THE INFLUENCE OF CATTLE GRAZING ALONE AND WITH GOATS ON FORAGE BIOMASS, BOTANICAL COMPOSITION AND BROWSE SPECIES ON RECLAIMED COAL-MINE PASTURES

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INTRODUCTION

An estimated one million acres of Appalachian land have been mined and reclaimed by coal mining operations since the Public Law 95-87, Surface Mining Control and Reclamation Act of 1977 (SMCRA) was implemented, in addition to hundreds of thousands of acres that were mined prior to its passage. SMCRA mandates that mined land be reclaimed and restored to a use capability that is equal to or better than its pre-mining condition. Although much of the land that is created by coal-mining operations is restored to a condition that is suitable for livestock grazing, these lands are sometimes abandoned from grazing use after mining. Difficulty of controlling woody vegetation is one factor that causes such sites to be abandoned, as the unmanaged land slowly succumbs to brushy, woody vegetation with little or no commercial value. Thus, lands restored by mining operations constitute an unused resource with the potential to support economic activity in a region that is suffering economically.

Reclaimed coal mined lands at the Powell River Project Research and Education Center in Wise County, Virginia, are in use as cattle pastures. When established in 1989 and 1990, the pastures at this experimental site were primarily tall fescue (*Festuca arundinacea* Schreb.), orchardgrass (*Dactylis glomerata* L.) and ladino white clover (Trifolium repens L.). For the last few years, however, the pastures have been increasingly infested with brushy vegetation including multiflora rose (*Rosa multiflora* Thunb.), brambles (*Rubu*s spp.), honeysuckle (*Lonicera japonica*), honey locust (*Gleditsia triacanthos* L.), mulberry (*Morus alba, Morus rubra, Morus negra***),** black locust (*Robinia pseudoacacia* L.), autumn olive (*Eleaganus umbellata* Thunb.), as well as many broadleaf weeds such as thistle (*Cirsium* spp.). These species have infested potential pasture and crop lands on coal mined landscapes throughout the Appalachian regions of Virginia and adjacent states. Several of these species are especially prone to invade pastures in the coalfield region (esp. honey locust, black locust, and autumn olive), because they are currently or have in the past been used commonly for reclamation of coal-mined sites. Due to the nature of the land and its soil, and the low economic returns to cattle grazing in this landscape, restoration of pasture vegetation on these areas using a conventional system such as the use of herbicide and re-planting is not a viable option. Low cost, environmentally safe and economically viable invasive brush control techniques are needed to maintain productive and sustainable grazing systems. The narrow margins of profit for most cattle and goat enterprises necessitate the development of methods to increase efficiency of forage use.

Different species of animals differ in grazing habits (Van Keuren and Parker, 1967), offering opportunities for complementary pasture use. For example, sheep consume forage near dung, whereas cattle often reject such forage (Brelin, 1979). Moreover, sheep graze a variety of

In M.S. Reiter (ed.) A multidisciplinary approach to conservation. Proc. 31st Southern Conservation Agric. Systems Conf., Melfa, VA. 20-23 July 2009. Extension Publ. 2910-1417. Dep. Crop and Soil Environ. Sci., Eastern Shore Agric. Res. Ext. Cntr., Virginia Polytechnic Inst. and State Univ., Painter, VA. Available at: http://pubs.ext.vt.edu/2910/2910-1417/2910-1407.html.

weeds, even in the presence of other forages considered more desirable (Van Keuren and Parker, 1967). Sheep graze more selectively than cattle (Dudzinski and Arnold, 1973) generally preferring broadleaf plants (legumes and other forbs) and the smaller stems and leaves although they will eat large leaves and flowers (Ely, 1995). In some areas output per unit area has been greater than with single-species grazing (Bennett et al., 1970). Mixed grazing with sheep and cattle resulted in earlier weaning and increased lamb performance and body weight (Abaye et al., 1994). Advantages from mixed grazing may occur if the beneficial effects of sheep on herbage production from the mixed-stock sward cause higher levels of herbage consumption by either sheep or cattle under mixed stocking (Hodgson et al, 1987). There may be greater advantages to mixed grazing where pasture composition is more complex (Bell, 1970).

Whereas effects of mixed grazing systems has been explored experimentally with cattle and sheep, few such investigations have been conducted that utilize cattle and goats; to our knowledge, none have been conducted on mined lands. Research in North Carolina has shown that mixed grazing goats with cattle has been successful in converting brush-infested pasture into a desirable mix of grasses and legumes beneficial for cattle (Luginbuhl et al. 1996). The total animal output for mixed grazing is generally improved over single species grazing as animal performance or carrying capacity of pasture is improved. Improvement of total animal output of mixed grazing can be as high as 24% over single animal grazing.

Given that goats, unlike sheep, have dietary preferences that include woody species such as those which invade pastures in coal-mined Appalachian pastures, we conducted a study of co-grazing utilizing cattle and goats on reclaimed mine pastures at Powell River Project Research and Education Center, The study hypothesis was that cattle and goat grazing together would improve pasture utilization and pasture botanical composition to a greater degree compared with cattle grazing alone.

MATERIALS AND METHODS

An experiment was conducted in 2006, 2007 and 2008 at the Powell River Research and Education Center near Wise, VA to determine the effects of grazing practices on forage biomass, relative plant abundance and browse species. The three treatments included an ungrazed control, cattle grazing alone, and mixed grazing goats with cattle. Experimental design was a randomized complete block with two replicates for the control and three replicates for the grazed treatments. Replicate paddocks for grazing treatment were 4.5 acres each and control replicates were 0.5 acre each. Three steers (616 lbs ac^{-1} ± 8.0 lbs SE) were allocated to each grazing treatment. The stocking rate was based on 0.6 ha $steer^{-1}$. The mixed grazing treatment included 15 young intact male goats (44 lbs ac^{-1} ± 5.5 lbs SE). Animals were rotationally stocked among replicates by grazing one replicate for two weeks and then allowing 4 weeks rest for that replicate area. Water and trace minerals were provided free choice at all times.

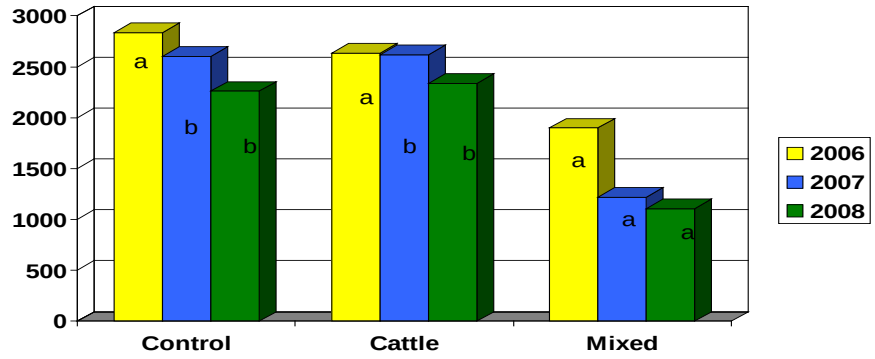
Pastures were evaluated for forage biomass, nutritive values, species diversity and effect of grazing on browse species during spring, summer, and fall of each grazing season. Forage biomass was determined by clipping 8-2.7 ft^2 square quadrants per grazing treatment and 4-2.7 ft^2 to a 1 inch height. Samples were dried in a forced-air oven for at least 48 h. Results are presented on a dry weight basis. Prior to harvesting the forages within each quadrant, the area

was visually evaluated by trained evaluators for botanical composition using the Double DAFFOR scale (Brodie, 1985). Autumn olive shrub height was measured with a clinometer from a distance of 10 m from the shrub. Branch length was measured with a tape measure from the base of the branch to the end tip. Shrub survival was measured by counting shrubs in each replicate and determining visually percent leaf-out.

RESULTS AND DISCUSSION

Forage biomass was influenced by year ($P < 0.01$) and season ($P < 0.1$). When compared to control and cattle alone grazing, forage availability was lower for mixed grazing over the three growing seasons (Figure 1). Each year by the end of each grazing season, forage biomass was always lower in pastures occupied by the mixed animals species compared to cattle alone or the control treatments.

Figure 1. Influence of cattle alone and mixed grazing vs. no grazing control on total forage biomass (lbs/acre) by year (values followed by same letter not significant at P = 0.05)



In 2006, initially, forage biomass was similar among treatments. By summer, forage biomass was high in control, intermediate for cattle alone grazing and lowest for mixed grazing ($P < 0.05$), reflecting effects of differences in grazing pressure exerted by the treatments. In the fall, forage biomass declined relative to summer levels for all treatments, but fall forage declined relative to spring measured values only where cattle grazed in mix with goats (Figure 2A). The seasonal forage distribution curve for control and cattle alone grazing (Figure 2A) reflected a warm-season forage distribution curve where most of the forage is produced during the summer months.

Forage biomass during the 2007 growing season was negatively impacted by the dry conditions that prevailed over much of the growing season (Figure 2B). Forage biomass was similar for control and cattle alone grazing but was lowest in mixed grazing for all sampling dates. By summer, the decline in forage biomass relative to spring levels was 42 and 61% in

cattle alone and mixed grazing treatments, respectively (Figure 2B). Due to the less than optimum available forage driven by the severe drought, animals were removed from pastures much earlier than the previous year allowing some forage recovery to occur by fall. Seasonal forage biomass distribution in 2007 followed a pattern typical of a cool-season grass, highest in spring, declining in summer, and increasing in fall. The overall forage biomass was much lower than in 2008 compared to 2006 for the control and cattle treatments, but mixed grazing biomass remained relatively constant. However the seasonal forage distribution observed in 2008 was similar to 2006. This reflects the dominance of the warm-season species (in this case mostly sericea lespedeza), especially in the ungrazed control, which responded to the resumed summer rainfall; and continued grazing pressure in the mixed grazing treatment.

Forage biomass in the mixed grazing treatment declined throughout both 2006 and 2008, and in 2007 prior to animal removal due to drought conditions, in mixed grazing treatment, demonstrating that forages were being fully utilized by the grazing animals, but standing biomass recovered by spring in both 2007 and 2008.

The weed component of forage standing biomass, comprised primarily of sericea lespedeza, declined throughout all three years, and over the prior to animal removal in 2007, in the mixed grazing treatment; this decline was evident as both kg/ha quantity and as proportionate share; in contrast, the weed component of forage increased from spring through fall in all three years for both the cattle-alone and ungrazed treatments, but with summer peaks for non-drought years,. This finding demonstrates the favorable effects of the goats on animal utilization of this forage component. However, in the mixed grazing treatment, legumes and grasses standing biomass quantities also demonstrated declining trends over the full year in 2006 and 2008, and prior to animal removal in 2007; the mixed-grazing-impacted decline in standing biomass was especially significant for the legumes, leaving grasses as the primary forage component (>70% grass) of the forage mix in the mixed-grazed pastures at the conclusion of each grazing season (data not shown).

In terms of the relative abundance of species, grazing treatment resulted in a shift in botanical composition that is more desirable by both animal species than the control treatment. When compared to an ungrazed control, both cattle alone and mixed grazed treatments resulted in an increase in persistence of grass species, such as tall fescue, orchardgrass, and bluegrass (data not shown). At the end of the two year experiment, white and red clovers disappeared from the control but although not in a great abundance remained part of the pasture component in the grazed treatments. Sericea lespedeza became a dominant weed in the control treatment mostly due to the lack of grazing pressure. The high grazing preference of goats for sericea lespedeza and of other weeds influenced the morphological characteristics of these plants. The growth pattern of sericea lespedeza was changed from an erect, woody, less leafy plant to a shorter, more palatable, and leafier plant due to goat grazing. The shorter and leafier sericea lespedeza was more acceptable and thus was readily grazed by cattle (Figure 3).

Figure 2. Influence of cattle alone and mixed grazing vs. no grazing control on total forage biomass 9lbs/acre) for the years 2006-2008. (values followed by same letter not significant at P = 0.05).

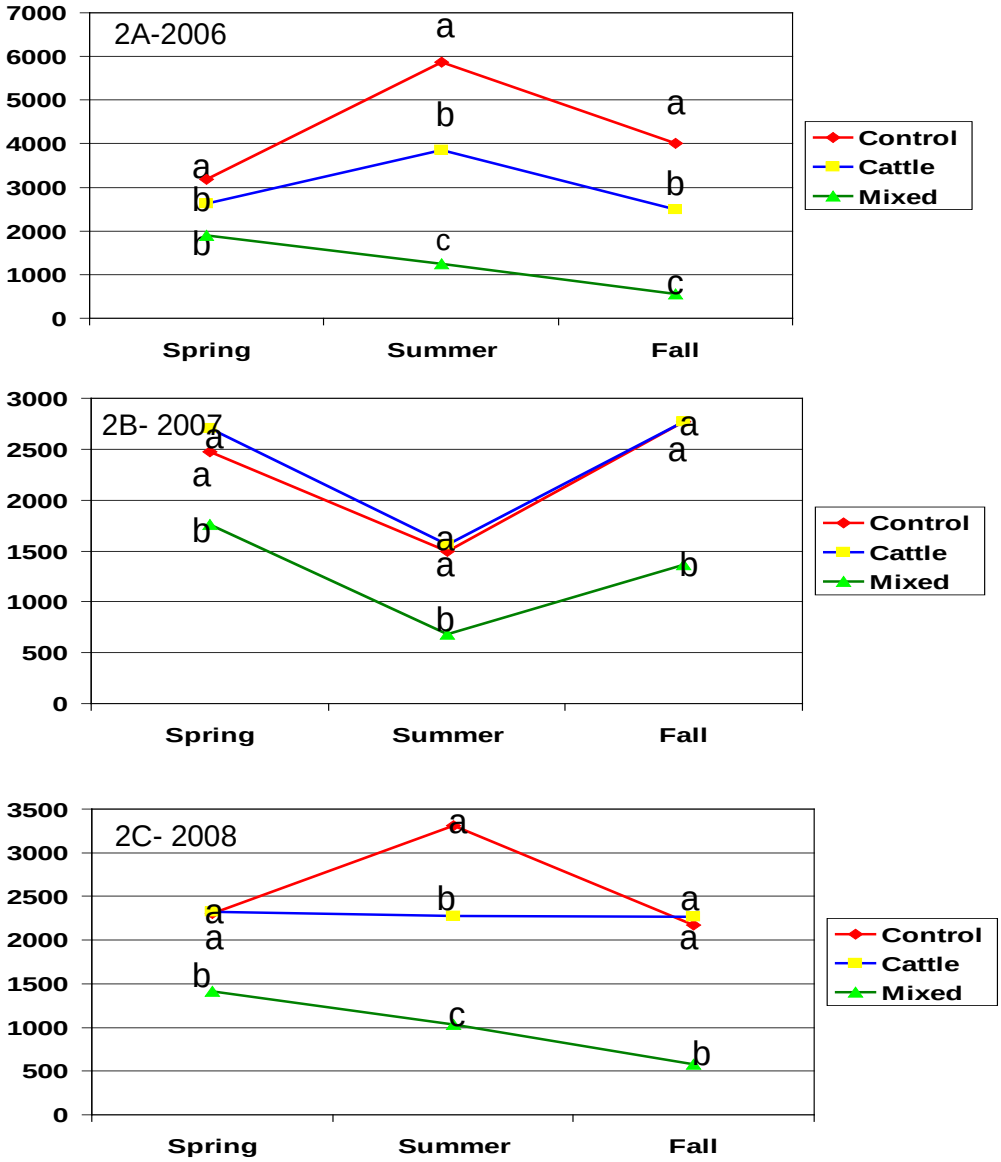


Figure 3. Effect of cattle grazing with goats vs cattle grazing alone on botanical composition of Sericea lespedeza.

Goat browsing had negative impact on autumn olive branch length and shrub height. In 2006 and 2008, branch length was negatively impacted by goat browsing but not in 2007, which was an excessive drought year. There was a decline of autumn olive shrub height in 2008 that may be attributed to reduced vigor caused by defoliation, bark-stripping, and girdling by the goats over the prior two growing seasons. Standing on their hind legs and placing their weight on branches resulted in the development of a browse line, broken, and dead branches (Webb and others 2009). Despite these severe and excessive browsings (Figure 4), autumn olive illustrated a degree of resiliency. After hard browsing and branch death, the shrub would occasionally produce numerous suckers from the base of the plant. This lush growth was highly preferred and accessible to goats (data not shown).

Figure 4. Goats browsing autumn olive, 2007

CONCLUSION

Incorporating goats into existing cattle operations in the Appalachian region may serve as a possible biological control for invasive plant species. Goats prefer browsing shrub species over grazing and foraging, and are well adapted to grazing on steep lands. They tolerate plant species that contain bitter compounds, such as tannins, that are unpalatable to cattle. Both sericea lespedeza and autumn olive, non-native invasive species that were present in the pastures used for this experiment, contain such compounds. The mixed grazing of goats with cattle is possible as each species selects for their preferred diet and competition between species for conventional forages is minimal. Overall, mixed grazing of goats with cattle can have positive influences on botanical composition and invasive plant species control on reclaimed coal-mined lands in the Appalachian region.

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