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Brush Clearing on Hill Land Pasture with Sheep and Goats

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Abstract

Much hill land pasture in the Appalachians is brush infested. Reclamation procedures which are low cost and require low input are needed to provide hill land pasture owners with ways to maintain production on these lands. A field experiment was carried out to evaluate the effectiveness of grazing either sheep (*Ovis* sp.) or goats (*Capra* sp.) separately or in combination for brush clearing on hill land pasture. Cutting or herbicide followed by grazing with sheep or goats were also compared. The experiment was conducted on a 1.8 ha powerline right of way for five years (1986 to 1990). Goats reduced brush cover from 45 % to just over 15 % in one year. Sheep took 3 years to bring about the same result. Cutting and herbicide application increased animal effectiveness, primarily that of sheep, but increased costs. Three year variable costs for brush clearing with goats were estimated at $33 ha^{-1}, sheep cost was $262 ha^{-1}, while cutting costs were $133 and herbicide $593 ha^{-1}. Brush was cleared more cost effectively and rapidly by goats, but at the end of 5 years all treatments reduced brush cover to 2 %.

Key words: Biological control, scrub, mechanical control, herbicide, cutting, costs, pasture renovation, range reclamation

Introduction

Much of the hill land in the Appalachian region was cultivated in the earlier part of the 20th century. In 1940, West Virginia had almost 3.5 million ha of land in farms, of which 1.5 million ha were in cropland (TEMPLETON 1963). Soil erosion and socioeconomic pressures resulted in a change from cropland to pasture and woodland so that by 1959 only 2.5 million ha of land were in farms with only 0.7 million ha in cropland. At the present time many acres of hill land pasture in the Appalachians are poorly managed and have been invaded by brush. Renovation of these pastures at low economic and environmental cost and the integration of them into sustainable farming systems is the

goal that prompted the research reported in this paper.

Clearing of brush and subsequent control with animals has been reported in the U.S. and other countries. A two-year study conducted in Oregon showed that sheep could be used to control *Acer circinatum* Pursh., *Rubus parviflorus* Nutt., and *Rubus ursinus* Cham. & Schlecht. in coastal Douglas-fir forests. Brush made little or no regrowth following grazing while grasses recovered soon after sheep were removed (SHARROW et al. 1989). In temperate hill land pasture of Northwestern Spain, researchers obtained good control of *Ulex europaeus* L. at a stocking rate of 14 sheep ha^{-1} (for 15 weeks of the growing season) (SINEIRO 1982). In Australia, goats were used to clear

Table 1. Principal plants in the study site

Shrubs and Trees	Solanum carolinensis L.
Rubus spp.	Poa pratensis L.
Robinia pseudacacia L.	Festuca pratensis Huds.
Smilax rotundifolia L.	Mentha spp.
Acer spp.	Verbascum blattaria L.
Quercus spp.	Danthonia spicata L.
Populus spp.	Rumex acetosella L.
Hypericum prolificum L.	Lespedeza cuneata (dumont) G. Don.
Rhus typhina L.	F. arundinacea Shreb.
Herbaceous	Cirsium spp.
Medicago lupulina L.	Holcus lanatus L.
Andropogon virginicus L.	T. repens L.
Potentilla spp.	Lysimachia quadrifolia L.
Solidago spp.	Achillea millefolium L.
Trifolium agrarium L.	

land heavily infested with *Rubus fruticosus* L. at stocking rates of 7 to 12 goats ha⁻¹ (DELLOW et al. 1988). Six months after grazing, brush plants less than 1 m high were dead. The use of goats in this study was cost-effective and vegetative ground cover was maintained at over 75 %. In New Zealand, goats severely defoliated *U. europeus*, eliminated *Juncus* spp., and killed *Leptospermum scoparium* J.R. and G. Forst. (LAMBERT et al. 1983).

MILLS and BRYAN (1983) found that sheep or goats defoliated brush in West Virginia as effectively as cutting or herbicide over 2 years. WOOD (1987) observed that goats took 1 year while sheep or cattle took 2 years to reduce brush in Vermont. Mixed grazing by goats and sheep more effectively reduced gorse in New Zealand to negligible levels under rotational grazing than either goats or sheep grazing alone after 3 years (RADCLIFFE 1985). In a subsequent study, sheep combined with goats controlled gorse even under set stocking. The choice of set stocking or rotational grazing did not seem to play a significant role in gorse control.

Few studies have been conducted on the use of animals for brush management on Appalachian hill land pastures. Furthermore, no studies have evaluated costs of using goat and sheep grazing vs. managing brush with conventional methods in this region. Therefore, the objectives of this study were to 1) compare sheep grazing alone, goats grazing alone, cutting or herbicide for brush clearing; 2) determine the effectiveness of sheep, and sheep combined with goats for brush control subsequent to clearing; and 3) evaluate the costs associated with the brush clearing methods.

Materials and Methods

Site Description

The experiment was carried out from 1986 to 1990 on a powerline right-of-way on a farm near Morgantown, West Virginia. Soils were Westmoreland (fine-loamy, mixed, mesic Typic Fragiudalfs) and Clarksburg (fine-loamy, mixed, mesic Ultic Hapludalfs) series. Vegetation on the site was controlled chemically prior to 1978 by the power company. The power company only kept the vegetation from reaching the wires. Over the years, cattle grazing an adjoining pasture had free access to the study site but about 50 % of the area was not penetrated by the animals due to dense brush that was 1.25 m tall on average.

The area was about 1.8 ha, had an average of 14 % slope (range 0—65 %), and a northeast aspect. Brush was defined as woody species and included several shrubs and invading hardwood trees (Table 1). All other vegetation was defined as herbaceous and the primary species included six grasses, and many weedy forbs and legumes.

Experimental Design

Phase 1 — Years 1, 2 and 3
The site was divided into 12 1500 m² (44 m × 34 m) plots using 4-wire, high tensile electric fence. Two animal treatments (either goats or sheep) were randomly assigned to each plot with three replications. In addition, another complete block was employed

with the same treatments providing a total of six replications for each treatment.

Each 1500 m² plot was grazed rotationally with either 3 Suffolk cross sheep (dry ewes) or 3 Toggenburg/Saanen goats (2 dry does and 1 mature wether). No mixed grazing was done during Phase I. Each 1500 m² plot was divided into 4 equal parts with polywire electric fence and animals were rotated on each part for 3 to 10 days. Sheep weighed an average of 60 kg and goats 45 kg (animals were weighed on and off experiment).

Before starting the animal grazing treatments, four small areas of 50 m² each (5 m × 10 m) were established in one quarter of each 1500 m² plot and randomly assigned the following treatments: 1) control, fenced so that no grazing was allowed; 2) cut plot, all the vegetation cut once (not removed) at the start of the experiment in August of 1986 at 6.4 cm with a 'Mountain Goat' sickle-bar mower[1], 3) herbicide, 1.5 % solution of Crossbow[1] (2, 4-D plus triclopyr) applied once to the brushy plants in August 1986 (2 days before grazing was initiated); 4) grazed as described by the animal grazing treatments. Cut, herbicide-treated, and grazed small plots were grazed at the same time in each cycle. Cutting or herbicide application were done only at the start of the experiment and were not repeated.

Phase II — Years 4 and 5
In 1989, fences splitting the 1500 m² plots into quarters were removed and each of the 12 plots were divided and fenced into halves. In each plot, half was randomly assigned to sheep alone and the other to a mixture of sheep and goats. Instead of small numbers of animals being assigned to each plot for the entire season as in Phase I, they were formed into two sheep and two goat flocks. On the mixed treatment plots, a sheep flock was put on half the plot when herbage mass was 1000 to 1500 kg ha⁻¹ and removed when herbage mass was 500 to 750 kg ha⁻¹. The sheep were able to remove this herbage in 1—4 days. The goat herd immediately followed the sheep. Goats defoliated the brush by 90—100 % within the same time frame. The sheep alone half-plots were treated similarly but not followed by goats. Flocks grazed reserve areas when necessary.

Measurements and Analysis

Vegetation cover (% blackberry, % bare ground, % herbaceous material, and % other brush) and herbage mass (kg ha⁻¹) were assessed visually by four to six people before each grazing season (once per year) and in May 1991. Plots were evaluated from a designated place near a corner. Small areas were evaluated from one end. Vegetation cover was estimated as the percentage of the plot occupied by each component. Herbage mass estimates were based on experience

obtained during previous years of calibrating various indirect measurements of pasture production (BRYAN et al. 1989). The experiment was initiated in August 1986 and animals grazed the plots through September. The effect of each year's grazing treatment was measured by visual estimates made the following May just before grazing. In 1987, 1988, 1989, and 1990, grazing started in mid May and ended in mid to late September.

Statistical analyses were performed using the general linear model procedure of the Statistical Analysis System (SAS 1988). Animal species were compared using 1500 m² plot data. Cutting, herbicide and grazing were compared using data from the small 50 m² areas. Phase II data were combined with Phase I by using data from the sheep alone half-plot for the sheep plot and the sheep and goats half-plot for the goat plot. Small area treatments were compared using orthogonal comparisons. The effect of years was examined by comparing each one to the final year.

Economic comparisons of brush clearing methods were made using partial budgeting techniques. It was assumed that animals would be purchased each spring and sold in the fall with no difference in price.

Results and Discussion

Northern West Virginia is characterized by hot dry summers which limit herbage growth (BRYAN and MILLS 1988). In 1987 and 1988, animals were removed in July and August due to dry conditions, and returned to the plots in September. In 1989 and 1990, none of the plots had enough herbage to allow grazing in August. Both sheep and goats cleared the brush; however, goats removed it more quickly than sheep (Fig. 1).

By the end of the second year (1987), total brush cover on goat plots was less than 20 % while sheep plots had about 40 % which was not different from control plots (Fig. 2). Two more years of sheep grazing were required to reduce brush below 20 %. By the end of the fifth year, all treated plots showed very low amounts of total brush.

Cutting and herbicide treatments reduced total brush cover (Fig. 2) and increased herbaceous material. Sheep and goats grazed the cut or herbicide areas with no subsequent mechanical or chemical treatments. There were no significant differences in percentage brush or herbaceous material between cutting and herbicide (both followed by grazing). However, brush was cleared more rapidly with cutting or

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[1] Mention of a trademark or proprietary product does not constitute a guarantee or warranty by WVU and does not imply approval to the exclusion of other similar products.
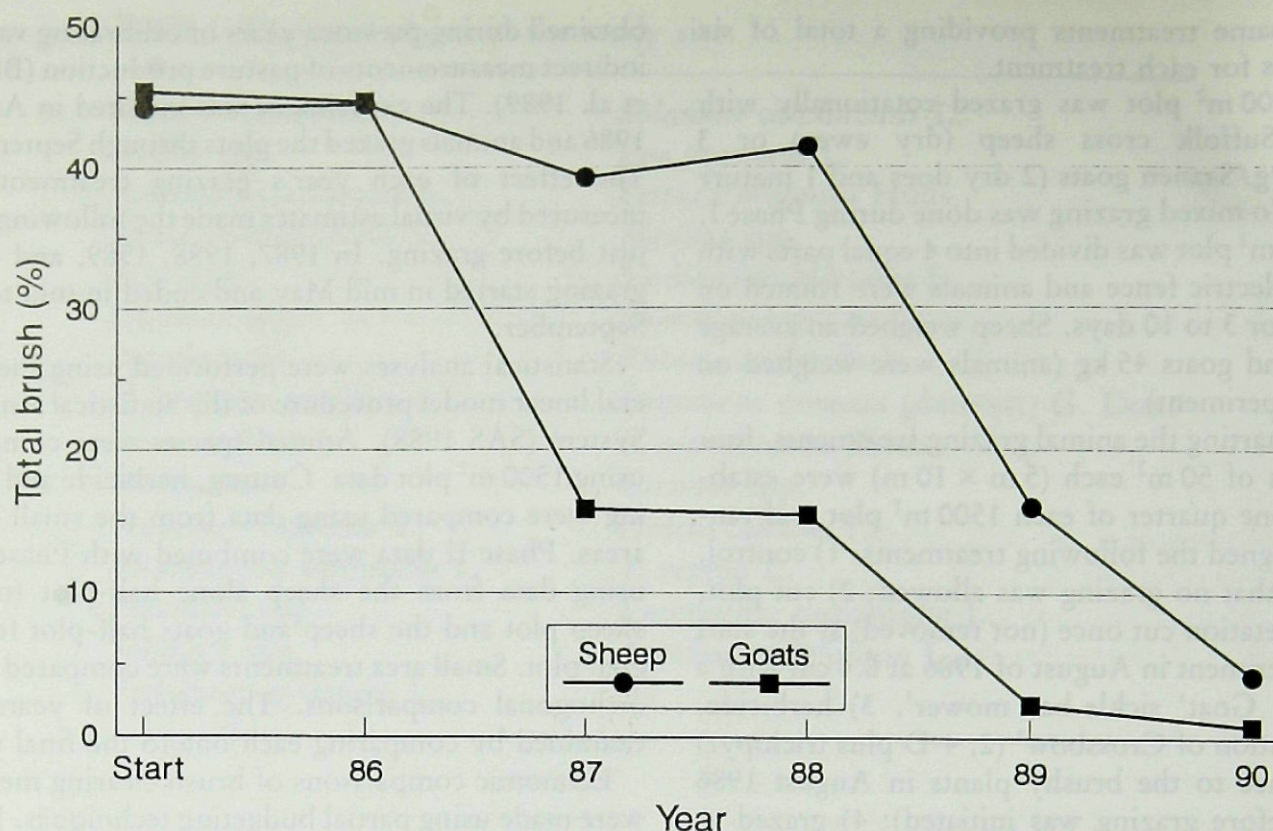
Fig. 1. Effect of goats or sheep and year on total brush cover. Start was August 1986. The effect of each year was measured by data taken the following May just before animals started grazing. In 1989 and 1990, sheep mixed grazed with goats on plots previously grazed by goats alone. Effect of animal species was not significant. Effects of year and animal species by year interaction were highly significant (P < 0.01)
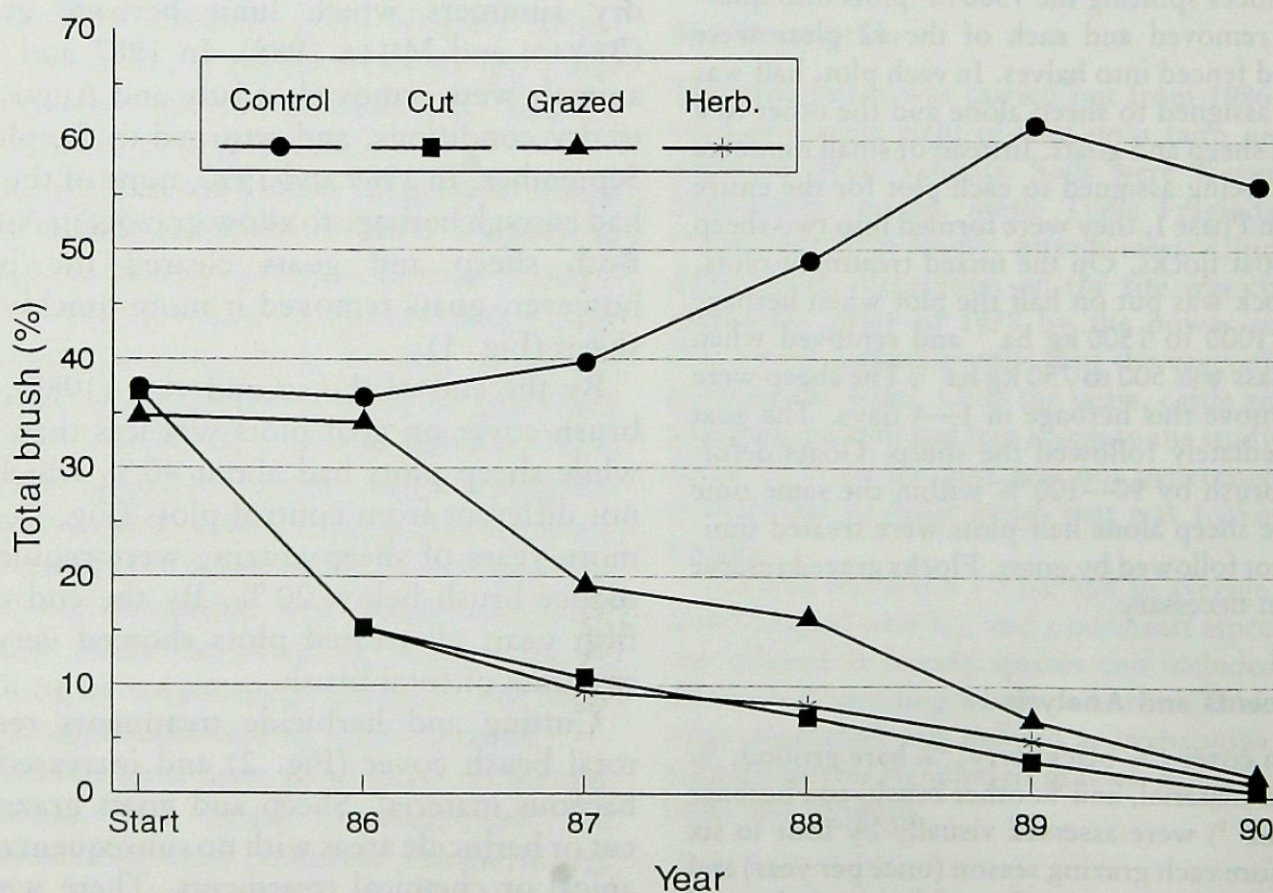

Fig. 2. Effect of pre-graze treatments followed by goats and sheep and year on total brush cover. Start was August 1986. The effect of each year was measured by data taken the following May just before animals started grazing. Effect of animal species was not significant, so the sheep and goat values were averaged and plotted on grazed treatment. Effects of treatment, year, and year by treatment interaction were highly significant (P < 0.01), and year by animal species interaction was significant (P < 0.05). Comparison between control and grazed treatments was highly significant (P < 0.01), and between herbicide or cut and grazed was significant (P < 0.05)
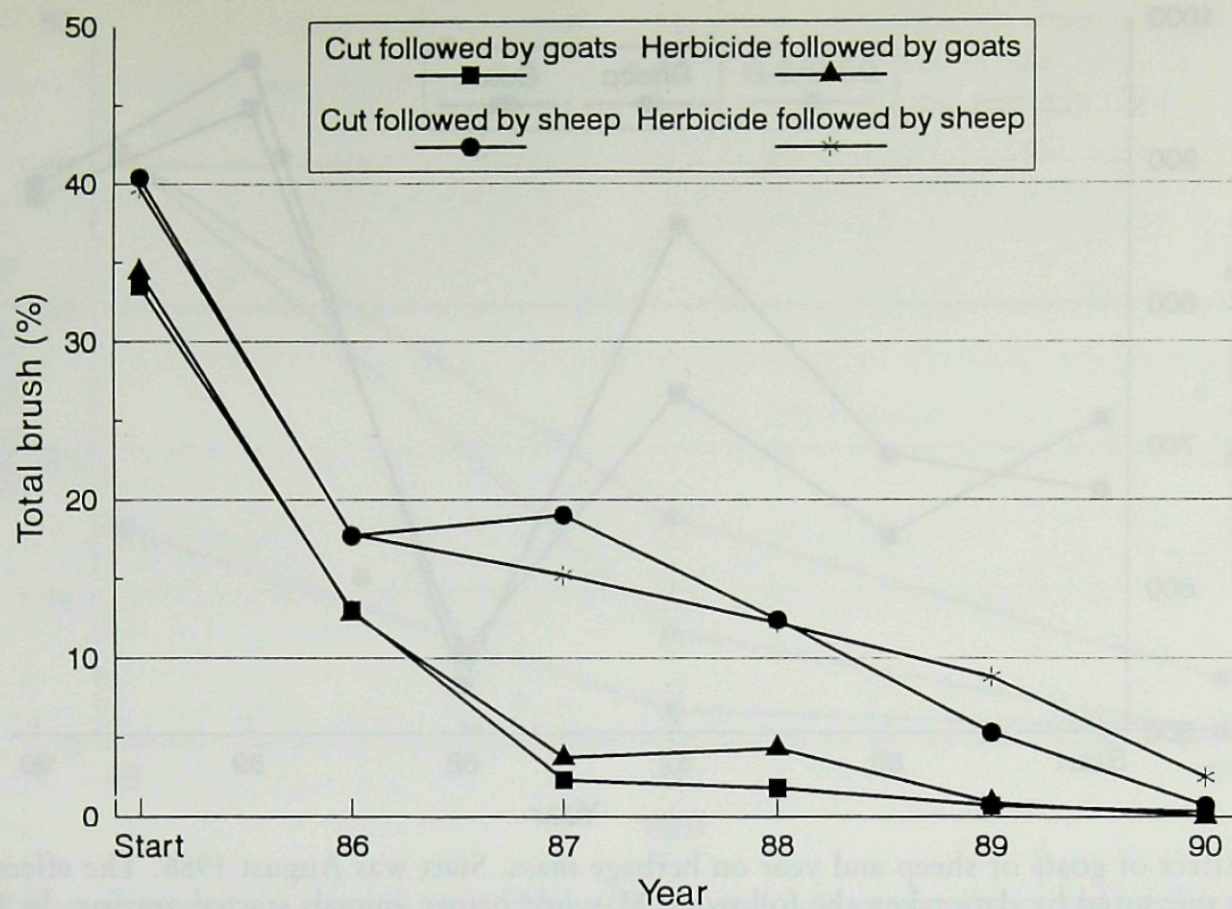
Fig. 3. Effect of pre-graze treatments with cutting or herbicide followed by goats or sheep on total brush cover. Start was August 1986. The effect of each year was measured by data taken the following May just before animals started grazing. Effects of treatment and all interactions were not significant. Effect of animal species was significant (P < 0.01) in 1987 and 1988

herbicide followed by goats vs. those treatments followed by sheep (Fig. 3). With the cutting or herbicide and goat combination, total brush was reduced to less than 5 % in 2 years while sheep grazing on brush after cutting or herbicide required more time for total brush to reach negligible levels.

There was no apparent effect of sheep or goat grazing on brush cover after one grazing season (Fig. 1). However, grazing did not start until August 1986. Even though animals completely defoliated the woody vegetation, loss of leaves in August/September had no significant impact on the vegetation and regrowth was 100 % the following spring. Therefore, 1987 was considered as the first year since grazing occurred throughout the growing season of this year.

In all cases, cutting or herbicide application followed by grazing with either sheep or goats reduced brush to below 20 % in one year (Fig. 2). Grazing by goats or sheep enhanced brush clearing and increased the cover of herbaceous vegetation and herbage mass (Fig. 4) on all treatments with time. The more rapid reduction in blackberry as compared to total brush was

due to animal preference for this species vs. other brush species. Bare ground increased significantly from 6 % the first year to 12 % in the second year, in part because precipitation was 21 % below normal (283 mm) from July to October 1987. However, in subsequent years total plant cover was similar to that at the start of the experiment.

Since sheep grazing showed no impact on total brush through 1988 (Fig. 1), we decided to divide the plots in half and graze half with sheep alone and the other with goats and sheep (Phase II). The result was a large drop in total brush on all plots (Fig. 5). By the end of 1990, brush was almost completely cleared by the animals. Goats were superior for brush clearing when they followed sheep reducing total brush from 41 % to 8 % in 1 year (1989). Sheep in Phase II following sheep in Phase I were also effective in clearing brush but it took 2 years. Between Phase I and II, two non-animal species factors contributed to brush clearing. First, grazing management was changed from set stocking (Phase I) to variable stocking (Phase II). In Phase I three animals grazed each quarter
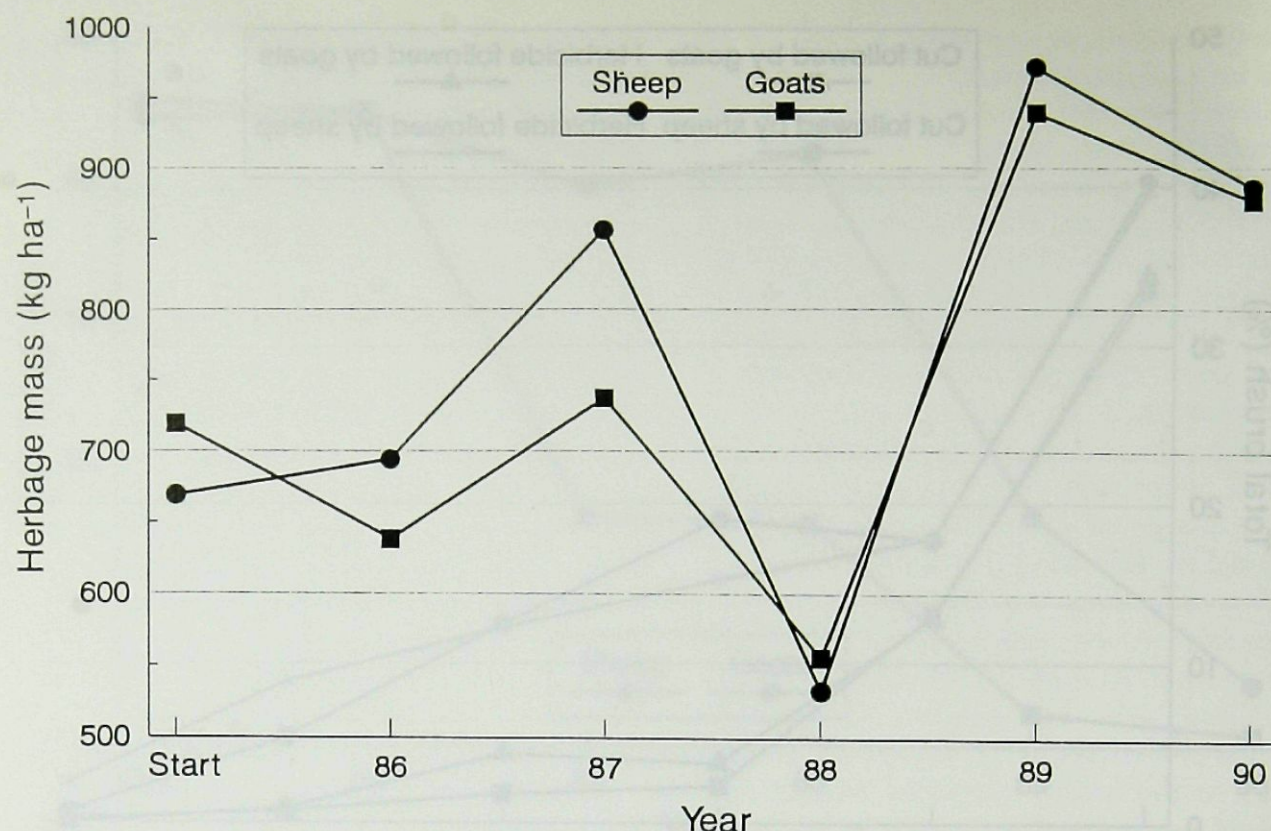
Fig. 4. Effect of goats or sheep and year on herbage mass. Start was August 1986. The effect of each year was measured by data taken the following May just before animals started grazing. In 1989 and 1990, sheep co-grazed with goats on plots previously grazed by goats alone. Effects of animal species and interaction with year were not significant. Differences between 1990 and start, 1986, 1987 and 1988 were highly significant (P < 0.01)

of the plot for about 7 days. In Phase II as many as 60 animals grazed half plots in 1 or 2 days. While sheep defoliated brush in Phase I, they grazed herbaceous material first in spring. With fixed animal numbers, there was a large excess of forage in spring and sheep did not defoliate brush heavily until later in the season when the effects of defoliation on brush survival was less deleterious. Since goats prefer brush to herbaceous material, they defoliated it quickly and early in spring. Even a small number of goats defoliated existing brush early and then grazed herbaceous materials later in the season. Variable stocking increased grazing pressure and forced the sheep to defoliate brush earlier in the season, resulting in more effective brush clearing. The second factor was an almost 100 % winter kill of *Hypericum prolificum* L. which was present in large amounts on three plots. This species was defoliated with difficulty by goats and almost not at all by sheep.

Economics of different methods of brush clearing were compared on a present value basis with the assumption that productive pasture would be available the year following reduction of brush to below 20 % (Table 2). Values of $36 ha^{-1}yr^{-1} for productive pasture (based on

the average pasture rental rate for West Virginia) and an interest rate of 10 % were used. Since the longest treatment involved 3 years (sheep alone), all treatments were compared using this same time period but with the costs expressed in terms of present value. Goats alone were the least expensive method for clearing brush at $33 ha^{-1}. At the other extreme, herbicide followed by goats or sheep, at $593 ha^{-1}, was the most expensive method. A sensitivity analysis of costs to interest rate changes revealed that these costs were not sensitive to small changes in interest rates. Fencing materials and installation costs for the experiment were nearly 80 % of total common costs with water supply materials and installation costs amounting to 16 %. Since these costs were common to all treatments, they were not included in the comparative cost analysis.

Goats or sheep were effective in clearing brush without clipping or chemicals. Goats preferred defoliating most woody plants such as *Rubus* spp., *Acer*, spp. and *Robinia pseudoacacia* L. than to graze grasses and herbaceous plants. Sheep preferred to graze herbaceous material first. Grazing management that defoliates brush early in spring and repeat-
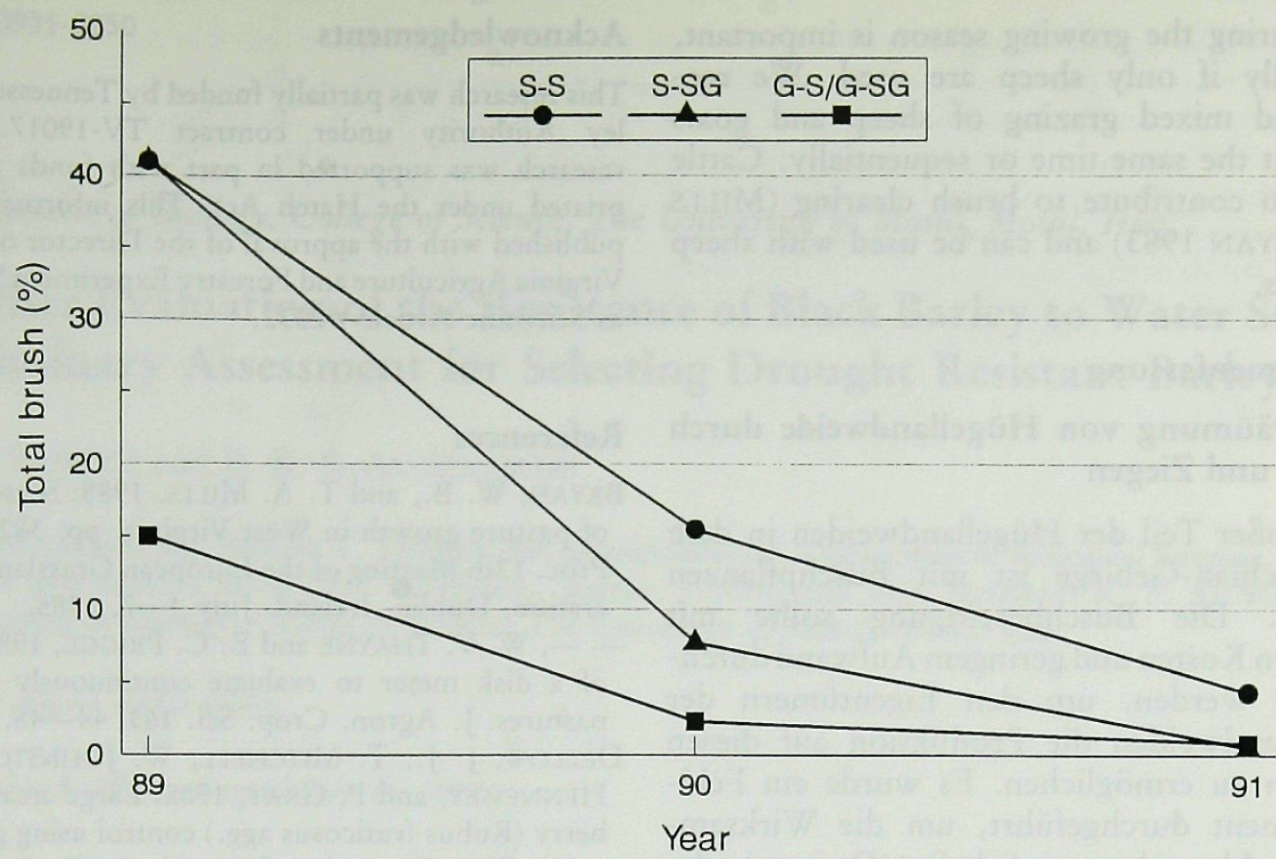
Fig. 5. Effect of sheep or sheep and goats (Phase II) grazing plots previously grazed by sheep or goats (Phase I) and year on total brush cover. Phase II began in 1989. The effect of each year was measured by data taken the following May just before animals started grazing. S-S = Sheep only in Phases I and II. G-S = Goats in Phase I followed by Sheep in Phase II. S-GS = Sheep in phase I followed by Sheep and Goats in Phase II. G-SG = Goats in Phase I followed by Sheep and Goats in Phase II. Effect of sheep or goats (Phase I plots) was highly significant (P < 0.01). Effect of sheep or sheep and goats (Phase II, half plots) was significant (P < 0.05). A significant interaction (P < 0.05) between Phase I and Phase II grazing treatments was found. Year effects and Phase I by year interaction were highly significant (P < 0.01)

Table 2. Comparison of length of time required to clear brush from pasture (1987 considered as the first year of treatment) and costs of six treatments used in this experiment. All treatments compared for a 3-year period

Method	Years needed to clear pasture (number)	Cost[1] ($ ha^{-1})
Goats	1	33
Cutting followed by goats	1	133
Herbicide followed by goats	1	593[2]
Sheep	3	262
Cutting followed by sheep	1	133
Herbicide followed by sheep	1	593[2]

[1] Estimated present value, assuming a pasture rental income of $36 ha^{-1}yr^{-1} and an interest rate of 10 %. Since the initial investment costs are common to all methods of brush clearing, they are excluded from the computations.
[2] Herbicide costs for aerial spraying based on power company estimates.

edly during the growing season is important, especially if only sheep are used. We recommend mixed grazing of sheep and goats either at the same time or sequentially. Cattle can also contribute to brush clearing (MILLS and BRYAN 1983) and can be used with sheep or goats.

Zusammenfassung

Buschräumung von Hügellandweide durch Schafe und Ziegen

Ein großer Teil der Hügellandweiden in dem Appalachian-Gebirge ist mit Buschpflanzen besetzt. Die Buschbeseitigung sollte mit geringen Kosten und geringem Aufwand durchgeführt werden, um den Eigentümern der Hügellandweiden die Produktion auf diesen Flächen zu ermöglichen. Es wurde ein Feldexperiment durchgeführt, um die Wirksamkeit des Abweidens mit Schafen (*Ovis* sp.) oder Ziegen (*Capra* sp.) allein oder in Kombination mit Buschräumung auf den Hügellandweiden zu untersuchen. Abschlagen oder Herbizideinsatz mit nachfolgendem Weiden durch Schafe oder Ziegen wurde ebenfalls berücksichtigt. Das Experiment wurde auf einem 1,8 ha-Gebiet einer Überlandleitung für fünf Jahre (1986—1990) durchgeführt. Ziegen reduzierten den Buschbewuchs von 45 bis knapp über 15 % in einem Jahr. Schafe benötigten drei Jahre für ein vergleichbares Ergebnis. Abschlagen und Herbizideinsatz erhöhten die Wirksamkeit der Beweidung durch Tiere, insbesondere durch Schafe, erhöhten aber auch die Kosten. Die variablen Kosten von drei Jahren für die Buschbeseitigung mit Ziegen wurde auf 33 $/ha, für Schafe auf 262 $/ha geschätzt, während das Abschlagen 133 $/ha und Herbizideinsatz 593 $/ha benötigteu. Am günstigsten erwies sich die Beseitigung der Büsche durch Ziegen; am Ende der fünf Jahre reduzierten alle Behandlungen den Buschbesatz auf 2 %.

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