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October 5 - 8, 2010
Knoxville, TN

Native Grasses on Working and Natural Landscapes

Center For Native GRASSLANDS Management

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INTRODUCTION

Native grasses and the communities they form are an important part of our natural legacy throughout the eastern United States and Canada. They provide soil stabilization, improved water quality, carbon sequestration, wildlife habitat, excellent forage, and potentially, tomorrow's fuel. Despite their importance though, native grasses in eastern North America have become all too uncommon and are now considered to be among the most imperiled ecosystems in the region. Other than ourselves, and those just like us who have gone before us, there is no one to blame. Rather, the plough, extinguished natural fires, development, and generations of heavy grazing have taken their toll. In recent decades, there have been many who have recognized the value of these grasses and their communities and have worked to conserve the small remnants found in glades or some out of the way odd place. Others have joined in this interest in native grasses as they have evaluated them for soil and water conservation, wildlife habitat, and other uses. This interest more recently has turned to biofuels, forages, and critical areas such as surface mines. Hence, this year's symposium theme, "Native Grasses on Working and Natural Landscapes", is in recognition that native grasses may play an important role well beyond simply conserving natural communities. Indeed, they may be come an important part of our working landscapes and contribute to the daily lives of many of us. Such a focus should not detract from conservation, but rather compliment it.

The six symposia that preceded this one were held as follows:

1997, Asheville, NC
1999, Baltimore, MD
2002, Chapel Hill, NC
2004, Lexington, KY
2006, Harrisburg, PA
2008, Columbia, SC

Each made important strides in advancing our understanding of native grasses, their conservation, and their management. We hope that this year's meeting in Knoxville continues in that same tradition and brings together practitioners, researchers, educators, and enables all of us to improve on the work we are doing, and stimulates us to look in new directions.

Thanks to all, especially the generous gifts of our sponsors (see back cover), the University of Tennessee, the Local Planning Committee, and the National Steering Committee for their contributions in making this symposium a success.

The Symposium Co-Chairs

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PLENARY SESSION

Courage to persevere

Jim Byford

University of Tennessee, College of Agriculture and Applied Sciences, Martin, TN

ABSTRACT

At one time, native grasses dominated much of this region's landscape. Over a period of decades, we have converted native grasslands to non-native plants that we felt suited our needs better. Recently, we've begun to have second thoughts. One reason is that our needs have changed some, and another is that we now know more about ecosystems and what makes them function. An effort is now underway to convert part of our landscape back to native grasses, but changing an old habit is difficult. People are reluctant to change something that's worked for them their whole life. Opponents of new ideas abound, and the internet and other instant media provide ready platforms from which to express their opinions. The result is a polarized and confused public, politicians unwilling to commit, unstable public policy, and frustrated change agents. Changing the old habit can be done, but it won't be easy. We first have to admit that native grasses are not a panacea—not the only answer. We must understand that we won't ever convert all the landscape back to native plants—we have too many people to feed. With that basic understanding, we must do three things to be successful in converting part of our landscape back to native plant communities:

- Provide leadership. And the initial leadership must come from people at this symposium.
- Develop a long-range strategic plan—with goals, benchmarks, and timelines.
- Be patient with those who oppose or try to distract us, keep our frustration at bay, and above all—persevere until the job is done.

Native grasses as forages

Bruce Anderson

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ABSTRACT

Native warm-season grasses, such as switchgrass, big bluestem, and indiangrass, can provide abundant, high-quality forage during summer after most spring growth of cool-season pastures has been used. Productivity and stand persistence of warm-season grasses decline readily under frequent severe defoliation, so proper harvest management is essential to optimize production, maintain healthy stands, and provide adequate forage quality. Take no more than two hay harvests during any one growing season; taking one cutting and then two cuttings in alternate years often is best. Although warm-season grasses can be grazed continuously throughout summer if stocked so rate of forage removal by livestock is similar to growth of these grasses, rotational stocking can provide more uniform use and give better control of the amount removed and length of recovery following grazing, especially in areas with longer growing seasons. Due to earlier maturity and reduced palatability, switchgrass is best used as a monoculture for either hay or pasture. *Switchgrass must be grazed before seedheads develop* while forage quality is high and palatability good. Heavy stocking when plants get 12+ inches tall that reduces plants to about 4 to 6 inches of stubble, followed by 40+ days of recovery and grazing a second time after 12+ inches of regrowth has been successful in many areas. Mixtures of other warm-season grasses work well and can be grazed similar to switchgrass. However, since other warm-season grasses have more basal leaf area, leaving a taller stubble by grazing to just one-half the original plant height results in faster recovery. Always leave at least 6 inches of stubble going into winter.

Native grasses as biofuel feedstocks

Joe Bouton

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ABSTRACT

Although many native grasses dominate the grasslands of North America, it was switchgrass (*Panicum virgatum*) that was chosen by the United States Department of Energy (DOE) as a main herbaceous, dedicated bioenergy crop due to its long-lived perenniality, ability for high yields, environmental enhancement characteristics, and ability to grow well on low input, marginal cropland. High-yielding, non-native perennial species, such as giant miscanthus (*Miscanthus gigantheus*) and energy cane (*Saccharum officinarum*) are also being considered, but currently have issues with expense of establishment, poor adaptation to most soils and climates, and potential invasiveness. Switchgrass is a warm-season native grass currently used in both monoculture and polyculture management systems for hay, pasture, and land conservation. As a bioenergy crop, its projected use is as a feedstock for cellulosic biofuel (mainly ethanol at this time) and biopower (mainly co-firing with coal to reduce emissions). Improving its feedstock value through plant breeding is relatively new. Switchgrass is a self-incompatible, out-crossing species; therefore, traditional breeding methodologies include population improvement to produce and identify parents for synthetic cultivars, and the possible production of F1 hybrid cultivars. The main traits slated for improvement include biomass yield, better seedling establishment, and increased feedstock quality (higher digestibility and lower lignin). However, application of genomic and transgenic molecular tools to supplement and enhance these traditional approaches is now underway in switchgrass. Genetic markers are being developed, and initial framework maps and mapping populations are in use. Effective tissue culture regeneration methods are documented, and transformation is successfully achieved using both microprojectile bombardment and *Agrobacterium* protocols. Recent grant awards from DOE should continue to advance genomic and transgenic information available for use in switchgrass improvement efforts.

Native grass use in Appalachian surface mine reclamation

David Ledford

Appalachian Wildlife Foundation, Corbin, KY

ABSTRACT
Mine reclamation in the Appalachians has progressed from large-scale plantings of tall fescue and sericea lespedeza to current attempts at complete reforestation and reclamation techniques targeting ecological restoration. Regulators and conservationists are advocating the use of only native vegetation, including native grasses in revegetating mine sites. While the use of native grasses in mine reclamation can benefit many wildlife species, there are specific habitat needs that cannot be met with native grasses. Regulators and native grass advocates need to be aware of the challenges associated with the use of native grasses in Appalachian mine reclamation. These include 1) cost, 2) planting techniques, 3) topography, and 4) legal requirements for groundcover.

ORAL PRESENTATIONS: FORAGE

Performance of Holstein replacement heifers grazing switchgrass or combinations of big bluestem and indiangrass during the summer in the Mid-South

John Waller[1], Elizabeth Doxon[2], Pat Keyser[2], Gary Bates[3], and Neal Schrick[1]

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ABSTRACT
This experiment was conducted to determine the performance of pregnant Holstein dairy heifers grazing switchgrass (*Panicum virgatum*) or a combination of big bluestem (*Andropogon gerardii)* and indiangrass (*Sorghastrum nutans*) during summer. Study 1 (June 5 to August 10, 2009) and Study 2 (May 14 to August 9, 2010) were conducted at the Middle Tennessee Research and Education Center near Spring Hill, TN. Heifers (Study 1, 1067 ± 33 lb; Study 2, 996 ± 106 lb) were used in a completely randomized design with two forage treatments: 1) switchgrass (SG) and 2) a combination of big bluestem and indiangrass (BB/IG). Stands were two and three years old at beginning of Studies 1 and 2, respectively. Initial and final body weight of heifers was established using an equilibration ration to adjust for gut fill. A put-and-take system used three heifers (testers) in Study1 and four heifers in Study 2 allotted to 3 acre paddocks with eight replications per treatment. Additional heifers were used to keep forage in a vegetative state. Heifers had free choice access to pasture, water, mineral, and shade. Data were analyzed using the MIXED procedure in SAS. Least square means for ADG of heifers were different ($P < 0.05$) for heifers grazing SG or BB/IG. The ADG were 1.49, 2.04 lb/d in Study1 and 1.40, 1.69 lb/d in Study 2 for SG and BB/IG, respectively. Our results demonstrate the ability of native warm-season grasses to provide suitable summer forage and animal performance for dairy heifers.

Performance of beef cattle grazing native warm-season grasses in Tennessee

William Backus[1], John Waller[1], Pat Keyser[2], Gary Bates[3], and Craig Harper[4]

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ABSTRACT

Native warm-season grasses have the potential to provide high-quality summer forage for livestock prior to being harvested for biofuels. However, performance of cattle grazing nwsg in the Mid-South is poorly documented. We allowed cattle to graze nwsg at Research and Education Centers near Grand Junction, Springfield, and Greeneville, TN in late spring 2010. Weaned beef steers (594 ± 27.6 lb) were used in a completely randomized design with three forage treatments: 1) switchgrass (SG); 2) a combination of big bluestem and indiangrass (BB/IG); and 3) eastern gamagrass (EG). There were three replicates of each treatment. A put-and-take system was used with four steers (testers) allotted to each 3-acre paddock. Additional steers were used to keep forage in a vegetative state. Steers had free choice access to pasture, water, mineral, and shade. A high-fiber equilibration ration was fed 5 days before and after the 30-day grazing period to adjust for gut fill. Least squares means for average daily gain (ADG) of steers grazing BB/IG differed from EG and SG ($P < 0.05$). There was no difference between steers grazing SG and EG. The ADG of steers grazing BB/IG, SG, and EG was 2.64, 2.21 and 1.69 lb/d, respectively. Our results demonstrate the ability of these nwsg to provide summer forage and animal performance for beef stocker cattle.

Using native warm-season perennial plants to supply forage for livestock

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ABSTRACT

Native warm-season perennials (NWSP) are infrequently used as forage species in grasslands managed for livestock even though they possess a variety of positive attributes such as high productivity and low input requirements. Increasing NWSP diversity in sown mixtures may have other benefits such as increased forage yields, improved forage nutritive value, and reduced weed invasion. Some research suggests that these positive diversity effects are due to plant interactions, while other results indicate that effects are due to the presence of just a few species. We hypothesized that managing NWSP mixtures for high diversity may enhance these benefits. In 2008, we established an experiment using 3 native plant mixtures containing 1, 4, or 10 species to evaluate how sown forage diversity affected forage yield and species composition. In both 2008 and 2009, sown forage yields were lowest in monocultures (52.4 kg/ha in 2008 and 485.6 kg/ha in 2009) and greatest in 4-species (390.7 kg/ha in 2008 and 1919.9 kg/ha in 2009) and 10-species mixtures (813.6 kg/ha in 2008 and 1726.6 kg/ha in 2009), but weed biomass was not affected by sown mixture in either year. Forage nutritive values were generally acceptable for maintaining beef cows in all 3 treatments (averages for NDF: 41-67%, ADF: 25-38%, CP: 10-17%), although quality tended to decrease as native grass cover increased. We also established a small plot experiment sown with randomly-assembled mixtures containing 1, 2, 4, 6, or 10 species to determine mechanisms that explain the diversity-productivity relationship; i.e., true diversity effects or sampling effects. We found multi-species plots overyielded, an effect that shifted over time. Our results suggest that NWSPs can be a viable forage option and that managing for diverse mixtures may improve productivity.

INTRODUCTION

There is an increasing need for the sustainable management of forage-livestock grasslands. A majority of the grasslands in the eastern United States are comprised of introduced cool-season species such as tall fescue (*Schedonorus phoenix*) that require regular nutrient inputs to remain productive. However, using native warm-season perennials (NWSPs) could complement traditional cool-season pastures in forage-livestock systems in a productive and sustainable agroecosystem. Native grasses and forbs such as switchgrass (*Panicum virgatum*), big bluestem (*Andropogon gerardii*) and indiangrass (*Sorghastrum nutans*) were historically present in eastern American tallgrass prairies but were replaced with current cool-season species by European settlers (Jackson 1999). NSWPs are adapted for growth during the hottest part of the year and are tolerant of drought and low nutrient conditions while remaining highly productive. One concern about using NWSPs is their lower nutritive value. However, with appropriate management, warm-season species can sustain beef cow grazing (Roberts and Gerrish 1999). Therefore, NWSP grasslands have great potential to supply ample and adequate quality forage during the summer, especially during years of drought.

Low plant species diversity is common in traditional pastures. For example, northeastern U.S. pastures are dominated by a few cool-season forage species; any diversity present is from weedy species that provide little forage value (Tracy and Sanderson 2000, Sanderson et al. 2007). Research suggests that incorporating diversity into forage systems may improve agronomic value such as increasing forage yield, adding flexibility to the grazing system (Moore et al. 2004, Sanderson et al. 2004), reducing toxin consumption and creating a more balanced diet for livestock (Tracy and Faulkner 2006). Diverse forage systems may also reduce weed invasion (Tracy and Sanderson 2004), improve system stability (Schwartz et al. 2000) and enhance nutrient cycling (Tilman et al. 1996). Research suggests that native prairie plants may produce similar results (Tilman et al. 1996).

Although many studies agree that diversity is linked to increased productivity, the mechanisms behind the diversity-productivity relationship are not understood. Biodiversity effects fall under 2 categories: complementarity effects (CE) and selection effects (SE). Loreau and Hector (2001) developed a series of calculations that partition the diversity effect into these 2, not mutually exclusive mechanisms. There is a positive complementarity effect when productivity increases through facilitation and more complete resource use. This is a true diversity effect, whereby species interactions affect the total assemblage yield. The selection effect suggests that more diverse assemblages have a greater chance of containing a highly productive species, and as such, can be considered a sampling artifact instead of a true diversity effect (Huston 1997). Understanding what causes the net biodiversity effect may be complicated, as it can be caused by 1 or both mechanisms and can change over time (Cardinale et al. 2007, Fargione et al. 2007)

Managing for a diverse NWSP assemblage could provide many advantages to grazing systems through high plant productivity, drought tolerance, and summer growth and nutritive value. Our experiments have 2 objectives. Using a large plot experiment, we evaluated how managing for NWSP grasslands sown with 3 forage mixtures of varying plant diversity affects forage productivity, weed biomass and species composition. We hypothesized that more diverse assemblages would have increased forage productivity, improved nutritive value for cattle and reduced weedy biomass. In a small plot experiment, our second objective was to determine how complementarity and selection effects related to forage productivity across a range of diversity treatments.

MATERIALS AND METHODS

Two experiments (1 small plot and 1 large plot) were established near Blacksburg, VA (37°12'0" N, 80°34'40" W) using native plant species drawn from a 10-species pool of 4 warm-season grasses, 1 cool-season grass, 3 legumes, and 2 non-legume forbs (Table 1).

Table 1: Ten-species pool used in all 3 experiments.

Functional group	Species name	
C4 grass	Switchgrass	*Panicum virgatum*
C4 grass	Big bluestem	*Andropogon gerardii*
C4 grass	Indiangrass	*Sorghastrum nutans*
C4 grass	Little bluestem	*Schizachyrium scoparium*
C3 grass	Virginia wild rye	*Elymus virginicus*
Legume	Illinois bundleflower	*Desmanthus illinoensis*
Legume	Showy tick trefoil	*Desmodium canadense*
Legume	Partridge pea	*Cassia fasciculata*
Forb	Black-eyed susan	*Rudbeckia hirta*
Forb	Oxeye sunflower	*Heliopsis helianthoides*

In June 2008, we established 4, 3-ha pastures for the large plot experiment. Each pasture was divided into 3 paddocks approximately 1 ha in size and planted using a no-till seed drill at a seeding density of ~12.3 PLS kg/ha with 1 of 3 treatments: 1) a monoculture of switchgrass, 2) a 4 species mixture of grasses, or 3) a 10 species mixtures. Species composition and cover were measured with randomly placed 0.5 m^2 quadrats in September 2008 and July 2009. Above-ground biomass was harvested from these quadrats, hand sorted to species or weeds (i.e., unsown species), dried and weighed. Due to the large amount of biomass in the second year, biomass was only collected from half of each 0.5 m^2 quadrat. Forage samples collected in June and July were analyzed for nutritive values [neutral detergent fiber (NDF), acid detergent fiber (ADF), and crude protein (CP)].

In 2009, we initiated a grazing treatment. In June 2009, each of the 12 treatment plots were divided into 2 strips using electrified wire and was grazed by 1 cow. In the 4-species and 10-species plots, cows remained on the first strip for 7 days, moved to the second strip for 7 days and then taken off the pastures. Due to lower grass availability in the switchgrass plots, cows remained on each strip for 3-4 days before being moved and were removed from the pastures 4 days later. A second graze period occurred in August and September 2009. Cows were initially separated with 1 animal per entire plot (no strips were designated for the second graze period). Fifteen days later, fences within each plot were removed and animals were allowed equal access to all 3 forage mixture plots. The plots were mowed to a height of 15-20 cm after both grazing events.

We conducted the small plot experiment on 6-m^2 plots that consisted of 5 randomly assigned species richness treatments: 1, 2, 4, 6, or 10 species. All 10 species plots were planted in monoculture and replicated 4 times. Species composition for each of the 2-, 4- and 6-species plots was randomly chosen from the pool of 10 species, so that each plot contained a unique assemblage of species. Six assemblages of each of the multi-species plots were sown, with no repetition of any individual assemblage. Plots were weeded periodically throughout the first season of establishment, but weeds were not removed in the second year. Species composition data was collected by harvesting 0.25-m^2 quadrats from each plot in August 2008 and 2009. After clipping vegetation to 10-15 cm, plants were hand sorted to species or weeds, dried to a constant weight and weighed.

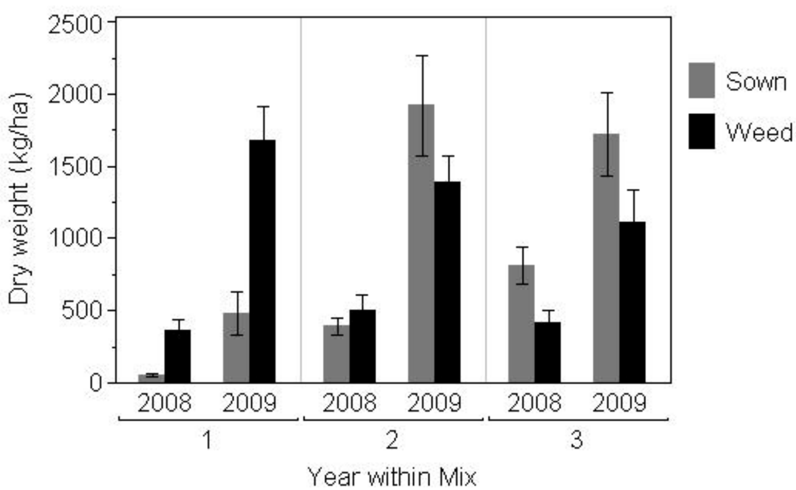
We measured overyielding by comparing the observed multi-species plot yields against expected yields based on monoculture performance. Net biodiversity effects were separated into complementarity and selection effects as described by Loreau and Hector (2001). In our calculations we did not include weed biomass, as plots were weeded in the establishment year and weed biomass was generally small in 2009.

RESULTS

Large plot experiment

In both 2008 and 2009, the switchgrass monoculture plots produced the least amount of forge biomass and had the lowest relative cover, while the 4- and 10-species mixes produced comparable amounts of biomass and cover (Fig. 1; $P < 0.05$). As the plants established, forage yields increased from 2008 to 2009 by an average of 433 kg/ha (an increase of 827%) for the monoculture plots, 1529 kg/ha (391% increase) for the 4-species plots, and 913 kg/ha (112% increase) for the 10-species plots. While forage biomass was affected by treatment, weedy biomass was not significantly different in either year. However, weed relative cover was greatest in the monoculture plots in 2009.

Figure 1: Average dry weight yields, separated by sown species (gray) and weedy unsown species (black), by year for each forage mixture in the large plot experiment. Error bars represent 1 standard error above from the mean.



Botanical composition shifted from forb-dominated in 2008 to grass-dominated in 2009. In 2008, sown forbs made up 21% of the relative cover in 10-species plots, and black-eyed susan (*Rudbeckia hirta*) was the most abundant. Black-eyed susan constituted nearly 30% of dry weight biomass in the 10-species plots in the first year. Sown forbs became less common in 2009 with cover diminishing to 11% and biomass to less than 4% of plot biomass. Both sown forage grass and weed species relative cover increased in all 3 mixtures over time as the amount of bare ground decreased. Big bluestem and indiangrass were the 2 most common forage grasses in both years. Weed species composition also changed, with thistles and crabgrass (*Digitaria* spp.) more common in 2008, while horseweed (*Conyza canadensis*) was particularly prevalent in 2009.

Our results from the grazing treatment in 2009 showed that, like the grazed areas, yields in grazing exclosures were affected by mixture, with the switchgrass monocultures contained less biomass than the 4- and 10-species mixtures. Sown species yielded 1251.9 kg/ha in monocultures, compared to 3655.8 kg/ha and 5385.7 kg/ha in the 4- and 10-species plots, respectively ($P < 0.05$), while yields from weedy species did not vary significantly. Overall, yields were higher in the exclosures than the grazed areas which had biomass removal both through grazing animals and the June 2009 mowing event.

Forage quality for all 3 mixtures was adequate to maintain beef cattle in 2009. The effect that sown mixture had on nutritive values changed from June to July (Table 2). In June, monoculture plots had lower NDF and ADF, while CP was not influenced by forage mixture. By the end of July, differences were not significant ($P > 0.05$), although trends present in June could still be seen. Forage quality also declined significantly between the June and July sampling dates for all variables analyzed ($P < 0.001$). The lower NDF and ADF in switchgrass monocultures than other mixtures may be a factor of the relatively high amount of weedy biomass present in these plots, which could reduce the contribution of the high fiber switchgrass. In addition, as the proportion of sown grass cover increased across all 3 mixtures, NDF and ADF also increased, while CP was not affected. Because forage forbs and legumes constituted a small portion of biomass in 2009, their impacts on nutritive values were also small.

Table 2: 2009 forage nutritive values in a) June, and b) July.

a) June averages by sown mixture

	1	4	10	p-value
CP[†]	17.40±1.31	15.05±1.23	15.80±1.11	0.2780
NDF	41.11±4.57[a]	58.45±3.59[b]	55.85±3.28[b]	0.0005
ADF	25.85±1.95[a]	31.78±1.48[b]	30.55±1.38[b]	0.0034

b) July averages by sown mixture

	1	4	10	p-value
CP	11.68±0.63	9.75±0.71	11.89±1.19	0.1321
NDF	57.69±1.97	66.76±2.83	61.44±3.77	0.0818
ADF	34.03±0.70	37.88±1.32	35.63±1.80	0.1554

Tables display means ± 1 standard error. Letters indicate where means significantly differ from each other across mixtures at $\alpha=0.05$, based on LSD.

[†] CP: crude protein; NDF: neutral-detergent fiber; ADF: acid-detergent fiber

Small plot experiment

In 2008, multi-species plots produced significantly more biomass than the 1- and 2-species plots (Fig. 2, $P < 0.05$). However, in 2009, there were no yield differences among the 5 diversity level treatments. We analyzed for overyielding in multispecies plots by taking the sum of the relative yields (based on monoculture yields) for each species present in the mixture (Table 3). We consider the plot to have overyielded if the relative yield total (RYT) was greater than 1. In 2008, 42% (10 of 24 plots) overyielded and increased to 67% (16 of 24) in 2009. We calculated the net biodiversity effect (ΔY) by taking the difference between observed and expected yields and found a positive effect in 19 plots in 2008 and 13 plots in 2009. Using additive partitioning, we then separated the net biodiversity effect into complementarity effects (CE) and selection effects (SE). In 2008, SE was positive for 20 plots and CE positive for 10. In 2009, we documented 9 plots with a positive SE and 16 plots with a positive CE.

Table 3: Biodiversity effects and additive partitioning tallies based on species richness in a) 2008 and b) 2009. There are a total of 24 multi-species plots analyzed (6 per diversity level).

a) 2008 results

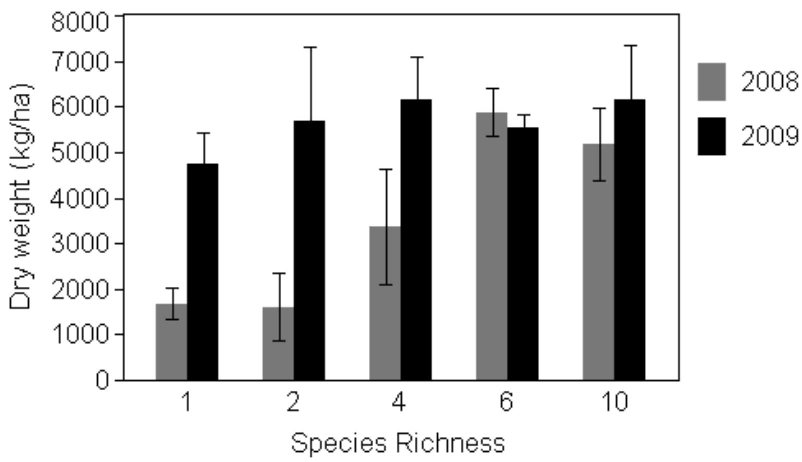
Diversity	RYT‡ > 1	+ ΔY	+ CE	+ SE
2	2	3	2	4
4	4	4	4	4
6	3	6	3	6
10	1	6	1	6
Total	10	19	10	20

b) 2009 results

Diversity	RYT > 1	+ ΔY	+ CE	+ SE
2	2	3	2	5
4	4	4	4	2
6	5	3	5	2
10	5	3	5	0
Total	16	13	16	9

‡RYT: Relative yield total - sum of the relative yields for species in a mixture based on monoculture data.
ΔY: Net biodiversity effect - difference between observed and expected yields; ΔY = CE + SE.
CE: Complementarity effect - changes in yield caused by species interactions.
SE: Selection effect - changes in yield caused by the presence of a particular species.

Figure 2: Average dry weights for sown species for the 2008 (gray) and 2009 (black) seasons of the small plot experiment. Error bars represent 1 standard error from the mean.



DISCUSSION

Our data suggest that using diverse NWSP mixtures can be a viable forage alternative or supplement to traditional cool-season pastures. More complex mixtures had higher yields of sown species in both experiments in 2008 and in the large-plot experiments in 2009. While not significant, we also documented a trend of reduced weedy biomass in 2009.

The large-plot experiment demonstrates that more complex mixtures are productive and can produce forage of sufficient quality for grazing beef cows. One hypothesized benefit to increased forage mixture complexity is maintaining stability and buffering against poor productivity of certain species. Diversity may help maintain a plant community's productivity at a certain level if some species can compensate for the poor growth of others (Tilman et al. 2006). In our large-plot experiments, switchgrass had particularly poor establishment compared to the other warm-season grasses. Because of this, switchgrass monocultures had low yields, but other grasses in the 4- and 10-species were able to make up for this and produce much higher yields than that of the monoculture. Protection against yield losses is a major advantage that diverse mixtures may provide to producers.

We hypothesized that increased forage plant diversity would also increase nutritive value through the incorporation of more nutritious forbs and legumes. However, these plants did not make up a large proportion of biomass in our large-plot experiment in 2009 and subsequently did not impact forage quality. The amount of warm-season grasses present was an important element of nutritive values; as warm-season grass cover increased, NDF and ADF also increased. Adler et al. (2009) found that increases in hemicellulose and cellulose concentration were associated with increasing warm-season grass cover, while increasing species richness resulted in lower concentrations. In their study, increasing grass cover was correlated with decreasing diversity, so that the impact of grasses on nutritive values would be larger at lower diversity levels. This also supports our results on the importance of warm-season grass cover for forage quality.

Weed biomass was not significantly affected by forage mixture in the first 2 years, but by 2009 there were trends that more diverse plots had reduced weed cover and a tendency for lower biomass. As the large-plot stands continue to establish we plan on monitoring weed invasion and persistence to see if this trend continues.

We also determined that forage yields and the effects of NWSP diversity changed with time. In our small-plot experiment, more diverse assemblages produced significantly more biomass in 2008, while all 5 richness levels were equal in 2009. However, positive biodiversity effects were present in 42% and 67% of multi-species plots for 2008 and 2009, respectively, providing evidence that there are yield benefits attributable to diversity. The mechanisms behind the positive diversity effects also shifted, with more plots having a positive selection effect in 2008, compared to more with a positive complementarity effect in 2009. This shift over time from selection effects to complementarity has been found in another grassland diversity study that hypothesized that diversity improved the input and retention of N, a limiting nutrient (Fargione et al. 2007). The frequent positive selection effect seen in 2008, indicative of inclusion of a high-performing species in mixture, was most likely due to the presence of the forb, black-eyed susan. In 2008 this species was the dominant plant in all the plots in which it was present, and this wildflower produced the most biomass in monoculture. In 2009, black-eyed susan was not as abundant or vigorous, which may have allowed positive plant interactions among the other species to occur.

In conclusion, our initial work suggests that native warm-season perennial diversity may become valuable as a method to maintain productivity with low nutrient inputs, protect against annual variations in productivity, and lower weediness in forage systems. In addition, the magnitude of and mechanisms behind these diversity effects may also change over time as communities establish. We plan to maintain monitoring of these experiments to determine whether the trends found in the first 2 years will continue in future seasons.

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Effects of cutting height and variety on switchgrass yield in Tennessee

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ABSTRACT

Switchgrass (*Panicum virgatum*) is often promoted as a high-yielding forage species. However, it is less understood how different varieties compare and how cutting height may influence yield. To examine the impact of varietal type and cutting height, we established 48 plots representing 3 varieties of switchgrass in 1990. These varieties included one upland variety (Cave-in-Rock) and two lowland varieties (Kanlow and Alamo). Beginning in 2008 and continuing to the present, we harvested the 18-year-old switchgrass plots at 4-, 8-, 12-, and 16-in cutting heights in June and August to determine if cutting height or variety influenced yield. We determined yields were similar among the 3 varieties examined. However, we determined yield interacted with year and cutting height. Yield was 55% higher in 2008 compared to 2009. In tons/acre, yield was 4.1 in June 2008 and 2.9 in September 2008. In 2009, yield was 2.3 and 2.2 in June and August, respectively. In June 2008, yields were similar among the four cutting treatments. However, in August 2008, the 8-in cutting height produced higher yields than the 16-in cutting height. In 2009, we documented the reverse trend. In June and August 2009, the 16-in cutting treatment had higher > 70% higher yields than the 4- and 8-in cutting treatments, the equivalent of > 1.2 tons/acre. These results suggest Kanlow, Cave-in-rock, and Alamo switchgrass will produce comparable yields given similar growing conditions. However, harvesting switchgrass at shorter cutting heights did not necessarily produce higher yields. Yield differences in cutting height became more apparent after two consecutive years of 2-cut harvesting which may suggest shorter cutting heights may have negative impacts on long-term yields.

Native warm-season grass economic decision support tool for Mid-South producers

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ABSRACT

Native warm-season grasses (NWSG) have been promoted as low-input, low-maintenance alternative summer forage. Before adoption into a forage or grazing system, the economics of production should be examined to determine if they are conducive to the farm management. Because previous budgets have focused on switchgrass' (*Panicum virgatum*) use as a biofuel and may not be valid in a forage or grazing system, we developed an interactive, web-based decision support tool to be used by mid-South producers. This tool can be used to examine the impacts of fuel cost, seed cost and rates, herbicide cost and rates, and fertilizer price and application rates on the economics of short-duration grazing, continuous grazing, and haying. Using published data and preliminary data from an ongoing NWSG forage project in Tennessee, we conducted a sensitivity analysis to compare various break-even points to examine NWSG's economic viability. During establishment, seed costs are the dominant expense (> 60% of total cost) with herbicide and fuel costs the next most expensive inputs (15 and 9%, respectively). For NWSG, our analyses suggest that NWSG are sensitive to fertilizer inputs. As an example, for each additional 10 lbs of nitrogen per acre, the total budget increased by 20%. As these results are preliminary, further research into the economics of NWSG production would be beneficial to mid-South producers.

ORAL PRESENTATIONS: ECOLOGICAL RESTORATION

Rivercane (*Arundinaria gigantea*) flowering but no seed production: A potential answer

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ABSTRACT
Rivercane, *Arundinaria gigantea*, brakes are found though out the southeastern U.S., but are only remnants of their former populations. Canebrakes were an important ecosystem, being critical to the well-being of many animal species. However, agricultural and urban expansion have reduced stands to small clonal clumps along roadsides, edges of agricultural fields, and right-of-ways between housing developments. Such depletion would impact genetic diversity/variability, which compromises rivercane's ability to propagate sexually, since it is obligately out-crossed. A decrease in genetic diversity could exacerbate an already problematic situation. Like many bamboo species, rivercane is monocarpic and undergoes gregarious flowering, once flowering occurs, seed must be produced to replace the parent plant. During the last three years flowering events among isolated canebrakes in Mississippi have been observed, but seed production is nearly non-existent. Flowering brakes were sampled and evaluated via DNA fingerprinting to determine number of individuals and genetic composition. Data suggests that brakes examined in Mississippi are derived from one or a small number of related individuals. Seed production from these brakes is unlikely unless an adjacent unrelated brake is also flowering. This information will help in the making decisions on sound re-establishment of rivercane in restoration projects around the South.

Response of rivercane (*Arundinaria gigantea*) to native and exotic grass competition and site preparation techniques for canebrake restoration

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ABSTRACT

Canebrakes are dense stands of *Arundinaria gigantea* that once were prominent in the southeastern United States. Rivercane still occurs as an understory component of bottomland hardwood forests, but with intense agricultural development over the past 200 years, canebrakes are now considered a critically endangered ecosystem. There is increasing interest in the use of *A. gigantea* in riparian restoration and soil stabilization. Additionally, *A. gigantea* possesses cultural significance to Native Americans as a major component of construction, basketry, and weapon making. This research assesses response of *A. gigantea* to existing plant assemblages and to site preparation techniques, when planted with primarily native grasses (big bluestem, *Andropogon gerardii*, and indiangrass, *Sorghastrum nutans*), versus primarily exotic grasses (johnsongrass, *Sorghum halepense*, and bermudagrass, *Cynodon dactylon*). To assess site preparation techniques, soil tillage and herbicide application (a combination of 2.0% active ingredient glyphosate followed by application of a pendimethalin-based pre-emergent) were applied in a factorial design to plots dominated by the above-mentioned plant assemblages. Effectiveness of the treatments and competitiveness of *A. gigantea* with existing vegetation were determined from measurements of shoot height and diameter, production of new shoots, and a plant size index (approximating canopy volume). Analyses of the first year's data indicated that *A. gigantea* mean plant size was influenced by herbicide site prep, as well as soil tillage, when planted in exotic vs. native grass plots. Although soil tillage was not a significant factor by itself, *A. gigantea* mean plant size appeared to respond differently in the native vs. exotic plots. Tilling in the exotic plots caused a doubling of mean plant size (13,129 cm^3) compared to untilled treatments (5151 cm^3). Similarly, herbicide also was a non-significant factor by itself, but *A. gigantea* mean plant size appeared to respond differently in the native vs. exotic plots. Herbicide application in the native plots caused a significant 95% decrease in mean plant size (462 cm^3) compared to no-herbicide treatments (9634 cm^3). Mean shoot height and the number of shoots were significantly higher in the native grass plots vs. the exotic grass plots. From these first-year data, it can be concluded that *A. gigantea* planted into plots dominated by non-native plants benefited significantly more from site preparation (tilling, herbicide) than cane planted into native-species-dominated assemblages. However, it is not yet know whether these patterns have persisted through year two. If the patterns observed in year one persist, this research should contribute to improving the success of future cane restoration projects by indicating when intensive site preparation is necessary, and when it should be avoided.

Rivercane response to light conditions

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ABSTRACT

Arundinaria gigantea is the native woody evergreen grass commonly known as rivercane, and has been in rapid decline since the European colonization of North America. Canebreaks were once plentiful throughout the forests and bottomlands of the Southeast and provided wildlife habitat, erosion control, and buffers for sensitive ecosystems. Considering the extensive decline of their former range, plant establishment is now a primary focus. Five light regimes were tested on seedling plants to determine optimal light requirement for maximize growth as measured by total biomass accumulation. A randomized complete block design was conducted in the field. Shade structures were constructed to reduce sunlight by 0, 30, 50, 60, and 85% of ambient. All structures were removed at arboreal leaf senescence in autumn and replaced during spring leafing. Plant Growth Index (PGI), a non-destructive indicator of growth, was used to access growth during the first year; and biomass accumulation was used to measure actual plant growth. PGI indicated maximum plant canopy was achieved under 50-60% light reduction. After two years growth, plants were sacrificed. Biomass dry weight indicated a different optima; maximum growth occurred with 0% light reduction. Results indicate seedling plants compensate by increasing leaf canopy up to 50-60% light reduction, amplifying PGI. However, biomass accumulation indicates PGI is not a suitable measure of actual plant growth. These data would seem to indicate that rivercane is not an understory species, but persists there.

Native grassland restoration in the Black Belt Region of Mississippi and Alabama: Current efforts and barriers to implementation

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ABSTRACT
The Black Belt Region of Mississippi and Alabama once included more than 350,000 acres of native grasslands. Many of the native grasslands in the region have been converted to production agriculture, pine plantations or significantly degraded by the presence of non-native grasses and invasive native woody plants. Remnant grassland sites are scattered across the region, most of which are no greater than 10 – 20 acres in size. Over the past several decades, grasslands in the Black Belt region have gained minor interest from the scientific community; however, no formal effort had been made at restoration. In 2004, Wildlife Mississippi, in cooperation with state and federal partners, began the Blackland Prairie Restoration Initiative, which sought to restore, enhance and protect native prairie habitat within Blackland Prairie Region of Mississippi and Alabama. Recently, the initiative was granted a conservation practice under the Conservation Reserve Program. Currently, approximately 8,000 acres have been restored and or enhanced under the initiative with several more projects underway. Restoration efforts are constantly evolving based on information gained in the field and through research projects. Barriers to native grassland restoration in the Black Belt include difficulty eliminating non-native grasses and woody plants during establishment, associated costs, and difficulty working with constraints in existing programs.

Species selection for native grassland establishment and restoration in the Black Belt Region of Mississippi and Alabama

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ABSTRACT

The Black Belt Region of Mississippi and Alabama is characterized by thin calcareous alkaline soils overlaying Upper Cretaceous marine deposits. These soils fostered and supported significant areas of native grasslands pre-European influence. In 2009, we conducted a botanical survey on a 250-acre prairie remnant in Chickasaw County, Mississippi, documenting the vascular flora and defining the vegetation types on the site. The study documented 452 taxa in 234 genera and 74 families with a non-native species occurrence of only 7.4 percent. The highly diverse flora documented contained 14 species with little or no prior record in Mississippi, 16 species listed for "tracking" or "watchlist" by Mississippi Natural Heritage Programs, and 3 species that appear to be undescribed taxa. The study methods gave particular emphasis to documenting the vegetation type within which each species was found. In addition, detailed frequency data were collected for each species located with 265 grassland species. Three primary vegetation types were identified on the study site. A synthesis of the species frequency data by vegetation type is being used to formulate seed mixes for establishment and restoration of native grasslands in the upland Black Belt ecological region. Diverse seed mixes are proposed to provide self-perpetuating plant communities consisting of the dominant grass, forb, and legume species found in this region.

Ecological site descriptions: What they are and what has been done in flatwoods longleaf pine systems

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ABSTRACT

Ecosystems, whether naturally occurring or human-maintained, are a dynamic and complex interaction of microbes, animals, plants, and multiple edaphic factors. To be effective, land managers must interpret and apply knowledge from several biological and ecological science disciplines. Information is typically compiled from various sources that deal with the particular parts of the natural system of interest to the manager, and then she or he must reconcile the sometimes seemingly unrelated parts into a whole that can help with decision making. Ecological site descriptions (ESD) provide information relating the interactions of soils, vegetation, animals, and land management. Therefore, ESD is a tool that can aid in the classification of diverse ecosystem components, and when well developed, can make conservation planning, ecosystem restoration, and land management easier. They can be useful for understanding the condition of a historic plant community, how that may differ from a current state, and provide options for moving from one state to another. Central to the ESD is a state and transition model which seeks to capture possible vegetation states that exist on the site, thresholds of change and pathways for moving between states. An introduction to ESD will be presented, in addition to a discussion of their usefulness to the land manager, and initial attempts at developing an ESD for longleaf pine communities.

Planting native species to control site reinfestation by Japanese knotweed (*Polygonum cuspidatum*)

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ABSTRACT
Japanese knotweed (*Polygonum cuspidatum*) is an invasive species that has quickly become a serious problem both in riparian zones and in upland sites throughout the eastern US. It is an herbaceous perennial that can reach heights of 10 ft or more, and is capable of reproducing and quickly spreading by creeping rhizomes and root and stem fragments. Once established, it forms solid colonies that usually choke out all other herbaceous vegetation. This study focuses on planting native species mixtures in plots from which the Japanese knotweed had been suppressed by mowing and herbicide treatments for either one or two years beginning in 2006. The following mixtures were planted on 1 June 2007 and on 3 June 2008: 1) 27-species commercial riparian buffer mixture; 2) native cool-season mixture including Virginia wildrye, autumn bentgrass, and fowl bluegrass; 3) Virginia wildrye-bluejont mixture; 4) Virginia wildrye-prairie cordgrass mixture; 5) 'Hightide' switchgrass; and 6) 'Kanlow' switchgrass. All mixtures established well in 2007. By 16 months after planting the Japanese knotweed had reestablished itself to some degree in all plots (45 to 82% of ground cover), and by October 2009, only the riparian mixture provided adequate resistance to Japanese knotweed reinvasion. Only the commercial riparian and Virginia wildrye-prairie cordgrass mixtures had adequate establishment after the 2008 seeding. Both mixtures continued to show good suppression of Japanese knotweed in October 2009, suggesting that two years of knotweed control might increase the likelihood of reestablishing desirable plant cover at previously impacted sites.

A regal story: Propagation techniques for grassland restoration

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Fort Indiantown Gap (FIG) National Guard Training Center is located in southcentral Pennsylvania, 22 miles north of the state capital. Governor Gifford Pinchot authorized the creation of Fort Indiantown Gap (FIG) National Guard Training Center in 1931. Today, the 17,000-acre post is the second busiest National Guard training site in the US, supporting more than 800,000 military training days each year.

FIG is home to the largest and highest-quality areas of native warm-season grasslands in the Mid-Atlantic region (Latham and Thorne 2007). The 900+ acres of native grassland found on post provide breeding habitat to many grassland species on the Comprehensive Wildlife Conservation Strategy (CWCS) priority species list (Table 1). Three plants listed as species of concern are also found in FIG grasslands: Vasey's eupatorium (*Eupatorium godfreyanum*), striped gentian (*Gentiana villosa*), and yellow-fringed orchid (*Platanthera ciliaris*) (CWCS 2005). One listed species, the regal fritillary butterfly, *Speyeria idalia,* is a high-responsibility immediate concern species.

Many of the grassland restoration and management programs at FIG are designed to meet habitat requirements for the regal fritillary butterfly. In addition, as illustrated in the chart below, many other priority species reap the benefits from this ecosystem's maintenance. FIG uses mowing, selective herbicide applications, manual tree and brush removal, and prescribed burning to slow native woody plant succession and non-native plant invasion.

Table 1. Grassland CWCS priority species documented to occur at FIG (CWCS 2005)

Invertebrates

<u>Black-tipped Darner</u>	*Silvery checkerspot*	*Black-waved flannel moth*
Common roadside-skipper	**A hand-maid moth**	<u>Northern pygmy clubtail</u>
Comet darter	<u>Baltimore checkerspot</u>	<u>Amber-winged spreadwing</u>
Spiny oakworm moth	<u>Black dash</u>	*Golden-winged skimmer*
Pipevine swallowtail	*Zebra swallowtail*	*Slaty skimmer*
Ocellated darner	*Eastern tailed-blue*	*Footpath sallow moth*
Juniper Hairstreak	*Pink streak*	*Swarthy skipper*
Frosted elfin	*Harlequin darter*	<u>Edwards Hairstreak</u>
Halloween pennate	*Barrens buckmoth*	*Coral Hairstreak*
Indian skipper	<u>Leonard's skipper</u>	<u>Eyed Brown</u>
Regal fritillary	*Eastern Pine Elfin*	*White-m Hairstreak*
Pine barrens zale	*Northern Pearly-eye*	*Aphrodite Fritillary*
Southern Cloudywing		

Birds

Blue-Winged Warbler	Eastern Meadowlark	**Loggerhead shrike**
Golden-Winged Warbler	Grasshopper Sparrow	**Wilson's Snipe**
Bobolink		<u>Peregrine Falcon</u>
Brown Thrasher	Willow Flycatcher	Barn Owl
Common Nighthawk	Yellow Breasted Chat	<u>Northern Harrier</u>
<u>Dicksissel</u>		

Herptiles

Fowler's toad	**Wood turtle**	<u>Queen snake</u>
Eastern timber rattlesnake	Eastern hognose snake	Eastern box turtle
Spotted turtle	Smooth green snake	<u>Eastern ribbon snake</u>

Bold = immediate concern, <u>Underline</u> = high concern, *Italic* =Vulnerable, Black = maintenance concern

The regal fritillary butterfly was once found across North America from the East Coast to the Rockies, north to New Brunswick and south to Georgia. Today, Fort Indiantown Gap is home to the only known viable population (>100 adults) remaining in eastern North America. Habitat loss has been attributed to the regal's population decline. The butterfly is endemic to warm-season grasslands, an ecosystem that has been suffering worldwide since the early 1900's. A grassland specialist, the regal requires three different types of plant hosts during its life cycle: 1) violets for larval feeding, 2) adult nectar sources, and 3) warm-season bunch grasses for resting and protection.

Female *S. idalia* oviposit from late August through September. Eggs hatch two to three weeks later, and first instar larvae diapause overwinter until their emergence in early spring. Immediately following their "awakening," the larvae seek out the tender, new-growth leaves of *Viola spp*. for consumption (Swartz 2009). Larval success has been shown to directly correlate to the availability of these young leaves—mature violet leaves have caused significant increases in mortality in laboratory studies (Wagner et al 1997). However, females show little effort to oviposit near the needed violets (Kopper et al 2000), emphasizing the need for a large *Viola* population in areas expected to sustain regals.

The larvae begin pupation in early June, in the protective tufts of warm-season bunch grasses. They emerge as adults two to four weeks later; males emerge about two weeks prior to females (Swartz 2009). Consistent nectar sources for nutrition are required throughout their flight time, June through October. Warm-season bunch grasses and small shrubs are essential for resting and protection. Larvae overwinter in the tufts of the grasses and females will undergo a brief diapause in the safety of the plants prior to ovipositing.

Recent efforts have been made to repatriate the regal fritillary to sites that possess historic records of the butterfly. Because of the unique ecology and plant requirements of all species of *Speyeria*, grassland habitat must be managed carefully. Sites considered for reintroduction must possess the three groups of plants essential to the regal's lifecycle, either naturally occurring or through plant introduction. Sites that are currently being considered include Gettysburg National Military Park, Bald Eagle State Park, Lehigh-Gap Nature Center, Memorial Lake State Park and Swatara State Park.

Viola sagittata, the arrow-leaf violet, serves as the larval *S. idalia*'s (along with the four other fritillaries on post) primary food source at FIG, making it crucial to grassland management here and at future repatriation sites. The *V. sagittata* grows naturally in moderately disturbed soil. It prefers patchy areas of fields with little competition from other plants. Ants assist in violet seed dispersal and growth, though the precise effects of this myrmecochory (ant-plant mutualistic relationship) are unknown and effects have not yet been mimicked.

FIG applies large efforts to the seed collection of all native grassland plants, including *V. sagittata*, which produce seed pods in two cycles from May through October. Collection of the pods is manual and timing essential. Pods develop from a dark green color to a lighter shade of yellow-green, and begin pointed downward and point upwards when developed. When pods are firm, yellow, and pointed up, seeds will be dark brown and ready to harvest. This is a very brief window, and in a few minutes to a few hours, the seeds will be dehisced and expelled several feet into the air (making collection a challenge).

Biologists at FIG have developed a simple method to capturing the seeds prior to expulsion. Using one inch thick waterproof medical bandage tape, the pods are wrapped when they are about horizontal to the horizon. A piece of tape about three inches long is cut and wrapped diagonally around the pod, ensuring it is tightly attached to the stem and no openings at the top (seeds are notorious for escaping). The tape allows air flow, reducing the possibility of mold growth, and does not retain moisture. Though the tape is light weight, larger seed pods may need to be propped up to prevent stem breakage.

Unfortunately, biologists have not had success in seed germination. Several methods have been tried and experimentation continues in anticipation of finding a reliable method. Techniques that have been tried include:

- Moist and dry cold stratification for various periods of time
- Manual removal of seeds' elaiosomes to mimic myrmecochory
- Exposing seeds to fire
- Hormone application (Gibberellic Acid 3 and Rootone Rooting Hormone) to induce germination
- Sowing directly in fine seedling soil
- Freezing and thawing
- Sowing seeds in trays in fall and allowing them to overwinter in natural weather conditions (experiment that will be performed in the upcoming winter)

Trials continue with each of these experiments and results still pending. Limited germination has occurred, but not on a scale large enough for production.

Another method that has delivered preliminary success is leaf-cutting and rooting using Rootone, a rooting hormone. Large, healthy *V. sagittata* leaves are cut at their base. The base is dipped into water and then dipped into the rooting hormone. The leaf is allowed to root in a moist paper towel medium, and transplanted in a loose soil mix after 3 weeks.

The method of violet propagation that has given the most success is through the dividing of the crown. *V. sagittata* growing naturally are extracted from the soil, preserving as much of the root structure as possible. Violets that are lower to the ground and fuller are easier to divide because of the nature of their leaf structure. In long and lanky violets, found in areas with more plant competition, leaves tend to fall over after dividing. It is important to keep the roots moist at all times. The number of times the violet can be divided is dependent upon the root and leaf structure: a violet with 5 leaves could be divided 5 times, so long as each leaf is left with a part of the root structure. A scalpel is used to make a clean, precise cut. Each divide is then planted into a 38-slot growing tray. The trays are filled with moistened Miracle Grow® potting soil. Care is taken to ensure the roots remain pointed down. If roots are too long to be planted they are trimmed to an appropriate length, approximately two inches.

The best time to extract the violets is in the spring when soil is consistently moist. Divided violets should be kept moist and in partial-to-full sun after planting. Prior to transplanting to grasslands, root structures should be developed within the cells (about two months). Violets will continue to produce seed pods during their development in the trays. These seeds are easily collected using the tape method described above.

V. sagittata thrives in disturbed soil conditions often occurring without effort at FIG. Disturbance caused by various National Guard training tactics, including wildfires and foot and vehicle traffic, allow the violet to thrive. Land stewardship, including mowing, prescribed burns, and tree and brush removal, also create the necessary soil disturbance and open conditions in which the violets grow.

Regals require nectar plants for feeding throughout their adult lifecycle. When maintaining and developing grassland for regal habitat, it is important to ensure nectar sources are consistently available throughout their flight time (June-October). Primary nectar plants used by the regal (organized as a timeline through shifting preference) and their approximate flowering times include:

- *Asclepias syriaca* (Common Milkweed): May-July
- *Asclepias tuberosa* (Butterflyweed): July-Aug.
- *Cirsium pumilum* (Pasture Thistle): Jun.-Aug.
- *Cirsium discolor* (Field Thistle): Aug.-Oct.

Secondary nectar sources include:

- *Asclepias incarnata* (Swamp Milkweed): Jun.-Aug.
- *Monarda fistulosa* (Monarda): Jun.- Aug.
- *Pycnanthemum muticum* (Short-toothed Mountain Mint): Jun.-Aug.
- *Pycnanthemum tenuifolium* (Narrow-leaf Mountain Mint): Jun.-Aug.
- *Apocynum* spp. (Dogbane): Jun.-Aug.

Great time and effort is placed in seed collection of nectar plants at FIG. Collection is mostly manual and occurs throughout the summer and into the fall, dependent upon the plant species. Seeds collected in large numbers (Common Milkweed, Butterfly Weed, Pasture and Field Thistle) are sent to Ernst Conservation Seeds for cleaning. A partnership has been developed with Ernst for cleaning seed. About 1/3 of the seed cleaned is kept. In addition, Ernst is permitted to collect FIG seed on the premises, with a 5% return to FIG on all that is collected. Seed is occasionally grown through Ernst, but this is costly.

When propagating Pennsylvania ecotype nectar plants from seed, most require cold, moist-stratification to stimulate seed into germinate. Immediately after collection, uncleaned seeds are placed on drying racks for three to five days, or until it can be cleaned. Seed that is prone to predators is kept in cold, dry-storage to slow possible pests from damaging the seed prior to cleaning. Post-cleaning, seed is again kept in cold, dry-storage until it is needed. Seeds are cold, moist-stratified to induce germination at approximately 40°F. The most effective technique for this stratification has been placing the seeds in a moist sphagnum peat medium in a large Ziploc® bag.

After stratification, seeds are planted in flats filled with sifted Miracle Grow®. Flats are allowed to germinate indoors until emergence from soil, and then placed outside with daily watering. Once weather conditions are favorable, the nectar plants can be transplanted to desired grasslands. When precipitation is minimal, transplants should be watered opportunistically to reduce transplant stress in the days/weeks after planting.

Timing is important when collecting any seed—especially those seeds prone to predators. Milkweeds are preyed upon by milkweed longhorn beetles and milkweed bugs. The most effective means of combating these pests have been monitoring the pods and collecting them as soon as they have matured, before the insects can infest them. Aphids also infect the milkweeds. Organic pesticide, sprayed during the seed stage directly on the insects, has success in minimizing the damage done by the aphids. Because these insects are all native, however, their damage is limited and does not typically destroy the plant and all of its seed.

Thistles at FIG have fallen victim to a more threatening, invasive pest: weevils. Introduced by the USDA to control Canada thistle (*Cirsium arvense*), *Larinus planus* is multivoltine (more than two life cycles in one year) and infests the thistle throughout its flowering. Adults will burrow into the stalks of the thistle, while larvae develop in the flower heads, consuming and destroying the seed as they grow. Because thistles are a primary nectar source of the regal (affected by insecticide), methods to control damage by the weevils have been a challenge. Manual removal of the weevils and their larvae is time consuming and appears ineffective. One means of removal has been to inject the heads immediately post-flowering with Sevin® pesticide. The head is then closed with a rubber band to prevent seed loss to the wind. Another possible solution is to prevent the weevils from entering the flower head by covering the head with pantyhose or crinoline. This procedure also protects the seed, but the material must be removed during peak flowering to allow pollination (Phoebus pers. comm.). FIG biologists anticipate experimenting with both of these methods in the spring of 2011.

The main grass species used by *S. idalia* at FIG are little bluestem (*Schizachyrium scoparium*) and broomsedge bluestem (*Andropogon virginicus*). Both of these species provide cover and protection from elements, predators, and possibly fire and dehydration, both as larvae and for forming the pupa. FIG-ecotype little bluestem seed is available commercially from Ernst Seeds after developing a partnership in 2003. Broomsedge presents a more difficult circumstance for seed collection and is not currently propagated by DMVA Wildlife.

Little bluestem is spread by two types of tractor-driven broadcast seeders. The first, a native seed drill, is common in the industry for planting bearded seed. Drills cut narrow furrows and plant the seed at ¼-inch depth. The second method is a Vicon spin spreader, which weights the seed through the funnel before getting spread by a spinning platform. Seed is usually aided through the Vicon by an inert carrier, such as topsoil, lime, or fertilizer.

In soils with a thick vegetation cover, DMVA Wildlife chooses between three options for seedbed preparation. The first is a broadcast herbicide application employed when the existing vegetation is unwanted or aggressive. This is done at least two weeks prior to planting, and often involves triclopyr, glyphosate, imazapic, and/or sethoxydim, depending on the target species and desirable species in the treatment area. The second option is a heavy disking, obtained with a soil disk, cultipacker, or other surface tilling device. The third is mowing, which may allow a native seed drill to work more efficiently.
The seed is generally sown in early fall (September or October) to allow time for seedbed preparation and sowing before ground freeze and snow accumulation. This early period allows the seed to cold-stratify overwinter and can obtain obvious coverage results in the next growing season.

Once growing, little bluestem can be further stimulated by prescribed fire to invigorate growth, cover, and seed production. Fire suppresses cool-season competitors in a manner that can't be repeated with mowing or herbicides alone. Fire additionally opens the interstitial space necessary for seed-to-soil contact, which benefits nectar plants and violets.

Prescribed fire has been used to restore Regal Fritillary habitat at FIG since 2004, though training-related burns have been an important component of the regal's life history there since the base was established. Fire decreases the amount of plant leaf littler/mulch and woody vegetation and creates bare soil necessary for the germination of violet, nectar, and native grass seed. It also reduces pests and disease, and is a tool to control some invasive plant species. Controlled fire is more efficient in reaching these goals than unplanned training incidents and prevents burns during critical points in the regal's life cycle.

Through intense habitat restoration and management practices at FIG, the regal fritillary population continues to rise. Advances in plant propagation techniques have allowed biologists at FIG to transplant nectar plants and violets, and to seed warm-season grasses to potential repatriation sites. The success of these three types of native plants brings hopes of establishing a breeding population of the regal fritillary to areas of historic record of the butterfly. Preserving and restoring grasslands, an ecosystem that has suffered in recent decades, also allows for many other species of concern to thrive.

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Evaluation of herbicides to aid in the establishment of rivercane (*Arundinaria gigantea*)

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ABSTRACT

Rivercane (*Arundinaria gigantea*) is a bamboo native to North America that serves many environmental and cultural purposes. Rivercane exhibits an extensive rhizome network that provides soil stabilization and sediment filtration for streams and riverbanks. The southeastern United States was once supported vast canebrakes. During the last 70 years, these stands have been reduced to 2% of their original land area. Restoration efforts using transplants and seedling establishment are hampered by a number of problematic weeds and non-native species. These weeds compete for water and light, negatively affecting rivercane performance. Pre-emergence herbicides are effective in controlling small-seeded broadleaf and grassy weeds in 4- to 6-month-old rivercane transplants. Dicamba, MCCP, and 2,4-D can be effective postemergence herbicides to control broadleaf weeds and shrubs, such as privet (*Ligustrum*), wild rose (*Rosa*), and briar (*Rubus*), without negative effects on rivercane transplants. However, sedges *(Cyperus*), johnsongrass (*Sorghum*), dallisgrass and bahiagrass (*Paspalum*), crabgrass (*Digitaria*), foxtail (*Setaria*), and bermudagrass (*Cynodon*) are the most problematic weed species when establishing rivercane in the Southeast. Herbicides are currently labeled for control of these grasses, but little is known of their effect on rivercane. Field studies were conducted to determine the effects of eight herbicides (fluazifop; halosulfuron; sethoxydim; imazaquin; nicosulfuron + metsulfuron; imazapic; trifloxysulfuron; and nicosulfuron) on rivercane. Five rivercane transplants composed a plot. Nine plots (eight herbicides + control) were replicated four times in a randomized complete block design. Herbicides were applied at rates labeled for their respective primary crop. After herbicide application, injury to rivercane plants was monitored for 28 days. Individual rivercane plants were rated every seven days on a 1-5 scale (1 severe injury, and 5 no observed injury). All herbicides tested controlled target weeds. Control plots (1.8 rating) indicated droughty conditions impacted rivercane appearance. After 28 days, fluazifop at a half rate (6 oz/acre; 2.15 rating) resulted in less injury to rivercane than nicosulfuron (1 oz/acre; 1.55 rating), imazapic (8 oz/acre; 1.45 rating), or trifloxysulfuron (0.1 oz/acre; 1.25 rating). Ideally, transplanting with no weed competition would be best, but a graminicide, such as fluazifop at the half rate, can better aid in establishing rivercane by reducing competition for resources. No herbicides are currently labeled for use in rivercane.

Switchgrass establishment during the dormant season and with winter annuals: Preliminary evaluation

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ABSTRACT

Establishment success of switchgrass has not been consistent. Failures are often linked to seed dormancy, a common trait in this species. One strategy for breaking dormancy is dormant-season planting, but success of this approach has not been well documented. Because of allelopathy of winter annuals, planting into them has been suggested as both a solution and a potential problem, but regardless, the approach has not been documented. We initiated two experiments in Tennessee to evaluate these establishment methods. In the first experiment, we planted switchgrass in December 2008, February, March, and May 2009 (whole plots) using high- and low-dormancy seed lots at 6 and 9 lb/ac rates (split plots) at two sites. In the second experiment, we planted switchgrass in March, May, and June 2009 (whole plots) into four winter annuals (wheat, oats, cereal rye, and barley) and a fallow control (split plots) at three sites. Neither grass height nor weed height differed among planting dates for experiment one (dormant planting) for the two locations. Switchgrass frequency was differed, but overall success was low and patterns between the two locations were not consistent (Mar = May > Feb = Dec at one location; Dec = Feb = Mar > May at the other location). Seed dormancy levels and seeding rates did not affect establishment success. In experiment two (winter annuals), results also varied by location with May plantings better (greater frequency and height of switchgrass) at one location, June plantings better at the second, and dates similar at the third location. However, regardless of date, overall establishment success in experiment two was much better than in experiment one (approximately 40% vs. 10% frequency or 3.8 vs. 0.9 plants/ft^2). Among the winter annual treatments, oats and wheat appeared the best choices among the three locations ($P < 0.09$) and none proved to be a problem. A second year of the experiment is now underway and biomass yield figures will be collected on second-year stands.

ORAL PRESENTATIONS: BIOFUELS

Yield comparisons of new switchgrass varieties with Alamo and Kanlow

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ABSTRACT
Interest in switchgrass (*Panicum virgatum*) as a feedstock for biofuels and other bio-products continues to grow. Tennessee has approximately 5100 planted acres of 'Alamo' switchgrass for those intended purposes. As the bioenergy industry grows there will be increased demand for higher yielding and better quality varieties. Recently, new varieties and experimental lines have been produced from breeding programs in GA and OK. The objective of this research is to compare the yields of some new varieties and experimental lines with older varieties. Nine lowland ecotypes: 'Alamo' (USDA-TX), 'Alamo' (Bammert Seed, TX), 'Kanlow', 'Cimarron'(OSU), OK NSL-2001-1 (OSU), Blade EG 1101(GA993), Blade EG 1102 (GA 992), C75, C77 (Noble Foundation, OK) and three upland ecotypes: 'Blackwell', Hoop House', and C62 were planted at the East Tennessee Research and Education Center (ETREC) in Knoxville. Eight of the twelve (Blade varieties, USDA source of Alamo, Hoop House were excluded) were also planted at the Highland Rim Research and Education Center (HRREC) at Springfield, TN. The tests at both locations were seeded in late May, 2007. The experiments were conducted in a randomized complete block design with three replications at both location in plot sizes of 4ft x 25ft (ETREC) or 5ft x 30ft (HRREC). Plots were harvested according to a one-cut system in November, 2007-2009. Results indicate that some of the new varieties and experimental lines are higher yielding than Alamo and Kanlow. Furthermore, the lowland ecotypes are higher yielding than the uplands, as reported previously by other researchers.

Comparison of switchgrass cultivars and corn grown as bioenergy feedstocks in New Jersey

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ABSTRACT

Switchgrass (*Panicum virgatum*) is a native perennial warm season grass (C4) currently being used as a bioenergy feedstock. However, little information is available on switchgrass production in the northeastern US. The objectives of this study were to evaluate the performance of four switchgrass cultivars with corn (*Zea mays*) at two locations in New Jersey. Four switchgrass cultivars (Alamo, Carthage, Cave-in-Rock, and Timber) and a corn hybrid were planted in a randomized complete block design with three replicates at two locations, Pittstown and Upper Deerfield, NJ in spring of 2007 at a rate of 11.2 kg PLS ha-1. Adapted Round-Up Ready™ corn hybrids were planted at each location at a rate of 11,340 seeds ha-1. Both trials received 60 kg N ha-1 applied in mid-May of each year. A single fall harvest in 2009 was made at each location. The corn grain and stover were also separated to determine plant biomass and grain yield. Ash was determined from subsamples of switchgrass plots collected monthly after harvest. Biomass yields for switchgrass ranged from 9.36 to 14.16 Mg ha-1. Total corn yields ranged from 4.66 to 6.18 Mg ha-1. Cultivars Timber, Alamo, and Carthage had the highest yields at both locations. Mean ash content decreased after fall harvest at both locations and reached the lowest values in early spring. Results suggest that once an infrastructure for cellulosic ethanol is established, Timber, Alamo, and Carthage could be promising cultivars for biomass production in NJ as an alternative to corn.

Alternative nitrogen for southern switchgrass production

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ABSTRACT

Switchgrass (*Panicum virgatum*) has become an important biomass crop. Nitrogen is the most abundant element in the atmosphere and is often a limiting factor for plant growth. One of the greatest input costs for crop production is nitrogen. Warm winter temperatures in the southeastern US allow establishment of cool-season legumes. These legumes have the potential to provide nitrogen to switchgrass, replacing or reducing the need for chemical nitrogen fertilizer. This study was arranged as an RCB with four reps, comparing biomass production of switchgrass plots fertilized with three levels of nitrogen (0, 22.7, and 45.4 kg/ha) and seeded to four clover species: arrowleaf (*Trifolium vesiculosum*), ball (*T. nigrescens*), crimson (*T. incarnatum*), and white (*T. repens*). Clovers were planted on December 18, 2006 and November 3, 2008, and yield data collected in October, 2007 and 2009, respectively, on already established switchgrass plots. In 2006-07, plots seeded to white (8.96 kgN/ha) and crimson (8.39 kgN/ha) clover produced more switchgrass than 0 kgN/ha (6.54 kgN/ha), but between 22.7 kgN/ha (8.21 kgN/ha) and 45.4 kgN/ha (11.26 kgN/ha). In 2008-09, plots seeded to crimson (17.54 kgN/ha) and ball (17.77 kgN/ha) had switchgrass yields similar to 22.7 kgN/ha (18.72 kgN/ha) and 45.4 kgN/ha (16.91kgN/ha). Crimson clover plots had consistent performance (replacing between 22.7 and 45.4 kgN/ha) both years. Follow-up work is necessary to determine the value of legumes in a low-input system. Subsequent studies will observe re-establishment of the legume crop from seed/rhizomes to persistence and reseeding requirements.

Establishment and persistence of legumes in switchgrass *(Panicum virgatum)* biomass and forage/biomass production systems

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ABSTRACT

Switchgrass is being used as a biofuel feedstock for ethanol production on marginal and crop land. Legumes may be interseeded into switchgrass to improve available N in the soil, reduce fertilizer costs, and enhance switchgrass yield and forage quality. The objective of this research is to develop legume management strategies for switchgrass production systems that are economically and ecologically sustainable for biomass and forage production. Seven cool- and warm-season legumes were examined for four years at the East Tennessee (Knoxville), Plateau (Crossville) and Milan Research and Education Centers. Cool-season legumes included alfalfa *Medicago sativa* cv "Evermore," red clover *Trifolium pretense* cv "Cinnamon Plus," crimson clover *Trifolium incarnatum*, common vetch *Vicia sativa*, and hairy vetch *Vicia villosa*. The warm-season legumes included Illinois bundleflower *Desmanthus illinoensis* and partridge pea *Chamaechrista fasciculata*. Legumes were interseeded into established switchgrass (cv. "Alamo") and monitored for establishment, self-reseeding, and N contribution as determined by increases in yield. Nitrogen fixation rates of common vetch and hairy vetch were 13.94 kg/ha and 14.84 kg/ha respectively at ETREC for similar-sized plants. Preliminary results indicate alfalfa and Illinois bundleflower are not feasible for establishment in lowland types of switchgrass. Hairy and common vetch, crimson and red clover, and partridge pea look promising for establishment and self-reseeding in established stands of switchgrass. In the forage/biomass system, presence of legumes did not significantly alter ADF (37.4 g/kg % DM), NDF (68.7 g/kg % DM), NEL (0.61 g/kg % DM), TDN (59.1 g/kg % DM), and switchgrass height (29.6 inches). CP (8.72 g/kg % DM) of legume treatments was statistically similar, and red clover CP was not significantly different from 120 lbs N/acre treatment. Total DM yield of red clover, crimson clover, and partridge pea (1.87 tonnes/ha) were not different when compared to 60 lb N treatment, and hairy vetch DM (1.52 tonnes/ha) was not different from the other legume treatments (1.65 tonnes/ha) in 2009. In the biomass system, legume presence did not alter DM yield (2.42 tonnes/ha) in 2009 and switchgrass height (31.8 inches) in 2009-10 from 60 lbs N/ acre treatment.

Integration of switchgrass bio-mass and forage on Mid-South farms

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ABSTRACT

Switchgrass (*Panicum virgatum*) is a warm season perennial grass native to the United States that has been shown to be an acceptable forage. Currently switchgrass is being investigated as a biofuel crop. The objective of this research is to determine if a one-time forage harvest is possible at either the vegetative or the boot stage without significantly reducing the yield of a fall bio-mass harvest. Small plot studies were conducted for one year in Milan, TN and three years in Knoxville, TN on Alamo switchgrass. A randomized complete block design was employed. Harvest treatments consisted of either a vegetative (May) or boot stage (June) forage harvest, each followed by a November biomass harvest, or a single November biomass harvest. A fertilization treatment consisted of either 30 or 60 lb of N at green-up. The plots harvested for forage received either 0, 30, or 60 lb of N/acre after the early harvest. In 2009, the single harvest treatment yielded 8.8 tons of biomass per acre, while the biomass from the two cut systems produced an average of 8.9 tons per acre with additional average 1.2 tons per acre harvested in May or 3.0 tons per acre harvested in June. This initial data indicates that it is possible to conduct a single harvest of switchgrass for forage without significantly impacting the yield of a fall bio-mass harvest in a mature stand of at least 3 years old.

Timing one-cut harvest of switchgrass with optimum decline in phosphorus and potassium levels in aboveground biomass

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ABSTRACT

Switchgrass remobilizes nutrients, especially phosphorus and potassium, during senescence. Identifying the appropriate harvest window in a one-cut biomass system based on the remobilization of these nutrients can be economically beneficial for producers. The objective of this research was to determine if a one-cut harvest can be executed earlier in the fall based on the optimum timeframe of translocation of phosphorus and potassium from stems and leaves to the crown and roots. The current recommendation is to harvest after the first killing frost or early November, whichever comes first. In 2007, 'Alamo' and 'Kanlow' cultivars were planted at the East Tennessee Research and Education Center in Knoxville. Ten plant tillers, clipped at 3-5 cm above ground level, were collected from each plot throughout the fall (July through November, 2008). Each 10 tiller sample was separated into panicles, leaves, and stems then ground and analyzed for P and K. Although P and K levels declined numerically throughout the fall, there were not significant changes in stems or leaves from July to late October for both varieties. Conversely, both P and K substantially increased in the stems and leaves collected in November. The P and K levels were: panicle > leaves > stems. Potassium ranged from 3X-9X higher than P in different tissues. Data from crowns, roots and above ground biomass (2009) followed the same trends observed in the tillers (2008). Based on these results, harvest can be executed earlier in the fall (e.g., late September) without removing significantly more P and K.

ORAL PRESENTATIONS: WILDLIFE MANAGEMENT

Factors influencing vegetation and avian species response to oak savanna restoration in the Mid-South

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ABSTRACT
Oak savannas are among the most imperiled ecosystems in the United States as a result of land-use conversion, incompatible silviculture, and disrupted fire regimes. Consequently, associated vegetation and avian communities have also declined. Restoration of savanna communities may be an important strategy for conserving avian species that depend on early successional habitat, which is underrepresented on regional landscapes. Therefore, we evaluated savanna restoration strategies through a meta-analysis of twelve case studies in Tennessee and Kentucky. Specifically, we looked at factors influencing vegetation and avian response following mechanical overstory thinning and dormant-season fire. We measured herbaceous and woody understory groundcover, and woody stem density. We conducted point counts to assess breeding bird use of the sites. Vegetation strata and breeding bird abundance were analyzed using hierarchical linear modeling. Total grass cover (0-74%) was negatively related to canopy cover (0-100%). Total forb cover (0-56%) was negatively related to total basal area (0-40 m^2/ha). Oak regeneration density (0-25 stems/m^2) was positively related to canopy cover (0-100%). Grass and forb cover and herbaceous species richness were not related to topographic variables. With respect to breeding birds, forest species persisted within case studies that were two years post-disturbance. Only three grassland obligate bird species, *Tyrannus tyrannus*, *Aimophila aestivalis* and *Spiza Americana*, were observed on any sites. Presence of *Passerina cyanea* was positively related to ground layer development; whereas, *Melanerpes erythrocephalus* was positively related to basal area of dead trees. Based on our results, combinations of canopy reduction and late growing-season fire targeted at oak savanna restoration should be evaluated in future research.

Wildlife and warm-season grasses: Challenges and opportunities in the Piedmont of North Carolina

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ABSTRACT

In 2000, the North Carolina Wildlife Resources Commission began a Cooperative Upland habitat Restoration and Enhancement (CURE) program to address the decline of early successional wildlife, especially northern bobwhite. The program established three 5,000-acre private land cooperatives across the state. Many cost-share practices were offered, including field borders, herbicides, prescribed burning, and native warm-season grass (NWSG) establishment. In the western piedmont cooperative, which is dominated by cool-season grasses, NWSG was the only practice readily accepted by farmers. Therefore, we expanded the use of NWSG in the second phase of CURE (2006-2009). From 2006-2009, we worked with 21 farmers to establish 337 acres of NWSG forage. We provided $180/acre, as well as access to a sprayer, Truax drill, and technical assistance. We dealt with seed quality issues, drought, and general resistance to an unknown forage type. Overall, farmers have been pleased with the benefits of NWSG. We measured population increases for rabbits and a variety of songbirds. Based on field observations, habitat conditions have improved as a result of conversion from tall fescue to NWSG. Wildlife seems to be benefiting from the improved structure and delayed harvest that NWSG provide over traditional forages. Although positive population responses have not been detected for bobwhites in our surveys, landowners and staff are reporting seeing and hearing more quail and other wildlife on these same acres than in the past. Interest in NWSG remains strong even though CURE financial incentives have ended. We still offer technical assistance and planting equipment, and worked with 8 farmers in 2010 to plant another 74 acres. We believe continued popularity is a result of increased knowledge and exposure to NWSG as a forage alternative. Also key to this has been the reduction in the cost of NWSG conversion over the past several years, which we believe was a major concern for landowners. NWSG has become cost competitive with other forages and therefore more feasible.

Influence of native warm-season grasses on northern bobwhite survival on reclaimed mined land

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ABSTRACT

The decline of northern bobwhite (*Colinus virginianus*) throughout the species' range has led to increased concern for this important game bird. One opportunity to increase habitat for northern bobwhite is by managing reclaimed mined lands. However, dense stands of sericea lespedeza and other non-native invasive species have resulted in unfavorable structure for bobwhite quail on many reclaimed mine sites. We are conducting an assessment of bobwhite populations using banding and radio telemetry on Peabody WMA, a reclaimed coal mine site in western Kentucky. Two units, Sinclair (3,634 ac) and Ken (4,579 ac) were chosen for this study. Key vegetation types have been delineated in GIS: open herbaceous, shrub, and native warm-season grass (NWSG). During the first year of study, a total of 383 birds were collared and monitored, with crude mortality rates of 55% (Sinclair) and 45.5% (Ken). Trapping success on Sinclair was 2.03% and 3.32% on Ken. Of the birds captured during the first year, 152 had usable home ranges and were included in survival analyses. Program MARK was used to analyze influence of NWSG on bobwhite survival during both winter and summer. Based on previously published studies, birds were categorized into groups based on the amount of NWSG within their home range (0-29%, 30-50%, 51-100%). Program MARK was also used to analyze survival rates of nests within NWSG and other vegetation types. Presence of NWSG within a home range affected survival on Ken during summer (ΔAIC = 1.95) and Sinclair during winter (ΔAIC = 1.51), but not on Ken during winter (ΔAIC = 2.64) or Sinclair during summer (ΔAIC = 3.97). Summer survival at Ken was greatest when NWSG composed 30-50% of the home range (83% chance of survival). Small sample size precluded further evaluation of survival patterns for the Sinclair winter group. Daily nest survival within NWSG (96%) was not different than within other vegetation types (94%); however, hatching success was greater within NWSG (21%) than in other vegetation types (11%), possibly indicating a higher recruitment associated with NWSG.

Habitat selection of northern bobwhites on a reclaimed surface coal mine in Kentucky

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ABSTRACT

Reclaimed coal mines in the eastern United States offer an opportunity to increase large tracts of early successional habitat essential to declining northern bobwhite populations. The Surface Mining Control and Reclamation Act of 1977 led to the release of more than 153,022 hectares of reclaimed land in Kentucky. Revegetation of reclaimed land was traditionally dominated by non-native plantings. To determine the effects of vegetation structure on northern bobwhite populations, we sampled vegetation and monitored populations with radio telemetry on a reclaimed surface coal mine in western Kentucky beginning in the winter of 2009. Four vegetation types were delineated: native warm-season grasses, deciduous forest, scrub-shrub, and open herbaceous (dominated by forbs). Point transects were used to measure factors that may influence selection, including vegetation composition, ground-sighting distance, and litter depth. The Chesson index was used to interpret use versus availability of vegetation types. GIS analysis of all Peabody displayed 32% coverage scrub-shrub, 23% native warm-season grasses, 20% deciduous forest and 15% open herbaceous. Selection percentages reflect birds selecting for more than one vegetation type, and in proportion to what is available within individual home ranges. Within the home ranges of 127 bobwhites, 64% selected for scrub-shrub habitat during winter, 37% for open herbaceous areas and 33% for native warm-season grasses. During summer, 57% selected for scrub-shrub, 72% for open herbaceous areas and 69% for native warm-season grasses. Of the bobwhites that had deciduous forest within their home range, 87% selected against it year-round. First-year data indicate a strong selection for open herbaceous and native warm-season grass areas during the summer, and for scrub-shrub areas year-round. This exemplifies the selection differences and use of each vegetation type seasonally in proportion to their availability within the bobwhite's home range.

Grazing as a tool to manage grassland habitat: Implications for forage production in the Mid-South

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ABSTRACT

Habitat loss, habitat degradation, and agricultural intensification are primary factors contributing to the decline of many birds that use grasslands, including the endangered grasshopper sparrow and the northern bobwhite. Current grazing practices in the Mid-South focus on getting high yields from dense, monotypic stands of non-native forages, which provide no bare ground, little vertical structure, and poor plant species richness. Few studies have examined the vegetative response of native warm-season forages to various grazing systems with respect to bird habitat, and none have been conducted in the Mid-South. We measured vegetative response to two grazing strategies on three native warm-season grass forages at Ames Plantation Research and Education Center, Grand Junction, Tennessee, May-July, 2010. Our grazing strategies were full-season, low-density grazing (4-5 head/acre, approx. 100 days) and short-duration, intensive grazing (6-8 head/acre, approx. 28 days). Forages used were eastern gamagrass, switchgrass, and a mixture of big bluestem and indiangrass. Plant species richness was similar between pastures in full-season, low-density grazing (25 species) and short-season, intensive grazing (24 species). Full-season, low-density grazed pastures (31%) had less coverage of undesirable grasses and forbs than short-season, intensively grazed pastures (37%). Short-season, intensively grazed switchgrass pastures had the highest coverage of undesirable grasses, such as dallisgrass (47%), and full-season, low-density grazed eastern gamagrass had the lowest coverage (7%). Neither grazing strategy promoted desirable seed-producing forbs (<1% coverage). Full-season, low-density grazed pastures were slightly more open at ground level (84 cm) than short-season, intensively grazed pastures (78 cm), with switchgrass pastures being the least open (76 cm). First year results indicate full season, low-density grazing of big bluestem/indiangrass and eastern gamagrass pastures increases openness and creates more diverse habitat than short-duration intensive grazing, particularly during brood rearing periods.

Bachman's sparrow population, habitat requirements, and detectability in oak savannas at Fort Campbell, Tennessee-Kentucky

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ABSTRACT

Bachman's Sparrow (*Aimophila aestivalis*) is a national species of conservation concern because of declining populations and loss of savanna ecosystems. Populations have decreased an average of 1.6 % per year from 1966 to 2007 across the entire range based on analyses from North American Breeding Bird Survey data. Bachman's Sparrows are traditionally found in pine savannas in their core range along the Gulf and Atlantic coasts, but use oak savannas in the northerly portion of their range, which reaches as far as Illinois and Pennsylvania. Fort Campbell, located on the border of Tennessee and Kentucky, contains the largest known breeding population of Bachman's Sparrows in oak savanna habitat. The goal of our research at Fort Campbell during 2009-2010 was to document population size, habitat use, and breeding ecology. Forty-three Bachman's Sparrows were found in patches of frequently burned and disturbed areas, and territories were mapped for 27. Occupied territories had a higher percent cover of forbs (27.67%) than the adjacent available savannas (20.45%), but did not differ in percent cover of native warm-season grasses (28.68%, 27.58%), standing senescent grass (6.79%, 4.56%), woody species (9.48%, 10.47%), sericea lespedeza (5.7%, 2.8%), litter (13.90%, 11.94%), or bare ground (15.11%, 16.62%). Territory size per bird was 2.66 ha ± 0.57and basal area per territory was 2.25 m^2/ha ± 0.65. Occupancy of Bachman's Sparrows on point counts was low during both breeding seasons (ψ=0.1), demonstrating the difficulty of using traditional ground-based monitoring for accurate population estimates. Our long-term goal is to use these data to develop a conservation strategy to both monitor and enhance populations of this high-priority species at Fort Campbell and elsewhere in the region.

A regional assessment of the effects of conservation practices on grassland bird populations

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ABSTRACT

Grassland and other early successional birds are declining more than any other avian group in North America. Nine of fourteen species that occur east of the Mississippi River, including Northern Bobwhite, have declined more than 2% per year between 1966 and 1994. Although the effects of individual conservation practices have been documented at the local (i.e., field or farm) scale, little research has attempted to document conservation effects at broader scales. The objective of our research is to undertake a broad-scale assessment to determine where and under what circumstances conservation practices have positively influenced grassland bird populations. We designed a roadside-based survey that targeted grassland and early successional bird species in the Central Hardwoods Bird Conservation Region. Surveys were conducted on secondary roads from May 15^{th} to July 15^{th}, 2008-2010 across 45 counties in 8 states. Survey routes were 24 km long with 5-minute point counts conducted every 800 m along the route. We focused on detecting 10 priority grassland and early succesional avian species including the Northern Bobwhite. In 2010 we recorded 15,043 individuals of the target species. The two rarest species detected during 2008/2009 surveys, Henslow's sparrow and blue-winged warbler, decreased in detections and relative abundance (birds/route) in 2010 over the entire survey area. Northern Bobwhite abundance decreased in all but two states, Illinois and Indiana, from the 2008/2009 surveys to 2010, with the sharpest decline of 72% in Tennessee. Other analyses will focus on the response of populations to conservation actions across multiple spatial scales.

Restoration for a butterfly: Promoting grassland habitat components at Gettysburg National Military Park

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ABSTRACT

The only known stable population of the regal fritillary butterfly (*Speyeria idalia*) in the eastern United States is found at Fort Indiantown Gap (FIG) National Guard Training Center, PA. To aid in species recovery, a repatriation plan has been implemented at several sites, including Gettysburg National Military Park (GNMP), PA. This study tested three experimental treatments (solarization [an agricultural technique that traps heat under plastic to raise the soil temperature and reduce annual species and soil pathogens], disking, and mowing) on larval host plant (violets) density and survivorship of transplanted nectar plants (native milkweeds and thistles). The goal of this project was to assess the efficacy of these three treatments in relation to the growth and survival of host plants. Once the most suitable management method(s) has been identified, large scale replication can commence with the goal of creating functional grasslands for the repatriation of this butterfly. Vegetation was surveyed at GNMP in 2008, 2009, and 2010. Surveys assessed larval (rosettes/m^2) and adult (stems/m^2) host plant density within experimental plots. Subsequently, supplemental nectar transplants were planted and surveyed for survivorship. No significant treatment effect on larval host plant density (solarization $\bar{x}$=4.92±1.32; disk $\bar{x}$=5.76±1.51; mow =11.69±3.63) or nectar transplant survivorship was found. Violet density increased significantly in 2009 and decreased in 2010. As of 2010, experimental plot violet density was five times greater than pre-treatment and three times greater than values at FIG in 2004. Nectar transplant survivorship was significant between species and year. In 2010, 5.2% of transplants had survived with *Cirsium discolor* as the most successful. Unfavorable weather conditions and transplant hardiness may have contributed to this low outcome. Overall, the presence of essential habitat components increased at GNMP because of this project, thus, improving site suitability and chances of a successful repatriation of this rare species in the future.

Avian response to production stands of native warm-season grasses

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ABSTRACT
Production uses for NWSG have the potential to affect substantially more area due to market-based incentives they provide to landowners. Production practices and their effect on grassland birds have been studied to a limited extent in the Great Plains, but not in the eastern US. We examined production stands of NWSG in Kentucky and Tennessee including forages (grazing and haying), seed and biofuel production, and control (unmanaged NWSG) fields. We monitored 102 fields, 90 in 2009 and 87 in 2010. Fields was visited three times point count survey to assess presence of 9 target species (northern bobwhite, eastern meadowlark, prairie warbler, field sparrow, Henslow's sparrow, grasshopper sparrow, red-winged blackbird, horned lark, and dickcissel), and a fourth time to measure vegetation (species composition, vertical cover, height, and litter cover and depth). Vegetation varied among field types with biofuels and seed production stands having the highest percent NWSG cover (>58%) and controls having the highest percent forbs (>34%) and litter cover (>94%) and greatest litter depth (>3.8 cm). Although there were detections among individual species (red-winged blackbird, field sparrow, all birds together), there was no clear preference for treatments or controls. Patterns of field selection among birds did not vary by year. Despite clear differences in key vegetation measurements, birds did not differ in stand preference or avoidance suggesting that production stands could play a valuable role in the recovery of grassland birds.

ORAL PRESENTATIONS: SEED PRODUCTION/LANDSCAPING

Harvestability indexes for native wildflowers

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ABSTRACT
A study funded by the Montana Board of Research and Commercialization Technology was initiated in 2010 to evaluate the impact of thirteen morphological and physiological characteristics on the harvest efficiency of native wildflowers in the US and Canada. The cumulative total of the positive and negative influence of these characteristics on seed harvest resulted in a Harvestability Index (standard combine harvest) for each of 388 commonly traded native wildflower species. A second Harvestability Index was developed for the Arbuckle Native Seedster™, a front-end loader mounted seed stripper/plucker that utilizes a counter-rotating brush and combing drum to dislodge and capture seed in a seed hopper. The plant characteristics that were documented included plant growth form, plant height, foliage density, inflorescence position in relation to foliage, type of inflorescence, flowering and ripening uniformity, tendency to shatter, seed container type, container integrity, seed type, seed size, seed and container appendages, and seed surface. The characteristics determined to have the greatest impact on harvestability were plant height, flowering and ripening uniformity, tendency to shatter, seed and container appendages, and container integrity, respectively. The harvest efficiency of species that ripen over an extended period of time is relatively poor when harvested with the direct combine or swath and combine method, but is considerably improved by using multiple harvests with a Seedster as the seed progressively matures. Seed appendages make it difficult to glean through the sieves of a combine, but rather than hinder the harvest efficiency of the Native Seedster, these appendages contribute to harvest effectiveness. Seed containers that are rigid or seed that is recessed into the receptacle require the extra threshing action of the cylinder/concaves of a combine to dislodge and capture the seed.

INTRODUCTION
The native wildflower seed production industry is a fledgling industry with the first cultivar release made in the early 1970's. In the last 35 years, 95 cultivars and germplasm releases, involving 69 species, have been made. Official releases of native grass began in 1940. In the last 68 years, a total of 267 cultivar and germplasm releases of 70 species of native grasses have been released to the commercial seed industry. Almost all of the major grass species are represented by a least one release, with some species having numerous releases made from across their natural range of adaptation. An estimated 450 native wildflower species are in commercial production or being wildland collected. At this time, only about 16% of the wildflower species have formal releases. This is an indication of the potential for new wildflower releases and the potential for considerable expansion of the wildflower seed production industry. Most wildflower seed production is on a relatively

small scale, in part, because of the difficulty in raising and harvesting seed. Commercial wildflower seed production is usually done in fields with spaced rows as mechanical cultivation is one of the few options for weed control. There are limited chemicals that can be used for broadleaf weed control in wildflower seed production. Some species are hand harvested because there is presently no harvesting technology available or current technology is inefficient. With the development of Harvestability Indices for both standard combine harvest and Seedster, Native Seedsters, Inc. is attempting to determine 1) how efficient is present standard combine harvest, and 2) what is the potential of the Seedster harvest technology for commercial and wildland wildflower harvest. Also, wildflower seed producers and collectors can use these Harvestability Indices to evaluate the most efficient harvest technique for each of their wildflower species and determine if a new species is even economical to produce.

METHODS AND PROCEDURES

Development of Species List

The first step in this study was to establish a list of all major native wildflowers commercially available in the US and Canada. By using seed company web sites, sales brochures and databases of commercial seed producers, marketers, and researchers a list of 420 species was compiled. Upon further examination some species were omitted because of foreign origin or insignificant market value. The current list contains the major commercially traded native wildflower species from the continental US states and Canadian provinces. The final total of 388 species represents 38 families. The most commonly represented families include Asteraceae (asters; 117 species), Fabaceae (legumes; 53), Scrophulariaceae (figworts; 37) and the Ranunculaceae (buttercups; 20).

Identification and Evaluation of Morphological Characteristics

The morphological and physiological characteristics of wildflower plants, inflorescences, and seed that may have some influence on harvest plausibility and efficiency were identified by interviewing wildflower seed producers, marketers and wildland seed collectors. The 13 characteristics used in this study include:

1. Growth form
2. Plant Height
3. Foliage Density
4. Inflorescence Type
5. Inflorescence position
6. Uniformity of Ripening
7. Tendency to Shatter
8. Seed Container Type
9. Container Integrity
10. Seed Type
11. Seed Size
12. Seed Appendages & Size
13. Seed Coat/Surface

A team of botanists reviewed regional flora publications, USDA PLANTS database, commercial seed producer web sites and sales brochures, university and government research data, and regional herbariums to characterize the key morphological and physiological characteristics. Most of the data was found in these literature sources, however, information on “uniformity of ripening” and “tendency to shatter” was obtained from interviews with wildflower grower and collectors. Average seed harvest dates, regions of adaptation, and official releases were listed for all species as general information, but are not factored into the calculation of the Harvestability Indices.

An Excel spreadsheet was used to list the all of the morphological and physiological characteristics and calculate the resulting Harvestability Indices for standard combine harvest and Seedster harvest.

Following is an interpretation of how each characteristic influences wildflower seed harvestability:

1. **Plant Growth Form** If the plant is in a upright position, they are generally harvestable, however decumbent or creeping plants are difficult to pick up with any kind of harvest equipment.
2. **Plant Height** Very tall plants may pose a problem for combine harvest because of the amount of biomass that needs to be run through the machine. With a Seedster, only seed and a minimal amount of trash is captured leaving the stand intact. Short and very short plants are difficult to harvest mechanically, most often requiring hand harvest.
3. **Foliage Density** Only thicker amounts of leafy biomass negatively impact seed harvest.
4. **Inflorescence Type** Generally, most types of inflorescence are just as easily harvested by a seedster or combine, except for tight heads or clusters which retain seed well past maturing and often need some form of threshing to dislodge the seed.
5. **Position of Inflorescence** If the inflorescence extends well above the foliage it is more easily harvested than if inflorescence is hidden within the foliage or in the axils of the leaf stems.
6. **Uniformity of Ripening** The combine harvest efficiency of plants that mature over an extended period of time is relatively low because of the production potential lost as immature seed or un-ripened inflorescences. Multiple harvests with a Seedster will capture only the mature seed, allowing immature seed to continue to ripen, to be harvested at a later date.
7. **Tendency to Shatter** How well the seed is attached to the receptacle or how strongly held in a seed container affects the seed shatter potential. Seed that readily shatters has low harvest efficiency both with a combine or a Seedster. Seed that is strongly held after maturity are best harvested with a combine because of the potential for threshing by the abrasive action of the cylinder/concaves.
8. **Container Type** The type of container is less important than how well the containers hold the seed once mature.
9. **Container Integrity** Seed that is not contained within a pod or capsule or are loosely attached to the receptacle are very susceptible to shatter. Also, harvest efficiency is quite low for species that use explosive containers to disseminate the mature seed. Containers that are strong or rigid often require some form of threshing to dislodge the seed. The combine has a definite advantage over the Seedster on seeds that are in tough pods/capsules or are recessed in the receptacle.
10. **Seed Type** The type of seed has very little influence on harvestability.
11. **Seed Size** Only the small and very small seed may pose a problem with combine harvest. All cracks in the conveyance system must be sealed to prevent seed loss. The larger seed are more easily harvested with a combine.

12. **Seed Appendages** Seed with attached hairy pappuses, awns, and barbs are difficult to glean through the sieves of a combine and often attach themselves to the chaff and straw and are lost out the back of the combine. The cylinder and concaves provide grinding action that sometimes dislodge or break seed appendages. Any appendage that adds bulk or fluffiness to a seed contributes to the efficiency of Seedster harvest. With the help of seed appendages, the brush is able to pull seed free from the inflorescence and capture it in the seed hopper.
13. **Seed Coat** The seed coat/surface influence the flowability of seed. Once seed is captured in the seed hopper of a combine or a Seedster, the flowability of the seed affects the unloading process and the flow through cleaning equipment.

RESULTS

Development of Harvestability Indices

Each of the 13 characteristics were broken down into various factors with each of the factors being assigned a positive or negative number depending on whether it had a favorable or limiting impact on harvestability (see Table 1). The range of the positive or negative numbers was an indication of how strong of an influence (positive or negative) each factor had on harvestability. The numbers were derived from years of experience of select growers, collectors, and researchers. The cumulative sum of all of the positive and negative rankings was used to produce a Harvestability Index for both standard combine harvest and Seedster harvest.

For some characteristics, the ranking of factors was the same for both the Combine Index and the Seedster Index (plant growth form, foliage density, inflorescence position, seed type, and seed surface. The primary characteristics for which the Seedster ranked higher than a combine were “uniformity of ripening” and “seed appendages.” With many of the wildflowers, the flowering and seed maturity takes place over an extended period of time. With direct cut or swath/combine harvesting, only the mature seed and the seed that continues to mature in the windrow are captured. With a Seedster, there is an opportunity for multiple harvests, where only mature seed is harvested, allowing immature seed to continue ripening and be harvested at a later date. Multiple harvests with a Seedster are possible only if the crop row spacing corresponds to the tractor wheels spacing so none of the crop is trampled. Narrow tires in both the front and back of the tractor make it possible for multiple trips through a field with minimal damage to the maturing crop. Seed appendages, such as hairy pappuses, awns/wings, and barbs, make it difficult to glean seed material through the sieves of a combine, but actually contribute to the dislodgement and capture of seed by a Seedster. Combines have an advantage for any species that require threshing to dislodge the seed from the container or receptacle.

The Harvestability Indices (see Table 2) were a cumulative total of all positive and negative rankings of the various factors of the 13 morphological characteristics. The Indices range from -65 to +195.

The Indices were grouped into four categories:

- below 40: considered **difficult** to harvest
- 45 to 100: considered **moderate** to harvest
- 105 to 140: considered **easy** to harvest
- above 145: considered **very easy** to harvest

The majority of the species fell within the moderate to easy category. The combine Harvestability Indices showed 65 species in the difficult category, 180 in the moderate category, 102 easy to harvest, and 41 very easy to harvest. The Seedster Harvestability Index had 39 species in the difficult to harvest category, 160 in the moderate category, 179 easy to harvest, and 10 very easy to harvest. Table 2 shows select examples (37 species of the 388) of the Harvestabilty Indices for combine and Seedster harvest. The full spreadsheet, with the ranking of each of the factors of the 13 characteristics and the resulting Harvestability Indices, will be available for viewing on the Native Seedster website at the completion of this study (nativeseedsters.com). Yet to be completed are field validation harvests of select wildflower species, which will verify the accuracy of the Seedster Harvestability Index. Seedster wildflower harvest efficiency is somewhat intuitive, as actual harvest trials have been conducted on only a limited number of species.

SUMMARY AND DISCUSSION

The Seedster exhibited a higher Index than a combine for 219 species (56%). Excluding the species that were considered "difficult" to harvest with either technique, the Seedster had a higher Index on 52% of the species. The species in the Asteraceae family that had hairy pappuses were favored by Seedster harvest, while the species with seed recessed into the receptacle were favored by combine harvest. Many species in the Fabaceae and Saxifragaceae families have strong, thick pods and capsules, and are best harvested with a combine because of the extra threshing that is required. Of the 388 species in this study, 100 (26%) species had a ripening period in excess of 14 days. This poor "uniformity of ripening" greatly reduces the harvest efficiency of the direct combine or swath/combine harvest technique. However, this extended period of maturation makes it possible for multiple harvests with a Seedster.

Table 1. Harvestability Index Worksheet

		Combine Index		Seedster Index	
		Positive	Negative	Positive	Negative
Morphological Characteristics Affecting Harvestability	**Factors**	**Favor Score**	**Limit Score**	**Favor Score**	**Limit Score**
Plant growth form	upright	30		30	
	Decumbent		-10		-10
	creeping/vine		-20		-20
Plant Height	tall >3'	10		20	
	mid 1.5 - 3'	20		20	
	short 1-1.5'		-20		-20
	very short <1'		-40		-40
Foliage density	sparse	10		10	
	medium	5		5	
	thick		-10		-10
Type of Inflorescence	spike	10		10	
	raceme	10		10	
	panicle	10		10	

	umbel/corymb/cyme	10		10	
	solitary	10		10	
	heads	20			-10
Inflorescence position in relation to foliage	well above	20		20	
	terminal	10		10	
	in foliage		-10		-10
	axillary		-20		-20
Flowering & ripening uniformity	very uniform	30		30	
	3-7 days	10		10	
	7-14 days		-10	10	
	14+ days		-20	10	
Tendency to shatter seed (disarticulation)	none	30		10	
	slight	10		10	
	moderate		-10		-10
	severe		-30		-30
Container type	capsule/loments	20		20	
	pod/follicle/silique /nutlet	10		10	
	recessed in receptacle	20			-10
	not contained	0		10	
Container integrity	strong	20			-10
	moderate	10		10	
	fragile		-10		-5
	explosive		-20		-20
Seed Type	seed	10		10	
	achene	10		10	
	nutlet	5		5	
	mericarp	5		5	
Seed Size	very small >1,000,000		-10	5	
	small (200,000 to 1,000,000	0		5	
	medium (80,000 to 200,000	5		5	
	large (<80,000)	10		5	
Seed &/or Container appendages	hair/bristle pappus minute		-5	5	
	scales/awns/wings 0.5-1x		-5	5	
	2-3x		-10	10	

	>3x		-15	10	
	hooks/barbs		-5	5	
	hairs		-5	5	
	none	20		5	
Seed Coat/surface (flowability)	smooth	10		10	
	hairy		-10		-10
	ridged/deep nerved		-10		-10
	angular		-5		-5
	nerved/striate/wrinkled		-5		-5
	wooly		-20		-20

Table 2. Representative Combine and Seedster Harvestability Indexes

Scientific name	Common Name	Combine Index	Seedster Index
Apiaceae family			
Eryngium yuccifolium	rattlesnake master	50	100
Ligusticum scoticum	beach lovage	125	110
Lomatium nuttallii	Nuttall desert parsley	35	60
Zizia aurea	golden Alexanders	130	105
Asteraceae family			
Achillea millefolium	western yarrow	85	125
Eriophyllum lanatum	wooly daisy	5	50
Helianthus maximiliani	Maximilian sunflower	145	70
Liatris puntata	dotted gayfeather	75	115
Ratibida columnifera	prairie coneflower	105	90
Rudbeckia hirta	black-eyed Susan	105	65
Solidago multiradiata	northern goldenrod	65	120
Symphyotrichum novae-angliae	New England aster	55	130
Zinnia acerosa	desert zinnia	25	10
Fabiaceae family			
Amorpha canescens	leadplant	175	110
Astragalus crassicarpus	groundplum	15	-10
Baptisia bracteata	cream false indigo	80	50
Desmanthus illinoensis	Illisnois bundleflower	110	105
Lupinus rivularis	riverbank lupine	95	95
Thermopsis divaricarpa	foothills golden banner	130	115
Malvaceae family			
Iliamna rivularis	wild hollyhock	115	100
Sphaeralcea grossulariifolia	gooseberry globemallow	110	140
Mirabilis nyctaginea	four o'clock	70	85
Onograceae family			
Epilobium coloratum	willow herb	40	110
Gaura coccinea	scarlet gaura	100	140
Oenothera speciosa	showy evening primrose	85	90

Polemoniaceae family			
Ipomopsis rubra	standing cypress	85	85
Phlox drummondii	Drummond phlox	-10	30
Polemonium reptans	Jacob's ladder	70	75
Polygonaceae family			
Eriogonum fasciculatum	California buckwheat	110	160
Eriogonum niveum	snow buckwheat	40	30
Scientific name	Common Name	Combine Index	Seedster Index
Ranunculaceae family			
Acotinum columbianum	monkshood	135	110
Anemone virginiana	tall thimbleweed	45	85
Aquilegia chrysantha	golden columbine	120	135
Thalictrum dioicum	early meadowrue	65	105
Scrophulariaceae family			
Castilleja coccinea	scarlet indianpaintbrush	95	115
Penstemon digitalis	smooth penstemon	145	120
Veronicastrum virginicum	Culver's root	105	105

Complete spreadsheet of all 388 species to be posted on nativeseedsters.com upon completion of the study.

Maximizing efficacy of seed storage methods to enhance rivercane (*Arundinaria gigantea)* seedling production for habitat restoration programs

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ABSTRACT
Canebrakes (stands of *Arundinaria gigantea*) provide exceptional wildlife habitat, promote stream bank stabilization, and improve water quality, making them ideal focal points for riparian restoration projects. However, availability of viable seed for seedling production is limited due to infrequent flowering events, naturally low seed viability, recalcitrant nature of seed, and failure of flowering stands to produce seed. The purpose of this study was to examine seed storage methods to extend stored seed viability and seed germination for future use in rivercane seedling production for restoration programs. To test for effect of container type, seed viability and percentage germination were compared for 2 storage container types (paper and plastic bag) at 2 storage temperatures (5°C and 21°C) over 5 months. To test for effect of storage temperature, seed viability and percentage germination were compared over 3 storage temperatures (-5, 5, and 21°C). Seed viability decreased over time independently of container type or storage temperature. Plastic bags demonstrated a greater percentage germination than paper bags, but viability showed no difference. The greatest viability and percentage germination among storage temperatures occurred at -5°C, and no differences were observed for 5 and 21°C. These results suggest that rivercane seed germination potential can be prolonged by storage in plastic bags at sub-zero temperature.

INTRODUCTION
Rivercane (*Arundinaria gigantea*) is 1 of only 3 native species of bamboo in North America and was once an important structural component of bottomland and riparian ecosystems of the southeastern of United States (Meanley 1972, Delcourt 1976, Simon 1986, Platt and Brantley 1997). Extensive stands of mature rivercane form a dense monotypic habitat known as canebrakes (Platt et al. 2001). Distribution of rivercane has declined dramatically since the arrival of European settlers due to extensive clear-cuts for agricultural practices, river channelization, urbanization, and alteration of fire regimes (Noss et al. 1995). This habitat is considered a critically endangered ecosystem (Platt et al. 2001), and the loss of these vulnerable habitats has affected many wildlife species (Platt et al., 2001).

Ecologically, rivercane provides soil stabilization, which prevents erosion and enhances water quality by holding the soil with its interlocking rhizomes. It also intercepts surface water with an extensive array of culms as rainfall runoff moves towards streams and rivers. It is known to provide prime shelter for the threatened Louisiana black bear (*Ursus americanus luteolus*) and several migratory birds including the American Woodcock

(*Scolopax minor),* Swainson's Warbler (*Limnothlypis swainsonii*) and Hooded Warbler (*Vermivora bachmanii*) (Thomas et al. 1996, Moorman et al. 2002).

Whereas rivercane provides important wildlife habitat and water quality benefits, many state, tribal, and federal natural resource agencies have expressed significant interest in restoring canebrakes within the native range of rivercane. Brantley and Platt (2001) indicated that workable rivercane restoration techniques were largely unavailable 10 years ago. Although restoration sites were available, techniques necessary to produce large numbers of propagules (sprouts, seedlings, or rhizomes) had not been developed (Platt and Brantley 1992; 1993; 2001).

One of the major obstacles to rivercane propagation is the low availability of viable seed. This species flowers infrequently, and some reports suggest gregarious flowering after periods ranging from 3 to 50 years, followed by complete die-offs of entire stands (Platt and Brantley 1997). Judziewicz et al. (1999) also reported rivercane produced significant percentages of sterile or nonviable seed, and Baldwin et al. (2009) indicated that seed is recalcitrant in nature with a 10-week limit on storability at 20°C and 60% RH.

Much effort has been spent to find ways to store recalcitrant seed without a loss of viability (Baskin and Baskin 2001). The purpose of this study was to examine seed storage methods to extend viability and maintain seed germination rates for future use in rivercane seedling production for restoration programs.

MATERIALS AND METHODS

Seed Source

This experiment was conducted with seed collected on 15 May 2009 from a rivercane stand in Harrison County, Kentucky. The whole plant tops were cut and left to dry slowly for 14 d at 1-5°C, and then sealed and stored with moisture content of 15-25% at 1-5°C until the beginning of the storage experiments in October 2009.

Storage Container Experiments

Seed Viability – Two container types were examined for effect on seed viability: plastic zipper-seal freezer bags and brown paper bags. Seed were randomly selected, and 50 seeds were placed in each of 10 bags of each container type. Five bags of each container type were stored at room temperature (21°C) and 5 bags of each type were stored at 5°C. Once each month for 5 months, 10 seeds from each replicate were removed for viability testing (n = 50).

Percentage germination – The same 2 container types were examined for effect on percentage germination: plastic zipper-seal freezer bags and brown paper bags. Seed were randomly selected, and 250 seeds were placed in each of 6 bags of each container type. Three bags of each container type were stored at room temperature (21°C) and 3 bags of each type were stored at 5°C. Once each month for 5 months, 50 seeds from each replicate were removed for germination assessments (n = 250).

Storage Temperature Experiment

Seed Viability – Three temperatures were selected based on typical storage environments: freezer (-5°C), standard refrigeration (5°C), and room temperature (21°C). Seed were randomly selected, and 50 seeds were placed in each of 15 plastic freezer bags. Five bags were stored under each storage temperature. Once each month for 5 months, 10 seeds from each replicate were removed for viability testing (n = 50).

Percentage germination – The same 3 temperatures were used for percentage germination trials: freezer (-5°C), standard refrigeration (5°C), and room temperature (21°C). Seed were randomly selected, and 250 seeds were placed in each of 9 plastic freezer bags. Three bags were stored under each storage temperature. Once each month for 5 months, 50 seeds from each replicate were removed for germination assessments (n = 150).

Determining Viability

Viability was tested using Tetrazolium staining (Baskin and Baskin 2001, Baldwin et al.2009). Each seed was cut in a longitudinal cross section bisecting the embryo, and then immersed in 0.1% Tetrazolium (2,3,5-triphenyl tetrazolium chloride) solution for approximately 24 h. Tetrazolium stains living embryonic cells that are actively engaging in cellular respiration because it is reduced by dehydrogenases resulting in the production of formazan, which stains a distinctive red color (DeLouche et al. 1962, Baldwin et al. 2009). When examined under 3× magnification, seed that showed red stained embryos were counted and recorded as a viable seed.

Determining Percentage Germination

Seed were soaked in a disinfectant solution (10% chlorine) for 5 minutes to control fungal growth and then were rinsed with distilled water. Seed were germinated in Petri dishes using autoclaved sterilized sand as a substrate (Baskin and Baskin 2001). Foil paper was used as a cover, and Petri dishes were placed in a germination chamber (Percival model 135LLVL, Boone, Iowa) set at 12-hour, 35°C day and 12-hour, 20°C night regime. Seed germination (emergence of at least 1 mm of radicle) was monitored every 4-5 d until seed were clearly nonviable or degraded by fungus.

Data Analysis

The responses in seed viability and germination to container type and storage temperature were analyzed by using 2-way analysis of variance. For pairwise post-hoc multiple comparisons, the Holm-Sidak test was used. Germination and viability data were transformed using the arcsine-square root transformation (Zar 1999, Devine et al. 2010) to achieve normality. Statistical analyses were performed using SigmaStat 3.11 (Systat Software Inc., San Jose, California 2004).

RESULTS

Viability was greatest for seed stored at -5°C (mean viability = 40%) compared to other storage temperatures ($P < 0.001$). There were no differences detected between 5°C (mean viability = 29%) and 21°C (mean viability = 24%) (Fig. 1). Viability decreased over time ($P < 0.001$), with a precipitous drop (e.g., for -5°C treatment, viability dropped from 58% to 12%) in viability between the third and fourth month of storage. Percentage germination was different between temperatures ($P < 0.001$), with the greatest percentage germination observed at -5°C (mean percentage germination = 31%), followed by 5°C (mean percentage germination = 11%), and the lowest seed germination rate was observed in seed stored at 2°C (mean percentage germination = 31%) (Fig. 2).

No differences in viability ($P > 0.6$) were observed between container types. However, percentage germination of seed stored in plastic bags was greater than seed stored in paper bags ($P \leq 0.01$) (Fig. 3).

Figure 1. Response of seed viability to storage temperature over 5 months. Temperature treatments with the same letter are not statistically different.

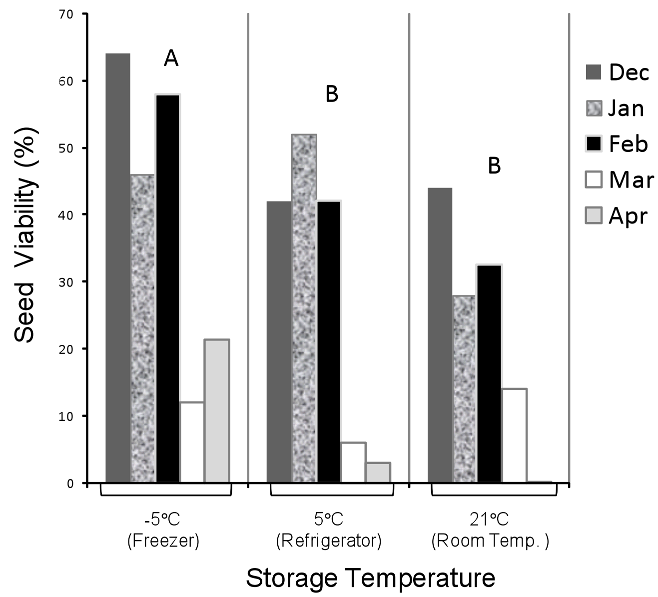


Figure 2. Response of seed germination to storage temperature over 5 months. Temperature treatments with the same letter are not statistically different.

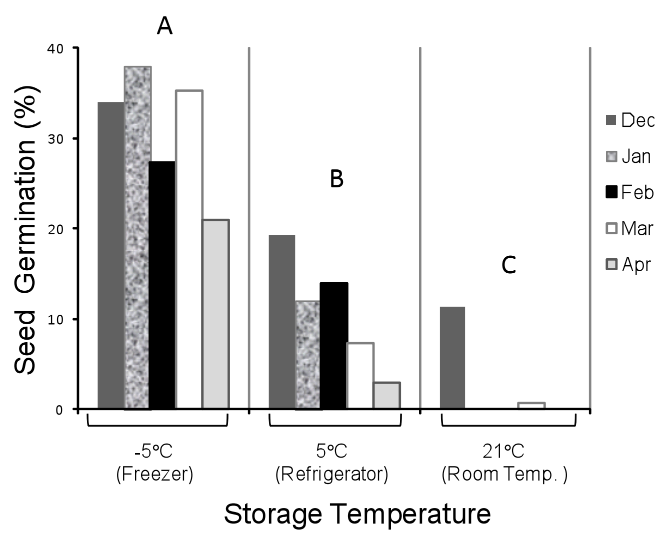
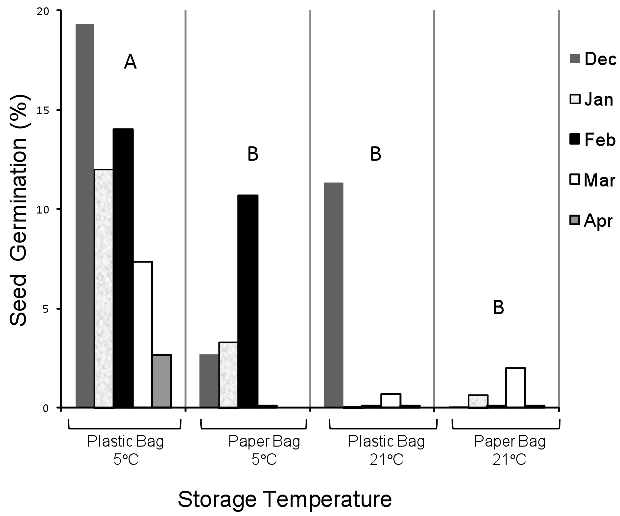


Figure 3. Effect of storage container type on seed germination at 2 storage temperatures. Temperature-container treatments with the same letter are not statistically different.



DISCUSSION

The results of this study suggest that rivercane seed should be stored in plastic freezer bags at sub-zero temperatures to extend embryo viability and germination potential. Plastic freezer bags seal in moisture, which may be important for recalcitrant seed (Hong and Ellis, 1996) such as rivercane. Paper bags are permeable and allow air transfer, which likely leads to seed desiccation and reduced viability. Storage at room temperature, which was set at 21°C in this study, appeared to be the least effective storage method. This may be due to metabolic processes within the seed, particularly cellular respiration, which continues normally at room temperature but is slowed at cooler temperatures (Baskin and Baskin 2001). Regardless of the mechanism, rivercane seed stored in plastic bags in the freezer appeared to be most likely to produce seedlings.

Despite the improvements in seed storage indicated in this study, storage periods of 3 months or more during this study substantially reduced viability and germination percentage. However, seed used in this study had been stored for 150 d prior to the onset of the study, and it is unknown what effect this lengthy storage may have had on seed performance. Mean seed viabilities during the first month of the study ranged 44-64%, and first-month germination percentages ranged 11-34%. It is possible that both viability and germination would be greater for seed planted immediately after harvest, as some seed germinated during the initial drying period. Likewise, storage prior to the experiment was conducted at temperatures ranging 1-5°C. Storage at sub-zero temperatures, as suggested by this study, may have yielded great starting viabilities and germination percentages.

The discrepancies observed between percentage viable and percentages germinating were unanticipated. Although it is expected that not all viable seed will germinate, percentage germination was 58% lower than viability within each storage temperature. These seed came from the same seed stock, and conditions were the same for both experiments. Whereas the process of germination is a function of having a living embryo, aleurone, and endosperm (food source), it is possible that the quality of one of these components was insufficient for germination (Baskin and Baskin 2001). Additional studies could examine seed anatomical development as is related to viability and germination.

ACKNOWLEDGEMENTS

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Outcrossing reciprocity study between remnant big bluestem *(Andropogon gerardii)* populations in the Carolinas

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ABSTRACT

An out-crossing reciprocity study was conducted with five *Andropogon gerardii* populations across North and South Carolina for growing seasons 2007-08. A total of 15 treatments each were established at four garden sites. Both out-crossing (5.1%) and selfing rates (3.5%) were low for seed germination. However, germination was significantly higher for both outcrossed and selfed seeds from plants from the Suther Prairie population. There were no significant differences in seed set among plants from the five populations. In addition, there were no significant differences in parental effect in either germination or seed set among plants from the five populations. Plants from the Black Jack Serpentine Barren population (paternal) x Suther Prairie population (maternal) and it reciprocal SP x BJ had the highest combined percent seed germination (21.3% and 5.8%, respectively). Plants from the Suther Prairie population (paternal) x Buck Creek Serpentine Barren (maternal) and its reciprocal BC x SP had the highest combined percentage of seed set (22.7% and 9.6%, respectively). Plants from the The Sumter National Forest population failed to produce germinable seeds.

Seed safening for use in switchgrass establishment

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ABSTRACT

Switchgrass (*Panicum virgatum*) is a native warm season grass that is considered to be in the forefront of biomass-to-fuel production. The major limiting factor in the establishment of switchgrass is annual grassy weed control. The objective of this research is to test the seed safener, fluxofenin at four rates and two treatment methods. Determining the optimal rate and seed application method would provide distinct advantages in switchgrass establishment and weed control, potentially enabling fertilization and significantly increasing production during the establishment year. Fluxofenin, the active ingredient in the commercial safener Concep III®, safens seed against the herbicide metolachlor. Preliminary testing of nine safeneners indicated that fluxofenin, applied at a quarter the labeled rate for sweet sorghum (*Sorghum bicolor*) (0.4 g a.i./kg of seed), protected switchgrass seedlings from herbicidal injury, while providing excellent weed control. Subsequent testing of safener coating methods (seed soak vs. brushing), rates (full rate, half rate, quarter rate), and eleven switchgrass varieties (lowland and upland) was conducted in the summer of 2010 at four sites: Mississippi State, Iowa State, Virginia Tech, and South Dakota State University. Nine treatments were planted on 3 m (10 ft) rows with 50 cm (20 in) spacing in four replications. All varieties were tested for germination pre-coating and were planted at a 9 kg PLS/ha (8 lb PLS/A) seed rate. Metolachlor was applied in the form of Dual Magnum® at a rate of 0.91 kg a.i./L (1.17 L/ha or 1.0 pt/A) immediately following planting. Seedling counts were conducted four weeks after planting and there were no significant differences between the control (no safener/no herbicide; 4.92 seedlings per 15 cm) and the quarter rate of safener (4.37 seedlings per 15 cm). There were no significant differences in weed control ratings between treatments, however there were differences between weeks; as season progressed, weed pressure increased. End of season harvest results show the quarter rate of safener with the variety 'Alamo' and the control were significantly higher in tonnage than all other switchgrass varieties and treatments with 3.45 Mg/ha (1.20 ton/A) and 2.14 Mg/ha (0.96 ton/A), respectively. In conclusion, ease of establishment along with establishment year fertilization can be achieved through the use of the safener Concep IIII® and the pre-emerge herbicide Dual Magnum®.

BIOFUELS FORUM

Dedicated energy crop production in Tennessee

Sam Jackson

University of Tennessee Center for Renewable Carbon and Genera Energy LLC

ABSTRACT
Working with partners at Genera Energy LLC, the University of Tennessee's (UT) Biofuels Initiative is developing a farm-to-fuel business plan supported by the State of Tennessee, the UT Institute of Agriculture, and Oak Ridge National Laboratory researchers. Tennessee has made a commitment to lead the transition to an advanced biofuels economy by supporting the development of a dedicated bioenergy crop supply chain and the construction of a 250,000-gallon-per-year demonstration cellulosic ethanol facility, which is now operational with partners at Genera Energy and Dupont Danisco Cellulosic Ethanol. UT and Genera are establishing a dedicated energy crop (switchgrass) supply chain to demonstrate and improve biomass-to-energy technologies and ultimately commercialize the technology across the state. We work with local farmers to develop switchgrass production and provide one-on-one technical assistance through UT Extension and wide-ranging research related to all aspects of the feedstock supply chain. This research focuses on improving efficiencies and reducing costs in production, harvesting, storing, transporting, and preprocessing switchgrass feedstock. Approximately 5,100 acres of switchgrass have been planted under the Biofuels Initiative's incentive program. Genera is also currently constructing the Tennessee Biomass Innovation Park to showcase processing, handling, storage, and conversion of a variety of cellulosic feedstocks. The development of the bioenergy feedstock supply chain, from biomass to fuels and products, will have a significant impact on the energy future of the state and nation. The work in Tennessee seeks to provide a viable path to a sustainable, biomass-based future for rural economies and the nation.

Forests and dedicated energy crops

Mike Cooley

Catchlight Energy LLC

ABSTRACT

Catchlight Energy LLC (CLE) was formed as a non-directed joint venture between Chevron Corporation and Weyerhaeuser Company in February 2008 for the purpose of commercializing the production of liquid transportation fuels from forest-based resources. CLE has a large, established feedstock development program that includes testing a variety of crops, cropping techniques, harvesting methods, and integration strategies for commercial-scale production. Another major focus of the feedstock program has been to clearly identify environmental issues that may be associated with the production of biofuel feedstocks. CLE has initiated large replicated field research trials in eastern North Carolina, Mississippi and Alabama. These studies are designed to evaluate impacts of biofuel feedstock production on wildlife populations, plant biodiversity, water quality, water quantity, soil carbon, nutrient cycling, and long-term site productivity. The studies investigate the effects of intensive removal of forest harvest residues and harvesting native understory, as well as production and annual harvest of switchgrass intercropped in loblolly pine plantations. Utilizing non-food crops, such as forest residues, understory biomass, or a dedicated energy crop, such as switchgrass, provides a new opportunity for private landowners to generate a revenue stream throughout the maturation of their forest plantations, which is important since forests are long-term investments with an average rotation age greater than 25 years. Additionally, this can be achieved with no direct or indirect land-use change because the space between the rows of pine trees is being efficiently utilized resulting in no displacement of valuable agricultural land.

Biomass for bioenergy: Where industry appears to be going

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ABSTRACT

As with any new crop, in order to provide raw product, producers must understand the demands of the industrial consumer. However, industry must have realistic economic and quality demands of the producer. Production of alternative crops in an emerging market must be coupled exactly with industrial demand. Former President Bush stimulated biomass for fuel research by mentioning the word "switchgrass" in his January 2006 State of the Union Address. The push for non-petroleum liquid fuels was initially met by ethanol from corn. Consumption of grain corn for ethanol production stimulated speculation, which in turn increased the price of food/feed corn to record levels. Corn-based ethanol production has been capped to stimulate practical production of ethanol from non-food sources. Cellulose as a feedstock is the most likely candidate. Sources of cellulose vary greatly from solid municipal waste to wood, stover, and straw. Feedstock selection is based on economics of availability and delivery. The Department of Energy's push for cellulosic ethanol production has stimulated research, and is now funding some small scale production plants focused on: acid hydrolysis, enzymatic conversion, and thermochemical hydrolysis of cellulose to make ethanol. Recently, interest has increased in the thermochemical production of bio-oil, a liquid fuel analogous to oxygenated crude oil. In the background, coal-burning electric power plants have been test-firing boilers with grass straw to offset coal consumption and reduce emissions. Their potential to consume vast quantities of cellulosic feedstock should not be ignored. However, to keep the price of fuel (liquid or electric) low, pricing of these biomass feedstocks will require the economics of production to be low. In turn, acreage for biomass production will be driven to marginal, CRP, sloping land, not suitable for higher-value crops. Currently, industrial applications are optimizing for wood. However, wood can only act as a bridge to the more abundant annual production of warm-season grass straw. Production of perennial grasses on marginal land offers significant positive economic and environmental

SAVANNA RESTORATION FORUM

Collaborative landscape-scale fire restoration management and planning in the Boston Mountains, Arkansas

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ABSTRACT
Collaborative fire management restoration depends upon landscape managers finding common ground in their understanding of ecosystem structure and function and desired ecological conditions. The Ozark-St. Francis National Forest, The Nature Conservancy, Arkansas Game and Fish Commission, Arkansas Natural Heritage Commission, private landowners, and others are collaborating to restore oak-hickory and oak-pine ecosystems in the Boston Mountains, which have been degraded from past timber management and fire exclusion activities. There are substantially more closed-canopy forest and less woodland/savanna today than occurred under the region's historic fire regime, in which low-intensity fire burned these systems about every 2-15 years. Plant and animal species, such as the royal catchfly, northern bobwhite, Bachman's sparrow, Diana fritillary, Indiana bat, and elk, are adapted to the vegetation mosaic that this frequent fire regime maintained. This collaboration faces other challenges as well: red oak decline has impacted at least 300,000 acres of Ozark National Forest, including the Big Piney Ranger District and intermixed private property, increasing hazardous fuels in the wildland-urban interface and threatening municipal water supplies. The Big Piney Ranger District and many partners are implementing a long-term, landscape-scale ecosystem restoration project on 60,000 acres to increase forest health, restore fire-dependent woodland ecosystems, protect municipal water sources, and promote safety in the wildland-urban interface using periodic prescribed fire and forest thinning by commercial and non-commercial methods. A monitoring program is currently being implemented to track changes towards desired ecological conditions that were described using an ecological classification system.

Historic savanna of the Cumberland Plateau

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ABSTRACT

Oak savannas and woodlands represent some of the rarest ecological community types occurring in Tennessee. From what was described by explorers and settlers years ago as "vast and expansive," these communities have all but disappeared from the Tennessee landscape. Disappearance of these communities has had a negative effect on both floral and faunal diversity in our state. Beginning in 1999, restoration of oak savannas and woodlands was initiated by the Tennessee Wildlife Resources Agency (TWRA) on the Catoosa Wildlife Management Area in Cumberland County following timber salvage operations responding to an historic outbreak of southern pine beetle, which killed Virginia, shortleaf, and loblolly pines throughout Catoosa and across the Cumberland Plateau. After pine salvage operations were underway, prescribed fire was used to remove the litter layer and allow the existing plant community to thrive with adequate sunlight. The response by grasses and forbs to the removal of trees and reintroduction of fire on Catoosa was dramatic. However, the savanna and woodland communities that developed were not surprising, particularly after studying the history of the Cumberland Plateau. Longhunters and explorers traveling throughout the Cumberlands noted bison and elk in expansive grassy openings across the region. Early travelers also described fires and evidence of fires set by Native Americans. The use of fire was continued by early settlers on the Plateau to increase and rejuvenate grasses and forbs for free-ranging livestock. In fact, Cumberland County was one of the top cattle-producing counties in the state through the late nineteenth century. Free-range practices continued in Cumberland County until 1947. The fires that occurred throughout the Plateau region served to promote native grasses and forbs and, on some sites, shortleaf pine, a fire-tolerant species.

Shortleaf pine-bluestem restoration on the Ouachita National Forest — A case study in ecosystem recovery through active management

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ABSTRACT

Shortleaf pine (*Pinus echinata*) is the only naturally occurring pine distributed throughout the Ozark-Ouachita Highlands. It dominated south-facing slopes in the Ouachita Mountains and occurred further north in the Ozark Mountains as isolated pure stands or as an important component in mixed stands. Until about 1930, open stands of shortleaf pine with bluestem grasses in the understory were prominent in the Interior Highlands. However, following the logging of the original stands and 6 decades of effective fire exclusion, these woodland communities with their unique flora and fauna have all but disappeared. Guided by concerns about habitat for the red-cockaded woodpecker, federal land managers have developed silvicultural tools and tactics to restore shortleaf pine-bluestem communities using timber sales, woody midstory removal, prescribed burning, cavity management, and research support in a management program that has become a showplace not just for recovery of an endangered species, but also for an entire ecosystem at ecologically significant scales across the landscape of the western Ouachita Mountains.

POSTERS: FORAGE

Canopy characteristics of eastern gamagrass (*Tripsacum dactyloides*): Implications for production in the Alabama Black Belt

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ABSTRACT

Eastern gamagrass (*Tripsacum dactyloides*) is a productive warm-season perennial grass that has the potential to increase animal production in the southern U.S. It is a multiple-use crop with moderate to high forage quality that can serve as a barrier crop and wildlife habitat for limited resource producers in the southern U.S. This study measured yield and canopy characteristics of three eastern gamagrass ecotypes found in the South (Texas, Florida, and Arkansas). Plants were established and harvested to 10-inch height every 35 days. Plant height, total yield, and daily growth rate were measured. Leaf and stem mass, and other yield components were used as quality factors. Data indicated that yield ranged from 3.6 to 5.3 tons ac^{-1} equivalent among three ecotypes over three harvests. Daily average plant growth during the study ranged from 1.16 to 1.36 inches day^{-1}. San Marcos (TX) and Bumpers (AR) had peak leaf production at harvest 2, while the Florida ecotype had maximum leaf production at harvest 3. All ecotypes produced less stem mass at harvest 3. These findings indicate that further study is needed to identify ecotypes that exhibit growth patterns that satisfy specific producers' needs for sustainable production in the Alabama Black Belt.

INTRODUCTION

A reliable supply of forage is a critical requirement for successful livestock production operations (Baron et al. 2000; Rhoden et al. 2002; Belesky 2006). Matching forage availability and nutritive value with animal production goals and other operations is often a challenge for limited resource producers (Rhoden et al. 2002, 2006; Smith et al. 2010a, 2010b). Flexible, high-producing forages offer the potential for farmers, ranchers and conservationists to use highly weathered soils in the southern U.S. When evaluating multiple use crops, it is important to consider traits such as forage mass, forage quality, plant morphology, canopy characteristics, regrowth potential, and persistence. This will allow ranchers, farmers, and conservationists to target plant types and management practices for specific environments and production conditions.

Eastern gamagrass (*Tripsacum dactyloides*), is a perennial warm-season grass found in the eastern U.S. (Newell and deWet 1974; Harlan and deWet 1977; de Wet et al. 1982). It is suitable for use on highly weathered, acidic, claypan, and other marginal soils (Alberts et al. 1996; Foy 1997; Clark et al. 1998; Kemper et al. 1998; Foy et al. 1999; Gilker et al. 2002; Krizek et al. 2003). Previous study of various eastern gamagrass cultivars and improved ecotypes has identified well-adapted and productive plant types suited to various uses

(Faix et al. 1980; Horner et al. 1985; Bidlack et al. 1999; Smith et al. 2010). It can be used as fresh or preserved forage, a barrier crop, or as cover for wildlife (Burns et al. 1996; Dewald et al. 1996; Beitelspacher 1998; Gillen et al. 1999; Rhoden et al. 2002; USDA-NRCS 2005). The USDA-NRCS has released selected germplasm from the southern U.S. (USDA-NRCS 2000; USDA-BPMC 2000a, 2000b).

Eastern gamagrass has been referred to as the "ice-cream" of forage crops (Beitelspacher 1998). Cattle tend to overgraze eastern gamagrass over other grass species, if not properly managed, leading to depletion of carbohydrate reserves and reduced regrowth. By providing a high leaf proportion well above the heavy stem bases, eastern gamagrass offers a potential feed source of predominately leafy tissue that can be grazed or harvested mechanically (Burns et al. 1992; Aiken and Springer 1994; Coblentz et al. 1998; Burns and Fisher 2000). Researchers have documented the preference by cattle for leaf over stem (Laredo and Minson 1973; Chacon and Stobbs 1976; Aiken 1997). According to Aiken and Springer (1994), cattle generally grazed eastern gamagrass leaf blades over more fibrous leaf sheath and stems. Aiken (1997) found the disparity in nutritive values between leaf blade and leaf sheath seemed substantial enough to induce preferential consumption of leaf blades. Cattle, seemed to prefer to graze the tips of leaf blades, and eventually grazed total leaf blades and sheaths as the availability of intact leaf blades diminished just before pastures reached their targeted canopy heights.

Variability in eastern gamagrass ecotypes has been observed when used for forage production. It has been noted, however, that leaf and stem heights and width, plant architecture, and degree of center persistence of different eastern gamagrass ecotypes may also differ (Newell and de Wet 1974; Faix et al. 1980; Wright et al. 1983; Fine et al. 1990; Snider 1995; Surrency et al. 1998). Leaf:stem ratio of grasses is an important factor affecting diet selection, quality, and forage intake (Smart et al. 2004). The identification of high-quality, high-yielding perennial plants is a potential boon to limited resource farmers and ranchers, who need to maximize farm inputs. As a result, the objective of this study was to evaluate selected eastern gamagrass ecotypes for yield, plant height, and leaf and stem components.

MATERIALS AND METHODS

Experimental Procedure

The greenhouse experiment was conducted at the George Washington Carver Agricultural Experiment Station, Tuskegee University in Tuskegee, Alabama. To initiate the study, eastern gamagrass ecotypes from three states of origin (TX, FL, and AR) were established vegetatively and selected for uniformity. A native grass specialist examined the plants to ensure that they represented the accessions. The growth media used was Marvyn loamy sand topsoil (Fine-loamy, siliceous, thermic Fluvaquentic Eutrochrepts).

Throughout the course of the study, mean day/night temperature ranged from 77 to 86±5°F, with relative humidity between 80 and 90% in the greenhouse. Seedlings were grown in a potting mixture containing soil and JiffyMix© in a volume ratio of 1:1 respectively. The plants were watered every other day or when necessary. A nutrient solution of 20-20-20 (NPK) was applied at a rate of 40 lbsN/ac. Plants were harvested 35 days after planting to a height of 10 in. Following harvest, N was supplied to each plant at a rate of 40 lbs/ac. Plant height and dry matter yield were recorded at each harvest. Dry weight of leaf and stem components were weighed on a scale/balance with decigram accuracy. A portion of all forage was separated into leaf (blade), and stem (sheath+stem) fractions. Leaf and stem portions of gamagrass forage were separated by breaking off each leaf at the collar (Coblentz et al. 1999).

Table. 1 The eastern gamagrass accessions evaluated at Tuskegee University

Accession	Designation	P.I. #	PMC Origin	Cultivar
1	TX1	434493	Knox City, TX	San Marcos
2	FL2	9059213	Brooksville, FL	unreleased
3	AR2	9058495	Booneville, AR	Bumpers

Plant material from three southern states was evaluated in this study (Table 1). San Marcos germplasm of eastern gamagrass is a selection of naturally occurring germplasm and has been unaltered from its original collection. Accession 9059213 was originally collected from Clay County, Florida. The original seed of Bumpers was collected from a native roadside stand in Yell County, Arkansas, and was tested under the accession number 9058495. A Complete Randomized Design (CRD) was used with treatments assigned to pots replicated in a completely randomized manner. Ecotype means were used in the analysis of variance. Where means were shown to be significantly different after an F-test ($P \leq 0.05$), an LSD procedure was used to further separate them.

RESULTS

Plant height

Previous investigators have shown eastern gamagrass leaves can grow between 1 and 2 inches day^{-1} following defoliation (Springer and Dewald 1994). Over the full course of the study, all three ecotypes grew more than 1-inch day^{-1} (Table 2). As a result, some of the plant heights achieved in this study were similar to those reported in literature (Snider 1995). The average plant heights of San Marcos eastern gamagrass were comparable to those reported by Snider (1995). On average, Bumpers plants were the shortest over the course of the study, while the Florida ecotype plants were the tallest on average.

Table 2. Yield and yield components of eastern gamagrass ecotypes grown under greenhouse conditions

Accession	Total Yield (tons/acre)	Average Height* (inches)	Growth Rate (inches/day)
TX1	4.20 [b]	43.55 [b]	1.24 [b]
FL2	5.25 [a]	47.59 [a]	1.36 [a]
AR2	3.64 [b]	40.70 [c]	1.16 [b]

Means with the same superscript within the same column are not significantly different $LSD_{.05}$
* Average height at the time of harvest

Yield

It was expected that plant height would reflect the amount of forage that eastern gamagrass produces. This was consistent with results of investigators who have observed that it was common that high-yielding eastern gamagrass plants are usually tall (Rhoden et al. 2000). Ecotypes showed similar yield components at the end of the study (growth rate, average height, and total yield): the Florida ecotype was highest, followed by San Marcos, and Bumpers.

Dry matter production per pot was converted to acre production equivalent according to the recommendation of Springer et al. (2003). 'Bumpers' yields were equal to those reported by Faix et al. (1980) in the establishment year southern Illinois, while 'San Marcos' and the Florida ecotype exceeded those reports (Table 2). All ecotypes produced higher DM yields than those reported for 'Pete' eastern gamagrass by Fine et al. (1990) during the establishment year at Woodward, Oklahoma, and production by Foy et al. (1999) after liming in an acid soil. All ecotypes also produced higher yields than reports given by McLaughlin et al. (2004) over a three-year period. A decline in yield with successive harvests was consistent with results reported by Surrency et al (1998).

Canopy Morphology and Characteristics

Grasses can be divided into leaf, sheath and stem: digestible portions, less digestible portion, and fibrous components, respectively. Researchers have noted the preference of animals for leaf over stem (Laredo and Minson 1973; Chacon and Stobbs 1976; Aiken 1997). Ecotypes showed the greatest variation for the amount of leaf produced during the first and third harvests. Although there was less difference in variation of leaf produced during the second harvest, plants produced a higher proportion of leaf at harvest 3. Generally, proportions of leaf tissue of the ecotypes compared favorably with those reported in literature. All ecotypes produced higher percent leaf than the 59% reported by Burns et al. (1992) and Burns and Fisher (2000), during harvest 1. Percent leaf achieved during harvest 2 and 3 compared favorably with eastern gamagrass at boot stage reported by Coblentz et al. (1998) and Burns and Fisher (2010).

Table 3. Leaf components of 3 eastern gamagrass accessions grown under greenhouse conditions (harvest1)

Accession	Total	Blade	Stem	Leaf:Stem ratio
	---------------- tons/acre------------------			
TX1	1.52 [b]	1.06 [b]	0.47 [b]	2.27 [a]
FL2	1.93 [a]	1.38 [a]	0.56 [a]	2.47 [a]
AR2	1.40 [b]	0.86 [c]	0.54 [a]	1.61 [b]

Means with the same superscript within the same column are not significantly different $LSD_{.05}$

Table 4. Leaf components of 3 eastern gamagrass accessions grown under greenhouse conditions (harvest 2)

Accession	Total	Blade	Stem	Leaf:Stem ratio
	-------------tons/acre----------------			
TX1	1.49 [a]	1.24 [a]	0.25 [b]	5.02 [a]
FL2	1.57 [a]	1.06 [a]	0.50 [a]	2.12 [c]
AR2	1.49 [a]	1.20 [a]	0.29 [b]	4.08 [b]

Means with the same superscript within the same column are not significantly different $LSD_{.05}$

Higher amount of stem was produced by all ecotypes at harvests 1 and 2 compared to harvest 3. The data indicated that all ecotypes produced their highest proportion of stem at harvest 1. At harvest 1, all ecotypes produced close to half a ton stem $acre^{-1}$. The Florida ecotype, however, produced twice as much stem at harvest 2, compared to ‘San Marcos and ‘Bumpers’ (Table 4). The opposite was true at the third harvest. The Florida ecotype produced the lowest amount of stem on average, less than a third of the amount produced by ‘San Marcos’ and ‘Bumpers’ (Table 5).

Eastern gamagrass stems comprise a relatively low proportion of the overall herbage (Burns et al. 1992). Overall, proportions of stem tissue of the ecotypes compared favorably with those reported in literature. Proportion of stem produced by all ecotypes in this study were lower than eastern gamagrass stem reported by Burns et al. (1992) and Sauvé et al. (2010), but similar to Burns and Fisher (2010).

Table 5. Leaf components of 3 eastern gamagrass accessions grown under greenhouse conditions (harvest 3)

Accession	Total	Blade	Stem	Leaf:Stem ratio
	-------------- tons/acre		-----------------	
TX1	1.19 [b]	1.11 [b]	0.07 [a]	15.24 [b]
FL2	1.75 [a]	1.74 [a]	0.02 [b]	98.79 [a]
AR2	0.76 [c]	0.69 [c]	0.07 [a]	10.08 [c]

Means with the same superscript within the same column are not significantly different $LSD_{.05}$

Determination of leaf:stem ratio involves a labor-intensive process of separating leaf and stem fractions (Smart et al. 2004). It has been reported that plant leaf:stem ratio is positively correlated with digestibility (Claessens et al. 2005). Burns et al. (1992) reported leaf:stem ratio of 2.4:1 for eastern gamagrass and 0.36:1 for bermudagrass. Eastern gamagrass evaluated in this study produced comparable leaf:stem ratios to Burns et al. (1992) at harvests 1 and 2 with the exception of San Marcos at harvest 2. All accessions produced much higher leaf:stem ratios at harvest 3 (Table 5).

CONCLUSION

Eastern gamagrass has shown promise as a multiple-use crop for sustainable production. High forage production potential and maintenance of plant reserves can allow producers to take advantage of longer growing periods under limited resource conditions. A decline in yield with successive harvests in this study was consistent with previous studies. The Florida ecotype, however, exhibited a smaller reduction in total biomass produced by the third harvest. This might be related to the fact that this grass evolved in a subtropical climate, where grazing pressure, and/or harvest frequency was higher over a longer growing season. These results demonstrate a need to investigate high-performing ecotypes further. Morphological differences in these eastern gamagrass ecotypes may play a role in adaptation to specific environments, as well as management and utilization. Intensive replicated trials are needed to establish interactions between genotype and environment in order to fully utilize different eastern gamagrass ecotypes. Description of the distribution of individual components of plant biomass can also provide a framework for models to predict the leaf:stem ratios of eastern gamagrass ecotypes, and to develop location, species, and management specific methods for improving these ecotypes for various uses. Improved populations can be derived further study to meet the animal feed, conservation, biomass, and wildlife needs of limited resource farmers and ranchers in the Black Belt of Alabama.

ACKNOWLEDGEMENT
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POSTERS: ECOLOGICAL RESTORATION

USDA NRCS Plant Materials Centers 75 Years of native grasses for conservation

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ABSTRACT
The NRCS Plant Materials Program (PMP) was created to provide plants for the Soil Erosion Experiment Stations developed by Hugh H. Bennett. In the 75 years since the creation of The Soil Conservation Service the East Region Plant Materials Centers have produced 45 releases of 25 species of native grasses for the eastern US. These grasses have provided habitat for wildlife, biomass for fuel and forage, stabilization of coastal areas and shorelines and controlled erosion improving air and water quality. Releases such as 'Highlander' eastern gamagrass produce 13,952 kg ha-1 of dry matter (DM) with a crude protein (CP) content of 10% as compared to 11,155 kg ha-1 DM and 7% CP for 'Tifton 44' bermudagrass. The PMP has released eastern gamagrass adapted to Florida, Georgia, New York and Maryland. The program has produced 8 releases of switchgrass adapted to the eastern region, including Timber germplasm in 2009. The PMP strives to increase the use and productivity of native grasses throughout the region. This includes developing technology for using native grasses for poultry odor attenuation, components of pollinator borders, vegetative barriers, and borders.

Native grass cultivars adapted to the eastern United States

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ABSTRACT

Cultivars of native grasses have been developed by the USDA Natural Resources Conservation Service, USDA Agricultural Research Service, and land grant universities over the last seventy years. These cultivars have been thoroughly tested to prove their adaptation to geographic areas, soil drainage and pH, and specific uses. The existence of these cultivars has allowed agencies, universities, and organizations to promote the use of native grasses for a variety of conservation uses throughout the eastern United States. The proven range of adaptation has allowed commercial seed producers to market seed over large geographic areas and to earn profit sufficient to continue to produce seed of native grasses. It is critical that persons promoting and using native grasses appreciate the proven adaptation of the cultivars to the specific geographic areas, soil drainage and pH, and uses. Promotion or use of the cultivars outside of their proven adaptation will result in poor stands and poor performance for the intended use. This poster will list those cultivars, their geographic adaptation, and unique characteristics.

The use of native warm season grasses, forbs and legumes for biodiversity management on Tennessee Valley Authority lands

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ABSTRACT
Since 1996, Tennessee Valley Authority (TVA) natural resource managers have established native warm-season grasses, forbs, and legumes on numerous parcels of TVA managed lands ranging from upper east Tennessee through northern Alabama to western Kentucky. Principal objectives driving these efforts included: eradication of non-native invasive plant species and enhancement of grassland/early successional wildlife habitat (650 acres); development of native grass forage crop demonstrations (50 acres); timber salvage site restoration (75 acres); and visual/aesthetics improvements associated with high dispersed recreation public use areas and residential shoreline demonstration projects (30 acres). A variety of partners and stakeholders assisted in these efforts, including state wildlife agencies, non-government organizations, native plant nurseries/seed producers, local agricultural licensees, and universities. Several native species mixtures have been used, depending on local site conditions and specific project objectives. Typical grassland wildlife habitat enhancement projects used a mixture of three or four native grass species with one or more native legumes. On projects where visual/aesthetics/observable wildlife was the driver, more native wildflowers were added to mixtures. On agricultural forage crop demonstrations, single native grass species, such as big bluestem or switchgrass, were used with mixed species field buffers. These native plant stands have been managed with periodic prescribed fire, mowing for hay crops, disking, and applications of selective herbicides.

The Cape May Plant Materials Center — Native grass technologies for the future

Christopher Miller

USDA-NRCS, Cape May Plant Materials Center

ABSTRACT

The USDA-NRCS recognizes that climate change and climate variability may impact the environment by potentially changing, among other things, soil and vegetation relationships. Due to the network of Plant Centers nationwide, the NRCS Plant Materials Program is particularly well-positioned to design and conduct regionally and nationally coordinated studies needed to support the Agency's goals. In light of this, the Cape May Plant Materials Center (PMC) is taking a multipronged approach in relation to developing new plant technologies. The Center is screening existing PMC releases to determine tolerance to projected climate changes (e.g., increased drought, prolonged flooding, increased salt, etc.) and is developing new plant materials as needed to ensure sustained ecosystem diversity. Some of these priorities include selecting and testing more southern germplasm for adaptability to the northern Mid-Atlantic/Southern New England area. An example of this is the selection of cold-tolerant sea oats (*Uniola paniculata*) for added plant diversity on coastal dunes, north of where it presently occurs naturally. Also in the coastal environment, we are developing seeding technologies for smooth cordgrass (*Spartina alterniflora*) in cooperation with the Army Corps of Engineers when restoring tidal marshes. Lastly, native grasses are known for being deep rooted, but at what rate do native grasses assimilate organic carbon to various depths? A cooperating project with the USDA-ARS attempts to answer that question.

Assessment of *Elymus spp*. in the southeastern U.S.

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ABSTRACT

Introduced species account for a majority of forage grasses grown for livestock in North America. Cool-season non-native species include: tall fescue (*Festuca arundinacea*), annual and perennial ryegrass (*Lolium spp.*), bluegrass (*Poa spp*.), and orchardgrass (*Dactylis glomerata*). Wildrye is a native cool-season perennial grass with forage potential. It also has potential for prairie restoration and conservation projects. Literature usually cites only two species, *E. virginicus* and *E. canadensis*, however there are six main species that are commonly found in the southeastern United States: *E. canadensis, E. virginicus, E. hystrix, E. riparius, E. villosus,* and *E. glabriflorus*. The goal of this project is to accurately describe the differences in each species, briefly summarize the plant community in which they inhabit, discover their potential use in forage or wildlife plantings, and define any traits they may be useful in native grass breeding programs. Differences between these six species are very acute, however each fills an important role in their respective habitat. *E. virginicus* prefers moist soils and higher soil fertility. This shade tolerant species can produce as much as 3,700 kg of dry weight forage per dryland hectare. *E. hystrix*, otherwise known as glumeless wildrye or bottlebrush grass, is also a shade tolerant species that produces fewer seed. *E. glabriflorus* grows in a variety of soils and can be found in tall grasslands and open woods. This species is a prime candidate for a native cool-season forage due to its full-sun tolerance. *E. villosus* is a lesser known wildrye that is shorter in stature and has a hairier seed head. *E. riparius*, or riverbank wildrye, is similar to Virginia wildrye, except it possesses nodding spikes and is glumeless. It can grow in much poorer soils including rocky and woody slopes. *E. canadensis*, or Canada wildrye, is not found in the deep south, but can be observed on sandy soils in the upper southeast along forest borders, riverbanks, and streams. Canada wildrye is palatable for most livestock with high energy, but poor protein. These summaries will help in establishing a base knowledge that, in turn, will benefit land managers in determining which species would be best suited for their project.

Integrated carbon sequestration and environmental stewardship pilot project

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ABSTRACT

The Tennessee Valley Authority (TVA) is conducting a small-scale pilot project on TVA owned land in Rhea County, Tennessee. The purpose of the project is to generate certified and fungible carbon offsets from planting indigenous trees and warm-season grasses on hay land; but more importantly, to develop internal knowledge and expertise that could be applied to similar, larger-scale projects in the future. The project site consists of five tracts totaling 41 acres. The site has been mainly used for farming. The current vegetation cover is primarily tall fescue. A mix of hardwood tress will be planted on two tracts of land (15 acres total). Switchgrass will be planted on one tract (12 acres) and other native warm-season grasses will be planted on the remaining two tracts (14 acres total). The 12-acre tract where the switchgrass will be planted will be divided into three 4-acre tracts to evaluate different row spacing. The trees will be hand-planted in early 2011 and the grasses will be planted in the spring of 2011. Soil and aboveground carbon measurements will be made prior to and after planting. Periodic carbon and biomass measurements will be made over a 10 to 20-year period. Environmental stewardship is an integral component of this project. Trees, grasses, and legumes that support biodiversity and wildlife habitat will be planted. Also, different planting, harvesting, and management practices for warm-season grasses will be used to evaluate the impact on soil carbon uptake and storage and biomass production.

POSTERS: BIOFUELS

In-field weathering influences biomass and biofuel quality of native warm-season grasses

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ABSTRACT

Energy derived from direct combustion of biomass requires feedstocks low in nutrients, ash and moisture concentrations. In-field weathering offers a practical management strategy for improving biofuel quality of the feedstock, however prolong weathering may decrease harvestable biomass. Objective of our study is to evaluate switchgrass (*Panicum virgatum*), big bluestem (*Andropogon gerardii*) and indiangrass (*Sorghastrum nutans*) biomass yield and biofuel quality influenced by in-field weathering in the Texas Rolling Red Plains. Replicated plots of 'Alamo' and 'Kanlow' switchgrass; 'Earl' and 9083274 big bluestem; and 'Lometa' indiangrass were harvested for biomass at 50% seed maturity, then every 6 weeks for approximately 24 weeks (5 total harvests) during 2008-2010. Samples collected from each harvest were used to determine nutrient analyses (N, K, Ca, S), total ash, and moisture concentrations. Weathering did not significantly reduce biomass of Alamo (6.5), Kanlow (4.9), and 9083274 (2.3 Mg ha-1) during 2008-2009 compared to the initial harvest. Conversely, biomass was significantly reduced in 2009-2010 harvests except for Earl (1.8 Mg ha-1). The greatest biomass loss occurred in the switchgrass cultivars (>50%). Effects of precipitation (rain, sleet, and snowfall) received during late fall, winter and early spring contributed to reduction in biomass. Nutrients, total ash, and moisture concentrations decreased in all grasses after initial harvest. Preliminary results indicate in-field weathering reduces nutrients, total ash, and moisture concentrations in switchgrass, big bluestem, and indiangrass grown for biomass in the Rolling Red Plains, and biomass loss is influenced by the amount and type of precipitation received during the weathering period.

In-field weathering influences harvestable biomass and biofuel quality of warm-season grasses in the Lincoln Hills of Elsberry, Missouri

Jerry Kaiser[1], Steven Bruckerhoff[1], and Joel Douglas[2]

[1]USDA NRCS, Elsberry Plant Materials Center; [2]USDA NRCS National Technology Support Center

ABSTRACT

Energy derived from direct combustion of biomass requires feedstocks low in nutrients, ash and moisture concentrations. In-field weathering offers a practical management strategy for improving biofuel quality of the feedstock, however prolong weathering may decrease harvestable biomass. Objective of our study is to evaluate switchgrass (*Panicum virgatum*), big bluestem (*Andropogon gerardii*), indiangrass (*Sorghastrum nutans*), and giant miscanthus (*Miscanthus x giganteus*) biomass yield and biofuel quality influenced by in-field weathering in the Lincoln County Hills of Elsberry Missouri. Replicated plots of 'Alamo', 'Kanlow'; 'Cave-in-Rock' switchgrass, 9083274 big bluestem; 'Rumsey' indiangrass and 'Freedom' Miscanthus were harvested for biomass at seed maturity, then every 6 weeks for approximately 24 weeks (5 total harvests) during 2008-2010. Samples collected from each harvest were used to determine nutrient analyses (N, K, Ca, S), total ash, and moisture concentrations. Weathering reduced biomass (lb/acre) of Alamo (21%), Kanlow (20%), Cave-in-Rock (31%), 9083274 big bluestem (32%), and Rumsey indiangrass (15%); however, Miscanthus increased 13% during 2008-2009 compared to the initial harvest. Conversely, biomass was again reduced by infield weathering in 2009-2010 harvests except for Miscanthus and Kanlow switchgrass. The greatest biomass loss (18%) occurred in the 9083274 big bluestem. The highest biomass yields followed harvest in November-December for all six varieties. Nutrients, total ash, and moisture concentrations decreased in all grasses after initial harvest. Preliminary results indicate in-field weathering reduces nutrients, total ash, and moisture concentrations in switchgrass, big bluestem, indiangrass, and Miscanthus grown for biomass in the Lincoln Hills of Missouri, and biomass loss is influenced by the amount and type of precipitation received during the weathering period.

Developing management criteria for maximum biomass production of Alamo and Cave-in-Rock switchgrass cultivars in western Arkansas

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ABSTRACT

Western Arkansas and eastern Oklahoma are in the center of the switchgrass *(Panicum virgatum)* production belt. Increasing interest in cellulosic ethanol production, especially switchgrass-based production, has highlighted the need for information about maximizing production of this feedstock. Little information exists about switchgrass performance under animal waste fertility, or commercial fertility, and no information exists about supplemental irrigation. We randomly planted 'Alamo' and 'Cave-in-Rock' cultivars in 40'X40' subplots with three replications. Treatments included 2 tons/ac animal waste (dry poultry litter), the nutrient equivalent of commercial fertilizer, supplemental irrigation (2"/week), and control. Half of each subplot was harvested in mid-June, with yield and forage quality data recorded (Table 1). The remaining half of each subplot was annually harvested in early December. The subplot half harvested in mid-June was harvested again in early December. Biomass production was similar across fertility treatments for the first growing season. Animal waste-fertilized plots yielded more biomass than commercial fertilized plots in subsequent years. Differences in yields by cultivar were not significant. Annual harvests and semiannual yields were not significantly different (Table 2). Animal waste fertility yielded more biomass, in both cultivars, over two growing seasons than the equivalent rate of commercial fertilizer. Supplemental irrigation increased biomass yield during years with less than 45 inches of rainfall. 'Cave-in-Rock' lodged under high rates of fertility and supplemental irrigation. Annual harvests were economically more feasible than multiple harvests.

Table 1.

Forage quality; % crude protein,% acid detergent fiber, and % neutral detergent fiber of Alamo and Cave-in Rock switchgrass. (6/8/2008 and 6/16/2009)

Treatment	CP 2008	CP 2009	ADF 2008	ADF 2009	NDF 2008	NDF 2009
	------	------	------	%	------	------
Alamo Fert.	6.75	**11.69**	34.83	**34.04**	65.99	**62.45**
Alamo Litter	7.81	**7.50**	36.76	**35.49**	65.94	**65.13**
Alamo Irrig. Fert.	6.44	**10.38**	33.09	**33.05**	64.99	**62.98**
Alamo Irrig. Litter	7.99	**7.25**	36.74	**34.92**	66.21	**64.36**
Cave-in-Rock Fert.	7.99	**12.85**	35.24	**33.42**	63.92	**62.04**
Cave-in-Rock Litter	9.23	**8.19**	38.65	**38.24**	66.34	**64.51**
Cave-in-Rock Irrig. Fert.	7.61	**13.68**	33.14	**37.46**	63.91	**61.96**
Cave-in-Rock Irrig. Litter	9.13	**8.00**	36.44	**35.71**	66.35	**65.73**

Fert. = Commercial Fertilizer

Litter = Poultry litter
Irrig = Irrigation water applied

Table 2.

Cultivar/Treatment	**2008 Dry Matter Mean Harvest 1 (June 19)**	**2008 Dry Matter Mean Harvest 2 (Nov. 17)**	**2008 Two Harvest Mean Total**	**2008 Single Harvest Mean (Nov. 17)**	**2009 Dry Matter Mean Harvest 1 (June 16)**	**2009 Dry Matter Mean Harvest 2 (Dec. 14)**	**2009 Two Harvest Total Mean**	**2009 Single Harvest Mean (Dec. 14)**
	-------------------------------- Lbs./Acre -------------------------------------							
Alamo Comm. Fert.	10820	4873	**15693**	**10400**	6009	4865	**10874**	**7597**
Alamo Litter	12487	6507	**18993**	**11853**	7740	5163	**12903**	**11375**
Alamo Irrig. Comm. Fert.	7460	3880	**11340**	**10633**	6201	5116	**11317**	**13411**
Alamo Irrig. Litter	12220	5807	**18027**	**14600**	7997	6967	**14964**	**12467**
Cave-In-Rock Comm. Fert.	8360	2393	**10753**	**7280**	7836	2958	**10794**	**7313**
Cave-in-Rock Litter	9633	3900	**13533**	**8227**	7633	3887	**11520**	**9643**
Cave-In-Rock Irrig. Comm. Fert.	9440	2907	**12347**	**8440**	6360	4580	**10940**	**9438**
Cave-In-Rock Irrig. Litter	12093	4713	**16807**	**8287**	7952	4579	**12531**	**8619**

Litter = Dry broiler litter

Comm. Fert. = Commercial Fertilizer

Establishment of switchgrass cultivars in prime vs. marginal land in seven states

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ABSTRACT
The national strategy is to produce bioenergy crops on marginal cropland where there will be no competition with food production. The stress tolerance characteristics of switchgrass (*Panicum virgatum*) make it an excellent candidate for sustainable biomass production on marginal land. However, few studies have evaluated switchgrass performance on marginal land. The objectives of the project are to identify the best performing switchgrass cultivars on marginal land in specific locations and identify cultivars with broad adaptation across several regions. Fourteen switchgrass cultivars representing a range in adaptation, from southern lowland to northern upland ecotypes, were established in 'paired' field trials (on marginal soil and on prime farmland soil) in NJ, NY, WI, SD, PA, OH, and MD. Two nitrogen treatments (0, 120 kg ha^{-1}) were applied in the spring of each year. Biomass and agronomic data were collected in 2009 and 2010 to determine the effects of marginal soil on switchgrass performance. Marginal and prime farmland sites were established successfully at all locations except WI. Prime sites had higher percent establishment (80-97%) compared to marginal sites (37-85%) at most, but not all locations. Upland cultivars established best (64-86%) across all locations, followed by northern lowland, while southern lowland cultivars exhibited the poorest establishment (36-46%) across all locations. This information will be useful in identifying switchgrass cultivars with improved biomass production on marginal land.

POSTERS: WILDLIFE MANAGEMENT

Wildlife habitat potential of switchgrass managed for biomass compared to cool-season grass hay and corn fields in Kentucky

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ABSTRACT

Switchgrass (*Panicum virgatum*), a native warm-season grass often used in wildlife habitat plantings, has the potential as a bioenergy crop. Bioenergy switchgrass are typically monoculture stands, harvested annually, and managed for maximum yield, which may impact the wildlife habitat quality. Our objective is to investigate small mammal populations in bioenergy switchgrass compared to cool-season grass hay and corn (*Zea mays*) fields (no-till and conventional till systems). In 2009, 4 three-night trapping sessions were conducted at 4 locations in Kentucky using Sherman livetraps. Trapping sessions occurred in April/May before first hay harvest (spring), July/August (mid-summer), September/October before switchgrass and corn harvest (late-summer), and December after harvest (fall). Small mammal relative abundance was calculated using a capture per unit effort (CPUE) index (per 100 trapnights). Six mammalian species were recorded: *Peromyscus leucopus*, *P. maniculatus*, *Mus musculus*, *Blarina brevicauda*, *Microtus ochrogaster*, and *M. pennsylvanicus*. *Microtus* species were classified as *Microtus* spp. due to difficulties in field identification. All species were recorded in switchgrass and hayfields, while *B. brevicauda* and *Microtus* spp. were not found in corn. Chronological CPUE indexes were 5.32, 18.52, 30.05, and 18.61 in switchgrass; 3.06, 22.45, 11.11, and 3.06 in corn; and 2.45, 2.55, 3.79, and 4.72 in hay. Relative abundance in switchgrass and corn were higher than hay in mid-summer, and switchgrass was highest in late-summer. Relative abundance of no-till corn was higher than conventional till corn during all trapping sessions except spring. In conclusion, time of year and management practices (crop species, tillage system, and harvest regime) influence small mammal relative abundance and species richness.

POSTERS: SEED PRODUCTION/LANDSCAPING

Native grass selections for landscape use in Florida

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ABSTRACT
Several species of native grasses are widely used in public and private landscapes in the southeastern U.S. Most of the materials currently available in the nursery trade are selections from native stands that have not undergone comparative evaluations and are therefore marketed solely by species name (i.e., without cultivar or variety names). The USDA, Natural Resources Conservation Service, Plant Materials Center (PMC) in Brooksville, Florida has made numerous collections of grasses native to Florida and evaluated these plants for their potential to solve conservation problems, such as to restore grazing lands and natural areas, improve water quality, and provide wildlife habitat. Occasionally, some individual plants (accessions) in the assembled collections possess atypical phenotypic features (e.g., foliage color, flower color, growth habit, etc.) that create opportunities to utilize them as ornamentals. Releasing these selections for production by the industry creates a potential niche market for smaller nursery producers. Some examples of ornamental grass releases resulting from the evaluation program at the Brooksville PMC include Morning Mist germplasm hairawn muhly (*Muhlenbergia capillaries)*, which has white flowers as opposed to the normal pink flowers of the species, and Osceola Blue germplasm lopsided indiangrass (*Sorghastrum secundum*), which has a more pronounced bluish tint to the foliage and culms.

Developing native plants for Louisiana ecosystems — The Louisiana Native Plant Initiative

Morris Houck[1] and Garret Thomassie[2]

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ABSTRACT

The lack of adapted commercial seed sources for restoration of coastal prairies and longleaf pine savannahs has caused limited success in Louisiana. The Louisiana Native Plant Initiative was established to collect, preserve, increase, and study native plants in the state. Seeds and plants of native species developed by the partnership will be released to commercial growers for production and eventual sale to the public. Currently, LNPI is comprised of 22 federal, state, and non-governmental organization partners. Over the past six years, evaluation and production locations including the USDA-NRCS Plant Materials Centers at Galliano, LA (GMPMC) and Nacogdoches, TX (ETPMC), Nicholls State University Farm at Thibodaux, LA, McNeese State University Farm at Lake Charles, LA, and University of Louisiana at Lafayette - Center for Ecology and Environmental Technology (CEET) have been established to select and increase seeds and plants of Louisiana ecotypes. The GMPMC is evaluating 25 collections of switchgrass (*Panicum virgatum*) from coastal areas with the hope of finding a selection with quick germination. At ETPMC, seed increase fields of rough coneflower (*Rudbeckia grandiflora),* ashy sunflower *(Helianthus mollis),* and little bluestem (*Schizachyrium scoparium)* have been established and are being managed for seed production. At the Nicholls State University Farm, upland collections of big bluestem (*Andropogon gerardii)*, indiangrass *(Sorghastrum nutans)*, switchgrass (*Panicum virgatum*), rough coneflower (*Rudbeckia grandiflora),* ashy sunflower *(Helianthus mollis)*, and eastern gamagrass *(Tripsacum dactyloides*) are being evaluated. At McNeese State University Farm, production and harvest protocols are being developed for rattlesnake master (*Eryngium yuccifolium*), wooly rose-mallow (*Hibiscus lasiocarpus*), and Texas coneflower (*Rudbeckia texana*). McNeese is also screening various herbicides for use on native seed production fields. At CEET, initial collection evaluations and seed increase of rattlesnake master (*Eryngium yuccifolium*), lance leaf blanketflower *(Gaillardia aestivallis),* gulf coast muhly *(Muhlenbergia capillaris),* shiny goldenrod *(Oligoneuron nitidum),* Kansas blazing Star *(Liatris pycnostachya*), and longspike tridens (*Tridens strictus*) are ongoing and a new seed processing facility is being built to assist with seed cleaning of harvested materials from all sites. In the fall of 2010, the LNPI plans to release its first group of Louisiana ecotypic selections to commercial growers.

Long Island Native Grass Initiative

Polly Weigand

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ABSTRACT
The Long Island Native Grass Initiative (LINGI), is a volunteer effort of non-profit organizations, governmental agencies, and nursery professionals whose mission is to provide sources of native plant materials for commercial native plant propagation and thereby protect the genetic integrity of Long Island's native plants. LINGI's founding goal is the creation of a commercial source of Long Island-ecotype seed of *Andropogon gerardii*, *Panicum virgatum*, *Schizachyrium scoparium*, and *Sorghastrum nutans*. LINGI defined ecotypic boundaries, established collection protocol, identified collection sites, and conducted seed collection, cleaning, and banking to facilitate seed collection from wild stands. Standard bulk seed production techniques are applied to increase seed quantities for commercial production through founder plots. A partnership with Ernst Conservation Seed ensured the commercial increase of the founder seed to a saleable product. In 2011, the founding goal of LINGI will be recognized, as source-identified, certified, Long Island ecotypes of *A. gerardii*, *S. nutans*, *S. scoparium*, and *P. virgatum* become commercially available through Ernst Conservation Seed. Collection activities have expanded from grasses to forbs, shrubs, and trees to meet public demand and expand future commercial seed production activities. A plant sale is held annually to provide immediate sources of all plant materials, especially trees and shrubs, and to support LINGI's activities.

Index of Primary Authors

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