and this additional animal impact should be encouraged. The water cycle was less effective than desired with too much bare ground, some signs of erosion, and a soil cap. The mineral cycle was slower than desired, and production within energy flow was well below the site's potential. Low and mid-seral plants dominated the site. Highly desired species like needleandthread and green needlegrass were present, but not in abundance.

Extra animal impact will help jumpstart both the water and mineral cycles. The capped soil surface will be disturbed, extra litter will contact the soil surface, germination sites will form, and erosion will be prevented. Management should consider more aggressive actions to promote impact of soils, such as breaking up a salt block and scattering it through the brush.This "building of infrastructure" will result in increased productivity initially, although, as in other pastures on Merlin Ranch, production may be composed of undesired species such as cheatgrass and Japanese brome. To help desired bunchgrasses compete with these low-seral plants, management must ensure that utilization rates are kept at moderate levels, recovery times between grazings are adequate, and grazing durations remain short.

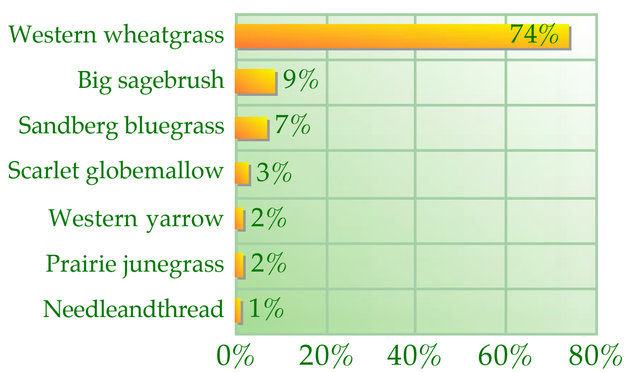
Data from the Hall Pasture site will be displayed on the following pages. Indicators of rangeland health will first be discussed. Next, both photo and data comparisons will be made between the two sample years. Finally, a discussion of data between the two years will ensue, trend determination made,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

Hall Pasture – MRT07

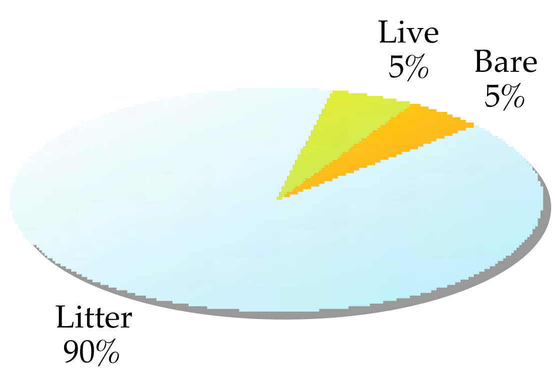
Data Summary



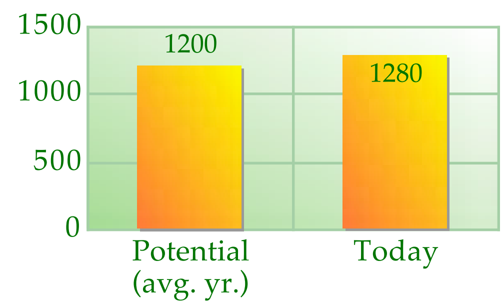
Basal Cover by Species - Top 7 Species



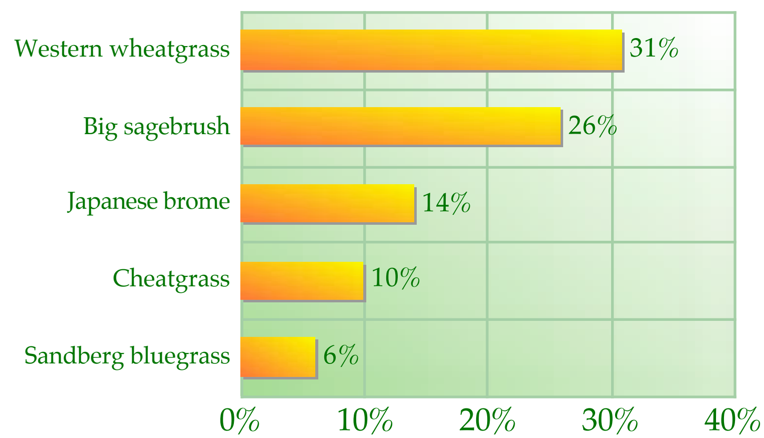
2011 Basal Cover



Forage Production

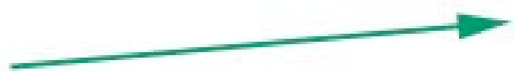


Predominant Species: Composition by Weight



Additional Info:

Apparent range trend:



Site sampled August 11, 2010.

UTM coordinates (NAD 83): 13T 0375390E / 4915369N

Relative basal plant spacing: 1.4 inches.

21 plant species found at site.

Plant species encountered at site:

Japanese brome
Cheatgrass
Western wheatgrass
Needleandthread
Sandberg bluegrass
Prairie junegrass
Kentucky bluegrass
Blue grama
Threadleaf sedge
Big sagebrush
Fringed sage
Salsify
Peppergrass
Western yarrow
Tansymustard
Pricklypear cactus
Scarlet globemallow
Mustard species
Winterfat
Vetch species
Dandelion

Hall Pasture (Transect MRT07)

This site was first chosen in 2005 to be representative of an area of the Hall Pasture. Big sagebrush in the area also appeared of a single age class with a tall and abundant canopy. Monitoring the site would track changes in the brush canopy through time, along with responses from herbaceous vegetation.

The first plot studied in the Hall Pasture.

The **Bullseye Target** displays the analysis of 16 indicators of rangeland health. Function of indicators is shown using colors of the Olympics. Those whose scores fall in the gold were functioning optimally, those in the silver require improvement, while those in the bronze require more urgent management attention.

The **water cycle** was effective here. Almost no **bare soil** was displayed within the study plots, and as may be seen in the **basal cover pie chart,** the point intercept method revealed that only 5% of the soil was bare. No signs of either wind or water **erosion** were evident, and no signs of a **soil cap** were present. Any precipitation falling from the sky should enter the soil, rather than running off. Plants were also well **distributed** across the soil surface, and the measure of **relative basal plant spacing** was 1.4 inches, an acceptable figure for this site.

The **mineral cycle** was moderately rapid. The amount of litter was optimal and was adequately covering the soil surface. Litter was **incorporating** well, and digging a finger into the soil surface revealed a good mixture of soil and litter that will help maintain the speed of the mineral cycle. Conversely, dung piles appeared older, meaning they were not breaking down rapidly. These conflicting indicators suggest that the mineral cycle still has room for improvement.

Within **energy flow**, annual **production** from the clipped plot revealed 1280 pounds per acre, or just over the site's average year potential of 1200. This was encouraging for a below-average precipitation year like 2010. **Plant vigor** was high, and leader growth on big sage plants approached 12 inches. The **plant canopy** was abundant even in the intespaces between big sage plants. This indicator suggests that management has succeeded in keeping stock densities high enough where hoof action may disturb any soil cap present. This helps plants grow in those large gaps between big sage plants. As the **composition by weight** table shows, much of the production at this site was composed of Western wheatgrass and big sage plants.

They are both desired species for this site. However, the more highly desired species such as bluebunch wheatgrass, green needlegrass, or even Idaho fescue were not found in abundance here. Rather, undesired species like Japanese brome and cheatgrass composed much of the site's total production in 2010.

Management has produced an effective water cycle, a moderately rapid mineral cycle, and high energy flow on this site. The function of these three processes point to a certain level of resilience of this site: water was moving into the soil, minerals were cycling, and photosynthesis was occurring. These were all positive factors, and management should be given credit for producing this position of site durability. Next, the **successional process** must advance. The **percent desired plants** was not low, but could be higher. As may be seen on the **basal cover by species** table, mid seral plants (those neigher highly desired nor undesired) dominated the site. These were Sandberg bluegrass, western yarrow, and prairie junegrass. The highly desired species needleandthread was present, but not in the desired abundance. Ideally, needleandthread, bluebunch wheatgrass, and green needlegrass will increase their presence here and serve as a strong competitor to Japanese brome, cheatgrass, and blue grama.

The advancement of the successional process will be discussed further below in the comparison of changes in plant species through time.

Transect view. Photo taken August 11, 2010.

Transect view. Photo taken August 17, 2007.

Transect view. Photo taken September 4, 2005.

The first plot studied at the Hall Pasture site. Photo taken August 10, 2010.

The first plot studied at the Hall Pasture site. Photo taken August 17, 2007.

The first plot studied at the Hall Pasture site. Photo taken September 4, 2005.

BIG SAGEBRUSH DATA

2005	2007	2010	*Line intercept:*
56	43	39	*Number encountered*
			Line Intercept: Age Class
0%	0%	0%	seedling
0%	0%	0%	young
95%	93%	97%	mature
5%	7%	3%	decadent
26	28	29	*Avg plant height - inches*
48%	32%	36%	*Percent canopy cover*
103	99	75	*Density per 1000 square feet*

PRODUCTION: Pounds per acre

2005	2007	2010
670	850	1280

ADDITIONAL INFORMATION

Site sampled September 4, 2005.
Site sampled August 17, 2007.
Site sampled August 11, 2010.

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

2005		2007		2010	
Big sagebrush	32%	Big sagebrush	27%	Western wheatgrass	31%
Western wheatgrass	21%	Western wheatgrass	18%	Big sagebrush	26%
Blue grama	11%	Cheatgrass	18%	Japanese brome	14%
Japanese brome	11%	Japanese brome	17%	Cheatgrass	10%
Cheatgrass	9%	Sandberg bluegrass	12%	Sandberg bluegrass	6%

BASAL COVER

2005	2007	2010	
19%	12%	5%	Bare
79%	83%	90%	Litter
2%	5%	5%	Live

RELATIVE BASAL PLANT SPACING - inches

2005	2007	2010
1.6	2.1	1.4

RELATIVE BASAL PLANT SPACING BY SPECIES (Top 7 species)

2005		2007		2010	
Western wheatgrass	60%	Western wheatgrass	59%	Western wheatgrass	74%
Sandberg bluegrass	14%	Big sagebrush	14%	Big sagebrush	9%
Big sagebrush	13%	Blue grama	13%	Sandberg bluegrass	7%
Blue grama	9%	Sandberg bluegrass	9%	Scarlet globemallow	3%
Western yarrow	2%	Dandelion	4%	Western yarrow	2%
Pricklypear cactus	1%	Needleandthread	1%	Prairie junegrass	2%
Cusick bluegrass	1%	No seventh species		Needleandthread	1%

PLANT SPECIES FOUND IN TRANSECT AREA

2005	2007	2010	
21	*24*	*21*	***Total count***
X	X	X	Japanese brome
X	X		Cusick bluegrass
X	X	X	Cheatgrass
X	X	X	Western wheatgrass
X	X	X	Blue grama
X	X	X	Needleandthread
X		X	Threadleaf sedge
X	X	X	Prairie junegrass
X	X		Sixweeksgrass
X	X	X	Sandberg bluegrass
X	X		Silver sagebrush
X	X	X	Big sagebrush
X	X	X	Winterfat
X	X	X	Lepidium
X	X	X	Pricklypear cactus
X	X	X	Western yarrow
X	X	X	Tansymustard
X	X		Vagrant lichen
X	X	X	Scarlet globemallow
X	X	X	Dandelion
	X		Clover species
	X		Pennycress
	X		Woolly plantain
	X	X	Fringed sage
		X	Kentucky bluegrass
		X	Salsify
		X	Vetch species
		X	Mustard species
1	1		Unknown perennial forbs

DISCUSSION OF HALL PASTURE DATA FROM 2005, 2007, AND 2010

Photos

The photo sets on the previous pages show three years worth of photos displayed side-by-side. See first the transect view photos. The photo from 2005 was taken in a much drier year than either of the other two sample years, and the differences in plant vigor were obvious. Plants displayed much higher vigor in both 2007 and 2010. Further, some signs of bare ground are visible in the 2005 shot, whereas this bare ground is not so evident in the other two years. An obvious difference in sagebrush presence also exists in these transect view photos: many big sage plants are evident in the 2005 photos, but the number of living plants appears to decline with each sample year. The number of standing brush skeletons also appears to increase though time. As the sagebrush data discussion will reveal, big sage plants were declining in presence at this site.

The plot photos also show loss of big sage through the years. That mature big sage plant found in the 2005 photo was missing by 2007 and had not been replaced by 2010. Some bare ground is also visible in the 2005 plot photo, where none appears in either 2007 or 2010. This is an indicator of positive change at the site.

Sagebrush data

A walk around the site in 2010 showed much change in the big sage community: multiple decadent and dead sagebrush plants were observed, and some young plants were now growing. These observations suggest that the big sage community was replacing itself. Data gathered through the years support these observations. The number of big sage plants encountered along the transect line had slowly declined, from a high of 56 in 2005 to 39 in 2010 (a decline of 30%). The age class distribution of these plants points to further decline, where a certain percentage of decadent plants was found each sample year. Those new plants discussed earlier had not yet appeared on the transect line. The density of big sage plants also continued to fall, dropping 27% since 2005.

Some big sagebrush plants that had been encountered on the transect line appeared to have died between 2007 and 2010. This left a large void on the soil surface where the plant had once grown (see photo on next page). The skeleton of that plant is visible in the center of the photo just to the left of the transect's tape measure. The loss of this single plant changed the hydrology of the site to the extent that large numbers of cheatgrass and Japanese brome plants grew in behind it. Lots of litter and nutrients may be found at this particular spot, and these colonizers took advantage of their presence to grow and propagate.

The point of this discussion and of showing the photo, is that with the continued churn of the sagebrush community in this portion of the pasture, management has the opportunity to greatly influence the future species composition of the area. Ideally, those Japanese brome and cheatgrass plants will be replaced by green needlegrass and other high-seral grasses. When that occurs, the ranch will be able to quantitatively measure benefits through improved plant productivity, more constant plant productivity through wet years and dry years, and increased stocking rates. See the management recommendations discussion below for achieving such benefits.

Production
The Wyoming State Range Site Guides for this site suggests that plant productivity should be 1900 pounds per acre (USDA, 1990). Below-average precipitation in 2010 helped produce a clipped plot that exceeded the site's potential, which was a testament to the effectiveness of the water cyle. Future increases in production are possible, since much of 2010's crop appeared to be composed of cheatgrass. In time, the more desired plants such as sand dropseed and green needlegrass, which are much more productive than cheatgrass, should become more prominent in this community. This will drive production to more elevated levels.

Composition by weight
As the energy flow discussion on previous pages presented, the most productive plants at Hall Pasture site continue to be either low-seral (undesired plants like cheatgrass and Japanese brome), or mid-seral (middle-of-the-road plants like blue grama and Sandberg bluegrass). The desired high-seral plants like needleandthread were present, but not in the desired abundance.

Big sagebrush continued its slow decline in community composition, and it appears to have been replaced by Western wheatgrass. Ideally, as this community continues to change with loss of sagebrush, high-seral plants will begin to replace the Western wheatgrass.

Basal cover
The site displayed a constant decline in the amount of bare soil, which was highly desirable change. At 5% in 2010, the amount of bare soil was about as low as it could go. Ideally, with the site's effective water cycle, the percent live cover should begin climbing. This will happen when more high-seral plants like

needleandthread, green needlegrass, and perhaps Idaho fescue begin propagating here.

Relative basal plant spacing

The basal cover pie chart is generated using a monitoring method called the point intercept. Investigators drop a steel rod to the soil surface at regular intervals along the tape measure and record ground cover, depending on what the tip of the rod strikes (bare ground, litter, rock, live plant cover, etc.). Simultaneously, a measurement is taken to the nearest perennial plant (see photo below). When averaged over all the data points, the distance to the nearest perennial plant, or "relative basal plant spacing" (in the jargon of rangelands) may be determined.

This photo shows the yellow tape measure with the steel rod dropped to the soil surface at the 91-foot mark. The red ruler measures the distance to that nearest perennial plant. In this case, the plant was 3 cm away. That data point is recorded. The process is then repeated, and the measurements are averaged over 100 data points.

If relative basal plant spacing declines through time, then we may conclude that either more plants were found on the soil surface, or plant crowns have become larger. The reverse is also true: if the distance increases, either fewer plants are growing on the soil surface, or plant crowns have diminished in size.

At the Hall Pasture site, the distance increased from 2005 to 2007, which was during the series of dry years. It is highly possible that plants were lost on this site and plant crowns shrunk in size. Fortunately, the distance greatly fell between 2007 and 2010. This suggests propagation of new plants and potential expansion of plant crowns, both positive signs.

Relative basal spacing by species

When measuring that distance to the nearest perennial plant, that plant's species is also recorded. In the sample photo to the left, a Western wheatgrass stem may be seen growing at the 3 cm mark on the red ruler. When the measurement is repeated and averaged over 100 data points, a table may be generated showing the most basally abundant plant species at the site (relative basal spacing by species).

Ideally, high-seral plants will increase their basal abundance through time, and low-seral plants will decline. This would suggest positive change.

At the Hall Pasture, big sagebrush again shows signs of decreasing in presence in the community, and Western wheatgrass appeared to increase in presence. While both plants are high-seral (and therefore desirable plants) on this site, they are not the big-producing bunchgrasses like green needlegrass and needleandthread that should be found here. Needleandthread grass made the list of the top seven species in both 2007 and 2010. Ideally, this species should have increased its presence, especially in the wet year of 2010. This suggests corrective actions are required in grazing management that will be discussed below.

Plant species list
The number of plant species changed little in each sample year. But the composition of plants changed on this list. Note the number of large forbs that were added to the list in 2010: salsify, vetch, and mustard. These are all large-producing forbs that would not grow without an effective water cycle. The presence of these plants was a positive sign. Some plants dropped from the list: vagrant lichen, clover, and plantain. In such big-producing years like 2010, these plants can be quite difficult to locate on the soil surface, so may be been present, but were simply unobservable. Silver sagebrush also dropped from this list. This is a desirable plant here, and it will ideally return in time.

Range trend
Range trend here was slightly upward. This determination was made primarily through the basal cover data table, where bare ground continued to decline, and relative basal plant spacing, which continued to decline as well. When changes in plant species composition begin occurring favorably here, then upward trend will increase its speed.

Management recommendations
The water cycle was effective, the mineral cycle was moderately rapid, and energy flow was high at this site. The site also displayed an upward trend. Yet, the successional process was lagging, which is a normal situation for changing rangelands. Simply put, those desired perennial bunchgrasses must propagate across the soil surface through sexual reproduction, which make take some time. Management has created the conditions where these high-seral plants may thrive, but time is now required for them to propagate.

The species composition of the site changed little between 2007 and 2010, which may have be attributable to below-average precipitation in 2010 and the grasshopper outbreak of 2009. Hoppers stripped much of the standing vegetation in the late growing season of 2009, largely removing much of the site's potential litter cover and seed source. This single action likely slowed the ability of desired grasses to propagate across the site. Further, the wet spring of 2010 combined with the drier summer months favored the growth of cheatgrass and Japanese brome, rather than the desired bunchgrasses.

Management should pursue two actions to improve this pasture. The first is to continue the program implemented a few years ago of extended recovery times between grazings. This action has not yet had opportunity to pay dividends and must be tested further. Second, management should utilize this pasture in the later season for the next two years. Favoring those desired perennial bunchgrasses will require allowing them rest during the early growing season where they may fully develop and produce seed. They may be grazed later in the year (July forward), but give them a chance to grow in the early season.

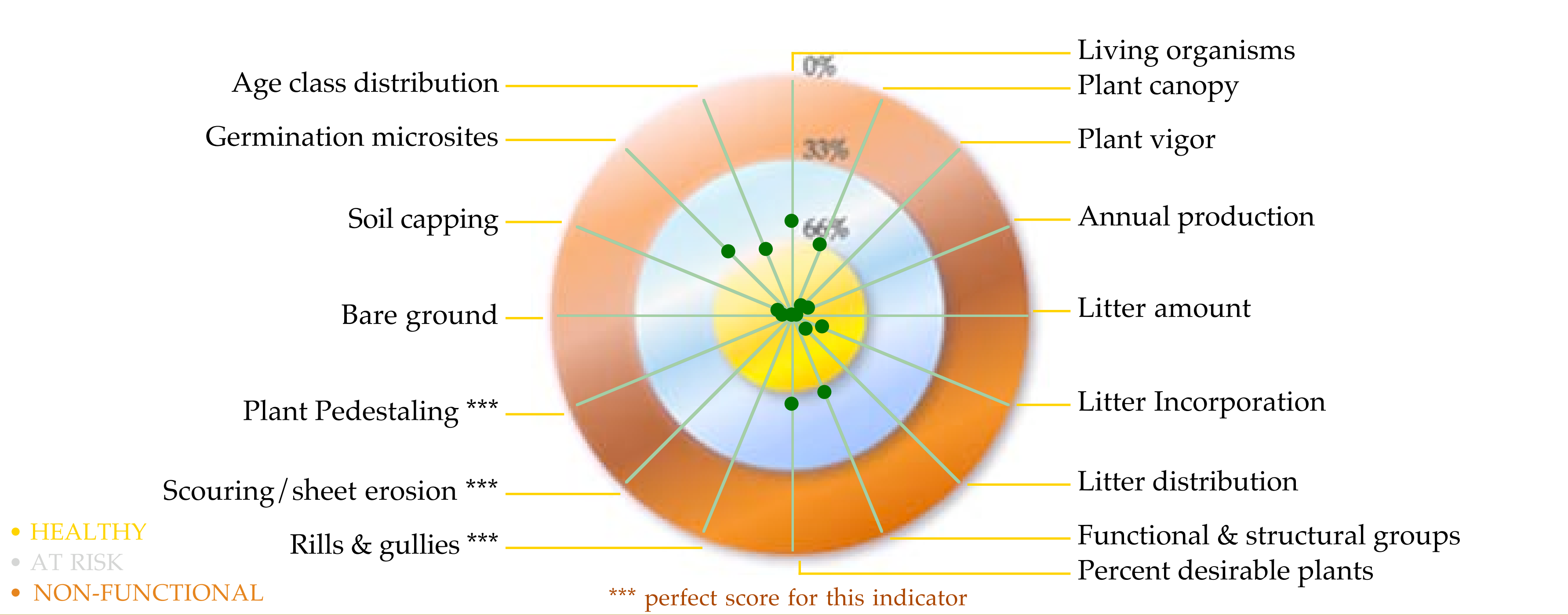
The timing for examining these variables of rangeland health could not be more opportune. As sagebrush continues its decline in the area, management has the opportunity to fill the void on the soil surface with highly desired plants that put weight on cattle, increase revenues for the ranch business, and provide better wildlife habitat simultaneously. Given the area's wide fluctuations in precipitation and occasional grasshopper outbreaks, such progress will come slowly, but it will come.

Early-warning indicators:
If management actions are improperly applied, look first for poor plant vigor and increased bare ground. This would suggest utilization rates have been too high and that grazing durations may have been too long. Next, look for shifts in species composition toward the undesired plants. This suggests continued issues with recovery times, grazing durations, and timing of grazings.

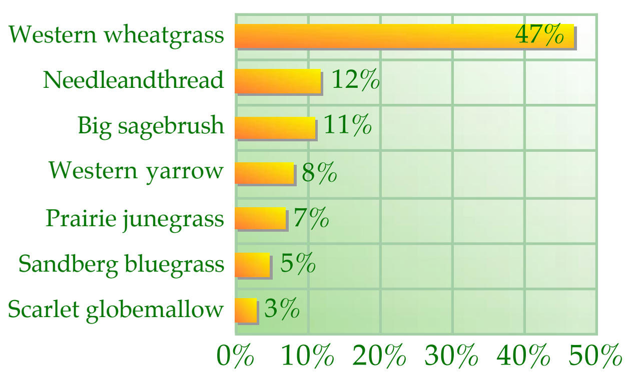
If management recommendations are properly applied on this site, look first for high plant vigor and a good plant canopy, even in drier years. Next, look for increases in live plant cover and continued improvement in the mineral cycle. Lastly, look for shifts in plant species composition toward the desired perennial bunchgrasses.

Three Section Pasture – MRT11

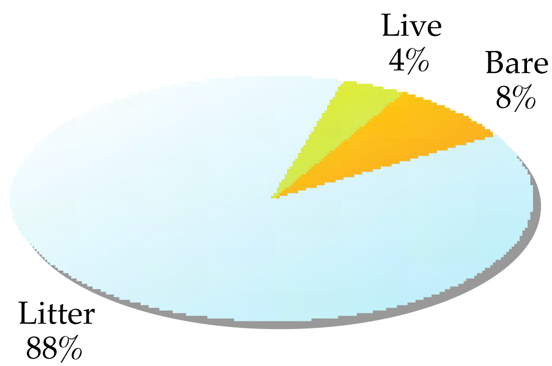
Data Summary



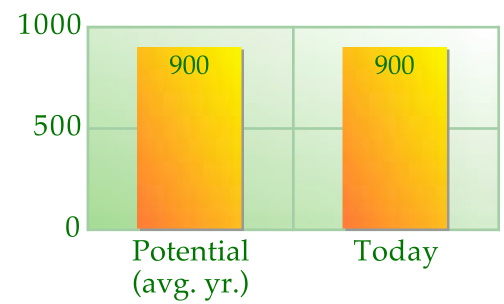
Basal Cover by Species - Top 7 Species



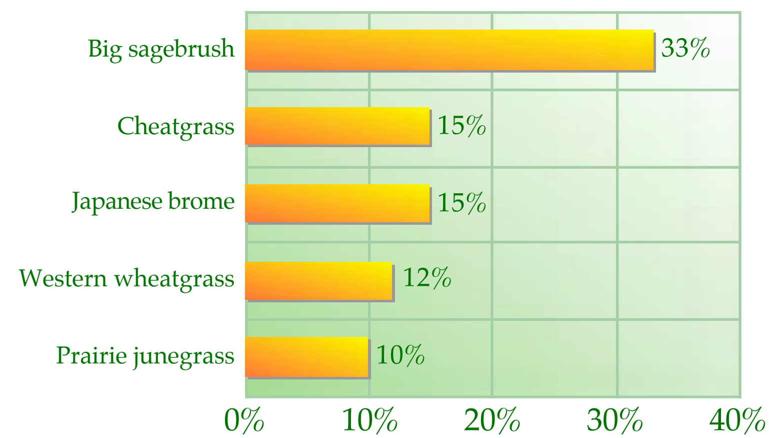
2011 Basal Cover



Forage Production



Predominant Species: Composition by Weight



Additional Info:

Apparent range trend:

Site sampled August 10, 2010.

UTM coordinates (NAD 83): 13T 0379330E / 4917678N

Relative basal plant spacing: 2.6 inches.

27 plant species encountered at site.

Plant species encountered at site:

Cheatgrass
Western wheatgrass
Green needlegrass
Japanese brome
Sandberg bluegrass
Prairie junegrass
Needleandthread
Bluebunch wheatgrass
Blue grama
Sixweeksgrass
Big sagebrush
Fringed sage
Greasewood
Rubber rabbitbrush
Mustard species
Scarlet globemallow
Salsify
Pricklypear cactus
Western yarrow
Vetch species
Peppergrass
Sego lily
Broom snakeweed
Dandelion
Plains goldenaster
Curlycup gumweed
1 unknown perennial forb

3 Section (Transect MRT11)

This site was established in 2007 as being representative of the large, flat bottom in the 3 Section Pasture. Additionally, the site was treated with a Lawson renovator in spring 2009. The machine made two large swaths diagonally across the transect line. A large stand of big sagebrush went untreated in the middle of the transect area.

The first plot studied at the 3 Section site.

The **Bullseye Target** displays the analysis of 16 indicators of rangeland health. Function of indicators is shown using colors of the Olympics. Those whose scores fall in the gold were functioning optimally, those in the silver require improvement, while those in the bronze require more urgent management attention.

The **water cycle** was effective with few signs of bare soil within the study plots. Further, the point intecept method revealed that 8% of the soil was bare, as may be seen on the **basal cover** pie chart. No signs of **erosion** were observed, and a minor **soil cap** was present. Plants were also well **distributed** across the soil surface.

The **mineral cycle** was moderately rapid with a desirable **litter amount** that served to cover the soil surface and prevent erosion. **Litter incorporation**, a strong indicator of the overall speed of the mineral cycle, was occurring moderately well: litter was contacting the soil surface, but was not mixing well with soil. Area dung piles appeared to be about two years old, which suggested microorganisms of decay were not decomposing manure as well as desired. Litter was well **distributed** across the soil surface. The Lawson treatment helped to both increase the amount of litter and distribute litter across areas where the treatment occurred.

Energy flow was mixed: where the Lawson treatment occurred, the **plant canopy** was composed of cheatgrass and Japanese brome. Away from the Lawson treatment, the canopy was composed largely of big sagebrush. All plants at the site displayed good **vigor** in mid August, with much of the vegetation still green and growing. As may be seen on the **forage production** bar graph, annual production was 900 pounds, or exactly the site's potential for an average precipitation year. Even with the Lawson treatment, the most productive species at the site was big sagebrush (remember, the Lawson machine didn't hit the whole transect area, but only part of it.) Most of the other species on the **composition by weight** bar graph were either undesired plants or middle-of-the-roadspecies. In time, this site will ideally contain more of the highly desired perennial bunchgrasses.

Within the **successional process**, desired species such as green needlegrass, needleandthread, and bluebunch wheatgrass were all present, but not in the desired abundance. The Lawson treatment greatly disturbed the big sagebrush community, leaving abundant cheatgrass and Japanese brome behind. No undesired plants such as leafy spurge were observed. The **basal cover by species** bar graph shows that many of the most basally abundant plants were mid-seral plants (meaning neither desired, nor undesired). Fortunately, needleandthread grass composed 12% of the basal area, and its presence will ideally increase here. The ability of needleandthread to **germinate** was only hindered by the minor soil cap found in the area.

Big sagebrush plants appeared to be replacing themselves in the community, where several decadent and young members were observed. These plants were observed in the areas not treated by the Lawson machine.

Site photos and data from the two sample years are contained on the next pages of this document.

Three Section transect view. Photo taken August 10, 2010.

Three Section transect view. Photo taken August 17, 2007.

The first plot studied on the Tree Section transect. Photo taken August 10, 2010.

The first plot studied on the Three Section transect. Photo taken August 17, 2007.

BIG SAGEBRUSH DATA

2007	2010	
		Line intercept:
43	41	*Number of big sage plants encountered*
		Line Intercept: Age Class Distribution
0%	0%	seedling
0%	8%	young
100%	77%	mature
0%	15%	decadent
27	20	*Average plant height - inches*
29%	24%	*Percent canopy cover*
152	135	*Density per 1000 square feet*

PRODUCTION: Pounds per acre

2007	2010
330	900

ADDITIONAL INFORMATION

Site sampled August 17, 2007.
Site sampled August 10, 2010.

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

2007		2010	
Big sagebrush	33%	Big sagebrush	33%
Japanese brome	15%	Japanese brome	15%
Green needlegrass	11%	Cheatgrass	15%
Cheatgrass	10%	Western wheatgrass	12%
Sandberg bluegrass	9%	Prairie junegrass	10%

BASAL COVER

2007	2010	
16%	8%	Bare
79%	88%	Litter
5%	4%	Live

RELATIVE BASAL PLANT SPACING - Inches

2007	2010
2.3	2.6

RELATIVE BASAL PLANT SPACING BY SPECIES (Top 7 species)

2007		2010	
Western wheatgrass	34%	Western wheatgrass	47%
Big sagebrush	13%	Needleandthread	12%
Blue grama	10%	Big sagebrush	12%
Sandberg bluegrass	8%	Western yarrow	8%
Kentucky bluegrass	7%	Prairie junegrass	7%
Needleandthread	5%	Sandberg bluegrass	5%
Prairie junegrass	5%	Scarlet globemallow	3%

PLANT SPECIES FOUND IN TRANSECT AREA

2007	2010	
26	*27*	***Total count***
X	X	Cheatgrass
X	X	Japanese brome
X	X	Green needlegrass
X	X	Sandberg bluegrass
X	X	Western wheatgrass
X	X	Blue grama
X	X	Bluebunch wheatgrass
X	X	Prairie junegrass
X	X	Lepidium
X	X	Western yarrow
X	X	Pricklypear cactus
X		Hood's phlox
X		Stickseed
X	X	Scarlet globemallow
X		Tansymustard
X	X	Dandelion
X	X	Mustard species
X	X	Salsify
X	X	Big sagebrush
X	X	Fringed sage
X	X	Broom snakeweed
X	X	Rubber rabbitbrush
X	X	Needleandthread
	X	Sixweeksgrass
	X	Greasewood
	X	Vetch species
	X	Sego lily
	X	Plains goldenaster
	X	Curlycup gumweed
3	1	Unknown perennial forbs

DISCUSSION OF 3 SECTION PASTURE DATA FROM 2007 AND 2010

Photos

First see the transect view photos for the two sample years. The path of the Lawson renovator is clearly visible in the 2010 photo. The machine traveled from the left-hand side of the photo to the right, but diagonally away from the photopoint location. Even some of the brush to the immediate right of the transect line was disturbed by the Lawson. A large patch of big sagebrush is visible in the 2010 photo, representing an area the Lawson skipped. Another one of these "swaths" of treated ground lay beyond that patch of brush.

Plant vigor appears much stronger in 2010 versus 2007. Leader growth on big sagebrush was high in both years, but better in 2010. Further, the growth of various grasses appears much more vigorous in 2010. The yellow/gold colored plants are the seedheads of Japanese brome and cheatgrass in the areas treated by the Lawson machine in spring 2009.

In the plot photo, the prominent big sagebrush plant appears of higher vigor in 2010 versus 2007. The canopy of this plant appears to have grown substantially between the two sample years. Further, more cheatgrass appears in the 2010 shot.

Sagebrush data

The Lawson machine cut two large swaths through the 200-ft transect line, removing the standing sagebrush in its wake. Even so, the number of big sage plants encountered on the transect line fell by only two plants. No new big sage sprouts appeared in the treated area. As may be seen on the age class distribution data set, some plants were young and some decadent. Each of these occurred in the untreated area, and the data suggest that big sagebrush was replacing itself in the community in the untreated area. Note too, that even after the Lawson renovator affected this transect area, the overall sagebrush canopy declined by only seven percentage points between 2007 and 2010. Further, the density of big sage plants decreased by only 11%. These data suggest that much sagebrush sprouted between 2007 and 2010. Had the Lawson treatment not occurred, sage density and canopy could likely have been much higher.

Production

The Wyoming State Range Site Guides for this site suggest that plant productivity should be 900 pounds per acre (USDA, 1990). 2010 precipitation helped produce a clipped plot that reached the site's potential. This was a strong increase over the 2007 production figure of 330 pounds per acre. Much of the production was composed of big sagebrush, cheatgrass, and Japanese brome. The Lawson treatment removed much of the big sage canopy, resulting in a flush of growth by these two undesired grasses. Yet the increased productivity suggests the water cycle of this site was effective, where precipitation was available to plants and high levels of productivity were achieved. In time, as desired plant species like the needlegrasses increase on this site, production should increase even more. These plants should be strong competitors to the shallow-rooted cheatgrass and Japanese brome.

Composition by weight

Even with the Lawson treatment, the top plants of big sagebrush and Japanese brome did not change their productive composition of the site. This is likely due to the good moisture year and the productive response of big sagebrush in the non-treated areas. Likewise, Japanese brome thrived in the treated areas, as did cheatgrass. The reduction of green needlegrass represents undesired change. The plant crowns of this highly desired species likely were disturbed during the treatment and must regrow. In time, green needlegrass should increase its presence on this site and make a stronger contribution to the productive capacity of the site.

Basal cover
Percent bare ground was cut in half between the sample years. The Lawson treatment likely had much to do with this, as the canopy of big sage and other plants was knocked to the soil surface as litter. Not surprisingly, the amount of live cover dropped following the treatment: the teeth of the Lawson machine likely split plant crowns into smaller pieces, potentially even killing some of these plants. In time, with the loss of big sage as the major hydrologic factor on the site, the disturbed perennial bunchgrasses should recover, and live cover should increase on the site.

Relative basal plant spacing
The basal cover pie chart is generated using a monitoring method called the point intercept. Investigators drop a steel rod to the soil surface a regular intervals along the tape measure and record ground cover, depending on what the tip of the rod strikes (bare ground, litter, rock, live plant cover, etc.). Simultaneously, a measurement is taken to the nearest perennial plant. When repeated over 100 data points along the transect line and this distance is averaged, relative basal plant spacing may be discerned. When this distance drops through time, we may conclude that either more plants are growing on the soil surface or the crowns of plants have increased in size. The opposite is also true: when this distance increases, either plants have been lost from the site, or size of plant crowns has declined.

At the 3 Section site, relative basal plant spacing increased by 0.3 inches. This may be an undesirable change in any given year, but the Lawson treatment confounded the data. It is likely that the mechanical treatment disturbed many plant crowns on the site (including big sagebrush), resulting in either loss of plants, or shrinking of plant crowns themselves. Thus, we should expect the distance between plants to have increased. In time, and as plants re-grow following the treatment, relative basal plants spacing should decline. If it doesn't, something went wrong at the site: major drought, grasshoppers, fire, or a mishap in grazing management occurred.

Relative basal spacing by species
When measuring that distance to the nearest perennial plant, that plant's species is also recorded. When averaged over 100 data points, a table may be generated showing the most basally abundant plant species at the site (relative basal spacing by species).

Ideally, high-seral plants will increase their basal abundance through time, and low-seral plants will decline. This would suggest positive change.

At the 3 Section site, the basal abundance of Western wheatgrass increased substantially between the two sample years. This should not be surprising, since this plant will respond rapidly to mechanical treatments like the Lawson. Western wheat will be a strong early competitor when species like big sage are disturbed. The basal abundance of big sage did not change much percentagewise. This is likely due to the number of big sage plants that had sprouted in the untreated area. The strong increase in basal abundance of needleandthread was an encouraging sign. This highly desired perennial bunchgrass is expected in abundance on this site, and it will ideally only continue its propagation. Blue grama fell from the list of most basally abundant plants, which also represented positive change. This low-growing species is not undesired here, but has a much lower productive capacity to a site like this than needleandthread.

Plant species list

The number of plant found at the site increased by only one between the two sample years. Species that left the list, such as stickseed and tansymustard, were not overly beneficial to the site anyway. Species added to the list, such as vetch, sego lily, and goldenaster, are highly productive forbs that thrive in wet years. Greasewood was found in the area for the first time, and this plant must continue to be monitored. It is a highly aggressive competitor that may change overall land health in a negative direction.

Management may take comfort with this list in knowing that all of the desired plants found in 2007 were still present in 2010. The Lawson treatment removed none of the highly desired perennial bunchgrasses.

Range trend

Determining range trend here was difficult because of the Lawson treatment. It represents a disturbance to the soil surface and plant community where examination of a continuum of change through time is not possible. Rather, the Lawson represents a disruption in the smooth, steady growth of plants and a massive injection of nutrients into the soil surface. As such, the overall health of the land changed little between the sample years. Further, the Lawson treatment occurred in spring 2009, meaning nearly two full growing seasons had passed prior to the site's being sampled again in August 2010. Given these factors, range trend here may best be characterized as stable. It's as if the soils and plants are slowly recovering from the Lawson treatment, and were storing their productive capacity for a large propagation in the future. This may be consistent with other Lawson treatments conducted on Merlin Ranch, where treated areas seemed almost stagnant for a few years following a treatment. Then, they seemed to greatly increase their productive capacity, and strong improvements in plant species composition were observed.

Management recommendations

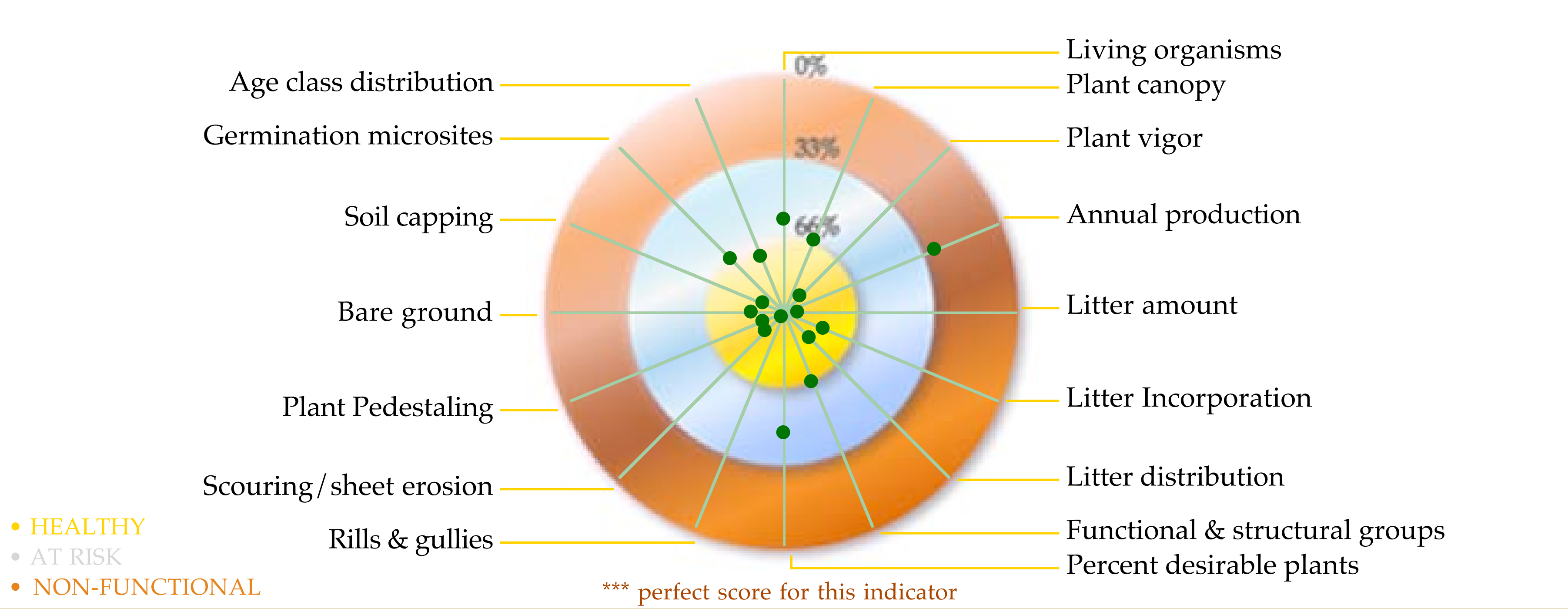
Management must help plants and soils recover from the Lawson treatment. Those highly desired perennial bunchgrasses need time to recover, re-establish their plant crowns, achieve high vigor, and produce seed. Management now has a golden opportunity to define which plants respond best to the treatment by favoring the growth of the desired bunchgrasses. This is accomplished in three ways. First, utilize the 3 Section Pasture later in the growing season. Deferment of this pasture in the early growing season will help those bunchgrasses gain a competitive advantage over cheatgrass and the mid-seral plants like blue grama. Such deferment should occur for the next two growing seasons at a minimum. Second, management must ensure that recovery times between grazings are kept long. This pasture may be grazed, but only graze it once per year for the next few years, ideally later in the growing season. Third, heavy utilization rates must be avoided. Heavy use will mean that plants must halt root growth to replenish lost leaf material. This may also reduce their competitive advantage. Moderate utilization rates (between 30 and 50%) should be practiced.

Early-warning indicators:
If management actions are improperly applied on this site, look first for reductions in plant vigor and productivity. Next, look for increased bare ground in areas where the Lawson machine did not treat. [Note: Increased bare soil should be expected in areas treated by the Lawson as microorganisms of decay begin decomposing the large amount of plant material that was suddenly dropped to the soil surface. Bare ground levels may rise dramatically over the next two to five years.] After that, look for shifts in species composition away from the desired plants: more blue grama, cheatgrass, Japanese brome, and prairie junegrass will be prominent. These signs suggest issues with recovery periods between grazings and timing of grazings. Also watch the growth of greasewood. This less-desired species has the potential to propagate on this site, which would result in negative changes in rangeland health.

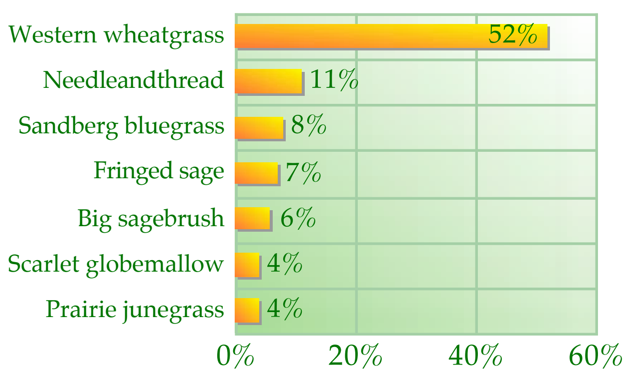
If management actions are properly applied here, look first for high plant vigor, even in years not as wet as 2010. Next, look for maintained or even increased plant productivity. These indicators would suggest that recovery times between grazings are adequate and that utilization rates are adequate. Lastly, look for increased presence of the desired plant species.

Lower Hepp Pasture – MRT21

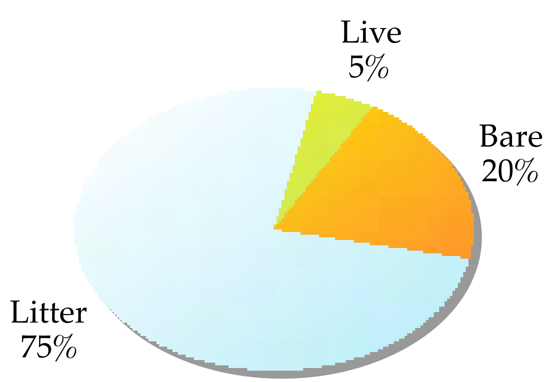
Data Summary



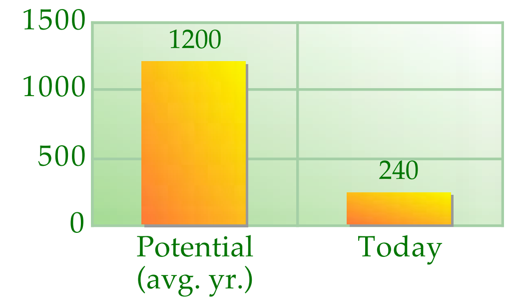
Basal Cover by Species - Top 7 Species



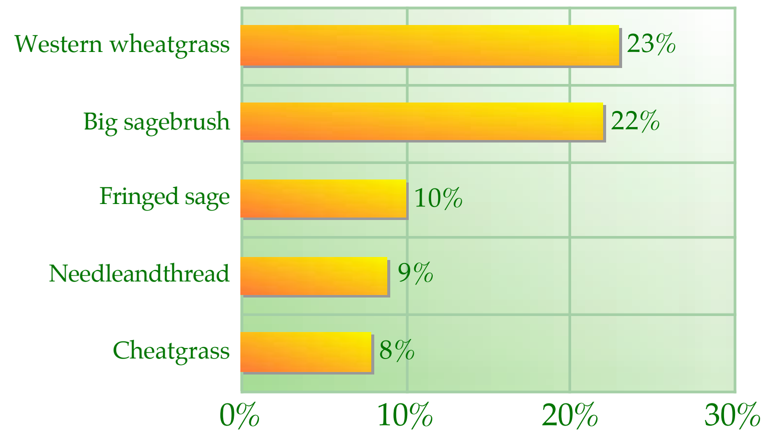
2011 Basal Cover



Forage Production



Predominant Species: Composition by Weight



Additional Info:

Apparent range trend: 

Site sampled August 11, 2010.

UTM coordinates (NAD 83): 13T 378555E / 4914705N

Relative basal plant spacing = 1.3 inches.
26 plant species found at site.

Sagebrush data:
25 plants encountered along transect line for 20% canopy cover.
Age class distribution: 96% mature, 4% decadent.
Average plant height: 19 inches.
Belt transect; 63 plants growing in 1000 square feet.

Plant species encountered at site:

Western wheatgrass
Cheatgrass
Sandberg bluegrass
Japanese brome
Sixweeksgrass
Prairie junegrass
Blue grama
Needleandthread
Threadleaf sedge
Green needlegrass
Big sagebrush
Fringed sage
Nailwort
Peppergrass
Salsify
Broom snakeweed
Scarlet globemallow
Hood's phlox
Golden pea
Western yarrow
Plains daisy
Pricklypear cactus
Sego lily
Mustard species
Vetch species
1 unknown perennial forb

Lower Hepp (Transect MRT21)

This portion of Lower Hepp had not received much grazing in past years as cattle chose to graze other portions of the pasture. Management is correcting this distribution issue with new stock water developments and fencing. The transect location lies roughly 0.25 miles away from a stock tank, and it will capture changes in rangeland health as the area is utilized differently.

The first plot studied in the Lower Hepp Pasture.

The **Bullseye Target** displays the analysis of 16 indicators of rangeland health. Function of indicators is shown using colors of the Olympics. Those whose scores fall in the gold were functioning optimally, those in the silver require improvement, while those in the bronze require more urgent management attention.

The **water cycle** was moderately effective. A bit too much **bare soil** was observed in the study plots, and the point intercept method revealed that 20% of the soil was bare. This must be covered either by additional litter, and/or living plants. The increased stock density from new stockwater developments and fencing should greatly enable such progress. The site also displayed some signs of **sheet erosion** caused by wind, and desert pavement had formed. **Plant pedestals** were also present, but none so severe that roots had become exposed. A minor **soil cap** had formed on the soil surface that might have inhibited the percolation of water into the soil surface.

The **mineral cycle** was moderately rapid. **Litter amount** was too low, and more of it was needed to help cover the site's bare soil. Litter was contacting the soil surface, but it was not **incorporating** well. This slows the mineral cycle, since microorganisms of decay generally are found in the soil and not on it. When more hoof action is employed to help increase litter's contact with soil, and mixing of litter and soil occurs, the mineral cycle will increase its speed.

Within **energy flow**, the **plant canopy** tended to be clustered around prominent big sagebrush plants. Here, grasses and forbs grew prominently. Away from the protection of big sage plants, the plant canopy was generally lacking, and large gaps were present on the soil surface where no plants grew. **Plant vigor** was high, where plants had achieved tall stature, were firmly rooted to the soil surface, had produced seed, and were green and growing in mid August. Some of the big sagebrush plants had a hedged appearance, as if they had been severely browsed by pronghorn. As may be seen on the **forage production** bar graph, annual production was well below the site's potential of

1200 pounds per acre (USDA, 1990). The single clipped plot revealed production of 240 pounds per acre, or roughly 20% of what it should be producing.

Within the **successional process**, undesired species such as cheatgrass, Japanese brome, and fringed sage were abundant. This reulted in low **percent desired plants**. Desired species such as needleandthread and green needlegrass were present, but not in the desired abundance. As may be seen on the **basal cover by species** bar graph, desired species like Western wheatgrass, needleandthread, and big sagebrush were some of the most basally abundant plants at the site. But the mid-seral species (those neither desired nor undesired) such as prairie junegrass and Sandberg bluegrass were also prominent. Ideally, these mid-seral plants will be replaced by the more desirable plants in time. The big sagebrush community was slowly replacing itself, where much of the community was composed of mature plants, but many decadent or already dead plants were observed in the area. Management must fill the void of these dying plants with desired perennial bunchgrasses. The **plant species list** showed 26 species found at the site, which was a high number for this area. This high number of species with a good blend of forbs, grasses, and shrubs, resulted in a high score for the **functional and structural groups** indicator. No truly undesired species like leafy spurge or knapweed were observed here.

Apparent range trend:
The trend here was stable.

Management recommendations:
The site appeared to be a bit stagnant in 2010. Cattle appeared to use this site only slightly over the past several years, and it showed signs of such non-use. Further, the water cycle could be improved, as some of the available precipitation was leaving the site and not percolating into the soil. The site could benefit from an introduction of energy into its system.

Fortunately, management has already taken steps to begin that energy introduction with the new stockwater tank and fencing. Stock densities will increase substantially over past years, and the badly needed hoof action will be delivered to the soils. These actions in themselves should help improve rangeland health of this portion of the pasture. But more aggressive actions may be utilized here, such as scattering broken salt blocks through the sagebrush. Using a large hammer, break salt blocks into small pieces and scatter them through the brush. Cattle will find them, fight over them, and greatly disturb the sagebrush, the soil cap, and will dramatically improve both the water and mineral cycles.

Undertaking of this effort to increase stock densities and animal impact will likely result in large increases of undesired species such as cheatgrass and Japanese brome as has happened in other Merlin pastures. These low-seral species will be the first to respond to the improved water and mineral cycles. Their large presence should be expected over a three to five year period in this area. After that, once energy flow has caught up to the improved water and mineral cycles, the successional process should become more active, and those desired perennial bunchgrasses will increase their presence on the site.

While this site is improving, management must ensure that utilization rates are kept at moderate levels: 30 - 50%. Heavy use of perennial bunchgrasses should be avoided on perennial bunchgrasses, for they will lose their competitive advantage to low and mid-seral species.

Management must also ensure that recovery times between grazings are adequate for the high-seral bunchgrasses. Once these plants are bitten, they must receive plenty of recovery time before they are bitten again. This means grazing this pasture only once per year for the next two to three years.

Early-warning indicators:
If management actions such as animal impact and grazing are improperly applied here, look first for decreased plant vigor (production may drop in a dry year, but plant vigor should stay elevated). This suggests that utilization rates have been too high. Next, watch for signs of increased bare ground. This suggests that either grazing durations have been too long or recovery times between grazings have been too short.

If management actions are properly applied on this site, look first for increased presence of undesired plants like cheatgrass and Japanese brome. Although these plants are disliked, they are the first indicators that the water cycle is improving. Next, look for maintained plant vigor, even in years not as wet as 2010. Next, look for reduced bare ground and soil capping. These show that the combination of increased stock densities and animal impact are beginning to make both the water and mineral cycles more effective. Lastly, watch for increases in presence of high-seral grasses. Once these plants compete with cheatgrass, real success will become evident.

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 was first sorted to remove plant species like sagebrush that livestock would not graze. The remaining sample, mostly grasses, was 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 2010.

	Hall Pasture	Three Section	Lower Hepp
Crude Protein (%)	7.82	6.88	8.47
Acid Detergent Fiber (%)	45.8	43.8	44
Total Digestible Nutrients (%)	50.3	52.6	52.4
Net energy-lactation (Mcal/lb)	0.51	0.53	0.53
Net energy-maintenance (Mcal/lb	0.47	0.5	0.5
Net energy-gain (Mcal/lb)	0.26	0.28	0.28
Sulfur (%)	0.09	0.11	0.13
Phosphorus (%)	0.1	0.11	0.14
Potassium (%)	1.18	1.41	0.85
Magnesium (%)	0.13	0.1	0.12
Calcium (%)	0.36	0.35	0.52
Sodium (%)	0.01	0.1	0.01
Iron (ppm)	63	37	144
Manganese (ppm)	26	48	38
Copper (ppm)	2	2	4
Zinc (ppm)	10	15	20

Each of these three samples shows satisfactory levels of crude protein. This is likely due to the green year of 2010 that resulted in green and growing plants in mid August when they were clipped. Energy levels of the forage (total digestible nutrients) also reached desirable levels. As has been found in previous years, trace minerals such as phosphorus, copper, and zinc fell at less than desirable levels.

No trace minerals such as iron or manganese appeared at toxic levels that would affect livestock performance.

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 Pasture** sample will return the following to her:

Dry Matter	Crude Protein	TDN	Ca	P
21.6#	1.7#	10.9#	35g	10g

Our sample cow was just short on daily crude protein, but was over 1 pound short on energy (TDN). The calcium level was abundant, but the phosphorus level was well below the cow's requirements.

The plant species in this lab sample would have been Western wheatgrass, Japanese brome, and cheatgrass. Though these mid and low-seral plants contained some green material in mid August, they still were not sufficient to meet all the needs of our lactating cow.

Moving to the **3 Section** sample, plants there would provide the following to our same sample cow:

Dry Matter	Crude Protein	TDN	Ca	P
21.6#	1.5#	11.4#	34g	11g

The 3 Section sample was again not sufficient to meet the needs of our sample cow's crude protein, TDN, and phosphorus requirements. Like the Hall Pasture sample, the plant species composing this lab sample would have been cheatgrass, Japanese brome, Western wheatgrass, and prairie junegrass. Note that none of these plants was a high-seral species whose deep root structures may have had better access to trace minerals stored in the soil profile. In time, and as high-seral plants compose more of this community, the nutrient content of these plants may improve.

A glance back at the 2007 nutrient analysis for the 3 Section pasture shows striking similarity between the 2007 and 2010 samples for this site. A comparison may be made between these two samples (before and after the Lawson treatment) and a future sample where ideally the high-seral grasses compose more of the community and the lab sample.

The **Lower Hepp** sample was the best sample of the set. Plants on this site would return the following to the cow:

Dry Matter	Crude Protein	TDN	Ca	P
21.6#	1.8#	11.3#	51g	14g

Again, the sample did not meet the protein, TDN, and phosphorus requirements of our sample cow, although crude protein and TDN were close. The plant species enclosed in this lab sample would have been composed largely of Western wheatgrass, needleandthread, and cheatgrass. This is the only sample of the three that would have contained a high-seral plant (needleandthread grass). Western wheatgrass would have had the greatest contribution to the sample, but the inclusion of needleandthread would have affected this sample's results. It is possible that this high-seral plant contributed to a better sample than the other samples that contained only mid-seral and low-seral plants.

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.

Fortunately, the ranch moves its livestock through a series of pastures constantly, meaning cattle are exposed to a wide variety of fresh forages on a regular basis. This should greatly assist in meeting the needs of the herd, and the result of this effort should be measured in cow longevity and breedback. Cows should be producing many calves over the course of their reproductive lives and should be rebreeding well in Merlin's management scenario. If not, then additional management factors must be considered.

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 the herd, calves may be weaned earlier in the fall than they previously were. Removal of the calf to limit 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 hay or forage for roughly 100 days prior to calving. Nutrients could be stored in the cow's body and be ready when nutrient content of the plants decline in the fall.

MONITORING METHODS

On August 10, 2010, Mark Gordon of Merlin Ranch and Todd Graham of Ranch Advisory Partners toured the ranch, examining potential study sites. They selected three study sites to be sampled in 2010.

Graham read those transects over the next few days. They 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.

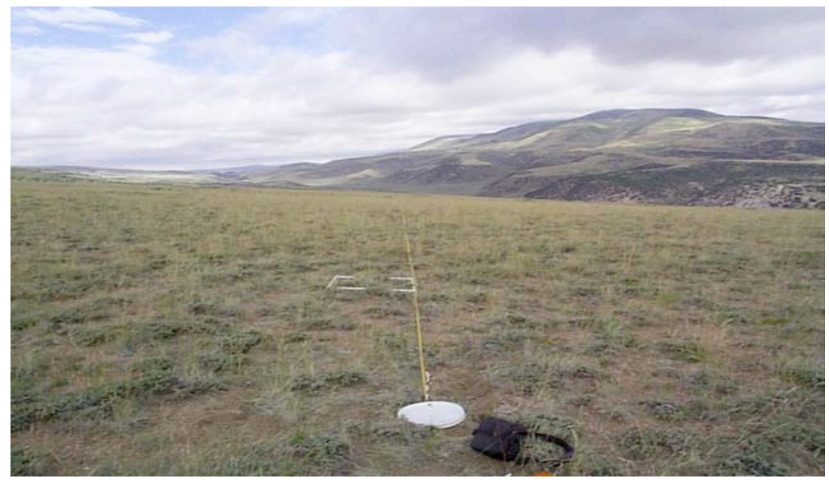


***Figure 2: Permanent transects were 200 feet long and were permanently marked* on each end.**

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.

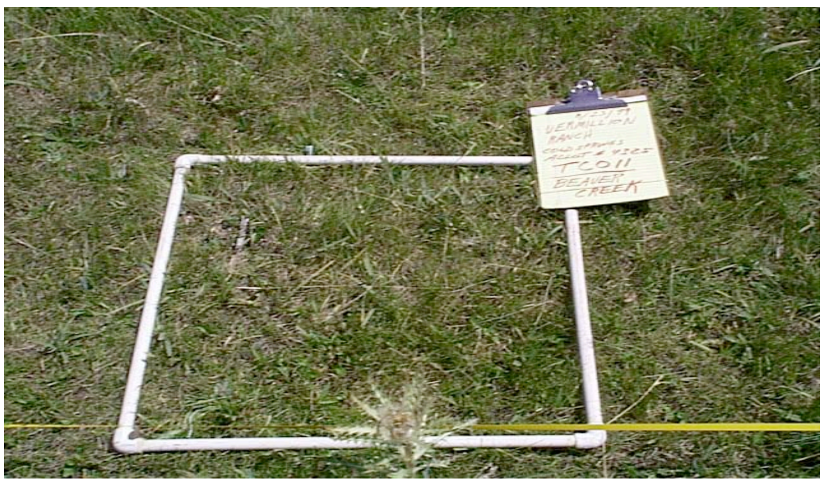


Figure 3: The first plot on a transect. [This sample plot lies in Colorado.]

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.

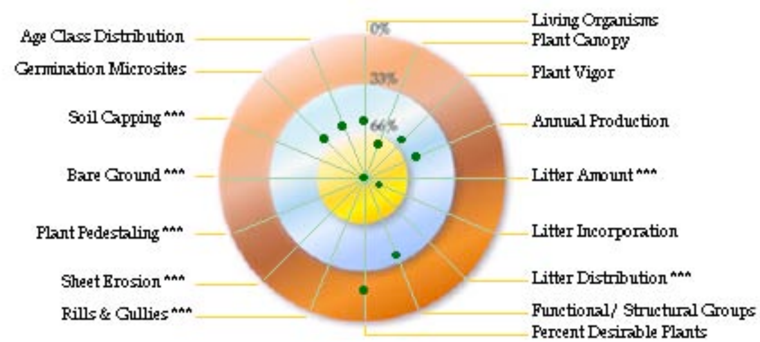


Figure 4: The target portrays results of each of the 16 indicators studied based on field scores.

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 to the right. 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.

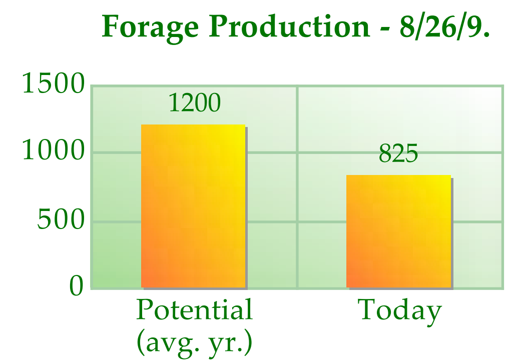


Figure 5: Plant production on sample day as compared with the site's potential from the soil survey.

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.

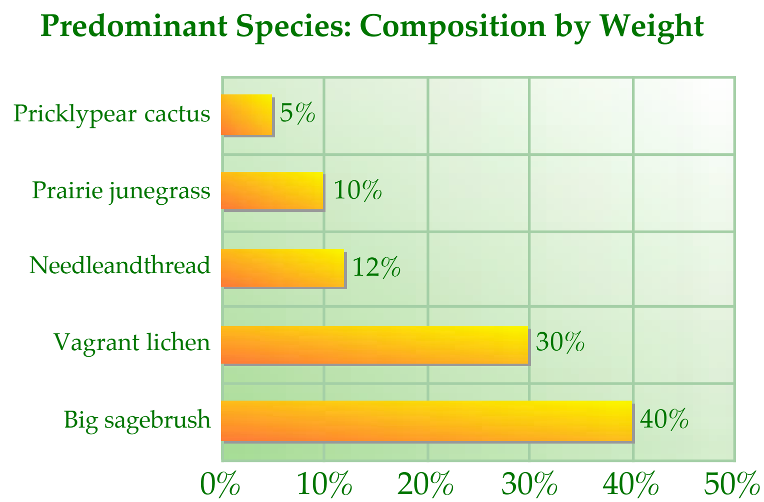


Figure 6: The most abundant species as composition by weight.

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 basal plant spacing. Using the point intercept method, a steel 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 7).

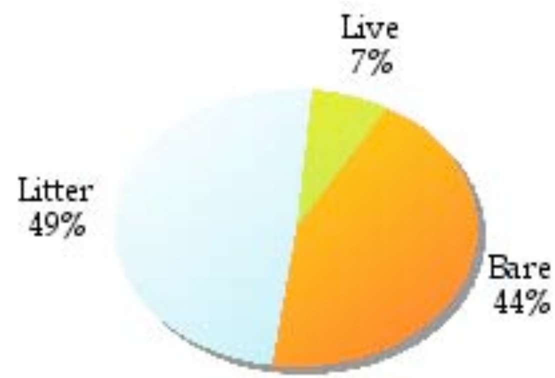


Figure 7: The ground cover chart generated by using the point intercept method.

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 (see photo in Figure 8). 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 are portrayed in the "Basal Cover by Species" bar graph (Figure 9).

Figure 8: This photo shows the point intercept method. A steel rod is lowered to the soil surface every other foot along the transect line. The tip of the rod may strike bare soil, litter, rock, or live plant cover, and this data point is collected. Additionally, the distance to the nearest perennial plant is measured. In this photo, the nearest plant from the yellow tape measure is 3 cm away from the steel rod. Averaging all data points along the transect generates the relative basal plant spacing figure shown in this document. Lastly, that nearest plant's species is recorded (Western wheatgrass is the stem seen growing at the 3 cm mark on the red ruler). This generates the basal cover by species graph shown in Figure 9.

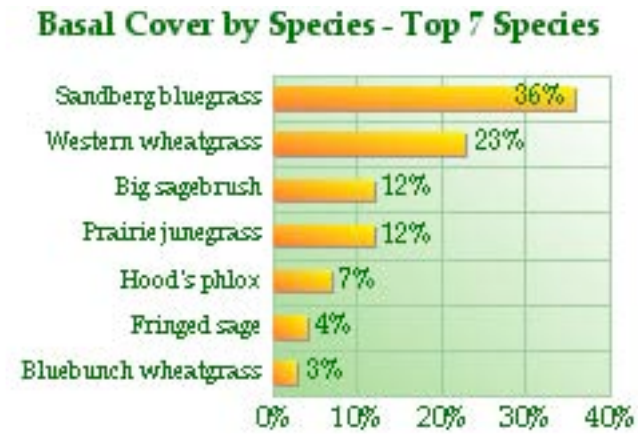


Figure 9: Basal cover by species bar graph created by measuring the distance to the nearest perennial plant using the point intercept method. The seven most numerous species are displayed here.

This means of collecting basal cover by species data was developed by Holistic Management International in Albuquerque, NM.

The scoring guides used to evaluate rangeland health indicators may be seen on the following pages.

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.	[illegible] 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.

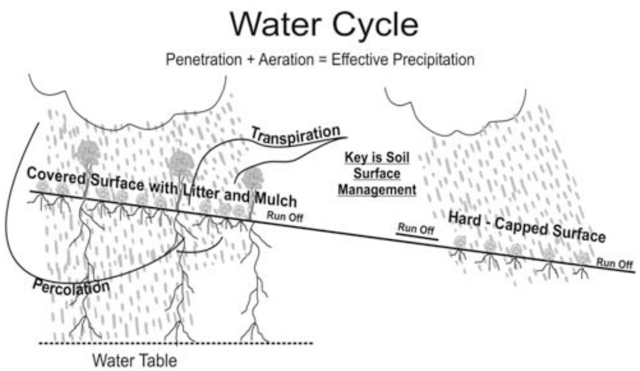
Indicator	5	4	3	2	1
Soil Crusting	No physical crusting present.	Recently formed physical crust seen over some of plot.	Recently formed physical crust seen over much of plot.	Older physical crust formed over much of plot.	Plot dominated by older physical crust.
Germination Microsites	Microsites present 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.

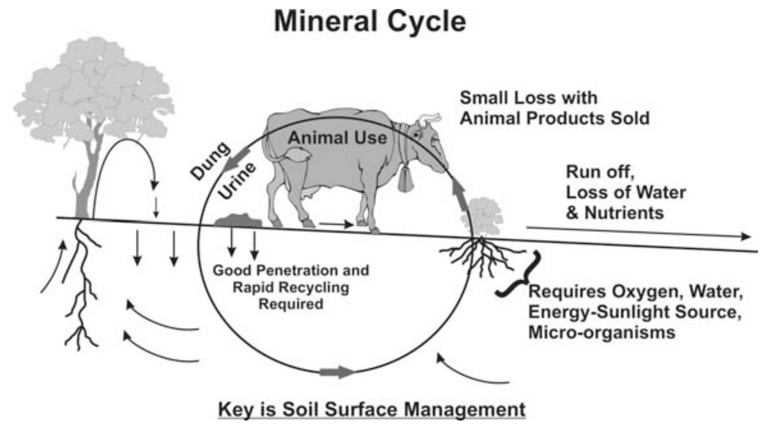
RANGELAND HEALTH

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.

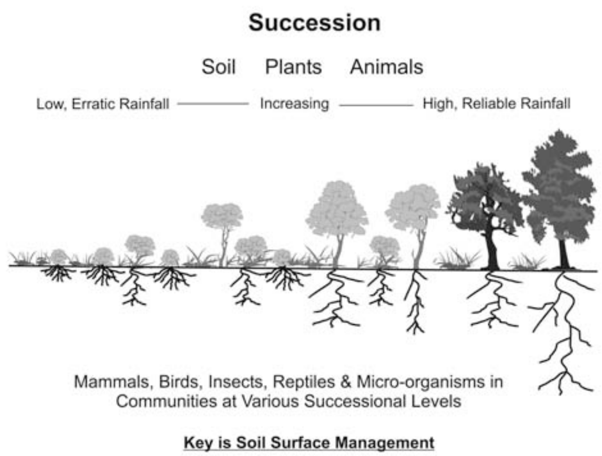
The following pages visually describe the ecosystem process described in this report. They are the water cycle, mineral cycle, community dynamics (succession) and energy flow.

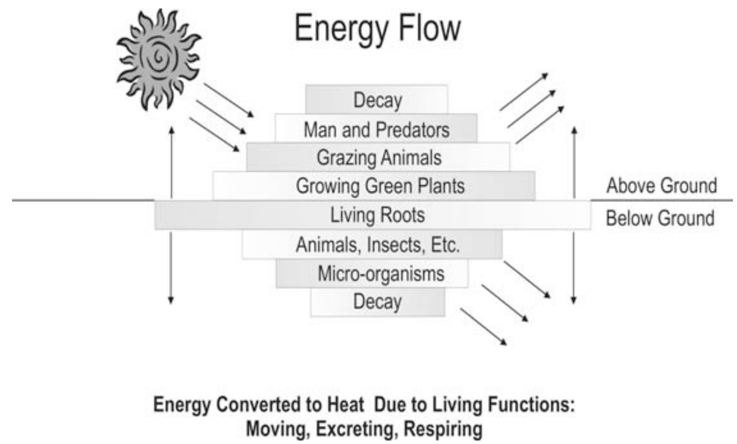




An effective water cycle requires covered soil and high biodiversity. When effective, most water soaks in quickly where it falls. Later, it's released slowly through plants that transpire it, or through rivers, springs, and aquifers that collect through seepage what the plants don't take. When biodiversity 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).

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