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GRAZING WITH GOATS CHANGED THE WOODLAND PLANT-SPECIES COMPOSITION DURING SUMMER

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Abstract

Woodland grazing is a common practice in the Southeast; however, information is limited on its effects on the woodland plant-species composition. The study objective was to determine the effect of summer grazing on woodland plant-species composition. Before- and after-grazing observations were taken at the ground, mid, and high levels in three plots (1-acre each) along the pre-established transects. Kiko wethers (29, 6-8 months old, 26.8±0.67 kg body weight) were allowed to graze the plots after before-grazing observations were taken. After-grazing observations were taken immediately after the goats were moved out from the plots. Grazing showed a significant effect on the plant species diversity at the ground- and mid-level ($p<0.0001$). The evenness indices after grazing for the ground- and mid-level vegetation were decreased by 26% and 24%, respectively. The results suggest that goats' grazing can have a significant short-term impact on the woodland-plant community below 1.5 m height.
Keywords: Browse, Evenness index, Kiko, Species diversity, Wether

Introduction

Goats (*Capra aegagrus hircus* L.) are among the first domesticated farm animals (Wilson, 1991). Their domestication history can be traced long back to 8000 BC, raised for milk, meat, or fiber (Boyazoglu et al., 2005). Increasing ethnic and faith-based populations accustomed to eating goat meat is making meat goat popular in the U.S. (Solaiman, 2007). The expansion of the meat goat industry in the Southern US is also due to producers switching from tobacco to meat goat production in response to financial settlements resulting from class action lawsuits against the US tobacco industry (Spencer, 2008). The traditional approach of raising goats involves allowing them to scavenge on household waste and grass along the roadside and fallow areas. Although this approach may be cheaper compared to feeding goats on commercial feeds, grain, or improved pastures, it can result in poor production performance (Pamo et al., 2006). Feeding costs for goats, which is the single most significant variable cost in a livestock operation (Solaiman, 2006), can be reduced significantly by increasing the grazing opportunity for an extended period (Karki, 2013a). Better performance of goats can be achieved with the provision of quality forages.

The climatic condition in Alabama and other states in the southeastern U.S. allow forage growth throughout or most of the year. Forage is any portion of plants, except separated grains, that is eaten by animals to fulfill their nutrient requirements, or that is harvested as animal feed (Barnes et al., 2007). The pastures of most of the goat producers in the Southern Region are poor in production and dominated with seasonal grasses (Karki, 2013b). There will be no or negligible forage available for grazing in pastures during two critical periods in a year: (1) when cool-season forages are dead or dormant and warm-season forages are not yet ready to emerge or not available, such as from late April to late May or early June, and (2) when warm-season forages

are about to be dormant or dead and cool-season forages are yet to emerge or not available, such as from late September or October to December or January (Figure 1).

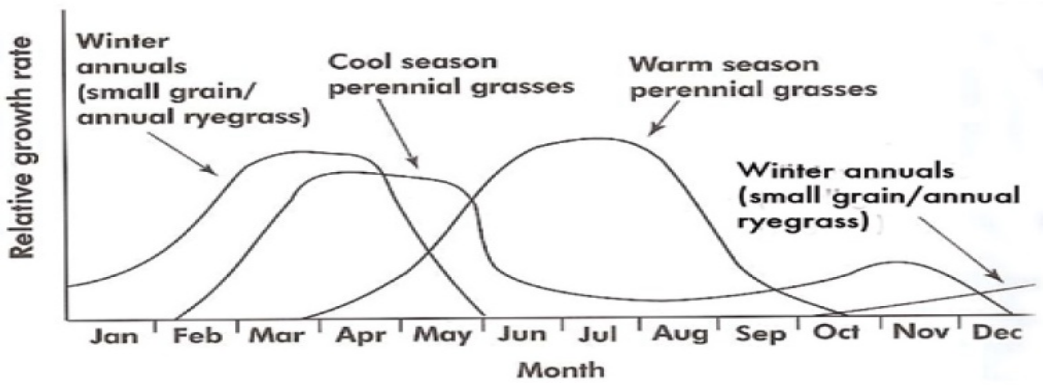

Figure 1. Relative Growth Rate of Southern Forages
Source: Ball et al., 2007

Year-round grazing can be made possible in Alabama by improving pastures with warm- and cool-season forage cultivation, stockpiling, and incorporating browse species and woodlands into the grazing system. Integrating woodlands into a goats' grazing system may help add to the sustainability of the system with several benefits, but requires research to determine best practices. In addition, the natural vegetation of the Southeast is dominated by broad-leaved deciduous trees and pines (Bryant et al., 1993; Skeen et. al., 1993; Stephenson et al., 1993), which allow different types of forages to grow beneath them. Alabama has about 9.3 million hectares of forest cover, i.e., roughly two-thirds of the state (Chen, 2010). This presents a huge potential for managing and utilizing the under-story forest vegetation in order to increase the grazing opportunity for small ruminants, especially when the forage biomass in pastures is not available for grazing.

The purpose of vegetation management often is to restore biodiversity by controlling dominating, often invasive species, thereby increasing the number of contributing species in an ecosystem (Hart, 2013). Sustainable management of woodland resources is of prime importance for the economic viability of goat production (Dubeuf et al., 2004). However, there is not much information available on woodland-plant species in Alabama, and how the composition of these species would be affected by grazing with goats. The objective of this study was to determine the change in woodland plant-species composition because of grazing with goats.

Literature Review

Foliage of woody species is highly preferred by goats, and comprises a great proportion of their diet whenever it is available (Liacos et al., 1980; Papachristou and Papanastasis, 1994). These species can fill the summer and winter feed gaps if they are evergreen or seasonally dimorphic (Kebaili and Papanastasis, 2005). Studies suggest that woodland species can fulfill the nutritional demand of goats more economically than supplementary feeds during times when the available forage biomass in pastures is limited (Papachristou and Nastis, 1990). Besides their feeding value, woodland plant species are also known for their high content of secondary plant metabolites, such as condensed tannins (CT) (Monforte-Briceno et al., 2005), which has

antihelminthic properties. Moreover, the chances of picking up infective worm larvae will be minimized when goats have access to browse species (Hart, 2013). Mixing of shrubs/trees is an easy and efficient way of overcoming a nutrient deficiency/imbalance and also can dilute the negative effects of undesirable secondary compounds (Ben Salem and Smith, 2008). Although some work is going on in identifying suitable forages for goats to improve pastures and manage them with sustainable grazing, not much information is available on managing woodland vegetation using goats. One of the changes that can occur in woodland vegetation because of grazing is species composition.

Plant-species composition is the proportion of various plant species in relation to the total plant species in a given area. It gives an estimation of forages available for animals with different feeding habits, and composition over time is used to characterize the range trend (Launchbaugh, 2008). Diversity is an important plant-community attribute that can determine stability and productivity of that community (Stirling and Wilsey, 2001). Species evenness in a community captures another aspect of diversity by determining diversity as a standardized index of relative species abundance (Krebs, 1999). Measures of plant functional diversity that include evenness represent a promising tool to detect and quantify disturbance effects on ecosystem (Hanke et al., 2014). Browsers such as goats, while browsing on the woodland vegetation, can affect the plant-species composition and diversity in various ways. Some of the browsing-induced effects have been described as limiting woodland regeneration (Belsky, 1984; Augustine and McNaughton, 1998; 2004), affecting vegetation structure (Augustine and McNaughton, 2004; Pellew, 1983), influencing species composition and distribution (Bond and Loffell, 2003), and reducing the vigor of woody species (Hart, 2013). Selective browsing is found to reduce the local abundance of palatable deciduous woody plants, and contribute to the early dominance of unpalatable, evergreen, and slow-growing species in the vegetation succession (Pastor et al., 1988; Seagle and Liang, 2001; Wardle et al., 2001). However, vegetation responses under chronic-browsing pressure are sometimes contradictory and do not always lead to a clear dominance of less-preferred species.

Studies in African woodlands and other parts of the world show that the social behavior of animals, and plant tolerance of herbivory supported by nutrient recycling and compensatory growth ability are the reasons behind the dominance of preferred species (Jachmann and Bell, 1985; Tilghman, 1989; Augustine and McNaughton, 1998; du Toit et al., 1990; Oba and Post, 1999). Hanke et al. (2014) found reduction in total plant cover and substantial alteration of species as a result of heavier grazing intensity of livestock. Likewise, Tsiouvaras et al. (1989) found the varying degree of reduction in understory brush in forests and fuelbreak by grazing Spanish goats.

Methods

Study Site and Grazing

This research was conducted from May to July, 2015, at the Atkins Agroforestry Research and Demonstration site, Tuskegee University, Tuskegee, Alabama. Three fenced-woodland plots were rotationally grazed with 29 Kiko wethers, which were 6-8 months old and weighed 26.8±0.67 kg at the beginning of the study. Goats had free access to shelters, clean drinking water, and minerals in each plot throughout the study. The grazing plots were dominated by pines (loblolly, *Pinus taeda* L.; longleaf, *Pinus palustris* Mill.), oaks (water, *Quercus nigra* L.;

southern red, *Quercus falcate* Michx.), and sweetgum *(Liquidambar* L.) as the over-story trees. The mid-story vegetation was mainly comprised of yaupons (*Ilex vomitoria* Aiton), blackberry (*Rubus* L.), muscadine (*Vitis rotundifolia* Michx.), greenbrier (*Smilax* L.), and beautyberry (*Callicarpa* L.). The major ground-level vegetation consisted of panicgrass (*Panicum* L.), blackberry (*Rubus* L.), broomsedge (*Andropogon* L.), rust weed (*Polypremum procumbens* L.), and dogfennel (*Eupatorium capillifolium* Lam.).

Measurement of Plant-Species Composition and Cover Category

Locations for species-composition measurements were fixed before taking observations. A baseline, a line that ran from one end to the other end of each observation plot, was established, and 10 random transects (each 10-m-long) were drawn perpendicular to the baseline. If a transect location on the baseline was found to be inaccessible up to the transect length into the woodland from the baseline, it was moved to nearby location on the baseline where the woodland could be accessible to the observer. Ten observation locations were fixed along each transect: one meter apart, starting at one meter from the baseline. These locations were used to take the observations throughout the study (Figure 2).

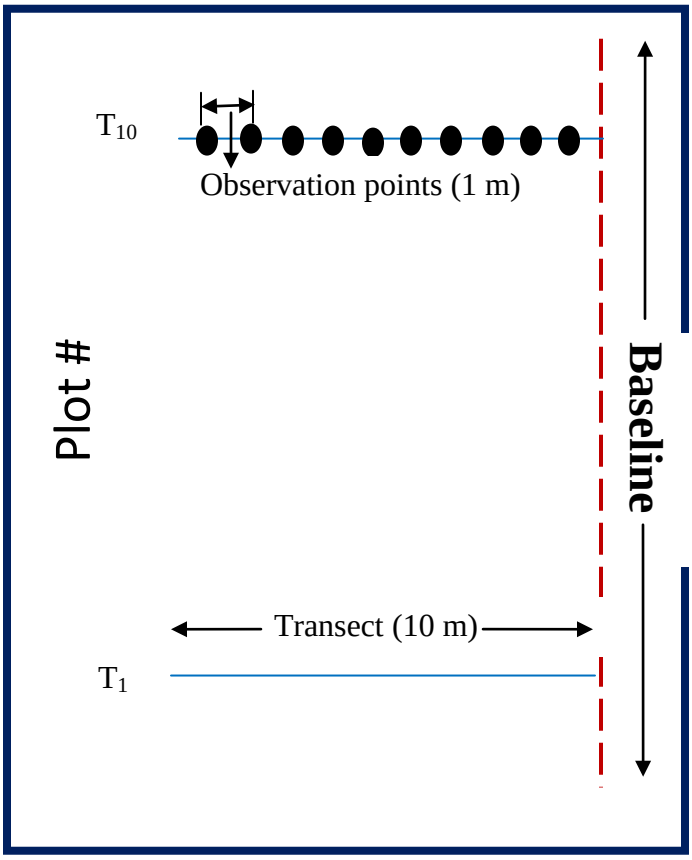

Figure 2. Schematic Diagram of Observation Locations in the Study Plots for Determining Woodland Plant-Species Composition, May-July 2015, Atkins Agroforestry Research and Demonstration Site, Tuskegee University, Tuskegee, AL, USA

Woodland plant-species composition and cover category were measured using the intercept method (USDA-FS, 1996) with an optimal point projection device (Buckner, 1985). The point projection device was placed at each observation location and cover categories for ground- (0-91 cm), mid- (91-152 cm), and high-level (>152 cm) were recorded at 0°, 45°, 90°, 135°, and 180° relative to each transect by moving the rotating head of the projection device in a semi-circle opposite to the standing position of the observer (500 readings per level per plot) (Figure 3). Observations were taken twice in each plot: once just before grazing and another immediately after the animals were moved out of the plot. Disturbance to the vegetation on the side of the transect where the cover was being recorded was avoided until all readings for that transect was completed.

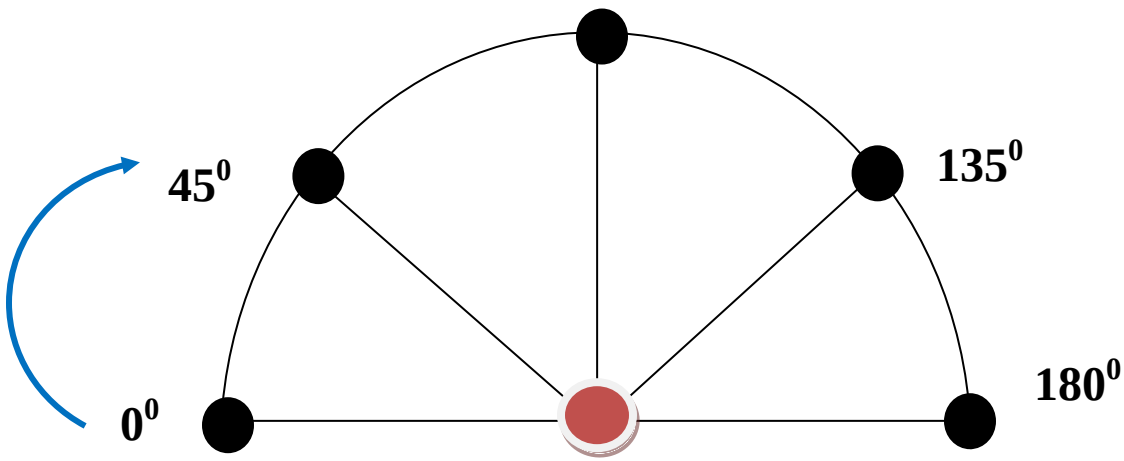

Figure 3. Pattern of Rotating the Head of the Point Projection Device for Observing the Woodland Plant-Species Composition, May-July 2015, Atkins Agroforestry Research and Demonstration Site, Tuskegee University, Tuskegee, AL, USA

Data Analysis

Species diversity and evenness indices were calculated using Shannon's method (Magurran, 1988). Shannon's method is useful to determine the significant differences in diversity indices between observation times by performing t-test using the method provided by Hutcheson (1970). The equations used to calculate the diversity and evenness indices are presented below:

Diversity index, $H' = -\sum pi \ln pi$

Where, $pi = \frac{ni}{N}$ is the proportional abundance of the ith species, ni abundance of particular plant-species observed in the study area, N is the total number of observations. There is an increasing trend toward standardizing on natural logs (ln) and it is essential to use these in the series (Magurran, 1988).

Evenness index, $E = \frac{H'}{\ln S}$

Where, S is the total number of plant species observed in the study area.

Cover category was calculated as the percentage covered by a particular category out of the total coverage.

Results and Discussion

The diversity index was significantly reduced after grazing at the ground-level (40%) and mid-level (38%), but not at the high-level of the woodland vegetation (Table 1). The evenness indices after grazing for the ground- and mid-level vegetation were decreased by 26% and 24%, respectively.

Table 1 Diversity and Evenness Indices of Woodland-Plant Community at Ground, Mid and High Levels Before and After Grazing with Kiko Wethers, May-July 2015, Atkins Agroforestry Research and Demonstration Site, Tuskegee University, Tuskegee, AL, USA

Parameter	Ground-level (0-91 cm)		Mid-level (91 - 152 cm)		High- level (>152 cm)	
	Before grazing	After grazing	Before grazing	After grazing	Before grazing	After grazing
Number of observation (N)	1500	1500	1500	1500	1500	1500
Number of species (S)	45	22	37	19	22	22
Diversity index (H')	1.76^{a****}	1.06^{b}	2.45^{a****}	1.53^{b}	2.03	1.97
Evenness index (E)	0.46	0.34	0.67	0.51	0.65	0.63

Diversity index in a row under the same level with different superscript are different (****P<0.0001)

These results are similar to the after-grazing results of Hanke et al. (2014) who observed the evenness indices ranging from 0.58 to 0.66 and from 0.46 to 0.58, and Shannon's diversity indices ranging from 1.81 to 2.02 and from 1.09 to 1.87, respectively, for lightly-grazed and heavily-grazed dryland ecosystems of Southern Africa. Not much change was found in evenness and diversity indices for the high-level vegetation in this study. The reason might be because of inaccessibility of goats to that level, which was also reflected by a little change in vegetation cover at that level after grazing (Table 2).

The overall decrease in vegetation cover after grazing at the ground-level, excluding the percentage covered by litters (plant debris) and bare ground was 50%. Similarly, the reduction in vegetation cover, excluding no-cover category at the mid-level was 46%, and at the high level was 3%. These results are in agreement with the prior findings of Tsiouvaras et al. (1989), who reported the reduction in vegetation cover by 41% and 48% respectively at heights below 0.5 m and from 0.5 to 1.5 m, after allowing Spanish goats to graze in the Monterey pine (*Pinus radiata* D. Don) and red gum (*Eucalyptus camaldulensis* Dehnh.) forests of California. The vegetation removal in the fuel break was 46% and 82% at heights below 0.5 m and from 0.5 to 1.5 m, respectively, in the Tsiouvaras et al. study. No vegetation was removed above 1.5 m. Hanke et al. (2014) found a reduction in vegetation coverage ranging from 13 to 38% and from 8 to 28%, respectively, in lightly-grazed and heavily-grazed dryland ecosystems of Southern Africa. The plant species that dominated the study plots, and were reduced the most after grazing by goats in this study, included blackberry, yaupon, and greenbrier.

Table 2. Cover Categories at the Ground, Mid, and High Levels Before and After Grazing Woodlands with Kiko Wethers, May-July 2015, Atkins Agroforestry Research and Demonstration Site, Tuskegee University, Tuskegee, AL, USA

	Ground-level (0-91 cm)		Mid-level (91 - 152 cm)		High-level (>152 cm)	
Cover Category	Before	After	Before	After	Before	After
			%			
Litter	63	78	0	0	1	1
Blackberry (*Rubus* L.)	8	5	12	5	0	0
Water oak (*Quercus nigra* L.)	4	3	19	19	26	25
Yaupon (*Ilex vomitoria* Aiton)	4	1	16	0	1	0
Greenbrier (*Smilax* L.)	3	0	4	0	3	2
Panicgrass (*Panicum* L.)	2	2	0	0	0	0
Sweet gum (*Liquidambar* L.)	2	2	4	4	2	3
Bare ground	1	3	0	0	0	0
Dog fennel (*Eupatorium capillifolium* Lam.)	1	0	0	0	0	0
Hickory (*Carya* Nutt.)	1	0	2	2	1	1
Honey suckle (*Lonicera* L.)	1	0	1	0	0	0
Lespedeza (*Lespedeza* Michx.)	1	0	0	0	0	0
Muscadine (*Vitis rotundifolia* Michx.)	1	1	3	2	4	5
Southern red oak (*Quercus falcata* Michx.)	1	1	2	2	4	4
Sparkleberry (*Vacciniumarboreum* Marshall)	1	1	3	2	1	1
Broomsedge (*Andropogon* L.)	1	1	0	0	0	0
Virginia creeper (*Parthenocissus quinquefolia* L.)	1	0	0	0	0	0
Willow oak (*Quercus phellos* L.)	1	0	1	2	1	1
Yellow Jasmine (*Gelsemium sempervirens* L.)	1	0	0	0	0	0
Beautyberry (*Callicarpa* L.)	0	0	2	0	0	0
Black cherry (*Prunus serotina* Ehrh.)	0	0	1	0	0	0
Black gum (*Nyssa sylvatica* Marshall)	0	0	1	0	0	0
Hackberry (*Celtis* L.)	0	0	1	0	0	0
Loblolly pine (*Pinus taeda* L.)	0	0	0	1	8	8
Longleaf pine (*Pinus palustris* Mill.)	0	0	0	0	7	7
No cover	0	0	23	57	37	38
Persimon (*Diospyros virginiana* L.)	0	0	1	2	2	2
Sumac (*Rhus* L.)	0	0	1	0	1	0
Wild plum (*Prunus* L.)	0	0	1	0	1	1

The increased coverage by some species, such as willow oak (*Quercus phellos* L.), loblolly pine, and persimmon (*Diospyros virginiana* L.) at the mid-level, and sweetgum and muscadine at the high-level, after grazing (Table 2) might be because of the unmasking effect. The species undetected at the before-grazing observation may have been masked by some other species, but exposed later when the masking species were eaten, killed, or disturbed by the goats.

Conclusion

Results from this study indicated that grazing with goats can have a significant short-term impact on woodland-plant communities up to 1.5 m height. The diversity and evenness indices as well as the vegetation cover at the ground- and mid-level were reduced after grazing with goats. The cover with litter and bare ground increased, while vegetation cover decreased after grazing. Further studies are needed to assess the long-term impact of grazing on woodland-plant community to understand the response of these species to repeated grazing. Such information will be useful for developing sustainable management guidelines of woodland vegetation using goats.

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