Effect of Grazing Intensity on Livestock Performance in the Coteau Region[1]

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Research Summary: Results so far indicate that grazing at a higher stocking rate than is normally recommended may result in a higher average annual return, but it is accompanied by higher return volatility. Profits are greater when prices are favorable and losses are greater when prices are not favorable. In addition, rangeland deterioration is occurring at the higher stocking rates and the higher average annual returns may not be sustainable. This trial is continuing and these relationships need more study before the stocking rate which will give the greatest sustainable return can be identified.

A grazing intensity study (see footnote for reference) was initiated at the Central Grasslands Research Center to determine if there is an economic optimum stocking rate for grazing cattle in the Coteau region of North Dakota that is sustainable. Specific objectives were: 1) to determine an optimum stocking rate that would not damage the rangeland resource; 2) to develop a model to predict forage production in the spring so that livestock producers can better plan their forage requirements for the year; and 3) to develop techniques to inventory rangeland and monitor utilization, range trend and range condition. Instruments for estimating forage production were also tested.

Five grazing treatments were included in the study: zero or no grazing and light, moderate, heavy and extremely heavy intensities of grazing. Light was defined as that grazing intensity where 65% of the forage produced in an "average" year was left remaining at the end of the grazing season. The moderate grazing treatment was stocked to leave 50%, the heavy treatment 35% and the extreme treatment 20% of expected forage production. A certain amount of trial and error was required in adjusting stocking densities, grazing patterns and length of grazing season to achieve these grazing intensities. Each treatment was applied to three different pastures. Changes in forage production and botanical composition were monitored on plots located on silty and overflow range sites in each pasture. These sites were chosen because they are the most common range sites in the Coteau region. Pastures with no grazing were simulated by fencing out areas on three silty range sites and three overflow range sites located within the grazed pastures.

Grazing began each year around mid-May. Table 1 gives the stocking history of the study. To keep the same level of stress on the plants each year, grazing continued until half of the amount of forage produced in an average year remained on the pastures grazed at the moderate rate.

Average forage production (Table 2) was 3,783 and 2,750 lbs/acre on overflow and silty range sites, respectively. Therefore, an average of 1,892 and 1,375 lbs/ac should remain on overflow and silty sites, respectively, at the end of the grazing season on pastures stocked at the moderate stocking density. Table 2 also presents the above ground biomass remaining at the end of the grazing season. Residual above ground biomass averaged 249 lb/ac greater than ideal across all treatments between 1989 and 2000.

Table 3 shows the average nutritional quality of grasses and forbs on each treatment. Although differences in nutritional quality developed between the grazing treatments, definitive reasons for the differences are not clear. On silty range sites, grasses had higher crude protein and digestibility and lower fiber components when grazed at higher intensities. On the heavily grazed treatments, the grass available for grazing was mostly regrowth which tends to be of

[1]Summarization taken from B. Patton, P. Nyren, B. Kreft, J. Caton and A. Nyren, Central Grasslands Research Center. (http://www.ag.ndsu.nodak.edu/streeter/2000report/grazing_intensity.htm; May 11, 2001)

higher quality. However, increasing grazing intensities tended to increase fiber components of both grasses and forbs. Perhaps on these sites, cattle selected plant species of higher quality and avoided those species lower in quality and higher in fiber. On silty sites, forbs were highest in neutral detergent fiber on the ungrazed and extreme grazing treatments. As ungrazed forage matures, it tends to become higher in fiber. On the heavily grazed treatments only forbs of lower quality would tend to remain ungrazed. These differences in nutritional quality occurred gradually over the course of the study.

Table 4 shows the average daily gains and gains/acre of cattle on the trial each year from 1989 to 2000. The average body condition scores for each treatment from 1994 to 2000 are also shown on table 4. This is a visual ranking of the amount of fat on an animal's body with 10 being extremely fat and 1 being extremely thin. In general, individual animal performance (gain and condition scores) tended to be greatest with lighter stocking rates. Comparing forage quality and individual animal performance across treatments, one might speculate that forage quantity and an opportunity for selective grazing are more important determinants of individual animal performance than overall forage quality in a pasture. In contrast, animal gain per acre tended to be maximized at heavier stocking rates.

The relationships between average daily gain, gain per acre and economic return with stocking rate for 1991 to 2000 are depicted in figures 2, 3 and 4, respectively. Reference lines indicate the average stocking rate of each of the four grazing treatments in the study. The figures for economic return do not include the costs for land, labor or management which vary widely from one operation to another. The years 1989 and 1990 are not included in these graphs because none of the pastures were stocked heavily enough to significantly reduce average daily gains. As the grazing intensity increased, average daily gain decreased. Gains per acre increased until they reached a certain level and then declined. Return per acre revealed a similar pattern. As is apparent from figure 2, the relationship between stocking rate and average daily gain differed significantly between years ($p<0.0005$). These differences may have been due to variations in forage quality, the effect of weather on the animals, class of animal, their initial weight, or their potential to gain.

Table 5A shows the stocking rate which would have resulted in the maximum gain per acre in each year. Since it is impossible to predict what stocking will result in the maximum gain in the future, it is impossible to stock each year for the maximum gain. In retrospect, a stocking rate of 2.47 AUM/ac would have maximized gain per acre over this time period. This is the point labeled as "optimum" in figure 3.

Table 5B shows what the gain/acre would have been in each year if we had stocked at this “optimum” rate. Table 5C shows what the gain per acre would have been if we had stocked at the moderate stocking rate. It is important to note that the pastures which are stocked at heavier rates were in good condition at the beginning of the study and that their condition has slowly deteriorated over the course of the study. Thus, increased production from heavier stocking rates may not be sustainable.

Table 6A gives the stocking rates with the maximum predicted return per acre for each year from 1991 to 2000. These values correspond to the peaks of the curves in figure 4. Just as the stocking rate that will result in maximum gain per acre can not be predicted, the stocking rate that will provide the greatest economic return in any future year is equally ambiguous. With cattle prices over the last ten years and performance that was achieved in this experiment, a stocking rate of 1.86 AUMs/ac would have resulted in the greatest economic return. This is the point labeled optimum in figure 4. Table 6B shows what the annual return/acre would have been if pastures had been stocked at this rate. Table 6C shows what the return would have been if pastures were stocked at a moderate rate. Although the average return per acre was higher under the optimum rate, there were three years with negative returns; while, all years had positive returns under the moderate stocking rate. (Cost for land, labor and management have not been subtracted). Comparing tables 5 and 6, it can be seen that in all but three years, the stocking rate with the greatest economic return was less than the rate with the greatest gain per acre.

Results so far indicate that grazing at a higher stocking rate than is normally recommended may result in a higher average annual return, but it is accompanied by higher return volatility. Profits are greater when prices are favorable and losses are greater when prices are not favorable. In addition, rangeland deterioration is occurring at the higher stocking rates and the higher average annual returns may not be sustainable. This trial is continuing and these relationships need more study before the stocking rate which will give the greatest sustainable return can be identified. For example, stocking rangelands in the Coteau region at the rate which produced the greatest economic return in 1999 would damage the pasture resource and, if prices were low, it could result in substantial financial losses. The returns from a moderate stocking rate are generally "moderate," higher than the "optimum" stocking rate when prices are poor, and lower when prices are good. An optimum stocking rate of 1.86 AUMs/acre based on 10 years of data is tenuous at best and range deterioration and/or sustained periods of low cattle prices could make it inappropriate. Furthermore, producers are cautioned that an optimum stocking rate for a stocker or yearling cattle may not equate directly to an optimum for a cow-calf pairs. Producers are encouraged to follow this research in the future to ascertain if optimum stocking rates that are biological and economically sustainable really exist.

Table 1. Stocking history of the grazing intensity trial.

Year	Class of Animal	Date		Length of
		Stocked	Removed	season (days)
1989	Steers	May 22	Aug 22	92
1990	Heifers, bred	May 30	Nov 27	181
1991	Heifers, bred	May 29	Sep 25	119
1992	Heifers, bred	June 1	Aug 25	85
1993	Heifers, bred	May 29	Sep 26	120
1994	Steers & Heifers, open	May 17	Nov 10	177
1995	Heifers, open	May 18	Oct 30	165
1996	Heifers, open	May 20	Sep 23	126
1997	Heifers, open	May 27	Nov 5[a]	162[a]
1998	Heifers, open	May 16	Oct 28	165
1999	Heifers, open	May 27	Nov 4	161
2000	Heifers, open	May 18	Sep 25	130

[a] Livestock on the extreme grazing intensity treatment were removed early (Aug 27; 92 day grazing season) due to a lack of forage.

Table 2. Peak total above ground biomass production (lb/ac) on two range sites and above ground biomass remaining (lb/ac) on each treatment at the end of the grazing season, 1989 - 2000.

	Total Above Ground Biomass[a]		Above Ground Biomass Remaining			
Year	Overflow sites	Silty sites	Light	Moderate	Heavy	Extreme
1989	3,863	2,089	2,078	2,074	2,035	1,701
1990	3,847	2,962	2,634	2,383	2,023	1,985
1991	3,142	2,629	2,385	1,494	833	641
1992	2,758	2,065	1,915	1,353	574	406
1993	3,999	3,446	2,924	2,256	1,290	608
1994	4,201	2,803	2,017	1,728	1,393	901
1995	4,773	3,134	2,772	1,906	1,583	504
1996	3,837	2,645	2,552	1,975	1,064	513
1997	3,351	2,376	2,550	1,711	689	560
1998	3,334	2,855	2,674	1,848	686	522
1999	4,338	3,152	2,269	2,108	806	609
2000	3,950	2,846	2,387	2,246	1,130	718
12-yr ave.	3,783	2,750	2,430	1,924	1,176	806
Ideal[b]			2,148	1,693	982	516

[a] Biomass production averaged across all treatments.
[b] Ideal above ground biomass remaining would be 65, 50, 35 and 20% of the forage produced in an "average" year for the light, moderate, heavy and extreme grazing intensities, respectively.

Table 3. Average nutritional quality of forage on two range sites (overflow and silty) from forbs and grasses, 1989 - 1998.

	Overflow site		Silty site	
Treatment	Forbs	Grasses	Forbs	Grasses
	Crude Protein, %			
None	9.17[c]	6.57[d]	10.40	7.35[c]
Light	8.80[c]	7.03[bc]	10.75	7.36[c]
Moderate	9.13[c]	6.73[cd]	10.88	7.88[b]
Heavy	10.42[a]	7.29[ab]	10.79	8.40[a]
Extreme	9.87[b]	7.57[a]	10.76	8.55[a]
	In Vitro Dry Matter Digestibility, %			
None	61.86	50.65	59.22[b]	49.11[c]
Light	60.53	51.38	61.94[a]	46.68[d]
Moderate	61.74	50.63	60.48[ab]	50.55[bc]
Heavy	59.99	49.91	60.33[ab]	51.14[b]
Extreme	60.14	52.12	62.00[a]	55.86[a]
	Neutral Detergent Fiber, %			
None	43.06[b]	67.03[c]	50.01[a]	69.44[bc]
Light	44.85[ab]	67.69[bc]	45.40[b]	72.05[a]
Moderate	44.79[ab]	68.46[ab]	44.85[b]	71.43[ab]
Heavy	46.40[a]	69.37[a]	45.42[b]	71.48[ab]
Extreme	44.64[ab]	68.85[ab]	48.70[a]	68.37[c]
	Acid Detergent Fiber, %			
None	35.98	42.56[b]	36.58[a]	42.84[ab]
Light	38.08	42.80[ab]	36.15[ab]	43.64[a]
Moderate	37.67	43.02[ab]	34.43[c]	42.32[b]
Heavy	37.19	43.85[a]	34.97[bc]	40.83[c]
Extreme	36.82	41.01[c]	33.86[c]	39.31[d]
	Acid Detergent Lignin, %			
None	6.80[c]	4.67	7.80	4.17[b]
Light	7.52[ab]	4.42	7.35	4.64[a]
Moderate	7.31[abc]	4.58	7.41	4.19[b]
Heavy	7.81[a]	4.61	7.73	4.24[b]
Extreme	7.23[bc]	4.57	7.31	4.04[b]

[a,b,c,d] Means within a column and nutrient with differing superscripts differ ($P<.05$).

Table 4. Effect of grazing intensity on average daily gain, gain per acre and body condition scores, 1989 - 2000.

Treatment	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
	---------- Average Daily gain, lb/hd/d ----------											
Light	2.18	1.01	1.42[a]	2.04[a]	1.56[a]	1.10[a]	1.05[a]	1.07[a]	1.63[a]	1.53[a]	1.40[a]	1.20[a]
Moderate	2.35	1.23	1.13[ab]	1.89[a]	1.56[a]	.90[ab]	.94[a]	.93[a]	1.46[a]	1.31[ab]	1.30[a]	1.07[ab]
Heavy	2.03	1.17	0.91[b]	1.70[a]	1.68[a]	.74[b]	.86[a]	.81[ab]	1.20[ab]	1.03[b]	1.19[ab]	.97[ab]
Extreme	2.00	1.05	.69[b]	1.20[b]	1.06[b]	.20[c]	.55[b]	.44[b]	.83[b]	.60[c]	.96[b]	.82[b]
	---------- Live Weight Gain, lb/ac ----------											
Light	16.84[c]	13.69[c]	16.86[b]	18.60[d]	13.82[c]	20.10[b]	12.78[c]	14.14[c]	30.27[c]	28.29[c]	36.50[b]	33.03[c]
Moderate	33.27[bc]	27.63[b]	43.10[a]	54.33[c]	45.34[c]	38.70[ab]	42.37[b]	30.10[bc]	66.05[b]	62.25[b]	59.73[b]	42.39[bc]
Heavy	41.28[ab]	36.47[b]	58.83[a]	105.58[b]	119.31[b]	57.23[a]	70.45[a]	53.25[a]	110.13[a]	97.86[a]	93.93[a]	58.24[ab]
Extreme	61.00[a]	52.87[a]	61.90[a]	129.22[a]	166.77[a]	26.64[ab]	77.04[a]	45.38[ab]	71.10[b]	67.98[b]	108.49[a]	74.44[a]
	---------- Body condition score ----------											
Light						5.19[a]	5.08	5.19[a]	5.35	5.81[a]	5.72[a]	5.18[a]
Moderate						4.84[ab]	5.13	5.11[a]	5.24	5.71[ab]	5.65[ab]	5.20[a]
Heavy						4.80[ab]	5.16	4.91[ab]	4.93	5.21[b]	5.54[bc]	5.01[a]
Extreme						4.21[a]	4.74	4.37[b]	--	4.65[c]	5.41[c]	4.61[b]

[a,b,c,d] Means within a column and variable with differing superscripts differ ($P<.05$).

Table 5. Comparison of gain per acre (lb/ac) from selected stocking rate regimens.

	A: maximizing gain each year		B: maximum gain with constant stocking rate		C: gain with moderate stocking rate	
Year	AUM/ac	gain/ac	AUM/ac	gain/ac	AUM/ac	gain/ac
1991	2.26	62.5	2.47	62.0	.97	41.8
1992	2.68	134.8	2.47	133.9	.97	78.6
1993	3.41	175.8	2.47	161.1	.97	76.2
1994	2.27	58.1	2.47	57.7	.97	38.7
1995	3.08	84.7	2.47	81.3	.97	43.1
1996	2.04	57.0	2.47	54.0	.97	39.4
1997	1.92	92.4	2.47	83.6	.97	66.4
1998	2.08	91.2	2.47	87.5	.97	61.0
1999	3.18	111.4	2.47	105.3	.97	52.6
2000	2.81	76.6	2.47	75.5	.97	43.3
10-yr average	2.57	94.4	2.47	90.2	.97	54.1

Table 6. Comparison of return per acre (lb/ac) to land, labor and management and gain (lb/ac) from selected stocking rate regimens.

	A: maximizing return each year			B: maximum return with constant stocking rate			C: return with moderate stocking rate		
Year	AUM/ac	return/ac	gain/ac	AUM/ac	return/ac	gain/ac	AUM/ac	return/ac	gain/ac
1991	.88	$4.10	38.8	1.86	($3.01)	60.6	.97	$4.04	41.8
1992	3.13	$97.11	130.0	1.86	$80.65	121.8	.97	$49.36	78.6
1993	2.39	$105.11	158.3	1.86	$99.88	135.6	.97	$67.22	76.2
1994	.67	$1.99	28.5	1.86	($6.09)	56.2	.97	$1.46	38.7
1995	1.44	$2.05	59.5	1.86	$0.84	70.8	.97	$0.59	43.1
1996	2.06	$31.83	57.0	1.86	$31.50	56.5	.97	$21.88	39.4
1997	1.11	$13.35	73.5	1.86	$6.60	92.3	.97	$13.11	66.4
1998	1.01	$2.11	63.1	1.86	($5.10)	90.0	.97	$2.09	61.0
1999	3.24	$56.58	111.3	1.86	$45.21	90.4	.97	$25.82	52.6
2000	2.19	$18.05	72.8	1.86	$17.57	67.7	.97	$11.38	43.3
10-yr average	1.81	$33.23	79.4	1.86	$26.81	84.2	.97	$19.70	54.1

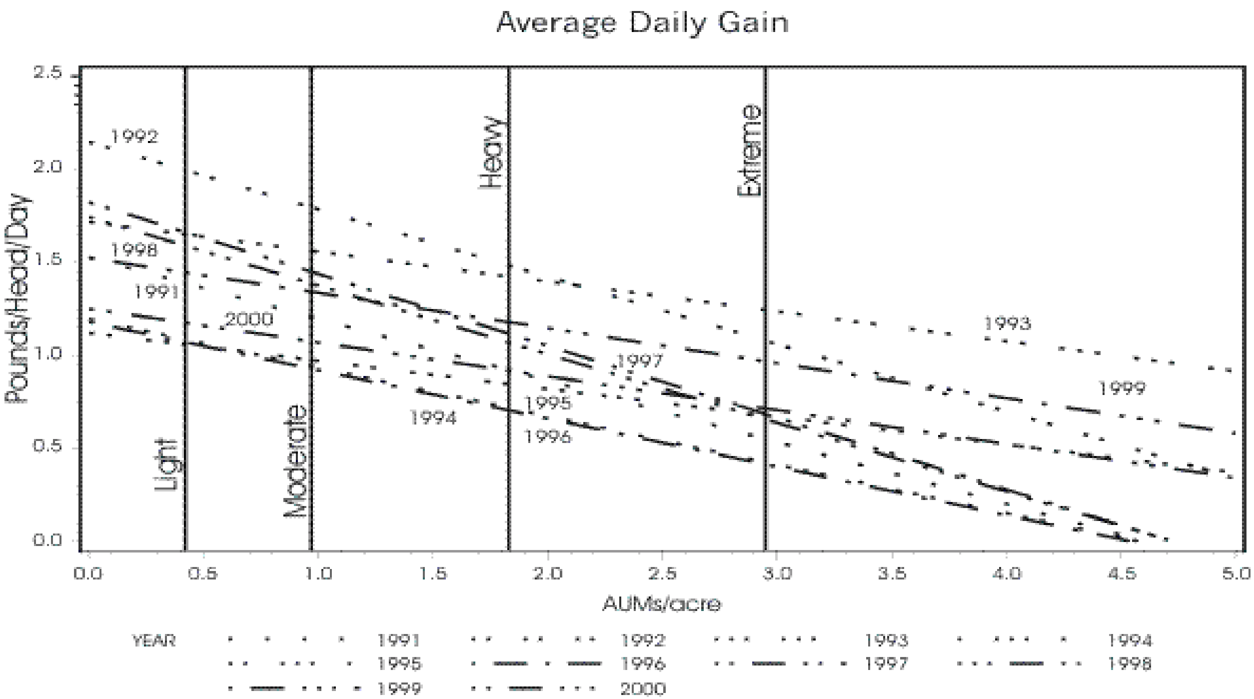

Figure 2. Relationships between average daily gain and stocking rate on the grazing intensity trial from 1991 to 2000.

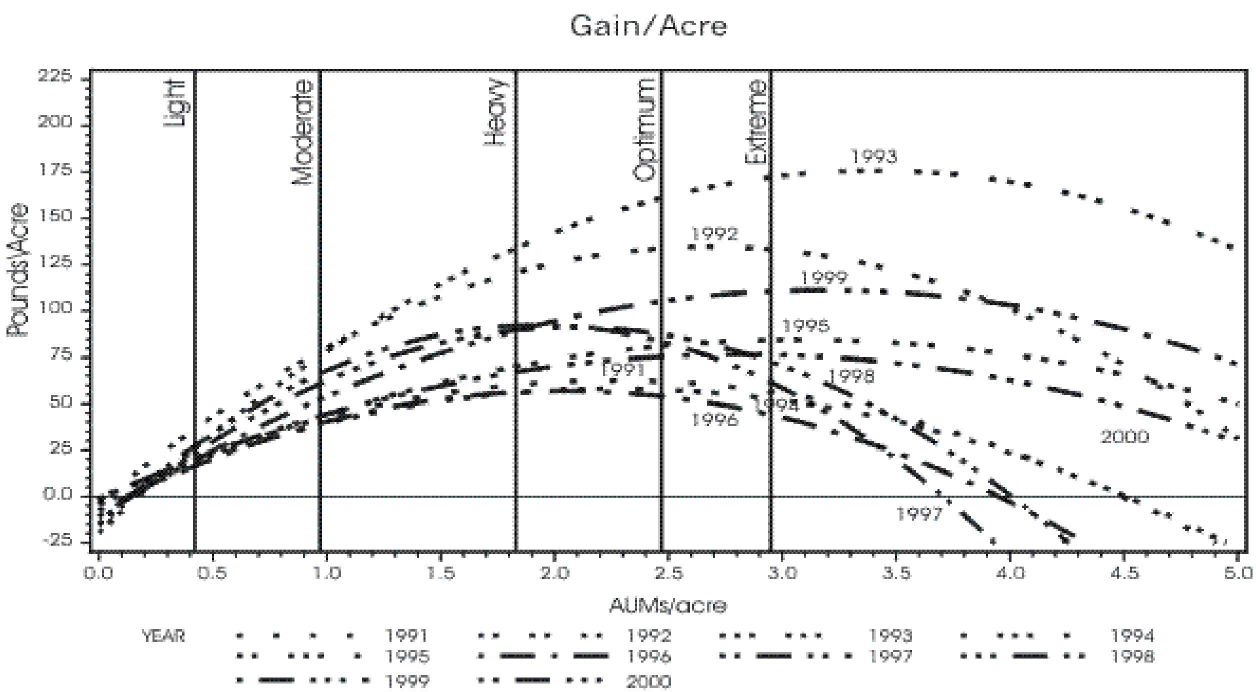

Figure 3. Relationships between gain/acre and stocking rate on the grazing intensity trial from 1991 to 2000.

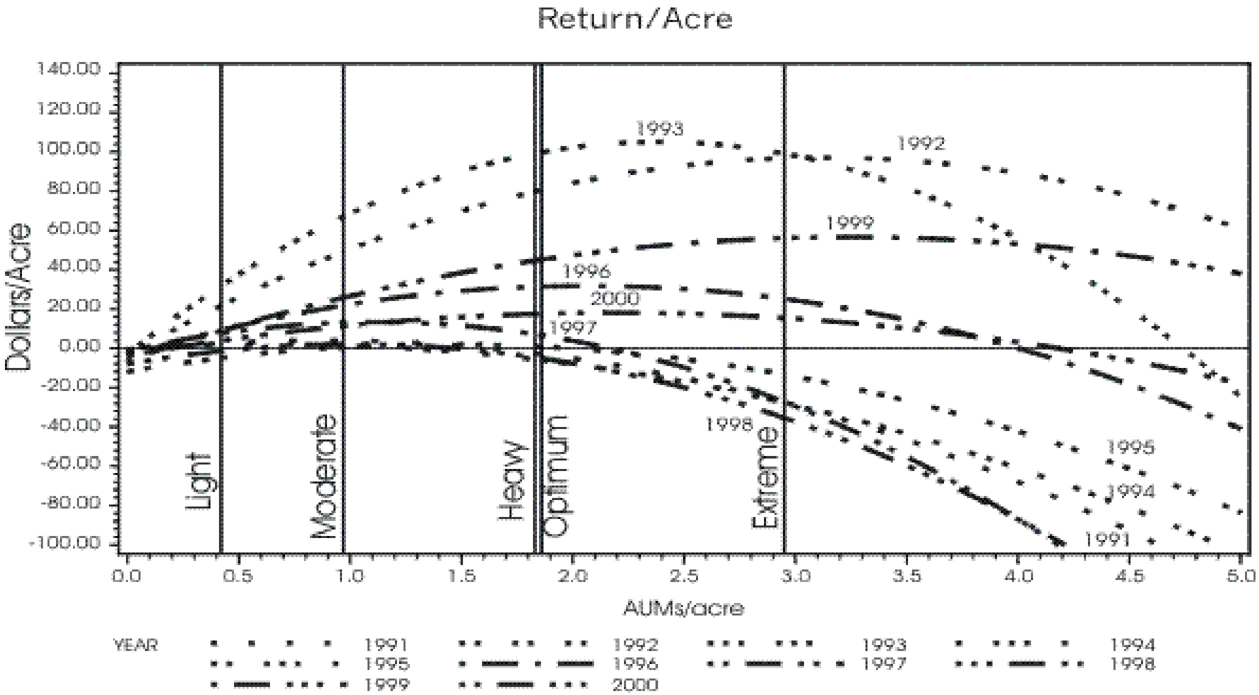

Figure 4. Relationships between returns to land, labor and management and stocking rate on the grazing intensity trial from 1991 to 2000.