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MODIFICATION TO NATIVE RANGE VEGETATION BY GRAZING MANAGEMENT TO AFFECT GRASSHOPPER POPULATIONS, 1993-1994

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Grasshopper population outbreaks whether on small or large scale are extremely detrimental to the region they occur and are economically costly to individual land owners and society in the lost or destroyed vegetation production and also in the expenses of the treatment program. It would be, presumably, less devastating and costly if cultural management practices could be used to reduce or eliminate the occurrences of pest grasshopper population outbreaks.

Grasshopper egg laying and development of nymphs can be altered by modifications in vegetation structure and density (Onsager 1995, and pers. comm.). Grazing management can be used to modify vegetation structure and density. Grazing research in western North Dakota has shown that the twice-over rotation grazing system on native range as described by Manske and Conlon (1986) can increase herbage production (Manske 1992), grass basal cover (Manske, Barker, and Biondini 1988), and livestock performance (Manske *et al.* 1988) compared to seasonlong grazing treatments and long-term nongrazed (idle) areas. This research project was conducted to determine if the beneficial changes in vegetation structure and density that resulted when defoliation was regulated by twice-over rotation grazing management would be sufficient to negatively affect grasshopper nymphal development and adult egg laying. This was a cooperative project between the Range Research Laboratory at the NDSU, Dickinson Research Center, Dickinson, North Dakota and the Rangeland Insect Laboratory, USDA-ARS, Bozeman, Montana. The range laboratory team was responsible for the grazing management and vegetation data and the insect laboratory team was responsible for the grasshopper and micro-climatic data. The basic premise that we are working with is that most of the rangeland pest grasshopper species are favored by open canopy and bare areas which are used by the grasshoppers to provide access to solar radiation during nymphal development for thermoregulation and by some species for egg laying sites. The assumption that we have made from this premise and are testing with this project is that if defoliation management treatments using grazing can be developed that decrease open areas in the vegetation canopy then grasshopper development should be affected and should be shown as a change in population density or species composition. The alternative to this first assumption is that if management can not be developed that causes a decrease in the canopy open areas for the entire year, then we should find management practices that annually change the time when the open areas occur and are available for grasshopper use. This should, presumably, disrupt the natural patterns of the grasshoppers' phenological development enough to affect the populations and assure that no single pest grasshopper species would be strongly favored for successive years.

The changes in the vegetation that are presently expected to negatively affect grasshopper populations are: increases in live plant basal cover, decreases in open areas in vegetation canopy cover, and increases in plant biomass. These vegetation parameters should yield lower temperatures, higher relative humidity, and reduced irradiation within the grasshopper microhabitat. These changes in the grasshopper microhabitat should affect nymphal growth and development and affect changes in the population. This report will include a summary of the native range vegetation data collected during the 1993 and 1994 field seasons (Manske 1993, Manske 1995).

METHODS AND MATERIALS

Study sites were located in the McKenzie County Grazing District of the Little Missouri National Grasslands, 21 miles west of Watford City between 47^{o}35' and 47^{o}50' N. lat. and 104^{o}00' and 103^{o}45' W. long., North Dakota. This study was conducted with the cooperation of the USDA Forest Service and the McKenzie County Grazing Association. The project was funded by USDA, Animal and Plant Health Inspection Service, Plant Protection and Quarantine, Cooperative Grasshopper Integrated Pest Management Project.

The four native rangeland treatments were designed with two replications. The rotation grazing treatments had four pastures with each grazed for two periods, one period between the third leaf stage and anthesis phenophase, 1 June - 15 July, followed by a second period between anthesis and winter dormancy, 15 July - 31 October. The dates for the four pastures during 1993 were: Grazed 1^{st}, 1-15 June and 16-31 July; Grazed 2^{nd}, 16-24 June and 1-31 August; Grazed 3^{rd}, 25 June - 4 July and 1-30 September; and Grazed 4^{th}, 5-15 July and 1-31 October. The dates for the four pastures during 1994 were: Grazed 1st, 1-13 June and 16 July - 16 August; Grazed 2nd, 14-27 June and 17 August - 1 September; Grazed 3rd, 28 June - 8 July and 2-30 September; and Grazed 4th, 8-15 July and 30 September - 22 October. Calves were weaned 22 October and placed in dry lot. The dry cows were rotated through the pastures for a third rotation. The dates for the third rotation were: Grazed 1st, 7-14 November; Grazed 2nd, 31 October - 6 November; Grazed 3rd, 15-25 November; and Grazed 4th, 22-30 October. The first grazing period for the rotation system was designed to stimulate grass tiller development and activity of soil organisms in the rhizosphere. The second grazing period was designed to harvest some of the increased herbage biomass and secondary tillers (Manske 1994).

The seasonlong grazing treatments consisted of two pasture study locations each with two replications. Each study location was grazed as a single pasture from 1 June to 31 October 1993 and 1994. The ungrazed treatments consisted of two pasture study locations each with two replications. The ungrazed treatments had no livestock grazing during the 1993 and 1994 growing season but had grazing during the winters of 1992-1993 and 1993-1994. The ungrazed treatment was used as the control treatment for the vegetation data and used as the control to determine percent utilization. The long-term nongrazed treatment had not been grazed, mowed, or burned for over 35 years. A large barbed wire exclosure had been constructed on the study area in 1958. Only nondestructive sample data was collected on the long-term nongrazed exclosure treatments. Nongrazed herbage biomass data was collected in 1994 on nongrazed areas that had been excluded from grazing for a 5 year period near the nongrazed exclosure.

Vegetation data were collected on similar range sites for each replication. Aboveground plant biomass was collected on five dates from May to October 1993 by clipping five .25m^2 quadrants and on four dates from May to August 1994 by clipping four .25m^2 quadrants to ground level (Cook and Stubbendieck 1986). The major components were separated into live material (by growth form), standing dead material, and litter. Plant biomass samples were oven dried at 60^oC. Values reported represent amount of aboveground herbage dry matter remaining on the site on each sample date after grazing. Plant species composition was determined by the ten pin point frame method (Cook and Stubbendieck 1986) between mid July and mid August 1993 and 1994 and reported as percent basal cover. Line intercept method (Canfield 1941, Cook and Stubbendieck 1986) was modified to measure linear length of intercepted open areas not covered by vegetation canopy. Each replication was sampled four times between June and August 1993 and May and August 1994 with ten 2000 cm transects. Total percent open area not covered by canopy and a frequency distribution of the length of open areas placed in 5 cm categories ranging from 0 cm to 60 cm were determined from the line intercept data. Statistical methods used to analyze differences between means were a standard paired plot t-test (Mosteller and Rourke 1973). Each treatment except the ungrazed treatments had coordinated sample plots for micro climatic data and for grasshopper population and phenology data, which were collected and will be reported by the Rangeland Insect Laboratory research team at Bozeman.

RESULTS AND DISCUSSION

Seasonlong grazing for five and six months during the summer has been a commonly used grazing practice in western North Dakota since the 1920's and has been regarded as a standard for vegetation responses to grazing. The seasonlong grazing treatments used during this study had not been abused in the past and were in very good condition. The basal cover was significantly ($P<0.05$) greater on the seasonlong grazing and ungrazed treatments than on the nongrazed treatment in 1993 (Table 1). The basal cover was significantly ($P<0.05$) greater on the seasonlong treatments compared to the nongrazed and ungrazed treatments in 1994 (Table 2). The percent open ground on the seasonlong grazing treatments was not different than on the nongrazed and ungrazed treatments in June 1993 but percent open areas was significantly ($P<0.05$) lower in July and August than on the nongrazed treatment (Table 3). The percent open ground not covered by vegetation canopy on the seasonlong treatments was significantly ($P<0.05$) lower than the percent open ground on the ungrazed and nongrazed treatments in 1994 (Table 4). There was 70% less plant biomass on the seasonlong treatments on 15 October 1993 than on the ungrazed treatments (Table 5). The herbage biomass on the seasonlong grazing treatments in 1994 was significantly ($P<0.05$) lower than the herbage biomass on the ungrazed treatments in July and August and significantly ($P<0.05$) lower than the herbage on the nongrazed treatment in August (Table 6). The herbage biomass on the seasonlong grazing treatments was significantly ($P<0.05$) lower than on the rotation grazing treatments in June, July, and August (Table 6). The seasonlong grazing treatment generally had greater basal cover and lower percent open ground areas than the ungrazed and nongrazed treatments, but the seasonlong grazing treatments do not provide the changes in the vegetation that were expected to negatively affect pest grasshopper populations.

Grazing management can be used to manipulate changes in native range vegetation structure and density. Changes in vegetation on native range that were expected to show beneficial affects by negatively altering pest grasshopper habitat have been shown to occur on the twice-over rotation grazing management treatment. The twice-over rotation grazing treatment stimulates secondary tiller development which increases plant basal cover, decreases open ground not covered by vegetation canopy, and increases herbage biomass. The basal cover on the rotation treatments was 42% greater than on the long-term nongrazed treatment in 1993 (Table 1), which was significant ($P<0.05$). Percent plant basal cover was significantly ($P<0.05$) greater on the rotation treatments than the nongrazed and ungrazed treatments in 1994 (Table 2). The percentage of open ground was significantly ($P<0.05$) lower on the rotation treatments in 1993 than on the nongrazed and ungrazed treatments (Table 3). The percentage of open ground not covered by vegetation canopy was also significantly ($P<0.05$) lower on the rotation treatments in 1994 than on the nongrazed treatments (Table 4) and significantly ($P<0.05$) lower than on the ungrazed treatments in June, July, and August (Table 4). The amount of plant biomass remaining on the ground on 15 October 1993 at the end of the grazing season was only 14% less on the rotation treatments than on the ungrazed treatments (Table 5). The herbage biomass remaining on the rotation treatments in 1994 was not significantly different than the amount of herbage biomass present on the ungrazed treatments in May, June, and July but was significantly ($P<0.05$) lower than the ungrazed treatments in August (Table 6). The herbage biomass remaining on the rotation treatments was significantly ($P<0.05$) greater than the amount of herbage biomass on the nongrazed treatment in May and not different than the herbage on the nongrazed treatment in June, July, and August (Table 6). The amount of herbage that was removed by livestock on the rotation treatments was not included in these data. The amount of herbage that remained on the rotation treatments after grazing was similar to the total amount of ungrazed vegetation on the ungrazed and nongrazed treatments. The amount of herbage that was removed by livestock on the rotation treatments was the amount that the herbage production had been increased as a result of the stimulation effects from the twice-over rotation grazing treatment. Increases in secondary tiller development and growth on native range grass plants can be effectively manipulated with management if a 7 to 15 day period of grazing defoliation can be coordinated on each pasture to occur some time between the third leaf stage and flowering phenological stage which generally occurs from 1 June to 15 July in western North Dakota for the major native range grass species.

The herbage biomass on the rotation pastures was significantly ($P<0.05$) greater than on the seasonlong treatments in June, July, and August (Table 6). The seasonlong treatments may also stimulate grass growth at the same phenological stages as the rotation treatment but the grass tillers were generally consumed before they could develop. The twice-over rotation system stimulates plant growth on native prairie and can be used to manipulate the vegetation in the direction that should be less suitable as grasshopper habitat.

Interpretation of the grasshopper population and phenology data for 1993 (Kemp and Onsager 1993, Onsager 1995) (Table 7) indicates a positive trend for the potential use of livestock grazing management as a tool to alter structure and density of vegetation and cause negative impacts on grasshopper populations. Generally, the nymph and adult population on the native range pastures grazed with the rotation system had lower numbers of grasshoppers than the pastures grazed with seasonlong management. The length of time required for the nymph grasshoppers to develop through their 5th instar stage was longer on the rotation pastures than on the seasonlong pastures. This increase in time is desirable and indicates that the increase in vegetation reduces the quantity of solar radiation that reaches the nymph grasshoppers and retards their growth rate. This exposes the nymph grasshoppers to numerous causes of mortality for a longer period of time. The average daily mortality rate was greater on the rotation system. The longevity of the adult grasshoppers was slightly shorter on the rotation pastures than on the seasonlong pastures. It is not known at this time if this difference in longevity is significant or not but the trend is desirable and would mean that the adults would have a shorter period of time to develop, mate, and lay eggs. With a decreased longevity, some of the adult females may not successfully lay eggs. The predicted number of eggs laid on the seasonlong pastures was eighteen times greater than on the rotation pastures. Preliminary interpretation of the grasshopper population data for 1994 (Kemp and Onsager 1995) indicates that there were 75% fewer nymphs at the 3rd instar stage and 96% fewer adults on the rotation treatments compared to the seasonlong treatments on native range.

CONCLUSIONS

These two years of data are very promising and exciting. The data show that defoliation management with twice-over rotation grazing can cause significant changes in vegetation structure and density by timing the grazing treatments differently in relation to the phenological development of the plants. Rotation grazing defoliation treatments can be used to increase the plant density, decrease open areas, and increase plant biomass. These changes in vegetation seem to retard development of nymph grasshoppers, decrease longevity of adult grasshoppers, and reduce the numbers of living grasshoppers. The future years of this study will be able to determine if these changes in vegetation structure and density and grasshopper populations can provide long-term negative affects on the rangeland grasshopper species that are economically important.

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Table 1. Percent basal cover and percent greater than nongrazed control on native range treatments, 1993.

Treatments	%Basal Cover	% Greater Than Nongrzed
Nongrazed	29.3a $\pm$2.1	0.0
Ungrazed	34.6b $\pm$2.0	17.9
Seasonlong	36.2b $\pm$3.9	23.3
Rotation	41.7b $\pm$5.2	41.9
Grazed 1st	34.5	
Grazed 2nd	42.4	
Grazed 3rd	43.0	

	Grazed 4th	47.0	
Means of same column followed by the same letter are not significantly different ($P<0.05$).			

Table 2. Percent basal cover and percent greater than nongrazed control on native range treatments, 1994.			
Treatments		%Basal Cover	% Greater Than Nongrazed
Nongrazed		28.3a $\pm$0.4	0.0
Ungrazed		27.6a $\pm$1.1	-2.4
Seasonlong		34.5b $\pm$0.5	22.2
Rotation		33.2b $\pm$2.1	17.3
	Grazed 1st	32.6	
	Grazed 2nd	31.4	
	Grazed 3rd	32.0	
	Grazed 4th	35.2	
Means of same column followed by the same letter are not significantly different ($P<0.05$).			

Table 3. Percentage of ground not covered by vegetation canopy on the native range treatments, 1993.

Treatments		Early June	late June	Mid July	Mid August
Nongrazed		-	21.1a ±10.0	12.0a ±2.3	11.5a ±2.4
Ungrazed		-	14.8a ±4.0	-	-
Seasonlong		10.5a ±1.2	14.1a ±3.4	7.8b ±1.6	6.0b z ±0.9
Rotation		6.5b ±2.5	3.9b ±1.9	6.1b ±2.1	5.9b ±1.7
	Grazed 1st (4)	8.0	6.4	7.3	6.3
	Grazed 2nd (7)	8.2	4.8	5.3	7.9
	Grazed 3rd (6)	6.9	2.0	8.1	3.8
	Grazed 4th (5)	2.9	2.5	3.6	4.6

Means of some column followed by the same letter are not significantly different (P<0.05).

Table 4. Percentage of ground not covered by vegetation canopy on the native range treatments, 1994.

Treatments		Mid May	Mid June	Mid July	Mid August
Nongrazed		9.3a ±1.2	-	-	-
Ungrazed		9.1ab ±2.3	8.6a ±1.9	13.8a ±2.0	18.8a ±7.4
Seasonlong		4.1c ±1.6	3.6b ±1.4	4.1b ±1.6	5.5b ±1.1
Rotation		4.0bc ±3.2	3.5b ±2.9	3.6b ±2.1	4.8b ±2.2
	Grazed 1st (5)	0.6	0.7	1.6	2.7
	Grazed 2nd (4)	4.5	2.5	3.9	5.7
	Grazed 3rd (7)	4.8	4.0	3.2	5.0
	Grazed 4th (6)	5.9	6.9	7.7	7.0
Means of same column followed by the same letter are not significantly different ($P<0.05$).					

Table 5. Total aboveground plant biomass in pounds/acre and percent utilization on native range treatments, 1993.						
Treatments	1 Jun	24 Jun	9 Jul	12 Aug	Sep	25 Oct
Nongrazed	Destructive sampling data not collected on this treatment.					

Ungrazed						
lbs/acre	-	1382	1410	1152	-	1655
% utilization						
Seasonlong	I---I[a]					
lbs/acre	557	923	1094	609	-	504
% utilization		33.2	22.4	47.2		69.6
Rotation	I---I					
lbs/acre	897	998	1131	952	-	1424
% utilization		27.8	19.8	17.4		13.9
Grazed 1^{st} (4)	I---------I		I---------I			
lbs/acre	1024	919	818	644	-	1184
% utilization		33.5	42.0	44.1		28.4
Grazed 2^{nd} (7)		I--------I		I----------I		
lbs/acre	819	809	829	799	-	1797
% utilization		41.4	41.2	30.6		-8.6
Grazed 3^{rd} (6)		I---------------I		I-------------------I		
lbs/acre	876	1182	1579	1048	-	1521
% utilization		14.5	-12.0	9.0		8.1
Grazed 4^{th} (5)		I---------------I			I-------------------I	

lbs/acre	869	1080	1298	1314	-	1193
%utilization		21.8	7.9	-14.1		27.9

Negative percent utilization values indicate greater herbage remaining after grazing compared to ungrazed control plots.

[a]dashed lines indicate period of grazing.

Table 6. Total aboveground plant biomass in pounds/acre and percent utilization on native range treatments, 1994.

Treatments	25 May	23 Jun	20 Jul	11 Aug	Sep	Oct
Nongrazed (5 years)						
lbs/acre	589	726	974	1301	-	-
% difference	31.2	54.1	31.3	42.3	-	-
Ungrazed						
lbs/acre	857	1584	1418	2254	-	-
% utilization	-	-	-	-	-	-
Seasonlong	I--I[a]					
lbs/acre	810	835	854	749	-	-
% utilization	5.5	47.3	39.8	66.8	-	-
Rotation	I--I					

<table>
<tr><td>lbs/acre</td><td>875</td><td>1313</td><td>1239</td><td>1343</td><td>-</td><td>-</td></tr>
<tr><td>% utilization</td><td>-2.1</td><td>17.1</td><td>12.6</td><td>40.4</td><td>-</td><td>-</td></tr>
<tr><td>Grazed 1st (5)</td><td>|---------|</td><td></td><td>|-----------|</td><td></td><td></td><td></td></tr>
<tr><td>lbs/acre</td><td>907</td><td>1142</td><td>1539</td><td>1243</td><td>-</td><td>-</td></tr>
<tr><td>% utilization</td><td>-5.9</td><td>27.9</td><td>-8.5</td><td>44.9</td><td>-</td><td>-</td></tr>
<tr><td>Grazed 2nd (4)</td><td></td><td>|--------|</td><td></td><td>|-------|</td><td></td><td></td></tr>
<tr><td>lbs/acre</td><td>912</td><td>1522</td><td>1306</td><td>1724</td><td>-</td><td>-</td></tr>
<tr><td>% utilization</td><td>-6.5</td><td>3.9</td><td>7.9</td><td>23.5</td><td>-</td><td>-</td></tr>
<tr><td>Grazed 3rd (7)</td><td></td><td>|---------|</td><td></td><td colspan="2">|-----------------------|</td><td></td></tr>
<tr><td>lbs/acre</td><td>922</td><td>1813</td><td>1196</td><td>1027</td><td>-</td><td>-</td></tr>
<tr><td>% utilization</td><td>-7.7</td><td>-14.5</td><td>15.6</td><td>54.5</td><td>-</td><td>-</td></tr>
<tr><td>Grazed 4th (6)</td><td></td><td colspan="2">|--------|</td><td></td><td colspan="2">|-----------------------|</td></tr>
<tr><td>lbs/acre</td><td>759</td><td>775</td><td>915</td><td>1380</td><td>-</td><td>-</td></tr>
<tr><td>%utilization</td><td>11.5</td><td>51.0</td><td>35.5</td><td>38.8</td><td>-</td><td>-</td></tr>
<tr><td colspan="7">Negative percent utilization values indicate greater herbage remaining after grazing compared to ungrazed control plots.
[a]dashed lines indicate period of grazing.</td></tr>
</table>

Table 7. Responses of grasshoppers to the changes in vegetation caused by grazing on two grazing

management systems in the Little Missouri National Grasslands near Watford City, North Dakota, 1993.

	Grazing Management		
Grasshopper Population Parameter	Seasonlong	Twice Over Rotation	% Difference
Density of nymphs (per yd $^{-2}$)	17.91	3.75	-79.06
Nymphal development time (# days)	26.20	36.60	+39.69
Average daily mortality rate (%)	6.15	7.05	+14.63
Density of adults (per yd^{-2})	3.40	0.26	-92.35
Egg production (per yd^{-2})	32.70	1.80	-94.50
From J.A. Onsager, 1995.			

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