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THE EFFECTS OF MULTISPECIES GRAZING ON PASTURE MANAGEMENT AND UTILIZATION

A Thesis
Presented to
The Faculty of the Department of Agriculture
Western Kentucky University
Bowling Green, Kentucky

In Partial Fulfillment
Of the Requirements for the Degree
Master of Science

By
Chelsea E. Williams

May 2011

THE EFFECTS OF MULTISPECIES GRAZING ON PASTURE MANAGEMENT AND UTILIZATION

Date Recommended 4/22/11

Paul B. Woodley
Director of Thesis

Elmer Gray

L. Gonzales

Richard G. Bowker May 10, 2011
Dean, Graduate Studies and Research Date

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THE EFFECTS OF MULTISPECIES GRAZING ON PASTURE MANAGEMENT AND UTILIZATION

Chelsea E. Williams May 2011 34 Pages

Directed By: Paul Woosley, Linda Gonzales, and Elmer Gray

Department of Agriculture Western Kentucky University

Multispecies grazing research was conducted using meat-type goats (*Capra hircus* L.) and Jersey heifers (*Bos taurus* L.) to determine the relationships between multiple grazing treatments and pasture utilization. The study was conducted for 60 days on the Western Kentucky University Farm in Bowling Green, KY. Cattle and goats have shown to differ in grazing preferences and to be economically important to the area. Grazing treatments included goats and cattle grazing simultaneously, sequentially, and goats grazing alone. A typical established Kentucky pasture was utilized with no weed management practices employed. Predominant forage species included tall fescue (*Festuca arundinacea* Schreb.), orchardgrass (*Dactylis glomerata* L.), Kentucky bluegrass (*Poa pratensis* L.), and white clover (*Trifolium repens* L.). Exclosures were utilized as controls. Data included forage quality, composition, availability, height, visual weed cover and live ground cover, and thistle consumption, collected every 15 days.

Results indicated a significant difference in sample dry weights between grazing treatments and ungrazed controls in every treatment except when goats followed cattle. At day 60, grazed areas had significantly lower forage heights than the control when goats grazed with and before cattle. Instances where goats followed cattle resulted in significantly higher NDF compared to the control. All treatments containing goats had

significantly lower leaf numbers per thistle plant (*Carduus nutans* L.) than cattle only treatment. Based on this study, sequential and simultaneous grazing of cattle and goats may be an effective nodding thistle control strategy, but future experimentation is needed for determination of forage utilization and quality relationships.

CHAPTER ONE

Introduction

The amount of farm and pasture land is decreasing in Kentucky and nationally (KDA, 2009). Thus, the benefits of a co-grazing system, or the grazing of multiple species on the same land area, are immediately obvious through increased animal and pasture production and increased economic benefits through increased saleable products and a diversified risk of loss. Especially if the species of animals are capable of consuming different plant species found in pastures, including weeds. With an increase in 'environmental consciousness' of both producer and consumer, co-grazing may also be a best management strategy to support farm sustainability.

Additionally, with farmer's markets and the local food movement both being in an upswing (Eaton, 2008), producers who employ a multispecies grazing strategy may be able to find a niche market here by being able to better and more fully supply products to area consumers. Multispecies grazing allows for an increase in saleable products that can be marketed through these markets and can thereby meet the current demand for 'local foods'. Further, many species that might be used in a multispecies grazing system (like sheep and goats) produce products that are not widely available commercially, but might be highly sought in the producer's area. Simply put, multispecies grazing merely allows a producer to raise more animals on the same amount of land and have more local products to offer to local consumers.

With such possibilities in mind, a co-grazing research project was initiated at the Western Kentucky University Research Farm. This study had two objectives: to determine pasture utilization with regards to species consumption, from simultaneous and sequential grazing of goats (*Capra hircus* L.) and cattle (*Bos taurus* L.); and, to determine the viability of multispecies grazing as a pasture management strategy, concerning forage availability, weed presence, and forage quality. To better understand the context in which this research was conducted, studies conducted by others will be explored and discussed.

CHAPTER TWO

Literature Review

Grazing, in the traditional sense, can be assumed to have existed since the beginning of time, with the existence of ruminants and other herbivores that depended solely upon plants for their nutrition. However, since the domestication of goats (*Capra hircus* L.) 10,000 years ago (Clutton-Brock, 1987) and cattle (*Bos taurus* L.*)* 8,000 years ago (Montgomery, 2004), grazing livestock has been a part of the human lifestyle, as man transformed from the hunter-gather to the herder (Provenza, *et al.*, 2007). Multispecies grazing, though, has only relatively recently become regarded as an effective and efficient use of grazing land (Baker and Jones, 1985; Merrill and Miller, 1961).

Multispecies grazing has been utilized for many different reasons. It is primarily touted as a means to maximize both animal and pasture production (Merrill and Miller, 1961; Animut, *et al.*, 2005). It is also ideal for vegetation management, especially for invasive, noxious, or unwanted species (Hart; Luginbuhl, 1996). When single species grazing is employed, overgrazing is a much greater concern because the whole of the grazing pressure is determined by one animal species with specific grazing preferences (DiTomaso, 2000). Overgrazing stresses the desirable pasture species, which can allow undesirable weeds to establish. Multispecies grazing can reverse pasture stress and allow the desirable species to recover (DiTomaso, 2000) by spreading the grazing pressure more equitably among different plant species (Squires, 1982).

In 1987, it was estimated that 400 million ha, or 42% of the total U.S. land area, was used for pasture and grazing (Bovey, 1987). An estimated 60% of that area was inhabited by undesirable species (Glimp, 1995), including about 8 million ha in the southeastern U.S. (Child, *et al.*, 1985). These weeds and undesirables have more of an economic impact than all other pests combined (Quimby, *et al.*, 1991), with an estimated annual loss of $2 billion (Bovey, 1987). Multispecies grazing has been shown to be an effective biological means to control these undesirables and reduce their economic impact (Luginbuhl, 1996).

Multispecies grazing "takes advantage of the inherent grazing preferences among different classes of livestock" (Walker, 1994) and must be considered so the most appropriate animals can be selected for the situation (DiTomaso, 2000). Most plant species are ingested by every livestock class, but in different proportions (Squires, 1982). In this area of the U.S., cattle and goats are the two ruminant species that appear to have the greatest proportional differences in grazing preferences (Ball, *et al.*, 2007). This is especially true in summer, when a greater variety of plant species is often available (Squires, 1982).

Research indicates cattle prefer a diet composed of 65-75% grass, 20-30% broadleaf weeds and legumes, and 5-10% browse. Goats prefer a diet composed of 20-30% grass, 10-30% broadleaf weeds and legumes, and 40-60% browse (Ball, *et al.*, 2007). Goats will also consume a wider range of plants than will cattle (Ball, *et al.*, 2007), including plants with bitter tastes, like those containing tannins (Luginbuhl, *et al.*, 1998). Goats grazing with cattle provide an effective biological control of weeds and brush (Ball, *et al.*, 2007) while also producing an additional saleable product and diversifying income (Hart). Grazing both cattle and goats shifts the composition of the pasture to a higher percentage of grass, making the pasture more suitable for cattle, with no mechanical or chemical intervention (Prevenza, *et al.*, 2007).

Grazing differences between goats and cattle make a diverse pasture ideal for this multispecies pairing. Cattle utilize the tongue to grasp the forage, hold it tightly between the gums, and tear it from the ground (Ball, *et al.* 2007). Goats have a prehensile lip which allows them to nibble or bite the forage selectively (Ball, *et al.* 2007). The adaptation of the lip allows them to consume plants with spines or thorns, such as thistle, which cattle refuse (DiTomaso, 2000). Cattle also usually graze close to the ground, whereas goats prefer to graze at or above their shoulder height (Ditsch *et al.*).

Economically, this combination is beneficial. In most states, goat numbers are only about 1-5% of cattle numbers (Hart), but that number is expected to rise. Current market demand for goat products far exceeds supply (Glimp, 1995), with about half of the demand being met through imports (Spence, 2008). In 2009, goats were the fastest growing agricultural industry in Kentucky, ranking 5th in national goat production (KDA, 2009). Kentucky also ranks 12th nationally in overall cattle production, with 13.7% of all Kentucky agricultural revenue coming from cattle (KDA, 2009).

Moreover, on an animal unit basis, five goats are the equivalent of one mature cow, allowing the risk of loss to be spread more evenly among more animals (Ball, *et al.*, 2007; Glimp, 1995). There is no feed efficiency advantage for goats over cattle when goats are fed high quality forage (clovers and high quality grasses), which allows goats to perform very efficiently on lower quality plant species that are usually avoided by cattle (Ball, *et al.* 2007). Thus, pastures become more “cattle friendly” by reducing weeds and other low quality undesirable forage species (Coffey, 2001).

Additional benefits include parasite control in both goats and cattle (Walker, *et al.*, 2006). Parasites are species specific (Coffey, 2001). Parasites that infect goats cannot infect cattle and vice versa (Burton, 2010).The usual inability of parasites to cross infect is important because parasites are one of the primary management issues with small ruminant husbandry (Hale, 2006). Multispecies grazing breaks the parasite cycle (Walker, *et al.*, 2006). Parasites must complete their life cycle inside their host (Christensen, 2005). When they are ingested by an animal other than their host, they are unable to survive (Walker, *et al.*, 2006).

Burton (2010) suggested that cattle graze before goats or other small ruminants in fields that are heavily infested with parasites. This sequence of grazing is especially important to reduce the number of anthelmintic treatments needed to control these parasites (Walker, *et al.*, 2006). With the repeated use of these dewormers and the limited number of control options available, extensive parasite resistance is being seen in small ruminants, especially goats, worldwide (Chandrawathani, *et al.* 2004). This resistance is particularly devastating, as death is not uncommon from untreated infections (Hale, 2006).

With the condition of many pastures, it is estimated that 1-3 goats can be added per cow without a change in the stocking rate (Glimp, 2005). However, an increased stocking rate limits forage selectivity and forces the animals to consume all species present (Animut, *et al.*, 2005). Grazing goats with cattle, using the highest stocking rate possible without exceeding the carrying capacity of the land, could be beneficial in more effectively renovating the pasture (Animut, *et al.*, 2005).

There are many challenges to multispecies grazing. Challenges potentially include a producer's lack of knowledge of the species or increased labor needs to manage multiple species (Walker, *et al.*, 2006). Reportedly, the most challenging is fencing

(Walker, *et al.*, 2006; Spence, 2008). Goats like to climb and jump (Ditsch, 2007); therefore, exterior fencing should be at least 1.1m tall with offset electrical fencing if desired (Luginbuhl, 1998). Interior fencing should be electric with at least three strands at 25cm, 51cm, and 91cm above the ground (Ball, *et al.* 2007). Luginbuhl (1998) recommended 5 strands of electrical wire.

Goats, unlike cattle, have an aversion to being wet (Ditsch, 2007). This aversion may be due to a smaller fat layer (Luginbuhl, 1998). Therefore, adequate shelter should be provided in the field when using goats as part of a grazing system (Luginbuhl, 1998). Goats are also prone to predation and should have measures in place (e.g. guard animal) for protection (Ditsch, 2007).

Despite the challenges of multispecies grazing with cattle and goats, research has shown it to be effective for improving both the health of the animal and the pasture. Prosser, *et al.* (1995) performed a study in North Dakota using cattle and goats to control leafy spurge (*Euphorbia esula* L.), a herbaceous, noxious weed that has spread worldwide. Over three grazing seasons, when only cattle grazed leafy spurge infested pastures at a stocking rate of 0.39 ha/AUM, there was a slight increase (3.1%) in the weed population. However, when goats grazed at stocking rates of 0.42 and 0.38 ha/AUM, there was a significant decrease (71.5%) in leafy spurge population. With multispecies grazing, a significant decrease of 42.7% in leafy spurge population still existed. The multispecies grazing treatment had stocking rates of 0.55 and 0.39 ha/AUM.

Luginbuhl, *et al.* (1996) conducted a four year study in the Appalachian region of Western North Carolina. Using two treatments, goats alone and goats with cattle, they sought to renovate overgrown pastures and control weeds and brush, specifically multiflora rose (*Rosa multiflora* Thunb.), with similar stocking rates in both treatments. Stocking rates of the goat only treatment were maintained at 30 mature does/ha. The cattle and goats multispecies grazing treatment was stocked at a rate of 17 mature does and 2-3 steers/ha. In the goat only paddock, vegetative cover increased 65-86% in the four year period and the favorable grass/legume cover increased from 16 to 63%. In the goats and cattle paddock, the vegetative cover increased from 65 to 80% and the favorable grass/legume cover increased 13-54% over the four year period. This increase is compared to the control, which experienced a decrease in vegetative cover, from 70 to 22%, with favorable grass/legume cover rates that varied from 10 to 27%. Multiflora rose was also controlled in this study, with a 100% decrease in the goats only treatment and 92% in the goats and cattle treatment.

Nielson (2008) and Spence (2008) have both written about unpublished data of a study currently ongoing with the University of Kentucky. This study rotationally grazed cattle and goats grazing simultaneously and cattle and goats grazing sequentially, in a leader-follower system, with goats grazing first. Grazing was conducted on a typical Kentucky pasture that was not reseeded. Results are preliminary, but seem to indicate favorable results, especially observationally. Visual observation suggested goats are very effective at weed control and eradication, especially for multiflora rose, honeysuckle (*Lonicera* genus), and ironweed (*Vernonia altissima* Nutall) (Spence, 2008). Results also indicated that goats can thrive regardless of the grazing arrangement, while cattle, when they follow goats as “clean up grazers” weigh an average of 13.6 kg less than those cattle that grazed with goats simultaneously (Nielson, 2008). This study is being continued.

CHAPTER THREE

Materials and Methods

The multispecies grazing study was conducted at the Western Kentucky University Farm located in Bowling Green, KY (Lat. 36.93°; Lon. -86.47°). The 2.02 hectare pasture utilized for this study was previously in dairy cattle production. The field was typical of an established Kentucky pasture, with white clover (*Trifolium repens* L.), tall fescue (*Festuca arundinacea* Schreb.), and orchardgrass (*Dactylis glomerata* L.) being the predominant forage species. Kentucky bluegrass (*Poa pratensis* L.), bermudagrass (*Cynodon dactylon* L.), and timothy (*Phleum pretense* L.) were also present in lesser quantities. The field also had an established weed presence, with hairy buttercup (*Ranunculus sardous* Crantz), nodding thistle (*Carduus nutans* L.), chicory (*Cichorium intybus* L.), dandelion (*Taraxacum officinale* Weber), field bindweed (*Convolvulus arvensis* L.), blackseed plantain (*Plantago rugelii* Dcne.), and horsenettle (*Solanum carolinense* L.) being the most common, based upon visual observation.

On February 19, 2010, a soil test was conducted. The area was then fertilized with 19-19-19 at a rate of 336.8 kg per ha to meet recommended soil fertility standards. Fencing was installed during the week of March 8, 2010 using commercial fencing supplies commonly available. Woven wire fencing, 1.2m tall with alternating rows of 5.08cm x 10.16cm and 5.08cm x 20.32cm squares, was used as a perimeter for added protection. Six-foot t-posts were driven approximately every 3.05m throughout the field, sub-dividing the field into 5 paddocks to be used for the study treatments. Polywire electric fencing was used internally for sub-division as well as along the perimeter. Five strands of wire were strung at approximately 125, 91, 58, 41, and 25 cm above the ground, to create the paddocks. Water was made available through the use of a frost free hydrant installed in the field, with lengths of water hoses running to each paddock. Water containers were filled twice daily, in the morning (8-9am) and in the evening (5-6pm). Shelter/shade was also provided in each paddock using shade cloth, calf hutches, or existing shade trees.

For the purpose of this study, Jersey heifers (*Bos taurus* L.) and a mix of meat type doe goats (*Capra hircus* L.) (primarily African Boar) were used. These species were selected based on prevalence in Kentucky, ease of handling, and ease of acquisition. Only female animals were used for this study for similar reasons and to avoid concerns regarding breeding effects on the outcome of the study. Five heifers were obtained on April 28, 2010 from Chaney's Dairy Farm in Bowling Green, KY on loan for the duration of the study. The 22 slaughter does used were purchased from Barren River Livestock at a graded sale on April 8, 2010 and from private producers on April 17, 2010.

Prior to the onset of the study, all animals were inoculated and kept in an area away from the study field, separated by species. Heifers were tagged, treated with a 0.1% solution of moxidectin (Cydectin) at a rate of 1mL for every 10kg, and allowed to graze. The goats were tagged, treated with moxidectin at a rate of 1mL for every 9.1kg, a 1% solution of ivermectin (Ivomec) at a rate of 3mL for every 45.4kg, inoculated with a CD/T vaccine (*Clostridium perfringens* Veillon and Zuber. types C and D for overeating disease and *Clostridium tetani* Flugge for tetanus) at a rate of 2mL per animal, and inoculated with Vitamin B complex at a rate of 4-5mL per animal and allowed to graze in a small lot with supplemental feed of hay and medicated goat feed. A Monensin medicated feed was used for the control of coccidiosis and other parasites. Parasite levels were monitored regularly with the McMaster method of fecal flotation monitoring (Gordon and Whitlock, 1939) and treated with moxidectin and ivermectin accordingly. The cattle were visually monitored and treated accordingly.

On May 12, 2010 the 60-day study was initiated. It consisted of 4 treatments, with a 5th paddock in the field being used for replacement animals. Treatment 1 was goats only (G) and contained 6 does at the onset of the study in an area of 0.2ha. This number increased to 7 when one doe kidded during the study. However, the kid was not weaned during the study, thus, having no effect on the grazing pressure or, consequently, the study results. Treatment 2 (G+C) contained 6 does and 2 heifers in a 0.4ha area. Treatments 3 and 4 were grazed rotationally at 15 day intervals. Each measured 0.2ha and at the study onset, Treatment 3 (C,G) contained 2 heifers and Treatment 4 (G,C) contained 6 does. Paddock 5 was not measured and contributed no data.

A stocking rate of 1793 kg/ ha was utilized, using 45.4 kg does and 226.8 kg heifers. The stocking rate was determined using dry matter production data for a mixed forage (grass/legume) Kentucky pasture during the summer months, dry matter intake per goat, and the study length (Lee, *et al*., 2007; Ditsch, *et al*., 2007). A rate of 3 goats per heifer was chosen to ensure animal unit (AU) equivalency across each paddock (Ball, *et al*., 2007). One AU is defined as a 454 kg cow fed at a maintenance level (Ball, *et al*., 2007). The heifers used in this study were equivalent to 0.6 AU each, whereas the goats were equivalent to 0.2 AU each.

Throughout the 60-day study, data were collected every 15 days, for a total of 5 collection dates (Day 0, 15, 30, 45, 60). Data were taken both in the field and from harvested samples. Exclosures were constructed in each paddock to serve as a control. Each exclosure was 1.2m x 6.1m to accommodate five 0.91m x 1.2m harvest plots and one 1.2m x 1.2m field data plot (Figure 1). Three ungrazed exclosures and three grazed sample areas, as marked by metal t-posts, were randomly placed in each paddock.

Field data was taken using a 1.2m x 1.2m grid with sixteen 0.3m x 0.3m squares. Data collected included the percentage of live ground cover, weed cover, and sward height. Ground and weed cover measurements were taken by visually estimating cover percentage in each of the sixteen squares with a mean determined for the grid. Sward height was measured in each square, with a grid mean determined. This field data was taken at the same field location each time to provide continuity in results.

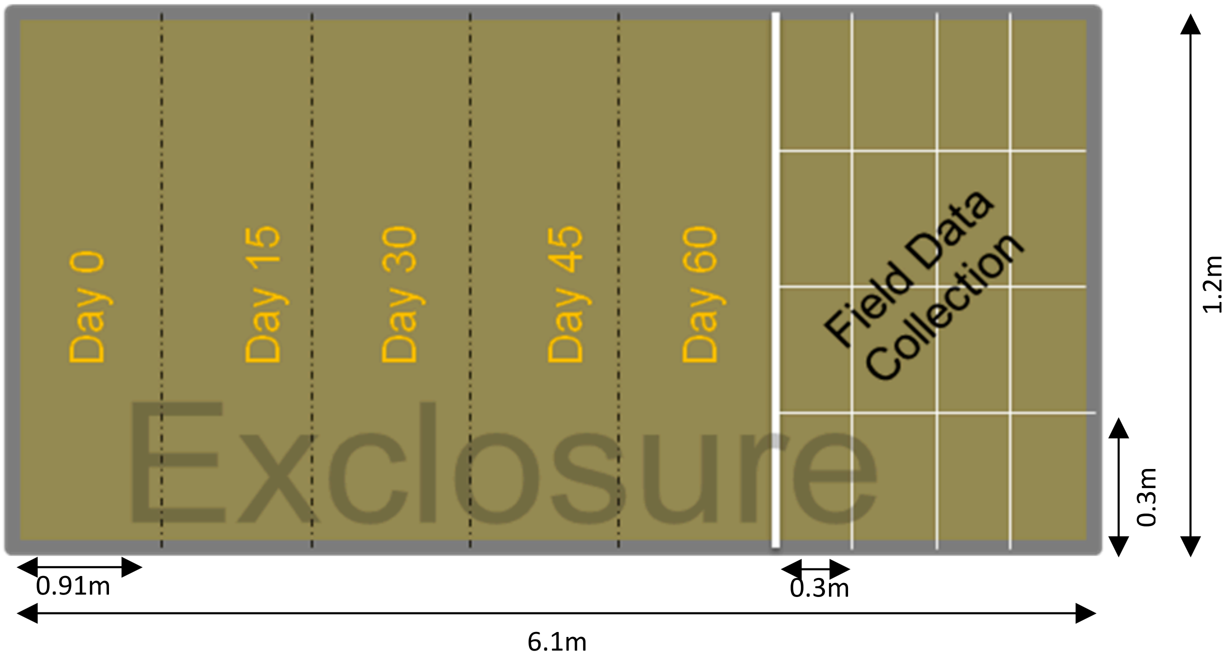
Samples were harvested using a 0.91m sickle bar mower to determine total biomass on a dry matter basis, the pasture composition, and the forage quality. Forage quality measures consisted of acid detergent fiber (ADF), neutral detergent fiber (NDF), and crude protein (CP). The ADF measures the amount of cellulose and lignin in the forage, which is a good measure of digestibility (Harris, 1992). The NDF measures the amount of cellulose and lignin, like ADF, but also measures the amount of hemicellulose present, which is a good indicator of dry matter intake (Harris, 1992). The NDF is a more complete measure of the total fiber in the forage (Harris, 1992).

Each sample was harvested directly beside the previous harvest plot, to minimize variability (Figure 1). Samples were dried in a forage drying oven at 65.6°C (150°F) to a constant weight. Samples were weighed and hand separated into grass, legume, and weed components. These individual components were then dried again to a constant weight and reweighed. Grass, legume, and weed percentages were determined. Samples were recombined and ground in a Wiley mill to pass through a 50 mesh screen and then analyzed using Near Infrared Spectrophotometry (NIR). Analysis was performed at the Noble Foundation (Ardmore, Oklahoma) with a Foss 6500 NIR using a grass hay equation.

Individual nodding thistle (*Carduus nutans* L.) plant data were also taken in each paddock after visual observation suggested a preference for nodding thistle among the goats. Ten thistle plants per paddock were randomly selected by tossing an object. Data collected included thistle height and number of leaves per plant. Due to public concerns of spreading thistle seeds, thistle plants were clipped, thus halting subsequent data sets. As a result, only one data set was collected on May 29, 2010. The study concluded on July 12, 2010.

Data analysis was completed using SAS v. 9.2 software, at a 0.05 level of probability. When significant F values dictated, a Least Significance Difference test was utilized for means separation.

Figure 1. Diagram of exclosure and forage harvest methodology.



CHAPTER FOUR

Results

Results varied distinctly among paddocks (treatments) and measured parameters. Results were established through the comparison of data taken from grazed and ungrazed areas in each paddock for each sample date with each parameter. Results are described as the mean of each area (grazed or ungrazed).

Significant differences in live ground cover percentage occurred in Treatment 1 (G) on day 45 and in Treatment 4 (G,C) on day 30 (rotation with cattle) and on day 45 (rotation with goats). In all cases of significant differences, the ungrazed areas had significantly higher percentages of live ground cover (Table 1).

No significant differences existed in the amount of weed cover between grazed and ungrazed areas in any paddock on any sample date (Table 2).

Sward height significantly differed in Treatment 2 (G+C) on days 45 and 60 as well as in Treatment 4 on day 60 (rotation with cattle). The ungrazed areas had significantly higher forage heights than did the grazed areas (Table 3). Although there is a numeric decrease in forage heights from day 0 to day 60, this difference was not significant (Figure 2).

The ungrazed control areas resulted significantly higher forage weights (on a dry matter basis) from the harvested samples throughout the study (Table 4). Significantly higher weights occurred in Treatment 1 (G) on day 45, in Treatment 2 (G+C) on days 15 and 30, and in Treatment 4 (G,C) on day 30.

Table 1. Mean percentage live ground cover throughout study

	Day 0	Day 15	Day 30	Day 45	Day 60
T 1 (G)					
Grazed	87.5	91.04	74.17	76.67*	51.98
Ungrazed	82.19	94.98	91.98	94.17*	50
T 2 (G+C)					
Grazed	93.85	97.61	90.52	68.23	40.73
Ungrazed	94.59	93.44	75.1	78.5	55.83
T 3 (C,G)					
Grazed	96.46	91.96	71.77	75.42	37.81
Ungrazed	94.27	95.65	81.88	66.46	50.52
T 4 (G,C)					
Grazed	95.53	89.17	79.38*	73.22*	59.27
Ungrazed	94.06	94.27	89.38*	92.19*	67.71

*Indicates significant difference between grazed and ungrazed control

Table 2. Mean percentage weed cover throughout study

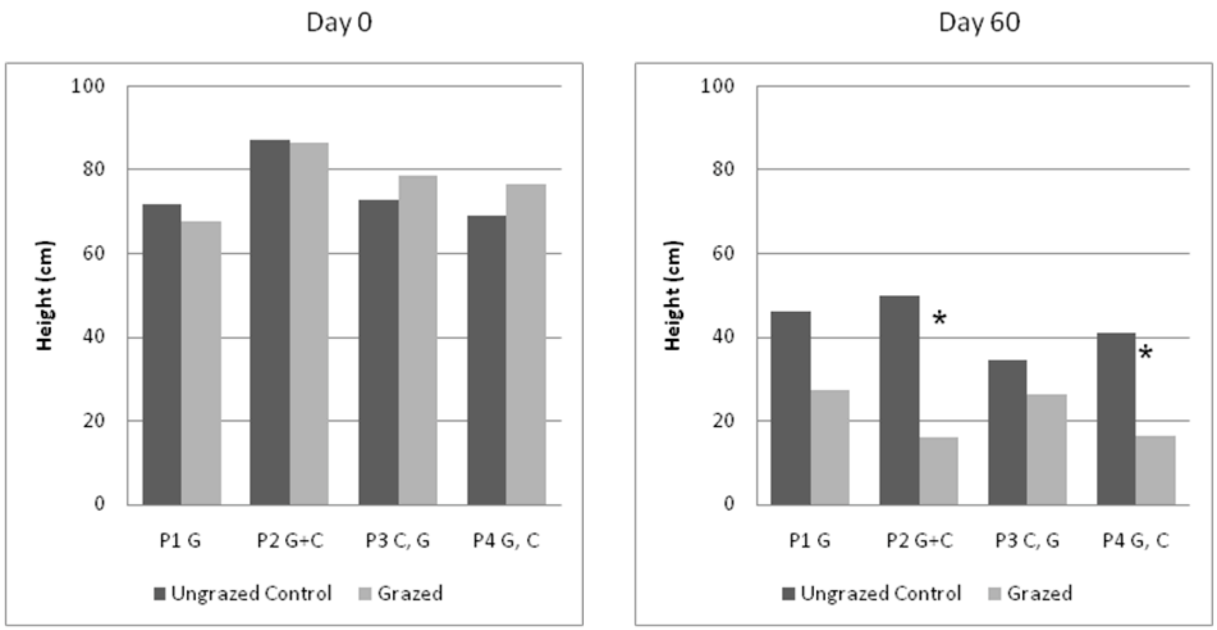
	Day 0	Day 15	Day 30	Day 45	Day 60
T 1 (G)					
Grazed	11.88	7.81	0.627	0.937	0.313
Ungrazed	20.32	9.69	8.13	6.77	4.69
T 2 (G+C)					
Grazed	3.34	0.417	0	0	0.104
Ungrazed	4.27	0.417	0.208	0.521	0.627
T 3 (C,G)					
Grazed	13.33	8.65	3.75	3.96	2.08
Ungrazed	4.79	1.46	1.98	1.04	3.13
T 4 (G,C)					
Grazed	2.19	1.56	0.417	0.417	0.313
Ungrazed	8.02	11.67	0.521	2.08	0.208

Table 3. Mean sward height (cm) throughout study

	Day 0	Day 15	Day 30	Day 45	Day 60
T 1 (G)					
Grazed	67.67	59.88	35.17	28.63	27.33
Ungrazed	71.96	79.5	44.69	42.42	46.19
T 2 (G+C)					
Grazed	86.63	40.25	19.74	11.9*	16*
Ungrazed	87	55.5	50.4	36.9*	50*
T 3 (C,G)					
Grazed	78.59	62.38	31.23	18	26.23
Ungrazed	72.79	57.36	44.59	36.29	34.62
T 4 (G,C)					
Grazed	76.48	31.31	18.9	18.36	16.54*
Ungrazed	69	57.88	38.25	41.92	41.13*

*Indicates significant difference between grazed and ungrazed control

Figure 2. Mean sward height, day 0 and day 60



*Indicates significant difference between grazed and ungrazed control

Table 4. Mean sample weights (g), dry matter basis

	Day 0	Day 15	Day 30	Day 45	Day 60
T 1 (G)					
Grazed	433	565	385	312*	178
Ungrazed	470	682	590	657*	385
T 2 (G+C)					
Grazed	487	277*	243*	255	155
Ungrazed	520	722*	417*	437	427
T 3 (C,G)					
Grazed	475	375	357	245	127
Ungrazed	460	468	433	352	342
T 4 (G,C)					
Grazed	498	328	177*	292	287
Ungrazed	379	687	653*	573	522

*Indicates significant difference between grazed and ungrazed control

Forage composition comparisons resulted in few differences of significance (Table 5). No differences existed in grass biomass between grazed and ungrazed areas. However, on day 30 (rotation with goats) in Treatment 3 (C,G), the ungrazed area had a significantly higher percentage of legume biomass than did the grazed area. Also, on day 0, Treatment 4 (G,C) had a significantly higher percentage of weed biomass in its ungrazed area than in its grazed counterpart (Table 5).

Forage quality also yielded significant differences throughout the study. In Treatment 3 (C,G) on day 30 (rotation with goats) the grazed areas had significantly higher both ADF and NDF (Figures 3, 4). Day 60 (rotation with goats) also resulted in a significantly higher NDF in the grazed areas. NDF was also significantly higher in the grazed areas in Treatment 4 (G,C) on day 45 (rotation with goats) (Figure 4). No significant differences existed among the crude protein (Figure 5).

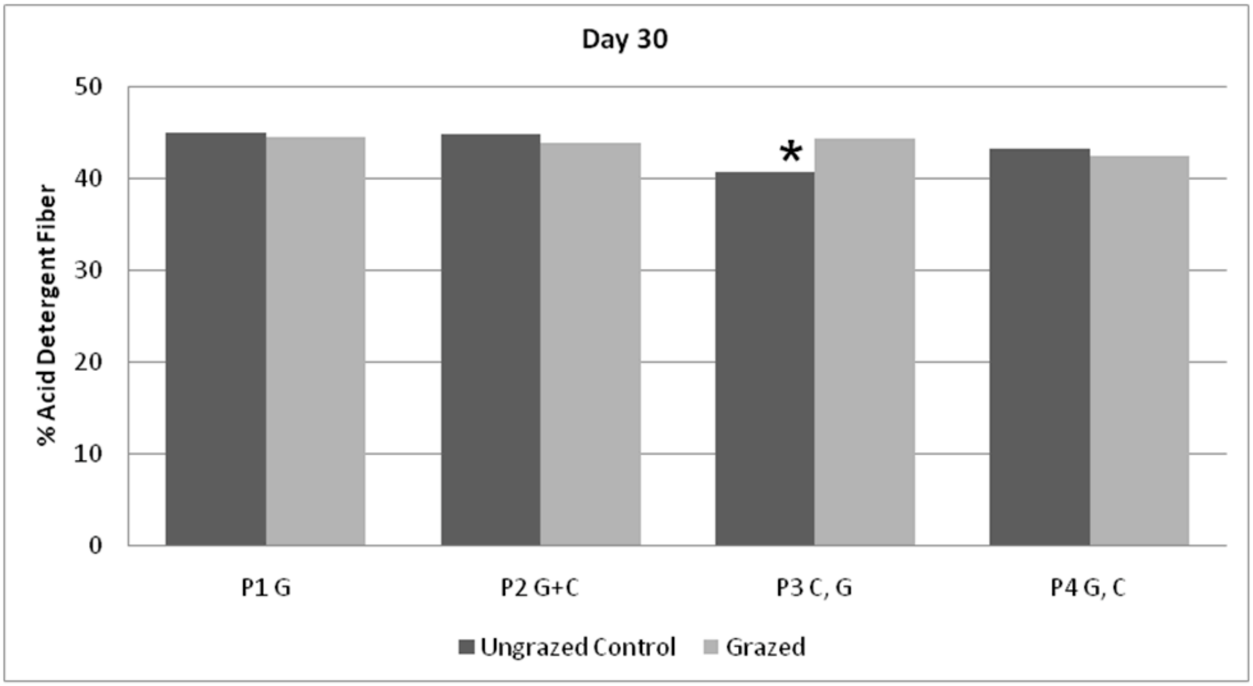
Concerning the thistle data collected, only the thistle height and the number of leaves per thistle plant were analyzed for significance. As previously stated, thistle data were only available for one collection date, day 15, due to an unforeseen situation requiring the topping of all thistle plants. Therefore, on day 15, there was a significant difference in thistle height between Treatments 1 and 3 only (Figure 6). Also on day 15, there were significant differences with the number of leaves per plant. Treatment 3 was significantly different from all other treatments, whereas Treatment 1 was significantly different from only Treatments 3 and 4 (Figure 7).

Table 5. Mean percentage forage composition

-	- Day 0		-	- Day 15		-	- Day 30		-	- Day 45		-	- Day 60		-
	Grass	Legume	Weed	Grass	Legume	Weed	Grass	Legume	Weed	Grass	Legume	Weed	Grass	Legume	Weed
T 1 (G)															
Grazed	89.53%	1.20%	5.90%	95.58%	0.94%	2.50%	97.11%	2.57%	1.11%	100%	1.67%	0.24%	98.38%	0.42%	0.58%
Ungrazed	89.70%	2.13%	4.57%	93.04%	1.30%	6.19%	96.33%	0.28%	3.16%	98.83	0%	1.92%	94.59%	0%	3.68%
T 2 (G+C)															
Grazed	96.27%	0%	0.37%	97%	1%	1.53%	100%	0%	3.67%	100%	0%	0%	98.33%	0%	0%
Ungrazed	93.27%	0%	1.54%	96.39%	0%	2.08%	99.50%	0%	0.33%	102.20%	0%	0.13%	97.75%	0.90%	0%
T 3 (C,G)															
Grazed	71.10%	4.47%	22%	90.52%	1.85%	7.64%	85.02%	1.45%*	15.10%	90.12%	0%	12.90%	100%	0.53%	0%
Ungrazed	78.27%	10.35%	9.12%	73.93%	7.73%	14.89%	71.30%	10.1%*	16.96%	81.44%	3.51%	16.14%	73.02%	9%	17.70%
T 4 (G,C)															
Grazed	82.13%	11.43%	1.36%*	62.08%	16.88%	22.93%	83.04%	6.60%	7.33%	85.04%	2.70%	14.97%	86.11%	6.36%	6.95%
Ungrazed	61.03%	20.50%	13.17%*	55.70%	11.27%	27.60%	75.09%	3.04%	19.58%	71.63%	6.87%	22.88%	79.50%	4.70%	14.88%

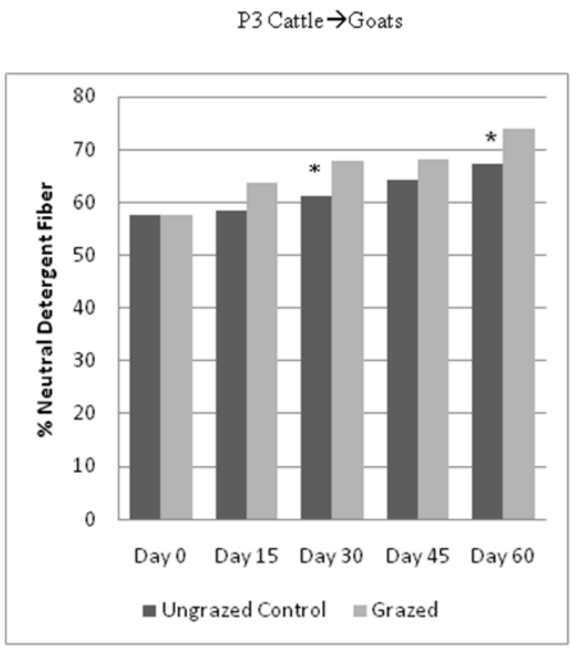
*Indicates significant difference between grazed and ungrazed control

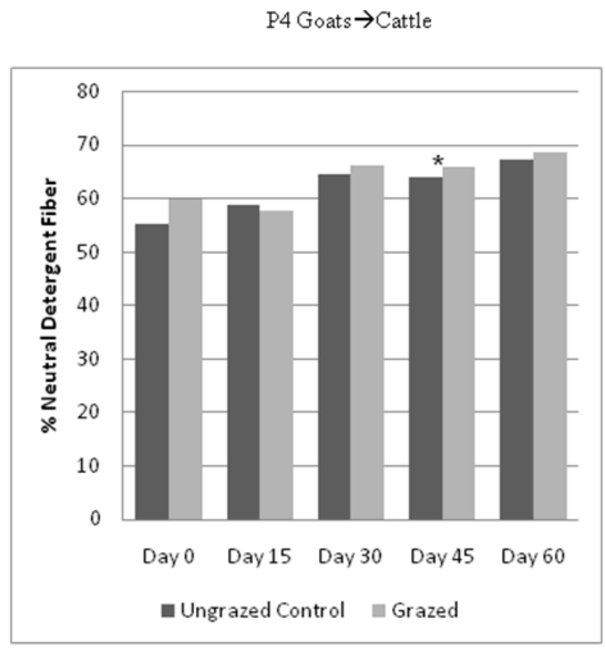
Figure 3. Mean ADF for Treatments, day 30



*Indicates significant difference between grazed and ungrazed control

Figure 4. Mean NDF for samples in Treatments 3, 4





*Indicates significant difference between grazed and ungrazed control

Figure 5. Mean percentage crude protein throughout the study

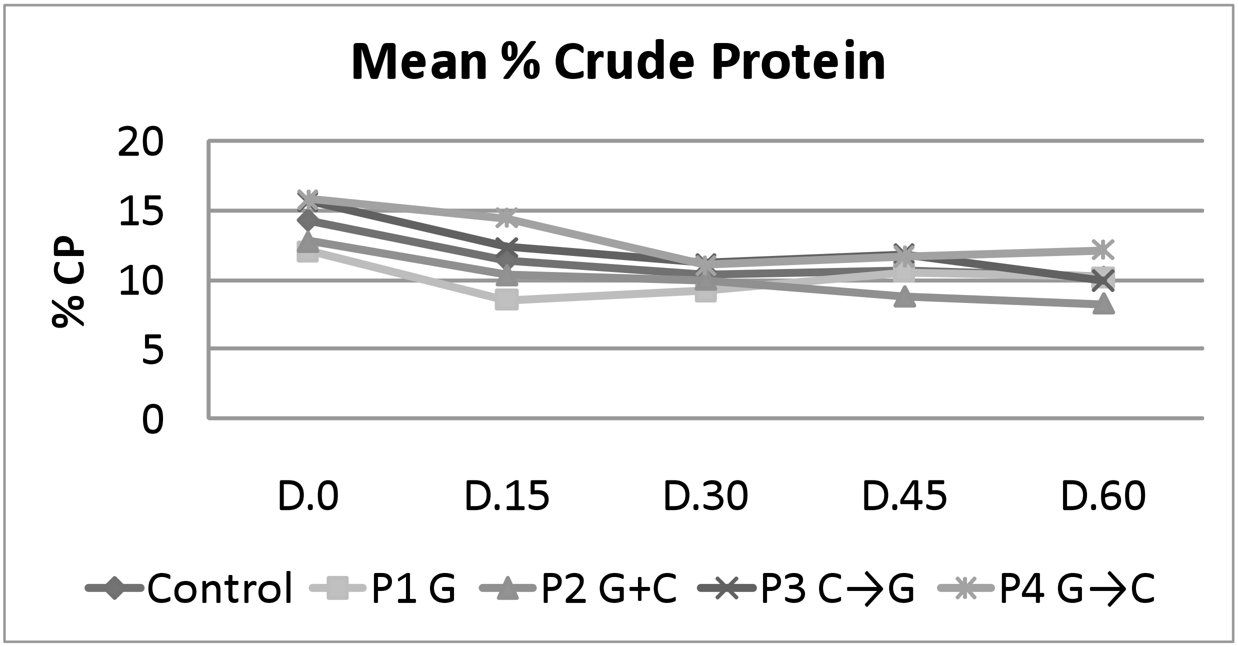


Figure 6. Mean thistle height (cm), day 15

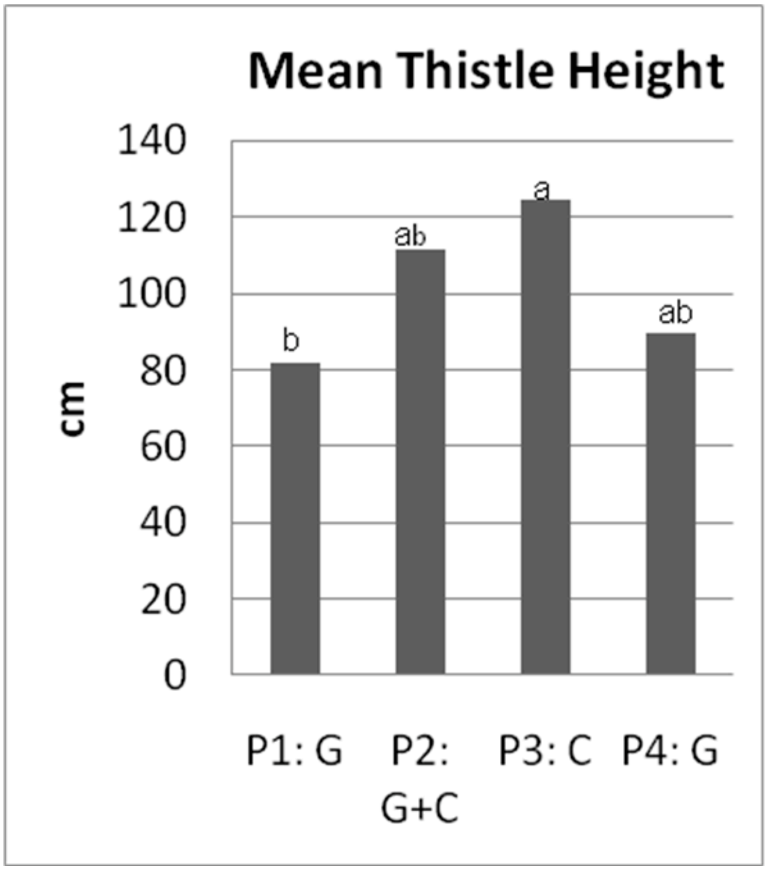
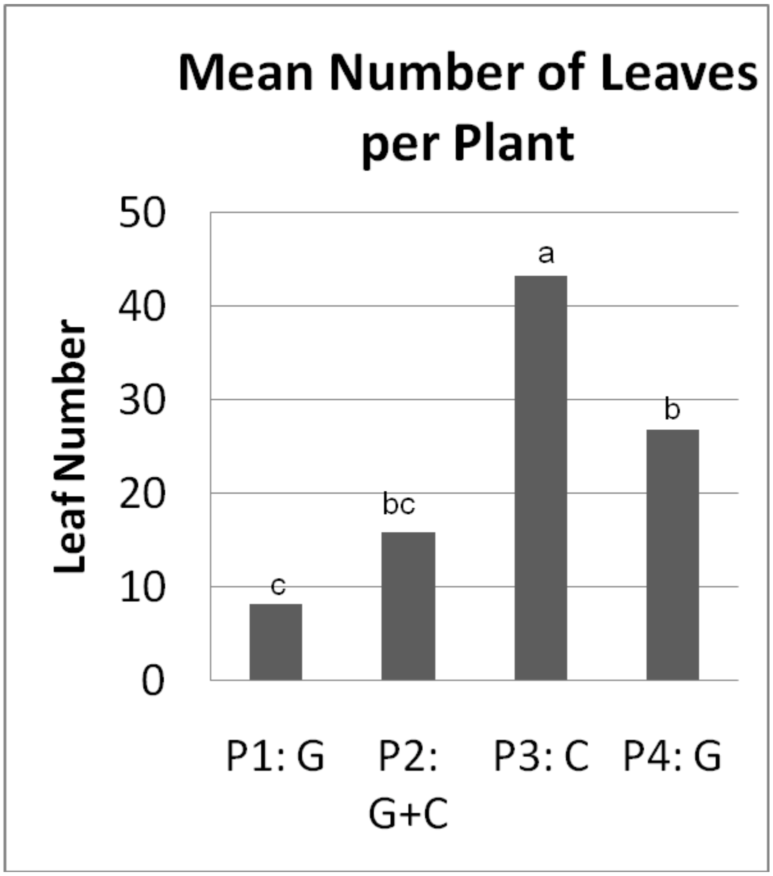


Figure 7. Mean number of leaves per thistle plant, day 15



CHAPTER FIVE

Conclusion

This research was undertaken to determine the possibility of introducing goats into an established grazing program, specifically with cattle, to improve the pasture and its utilization. To that end, these results can provide suggestions, with the understanding that additional research is needed to provide definitive recommendations for the establishment of a co-species grazing program.

As an introductory caveat, however, fewer significant differences were actually discovered than were expected. This is likely due, in part, to the stocking rate. For this study, occurring during late spring and early summer, a lower stocking rate than necessary was unintentionally used. With proactive fertilization and significant moisture at the onset of the study, forage growth rates visually appeared to have provided higher amounts of dry matter than the animals could consume, affecting study results. A management intensive grazing study would likely provide more definitive results on the co-species grazing question. This study does, however, provide an adequate introduction to this discussion and suggestion for further evaluation.

Field data (% live ground cover, % weed cover, sward height) seems to suggest that perhaps a rotational grazing system where goats follow cattle provide the best scenario for the pasture environment. With this rotational arrangement, there was no significant difference in any of the parameters between grazed and ungrazed areas. This would suggest that this arrangement does not deplete the pasture as readily and perhaps allows for regrowth more quickly and easily. However, it also did not indicate any reduction in weeds. This may be a result of a low stocking rate. A higher stocking rate might also decrease the beneficial pasture effect of a decrease in depletion and increase in regrowth, but it might be suggested that with the difference in species diet preferences, this benefit could be sustained, allowing the goats to follow the cattle, eating the undesirables (including weeds) left behind.

This idea is also supported by the collected sample data (forage dry weights, and forage composition). Each treatment other than goats rotating after cattle (Treatment 3) showed a significant decrease in available forage amounts versus the control areas during the study. Compositionally, Treatment 3 did show a significantly lower amount of legume biomass in the grazed areas halfway through the study, but the amount did rebound after that.

Forage quality analysis might provide a different interpretation, however. Throughout the study, with both rotational treatments, whenever goats grazed after the cattle, the neutral detergent fiber (NDF) of the grazed areas was significantly higher than the control. It is important to remember that this data is taken from forage that the animal left behind, not that which the animal consumed. This may suggest that while goats may consume different forage species than did the cattle, they may be more selective in their consumption. Meaning, they may instinctively consume lower fiber forages than do the cattle (not exclusive of weeds and other "undesirables" of cattle). Because this only occurred when the goats grazed rotationally *after* the cattle, the repeated high fiber content of the forages left behind would support this supposition.

Acid Detergent Fiber (ADF) of the grazed areas (forages left behind) was also significantly higher on one test date (day 30) when goats grazed following the cattle. This would support the above mentioned theory. A higher stocking rate might have yielded a greater difference and a better chance to further develop this theory. No significant differences were found in crude protein between the grazed and ungrazed areas.

While little research has been conducted on thistle consumption by goats, this study yielded some introductory results. Thistle height results yielded exactly as expected, with Treatment 1(G) being significantly lower than Treatment 3 (cattle only, in this rotation). Treatments 2 (G+C) and 4 (goats only, in this rotation) had lower numbers of thistles than Treatment 3, but not significantly. This can be attributed to a lower stocking density of goats in Treatment 2 (because both species were present in a larger land area) or a much higher concentration of thistle plants (as visually observed in Treatments 3 and 4). Additional study would be necessary for a definitive conclusion.

Mean number of thistle leaves per plant provides a similar conclusion. Treatment 3 has significantly higher leaf numbers than all other paddocks, as expected due to lack of goat presence. The significant differences that also exist between Treatments 1 and 4 are presumably due to the differences in visually observed thistle plant concentrations. The paddocks, during this rotation, are both goats only with the same land area and same number of animals. Treatment 1 had greatly reduced thistle plant numbers, as compared to Treatment 4, thus the goat to thistle plant ratio is much higher, forcing each thistle plant to be consumed more completely. Thistle data, however, was only taken once, due to unforeseen circumstances negating any further data collection. Additional collection days could potentially alter these results. Visual observations would suggest that these results would be maintained throughout the length of the study, with little, if any, differences.

Overall, this study suggests goats as a potential weed control method, especially for nodding thistle. These results suggest a sequential or leader-follower rotational grazing scheme by species for best overall pasture management and utilization, with goats following cattle.

CHAPTER SIX

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