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Cool-season Forage Breeding for Livestock and Wildlife Enterprises in the South-eastern U.S.

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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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Brunswick Grass or Brown Seeded Paspalum (Paspalum nicorae): A Weed Contaminant in Southern Pastures and Bahiagrass Seed Production Fields

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Rationale: Brunswick grass (*Paspalum nicorae* Parodi), sometimes referred to as "Brown seeded paspalum", is becoming a problematic weed in summer perennial grass pastures in the southeast. This plant is native to southern Brazil, northern Argentina, Paraguay and Uruguay. It was introduced into the U.S. as a soil conservation plant for erosion control and as a potential forage crop. Brunswick grass is well adapted to moderately acid, sandy soils, but it also grows well in sandy loam and well-drained, light to medium clay-based soils. This plant has become naturalized and is contaminating bahiagrass seed production fields and pastures in Florida, Georgia and Alabama. The plant is competitive with bahiagrass and bermudagrass. Since it is less palatable, it can eventually dominate a perennial grass pasture. Brunswick grass has reportedly contaminated bahiagrass seed fields and pastures in several Florida counties.
Not harvesting production fields contaminated with Brunswick grass is the best preventive action a producer can take to avoid further distribution of this grass. It is important to remember that large quantities of bahiagrass seed are sold without any field inspections for purity, resulting in the sale of some contaminated seed for use in new pasture plantings. When purchasing seed to establish new pastures, purchase from reliable seed sources. There are no selective herbicides that are effective in removing Brunswick grass from established bahiagrass pastures. Total field renovation with glyphosate or cultural (mechanical) methods may need to be used to destroy a contaminated stand.

Appearance: Brunswick grass is a perennial summer grass, with a similar growing season and appearance to that of bahiagrass. Brunswick grass looks similar to Pensacola bahiagrass (*P. notatum var. saurae* Parodi), but it often has 3-4 racemes per seed head, compared to bahiagrass with typically 2 to 3 racemes (Hitchcock, 1971). Brunswick grass has a deep and aggressive rhizome system. Seed are slightly smaller than that of Pensacola bahiagrass, and the seed coat has a dark, chestnut brown center that varies somewhat in size by variety.

Variety/Germplasm: Two seed sources were released for conservation plantings by the Natural Resource and Conservation Service-NRCS), from Plant Materials Center-Americus, GA (Belt and Englert, 1999 and NPGS GRIN GLOBAL, 2016). 'Amcorae' (Origin: Argentina) is a blueish green, vigorous introduction released in 1969. A later release, 'Doncorae' (Origin: Brazil) occurred in 1993. It has rapid seedling establishment, vigorous growth habit and winter hardiness.

Eradication: To our knowledge no herbicides currently exist that will selectively remove Brunswick grass without severely injuring or killing the desirable pasture grass. High rates of glyphosate will likely be required to kill the pasture as the first step of total renovation.

Mechanical cultivation, in addition to herbicides and crop rotation, may provide successful control of Brunswick grass, since seed survival in a soil seed bank is not believed to be long-term.

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Screening Bermudagrass Genotypes for Nitrogen Use Efficiency

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Bermuda grass is the most important warm-season pasture and hay grass in the southern USA. It has several advantages as aggressive growth, grazing tolerance and adapted to a wide range of soil conditions, however requires high amounts of nitrogen (N) to reach its biomass production potential and quality. Our objective was to select N use efficient plants from the bermudagrass collections. A greenhouse experiment was conducted to evaluate 286 bermudagrass genotypes and four common cultivars under two doses of N (0 and 2.43 g of N/ pot) in pots containing 2 Kg of low N soil. Leaf length and width, internode length and diameter were measured before and after the N doses were applied. Biomass production and N content were evaluated and used to calculate the NUpE (N uptake efficiency), NUtE (N utilization efficiency) and NUE. The statistical analysis indicated differences between genotypes for all morphological traits evaluated ($P<0.0001$). The differences between the N^+ treatment and N^0 treatment increased as the doses of N were applied for leaf length and leaf width, achieving an increase of 46% and 29%, respectively, at the final evaluation. The average of all genotypes for total biomass production was 7.8 g in N^+ and 5.9 g in N^0. Significant differences were observed among genotypes for all the NUE variables ($P<0.0001$). According to the Pearson correlation analysis NUE is highly and positively correlated with DM (99%) and NUpE (90%), however, it is negatively correlated with NUtE (-24%). The values for NUE ranged from 1.7 to 5.2 with an average of 3.3 for all genotypes and 4.2 for 50 best genotypes. The cultivars Midland and Tifton 85 ranked among the top 50 genotypes with high NUE, however 20 genotypes had higher NUE than all controls. We selected 42 genotypes with high NUE, 5 genotypes with low NUE and 3 check cultivars to be evaluated further in greenhouse and hoop house experiments under 4 doses of N. According to our results it is possible to select high NUE genotypes aiming to decrease the N fertilization in at least 10% without reducing forage production and quality.

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Using Soil Moisture Sensors to Determine Soil Water Movement in Mixed Grass Pastures

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In the humid regions of the United States, a majority of pasture lands have historically relied on rainfall to supply grass mixtures with enough water to maintain production throughout the year. However, increasingly intense rainfall patterns combined with prolonged drought periods during summer months have plagued Louisiana in recent years. This has resulted in an interest for irrigating pastures to maintain forage productivity and stand density. The objective of this study was to evaluate soil water relationship on three distinct soil types with two irrigation strategies to determine evapotranspiration demand, infiltration characteristics, and effects of irrigation management on pasture production. The soils fall within the range of medium to heavy textures with one location having a hard pan located about 14 inches deep. Two locations are surface irrigated using lay-flat tubing spread across the highest point in the field. The third location was selected for installation under a center pivot irrigation system. Irrigation will be measured at the surface irrigation locations using flow meters attached to the irrigation risers. Two types of soil moisture sensors were installed at three grass-based pasture locations in West Carroll Parish to measure the movement of water within the upper two feet of soil. The Watermark (Irrometer Company, Riverside, CA) sensor estimates soil moisture gravimetrically (kPa) whereas the GS1 (Decagon Devices, Pullman, WA) sensor estimates soil moisture volumetrically as a percentage. Each sensor system includes three sensors with one sensor installed at 6 inches, 12 inches, and 18 inches. Sensors were installed on April 6, 2016; preliminary results since installation indicate excess rainfall has decreased evapotranspiration thus resulting in decreased growth. However, visual observation has indicated that the high moisture conditions has encouraged germination of new plant material. Data will continue to be collected to gain insight to the soil water relationship in pastures on a seasonal and annual basis.

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Complimentary Uses of Forage Crops

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Forage research and extension funding is waning for traditional projects, which are defined here as projects that focus on forages for grazing or hay and silage production, and storage for livestock. The purpose of this topic is to provide information about an ongoing paradigm shift in forage research and extension, and to encourage the expansion of creativity in forage research so that the needs of an increasing number of small landowners with alternative management practices and new potential research collaborations may be identified. While some complimentary uses of forages may seem obvious, they are related to the fundamentals of forage science and are worthy of further investigation and dissemination. Four major categories are covered:

Phytoremediation

Phytoremediation is defined by the US Environmental Protection Service (EPA) as "the direct use of living plants for in situ remediation of contaminated soil, sludges, sediments, and ground water through contaminant removal, degradation, or containment". Forage crops are particularly attractive for this use, as many species display rapid growth, high transpiration rates, and massive root systems, particularly perennial grass forages. Phytoremediation has been in use over several decades, but with contaminant lists growing and the advent of new, multi-omics tools and research, it may be time to readdress the untapped potential of forage crops in phytoremediation for the 21st century. The EPA categorizes six types of phytoremediation as follows: 1) Phytoextraction (absorption and transport of target pollutant from soil or air into above-ground plant parts), 2) Rhizofiltration (absorption and concentration of target pollutant in plant roots from water), 3) Phytostabilization (reduction of target pollutant mobility in soil via rhizosphere), 4) Phytodegradation (breakdown of contaminants taken up by plants through metabolic processes or external to the plant via enzymes, etc.), 5) Rhizodegradation (breakdown of contaminants in the soil through microbial activity that is enhanced by the rhizosphere, and 6) Phytovolatilization (uptake and transpiration of a contaminant with release to the atmosphere). Phytoextraction is what many typically think of when they hear the term phytoremediation, where hyperacumulators are used to remediate heavy metals from soil. However, use of high-yielding forages to remove excess nutrients from impacted soils (such as dairies and mining landscape) are also included. Perennial and annual ryegrass has been used in Europe indicators and to help process air contaminants, such as poly aromatic hydrocarbons (PAHs) and heavy metals. Rhizofiltration has recently been used with soybean to clean uranium and cesium contaminated water. If soybean works, then it is likely the forage soybean, with greater biomass, might be an even more attractive option. Fescues have helped via phytostablization with mercury contamination and several of the perennial prairie grasses that grow in the southern US have been used to phytostabilize herbicide residues, thereby lessening leaching and run-off losses to ground and surface waters. Pytodegradation and rhizodegradation are attributed to ryegrass and several perennial praire grasses (Indian grass, switchgrass, big bluestem) for treating PAHs and crude oil contaminants. Much less is reported on the use of forage crops for phytovolatilization, but Rhodes grass (*Chloris* *gayana* Kunth.) demonstrated some response with naphthalene and alfalfa with crude oil contaminants.

It is interesting to note that many of the C4 perennial grass species that derive from Central and South America are infrequently listed (or not at all) in the phytoremediation literature. Greater growth is often associated with C4 grass species, which seems like it will be an attribute for phytoremediation. In addition, climate changes result in weather extremes, may favor C4 species. These species tend to tolerate heat, drought, and limited fertility episodes better than many C3 species. Beyond forage inherent adaptability and survivability, the entry of various multi-omics research and tool developments is turning plant and soil research on its head. Much of phytoremediation works as a combination of plant and soil microbiological processes. Not only are mechanisms being worked out on how a compound or metal interacts in the plant-soil system, chemical signaling and genetic underpinnings are being identified so that genetic manipulations can be made to improve both, form and function at many levels. It is unclear how far multi-nomics will take us, but for now, it is an exciting challenge to try to keep up with all of the new, pertinent information coming from labs and to determine how to best utilize this information and potential collaborations for use in phytoremediation or more generally, our overall forage programs.

Native forage species

Native forages are often underestimated as an alternative option for sustainable, low-input grazing and fodder for livestock. Native forages afford many benefits. They provide habitat protection, especially if grown with other native plant species. Deep-rooted, perennial native forages can result in water savings and water quality protection, as well as provide a means for soil carbon sequestration. Some of the more productive species, such as switchgrass, can act as a biofuels feedstock. The same attributes that make some native forages attractive for livestock, also offer phytoremediation capabilities, as discussed in the previous section.

Native forage options in the southern US are typically represented by grass and legume species. Among these, only a handful of species are considered suitable as forages for the southern US at this time, and the native forage legume options are nearly non-existent. Some of the challenges in using native species as forage include limited seed source and demand for seed, as well as finding ecotypes suitable for optimal production. Limited choices translates into concerns over preserving and perpetuating genetic diversity within native forage species. Plant establishment and seedling vigor can be critical, especially when trying to establish in reclaimed pastures, where introduced species that were not completely eradicated, may be aggressive competitors. More needs to be learned about native forage grazing and cultural management, including optimal grazing schedules, the use of herbicides and pesticides, and how to improve ecological diversity by including additional plant species. For example, increasing diversity may benefit low-input systems through optimizing resources that are spatially and temporally stratified (i.e., light, water, nutrients), resulting in a healthier and more resilient system. Mixed species are especially challenging to manage if weeds or pests encroach upon the system.

Among native grass species, the most commonly reported include *Panicum virgatum* L. (switchgrass), *Andropogon Gerardi* Vitman. (big bluestem), *Sorghastrum nutans* (L.) Nash. (Indiangrass), and *Tripsacum dactyloides* L. (Eastern gamagrass). Dr. Pat Keyser (University of Tennesee) and others in SPFCIC have worked with many of these grasses as forage and some as bioenergy crops. Other native grass species worthy of further study for wetter landscapes include

Panicum hemitomon Schult. (maiden cane) and *Arundinaria gigantean* Michx. (river cane), although seed sources are scarce. In addition, SPFCIC member Dr. Brian Baldwin (Mississippi State University) is investigating *Elymus glabriflorus* (Vasey ex L.H. Dewey) Scribn. & C.R. Ball (southeastern wildrye) as a native annual grass forage. *Desmanthus illinoensis* (Michaux) MacMillan ex Robinson and Fern. (Illinois bundle flower) in the mid-south, *Aeschynmene americana* L. (deer vetch), and various *Desmodium spp*. tend to round-out the native legumes. Less information is available on native legume options as forages. Additionally, SPFCIC member Dr. James Muir (Texas A&M) has studied native forage species, including native legumes over many years and finds that few native legumes have been adopted into grasslands, with seed cost and marketing among the limitations to expanding adoption by producers. Some researchers are embarking on investigations into the use of various rhizobium and mycorrhizal preparations to induce improved biological N_2 fixation, and therefore legume production. As mentioned in the previous section, a wave of multi-omic activity is occurring within the plant-soil-water continuum. It is likely that new findings will be transferrable to native forage production and help support development of productive and diverse native forage systems for livestock production, while enhancing ecosystem services.

Cover crops

On the surface cover crops are simple additions to systems. However, with public incentives programs which are not scientifically based in place, research is necessary to understand the impacts, both environmentally and economically. Forages are prime candidates for inclusion into row crop systems and the benefits of year-round soil coverage to reduce erosion cannot be scientifically disputed. However, placing adapted forage species with the correct timeframe for growth and maturity, which are low water users while covering the soil, and which will not compete with the target row crop(s) are more complicated systems to develop, especially in semi-arid regions or in soils which are heavy clays or coarse sands.

Wildlife and other animal species

Forage programs in the western USA are focused on the balance of wildlife and livestock due to government ownership of land and arid environments conducive to rangelands versus introduced pasture systems. Rangeland ecologists consulted indicate that questions of how to best balance livestock and wildlife via habitat management in specific environments is still a valuable research area. Recently, quail habitat has become of interest by many local and state funding resources due to the value of hunting and the reduced numbers of quail. Quail response to introduced grasses and the nesting potential of these introduced forages are of interest, as is the impact of grazing management on quail populations. Zoos and wildlife preserves are under-served target audiences. Contacts at Disney and Busch Gardens in Florida confirm that browse and forage (primarily as hay) management and quality are topics which are important to their goals. Extension has served Busch Gardens historically. Collaborative work with ecologist or marine biologist may also provide fruitful areas of research and extension for communities.

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Walk-Over-Weighing System Applications

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Cattle walk-over weighing (WOW) systems have many advantages over traditional weighing facilities. Time savings, reduction in animal stress and injuries to animals and personnel due to handling, and recording of multiple weights per day are some benefits associated with automated on-paddock cattle weighing. The objectives of this trial were to evaluate the potential of WOW as an alternative to the conventional cattle weighing method and to determine the point at which animals were no longer gaining weight so that producers know when it's most economical to sell cattle. Three Walk-Over-Weighing units (Tru-Test™, New Zealand) were installed in three grazing paddocks in Ardmore, OK in February 2016 to measure individual weights of two tester steers per paddock. Total WOW system and materials to install a unit cost approximately $9740 each. Average daily gain (ADG) was calculated and compared to weights obtained via traditional weighing method. Similar ADG were observed between the traditional and WOW systems. Additionally, problems and issues such as those related to animal behavior, system complexity, and weight variation within day that were encountered during this trial period will be discussed. Future goals include the development of real-time data collection that will upload data to the server every day, eliminating the need for manual removal of data from scales.

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Forage Evaluation of Cool Season Annual Cover Crops

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Winter hay feeding can be one of the largest expenses of cattle production. A practical approach to reduce these costs would be to increase the grazing season by overseeding cool season annual cover crops onto warm season perennial grass pastures. With Louisiana's mild climate and extended growing season it is possible to have nearly year round grazing if proper management practices are implemented. Substituting winter annuals for the traditionally fed bermudagrass (*Cynodon dactylon*) and bahiagrass *(Paspalum notatum*) hay can better provide the energy and protein needed to meet livestock demands. A two-year field study was performed to determine the production potential of a variety of cover crops. Plots were planted with monocultures of annual ryegrass (*Lolium multiflorum*), rye (*Secale cereal*), tillage radish (*Raphanus sativus*), hairy vetch (*Vicia villosa*), oats (*Avena sativa*), triticale (*Triticale hexaploide*), and crimson clover (*Trifolium incarnatum*). Three plots were planted with forage mixes: oats/tillage radish, triticale/annual ryegrass/crimson clover, and triticale/tillage radish/crimson clover. Two harvests were made, one in February and one in April. From these harvests, yield and forage quality from wet chemistry analyses were determined. The first year data demonstrates a higher yield from the second harvest of each plot but a decrease in percentage of digestible dry matter content. The oats and the oats/tillage radish treatments yielded more than all others with over 3,100 lbs/ac *in vitro* digestible dry matter. Tillage radish monoculture produced approximately 86% of annual ryegrass biomass, indicating forage potential. Although hairy vetch monoculture had less biomass than that of the small grains, the legume had high digestibility and high crude protein. First year performance of all cover crop treatments indicates the feasibility of extended the grazing season and thereby reducing winter hay feeding.

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The Practical Equine Management Workshop: A hands-on workshop for horse owners in the Tennessee Valley region of Alabama

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Alabama currently has 187,000 horses in the state, which is an increase of 44% since 1977. The horse industry plays a pivotal role in maintaining the state's rural infrastructure and bolstering Alabama's economy to $2.39 billion annually. Due to the percentage increase of horses and their economic importance in the state of Alabama, more equine management trainings are warranted to ensure sustainable husbandry on small-acreage farms and to promote responsible horse ownership. For this reason, the Practical Equine Management workshop was developed with the goal of covering the state of Alabama in the north, central, and south regions. The workshop was held for 1 day with a total of 6 hours of instruction. It was conducted in a hands-on and interactive manner in order to increase participation in and effectiveness of the workshop. Attendees were divided into seven groups and rotated among eight stations that lasted approximately 28 minutes each. Topics taught in this 1-day workshop included: forage variety identification; herbicide use; soil fertility; body condition scoring; topline evaluations; first aid; and deworming principles. Evaluation of the program was positive, and participants increased their pre-test/post-test scores 87%. Of 45 attendees, 95% completed the written evaluation. Using a 5-point Likert-type scale (1 = never, 5 = always), 20% indicated that they always used these management techniques prior to the workshop, while 57% indicated that they will always use these management techniques because of knowledge gained at the workshop. The topics included in this workshop were based on the following objectives: 1) to increase horse owner and manager knowledge of techniques and resources to help them improve their equine management systems, 2) to attract greater attendance at horse owner education programs by providing timely topics of interest, 3) to offer horse owners an opportunity to suggest topics and frequency of future equine Extension educational programs.

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Germination of Seven Legumes Native to Central Argentina

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In the last two decades in the southwest portion of Buenos Aires Province (Argentina) the ongoing process of soil deterioration and natural grasslands impoverishment has accelerated. To restore these degraded ecosystems, it is necessary to reincorporate key species from the original plant community, such as native legumes, a very important group due to its ability to improve forage supply and recover fertility through biological nitrogen fixation. The aim of this study was to evaluate germination under different pre-germination treatments of *Adesmia filipes* (Af), *A. incana* (Ai), *A. muricata* (Am), *Lathyrus nervosus* (Ln), *L. pubescens* (Lp), *Rhynchosia diversifolia* (Rd) and *R. senna* (Rs), all of them promising native legumes. The seven pre-germination treatments used were control, physical scarification with sand paper (SP), physical scarification with mechanical scarifier (ESC) and immersion in hot water with an initial temperature of 40, 50, 60 and 70°C, for 48 hours. The species Ai, Ln, Lp, Rs and Rd achieved high germination percentages (GP) in at least one treatment, with maximums of 88%, 93%, 96%, 95% and 96%, respectively. Af and Am showed lower GP, with maximums of 17% and 51%, respectively. The best GP considering all the treatments was shown by Ln and Lp. For all species except Ln, SP was successful ($p<0.01$). ESC was not different from SP only in Af and Ln and was higher than the control in every case ($p<0.01$), except Ln. Immersion in hot water showed no differences with the control in any species except Lp at 50°, 60°C and 70°C and Ai in 40°C ($p<0.05$). The temperatures used were probably insufficient to weaken the seed coat. Future studies should test more time in the mechanical scarifying for Ai, Rd and Rs and higher temperatures of immersion in hot water for all the species. Determining how to germinate these species is the first step to knowing how to successfully cultivate them for sustainable utilization.

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A New, Late Maturing Crabgrass Cultivar for the Southern USA

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The Noble Foundation's 'Red River' crabgrass (*Digitaria ciliaris* (Retz.) Koeler) is the main commercial crabgrass cultivar for Southern USA livestock operations. Based on farmer feedback, one limitation is the cultivar's short vegetative growth period that reduces its overall nutritive quality. Therefore, the Foundation's Forage Improvement Division began a breeding program to develop a new crabgrass cultivar that was later maturing than Red River, with higher nutritive value, but competitive yield, adaptation, and reseeding ability. NFCG07-1 was essentially derived from Red River by recurrent phenotypic selection for late flowering and good individual plant growth. In trials established at Ardmore, OK, in 2014 and 2015, NFCG07-1 headed significantly ($p<0.05$) later that Red River and the early maturing cultivar 'Quick-n-Big'; an average of 8 and 10 days later, respectively. The positive effect of NFCG07-1 later maturity was demonstrated by significantly higher ($p<0.05$) in-vitro true dry matter digestibility (IVDMD) than Red River and Quick-n-Big (69.7% vs. 68.5% and 66.5%, respectively, across 11 harvests) and lower neutral detergent fiber (NDF; 63.5% vs. 65.4%) than Quick-n-Big. Crude protein (CP) content was not different among the three cultivars, but averaged 13.7% for NFCG07-1; an excellent average summer CP for any warm season grass species. In yield performance trials in Oklahoma during 2010, 2011 and 2014, there were no consistent differences in monthly or total dry matter yields when NFCG07-1 was compared to Red River (NFCG07-1 ranged from 8,170 to 17,630 lbs acre^{-1}, depending on year and location). However, NFCG07-1 crabgrass was higher in yield ($p<0.05$) at all late season harvest dates (mid-July-early October) when compared to Quick-n-Big; while at Vashti, TX, in 2014, NFCG07-1 produced significantly more monthly forage and total dry matter yield ($p<0.05$) than both Red River and Quick-n-Big. When tested in Mississippi and Tennessee, yields of NFCG07-1 were good (range 1.5 to 5.5 tons/acre across all locations and years) and cultivar differences were similar to Oklahoma results. Under proper management conditions, NFCG07-1 demonstrated excellent summer animal gains of 2.1 lbs/head/day and total season gains of 325 lbs/acre. NFCG07-1 is currently under evaluation by a potential commercial partner with licensing anticipated in the near future.

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Harvest Regimens to Maximize Sericea Lespedeza Crude Protein and Condensed Tannins

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Sericea lespedeza (SL; *Lespedeza cuneata*) is sold as hay or pellets for its crude protein (CP) and condensed tannin (CT) content, the latter to promote rumen bypass protein, depress methane emissions in livestock, and suppress gastro-intestinal parasites in small ruminants. Maximizing these forage components may depend on harvest regimen. We collected SL AU Grazer herbage samples in five states (Raleigh NC, Fort Valley GA, Tallassee AL, Baton Rouge LA, and Stephenville TX) during one growing season. We compared season-long averages from forage harvested at 35-d regrowth (35-d), 40-cm height regrowth (40-cm), and monthly accumulated (ACUM). The 35-d and 40-cm plants had 27% greater ($P \leq 0.05$) CP (168 g kg^{-1}) than ACUM forage; TX, the driest site, had lower ($P \leq 0.05$) CP content than the others. Where there were differences ($P \leq 0.05$) in CT content, ACUM plants were inferior to the other harvest regimens while forage in TX and AL had among the greatest values (up to 100 g kg^{-1} for 35-d in TX) compared to others (62.7 g kg^{-1} in LA). We do not recommend harvesting accumulated SL forage for optimum CP or CT. We advise that individual SL hay or pellet batches be assayed prior to sale because of the wide variability among locations and harvest regimens, especially for CT.

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Autumn and Winter Dynamics of White-tailed Deer Browse Nutritive Values in the Southern Cross Timbers and Prairies

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White-tailed deer (*Odocoileus virginianus*) are aesthetically and economically important to landowners in Texas. Deer herd health, productivity and survivability decline when population size exceeds the available forage. During stressful times, such as dry winter periods, nutrition is limited and forage availability decreases drastically. White-tailed deer winter diets are mainly comprised of browse species because herbaceous production decreases as winter progresses. The objective of this study was to determine the influence of winter progression on biologically active condensed tannins, nitrogen (N), and in-vitro organic matter disappearance (IVOMD) (using white-tailed deer rumen liquid) of six browse species of moderate to high forage importance. Woody plant samples were collected during pre-frost, mid-winter, and late winter from four (replications) properties in the Cross Timbers of Texas, USA over 2 years. There was a difference between years ($P \leq 0.05$). There was an interaction ($P \leq 0.05$) between species and season for all forage values. Nitrogen, a desirable nutrient, decreased as winter progressed, IVOMD decreased as fiber increased with winter progression in five of the six browse species. The only exception was evergreen live oak (*Quercus virginiana* Mill.) which kept its leaves throughout winter and maintained an average 1.33% N with lowest fiber levels during late winter, along with no difference in IVOMD throughout the study periods. Protein-precipitable phenolics (PPP) decreased with winter progression in all species, excluding live oak and Texas oak (*Quercus buckleyi*). Results confirm that nutritional value of browse, especially N and fiber, decreases after the first freeze when most browse species shed leaves. The anti-nutritive qualities associated with PPP and lignin may limit overall digestibility by reducing availability of N, ultimately limiting fiber digestion. Differences in browse species' nutritive values, within and between periods, highlight the importance of plant biodiversity for supporting white-tailed deer nutritional requirements during late fall and winter.

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Valuation of Grassland Ecosystems Services for Sustainable Livestock Production

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Several forms of interrelated ecosystems services are provided by natural and naturalized grasslands, but they are rarely quantified or play only minor roles in the overall economic assessment that prioritizes meat production per unit land area. Services such as carbon sequestration, soil erosion prevention, habitat, and aesthetics may have to be monetarized further in the future to help sustain livestock farming. Four main ecosystems services from grassland have been categorized: (1) provisioning services such as meat, milk, and bioenergy; (2) regulating services such as air quality, water quality, climate regulation, and erosion prevention; (3) habitat services such as wildlife corridors and plant-genetic diversity; and (4) cultural services including recreation and agri-tourism. Carbon sequestration has been identified as a major benefit from grasslands to absorb CO_2 emissions and is relatively easy to quantify. Permanent grassland, when converted from arable land, can increase soil carbon stocks by 450 lb per acre per year on average. In contrast, erosion from grasslands has been considered minor. On average, 580 lb of soil per acre per year is being lost from grasslands compared with ≥ 2,670 lb per acre per year from arable land. Annual benefits from grass cover to prevent erosion has been estimated at $120 per acre, although values may vary drastically dependent on region and country. Runoff coefficients in grasslands are low (0.2-0.3) in comparison to arable land (0.4-0.6). Options for deliberate water retention exist in forms of vegetated swales intersecting cropland or temporary water storage in alluvial grasslands (floodplains). These can also help remove nitrates through denitrification by releasing N_2 into the atmosphere, thus reducing leaching. Best-case scenarios estimate nitrate abatement values around $80 per acre. Aesthetic and recreational opportunities in grasslands are diverse and depend on activities such as hunting and bird-watching. Total services from grasslands average $1,200 per acre according to a Central-European study, with water filtration services leading in value (65%) followed by livestock production (23%), and soil erosion prevention (6%).

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Effects of Planting Date and Small Grain Mixtures on Forage Yield and Nutritive Value

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Field experiments (split-plot design) were initiated in the autumn of 2014-15 and 2015-16 to investigate the effects of three planting dates (PD) and 15 seed mixtures of four annual small grain species on their forage yield and nutritive value. Main plots consisted of planting the first weeks of September, October, and November. Sub-plot treatments (15) included monocultures of 'Bates RS4' rye (*Secale cereale* L.), 'NF 101' winter wheat (*Triticum aestivum* L.), 'Heavy Grazer II' oat (*Avena sativa* L.), and 'NF 96210' triticale (*Triticosecale rimpaui* C. Yen & J.L. Yang [*Secale cereale* × *Triticum aestivum*]), as well as selected two- and three-way mixtures. Locations were near Vernon, TX (2015-16) and Gene Autry, OK (both seasons), two sites of differing annual precipitation in the Texas-Oklahoma Red River valley area of the southern Great Plains of the USA (25 in yr^{-1} and 37 in yr^{-1}, respectively). Arranged in four replications, these forage clipping experiments followed the previous season's cropping of non-cereal grains plus summer chemical fallow prior to planting. Regardless of species composition, all plots were seeded at a standardized 1.7M pure live seeds per acre on 7.0 inch row spacing using a 7-row experimental plot seed drill (Hege Model 500; Coldwich, KS). Forage was harvested from the five center drill rows at 2.5 inch stubble height at approximately 60, 45, and 120 days after planting for the September, October, and November planting dates, respectively, to determine dry matter yield (DMY). Harvesting intervals were discontinued by mid-April for all locations. Although differences in crude protein (CP) were detected among treatments and PD, the minimum mean value was greater than 22%; therefore all treatments at any PD would be considered adequate for grazing animal nutrition. Cumulative DM yields for September and October PDs did not differ from each other, but both were greater than those for the November PD. When planted in September, monoculture Heavy Grazer II oat and the 75:25 oat:wheat mixture produced greater early (Nov/Dec) forage DMY than the rye or triticale monocultures; but were not different than any other treatment. When planted in October, generally there were no differences between any treatments. When planted in November, rye and rye mixtures were generally greater than wheat, oat, and triticale monocultures, but did not differ from other mixtures. Based on this data, maximum fall forage production is attained by planting in early September and utilizing Heavy Grazer II forage oats.

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