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IMPACT OF USING DIFFERENT STOCKING RATES OF GOATS UNDER PINE PLANTATION ON PLANT SPECIES OCCURRENCE AND ANIMAL PRODUCTIVITY

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Abstract

The study assessed the impact of using different stocking rates of goats under pine plantation on plant species occurrence and animal productivity. It was conducted on an 11 year-old loblolly pine plantation site in Epes, Alabama from July to October 2011. Thirty-six Kiko crossbred male goat kids of 4 to 5 months of age were assigned to different stocking rates, namely, low (4 goats/acre), medium (8 goats/acre), and high (12 goats/acre) with three replications each. Forage composition, animal daily gain (ADG) and blood urea nitrogen (BUN) were monitored. Bahia grass (*Paspalum notatum*) was the most dominant grass species across all treatments. Quantities of understory plant species decreased across all stocking densities with season, but there were no statistical differences ($p > 0.05$); ADG and BUN were similar. Long-term studies need to be conducted before any meaningful inferences can be drawn.
Keywords: Silvopasture, Loblolly Pine, Goats, Understory Species Composition

Introduction

Benefits from agroforestry are derived from biophysical interactions created with either crops or livestock or both (Garret et al., 2004). There are several methods of practicing agroforestry, all of which help to diversify and enhance income sources for land owners. Examples of these methods are alley cropping, windbreaks, riparian forest buffers, forest farming, and silvopasture systems. Alley cropping involves planting rows of trees, and allotting space within the alleys of the rows to horticultural crops such as peppers, tomatoes, and garden eggs. Windbreaks are established to reduce wind speed, which can help to increase crop yield and reduce soil erosion. A riparian forest buffer is a living filter consisting of trees, shrubs, forbs, grasses, and native plants. Forest farming is production and marketing of specialty crops such as mushrooms with short-term benefits, and timber production with long-term benefits (National Agroforestry Center, 2008).

The most common form of agroforestry in the southeastern United States is silvopasture, or managing property for livestock, forage, and timber on the same parcel of land (Barlow, 2010; Sharrow, 2008). Proper and simultaneous management of all three components is essential for the success of the system. Silvopasture systems are designed with considerations for economic and environmental variables. Environmental considerations include tree selection quality, tree selection market, tree selection growth rate, tree selection shade allowance, forage compatibility, forage tolerance, forage tolerance to intense management, and species of animals selected for grazing (National Agroforestry Center, 2008). Intense management practices include surveying soil compaction levels, cover crown density changes, plant biomass capacity, and animal nutrition requirements on a regular basis. Economic considerations include costs saved in the maintenance of trees in terms undergrowth vegetation management, labor cost assessments, and periodic short-term sales of animals by landowners to accrue some income while they wait for the sale of timber or pulpwood.

Silvopasture is practiced by landowners in the southern pine region, Midwest region, and Northwest region of the United States. The Southeast region leads the nation in development of silvopasture systems because of climatically favorable growing conditions for both timber and livestock production on the same site (Rietveld and Francis, 2000; Allen, 2003). Cattle are the most commonly integrated livestock species used in silvopasture systems (Zinkhan, 1996; Garrett et al., 2004). These systems vary from rotational grazing in pine forest to intentional grazing under hardwoods and pecan orchards. Silvopasture in the Southeast has traditionally included forest grazing with cattle, such as flat woods rangeland (Pearson, 1997), pine managed for turpentine, and saw log with forage (Byrd et al., 1984).

However, goats have the unique ability and the tendency to utilize plants species such as woody plant species, forbs and grasses which are not generally consumed by other domestic livestock (Hart, 2001). Therefore, incorporating meat goats can be more favorable to small-scale farmers, over incorporating cattle into the system. The two unique characteristics that give meat goats an advantage are their browsing height and diverse diet preference. Meat goats can rapidly change foraging behavior according to changes in vegetation and plant growth form (du Plessis et al., 2004). The overall objective of the study was to assess the impact of using different stocking rates of goats under pine plantation on plant species occurrence and animal productivity. Specific objectives were to (1) monitor changes in species composition due to grazing by goats in different stocking densities, and (2) identify browse, forb, or grass species that were available and competing with the pine trees as well as impacts on animal productivity.

Literature Review

Scope of Silvopasture Systems and Reasons for Adoption

According to Barlow (2010), there are many financial and ecological benefits in adopting silvopasture systems such as native forage establishment, wildlife habitat creation, longleaf pine restoration, and pine straw production. Annual incomes from grazing and long-term profits from timber respond to different market pressures when combined in the same operation (National Agroforestry Center, 2008). In a survey conducted in Argentina, difficulties such as investment requirement cost and labor were of great concern (Dagang and Nair, 2003; Pagiola et al., 2004). Both small- and large-scale landowners were encouraged to consider all the potential profitability over the initial costs to establish the system. Economic analyses were based on the adjusted equivalent annual income (AEAI) per hectare for farms of varying scales at varying wage rates. Small-scale farms had adequate AEAI at a lower wage rate (Ar$15 per day), while large-scale farms were more productive at a higher wage rate (Ar$58 per day). The study concluded that small, medium, and large farmers in Northeastern Argentina had different views of silvopasture systems. Small-scale farms were more interested in financial gain being that they had less labor load, while large-scale farmers appreciated the environmental contributions such as improved microclimate, weed control, and fire control (Frey et al., 2007).

Other issues, such as water supply, fencing, poisonous plant species, soil compaction and predation, also need to be considered before adopting silvopasture systems. For example, the National Agroforestry Center (2008) contended that proper fencing materials and water system design help to create a more productive environment in silvopasture systems. Beckford (2011) suggested that fences should be at least 7 feet high to prevent predators such as coyotes from jumping them, and top wires should slant outward towards the bottom to prevent digging.

According to Ball et al. (2007), sheep and goats are reported to need approximately 1.5 gallons of water per head daily in cold seasons, and approximately 3.5 gallons per head in the warm season. Ball et al. also suggested installing water within 800 feet travel distance due to the fact that traveling longer distances to water supply sources promotes overgrazing in areas closet to water and underutilization of forages located in areas further away.

As indicated earlier, although silvopasture systems typically integrate cattle, there are several reasons to incorporate meat goats. For instance, their ability to browse and propensity for diverse diets make them strong candidates for the system. Both Donaldson (1979) and Erasmus (2000) concluded that goats complement grazers in savanna areas by utilizing the woody component, but doubted their efficiency as bush control agents in extensive production systems and in the absence of fire. Meat goats have a great potential to be used as an integrative part of a silvopasture system. Moreover, the system serves as a source of major supplemental income (from sale of animals) to forest landowners in the short-term, while they wait for the maturity of their trees to be sold as timber in the long-term, 25-30 years.

Over the last six years, the USDA had assisted farmers, ranchers, and landowners financially to establish approximately 336,000 acres of wind breaks, alley cropping and riparian forest buffers; 500 acres of forest farming, and about 2,000 acres of silvopasture. All the above mentioned numbers of acres represent just less than 1% of the potential lands available for these agroforestry practices, indicating large potential for expansion and great benefits such as job creations in rural America, economic growth, and reduction of greenhouse gases in the atmosphere, among others (USDA, 2013).

Management of Stocking Density, Grazing Goats, and their Browsing Habits

Lu (1988) stated that goats are versatile in harvesting forage and can survive under adverse foraging conditions which set them apart from other species of livestock. Vallentine (1990) emphasized that goats have mobile upper lips and unique tongues that allow them to ingest small leaves while browsing thorny species such as blackberry. Lu (1988), in addition, coined goats as "mixed-feeding 'opportunists'", because they adapt much faster than cattle or sheep to seasonal and geographic variation. Lu noted that goats preferably select plant parts that are higher in digestibility when stocking density is low. In fact, the patterns of rumination in goats do not differ from cattle and sheep although a faster rate of eating and more frequent feeding may be observed in goats.

Grazing management in a silvopasture system helps eliminate the problem of under-utilization of pasture, because the animals are being grazed in specific pastures and not allowed access to the entire acreage (USDA Agroforestry Department, 2008). Once introduced, animals must be controlled through stocking management and rotational grazing to improve efficiency of forage utilization (Barlow, 2010). Silvopasture systems are intended to be extensive grazing management systems. An extensive grazing management system is defined by Vallentine (1990) as one that utilizes large areas per animal and a low input level of labor, resources, or capital, and which depends on cost-cutting measures in order to maintain profits. Rotational grazing is best suited for silvopasture management of goat over continuous grazing. Toit (2001) conducted a study on goats grazing on Eastern Mixed Karoo and concluded that continuous grazing by goats resulted in a higher mortality of trees, and more efficient control of regrowth than did rotational grazing.

Methodology

Experimental Setup

An existing 6-acre, 11-year old loblolly pine plantation, at the experimental site in Epes, AL, was thinned and pruned and divided into 12 paddocks of approximately 0.5-acres each. There were four treatments; control (no grazing: Trt1); 0.2 Animal Unit Equivalent (AUE)/acre: Trt2); 0.3 (AUE/acre: Trt3); and 0.4 (AUE/acre: Trt4), equivalent to 0, 4, 8, and 12 goats/acre, respectively. Each treatment was replicated three times. Goats were weighed and then randomly assigned to the treatments. The ungrazed plots (control: Trt1) were used for baseline data collection. The existing vegetation consisting of grasses, browse, and forbs were characterized for species composition and available biomass at the beginning (baseline) and at the end of the experiment. Performance was measured over the period of July 16, 2011 to October 1, 2011.

Thirty-six (36) Kiko crossbred male goat kids with an average body weight (BW) of 21.0 ± 0.98 kg and an average age of 4 to 5 months were purchased from a breeder in Ashland, Tennessee. A complete physical examination including inspection of lymph nodes, lameness, pinkeye, and skin conditions was conducted by the Institution's College of Veterinary Medicine. Prior to being used in the study, the goats were quarantined in an open pasture from June 20 to July 15, 2011. They were dewormed for the control of internal parasites using a combination of 3 mL of Valbazen (Albendazole Broad Spectrum, Pfizer 500mL) and 5 mL of Cydectin (Moxidectin, Fort Dodge) by separate oral ingestion one following the other. A sporadic dose of LA-200 (Pfizer, Animal Health Liquamycin (oxytetracyline injection) was administered to animals that exhibited nasal discharge or coughing to ensure that all animals used in the study were healthy.

Species Composition

The Shannon-Weiner diversity index was calculated for understory, midstory, and overstory plant species present at the beginning and at the end of the foraging period. Initial evaluation of data indicated that the experimental plots were similar in plant species composition across treatments. For plant species composition determination, three levels were designated: level 1 (0-36 inches from ground level); level 2 (36-60 inches), and level 3 (above 60 inches from ground level) and 300 points were read for each level. However, data are presented for combined composition below 60 inches in this paper because goats can reach up to 60 inches for browsing. Animal productivity as expressed by average daily gain (ADG) and blood urea nitrogen (BUN) levels was monitored. The data were analyzed using the Mixed Procedure in SAS 9.1 with replication as a random factor (Little et al., 2006).

Results and Discussion

Species Composition below 60 Inches

Species composition was evaluated in four subcategories: grass species, forbes species, young trees, and others as indicated in Tables 1 to 3.The 'others' subcategory included bare ground, leaf litter, pine needles, and goat feces observed below the height of 60 inches per sample point within each sampling point and treatment.

In the control treatment, grass species represented 23.5% (Table 1); forbs represented 17.5% (Table 2); young trees represented 11.1%, and 'others' represented 40.0% (Table 3) in July 2011. Bahia grass (*Paspalum notatum*) dominated in the grass species (Table 1); blackberry (*Rubus fruticosus*) dominated in the forbes species (Table 2); groundsel (*Senecio vulgaris*) dominated in the young tree subcategory, and leaf litter dominated in the 'others' subcategory (Table 3). However, in October 2011, grass species decreased to 21.7% (Table 1); forbes species decreased to 10.1% (Table 2), whereas young tree species decreased to 7.5%, and 'others' increased to 52.5% (Table 3). Bahia grass (*Paspalum notatum*) dominated in the grass species; goldenrod (*Solidago sp.*) in the forb species; groundsel (*Senecio vulgaris*) dominated in the young tree subcategory, and leaf litter in the 'others' subcategory (Tables 1 to 3).

Table 1. Cover Categories for Grasses (< 60 inches) under Different Stocking Rates Observed in July 2011 (Before) and October 2011 (After), Epes, Alabama

Grasses		**Stocking Density (goats/acre)**							
Scientific Name	Common Name	**Before**				**After**			
		----------------------------------		%	---				
		0	**4**	**8**	**12**	**0**	**4**	**8**	**12**
Paspalum notatum	Bahia grass	16.9	31.9	29.7	32.3	10.4	23.4	19.3	17.4
Cynodon dactylon	Bermuda grass	0.6	0.1	0.0	0.0	0.5	0.0	0.1	0.0
Axonopus *Fissifolius*	Carpet grass	0.6	0.3	0.0	0.4	1.1	0.4	0.3	0.4
Festuca arundinacea	Tall fescue	5.2	1.1	1.3	0.5	9.4	6.5	4.0	0.5
Tripsacum dactyloides	Eastern gamma grass	0.1	0.0	0.0	0.3	0.0	0.0	0.0	0.0
Paspalum dilatatum	Dallis grass	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0
Pancium Species	Switch grass	0.1	0.8	0.3	0.0	0.3	0.5	0.0	0.1
Total		**23.5**	**34.2**	**31.4**	**33.5**	**21.7**	**30.8**	**23.7**	**18.4**

Overall, in assessing the values in Tables 1 to 3, the following general deductions could be made. In the low treatment (4 goats/acre), grass species represented 33.1% (Table 1); forbs represented 13.4% (Table 2); young trees represented 8.1%, and 'others' represented 38.6% (Table 3) in July 2011. Bahia grass (*Paspalum notatum*) again dominated in the grass species; golden rod (*Solidago sp.*) and black berry (*Rubus fruticosus*) dominated in the forbs species; groundsel (*Senecio vulgaris*) dominated in the young tree subcategory, and leaf litter in the 'other' subcategory. In October 2011, grass species decreased to 30.8% (Table 1); forbs decreased to5.7% (Table 2); young trees decreased to 3.1%, and 'others' increased to 42.4% (Table 3). Bahia grass (*Paspalum notatum*) dominated in the grass species; goldenrod (*Solidago sp.*) dominated in the forbs species; Pecan (*Carya ilinoinensis*) dominated in the young tree subcategory, and leaf litter in the 'other' subcategory.

Table 2. Cover Categories (< 60 Inches) for Forbs under Different Stocking Rates Observed July 2011 (Before) and October 2011 (After), Epes, Alabama

Forbs Scientific Name	Common Name	**Stocking Density (goats/acre)** **Before**				**After**			
		%							
		0	**4**	**8**	**12**	**0**	**4**	**8**	**12**
Rubus fruticosus	Blackberry	6.4	4.4	9.4	4.9	3.6	2.0	0.6	0.7
Solidago sp.	Golden rod	5.7	8.1	6.0	6.4	3.3	3.6	1.1	1.5
Lonicera sp.	Honey suckle	4.6	0.5	2.5	6.0	0.0	0.1	0.8	0.4
Gleditsia Triacanthus	Honey locust	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.0
Juncus effusus	Rush	0.8	0.4	0.1	2.1	0.5	0.0	0.1	0.6
Ipomoea species	Morning glory	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0
Aloysia gratissima	Lippa species	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0
Lespedeza cuneate	Sericea lespedeza	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0
Amaryllis	White nymph	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0
Ambrosia Trifida	Giant ragweed	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0
Hordeum Pusillum	Little Barley	0.0	0.0	0.0	0.4	0.0	0.0	0.0	0.0
*Parthenocissus*s *quinquifolia*	Virginia creeper	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0
Polygonum cilinode	Black fringe knotweed	0.0	0.0	0.0	0.0	2.4	0.0	0.0	0.0
Ampelopsis Arborea	Peppervine	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0
Vernonia gigantea	Iron weed	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0
Oxalis sp.	Shamrock	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0
Phyla sp.	Frog fruit	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0
Rumex Crispus	Curly dock	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1
Dichondria Species	Dichondria	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1
Total		**17.5**	**13.4**	**18.7**	**20.0**	**10.1**	**5.7**	**2.7**	**3.4**

In the medium treatment (8 goats/acre), grass species represented 31.4% (Table 1); forbs represented 18.7% (Table 2); young trees represented 8.8%, and 'others' represented 37.3% (Table 3) in July 2011. Bahia grass (*Paspalum notatum*) dominated in the grass species;

goldenrod (*Solidago sp.*) dominated in the forbs species; Pecan (*Carya ilinoinensis*) dominated in the young tree subcategory, and leaf litter dominated in the 'others' subcategory similar to results found in the low treatment. In October 2011, grass species represented 23.7% (Table1); forbs represented 2.7% (Table 2); young trees represented 3.1%, and 'others' increased to 70.6% (Table 3).

Table 3. Cover Categories (< 60 Inches) for Young Trees and "Others' under Different Stocking Rates Observed in July 2011 (Before) and October 2011 (After), Epes, Alabama

Young Trees		**Stocking Density (goats/acre)**							
Scientific Name	Common Name	**Before**				**After**			
		%							
		0	**4**	**8**	**12**	**0**	**4**	**8**	**12**
Prunus serotina	Cherry	0.0	0.1	0.4	0.0	0.0	0.0	0.0	0.0
Senecio vulgaris	Groundsel tree	5.2	3.4	1.8	0.5	5.4	1.3	0.1	0.0
Carya illinoinensis	Pecan	3.7	3.0	3.1	3.2	1.1	1.8	0.1	0.3
Pinus taedaa	Pine	0.1	0.0	0.0	0.9	0.4	0.0	0.0	0.0
Quescus sp	Oak	0.1	0.0	0.0	0.9	0.0	0.0	0.0	0.0
Ulmus procera	Elm	0.0	0.0	0.4	0.5	0.0	0.0	0.0	0.0
Rosa braceteata	McCartney Rose	1.0	0.8	1.5	1.4	0.3	0.0	1.4	0.7
Liquidambar styraciflua	Sweet gum	1.0	0.8	1.5	1.4	0.3	0.0	1.4	0.7
Prunus americana	Wild plum	0.0	0.0	0.1	0.0	0.0	0.0	0.1	0.3
Total		**11.1**	**8.1**	**8.8**	**8.8**	**7.5**	**3.1**	**3.1**	**2.0**
Others									
	Bare ground	0.1	2.1	1.0	0.9	0.8	1.4	1.1	1.9
	Litter	39.9	36.5	36.3	34.5	41.8	39.5	40.8	53.6
	Pine needle	0.0	0.0	0.0	0.0	9.9	1.5	28.6	19.8
	Goat feces	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.3
Total		**40.0**	**38.6**	**37.3**	**35.4**	**52.5**	**42.4**	**70.6**	**75.6**

Bahia grass (*Paspalum notatum*) dominated in the grass species, goldenrod (*Solidago sp.*) dominated in the forbs species; groundsel (*Senecio vulgaris*) dominated in the young tree subcategory, and leaf litter dominated in the 'others' subcategory.

In the high treatment (12 goats/acre), grass species represented 35.5% (Table 1); forbs represented 20.0%; young trees represented 8.8%, and 'others' 35.4% (Table 3) in July 2011. Bahia grass (*Paspalum notatum*) dominated in the grass species; goldenrod (*Solidago sp.*) dominated in the forbes species; Pecan (*Carya ilinoinensis*) dominated in the young tree subcategory, and leaf litter dominated in the 'others' subcategory similar to results found in the low and medium treatment at the height of < 60. In October 2011, grass species decreased to 18.4% (Table 1); forbs decreased to 3.4%; young trees decreased to 2.0%, and 'others' increased to 75.6% (Table 3). Bahia grass (*Paspalum notatum*) dominated in the grass species, goldenrod (*Solidago sp.*) dominated in the forbes species; Pecan (*Carya ilinoinensis*) dominated in the young tree subcategory, and leaf litter dominated in the 'others' subcategory similar to results found in the low treatment at this height.

In summary, at the height of < 60 inches, Bahia grass (*Paspalum notatum*) dominated across all treatments from July to October 2011 (Table 1). In July 2011, blackberry (*Rubus fruticosus*) dominated the control treatment while goldenrod (*Solidago sp.*) was prevalent across all the treatments in the forbs category. In October 2011, goldenrod (*Solidago sp.*) dominated across all treatments. In July 2011, groundsel (*Senecio vulgaris)* dominated the control and low treatments in the young tree subcategory, while Pecan (*Carya illinoinensis*) dominated the medium and high treatments. In October 2011, groundsel and pecan switched dominance interchangeably within the young tree subcategory. Leaf litter was most prevalent across all treatments from July to October 2011 in the subcategory of 'others'. A detailed summary of all categories of vegetation change are presented in Table 4 showing a linear decrease ($p < 0.05$) among grasses and forbs indicating that as stocking rates increased, there was a corresponding reduction of edible and palatable vegetation among grasses and forbs. However, in the young trees category, the control treatment increased to almost 36.8%, whereas the other treatments showed a decreasing trend. The effects of the "Others" category was just the opposite of what was observed in the young trees category.

Animal Productivity

There were no significant differences ($p > 0.05$) among treatments on body weight gains during the grazing period (Table 5). However, the ADG values indicated that there were periods of time where the biomass quantity was inadequate for weight gain as indicated in Table 5. This means that as stocking rates increased, ADG decreased across treatments, although not statistically different ($p > 0.05$). This may be due to the fact that the amount of biomass left for the animals were inadequate, and far lower than the critical biomass of 1,000 kg dry matter/hectare indicated by (Ball et., 2007). They intimated that in order for animals not to lose weight, an acceptable amount of one (1) ton/hectare biomass/dry matter must be left for the animals to select from.

In addition, BUN values were similar between treatments at the beginning and the end of the grazing period (Table 5). It is worthwhile to mention that experimental animals were not provided any supplements throughout the duration of the experiment. Salt blocks and water were provided ad libitum. The poor animal performance may also be due to lower digestible energy, extreme weather conditions, and prevalence of internal parasites. Further studies are required to minimize the annual variability due to extreme weather conditions. The relatively high concentration of BUN is indicative of excess dietary protein (nitrogen) relative to digestible energy intake (Hammond, 1992), however, protein degradability and level of protein intake can also affect BUN.

Table 4.Effects of Using Different Stocking Rates of Goats on Combined Changes in Vegetation Categories (< 60 inches)

Vegetation Categories/ Treatment	Control		Low		Medium		High		Level of Significance
	July	Oct.	July	Oct.	July	Oct.	July	Oct.	
Grasses	23.5	21.7	34.2	30.8	31.4	23.7	33.5	18.4	
% Change in Occurrence	-7.6		-9.9		-24.5		-45.0		Linear
Forbs	17.5	10.1	13.4	5.7	8.7	2.7	20.0	3.4	
% Change in Occurrence	-43.2		-57.4		-85.5		-83.0		Linear
Young trees	11.1	7.5	8.1	3.1	8.8	13.1	8.8	2.0	
% Change in Occurrence	-32.4		-61.7		-64.7		-77.2		Linear
Others	40.2	52.6	36.6	55.9	37.2	70.6	26.6	75.6	
% Change in Occurrence	+31.2		+9.8		+89.2		+106.3		NS

NS = Not significant at ($p < 0.05$); Oct = October; (-) = reduction; (+) = increment

Conclusion

The preliminary results indicated that goats can be integrated into pine silvopasture systems and they can change the species compositions of vegetation. Also, understory vegetation changed with season as well as stocking rates, albeit, changes due to stocking rates were more pronounced than season. The amount and pattern of rainfall for the study area was also observed to be above normal in 2011, and hence, influencing the changes that occurred with the vegetation species. Consequently, stocking rates need to be adjusted according to the amount of plant biomass available, and if needed, additional feed supplements should be provided. The study needs to be conducted for several grazing seasons to evaluate the impact of using different stocking rates of goats on soil and water quality, as well as tree growth.

Table 5. Least Square Means ± Standard Error of Initial Body Weight (kg), Final Body Weight (kg) and Average Daily Gain (g/d), Initial and Final BUN (mg/dL) by Different Stocking Density of Meat Goats Grazed under Pine Silvopasture System, July 2011 and October 2011, Epes, Alabama

Item	Stocking Density (goats/acre)			P-values	
	4	8	12	Linear	Quadratic
Initial BW (kg)	21.7 ± 1.29	20.8 ± 0.91	20.5 ± 0.75	0.43	0.77
Final BW (kg)	20.6 ± 1.95	19.4 ± 1.38	19.0 ± 1.13	0.49	0.83
ADG (g/d)	(-14.8) ± 19.6	(-17.7) ± 13.8	(-14.8) ± 19.6	0.83	0.98
Initial BUN (mg/dL)	8.0±1.8	7.9 ± 1.2	9.4 ± 0.8	0.52	0.64
Final BUN (mg/dL)	22.5 ± 3.1	20.3 ± 2.2	25.5 ± 1.9	0.45	0.26

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