MERLIN RANCH:

2011 Rangeland Health Monitoring: Lower, M&M #1, and Lawrence 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 2011. These sites were located in the Lower, M&M #1, and Lawrence Pastures. The Lower and M&M #1 sites had been established previously, and data from past readings will be displayed side-by-side with 2011 data. The data will also provide evidence of range trend. The Lawrence Pasture transect was established in 2011.

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:

Merlin Ranch Transect Readings	
Year	***Site Name***
2006	Hall Pasture
	Hall Homestead
2007	Three Section
	Tipperary
2008	Pigpen
	Lower
	M&M #1
2009	Hall Homestead
	Tipperary
2010	Hall Pasture
	Three Section
	Lower Hepp
2011	Lower
	M&M #1
	Lawrence

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 MADE IN THIS DOCUMENT

Summary findings from each of the three 2011 transect sites are displayed here, along with management recommendations for continued improvement of the resource base. See the individual site summaries later in this document for added detail.

Lower Pasture – MRT13

This site was first established in 2008 on an area representative of the flatter pasture rangelands. Since then, the transect showed slow, but steady improvement in rangeland health. Highlights of those changes include:

- Bare ground dropped from 23% in 2008 to 0% in 2011. This was a strong improvement.
- Distance between perennial plants fell by 17% between the two sample years, suggesting positive change and that more perennial plants grew on the soil surface.
- Relative basal composition of the desired needleandthread grass increased from 1% to 17%.
- Production of undesired species like Japanese brome and cheatgrass was a combined 42% in 2008, and this composition fell to 18% in 2011. Production of these two plants appeared to be replaced by that of the desired needleandthread grass.

Grazing management of the past three years produced an upward range trend, so no major corrections to the existing program were warranted. Managers must continue practicing short grazing durations in the spring window and prevent excessive utilization of forages. Further desired shifts in plant species composition represent the next phase of improvement for this pasture.

M&M #1 – MRT14

This site was first established in 2008 in an area representative of the pasture. The site was specifically chosen in an area that had a greater mix of grasses, forbs, and shrubs than surrounding areas. The site showed minimal signs of change between the two sample years, and highlights of change include:

- Bare ground dropped from 42% in 2008 to 30% in 2011.
- Distance between perennial plants fell by 56%, reflecting recruitment of new perennial plants on the soil surface.
- Basal cover of mid-seral plants (like Western wheatgrass and Sandberg bluegrass) increased substantially, while that of highly desired and less-desired plants fell.
- Productivity of the undesired species Japanese brome dropped substantially.
- Multiple dying and dead big sagebrush plants were observed, and data display reduced composition of big sage through time.

This pasture has been used for spring grazing for the past few years, and a short grazing duration has been attained. Continue keeping this grazing duration short and ensure that utilization rates are at moderate levels (30 – 50% of current year's growth). Improvements in the water cycle and successional process will be the next stages of improvement for this pasture, which will be made more rapid by the decline in big sagebrush.

Lawrence Pasture – MRT23

This transect was established in 2011 in a flatter portion of the pasture not far from stockwater and the pasture boundary fence. The site displayed high rangeland health, but still had room for improvement. Highlights of the site include:

- Only 8% bare soil and a desirable level of live plant cover at 10%.
- The basal cover of desired perennial grasses green needlegrass, bluebunch wheatgrass, and needleandthread together totaled 26%. This was a strong figure, but one that can still be improved.
- 27 plant species were found in the area, and most of them were desired grasses, forbs, and shrubs.
- The area displayed multiple dying and dead big sagebrush plants, suggesting this plant was decreasing is presence in the community.

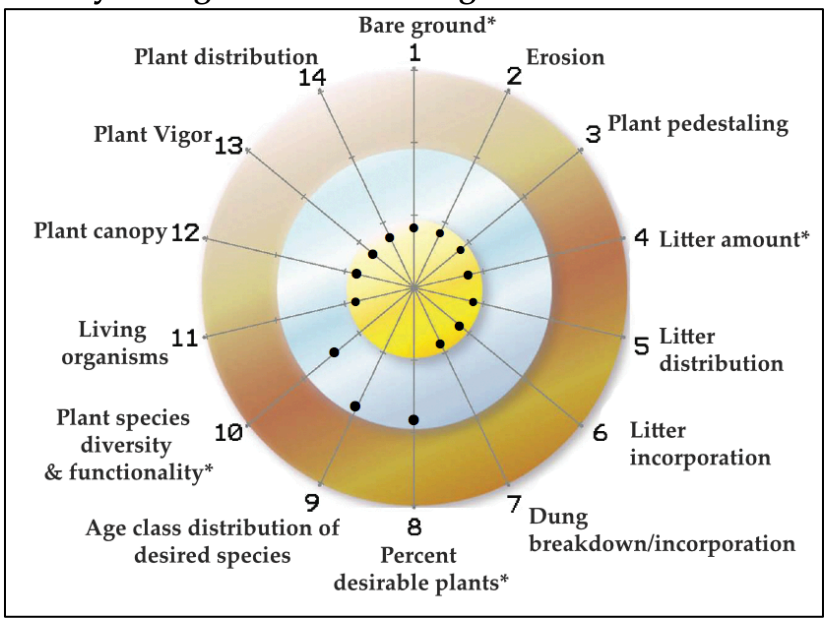
The management program of the past few years produced a site of high rangeland health, but with a successional process that still had room for improvement. More of those desired perennial bunchgrasses were desired here. Multiple young green needlegrass plants observed in the area suggest the successional process should begin displaying signs of more rapid improvement in the near future.

Lower Pasture

MRT13

Data Comparisons

Bullseye Rangeland Health Target



This site was established in 2008 to represent the Lower Pasture. The transect lies in a flat portion of the pasture containing multiple plant species. A stock water tank was not far away, and a nearby draw contained smooth brome that appeared to be moving upward into the rangelands. The area was used in recent years for late-winter calving.

A glance at the Rangeland Target above shows how the 14 indicators of rangeland health were performing on sample day. Using the colors of the Olympics, those indicators falling in the gold (or bull's eye) were functioning optimally; those in the silver were at mid-level function and displayed room for improvement; and those falling in the bronze area require more urgent management attention.

The water cycle here was effective. Almost no **bare soil** was observed, no signs of **erosion** were found, and no **plant pedestals** were evident.

The mineral cycle was rapid. The **litter amount** was optimal for this site, litter was well **distributed** across the soil surface, and litter was also **incorporating** well with soil. Further, few dung piles could be found in the area, suggesting they were **decomposing** rapidly. These indicators suggest nutrients were cycling rapidly in the system.

Within the successional process, undesired species of cheatgrass and Japanese brome were prominent. Most of the other plant species found at the site were mid-seral, meaning neither desired, nor undesired. Few young **age classes** of desired species like green needlegrass and needleandthread were observed. Further, **plant species** diversity was not optimal, with only 19 species found at the site. Ideally, more grasses and forbs should be found here. Overall, the successional process was lagging at this site.

Energy flow was elevated. As the site photos below will show, the **plant canopy** was robust. **Plant vigor** was also high, with plants having achieved tall stature, produced seed, and they were green and growing in mid August. Plants were also well **distributed** across the soil surface.

Transect view. Photo taken August 27, 2008.

Transect view. Photo taken August 10, 2011.

Quadrat view. Photo taken August 27, 2008.

Quadrat view. Photo taken August 10, 2011.

BASAL COVER

2008	2011	
23%	0%	Bare
72%	96%	Litter
5%	4%	Live

RELATIVE BASAL PLANT SPACING - inches

2008	2011
1.8	1.5

RELATIVE BASAL PLANT SPACING BY SPECIES (TOP 7 SPECIES)

2008		2011	
Western wheatgrass	58%	Western wheatgrass	50%
Silver sagebrush	20%	Needleandthread	16%
Scarlet globemallow	12%	Silver sagebrush	15%
Smooth brome	3%	Western yarrow	7%
Western yarrow	2%	Green needlegrass	5%
Green needlegrass	2%	Smooth brome	3%
Needleandthread	1%	Sandberg bluegrass	3%

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

2008		2011	
Cheatgrass	28%	Silver sagebrush	28%
Silver sagebrush	25%	Western wheatgrass	25%
Western wheatgrass	23%	Cheatgrass	11%
Japanese brome	14%	Needleandthread	9%
Scarlet globemallow	2%	Japanese brome	7%

PRODUCTION: Lbs per acre

2008	2011
1740	1740

ADDITIONAL INFORMATION

Site sampled August 27, 2008.
Site sampled August 10, 2011.

PLANT SPECIES FOUND IN TRANSECT AREA

2008	2011	
20	*18*	***Total count***
X	X	Cheatgrass
X	X	Western wheatgrass
X	X	Green needlegrass
X	X	Smooth brome
X	X	Japanese brome
X	X	Sandberg bluegrass
X	X	Silver sagebrush
X	X	Fringed sage
X	X	Scarlet globemallow
X	X	Salsify
X		White alyssum
X		Pricklypear cactus
X	X	Tansymustard
X	X	Western yarrow
X	X	Kochia
X		Musk thistle
X		Curlycup gumweed
X		Mustard species
X		Woolly plantain
X	X	Pennycress
	X	Alfalfa
	X	Curlydock
	X	Purple fleabane
	X	Winterfat

SILVER SAGEBRUSH DATA

2008	2011	
		Line intercept:
55	63	***Number of big sage plants encountered***
		Line Intercept: Age Class Distribution
0%	3%	seedling
7%	11%	young
88%	86%	mature
5%	0%	decadent
19	17	***Average plant height - inches***
23%	32%	***Percent canopy intercept***
156	220	***Density per 600 square feet***

LOWER PASTURE DISCUSSION

Photos

The major change evident in both the transect view and quadrat photos is the vigor on silver sagebrush. This species was performing well in 2008, but appeared to thrive in the wet season of 2011. Leader growth on silver sage plants was well over 12 inches. The undesired species cheatgrass and Japanese brome appear prominently in both years' photos, but more needleandthread and green needlegrass was evident in the 2011 transect view photo. More will be discussed on recruitment of these species into the community below.

Basal Cover

The basal cover chart depicts the relationship among bare ground, litter cover, and live plant cover. Note the tremendous reduction in bare soil here (23% in 2008 to 0% in 2011). This was terrific improvement. Unfortunately, percent live cover barely changed (and actually dropped 1 point). The reduction was not cause for alarm, but this site should contain roughly 10% live cover with a mix of desired perennial bunchgrasses and forbs. Some positive change was made here with the reduction in bare soil, but room for improvement exists.

Relative Basal Plant Spacing

This is a measure of the distance between perennial plants. A lower number denotes tighter plant spacing, which is desirable. At the Lower Pasture, the distance between perennial plants dropped by 0.3 inches, a positive sign. This suggests more perennial plants were growing on the soil surface, or that the size of plant crowns had expanded. In time, the recruitment of additional perennial plants to the site should be measured through new live plant cover.

Relative Basal Plant Spacing by Species

When relative basal plant spacing data are collected, the species of those plants may also be determined. This data set portrays the most basally abundant plant species on the soil surface. Notably, the composition of the desired grass needleandthread jumped from 1% in 2008 to 16% in 2011, which was a positive change in a short time. Likewise, green needlegrass increased from 2% to 5%. Both are signs of recruitment of these desired plants into the community. Further, the introduced species smooth brome did not increase its composition, and silver sagebrush declined. These data portray positive changes in the site's plant species composition.

Relative Composition by Weight

The next chart portrays the five most abundant plant species as measured by weight. Unlike the basal spacing data set above, this measure includes annual plants. The 2008 data contained 42% production from the undesired species cheatgrass and Japanese brome, which was too high for this site. By 2011, these invasives contributed 18%, which was a substantial drop. The desired grass needleandthread increased its composition, which was also positive change. While change in species productivity was moving in the right direction, this list of plants still did not contain enough high-seral grasses and desired forbs. More green needlegrass and flowering forbs should be found at this site, and they should be found in this data set.

Production
Plant productivity was the same between the two sample years. This means that more of the site's production was composed of plants like silver sagebrush, Western wheatgrass, and needleandthread (as the production of invasive species declined), which was positive change.

Plant Species
The number of plants found at the site fell by two. While more plants would ideally be found through time (especially in a wet year like 2011), those that were not found in 2011 included the less-desired species like white alyssum, pricklypear cactus, musk thistle, and woolly plantain. These were positive losses. Conversely, the site added species like alfalfa, fleabane, and winterfat, all desired plants. Ideally, more than 25 species should be found here, and shifts in species composition through time may increase plant species in the area.

Silver Sagebrush Data
The number of new silver sage plants increased from 55 to 63 plants along the transect line, a large increase. The age class data suggest this species' recruitment was rapid in the community. Both percent canopy cover and density increased greatly in the three years between transect readings. That 32% canopy cover was noteworthy, for it marks the point at which silver sage canopy was becoming excessive (30% canopy cover also becomes hard to walk through, as may be seen in the site photos). Management may consider corrective actions on this species in the future as will be described in the management recommendations below.

Range Trend
At the Lower Pasture, the water cycle was effective, the mineral cycle was rapid, and energy flow was elevated. The successional process was lagging behind the other ecosystem process, but was gaining ground between the two sample years. Range trend here was upward. Much room for improvement existed here in the form of continued shifts in plant species composition.

Management recommendations
This pasture has been used over the past four years or so as a calving pasture. Cattle enter the pasture in the mid-March window (depending on the year's planned herd movements) and spend roughly 14 days here. At this time of year, most grazing will occur on prior year's growth, so less damage to plants should be expected. Afterward, the pasture is rested (with the exception of grazing for some horses in summer and a few bulls in fall) for the bulk of the growing season. This management program has produced an upward range trend, so no major course corrections were warranted at this time. That being said, management must take care to keep grazing durations short in the early growing season (again, depending on the year's planned herd movements) so that no rapidly growing plants are bitten twice while the herd is in the pasture. Next, ensure that the utilization rate is not excessive here (take 30 – 50% of the spring growth) in an effort to avoid slowing regrowth. The less taken of a perennial bunchgrass, the quicker it will regrow.

Managers should continue watching movements of silver sagebrush. At 32% canopy, the species gains a prominent position in the plant community that may negatively reduce the performance of other desired

plants. Should recruitment of silver sagebrush appear evident at this site, consider feeding hay atop the site in that late winter grazing window to apply a dose of animal impact to the silver sage plants. Let the hooves of cows in late winter open this plant canopy in an effort to favor the growth of more desired grasses and forbs. Note that the effort here would not be to rid the site of silver sagebrush (the canopy may trap wind-driven snow from which all plants would benefit), but to simply open the canopy and prevent silver sage from becoming too prominent.

Early-warning indicators

Early-warning indicators provide managers rapid feedback regarding how their management actions are affecting a particular site. Should implemented plans be taking a site away from a desired state, managers must make changes quickly before costly and time-consuming corrections are needed. Early-warning indicators provide those first glimpses at a site that something is awry and course corrections are needed.

If management actions are improperly applied here, look first for reduced plant vigor and a more open plant canopy, along with increased bare soil. These suggest utilization rates have been too high and/or grazing durations too long. Next, look for shifts in species composition away from the desired perennial bunchgrasses toward less desired plants.

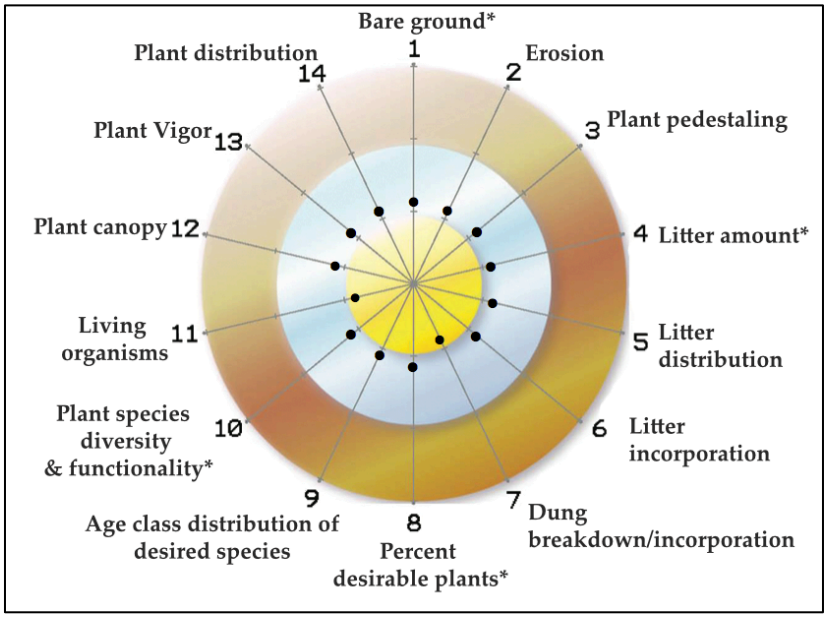
If management actions are properly applied, look for maintained plant vigor, even in years not as wet as 2011. Next, look for increased live plant cover and shifts in plant species composition toward the more desired plants.

M & M #1

MRT14

Data Comparisons

Bullseye Rangeland Health Target



This site was established in 2008 in a saddle that featured area livestock trails as cattle moved between a nearby stockwater tank and the rest of the pasture. The pasture boundary fence was about 1 mile to the north.

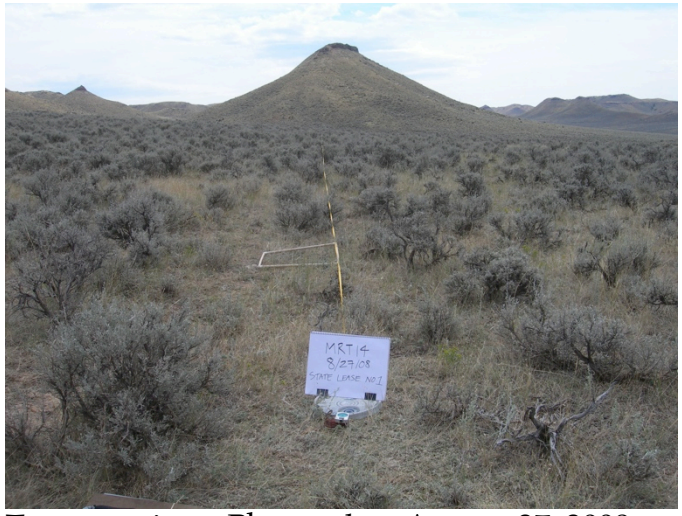
The water cycle was less effective. Too much **bare soil** was found to adequately absorb moisture falling from the sky, and some soil capping was present. Some signs of **wind erosion** were evident, and plants were **pedestaled**. Pedestals were not so large that roots were exposed.

The mineral cycle functioned more slowly than desired. More **litter amount** was needed to cover the site's bare ground. The **distribution** of litter across the soil surface was mixed, with some areas displaying uniform litter cover, while other areas had large gaps. Litter was not **incorporating** well with soil: litter was contacting soil, but was not mixing well with the soil surface. **Dung breakdown** appeared to be rapid, and a few dung beetles were observed in the area.

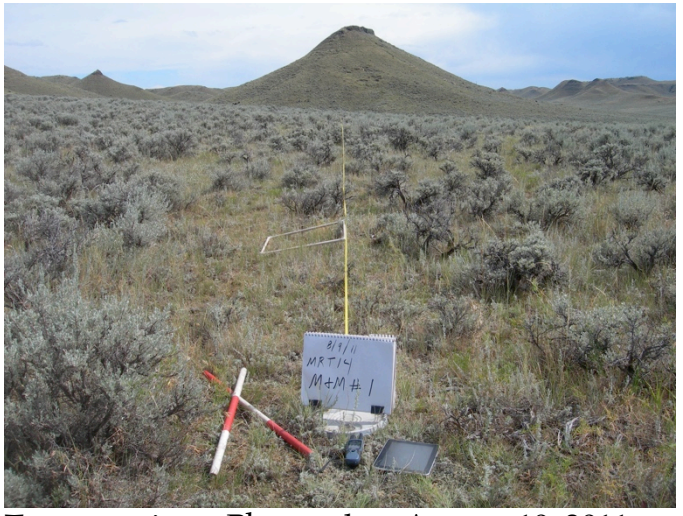
Within the successional process, the only undesired species present was Japanese brome, and it was not found in abundance. Overall, mid-level species dominated the site, including Western wheatgrass and prairie junegrass. Desired species like needleandthread were present, but not in the abundance desired. Further, few **age classes** of desired plants were found, suggesting these were not being recruited into the community. **Plant species diversity** was not optimal, for more forbs and grasses should be found here. Multiple big sagebrush plants appeared to be dying in the area. This species was decreasing presence in this portion of the pasture.

Energy flow functioned at moderate levels. The **plant canopy** was not robust, nor were plants well **distributed** across the soil surface. Much sunlight energy struck the soil surface, rather than being intercepted by living plant leaves. Plants did not display high **vigor**, with few seedheads produced on grasses, and only low stature achieved. Leader growth on big sagebrush was less than 6 inches.

The photos below portray the site as it appeared when sampled in 2008 and 2011.



Transect view. Photo taken August 27, 2008.



Transect view. Photo taken August 10, 2011.

Quadrat view. Photo taken August 27, 2008.

Quadrat view. Photo taken August 10, 2011.

BASAL COVER

2008	2011	
42%	30%	Bare
52%	64%	Litter
6%	6%	Live

RELATIVE BASAL PLANT SPACING - inches

2008	2011
1.8	0.8

RELATIVE BASAL PLANT SPACING BY SPECIES (TOP 7 SPECIES)

2008		2011	
Western wheatgrass	29%	Western wheatgrass	36%
Fringed sage	17%	Sandberg bluegrass	15%
Needleandthread	15%	Prairie junegrass	14%
Big sagebrush	11%	Fringed sage	9%
Hood's phlox	9%	Big sagebrush	5%
Prairie junegrass	4%	Threadleaf sedge	5%
Threadleaf sedge	4%	Needleandthread	5%

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

2008		2011	
Big sagebrush	31%	Big sagebrush	23%
Green needlegrass	19%	Needleandthread	17%
Western wheatgrass	19%	Western wheatgrass	16%
Japanese Brome	18%	Prairie junegrass	11%
Bluebunch wheat	5%	Fringed sage	10%

PRODUCTION: Lbs per acre

2008	2011
860	720

ADDITIONAL INFORMATION

Site sampled August 27, 2008.
Site sampled August 10, 2011.

PLANT SPECIES FOUND IN TRANSECT AREA

2008	2011	
25	*29*	***Total count***
X	X	Japanese brome
X		Cheatgrass
X	X	Prairie junegrass
X	X	Western wheatgrass
X	X	Sandberg bluegrass
X	X	Green needlegrass
X	X	Needleandthread
X	X	Threadleaf sedge
X	X	Blue grama
X		Bluebunch wheatgrass
X	X	Big sagebrush
X	X	Fringed sage
X	X	Broom snakeweed
X	X	Pricklypear cactus
X	X	Scarlet globemallow
X	X	Vagrant lichen
X	X	Vetch species
X		Curlycup gumweed
X		Fleabane species
X		Hood's phlox
X		Yellow salsify
X	X	Western yarrow
X		Bastard toadflax
X		Clover species
X		White alyssum
	X	Allium species
	X	Dandelion
	X	Daisy species
	X	Lupine
	X	Muttongrass

PLANT SPECIES CONTINUED

	X	Needleleaf phlox
	X	Penstemon species
	X	Peppergrass
	X	Salsify
	X	Smooth brome
	X	Showy fleabane
	X	Tansymustard
	X	Second vetch species

BIG SAGEBRUSH DATA

2008	2011	
		Line intercept:
46	41	***Number of big sage plants encountered***
		Line Intercept: Age Class Distribution
0%	0%	seedling
9%	0%	young
91%	80%	mature
0%	20%	decadent
14	10	***Average plant height - inches***
20%	18%	***Percent canopy intercept***
221	193	***Density per 600 square feet***

M & M #1 DISCUSSION

Photos
Two changes are most visible in the transect view photos. First, fewer big sagebrush plants are visible in 2011 than 2008, suggesting this species was declining in the community (more on that below). Second, plant vigor appeared to be slightly better in 2011, although not much. Plants appeared of low vigor both sample years.

The quadrat photos again show low vigor and the bare soil found at the site. Likewise, gaps between plants portray the less-than-uniform plant distribution found.

Basal Cover
The Basal Cover chart depicts the relationship among bare soil, litter cover, and live plant cover. The amount of bare soil dropped by 12 percentage points, representing desired change. The percent live cover did not increase. Ideally, this figure will surpass 10% in coming years to optimize the amount of live plant cover.

Relative Basal Spacing by Species
Relative spacing by species is a measure of the distance between perennial plants. The lower the number, the tighter the spacing between plants. This distance fell by one full inch, a reduction of 56%, denoting rapid improvement in this measure. This distance between perennial plants of less than one inch was a good figure for this site.

Relative Basal Plant Spacing by Species
When the figure for the distance between perennial plants is measured, the most predominant perennial plant species are also determined. The composition of prairie junegrass, Western wheatgrass, and Sandberg bluegrass increased, which accounts for that one-inch drop in the distance between perennial plants. These three species increased their presence substantially, and they are all mid-level species. On a positive note, the composition of the less-desired fringed sage dropped, but that of the desired needleandthread also dropped. These data portray a shift toward mid-level plant species. Ideally, more high-end plants like needleandthread and green needlegrass should be found here in greater numbers.

Relative Plant Species Composition by Weight
This data set displays the five most abundant plants as relative composition by weight. Much change may be observed in this table. First, relative production of big sagebrush declined by several percentage points, a trend which was reflected in the basal plant spacing data and the line intercept data. This species appeared to be declining in this portion of the pasture. Next, the highly desired green needlegrass fell from the list of the top five plants, and this species had a poor year in 2011. Conversely, composition the highly desired needleandthread increased substantially, for it was not found on the list of the top five in 2008. The changes in these plants depict mixed change: one desired plant was replaced by another. Next, the composition of the undesired Japanese brome fell substantially, denoting positive change. Lastly, production of bluebunch wheatgrass, another highly desired grass, fell. This species also did not perform well in 2011. These data portray a site in change, but one whose direction was unclear. On the one hand, undesired Japanese brome fell from the list and the desired needleandthread increased. On the other hand, the desired green needlegrass and

bluebunch wheatgrass both declined. Expect more change in species composition by weight here in the near future.

Production
The pounds per acre production dropped between the two sample years. Note that much of the site's 860 pounds per acre productivity in 2008 was from contributions by Japanese brome and sagebrush. In 2011, productivity of both these species dropped, suggesting the production was composed more of mid and high-level plants. Again, these data depict mixed change. On the one hand, overall productivity dropped, but on the other hand, production was composed of more desired plant species by 2011.

Plant Species
Four more plant species were found in 2011, which was a positive direction. The new plant species found were various forbs (lupine, dandelion, allium, salsify, and two vetches) and all of them were desired plants. Such forb growth should be expected in the wet year of 2011. But other data were mixed: cheatgrass fell from the list (a positive sign,) as did curlycup gumweed (a plant favored by sage grouse), and so did bluebunch wheatgrass (a highly desired grass). These data again portray a site in transition.

Big Sagebrush Data
The number of big sagebrush plants declined between the two sample years, as measured by the line intercept, density, and plant canopy. Further, notice the age class distribution data set. Twenty percent of the plants were found to be decadent along this transect line, suggesting rapid change in the big sage community. Such change bears continued examination, for multiple big sage plants in this portion of the pasture appeared to be decadent or dead. Just across the two-track road from the transect site lay an area where most of the big sage plants had died. The understory growth of forbs and herbaceous plants (including Japanese brome, cheatgrass, green needlegrass, and Western wheatgrass) was substantial. The effect appeared to be forming a "mosaic of vegetation" that will serve to collect wind-driven snow, change they hydrologic pattern, alter plant species composition, and alter wildlife habitat through the area.

Range Trend
Range trend here was undetermined. Both positive and negative signs of change were occurring, and the best that could be said for this site was that it was indeed changing. On the positive side, species like Japanese brome and cheatgrass had declined, but also had desired species like green needlegrass and bluebunch wheatgrass. The site appeared to increase its presence of mid-level plants, which ideally will be replaced by more desired plants in time.

Management recommendations
This pasture has been used in recent years as a springtime transition pasture for yearlings on their way to summer pasture. Grazing durations tend to be around 10 days, and then the pasture receives total rest for the remainder of the growing season.

Given this spring grazing window and short grazing duration, management must ensure that utilization rates occur at roughly 30 – 50% of the current year's crop. Don't take too much of the current year's plant material, or recovery times will be longer, effectively giving the

ungrazed (and often undesired) plants a competitive advantage over the regrowing plants. Manage for good utilization in this spring window, and range trend should begin moving in the desired direction as big sagebrush declines in the community.

Early-warning indicators

As big sagebrush plants continue their decline, look for massive increases in production of Japanese brome and cheatgrass as they colonize where big sage declined. Management has little leverage in preventing the growth of these species. However, managers may examine the vigor of the desired grasses as evidence of change. If the site is managed improperly, look for poor vigor on the desired grass species of needleandthread and green needlegrass. If the site is managed properly, look for maintained plant vigor on these species, even in years not as wet as 2011. Next, look for altered bare ground amount. Ideally, less bare soil will be found here, and plant productivity will increase. Lastly look for shifts in species composition toward the more desired grasses as evidence that management strategies are working.

Additional commentary

In 2008, a fenceline contrast photo was taken when crossing from the Merlin Ranch Pasture into M&M #1. That picture (shown at the upper right) displayed much higher plant cover on the Merlin (left) side of the fence than the M&M#1 side. The road was even visible in this photo. In 2011 the same fenceline contrast photo was taken and is shown at the lower right.

The 2011 photo displays a strong improvement in plant vigor over 2008, but note the improvement in plant growth on the M&M #1 (right) side of the fence. The two-track road was largely grassed over, and plant cover appeared to be much higher in 2011. Note also the strong improvement in silver sagebrush vigor, especially with those plants in the foreground. These photos demonstrate continued change in this pasture. The pasture was changing, but was changing unevenly. The pasture requires careful management in coming years to ensure change moves in the desired direction.

2008 photo

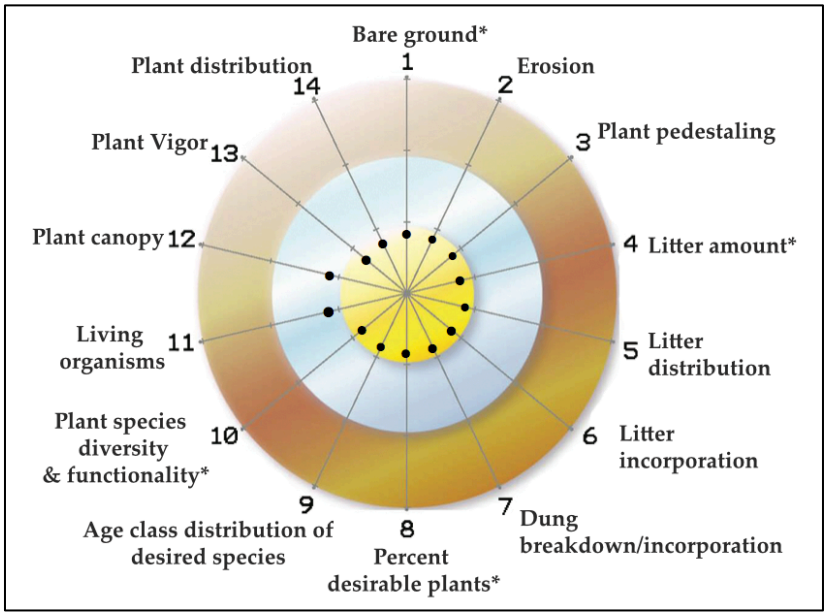
2011 photo

Lawrence Pasture

MRT23

Data Comparisons

Bullseye Rangeland Health Target



This transect was established in 2011 in an open bowl of the Lawrence Pasture not far from the pasture boundary fence and also from stockwater. This portion of the pasture contained mixed plant cover, including steeper slopes, small flats, areas with little big sage cover, and areas with much big sage. This transect was specifically chosen to lie in an area that contained a mix of grasses, forbs, and shrubs. It should provide a good representation of changes occurring in the pasture.

The Rangeland Target above displays indicators whose scores largely fell in the desired gold range. This denotes a site in high rangeland health.

The water cycle here was effective. Little **bare soil** was evident, no signs of **erosion** were observed, and no **plant pedestals** were observed on this mild slope. The day before the transect was read, a large thunderstorm dropped ample rainfall in the area. No signs of erosion were observed from this storm, which was another indicator of the water cycle's effectiveness.

The mineral cycle appeared to be functioning rapidly. The **litter amount** was optimal for this site, and litter was well **distributed** across the soil surface. Litter was contacting with soil, but was not mixing well, suggesting the **incorporation** process could be faster. **Dung breakdown** appeared to be rapid. Cattle had grazed the area in high stock densities (judging by the number of cow pies), and breakdown appeared to be occurring in two years or less.

Within the successional process, undesired species like cheatgrass and Japanese brome were abundant. This was likely the result of failing big sagebrush plants in the area. Obvious young **age classes** of the desired green needlegrass were abundant, suggesting this species was moving rapidly into the community. **Plant species diversity** was high with nearly 30 species found at the site.

Energy flowed at moderate levels. Some sunlight energy struck the soil surface, but much of it was intercepted by living plant leaves. The **plant canopy** was moderate, and, as the site photos below will portray, **plant vigor** was high. Plants were also well distributed across the soil surface.

Transect view. Photo taken August 10, 2011.

Quadrat view. Photo taken August 10, 2011.

BASAL COVER

2011	
8%	Bare
82%	Litter
10%	Live

ADDITIONAL INFORMATION

Site sampled August 10, 2011.

RELATIVE BASAL PLANT SPACING - inches

2011
1.2

RELATIVE BASAL PLANT SPACING BY SPECIES (TOP 7 SPECIES)

2011	
Western wheatgrass	33%
Green needlegrass	17%
Needleleaf phlox	12%
Sandberg bluegrass	11%
Big sagebrush	7%
Bluebunch wheatgra	5%
Needleandthread	4%

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

2011	
Big sagebrush	24%
Green needlegrass	23%
Western wheatgrass	13%
Japanese brome	7%
Vetch species	6%

PRODUCTION: Lbs per acre

2011
860

PLANT SPECIES FOUND IN TRANSECT AREA

2011	
27	*Total count*
X	Allium species
X	Big sagebrush
X	Blue grama
X	Bluebunch wheatgrass
X	Broom snakeweed
X	Cheatgrass
X	Dandelion
X	Fringed sage
X	Green needlegrass
X	Japanese brome
X	Mushroom
X	Needleleaf phlox
X	Peppergrass
X	Prairie junegrass
X	Pricklypear cactus
X	Salsify
X	Sandberg bluegrass
X	Scarlet globemallow
X	Sego lily
X	Showy fleabane
X	Second fleabane species
X	Threadleaf sedge
X	Unknown perennial forb
X	Vetch Species
X	Western wheatgrass
X	Western yarrow
X	Winterfat

BIG SAGEBRUSH DATA

2008	*Line intercept:*
45	*Number of big sage plants encountered*
	Line Intercept: Age Class Distribution
0%	seedling
0%	young
82%	mature
18%	decadent
17	*Average plant height - inches*
25%	*Percent canopy intercept*
99	*Density per 600 square feet*

LAWRENCE PASTURE DISCUSSION

Photos
A close look at the transect view photo shows some sagebrush skeletons. This species appeared to be in decline in the area, and herbaceous plants were taking advantage of the absence. Desired green needlegrass plants appear as the tall plants in the scene, while much of the green growth on the soil surface was Western wheatgrass.

Basal Cover
The basal cover chart depicts the relationship among bare soil, litter cover, and live plant cover. The 8% bare was a low and desirable number for this site. Further, 10% live plant cover was optimal. Most of the live plant cover consisted of desired green needlegrass plants. This chart depicted a favorable relationship among these three variables.

Relative Basal Plant Spacing
This datum displays the distance between perennial plants on the soil surface. The lower the number, the tighter the plant spacing. At the Lawrence site, the distance between perennial plants was 1.2 inches, which was not a bad figure for this site, but also shows room for improvement. Ideally, this figure should drop below 1 inch to be optimal, so room for improvement existed.

Relative Basal Plant Spacing by Species
When determining the distance between perennial plants in the prior measurement, the predominant species found on the soil surface may also be determined. This data set displays a favorable mix of plant species, but one that also allows room for improvement. The highly desired grasses of green needlegrass, bluebunch wheatgrass, and needleandthread were found in abundance, but ideally should compose more of the soil surface here. Further, plants like needleleaf phlox and Sandberg bluegrass should be replaced by those high-end perennial bunchgrasses. Also, some more desired forbs like lilys vetches, alliums, and/or fleabanes should make this list.

Relative Composition by Weight Ranking
This data set displays the five most productive plants as composition by weight. Japanese brome composed too much of this community, and it appeared to be thriving in areas where big sagebrush plants were decadent or dead. Watch for changes in this species' community composition in the future, and also watch for changes in the big sage composition as this species continues to decline. The desired grass green needlegrass composed 23% of this community, which was a strong contribution, and the vetch appeared prominently in the wet year of 2011. This nitrogen fixer was a good forb for this community. This data set also displays decent composition with room for improvement.

Production
At 860 pounds per acre, the site was producing under the site's average year potential of 1100-pounds per acre in a Loamy ecological site. Plant productivity here was in flux, with losses of big sagebrush and much Japanese brome and cheatgrass growing under the skeletons. As this community changes, look for corresponding changes in plant productivity.

Plant Species
At 27 total species found, this figure represents high species richness for this site. This group of grasses, forbs, and shrubs will serve to complement one another through varied plant canopies that trap wind-driven snow, and elevate nutrients found at different levels of the soil profile through diverse root structures. The only undesired species on this list were Japanese brome and cheatgrass. Conversely, the most desired species found in the area were on the list: bluebunch wheatgrass, green needlegrass, and winterfat. The various forbs such as yarrow, lily, fleabane, salsify, and the vetch were also desired.

Big Sagebrush Data
Two data are worth noting in this chart. The first is plant canopy intercept at 25%, which is just below the 30% level where big sage canopy becomes hard to walk through. At canopy intercept above 30%, actions should be considered to open the canopy for promotion of herbaceous growth. For unknown reasons, sagebrush appeared to decline prior to reaching that 30% threshold. Second, see the age class distribution figures. At 18% decadent, this portrays rapid decline in the big sage community. This site bears further examination in the future as big sagebrush declines and other species move into the community.

Range Trend
Apparent range trend here was slowly upward. The decline in the big sagebrush community offered opportunity for increased green needlegrass.

Management Recommendations
This pasture has been grazed with short grazing durations and high stock densities for several years, and the timing of grazings varies based on the grazing plan. In some years, use occurs in late May and early June, and may occur as late as August. This program has produced a site of high rangeland health that still has room for improvement. The water cycle was effective, the mineral cycle was rapid, and energy flow was high. The successional process was lagging, but appeared to be making rapid improvements with the decline in the big sagebrush community coupled with multiple young green needlegrass plants. The current management program requires no major course corrections. The lagging successional process should begin displaying signs of improvement in the near future.

Early-warning indicators
If management actions are improperly applied, look first for reduced vigor of desired grasses and more bare soil. These indicators suggest utilization rates are too high, grazing durations are too long and/or recovery periods between grazings are too short. Next, look for shifts in species composition away from the desired perennial bunchgrasses toward mid-seral grasses and/or undesired plants.

If management actions are properly applied, look first for maintained plant vigor, even in years not as wet as 2011. Next, look for reduced bare soil (that small percent could still be reduced). Lastly, look for increased presence of green needlegrass, bluebunch wheatgrass, and winterfat.

NUTRIENT ANALYSIS

At each of the three sites, a single plot of forage 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 species like sagebrush that cattle would not graze, and then the samples were sent to Midwest Labs in Omaha, NE for nutrient analysis. The following table displays the dry-matter nutrient content of each of the samples in 2011.

	Lower	M&M#1	Lawrence
Crude Protein (%)	9.04	7.33	7.31
Acid Detergent Fiber (%)	38.2	36.4	36.6
Total Digestible Nutrients (%)	59	61	60.8
Net energy-lactation (Mcal/lb)	0.6	0.63	0.62
Net energy-maintenance (Mcal/lb)	0.58	0.6	0.6
Net energy-gain (Mcal/lb)	0.34	0.32	0.36
Sulfur (%)	0.16	0.14	0.16
Phosphorus (%)	0.14	0.13	0.13
Potassium (%)	2.01	1.1	1.7
Magnesium (%)	0.12	0.23	0.2
Calcium (%)	0.55	0.86	0.87
Sodium (%)	0.01	0.01	0.01
Iron (ppm)	57	121	77
Manganese (ppm)	49	42	67
Copper (ppm)	3	4	3
Zinc (ppm)	21	13	15

No nutrients were contained at toxic levels in these samples, but some (copper, zinc, phosphorus) were low, which has been the case during the history of taking these samples at the ranch.

As was done in previous years, the nutrients provided by the samples will be compared against the needs of an 1100-pound lactating cow. The plants were collected in mid August of a wet 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 here dry matter requirements, the **Lower** sample will return the following to her:

Dry Matter	Crude Protein	TDN	Ca	P
21.6#	2#	12.7#	54g	14g

As may be seen, our cow is short only on phosphorus. (The Lower's 2011 nutrient sample was a good one.) Next, the calcium to phosphorus ratio was 4:1, or well within the accepted limits of 7:1. The management recommendations below will address the phosphorus shortage.

At **M&M #1**, the forage will return the following to our sample cow:

Dry Matter	Crude Protein	TDN	Ca	P
21.6#	1.6#	13.1#	84g	13g

This forage was short in both crude protein (by 0.4 pounds per day) and phosphorus (by 9 grams per day). Further, the calcium to phosphorus ratio was 6, which is just below that 7:1 limit.

Lastly, the **Lawrence** sample will return the following to our sample cow:

Dry Matter	Crude Protein	TDN	Ca	P
21.6#	1.6#	13#	85g	13g

Again, this sample was short on crude protein and phosphorus. The calcium to phosphorus ratio was 6, again within that 7:1 limit.

Note that the TDN samples were all strong in 2011. This was not common for previous Merlin Ranch samples.

Management recommendations from nutrient analysis

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. That being said, the analysis is intended to be a "shotgun" approach to livestock performance, rather than a precise science. Simply put, livestock have access to a variety of forage sources in each of these pastures, and not just forage from the sample sites. This provides variety in the diet and likely meets the cow's needs, including those critical crude protein levels.

The ranch also moves its livestock through a series of pastures during the course of the growing season, providing cattle with fresh feed sources on a regular basis. This action in itself presents the best means of meeting the needs of the lactating cows.

If livestock performance is lacking, once calves are weaned in the dormant season, management may place dry cows on the hay meadows that were irrigated all season. Nutrient content of these plants should be higher than the rangeland plants. Once hay feeding begins, much of the cow's daily nutrient requirement should be met, and the cow will rebuild body condition.

Lastly, to meet the needs of the herd, management may take more aggressive actions, such as weaning calves earlier. If performance suffers and cow longevity is also an issue, then the calf may be weaned so the body condition of the cow may be replenished more readily. Only pursue this option if cow performance is an issue.

MONITORING METHODS

On August 8 2011, 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 2011.

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.

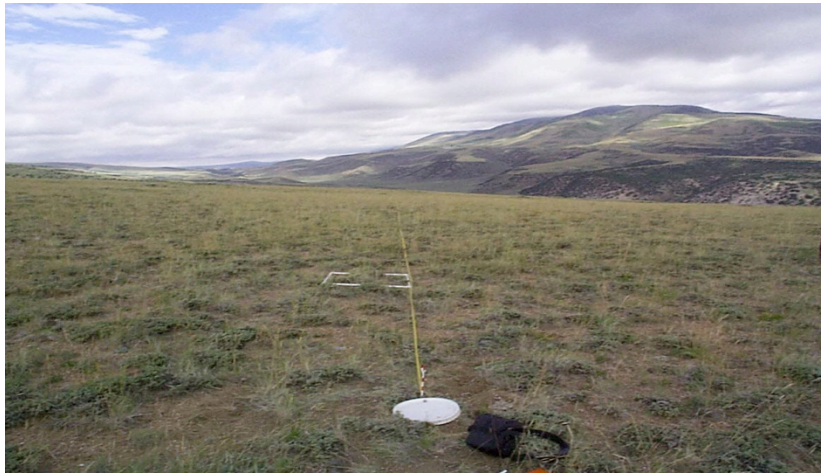


***Figure 2: Permanent transects were 200 feet long and were permanently marked* on each end.**

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.

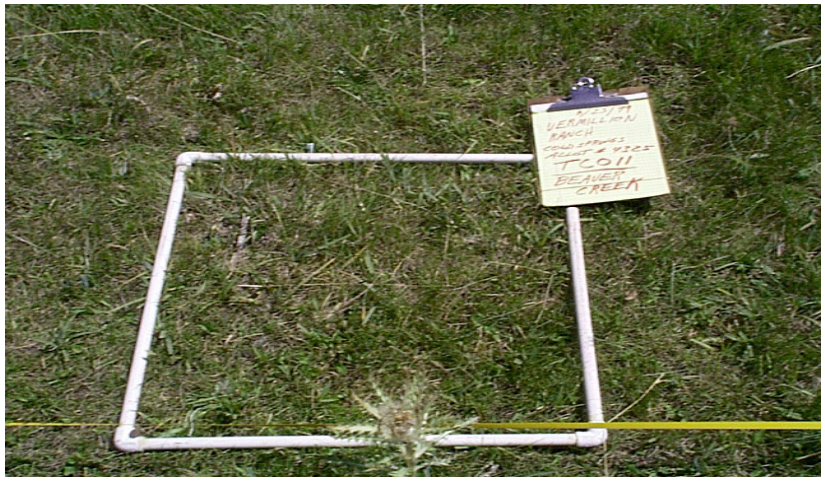


Figure 3: The first plot on a transect. [This sample plot lies in Colorado.]

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.

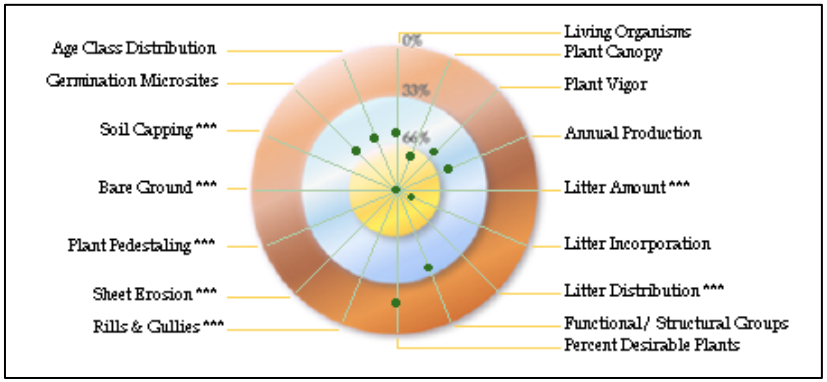


Figure 4: The target portrays results of each of the 16 indicators studied based on field scores.

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 14 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.

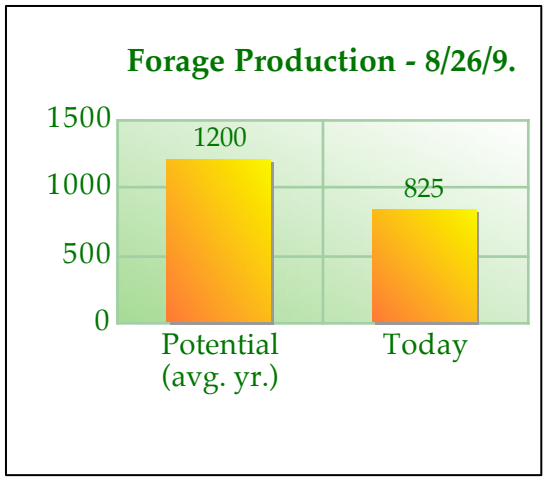


Figure 5: Plant production on sample day as compared with the site's potential from the soil survey.

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.

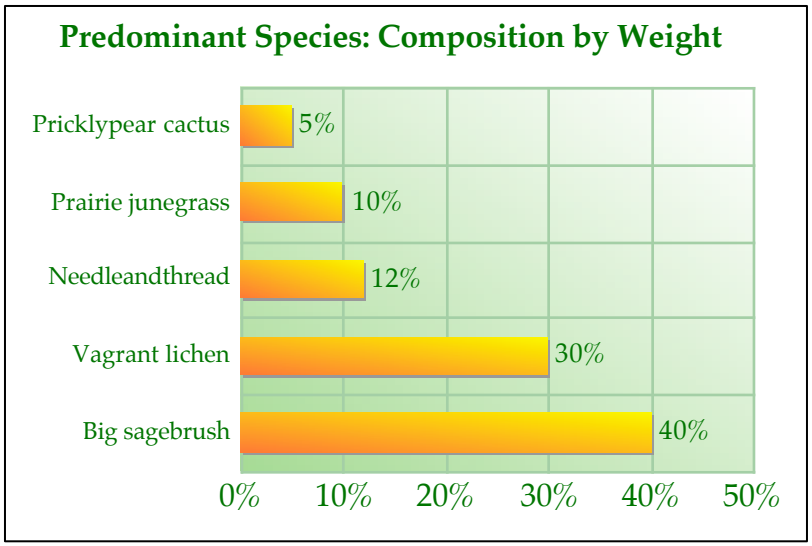


Figure 6: The most abundant species as composition by weight.

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).

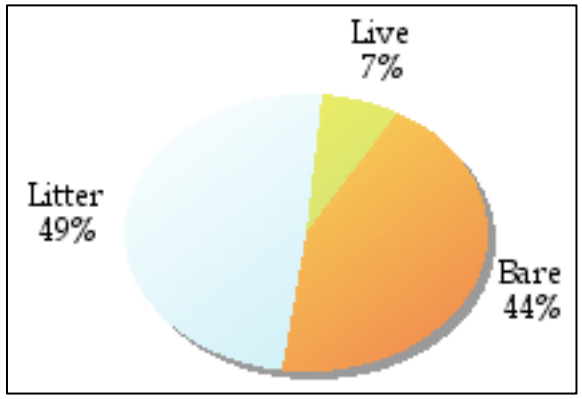


Figure 7: The ground cover chart generated by using the point intercept method.

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.

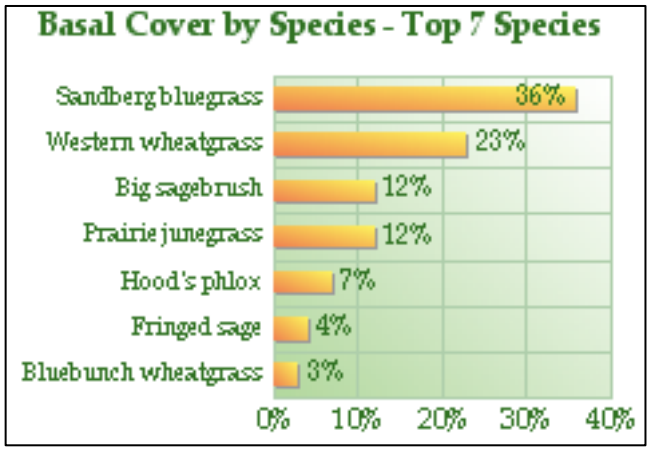


Figure 9: Basal cover by species bar graph created by measuring the distance to the nearest perennial plant using the point intercept method. The seven most numerous species are displayed here.

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.	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.

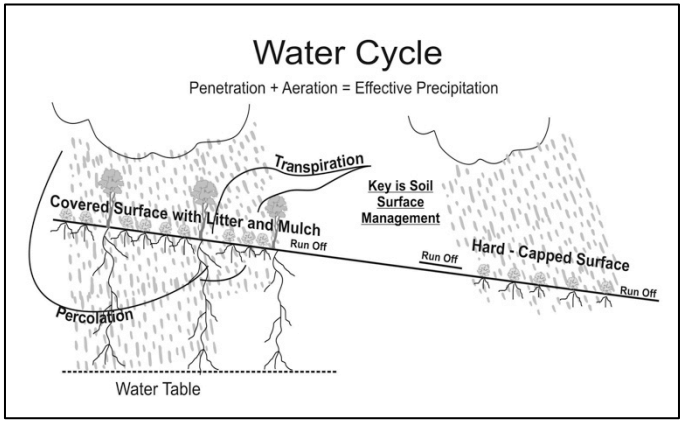
Indicator	5	4	3	2	1
Soil Crusting	No physical crusting present.	Recently formed physical crust seen over some of plot.	Recently formed physical crust seen over much of plot.	Older physical crust formed over much of plot.	Plot dominated by older physical crust.
Germination Microsites	Microsites present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

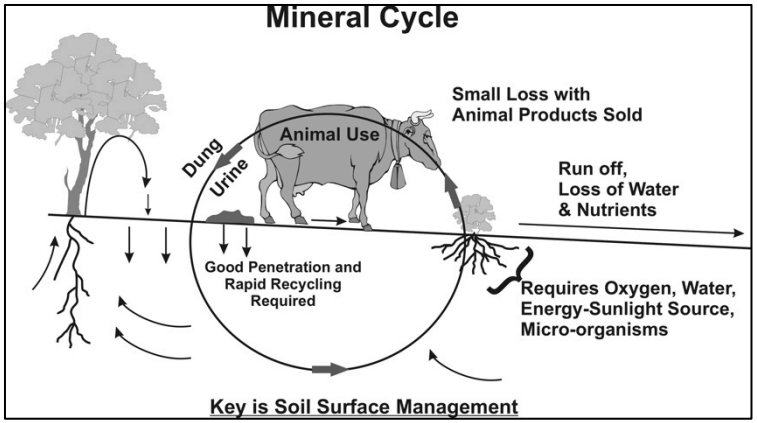
The monitoring methods used here were intended to observe changes in rangeland health through time. Both qualitative observations and quantitative methods were employed. Both are intended to provide decision-making information to land managers. Methods used in generation of this report are aligned with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



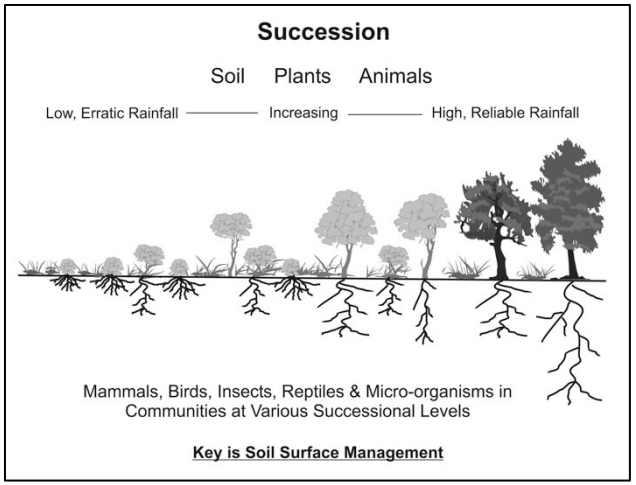
An effective water cycle requires covered soil and high biodiversity. When effective, most water soaks in quickly where it falls. Later, it's released slowly through plants that transpire it, or through rivers, springs, and aquifers that collect through seepage what the plants don't take. When biodiversity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

The water cycle will be described as either being "effective," or "ineffective." If the water cycle is effective, then precipitation appeared to be moving into the soil. Conversely, an ineffective water cycle would display signs of water leaving the site, including signs of erosion, plant pedestaling, and soil capping.



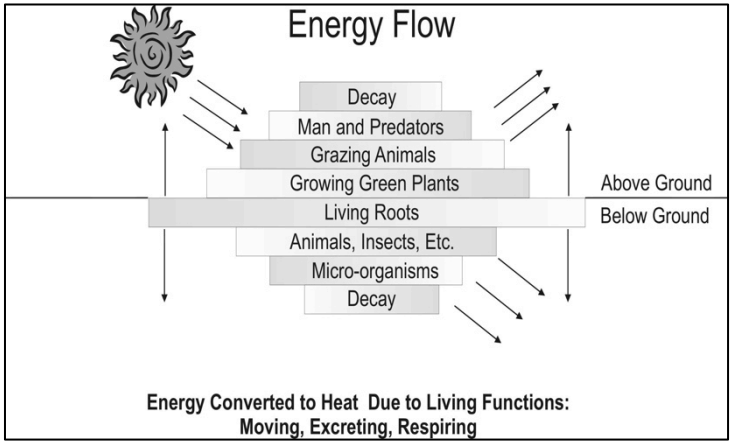
Like the water cycle, an effective and rapid mineral cycle requires covered soil and high biodiversity. When effective, many nutrients cycle between living plants and living soil continually. When soil is exposed and biodiversity low, nutrients become trapped at various points in the cycle, or are lost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

The *speed* of the mineral cycle will be described. If the cycle is moving slowly, then nutrients are not moving back into the system. An indicator of this would be past plant growth (known as "litter") either elevated above the soil surface or lying idly on the soil surface that is oxidizing rather than breaking down. Ideally, litter should contact the soil surface where soil-borne organisms of decay may begin decomposition and speed the re-utilization of nutrients in the system.



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.

Monitoring will describe plant species found at each sample site, for plants help characterize past management actions and help shape expectations for both pasture and livestock performance. Plants will be classified as high seral, meaning desirable, mid seral, meaning neither really desired nor undesired, and low seral, meaning weedy or less desired species. Importantly, indicators like seedlings and young plants of different species portray expected changes in the plant community to be witnessed in coming years. These further shape management expectations.



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).

Energy flow will be described as functioning at "elevated," "moderate," or "reduced" levels. Energy flow at elevated levels suggests that much solar energy was being captured by living plants and that much photosynthesis was occurring. Conversely, reduced energy flow suggests that much sunlight energy was striking the soil surface and not being captured.

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