CAN A DIVERSE NATIVE GRASSLAND:

• Produce TWICE as much forage (yet be high quality)
• Provide wildlife and pollinator habitat
• and promote healthy soils?

Read on to find out...
Amy Hamilton started thinking about plant diversity and grazing. She and Rex Hamilton hypothesized that a diverse native grassland would have many benefits over a fescue pasture or even a monoculture of native warm season grasses. So we wrote a Conservation Innovation Grant for the Natural Resources Conservation Service. It was accepted and we began the process of converting 73 acres of fescue pasture (58 acres in Texas County and 15 acres in Montgomery County) to diverse native grassland. The Missouri Department of Conservation was also interested in the project and became a partner.
We hypothesized...

That the benefits would be:

• More forage
• Healthier soils
• Excellent pollinator & wildlife habitat
• Good weight gains on cattle which reflect quality forage
• Not to mention the pretty flowers

There was only one way to find out if our hypothesis was true...

Hmm...This is too good to be true!
So, kill the fescue

Fescue is no match for some glyphosate and patience. From our previous experience, we knew that the long-term success of the planting would depend upon getting a good kill of not only the existing plants, but also the seeds in the soil. So, we sprayed first in October 2010. We followed up 3 weeks later to kill any misses and those hard-to-get-with-a-boom-sprayer plants under the trees.
After annihilating the mother fescue plants, we turned our concern to fescue seedlings. After allowing time for seedlings to germinate in the spring, we sprayed again in early June. This was followed by seeding a cover crop of millet. In August, the area was again sprayed in an effort to kill yet more seedlings. A fall cover crop of millet, turnips, and tillage radish was seeded in late August.
The cover crops were grazed both in summer and winter. They provided high quality forage for the livestock.
Lessons Learned...
Spraying & Cover Crops

• Careful attention must be given to killing plants under trees, in fence rows, and other hard-to-spray places.

• It is best to always have soil cover. Soil cover is protection from erosion, increases moisture retention, and is just generally good for soil health, which all help get a stand of natives. One way to leave cover is to only graze the cover crops lightly. Another method is to have a cover crop species in the mix that is less palatable at grazing time (e.g. full-season millet in winter).

Example where full season millet turned to mulch (on the left), whereas, on the right the millet was grazed earlier in the season when it was more palatable, which removed the potential for millet mulch. Then, during the winter the more palatable turnips made a poor mulch. The same mix (millet, turnips, and radish) was planted on both sites.

• Cover crops can produce a lot of high quality forage or none. Many factors, such as timely rains and depth at which the seed is planted can result in stand failures (e.g. 15 turnips on 15 acres as happened at the Montgomery County site). Don’t count too heavily on the forage production from the cover crops.
Plant the natives

Broadcast seeding the native grass and wildflower seeds.

Over 100 species of native plants were seeded onto the area in early February (winter seeding was necessary for the wildflower and Eastern Gamagrass seed to break dormancy). The soils were carefully considered and different mixes were developed for wet, mesic, and dry areas. We also made sure to have representation from each functional diversity group: cool season grass & grass-like species, warm season grasses, legumes, and forbs. Glyphosate was applied a final time before germination in late February.
Lessons Learned...

Traditional Establishment Guidelines

These are guidelines; weather and individual pasture situations can change the process. These guidelines are for fescue/clover pastures; if the pasture contains Johnson Grass, Sericea Lespedeza, Caucasian Bluestem, Crown Vetch or other less common species, the guidelines may also need to be adjusted.

• **Graze pasture short & even (~August)** - before fall rains, graze the pasture so that it will be actively growing and herbicide can make good contact with the regrowth of all plants.

• **Spray with glyphosate (~October)** – fescue should be actively growing.

• **Spray with glyphosate (~May)** – once seedlings have had time to germinate and grow in spring, spray.

• **Plant cover crop (immediately following the spray)** – pearl millet, sorghum x sudan, soybeans, buckwheat, and cowpeas all make great choices. Get seed-to-soil contact by drilling the seed or broadcasting and dragging. Keep in mind that bigger seeds need more soil coverage while it is easy to get too much coverage with smaller seeds.

• **Graze (summer)** – the cover crop is acting as a smother crop; graze in such a way that leaves a smothering canopy of plants. However, the last graze of the summer before fall rains (~August) should open up the canopy to encourage germination of weed seeds and allow good penetration of herbicide with the next spray.

• **Spray with glyphosate (~September)** – at least a couple weeks after a nice fall rain that has encouraged germination of seedlings, spray again. This can be done as late as October or early November, but cover crop growth will be limited by the onset of winter.

• **Plant cover crop (immediately following the spray)** – spring oats, turnips, tillage radishes, and rape all work well.

• **Graze (fall, winter)** – winter and grazing should kill out the above mentioned cover crops. Leave some plant material as soil cover.

• **Plant diverse natives (winter)** – January is a great target but definitely before February 15th.
Lessons Learned... Alternate Establishment Plans

- Based upon the knowledge that warm season grasses are slow to establish, we believe that there may be occasions where an alternate establishment plan involving imazapic (i.e. Panoramic, Plateau) may be a better choice. The advantage is quicker establishment of the Big Bluestem, Indiangrass, Little Bluestem, and Sideoats Grama component of the mix. The disadvantage is that the planting will be dominant in the above mentioned grasses (of which the latter two are not typically used at heavy rates in grazing mixes unless it is a dry site). The establishment timeline would look like this:
  1) Spray glyphosate in the fall.
  2) In spring, the imazapic-tolerant warm season grasses should be seeded. At planting time, glyphosate and a low rate of imazapic should be applied.
  3) After frost but before it gets too cold, glyphosate should again be applied.
  4) The remaining seed (i.e. forbs, cool season grasses, and other warm season grass species) can be planted in winter (between November 15th and February 15th).

- When the area is being cleared or having the trees substantially thinned, there is usually not a need to apply herbicides (except as needed to control resprouts from the trees). In this case after clearing and ensuring that seed-to-soil contact can be achieved, the seed may be planted between November 15th and February 15th without prior herbicide applications. However, when the trees are cleared from grown up old fields that show remnant undesirable plants such as fescue, sericea lespedeza, etc. then attention must be given to getting rid of these plants.
• We chose to plant over 100 species to learn about how they react to grazing and their palatability to grazing animals. This is more species than is practical and cost-effective for most plantings.
• A ratio of 60% warm season grasses (WSG), 20% cool season grasses and grass-like (CSG), and 20% native forbs and legumes (NFL) is a nice combination. However, a number of factors might be consideration for change. For instance, in shady areas (e.g. a pasture with scattered trees across it), cool season plants have a decided advantage due to their photosynthetic pathway. In this case a 20% WSG, 60% CSG, 20% NFL mix might be better. For ranchers who currently have all or mostly CSG pastures, getting a big component of warm seasons in the first plantings is important; in this case, it might be best to increase the WSG component of the mix. In contrast, a ranch with a lot of WSG pasture already in place might want to increase the CSG and/or NFL components of the new plantings.
• In previous plantings, we planted introduced cool season grasses (e.g. friendly endophyte fescue or orchard grass) with native WSG. For a number of reasons, we find that these plantings do not work very well.
• Each plant has a unique growing season. Each also has a distinctive root system, response to drought, architecture, and other unique characteristics that contribute to it filling a unique niche. Because each plant is unique, we believe that it is more important to use a diversity of plants rather than find the “perfect” plant(s). See a Solar Collector Chart on the next page to see the unique growth season of a few different native plants.
Sunflower, Ox-eye
Switchgrass
Wild Rye, Canada
Wild Rye, Virginia
Wingstem, Yellow

Aster, New England
Beardton, White
Big Bluestem
Blazing Star, Prairie
Compass Plant
Coneflower, Gray-headed
Coneflower, Pale Purple
Coreopsis, Grandiflora
Coreopsis, Plains
Coreopsis, Tickseed
Cup Plant
Eastern Gamagrass
Fescue, Cluster
Illinois Bundleflower
Indiangrass
Leadplant
Lespedeza, Roundhead
Lespedeza, Slender
Little Bluestem
Partridge Pea
Prairie Clover, Purple
Prairie Clover, White
Prairie Dock
Purple Top
Quinine, Wild
Rattlesnake Master
River Oats
Rosin Weed
Sampson’s Snakeroot
Sedge, Short’s
Sensitive Brier
Spiderwort, Ohio
Sunflower, Ox-eye

Solar Collector Chart. Green is actively growing; light green represents green plants that do not seem to be contributing significantly to the above-ground growth; brown signifies dormant plants. Note that observations were collected on ungrazed plants that were allowed to mature.
The first growing season was during the 2012 drought, which we feel slowed the establishment of our native grass and wildflower species. During the first growing season, we bush hogged the field twice at a 6” then 8” height to reduce competition and shading from the annual weed species. Being an old fescue pasture, an abundance of white and red clover and ragweed, among other common pasture species, expressed themselves. We did not graze the field any during the 2012 growing season.
2nd growing season

The clovers, which love cool weather, got a quick start on the second growing season. This promised to give the native seedlings a lot of competition. To reduce the competition, we flash grazed; in other words, the cattle were grazed at a fairly high density (i.e. 25-30 cows per acre) for a short period of time (e.g. 1-2 days on any given area), which allowed more control of what the cattle ate. The clovers, being very palatable, were generally consumed first then the animals were moved. This graze was timed so that with the warmer weather of May, the native seedlings would take off, grow, and express themselves.

Clover plants before (photo on left) and after (photo on right) a flash graze in late April. Notice the defoliation on the grazed plants on the photo on the right; pocket knife is to show scale.
Cattle flash grazing the diverse native planting in late April of the 2nd growing season.

Diverse native planting in July of 2nd growing season. Notice the quick-to-establish, native, yellow blooming Plains Coreopsis blooming alongside the weedy white-blooming Queen Anne’s Lace and reddish-purple Red Clover.
Finally, a year to focus on the forage from the diverse native grassland. We felt that the plants, although far from mature, were well enough established to be grazed multiple times during the year.

Top: a dormant season graze (early March) served to “prime the solar collector” and get last year’s growth turned into thatch so that the plant’s new growth could see sunlight. Notice that the area on the right has been grazed while the left has yet to be grazed.

Middle: stocker cattle grazing. Bottom: a comparison of grazed (on the right side of the picture) and yet-to-be-grazed (left side).
Forage production! The diverse native grassland was grazed multiple times through the year and the native plants provided significant forage whereas in prior years the clovers and annual weeds provided a large component of the forage.

Grazing the diverse native planting in early May. On bottom left photo notice the growth on the Grayheaded Coneflower, and on the bottom right, notice the growthy Wild Rye plant near the calf’s nose.
Photos taken during the rest period after the 2nd graze. Photos were taken mid-August.
The 3\textsuperscript{rd} graze of the 4\textsuperscript{th} growing season, which occurred in mid-September. Top left: notice the cow eating Maximillian Sunflower vegetation. Top right: Grazed about a week prior to the photo being taken, the cool season plants are regrowing after the graze. Bottom: on the left side of the fence, the area has been grazed for the 3\textsuperscript{rd} time, but on the right side of the fence, the plants are awaiting the 3\textsuperscript{rd} graze of the growing season.
Did we get a stand?

In the second growing season, a vegetation analysis was completed to see if we had a good stand of natives at the Texas County site. The results were summarized by Justin Thomas with the Institute of Botanical Training as follows:

“...the restoration area was in an early successional stage dominated by *Lespedeza stipulacea* (Korean Lespedeza), *Plantago lanceolata* (Narrowleaf Plantain), *Trifolium pratense* (Red Clover), *Daucus carota* (Queen Anne’s Lace) and *Ambrosia artemisifolia* (Common Ragweed). The average Native C value of 2.4 also reflects the early successional stage; given that a C value of 4.0 is considered typical of intact and diverse natural communities. Given proper management the C value should increase over time.

Many of the species sown as seed, though present, have yet to achieve dominance or prevalence. However, establishment is taking place. Native grasses accounted for nearly 20 percent of plant cover and non-native grasses accounted for less than two percent. Follow-up sampling after the community has had more time to establish is recommended. A follow-up seeding may be necessary depending on the ultimate goals of the project.”

At the time, we were also concerned about a lack of native plants and the abundance of weedy, early successional species. But knowing that with diverse plantings it is often best to wait until the 3rd growing season to evaluate the success of the planting, we decided to wait and see.
By the 4\textsuperscript{th} growing season we were finally content. However, we feel that under different establishment circumstances (e.g. lack of drought and extreme competition from clovers), the stand would have developed more quickly with a greater species richness and better representation of all species planted.

At the Montgomery County site, the expression of native plants was also lacking during the 2\textsuperscript{nd} growing season; we waited to see what would happen. As of the 4\textsuperscript{th} growing season, we feel that this stand was a failure because of the lack of native warm season grasses in the stand. We believe that many factors contributed to this including a drought in the 1\textsuperscript{st} and 2\textsuperscript{nd} growing seasons, extreme competition from clovers, and an exceptionally wet 4\textsuperscript{th} growing season (i.e. 19 inches of rain in June and above average amounts in May and July).
Lessons Learned…
Grazing in the First Years

There are some goals and general guidelines that we aim for when grazing a diverse native grassland. We also think that it is very important to get out and see how other folks are grazing diverse native grasslands and learn from them. To see a more detailed discussion of these guidelines, see Discussion 1 in the Appendix. To see a discussion of grazing when using the alternate establishment plan of Panoramic, also see the Appendix (Discussion 2).

Year 1: Don’t count on forage from the planting; rather, view the livestock as a management tool to open up the canopy and reduce competition for the small, developing native seedlings. This may be accomplished with very careful grazing or brush hogging. For more rules of thumb on how to accomplish this goal and the others below, see the discussion in the appendix.

Year 2: There will probably be a small amount of forage to be gleaned this year, but the grazing should be used as a management tool; don’t count on the forage. The goal is again to open up the canopy and reduce competition, especially for the slow-to-develop warm season grasses. Grazing is a great tool to achieve this, but must be very carefully applied.

Year 3: Finally, some forage to count on! However, don’t count on full production from the area. While forage production is a big goal, promoting warm season grass development, and letting seed from cool season plants fall on the ground is also a concern. The times of the grazes must be well-thought-out to further these other goals. Also the duration of the graze period in any one place needs to be short so that regrowing plants are not regrazed.

Year 4+: Let’s graze! At this point, the stand should be fairly well established although many plants are not yet mature. The aims are now to get forage production, maintain and promote plant diversity, provide good wildlife habitat, and build up armor (thatch) on the soil to promote soil health.
Too good to be true?

Here we are 5 years later. Did we achieve what we hypothesized might be possible?

• More forage
• Healthier soils
• Excellent pollinator & wildlife habitat
• Good weight gains on cattle which reflect quality forage
• Not to mention the pretty flowers

Let’s take a look...

So, what happened???
More forage?

We had reason to believe that a diverse native grassland can produce twice as much forage as a monoculture. Researchers at the University of Minnesota published findings that a 16 species diverse mix of natives given a low level of inputs could out produce a monoculture of Switchgrass, a very high tonnage producer, by 238%. We reasoned that that would be a big deal. It is like tripling the size of a ranch! Wow, three times as much production from the same acre of ground! Could we do that in Missouri and get twice as much grazing from our forage acres?

Can I have three times as many cows on the same land?!?!
Data from Tilman’s research project showing the ratio of biomass energy production of 16 species plots to the energy production of lower diversity plots (i.e. 1, 2, 4, and 8 species). In the last 3 years of the study, the 16 species plots produced 238% more energy than single species plots. The 8 species plots produced 157% more than the single species plots. (Tilman D, Hill J, and Lehman C. 2006. Carbon-Negative Biofuels from Low-Input High-Diversity Grassland Biomass. Science. 314: 1598-1600.)

Comparison of grazing days on the newly established diverse native grassland (planted in 2012) and long-established fescue pastures. See pages 12-18 for a description of the diverse native grassland in each growing season. The production of the fescue pastures was decreased somewhat in 2015 because we did not graze the fescue in the summer due to the endophyte issues and the negative effects on the cattle. Note that all 2015 data includes an estimate for the dormant season grazing days.
It appears that the forage production on the diverse native grassland has become about equal to that of our established fescue pastures as of the 4th growing season. The fescue pastures have a fair amount of diversity in them, which likely increases their yield over that of a true fescue monoculture. We yet see a lot of potential for improvement in production in the diverse native grassland as the native plants start to occupy a larger footprint and replace even more of the early successional species. These early successional species such as Queen Anne’s Lace and Ragweed often don’t contribute substantially to the forage production. We are anxious to watch the forage production of the diverse native grassland in future years to see if it will produce more than fescue pastures.
We have 9 reasons to believe that the diverse native grasslands will out produce fescue pastures:

1) **Solar collectors** – in a diverse native grassland, plants are collecting sunlight and growing for more of the year than in a fescue pasture.

2) **Plant architecture** – with diversity, each plant has a unique growth habit (e.g. tall, short, upright, trailing, etc.) that helps maximize the capture of sunlight, whereas all fescue plants are alike.

3) **Root architecture** – when diversity is present, there is a variety of roots (e.g. deep vs. shallow, fibrous vs. tap rooted) that can collect water and nutrients from different locations. In a fescue pasture, all root systems are alike.

4) **Hydraulic lift** – some deep rooted plants bring up water from deep in the soil that other plants use.

5) **Soil armor** – fescue pastures often do not have good soil cover whereas native warm season grasses do. Armor helps protect the soil, hold in moisture, and moderate extreme temperatures.

6) **Speedy nutrient recycling** - with diversity, recycled nutrients may be utilized more often and there is less potential for their loss than in a fescue pasture because of the extended growing season.

7) **Nitrogen fixation** – diversity that includes legumes gives the advantage of “free nitrogen fertilizer”.

8) **Mycorrhizal fungi** – these fungi acquire phosphorus and other things for the plants they are associated with. Most native plants have these associations, however fescue doesn’t.

9) **Soil organic matter** – diversity increases SOM which holds more water and nutrients and increases forage production.
Healthier Soils?

We had a number of reasons to believe that the soil in a diverse native grassland managed with herbivores would be healthy.

- Good organic matter production
- Deep nutrients can be brought to the surface
- Native legumes can “create” free nitrogen fertilizer
- Most native plants form associations with mycorrhizal fungi, which bring the plant nutrients and water
- Water infiltration can be increased and runoff decreased
- Nutrients are recycled more quickly because of the herbivores

For a more detailed discussion, see the Discussion 3 in the Appendix.

Is a diverse native grassland better for the soil?
Data from Tilman’s research showing the change in the soil carbon sequestration, which relates to the soil organic matter content (represented by the solid line; dashed lines are for statistics). Notice that the monoculture actually had a very small decrease while the diverse mixes had significant increases in soil carbon. (Tilman D, Hill J, and Lehman C. 2006. Carbon-Negative Biofuels from Low-Input High-Diversity Grassland Biomass. Science. 314: 1598-1600.)

We took soil samples at the beginning and end of the project. Because of the variability in the soil and site characteristics at the Texas County site, we took composite soil samples in each soil series. At the Montgomery County site, we took one composite sample.

We were very interested to see if there was any change in soil organic matter as this is a very important aspect of soil health. Organic matter has glue-like properties which bind soil particles into units of structure that make the soil environment more suitable for plants and other organisms, it functions as a “sponge” to hold and release water and nutrients as needed by the plants, and it is the backbone of the soil microbial community, among other things.
We were pleasantly surprised with the change in organic matter in the short period of time. Some areas of the field increased by as much as 73% while others remained steady. On average, organic matter increased by 27%. Practically speaking, this means that our organic matter “sponge” that holds water and nutrients got 27% bigger.

We think that this is a big deal.

Results of the soil analysis. The table at the bottom shows all data while the graph at the top illustrates the change in organic matter. Note that the sample labeled “Steele” is the Montgomery County site.
Pollinators & Wildlife?

We suspicioned that a diverse native grassland could be grazed yet provide high quality habitat for pollinators and other wildlife. Our rational revolves around the fact that before white man settled this country, bison, elk, and other herbivores grazed diverse native grasslands and coexisted with pollinators and other wildlife.

<table>
<thead>
<tr>
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<th>Stony Point Prairie (Grazed Diverse Native Grassland)</th>
<th>Talbot (Traditional Quail Management Area)</th>
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<tr>
<td># Birds</td>
<td>26</td>
<td>27</td>
</tr>
<tr>
<td>Nests Incubated</td>
<td>23</td>
<td>13</td>
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<tr>
<td>Nests Hatched</td>
<td>9</td>
<td>5</td>
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We have also seen some exciting data (see table above) that indicates that quail nests are much more successful on a grazed diverse native grassland than under other quail management.

Can beef, bees, birds, and butterflies all coexist?

Results – Wildlife
Turkeys frequent the area.

It is a great place to see a turkey feeding or a gobbler strutting. In our estimation there were also more hens sitting on nests in this pasture than other nearby pastures. It is a coveted turkey hunting spot.

At top, turkey gobblers foraging in the diverse native grassland in the mid-afternoon quickly depart due to human presence. At bottom, a closer examination reveals the gobblers’ favorite foraging site - cow manure from a previous graze that has dried out but provides ideal habitat for insects.
A number of wildlife professionals have also visited the diverse native grassland. Below are some thoughts from a couple of these professionals.

The diverse native planting for grazing has been providing quality brood rearing and nesting habitat throughout the growing season for quail and other grassland birds. The variation in structure, species composition, and ample rest periods have created an ideal patchwork of habitat. Quail can easily find quality nesting cover before and after a grazing event. The stands continue to provide quality brood rearing habitat with a rich diversity of native forbs attracting insects throughout the growing season and ample seeds in the fall.”

--Ryan Diener
Quail Forever Farm Bill
Biologist

I visited the diverse native grazing project in early June 2015 with Elizabeth Hamilton-Steele. My first impression was the diversity of both warm and cool season species along with the great structural variations of heights, thickness, and overhead cover this could provide to small game such as bobwhite quail. For those more interested in larger game the cool season components along with high protein forbs should greatly fit the need for nutritious browse for whitetail deer. The stand had been grazed some prior to my visit which greatly enhanced the structural diversity as well. Best of all bobwhite quail were whistling throughout the farm this day.

--Brad McKee
Missouri Department of Conservation Private Lands Services Regional Supervisor
The population of native pollinators is declining in the US. Quality habitat for these bees, butterflies, hummingbirds, and other pollinator species includes a steady diet of nectar and/or pollen from the spring through the fall. To get an idea of the quality of habitat for pollinators we photographed the diverse native grassland in various seasons and observed how grazing impacted the abundance of blooms.

Following are some photographs to illustrate the habitat. We believe that the quality of habitat will continue to improve as the planting continues to mature. At this point, most of the wildflowers that are mature enough to bloom are quick-to-establish, early successional species. We see the vegetation of other species that are still maturing.

A pollinator visits a Grayheaded Coneflower in the diverse native grassland.
By the middle of May, Tickseed Coreopsis (the yellow flowers) were blooming. In previous years, the blooms had been more prolific; yearly fluctuations in bloom density are common due to weather and management differences.
These photos were taken in the last part of June. At top, this portion of the diverse native grassland is between the 1st and 2nd grazes for the growing season. Notice the purple-blooming Wild Bergamot and yellow Tickseed Coreopsis. The white flowers are Daisy Fleabane and Queen Anne’s Lace. At bottom, this area was just grazed. Notice the presence of the purple-blooming Hoary Vervain and the tall Grayheaded Coneflowers that are just beginning to bloom.
Mid-September between the 2\textsuperscript{nd} and 3\textsuperscript{d} grazes of the growing season. At top notice the Grayheaded Coneflowers that are still blooming as well as Oxeye Sunflower. At bottom, an Ashy Sunflower awaits pollinator visits.
Late-September. The Maximillian and Sawtooth Sunflowers are blooming in profusion. On the left side of the fence, the diverse native grassland has just been grazed for the 3<sup>rd</sup> time during the growing season and the sunflowers still have many blooms. On the right side of the fence, the sunflowers and pinkish-colored Indiangrass await their 3<sup>rd</sup> graze.
Various plant species seem to have different responses to herbivory. Take for instance Tickseed Coreopsis; it is quite palatable year-round. To bloom and make seed, it seems to have a 2-pronged approach: bloom early in the season and if grazed off, grow another flower and try again. As a result a plant that was grazed off before it bloomed could easily bloom a month later than its contemporaries (see the pictures from late-June). However other species such as Rosin Weed may just have the stem tips grazed off due to an apparent decreased palatability of the lower portions of the plant. These species still have some leaves and a good portion of stem intact and readily regrow and produce blooms. Other species, such as Maximillian and Sawtooth Sunflowers, seem to be unpalatable early in the growing season, which allows the plant to get a good start, but then the leaves and upper part of the stem become quite palatable later in the growing season. At this point in the season, the plant recovers quite easily and will still produce many blooms. See pictures illustrating this on the next page.
Responses to herbivory. At top, a Rosin Weed has regrown after being grazed off earlier in the season. Notice that the finger is pointing at the stem that was grazed off. At bottom, Maximillian and Sawtooth Sunflowers. The photo on the left was taken in early-May just after a graze. Notice that the tallest plants in the area, the Sunflowers, were not grazed. However, on the right, the photo was taken in late-September. Notice that the Sunflowers are missing their lower leaves because they were grazed off but are still blooming profusely.
Quality forage?

We had reason to believe that a diverse native grassland can produce excellent quality of forage. The Flint Hills, just over the state line in Kansas are famous for their pasture quality and the gains that they can put on stocker cattle. In comparison, Missouri’s ubiquitous endophyte infected tall fescue pastures are notorious for poor gains and other problems, such as heat-stressed and poor blood circulation, which are caused by the endophyte.

Is this stuff really worth grazing? I mean with all those flowers and whatnot out there...
We collected fecal samples, which were analyzed for various quality factors. In order to compare to the quality of fescue pastures, we also collected samples when the cattle were grazing fescue.

Crude Protein

- Mid-May 2014 Fescue Regrowth
- Mid-May 2014 Diverse Native Grassland
- Early-June 2014 Fescue Old Growth
- Early-June 2014 Diverse Native Grassland
- Mid-June 2015 Fescue Regrowth
- Mid-June 2015 Diverse Native Grassland

Digestible Organic Matter

- Mid-May 2014 Fescue Regrowth
- Mid-May 2014 Diverse Native Grassland
- Early-June 2014 Fescue Old Growth
- Early-June 2014 Diverse Native Grassland
- Mid-June 2015 Fescue Regrowth
- Mid-June 2015 Diverse Native Grassland

Crude Protein and Digestible Organic Matter as measured by fecal samples. To see more data, see Table 4 in the Appendix.
We also made some in-the-field observations of quality.

Right before the 3rd graze of the season, we moved from a Big Bluestem field, which had just been grazed for the 3rd time as well, to the diverse native grassland. While Big Bluestem is known as quality summer forage, we observed that it was lower in protein content in this 3rd graze than the diverse native grassland as indicated by the appearance of the manure.

A second observation involved calf weaning weights. While we did not start out to make this comparison, we observed a large increase in our calves’ 2015 weaning weights. In 2014, we spent the summer months rotating the cows and calves between endophyte-infected tall fescue, the diverse native grassland, and some other cool season grass pastures. In 2015, we decided to not graze any endophyte-infected tall fescue pastures during the summer; rather we included a Big Bluestem field in the rotation that was otherwise similar to that of 2014. At weaning, we found that the steers were 12% heavier in 2015 in spite of weaning 5 weeks earlier. We attribute this to the absence of endophyte-infected tall fescue in the cows’ diet and the presence of a large component of native pastures. Other management factors, the cow herd, and other factors that can be controlled between years were very similar. This increase in weaning weights is a big deal to the economics of a cattle operation!
Pretty flowers?

Many species of wildflowers are beautiful when in bloom. In fact, wildflowers are becoming increasingly common to see in high-class landscaping projects. So, it stands to reason that if we plant these wildflowers in the pasture, there should be pretty flowers to enjoy.

Can a pasture double as a place for men to pick a bouquet of flowers for their significant other?
It sure beats the lack of color in a fescue pasture! It is a pleasant place to take a moment and enjoy the bees a buzzin’ and birds a chirpin’.

Clockwise from top left: Greyheaded Coneflower and Oxeye Sunflower; Wild Bergamot and Tickseed Coreopsis; Maximillian Sunflower; Plains Coreopsis.
In conclusion...

We are anxious for the planting to continue to mature. We believe that the production will continue to increase for many years to come based on Tilman’s research but also the observations of the lack of maturity of the planting. We also think that the wildlife habitat that is provided by this pasture will continue to improve as the plants mature.

In the meantime, we feel that this planting has made a major improvement to our ranch. As a result, we are preparing to convert more acres of our existing endophyte-infected tall fescue pasture to diverse native grassland for grazing.

I like it!
Grazing of Diverse Native Plantings

(Traditional Establishment)

While we do not have a “cookbook recipe” for grazing a diverse native planting, there are some goals and general guidelines that we would aim for. We think that in addition to the thoughts recorded here, it is very important to get out and see how other folks are grazing diverse native grasslands and learn from them. Visit us at our Pasture Walk to see how we are grazing our diverse native planting.

**Traditional Establishment Plan** - In short, spray glyphosate in fall, spring, and fall. Seed a diverse native mix in winter.

**Year 1:** Don’t count on forage from the planting; rather, view the livestock as a management tool.

**Goal:** Open up the canopy and reduce competition for the small, developing native seedlings

**Rules of Thumb:**
1. While the seedlings are small, grazing has the potential to do much harm to the stand if done improperly. If grazing is chosen as the method of opening up the canopy, keep in mind that the natives should not really be grazed off at all. Aim for the cows to take just one bite off of the weed plants (in other words, no plant has 2 bites taken from it). Another, more predictable option to open up the canopy is to brush hog the area at an 8” height; this option provides much more control than using grazing animals.
2. Limit the grazing period for any particular area to no more than 2 days to avoid biting off regrowth, excessive trampling, etc. More animals on an area for a shorter period of time generally give more control over the grazing result.
3. One to two grazes or brush hoggings should be adequate. They should be timed when the canopy of weeds begins to get closed in and small native seedlings cannot receive sunlight.
4. Graze new plantings when the ground is firm; hoof prints should not be visible after the graze.

**Year 2:** There will probably be a small amount of forage to be gleaned this year, but again view grazing as a management tool and don’t count on the forage.

(Continued on the next page)
Goal: Again, the aim is to open up the canopy and reduce competition, especially for the slow-to-develop warm season grasses.

Rules of Thumb: 1) Usually grazing an area twice is about right. The first is usually timed in mid-late May and the second is usually mid-July, but time the grazings to achieve the goal of grazing the weeds. 2) During these grazes, watch the native warm season grass plants (e.g. Big Bluestem, Indiangrass, Eastern Gama Grass, etc.) and do not allow them to be grazed below 8” the first graze and 10” the second graze. If the warm season grass seedlings are not readily identifiable, it is safest to not take more than one bite off of any plant in the field. 3) Limit grazing for any particular area to no more than 2-3 days. 4) Graze new plantings when the ground is firm; hoof prints should not be visible after the graze.

**Year 3:** Finally, some forage to count on! However, don’t count on full production from the area.

Goal: This year the goals include forage production, promoting warm season grass development, and letting seed from cool season plants fall on the ground.

Rules of Thumb: 1) Timing the first graze in May opens up the canopy for the warm season grasses to take off well. The second grazing is usually timed in July and the third after frost. 2) Because the plants are still developing, a minimum of 60 days rest (more if conditions are adverse) between grazes is usually desirable. 3) While grazing during the growing season, the native warm season grass height should be monitored. Do not allow these grasses to be grazed to heights less than 6-8”. 4) Grazing periods on any particular area should be limited to no more than 3-4 days per graze. 5) Until there is a good sod formed by the root systems of the native plants (especially the grasses), the planting should only be grazed when the ground is firm; hoof prints should not really be visible after the graze.

**Year 4+:** Let’s graze!

Goal: At this point, the stand should be fairly well established although many plants are not yet mature. The aims are now to get forage production, maintain and promote plant diversity, provide good wildlife habitat, and build up armor (thatch) on the soil to promote soil health.

Rules of Thumb: 1) Vary the time of grazing from year to year so as not to favor any certain species of plants while hurting others. 2) During the

(Continued on the next page →)
growing season, the goal is to graze but leave some factory (the leaves that produce food for the plant). In other words when grazing, leave plenty of leaf material to promote quick regrowth. Generally, this translates into the guideline that from about the beginning of June to the end of September, the warm season grass plants should be monitored to watch that they are not being grazed below 6-8”. During the active growth period of the cool season plants, the grazing guideline is usually to leave 4”+ of above-ground growth; however the growth habits of some native cool season grasses (e.g. the Wild Ryes) are more upright and 8” may be more ideal in these instances. 3) During the dormant season, the goal is to graze the stockpiled forage while ensuring that residue is left on the soil. 4) A rest period of 45 days is usually the minimum. However longer rest periods are often needed and should be considered during a drought, unseasonably hot or cold temperatures, severe grazing in the previous graze that removed too much of the plant’s “factory”, or any other factor that leads to slow growth or regrowth of the plants. 5) Until there is a good sod formed by the root systems of the native plants (especially the grasses), the planting should only be grazed when the ground is firm; hoof prints should not really be visible after the graze. Keep in mind that decreasing the density of livestock in wet times can help. 6) Occasionally, seeds need to be allowed to fall on the ground for all species. For shorter lived species (e.g. annuals, biennials, other quick-to-establish forbs, and generally cool-season grasses), there needs to be a good amount of seed “stored” in the soil to replace the parent plants when they die. For longer-lived species such as many of the warm season grasses, seed does not need to fall on the ground as often. 7) Always think about the previous pasture the animals were grazing in. If they were grazing seeds of a plant you do not want in the diverse native planting (e.g. fescue, sericea lespedeza, Johnsongrass, etc.), put them on another pasture to “clean out” their digestive tracts and hair coats for a couple days. 8) Realize that a diverse native planting has many different plants of many different appearances and heights. Livestock graze each species of plant differently; some are grazed from the top down like a grass plant while others may only have the leaves removed from the stalk. The graze on a diverse native planting will not appear even, and the neighbors may even wonder why you have such a ragged looking weed patch. Keep in mind that other than hurting your image at the coffee shop, this appearance doesn’t hurt anything and is actually really good for wildlife.
Grazing of Diverse Native Plantings

(Panoramic Establishment)

While we do not have a “cookbook recipe” for grazing a diverse native planting, there are some goals and general guidelines that we would aim for. We think that in addition to the thoughts recorded here, it is very important to get out and see how other folks are grazing diverse native grasslands and learn from them. Visit us at our Pasture Walk to see how we are grazing our diverse native planting.

Plateau/Panoramic (Imazapic) Establishment Plan - Spray glyphosate in fall. The following spring the imazapic-tolerant warm season grass species should be seeded. At planting time, glyphosate and a low rate of imazapic should be applied. After frost in fall, glyphosate should again be applied. The remaining seed can be sowed in winter (before February 15th).

**Year 1:** Don’t count on forage from the planting.

Goal: The focus is to get good establishment of the warm season grasses.

Rules of Thumb: 1) Imazapic removes much of the annual weed competition. In an exceptional growing year, the warm season grasses may be grazed once. Focus on taking only one bite from the plants. 2) Limit the grazing period for any particular area to no more than 2 days to avoid biting off regrowth, excessive trampling, etc. More animals on an area for a shorter period of time generally give more control over the grazing result. 3) Graze new plantings when the ground is firm; hoof prints should not be visible after the graze.

**Year 2:** There should be some amount of forage to be gleaned this year.

Goal: Continue to allow for development of the slow-to-develop warm season grasses and allow for establishment of the cool season grasses and the forbs.

Rules of Thumb: 1) Usually grazing the area twice is about right. The first is usually timed in early June so as to give the new seedlings time to establish. The second graze is usually late July but definitely before August 15th to allow the warm seasons plenty of time to regrow before frost. 2) During these grazes, the warm season grass plants should not be grazed below 8”

(Continued on the next page →)
the first graze and 10” the second graze. 3) Limit grazing for any particular area to no more than 2-3 days. 4) Graze new plantings when the ground is firm; hoof prints should not be visible after the graze.

**Year 3:** Finally, some forage to count on! However, don’t count on full production from the area.

Goal: This year the goals include forage production and development of the forbs and cool season grasses.

Rules of Thumb: 1) The warm season grasses may be grazed during this season a near-full production. However, concern must be given to the slow-to-develop seedlings that were seeded in the second planting, especially some of the forb species. To this end, begin grazing when the native warm season grasses are growing well (maybe late May to early June). The last grazing of the summer should be no later than mid-August. 2) A rest period of 45 days is usually the minimum. However longer rest periods are often needed and should be considered during a drought, unseasonably hot or cold temperatures, severe grazing in the previous graze that removed too much of the plant’s “factory”, or any other factor that leads to slow growth or regrowth of the plants. 3) Do not allow the warm season grasses to be grazed to heights less than 6-8”. 4) Grazing periods on any particular area should be limited to no more than 3-4 days per graze. 5) Until there is a good sod formed by the root systems of the native plants (especially the grasses), the planting should only be grazed when the ground is firm; hoof prints should not really be visible after the graze.

**Year 4+:** Let’s graze!

Goal: At this point, the stand should be fairly well established although many plants are not yet mature. The aims are now to get forage production, maintain and promote plant diversity, provide good wildlife habitat, and build up armor (thatch) on the soil to promote soil health.

Rules of Thumb: 1) Vary the time of grazing from year to year so as not to favor any certain species of plants while hurting others. 2) During the growing season, the goal is to graze but leave some factory (the leaves that produce food for the plant). In other words when grazing, leave plenty of leaf material to promote quick regrowth. Generally, this translates into the guideline that from about the beginning of June to the end of September,

(Continued on the next page →)
the warm season grass plants should be monitored to watch that they are not being grazed below 6-8”. During the active growth period of the cool season plants, the grazing should be monitored to leave 4” of above-ground growth. 3) During the dormant season, the goal is to graze the stockpiled forage while ensuring that residue is left on the soil. 4) A rest period of 45 days is usually the minimum. However longer rest periods are often needed and should be considered during a drought, unseasonably hot or cold temperatures, severe grazing in the previous graze that removed too much of the plant’s “factory”, or any other factor that leads to slow growth or regrowth of the plants. 5) Until there is a good sod formed by the root systems of the native plants (especially the grasses), the planting should only be grazed when the ground is firm; hoof prints should not really be visible after the graze. Keep in mind that decreasing the density of livestock in wet times can help. 6) Occasionally, seeds need to be allowed to fall on the ground for all species. For shorter lived species (e.g. annuals, biennials, other quick-to-establish forbs, and generally cool-season grasses), there needs to be a good amount of seed “stored” in the soil to replace the parent plants when they die. For longer-lived species such as many of the warm season grasses, seed does not need to fall on the ground as often. 7) Always think about the previous pasture the animals were grazing in. If they were grazing seeds of a plant you do not want in the diverse native planting (e.g. fescue, sericea lespedeza, Johnsongrass, etc.), put them on another pasture to “clean out” their digestive tracts and hair coats for a couple days. 8) Realize that a diverse native planting has many different plants of many different appearances and heights. Livestock graze each species of plant differently; some are grazed from the top down like a grass plant while others may only have the leaves removed from the stalk. The graze on a diverse native planting will not appear even, and the neighbors may even wonder why you have such a ragged looking weed patch. Keep in mind that other than hurting your image at the coffee shop, this appearance doesn’t hurt anything and is actually really good for wildlife.
Healthy Soils & Ecosystem Services

There is abundant evidence that a diverse stand of natives managed with herbivores would provide a host of ecosystem services and support healthy soils; the plants that grow on the grasslands are the foundation of this. Plants are the primary producers in grasslands; they utilize energy from the sun to capture atmospheric carbon dioxide via photosynthesis. More than half of most plants is found underground, and in grasslands this “hidden half” of the plant is the primary contributor of soil organic matter (SOM) (Brady & Weil, 1999), an organic form of carbon. This SOM has an immense effect on soil properties and consequently on plant growth. The SOM has glue-like properties which bind soil particles into units of structure and make the soil environment more suitable for plants and other organisms. The SOM also functions as a “sponge” to hold and release large amounts of water and nutrients for plant use. Furthermore, SOM is the backbone of the soil microbial community. When a plant takes carbon from the air and grows, part of this growth is eventually converted into SOM, which creates more optimal growing conditions for the plant. This, in turn, results in a plant that can produce even more SOM. To produce more SOM, David Tilman found that a diverse mix of grassland plants (16 species) will produce 238% more aboveground biomass than a monoculture of switchgrass which is typically considered one of the highest biomass producing grasses (Tilman et al., 2006). The researchers found that this increased growth translated into additional SOM production.

A diverse native grassland also has the ability to be productive without the addition of large quantities of fertilizer. An examination of the grasslands in the Midwest reveals that plants capable of fixing atmospheric nitrogen via organisms in root nodules are a vital and abundant component of the ecosystem. Nitrogen, a limiting nutrient in many situations, is made available to these plants and becomes available to other plants after the plant’s leaves and roots senesce and decompose. Nitrogen is not the only element that is made more available to the plants in the ecosystem due to plant diversity. Phosphorus is gathered by mycorrhizal fungi and while the plant gives the fungus “food”, the fungus supplies the plant with phosphorus, water, and other things that it is highly efficient at acquiring. Also, other elements found deep within the profile of the soil such as calcium, magnesium, and some trace elements can be brought to the upper horizons of the soil by deep rooted plants for use by other shallower rooted plants.

Diverse native grasslands also show promise in improving the water...
cycle. A study that compared watersheds with tallgrass prairie to those with agricultural cover showed that the streams surrounded by ag land see large peak flows (water levels during a precipitation event) and a decrease in the amount of water contributed to the stream by base flow or ground water movement (water level between precipitation events (Heimann and Blevins, 2010). A native planting has the potential to produce many of the same results as the prairies due to the abundance of warm season grasses in the tallgrass prairie and diverse planting. These grasses have the water-conserving C4 photosynthetic pathway (Pearcy and Ehleringer 1984), promote the development of soil aggregates (Jastrow 1987) which can increase water infiltration into the soil, and have large interception storage (precipitation trapped on a plant) (Brye et al., 2004); these factors, along with the potential for an increase in SOM, indicate that converting from a cool season dominated pasture to a diverse native grassland could improve the water cycle.

Grazing animals are also a piece of the puzzle. Defoliation, which results in a pruning of the root system as well, stimulates the plant to grow more roots and leaves; this has the potential to increase SOM. Grazing can also improve the nutrient cycles as the plant is chewed into smaller pieces, then partially decomposed in the herbivore’s gut, and subsequently deposited onto the soil as fecal matter. This process results in the nutrients in the plant material being made available for other plants quicker than the nutrients in ungrazed plants. Healthy grassland ecosystems with herbivores will also support a community of dung beetles which greatly enhance the nutrient cycle as they excavate tunnels to bury the dung and lay their eggs (Brady and Weil 1999). In these ways, herbivores can create healthier soil and speed up nutrient cycling.

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**Discussion 3. Page 2 of 2. Plant diversity and soil health.**

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<th>Pasture Type</th>
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**Understanding the NIRS Report** - The GAN Lab uses near infrared spectroscopy (NIRS) to evaluate the forage component of the diet and predict the quality of the grass and hay the animals were consuming for the past 36 to 48 hours. Therefore, the analyses do not reflect supplements that may have been fed. - Crude protein (CP) analysis measures grams of crude protein per gram of dry matter in the manure. - Digestible organic matter (DOM) measures grams of digestible organic matter per gram of dry matter in the manure. - The DOM/CP ratio is an indicator of rumen efficiency. The acceptable range for this ratio is 4 to 7 with 4 being optimal. A ratio of 4 or less usually coincides with very lush, cool season or early spring pastures and very runny feces. Most warm season and native range grazing has a ratio of 5 to 6. Late summer or drought stressed forage, some stockpiled grasses, and very mature, dry grass often has a ratio greater than 7. - Fecal nitrogen (FN) is a direct measurement of the amount of nitrogen in the manure and is not necessarily correlated to dietary nitrogen. FN can be used to roughly quantify the amount of nitrogen going back onto the pasture where the animals were grazing. - Fecal phosphorus (FP) analysis measures the percent of phosphorus (P) in the manure itself. FP can be used to roughly gauge whether dietary P is adequate. An FP value greater than 0.3 generally indicates that dietary phosphorus intake is adequate. - Information from Blackland Research and Extension Center - Grazingland Animal Nutrition Lab

**Table 4.** Forage quality as measured by fecal samples.

**Appendix**
To get updates on the grazing of our diverse native grassland, get reminders of when management activities can be accomplished on native plantings, and other native plant philosophy, sign up for the blog at our website www.HamiltonNativeOutpost.com.

Questions? Comments? Or, to learn more about the grazing of our diverse native grassland, please feel free to contact us at:

Hamilton Native Outpost
16786 Brown Road
Elk Creek, MO 65464

Phone: 417-967-2190
Fax: 417-967-5934
Email: natives@hamiltonnativeoutpost.com
www.HamiltonNativeOutpost.com