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TWO GRAZING SYSTEMS AND THREE FORAGE SPECIES
FOR ROTATIONAL GRAZING IN NORTHERN MICHIGAN

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TWO GRAZING SYSTEMS AND THREE FORAGE SPECIES FOR ROTATIONAL GRAZING IN NORTHERN MICHIGAN

By

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ABSTRACT

TWO GRAZING SYSTEMS AND THREE FORAGE SPECIES FOR ROTATIONAL GRAZING IN NORTHERN MICHIGAN

By

Dana Jeannine Barclay

Rotational grazing has gained popularity in recent years, however few research studies have explored different grazing systems and forage mixtures. In this study 108 Holstein yearling heifers were in either 10 day conventional rotations or 3-5 day intensive rotations on three pasture mixes: alfalfa (*Medicago sativa* L.) + bromegrass (*Bromus inermis* Lyss.*)*, birdsfoot trefoil (*Lotus corniculatus* L.*)* + bromegrass and bromegrass with 224 kg/ha N fertilizer applications. The stocking rate was .61 head/ha for all treatments. After two grazing seasons, grazing days averaged 145 days, an increase for northern Michigan where historically grazing seasons average 120-130 days. Results show bromegrass + 224 kg/N/season produced more forage but the least animal gains/ha and lowest average daily gains when compared to pastures with legumes present. The birdsfoot trefoil + bromegrass pastures grazed intensively produced the highest average daily gains and the highest total gains/ha on minimal forage. Alfalfa + bromegrass pastures produced intermediate forage yields and average daily gain in heifers. There was little difference between the grazing systems when averaged over all treatments for both years; however the differences between the systems were greater the second year within forage mixtures.

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INTRODUCTION

The importance of rotational grazing was speculated at as early as the turn of the century when it was noted for increasing productivity in certain grazing situations (Heady, 1963). Since that time numerous studies have been conducted attempting to quantify the effects of rotational grazing on both animal and forage aspects. As the popularity of grazing livestock grows so do the questions being raised by livestock producers and researchers alike. In certain areas, such as northern Michigan, where livestock and forage production are the mainstay of the agricultural system, grazing has become a viable option for production agriculture. There is a need to determine which rotational grazing systems and forage species will work best for producers there.

Rotational grazing has proved successful throughout the world as research has been conducted worldwide. A number of positive factors have been identified that increase the favorability of rotational systems, such as annual net primary production (ANPP). Utilizing a rotational system may result in higher levels of ANPP (Heitschmidt et al., 1982a; Voisin, 1959). Rotational grazing systems are designed to take advantage of compensatory growth response in plants (McNaughton, 1979). Rates of nutrient uptake (N, P, Fe, Ca, and K) are known to increase with grazing (Pearson and Lison, 1987: Cuykendall and Marten, 1968). There is increased proliferation of meristematic tissue and increased rates of elongation and tillering (McNaughton, 1979; Voison, 1959; Brockman et al., 1971). Water use efficiency and conservation are increased in response to rotational grazing as evapotranspiration for the entire sward is reduced. It has been seen several times in drought conditions that rotational plots survive and even flourish (McNaughton, 1979; Cuykendall and Marten, 1968; personal communications 1988-1996).

Rotational grazing can increase the carrying capacity of a pasture because there is an increase in forage production and/or forage quality. Heitschmidt et al., (1982a and b) reported forage production of 330 g/m^2 in rotationally grazed plots vs. 234 g/m^2 in continuous plots. Forage quality, as measured by % crude protein (CP) was generally higher in rotational plots and %CP increased in response to tiller defoliation. It is theorized that the increase in forage quality is a primary mechanism that increases the energy flow in a rotational grazing system which increases the carrying capacity.

Competition for light is reduced in rotational systems in the time period following the grazing activity. All of the plants are grazed to uniform height so light energy is more efficiently utilized by all of the plants in the sward. A study of LAI indicates that rotational grazing systems are far more efficient converting light energy into actual animal production (Parson et al., 1983).

Many studies have been conducted that compare continuous vs. rotational grazing. It appears that grazing systems need to be developed then adapted to local conditions. It is documented that continuous grazing has an advantage in range situations and other areas where there is a low ANPP. Heady (1963) reported that continuous grazing is as productive vegetatively as rotational if not more so in the annual grasslands of California. This is also true in the mixed prairie of the Great Plains, short grass range of Wyoming, and in areas of the Southwest U.S.. An eight year comparison study of continuous and rotational grazing systems showed no significant differences in cattle gains or in vegetative improvements (McIlvain and Savage, 1951). However, in areas of greater ANPP, rotational grazing shows an advantage. Voisin (1959), reported data from a continuous vs. rotational study which showed forage production much greater under rotational grazing. Continuous systems provided 80 kg/ha/day of herbage vs. 266 kg/ha/day under rotational management for the months of May and June. In August and September the yields were 40 kg/ha/day vs. 133 kg/ha/day, respectively.

In terms of animal response to grazing intensity the results are quite variable. A twenty-five year study of the mixed prairie of the Northern Plains showed rotational grazing as an acceptable method for range management, as 2 year old steers gained 15.8 kg/ha more per head on a rotational system than on continuous one (Rogler, 1951). Lawrence et al., (1989) observed that yearling heifers not only exhibited higher average daily gains but also greater animal gain per acre on a continuous system rather than an intensive short duration system, however, Kirby and Niren (1989), in a rotational vs. continuous study in North Dakota, found a 41% increase in calf gain per acre but showed no significant differences in average daily gain in calves. Blount et al. (1991) in Oregon found similar results in yearling steers. McCann et al., (1991) conducted a 12-paddock rotational system vs. continuous grazing and showed a 36% increase in calf weight gain per acre. They found there was no difference in individual calf weaning weight. Beck et al., (1991) in Iowa compared calf weight gains from a study comparing continuous vs. 8-paddock rotational system. They found average daily gains to be 10% higher for the continuous system but calf gain per acre was 50% greater for the 8-paddock system. Similar findings were reported by Boston et al (1991).

Relatively few studies have attempted to compare rotational grazing that vary in both grazing intensity and forage species. The success of any grazing system relies not only on the grazing scheme utilized, but the forage species as well. The most popular forages used in northern Michigan are alfalfa, birdsfoot trefoil, bromegrass and simply native pasture.

Alfalfa, known for its superiority in terms of yield, quality and palatability is capable of producing high-quality pasture (Barnes and Schaeffer, 1985). The drawback lies in its tolerance to continued defoliation. Blaser et al., (1986) found that alfalfa in an alfalfa-grass pasture was 90% absent by the second year in a continuous pasture while rotational stands were excellent. A variable rest period for plant regrowth is provided with rotational systems that allows for plant rejuvenation to insure high nutrient quality and productivity. In an initial alfalfa grazing study in Michigan (Schlegel, 1993) reported on steer gains on pure alfalfa stands with variable stocking rates and grazing methods. Results showed that high stocking rates initially gave decreased average daily gains but increased over time and that grazing method did not affect average daily gains. Another study in Kentucky reported gains of 535 to 820 kg/ha with beef animals on rotationally grazed alfalfa stands (Burris et al., 1993).

Birdsfoot trefoil, a long-lived non-bloating legume, is well adapted to the climate of northern Michigan. Even though birdsfoot trefoil does not yield as high as alfalfa it can tolerate poorly drained and acidic soils that make alfalfa management difficult

(Undersander et al., 1993). Like alfalfa, birdsfoot trefoil stands can be greatly reduced under continuous grazing but thrives quite well when managed rotationally (Van Keuren and Davis, 1968).

Bromegrass is highly suited for intensive grazing in Michigan (Moline et al., 1991). It is very popular among northern Michigan graziers. When grown alone and fertilized with nitrogen, bromegrass can produce greater dry matter yields than legume-grass mixes (Tesar, 1974).

It is obvious after reviewing all the variations in research results, that grazing programs need to be developed that function well within specific environments. There is a need to determine which systems work best in northern Michigan where livestock and forage production is prominent. The objectives of this study are:

1) To compare the productivity of two methods of managing a rotational grazing system.
2) To compare the productivity of two legume-grass mixes and a straight grass pasture in rotational grazing systems under northern Michigan conditions.

MATERIALS AND METHODS

PASTURE ESTABLISHMENT

This study began in 1992 at the Lake City Experiment Station in Lake City, Michigan which is located in northern lower peninsula. The soils at the site were approximately 60% Nester sandy loam (fine, mixed Typic Eutroboralfs), 30% Kawkawlin loam (fine, mixed Aquic Eutroboralfs), 6% Montcalm-Greycalm complex (coarse-loamy, mixed, frigid Eutric Glossoboralfs and mixed, frigid Alfic Udipsamments), and 4% Sims loam (fine, mixed, nonacid, frigid Mollic Haplaquepts).

The 29.16 ha area was sprayed with Roundup (1.9 liter/ha) in May of 1992. In late May the area was plowed, disced and periodically fallowed until late July. Seeding took place from July 29 thru August 1. A brillion seeder was used to plant each of the 18-1.62 ha paddocks. Six pastures were planted to alfalfa (6.4 kg/ha) + bromegrass (3.6 kg/ha). Another six pastures were planted to birdsfoot trefoil (3.6 kg/ha) + bromegrass (3.6 kg/ha) while the remaining six were sown with straight bromegrass (3.6 kg/ha) which received 224 kg/ha N/season, as urea, applied in a split application spring and fall. The first N application occurred in May of 1993. During July of 1993 the site was mowed and chopped for haylage or baled as hay. The second N application took place in September of 1993.

In 1993 the high tensile fencing system was constructed. The perimeter was either a 5-wire high tensile permanent structure, or in some areas, a preexisting woven wire fence. Posts included both wooden and fiberglass materials. Interior fencing between the pastures was 3-wire high tensile fence with poly-tape gates. Polywire with step-in posts was used for the interior fencing within paddocks.

The watering system was also installed in 1993, after the fencing project. The site had its own well and pump capable of supplying a constant source of water to the pastures at all times. Each pasture had black plastic tubing with couplers installed along each side to facilitate a movable waterer with a full flow valves.

MANAGEMENT OF PASTURES

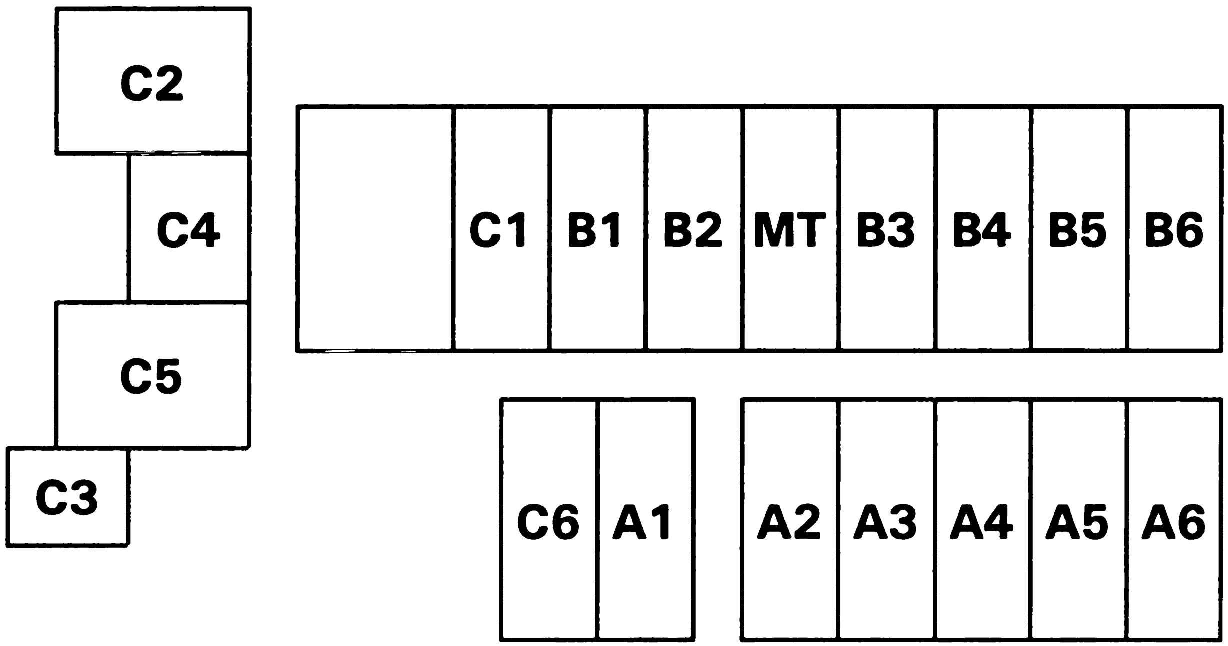
There were two grazing treatments in this project. The conventional © pastures were divided into 4-.41 ha paddocks and grazed 10-11 days /paddock resulting in a 33-day rest for each paddock. The intensive (I) pastures were divided into 12-.13 ha paddocks, grazed for 3-5 days, depending in forage availability, and rested for 33-45 days. The intensive pastures were first staged before the intensive management began. The grazers were allowed to graze the entire .41 ha pasture for 10 days, cut back to 2/3rds of the area for 10 days and given the back 1/3 for 10 days. After this 30 day period the grazers were brought back to the front of the pasture and given the first .13 ha paddock. Grazing began on May 10 in 1994 and May 18 in 1995 lasting 155 and 134 days, respectively. Historically this area of Michigan has a 120-130 day grazing season.

THE GRAZERS

A total of 108 Holstein heifers were used each season in this study. They were divided into groups of six and allocated into one of the eighteen pastures, blocked by weight. This gives a stocking rate of 3.7 hd/ha. While on pasture the heifers were given free choice salt/mineral mix and water. At the beginning of the grazing season the heifers were weighed twice over two days and taking the average weight (180-230 kg) before going on to pasture. The heifers were weighed every 28 days during the grazing season and weighed coming off of the study. After a 5 day uniform feeding period the heifers were weighed two days in a row and weights averaged. From this data, average daily gains (ADG) were calculated as well as total animal gain/ha. Analysis of variance calculations (ANOVA) were then performed. Fischer's Protected Least Significance Difference (LSD) test at %5 level of significance was utilized.

FORAGE DATA COLLECTION

Prior to each rotation of the heifers, forage samples were taken using a quarter meter quadrant. Samples were hand separated by species, dried and weighed. From this information, total forage yield was determined along with yield by species. These samples were then analyzed for forage quality: crude protein (%CP), neutral detergent fiber (%NDF) and acid detergent fiber (%ADF) using near-infrared reflectance spectroscopy (NIR) analysis followed by wet chemistry. ANOVA's for total production were performed using LSD at .05 significance level.



LAKE CITY GRAZING RESEARCH PROJECT

A1	ALFALFA/BROME	CONVENTIONAL
A2	BROMEGRASS	CONVENTIONAL
A3	BIRDSFOOT TREFOIL/BROME	INTENSIVE
A4	BROMEGRASS	INTENSIVE
A5	ALFALFA/BROME	INTENSIVE
A6	BIRDSFOOT TREFOIL/BROME	CONVENTIONAL

B1	BIRDSFOOT TREFOIL/BROME	INTENSIVE
B2	BROMEGRASS	INTENSIVE
B3	ALFALFA/BROME	CONVENTIONAL
B4	BIRDSFOOT TREFOIL/BROME	CONVENTIONAL
B5	ALFALFA/BROME	INTENSIVE
B6	BROMEGRASS	CONVENTIONAL

C1	BIRDSFOOT TREFOIL/BROME	INTENSIVE
C2	ALFALFA/BROME	CONVENTIONAL
C3	BROMEGRASS	INTENSIVE
C4	BROMEGRASS	CONVENTIONAL
C5	BIRDSFOOT TREFOIL/BROME	CONVENTIONAL
C6	ALFALFA/BROME	INTENSIVE

RESULTS AND DISCUSSION

Grazing Season 1994

Total forage production for 1994 on a DM basis is shown in Table 1. It was a season of more than adequate rainfall. During the grazing season a total of 63.3 cm of rain was recorded, with a yearly total of 92.2 cm. The mean forage yield was 11536 kg/ha. The conventionally managed bromegrass + N produced significantly more forage when compared to the other treatments while both of the birdsfoot trefoil + bromegrass pastures produced the least forage. There were no significant differences between all other pastures.

Table 1. Total forage DM production on the Lake City Pastures (1994).

Forage species	Grazing system	Seasonal Yield kg/ha
Alfalfa + Bromegrass	Intensive	11872
Alfalfa + Bromegrass	Conventional	11469
Birdsfoot Trefoil + Brome	Intensive	11066
Birdsfoot Trefoil + Brome	Conventional	10618
Bromegrass + N	Intensive	11760
Bromegrass + N	Conventional	12454
LSD .05		508

Average daily gains (ADG) in 1994 are shown in Table 2. Heifers on pastures containing legumes had significantly higher ADG's than those on smooth bromegrass + N pastures. While not significantly higher than conventional management in 1994, birdsfoot trefoil + bromegrass pastures, intensively managed, produced the highest ADG's in the heifers with the second to lowest amount of dm/ha. Bromegrass + N intensively managed pastures on the other hand produced significantly lower ADG's on ample forage.

Table 2. Average daily gains in Holstein heifers on 1994 Lake City Pastures.

Forage species	Grazing system	Average Daily Gain kg/day
Alfalfa + Bromegrass	Intensive	1.08
Alfalfa + Bromegrass	Conventional	1.07
Birdsfoot Trefoil + Brome	Intensive	1.10
Birdsfoot Trefoil + Brome	Conventional	1.06
Bromegrass + N	Intensive	0.97
Bromegrass + N	Conventional	1.00
LSD .05		0.0626

Total seasonal animal gain per hectare in 1994 (Table 3.) was similar to the ADG data because of similar stocking rate. Legume pastures produced significantly higher gains (kg/ha/season) in 1994 than either of the bromegrass + N pastures. Birdsfoot trefoil + bromegrass pastures, intensively managed, produced the highest gain/ha/season, however, not significantly better than alfalfa + bromegrass pastures.

Table 3. Seasonal gain per hectare from Holstein heifers in 1994 at Lake City.

Forage species	Grazing system	Heifer Gain (kg/ha/season)
Alfalfa + Bromegrass	Intensive	620.4
Alfalfa + Bromegrass	Conventional	611.8
Birdsfoot Trefoil + Brome	Intensive	632.1
Birdsfoot Trefoil + Brome	Conventional	610.2
Bromegrass + N	Intensive	554.6
Bromegrass + N	Conventional	574.7
LSD .05		38.37

Grazing Season 1995

In 1995 rainfall totaled 77.8 cm with 44 cm of it occurring during the grazing season. In 1995, forage production (Table 4) increased overall (mean = 13574.4 kg/ha). Intensive and conventional bromegrass + N pastures and intensively managed alfalfa + bromegrass produced significantly higher total forage. Conventionally managed bromegrass + N produced the highest amount of forage. Conventionally managed alfalfa + bromegrass and intensive birdsfoot + bromegrass pastures produced intermediate forage yet significantly higher than conventional birdsfoot trefoil + bromegrass pastures.

Table 4. Total forage DM production on the Lake City Pastures (1995).

Forage species	Grazing system	Seasonal Yield kg/ha
Alfalfa + Bromegrass	Intensive	14426
Alfalfa + Bromegrass	Conventional	12992
Birdsfoot Trefoil + Brome	Intensive	13328
Birdsfoot Trefoil + Brome	Conventional	12096
Bromegrass + N	Intensive	13754
Bromegrass + N	Conventional	14829
LSD .05		1100

Pasture mixtures and the management effects on average daily gains (Table 5.) became apparent in 1995. Heifers grazing intensively on birdsfoot trefoil + bromegrass pastures had significantly higher average daily gains than other heifers in spite of the low to moderate forage production. In 1994 all pastures containing legumes achieved highly significant differences from bromegrass + N pastures. The legume pastures in 1995 had significantly higher ADG's than either of the bromegrass + N pastures.

Table 5. Average daily gains in Holstein heifers on 1995 Lake City Pastures.

Forage species	Grazing system	Average Daily Gain kg/day
Alfalfa + Bromegrass	Intensive	0.97
Alfalfa + Bromegrass	Conventional	0.97
Birdsfoot Trefoil + Brome	Intensive	1.05
Birdsfoot Trefoil + Brome	Conventional	0.97
Bromegrass + N	Intensive	0.85
Bromegrass + N	Conventional	0.83
LSD .05		0.0457

Seasonal total gains/ha among the heifers in 1995 followed the trends as their average gain (Table 6). The intensively grazed birdsfoot trefoil + bromegrass pastures had significantly higher total gains/ha than all other treatments. Both intensively and conventionally grazed bromegrass + N pastures produced the lowest gains while the remaining alfalfa and birdsfoot trefoil pastures produced significantly higher gains than the bromegrass + N pastures.

Table 6. Seasonal gain per hectare from Holstein heifers in 1995 at Lake City.

Forage species	Grazing system	Heifer Gain (kg/ha/season)
Alfalfa + Bromegrass	Intensive	468.8
Alfalfa + Bromegrass	Conventional	481.4
Birdsfoot Trefoil + Brome	Intensive	519.9
Birdsfoot Trefoil + Brome	Conventional	479.7
Bromegrass + N	Intensive	422.1
Bromegrass + N	Conventional	409.3
LSD .05		30.27

FORAGE SPECIATION

The percentage of the legume, grass and other components in 1994 and 1995 are shown in Table 7. Using the comparisons for the two seasons, changes in these pasture components were observed. The legume components in all four of the treatments containing seeded legumes increased or stayed at the same levels from 1994 to 1995. Legumes under intensive grazing management increased to a greater degree than those under conventional grazing. Alfalfa in the conventional pastures remained about the same but the total seeded grass component decreased from 1994 to 1995. The seeded grass portion in the intensive alfalfa pastures also decreased as a portion of the pasturage. The grass components in both birdsfoot pastures decreased between 1994 and 1995 while seeded legumes increased. The percentages of other plants in all of the pastures increased from year 1 to year 2 except for the intensively grazed bromegrass pastures which demonstrated a decrease in percentages of other plants. Both bromegrass + N pastures changed very little in terms of total grass production. Seeded grass in conventional bromegrass + N pastures declined slightly as other plants percentages increased, while bromegrass + N increased under intensive rotation and other plant populations declined slightly over the two-year period.

Table 7. Legume grass and other plant components (%) in Lake City Pastures in 1994 & 1995.

Forage species	Grazing system	Legume		Grass		Other Plants	
		94	95	94	95	94	95
Alfalfa + Brome	Intensive	37.5	42.4	56.3	53.6	6.2	9.3
Alfalfa + Brome	Conventional	37.5	37.5	59.4	55.2	3.1	7.3
BFT + Brome	Intensive	32.8	39.4	60.8	48.6	6.4	12
BFT + Brome	Conventional	28.8	33.5	62.9	57.0	8.3	9.5
Bromegrass + N	Intensive			94.4	95.7	5.6	4.3
Bromegrass + N	Conventional			96.6	94.7	3.4	5.3
LSD .05		.81	.31	.96	.17	.13	.48

Legume component yields of DM (kg/ha) from 1994 to 1995 (Table 8) shows clearly that the legume yield components increased from year 1 to year 2 and also increased as a percent of the total as shown previously in Table 7. The alfalfa component under intensive management increased 1389 kg/ha between 1994 and 1995. The legume component in conventional alfalfa pastures increased in dry matter yield but remained the same as a percentage of DM. Birdsfoot trefoil yields in the intensively managed pastures increased 1388 kg/ha while conventional birdsfoot trefoil increased 604 kg/ha.

Table 8. Legume component in Lake City Pastures 1994 & 1995.

Forage species	Grazing system	kg/ha 1994	kg/ha 1995
Alfalfa + Bromegrass	Intensive	4525	5914
Alfalfa + Bromegrass	Conventional	4122	4525
Birdsfoot Trefoil + Brome	Intensive	3898	5286
Birdsfoot Trefoil + Brome	Conventional	3114	3718
LSD .05		100	67

FORAGE QUALITY

Forage quality analysis were determined on sorted samples collected in 1994 and 1995. Average %CP for legume components (Table 9) shows that the %CP tended to be lower in 1995 when compared to 1994. When averaged over two years samples from the intensively managed birdsfoot trefoil pastures provided the highest %CP among the pastures. Both alfalfa treatments were similar and conventionally grazed birdsfoot trefoil pastures had the lowest %CP. In 1994 conventionally grazed alfalfa + bromegrass and intensively grazed birdsfoot trefoil + bromegrass legumes produced the highest %CP while conventionally grazed birdsfoot trefoil + bromegrass had the lowest %CP in 1994 and 1995. Intensively grazed birdsfoot trefoil + bromegrass supplied the significantly higher %CP in 1995.

Table 9. Average % CP in legume components.

Forage Species	Grazing System	% CP 1994	% CP 1995	2 yr. ave.
Alfalfa + Brome	Intensive	23.7	21.1	22.4
Alfalfa + Brome	Conventional	24.2	20.7	22.5
BFT + Brome	Intensive	24.2	21.9	23.1
BFT + Brome	Conventional	22.8	20.6	21.7
LSD .05		.33	.35	

Average %NDF in legume components for 1994 and 1995 are shown in Table 10. The two year average shows the legume portion in the intensive birdsfoot trefoil plots had the lowest NDF values and samples from the conventional birdsfoot pastures had slightly higher NDF values. Alfalfa from conventional pastures had the highest NDF while intensive alfalfa had the second highest rank among pastures. In 1994 and 1995 intensively grazed birdsfoot trefoil + bromegrass legume samples had significantly lower NDF values than all other legumes from the pastures.

Table 10. Average %NDF in legume components.

Forage Species	Grazing System	% NDF 1994	% NDF 1995	2 yr. ave.
Alfalfa + Brome	Intensive	38.9	35.5	37.2
Alfalfa + Brome	Conventional	37.9	38.1	38.0
BFT + Brome	Intensive	36.3	34.5	35.4
BFT + Brome	Conventional	37.9	35.8	36.9
LSD .05		0.47	0.66	

Table 11 shows average %ADF for legume components in 1994 and 1995. Average ADF values tended to be lower in 1995. Intensive birdsfoot trefoil pastures supplied the lowest ADF values while conventional birdsfoot pastures the highest. Both alfalfa treatments were virtually the same. In 1994 and 1995, intensively grazed birdsfoot trefoil + bromegrass legumes samples produced significantly lower %ADF than all other legume pasture samples. Intensively grazed alfalfa + bromegrass legume samples also had significantly higher ADF values in 1995.

Table 11. Average % ADF in legume components.

Forage Species	Grazing System	% ADF 1994	% ADF 1995	2 yr. ave.
Alfalfa + Brome	Intensive	28.4	26.2	27.3
Alfalfa + Brome	Conventional	28.0	27.6	27.8
BFT + Brome	Intensive	27.2	26.0	26.6
BFT + Brome	Conventional	28.3	27.6	28.0
LSD .05		0.46	0.38	

The %CP in the grass components are shown in Table 12. In general, CP was lower in the grass samples in 1995. The two year average shows the highest CP levels in fertilized bromegrass pastures with intensively managed bromegrass pastures having the highest CP. In both 1994 and 1995 both bromegrass pastures had significantly higher %CP than the other pastures. Grass in the alfalfa pastures ranked intermediate and birdsfoot trefoil grass samples had the lowest CP in the grass samples.

Table 12. Average % CP in grass components.

Forage Species	Grazing System	% CP 1994	% CP 1995	2 yr. ave.
Alfalfa + Brome	Intensive	15.9	13.9	14.9
Alfalfa + Brome	Conventional	15.3	12.9	14.1
BFT + Brome	Intensive	13.6	13.0	13.3
BFT + Brome	Conventional	15.3	12.7	14.0
Brome + N	Intensive	16.1	15.0	15.5
Brome + N	Conventional	16.8	15.6	16.3
LSD .05		0.86	1.07	

NDF values for grass components (Table 13.) tended to be higher in 1995. The two year average shows the highest NDF values in grass components of the conventional alfalfa pastures. Conventional bromegrass had the lowest %NDF. All other treatments fell in between, not varying more than 2.5%.

Table 13. Average % NDF in grass components.

Forage Species	Grazing System	% NDF 1994	% NDF 1995	2 yr. ave.
Alfalfa + Brome	Intensive	57.0	60.6	58.8
Alfalfa + Brome	Conventional	57.8	63.6	60.7
BFT + Brome	Intensive	58.2	60.8	59.5
BFT + Brome	Conventional	57.2	63.2	60.2
Brome + N	Intensive	58.8	59.4	59.1
Brome + N	Conventional	56.7	60.5	58.6
LSD .05		1.14	1.06	

Average %ADF in grass components is shown in Table 14. The ADF values were generally higher in 1995 except in conventional bromegrass pastures. The significantly highest ADF values in grass components were found in conventional alfalfa grass samples in both years. Bromegrass in conventional plots had the lowest ADF values. The samples varied only 1.83%. In 1994 intensively grazed birdsfoot trefoil grass samples had significantly higher ADF values but in 1995 had significantly lower results.

Table 14. Average % ADF in grass components.

Forage Species	Grazing System	% ADF 1994	% ADF 1995	2 yr. ave.
Alfalfa + Brome	Intensive	31.4	32.9	32.2
Alfalfa + Brome	Conventional	32.4	34.9	33.7
BFT + Brome	Intensive	32.1	32.4	32.3
BFT + Brome	Conventional	31.5	34.0	32.8
Brome + N	Intensive	32.2	32.0	32.1
Brome + N	Conventional	31.1	32.4	31.8
LSD .05		0.69	0.80	

CONCLUSIONS

The Lake City Grazing Project is proposed to be a 10-year project and is intended to continue over the next 5-7 years. The results presented in this thesis are a report on the first two years of data collection. Consequently, the results should be considered preliminary.

Results show that birdsfoot trefoil and bromegrass pastures intensively managed produced the highest average daily gains and gain/ha in Holstein heifers grazing a moderate amount of forage. Conventionally managed birdsfoot trefoil was very similar to both alfalfa treatments in terms of average daily gain and gain/ha. Both alfalfa treatments, however, produced substantially more forage than conventional birdsfoot + bromegrass which produced the lowest forage among all treatments. Both bromegrass + N treatments produced the greatest amount of forage yet produced the lowest average daily gains and gain/ha.

The legume components in this study, managed intensively, increased as a percent of the total forage produced. Grass components in all legume plots declined over the two year period. What is not evident in viewing the data is that much of the grass in legume pastures, originally bromegrass, is being slowly replaced with grasses such as Kentucky bluegrass (*Poa pratensis* L.). This grass yields less dry matter/ha than bromegrass thus contributes less weight to the grass component. The other components increased from 1994 to 1995 except in the intensive bromegrass + N pastures.

LIST OF REFERENCES

Barnes, D.K., and C.C. Scheaffer.1985. Alfalfa. In: M.E.Health, R.F.Barnes, and D.S.Metcalf (Ed.) Forages, the Science of Grassland Agriculture. p 89. Iowa State Univ. Press, Ames.

Beck, A.M., J.R. Russell and M.R. Brasche.1991. Grazing system effects on cow-calf production from legume-grass and grass pasture. J. Anim. Sci. 69 (Suppl. 1):263.

Blaser, R.E. 1986. Forage-Animal Management Systems. Virginia Agricultural Experiment Station. Bulletin 86-7. Virginia Polytechnic Institute and State Univ., Blacksburg.

Blount, D.K., R.F. Angell, H.A. Turner and D.W. Weber. 1991. Effects of strip versus continuous grazing on diet parameters and performance of steers grazing eastern Oregon native flood meadows. Professional Anim. Scientist. 7:41.

Boston, A., B. Fagg, K. Hendrix, K. Johnson, F. Dotts, D. Redman, T. Springstun and D. Trotter.1991. Grazing system comparisons at Southern Indiana Purdue Agricultural Center. Beef/Dairy Day Rep., Purdue Univ., Aug., 1991. p 23-25.

Brockman, J.S., C.M. Rope, M.T. Stevens. 1971. The effect of the grazing animal on the N status of grass swards. J. Br. Grassld. Soc. 26:209-212.

Burris, R, J., Randolph, N. Gray, M. Rasnake, and G. Lacefield. 1993. Univ. Of Kentucky Beef Cattle Res. Rep. p 17.

Cuykendall, C.H., G.C. Marten. 1968. Defoliation by sheep grazing versus mower-clipping for evaluation of pasture. Agron. J. 60:404-408.

Heady, H.F.. 1963. Continuous vs. specialized grazing systems: a review and application to the California annual type. 1951. J. Range Manage. 4:182-193.

Heitschmidt, R.K., D.M. Price, R.A. Gordon, and J.R. Frasure. 1982a. Short duration grazing at the Texas experimental ranch: effects on aboveground net primary production and seasonal growth dynamics. J. Range Manage. 35:367-372.

Heitschmidt, R.K., R.A. Gordon, and J.S. Bluntzer. 1982b. Short duration grazing at Texas experimental ranch: effects on forage quality. J. Range Manage. 35:372-374.

Kirby, D.R. and P.E. Nyren. 1989. Short duration grazing in the mixed grass praires. North Dakota State Univ. Station Rep., NCR-87 1989 Annual Rep. P 84.

Lawrence, C.E., M.E. Boyd, C.E. Cantrell, D.E. Pinkerton and W.O. Campbell.1989. Continuous vs. high intensity, short duration grazing during spring-summer with stocker heifers. J.Anim. Sci. 67 (Suppl. 2):45.

McCann, M.A., C.S. Hovelland and N.S. Hill. 1991. Comparison of continuous versus rotational grazing systems for cow-calf production. J. Anim. Sci. 69 (Suppl. 1:270.

McIlvain, E.H. and D.A. Savage. 1951. Eight-year comparisons of continuous and rotational grazing on the southern plains experimental range. J. Range Manage. 4:42-47.

McNaughton, S.J. 1979. Grazing as an optimization process: grass-ungulate relationships in the Serengeti. Amer. Natur. 113:691-703.

Moline, W.J., J.M. Middleton, R. Plummer. 1991. Grasses and legumes for intensive grazing in Michigan. Michigan State Univ. Extension Bull. E-2307.

Parsons, A.J., E.L. Leafe, B. Collett, P.D. Penning, and J. Lewis. 1983. The physiology of grass production under grazing. 2. photosynthesis, crop growth and animal intake of continuously grazed swards. J. Applied Ecology. 20:127-139.

Pearson, C.J. and R. Lison. 1987. Agronomy of grasslands. Cambridge Univ. Press, Cambridge.

Rogler, G.A. 1951. A twenty-five year comparison of continuous and rotational grazing in the Northern Plains. J. Range Manage. 4:35-41.

Schlegel, M.A. 1993. Grazing systems for direct-seeded alfalfa pastures. M.S. Thesis Michigan State Univ. East Lansing.

Tesar, M.B. 1974. Nitrogen on grasses compared to alfalfa-grass mixtures in northern Michigan. Michigan Agr. Exp. Sta. Res. Rep. 256 p 101-104.

Undersander, D., L. Greub, R. Leep, P. Beuselinck, J. Wedberg, D. Smith, K. Kelling, J. Doll, D. Cosgrove, C. Grau, S. Peterson, M. Wipfli, and J. English. 1993. Birdsfoot trefoil for grazing and harvested forage. NCR-474.

Van Keuren. R.W. and R.R. Davis. 1968. Persistence of birdsfoot trefoil as influenced by plant growth and grazing management. Agron. J. 60:92-95.

Voisin, A. 1988. Grass Productivity. Island Press. Washington D.C.