MERLIN RANCH

2018 Rangeland Health Monitoring

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 16 permanent rangeland health transects have since been established. Three monitoring sites were re-read in 2018, and this document presents the findings from this effort.

The three sites assessed in 2018 were the Hall Pasture (MRT07), Pigpen (MRT12) and M&M 1 (MRT14). Trends in rangeland health were strongly positive at MRT07 and MRT12, but mixed at MRT14. Across all three sites, bare ground was declining, indicating active improvement in the water cycle. MRT07 and MRT12 showed ongoing improvement in the mineral cycle and active succession, pushing the site in a desired direction. MRT14 displayed a need for periodic springtime rest and greater animal impact. The successional process at this site was lagging, bare ground was still high, and mineral cycling was slower than desired.

Pastures on the Merlin Ranch are particularly sensitive to early season grazing. Thus, strategies that defer spring grazing for one to two years have benefited the ranch as a whole. This strategy may be particularly necessary to stimulate desired changes in M&M 1. In addition, 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 the continued positive impact was evident in 2018.

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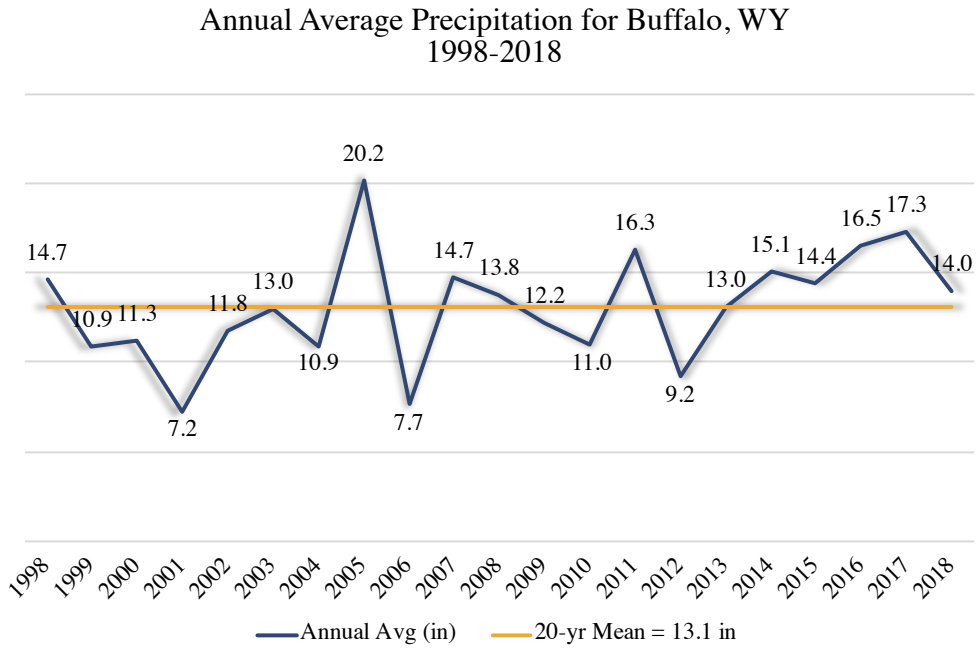
INTRODUCTION & PURPOSE

Merlin Ranch 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. This document presents the findings from three rangeland health monitoring transects (Hall Pasture – MRT7, Pigpen – MRT12, and M&M 1 – MRT14) on the Ranch read in August 2018. All three of the transects had been established in prior years and 2018 represented the third or fourth re-read for each site. The map below illustrates the locations of the 2018 monitoring sites.

SUMMARY OF FINDINGS & MANAGEMENT RECOMMENDATIONS

Bare ground, plant vigor, plant production and species composition are all influenced over time by a combination of management practices and precipitation. For the purposes of this report, and to provide some context for its findings, the most recent 20 years of precipitation data was pulled from the Buffalo Weather Station via the Western Regional Climate Center's website. The chart below summarizes the trend in precipitation for this time period and provides actual figures for each individual year. The mean precipitation for the past twenty years has been 13.1 inches. 2018 was an above average moisture year.



Data sourced from the Western Regional Climate Center database: https://wrcc.dri.edu/cgi-bin/cliMAIN.pl?wy1165

The three sites monitored on the Merlin Ranch in 2018 displayed some commonalities:

1. Bare ground was dropping. All three sites displayed steady declines in bare ground through time, indicating that the water cycle was improving.
2. Turnover was evident within the sagebrush community. All sites displayed both recruitment of younger plants as well as a degree of decadence. Turnover, rather than outright decline, was a good sign that the sagebrush community was renewing itself.
3. Species richness was down. All three sites displayed a declining trend in species richness. The reason for this was not entirely clear. It may have been simply due to the stage of the successional process, and/or that more forbs had gone dormant prior to the sites having been sampled.

The following paragraphs provide a summary of the findings and management recommendations for each individual site.

Hall Pasture (MRT07)
MRT07 was established in 2005 to track changes in rangeland health in an area that was intended for treatment with the Lawson Renovator, but which was missed when the treatment occurred. Regardless,

the trends in this area have been informative and indicative of much improvement in grazing management and rangeland health through time.

This site displayed substantial improvement in water and mineral cycling through time. Bare ground was only 1% in 2018. Although cheatgrass and Japanese brome were still overly abundant, the successional process was active, and recruitment of young desired bunchgrasses was obvious. Similarly, there was obvious turnover taking place within the big sagebrush community with younger, mature and decadent plants observed. Forage production was within an expected range, though not as high has previous, likely wetter years. Overall, the trend here was favorable and management should be commended for the improvements observed. No major course corrections in grazing management were warranted. Continue to keep growing season grazing durations short, stock density as high as possible, utilization rates light to moderate and alter the season of use.

Pigpen (MRT12)
This monitoring site displayed substantial improvement in the water cycle through time. Bare ground dropped from 23% in 2008 to 7% in 2018. In addition, the mineral cycle appeared to be improving with moderately rapid decomposition rates. Both indicators still showed room for improvement, but the trend was favorable. Further reinforcing this positive trend was the obvious recruitment of needleandthread, bluebunch wheatgrass and green needlegrass indicating that the successional process was pushing the plant community in a desired direction. Japanese brome was still overly abundant, but the increase in perennial bunchgrasses should help push it out over the long term.

No major management course corrections were warranted for this pasture, which was grazed for a short duration by 65 pair in the late summer in 2018. Any opportunity to increase animal impact in this area would help facilitate ongoing improvements in the mineral cycle and encourage continued recruitment of desired grasses.

M&M 1 (MRT14)
The M&M 1 site showed the most room for improvement of the three sites monitored in 2018. That said, the trend was favorable. Bare ground was still too high at 23%, but it had dropped from 42% in 2008. Litter amounts were still too light at 73%, but they were up from 52% in 2008. These findings indicate that the water cycle was indeed improving. Japanese brome no longer ranked among the highest producers by weight, and needleandthread had increased its basal coverage. However, the successional process still appeared to be lagging with few younger age classes observed within the grass community. Turnover was, however, obvious within the big sagebrush community. Finally, plant vigor was not as high as expected given the good moisture year.

The M&M 1 Pasture serves as a springtime transition pasture for the ranch, and despite a history of keeping grazing durations short in this window, the pasture would benefit from periodic springtime rest. This would help encourage growth in the desired perennial bunchgrasses. In addition, the site displayed a need for additional animal impact so any opportunity to split the pasture into smaller units should be pursued. This would not only add flexibility to the season of use, but it would increase stock density, which should, in turn, stimulate further improvements in water and mineral cycling as well as the successional process.

TRANSECT PHOTOS & DATA

Hall Pasture (MRT07)

Site Summary Notes

This monitoring site was established in 2005 to track changes in an area that was planned for treatment with the Lawson Renovator. The purpose of this treatment was to improve rangeland health and wildlife habitat by reducing the sagebrush overstory and releasing the herbaceous understory. However, the Renovator missed this area and the sagebrush community has persisted through time. Regardless, the data from MRT07 has been used to track trends in range condition through time.

Site Photos

Transect View: Photo taken August 17, 2007

Quadrat View: Photo taken August 17, 2007

Transect View: Photo taken August 11, 2010

Quadrat View: Photo taken August 11, 2010

Transect View: Photo taken August 12, 2014

Quadrat View: Photo taken August 12, 2014

Transect View: Photo taken August 24, 2018

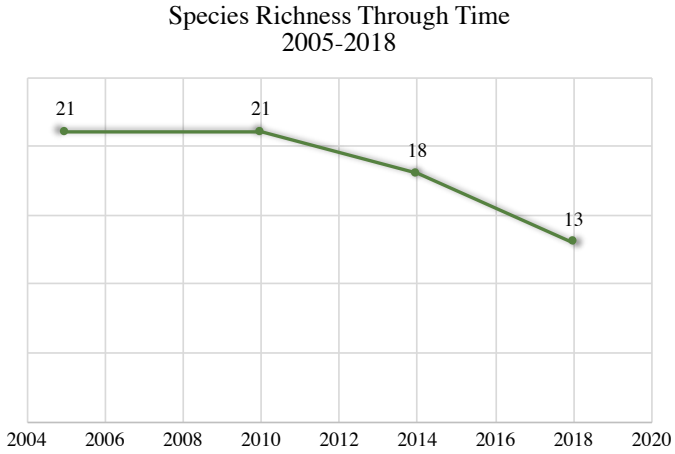
Quadrat View: Photo taken August 24, 2018

A look at the Site Photos reveals a declining trend in the big sagebrush community accompanied by ongoing high vigor and production from the herbaceous understory. In the 2007 and 2010 Transect View photos the big sagebrush community appears vigorous with an even distribution of plants throughout the site. By 2014, and continuing on into 2018, however, a visible reduction in both the number of sagebrush plants and their vigor had occurred. This suggests a declining trend within this community.

Both the Transect and Quadrat View photos illustrate vigorous grass production in all years. The grass community appears to be a mix of desired perennial bunchgrasses and undesired cheatgrass. Note the absence of bare ground in the Quadrat View photos – a good indication that the water cycle was functional.

Plant Community Composition

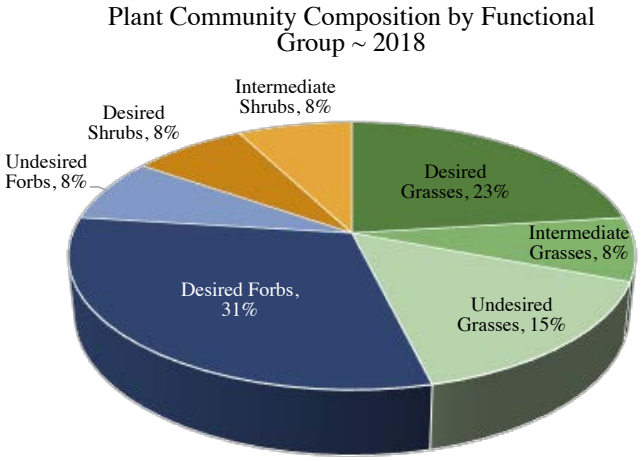
Interestingly, species richness has declined at this site from a high of 24 species in 2007 to a low of 13 in 2018. This might reflect fluctuations in species richness in response to moisture, but the trend is clearly negative. Ideally, richness will increase again through time and stabilize between 20 and 30 total species.



A look at the distribution of species richness across functional groups shows that Desired Grasses and Desired Forbs (species such as needleandthread, green needlegrass, scarlet globemallow, and western yarrow) together accounted for just over half of the species richness. Undesired grasses – largely cheatgrass and Japanese brome – accounted for 15% of the total richness. Overall the distribution of species across functional groups was favorable with room for improvement in the number of Undesired Grasses and Forbs as well as that of Desired Grasses and Forbs.

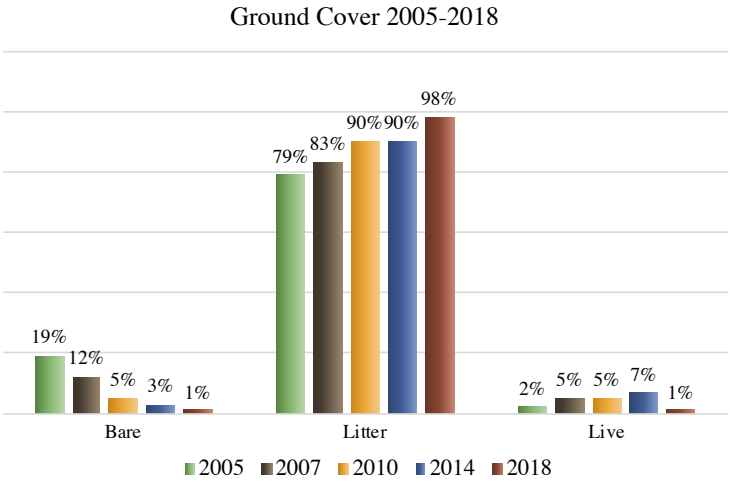
Plant Species List

Common Name	Functional Group
Western yarrow	Desired Forbs
Salsify	Desired Forbs
Scarlet globemallow	Desired Forbs
Unknown Perennial Forb	Desired Forbs
Green needlegrass	Desired Grasses
Needleandthread	Desired Grasses
Blue grama	Desired Grasses
Wyoming big sagebrush	Desired Shrubs
Sandberg bluegrass	Intermediate Grasses
Pricklypear Cactus	Intermediate Shrubs
Pennycress	Undesired Forbs
Cheatgrass	Undesired Grasses
Japanese brome	Undesired Grasses



Ground Cover

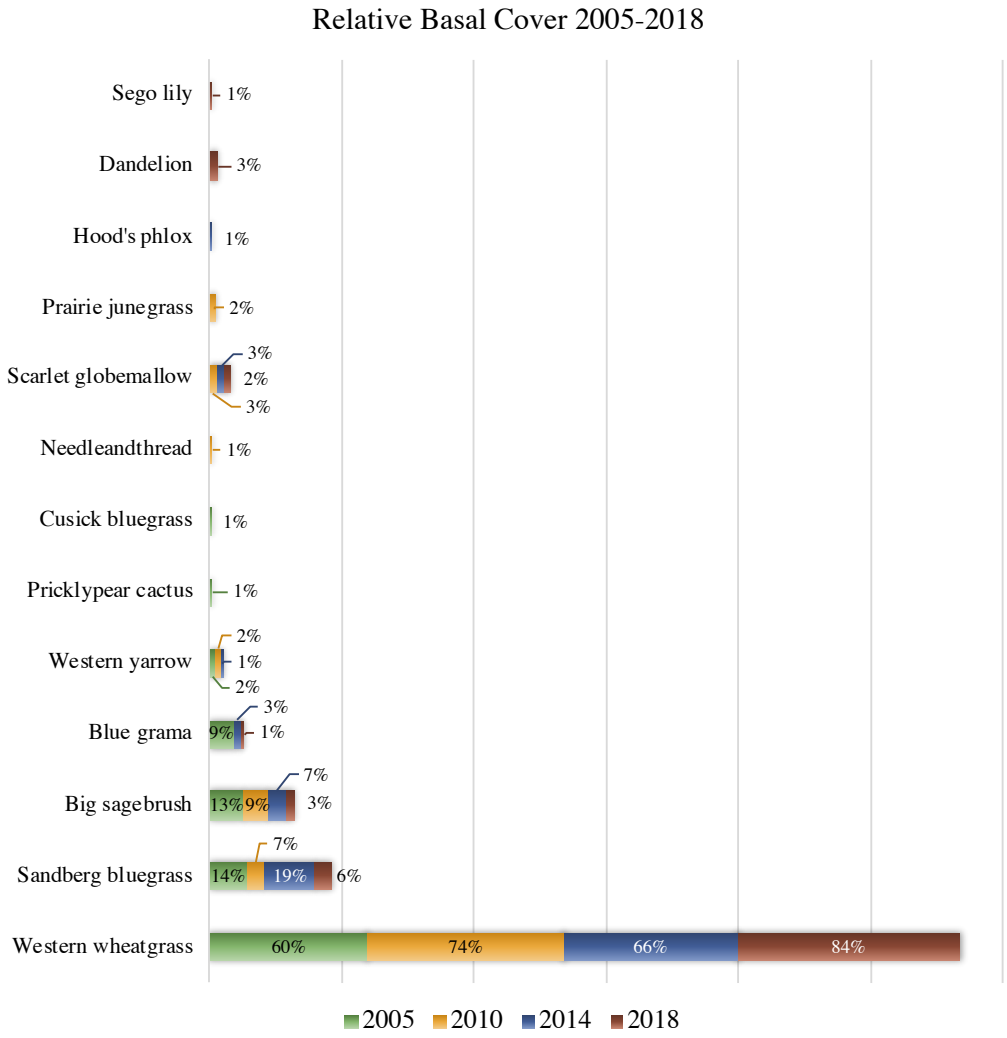
The Ground Cover chart reveals steady improvement in the water cycle through time. Bare ground has declined substantially (from 19% in 2005 to 1% in 2018) and litter cover has increased (from 79% in 2005 to 98% in 2018). Live ground cover has varied a bit more through time, but this was to be expected with shifts in species composition. The percentage of live cover was low in 2018, however, at 1% suggesting that perennial bunchgrasses were low in abundance.



Basal Cover

The Relative Basal Cover chart offers a look at the suite of *perennial* plant species dominating the soil surface, thus providing information on perennial plant community composition and relative abundances by species. A quick look at this chart reveals two important trends: First, western wheatgrass has been and continues to be the dominant perennial species on the soil surface; and second, the long list of species reflects active succession through time with few permanently establishing.

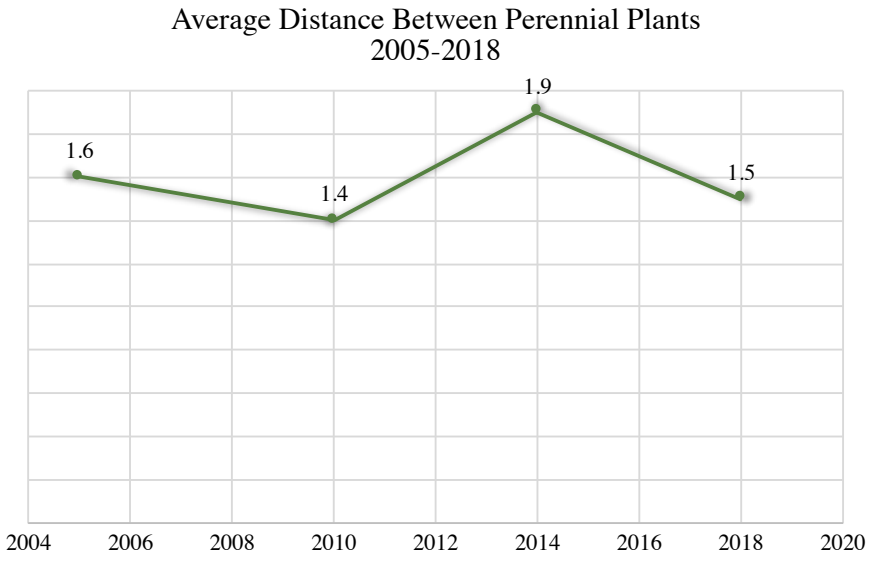
MRT07 lies in a Loamy 10-14" PZ ecological site where rhizomatous wheatgrasses (such as western wheatgrass) are expected to be dominant, along with needleandthread and blue grama. Ongoing shifts in community composition should be expected through time, and ideally a more established community of perennial bunchgrasses will emerge to complement the western wheatgrass.



Average Distance Between Perennial Plants

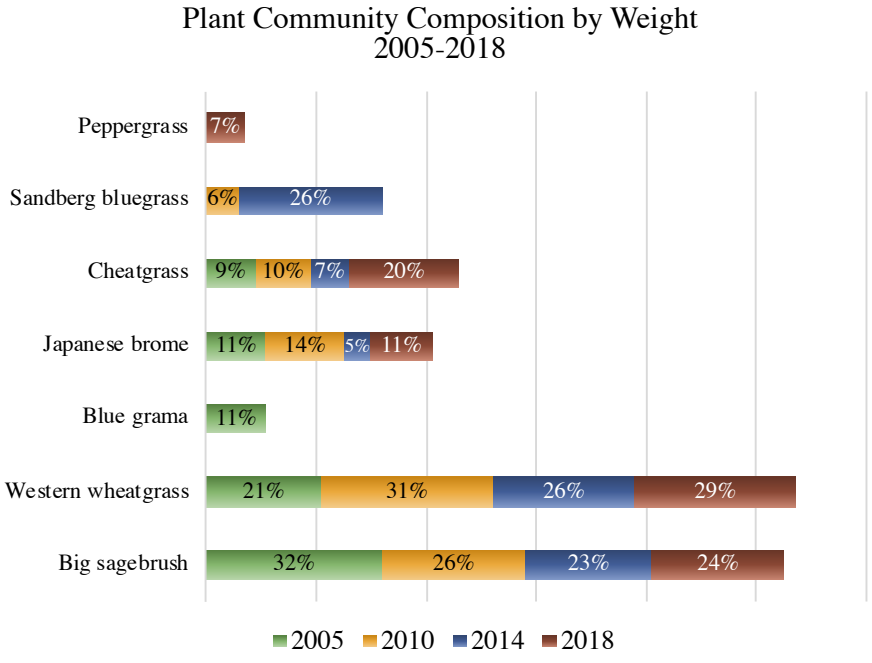
Measuring the average distance between perennial plants provides a look at the level of dominance of desired (perennial) species on the soil surface and insight into the stability of the site. Perennial plants

should be tightly spaced providing good soil coverage to limit erosion and prevent undesired species from gaining a foothold in the community. Results of less than 1 inch are ideal for this metric.



At this site, the average distance between perennial species has varied through time, which is to be expected, but has never dropped below 1 inch. Cheatgrass has remained a major component of the herbaceous community here through time, which has affected the average distance between perennial species (cheatgrass is an annual so while the spacing between plants may have been visibly tight in general, much of this was due to the abundance of cheatgrass). As the plant community continues to shift through time, and as perennial species gain a stronger foothold, cheatgrass will ideally drop in abundance and the distance between perennial plants will tighten up.

Plant Community Composition by Weight



The Community Composition by Weight chart shows the top five most productive species by weight, offering a look at species composition from the perspective of plant production. Comparing the results of this metric, which includes annual species, with those of the Relative Basal Cover chart, which excludes annuals, it becomes apparent that from a production by weight standpoint, there has been much less change through time. Western wheatgrass and big sagebrush have been the predominant producers by weight, as expected. This was a positive finding. However, cheatgrass and Japanese brome have also been consistently over abundant. In 2018, peppergrass was also overly abundant. These findings reveal a lack of perennial bunchgrasses and forbs at MRT07.

Shrubs

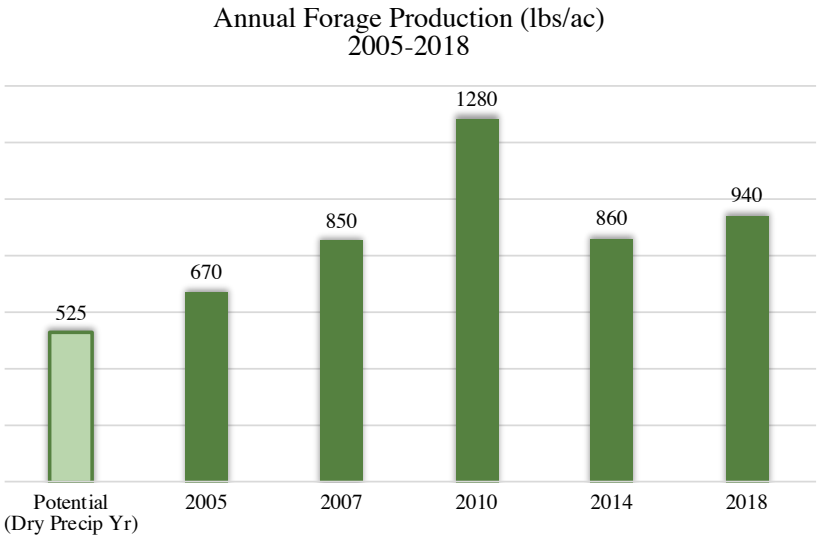
Shrub data provide information on the abundance, successional status, and habitat value of the various shrub communities that characterize a monitoring site. Here, Wyoming big sagebrush was the predominant shrub, and it has displayed a slow decline in abundance through time. In 2005, 56 plants were intercepted along the transect line while only 33 were intercepted in 2018. Similarly, shrub density declined from 103 plants per 1000 square feet in 2005 to 84 in 2018. These trends can be explained by the increasing level of decadence displayed by the community through time. In 2005, just 5% of the sagebrush community was decadent, but by 2018 40% was recorded as decadent. Ideally, decadence would be accompanied by recruitment of younger age classes. The data here reflect no active recruitment because no younger plants were intercepted along the transect line. However, observations made in the Bullseye suggest that recruitment of younger age classes was indeed taking place, which was a good sign indicating turnover rather than decline in the sagebrush community.

Big Sagebrush

2005	2010	2014	2018	
56	39	37	33	# Plants Encountered
				Age Class Distribution
0%	0%	0%	0%	*Seedling*
0%	0%	0%	0%	*Young*
95%	97%	89%	60%	*Mature*
5%	3%	11%	40%	*Decadent*
26	29	23	19	Avg. Plant Height (in)
48%	36%	29%	25%	% Canopy Intercept
103	75	70	84	Density/1000 sq ft

Production

Forage production is highly variable and dependent on both precipitation and when the last graze occurred in a pasture. The production figures through time were compared to the potential for the site in a drought year, which gives a good minimum level reference point. Forage production in the Hall Pasture has consistently been above the site's potential. Between 2005 and 2010, it climbed steadily reaching a high of 1,280 pounds per acre in a dry year (according to the Buffalo, WY weather station).

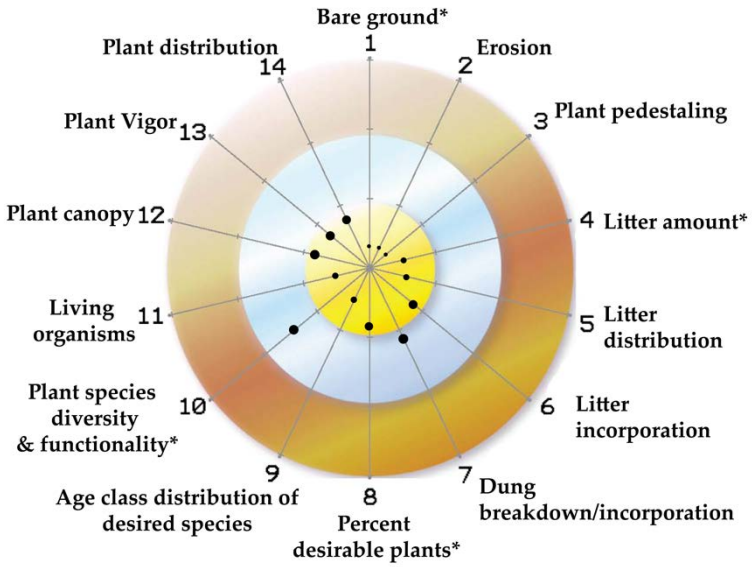


This was a very positive indication of improvements in water and mineral cycling. Production fell again to 860 pounds per acre in 2014 and increased slightly to 940 pounds per acre in 2018. Both 2014 and 2018 were average precipitation years. However, the Hall Pasture appeared to have been grazed not long before monitoring took place in 2018, suggesting that total production was likely even higher than 940 pounds per acre.

Bullseye Rangeland Health Target

The Bullseye provides an overview of rangeland condition at a specific point in time based on a visual assessment of qualitative indicators of rangeland health. Bare ground, erosion and plant pedestaling were all absent or nearly absent at this site. These observations indicate that the water cycle was effective.

Litter cover was high, in part due to the abundance of cheatgrass. Cattle had been in this pasture shortly prior to monitoring and had helped distribute the litter evenly across the soil surface. The litter was in contact with the soil with some sitting above the soil indicating a need for higher stock densities and greater animal impact. Where it was in contact with the soil, litter was mixing slightly. Several older and newer dung piles were obvious, but many of the cowpies were 1-2 years old indicating that the mineral cycle was a bit slow.



A total of 13 different plant species were observed in the area representing a moderate level of species richness. The percent desired species was moderately high with cheatgrass, Japanese brome and pennycress representing the undesired species. An abundance of young sagebrush plants were observed along with a fair number of young needleandthread and green needlegrass plants. Despite this, species diversity and functionality showed much room for improvement with an overabundance of cheatgrass and a lack of the high value perennial bunchgrasses and forbs. However, the obvious recruitment of younger age classes indicated that the successional process was slowly moving the site in a desired direction.

This site provided valuable habitat for wildlife including pronghorn, elk, deer, songbirds, raptors, predators, insects and rodents.

The plant canopy was slightly reduced because this site had recently been grazed. Utilization rates appeared light and very little sunlight was hitting bare soil. Plant vigor was high with the grasses displaying tall stature and gone to seed. Plants were well distributed across the soil surface. These findings indicate that the flow of energy was effective.

Management Recommendations

The Hall Pasture has displayed many positive trends through time, particularly with the water cycle. As of 2018, there was not only sign of active turnover in the sagebrush community, but recruitment of younger needleandthread and green needlegrass plants. This was a strong sign that the successional process was slowly pushing the herbaceous community in a desired direction. The more perennial bunchgrasses that can establish and expand, the greater the competition for cheatgrass and Japanese brome. Overall, the trend here was positive.

In 2018, this pasture was grazed by 181 head for 15 days in late January/early February and then again by 300 pair for 10 days in late July. Utilization rates appeared light to moderate. This was a good strategy that provided ample animal impact and should favor growth in the early growing season by desired species. No major management course corrections were warranted.

Early Warning Indicators

Grazing managers require a feedback mechanism to determine if management actions are being properly implemented. That mechanism comes in the form of early-warning indicators. Such indicators are the earliest signs that course corrections are required, and they may be contrasted to late-warning indicators, which may require more time consuming and costly corrections.

If management practices are properly applied, look first for maintained high plant vigor even in dry years. Next look for ongoing recruitment of desired species like needleandthread and green needlegrass. Finally, look for reductions in cheatgrass as the desired, late seral species gain a stronger foothold in the community and begin to push out the early seral, less desired annuals.

If management practices are improperly applied, look first for reductions in plant vigor. Next look for reductions in litter cover and increased bare ground. Finally, look for a loss of abundance on western wheatgrass and a lack of recruitment of needleandthread and green needlegrass accompanied by an increase in cheatgrass and Japanese brome.

Pigpen (MRT12)

Site Summary Notes

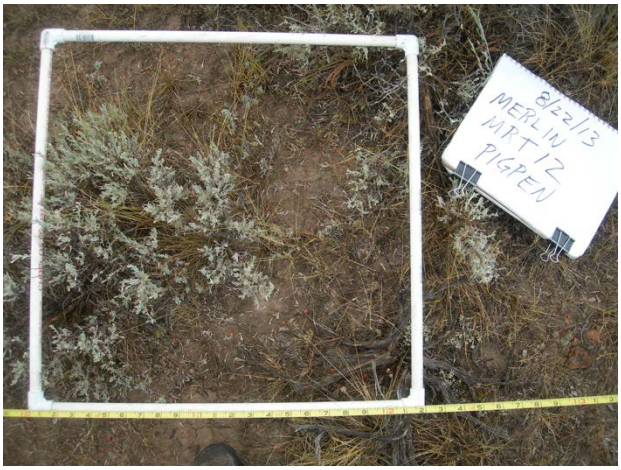
This monitoring site was initially established in 2008 in the northwestern end of the Pigpen pasture. The closest stockwater was ¼ - ½ mile away. The transect was located on a slope that was representative of the larger area and the main draw running through the pasture.

Site Photos

Transect View: Photo taken August 27, 2008

Quadrat View: Photo taken August 27, 2008

Transect View: Photo taken August 22, 2013



Quadrat View: Photo taken August 22, 2013

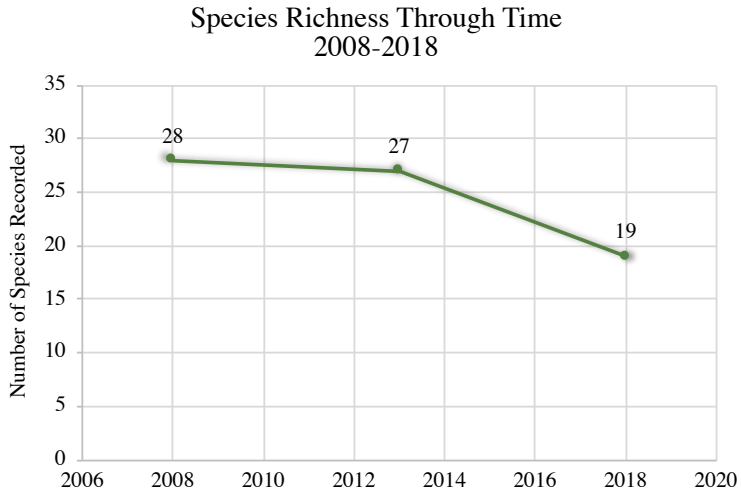
Transect View: Photo taken August 24, 2018

Quadrat View: Photo taken August 24, 2018

The Site Photos reveal minor changes within the sagebrush and herbaceous communities, but for the most part, little visible change can be seen here through time. The area of bare ground near the bucket lid in the Transect View photo has been fairly consistent through time, not growing nor contracting. Similarly, areas of bare ground have been consistently visible in the Quadrat View photos. Vigor appears fairly high across all the years shown.

Plant Community Composition

A total of 19 plant species were recorded in 2018. This was a noticeably lower level of species richness than had been recorded in previous years when richness was closer to 30. The distribution of species across functional groups was relatively even, which indicated that there were more undesired species present than desired. Cheatgrass, Japanese brome and crested wheatgrass were considered undesired. That said, the site was largely characterized by an abundance of desired grasses and forbs.

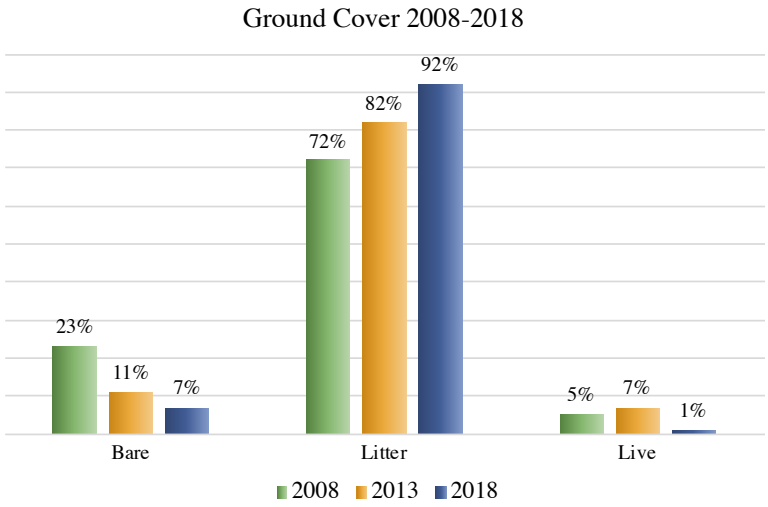


Plant Species List

Common Name	Functional Group
Western yarrow	Desired Forbs
Scarlet globemallow	Desired Forbs
Salsify	Desired Forbs
Hood's phlox	Desired Forbs
Flax	Desired Forbs
Green needlegrass	Desired Grasses
Needleandthread	Desired Grasses
Western wheatgrass	Desired Grasses
Bluebunch wheatgrass	Desired Grasses
Blue grama	Desired Grasses
Wyoming big sagebrush	Desired Shrubs
Silver sagebrush	Desired Shrubs
Rubber rabbitbrush	Desired Shrubs
Cudweed sagewort	Intermediate Forbs
Sandberg bluegrass	Intermediate Grasses
Prairie junegrass	Intermediate Grasses
Smooth brome	Intermediate Grasses
Fringed sagewort	Intermediate Shrubs
Broom snakeweed	Intermediate Shrubs
Pricklypear cactus	Intermediate Shrubs
Japanese brome	Undesired Grasses
Cheatgrass	Undesired Grasses
Crested wheatgrass	Undesired Grasses

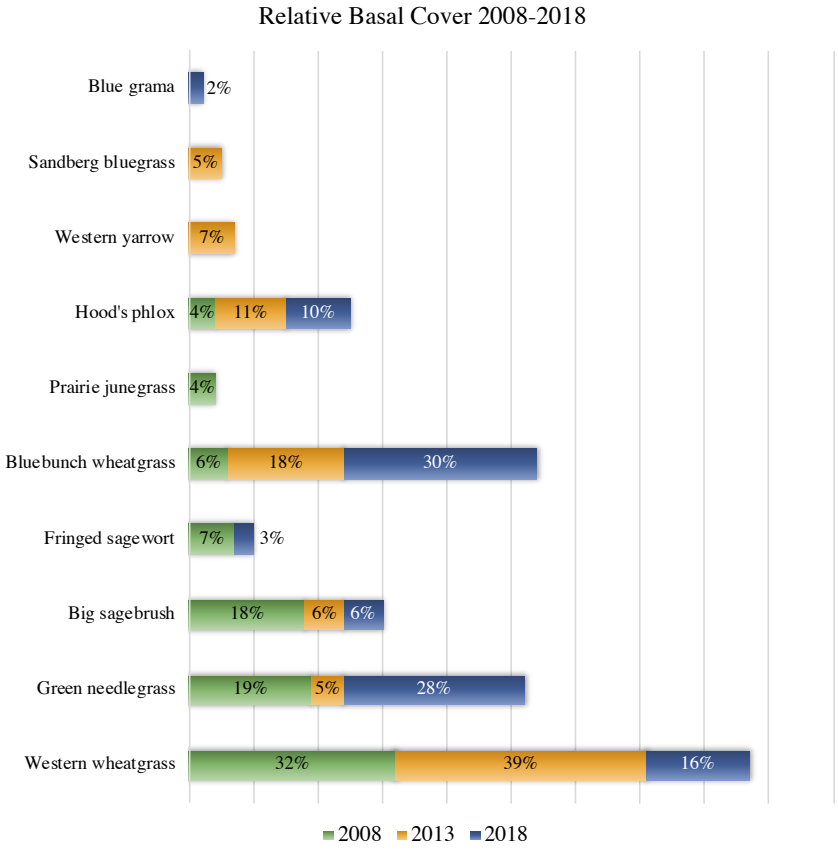
Ground Cover

The Ground Cover data show steady improvement through time. Bare ground declined from 23% in 2008 to 7% in 2018. While there was still room for improvement in the level of bare ground, this was a very positive trend. Similarly, litter cover increased from 72% in 2008 to 92% in 2018. Live ground cover has varied through time, which is to be expected. However it was notably low in 2018, suggesting a low abundance of mature perennial bunchgrasses. Overall, these data reveal improvements in the water cycle.



Basal Cover

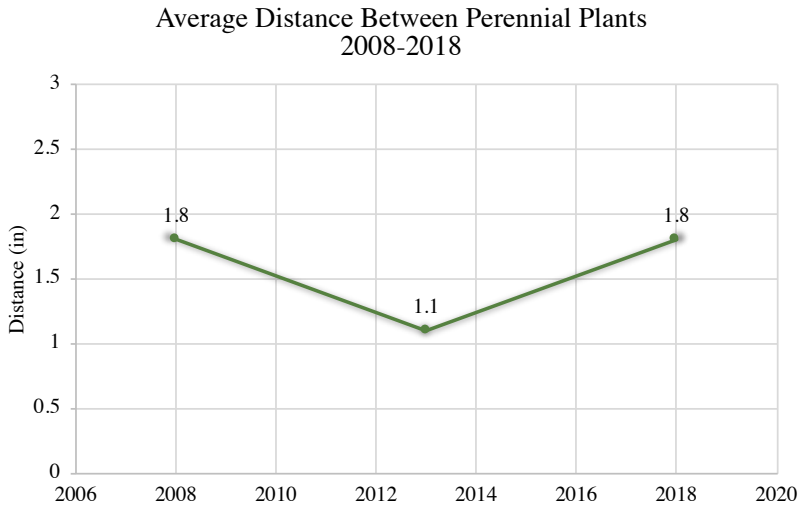
The Relative Basal Cover chart offers a look at the suite of *perennial* plant species dominating the soil surface, thus providing information on perennial plant community composition and relative abundances by species. A look at this chart quickly reveals some positive trends in species composition. Historically, western wheatgrass has been the dominant plant on the soil surface, and while this is not bad, it would have been more desirable for higher producing perennial bunchgrasses to dominate. This is, in fact, the trend beginning to appear. Between 2013 and 2018, western wheatgrass declined in abundance while desired bunchgrasses like green needlegrass and bluebunch wheatgrass increased. In 2013, green needlegrass composed only 5% of the basal cover, but by 2018 it accounted for 28%. Similarly, bluebunch wheatgrass composed 18% of the basal cover in 2013, but 30% by 2018. These were positive shifts in community composition.



Average Distance Between Perennial Plants

Measuring the average distance between perennial plants provides a look at the level of dominance of desired (perennial) species on the soil

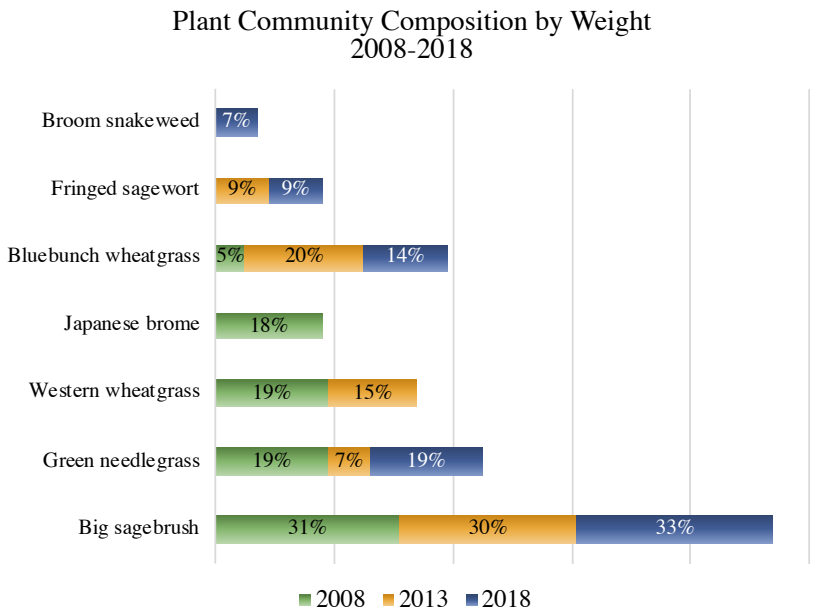
surface and insight into the stability of the site. Perennial plants should be tightly spaced providing good soil coverage to limit erosion and prevent undesired species from gaining a foothold in the community. Results of less than 1 inch are ideal for this metric.



At MRT12, the average distance between perennial plants has hovered between 1.8 and 1.1 inches over time, never dropping below 1 inch. This likely reflected the continued abundance of Japanese brome, which is an annual, and therefore not accounted for when measuring the distance between perennial species. Look for reductions in this figure as conditions continue to improve through time.

Plant Community Composition by Weight

The Community Composition by Weight chart shows the top five most productive species by weight, offering a look at species composition from the perspective of plant production. These data reveal a noticeable increase in the relative production by weight of green needlegrass and bluebunch wheatgrass along with a reduction in Japanese brome. These findings suggest that the perennial grasses may be starting to compete with less desired species. As expected, big sagebrush remained the most productive plant by weight.



Other shifts in composition included increases in fringed sagewort and broom snakeweed. While not particularly desirable, these shifts were likely representative of ongoing succession rather than a problem. These species will likely decline through time with ongoing improvements in overall range condition.

Shrubs

Shrub data provide information on the abundance, successional status, and habitat value of the various shrub communities that characterize a monitoring site. Wyoming big sagebrush has been the predominant shrub in this community through time. The most notable takeaways from this data set include the high levels of decadence observed in 2008 and 2013, which led to the subsequent reductions in percent canopy intercept and total shrub density. However, 2018 was the first year in which younger sagebrush plants

were encountered along the transect and the level of decadence showed a noticeable decline. These findings suggest a shift from a declining sagebrush community to one experiencing active turnover, which was a good sign.

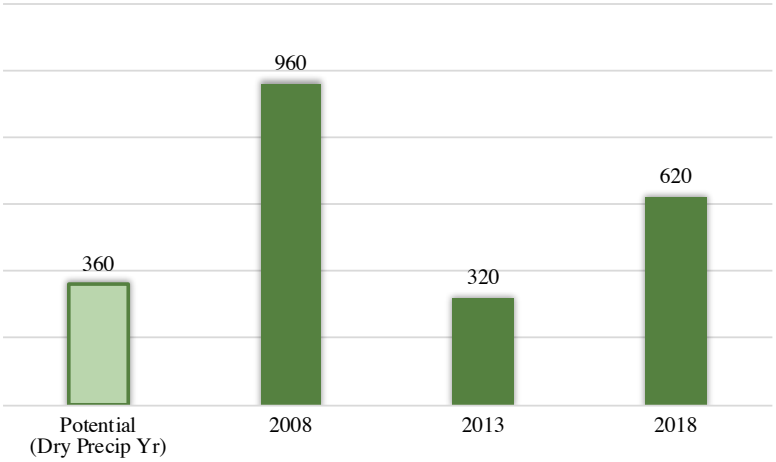
Wyoming Big Sagebrush

2008	2013	2018	
45	44	46	# Plants Encountered
			Age Class Distribution
0%	0%	0%	*Seedling*
0%	0%	4%	*Young*
76%	80%	87%	*Mature*
24%	20%	8%	*Decadent*
15.6	10.3	16.4	Avg. Plant Height (in)
23%	19%	11%	% Canopy Intercept
175	238	148	Density/1000 sq ft

Production

Forage production has consistently been above the site's potential in a dry year, which was good to see. The highest level of production was achieved in 2008, which was a good moisture year, when the site produced 960 pounds per acre. Production fell to 320 pounds per acre between then and 2013, but this was at least in part due to reductions in Japanese brome. By 2018, with active recruitment of desired species like green needlegrass and bluebunch wheatgrass, forage production was again beginning to rise and the site achieved 620 pounds per acre.

Annual Forage Production (lbs/ac)
2008-2018



Bullseye Rangeland Health Target

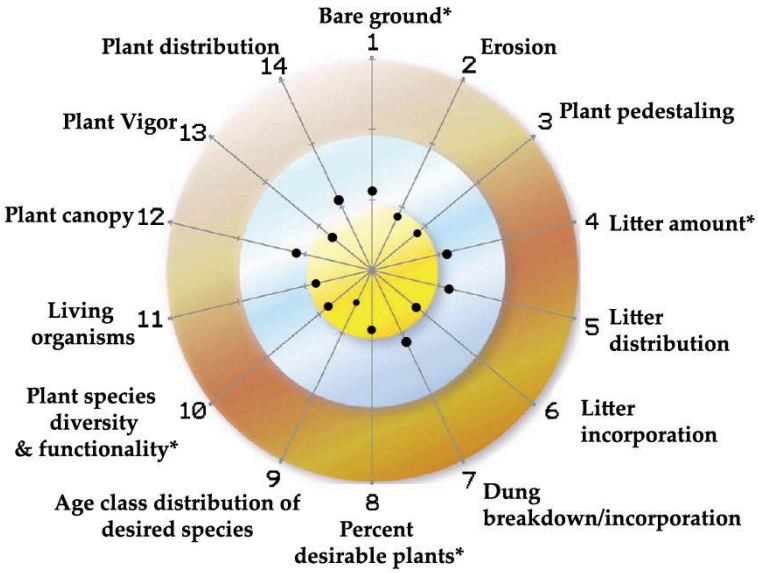
The Bullseye provides an overview of rangeland condition at a specific point in time based on a visual assessment of qualitative indicators of rangeland health. Bare ground had improved substantially, but still showed room for improvement. Signs of wind erosion and plant pedestaling were minor. These findings suggest that the water cycle was mostly effective.

Litter build up was a touch light, but not bad. Litter was patchily distributed and not incorporating as well as would be desired, but cattle were in the pasture at the time and signs of hoof action were obvious. Few older dung piles were observed in the area suggesting that decomposition rates were moderately rapid.

A total of 23 plant species were observed in the area representing a desired level of species richness. The percent desired species was high with only 3 undesired plants found. These were cheatgrass, Japanese brome and crested wheatgrass. Younger bluebunch wheatgrass, needleandthread and green needlegrass plants were obvious indicating active recruitment of desired species. In addition, the big sagebrush community displayed signs of active turnover with younger, mature and decadent plants evident. Species diversity and functionality was generally strong. Cheatgrass and Japanese brome were present at slightly higher levels of abundance than were desired, but the high value perennial bunchgrasses as well as forbs were also abundant and diverse. These findings indicate that the successional process was active and moving the site in a desired direction.

This site provided useful habitat for a variety of wildlife species including elk, deer, antelope, coyotes, rabbits, insects and birds.

The plant canopy was moderate with some sunlight still hitting bare soil. Plant vigor was high with the big sagebrush leaders pushing for inches, the grasses displaying tall stature and gone to seed, and the forbs flowered. Plant distribution was patchier than desired. These findings indicate that the flow of energy through the system was mostly effective.



Management Recommendations

Since 2008 when monitoring began, this site has been grazed at different times of year for short durations with a light to moderate utilization rate. In 2018, the Pigpen Pasture was grazed by 65 pair for 12 days in late August. Historically, cattle have preferred to eat the perennial bunchgrasses like bluebunch wheatgrass and green needlegrass indicating a need to maximize early springtime rest in this area to ensure ongoing recruitment and establishment of these species.

No major course corrections in grazing management were warranted here. Continue implementing short durations, long recovery periods, and light to moderate utilization rates. Any opportunities to increase stock density would further benefit the ecological processes.

Early Warning Indicators

Grazing managers require a feedback mechanism to determine if management actions are being properly implemented. That mechanism comes in the form of early-warning indicators. Such indicators are the earliest signs that course corrections are required, and they may be contrasted to late-warning indicators, which may require more time consuming and costly corrections.

If management actions are properly applied, look first for improvements in plant vigor even in dry years. Next look for ongoing reductions in bare ground and slight increases in the percent live cover. Finally, look for shifts in species composition that favor the perennial bunchgrasses and push out the early seral, less desired species like Japanese brome, fringed sagewort, and broom snakeweed.

If management actions are improperly applied, look first for reductions in plant vigor. Next look for increased levels of bare ground. Finally, look for slowing recruitment of desired species and shift toward more broom snakeweed, fringed sagewort, and Japanese brome.

M&M #1 (MRT14)

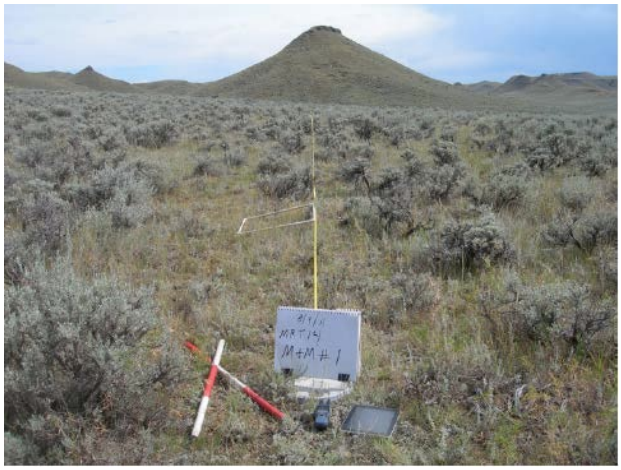
Site Summary Notes

This monitoring site was established in 2008 in a saddle where cattle tended to trail to nearby stockwater from other areas in the pasture. The pasture boundary fence sits approximately 1 mile to the north of the site. Monitoring data collected from this site will track changes in rangeland health in response to changes in management, precipitation and temperature.

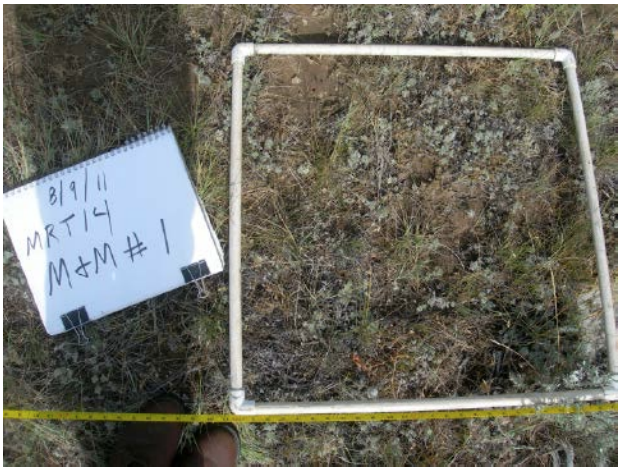
Site Photos

Transect View: Photo taken August 27, 2008

Quadrat View: Photo taken August 27, 2008



Transect View: Photo taken August 9, 2011



Quadrat View: Photo taken August 9, 2011

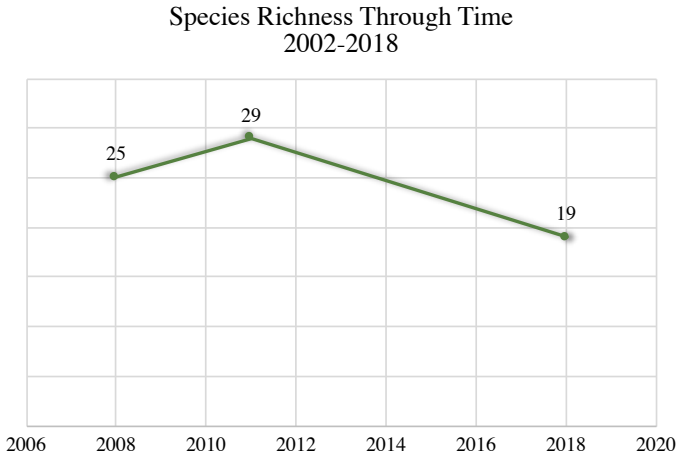
Transect View: Photo taken August 24, 2018

Quadrat View: Photo taken August 24, 2018

The Site Photos show a noticeable improvement in forage production and herbaceous plant vigor between 2011 and 2018. In addition, a look at the Quadrat View photos show a visible reduction in bare ground since 2011. The big sagebrush community appeared of lower vigor in 2018, which was not surprising as the community had displayed a declining trend for a while.

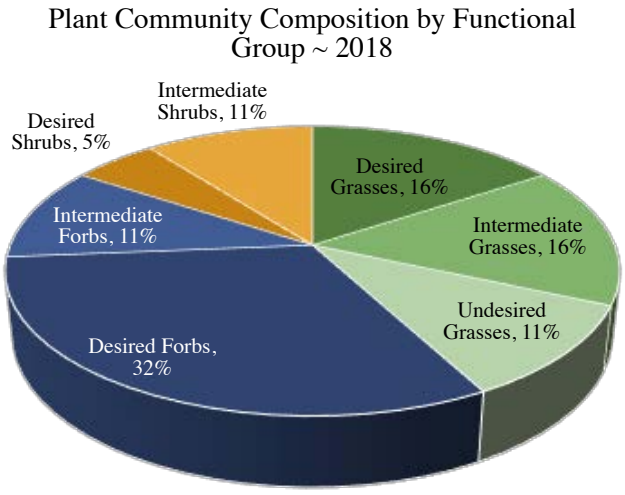
Plant Community Composition

A total of 19 plant species were recorded at this site in 2018, a noticeable reduction over previous years when species richness had approached 30 species. The distribution of species across functional groups was uneven with Desired Grasses lacking, and Intermediate and Undesired Grasses more plentiful. However, Desired Forbs accounted for over a third of the richness, which was a good finding. The undesired species found were cheatgrass, Japanese brome, and vagrant lichen.



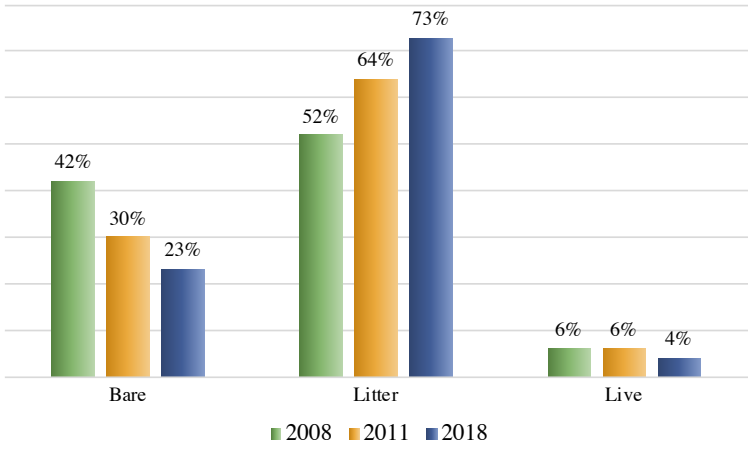
Plant Species List

Common Name	Functional Group
Unknown Perennial Forb	Desired Forbs
Scarlet globemallow	Desired Forbs
Showy fleabane	Desired Forbs
Hood's phlox	Desired Forbs
Scurfpea	Desired Forbs
Salsify	Desired Forbs
Western wheatgrass	Desired Grasses
Needleandthread	Desired Grasses
Blue grama	Desired Grasses
Wyoming big sagebrush	Desired Shrubs
Peppergrass	Intermediate Forbs
Desert alyssum	Intermediate Forbs
Prairie junegrass	Intermediate Grasses
Sandberg bluegrass	Intermediate Grasses
Smooth brome	Intermediate Grasses
Fringed sagewort	Intermediate Shrubs
Broom snakeweed	Intermediate Shrubs
Cheatgrass	Undesired Grasses
Japanese brome	Undesired Grasses
Vagrant lichen	Undesired Lichen



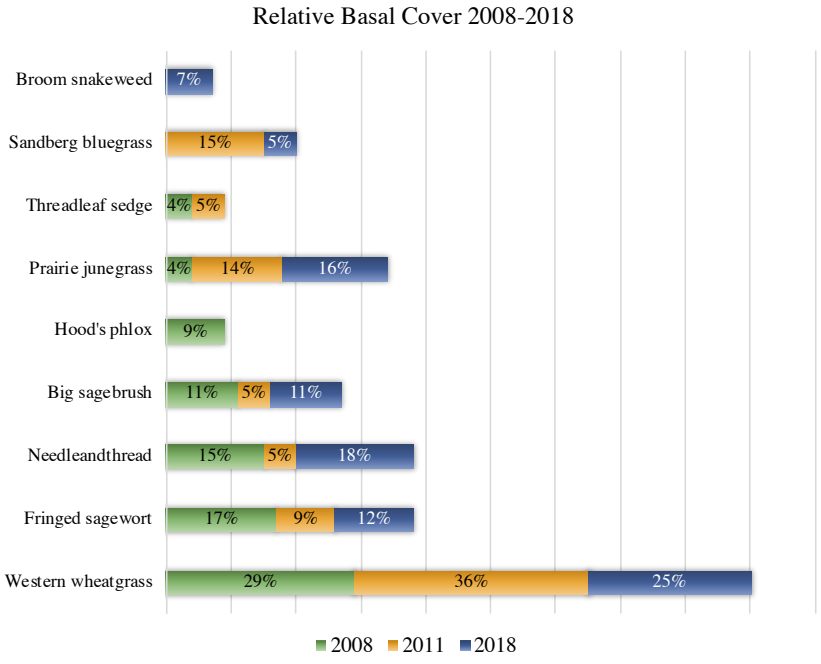
Ground Cover

The Ground Cover data reveal that although bare ground was still too high in 2018, the trend was moving in the right direction. Total bare ground fell from 42% in 2008 to 23% in 2018. Since litter cover tends to be inversely proportional to bare ground, it was not surprising to see a parallel increase in litter, from 52% in 2008 to 73% in 2018. Live ground cover dropped slightly, from 6% to 4%, during this same time frame, but overall, this was a favorable result. These findings indicate that the water cycle has been improving.



Basal Cover

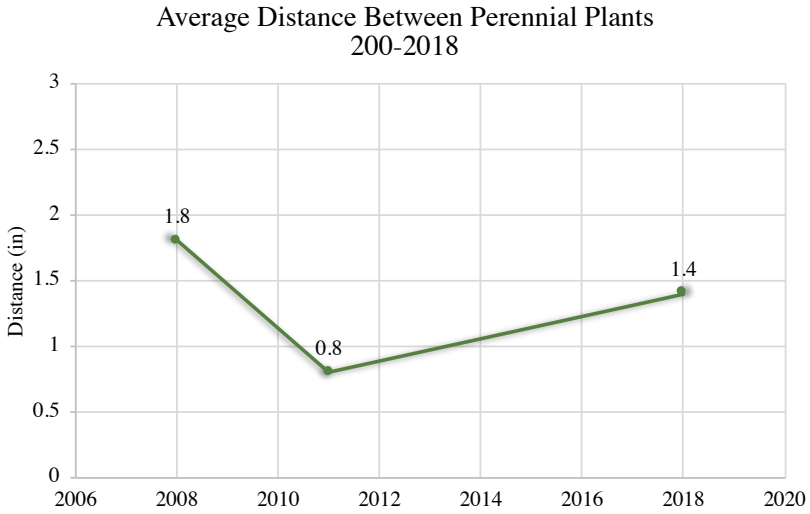
The Relative Basal Cover chart offers a look at the suite of *perennial* plant species dominating the soil surface, thus providing information on perennial plant community composition and relative abundances by species. A look at this chart reveals ongoing shifts in the relative basal abundance of a fairly consistent group of species, rather than a lot of new species moving in



and out of the community over time as was the case at some of the other sites monitored in 2018. Here, western wheatgrass, needleandthread, fringed sagewort, big sagebrush and prairie junegrass have been the primary species dominating the soil surface through time. Note that some of these species (such as needleandthread, fringed sagewort and prairie junegrass) have increased in relative basal abundance through time, while others (such as western wheatgrass) have declined. These were generally positive shifts, though the increase in sagewort and broom snakeweed was not particularly desirable. However, ongoing shifts in species composition should be expected as this site continues to improve in condition.

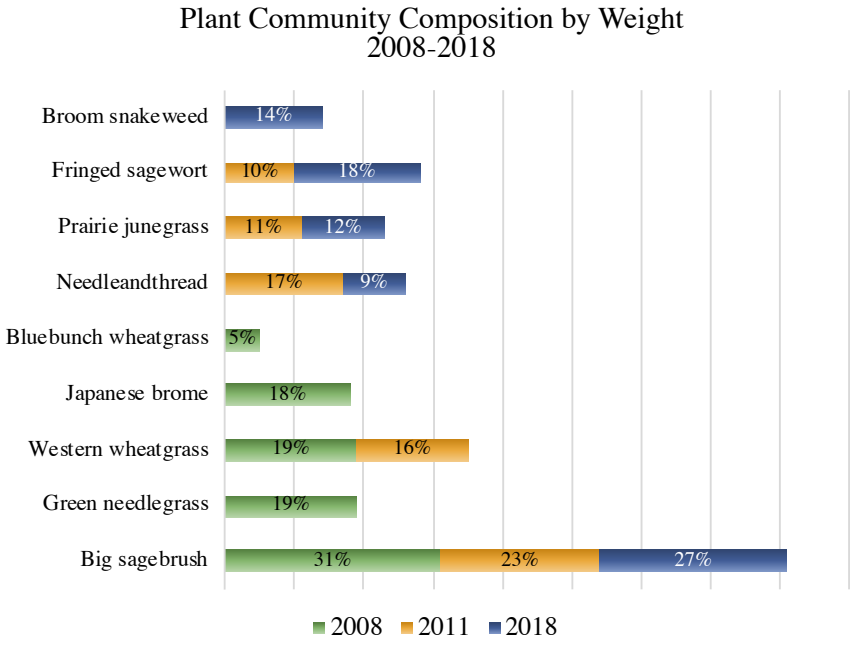
Average Distance Between Perennial Plants

Measuring the average distance between perennial plants provides a look at the level of dominance of desired (perennial) species on the soil surface and insight into the stability of the site. Perennial plants should be tightly spaced providing good soil coverage to limit erosion and prevent undesired species from gaining a foothold in the community. Results of less than 1 inch are ideal for this metric.



At MRT14, the average distance between perennial species declined by a full inch between 2008 and 2011. This reduction was accompanied by a noticeable increase in basal coverage by Sandberg bluegrass, prairie junegrass and western wheatgrass. However, between 2011 and 2018, the distance increased again to 1.4 inches, likely as a result of a substantial reduction in Sandberg bluegrass and slower increases in other perennial species. Overall, these results were mixed, but the trend will likely be favorable over the long term given continued improvements in rangeland health.

Plant Community Composition by Weight



The Community Composition by Weight chart shows the top five most productive species by weight, offering a look at species composition from the perspective of plant production. The results from this chart were interesting showing a wholescale shift in community composition between 2008 and 2011. In 2008, the most productive species by weight were big sagebrush, green needlegrass, western wheatgrass, Japanese brome, and bluebunch wheatgrass. By 2011, this composition had shifted to big sagebrush, western wheatgrass, needleandthread, prairie junegrass and fringed sagewort. Many of these species remained persistently productive into 2018 with the addition of broom snakeweed.

These shifts in species composition represent active succession as this site's ecological function begins to improve. Initial improvements in the water and mineral cycles are often accompanied by some less than desired shifts in species, as was the case here with the increase in broom snakeweed and fringed sagewort. Desired shifts, such as the reduction in Japanese brome and increase in needleandthread, also occurred, however. The bottomline is that management should expect ongoing changes in this community as the site continues to gain in rangeland health.

Shrubs

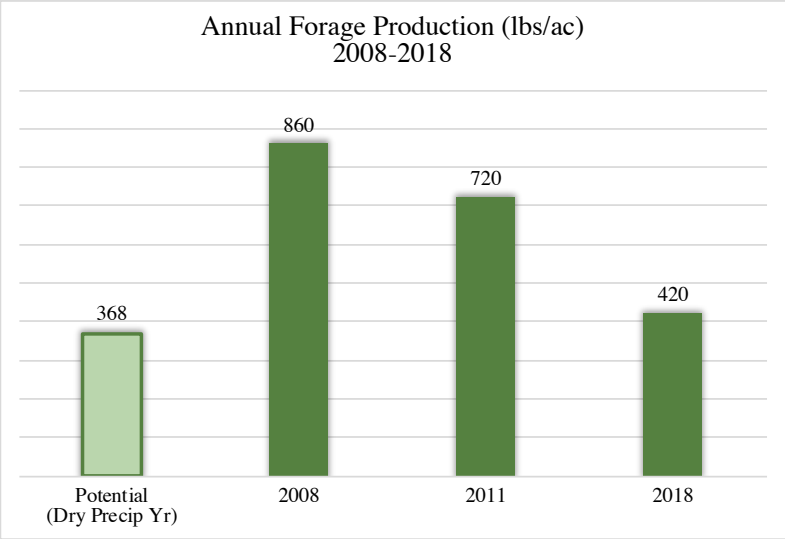
Shrub data provide information on the abundance, successional status, and habitat value of the various shrub communities that characterize a monitoring site. The sagebrush data for MRT14 show a steady decline in total shrub density over time, which can be explained by a shift from recruiting younger plants in 2008 to a trend of increasing decadence in 2011 and 2018. Based on this data alone, the sagebrush community would appear to be in decline. However, an abundance of younger sagebrush plants were observed in the area surrounding the transect even though none were actually intercepted by the tape. This would indicate that the community was actually experiencing turnover, which was a good sign.

Big Sagebrush

2008	2011	2018	
46	41	49	# Plants Encountered
			Age Class Distribution
0%	0%	0%	*Seedling*
9%	0%	0%	*Young*
91%	80%	61%	*Mature*
0%	20%	39%	*Decadent*
14	10	8	Avg. Plant Height (in)
20%	18%	20%	% Canopy Intercept
221	193	144	Density/1000 sq ft

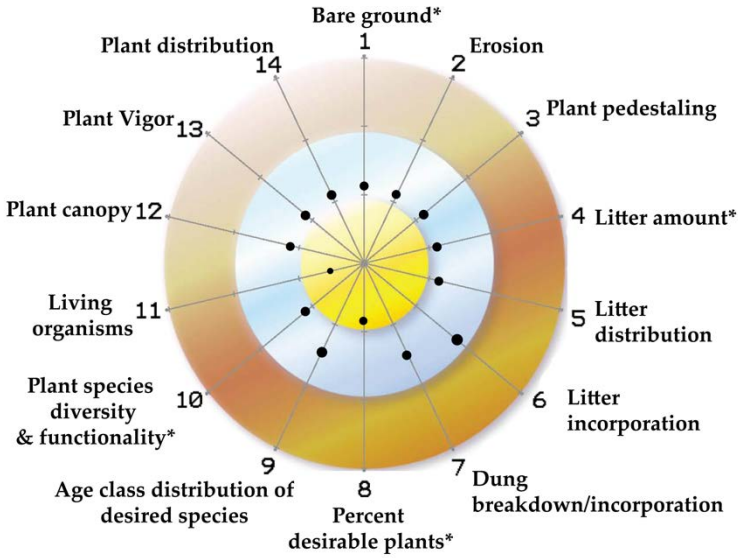
Production

Forage production has declined steadily at this site through time, but this does not necessarily reflect negative change. In 2008, much of the production was composed of big sagebrush and Japanese brome, but by 2011, Japanese brome had declined substantially and the later seral species were just beginning to establish. In 2018, cattle were in this pasture at the time of monitoring, so forage production was naturally reduced because it had been grazed. It would not be surprising to see an increase in production in future years as the site continues to respond to changes in management.



Bullseye Rangeland Health Target

The Bullseye provides an overview of rangeland condition at a specific point in time based on a visual assessment of qualitative indicators of rangeland health. Bare ground was higher than desired in this area. Similarly, there were moderate signs of wind erosion and minor signs of water erosion. Plant pedestaling was minor. These findings indicate room for improvement in the water cycle.



The build up of litter was a little on the light side indicating a need for more hoof action. In addition, litter was patchy rather than evenly distributed throughout the site and it tended to be suspended above the soil rather than incorporating. The cowpies in this area were two years or older indicating slow decomposition. These findings indicate that mineral cycling was slower.

A total of 20 different plant species were observed in the area representing a desired level of species richness. The percent desired species was high with the only undesired species recorded being cheatgrass and Japanese brome. No younger age classes were observed in the grass community, but turnover was obvious in the big sagebrush community with younger, mature and decadent plants found. Species diversity and functionality showed room for improvement: although the desired species were present, they lacked abundance while intermediate species (like Sandberg bluegrass and prairie junegrass) and undesired species (like cheatgrass and Japanese brome) were overly abundant. These findings suggest that while succession was active within the sagebrush community it was lagging within the herbaceous community.

This site provided useful habitat for a variety of species including pronghorn, elk, deer, songbirds, insects, mesocarnivores, raptors and small mammals.

The plant canopy was lower than desired with too much sunlight hitting bare soil. Plant vigor was moderate despite the good moisture year. Leaders on the big sage were pushing 6 inches, but many of the perennial bunchgrasses had not produced seed suggesting room for improvement in the water cycle. Finally, there were too many big gaps between plants indicating room for improvement in plant distribution. Overall, these findings reveal that the flow of energy through the system was only moderately effective.

Management Recommendations

The M&M 1 Pasture has historically been used as a springtime transition pasture for yearlings on their way to summer pasture. Grazing durations have tended to be around 10 days, which is a good duration. In 2018, the pasture was grazed for 13 days by 145 pair in mid- to late May, and then again by 180 head for 14 days in late November/early December.

Given the spring grazing window, management should ensure that utilization rates remain light to moderate (30%-50%). Further, any opportunity to mix up the season of use in this pasture and provide early growing season rest to the perennial bunchgrasses would help encourage their continued establishment. Finally, this site displayed a need for increased animal impact so any opportunities that become available to split the pasture would not only add flexibility to the season of use, but facilitate an increase in stock density and therefore animal impact.

Early Warning Indicators

Grazing managers require a feedback mechanism to determine if management actions are being properly implemented. That mechanism comes in the form of early-warning indicators. Such indicators are the earliest signs that course corrections are required, and they may be contrasted to late-warning indicators, which may require more time consuming and costly corrections.

If management practices are properly applied, look first for improvements in plant vigor, even in dry years. Next, look for ongoing reductions in bare ground and improvements in litter cover, followed by more rapid recruitment of desired species. Finally, look for shifts in species composition away from early and mid-seral species like fringed sagewort, broom snakeweed, prairie junegrass and Sandberg bluegrass, toward a greater abundance of needleandthread, green needlegrass, and bluebunch wheatgrass.

If management practices are improperly applied, look first for reductions in plant vigor. Next look for increases in bare ground, reductions in litter and more signs of erosion. Finally, look for shifts in species composition that favor weeds and intermediate species such as Japanese brome, dandelion, Sandberg bluegrass, prairie junegrass and fringed sagewort.

NUTRIENT ANALYSIS

At each of the three sites, a single plot of forage was clipped to determine above-ground productivity. Material 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 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 2018.

Nutrient	Hall	Pigpen	M&M 1
Crude Protein (%)	7.31	6.21	7.5
Acid Detergent Fiber (%)	52.2	49.4	50.4
Total Digestible Nutrients (%)	43	46.2	45.1
Net energy-lactation (Mcal/lb)	0.42	0.46	0.45
Net energy-maintenance (Mcal/lb)	0.39	0.42	0.41
Net energy-gain (Mcal/lb)	0.19	0.22	0.21
Sulfur (%)	0.1	0.09	0.12
Phosphorus (%)	0.1	0.07	0.12
Potassium (%)	0.43	0.38	0.68
Magnesium (%)	0.11	0.09	0.17
Calcium (%)	0.49	0.49	0.76
Sodium (%)	none taken	none taken	none taken
Iron (ppm)	277	136	389
Manganese (ppm)	64.8	43.8	64.7
Copper (ppm)	4.4	3.4	5.6
Zinc (ppm)	17.8	15.5	24.7

A glance at the table shows that none of the trace minerals occurred at toxic levels. As is typical in the Rocky Mountain West, some, particularly phosphorus, zinc, and copper, were low.

A comparison of the nutrients provided by each pasture against the needs of an 1100-pound lactating cow is provided in the table below. The plants were collected in mid-August in a year that was overall above average in precipitation, but experienced a hot, dry summer. The nutrient requirements for a 1100-pound lactating cow of average milking ability were drawn from Nutrient Requirements of Beef Cattle tables (NRC, 1984).

Nutrient Requirements vs. Nutrient Actuals

	Dry Matter	*Crude Protein*	*TDN*	*Ca*	*P*	*Ca:P Ratio*
1100-lb Lactating Cow	21.6#	2#	12.1#	27g	22g	1:1
Hall Pasture	21.6#	1.6#	9.3#	48.1g	9.8g	5:1
Pigpen Pasture	21.6#	1.3#	10#	48.1g	6.9g	7:1
M&M 1 Pasture	21.6#	1.6#	9.7#	74.5g	11.8g	6:1

Assuming our example cow meets her dry matter requirements, all pastures were short on crude protein and Total Daily Nutrients. All pastures exceeded the necessary calcium requirements and fell short on phosphorous, which is the norm on the Merlin Ranch.

The calcium to phosphorous ratio is important because calcium has a tendency to make phosphorous unavailable in a cow's system. Ratios that exceed 7:1 can therefore result in health problems like open cows. None of the pastures assessed in 2018 showed a Ca:P ratio that was too high.

Nutrient Management Recommendations

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. Further, seasonal variations in nutrient content of forage are normal. This provides variety in the diet and likely meets the cow's needs, including those critical crude protein levels.

The Merlin 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 requirements 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.

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APPENDIX: DETAILED MONITORING METHODS

The same suite of monitoring methods was repeated at each monitoring site visited during the summer 2016 monitoring effort. A 200-foot tape measure, laid along the soil surface, served as the basis of the monitoring protocol, and represented the transect line. A five-gallon bucket lid was nailed to the soil surface to permanently mark the beginning point of each transect (Figures 1).

FIGURE 1: *An example of the type of five-gallon bucket lid used to mark the beginning of each transect line.*

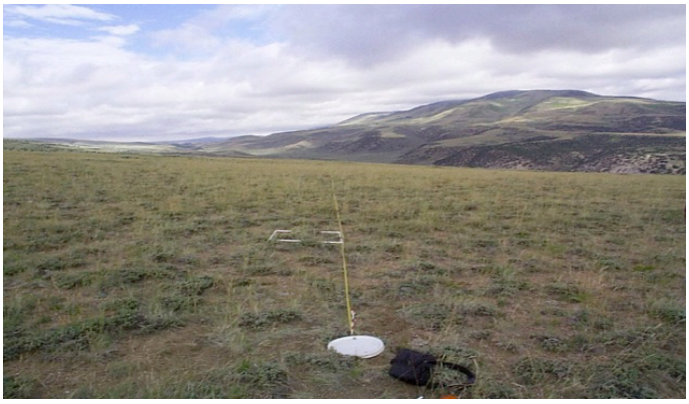

FIGURE 2: *An example of a permanent, 200-ft transect. Note the bucket lid marking the beginning point.*

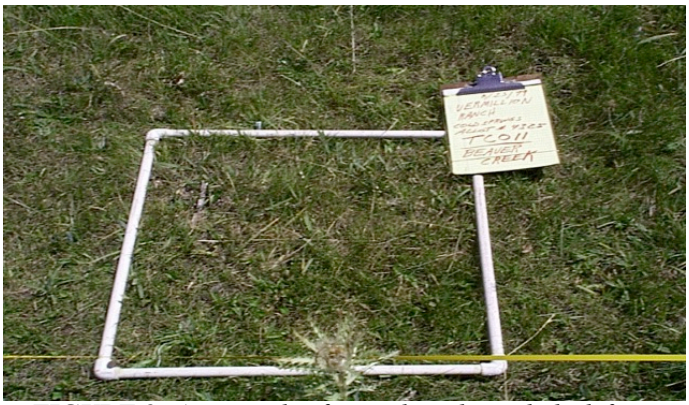

FIGURE 3: *An example of a quadrat plot with the left-hand, lower corner aligned with the 10-meter mark on the tape.*

Photographs of each transect (Figure 2), as well as of a 4.8 square foot quadrat placed at the 10-foot mark along the transect (Figure 3) were taken at each site.

Each assessment began with a qualitative examination of rangeland health using the Bullseye method developed by Gadzia & Graham (2009). This approach was based on several valuable sources, but one worthy of mention here is the 1994 report *Rangeland Health* by the National Research Council. This report 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 qualitative rangeland health indicators used in this initial assessment describe functionality in four fundamental ecosystem processes: the water cycle, mineral cycle, successional process, and energy flow.

An effective water cycle requires covered soil and high biodiversity. When effective, most water soaks into soils quickly where it falls, without running off. Later, this moisture is released slowly through plants that transpire it, or through rivers, springs, and aquifers that collect through seepage what the plants don't use. When biodiversity is reduced and soils

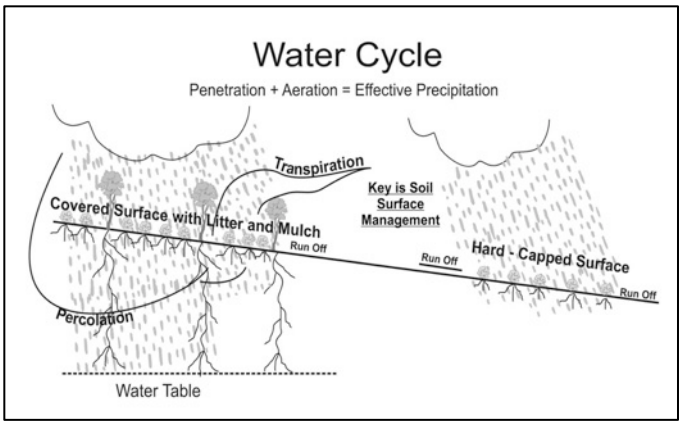

FIGURE 4: *A visual of the water cycle.*

exposed, much water runs off the soil surface. What little soaks in is released rapidly from evaporation which draws moisture back up through the soil surface (Figure 4; Savory, 1993).

The water cycle was described as either "effective," or "ineffective." If the water cycle was described as effective, then precipitation appeared to be moving into the soil and evaporation from the soil surface was minimal. Conversely, sites with an ineffective water cycle displayed signs of water leaving the site, such as 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 continuously between living plants and living soil. When soil is exposed and biodiversity low, nutrients become trapped at various points in the cycle, or are lost to wind and water erosion (Figure 5; Savory, 1993).

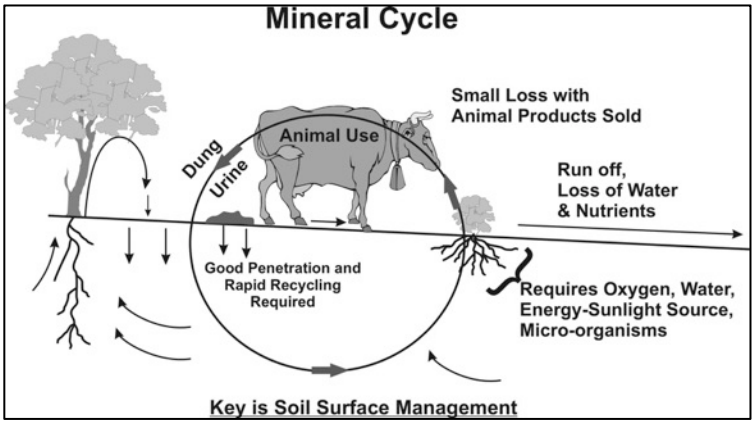

FIGURE 5: *A visual of the mineral cycle.*

In the monitoring report, the *speed* of the mineral cycle was described. If the cycle was moving slowly, then nutrients were not moving back into the system. An indicator of this would be past years' plant growth (known as litter) either elevated above the soil surface or lying idly on the soil surface and showing signs of oxidation rather than decomposition. Ideally, litter should contact the soil surface where soil-borne organisms of decay may begin to break it down and speed the re-utilization of nutrients in the system.

With few exceptions, ecological communities tend to cycle through processes of building complexity in response to disturbances, which tend to reduce complexity. From unstable bare ground, where biodiversity is low, stable complex range or forest communities, high in biodiversity tend to develop over time (Figure 6; Savory, 1993). This is succession.

The plant communities composing a site help characterize past management actions as well as shape current expectations for land and livestock performance. Thus, in this monitoring report, plant community composition was described and classified as high seral (meaning desirable), mid seral (neither desired nor undesired), and low seral (weedy or less desired). Importantly, indicators like the presence of seedlings and young plants of different species represent early changes in plant communities likely to become evident in coming years. Such observations further inform management expectations.

Almost all life requires energy that flows 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

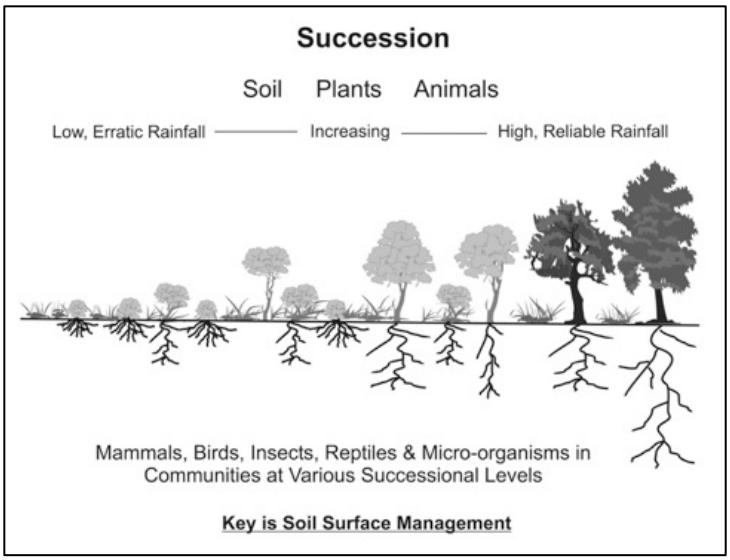

FIGURE 6: *A visual of the successional process.*

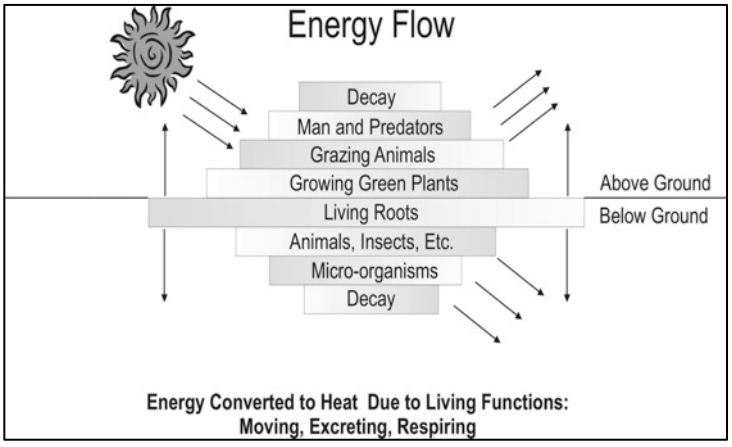

FIGURE 7: *A visual of the flow of energy through ecological systems.*

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 final product provides management with a visual portrayal of ecosystem function at a given point in time. More information on the Bullseye Target method of scoring can be viewed online at: http://ranchadvisory.com/rangelands-monitoring.

In addition to the qualitative methods described above, several quantitative methods were part of the monitoring process. First, a custom soil survey was generated for the sample area using NRCS's Web Soil Survey

whatever eats them, and in turn whatever eats the consumers of plants. Energy doesn't cycle, but flows through the ecosystem until it is consumed (Figure 7; Savory, 1993).

In this report, energy flow was described as "elevated," "moderate," or "reduced." Sites with elevated levels of energy flow showed signs that much solar energy was being captured by living plants and that much photosynthesis was occurring. The indicators of elevated energy flow include robust canopy cover, high plant vigor, and high plant stature. Conversely, sites with reduced energy flow showed signs that much sunlight energy was striking the soil surface and not being captured. These sites displayed higher levels of bare ground (relative to expectations for the ecological site and to current climatic conditions), lower plant canopies, vigor and stature.

A rangeland health qualitative scoring guide accompanies this document (shown on pages below) that describes the parameters by which each of the 14 indicators was evaluated. Each indicator was assigned a "score" relative to its degree of functionality. Each score has an associated color and position on the "Bullseye Target," providing an efficient, but effective means of characterizing the condition of a site (Figure 8).

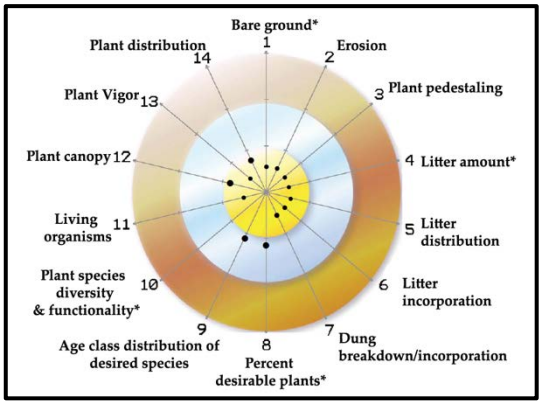

FIGURE 8: *The Bullseye Target provides a representation of the 16 indicators of rangeland health assessed during the qualitative component of the monitoring effort.*

(http://websoilsurvey.nrcs.usda.gov/app/HomePage.htm). The custom report generated 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 community composition, functional and structural groups, and expected levels of erosion, bare ground, and litter cover can be reviewed and compared to current conditions.

Second, various data were collected at each site along a permanent transect of 200 feet. The data in the charts entitled ***Predominant Plant Species by Weight*** provide a measure of plant species composition by most productive species. Ten quadrats were evaluated every 20 feet starting at the 10-foot mark to determine which species produce the most biomass by weight. The top five most abundant species by weight were estimated within each quadrat with the most abundant species receiving a score of 5 and the least abundant receiving a score of 1. The combined scores yield a percent composition by species for each monitoring site, and the top five most abundant plant species by weight were presented in a chart like the one portrayed below in Figure 9.

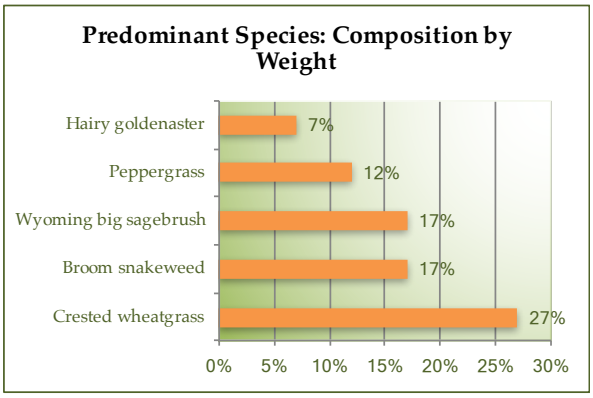

FIGURE 9: *An example of the data presentation for the most abundant plant species by weight. This provides information on the composition of the most productive species at a site.*

The 200-foot transect was also used as the basis for collecting data on ground cover, relative basal plant spacing by species (an assessment of those species with the broadest basal areas), and canopy cover by species using the ***line-point intercept method***. With this method, a steel rod or sturdy metal wire was lowered to the soil surface at every other foot along the tape measure (Figure 10) for a total of 100 points. At each point where the wire touched the ground, ground cover was recorded as either bare soil, litter (dead plant material), a living plant, or rock/gravel. The data from all 100 points were compiled and the percentage of each ground cover type calculated to yield a pie chart like the one portrayed in Figure 11.

FIGURE 10: *A visual of the line-point intercept method in action.*

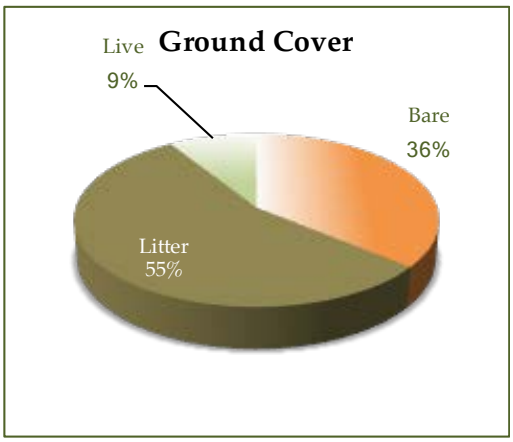

FIGURE 11: *An example of the ground cover chart generated from the line-point intercept data.*

In addition to ground cover data, the line-point intercept method was used to collect information on the most abundant perennial plant species covering the soil surface. At each point where the wire was lowered to the ground, the distance to the nearest perennial plant was measured and the species recorded. This data was compiled for all 100 points and the distance to each species averaged. The top seven most basally abundant species encountered were portrayed in a chart like the one in Figure 12. This data provides another look at species composition, but from the perspective of basal area rather than productivity.

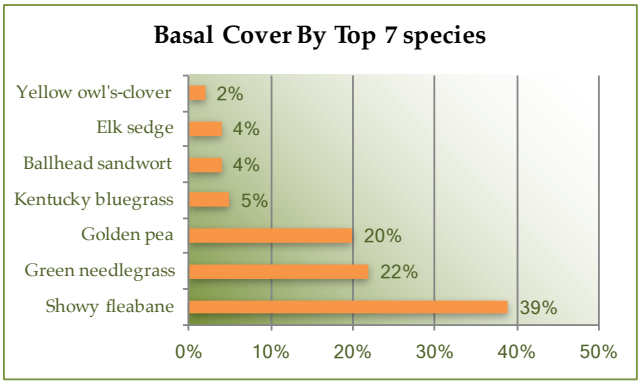

FIGURE 12: *An example of the basal cover graph. In this instance, showy fleabane was the most abundant plant on the soil surface, accounting for 39% of the total basal cover.*

ABOUT THE AUTHORS

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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