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Work Group Sessions Abstracts

Making the Weather Work for You

B. Bledsoe

Southern Livestock Standard Meteorologist

In agriculture, weather is one of the biggest deciding factors in whether your business is successful...or not. While I recognize that the weather can often times be unpredictable, I also recognize that short range and long range weather forecasting has never been more accurate. In my opinion, not nearly enough producers are taking advantage of this fact. It is my goal to show you that during wet or dry times, you can make the weather work for you and improve your business. I will be providing a long range weather outlook for the US and discussing the implications.

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Managing Grassland Structure to Enhance Pollinator Habitat

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Pollinators provide vital ecosystem services (ES) to crops and wild plants, maintaining biodiversity and agriculture production. Pollinators benefit 35% of global crop-based food production, and insects, particularly bees (Hymenoptera: Apoidea), are the primary pollinators of most agricultural crops and wild plants. Recent evidences, however, indicate declines in both wild and domesticated pollinators, with similar decline on plants that rely upon them. Reasons for bee decline include land-use change leading to loss and fragmentation of habitats, agriculture intensification, pesticide application and environmental pollution, decreased resource diversity, alien species, the spread of pathogens, and climate change. Grasslands can provide forage and habitat for pollinators. This ES provided by grasslands is vital to alleviate the current pressure on the bee population. Grassland structure and function as well as grazing management are important aspects to consider in order to optimize this ES. Grasslands with greater plant species richness provides greater foraging opportunities for bees. Grassland improvement by sowing flower-rich species (e.g. forage legumes) might be an option to improve habitat for pollinators. Even a modest increase in conventional grassland plant diversity with legumes and forbs could enhance pollinator functional diversity, richness, and abundance. These improvements would also lead to improved pollination services affecting positively surrounding crops and wildflower reproduction. Well-managed grasslands typically improves soil conditions, which is beneficial for ground-nesting bees. Litter commonly found in grasslands can also be used as nesting material for bees. Grazing management plays a crucial role on pollinator population. Because grazing pressure affects botanical composition, management should target to optimize the frequency of flowering plants beneficial both for cattle and pollinators. Lenient management intensity or deferred grazing can be useful management regimes to improve pollinator abundance. These management practices have a common goal of increasing the presence of flowering plants. Because of the increased fragmentation of grasslands, however, management strategies should be implemented on a landscape level rather than individual grasslands.

Keywords: bee, ecosystem service, flower, grazing, pasture

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Weather's Impact on Beef Cattle Market Prices

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Forage production is the lifeblood of cattle production as most cow-calf operations rely on pasture and mechanically harvested forages to feed cattle. However, forage production can be highly variable during time periods of extreme weather events such as drought, flooding, and adverse winter weather which can result in increased feed costs to an operation. Drought tends to be the most common weather event negatively influencing forage production regions for extended periods of time. During periods of drought, cattle producers are forced to change management tactics to conserve forage resources and prevent long-lasting damage to pastures. Change in management may include purchasing additional feed resources, marketing calves early, reducing herd size, or moving cattle to another region of the country and contract grazing where adequate forage is available. The breadth and severity of the drought is the primary determinant of the decision. The larger the region the drought covers then the more likely cattle will be marketed and harvested where as more localized droughts largely result in relocation of animals to regions with more feed resources. Largely, supply of cattle is determined by market prices. However, certain weather conditions can influence cattle supply which can impact market prices. The objective of this presentation is to demonstrate time periods where cattle prices and cattle supply were impacted by forage availability. A prime example of outside factors impacting cattle markets is the 2012 drought. The cattle market was primed for higher cattle prices which would have spurred heifer retention and herd expansion. However, the 2012 drought forced further cattle herd contraction which depressed prices as more beef entered the market. Subsequently, favorable forage conditions following 2012 allowed cattle producers to expand while cattle prices were at record levels. Weather and drought are not the primary influence to cattle prices, but they can impact the market during both expansion and contraction of the cattle herd.

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Responses of Grassland Communities to Climate Changes in Texas and *Oklahoma*

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Global climate has always exhibited temperature and precipitation cycles, but the recent, rapid increase in global mean surface temperature invites serious concern about the impact on productivity and stability of managed grasslands. Warming of subhumid to semi-arid zones of the Southern Plains will augment PET and accentuate the extent of soil water deficits. Native grass communities will likely shift towards greater dominance of warm-season (C4) types, and the proportion of opportunistic annual species may increase. Increased tree mortality may change the ecosystem type from savanna to semi-desert shrubland. Improvement of summer-dormant, cool-season grasses offers a promising opportunity in the Southern Plains to fill a fall-winter-spring forage void, with resilience to survive long periods of water deficit. This may provide a lower-cost, more reliable alternative to grazing wheat. The available choices of cool-season forage legumes will likely be reduced in the humid to subhumid zones. Alfalfa and some heat-tolerant, warm-season annual legumes may be the most reliable choices; however, high rainfall variability will limit their inter-annual consistency. Needs of the livestock component of grassland management include breeding for increased heat resistance, greater flexibility in adjusting stocking rates, greater use of supplementation, and construction of facilities for protection of livestock from heat. Promoting plant species diversity can contribute to stabilizing productivity of native and improved grasslands as swings in temperature and precipitation become more erratic.

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Responses of Grassland Communities to Climate Changes in Texas and Oklahoma

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Ecoregion and Grassland Descriptions:
The Southern Great Plains of the U.S. broadly describes the subtropical to warm-temperate, and humid to semi-arid zones of Texas, Oklahoma, and eastern New Mexico. This review will summarize effects of climate on grassland composition with emphasis on Texas ecoregions and projections of climate change on grasslands. Ecoregion descriptions typically list the native (or natural potential) vegetation in the region; however, agriculture has dramatically changed land use and therefore the types of vegetation. Therefore this discussion of climatic effects on modern grasslands will also include impacts on and adaptations of forages and livestock systems.

A commonly used ecoregion delineation used in Texas is that of Gould et al. (1960) (Fig. 1). See also Bailey (1995) and McNab et al. (2007) for U.S.-scale delineation of ecoregions. Average annual precipitation of the Southern Great Plains ranges from 56 inches in the east to 8 inches in extreme west Texas (Fig. 1). Mean annual lowest temperature ranges from 30 F in southernmost Texas to -5 F in northwest Oklahoma. Climatic averages naturally mask the wide variations in water supply and temperature. The dramatic declines in rainfall from east to west across Texas and Oklahoma impose a gradient of vegetation community type, height, and density, which combine with soil and landscape features to shape the vegetation descriptors of the ecoregions.

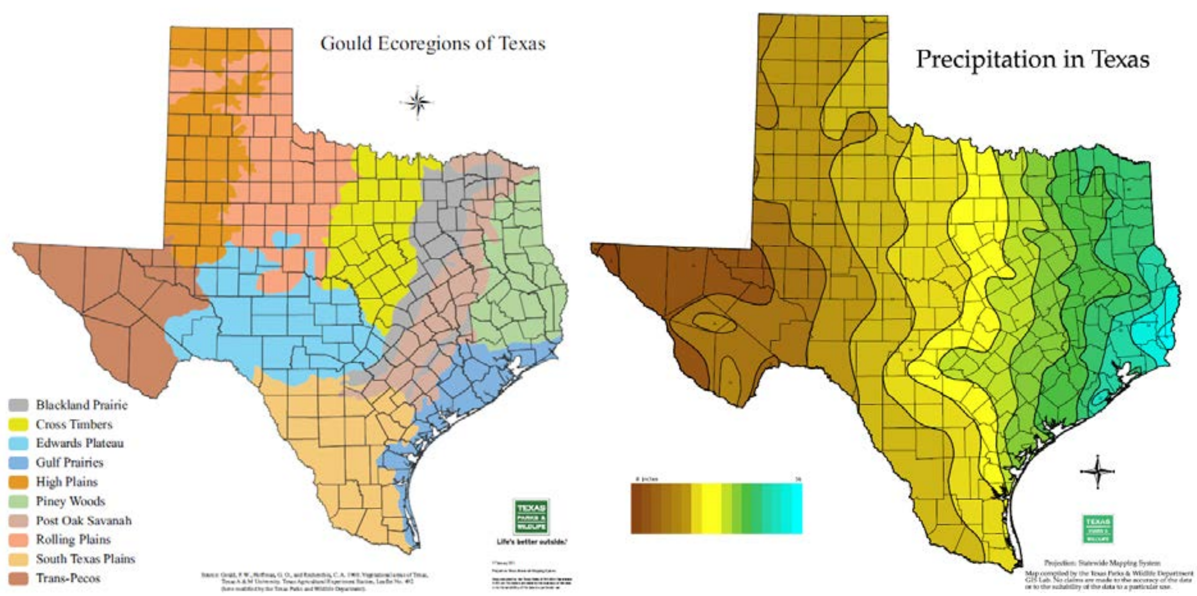


Figure 1. *Left*: Ecoregions of Texas (Gould et al., 1960). The Cross Timbers, Rolling Plains, and High Plains extend northward into Oklahoma. *Right*: Precipitation map of Texas in 4-inch increments, ranging from 8 to 56 inches. Source: Texas Parks and Wildlife Dept., Austin, TX.

As average annual precipitation decreases below about 20 inches, shortgrasses tend to replace midgrasses, and as annual precipitation increases above about 30 inches, tall grasses become more dominant (Weaver and Clements, 1938:510; Bailey, 1995). Above about 40 inches of annual precipitation, woodlands and forests begin to replace grasslands. Severity and duration of water deficit is a major determinant of vegetation distributions; therefore the natural vegetation change along a precipitation gradient is modulated by evaporative demand (potential evapotranspiration, PET) and the capacity of soil to absorb and store water.

In northeast Texas, native vegetation of the Piney Woods, Post-oak-Savanna, and Cross Timbers ecoregions (Fig. 1) consisted of pine-oak-hickory (*Pinus*, *Quercus*, and *Carya* spp.) forests and savannas. Much of the woodland was converted to annual cropland by early Euro-American settlers, and finally to managed pastures and meadows in support of today's beef cow-calf enterprises.

The other seven ecoregions of Texas include grasslands and shrublands, whose common native species are summarized below (see Diamond and Smeins, 1985, for details). Texas is home to more than 570 species, subspecies, and varieties of grasses, having the largest number of grass species in the USA (Gould, 1975). Moreover, grasslands contain numerous species of forbs and shrubs, which are not summarized here.

Native grasslands in the Blackland Prairie ecoregion are dominated by warm-season perennial grasses, including the climax dominant big bluestem (*Andropogon gerardii*), little bluestem (*Schizachyrium scoparium*), indiangrass (*Sorghastrum nutans*), tall dropseed (*Sporobolus asper*), eastern gamagrass (*Tripsacum dactyloides*) and switchgrass (*Panicum virgatum*). Most of the Blackland Prairie has been converted to annual row crops (mostly corn, *Zea mays*) and introduced pasture species. Bermudagrass (*Cynodon dactylon*) and dallisgrass (*Paspalum dilatatum*) are major components of pastures in this subhumid region, with a common winter cover of annual ryegrass (*Lolium multiflorum*).

The Rolling Plains is west of the Cross Timbers zone, and extends into the Panhandle of northwest Texas and northward into Oklahoma. This subhumid to semi-arid area was historically mid-grass prairie with scattered mesquite (*Prosopis glandulosa*), junipers (*Juniperus* spp.), and oaks. Grasslands of the Rolling Plains have been severely overgrazed by livestock. Dominant warm-season grasses include sideoats grama (*Bouteloua curtipendula*), little bluestem, sand bluestem (*Andropogon gerardii* var. *hallii*), switchgrass, hairy grama (*Bouteloua hirsuta*), three-awns (*Aristida* spp.), and sand dropseed (*Sporobolus cryptandrus*). Native cool-season perennial grasses are represented by Texas wintergrass (*Stipa leucotricha*) and Texas bluegrass (*Poa arachnifera*). The eastern part of the Rolling Plains contains a north-south belt of winter wheat (*Triticum aestivum*), which is frequently grazed by stocker cattle (*Bos* spp.) in winter, then allowed to produce grain in the spring. This wheat belt is interspersed with cotton (*Gossypium hirsutum*) in Texas and with winter canola (*Brassica rapa*) in Oklahoma. The western part of the Rolling Plains contains mesquite-infested, degraded rangeland, where improved Old World bluestems (*Bothriachloa* spp.) pastures have been established.

The High Plains is a flat plateau in west Texas that extends into eastern New Mexico and northward all the way to Canada. The native vegetation was primarily shortgrass prairie dominated by blue grama (*Bouteloua gracilis*) and buffalo grass (*Buchloe dactyloides*) in the Southern and Central High Plains, but also contained little bluestem, sand dropseed, sand bluestem, and sand lovegrass in the sandier southern parts. High Plains grasslands were heavily grazed for millennia by American bison (*Bison bison*), and then by cattle after European settlement. A large portion of the native prairie land of the High Plains has been converted to irrigated cropland, with cotton (*Gossypium hirsutum*) and corn predominating, which utilizes water pumped from the Ogallala Aquifer. Winter wheat is this region is mainly grown for single-purpose winter and spring grazing, with grain production dependent on irrigation or unreliable rains. Irrigated corn for grain and silage is used for feeding beef cattle and for dairy production.

The lowland, humid Gulf Prairies extend from Louisiana to Mexico along the subtropical Gulf Coast. Natural grasslands consist of tall and mid-size grasses with some post-oak savannah. Grasses are mainly warm-season perennials like indiangrass, little bluestem, brownseed paspalum (*Paspalum plicatulum*), indiangrass, cane bluestem (*Bothriochloa barbinodis*), and tall dropseed. Most of the Coastal Prairie has been cultivated and converted to row crops or improved pastures of bermudagrass, dallisgrass, bahiagrass (*Paspalum notatum*), and 'King Ranch' yellow bluestem (*Bothriochloa ischaemum*).

The southern-most subhumid, semi-arid, desert-like ecoregions (South Texas Plains, Edwards Plateau, and Trans-Pecos) contain vast areas of severely over-grazed, degraded rangeland dominated by shrubs and short- to midgrasses. Native grasses include the warm-season cane bluestem, various species of *Aristida*, *Chloris*, *Bouteloua*, *Setaria*, *Paspalum*, and *Hilaria*. Improved pastures have been established in the South Texas Plains with buffel grass (*Cenchris ciliaris*).

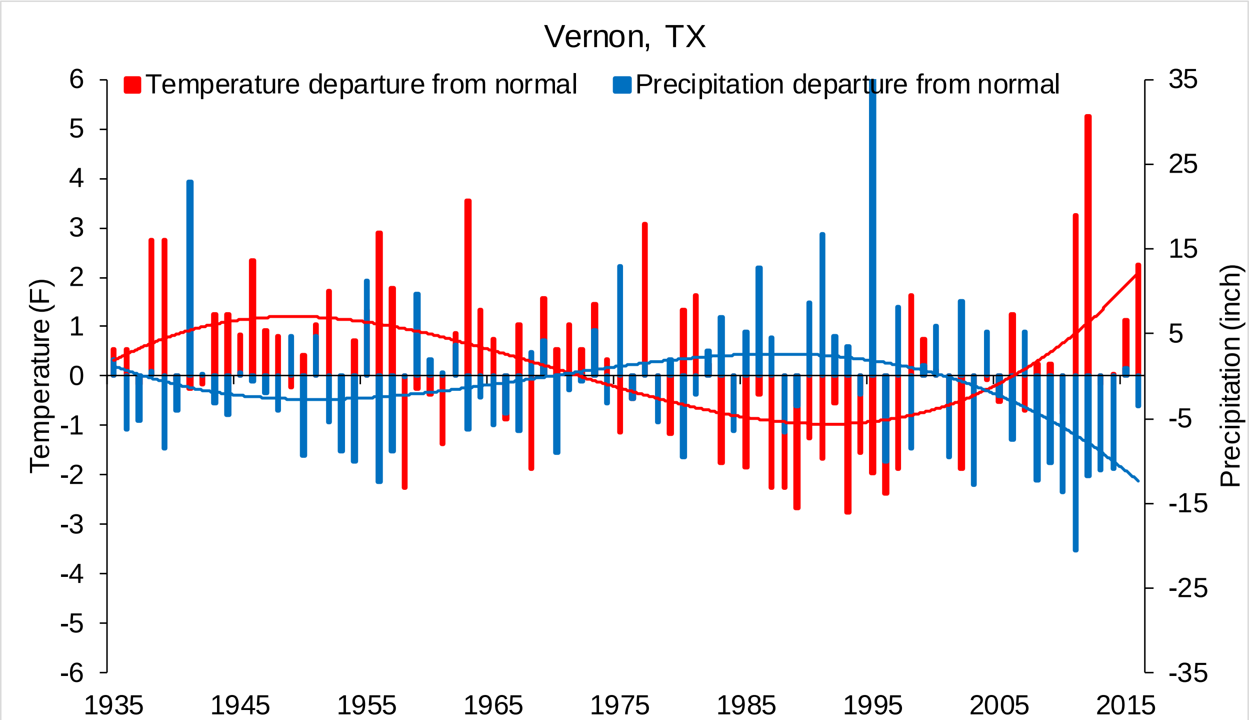
As noted in the above summaries of ecoregions, Euro-American settlement has caused dramatic changes in land use and vegetation. Forests in the east have been converted to species conducive to lumber and pulp production or to clearings for pasture. Dryland (nonirrigated) bermudagrass is the most common introduced forage system for hay and pasture in the humid to subhumid zones, mostly to support beef cow-calf production, and some irrigated bermudagrass exists in dryer areas. Old World bluestems such as King Ranch, 'WW-Spar', 'Plains' (both *Bothriochloa ischaemum*), and 'WW-B.Dahl' (*Bothriachloa bladhii*), and kleingrass (*Panicum coloratum*) have been seeded to restore parts of the degraded subhumid to semi-arid grasslands, all warm-season grasses (Redfearn and Nelson, 2003). The above grasses are used mainly for beef cow-calf and stocker production. Alfalfa (*Medicago sativa*) is not widely grown in Texas, Oklahoma, and eastern New Mexico because of unfavorable soils (low pH or root restrictive) in the east and high requirement for irrigation in the semi-arid west. In subhumid to semi-arid areas, grain sorghum (*Sorghum bicolor*) and forage sorghum and their hybrids (*Sorghum* spp.) are useful alternatives to corn where water is deficient, and contribute significantly to beef finishing and dairy production.

Climate variation and changes and impacts on grasslands:

Climate trends and extreme weather events have been intensively studied in recent years owing to a likely association between net atmospheric build-up of greenhouse gases (GHG) such as carbon dioxide (CO_2) (Stocker et al., 2013). Such build-up correlates closely with increases in global mean surface temperatures, and the build-up has been linked to human activities that release radiative-forcing gases, such as the burning of fossil fuels (Stocker et al., 2013). Climate models forecast, with varying rates of change, further increases in global temperatures, rising sea levels, and increased severity of weather events such as floods and droughts, especially in northern hemispheric mid-latitudes. Less clear are the effects on future precipitation patterns by region, although the southwestern U.S. is expected to experience lower precipitation in conjunction with a high likelihood of increased mean temperature (Cook et al., 2015; Stocker et al., 2013). Even if mean precipitation does not deviate from background variation, higher atmospheric temperatures would increase PET in subhumid and semi-arid environments, resulting in faster soil drying and greater demands on freshwater supplies to provide irrigation, supplies which are declining in the Ogallala Aquifer region of the High Plains.

Future climate-change simulations are associated with varying degrees of uncertainty and are modeled against a large background of natural short-term (inter-annual and several consecutive years), medium-term (multi-decadal), and long-term (centuries and millennia) climate variations. Multi-decadal cycles (40-60 years) can result in major shifts in rainfall patterns in the Southwest, which significantly impact ecological and hydrological systems. For example in San Antonio, TX (where Blackland Prairie and South Texas Plains meet, 29 in. annual rainfall), there were four dry periods (<70% of long-term average rainfall) lasting about a decade each between 1885 and 1956, during which annual rainfall averaged 24 in. From 1957-2015, there were four extended wet periods (>130% of long-term average rainfall) when rainfall averaged 34 in. This spread is enough to shift native vegetation from short- and mid-grasses to tall grasses and woodlands (compiled by T. McLendon). Similarly, the normally midgrass prairie at Hays, KS, shifted to shortgrasses after the 1930's droughts, and was shortgrass dominant between 1941-1946. During the abnormally dry 1952-1956 period, grass biomass production was 40% less than the subsequent relative wet 1957-1961 period. Midgrasses finally reappearing during the more rainfall-normal 1961-1964 (Hulett and Tomanek, 1969).

There is great concern in Texas over recent severe droughts, floods, and heat waves, and Texas seems very vulnerable to negative impacts of climate variation because of it spans the hurricane-prone Gulf zone to the semi-arid to arid west (Nielsen-Gammon, 2011). Recent trends suggest increased intensification of heat and drought. We present multi-decadal trends through 2016 in departures from normal temperature and precipitation for North Texas (Vernon) and South Texas (Brownsville) as examples (Fig. 2). Since 2000, Vernon has been experiencing above-normal temperatures (0.5 F) accompanied by consistent shortfalls in annual precipitation (5.85 in. below normal). At Brownsville, the average annual temperature increased by 2.2 F, and average annual precipitation decreased by 16.5 in. since 2000. Especially notable in Texas was the most severe drought in recorded history in 2011, causing an estimated $10 billion losses to the state economy (Combs, 2012). These recent trends suggest that vegetation patterns will shift to more aridic types and grassland productivity will decline. This interpretation is consistent with climate models (Cook et al., 2015; Thomey et al., 2014) and observations (Archer and Predick, 2008), which project increased water deficits in Texas and in the entire Southwest, notwithstanding the fact that it is difficult to tease out human-induced climate change from natural variation.



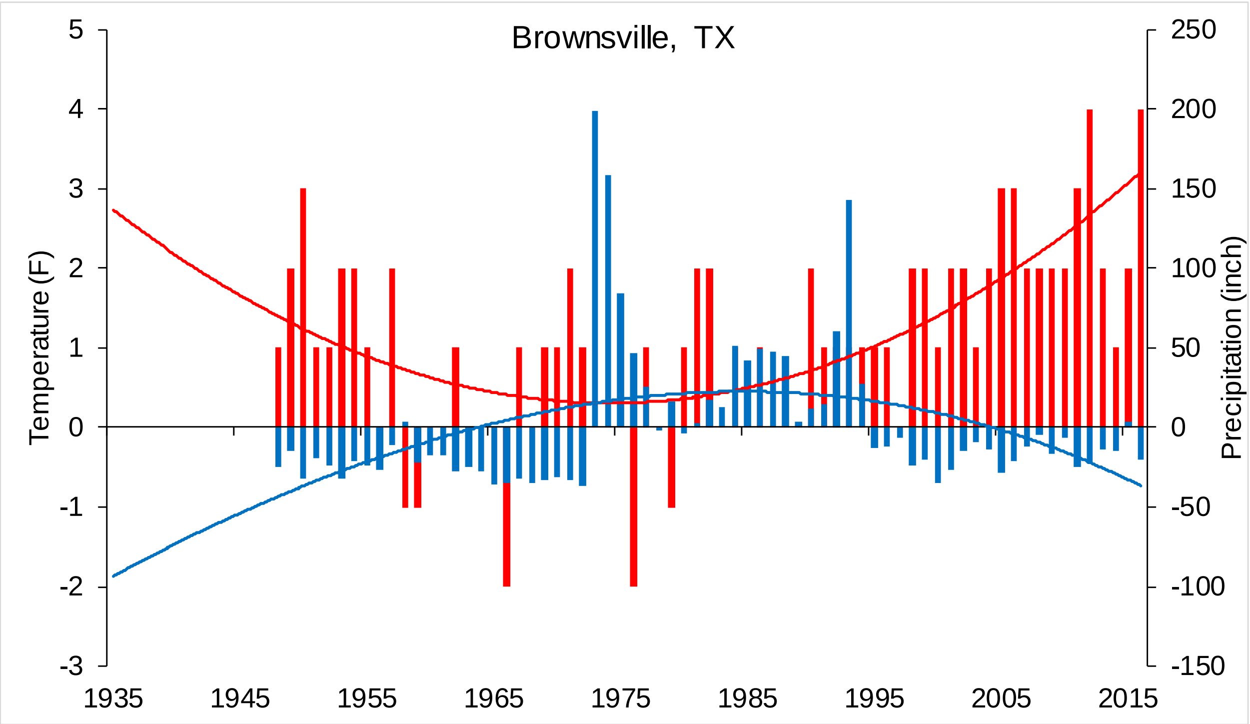


Figure 2. Examples of multi-decadal trends in average mean annual temperature and total annual precipitation for the North Texas (Vernon, top) and South Texas (Brownsville, bottom) regions, through 2016. Solid lines are 3rd degree polynomial curves fitted on the actual data. Temperature and precipitation data source: Weather Source LLC (2017), compiled by D. Malinowski.

Impacts on managed forage-livestock systems:
Managed grazing systems in Texas and Oklahoma have historically been based on four major forage resources, depending on the ecoregion: native rangelands and grasslands, dual-use or grazed-out wheat (*Triticum aestivum*), and introduced cool-season and warm-season perennial grasses (Northup et al., 2005). Rangelands ecosystems are particularly vulnerable because they are chronically in water deficit in relation to PET. Decreasing soil water availability will diminish forage and therefore animal productivity. Tree mortality has increased significantly in Texas rangelands observed during severe droughts since the early 2000's (Schwantes et al., 2016). Increasing deficit in precipitation and rising temperatures will increase the frequency and reach of wildfires (Chen et al., 2001), which cause losses in forage availability and livestock output. Projected climate changes may favor expansion of annual, non-native invasive grass species, i.e., medusahead (*Taeniatherum caput-medusae*), cheatgrass (*Bromus tectorum*), and red brome (*Bromus madritensis* subsp. *rubens*), which, besides their low nutritional value, can increase fire risk and inhibit persistence of native species (Bradley et al., 2009). Invasive plant species are already a problem in overgrazed Texas grasslands and their spreading would likely continue with progressive shifts toward aridity (DiTomaso et al., 2017).

Winter grazing systems in Texas are currently based almost exclusively on winter wheat pastures. In the 1970-80's, introduced cool-season perennial grasses played an important role in complementing forage from dual-use or grazed-out winter wheat pastures. Insufficient precipitation in autumn since the early 2000's has resulted in compromised timely planting of dual-use wheat in Texas and Oklahoma. The result has been a lack of wheat forage for grazing into the winter and early spring (Malinowski and Pinchak, 2015). Therefore further aridity will frustrate efforts to diversify forages with cool-season types, which are higher in nutritive value than C-4 (warm-season) types and fill a production fall-winter-spring production gap (Belesky and Malinowski, 2016).

Wheat is important as a cool-season forage in the Rolling Plains and High Plains because cool-season perennial grasses are already at the margin of their adaptation in the C-4 dominated grasslands (Malinowski et al., 2003; Gillen and Berg, 2005). Introduction of cool-season perennial grasses has met with poor success probably because of their inability to adapt to prolonged heat waves and frequent, extended dry periods (Malinowski et al., 2003; Gillen and Berg, 2005). Temperate (European continental) cool-season perennial forage grasses derive from germplasm originating from environments lacking extreme heat and prolonged droughts. One adaptation strategy to prolonged dry seasons may be adoption of grasses with a summer dormancy trait (Malinowski and Pinchak, 2015). Summer-dormant ecotypes of cool-season perennial grasses originate from the Mediterranean Basin and Mediterranean environments of California (Vegis, 1964), characterized by post-reproductive (summer) cessation of growth even when supplied water (Norton et al., 2016). The only two cool-season perennial grasses native to Texas, Texas bluegrass and Texas wintergrass, have also evolved as summer-dormant types, likely in response to water-deficient summers and mild winters (Read and Anderson, 2003).

In the Mediterranean Basin, summer-dormant ecotypes evolved in tall fescue (*Lolium arundinaceum*, formerly *Festuca arundinacea*) (Craven et al., 2010), orchardgrass (*Dactylis glomerata* ssp. *hispanica*) (Copani et al., 2012) and *D. glomerata* ssp. *judaica* (McKell et al., 1960), and others (Belesky and Malinowski, 2016). Summer-dormant cool-season perennial grasses were successfully introduced to Australia in the 1970's when climatic conditions threatened forage production from traditional grasslands (Norton et al., 2016). Norton et al. (2016) indicated summer-dormant cool-season grasses as the only viable option to sustain forage production during the cool-season in Australia, southern Europe, and Texas. Summer-dormant cool-season grasses were first introduced to the USA in 1998 (Mississippi) and 2000 (Texas). In north-central Texas, these grasses have been proven to be well adapted and persistent despite repeated severe summer and winter droughts (Malinowski et al., 2009). These grasses would have less adaptation potential in the High Plains of the Texas and Oklahoma Panhandles where dry, cold winters would limit their growth potential. Improvement programs of summer-dormant cool-season grasses are currently being conducted at the Samuel Roberts Noble Foundation at Ardmore, Oklahoma (Hopkins and Bhamidimarri, 2009) and Texas AgriLife Research at Vernon, TX (Malinowski et al., 2009). Introduction of new grasses invites concerns of potential invasiveness into native flora. Results by Malinowski et al. (2011) strongly suggest that summer-dormant tall fescue is not able to compete with summer-active competitors in Texas and Oklahoma. In these non-native environments, summer-dormant tall fescue cannot take advantage of summer soil moisture, in contrast to native temperate and warm-season vegetation.

Alfalfa (*Medicago sativa*) is the major perennial legume forage species produced on non-acidic soils in north, central, and east Texas and Oklahoma, and western zones under irrigation. Alfalfa is remarkably resilient under severe drought conditions, principally owing to deep rootedness, heat tolerance, and drought-inducible dormancy (Undersander, 1982). Alfalfa has persisted for over 7 yr in mixture with 'José' tall wheatgrass (*Thinopyrum ponticum*) and receiving minimal irrigation (9-12 in. per year) near semi-arid Lubbock, TX (Baxter et al. 2017). Alfalfa persisted for 4 yr with less irrigation (6-9 in. per year) at Lubbock when grown with WW-B.Dahl Old World bluestem (*Bothriochloa bladhii*) (Baxter et al., 2017). Results showed that alfalfa has an unrealized potential for High Plains grasslands where the declining Ogallala Aquifer will force producers to seek a low-water-input alternative to corn production. White clover (*Trifolium repens*) is grown in east Texas and Oklahoma where soils and grazing management allow its shallow root system to take advantage of frequent precipitation; however, its potential for use in this region is reduced by projected increases in temperatures and aridity.

Annual medics (*Medicago* sp.) have been naturalized from north to south Texas (Diggs et al., 1999) and could be an excellent companion to summer-dormant tall fescue (Butler et al., 2011). They originate from the same environments in the Mediterranean Basin as summer-dormant cool-season grasses. Among annual clovers, arrowleaf clover (*T. vesiculosum*) is the most productive, but also requires adequate water availability for growth. Other annual legumes, i.e., ball clover (*T. nigrescens*), crimson clover (*T. incarnatum*), rose clover (*T. hirtum*), and subterranean clover (*T. subterraneum*), are generally much less productive than the former species (Guretzky et al., 2012), and would likely not be adapted to increased heat and drought.

The majority of native and introduced forage grass species in Texas and Oklahoma are C-4 grasses. Native perennial warm-season grasses are well adapted to natural climatic variations that have occurred over millennia, and will likely continue to shift their regional adaptations accordingly. Many landowners in Texas are interested in restoring native vegetation for wildlife habitat enhancement. This opens options to increase income from hunting leases or to lower input costs when grazing livestock by virtue of the lower fertilizer requirements of native species relative to bermudagrass. Native grasslands that receive no fertilizer or irrigation inputs generally exhibit greater diversity of species, functional groups, and structure (associations with shrubs and trees) than managed introduced grasslands (Rajaniemi, 2002). Species diversity has been hypothesized to favor grassland stability under increased climatic disturbances compared with low-diversity grasslands (Kahmen et al., 2005), the latter of which is more typical of managed pastures. Isbell et al. (2015) investigated the relative roles of ecosystem resistance (less reduction due to drought) vs. resilience (quicker recovery after drought) in determining whether species diversity affected primary productivity. Their meta-analysis of 46 grassland experiments concluded that productivity of high-diversity communities (16-32 species) was reduced substantially less than that of low-diversity communities (1-2 species), but that resilience was unaffected. They advised that restoring diversity in grasslands would serve as a protective adaptation to increased climatic extremes.

Concluding Remarks:

1. There have always been temperature and precipitation cycles, but the relatively rapid increase in global mean surface temperature invites serious concern about the impact on productivity and stability of managed grasslands. Warming of subhumid to semi-arid zones of the Southern Plains will augment PET and accentuate the extent of soil water deficits.
2. Native grass communities will likely shift towards greater dominance of warm-season (C4) types, and the proportion of opportunistic annual species may increase. Increased tree mortality may change the ecosystem type from savanna to semi-desert shrubland.
3. Improvement of summer-dormant, cool-season grasses offers a promising opportunity in the Southern Plains to fill a fall-winter-spring forage void, with resilience to survive long periods of water deficit. This may provide a lower-cost, more reliable alternative to grazing wheat.
4. The available choices of cool-season forage legumes will likely be reduced in the humid to subhumid zones. Alfalfa and some heat-tolerant, warm-season annual legumes may be the most reliable choices; however, high rainfall variability will limit their inter-annual consistency.
5. Needs of the livestock component of grassland management include breeding for increased heat resistance, greater flexibility in adjusting stocking rates, greater use of supplementation, and construction of facilities for protection of livestock from heat.
6. Promoting plant species diversity can contribute to stabilizing productivity of native and improved grasslands as swings in temperature and precipitation become more erratic.

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Poster Session Abstracts

Black Oat as an Alternative Cool-season Grass in Florida's Livestock

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Over the past decade, collaboration among producers, researchers and extension faculty in the southeastern U.S. has led to a series of on-farm testing of cool-season forages. This research has been primarily funded through the Georgia and Florida Dairy Research and Education Project and SUNGRAINS (a cooperation of southern small grains breeding programs). Our goal has been to showcase cool-season forages "on-farm" for confinement or grazing dairies, beef cattle operations, and for use in wildlife forage food plots. Seasonal distribution of forage production differs among cultivars and among forage types. Oat cultivars are highly palatable and are highest in soluble sugars. Triticale (a rye-wheat cross) is also well suited, particularly in the southern Coastal Plain region of the U.S. where diseases, warmer climate, and drier, sandy soils are problematic. Wheat forage quality is very good, however few cultivars are bred for forage production and therefore foliage yields are typically lower than other cool-season forages. Cereal rye is cold tolerant, fairly disease resistant and withstands heavy grazing pressure. Ryegrass has excellent quality and yield, however it lags behind small grains on early-season forage production, often providing late grazing. Blending of cool-season forages (rye-ryegrass and triticale-ryegrass, etc.) maximizes forage yields, and blends are annually showcased in these demonstrations. We use these on-farm demonstrations to promote Best Management Practices (BMPs) by showing how cool-season forage production reduces erosion, and maximizes nutrient update and removal, a problem often associated with confinement dairies and beef operations with high stocking rates. On-farm testing of advanced forage breeding lines has led to the release and co-release of many new forage oat varieties, "Horizon 201", "RAM LA 99016", "Horizon 306", "Legend 567" and, experimental line "FL720". A tetraploid ryegrass, "Earlyploid" was also recently released by UF-IFAS that was developed specifically for dairies in the south-eastern U.S. Three triticale cultivars, "Trical 342", "Monarch" and newly released, FL01143 awnless triticale fit well in cool-season silage crop production systems, and are used as a component in blends for grazing and wildlife food plantings. SUNGRAINS breeders are now selecting potential forage wheat for southern forage systems. The strategy is to develop new cool-season forages and combinations of those forages to better enhance forage production and the quality of those forages for southern livestock enterprises and for wildlife purposes.

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Effect of Grassland Diversity on Primary Productivity across Diverse Environments and over 50 Years: a Meta-Analysis

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Ecological and agronomic research suggests increased crop diversity may improve ecosystem services, as well as yield stability; however, such theories are sometimes disproven by agronomic research, particularly at higher diversity levels. We conducted a meta-analysis on 2,753 trials published over the last 53 years to test: if biological N_2 fixation (BNF) supplies adequate nitrogen for plant growth relative to conventional systems; synergistic/antagonistic effects of multiple species within a pasture agroecosystem; forage quality impacts associated with plant diversification; how biculture crop physiological traits affect legume-grass symbiosis; and, how cultural practices affect BNF across diverse soils and climates overtime. Globally, primary productivity (PP) increased 44% via legume associations relative to sole stands. Several moderating variables affected symbiosis efficacy including: (i) photosynthetic pathway (mixtures of C_3 grasses resulted in 57% increase over grasslands without diversity, whereas C_4 grass mixtures increased 31%; similarly, cool-season legumes increased PP 52% compared to a 27% increase for warm-season legumes); (ii) legume life cycle (biculture PP response for perennial legumes was 50% greater than sole controls (with and without fertilizer), followed by a 28% increase for biennials, and a 0% increase for annual legumes); and, (iii) species richness (inclusion of one leguminous species in a grassland agroecosystem resulted in 52% increase in PP, whereas >2 legumes resulted in only 6% increases). Temporal and spatial effect sizes also influenced BNF efficacy, considering BNF was greatest (114% change) in Mediterranean climates followed by oceanic (84%), and tropical savanna (65%) environments; conversely, semi-arid and subartic had lowest *Rhizobium*-induced changes (5 and 0% change, respectively). *Rhizobium* associations were affected by soil texture; considering, a 122% PP increase in silt clay soils occurred compared to a 14% change for silt loam soils. Niche complementarity effects were greatest prior to 1971 (61% change), compared to recent studies (2011-2016; -7% change), likely owing to reduced sulfur deposition and increased annual temperatures overtime. These unambiguous trends suggest a great potential for BNF to displace inorganic-N and sustainably intensify global PP. Results provide a framework for ecologists and agronomists to improve crop diversification systems, refine research goals, and heighten BNF capacities in agro-grasslands.

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RFID Tags for Tracking Cattle to Improve Herd Management and Health

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In the US there are approximately 100 million head of cattle, 95 million cats, 70 million hogs, 65 million dogs, 9 million horses, and 6 million head of sheep and goats; animals someone would like to track as to location and situation. Approximately 15 years ago with a "Mad Cow Disease" scare, USDA considered mandating electronic ear tags for livestock in case of a widespread outbreak of Mad Cow Disease, Hoof and Mouth Disease, Anthrax, etc. However, the technology of the day (RFID) required the "reader" to be within 40 inches of the tag. Recently the Oakley Sustainable Agriculture Center had 28 cattle stolen from its inventory of approximately 1200 head of livestock. Efforts were begun by cooperating departments to identify methods of "tracking" livestock. The first generation "tracker" is affixed to a portable mineral feeder. Cattle will generally consume mineral supplements 2 or 3 times weekly. With current RFID technology, we can uplink data to wireless internet to make sure all animals are consuming mineral supplements. With the aid of solar panels affixed to the roof and adjustable to 8^0 to 45^0 for optimum solar charge, we can mount a camera and an electric sprayer pump. Every 2-3 weeks, cattle need treating for horn flies. The system can recognize cattle by electronic ID, and apply insecticide every 2-3 weeks as programmed. The logic can also adjust for current climatic conditions and delay applying insecticide under windy or rainy conditions. The camera can be controlled remotely. Further, plans are to apply de-wormers with the camera allowing a more exact location of the animal to have de-wormer applying to avoid loss of product. A comprehensive management plan is being developed as part of the package. Other technologies are being tested that can increase the tag range up to 300 yards. Another private company has developed an "active" ear tag with a reported range of 3 miles. We have signed an NDA with a different private company for marketing and adding drone technology. Numerous cattle management/ location characteristics can be measured following accurate location of livestock.

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Defoliation Frequency and Intensity Effects on Productivity and Persistence of 'Performer' Switchgrass

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'Performer' switchgrass (*Panicum virgatum* L.) was released in 2006 by the USDA-NCSU forage program because of its greater digestibility and potential to positively impact animal responses compared to standard cultivars grown in the Southeast USA. Information on the effects of defoliation management is critical to develop management recommendations that ensure forage productivity and persistence. The objectives of this study were to determine the effect of the factorial combination (4 x 4) of defoliation intensity (clipped to 10, 20, 30, and 40 cm stubble heights; SH) and defoliation frequency (clipped every 3, 6, 9, and 12-wk; DF) on herbage production, leaf to stem ratio, and weed infestation. The experiment was conducted at the Central Crops Research Station, Clayton, NC, using a mature stand (>8 yr) of 'Performer' switchgrass. Treatments were allocated in a randomized complete block design replicated four times. Herbage production ranged from 3.7 to 12.1 Mg ha^{-1}. There was no SH effect on herbage production for DF every 3- (4.4 Mg ha^{-1}) and 6-wk (6.4 Mg ha^{-1}); nevertheless, herbage production increased from ~6.8 to ~12.1 Mg ha^{-1} for both 9- and 12-wk DF being greater for 10- vs. 40-cm SH. Leaf to stem ratio differences were present for 3- and 12-wk DF only. For 3-wk DF, leaf to stem ratio decreased from ~2.5 for both 30 and 40-cm SH to ~1.7 for both 10- and 20-cm SH. For 12-wk DF, leaf to stem ration decreased from ~1.1 for both 40- and 30-cm SH to ~0.5 for both 10- and 20-cm SH. Leaf to stem ratio was intermediate ~1.0 for 6 and 9 wk DF. Weed infestation was mainly due to crabgrass (*Digitaria spp.)* and it was greater (~70% infestation) when defoliation occurred every 3 wk at 10-cm SH and remained below 15% for all other treatments. 'Performer' switchgrass is a productive forage and frequent defoliations, such as every 3 wk, should maintain a SH of at least 20 cm and defoliation frequencies ≥ 6 wk to 10 cm SH are warranted to ensure stand persistence and prevent weed infestation.

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Characterization and Evaluation of Ethyl Methanesulfonate (EMS) Treated Annual Ryegrass Populations for Improved Dry Matter Digestibility

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Mutation breeding has served as the genesis of a number of beneficial traits in crops. One of the preferred methods of mutation breeding is exposing seeds to ethyl methanesulfonate (EMS). Ethyl methansulfonate induces point mutations, wherein only a small segment of the genome is altered without sacrificing other vital areas of the genome necessary for basic biological functions. The objectives of this work were to use EMS mutagenesis to develop a new cultivar of annual ryegrass that has a greater in-vitro dry matter digestibility, without sacrificing other desirable traits. In-vitro dry matter digestibility can be visually assessed by a high leaf:stem ratio. During winter of 2015/2016, nine accessions of annual ryegrass that were previously selected for leafiness, dark green coloration, and strong regrowth potential were sent to us from a colleague in Texas. Each accession was dubbed "Rg1-Rg9", with Rg7 and Rg9 seed being treated with a 10% EMS solution for 24 hrs. These nine accessions were planted and harvested to increase seed. During the winter of 2016/2017, ryegrass accessions were planted in a characterization study. Each accession contained eight rows of 15-20 plants/row. Observations were made during the growing season. Characteristics measured were: survival, leaf:stem ratio, maturity, leaf-width, and color compared to the non-mutant ryegrass accessions. Of the quantitative traits, differences were observed in survival; Rg7 and Rg9 both ranked lowest on average. No differences in maturity were observed among any of the accessions. However, a number of individuals within the mutant accessions appear to have increased leaf width and leaf:stem ratio, darker green color, and greater leaf width, leading to possible options for selection and breeding.

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'Renovation': A New, Large Leaved, Intermediate Type White Clover Cultivar

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'Renovation', is a large leaved, synthetic intermediate type white clover (*Trifolium repens f. hollandicum Erith ex Jav. & Soo*) cultivar derived after hybridizing random, individual plants from a naturalized ecotype population from Oklahoma with those from the 'Regal', 'Patriot', 'Tillman', and 'SRVR' cultivars. Renovation was jointly developed, tested, and released in 2016 under the experimental designation NFWC04-49 by the Samuel Roberts Noble Foundation (NF), Ardmore, OK, and the University of Georgia Research Foundation, Athens, GA (UGARF). Botanically, there are three distinct, true breeding polymorphic forms of white clover based mainly on leaf size: the small leaved, wild type, *T. repens L. f. repens L.*, the intermediate leaved, common type, *T. repens f. hollandicum Erith ex Jav. & Soo*, and the large leaved, ladino type, *T. repens var. giganteum Lagr-Foss*. On average, plants from ladino populations are also taller and higher yielding than wild or intermediate types. However, stolon and seedhead numbers are higher in the intermediate types which usually lead to better spreading ability per individual plant and better persistence in pastures via more stolon survival and better reseeding ability due to higher seedhead numbers. The commercial seed market targets white clover cultivars for livestock pasture renovation and wildlife feed plots in the southeastern USA. Traditionally, ladino cultivars have dominated this market due mainly to their upright growth and high yield. But ladinos are not persistent, demonstrating only short term perenniality, and in some cases, persistent for only one season. Renovation was found to be an intermediate type based on seedhead numbers comparable to Durana, but higher than Regal (ladino type). Renovation's leaf size is larger than Durana and equal to Patriot; its plant height and stolon characteristics are intermediate between Regal and Durana and more like Patriot. Based on its morphological characteristics, and its agronomic and animal performance, Renovation should be able to be commercialized and used in both the intermediate and ladino seed markets. Renovation demonstrated animal performance and pasture growth rate much better than nitrogen fertilized controls, when overseeded into deteriorating tall fescue pastures in replicated paddocks grazed by beef steers. Renovation is licensed for commercial production and sales to Smith Seed Services, Halsey, OR.

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Sod-seeding Methods for Alfalfa into Bahiagrass (Paspalum notatum L.)

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There is a need to introduce perennial legumes into warm-season perennial grass systems (bermnudagrass and bahiagrass) in the southern USA to improve yield production and quality. Seeding perennial legumes into these warm-season grasses could reduce nitrogen fertilizer requirement. Bahiagrass and bermudagrass require high nitrogen fertilization to maintain maximum production. Research has already shown that alfalfa has the potential to be successfully inter-seeded into bermudagrass under proper management. However, there is very little information related to sod-seeding methods of alfalfa into bahiagrass. Sod-seeding alfalfa may reduce tillage needs for establishing into warm-season perennial grasses, but competition from existing vegetation must be suppressed for the seeded legume to become established. The objective of this study was to determine sod-seeding methods of alfalfa into bahiagrass that could increase legume competition and persistence. The study was conducted at Mississippi State University on a Marietta sandy loam that has a well-established stand of bahiagrass. 'Georgia Bulldog 505' alfalfa (FD5) was seeded into the stand of bahiagrass at a seeding rate of 20 lb/ac in October of 2015. Establishment methods consisted of a control(C, bahiagrass only plus nitrogen), no mow (NM), mow at one inch (M), paraquat suppression (P), paraquat suppression plus burning (PB), and minimum tillage (MT). Botanical separations by weight were determined at each harvest. Forage quality of the grass/legume mix was determined for each harvest among establishment treatments using the Forage and Feed Testing Consortium. There was sod-seeding method x harvest interaction ($P < 0.0001$). Seasonal forage production was also affected by alfalfa sod-seeding method ($P < 0.001$). Seasonal yields were 112, 111, 64, 78, and 94% higher for M, MT, NM, P, and PB, respectively when compare to the control. Early biomass production was dominated by alfalfa while bahiagrass was more predominant in mid-summer under hot and humid conditions. Forage quality changed throughout the season due to shift in species composition.

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The Status of the Joint Bahiagrass Breeding Program between the University of Florida (U.S.A.) and the National University of the Northeast (Argentina)

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Bahiagrass (*Paspalum notatum* Flüggé) is a warm-season perennial grass used for forage and turf in the subtropics. We have developed a joint bahiagrass breeding program between the University of Florida, United States, and the National University of the Northeast, Argentina through an international cooperation agreement. The program is two-fold; first we evaluate and select apomictic ecotypes *Paspalum* species, particularly *P. notatum* (bahiagrass) and close relatives and secondly, we create and evaluate apomictic hybrids. The main traits of interest in this collaboration include forage yield, frost tolerance, winter growth ability, nutritive value, seed production, seed retention and germination. The selection of ecotypes is based on the successful evaluation of individual apomictic genotypes and seed or plants will be conserved by both Universities. The creation of apomictic hybrids is carried out through crosses that we have made between sexual tetraploid genotypes and apomictic tetraploid genotypes. The obtained hybrids are then sorted by their mode of reproduction (apomictic, facultative apomictic or sexual). The highly apomictic hybrids and ecotypes that exhibit forage or turf potential are selected and evaluated in the field. This effort produces apomictic forage-types that can be introduced in subtropical beef-cattle production systems. An example of this is the release of the cultivar Boyero UNNE (Reg. No. CV-5, PI 676021) bahiagrass that was obtained by hybridization and was evaluated in different locations of Argentina and Florida. This cultivar had superior seasonal growth in comparison to the most popular tetraploid cultivars. At present, we are developing a new hybrid improvement technique based on a sexual, synthetic tetraploid population (SSTP) previously generated by researchers of Argentina. The development of this new synthetic sexual population will allow improving the tetraploid germplasm of *P. notatum* through recurrent selection based on combining ability. The objective of this technique is to exploit the heterosis of the obtained hybrids by crossing sexual genotypes selected from SSTP with apomictic genotypes based on additive and non-additive genetic effects. Ultimately, our goal is improving the forage characteristics of *Paspalum* species, focusing initially on bahiagrass.

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Developing Heat-tolerant Leguminous Cover Crops for Use in an Early-planted Mississippi Corn Production System

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Cover crops are an important component of sustainable agriculture. Agronomic benefits of cover crops such as soil stability and nutrient binding are maximized with a long season of growth. Many mainstream forage species have found additional uses as cover crops in commodity cropping systems. Legumes offer an added advantage over grass species by fixing atmospheric nitrogen. Establishment of cover crops following an early-planted Mississippi corn production system ideally requires planting cover crop species in early September and terminating by March. However, late summer germination of cool-season legumes is often limited by secondary seed dormancy. Cool-season cover crop species that germinate at greater soil temperatures would retrograde the early growing season into late summer. Additionally, early cover crop planting can scavenge residual nutrients from the prior field crop. This study compares germination, establishment, and biomass accumulation of unselected and heat-selected populations from four cool-season legume species [crimson clover (*Trifolium incarnatum* L.), balansa clover (*T. michelianum* Savi.), berseem clover (*T. alexandrinum* L.), and hairy vetch (*Vicia villosa* Roth.)]. All statistical analyses were conducted using PROC MIXED, significance set at $\alpha=0.05$. Efficacy of phenotypic recurrent selection in reducing secondary dormancy was assessed in lab and field comparisons using two populations (unselected and heat-selected) of each species. Laboratory germination results showed a positive response to selection for velocity of germination in hairy vetch and crimson cover. A replicated field trial was established to compare germination and biomass accumulation of unselected and heat-selected populations at various planting dates. Field studies indicated a significant difference in germination due to selection amongst all species and planting dates. Further selections are necessary to successfully reduce secondary dormancy in these species.

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Animal Performance and Forage Productivity of Annual Ryegrass Cytotypes

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Annual ryegrass (*Lollium multiflorum*) can be divided into two cytoypes. It can be either diploid [containing two sets of chromosomes (2n=2x)] or tetraploid [four sets of chromosomes (2n=4x)]. Industry pushes for tetraploid varieties because of the presumption of increased seedling vigor, more robust growth and corresponding greater yield. Research indicates there may be no yield difference between 2x and 4x varieties. Without a yield advantage there still may be an advantage to cattle grazing 4x versus 2x varieties. The objective of this study is to observe weight gain of cattle grazing 2x versus 4x varieties. Four common varieties were planted, two 2x and two 4x, at the Mississippi State Prairie Research Unit. Each of these varieties were planted in 2.5 acre pastures, replicated four times, on a target planting date of mid-Oct. Two steers were assigned to each of the 2.5 acre pastures from 4 Apr. to 31 May. Weights of cattle were taken over a two day period at the onset, mid and end of grazing season. In addition to weight gain, plant heights and forage samples were taken every two weeks to give an assessment of herbage mass, dry matter yield (DMY), in vitro dry matter digestibility (IVDMD), relative forage quality (RFQ). Research is currently underway and may provide information on how cytotype affects performance of cattle and help with economic decisions on production systems for the producer.

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Development of a Farmer-Based Working Group Program for Beef-Forage Systems Management in Alabama

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A working group is defined as a farmer-to-farmer network focused on a common theme or series of topics of interest. In 2016, a farmer-based working group was organized by Alabama Extension and formed in North Alabama to discuss beef-livestock management within the region. The intended audience was beef farmers with more than 10 years of experience in the industry. A series of five meetings were organized to highlight technologies and strategies for agronomic, animal, and economic best practices in beef cattle operations. Farmer meetings were located on-farm or at Auburn University affiliated research stations and demonstration sites, and offered from August 2016 through April 2017 to illustrate different management seasons. Topics included value-added calf marketing, bull selection and genetics, precision soil sampling, rotational grazing, bale grazing, and water quantity and quality in grazing systems. Group discussion was led by farmer participants and personnel from Alabama Extension, USDA NRCS Alabama, or another regional land-grant institution. A follow-up survey was conducted at the final meeting in April 2017 (n = 26 participants; average 66 head of cattle and 109 acres per operation). 100% of the participants indicated that the program met their expectations, and that it should be offered again. When asked which methods provided the best educational experience to farmers in the group, 52% indicated on-farm visits, 22% stated speakers at each meeting, 17% preferred field days on research/demonstration sites, and 9% indicated getting to know other farmers in the group. 75% of the farmers in the group reported that they had already started to adopt one or more of the management topics discussed as part of the program. Specifically, forage management strategies adopted by these farmers included working towards more than 300 days of grazing per year, precision soil sampling, and improving strategies for rotational stocking on-farm. Participants reported an average economic impact of $2,500 per operation. Results indicate that a farmer-focused discussion group may enhance on-farm understanding of beef systems by using resources at the local level.

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Genetic Influence on Annual Ryegrass Post-harvest Regrowth and Biomass Yield Within a Mississippi Forage Production System

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In the Southeast, annual ryegrass (*Lolium multiflorum* Lam.; ARG) provides forage production and cattle grazing operations with quality feedstock during winter months. Yield data for tetraploid (2n=4x) and diploid (2n=2x) ARG varieties in the Southeast varies among geographic locations. The objective of this research is to evaluate ploidy's influence on ARG post-harvest regrowth and biomass yield in a Mississippi forage production system. A field experiment was conducted at Mississippi State University. The experiment was designed as a randomized complete block consisting of six diploid and six tetraploid ARG varieties with four replications. The test was established 7 Oct 2016 at a rate of 30 lb/acre PLS with a 7-in. row spacing. Plots were fertilized in Nov at a rate of 50, 16.5, and 33 lb N, P, and K/acre, respectively, and 50 lb N/acre (33-0-0) following 21 March and 20 April harvests. Plot heights were measured daily for 28 d following the April 20 harvest. Biomass yield was determined by harvesting the center four rows of each plot. Statistical analysis was conducted using PROC GLM (yield) and PROC MIXED (regrowth). Means were separated using the appropriate LSD at $\alpha=0.05$. Post-harvest growth and biomass yield were significantly greater for tetraploid varieties compared to diploid varieties. Expanding the use of tetraploid ARG varieties could increase cool-season forage production in Mississippi. Results from future research focusing on the effect of temperature and rainfall distribution on biomass yield and linking ARG cytotypes to cattle weight gain would benefit forage production and cattle grazing operations in maximizing profitability.

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Nitrogen's Effect on Native Warm-season Grass Crown Growth

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Strip mining disrupts the land surface in order to obtain subsurface substances, including coal. Vegetation, especially grasses, fill important roles in restoring the landscape of coal mine land reclamation. Red Hills Mine (RHM), located in Ackerman, MS, is a current operating large scale strip mine for lignite (coal). The current reclamation practices utilize non-native species such as browntop millet (Urochloa ramosa L.) and bermudagrass (Cynodon dactylon (L.) Pers.) due to their quick emergence and soil stabilization. The objective of this study is to evaluate yield, crown expansion and nutritive value of native warm season grasses compared to bermudagrass. Big bluestem (Andropogon gerardii Vitman), little bluestem (Schizachyrium scoparium (Michx.) Nash.), indiangrass (Sorghastrum nutans (L.) Nash.), and upland switchgrass (Panicum virgatum L.) were the native warm season grasses included in this study. Bermudagrass and native warm season grass test plots, as well as surrounding monocultures, were established in the summers of 2015 and 2016 (2nd yr. testing). A fertilizer application (500 lbs/A; 13-13-13) was made to all test plots in early July (2016). A harvest followed in late August to compare the yield and nutritive values between the native warm season grasses and bermudagrass with and without nitrogen application. Tiller numbers were taken 2 and 4 weeks after March (2017) burn to determine nitrogen effect on crown growth. A significant difference in yield was detected between bermudagrass with nitrogen and all native warm season grasses. Yield increase of bermudagrass would suggest that it utilizes available nitrogen immediately for increased growth (yield). Native warm season grasses show small or no increase in yield due to nitrogen application. It is suspected that much of the nitrogen applied to the native warm season grasses is being utilized to increase crown growth for future yield. Tiller numbers indicate an increase in crown growth for big bluestem and upland switchgrass at 2 weeks, and for indiangrass at 4 weeks. In terms of nutritive value, there were no significant differences detected between bermudagrass and the native warm season grasses.

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Interseeding Options for Thinning Alfalfa Stands

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After several years of production, alfalfa (*Medicago sativa* L.) stands start thinning with a reduction in dry matter (DM) yields which is compounded by a usual drop of DM yields during the summer months. Various options exist for interseeding forages into these alfalfa stands to maintain quantity and quality. We tested teff (*Eragrostis teff* [Zucc.] Trotter), red clover (*Trifolium pretense* L.) and Italian ryegrass [*Lolium perenne* L. ssp. Multiflorum (Lam.) Husnot] and planted those in either spring or fall. Teff as a true summer annual was planted in spring only. Each species was planted separately into alfalfa and also in mixes of ryegrass+red clover and teff+red clover. The grasses were not combined. A non-interseeded alfalfa plot served as control. Seeding rates were 30 lbs/acre for Italian ryegrass, 8 lbs/acre for red clover, and 6 lbs/acre for teff. First-year results from 2016 indicated that alfalfa DM yields averaged 3,416 lbs/acre with no treatment differences observed (P>0.05) but with a date effect (P<0.01). There was a steep drop-off in DM yield at the last harvest of the year in October with 1,112 lbs/acre compared with previous months (P<0.01). The distinctly different seasonal growth curves of tested forage species were reflected in varying DM contribution to alfalfa yield and species composition throughout the year. In June, ryegrass and red clover were present, but they contributed only <5% to the overall plot DM. By August ryegrass and red clover disappeared, probably due to heat stress, but teff DM contribution peaked with 33% on average. By October, teff still averaged 18% in DM contribution despite its pronounced summer-annual growth characteristics. The success of interseeding and DM production of the forage species tested in alfalfa stands depends on either fall or spring planting. Teff was able to keep up with the rapid alfalfa growth in spring while ryegrass may have to be planted in fall to adequately compete with alfalfa the following spring.

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Performance and Stockpiling Potential of Limpograss in North Florida

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Collections of limpograss [*Hemarthria altissima* (Poir.) Stapf & C. E. Hubb.] have been established in North Florida since 2005, where the persistence of this grass indicates the potential to adapt in the Panhandle of Florida. Perennial warm-season forages go dormant in the cool-season due to low temperatures and short day length. Strategies to fill the gap when forage production is limiting are necessary to decrease livestock production cost. The main objective of this study was to assess the herbage accumulation (HA) and nutritive value of four limpograss cultivars in North Florida, and its stockpiling potential. The study was conducted from May 2015 to Feb 2017 at the North Florida Research and Education Center (NFREC) in Marianna, FL. A split-plot experiment in a randomized complete block design with four replications was performed, with the cultivars in the main plots and different harvest dates (stockpiling) in the split-plots. Plots were established in July 2014 and included four limpograss germplasms (breeding line 1 and the cultivars Kenhy, Floralta, and Gibtuck), and Tifton-85 bermudagrass was used as a control. The harvests started in May of each year, and plots were harvested at 17.5-cm stubble height with 5-weeks interval among them to estimate the HA and *in vitro* organic matter digestibility (IVOMD). After August, a stockpiling scenario was simulated with four split-plots, where each represented a different date (total of four), harvested every 5-weeks apart. Herbage accumulation and IVOMD were also evaluated in the split-plots. The cultivar Kenhy presented the greatest stockpiling potential in December of 2015 (6720 kg ha^{-1}). There was no difference among treatment for IVOMD and the values ranged from 55 to 60%. In conclusion, the limpograss cultivars evaluated in this study can be harvested during the warm-season and be stockpiled to fill the growth gap where neither, cool-season or warm-season forages are limiting.

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Efficacy of 2,4-DB Herbicide for Control of Broadleaf Weeds in Mixed Grass Stands in Alfalfa Overseeded Warm-season Grass Pastures in the South Central Louisiana

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Heavy weed competition is one of the most important factors affecting successful establishment of alfalfa (*Medicago sativa* L.) and its productivity in the southeastern region. A study was conducted to determine the effect of spring broadleaf herbicide (Butyrac®, 2,4-Dichlorophenoxy butyric acid) application and its application timing on alfalfa hay production. 'Bulldog 805' alfalfa was overseeded at 20 lbs PLS per acre in dormant warm-season grass pasture after light tillage at the Louisiana State University Agricultural Center's Ben Hur Research Station in Baton Rouge, LA. Soil type at the planting site was a Cancienne silt loam. The alfalfa pasture was fertilized according to the recommendations of Louisiana State University Agricultural Center Soil Analysis Lab. Buyrac 200® herbicide was applied at 2 quarts per acre after the first cutting in the spring of 2017 and will be applied later in fall. A field survey held after the spring herbicide application indicated that most of cool season broadleaf weeds were suppressed. Field survey taken before the second cutting indicated herbicide controlled over 95% of buttercup (*Ranunculus acris*), curly dock (*Rumex crispus*), and black medic (*Medicago lupulina*). The alfalfa demonstrated great tolerance to the herbicide application or with only minor injury. The CP (crude protein) in alfalfa ranged from 18 to 23% DM while CP in the weeds ranged from 11 to 18% DM. Spring herbicide application achieved a purer alfalfa stand and produced high nutrient value forage. The DM yield harvested from the herbicide treated pasture was 956 lbs/acre while DM from the untreated was 1,223 lbs/acre. Application of the herbicide containing 2,4-Dichlorophenoxy butyric acid in the spring produced more marketable alfalfa hay production in the southcentral LA. Residual effect of the herbicide on the subsequent growing season productivity of alfalfa overseeded warm-season grass pasture warrants further evaluation.

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Harvest Management to Extend the Supply of Forage or Feedstock from two NCSU's Switchgrass (Panicum virgatum L.) Cultivars

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Harvest management and timing may provide the opportunity to extend the supply of either forage or bioenergy feedstock from switchgrass. Switchgrass is a C_4, perennial warm-season grass, native to USA, and adapted to a wide range of growing conditions including marginal soils. Consequently, switchgrass can be grown in areas that otherwise would not be suitable for higher input crops. The objectives of the study were to evaluate the effects of harvest frequency (one, 1x; or two, 2x, clippings per year) and time of harvest (before frost, BF; after frost, AF, and late-winter, LW) on productivity (dry matter yield; DMY), canopy characteristics (leaf to stem ratio), and lodging score of switchgrass cultivars 'Performer' and 'BoMaster'. The two cultivars were released by the USDA-NCSU forage program because of their potential as forage ('Performer') and bioenergy feedstock ('BoMaster'). The experiment was conducted at the Central Crops Research Station, Clayton, NC, using matured (> 8 yr) stands of both cultivars. The experimental design was a split-plot design with main-plots arranged in a randomized complete block design replicated three times. Main-plot factor was harvest frequency and sub-plot factor was time of harvest. The experimental unit size was 25 m^2. For 'BoMaster', DMY was not different between 1x and 2x frequencies at BF (~10 Mg ha^{-1}); nevertheless, DMY for 2x was greater than 1x at both AF (~34% greater) and LW (~50% greater) harvests. Leaf to steam ratio for 'BoMaster' decreased from 0.5 at BF to 0.3 for both AF and LW. For 'Performer', DMY for 2x was consistently greater than 1x across harvest timings (21, 50, and 56% greater for 2x vs. 1x at BF, AF, and LW, respectively). There was no difference in leaf to stem ratio between harvest timings for 'Performer' (~0.42). Lodging score was higher (standing canopies) for all 2x compared with 1x harvest for both cultivars. Yield data indicates that 2x is a viable strategy to extend the supply of herbage mass. Information on chemical composition is further needed to evaluate the quality of the harvested herbage as forage or bioenergy feedstock.

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Summer Cover Crop Effect on Wheat Pasture and Stocker Cattle Performance

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Grazing wheat pasture with stocker cattle is an important livestock enterprise in the wheat belt of the southern plains. Producers who grow wheat for grazing typically will not rotate crops and the land area used for production is normally summer fallowed. Summer fallow is practiced in the belief that moisture is conserved for the fall planted wheat. Opportunities exist for the incorporation of cover crops into this production system during the summer between wheat crops. The effect of a summer cover crop on soil moisture, soil health and subsequent wheat pasture production and animal performance needs to be evaluated. To evaluate these effects we established a 2 x 2 factorial wheat pasture grazing study with five replications and four treatments of tillage and summer cover crops planted into 5-acre paddocks. Treatments included: tillage summer fallow (Till), tillage summer cover crop (TillCC), no-tillage chemical summer fallow (NT), and no-tillage summer cover crop (NTCC). The cover crop is a multi-species crop mixture consisting of 50% legumes and 50% summer annual grasses. Cover crops are planted following wheat pasture graze out in the spring (April or May). Wheat pasture is planted in September following summer cover crop termination. Cover crops receive no fertilizer. Wheat pasture receives 60 lb N/ac in the fall following emergence. Paddocks are soil tested yearly to ensure that phosphorus, potassium and pH are not limiting. Cover crops are grazed if forage is available. Wheat pasture is grazed with stocker cattle (560 lb) at a stocking rate of five head per paddock from November to May. No-till cover crops were planted in late May, 2016 and due to rain delays TillCC were planted in early June. Cover crops were grazed for 28 days in August, with the exception of one tillage paddock, then terminated and wheat was planted in September. The value of gain for stockers on wheat was \$0.61, \$0.76, \$0.77, and \$0.81 for NTCC, NT, TillCC, and Till treatments respectively. Differences are attributed to lower pasture production and grazing days of cover crop paddocks compared to summer fallow paddocks.

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Evaluation of Three Perennial Warm-season Grass Forage Systems for East-central Mississippi

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Increased awareness for grazing land sustainability and biodiversity has caused many livestock producers across the South to reevaluate their forage production systems. Several factors have contributed to this, including expanded federal environmental regulations, consumer perceptions on livestock production, and the continuous need to reduce costs associated with grazing livestock. One management practice that has the potential to alleviate some of the aforementioned problems is the incorporation of native warm-season grasses (NWSG) into a rotational grazing system. In order to promote on-farm sustainability, increased plant biodiversity, and the expansion of the grazing season for Mississippi producers, the adoption of NWSG into traditional low-input forage systems may prove cost effective. The objectives of this project are: 1) compare forage production [dry matter (DM) yield and forage quality] in three perennial grass systems, and 2) evaluate animal performance in the same systems. A grazing trial was established in Newton, MS, in a randomized complete block design (RCBD) in which three perennial grasses were evaluated: 'Argentine' bahiagrass (BG), big bluestem, indiangrass, and little bluestem (MIX), and big bluestem (BBS). Animals used in this study consist of 500 lb + SD commercial crossbred steers grazed 84 d, with weights recorded every 24 d. All grass treatments received 50 lb N/acre approximately 30 d prior to grazing. Only one year of data (2016) is presented. Cumulative DM yield was greatest for the MIX treatment (3,147 lb DM/acre). Crude protein (CP) and total digestible nutrients (TDN) were greater for the BG treatment throughout the 84 d season. At 28 d, ADG was greatest for BBS (2.20) compared to MIX (1.64) and BG (0.98). The same effect was noted at 56 d (1.46, 1.16, and 0.83) and 84 d (1.37, 0.95, and 0.62) for the BBS, MIX, and BG treatments, respectively. Though lower in forage quality, DM yield and animal performance on NWSG is greater than BG, which can bring added value to weaned calves during the summer months.

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Establishment Evaluation of Five Bermudagrass Cultivars in Spray Fields

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Bermudagrass (*Cynodon spp.* L.) is the most important warm-season perennial grass grown for forage and turf in the Southeastern USA. Because of its high dry matter (DM) yield and nutrient removal potential, bermudagrass has been used as receiver-crop of animal slurry lagoons ("spray fields"). Rapid establishment is a key desirable crop-trait in spray fields characterized by abundant water and nutrients. The objectives of this project were to evaluate herbage mass, ground coverage, and canopy height of five bermudgrasses ('Coastal', 'Tifton 44', 'Tifton 85', 'Ozark', and 'Midland 99') during the year of establishment in spray fields. The experiment was conducted at a cooperator's field located in Tar Heel, NC, during 2016. Bermudagrass cultivars were planted in 20- x 30-m plots arranged in a randomized complete block design replicated three times. Sprigs were planted on April 6 at a rate of ~300 kg ha^{-1}. There were herbage mass differences only during the first harvest event (July), out of a total of four harvesting events. In July, herbage mass of 'Midland 99' (3.8 Mg ha^{-1}) was greatest, followed by 'Tifton 44' and 'Ozark' (both ~2.3 Mg ha^{-1}) and lowest for 'Tifton 85' and 'Coastal' (~1.0 Mg ha^{-1}). Nevertheless, total herbage mass for the entire season (summation of all four harvesting events) was not different among cultivars (~8.7 Mg ha^{-1}). Canopy cover differences occurred mainly early in the growing season (June and July) and there was no difference (~100% cover) by Aug. In June, canopy cover was greatest for 'Midland 99' (29.7%) compared to the others (< 11%). In July, canopy cover was lowest for 'Tifton 85' (40.2%) compared to all others (>70%). Canopy height of 'Midland 99' and 'Coastal' was not different and it was greatest in June (~18 cm) followed by all the others (~10 cm). By July, canopy heights ranged from 33 to 49 cm and were greatest for 'Midland 99' and lowest for 'Tifton 85'. The cultivars tested in this experiment had similar total DM yields at the end of the growing season; however, the results indicate that there are in-season cultivar differences in terms herbage mass distribution and establishment.

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Forage 365: Evaluation of Bermudagrass Grazing Systems in the Southern Great Plains

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Grazing systems that could be utilized year-round could be cost effective for beef cattle (*Bos* spp.) producers in the southern Great Plains by reducing costs associated with feed and allowing more flexibility when purchasing cattle. Bermudagrass [*Cynodon dactylon* (L.) Pers.] is an important warm-season forage, however, quality and lack of cool-season growth can affect cattle production. Interseeding alfalfa (*Medicago sativa* L.) into established bermudagrass pastures can increase nutritive value and seasonal forage distribution as well as contribute to the nitrogen needs of bermudagrass. The objective of this study is to evaluate stocking rate, forage allowance, grazing days ac^{-1}, and animal performance of bermudagrass grazing systems in Ardmore, OK. Forage treatments are 1) monoculture bermudagrass with 0 lb N ac^{-1}, 2) monoculture bermudagrass with 0 lb N ac^{-1} and protein supplement 3) monoculture bermudagrass with 100 lb N ac^{-1}, 4) monoculture bermudagrass with 100 lb N ac^{-1} and protein supplement, and 5) bermudagrass with 800RR alfalfa. All treatments have a continuous (2.0 ac) and rotationally (4.0 ac) stocked (with 21 day rest period) component with three replications in a completely randomized design. Paddocks are grazed with Angus x Brangus heifers (670 ± 62 lb initial body weight), and stocking rate is adjusted every 28 d based on forage mass with the goal of achieving similar forage allowance across all treatments. First year (2016) results indicated alfalfa in bermudagrass provided earlier and later grazing than monoculture bermudagrass (175 vs. 140 days, respectively). Differences in stocking practice only occurred within the alfalfa treatments with an increase of 14 total grazing days for rotational vs continuous stocking management (182 and 168 days, respectively). Protein feed supplement generally resulted in greater animal performance. Protein supplement may be able to overcome a lack of N fertilizer as stocking rate, ADG, and total gain were all greater for BG + 0N + supplement than BG + 0N. At the conclusion of the final year of data collection, economic analyses will also be conducted to identify the most profitable grazing system for the southern Great Plains.

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The Effects of Plant Growth Regulator on Tall Wheatgrass Seed Production in the Southern Great Plains

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Grass seed production is an important agricultural enterprise. Oregon is the world's major producer of cool-season forage and turf grass seed and a widely recognized center of expertise in seed production. Most of the acreage is located in the Willamette Valley, the "grass seed capital of the world". Current estimates indicate that grass seed is grown on nearly 400,000 acres contributing more than $300 million to the state's economy. In the southern Great Plains, grass seed production is on a much smaller scale and primarily involves warm-season species. Optimum yields of high-quality cool-season grass seed may require practices that are not commonly applied to pastures in the southern Great Plains, such as wide row spacing's, residue burning, or the use of plant growth regulators (PGR). This study examines the effects of different rate applications of PGR on seed production of three different varieties of tall wheatgrass (*Thinopyrum ponticum* (Podp.) Barkworth & D.R. Dewey). The study was conducted over two years at the Noble Research Institute's Dupy farm. The experimental design was a 3 x 6 factorial arrangement of a randomized block design with 4 replications. The three tall wheatgrass varieties were Alkar, Jose and NFTW 6020. Six rates of Apogee® PGR were examined. Four single applications of 0, 7, 14 and 29 oz applied at 10% heading and two split applications of 7 and 14 oz applied at boot stage and at 10% heading. Lodging was significantly reduced ($p < 0.05$) by PGR regardless of year, application rate or variety when compared to the control treatment. No rate x variety interaction was detected for the response variables plant height, number of reproductive tillers or seed weight. Plant height was significantly lower (p <0 .05) in both 2013 and 2016 while the number of reproductive tillers significantly increased ($p < 0.05$) by application rates up to 14 oz Seed weights increased with the application of PGR for both years across all rates compared to the control. However, the split application treatment of 14 oz resulted in significantly greater ($p < 0.05$) seed weights when compared to the other PGR treatments. Data from this study will furnish information for those involved in or considering seed production of cool-season species in the southern Great Plains.

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The AFGC National Forage Bowl Competition: A National Forage-related Competition that Leads to Career Opportunities for Undergraduate Agriculture Students

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In the early 2000's, the American Forage and Grassland Council (AFGC) created a competition testing the forage knowledge of undergraduate students in a Jeopardy! ® style game at the annual conference. In 2014, a group of young AFGC members collaborated to improve the Forage Bowl and turn it into a sought after undergraduate competition. The first task was to modify the rules, structure and questions of the game. However, the real goal was to engage a diverse generation of agriculture students and introduce them to forage production and the potential career opportunities that exist within the forage industry. Today's National Forage Bowl Competition is well supported by the AFGC Board of Directors, well attended by schools from across the nation and has had significant impacts on the lives of students and the industry. In a recent survey of undergraduate students enrolled in a forage class at the University of Kentucky (unpublished data) found that a forage focused contest held at a national meeting appealed to 75% of students. Students are craving non-traditional experiences in college that will benefit them in the future. Several National Forage Bowl Competition alumni are now pursing advanced degrees in forage production or are working in the forage industry. The competition is still facing significant challenges such as cumbersome travel expenses which often limits the ability of some schools to attend. The committee is working to identify additional sponsors for the competition in hopes to continue providing support to teams, improve the overall student experience, and organize student focused tours and networking sessions in conjunction with the annual AFGC conference. The National Forage Bowl Competition has proven to be an effective education tool in teaching and challenging undergraduate agriculture students. It has also provided opportunities for undergraduate students to attend a national meeting, network within the three sectors (public, private, and producer) of AFGC, and led to career opportunities within the forage industry.

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