Use of Goats to Manage Vegetation in Cattle Pastures in the Appalachian Region of North Carolina[1, 2]

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Summary

A field study was initiated to evaluate the effectiveness of rotationally grazing goats (*Capra hircus hircus*) in combination with cattle (GC; 12 goats and 6 steers) or cattle (*Bos taurus*) alone (C: 6 steers) to manage vegetation in an overgrown mountain pasture (8.4 ha) that had not been grazed for two years. Black locust (*Robinia pseudoacacia*) trees were practically eliminated over the 4-year period in both C and GC ($P < .01$) but grew to a height of 5.3 m in the control (CTL). Height of multiflora rose (*Rosa multiflora*) bushes were controlled in GC (avg .6 m) but increased to 1.8 m in C and 2.5 m in CTL (C vs GC: $P < .02$; CTL vs C + GC: $P < .01$). Similarly, multiflora rose canopy area was controlled in GC (avg .5 m^2), but increased in C (from .6 to 7 m^2; $P < .01$) and greatly increased in CTL (from .5 to 11 m^2; $P < .01$). The cattle provided only modest control of multiflora rose. Inclusion of goats resulted in a reduction of live canes of multiflora rose at the conclusion of the study relative to other treatments (41% vs 96% vs 96%). Herbaceous vegetative cover decreased in CTL (75 to 40%; $P < .01$) but remained similar in C and GC (avg 81%), whereas the cover by grass species increased ($P < .01$) in the grazed pastures. Results indicated that controlled grazing improved mountain pastures, and that grazing goats with cattle was especially beneficial for the control of multiflora rose bushes and other woody species.

Key Words: Browse, Cattle, Goat, *Robinia pseudoacacia*, *Rosa multiflora*, *Rubus*, Vegetation Management

Introduction

Much of hill-land pasture in the Appalachian region of North Carolina is infested by brushy vegetation including multiflora rose (*Rosa multiflora* Thunb.). Multiflora rose was imported from Japan in 1886 for use in erosion control and as a rootstock for some varieties of ornamental roses (Mays and Kok, 1988). According to a 1977 survey by the North Carolina Department of Agriculture, multiflora rose had infested 58,514 ha of pastureland and an additional 18,480 ha of non-pastureland in 53 mountain and western counties. Since then, invasion of productive land by multiflora rose has increased, and in cases of heavy infestation, access to pasture and recreational areas has been severely restricted.

Controlling multiflora rose usually involved mechanical cutting and the use of herbicides. Multiflora rose seeds are widely dispersed by birds, rodents and water, and may remain viable in the soil for up to 20 years (Harvey, 1996). Consequently, an effective integrated manatement program is needed for years after controlling the original plants (Kay et al., 1995). Goats (*Capra hircus hircus*) have been useful as biological agents for the control of undesirable plants due to increased restrictions for herbicide use and elevated costs of other control methods such as mechanical cutting (Magadlela et al., 1995; Pearson and Martin, 1991).

Multiflora rose has been effectively controlled by goats (Luginbuhl et al., 1999). Integrating goats into grazying systems

1 Use of trade names in this publication does not imply endorsement by the North Carolina ARS of the products named or criticism of similar ones not mentioned.

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enables them to utilize the palatable brush as a feedstuff to produce a saleable commodity while suppressing the brush, resulting in greater grass production for cattle (Harrington et al., 1982). The inclusion of goats in a grazing system for mixed brush/grass pastures gave superior utilization compared to cattle alone (du Toit, 1972) by reducing brush competition and improving the pasture for cattle (Mackenzie 1993). The objective of this study was to investigate the effects of addition of goats to cattle grazing alone for controlling woody species and herbaceous vegetation in hill-land pastures.

Materials and Methods

A field study was conducted at the North Carolina Department of Agriculture and Consumer Services Research Station located in Waynesville at approximately 35.50° N latitude and 83.00° W longitude. Treatments were control (CTL), cattle alone (C) and goats with cattle (GC). There were three replicated pastures for each treatment with pastures being the experimental unit. Animals were rotationally grazed on the replicated pastures and the study was conducted over a four year period. The study site was an abandoned orchard (8.4 ha) that had been severely infested by multiflora rose and other woody vegetation. Over a four-year period, the area had been grazed by goats and larger trees had been removed by cutting. At the time this study started, the orchard had not been grazed for two years and multiflora rose and other brush had increased. The orchard, located on a Hayesville Loam soil, had slopes of 30 to 60%. The study site was fertilized each spring according to soil test results. Purebred and crossbred Boer bucks (43 kg initial BW) were used in 1996, whereas crossbred Boer does (30 kg initial BW) were used in subsequent years. Paddocks were grazed with crossbred Angus steers (260 kg initial BW) during the first three years of the study, and with Holstein steers (199 kg initial BW) in 1999. In 1996, the two groups of grazing animals were composed of 6 steers and 6 steers plus 9 goats. Because of the increased amount of forage growth in subsequent years, the number of steers was increased to 7 head, and the ratio of goats to cattle was increased to 2:1. During short periods of lush growth (2 to 3 wk), additional grazer animals (cattle and goats) were added. Grazers were removed when pasture availability was limited. Grazing periods were: 8 May to 24 September in 1996, 24 April to 10 November in 1997, 24 April to 2 September in 1998, and 15 April to 2 September in 1999. Due to drought, animals had to be removed from the paddocks from 1 August to 7 October 1997. Animals were grazed on adjacent mountain pastures during the 1997 drought period. Each paddock was fenced with six strands of electrified high tensile wire. All animals had free access to a low copper sheep mineral mix (SSC - 317803; Southern State Cooperative, Richmond, VA 23260). Water was supplied within each paddock. The GC and C paddocks were grazed on the same dates within each replication. The two groups of animals (goats + cattle grazing together and cattle grazing alone) were rotated to the next replicated paddocks when the average available forage present was approximately 5 cm or less.

Multiflora Rose and Black Locust Measurements

Random multiflora rose bushes were tagged to monitor the effects of browsing on plant survival, approximately 5 plants in each CTL and 10 for each grazed paddock. Measurements were taken spring and fall immediately before and after each grazing season. Tagged rose bushes were identified as individual plants or as a clump of contiguous plants. Tagged rose bushes were scored for canopy height, canopy area covered by live canes (stems), and the percent of canes which were live relative to the total number of existing canes per individual plant or clump at each observation time. Height was determined by measuring the average canopy height. Canopy area was determined by measuring the diameter of the canopy in two directions for each tagged rose bush or clump of rose bushes.

Four squares measuring 3 x 3 m were marked with wooden pegs in each paddock for black locust (Robinia pseudoacacia L.) measurements. The number of black locust clumps found within each square was recorded and the height of each clump measured to determine canopy height. Number of live black locust clumps relative to existing clumps were also recorded.

Herbaceous Plant Measurements

Species composition of herbaceous vegetation was estimated using permanently marked 100 x 10 cm rectangular quadrats (10 in the control and 30 in each grazed paddock). Plant species located within the 1,000 cm^2 rectangle were identified and recorded (Luginbuhl et al., 1999). Plant frequency was defined as the percentage of observation points within a given paddock that contained at least one plant of that individual plant species. In addition, percent vegetative ground cover and percent vegetative cover as grass were visually estimated within the rectangular area at each observation point. Measurements and visual observations were recorded spring and fall immediately before and after each grazing season.

Statistical Analyses

The experimental design was a randomized complete block with three agronomic replicates and a factorial arrangement of three grazing treatments (CTL, GC, and C) and two observation seasons (spring and fall). Treatment and season effects were tested by the GLM procedure of SAS (1998) using repeated measure variables generated by multiplying the original data by linear coefficients for orthogonal comparisons in four equally spaced years. Data from year 1, 2, 3, and 4 were multiplied by -3, -1, +1 and +3, respectively (Steel et al., 1997), then summed. The model used was Y= u + replicate + treatment + season + treatment x season + error. Pre-planned orthogonal contrasts (Steel et al., 1997) were used as follows to determine differences among treatments: 1) CTL vs GC and C and 2) GC vs C.

Figure 1. Effect of grazing mountain pastures in the Appalachian region of North Carolina with cattle alone or with goats and cattle on multiflora rose height (m) during four grazing seasons. Orthogonal contrasts: control vs cattle and goats + cattle (P < .01); cattle vs goats + cattle (P < .01); SE = .28.

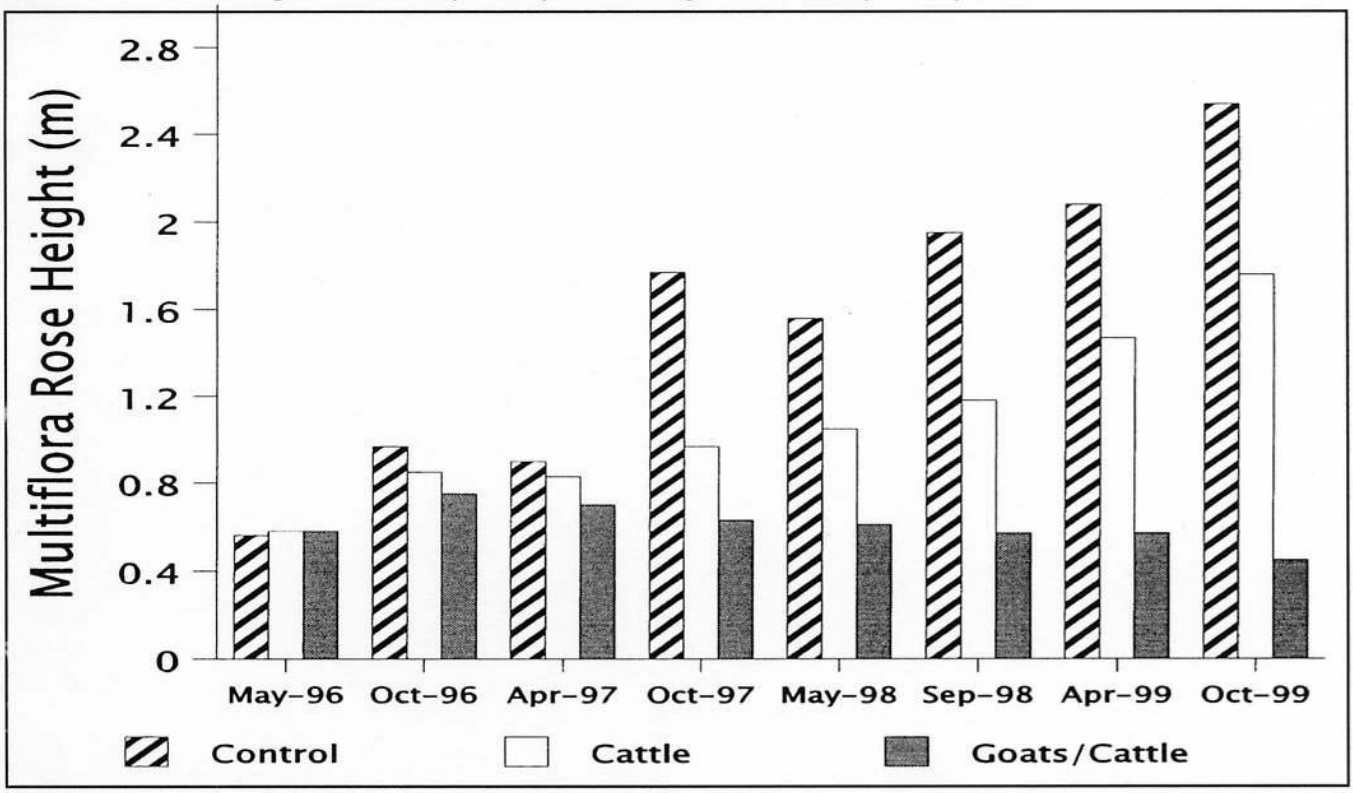
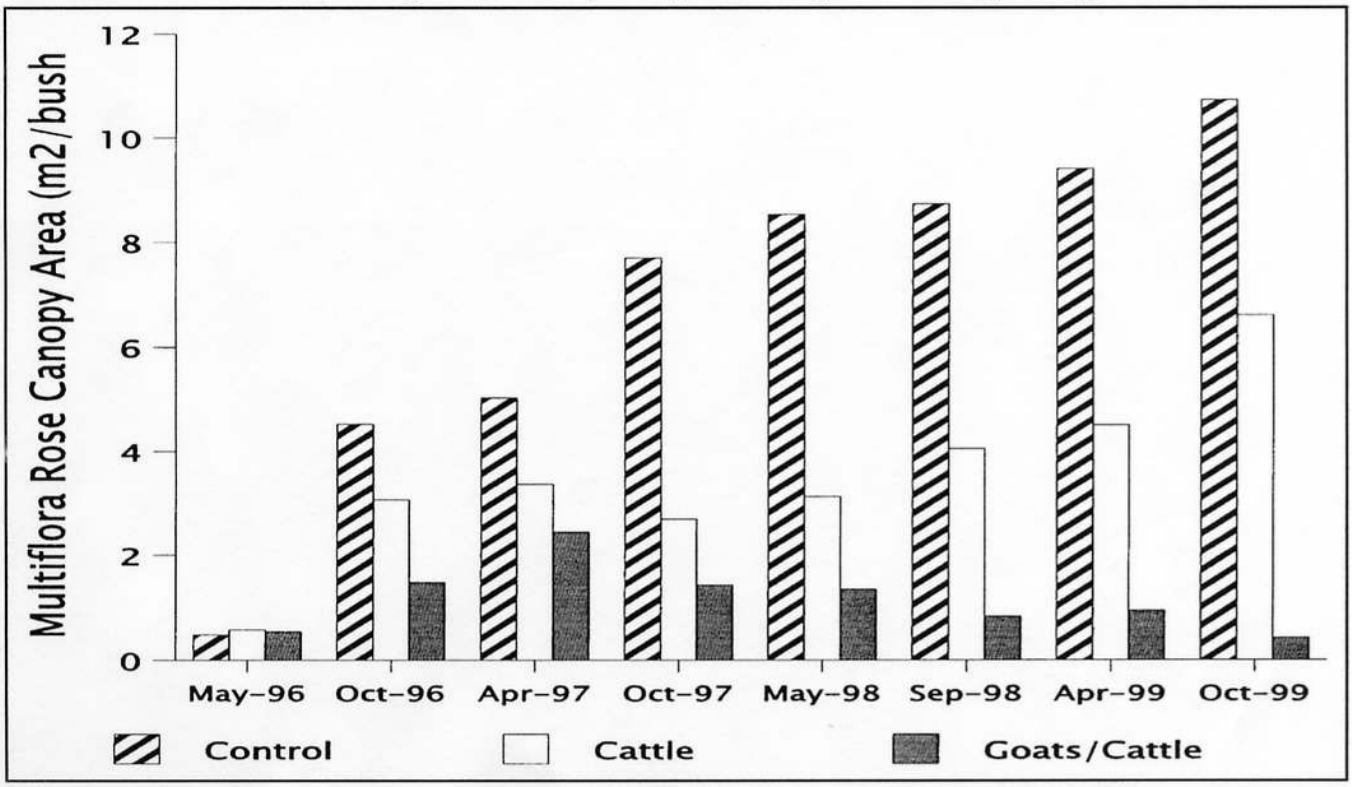


Figure 2. Effect of grazing mountain pastures in the Appalachian region of North Carolina with cattle alone or with goat and cattle on multiflora rose canopy area (m2/bush) during four grazing seasons. Orthogonal contrasts: control vs cattle and goats + cattle (P <.01); cattle vs goats + cattle (P < .03); SE = 2.5.



Results and Discussion

Multiflora Roses, Black Locust and Brambles

When grazed with cattle, goats were very effective in controlling multiflora rose bushes. The effects of repeated defoliation by goats on multiflora rose canopy area and height were clearly observed by October 1996 and October 1997, respectively (Figures 1 & 2). Multiflora rose canopy area declined steadily from 2.5 m^2 in April 1997 to .4 m^2 ($P < .01$) in October 1999 in the GC pasture, whereas multiflora rose height decreased at a slower rate, from .8 m in October 1996 to .5 m in October 1999 ($P < .01$). Conversely, over the four grazing seasons multiflora rose height and canopy area increased linearly ($P < .01$) in both CTL and C pastures, but the rate of increase was slower in the C pasture. In the CTL pasture, height and canopy area of multiflora roses bushes increased, respectively, from .6 m and .5 m^2 in May 1996 to 2.5 m and 10.7 m^2 in October 1999 ($P < .01$). Respective increases in height and canopy area for the C pasture were from .6 m and .6 m^2 in May 1996 to 1.8 m and 6.6 m^2 in October 1999 ($P < .01$). Occasional browsing of multiflora roses bushes by cattle and trampling around the bushes during grazing most probably reduced multiflora rose growth. After four grazing seasons, only 41% of multiflora rose canes were still alive in the GC pastures, compared to 95.5% in both CTL and C pastures ($P < .02$; data not shown). The reduction in height, canopy area and number of live canes of the multiflora rose bushes in the GC pastures after four growing seasons indicated that their condition was severely affected. Luginbuhl et al. (1999) observed a greater degree of mortality in multiflora rose by C and GC resulting in a 100 and 92% mortality of the canes at the end of the fourth year. Spring and summer are critical browsing times to reduce woody vegetation, whereas browsing after 1 August has very limited impact (W. B. Bryan, personal communication). Grazing cattle alone or with goats had a similar effect on black locust height (Figure 3). Repeated defoliation by goats and(or) cattle very effectively controlled the height of black locust trees, whereas in the CTL pasture black locust trees increased in height from 1.4 m in May 1996 to 5.3 m in October 1999. After four grazing seasons, 0% of the black locust clumps were found alive in the GC pasture, and only 25% were alive in the C pasture (data not shown); by contrast, 100% of the black locust clumps were alive in the CTL pasture ($P < .08$). Cattle have been categorized as non selective roughage grazers (Hoffman, 1985), but in the present study they were repeatedly observed defoliating the tender shoots of black locust trees. When given the opportunity or need, cattle will alter their eating behavior and become opportunistic browsers.

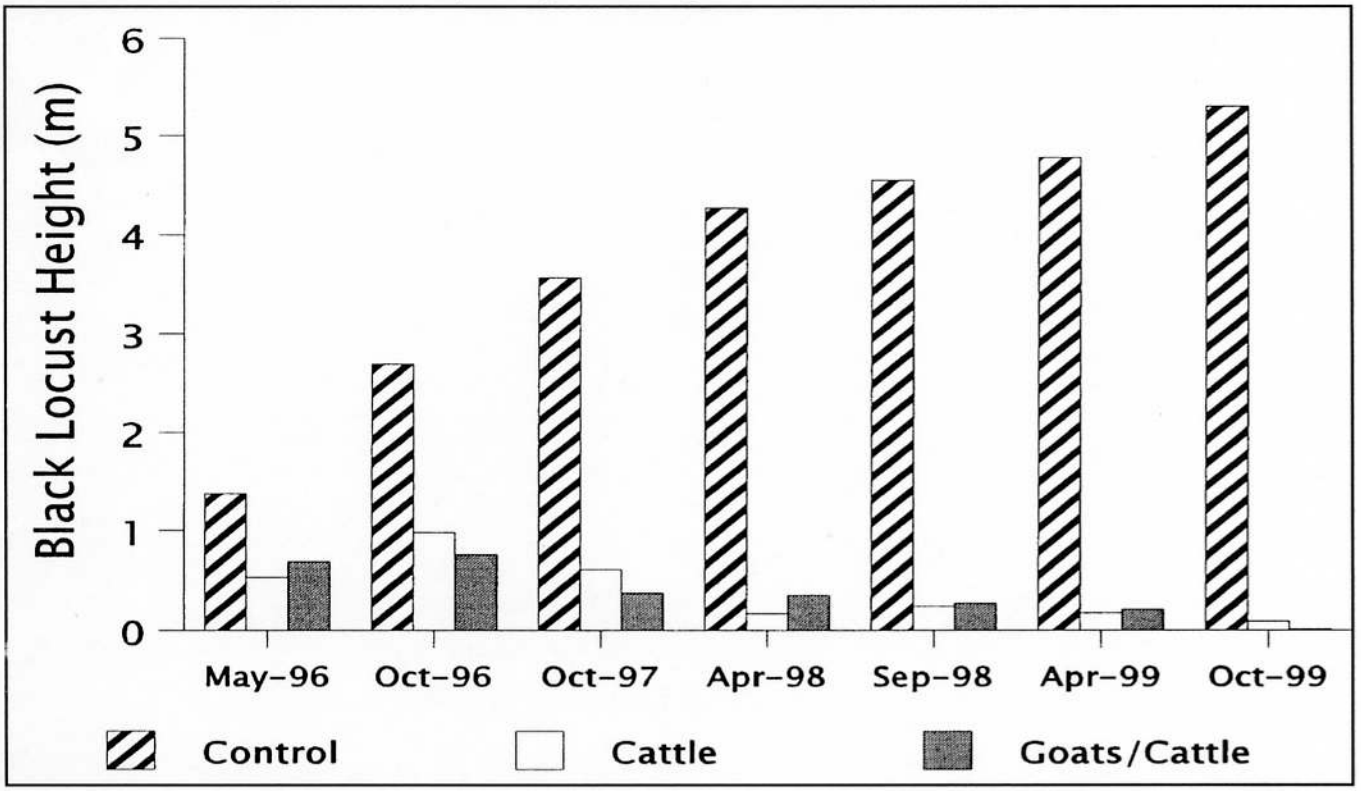
Goats grazing with cattle and cattle grazing alone were also very effective in controlling brambles (*Rubus* spp.). Brambles were grazed to a similar extent in both GC and C pastures (Figure 4), whereas their frequency in CTL increased from 6.7 % in October 1996 to 79.6% in October 1999 ($P < .01$). The low frequency of brambles in April 1997 in all pastures cannot be explained. Decreases in the frequency of brambles similar to those observed in CTL in April 1997 were reported by Luginbuhl et al. (1999). Research in West Virginia has shown that brambles were reduced from 39 to 9% by grazing hill-land pastures with cattle, sheep and goats (Mills and Bryan, 1983). In that study, goats and sheep defoliated brambles 100% the first year and controlled the number and height of regrowth shoots adequately the second year. The same authors also reported poor defoliation and control of brambles regrowth by cattle. In the present study, brambles were young and consisted mostly of green and tender shoots, and thus may have been more palatable to cattle than older plants.

Goats choose the most nutritious parts and portions of plants and given a choice among grasses, forbs and shrubs, they usually prefer high shrub diets (Wilson et al., 1975; Bryant et al., 1979). Grazing on a power line right of way, goats reduced brush cover from 45 to 15% in one year, and to 2% after five years of grazing (Magadlela et al., 1995). Selective feeding and a strong preference for browse (Norton, 1984) allows goats to reduce variations in dietary energy and protein caused by environmental conditions or management (Fedele et al., 1991). Because of their versatile grazing/browsing behavior, goats are able to successfully control encroaching vegetation while at the same time selecting a diet that meet their nutritional requirements (Child et al., 1985). This opportunistic behavior has served goats well in situations where other domestic ruminant species would be at a clear disadvantage or even nutrient deficient (Coblentz, 1977; Mackenzie, 1993).

Herbaceous Plants

Thirty-four of the 58 plant species recorded at the permanent transect sites occurred with a frequency of 15% or more during the course of the four grazing seasons. These plants were bluegrass (*Poa pratensis* L.), bromegrass (*Bromus* L. spp.), chickweed (*Stellaria* L. spp.), crabgrass (*Digitaria sanginalis* L.), dandelion (*Taraxacum officinale* Weber in Wiggers), tall fescue (*Festuca arundinacea* L. Schreb.), geranium (*Geranium* L. spp.), goldenrod (*Solidago canadensis* L.), greenbriar (*Smilax rotundifolia* L.), honeysuckle (*Lonicera japonica* Thunberg.), horsenettle (*Solanum Carolinense* L.), mint (*Mentha* L. spp.), mullein (*Verbascum thapsus* L.), mustard (*Brassica kaber* spp.), nimblewill (*Muhlenbergia schreberi* J.F. Gmel), orchardgrass (*Dactylis glomerata* L.), oxalis (*Oxalis stricta* L.), poison ivy (*Toxicodendron radicans* [L.] Kuntz), red clover (*Trifolium pratense* L.), red fescue (*Festuca rubra* L.), redtop (*Agrostis stolonifera* L.), smartweed (*Polygonum pensylvania* L.), sweet vernal grass (*Anthoxanthum odoratum* L. spp.), velvetgrass (*Holcus lanatus* spp.), violet (*Viola* L. spp.), white clover (*Trifolium repens* L.), wild clematis (*Clematis virginiana* L.), and wild strawberry (*Fragaria virginiana* Duchesne). Of those, the most prevalent plants were three important forage species (bluegrass, tall fescue and white clover), dan-

Figure 3. Effect of grazing mountain pastures in the Appalachian region of North Carolina with cattle alone or with goats and cattle on black locust height (m) during four grazing seasons. Orthogonal contrasts: control vs cattle and goats + cattle (P < .01); cattle vs goats + cattle (P < .87); SE = .41.



delion (a low productivity species consumed by G and C), sweet vernal grass (a grass species not readily consumed by either G or C following stem elongation), horsenettle and nimblewill (undesirable species not consumed by either G or C), and honeysuckle (consumed by C and relished by G). Sweet vernal grass and nimblewill were observed at higher frequencies than the other undesirable species.

Over the four grazing seasons, the vegetative ground cover was similar (avg 89.6%) in both the GC and C pastures (Figure 5). Vegetative ground cover in the CTL pasture followed the same trend during the first two grazing seasons, but decreased thereafter, from 97.1% in April 1998 to 66.3% in October 1999 (P < .01). The cover from herbaceous grass species remained the same (Figure 6) in both the GC and C pastures (avg 81%). Conversely, cover from herbaceous grass species decreased linearly in the CTL pasture, from 78% in May 1996 to 39% in October 1999 (P < .01). The shift in both vegetative ground cover and botanical composition in the CTL pasture was attributed to the overstory of brush, trees and rose bushes that shaded out herbaceous vegetation on the ground. A similar shift in botanical composition was observed by Luginbuhl et al. (1999), which allowed desired grasses to be more competitive.

Bluegrass frequency declined in CTL (Figure 7) compared to the GC and C pastures (P < .01), and was absent from CTL in September 1998 and April 1999. Grazed treatments had a similar frequency of bluegrass (avg 50.1%) with the GC treatment tending to have a lower frequency. Bluegrass, a cool-season grass, was strongly seasonal (P < .01) being observed at a higher frequency in spring than fall. Bluegrass frequency declined in CTL (Figure 7) until it nearly disappeared from the pasture. Tall fescue frequency was high in all pastures (Figure 8) and did not change during the course of the study (avg 77.2%). Although present (P < .01), the clear seasonality exhibited by bluegrass was not observed for tall fescue. White clover played a minor role in CTL (P < .02) where it was only observed in spring and fall 1996 and spring 1999 (Figure 9). Lack of sunlight at the ground level resulting from the natural successional reforestation process in the CTL pasture did not seem to affect tall fescue as much as bluegrass or white clover. In GC and C pastures, white clover frequency was similar (avg 55%) and exhibited no seasonality, but it had a tendency to be lower in GC than C pastures. Increasing the goat component of pastures grazed with different ratios of goats to sheep increased white clover frequency (Lambert et al., 1987) because goats preferred not to graze white clover. Luginbuhl et al. (unpublished) observed that goats readily ate white clover to a very short stubble at fence lines indicating that goats consume significant clover. Sweet vernal grass was present in the grazed pastures from the start of the second grazing season (Figure 10) and exhibited a strong spring seasonality (P < .01), but played a

Figure 4. Effect of grazing mountain pastures in the Appalachian region of North Carolina with cattle alone or with goats and cattle on brambles frequency (%) during four grazing seasons. Season (P < .01). Orthogonal contrasts: control vs cattle and goats + cattle (P < .01); cattle vs goats + cattle (P < .5); SE = 5.0.

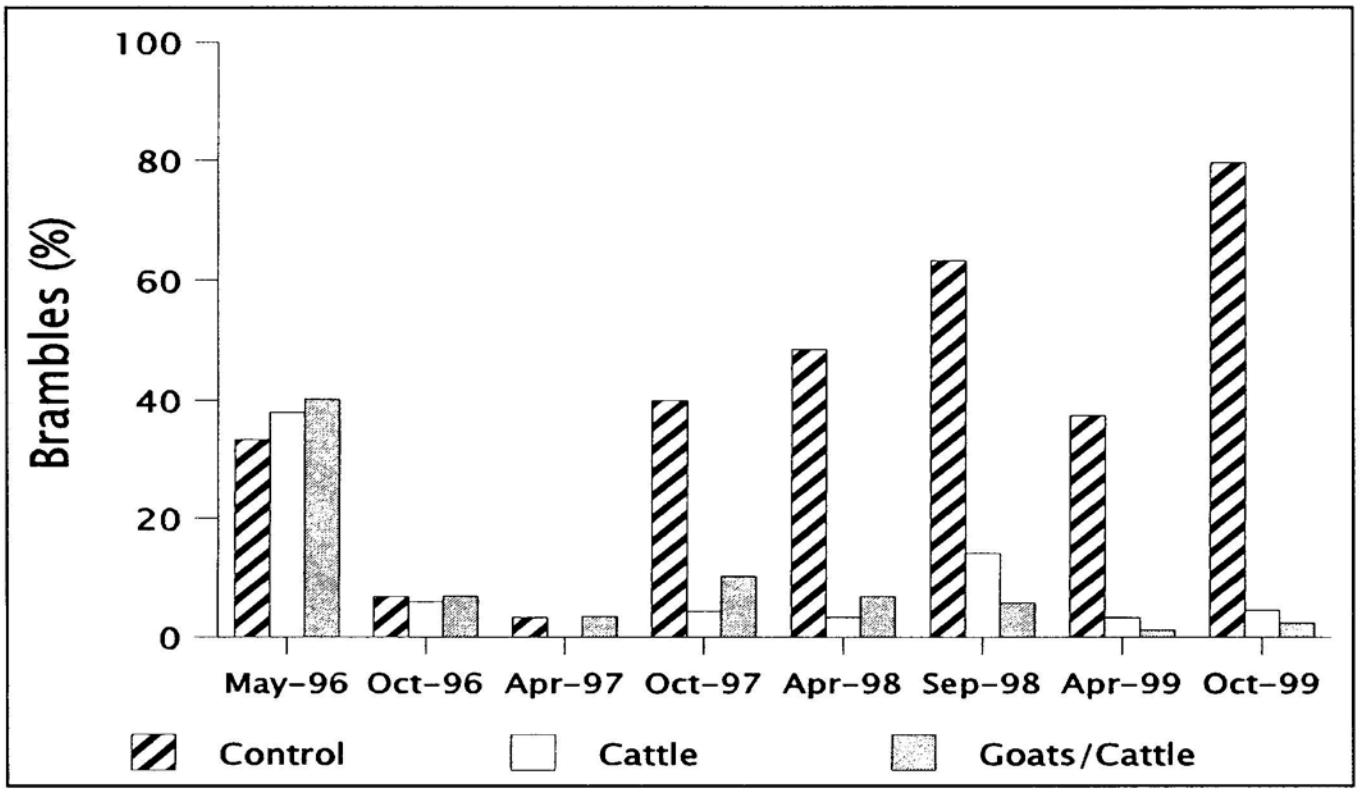


Figure 5. Effect of grazing mountain pastures in the Appalachian region of North Carolina with cattle alone or with goats and cattle on percent vegetative ground cover during four grazing seasons. Orthogonal contrasts: control vs cattle and goats + cattle (P <.01; cattle vs goats + cattle (P < .1); SE = 3.9.

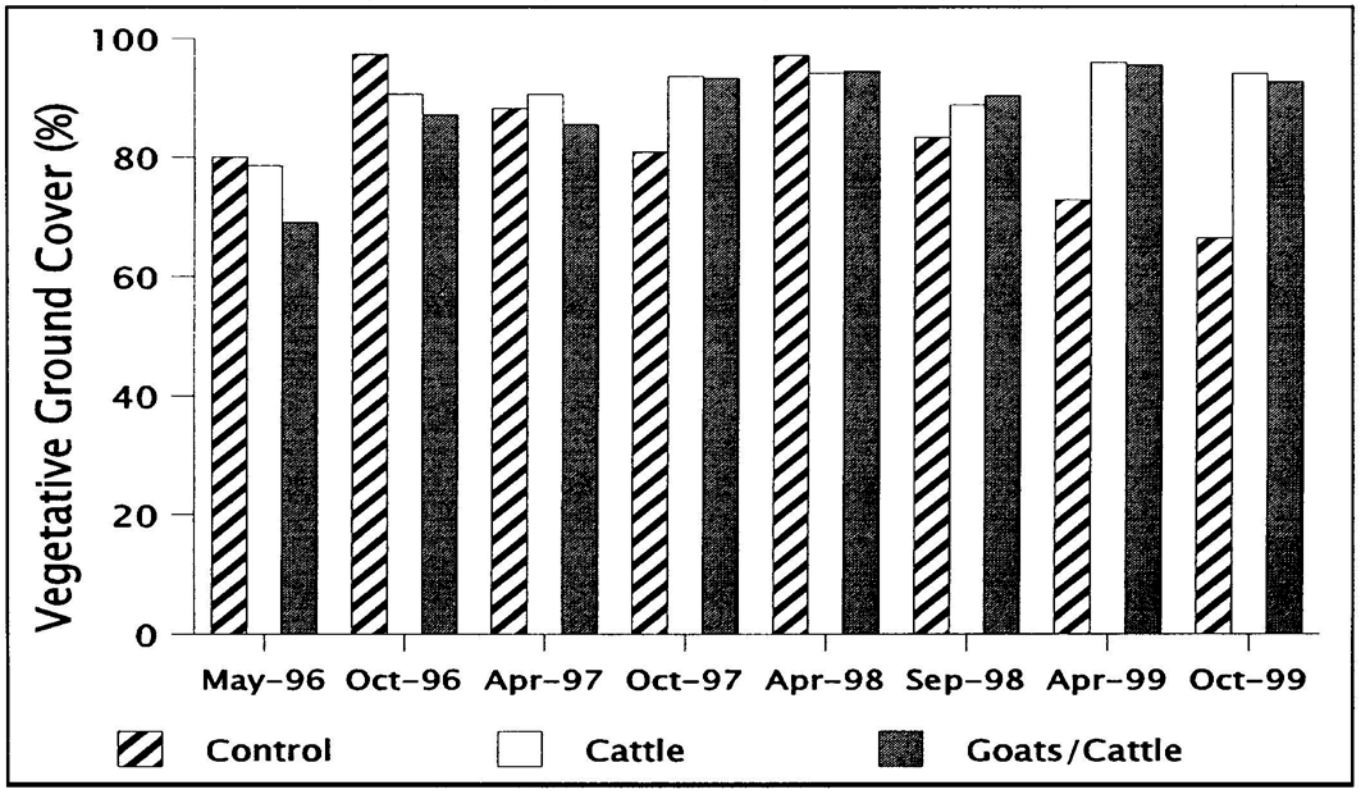


Figure 6. Effect of grazing mountain pastures in the Appalachian region of North Carolina with cattle alone or with goats and cattle on herbaceous grass species % during four grazing seasons. Orthogonal contrasts: control vs cattle and goats + cattle (P < .01); cattle vs goats + cattle (P < .5); SE = 6.4.

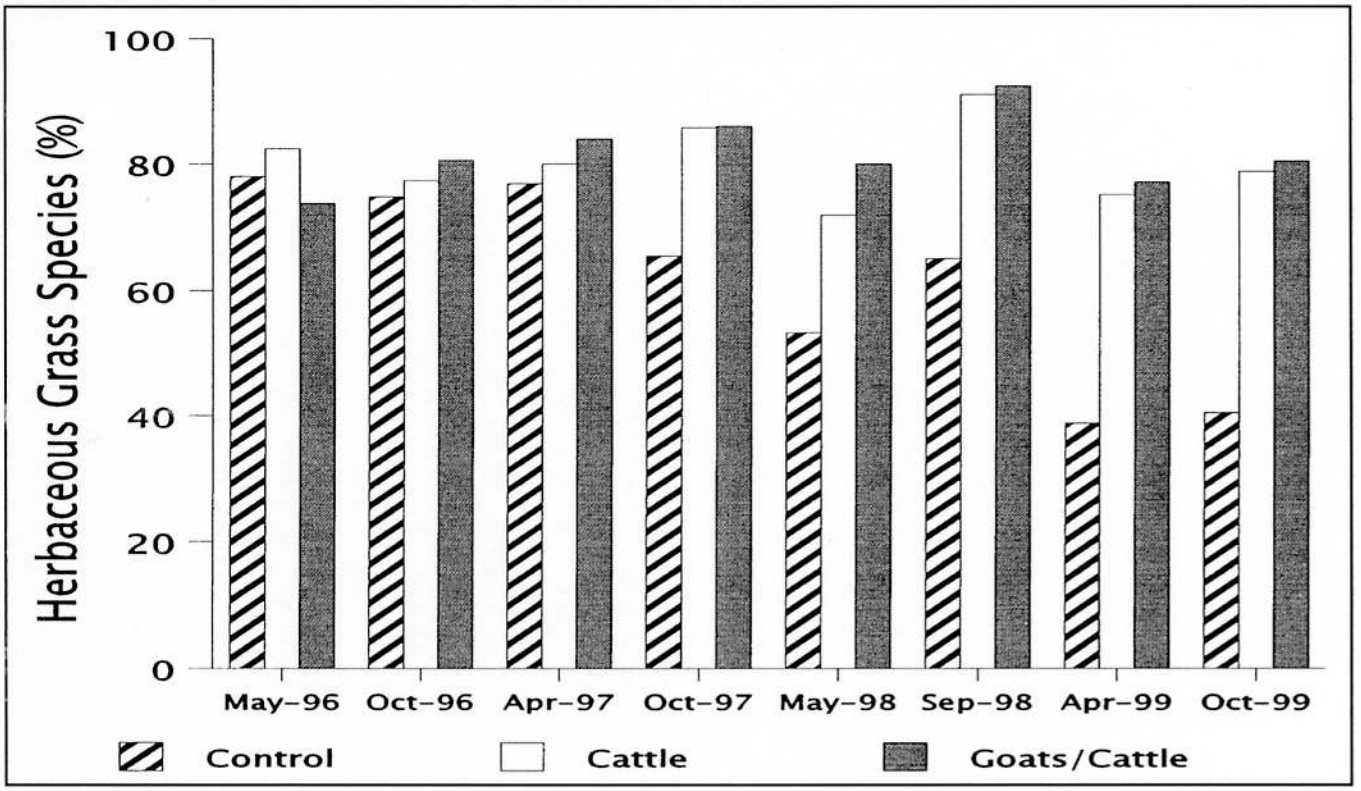


Figure 7. Effect of grazing mountain pastures in the Appalachian region of North Carolina with cattle alone or with goats and cattle on bluegrass frequency (%) during four grazing seasons. Season (P < .01). Orthogonal contrasts: control vs cattle and goats + cattle (P < .01); cattle vs goats + cattle (P < .4); SE = 8.8.

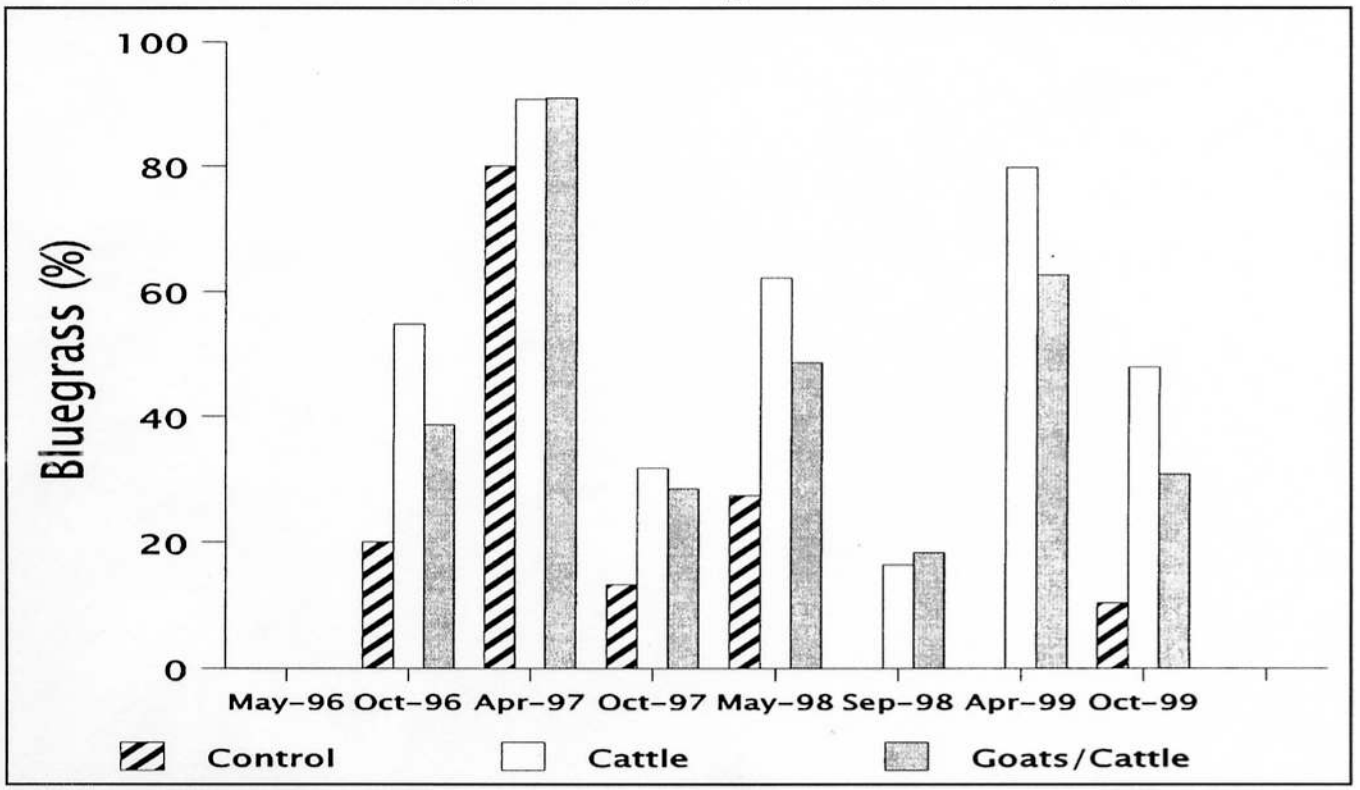
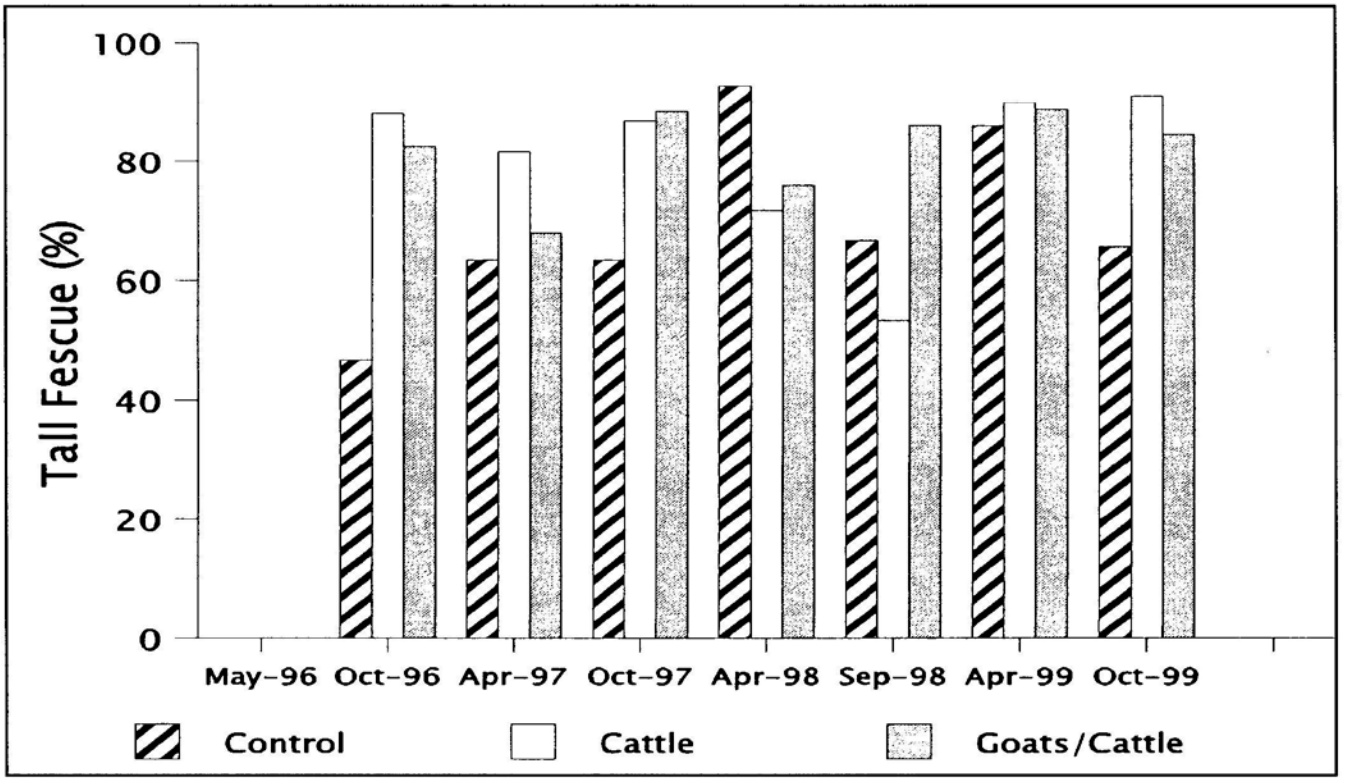


Figure 8. Effect of grazing mountain pastures in the Appalachian region of North Carolina with cattle alone or with goats and cattle on tall fescue frequency (%) during four grazing seasons. Season (P < .01). Orthogonal contrasts: control vs cattle and goats + cattle (P < .3); cattle vs goats + cattle (P < .7); SE = 12.2.



minor role in the CTL compared to the grazed pastures (P < .01). In addition, sweet vernal grass was observed at lower frequencies in GC than C pastures (P < .03). Sweet vernal grass has been invading hay fields in the mountains of North Carolina in recent years and it is rejected by hay-fed cattle.

Unproductive weed species are shown in Table 1. Nimblewill exhibited a strong seasonality pattern (P < .02), and was always observed at higher frequencies in fall than spring. However, no treatment difference was observed during the course of the study. Nimblewill is not considered a preferred grass by either goats or cattle, and increased nimblewill frequencies in pastures grazed with goats alone or with goats and cattle have been reported at this same site (Luginbuhl et al., 1999). The decline in nimblewill frequency observed during the course of the study may be due to increased shading in the CTL pasture and competition from other herbaceous species in the grazed pastures. Honeysucke was controlled to a similar extent in both the GC and C pastures where its frequency remained low. Conversely, honeysuckle increased in frequency in the CTL pasture (P < .01) because it tolerates shade. Dandelion was only present in the CTL pasture in April 1998 and April 1999. Dandelion frequency remained fairly similar in GC and C pastures, and higher than in the CTL pasture (P < .03). In the grazed pastures, dandelion was observed at higher frequencies in spring than fall (P < 01).

Horsenettle, a perennial broadleaf weed that spreads by creeping rhizomes, adventitious shoots from roots, and seeds (Uva et al., 1997), was absent from all pastures in spring except for a very low frequency observed in the C pasture in April 1998 and April 1999. Conversely, horsenettle was always present when fall measurements were made. It is possible that measurements were taken in spring before the emergence of horsenettle. Horsenettle frequency decreased with time in the CTL pasture, whereas the opposite occurred in the grazed pastures (P < .01). Horsenettle is not readily consumed by livestock, although goats and also cattle have been observed to occasionally nibble on horsenettle leaves, and consequently it can spread with little interference. This weed seems to be increasing in North Carolina pastures that are grazed on a regular basis.

The reduction in multiflora rose, black locust and other browse on pastures grazed by goats indicates that goats selected considerable woody species as shown by Merrill and Taylor (1981) and Malecheck and Provenza (1981). However, reports on botanical species changes over time due to grazing by goats and(or) cattle are limited. Grazing brush-infested pastures with different ratios of goats and sheep increased grasses and white clover populations (Clark et al., 1982; Yerex, 1986). Similarly, brush-infested mountain pastures grazed by goats alone or by goats and cattle grazing together showed increased overall vegetative ground cover and vegetative ground cover as grass, increased frequencies of bluegrass,

Figure 9. Effect of grazing mountain pastures in the Appalachian region of North Carolina with cattle alone or with goats and cattle on white clover frequency (%) during four grazing seasons. Orthogonal contrasts: control vs cattle and goats + cattle (P < .02); cattle vs goats + cattle (P < .2); SE = 9.2.

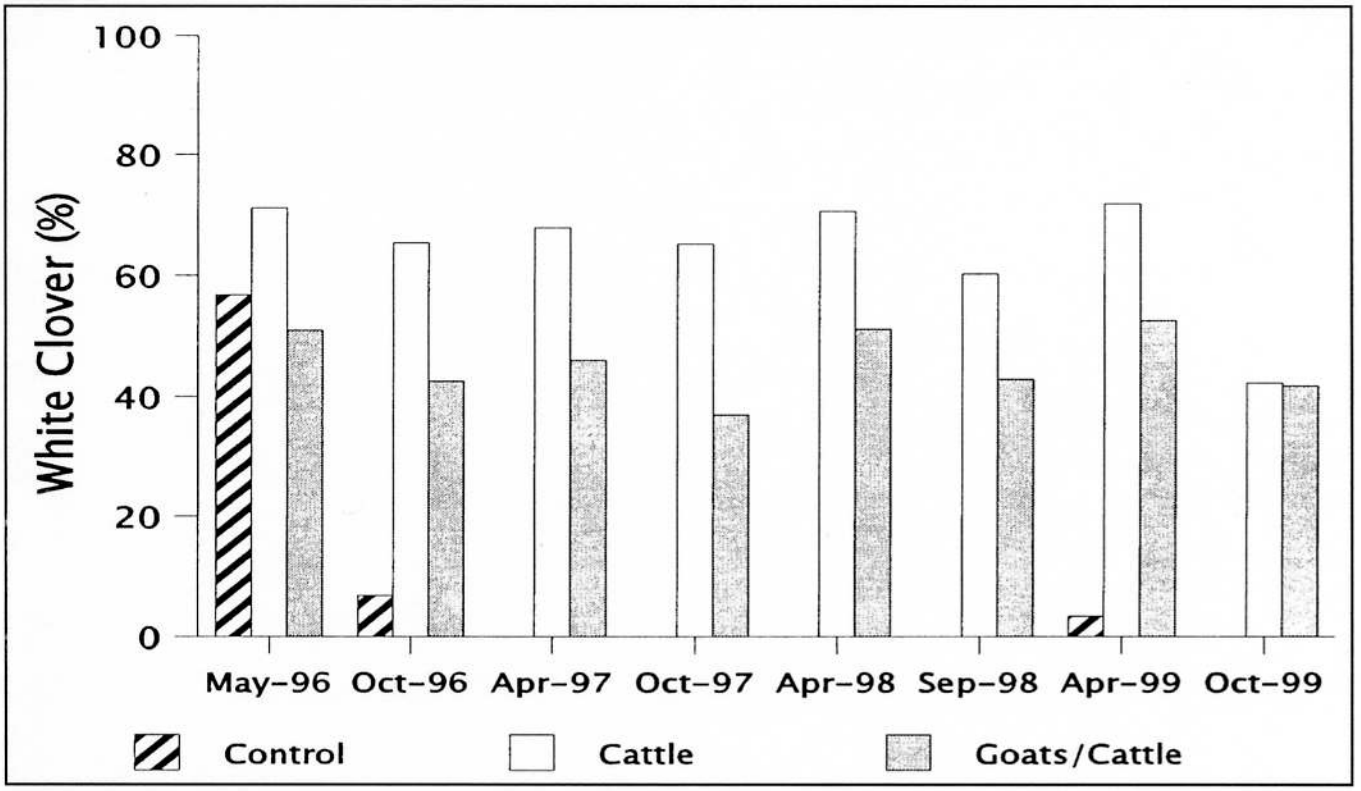


Figure 10. Effect of grazing mountain pastures in the Appalachian region of North Carolina with cattle alone or with goats and cattle on sweet vernal grass frequency (%) during four grazing seasons. Season (P < .01). Orthogonal contrasts: control vs cattle and goats + cattle (P < .01); cattle vs goats + cattle (P < .03); SE = 5.0.

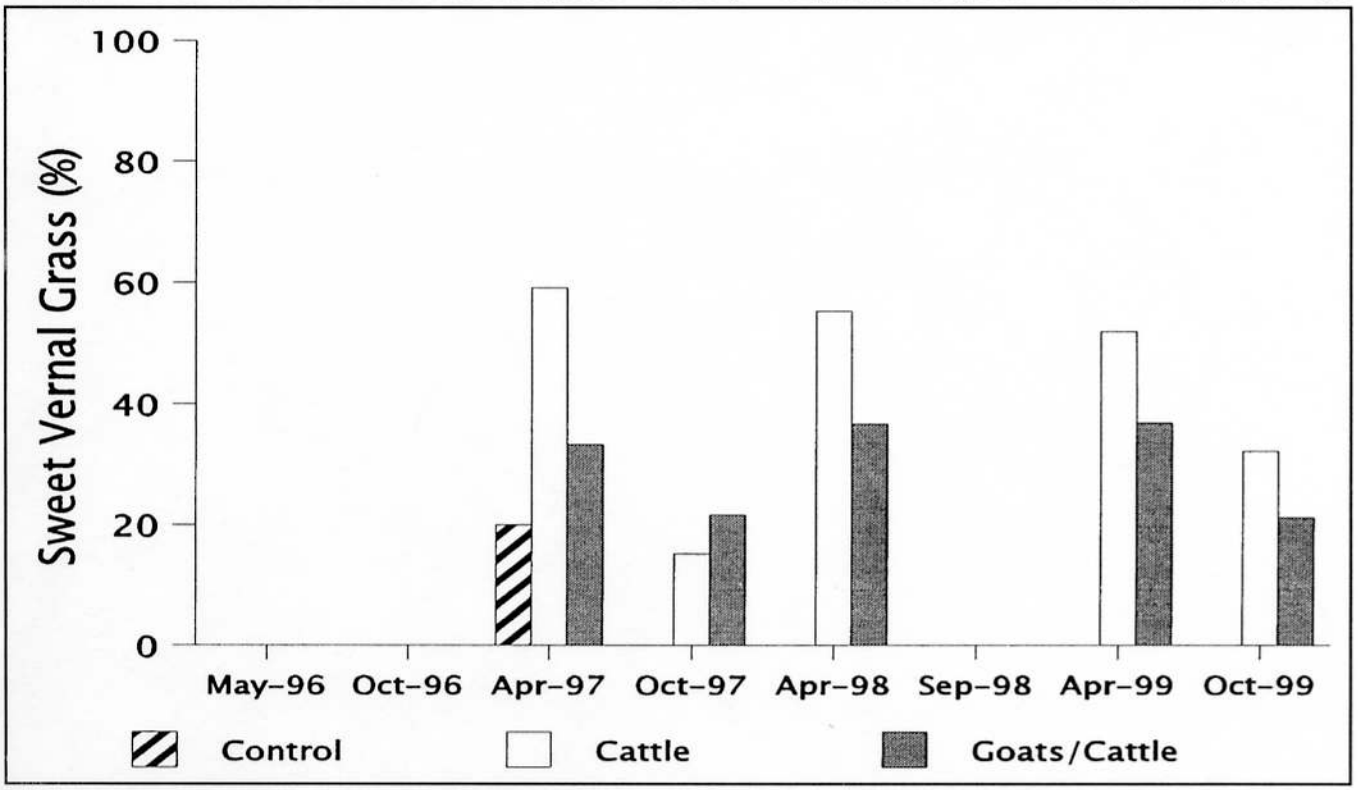


Table 1. Effects of grazing mountain pastures in the Appalachian region of North Carolina with cattle alone or with goats and cattle on four unproductive weed species frequency during four grazing seasons.

Frequency, %	May 1996			Oct 1996			Apr 1999			Oct 1999				CTL vs C & GC[a]	C vs GC[b]	Season
	CTL	C	GC	CTL	C	GC	CTL	C	GC	CTL	C	GC	SE[c]	P <	P <	P <
Nimblewill	0	0	0	77	44	53	0	1.1	1.2	37	19	31	11	.23	.77	.02
Honeysuckle	0	0	0	17	4.1	16	52	6.7	9.7	35	5.7	5.6	6	.01	.38	.01
Dandelion	0	0	0	0	16	23	3.3	35	41	0	30	25	7	.03	.92	.01
Horsenettle	0	0	0	33	13	3.4	0	1.1	0	6.7	36	23	6	.01	.5	.09

[a]Orthogonal contrast: Control vs cattle and goats+cattle.

[b]Orthogonal contrast: Cattle vs goats + cattle.

[c]Standard error derived from the statistical model.

tall fescue and white clover, and decreased frequencies of poison ivy, honeysuckle, nimblewill and wild strawberry (Luginbuhl et al., 1999). In addition, the same authors reported dramatic reductions in multiflora rose height, density, leaf out, and in the percentage of live multiflora rose canes.

Conclusions

The results of this experiment demonstrated that goats grazing with cattle or cattle grazing alone were effective in shifting botanical composition toward desirable forage species in overgrown mountain pastures. Goats effectively reduced the encroachment of mountain pastures by multiflora rose bushes and other woody species. Because multiflora rose is a persistent weed and difficult to eradicate, it would be beneficial to integrate goats into mountain grazing systems to maintain or improve pasture productivity. Manipulating goat numbers to strike a balance between grazing livestock and the plant community would be worth investigating. Woody species would provide a continuing source of palatable and nutritious browse for goats but could be controlled to minimize the loss of more favorable forage species preferred by other livestock species.

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