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Grazing Systems as Management Tools to Meet Multiple Objectives

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GRAZING SYSTEMS AS MANAGEMENT TOOLS TO MEET MULTIPLE OBJECTIVES

by

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INTRODUCTION

Grazing systems have in the past been developed to increase or maintain livestock production without degrading the land (Archer and Smeins, 1991). A grazing system is a "specialization of grazing management which defines the periods of grazing and non-grazing" (Jacoby, 1989). However, these systems can be developed for other uses besides just livestock. Grazing systems can be used as management tools by manipulating vegetation in specific directions to meet desired objectives. This is done by the livestock themselves because they act as "ecosystem regulators" by having a direct impact on the vegetation (Holechek et al., 1995). Livestock can alter the species composition of the vegetation, improve the nutritive quality of forage, increase the productivity of certain species, and increase the structural diversity of habitat (Heady, 1994). By affecting the structural diversity, livestock also have an impact on wildlife populations (Fleischner, 1994). The object of many grazing plans is to take livestock impacts into account and coordinate the needs of domestic animals with the needs of the wildlife (Heady and Child, 1994). Prolonged heavy grazing reduces the diversity of wildlife, but so does no grazing. However, specialized grazing systems have benefited wildlife - especially waterfowl (Heady, 1994).

Various grazing systems affect waterfowl in different ways depending on how the grazing system influences vegetation and what the vegetation habitat requirements of the waterfowl are. For example, Canada geese (*Branta canadensis*) consider safety first when selecting forage sites. They prefer areas with a high detection index (a measurement of predator recognition) and a low angle of flight (Conover and Kania, 1991). Vegetation structure can greatly influence these two factors. In fact, the variable most often correlated to goose habitat is the vegetation structure

(Balda, 1975). Low vegetation structure provides both a high detection index and a low flight angle. Continuous grazing is one grazing system that usually results in low vegetation structure and therefore could be used to improve Canada geese habitat. Continuous grazing is "unrestricted grazing through the whole of the grazing season" (Heady and Child, 1994). Because continuous grazing takes place during the "whole of the grazing season" it is also referred to as season-long grazing. Heavy grazing (maximum allowable grazing over the grazing season or grazing period for a particular area) can also be beneficial to Canada geese because tall emergent plants are reduced (Kantrud, 1985).

While Canada geese are favored by heavy grazing, other species are not. Ducks, especially mallards, avoid areas of heavy grazing (Reeves, 1954). However, that does not mean ducks only use areas that are ungrazed. Hopper (1972) found that broods were more likely to use moderately grazed than idle or heavily grazed wetlands. In southcentral North Dakota, Barker et al. (1990) found that there was a higher nest success in four of five pastures that utilized rest-rotation when compared to ungrazed and continuously grazed wetlands. A rest-rotation system is a grazing system that was developed by Gus Hormay, in which a pasture is not utilized for twelve months while the other pastures are grazed and absorb the load of the pasture that is on rest (Holechek et al., 1989). Mundinger (1976) also found that a rest-rotation system increased waterfowl populations when compared to continuous grazing. Continuous grazing could actually lead to a decrease in most waterfowl populations by causing a lack of cover for nesting. However, if a rotation system was used it could protect nesting cover until the young had left their nests (Heady and Child, 1994). A rotation system is a specialized grazing system in which livestock are moved from one pasture to another on a scheduled basis (Holechek et al., 1989).

Because of the effects grazing systems have on the vegetation, and subsequently habitat, they could be used as a viable management alternative, or tool, for waterfowl and perhaps other uses as well (Kantrud, 1985 and Barker et al., 1990).

The purpose of this study was to determine how various grazing systems could be used as management tools in a wetland environment to meet multiple objectives. There were three main objectives for the study site that were identified: 1) provide habitat for wetland birds, 2) maintain watershed values, and 3) support agriculture. There are many wetland bird species found in Cutler. However, those that were recognized as priorities were Canada geese, dabbling ducks -- mallards (*Anas platyrhynchos*), cinnamon teals (*A. cyanopters*), gadwalls (*A. streptera*), and blue-winged teals (*A. discors*) -- and over-water nesters -- redheads (*Aythya americana*), sandhill cranes (*Grus canadensis*) and some mallards. Other species, such as the American avocet (*Recurvirostra americana*) and the black-necked stilt (*Himantopus mexicanus*) were also recognized as concerns. But these colonial nesting birds were not found on the study site. Dabbling ducks were a priority for their recreational value and for hunting. Over-water nesters were also of concern for their recreational value. Canada geese were a major concern because without sufficient feeding habitat they would leave the site for neighboring grain fields. PacifiCorp, the landowner, wants to keep these geese on-site to reduce this agricultural depredation.

The second objective is to maintain watershed values. Cutler Reservoir is used as a filter for water coming out of the Logan sewage treatment plant. This water is high in nutrients and adversely affects water quality. Sediment loads are also high from bank erosion and upland erosion due to agricultural activities. These sediments reduce the storage capacity and life of the

reservoir. Thus, PacifiCorp wants to minimize erosion and try to maintain the watershed.

The third objective recognized was to support agriculture. On the study site this took the form of livestock. In particular, cattle production which had been the historical use of this area. PacifiCorp wanted to lease this land to generate enough income to at least maintain the property, while meeting the stated objectives.

To meet these objectives three grazing systems were studied as management tools. These systems were exclusion, season-long, and a rotation grazing system. In each system the vegetation and wetland bird populations were monitored. The vegetation structure and biomass were measured using a modified Robel pole (Schmidt, 1996). Obtaining the vegetation structure information was important in determining what habitat types were present for wetland birds. The biomass information was needed to determine the production of the vegetation and the amount of forage available for livestock. The biomass also needed to be monitored to ensure that enough vegetation was left on upland sites to keep erosion from increasing.

STUDY SITE

The study was conducted within the Cutler Reservoir properties, located in Northern Utah. The study area comprised 243 hectares (600 acres), located about six miles west of Logan, and is bounded on the north by U.S. Highway 30 and on the north by the Mendon Road.

On the site there were two main communities - the uplands and the lowlands. The uplands are those areas that are, on average, 30 cm higher in elevation than the surrounding topography. Because of this slight elevational increase the uplands are also sometimes referred to as the knolls. The dominant vegetation of these uplands is *Poa pratensis* and *Bromus*

japonicus. The lowlands support a more mesic community and is dominated by *Spartina pectinata*, *Glyceria striata*, *Typha spp*., and *Scirpus spp*.

METHODS

The production of the vegetation and forage available on the study site was determined through a three step process. First, a regression analysis was performed on the Robel pole readings and the dry weights of clippings that corresponded to those Robel pole readings. This resulted in an equation for each community that could be used to determine vegetation production from Robel pole measurements (see Appendix A). Second, the amount of forage utilized by the cattle in each sub-pasture was estimated. This estimate was then added to the season-end residual vegetation standing crop (calculated from regression equations) to obtain the total vegetation production and forage available in each sub-pasture (see Appendix B). The residual standing crop needed to be monitored to ensure that enough vegetation was left on upland sites to minimize erosion.

The upland bird populations were monitored by doing nest counts. This was accomplished by dragging a 61 m (200 ft) light chain between two four-wheelers (Klett et al., 1986). Every time a bird was flushed up the nest was found and marked, and the bird species was recorded. This was done to determine what the habitat requirements were for each species. It was found that dabblers would not nest in areas unless they had at least a 20 cm visual obstruction reading (VOR) on the Robel pole; and most preferred 38-44 cm VOR. Canada geese would not nest in areas that had greater than a 6-8 cm VOR, but preferred 2-4 cm.

Three grazing systems were implemented and evaluated on the study site. The first

system was an exclusion system that kept the area free from livestock. The second system evaluated was continuous, or season-long, grazing. The third system was a rotation grazing system that was modified by best-pasture system principles. The best-pasture system was developed by Valentine for areas in which forage production varies greatly over short distances, i.e. less than 10 km (Holechek et al., 1989). In this system the best pasture is grazed first until moderate use is achieved, and then the next best pasture is grazed, and so on. The principle behind the best-pasture system is that areas that can more readily tolerate grazing are grazed first so areas that are not yet ready to tolerate grazing will not be used until they are ready. The third system used a rotation system, but if one of the scheduled sub-pastures did not have sufficient regrowth it was not regrazed. Instead, another sub-pasture which had sufficient plant growth was selected.

RESULTS AND DISCUSSION

The first system that was evaluated was exclusion. Under this system there was a build-up of residual vegetation in the lowlands (greater than 4,950 kg/ha - and in some areas as high as 11,000 kg/ha). The residual vegetation on the uplands was approximately 2750 kg/ha, which was much higher than the amount of residual vegetation in systems utilizing livestock. While having high amounts of residual vegetation, the lowlands had a decrease in annual production under the exclusion system. This occurred because the residual vegetation on the surface allowed little light to penetrate and promote new growth. In addition, structural diversity was minimized because snow matted down the previous year's growth, which also suppressed new plant growth.

The condition of the vegetation in turn affected what habitat was available for wetland birds. Under exclusion the habitat for both dabbling ducks and Canada geese decreased. Dabbling duck nest habitat decreased because the vegetation was too dense and rank in much of the lowlands to be attractive for nesting sites. Most of the dabblers preferred to nest in the current year's growth. As for the uplands, the vegetation rarely exceeded a visual obstruction reading of 20-24 cm on the Robel pole. This VOR is too low for most dabblers to nest in as they require cover with a high VOR (Klett et al., 1988). On the other hand, these uplands had visual obstruction readings that were almost always above 8 cm. This made them unattractive to Canada geese which prefer a VOR of 2-4 cm. In addition, geese utilize uplands and other areas for feeding sites when VORs are less than 8 cm. The habitat for over-water nesters was unchanged because even when the area was grazed by livestock the cattle did not enter the over-water nesters' habitat.

The vegetation also had an effect on the watershed. On the uplands erosion was reduced because there was plenty of vegetation on these sites to intercept precipitation and reduce overland flow. The uplands next to water are the only areas where sediment from erosion enters the reservoir. Thus, there was minimum impact on the water quality.

The impact of the exclusion system on agriculture would have been in two areas. The livestock would have been removed reducing income for reservoir land maintenance and few geese feeding areas would have been available, thus increasing depredation.

The stocking rate was 0.53 ha/cow. Under the season-long grazing system the movement of the cattle was not controlled and they tended to congregate on the uplands. They did this for two reasons. First, the vegetation on the uplands was more palatable and therefore preferentially

utilized. Second, the slight elevational increase of the uplands made them drier so cattle tended to use these areas as loafing sites. Due to the high utilization, residual vegetation was usually less than 550 kg/ha, while the lowland residual vegetation was greater than 4,400 kg/ha. The lowlands received little use, and as in the exclusion system, there was a build up of mulch in many areas.

Under season-long grazing the nesting for Canada geese increased because the uplands mostly had VORs of 2 cm. However, the nesting habitat for dabbling ducks decreased because the vegetation was too dense and rank to be attractive. The over-water nesters' habitat was unaltered because the cattle did not disturb their habitat.

The heavy use on the uplands resulted in little residual vegetation and cover on these sites. This allowed little protection of the surface and opened these sites up for increased erosion, which is common in heavily grazed areas (Fleischner, 1994). This lead to a concern of increasing sediment load in the adjacent reservoir.

Season-long grazing has the cheapest operating costs of those systems that involve livestock. The farmers only needed to put their livestock out in the pasture, check on them from time to time, and then bring them back out at the end of the season. The production of both the livestock and the vegetation was good under this system.

The last grazing system that was evaluated was a rotation grazing system. The stocking rate was 0.53 ha/cow — which is the same stocking rate that was used for the season-long grazing system. In this system the cattles' movement was controlled so grazed areas had time to recover and the cattle were forced to utilize the lowlands. The uplands had residual vegetation of 1,430-2,090 kg/ha, and the lowlands had a residual vegetation of 2,310-4,290 kg/ha.

In this rotation system the pasture was divided into four sub-pastures. The cattle were kept in each sub-pasture for one to two weeks before being rotated to the next sub-pasture. The cattle were not put out until the first day of June. By this time 80% of the wetland birds had finished initiating nests and were gone. Those wetland birds left finish initiating nest by the middle of June (Vice, 1995). By having a rotation system only one-fourth of the study site was initially disturbed, leaving the rest of the area undisturbed for nesting. Rotating the cattle through also created Canada geese feeding habitat by always having a sub-pasture with low VORs in both the upland and lowland areas. In fact, the only sub-pastures where Canada geese were observed were in those sub-pastures that had just been grazed, or were currently being grazed.

Rotating the cattle through the sub-pastures also had another benefit. It forced the cattle to utilize the vegetation in the lowlands. This helped to keep the vegetation from becoming rank or too dense, allowing the production of the vegetation to increase. Robel pole measurements were taken before and after each rotation. Regrowth was so rapid and heavy in the lowlands that many of the sub-pastures actually had higher VORs at the beginning of the second rotation. Regrowth was always good on these lowlands and uplands as long as there was moisture. Because the uplands dry out much sooner there was not much regrowth after the second rotation and Robel pole measurements decreased as the season continued. These uplands were monitored and if Robel pole readings became low and regrowth seemed unlikely they were not used in the rotation again. Instead, sub-pastures with higher amounts of vegetation were used for a longer period. Especially those sub-pastures composed mainly of lowlands because the lowlands stayed wet for most of the season and VORs decreased mainly in the last rotation. Some sub-pastures

even had enough regrowth at the end of the season that the ending Robel pole measurements were the same as the measurements taken at the beginning of the grazing season. One of the four pastures (SG4A) had not been grazed the previous year and its beginning Robel pole readings were not as high as most of the other pastures. This is mainly due to the residual vegetation from the previous year. There was a greater amount of residual vegetation in this pasture because it had not been grazed and the residual vegetation was all laid over and matted down from the winter's snow. This prevented light penetration and new growth took longer to emerge.

However, the rest of the pastures had been grazed the previous year on a rotation system and thus had less rank residual vegetation. This allowed for abundant new growth and high VORs. The sub-pastures with the heaviest growth and the highest VORs were the last to be grazed in this year's rotation. This greatly increased the amount of nesting habitat for dabbling ducks by keeping the most suitable sites free from disturbance until the dabbler's nesting season was completed.

The feeding habitat for Canada geese was also increased because the rotation kept the upland sites open with low VORs of 2 cm. Also, many sub-pastures where the Canada geese nested were grazed last at the end of the grazing season so there would be little residual vegetation, making them more attractive for nesting the next year. As in the other two systems evaluated the over-water nesters' habitat was unaltered because the cattle did not utilize or enter their habitat.

The uplands maintained in excess of 1,000 kg/ha of residual vegetation which maintained a high cover and minimized erosion of these sites. The rotation system increased the cost of the livestock operation and time involved. Costs were increased because of the fecnicng needed to

divide the pastures into sub-pastures. However, solar powered electric fences were used to minimize this cost. The time involved was also increased because the cattle had to be moved through the sub-pastures. In this system the production of the cattle was the same as in season-long grazing. In fact, because of the large amounts of unused vegetation found in many sub-pastures, the stocking rate will probably be increased in the future.

CONCLUSION

Over-water nesters' habitat was unaltered in each system evaluated. The nesting habitat for dabbling ducks decreased in the exclusion and season-long grazing systems. In both cases this was due to the build up of dense, rank vegetation. Breeding ducks generally find open stands of emergent vegetation more appealing than dense, closed stands (Kantrud, 1985). The rotation system did no allow such a build-up and thus increasing the nesting habitat for dabbling ducks. The nesting and feeding habitat for Candada geese was decreased in the exclusion system because the uplands had VORs that were too high to be attractive. In season-long and the rotation grazing systems the habitat for Canada geese was increased because they created the desired VORs of 2-4 cm. However, the season-long grazing system only provided this habitat on the upland sites. Many of the feeding areas on lowland areas were eliminated with season-long grazing.

Among the systems evaluated there are some commonalties found. In each system evaluated the amount and type of wetland bird habitat available was determined by the vegetation. In the grazing systems the effects on vegetation was a function of the stocking rate (Heady and Child, 1994). For example, if one was only interested in maintaining Canada geese

habitat, season-long grazing could be used without adversely affecting the watershed or vegetation if the stocking rate was decreased. The appropriate stocking rate to use would need to be determined by only taking the forage available on the uplands into account.

The vegetation is being manipulated in each system. In fact, the systems can be used to not only alter the structure of the vegetaion, but the composition as well. In one sub-pasture the cattle were forced to utilize the cattails, pushing the composition to a carex dominated community. However, it should be noted that livestock does not have to be used to obtain these results. Fire could be used in the lowlands to get rid of the rank, dense vegetation to allow for abundant new growth the following year (Bailey, 1988). Haying could be used on the uplands to maintain low visual obstruction readings for Canada geese nesting and feeding habitat.

However, if you are going to use a grazing system as a management tool, remember that the key is to know what effects the grazing system will have on the vegetation, and how this affects the species you are interested in. Also, monitor the vegetation. Remember - this is a tool like any other. If you were going to do a prescribed burn you would monitor the conditions and adjust management depending on what those conditions dictate. Finally, the most important thing is to be *flexible and not limit your options*. For example, if one sub-pasture did not respond well to a rotation system, it could be put on a rest-rotation grazing system while the rest of the sub-pastures remained on a rotation system. This was done for one of the sub-pastures in Cutler. The sub-pasture was full of dense tall wheatgrass so cattle were put in to knock it down. The next year there was an increase in the number of dabbling ducks that nested there. But after two years the number decreased. Therefore, this sub-pasture could be put into the rotation system every three years and rest in between. Grazing systems can be used as management tools

to reach desired objectives as long as you are open-minded, flexible, and monitor conditions to ensure that your objectives are being met.

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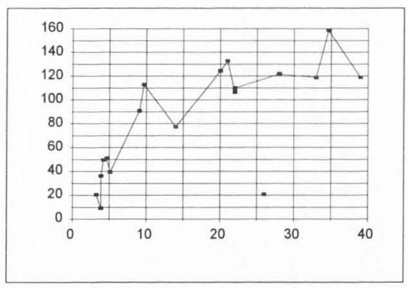
APPENDIX A

REGRESSION FOR THE HIGH COMMUNITY

Pasture	Exclosure	Date	Net g's	RP	IN/Out
SG1C	1	7-12	68.27	18	inside
SG1C	2	7-13	151.58	26	inside
		Average	109.93	22	
SG1C	1	7-12	9.87	5.14	outside
SG1C	2	7-13	68.84	5.14	outside
		Average	39.36	5.14	
SG2B	2	7-9	77.27	14	inside
		Average	77.27	14	
SG2B	2	7-9	9.06	3.89	outside
		Average	9.06	3.89	
SG3B	1	7-16	87.45	34	inside
SG3B	3	7-20	150.19	44	inside
		Average	118.82	39	
SG3B	1	7-16	102.05	9.71	outside
SG3B	3	7-20	123.37	9.71	outside
		Average	112.71	9.71	
SG3A	1	7-24	124.86	32	inside
SG3A	3	7-24	118.69	24	inside
		Average	121.78	28	
SG3A	1	7-24	86.17	9.09	outside
SG3A	3	7-24	95.19	9.09	outside
		Average	90.68	9.09	
SPIC	2	8-26	106.48	22	inside
		Average	106.48	22	
SPIC	2	8-26	20.78	3.26	outside
		Average	20.78	26	
SG5A	1	8-10	83.55	28	inside
SG5A	2	8-10	153.72	38	inside
		Average	118.64	33	
SG5A	1	8-10	22.28	4.69	outside
SG5A	2	8-10	79.58	4.69	outside
		Average	50.93	4.69	
SG2A	1	8-14	108.69	20	inside
SG2A	2	8-14	156.64	22	inside
		Average	132.67	21	

Avg. net g's	Avg. RP	
20.35	3.26	
9.06	3.89	
36.01	3.89	
49.40	4.23	
50.93	4.69	
39.36	5.14	
90.68	9.09	
112.71	9.71	
77.27	14.00	
124.15	20.00	
132.67	21.00	
106.48	22.00	
109.93	22.00	
121.78	28.00	
118.64	33.00	
158.60	34.67	
118.82	39.00	
20.78	26.00	oulier



Avg. net g's	Avg. RP
20.35	3.26
9.06	3.89
36.01	3.89
49.40	4.23
50.93	4.69
39.36	5.14
90.68	9.09
77.27	14.00
124.15	20.00
132.67	21.00
106.48	22.00
109.93	22.00
121.78	28.00
118.64	33.00
118.82	39.00

SG2A	1	8-14	9.88	3.89	outside			
SG2A	2	8-14	62.14	3.89	outside	20.78	26.00	outlier
		Average	36.01	3.89		158.60	34.67	outlier
						112.71	9.71	oultier
SG5B	1	8-20	218.30	48	inside			
SG5B	2	8-20	136.65	36	inside			
SG5B	3	8-20	120.85	20	inside			
		Average	158.60	34.67				
SG5B	1	8-20	72.54	4.23	outside			
SG5B	2	8-20	47.56	4.23	outside			
SG5B	3	8-20	28.11	4.23	outside			
		Average	49.40	4.23				
SG1C	1	8-27	127.28	20	inside			
SG1C	2	8-27	121.02	20	inside			
		Average	124.15	20				
SG1C	1	8-27	13.73	3.26	outside			
SG1C	2	8-27	26.97	3.26	outside			
		Average	20.35	3.26				

Regression Statistics	
Multiple R	0.842809
R Square	0.710328
Adjusted R Square	0.691016
Standard Error	24.69918
Observations	17

Analysis of Variance

	df	*Sum of S*	*Mean Sq*	*F*	*Significance F*
Regression	1	22439.23	22439.23	36.78264	2.16E-05
Residual	15	9150.742	610.0495		
Total	16	31589.97			

	Coefficie	*Standard*	*t Statistic*	*P-value*	*Lower 95*	*Upper 95.*
Intercept	36.44997	10.24712	3.557095	0.002627	14.60876	58.29118
x1	3.088155	0.509187	6.064869	1.64E-05	2.002848	4.173462

Y = 3.09X + 36.45

Regression Statistics	
Multiple R	0.860388
R Square	0.740268
Adjusted R Square	0.720289
Standard Error	22.41288
Observations	15

Analysis of Variance

	df	*Sum of S*	*Mean Sq*	*F*	*Significance F*
Regression	1	18612.4	18612.4	37.05162	3.86E-05
Residual	13	6530.382	502.3371		
Total	14	25142.78			

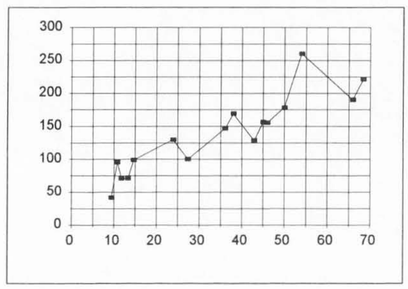
	Coefficie	*Standard*	*t Statistic*	*P-value*	*Lower 95*	*Upper 95.*
Intercept	32.50564	9.762917	3.329501	0.004962	11.41414	53.59714
x1	3.078707	0.505784	6.087004	2.8E-05	1.986028	4.171387

Y = 3.08X + 32.51

REGRESSION FOR THE LOW COMMUNITY

Pasture	Exclosure	Date	Net g's	RP	IN/Out
SG2B	1	7-9	190.16	66	inside
		Average	190.16	66	
SG2B	1	7-9	99.33	14.66	outside
		Average	99.33	14.66	
SG3B	2	7-20	149.19	40	inside
SG3B	4	7-20	163.70	50	inside
		Average	156.45	45	
SG3B	2	7-19	192.69	36.09	outside
SG3B	4	7-20	101.97	36.09	outside
		Average	147.33	36.09	
SG3A	2	7-24	155.57	46	inside
		Average	155.57	46	
SG3A	2	7-24	135.33	42.91	outside
SG3A	4	7-24	122.52	42.91	outside
		Average	128.93	42.91	
SPIC	1	8-26	169.09	38	inside
		Average	169.09	38	
SPIC	1	8-26	96.12	10.83	outside
		Average	96.12	10.83	
SG7	1	8-1	168.88	56	inside
SG7	2	8-1	203.00	50	inside
SG7	3	8-1	180.29	48	inside
SG7	4	8-12	303.84	76	inside
SG7	5	8-12	250.29	112	inside
		Average	221.26	68.4	
SG7	1	8-1	65.77	13.37	outside
SG7	2	8-1	94.58	13.37	outside
SG7	3	8-1	57.89	13.37	outside
SG7	4	8-12	67.13	13.37	outside
SG7	5	8-12	72.17	13.37	outside
		Average	71.51	13.37	
SG5A	3	8-10	260.45	54	inside
		Average	260.45	54	
SG5A	3	8-10	100.63	27.34	outside
		Average	100.63	27.34	
SP1A	1	8-20	170.08	56	inside
SP1A	2	8-20	187.18	44	inside

Avg. net g's	Avg. RP
41.86	9.46
96.12	10.83
71.56	11.8
71.51	13.37
99.33	14.66
130.25	24
100.63	27.34
147.33	36.09
169.09	38
128.93	42.91
156.45	45
155.57	46
178.63	50
260.45	54
190.16	66
221.26	68.4



Avg. net g	Avg. RP	
41.86	9.46	
96.12	10.83	
71.56	11.8	
71.51	13.37	
99.33	14.66	
130.25	24	
100.63	27.34	
147.33	36.09	
169.09	38	
128.93	42.91	
156.45	45	
155.57	46	
178.63	50	
190.16	66	
221.26	68.4	
260.45	54	outlier

		Average	178.63	50	
SP1A	1	8-20	91.20	11.8	outside
SP1A	2	8-20	51.91	11.8	outside
		Average	71.56	11.8	
SG1A	1	9-11	177.37	34	inside
SG1A	2	9-11	132.79	24	inside
SG1A	3	9-11	88.70	18	inside
SG1A	4	9-11	122.15	20	inside
		Average	130.25	24	
SG1A	1	9-9	54.98	9.46	outside
SG1A	2	9-9	12.61	9.46	outside
SG1A	3	9-9	27.90	9.46	outside
SG1A	4	9-9	71.96	9.46	outside
		Average	41.86	9.46	

Regression Statistics	
Multiple R	0.894357
R Square	0.799875
Adjusted R Square	0.78558
Standard Error	26.96322
Observations	16

Analysis of Variance

	df	*Sum of S*	*Mean Sq*	*F*	*Significance F*
Regression	1	40681.06	40681.06	55.95627	2.97E-06
Residual	14	10178.21	727.0151		
Total	15	50859.27			

	Coefficie	*Standard*	*t Statistic*	*P-value*	*Lower 95*	*Upper 95.*
Intercept	46.29165	14.07225	3.28957	0.004964	16.10967	76.47362
x1	2.65022	0.354289	7.480393	1.95E-06	1.890346	3.410094

Y = 2.65X + 46.29

Regression Statistics	
Multiple R	0.935048
R Square	0.874315
Adjusted R Square	0.864647
Standard Error	18.40747
Observations	15

Analysis of Variance

	df	*Sum of S*	*Mean Sq*	*F*	*Significance F*
Regression	1	30641.82	30641.82	90.43292	3.21E-07
Residual	13	4404.852	338.8348		
Total	14	35046.67			

	Coefficie	*Standard*	*t Statistic*	*P-value*	*Lower 95*	*Upper 95.*
Intercept	50.57251	9.662771	5.233748	0.000127	29.69737	71.44766
x1	2.381773	0.250459	9.509623	1.74E-07	1.840689	2.922858

Y = 2.38X + 50.57

APPENDIX B

FORAGE ATTRIBUTABLE TO EACH COMMUNITY

HIGH COMMUNITY

Sub-pasture	Estimated forage use	Year end residual	Total production
SG1A	1295.0	12854.1	14149.1
SG1B	14641.2	93925.3	108566.5
SG1C	38515.4	294491.4	333006.8
SG2A	4531.5	116908.3	121439.8
SG2B	3073.3	86249.7	89323.0
SG2C	4492.3	73643.4	78135.7
SG2D	6397.4	232597.2	238994.6
SG3A	47.0	952.2	999.2
SG3B	2806.7	45629.0	48435.7
SG4A	11884.3	359439.8	371324.1
SG4B	4241.2	129533.9	133775.1
SG4C	5327.3	469507.3	474834.6
SG4D	6035.4	406086.0	412121.4
SG4	14599.2		14599.2
SP1A	5017.6	125367.5	130385.1
SP1B	5433.1	71428.8	76861.9
SP1C	3810.2	85296.2	89106.4

LOW COMMUNITY

Sub-pasture	Estimated forage use	Year end residual	Total production
SG1A	32620.0	474838.5	507458.5
SG1B	53008.2	497191.0	550199.2
SG1C	13202.0		13202.0
SG2A	11148.5	499811.5	510960.0
SG2B	12606.7	513474.2	526080.9
SG2C	19027.7	475277.4	494305.1
SG2D	9282.6	535094.4	544377.0
SG3A	15633.0	541289.0	556922.0
SG3B	12873.3	463431.2	476304.5
SG4A	10795.7	575733.8	586529.5
SG4B	23478.8	1779431.5	1802910.3
SG4C	6432.7	913623.3	920056.0
SG4D	6564.6		6564.6
SG4	22360.8		22360.8
SP1A	10662.4	415004.6	425667.0
SP1B	18086.9	270763.9	288850.8
SP1C	11869.8	363315.0	375184.8