MERLIN RANCH

Rangeland Health Monitoring
2015

Written By:

RANCH ADVISORY PARTNERS

EXECUTIVE SUMMARY

The Merlin Ranch monitoring effort was initiated in 2006 to track changes in rangeland health and provide information for improving grazing management decision-making. A total of 13 permanent rangeland health transects have since been established, with three of them having been newly established in 2015. This document presents the findings from this monitoring.

The sites assessed revealed mixed rangeland health results. Ecological processes, such as water and mineral cycling, and the flow of energy through the system appeared effective, though mineral cycling was generally slower than desired. Bare ground was generally minimal, signs of erosion were few, and plant vigor was high, reflecting the wet spring of 2015. Further, the successional process, while active, appeared to be lagging behind other processes with few young shrubs and bunchgrasses showing up.

Altered grazing management since the early 2000's has led to substantial improvements in rangeland health across the ranch. Pastures on the Merlin Ranch appear particularly sensitive to early season grazing. Thus, strategies that defer spring grazing for one to two years have benefited the ranch as a whole. Further, pasture subdivisions have facilitated implementation of shorter grazing durations, longer recovery periods, and altered season of use. These strategies have been integral to the successful improvement of rangeland health across the ranch over the past decade and should be maintained.

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INTRODUCTION & PURPOSE

This document presents the findings of three rangeland health monitoring transects newly established on the Merlin Ranch in August 2015. Merlin began a monitoring effort in 2006 to track changes in land health through time. Figure 1 to the right displays the transects monitored by year. 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.

Figure 1: 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
2012	Tipperary
	Three Section
	Lower Hepp
2013	Hall Homestead
	Pigpen
	Lawrence Trap
2014	Hall Pasture
	Lawrence
	Lower
2015	Hepp
	Upper Hell's Canyon
	Petrified Forest

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 displayed later in this document. 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.

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 are used to inform the management recommendations contained herein.

SUMMARY OF FINDINGS & MANAGEMENT RECOMMENDATIONS

Summary findings from each of the three 2015 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.

Hepp Pasture – MRLN24

This transect was established on a mild southeasterly-facing slope in 2015 to represent this area of the pasture.

In August 2015 the site displayed rapid water cycling, but slightly slower mineral cycling. Perennial bunchgrasses showed strong establishment, but Japanese brome plants were also more numerous than desired. The sagebrush community was lagging in the successional process with approximately 16% of the community decadent, but no young plants moving in. This area would benefit from additional supplement scattering to expand and increase animal impact.

Upper Hell's Canyon – MRLN25

This site was chosen to represent the difficult terrain of the Upper Hell's Canyon pasture. The canyon itself is located less than ¼-mile away from the transect site. A new water source had recently been established approximately ¼-mile east of the transect, and another water source was present ½-mile to the southwest. This site appeared to have received very little grazing and animal impact in past years, but the new water should help remedy this, creating new grazeable terrain.

In August 2015 this site displayed functional water and mineral cycles with some room for improvement. The amount of bare ground at site was higher than desired. Western wheatgrass was overabundant, but the desired bunchgrasses like needleandthread and bluebunch wheatgrass were present. However, Japanese brome was also too abundant. The area would likely respond well to additional animal impact, which should be achievable now that water is more accessible. Also consider spreading supplement in this area to encourage cattle to use this new area.

Petrified Forest – MRLN26

This site was chosen to represent the Lawson Renovator treatment, which occurred in the late 2000's (~2007 or 2008). This transect represents the only monitoring within the renovator treatment area and was established to track the effects of the treatment over time.

In August 2015, this site was still responding to the 7- to 8-year-old treatment. The water cycle was functioning rapidly, and the mineral cycle was mostly rapid. Western wheatgrass was overabundant. The desired bunchgrasses were present, but not at desired levels. The renovator treatment has seemed to help stimulate succession, however, which was a positive sign. The late season, short duration grazing strategy has worked well for this site and should be continued.

DATA INTERPRETATION

Four different monitoring methods were used to gather data on this allotment:

- Photographs
- Line-point intercept method
- Line-intercept method

Each of these is reviewed in detail in the Methods section of this document. This portion serves to highlight means of examining the data being presented.

Photographs were taken of each transect site, including one looking down the transect line's outstretched tape measure, while another looks down at a 4.8 square foot quadrat placed at the transect's 10-foot mark.

The ***line-point intercept*** method was used to gather ground cover and canopy cover data. Ground cover data includes all things covering the soil surface, such as bare soil, litter (dead plant material lying on the soil surface), live plant cover, rocks, gravel (particle sizes between 3 cm and 6 cm), and coarse woody debris (larger chunks of litter with a diameter of at least 7 cm). Ideally, the amount of bare ground at each site is low. Excess bare ground may suggest increased chance for soil erosion, or increased opportunity for growth by invasive plant species. Further, the percent live plant cover should be relatively high, indicating the presence of abundant, living plants with large plant bases covering the soil surface.

In contrast to the line-point intercept method, the ***line-intercept method*** measures canopy cover (versus foliar cover). Plant species composition and relative contributions to the canopy can also be determined by the line intercept method. The line intercept method was only used to assess the proportion of shrub canopy present at a site. Comparisons of data across years will provide information on the expansion or contraction of shrubs on a site.

Lastly, much mention will be made in the data discussion about various indicators of rangeland health. These non-quantitative indicators provide information regarding the health of rangelands and associated wildlife habitat. They include, but are not limited to, signs of erosion, distribution of litter across the soil surface, signs of recruitment of desired plant species, and rates at which dung was breaking down. Many such qualitative indicators are often linked to a site's specific mix of soils and precipitation, which is referred by federal agencies as an Ecological Site. Given a particular point on the land, that site should have an associated Ecological Site Description (ESD), denoting its expected level of ground cover, plant productivity, and plant species composition. For example, a site might be expected to have between X% and Y% bare ground, and if data revealed those parameters were met, then certain conclusions can be drawn regarding health of the site. Investigators of rangeland health may find the Natural Resources Conservation Service's (NRCS) Web Soil Survey (http://websoilsurvey.nrcs.usda.gov/app/HomePage.htm), where the name and various rangeland health parameters may be found. These qualitative indicators will be presented in the format displayed in a "Bullseye Rangeland Health Target" that uses the colors of the Olympics to denote functionality of each.

TRANSECT PHOTOS AND DATA

Hepp – MRLNT24

Overview

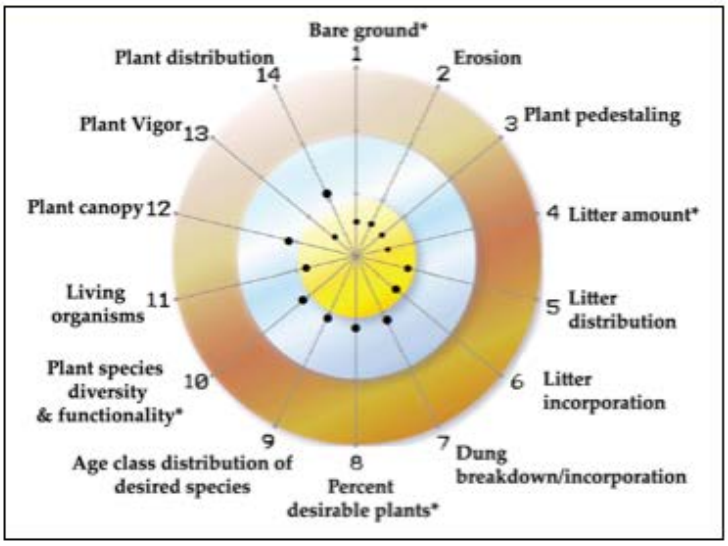
This site was placed on a mild southeasterly-facing slope. It was chosen to represent this area of the pasture and of the larger area surrounding it.

Photos & Data Presentation

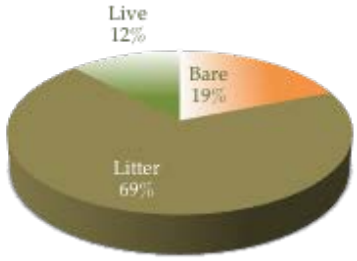
Transect View: Photo taken August 4, 2015

Quadrat View: Photo taken August 4, 2015

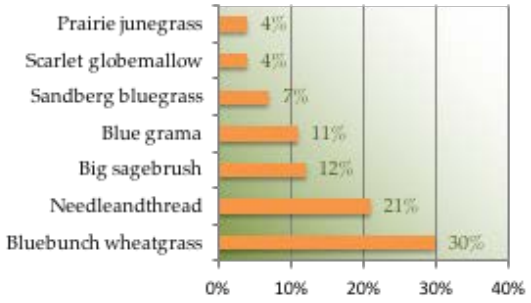
Bullseye Rangeland Health Target



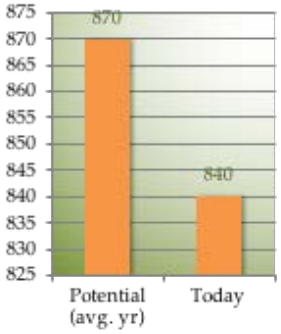
Basal Cover



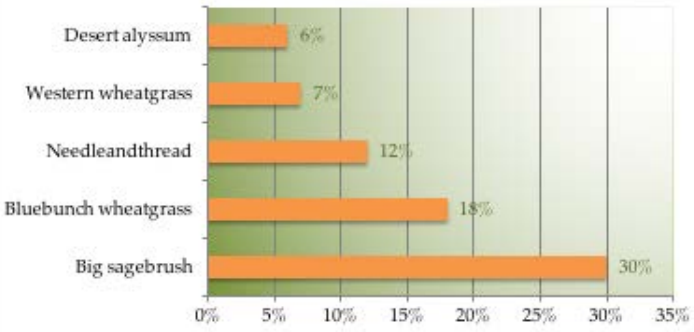
Basal Cover By Species - Top 7 species



Forage Production



Predominant Species: Composition by Weight



2015 LINE INTERCEPT DATA

	Big sagebrush	Silver sagebrush
# of plants encountered	49	1
Age Class Distribution		
seedling	0%	0%
young	0%	0%
mature	84%	100%
decadent	16%	0%
Avg plant height (in)	16.9	9
% canopy intercept	29%	0%
Density/1000 sq ft	161	4

Plant species encountered at site: 24 total

Japanese brome	Bluebunch wheatgrass
Needleandthread	Blue grama
Wooly plantain	Sandberg bluegrass
Cheatgrass	Scarlet globemallow
Current	Big sagebrush
Fringed sage	Desert Alyssum
Broom snakeweed	Prickly pear cactus
Prairie junegrass	Western wheatgrass
Threadleaf sedge	Yellow sweet clover
Vetch species	Black sagebrush
Golden pea	Yellow salsify
Silver sagebrush	Unknown perennial forb

Relative Basal Plant Spacing: 2.1 inches

Photos and Data Interpretation

The **Site Photos** display strong plant vigor in 2015. Note the stature of the bluebunch wheatgrass plant to the right in the foreground of the transect view photo. The quadrat view photo reveals a fair bit of bare ground and less litter cover than was desirable. Also note the high contribution of sagebrush to the plant canopy.

The **Bullseye Rangeland Health Target** provides a snapshot of how the 14 key rangeland health indicators were performing on the sampling day. Indicators falling in the gold were functioning in an optimal range, those that fell in the silver were functioning moderately with room for improvement, while indicators that hit the bronze require more urgent management attention.

At this site in August 2015, the water cycle was effective with relatively little bare ground for the ecological site, and few signs of erosion or plant pedestaling. Similarly, the mineral cycle was mostly effective, though was perhaps a bit slower than ideal. Litter cover, distribution and incorporation were good, but dung breakdown was lagging slightly.

Within the successional process, the percent desirable species was high, with an abundance of the desired bluebunch wheatgrass and needleandthread, but cheatgrass and Japanese brome were also present at higher than desired levels. The age class distribution was moderate with young bunchgrasses and sagebrush plants lacking. Plant species diversity and functionality was fairly high. High quality bunchgrasses like bluebunch wheatgrass and needleandthread were fairly abundant, but big sagebrush was approaching overabundance and cheatgrass and Japanese brome were also fairly abundant. Overall the successional process was functioning reasonably well with room for improvement.

Finally, energy flow at this site was moderate. Plant vigor was very high, but the plant canopy was lower than desired and plant distribution stood to be improved.

The **Basal Cover** chart illustrates the relationship between bare ground, litter and live cover. Ideally, bare ground will be minimal, litter will be high and live cover will also be high. In 2015, this site

displayed 19% bare ground, which left room for improvement. Litter cover tallied 69%. This finding again left room for improvement. Finally, live cover tallied 12%, a very positive finding that reflected the abundance of vigorous bunchgrass plants at the site.

The **Basal Cover by Species** chart illustrates the relative dominance of perennial plants across the soil surface. The findings of this metric were quite favorable: bluebunch wheatgrass and needleandthread, two highly desirable native bunchgrasses, accounted for approximately 50% of the basal cover. These were followed next by big sagebrush, blue grama, Sandberg bluegrass, scarlet globemallow and prairie junegrass, respectively. The presence of scarlet globemallow among the top 7 most basally abundant species was also a positive sign. Scarlet globemallow provides vitamin A, calcium and nitrogen to grazing herbivores, including cattle (Tollefson 2006).

The **Forage Production** chart shows that this site produced 840 pounds of forage per acre. This was approximately 30 pounds below the expected production of 870 pounds per acre. Future data will show how production changes in response to changes in management as well as variations in temperature and precipitation.

The **Predominant Plant Species by Weight** chart illustrates the productive contribution of the five most abundant species. In this chart big sagebrush by far made the most productive contribution to the site. This was, however, followed by four desirable species: bluebunch wheatgrass, needleandthread, western wheatgrass, and desert alyssum. That bluebunch wheatgrass and needleandthread out-performed western wheatgrass at this site was a very positive finding.

The **Line Intercept Data** for big and silver sagebrush illustrate the abundance of sagebrush at the site, and over time will capture changes in this abundance. In 2015, 49 big sagebrush plants were encountered along the transect line and the density per 1000 square feet was 161. Big sagebrush accounted for 29% of the canopy at this site, which was approaching a level at which management could be warranted. Eighty-four percent of the big sagebrush plants were mature and 16% were decadent suggesting that big sagebrush was not replacing itself at this site.

In contrast, only 1 silver sagebrush plant was encountered along the transect line and the density per 1000 square feet was 4. Silver sagebrush did not account for any significant canopy cover and all the plants encountered were mature.

The **Plant Species List** shows that a total of 24 species were recorded at this site, which represented a very favorable diversity of species encountered. The majority of these were desirable.

The **Relative Basal Plant Spacing** metric provides a measure of the distance between perennial plants. The lower the number, the tighter the plant spacing, which is desirable. Conversely, the higher the number, the looser the plant spacing. At this site, perennial plants were, on average 2.1 inches apart. This was a positive finding given the abundance of bunchgrasses at the site.

Management Recommendations

This pasture was scheduled to be grazed in mid-August 2015, but had not yet been grazed at the time of monitoring. The mid to late August grazing window provides the desired bunchgrasses with excellent

growth opportunities. Most plants had seeded out by early August in 2015. If managers bring cattle back through this site in the dormant season, make sure to keep utilization rates light to moderate. If grazed in the spring, keep grazing durations short and utilization rates light. Management has done a good job of scattering supplement throughout this pasture to improve animal impact. However, the transect site itself would benefit from additional hoof action. Consider focusing some of the supplement-spreading in this area.

Early Warning Indicators

Early-warning indicators provide managers with 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 that favor undesired species like cheatgrass and Japanese brome and/or early seral species like prairie junegrass and Sandberg bluegrass.

If management actions are properly applied, look for maintained or improved plant vigor, even in dry years. Next, look for further reductions in bare ground and shifts in plant species composition toward the more desired plants like needleandthread and bluebunch wheatgrass.

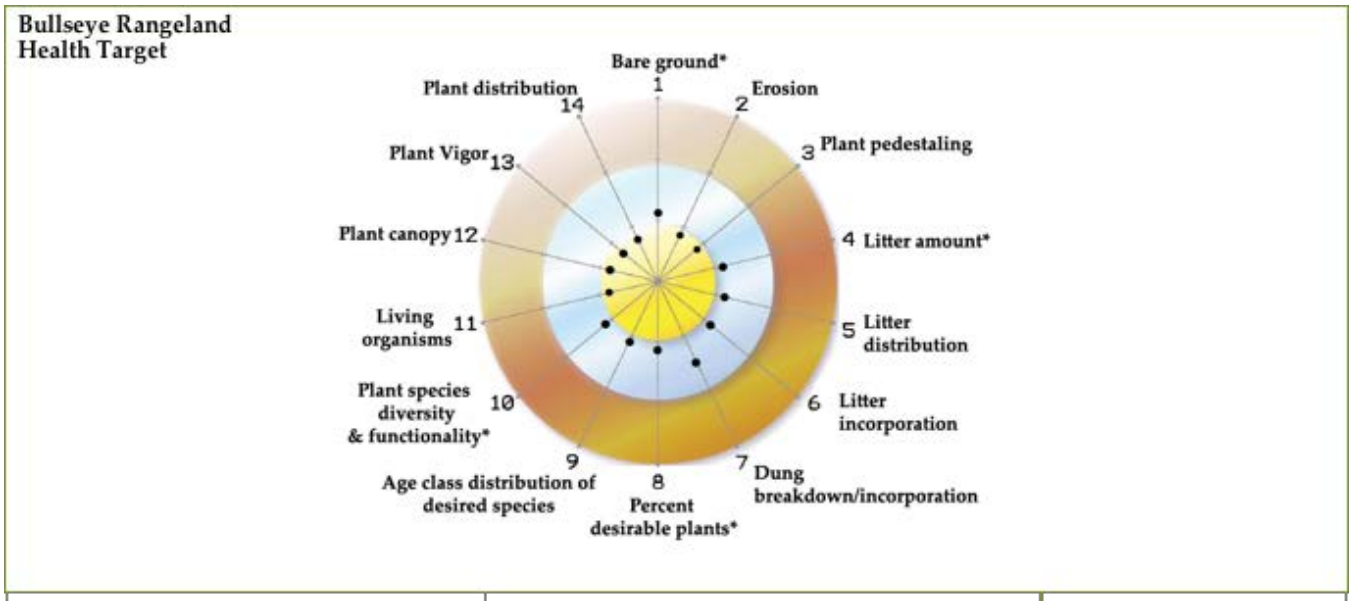
Upper Hell's Canyon – MRLNT25

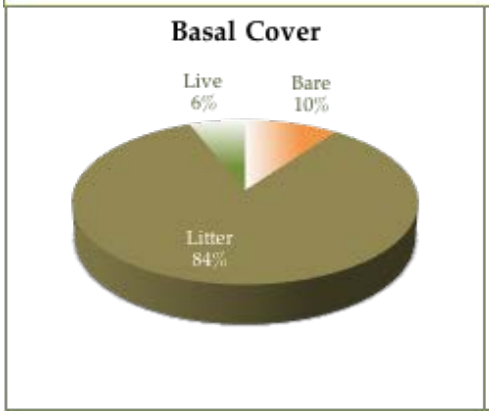
Overview:
This site was chosen to represent the difficult terrain of the Upper Hell's Canyon pasture. The canyon itself is located less than ¼-mile away. The pasture is rectangular in shape and bounded by electric fence on the east and west sides, with a large bowl in the middle. A new water source was recently established approximately ¼-mile east of the transect, and another water source is located ½-mile to the southwest. This site appeared to have received very little grazing and animal impact in past years, but the new water should help remedy this, creating new grazeable terrain.

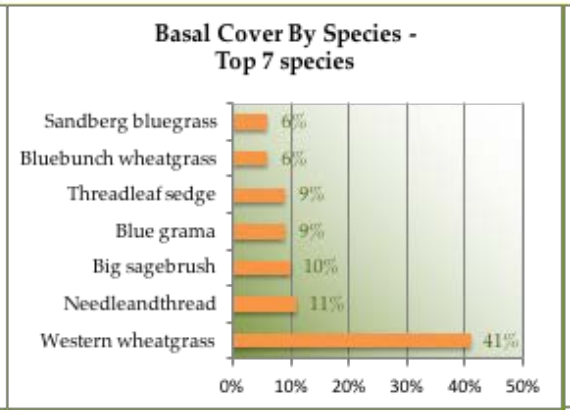
Photos & Data Display

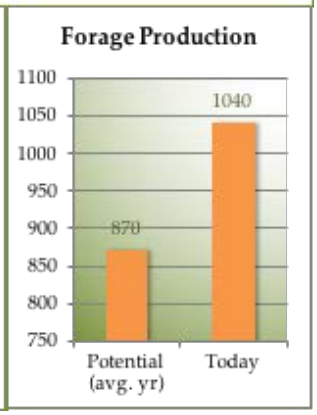
Transect View: Photo taken August 4, 2015

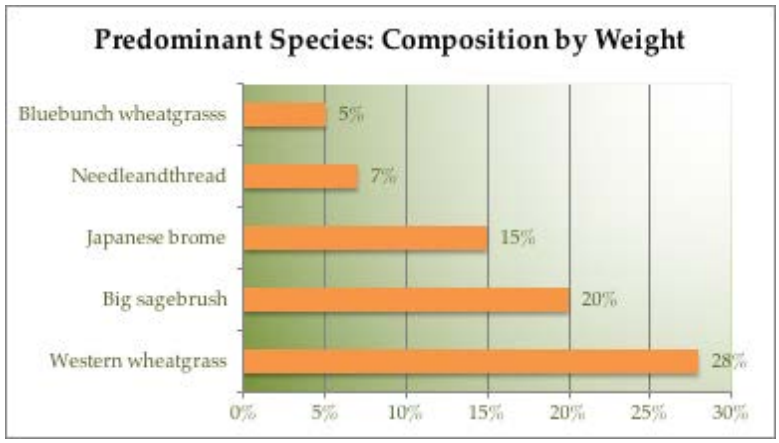
Quadrat View: Photo taken August 4, 2015











2015 LINE INTERCEPT DATA

	Big sagebrush
# of plants encountered	33
Age Class Distribution	
seedling	0%
young	0%
mature	30%
decadent	70%
Avg plant height (in)	20
% canopy intercept	24%
Density/1000 sq ft	114

Plant species encountered at site: 19 total

Japanese brome	Cheatgrass
Big sagebrush	Blue grama
Sandberg bluegrass	Prairie junegrass
Pepperweed	Snakeweed
Needleandthread	Western yarrow
Western wheatgrass	Bluebunch wheatgrass
Desert alyssum	Vetch
Threadleaf sedge	Pricklypear cactus
Scarlet globemallow	Fringed sagewort
Smooth brome	

Relative Basal Plant Spacing: 1.9 inches

Photos and Data Interpretation

The **Site Photos** display strong plant vigor in 2015, though most plants were dormant by August. A fair bit of cheatgrass and Japanese brome were present. The quadrat view shows relatively little bare ground, and moderate litter build up at this site. Likely, additional animal impact will help improve the amount of litter present.

The **Bullseye Rangeland Health Target** provides a snapshot of how the 14 key rangeland health indicators were performing on the sampling day. Indicators falling in the gold were functioning in an optimal range, those that fell in the silver were functioning moderately with room for improvement, while indicators that hit the bronze require more urgent management attention.

At this site in August 2015, the water cycle was moderately effective with some bare ground, and few signs of erosion or plant pedestaling. Similarly, the mineral cycle was moderately effective, though was perhaps a bit slower than ideal. Litter cover, distribution and incorporation were decent with room for improvement, and dung breakdown was slower than desired.

Within the successional process, the percent desirable species was moderate. Japanese brome and cheatgrass were more abundant than desired. The age class distribution was moderate with young bunchgrasses and sagebrush plants lacking. Plant species diversity and functionality showed room for improvement in the presence and abundance of desired perennial bunchgrasses and forbs. Overall the successional process was slower than desired at this site.

Finally, energy flow at this site was elevated. Plant vigor was very high, the canopy was strong, and plant distribution was fairly even. Grasses had gone to seed.

The **Basal Cover** chart illustrates the relationship between bare ground, litter and live cover. Ideally, bare ground will be minimal, litter will be high and live cover will also be high. In 2015, this site displayed 10% bare ground, which left some room for improvement, but was not a bad finding. Litter cover tallied 84%. This again was a positive finding, but still left room for improvement. Finally, live cover tallied 6%, also a positive finding. Ideally as more perennial bunchgrasses gain a hold in this pasture, this number will increase.

The **Basal Cover by Species** chart illustrates the relative dominance of perennial plants across the soil surface. Western wheatgrass was clearly the most basally abundant. Given the rhizomatous character of this species, this was not surprising. Western wheatgrass was followed by needleandthread, a highly desired, nutritious bunchgrass. Other species on the list included big sagebrush, blue grama, threadleaf sedge, bluebunch wheatgrass and Sandberg bluegrass. With additional animal impact at this site, look for favorable shifts in basal abundance favoring the high quality bunchgrasses like needleandthread, bluebunch wheatgrass, and green needlegrass.

The **Forage Production** chart shows that this site produced 1,040 pounds of forage per acre. This was approximately 16% above the expected production for this site, which was a terrific finding. Future data will show how production changes in response to changes in management as well as variations in temperature and precipitation.

The **Predominant Plant Species by Weight** chart illustrates the productive contribution of the five most abundant species. In this chart western wheatgrass again made the greatest productive contribution, followed by big sagebrush, Japanese brome, needleandthread, and bluebunch wheatgrass. Most importantly, this chart reveals the general abundance of Japanese brome (which is not a dense plant and therefore must be quite prevalent to register in this metric) at this site.

The **Line Intercept Data** for big sagebrush illustrate the abundance of big sagebrush at the site, and over time will capture changes in abundance. In 2015, 33 plants were encountered along the transect line and the density per 1000 square feet was 114. Big sagebrush accounted for 24% of the canopy at this site, which was high, but not alarmingly so. Most of the plants were either mature or decadent suggesting slow turnover in the community.

The **Plant Species List** shows that a total of 19 species were recorded at this site, the majority of which were desirable. As this site received more use by livestock, the number and composition of species should be expected to shift.

The **Relative Basal Plant Spacing** metric provides a measure of the distance between perennial plants. The lower the number, the tighter the plant spacing, which is desirable. Conversely, the higher the number, the looser the plant spacing. At this site, perennial plants were, on average 1.9 inches apart. This was a positive finding.

Management Recommendations

Overall, this site displayed decent rangeland health, but would benefit from additional animal impact. The new water development nearby was a good idea and should invite animals to use this pasture more fully. In the event that cattle still avoid these areas, strategic salting may be the only means of increasing the impact in this area.

Early Warning Indicators

Early-warning indicators provide managers with 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 that favor undesired species like cheatgrass and Japanese brome.

If management actions are properly applied, look for maintained or improved plant vigor, even in dry years. Next, look for increased live plant cover and shifts in plant species composition toward the more desired plants like needleandthread and bluebunch wheatgrass.

Petrified Forest – MRLNT25

Overview

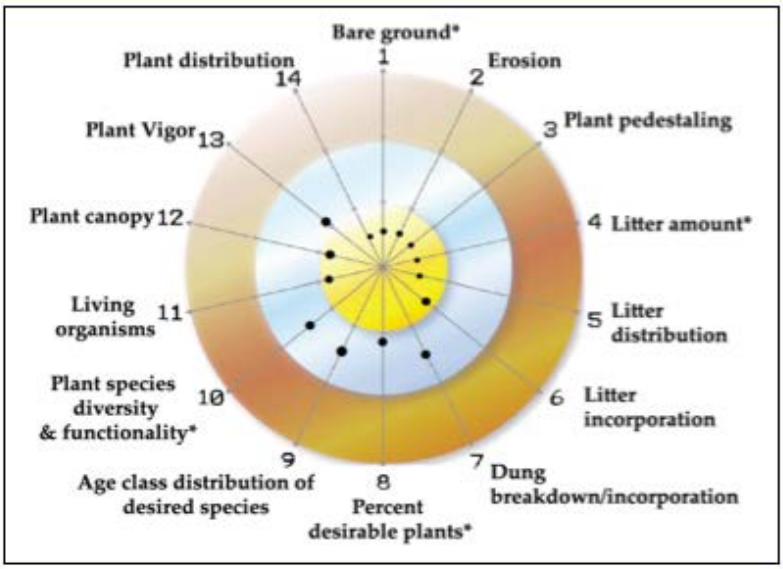
This site was chosen to represent the Lawson Renovator treatment, which occurred in the late 2000's (~2007 or 2008). This transect represents the only monitoring within the renovator treatment area and was established to track the effects of the treatment over time. The site was located on a gentle west-facing slope.

Photos & Data Display

Transect View: Photo taken August 4, 2015

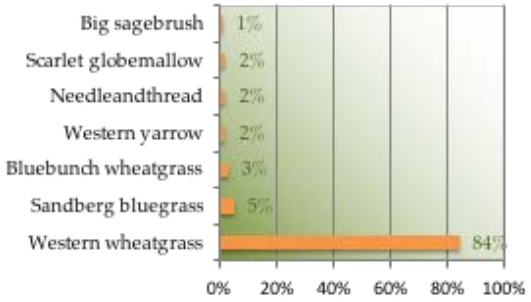
Quadrat View: Photo taken August 4, 2015

Bullseye Rangeland Health Target

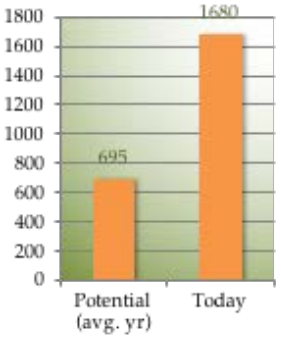


Basal Cover

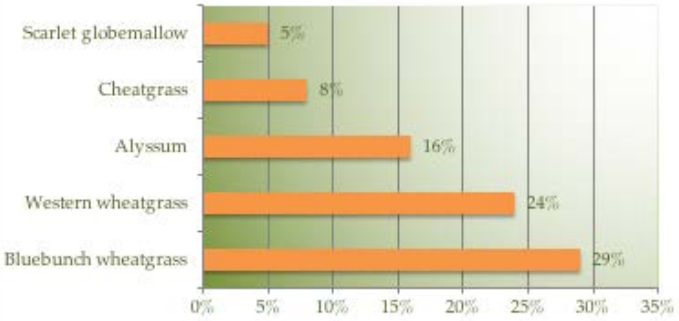
Basal Cover By Species - Top 7 species



Forage Production

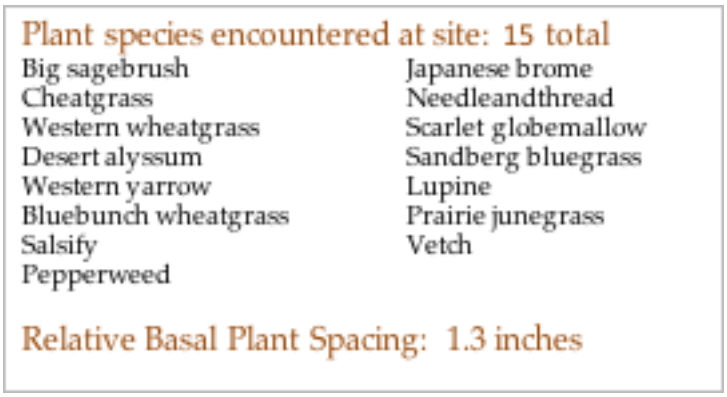


Predominant Species: Composition by Weight



2015 LINE INTERCEPT DATA

	Big sagebrush
# of plants encountered	2
Age Class Distribution	
seedling	0%
young	0%
mature	100%
decadent	0%
Avg plant height (in)	22
% canopy intercept	1%
Density/1000 sq ft	7



Photos and Data Interpretation

The **Site Photos** display strong plant vigor in 2015. Note the stature of the seeded out bluebunch wheatgrass plant in the quadrat view photo. Both photos illustrate low levels of bare ground and good plant canopy.

The **Bullseye Rangeland Health Target** provides a snapshot of how the 14 key rangeland health indicators were performing on the sampling day. Indicators falling in the gold were functioning in an optimal range, those that fell in the silver were functioning moderately with room for improvement, while indicators that hit the bronze require more urgent management attention.

At this site in August 2015, the water cycle was effective with little bare ground, and no signs of erosion or plant pedestaling. Similarly, the mineral cycle was moderately rapid, though was perhaps a bit slower than ideal. Litter cover, distribution and incorporation were excellent, but dung breakdown was lagging slightly.

Within the successional process, the percent desirable species was moderate. The site displayed a mix of desired species like bluebunch wheatgrass and needleandthread along with fairly abundant Japanese brome and cheatgrass. The age class distribution was moderate with young bunchgrasses and sagebrush plants lacking. Plant species diversity and functionality was fairly high. The plant species diversity and functionality was also moderate. The desired bunchgrasses were lacking in abundance, western wheatgrass was overabundant, and the forb community was strong. Overall the successional process was moderate with some room for improvement.

Finally, energy flow at this site was moderate to good. Plant vigor was moderate with plants green and growing, only some having gone to seed, and mixed regrowth (some showing regrowth, others not). The plant canopy was reasonably strong and plants were widely distributed across the soil surface.

The **Basal Cover** chart illustrates the relationship between bare ground, litter and live cover. Ideally, bare ground will be minimal, litter will be high and live cover will also be high. In 2015, this site displayed only 2% bare ground and 97% litter cover, both excellent findings. Live cover was low, at 1%, but this should be expected to increase with increases in the perennial bunchgrasses. It is likely that the Lawson machine disturbed the plant crowns of many perennial bunchgrasses and forbs, which explains

the low abundance of live cover here. Several years appear needed for those bunchgrasses to re-establish

The **Basal Cover by Species** chart illustrates the relative dominance of perennial plants across the soil surface. This chart displays the overabundance of western wheatgrass at this site, and the relative lack of abundance among other desired species. Ideally, the high quality, native bunchgrasses like bluebunch wheatgrass and needleandthread will begin to expand across the soil surface pushing some of the western wheatgrass out.

The **Forage Production** chart shows that this site produced 1,680 pounds of forage per acre. This was 59% above the expected production for this site, another excellent finding. Future data will show how production changes in response to changes in management as well as variations in temperature and precipitation.

The **Predominant Plant Species by Weight** chart illustrates the productive contribution of the five most abundant species. In this chart bluebunch wheatgrass and western wheatgrass made the greatest productive contributions, followed by desert alyssum, cheatgrass and scarlet globemallow. The presence of cheatgrass in the top 5 most predominant species by weight belies its abundance at this site. Cheatgrass is not a particularly dense species and must reach fairly high abundances to register with this metric. Ideally, species like needleandthread will begin to move into this chart in time.

The **Line Intercept Data** for big sagebrush illustrate the abundance of sagebrush at the site, and over time will capture changes in this abundance. In 2015, only 2 plants were encountered along the transect line. The density of sagebrush was 7 plants per 1000 square feet, and this shrub accounted for only 1% of the canopy cover. These results reflect the ongoing impact of the renovator treatment several years past.

The **Plant Species List** shows that a total of 15 species were recorded at this site. Overall, the majority of species were favorable with the exception of cheatgrass and Japanese brome.

The **Relative Basal Plant Spacing** metric provides a measure of the distance between perennial plants. The lower the number, the tighter the plant spacing, which is desirable. Conversely, the higher the number, the looser the plant spacing. At this site, perennial plants were, on average 1.3 inches apart. This was a positive finding that reflected the abundance of the rhizomatous western wheatgrass.

Management Recommendations

This site was grazed for 5 days in late June. This strategy of short duration, late growing season grazing is a good strategy for this site. By early August, only some plants were showing signs of recovery from the June grazing event, however. This suggests that management should avoid bringing cattle back into the site until late fall/early winter and keep utilization light to moderate when and if livestock are brought back in.

Early Warning Indicators

Early-warning indicators provide managers with 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 that favor undesired species like cheatgrass and Japanese brome and/or early seral species like prairie junegrass and Sandberg bluegrass.

If management actions are properly applied, look for maintained or improved plant vigor, even in dry years. Next, look for further reductions in bare ground and shifts in plant species composition toward the more desired plants like needleandthread and bluebunch wheatgrass.

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 2015.

	Upper Hell's	Hepp	Petrified Forest
Crude Protein (%)	7.25	6.5	7.57
Acid Detergent Fiber (%)	47.1	47.5	41.9
Total Digestible Nutrients (%)	48.8	48.4	54.8
Net energy-lactation (Mcal/lb)	0.49	0.48	0.56
Net energy-maintenance (Mcal/lb)	0.46	0.45	0.53
Net energy-gain (Mcal/lb)	0.24	0.24	0.3
Sulfur (%)	0.12	0.14	0.14
Phosphorus (%)	0.08	0.15	0.11
Potassium (%)	0.98	0.85	1.38
Magnesium (%)	0.09	0.08	0.1
Calcium (%)	0.53	0.46	0.45
Sodium (%)	none taken	none taken	none taken
Iron (ppm)	175	88.1	117
Manganese (ppm)	53.5	40.1	40.3
Copper (ppm)	3	11	4.4
Zinc (ppm)	18.4	13.7	19.2

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 early August of an average rainfall 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 **Upper Hell's** sample will return the following to her:

Dry Matter	Crude Protein	TDN	Ca	P
21.6#	1.6#	10.5#	52g	9g

As may be seen, our sample cow is short on all nutrients but calcium, with the most notable being phosphorus. See the implications for management section below for means of addressing this shortfall. The calcium to phosphorus ratio is high, but fell within the 7:1 range.

At the **Hepp**, the forage will return the following to our sample cow:

Dry Matter	Crude Protein	TDN	Ca	P
21.6#	1.4#	10.5#	45g	15g

Interestingly, the phosphorous in this forage went way up, while crude protein and energy (TDN) remained on the low side. Likewise, trace minerals like copper and zinc were noticeably higher than th other sites sampled. No ready explanation exists for such disparity, other than the sample contained a high concentration of bluebunch wheatgrass and needleandthread. The possibility exists that these two species, with their deeper roots, may have elevated nutrients stored at lower levels in the soil profile.

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

Dry Matter	Crude Protein	TDN	Ca	P
21.6#	1.6#	11.8#	10g	11g

Again, this sample was short on all essential nutrients.

As in 2014, TDN remained below desired levels, which was surprising since the Merlin Ranch has traditionally displayed forage energy levels above the recommended minimum. No ready explanation exits for why TDN levels were low in 2014 and 2015.

Management recommendations from nutrient analysis

Analysis of the sample nutrients 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 3 and 4, 2015, Kevin Rodriguez of Merlin Ranch, and Todd Graham and Katie Meiklejohn of Ranch Advisory Partners toured the ranch, examining potential study sites. They selected the monitoring sites to be examined that year.

Methods used at each transect location were the same. A 200-foot tape measure was laid along the soil surface that served as the basis of the monitoring protocol. Five gallon bucket lids were nailed to the soil surface to permanently mark the transect beginning locations (Figures 1 and 2). A variety of methods were then conducted from this tape measure.

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

A photograph was taken of a quadrat at each site, where a quadrat was placed at the 10-foot mark along the transect line (Figure 3). This photo will be used in successive years to display changes in the site.

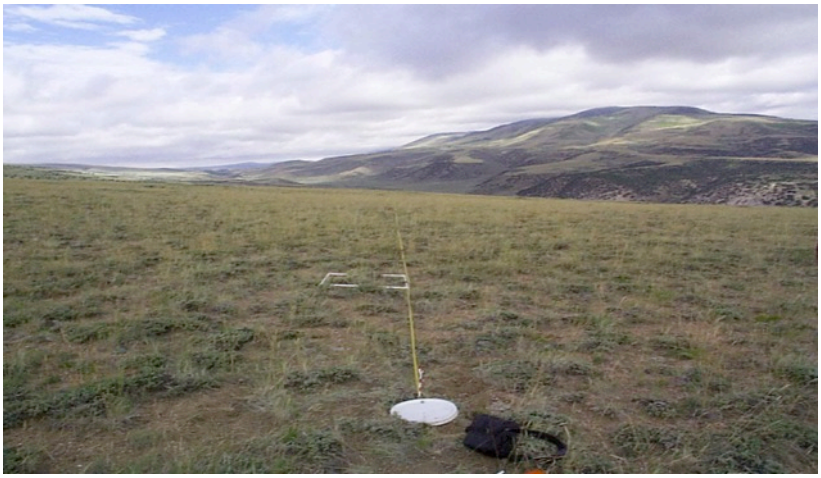


Figure 2: Permanent transects were 200 feet long and were permanently marked* on each end. *[This photo was taken in Colorado.]

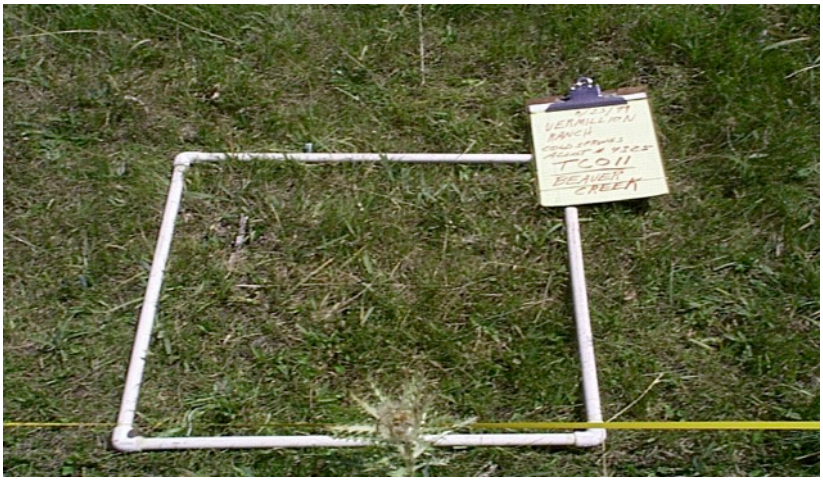


Figure 3: The first plot on a transect. [This plot lies in Colorado.]

A qualitative analysis of rangeland health was first conducted at the site where 14 indicators of rangeland health were examined. 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.

Rangeland health indicators portray function of four fundamental ecosystem processes: the water cycle, mineral cycle, successional process, and energy flow. They are summarized visually below.

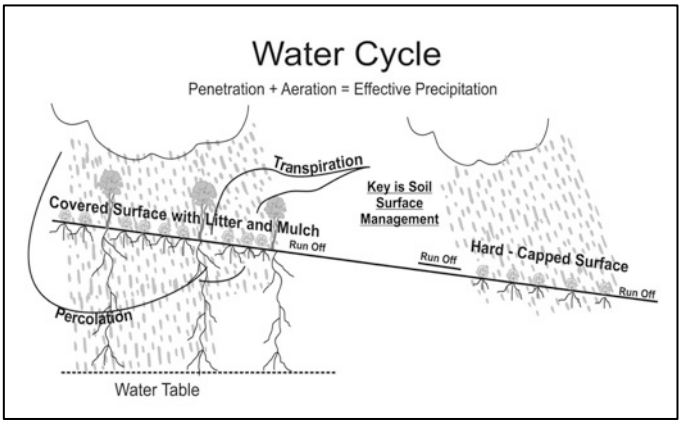


Figure 4: The Water Cycle.

An effective water cycle (Figure 4) 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.

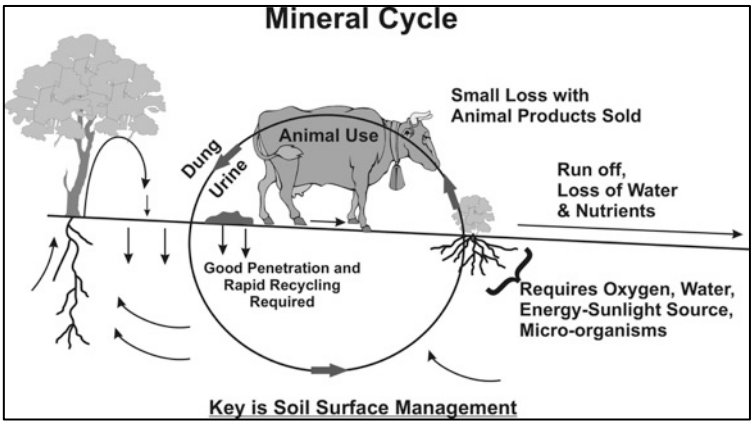


Figure 5: The Mineral Cycle.

Like the water cycle, an effective and rapid mineral cycle (Figure 5) 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.

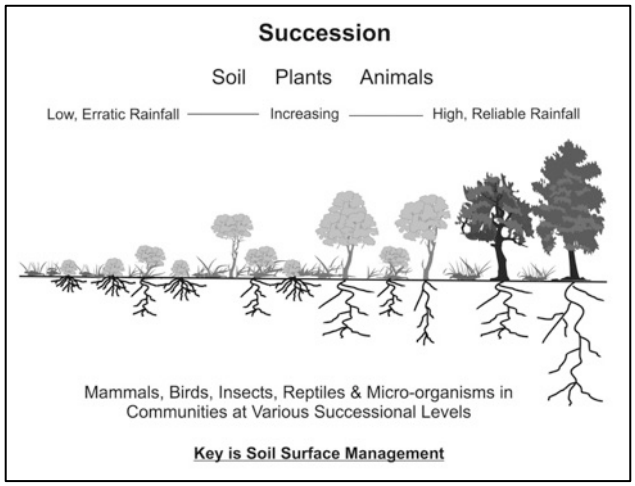


Figure 6: The Successional Process.

With few exceptions, communities strive to develop toward ever-greater complexity, and thus stability (Figure 6). 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.

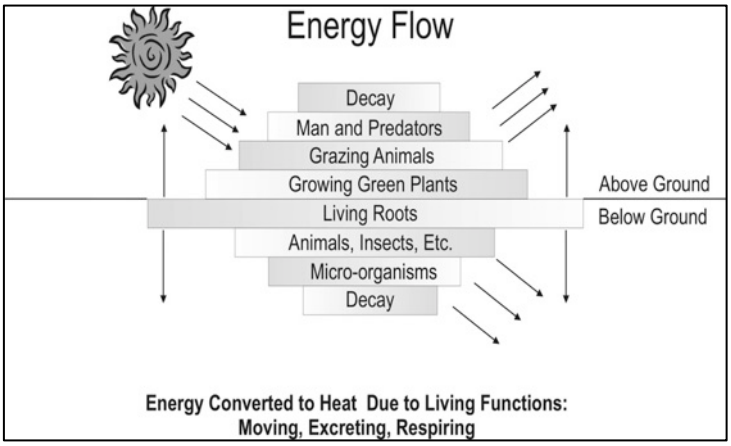


Figure 7: Energy Flow.

Almost all life requires energy that flows daily from the sun (Figure 7). 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.

A rangeland health qualitative scoring guide accompanies this document (shown on pages below) that portrays how each of the 14 indicators was evaluated. Each indicator is assigned a "score" as functioning optimally, functioning less than optimally, or not functioning well. Using a target representation, called the "Bullseye Target," and colors of the Olympics, "scores" of indicators are placed on the Target in the associated color of function (Figure 8). If, for example, the indicator litter distribution displayed uniform cover across the soil surface, this indicator was considered functional, and a mark was placed in the gold area on the Bullseye Target.

The result of evaluating rangeland health indicators in this way is a graphic portrayal of ecosystem process function. Management may view the Bullseye Target and determine where high function exists at the site and where further management attention is required.

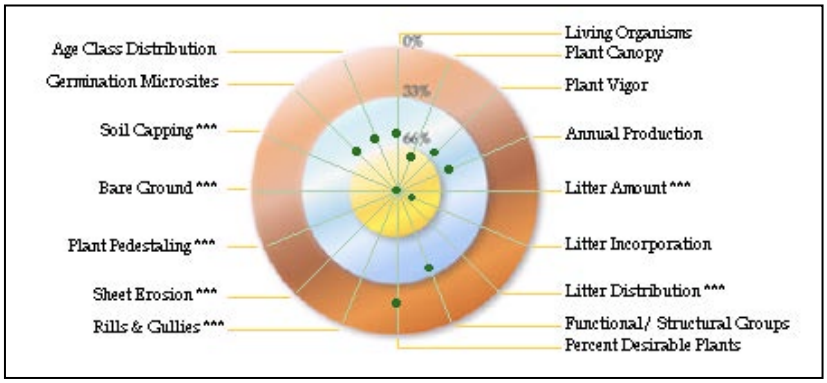


Figure 8: The Bullseye Target portrays results of each of the 16 indicators studied based on field scores.

Using the web-based soil report generator (available at: http://websoilsurvey.nrcs.usda.gov/app/HomePage.htm), a custom soil survey was generated for the sample area. From this report, the Natural Resources Conservation Service provides information on desired plant species, expected shifts in species composition under differing management regimes, and expected productivity of a site. Using this information, indicators for desired plant species, functional and structural groups, and other indicators may be considered.

Another study conducted involves determining which species are producing the most at each site. Using the transect's tape measure, 10 quadrats are evaluated to determine which species produce the most by weight within the quadrat. The first plot is examined at the 10—foot mark on the transect, the next at 30 feet, the next at 50 feet and so on until 10 transects have been evaluated. While looking in each study plot, that species estimated to be most abundant by weight is scored. 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 9 below.

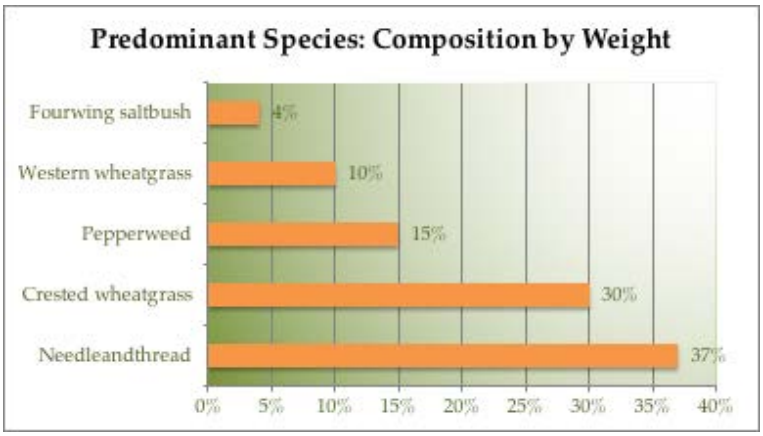


Figure 9: The most abundant species as composition by weight.

The methodology also uses the 200-foot tape measure as a base for collecting information such as basal cover, relative basal plant spacing, and relative basal plant spacing by species. Using this method, commonly known as point intercept, a steel rod is lowered to the soil surface using at intervals of every-other foot for 200 feet. (Figure 10).

Figure 10: Utilizing the point intercept method to collect three quantitative measures of rangeland health. The steel rod is lowered to the soil surface to gather basal cover data. The distance to the nearest perennial plant is measured (in this case, a plant lies 3 cm from the rod) and that distance is averaged over 100 data points. Lastly, the nearest perennial plant's species is recorded (in this case, it is a Western wheatgrass).

At each point, basal 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 11).

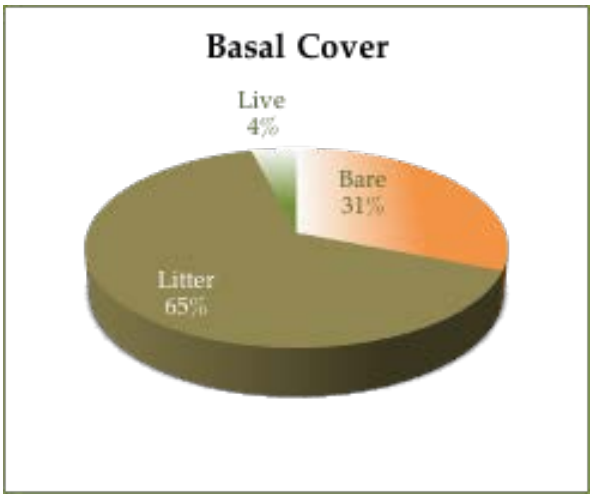


Figure 11: The basal cover chart generated by using the point intercept method.

Additional measures are also taken using the point intercept. At each point ground cover data was collected, the distance to the nearest perennial plant was measured. The average distance for all 100 points is calculated and the average distance to nearest perennial figure is found and displayed. 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 12).

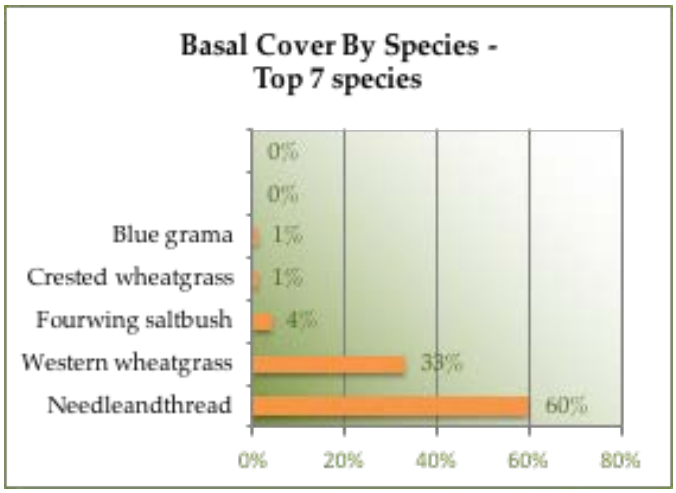


Figure 12: Basal cover by species bar graph created by measuring the distance to the nearest perennial plant using the point intercept method. The seven most numerous species are displayed here.

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

The **line intercept method** consists of horizontal, linear measurements of plant intercepts along the course of a transect. It is best suited where the boundaries of plant growth are relatively easy to determine, which makes it useful for measuring shrubs. It is not well adapted for measuring cover on single-stemmed species, or dense grassland situations.

The line intercept method was employed to measure canopy cover (versus foliar cover) of live plants intercepted on the transect. Looking down on the transect's tape measure, the observer measures the number of centimeters of canopy cover for each shrub species intercepted (Figure 15), which was big sagebrush at MSGR. Canopy cover by species is then displayed as a percentage.

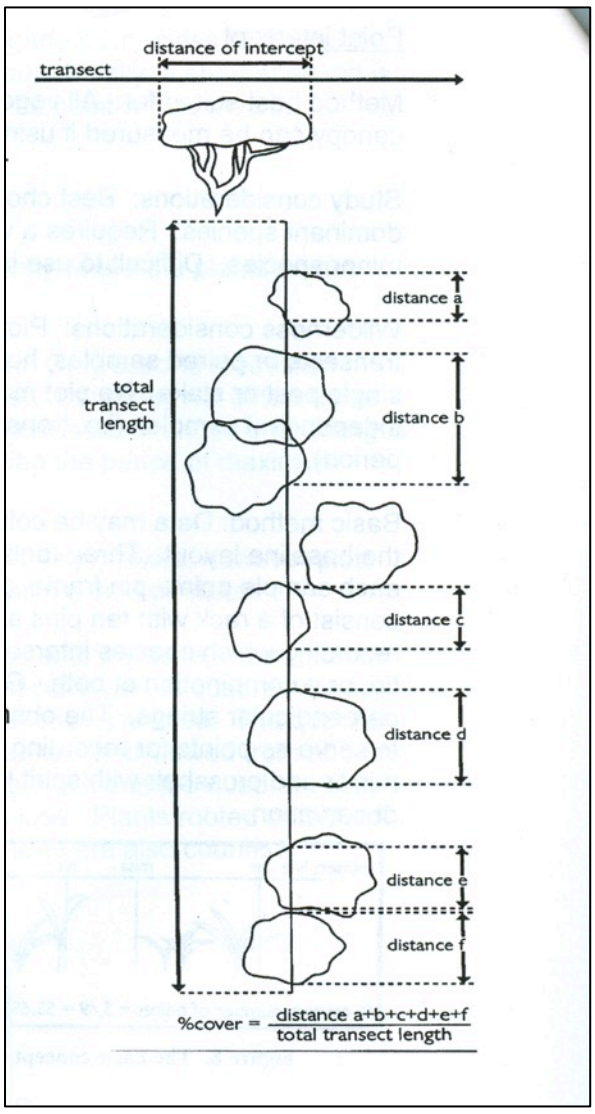


Figure 15: This figure displays the line intercept method. The straight line in the figure represents the outstretched tape measure of the transect. Each polygon represents canopy cover of a different plant – grass, forb, shrub, or tree – living or dead. The number of centimeters of canopy intercept is recorded for each species. The total number of inches for each species is then tallied. Lastly, that total number is divided by the number of inches in the transect (2,400 on a 200-foot transect), and the result is displayed as a percentage.

All big sagebrush plants were then assigned an age classification (seedling, young, mature, or decadent), and the height of each shrub was measured. Average height was then determined and displayed in the data sets in this document.

The scoring guides reference earlier in this Methods section may be seen on the following pages. They were taken from the *Bullseye! Achieving Your Rangeland Health Objectives* available at: http://ranchadvisory.com/rangelands-monitoring.

SCORING GUIDE SIDE 1

		Gold: Achieving Goal	Silver: Moving Toward/Away from Goal?	Bronze: Not Achieving Goal.
1	Bare Ground*	Amount and size of bare areas nearly to totally match that expected/ desired for site.	Amount and size of bare areas higher and larger than expected/desired for site. Bare areas may be large and sporadically connected.	Amount and size of bare areas are much higher and larger than expected/desired for site. Bare areas are generally connected.
2	Erosion	Little to no evidence of wind or water erosion, including desert pavement, rills, and/or gullies.	Some signs of soil loss, including formation of desert pavement, rills, and/or gullies.	Soil is actively leaving the site. Advanced formation of desert pavement, rills, and/or gullies may be seen.
3	Plant Pedestaling	No to minimal plant pedestals present.	Some to moderate plant pedestals present. No signs of exposed roots.	Plant pedestaling obvious and tall. Root exposure seen.
4	Litter Amount*	Amount of litter nearly to totally matches that expected/ desired for site.	Amount of litter less than that expected/desired for site.	Amount of litter much lower than expected/desired for site.
5	Litter Distribution	Litter is uniformly distributed across plot.	Less uniformity of litter distribution. Litter may be becoming associated with prominent plants or other obstructions.	Litter distribution not uniform. This may be due to general lack of litter and/or obvious patchy appearance of litter amount.
6	Litter Incorporation	Litter mixing well with soil, resulting in more rapid mineral cycle.	Some mixing of litter with soil. Litter may be elevated and its amount may be reduced. Mineral cycle not as rapid.	Litter not mixing with soil. Litter may be elevated and/or amount too little. Mineral cycle slower.
7	Dung Breakdown/ Incorporation	Dung breaking down rapidly, less than one year old.	Some dung breakdown, with most being around 2 years old.	Dung breaking down slowly, older than 2 years old.

*Refer to ecological site descriptions available from NRCS

SCORING GUIDE SIDE 2

		Gold: Achieving Goal	Silver: Moving Toward/Away from Goal?	Bronze: Not Achieving Goal.
8	Percent Desirable Plants*	Greater than 66% of plants in the area are desired. Remainder of plants are intermediate species (neither desired, nor undesired).	33% to 66% of plants species in the area are desired. Intermediate species (neither desired, nor undesired) have strong presence. Potential presence of undesired species.	Less than 33% of plant species in the area are desired. Intermediate plant species (neither desired, nor undesired) dominate. Undesired species also present.
9	Age Class Distribution	Variety of age classes seen in the area (seedling, young, mature, decadent).	More mature age classes present, seedlings and young mostly lacking.	Primarily old and/or deteriorating plants present.
10	Plant Species Diversity & Functionality*	Number of plant species in the area matches that expected for site. Plant forms (grass, shrub, forb, tree) also match that expected for site. Plants serving different functions.	Number of plant species in the area below that expected for site plant forms (grass, forb, shrub) reduced. Reduced functionality.	Number of plant species the area minimal. Plant forms (grass, forb, shrub) much below that expected for site. Poor functionality.
11	Living Organisms	Abundant signs of non-plant life.	Few to moderate signs of non-plant life. Something is missing from community.	Next to no signs of non-plant life. Components of the ecosystem are clearly missing.
12	Plant Canopy	Strong photosynthetic activity in the area. Canopy may cover greater than 66% of area.	Moderate photosynthetic activity in the area. Canopy may cover 33-66% of area.	Reduced photosynthetic activity in the area. Canopy may cover less than 33% of area.
13	Plant Vigor/ Color	Capability to reproduce (seed or vegetatively) not limited relative to recent climatic conditions. Growing plant exhibits bright green color.	Capability to reproduce (seed or vegetatively) is somewhat limited relative to recent climatic conditions. Growing plant exhibits pale green or may be yellowing.	Capability to reproduce (seed or vegetatively) is severely reduced relative to recent climatic conditions. Growing plant exhibits sickly yellow coloration.
14	Plant Distribution	Plants uniformly distributed across soil surface.	Distribution becoming fragmented, but some areas of uniformity.	Distribution obviously fragmented.

*Refer to ecological site descriptions available from NRCS

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Ranch Advisory Partners, Inc. provides agricultural advisory services in the ecological and financial aspects of ranching and agricultural properties. Services include total ranch management; structured finance strategies; operations financial optimization; agricultural operations design, implementation, and oversight; grazing planning; rangeland health evaluations and monitoring; wildlife habitat vegetative manipulation and monitoring; and hydrology.

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