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Winter grazing stockpiled native warm-season grasses in the Southeastern United States

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Abstract

In the Southeastern United States, native warm-season grasses (NWSG) are not harvested during autumn to rebuild root reserves, resulting in de facto stockpiled winter forage. Senesced NWSG forage is considered nutritionally inadequate by temperate livestock managers, but comparable forage is regularly utilized in rangeland systems. This experiment compared the forage characteristics of two NWSG pastures: switchgrass [*Panicum virgatum* L. (SG)] and a two species mixture of big bluestem/indiangrass [*Andropogon gerardii* Vitman/*Sorghastrum nutans* L. (BBIG)] to tall fescue [*Festuca arundinacea* Schreb. (TF)]. During two winter periods (January-April), monthly samples were collected and measured for dry-matter herbage mass (HM), crude protein (CP), *in-vitro* true dry-matter digestibility (48 hr; IVTDMD), neutral detergent fibre (NDF), NDF digestibility (dNDF) and lignin. Across sampling dates, TF provided adequate forage for low-input animal maintenance (90.3 CP g/kg; 488 g IVTDMD/kg; 4,040 kg DM/ha), while SG had lowest nutritive values and greatest DM (21.0 g CP/kg; 366 g IVTDMD/kg; 7,670 kg DM/ha). Samples of BBIG had results intermediate to SG and TF (32.1 g CP/kg; 410 g IVTDMD/kg; 5,160 kg DM/ha). Leaf sub-samples of NWSG indicated greater forage nutritive value compared to whole plant samples (*e.g.*, SG: 65 vs 27 g CP/kg respectively). This indicates that selective grazing could allow superior outcomes to those expected from whole plant NWSG nutritive values. Although consistently nutritionally inferior to TF, further research could reveal strategies to make stockpiled NWSG economically useful to livestock managers.

KEYWORDS
native warm-season grasses, stockpiling, tall fescue, winter grazing

1 | INTRODUCTION

Cool-season grasses have generally superior forage nutritive value compared to warm-season grasses, but do not thrive in the soils and climate of the mid-South. Tall fescue is a unique exception as a cool-season (C_3) grass that is reliably persistent in the region. In addition, it tolerates heavy grazing, stockpiles efficiently and has a long growing season (Poore & Drewnoski, 2010). Because of these advantages, TF now covers over 14 million hectares in the United States (Hoveland, 1993). Tall fescue has disadvantages, particularly poor performance under dry or hot conditions (>30°C). Although persistent, TF grows slowly during mid-summer and a fungal endophyte increases production of ergovaline and other alkaloids, further reducing the grazing value, with average daily gains of 0.46 kg and 0.97 kg for the high- and low-end infested pastures respectively (Read & Camp, 1986).

Native warm-season grasses (NWSG) are an alternative forage system (Backus et al., 2017). These grasses are foundation species

to many endangered local ecosystems (Noss, 2013). During summer, NWSG support economically competitive rates of animal gain (Backus et al., 2017; Bonin & Tracy, 2012; Lowe et al., 2016). The utilization of NWSG pastures to complement TF pastures could improve forage availability during summer and drought conditions.

A major drawback of NWSG is their short growing season. In Tennessee, NWSG begin growth in April and are fully dormant by late September, a disadvantage due to the mild winter that allows continued growth in cool-season species (Ball, Hoveland, & Lacefield, 2007). This productive period is further narrowed because NWSG are, in many instances, not grazed or mowed during late summer and fall to maintain stand vigour (Owensby, Smith, & Rains, 1977; Forwood & Magai, 1992; Cuomo, Anderson, Young, & Wilhelm, 1996) . Forage accumulated during this rest period has minimal nutritive value, with CP as low as 32 g/kg (Waramit, Moore, & Fales, 2012; Sarath, Baird, & Mitchell, 2014) . Late summer stockpiled NWSG forage has insufficient nutritive content (<70 g CP/kg) for most classes of livestock (Hickman, 2013), but prior studies have indicated that such forages can still support animals provided with protein supplements (Baron et al., 2016; Schoonmaker, Loerch, Rossi, & Borger, 2003).

Stockpiling is the practice of allowing forage to accumulate in the field for later use when other feed options are limited. Stockpiling is economically viable when the reduced nutritive value due to plant maturity and weathering is offset by reduced input costs from hay harvest or purchased feed (D'Souza, Maxwell, Bryan, & Prigge, 1990; Poore & Drewnoski, 2010). In the Southeastern United States, TF is regularly used for stockpiling because it maintains quality after freezing, produces more leafy forage in the fall instead of less desirable reproductive stems and has low ergovaline content (Dierking, Kallenbach, Kerley, Roberts, & Lock, 2008; Fribourg & Bell, 1984; Shireman, 2015).

Our research objective was to quantify the herbage mass and nutritive value of switchgrass (*Panicum virgatum* L.), mixed big bluestem/indiangrass (*Andropogon gerardii* Vitman; *Sorghastrum nutans* L.) and TF stockpiled during fall (August to December) and through the grazing period during winter (January-April).

2 | MATERIALS AND METHODS

The experiment was conducted at the Middle Tennessee AgResearch and Education Center, in Spring Hill, TN (soil Maury silt loam: fine, mixed, active, mesic Typic Paleudalf). A paddock array was established in October 2007 in a completely randomized design with five replications. Each experimental unit (1.2 ha paddocks) was assigned to one of three treatments: TF (cv. KY-31), SG (cv. Alamo), or the 1:1 mixture of big bluestem (cv. OZ-70) and indiangrass (cv. Rumsey).

The stockpiling period was conducted by mowing in late July to a stubble height of to initiate regrowth for winter grazing, which occurred from January until April. Winter grazing was carried out on all fifteen paddocks by 2 or 3 Angus crossbred yearling heifers per paddock (determined by forage availability). Heifers were supplemented with 0.18 kg CP heifer^{-1} day^{-1} through either blood meal/fishmeal or dried distiller's grains. McFarlane, Barbero, Nave, & Mulliniks, 2017 have provided full descriptions of livestock management protocols. In this simultaneous study conducted by McFarlane et al. (2017), a total of twenty-four paddocks were used; however for our experiment, we omitted nine paddocks due to differences in soil types that could have affected the present results.

Soil sampling (3 February 2017; 15 cm depth) indicated no significant differences between the fifteen paddocks of different species treatments and no micronutrient deficiencies in individual paddocks. Soil pH had a mean of 5.96 (*SE* = 0.19). Mehlich-1 extractions indicated mean phosphorus of 470 kg/ha (*SE* = 361), mean potassium 192 kg/ha (*SE* = 48), mean calcium 3,780 kg/ha (*SE* = 1,330) and mean magnesium 257 kg/ha (*SE* = 29). The phosphorus variability was due to three outlier paddocks (1,157, 1,129, 930 kg/ha) with shallow soils and phosphate-rich bedrock, which are common in the region.

2.1 | Sampling methods

Sampling occurred from January to April in 2016 and 2017. Each pasture was sampled for HM (stubble height 6-cm) by collecting 10 randomly assigned 0.1 m^2 areas on the first and last day of grazing each year. Additional nutritive value samples were manually collected from a randomly assigned 0.1 m^2 area (20-cm residual height for NWSG, 10-cm residual height for TF). Differences in stubble height between treatments were due to recommended residual heights for each forage species. During the 2016 winter grazing period, the nutritive value samples were collected on 27 January 2016, 3 March 2016 and 8 April 2016. During 2017, samples were collected on 4 January 2017, 3 February 2017, 3 March 2017 and 31 March 2017. On 3 February 2017, additional whole plant samples were collected from BBIG and SG paddocks. The leaf material for each sample was manually separated (blade and sheath), and leaf material was analysed for nutritive value.

Forage samples were dried at 60°C for 48 hr to constant weight and dry weights were recorded. Each sample was then ground through a Wiley Mill Grinder (1-mm screen; Thomas Scientific, Swedesboro, NJ) for near-infrared reflectance spectroscopy (NIRS) analysis of forage nutritive value a Unity SpectraStar XT near-infrared spectroscopy (NIR) instrument (Unity Scientific, Milford, MA) to quantify crude protein (CP), neutral detergent fibre (NDF), *in-vitro* dry-matter digestibility at 48 hr (IVDTMD) and neutral fibre digestibility at 48 hr (dNDF). Equations for the forage nutritive analyses were standardized and checked for accuracy with the 2014 Grass Hay Equation developed by the NIRS Forage and Feed Consortium (NIRSC, Hillsboro, WI). Software used for NIRS analysis was Win ISI II supplied by Infrasoft International (State College, PA). The Global H statistical test compared the samples against the model and samples from distinct data sets within the database for accurate results, in which all forage samples fit the equation, ($H < 3.0$), and are reported accordingly (Murray & Cowe, 2004).

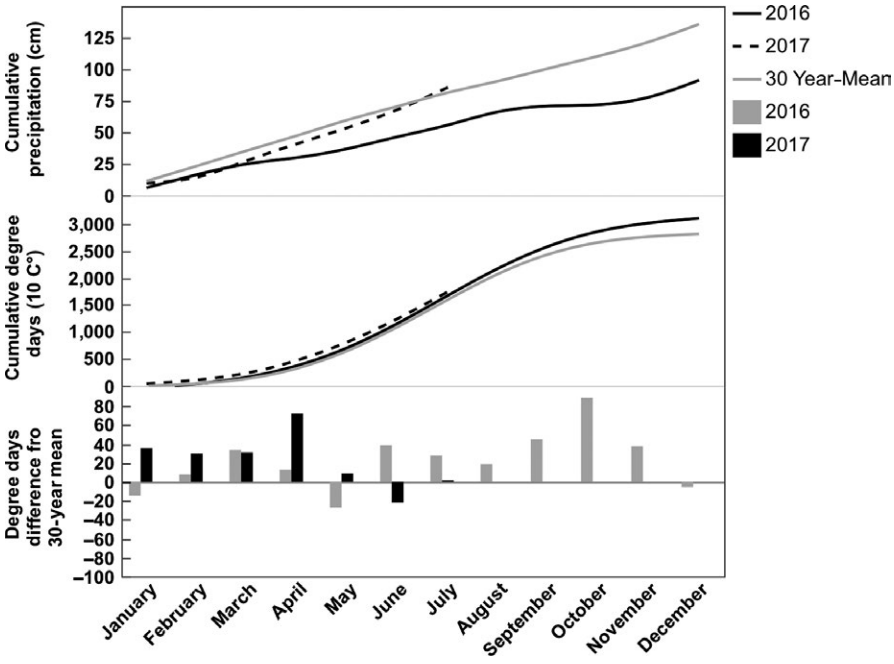

FIGURE 1 Weather for Spring Hill, TN, including 30-yr average for growing season of 2016 and 2017

2.2 | Statistical analysis

Data were analysed using JMP statistical software (JMP Pro 12, SAS Institute, Cary, NC). Mean significance differences threshold was set at $p < 0.05$. Nutritive values and HM data were checked for normal distribution and did not pass the Shapiro–Wilk test of goodness-of-fit. Lignin values were an exception, matching normal distribution without transformation. Non-normal data passed a goodness-of-fit test for lognormal distribution and was transformed for analysis, but are reported using initial values. Whole plant and leaf samples of the two NWSG were compared using two-way t test to determine if significant differences occurred between morphological components and species treatment.

A repeated-measures ANOVA was performed using sampling paddocks as subjects, year as a random effect, and the main and interactive effects of species treatment and sampling date as fixed effects. This model was run for each variable across two winter grazing seasons. In the model, significant variation due to sampling date for a species treatment would indicate a rate of change from zero. Interaction between date and species treatment would indicate a significant difference between rates of change of two species treatments for a given variable during the study period.

3 | RESULTS

3.1 | Environmental conditions

The fall of 2015 had greater mean temperature and precipitation than the 30-year mean. During the 2016 season, temperatures were greater than average and the highest average recorded in the previous 30 years (Figure 1). This was accompanied by a drought condition from August to late November. This impacted the 2016 fall stockpiling period. The 2017 spring and summer had average precipitation levels and greater than average growing degree day (GDD) accumulation (greatest in 30 years during 3 out of 7 sampled months; Figure 1).

3.2 | Forage responses to winter grazing

Mean variations due to forage species treatment were found for all variables and mean HM and CP decreased across sampling dates (Table 1). During winter grazing, HM was greater in SG (2,808 kg DM/ha) than both TF (1,845 kg DM/ha) and BBIG (1,895 kg DM/ha) ($p > 0.001$). The CP concentration was greater in TF (90.3 g CP/kg) than SG (21.0 g CP/kg) and BBIG (32.1 g CP/kg) for each sampling date (Table 2; $p < 0.001$). Similarly, a small but consistent decrease in CP occurred across sampling dates without significant interaction with species treatment (Table 2; $p < 0.05$). The greatest and least NDF values occurred in SG (877 g NDF/kg) and TF (838 g NDF/kg), respectively, with BBIG (736 g NDF/kg) being intermediate (Table 2; $p < 0.001$). Similarly, TF had the greatest IVTDMD values (488 g IVTDMD/kg) and SG had the least (366 g IVTDMD/kg), and BBIG intermediate (410 g IVTDMD/kg) (Table 2; $p < 0.001$). The lignin concentration was greater for SG (93.9 g/kg) than TF (72.3 g/kg) and BBIG (72.8 g/kg) (Table 2; $p < 0.001$). The dNDF concentration also varied due to species treatment, with BBIG samples indicating the greatest (312 g dNDF/kg), TF the least (229 g dNDF/kg) and SG intermediate (248 g dNDF/kg) (Table 2; $p < 0.01$).

Leaf samples from fully dormant warm-season grasses collected on 3 February 2017 indicated that leaf matter was richer in CP (Table 3; $p < 0.05$). Contrary to whole plant sample results, SG leaf nutritive value measurements were consistently equivalent to those of BBIG except for CP that was greater in SG than BBIG (Table 3; $p < 0.05$). Leaf

TABLE 1 Analysis of variance for forage nutritive value of stockpiled tall fescue (TF), big bluestem/indangrass mixture (BBIG) and switchgrass (SG) during two consecutive winter grazing periods (January-April)

	Species	Month	Species*Month
CP	***,‡	*	ns
NDF	***	ns	ns
Lignin	***	ns	ns
IVTDMD	***	ns	ns
dNDF	**	ns	ns

CP, Crude Protein; dNDF, neutral detergent fibre digestibility; IVTDMD, in-vitro true dry-matter digestibility (48 hr); ns, not significant.
‡,*Significant at the 0.05 probability level. **Significant at the 0.01 probability level. ***Significant at the 0.001 probability level.

TABLE 3 Nutritive value of whole plant and leaf sub-samples of dormant switchgrass (SG) and a big bluestem/indiangrass mixture (BBIG) taken on 3 February 2017

	Whole plant		Leaf	
	BBIG	SG	BBIG	SG
CP (g/kg)	31^{c}	27^{c}	51^{b}	65^{a}
NDF (g/kg)	824^{b}	860^{a}	818^{b}	824^{b}
Lignin (g/kg)	69^{b}	89^{a}	67^{b}	62^{b}
IVTDMD (g/kg)	401^{a}	368^{a}	410^{a}	431^{a}
dNDF (g/kg)	394^{a}	292^{c}	351^{b}	336^{b}

Notes. CP, Crude Protein; dNDF, neutral fibre digestibility; IVTDMD, in-vitro dry-matter digestibility (48 hr); NDF, Neutral Detergent Fibre.
Letters indicate significant difference within rows across species treatment and forage component according to two-way t test ($p < 0.05$; $n = 3$).

TABLE 2 Forage nutritive value of stockpiled tall fescue (TF), a big bluestem/indiangrass mixture (BBIG) and switchgrass (SG) during two winter grazing periods

	CP g/kg	Δ mo^{-1}	NDF g/kg	Δ mo^{-1}	Lignin g/kg	Δ mo^{-1}	IVTDMD g/kg	Δ mo^{-1}	dNDF g/kg	Δ mo^{-1}
BBIG	32.1^{b}		838^{b}	ns	72.8^{b}	ns	410^{b}	ns	312^{a}	ns
TF	90.3^{a}	−3.45	736^{c}	ns	72.3^{b}	ns	488^{a}	ns	229^{c}	ns
SG	21.0^{b}		877^{a}	ns	93.9^{a}	ns	366^{c}	ns	248^{b}	ns

CP, Crude Protein; dNDF, neutral detergent fibre digestibility; IVTDMD, in-vitro true dry-matter digestibility (48 hr); NDF, Neutral Detergent Fibre.
Means within a column without a common letter differ according to Tukey's Honestly Significant Difference test ($p < 0.05$).
Slopes (Δ mo^{-1}) significantly different from zero are reported ($p < 0.05$). Single values in a column indicate that Δ mo^{-1} did not significantly differ between forage species.

dNDF was significantly greater than whole plant values for SG and reduced relative to whole plant values in BBIG.

4 | DISCUSSION

The initial winter-grazed HM during 2017 was approximately half that in 2016 HM for all forage species due to a severe late summer drought and likely altered nutritive values (Figure 1). Despite one season of drought, mean TF HM and nutritive value variables were comparable to prior TF stockpiling evaluations (Hickman, 2013; Kallenbach, Roberts, Lory, & Hamilton, 2017; Nave, Barbero, Boyer, Corbin, & Bates, 2016; Shireman, 2015). Performance of BBIG during the autumn 2016 drought was poor, resulting in no overall HM differences between BBIG and TF. This contrasts with general observations of increased HM in NWSG and expectations of increased drought performance in C_4 species (Backus et al., 2017).

Overall, forage nutritive value of stockpiled NWSG was insufficient to meet the nutritional requirements of grazing ruminant without supplementation. However, forage nutritive values were comparable to dormant Kansas big bluestem hay reported by Del Curto et al. (1990). This suggests that warm humid winters in the southeast do not cause greater losses in nutritive as compared to rangeland systems.

Data on the analysed leaf sub-samples of dormant NWSG also indicated variation between NWSG nutritive value distributions. The CP concentration of leaves, contrary to whole plant values, was superior for SG compared to BBIG (Table 3). In addition, leaf material was otherwise comparable between SG and BBIG samples, despite differing whole plant values (Table 2). This could be the result of morphological differences between species or between species in their resistance to physical weathering.

Reduced dNDF in BBIG leaves relative to whole plant samples indicate that the whole plant dNDF advantage of BBIG (relative to TF and SG) occurs within stem material (Table 3), which again aligns with prior samples of mature BB hay (Del Curto et al., 1990). Greater whole plant dNDF value of BBIG indicates how BBIG can provide greater IVTDMD relative to SG despite comparable whole plant CP (Table 2). This contrasts with SG nutritive value concentrations, which can be attributed to the leaf portion of their HM. Livestock that are able to preferentially graze the leaf proportion of SG may provide superior results compared to those expected from whole plant SG nutritive values.

Since recommended NWSG management involves forage accumulation during fall to maintain plant vigour, stockpiled NWSG is currently produced as a by-product and therefore any utilization could improve efficiency and productivity. Further research could assess other warm-season species capable of producing large quantities of

dormant HM to evaluate variation in senesced nutritional value, either through leaf or stem digestibility. In field, evaluations could also determine the voluntary livestock intake of dormant NWSG when provided with winter supplementation typical to the region (e.g., fescue hay). Even low rates of voluntary livestock NWSG intake could result in economic gain by offsetting more costly winter-feed.

5 | CONCLUSION

Substantial losses in winter NWSG nutritive values are expected due to senescence and weathering during fall stockpiling. However, this experiment found that further reductions during the winter grazing period (January to April) were minor. While forage nutritive values for BBIG and SG were consistently below TF and below thresholds considered necessary to support most classes of livestock, two results indicate avenues for further research. First, nutritive values of BBIG were occasionally intermediate to SG and TF, indicating variation between dormant NWSG dNDF, despite reduced CP content. Second, the leaf portion of senesced NWSG (and SG specifically) has improved nutritive value relative to bulk samples. Due to the generally greater HM of NWSG, available leaf mass in isolation may provide economically useful forage resource for livestock. With improved management and protein supplementation to minimize the identified losses in forage quality and quantity, stockpiling NWSG for winter-feeding may be an economical approach to alleviate feed shortages.

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