MERLIN RANCH:

2012 Monitoring Report for Tipperary, 3-Section, and Lower Hepp Pastures

Prepared for Merlin Ranch Management

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INTRODUCTION

This document presents the findings of three rangeland health monitoring transects examined on Merlin Ranch in August 2012. These sites were located in the Tipperary, 3-Section, and Lower Hepp pastures. All three sites had been established in prior years, and the 2012 effort represents a re-read of the sites to determine rangeland health trend. Data from past readings will be displayed side-by-side with 2012 data.

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

Much discussion will be made concerning the function of four fundamental ecosystem processes. These are the water cycle, mineral cycle, energy flow, and successional process. These are reviewed graphically in the Methods section. Management may influence the function of these processes by altering such variables as stocking rate, stock density, grazing duration, recovery times between grazings, utilization rate, and timing of grazings. Data presented in this report will show how these variables interact with function of ecosystem processes, and how management may improve their interaction for the improvement of pasture performance, wildlife habitat, and profitability.

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

Merlin Ranch Transect Readings	
Year	***Site Name***
2006	Hall Pasture Hall Homestead
2007	Three Section Tipperary
2008	Pigpen Lower M&M #1
2009	Hall Homestead Tipperary
2010	Hall Pasture Three Section Lower Hepp
2011	Lower M&M #1 Lawrence
2012	Tipperary Three Section Lower Hepp

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

SUMMARY OF FINDINGS AND MANAGEMENT RECOMMENDATIONS MADE IN THIS DOCUMENT

Summary findings from each of the three 2012 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.

Tipperary – MRT10

This site was chosen in 2007 to be representative of the Tipperary pasture. It lies on the shoulder of a slope that best represents the mix of hills, slopes, and bottoms found in the area. Since the site was established, additional fencing was added to divide the pasture into smaller units, effectively increasing stock density, shortening grazing durations, and lengthening plant recovery periods between grazings.

Highlights of changes since 2007 include:

- Bare ground fell by 86%.
- Live cover increased by 100%.
- Relative spacing between perennial plants declined by 44%, suggesting more perennial plants were growing on the soil surface.
- Relative basal cover of mid-seral species like Western wheatgrass increased by 186%. These mid-level plants appeared to be moving aggressively into the site.
- Relative basal cover of highly desired bunchgrasses like bluebunch wheatgrass and needleandthread declined. This was undesired change.
- Few undesired species like cheatgrass and Japanese brome were observed in 2012.
- Plant productivity was nearly constant between 2007, a wet year and 2012, a dry year, suggesting a strong improvement in the effectiveness of the water cycle.
- Big sagebrush appeared to be in rapid decline, with 10% of the plants encountered decadent. Many more appeared dead in the area.

New fencing in 2008 greatly increased stock density and the use of animal impact in this pasture. This change has been positive, and the improved water cycle is the first signal of the management change. Plant vigor appeared high, even in the dry year of 2012, further evidence of positive changes occurring. The next step in the improvement of this pasture will be desired shifts in plant species composition. Management will enable these shifts by continuing to implement short grazing durations, especially in the spring green-up months. Achieve moderate utilization levels of forage, and ensure that recovery times between grazings are lengthy. If possible, use mineral tubs and/or salt blocks to concentrate hoof action in areas where big sage plants are dying. This will help speed the mineral cycle and should also hasten the successional process.

Three-Section – MRT11

This site was established in 2007 and lies nearly in the middle of the Three Section Pasture. The pasture consists of large draws, rolling hills, and bottomland. Much of the pasture occurs in shallow loamy soils. This site was chosen due to its abundance of plant growth and species diversity relative to other reaches of the pasture. The

pasture was treated with a Lawson Renovator in spring 2009, and the machine made two large swaths across the transect site. Highlights of changes since 2007 include:

- Bare ground has fallen from 16% to 1%.
- Live cover has also fallen in this time, which is undesired change. It is possible that the Lawson treatment disturbed the plant crowns of species growing at the site, and they have not recovered from the treatment.
- Spacing between perennial plants has fallen by one-half inch, a positive change.
- Mid-seral species like Western wheatgrass and prairie junegrass have greatly increased, while the presence of highly desired grasses like needleandthread and green needlegrass declined. This represents undesired change, which may signal those desired species had not yet recovered from the Lawson treatment.
- Plant productivity in the dry year of 2012 was slightly higher than the wet year of 2007. This points to a more effective water cycle, a sign of improvement.

This site appeared to still be recovering from the Lawson treatment. While the water cycle was effective and mineral cycle was rapid, the successional process was still correcting. Desired perennial bunchgrasses and new plants like four-wing saltbush appeared to be propagating on the soil surface, and management should give them every opportunity to succeed. This will best be accomplished by ensuring that any spring grazing duration remain short. If this pasture is grazed in springtime, keep the grazing duration short, and let it them recover from that initial bite. Spring grazing is acceptable in the pasture, and the animal impact at that time of year will be beneficial.

Should the pasture be grazed later in the growing season, management must ensure that utilization rates remain at moderate levels (30 – 50% of standing crop). This will allow plenty of plant material to remain behind as a litter source, maintain the water cycle, and help provide germination sites for those desired perennial bunchgrasses needing to grow more on this site.

Lower Hepp

This site was established in 2010 in an area that had not known much historic grazing. For some reason, cattle chose other areas of the pasture, largely ignoring this particular area. In an effort to correct this distribution issue, a stock water tank was located roughly 0.25 miles from the site, and new fencing was added to help move cattle into this area. This transect will help track changes in the area with increased use by livestock. Highlights of change since 2010 include:

- Bare ground fell from 20% to 4%.
- Percent live cover did not change.
- Relative basal plant spacing did not change.
- Mid-seral plant species increased strongly, and some highly desired species decreased. These data suggest an active successional process with mid-seral species responding to the more effective water cycle. More change in this plant community should be expected.

- Plant productivity was nearly identical between the wet year of 2010 and the dry year of 2012. This is a further indication of an improving water cycle.

When new fencing and stock water were added, the expected flourish of undesired species like Japanese brome and cheatgrass did not occur here. This flush of the undesired species has been commonly observed on Merlin, but it didn't happen in this portion of Lower Hepp. The low bare ground amount may have influenced this, as could the dry year of 2012. With the propagation of mid-seral species, the water cycle should become more effective, and management should continue to ensure that grazing practices promote the growth of more desired perennial bunchgrasses. This is accomplished through short spring grazing durations, moderate levels of utilization, and recovery times between grazings are lengthy. Increase the use of animal impact by placing salt blocks in portions of Lower Hepp. This will help speed the mineral cycle and should enable the successional process.

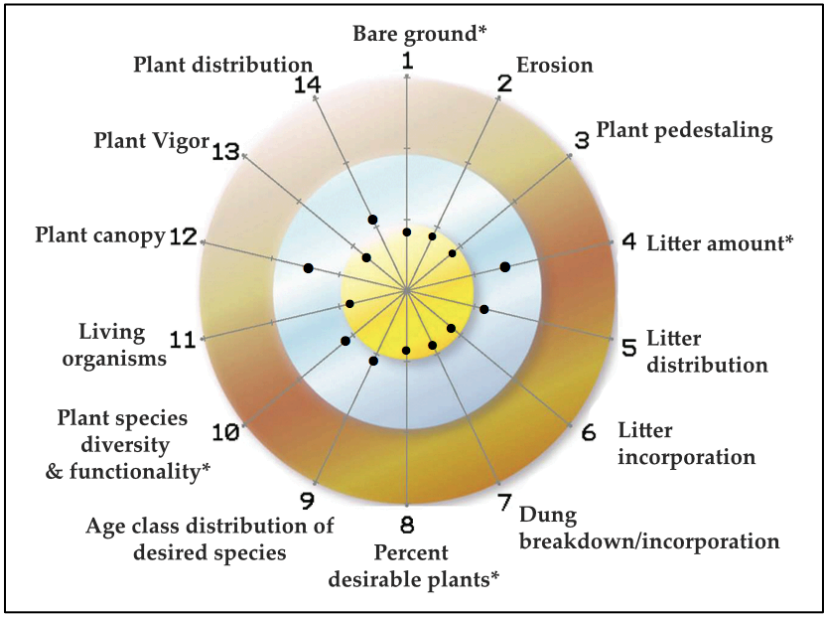
Detailed summaries of the three transect sites may be seen in the pages that follow.

Tipperary Pasture

MRT10

Data Comparisons

Bullseye Rangeland Health Target



This site was chosen in 2007 to be representative of the Tipperary pasture. The site lies on the shoulder of a slope that best represents the mix of hills, slopes, and bottoms found in the area. Since the site was established, additional fencing was added in the area that divided the pasture into smaller units, effectively increasing stock density, shortening grazing durations, and lengthening plant recovery periods between grazings.

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

The **water cycle** was effective at the Tipperary site, but the **bare ground** amount could still be decreased. No signs of **erosion** were observed, and no **plant pedestals** were observed.

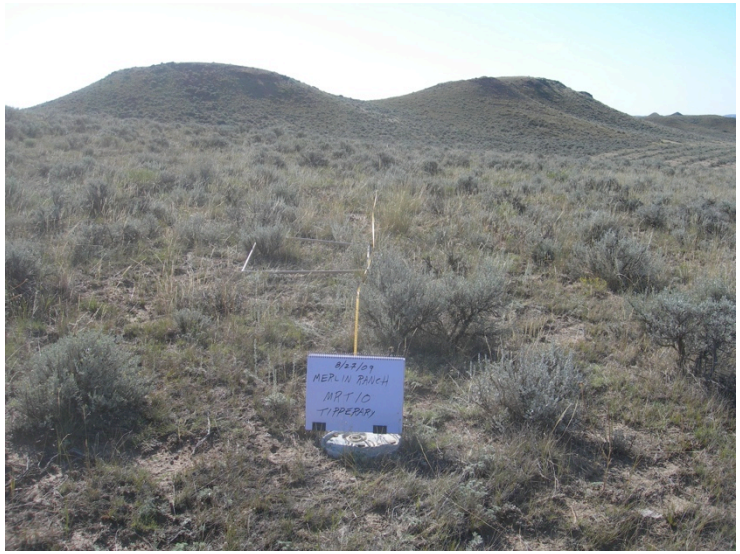
The **mineral cycle** was rapid, but room for improvement existed. A greater **litter amount** was desired to help cover that remaining bare soil, and **distribution** of litter was less than desired. Litter was **incorporating** well with soil, suggesting a rapid breakdown rate. Area **dung piles** appeared to be less than one year old, again suggesting rapid break down.

Within the **successional process**, **desired species** were present, but not in the abundance desired. Photos below will show the prominent decline in the site's big sagebrush population, which may allow for increased opportunity for those desired plants to propagate. No undesired species like cheatgrass and Japanese brome were observed. Additional forbs were also desired here.

In the dry summer of 2012, **energy flow** was high. While the **plant canopy** was minimal (see photos below), **plant vigor** was high, and plants were well **distributed** across the soil surface. These indicators also suggest the water cycle was functioning effectively.

Transect view. Photo taken August 16, 2007.

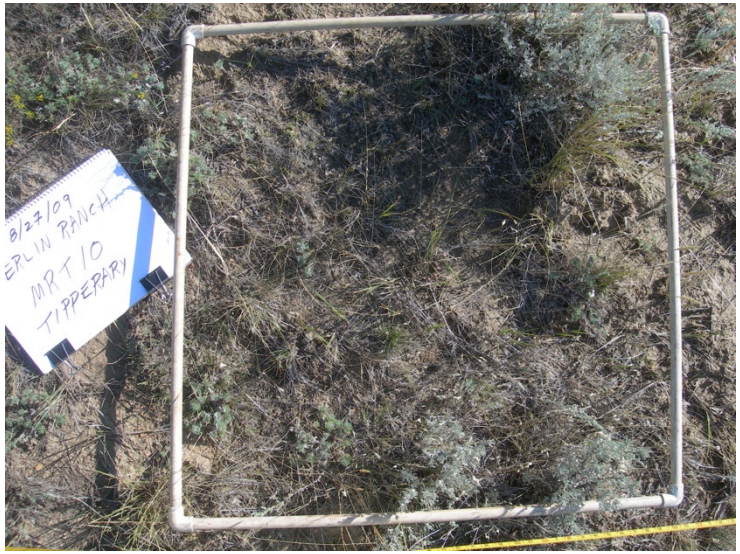
Transect view. Photo taken August 23, 2012.



Transect view. Photo taken August 27, 2009.

Quadrat view. Photo taken August 16, 2007.

Quadrat view. Photo taken August 23, 2012.



Quadrat view. Photo taken August 27, 2009.

BASAL COVER

2007	2009	2012	
52%	40%	7%	Bare
44%	55%	85%	Litter
4%	5%	8%	Live

ADDITIONAL INFORMATION

Site sampled August 16, 2007.
Site sampled August 27, 2009.
Site sampled August 23, 2012.

RELATIVE BASAL PLANT SPACING - inches

2007	2009	2012
1.8	1.6	1

RELATIVE BASAL PLANT SPACING BY SPECIES (TOP 7 SPECIES)

2007		2009		2012	
Bluebunch wheat	28%	Western wheatgrass	20%	Western wheatgrass	40%
Threadleaf sedge	18%	Prairie junegrass	20%	Threadleaf sedge	16%
Western wheatgrass	14%	Bluebunch wheat	10%	Bluebunch wheat	9%
Blue grama	11%	Threadleaf sedge	10%	Sandberg bluegrass	9%
Needleandthread	6%	Big sagebrush	7%	Prairie junegrass	6%
Scarlet globemallow	5%	Hood's phlox	7%	Hood's phlox	5%
Big sagebrush	5%	Needleandthread	5%	Fringed sage	4%

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

2007		2009		2012	
Big sagebrush	33%	Big sagebrush	32%	Big sagebrush	32%
Bluebunch wheat	20%	Vetch species	13%	Prairie junegrass	18%
Threadleaf sedge	15%	Bluebunch wheat	12%	Western wheatgrass	14%
Japnese brome	8%	Western wheatgrass	11%	Bluebunch wheat	10%
Western wheatgrass	7%	Prairie junegrass	9%	Vetch species	8%

PRODUCTION: Lbs per acre

2007	2009	2012
320	400	320

PLANT SPECIES FOUND IN TRANSECT AREA

2007	2009	2012	
30	***26***	***19***	***Total count***
X	X	X	Cheatgrass
X	X	X	Japanese brome
X	X	X	Bluebunch wheatgrass
X	X	X	Threadleaf sedge
X	X	X	Western wheatgrass
X	X	X	Blue grama
X		X	Sandberg bluegrass
X			Kentucky bluegrass
X	X		Needleandthread
X	X	X	Prairie junegrass
X	X		Scarlet globemallow
X	X	X	Pricklypear cactus
X			Stickseed
X	X		Lepidium (White alyssum)
X	X	X	Hood's phlox
X	X	X	Vetch species
X			Woolly plantain
X			Clover species
X			Senecio species
X			Aster species
X			Mustard species
X			Nailwort
X	X		Vagrant lichen
X	X		Salsify
X	X	X	Broom snakeweed
X	X	X	Big sagebrush
X	X	X	Fringed sage
X	X		Douglas rabbitbrush
	X	X	Green needlegrass

PLANT SPECIES CONTINUED

2007	2009	2012	
	X	X	Penstemon species
	X		Povertyweed
	X		Sunflower species
	X		Curlycup gumweed
	2		Other vetch species
2	0		Unknown perennial forbs
		X	Sixweeksgrass
		X	Tapertip hawskbeard
		X	Rubber rabbitbrush

BIG SAGEBRUSH DATA

2007	2009	2012	
			Line intercept:
35	36	28	*Number of big sage plants encountered*
			Line Intercept: Age Class Distribution
0%	0%	0%	seedling
0%	3%	0%	young
100%	89%	90%	mature
0%	8%	10%	decadent
15.2	12.9	12	*Average plant height - inches*
19%	20%	16%	*Percent canopy intercept*
127	106	79	*Density per 1000 square feet*

Photos
Refer to the transect photos above and note the decline in big sagebrush plants. As will be discussed in greater detail below, this species' presence was declining through the years, and this is apparent in the photos. A glance down the tape measure in the transect view photos reveals individual big sagebrush plants that have left the community since the site was established in 2007. Simultaneously, the amount of bare soil appears to decline. More litter and live plant cover is evident at this site. Plant vigor appears high in all three years, even though 2012 was a dry year. This high plant vigor suggests the water cycle was functioning effectively.

The quadrat photos also show the decline in bare soil experienced at this site. Much bare soil is evident in the 2007 site photo, while the soil surface at this same spot was well covered in 2012. Again, this suggests an improved water cycle since the site was first sampled in 2007.

Basal cover
Note the bare ground percentage in each sample year. This has declined steadily since the site was first sampled in 2007, resulting in a total bare ground decline of 86%. This was a large decrease. Simultaneously, live cover increased by 100%, which again shows a strong improvement at this site. These data portray a fairly rapid positive change.

Relative basal plant spacing
Correlated with that increase in live plant cover described above was a 44% reduction in relative basal plant spacing. This essentially means that more plants were found growing on the soil surface in 2012 than 2007, which again represents positive change. Ideally, that distance to the nearest perennial plant should be below one-half inch, so room for improvement also exists.

Relative basal plant spacing by species
With the strong improvement in plant spacing on the soil surface, what species filled in the gaps? The mid-seral species Western wheatgrass increased its relative presence by 186% since 2007. Likewise, threadleaf sedge, a moderately-desirable species also increased in relative spacing. These data suggest the more middle-of-the-road species were moving into the site fairly aggressively. They appear to be colonizing the soil voids where sagebrush plants were dying. Of concern at this site was the decline in desired plants such as bluebunch wheatgrass and needleandthread. The relative abundance of these species could be declining due to the strong increase in mid-seral species following the death of big sagebrush (that is, more Western wheat is growing where big sagebrush died, so the relative amount of the desired plants declined), but only time will tell if this is the case. With the improvement in the water cycle, the presence of those desired bunchgrasses should be expected to increase in coming years.

Relative plant species composition by weight
Like the data set described above, the relative composition by weight data show an increase in mid-seral species like Western wheatgrass and prairie junegrass. Again, they appear to be moving into the areas left open by the death of big sagebrush. While desired species like bluebunch wheatgrass declined, so did undesired species such as Japanese brome. This undesired plant was only found minimally in the area. This data set shows rapid change in

the area that should continue in time. Ideally, the more desired species such as bluebunch wheatgrass, needleandthread, and desired forbs should begin increasing in presence when this site is read again in the future.

Production

The annual production figures show each sample year's production in pounds per acre. Note the small spike in production in 2009, followed by a return to the same level of production in 2012. What is truly noteworthy is that 2007 was a wet year (see the Buffalo climate summaries at: http://www.wrcc.dri.edu/cgi-bin/cliMAIN.pl?wy1165), and both 2009 and 2012 were drier years. In fact, 2012 precipitation was roughly 5 inches below the average, and plant production was still the same as it was in the wet year of 2007. As was described above, this represents an effective water cycle. If moisture conditions improve in the future, look for increased productivity in this pasture. This has strong implications on stocking rate, herd size, and revenue generation potential.

Plant species

The number of plant species found in the transect area declined dramatically since the site was first sampled in 2007. However, a glance at this data set shows that 15 of the missing species were forbs, which likely did not grow well in the dry year of 2012. Thus, this decline in plant species does not present cause for alarm. It simply means that those plants did not grow well. That being said, management should take a look at this area in 2013 to check for the presence of various desired forbs. Those species should be found in this area with decent spring moisture.

Big sagebrush data

This data set shows a steadily declining big sagebrush community. The number of big sage plants, height, canopy, and density were all declining. For unknown reasons, big sagebrush was struggling at this site. The photo below shows one big sage plant of many that appeared to be failing at this site. This decadent plant may be dead in coming years, and seedheads from the colonizing species prairie junegrass are readily apparent in this photo. We cannot explain why the big sage is dying here, but it appeared to be doing so rapidly.

The decline in big sagebrush does not require management's attention, for the decline may be cyclical in nature. In a few years, overall plant species composition may have changed dramatically because of this decline.

Range trend

Trend here was upward. The steep decline in bare ground, the increase in live cover, and improved basal spacing all suggest improved water cycling. The increased presence of mid-seral species also reveals the successional process was readily active at this site, and continued change is expected.

Management recommendations

Given the decline in big sagebrush in this area, management is presented with a terrific opportunity to help improve this community's overall level of rangeland health. The addition of new fencing in 2008 that greatly increased stock density, shortened grazing durations, and increased recovery periods between grazings was a good move. Those grazing variables also appear to have been applied correctly, or these data sets would not show the positive changes that they do. Further, indicators such as plant vigor would not have appeared as strongly as they did had variables such as grazing duration and recovery period not been managed well. Thus, management should continue practicing short grazing durations, lengthy recovery times between grazings, and utilizing high stock densities in coming years. This should help maintain the strong water cycle found at the site, and, in time, the highly desired perennial bunchgrasses should increase in presence.

Management may speed change at this site by applying strategic animal impact. Speed the mineral cycle by breaking up a salt block in the area and letting cattle trample the soil surface as they compete for that block. Their hooves will disturb the soil surface, improve litter distribution and the litter amount all at the same time.

Early-warning indicators

If management actions are improperly applied here, look first for reductions in plant vigor, increased bare ground, and increased erosion. These are all signs that grazing durations have been too long, utilization rates have been too high, and/or recovery periods between grazings have been too short. If larger issues exist with the grazing management program, look for undesired shifts in species composition away from highly desired grasses and toward more early-seral species.

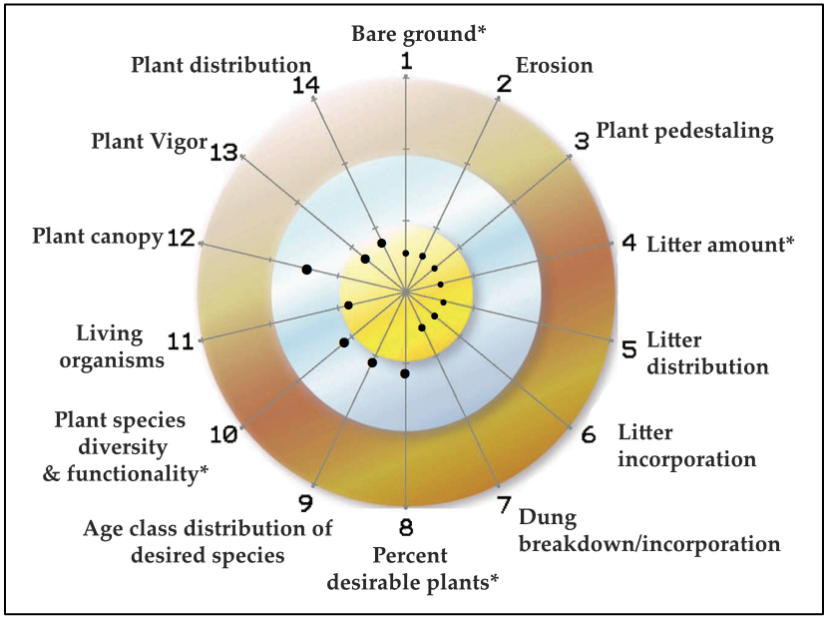
If management actions are properly applied, look first for maintained plant vigor, even in dry years. Look for continued declines in bare ground, increased litter amount, and reduced spacing between plants. These all suggest positive change is occurring. Expect more mid-seral plants in coming years if big sagebrush continues to decline. With continued good management, increases in the desired species will be apparent in the next three to five years.

3-Section Pasture

MRT11

Data Comparisons

Bullseye Rangeland Health Target



This site was established in 2007 and lies nearly in the middle of the Three Section Pasture. The pasture consists of large draws, rolling hills, and bottomland. Much of the pasture occurs in shallow loamy soils. This site was chosen due to its abundance of plant growth and species diversity relative to other reaches of the pasture. The pasture was treated with a Lawson Renovator in spring 2009, and the machine made two large swaths across the transect length.

The **water cycle** was effective with minimal **bare soil**, no signs of **erosion**, and no **plant pedestaling**. Precipitation appeared to be entering the soil surface, rather than running off.

The **mineral cycle** was fast. The **litter amount** was optimal, litter was well **distributed** across the soil surface, and litter **incorporation** was strong. Further, area **dung piles** appeared to be less than one year old. All these indicators suggest nutrients were cycling rapidly in the system.

Within the **successional process**, desired plant species were present, but not in the appropriate abundance. Few undesired plants were found here, which was a positive finding. Some younger members of desired grasses were observed, but not many. This may have much to do with the dry year of 2012. The big sagebrush community displayed some decadent plants and few young recruits, which is a marked contrast from the Tipperary Pasture not far away. Desired species like green needlegrass appeared to be increasing in the community as evidenced presence of younger **age classes** of this species. The dry year reduced **plant species diversity** as forbs found in prior years were absent in 2012.

In the dry summer, **energy flow** was at moderate levels. Photos below will show a reduced plant canopy that appeared to be lacking moisture. But, relative to recent climatic conditions, **plant vigor** was high. Plants had produced seed, and some even displayed green color.

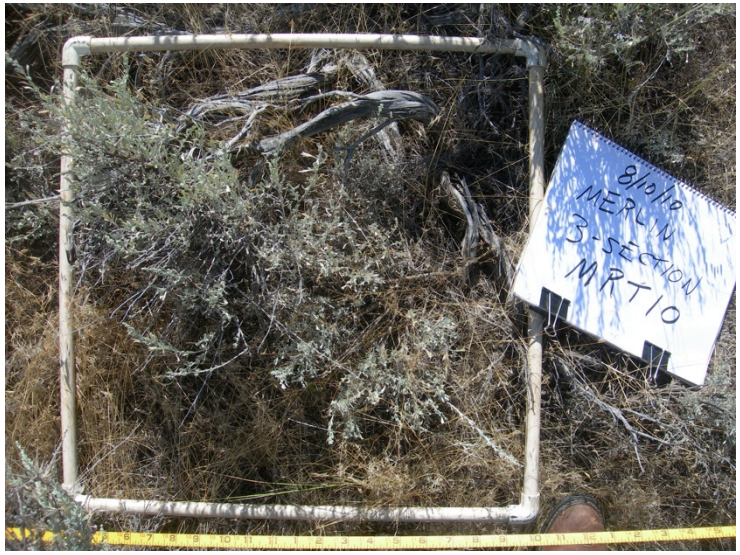
Transect view. Photo taken August 17, 2007.

Transect view. Photo taken August 23, 2012.


Transect view. Photo taken August 10, 2010.

Quadrat view. Photo taken August 17, 2007.

Quadrat view. Photo taken August 23, 2012.



Quadrat view. Photo taken August 10, 2010.

BASAL COVER

2007	2010	2012	
16%	8%	1%	Bare
79%	88%	98%	Litter
5%	4%	1%	Live

ADDITIONAL INFORMATION

Site Sampled August 17, 2007
Site Sampled August 10, 2010
Site Sampled August 23, 2012

RELATIVE BASAL PLANT SPACING - inches

2007	2010	2012
2.3	2.6	1.7

RELATIVE BASAL PLANT SPACING BY SPECIES (TOP 7 SPECIES)

2007		2010		2012	
Western wheatgrass	34%	Western wheatgrass	47%	Western wheatgrass	71%
Big sagebrush	13%	Needleandthread	12%	Big sagebrush	10%
Blue grama	10%	Big sagebrush	11%	Prairie junegrass	8%
Sandberg bluegrass	8%	Western yarrow	8%	Green needlegrass	4%
Kentucky bluegrass	7%	Prairie Junegrass	7%	Needleandthread	3%
Needleandthread	5%	Sandberg bluegrass	5%	Western yarrow	2%
Prairie junegrass	5%	Scarlet globemallow	3%	Scarlet globemallow	1%

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

2007		2010		2012	
Big sagebrush	33%	Big sagebrush	33%	Big sagebrush	31%
Japanese brome	15%	Cheatgrass	15%	Western wheatgrass	23%
Green needlegrass	11%	Japanese brome	15%	Japanese brome	14%
Cheatgrass	10%	Western Wheatgrass	12%	Cheatgrass	10%
Sandberg bluegrass	9%	Prairie junegrass	10%	Needleandthread	7%

PRODUCTION: Lbs per acre

2007	2010	2012
330	900	340

PLANT SPECIES FOUND IN TRANSECT AREA

2007	2010	2012	
26	*27*	*15*	*Total count*
X	X	X	Cheatgrass
X	X	X	Western wheatgrass
X	X	X	Green needlegrass
X	X	X	Japanese brome
X	X		Sandberg bluegrass
X	X	X	Prairie junegrass
X	X	X	Needleandthread
X	X		Bluebunch wheatgrass
X	X		Blue grama
	X		Sixweeksgrass
X	X	X	Big sagebrush
X	X	X	Fringed sage
	X		Greasewood
X	X		Rubber rabbitbrush
X	X		Mustard species
X	X	X	Scarlet globemallow
X	X		Salsify
X	X	X	Pricklypear cactus
X	X	X	Western yarrow
	X		Vetch species
	X		Peppergrass
	X		Sego lily
X	X	X	Broom snakeweed
X	X		Dandelion
	X		Plains goldenaster
	X		Curlycup gumweed
3	X	X	1 unknown perennial forb
X		X	Tanysmustard
		X	Four-wing saltbush

PLANT SPECIES CONTINUED

2007	2010	2012	
X			Hood's phlox
X			Lepidium
X			Stickseed

Big sagebrush data

2007	2010	2012	
			Line intercept:
43	41	41	*Number of Big sagebrush plants encountered*
			Line Intercept: Age Class Distribution
0%	0%	0%	seedling
0%	8%	0%	young
100%	77%	95%	mature
0%	15%	5%	decadent
27	20	18	*Average plant height - nches*
29%	24%	27%	*Percent canopy intercept*
152	135		*Density per 1000 square feet*

Photos
See the site photos above and note the strong plant vigor shown in all the photos. Notably, 2007 was a wet year, and 2012 was dry. Plant vigor and overall productivity appear somewhat constant between the two photos. These photos suggest the water cycle was functioning optimally. Even seedheads are evident in the 2012 photo, which would not be present in this dry year if the water cycle were not effective.

In both the 2010 and 2012 photos, a Lawson Renovator path is barely visible along the transect line. The machine crossed the transect line at an angle through this area.

The quadrat photos show some changes in the big sagebrush community. The prominent plant in the quadrat's center died and was replaced by two smaller plants along the quadrat's edge. This shows the slow turnover observed in the big sage community.

The quadrat photos also reveal undesired species like Japanese brome and cheatgrass in all three sample years. By looking at the photos, these species do not appear to have declined in abundance.

Basal cover
The percent bare soil dropped from 16% to 1% since 2007, a positive sign. The percent litter cover continued to climb, which was another positive sign, but live plant cover fell. This was undesirable change, suggesting plants with large bases like sagebrush and bunchgrasses may be leaving the community. This may also be due to the Lawson treatment, where the renovator's teeth could have split the crowns of bunchgrasses, and they may need more time to recover. The dry year of 2012 likely did not speed this process.

Relative basal plant spacing
The distance between perennial plants fell by over 0.5 inches since the site was first sampled in 2007, suggesting more plants were growing on the soil surface. This represented positive change.

Relative basal plant spacing by species
Much change may be seen in this data set. First, mid-seral species like Western wheatgrass and prairie junegrass both increased their relative abundance. These may be colonizing the areas impacted by the Lawson treatment. Second, desired species like needleandthread declined between 2010 and 2012, after spiking since 2007. This was not positive change. Third, highly desired species like green needlegrass increased their relative contribution, with this species making the list for the first time. This suggests positive change. This mixed results data set shows that the successional process was quite active and that continued change should be expected here.

Relative plant species composition by weight
Even with the Lawson treatment, the relative contribution by weight of big sagebrush, cheatgrass, and Japanese brome changed little since the site was first sampled. This is surprising, for a disturbance such as the Lawson should create much opportunity for change in plant species composition. Western wheatgrass continued to increase in this data set, which suggests this species is aggressively colonizing the areas disturbed by the Lawson machine. Note that the highly desired species green needlegrass fell

from the community's list of top five most abundant plants by weight. This is undesired change. Conversely, the highly desired needleandthread grass appeared to be increasing, suggesting positive change. One desired plant was replacing another. Again, these data show a plant community responding to a disturbance like the Lawson renovator, and continued change should be expected here in the future. Ideally, more desired grasses and forbs will be seen on this list in coming years.

Production

As was stated in the Tipperary Pasture discussion, 2007 was a wet year, 2010 was a nearly average precipitation year, and 2012 was a dry year. The production figures show high variation relative to the moisture year. Notably, the dry year of 2012 produced a bit more production than did the wet year of 2007. This again suggests the site had an effective water cycle and another wet year might yield high productivity in this pasture.

Plant species

The plant species list shows the number of species found in the transect area declined dramatically since 2010. One of the species notably absent was bluebunch wheatgrass, which was simply not found in 2012. Conversely, the highly desired species four-wing saltbush was found for the first time in 2012, which was a positive sign. Overall, most of the species not found in 2012 were forbs, or early-seral grasses that might be expected to struggle in a dry year. Given this site's effective water cycle, look for a rebound in forb numbers in this area in a wet year.

Big sagebrush data

The big sagebrush data set shows this species has not changed much since the transect was first read. This is surprising, given the disturbance to the big sage community caused by the Lawson treatment. Most measures show minimal change through time, but change could be coming to this area. Like other pastures sampled at Merlin, big sagebrush appeared to be in decline, and the 3-Section Pasture was no different. The age class distribution figures show some signs of decadent plants, and this could be a precursor of change to come. While the community appeared to be somewhat stable for now, look for continued changes in the future.

Range trend

Trend here was slowly upward. The main reasons include continued reductions in bare ground, strong improvements in relative basal plant spacing, and shifts in plant species composition. This site has improved its basic ecological functions of water cycle and mineral cycle. Improvements in the plant species composition and energy flow should be observed next.

Management recommendations

This site appeared to still be recovering from the Lawson treatment. While the water cycle and mineral cycles were effective and rapid, the successional process was still finding its direction. Desired perennial bunchgrasses and new plants like four-wing saltbush appeared to be propagating on the soil surface, and management should give them every opportunity to succeed. This will best be accomplished by ensuring that any spring grazing duration remains short. If those plants are grazed in springtime,

keep the grazing duration short, and then let them recover from that initial bite. Spring grazing should be acceptable in this pasture, and the animal impact should be beneficial, but keep grazing durations short.

Should the pasture be grazed later in the growing season, management must ensure that utilization rates remain at moderate levels (30 – 50% of standing crop). This will allow plenty of plant material to remain behind as a litter source, maintain the water cycle, and help provide germination sites for those desired perennial bunchgrasses needing to grow more on this site.

Early-warning indicators

If management actions are improperly applied, look first for reductions in plant vigor, more bare soil, and signs of erosion. These would indicate that utilization rates have been too high, and spring grazing durations have been too long. Should more undesired plant species increase and the desired plant species decline, then more issues with recovery period between grazings and timing of grazings are evident.

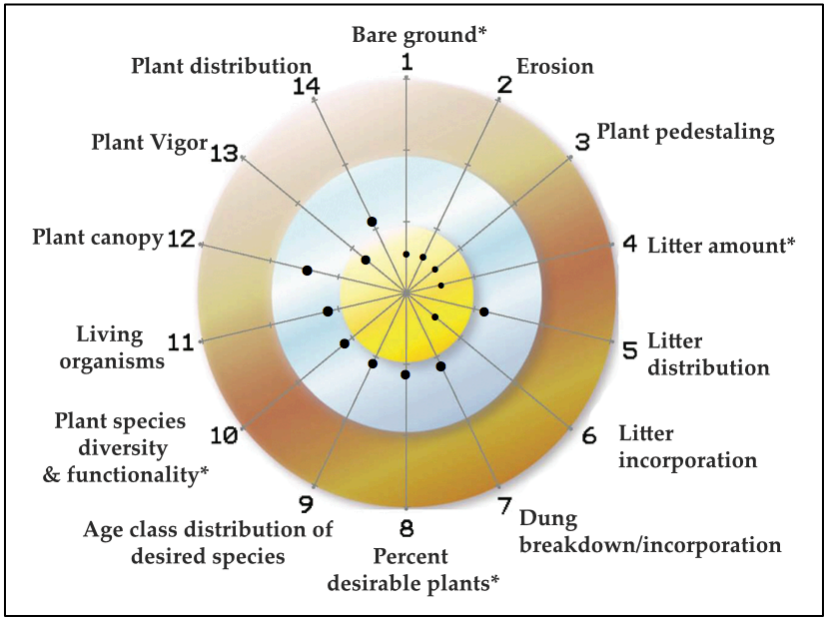
If management actions are properly applied, look for elevated plant vigor, even in dry years like 2012. Look for increased presence in desired species like four-wing saltbush, needleandthread, and green needlegrass. Such positive shifts in species composition suggest a good balance among grazing duration, recovery period, intensity, and frequency of grazing variables.

Lower Hepp

MRT21

Data Comparisons

Bullseye Rangeland Health Target



This site was established in 2010 in an area that had not known much historic grazing. For unknown reasons, cattle chose other areas of the pasture, largely ignoring this particular area. In an effort to correct this distribution issue, a stock water tank was placed roughly 0.25 miles from the site, and new fencing was added to help move cattle into this area. This transect will help track changes in the area with increased use by livestock.

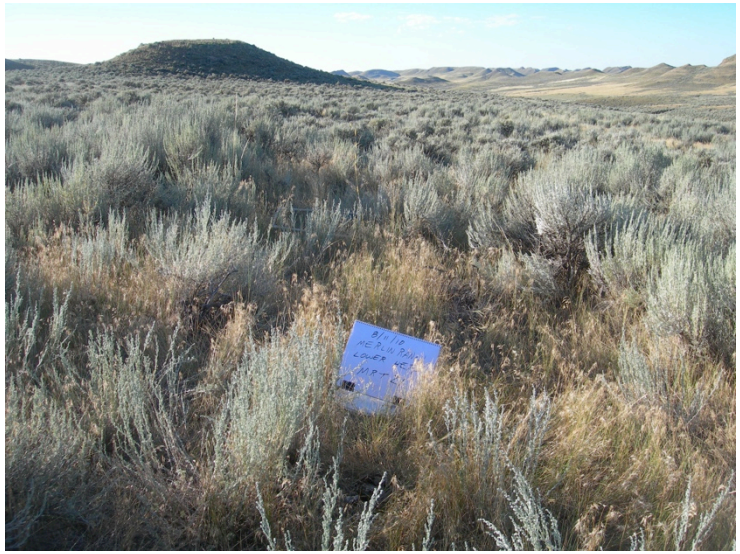
The **water cycle** was effective at this site with minimal **bare ground**, nearly no signs of **erosion**, and nearly no **plant pedestaling**. Any precipitation had opportunity to infiltrate the soil, rather than running off.

The **mineral cycle** appeared to be rapid. The **litter amount** was optimal, and litter was **incorporating** well. This suggests animal impact had been used appropriately since the new infrastructure of water and fence were installed. The **distribution** of litter had room for improvement, with some litter appearing clumped near big sage plants. Lastly, area **dung piles** appeared to be two years old or less.

The **successional** process was active on the site. Silver sagebrush appeared to be replacing itself in the community, with both young and decadent plants observed. The **percent desired plants** was moderate with too few desired species present, but very few undesired plants. **Diversity** was also moderate, as the dry year of 2012 likely reduced the growth of desired forbs.

Energy flow was moderate at the site. The photos below will show the reduced **plant canopy**, which likely resulted from the dry year of 2012. Relative to recent climatic conditions, **plant vigor** was high, with seedheads established, and some plants still green. Plants were not well **distributed** across the soil surface with open areas between perennial plants. Room for improvement existed here.

The site photos below show the site in both sample years of 2010 and 2012.



Transect view. Photo taken August 11, 2010.

Quadrat view. Photo taken August 11, 2010.

Transect view. Photo taken August 23, 2012.

Quadrat view. Photo taken August 23, 2012.

BASAL COVER

2010	2012	
20%	4%	Bare
75%	91%	Litter
5%	5%	Live

RELATIVE BASAL PLANT SPACING - inches

2010	2012
1.3	1.3

RELATIVE BASAL PLANT SPACING BY SPECIES (TOP 7 SPECIES)

2010		2012	
Western wheatgrass	52%	Western wheatgrass	49%
Needlendthread	11%	Sandberg bluegrass	13%
Sandberg Blugrass	8%	Fringed sage	9%
Fringed sage	7%	Prairie junegrass	9%
Silver sagebrush	6%	Silver sagebrush	8%
Scarlet globemallow	4%	Threadleaf sedge	5%
Prairie junegrass	4%	Scarlet globemallow	3%

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

2010		2012	
Western Wheatgrass	23%	Western wheatgrass	22%
Silver sagebrush	22%	Silver sagebrush	19%
Fringed Sage	10%	Prairie junegrass	19%
Needleandthread	9%	Green needlegrass	12%
Cheatgrass	8%	Fringed sage	9%

PRODUCTION: Lbs per acre

2010	2012
240	200

ADDITIONAL INFORMATION

Site sampled August 11, 2010.
Site sampled August 23, 2012

PLANT SPECIES FOUND IN TRANSECT AREA

2010	2012	
26	***16***	***Total count***
X		Blue grama
X	X	Needleandthread
X	X	Threadleaf sedge
X	X	Western wheatgrass
X	X	Japanese brome
X	X	Green needlegrass
X		Nailwort
X		Peppergrass
X		Hood's phlox
X		Vetch species
	X	Broom snakeweed
X	X	Pricklypear cactus
X		Plains daisy
X		Sego lily
X	X	Western yarrow
X	X	Scarlet globemallow
X	X	Fringed sage
X	X	Silve sagebrush
X	X	Cheatgrass
X	X	Prairie junegrass
X		Broom snakeweed
X		Mustard species
X		Sixweeksgrass
X	X	Salsify
	X	Vagrant lichen
1		Unknown perennial forbs
X		Golden pea
X	X	Sandberg bluegrass

SILVER SAGEBRUSH DATA

2010	2012	*Line intercept:*
25	39	***Number of big sage plants encountered***
		Line Intercept: Age Class Distribution
0%	0%	seedling
0%	0%	young
96%	87%	mature
4%	13%	decadent
19	17	***Average plant height - nches***
20%	24%	***Percent canopy intercept***
63	67	***Density per 1000 square feet***

Photos
No grazing had occurred in this pasture when both sets of photos were taken. 2010 was nearly an average precipitation year, while 2012 was dry. Note the obvious reduction in vigor of silver sagebrush plants, particularly in the photo foreground. Leader growth on these plants appears greatly reduced in 2012, suggesting the dry year had a large impact on this species. Vigor of perennial grasses also appears to be reduced in 2012 relative to the prior sample year.

The quadrat photos display good ground cover in both years, with abundant litter covering the soil surface to prevent erosion. Note the lack of growth and vigor on the silver sagebrush plants in the lower right-hand corner of the quadrat. This silver sage was still there, but its 2012 growth was limited.

Basal cover
Bare ground declined significantly, with a 16-percentage point drop. All of this bare ground was replaced by litter cover, which was a positive sign. Ideally, that 5% live cover figure will show improvement in the future. These data show positive change.

Relative basal plant spacing
The relative basal plant spacing figure displays the distance to the nearest perennial plant. The lower the figure, the tighter the spacing between perennial plants on the soil surface. This figure did not change between sample years, which is surprising given the next data set.

Relative basal plant spacing by species
While the relative basal plant spacing measure displays the distance between perennial plants, it also records those nearest species. With this data set, we see much change occurring at this site. Mid-seral species like Sandberg bluegrass, fringed sage, threadleaf sedge, and prairie junegrass all increased, while the highly desired needleandthread grass fell from the list. These data suggest that mid-seral species were capitalizing on the improved water cycle, while the more desired perennial bunchgrasses had not responded yet. Ideally, these desired plants will increase in presence through time. Look for continued change here in the future.

Relative plant species composition by weight
Like the basal spacing by species data, relative composition by weight also showed strong change. While western wheatgrass, silver sage, and fringed sage remained somewhat unchanged, much change occurred in the remaining species. The highly desired needleandthread grass fell from the list, but the highly desired green needlegrass appeared abundantly. Also, the undesired cheatgrass fell from the list of the top five species, while the mid-seral prairie junegrass also appeared abundantly. Again, these data show increases in mid-seral species like the junegrass with changes in some of the high-seral plants. More change should be expected here in the future.

Production
The production figures show minimal change between the sample years. This should be considered a positive finding, for 2012 was a much drier year than 2010. Were this site less healthy, production likely would have been much

lower, and pasture stocking rates would have required much more adjustment.

Plant species
Ten fewer plant species were found in 2012, which was a substantial decline from the previous count. A glance at the plant species data sets reveals that all of the missing plant species from 2012 were forbs. These moisture-loving species tend to thrive in wet years, but often do not grow well in dry years. This appears to be the case at Lower Hepp, and this decline in species count does not present cause for alarm.

Silver sagebrush data
The silver sagebrush data set shows mixed signs of change. On the one hand, the number of silver sage plants intercepted on the transect line increased, as did canopy cover and density. These figures point to increased silver sage. Conversely, the age class distribution figures suggest a community in decline, with a noteworthy percentage of decadent plants found in each sample year. At 24% canopy cover, having less silver sagebrush in the area may be beneficial to other plants, so the age class figures suggest more desirable change.

Range trend
Trend here was slowly upward. The decline in bare soil is the first sign that this site was benefitting from the added infrastructure of water and fence. The indicators suggest an improving area water cycle, but desired shifts in species composition have yet to occur.

Management recommendations
In 2010, it was surmised that the new increase in stock density and associated hoof action may greatly increase the growth of undesired species like Japanese brome and cheatgrass as has happened in other Merlin pastures. This did not happen by 2012. That being said, the improving water cycle may present opportunity for these undesired plants to thrive in the future. Until the successional process advances toward later-seral plant species, the threat of growth of these undesired species will be present.

During this transition, management should continue utilizing short grazing durations and lengthy recovery periods between grazings. Data suggest these variables were in balance at Lower Hepp between the sample years. But the site would benefit from increased animal impact to speed the mineral cycle and help jumpstart the successional process. Place mineral tubs and/or salt blocks in this pasture in the heavy stands of silver sagebrush to disturb the brush and promote the growth of desired grasses and forbs. Efforts like these will enable the transition of the site into a healthier state.

Early-warning indicators
If management actions are improperly applied, look first for reduced plant vigor, more bare ground, and signs of erosion. These suggest grazing durations have been too lengthy, utilization rates have been too high, and grazing durations have been too long. If much bare ground becomes evident quickly, then use of animal impact with salt blocks has been too heavy.

If management actions are properly applied, look first for strong plant vigor, even in dry years. If animal impact has been successfully used, look for decreased silver sagebrush canopy cover, and increased presence of desired forbs. Lastly, look for shifts in species composition toward those more favorable desired grasses.

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 2012.

	Tipperary	3 Section	Lower Hepp
Crude Protein (%)	5.3	7.92	5.97
Acid Detergent Fiber (%)	41.7	40.7	39.8
Total Digestible Nutrients (%)	55	56.1	57.2
Net energy-lactation (Mcal/lb)	0.56	0.57	0.58
Net energy-maintenance (Mcal/lb)	0.53	0.54	0.56
Net energy-gain (Mcal/lb)	0.3	0.31	0.32
Sulfur (%)	0.11	0.14	0.11
Phosphorus (%)	0.05	0.15	0.11
Potassium (%)	0.67	0.82	0.8
Magnesium (%)	0.12	0.13	0.14
Calcium (%)	0.55	0.47	0.69
Sodium (%)	0.01	0.01	0.01
Iron (ppm)	543	206	332
Manganese (ppm)	33	59	42
Copper (ppm)	2	3	2
Zinc (ppm)	14	21	18

Note first the variation in crude protein levels among the samples, where that from 3-Section was much higher than the other two. No ready explanation exists for this superior level, and nothing in the species composition of that sample give us evidence that the grasses there were better than the other sites. Since monitoring began on the ranch, Merlin's crude protein levels have consistently been found in the 7% - 8% range (Lower Hepp tested at 8.5% protein in 2010). The drop in protein could be drought related.

Another item of note in this data set is the iron levels. Looking back on the samples collected since monitoring began, Merlin's iron levels have tended to fluctuate from below 100 to the 500s. 2012 appears to be one of those high iron years. Some correlation may be made between iron levels and amount of precipitation received. For example, Tipperary was last sampled in 2009, which was another dry year, and iron levels were 473. By contrast, wet years like 2010 or 2011 often revealed iron levels below 100. Fortunately, iron is not toxic to cattle until roughly 1000 ppm, so these data present no cause for concern. But the correlation between iron levels, annual precipitation, and livestock performance is worth noting.

That being said, management should be aware of the performance of livestock and consider that any poor performance may be somehow related to nutrient content of forage that is different from what it has been in the past. See the management recommendations section below for rectifying possibilities.

Like usual, copper, zinc, phosphorus were low, which has been the case during the history of taking these samples at the ranch.

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

Dry Matter	Crude Protein	TDN	Ca	P
21.6#	1.1#	11.9#	54g	5g

Our sample cow in the Tipperary will be short nearly 1 pound of protein per day, which is a lot. Further, she is short 17 grams of phosphorus, another noteworthy issue. Lastly, the calcium to phosphorus ratio is nearly 11:1, well beyond the recommended 7:1 maximum. See the management recommendations area to see options for correcting this imbalance.

At **3 Section**, the forage will return the following to our sample cow:

Dry Matter	Crude Protein	TDN	Ca	P
21.6#	1.7#	12.1#	46g	15g

This forage was short in both crude protein (by 0.3 pounds per day) and phosphorus (by 7 grams per day). Further, the calcium to phosphorus ratio was 3, which is just below that 7:1 limit. The 3-Section sample was much stronger than the other two.

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

Dry Matter	Crude Protein	TDN	Ca	P
21.6#	1.3#	12.3#	68g	11g

Again, this sample was short on crude protein and phosphorus. The calcium to phosphorus ratio was 6, again within that 7:1 limit. TDN (a measure of energy) was strong for this sample, which is good.

Management recommendations from nutrient analysis
Analysis of the sample nutrients on the preceding pages serves as a guide for management when considering nutritional factors as they relate to livestock performance. That being said, the analysis is intended to be a "shotgun" approach to livestock performance, rather than a precise science. Simply put, livestock have access to a variety of forage sources in each of these pastures, and not just forage from the sample sites. This provides variety in the diet and likely meets the cow's needs, including those critical crude protein levels.

The ranch also moves its livestock through a series of pastures during the 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, cows whose calves have been weaned may be placed on the ranch's irrigated hay meadows in fall and early winter. There, they should graze plants containing much higher nutrient content than the range grasses can provide. 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 early so the body condition of the cow may be replenished more readily. Only pursue this option if cow performance is an issue. Finally, management should consider placing cattle on a trace mineral supplement with high levels of phosphorus, copper, and zinc to make up those missing in the forage in dry years like 2012. Some of the nutrients may be stored in the cow's body and utilized through time. The forage samples show Merlin's nutrient content lacking in those dry years. Consider placing the herd on a trace mineral package during winter, or in the last 100 days before calving. This should help minimize costs, minimize labor/infrastructure/fuel required to put mineral out, and should help livestock performance in dry years. This will also help correct that calcium to phosphorus ration imbalance.

MONITORING METHODS

On August 22, 2011, Mark Gordon of Merlin Ranch and Todd Graham of Ranch Advisory Partners toured the ranch, examining potential study sites. They selected three study sites to be sampled in 2012.

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

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

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

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

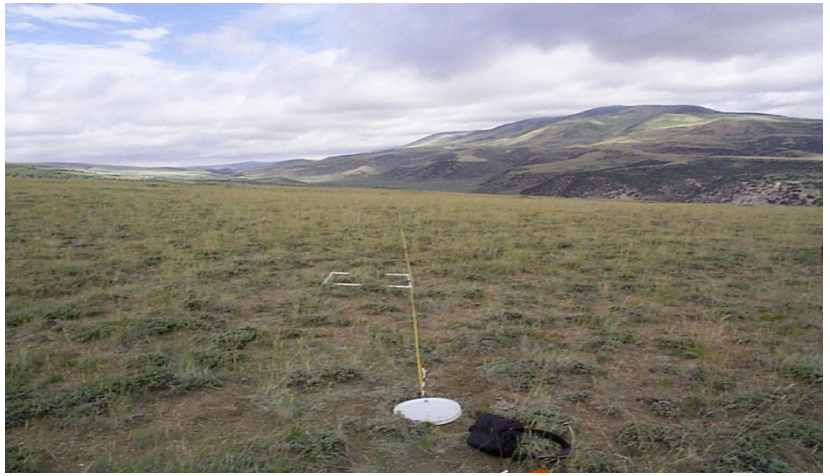


***Figure 2: Permanent transects were 200 feet long and were permanently marked* on each end.**

Ten plots along the transect line were examined and 16 indicators of rangeland health were evaluated (Figure 3).

The first plot lay at the 10-foot mark on the tape measure, and each successive plot was read at 20-foot intervals (10, 30, 50, 70 feet, etc.) Ocular utilization estimates were also recorded.

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

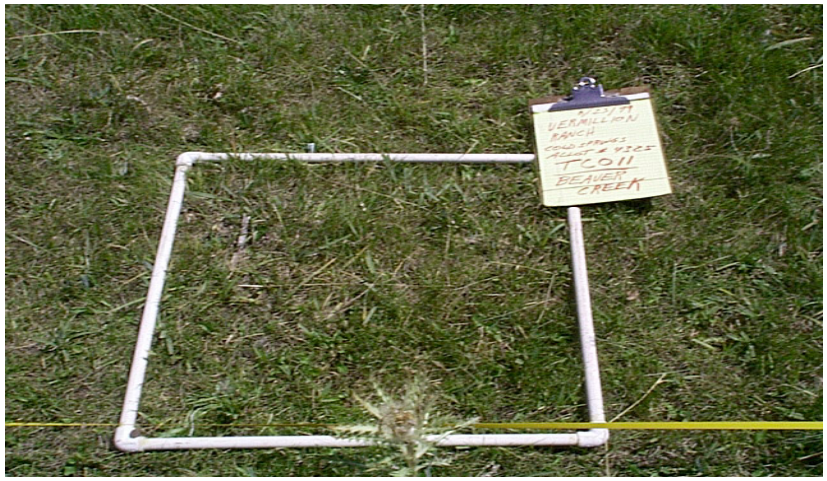


Figure 3: The first plot on a transect. [This sample plot lies in Colorado.]

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

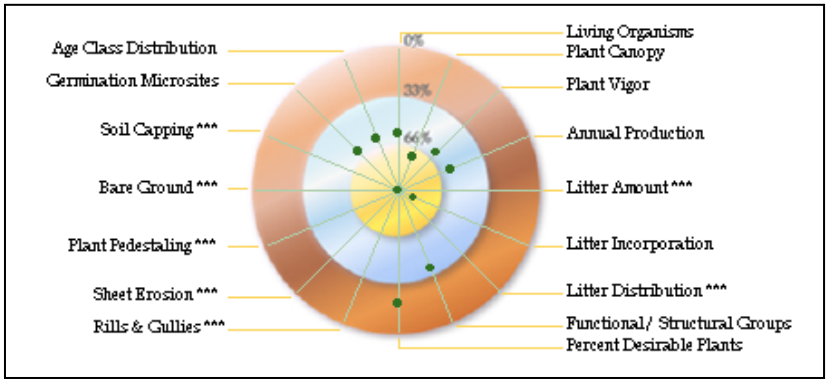


Figure 4: The target portrays results of each of the 16 indicators studied based on field scores.

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

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

Additionally, the 14 indicators of rangeland health provide information for making management decisions. This report provides a brief narrative on how each indicator was evaluated and what management recommendations arose through their evaluation.

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

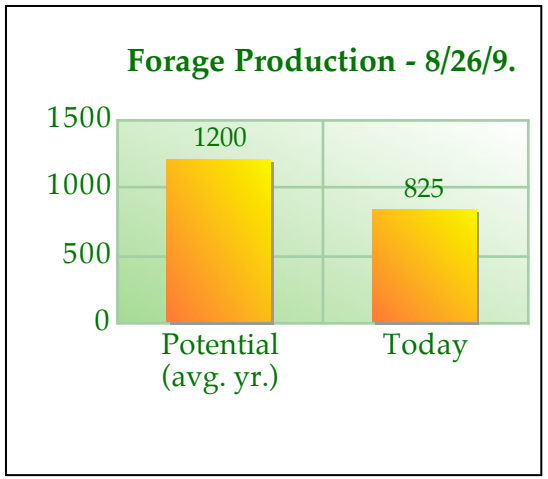


Figure 5: Plant production on sample day as compared with the site's potential from the soil survey.

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

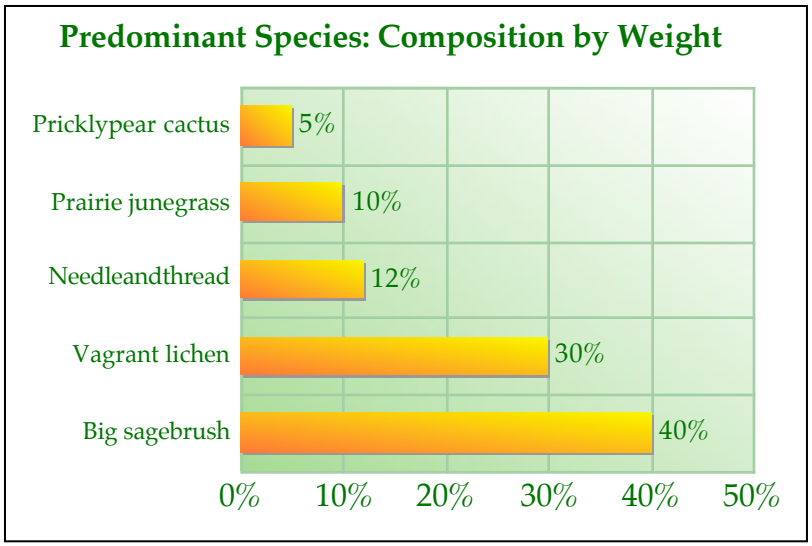


Figure 6: The most abundant species as composition by weight.

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

The procedure also uses the 200-foot tape measure as a base for collecting information such as ground cover and basal plant spacing. Using the point intercept method, a steel rod is lowered to the soil surface every other foot along the 200-foot tape measure. At each point, ground cover is classed as bare soil, litter, or live plant cover. After examining all 100 points, the percentage of each class is calculated. A pie chart is generated portraying the results (Figure 7).

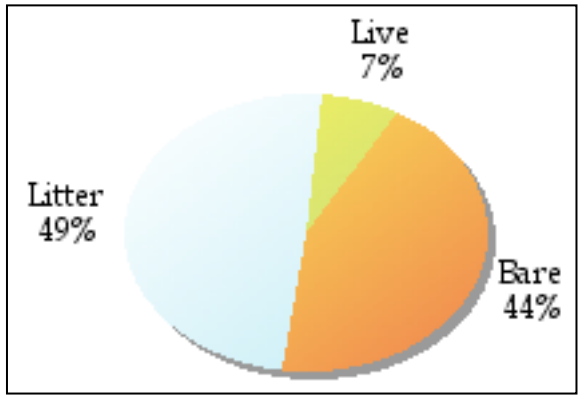


Figure 7: The ground cover chart generated by using the point intercept method.

At each point ground cover data was collected, data on basal cover by plant species was gathered. When the point intercept rod was lowered to the soil surface, the distance to the nearest perennial plant was measured (see photo in Figure 8). The average distance for all 100 points is calculated and the average distance to nearest perennial figure is found and displayed in the "Additional Information" box. Simultaneously, this nearest plant's species was recorded. The seven species representing the closest perennial plants are portrayed in the "Basal Cover by Species" bar graph (Figure 9).

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

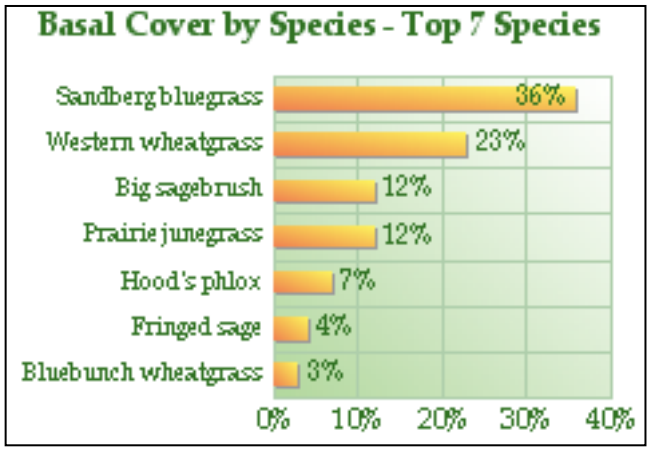


Figure 9: Basal cover by species bar graph created by measuring the distance to the nearest perennial plant using the point intercept method. The seven most numerous species are displayed here.

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

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

Rangeland Health Indicators Scoring Guide

Side One

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

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

Rangeland Health Indicators Scoring Guide

Side Two

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

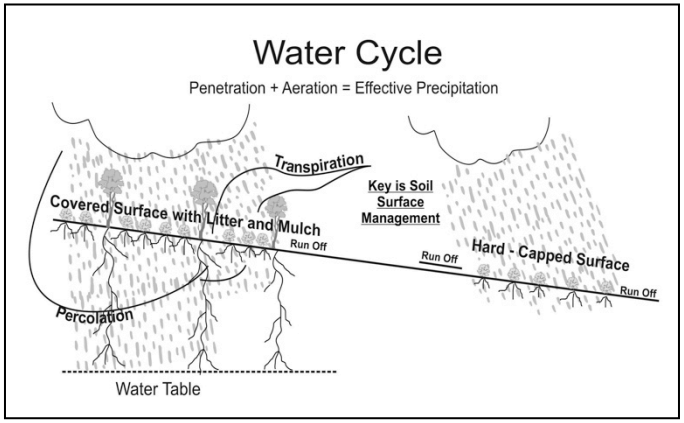
Indicator	5	4	3	2	1
Soil Crusting	No physical crusting present.	Recently formed physical crust seen over some of plot.	Recently formed physical crust seen over much of plot.	Older physical crust formed over much of plot.	Plot dominated by older physical crust.
Germination Microsites	Microsites present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

RANGELAND HEALTH

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

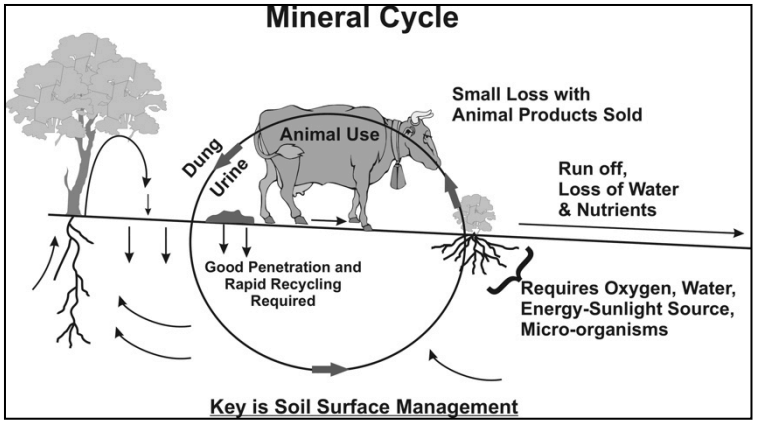
The monitoring methods used here were intended to observe changes in rangeland health through time. Both qualitative observations and quantitative methods were employed. Both are intended to provide decision-making information to land managers. Methods used in generation of this report are aligned with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

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



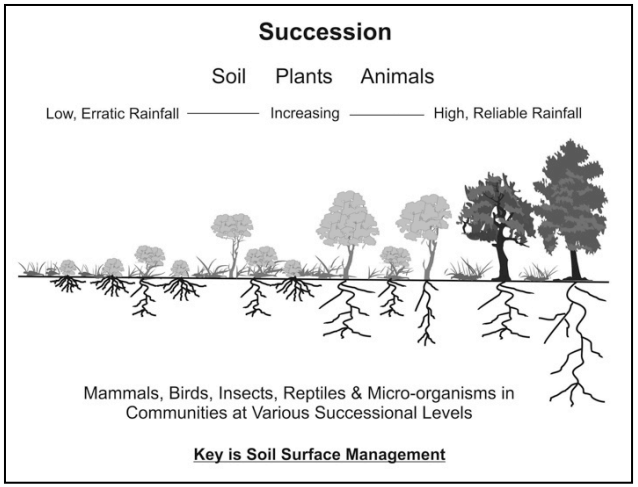
An effective water cycle requires covered soil and high biodiversity. When effective, most water soaks in quickly where it falls. Later, it's released slowly through plants that transpire it, or through rivers, springs, and aquifers that collect through seepage what the plants don't take. When biodiversity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

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



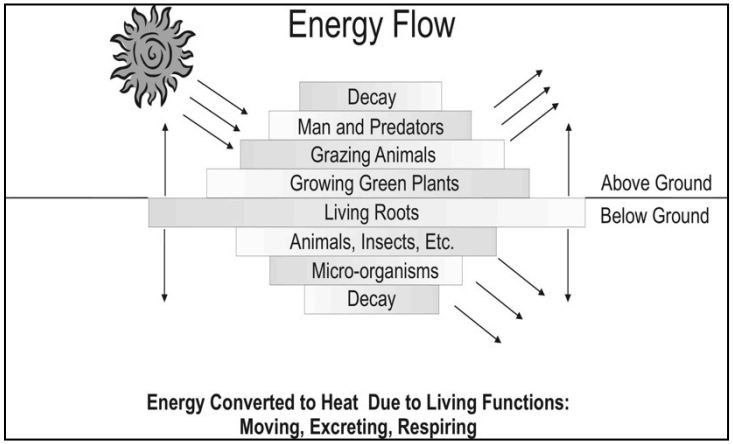
Like the water cycle, an effective and rapid mineral cycle requires covered soil and high biodiversity. When effective, many nutrients cycle between living plants and living soil continually. When soil is exposed and biodiversity low, nutrients become trapped at various points in the cycle, or are lost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

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



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

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



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

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

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