Long-term Grazing Intensity Research in the Missouri Coteau Region of North Dakota: Livestock Response and Economics - Final Report

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The effects of grazing intensity on cattle performance, profitability and the sustainability of forage production have been monitored on 12 pastures at the CGREC since 1989. The optimum stocking rate depends on objectives, but the best compromise between profitability and sustainability falls between a moderate stocking rate (50 percent utilization) and a heavy stocking rate (65 percent utilization).

Summary

The question of how heavily to stock native range is complex. The answer primarily depends on how much forage is available, which varies each year, depending on the temperature and precipitation. If stocking rates are too low, profits will not be maximized, but if rates are too high, cattle performance will suffer and the resource will be damaged.

This study began in 1989. Five treatments were included: no grazing, and light, moderate, heavy and extreme grazing. Our goal was to stock the pastures each year so when the cattle were removed in the fall, 65, 50, 35 and 20 percent of the forage produced in an average year remains on the light, moderate, heavy and extreme treatments, respectively.

In 2015, pastures were stocked the same as previous years, but in conjunction with another study (see Page 46) the animals were supplemented with dried distiller's grain at 0.3 percent of body weight each day.

Average daily gain and animal body condition scores have decreased with increasing grazing intensity. This effect has been significant ($P \leq 0.05$) in most but not all years. Initially, gain/ton (total weight gain of all animals/ton of available forage) increased as the stocking rate increased, but a point was reached at which gains/ton decline.

The constant stocking rate that would have resulted in the greatest average gain/ton of forage from 1991 to 2014 was 2.57 animal unit months (AUMs)/ton of forage, and the average gain/ton would have been 78.8 pounds/ton. If cattle prices were constant, then return/ton (dollars returned to the enterprise per ton of forage) would peak at a stocking rate somewhere below maximum gain/ton, with the exact point depending on carrying costs. The stocking rate with the maximum return/ton during those 24 years would be 2.53 AUMs/ton, with an average annual return of $54.01/ton. Because the cattle received supplementation in 2015, their gains were better but the costs were higher than in previous years.

Introduction

At low stocking rates, individual animal performance is high, but total gains from the pasture will be low (Hart 1972). As stocking rates increase, individual performance goes down but gain/ton of forage will increase as long as the individual gain of the animal added exceeds the reduced gain of the other animals in the pasture. But gain/ton will decline as more animals are competing for less forage (Hart 1972). If cattle prices are steady, then return/ton would peak at a stocking rate somewhere below maximum gain/ton, with the exact point depending on input costs (Hart 1972).

The optimum stocking rate varies with objectives, but we cannot know what stocking rate is optimum for any particular objective without knowing how cattle and rangeland respond to the stocking rate. Heavy stocking can damage the resource, reducing total forage production and shifting the species composition to species that are more resistant to grazing (Thurow 1991).

Stocking rate can be expressed two ways: on a land area or a forage basis (Table 1). The land area basis states how many animals are on a given amount of land for a given length of

Table 1. Examples of stocking rates in AUM/ton of available forage and the acres of land required to provide that much forage for one month assuming an average year's forage production on a loamy ecological site (2,848 lbs/acre in an average year). Stocking rate in AUM/acre is the inverse of the number of acres provided.

AUM/ton of available forage		Acres required	Stocking rate in AUM/acre
Average stocking rate on the light treatment	0.35	2.01	0.50
Average stocking rate on the moderate treatment	0.68	1.03	0.97
	0.70	1.00	1.00
	1.00	0.70	1.42
Average stocking rate on the heavy treatment	1.31	0.54	1.87
Average stocking rate on the extreme treatment	2.32	0.30	3.30
Stocking rate with the highest average return	2.53	0.28	3.60
Stocking rate with the highest average gain	2.57	0.27	3.66
	3.00	0.23	4.27

time. The forage basis describes how many animals are grazing a given amount of forage during a given length of time.

The drawback of the land area basis is that forage production varies from year to year and place to place, so a year with half the normal forage production will require half the normal stocking rate by cutting animal numbers in half, cutting the time they graze in half or doubling the amount of land area.

To express stocking rate on a forage basis, the ratio of forage demand to forage supply remains constant. In a year with half of normal forage production, a producer still would have to cut animals numbers in half, cut grazing time in half or double the amount of land area, but the stocking rate would remain the same because the ratio of animals to available forage remains the same.

The unit used to express animal demand is the animal unit month (AUM). An AUM is defined as the forage required to sustain a 1,000-pound cow and her calf for one month, assuming they require 26 pounds of forage a day on a dry matter basis. The animal unit is based on the metabolic weight of the animal, so a 1,200-pound cow would be 1.147 animal units and a 700-pound steer or open heifer would be 0.765 animal units.

A stocking rate of one AUM/acre allows the equivalent of one cow and calf to graze on an acre for one month. A stocking rate of 3 AUMs/acre holds the equivalent of three cows with calves on one acre for one month, but this is saying nothing about the amount of forage they will have to graze. A stocking rate of 1 AUM/ton of forage allows the equivalent of one mature cow and calf to graze on one ton of available forage for one month or 66.6 pounds per day. A stocking rate of 3 AUMs/ton of forage holds the equivalent of three mature cows with calves on one ton of available forage for one month or 22.2 pounds per day. Table 1 gives examples of stocking rates in AUM/ton of available forage and their equivalent in AUM/acre, assuming that the area produces 2,848 pounds/acre, the average of the loamy ecological site in our study.

Procedures

This study began in 1989 at the Central Grasslands Research Extension Center in Kidder County northwest of Streeter, N.D. The site was divided into 12 pastures of approximately 30 acres each. Grazing intensities were light, moderate, heavy and extreme. The target was to leave 65, 50, 35 and 20 percent of the forage produced in an average year on the light, moderate, heavy and extreme treatments, respectively. Exclosures were used to provide a fifth, ungrazed treatment to determine how rangeland changes when it is not grazed.

Table 2. Stocking history of the grazing intensity trial for 1989 through 2015 at Central Grasslands Research Extension Center, Streeter, N.D.

Year	Class of Animal	Stocking Date	Removal Date	Length of Grazing Season (days)
1989	steers	May 22	Aug 22	92
1990	bred heifers	May 30	Nov 27	181
1991	bred heifers	May 29	Sept 25	119
1992	bred heifers	June 1	Aug 25	85
1993	bred heifers	May 29	Sept 26	120
1994	open heifers and steers	May 17	Nov 10	177
1995	open heifers	May 18	Oct 30	165
1996	open heifers	May 20	Sept 23	126
1997	open heifers	May 27	Nov 5[1]	162[1]
1998	open heifers	May 16	Oct 28	165
1999	open heifers	May 27	Nov 4	161
2000	open heifers	May 18	Sept 25	130
2001	open heifers	May 21	Sept 11	113
2002	open heifers	May 23	July 17	55
2003	open heifers	May 23	Sept 19	119
2004	open heifers	May 19	Sept 9	113
2005	open heifers	May 17	Oct 27	163
2006	open heifers	May 11	July 27	77
2007	open heifers	May 18	Oct 1	136
2008	open heifers	May 20	Aug 25	97
2009	open heifers	May 21	Sept 1	103
2010	open heifers	May 11	Sept 20	132
2011	open heifers	May 18	Oct 17	152
2012	open heifers	May 7	Sept 25	141
2013	open heifers	May 24	Aug 28	96
2014	open heifers	May 22	Oct 8	139
2015	steers	May 13	Sept 14	124

[1]Due to lack of forage, livestock were removed early (Aug. 27) from the extreme grazing treatment, resulting in 92 days of grazing on that treatment.

Grazing began each year in mid-May, and cattle were removed when forage utilization on half of the pastures had reached desired grazing intensity (approximately mid- October). Table 2 presents the stocking history of the study. In conjunction with another study in 2015 (see Page 46), cattle were supplemented with dried distiller's grain at 0.3 percent of body weight each day.

Cattle performance was evaluated based on initial and final body weight, and body condition score. Economic return is determined by subtracting the initial value of each animal, interest on the initial value for the grazing period, death loss, and estimated costs per head for salt, mineral, veterinary fees and supplement from the final value of the animal when taken off pasture. Initial and final values of animals are based on weight using regression equations developed from sale prices at the Napoleon Livestock Auction during the same period.

Results

Forage production

Figure 1 shows how much forage remained at the end of the grazing season each year. Figure 2 shows the average production on the loamy and loamy overflow ecological sites during each year of the study and the total precipitation for the year.

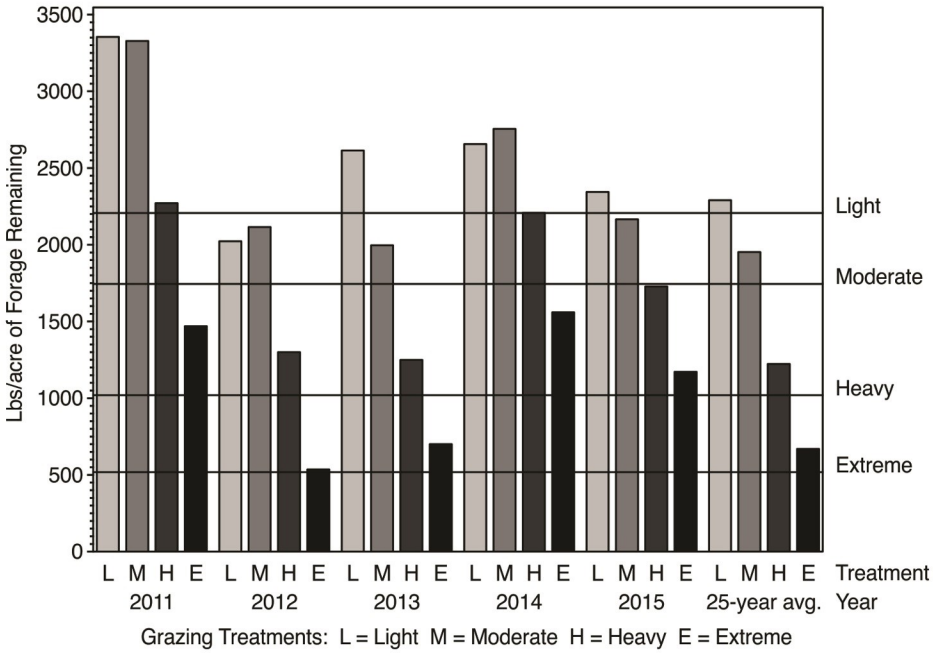

Figure 1. Forage remaining on each treatment at the end of the grazing season from 2011 to 2015 and the average forage remaining on each treatment over the last 25 years.

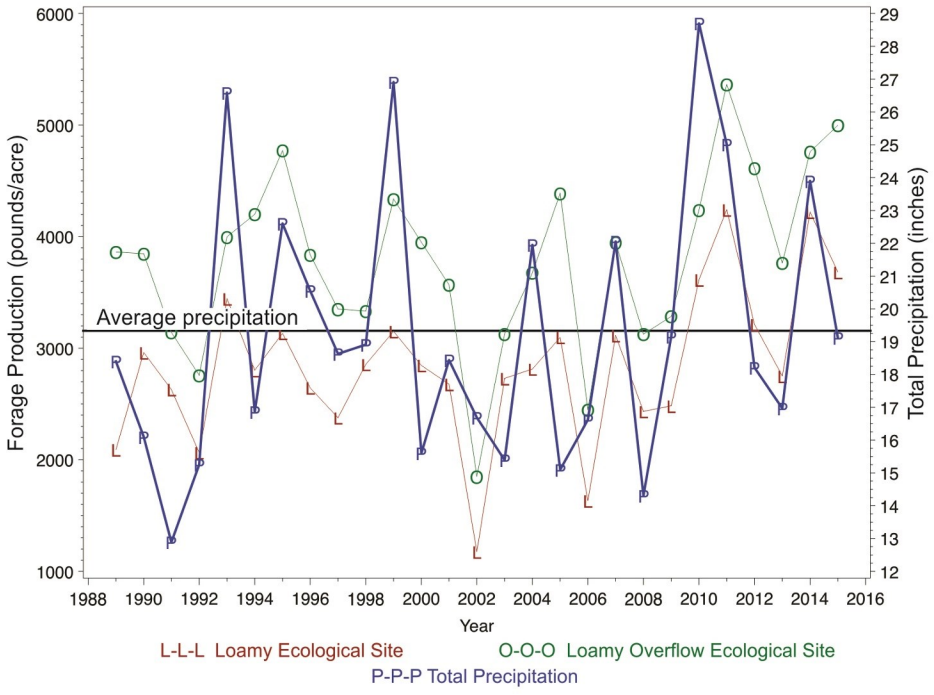

Figure 2. Total crop year precipitation (October 1 to September 30) and peak total above ground biomass production on loamy overflow and loamy ecological sites on the grazing intensity study from 1989 to 2015.

Livestock response

Table 3 shows the average daily gain, gain per acre, gain per ton of forage and body condition scores from the four grazing intensities. The relationships between stocking rate and average daily gain are illustrated in Figure 3 (next page). Initially, gain/ton of forage increased as the stocking rate increased, but a point was reached at which a further increase in stocking rate resulted in reduced gain/ton (Figure 4). Average body condition score decreased with increased grazing intensity each year with few exceptions ($P \leq 0.05$).

Table 3. Average daily gains, gains per acre, gain per ton of forage and condition scores from different stocking intensities.

Desired Grazing Intensity	2011	2012	2013	2014	2015	Average 1991-2015
	Average Daily Gains (lbs/head/day)					
Light	1.59	1.21a[1]	1.36	1.61	2.64	1.45a
Moderate	1.32	1.12a	1.31	1.57	2.66	1.34a
Heavy	1.30	0.98ab	1.09	1.38	2.55	1.17b
Extreme	1.17	0.72b	1.01	1.41	2.44	0.96c
LSD (0.05)	NS[2]	0.34	NS	NS	NS	0.11
	Average Gain (lbs/acre)					
	2011	2012	2013	2014	2015	Average 1991-2015
Light	51.55c	36.81	30.33b	50.54c	75.21c	33.80d
Moderate	83.22bc	62.85	53.27ab	94.89bc	135.60b	61.35c
Heavy	121.11ab	83.17	66.90a	126.92ab	198.53a	85.03b
Extreme	140.29a	80.16	80.60a	163.17a	236.63a	98.25a
LSD (0.05)	54.49	NS	27.97	48.18	53.19	11.42
	Average Gain (lbs/ton of forage)					
	2011	2012	2013	2014	2015	Average 1991-2015
Light	21.69b	17.88b	17.20b	21.19c	36.14c	20.19d
Moderate	32.82b	33.08ab	37.44ab	37.25bc	59.60bc	36.16c
Heavy	58.61a	54.07a	53.62a	51.00b	98.97ab	60.02b
Extreme	74.00a	58.94a	69.77a	91.49a	148.31a	79.09a
LSD (0.05)	22.96	30.27	34.87	21.48	55.36	7.36
	Condition Score					
	2011	2012	2013	2014	2015	Average 1994-2015
Light	5.41	5.02a	4.81	5.39	5.00	5.39a
Moderate	5.33	4.88a	4.69	5.26	5.00	5.28ab
Heavy	5.42	4.78ab	4.57	5.19	4.99	5.18b
Extreme	5.25	4.57b	4.48	5.15	4.99	4.95c
LSD (0.05)	NS	0.24	NS	NS	NS	0.15

[1]Means in the same column followed by the same letter are not significantly different at $P=0.05$.
[2]Means not significantly different.

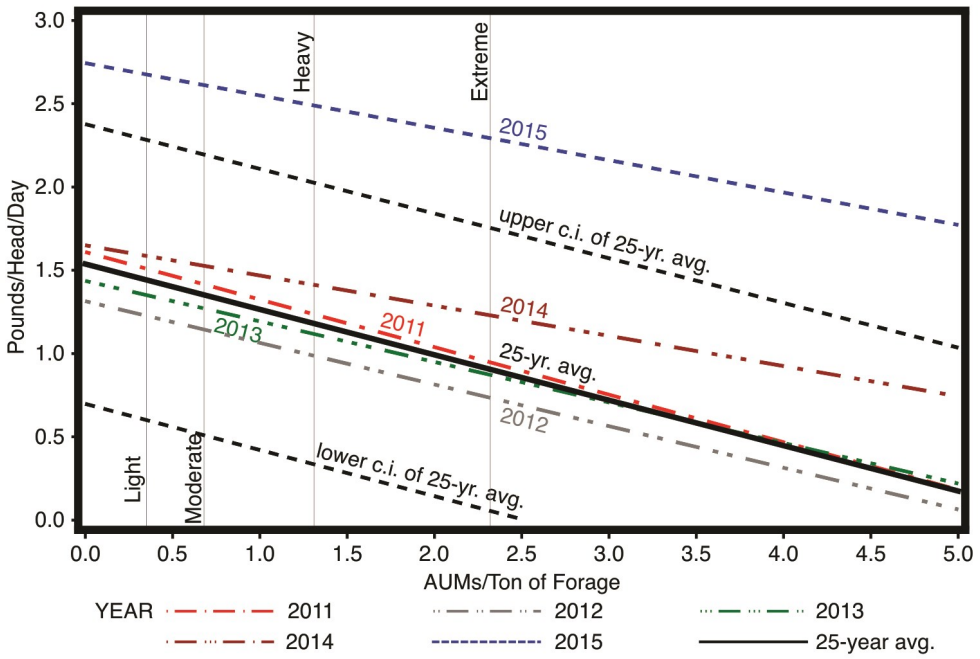

Figure 3. Relationships between average daily gain and stocking rate on the grazing intensity trial for 2011 to 2015 and the 25-year average with 95 percent confidence intervals.

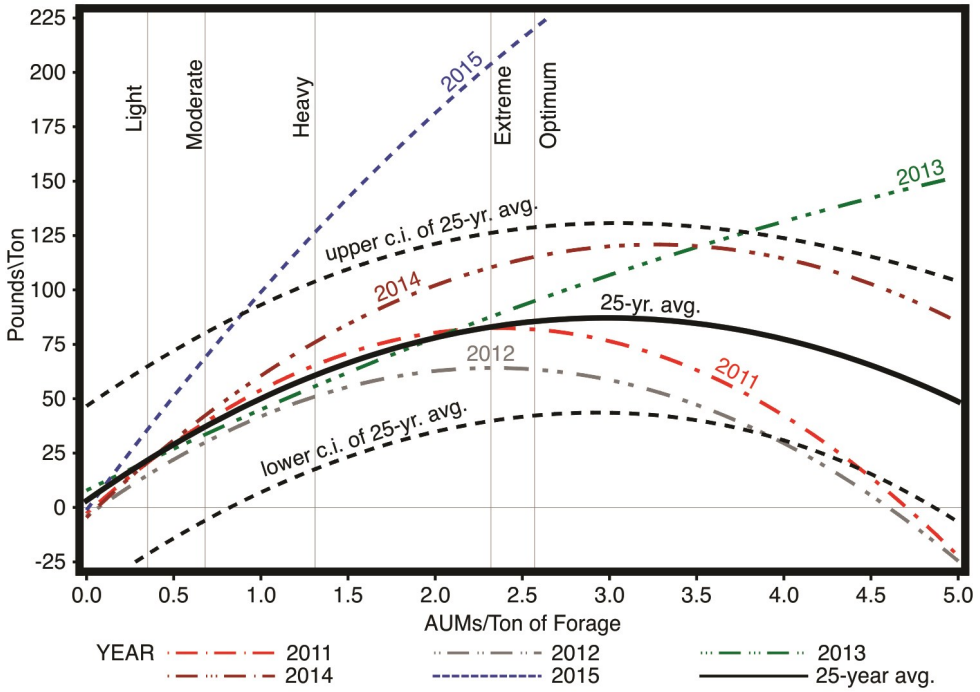

Figure 4. Relationships between gain/ton and stocking rate on the grazing intensity trial for 2011 to 2015 and the 25-year average with 95 percent confidence intervals.

Table 4A shows the stocking rate that would have resulted in the maximum gain/ton of forage in each year. The stocking rate that would have provided the maximum gain/ton if held constant from 1991 to 2014 would be 2.57 AUMs/ton ("Optimum" in Figure 4) (Values are based on regressions of gain on the stocking rate. All regressions were significant at least at the *P*=0.0068 level).

Table 4B shows what the gain/ton would have been each year if we had stocked at that rate. Stocking at 2.57 AUMs/ton each year, gain/ton would have ranged from 27.1 pounds/ton in 2004 to 153.0 pounds/ton in 1992, with an average of 78.8 pounds/ton.

The steers in 2015 were supplemented and the regression relationship suggests that the gain would have been 220.2 pounds/ton of forage if stocked at 2.57 AUM/ton; however the highest actual stocking rate was 2.22 AUM/ton of forage with a gain of 194.5 pounds/ton.

Table 4C shows gain/ton if the stocking rate had been held constant at 0.68 AUM/ton, the average of the moderate treatment.


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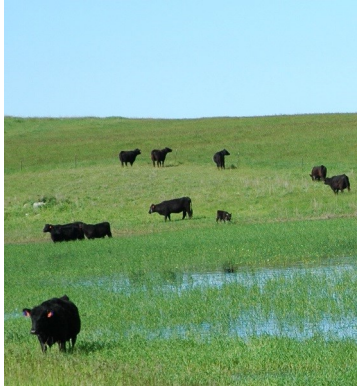
Table 4. Comparison of gain in pounds per ton of forage from selected stocking rates.

	A		B		C	
	Stocking rate in AUMs/ton of forage that would result in the maximum gain/ton in each year.		Stocking rate in AUMs/ton of forage that if held constant would result in the maximum gain/ton over the 24-year period.		Gain/ton over the 24-year period if stocking rate where held constant at 0.68 AUMs/ton of forage, the average of the moderate treatment over this period.	
Year	**AUMs/ton of forage**	**Gain/ton**	**AUMs/ton of forage**	**Gain/ton**	**AUMs/ton of forage**	**Gain/ton**
1991	2.61	56.5	2.57	56.5	0.68	27.1
1992	3.84	171.9	2.57	153.0	0.68	55.7
1993	2.07	102.9	2.57	96.2	0.68	53.1
1994	1.83	40.1	2.57	33.7	0.68	24.8
1995	2.52	60.3	2.57	60.3	0.68	28.3
1996	2.52	58.7	2.57	58.7	0.68	26.1
1997	2.30	95.4	2.57	94.0	0.68	46.0
1998	2.10	75.6	2.57	71.7	0.68	39.7
1999	3.46	108.3	2.57	100.9	0.68	36.6
2000	2.75	70.9	2.57	70.6	0.68	30.0
2001		*	2.57	110.0	0.68	36.1
2002		*	2.57	110.9	0.68	38.8
2003		*	2.57	79.4	0.68	28.5
2004	1.50	80.1	2.57	27.1	0.68	48.8
2005	2.43	48.3	2.57	48.1	0.68	22.5
2006	3.08	35.9	2.57	34.9	0.68	15.1
2007		*	2.57	113.1	0.68	34.3
2008	1.89	80.4	2.57	69.2	0.68	45.5
2009	2.25	95.7	2.57	93.9	0.68	53.2
2010	1.85	65.6	2.57	54.7	0.68	37.3
2011	2.48	82.5	2.57	82.3	0.68	37.8
2012	2.35	64.1	2.57	63.5	0.68	29.9
2013		*	2.57	92.7	0.68	33.0
2014	3.26	120.9	2.57	115.2	0.68	42.5
24-year Average	**2.48**	**79.7**	**2.57**	**78.8**	**0.68**	**36.3**
2015[1]	6.12	332.5	2.57	220.2	0.68	69.3

* The regressions for 2001, 2002, 2003, 2007 and 2013 were not suitable to project the peak in gain/ton.
[1] Cattle in 2015 were supplemented dried distiller's grain at 0.3 percent of body weight per day. Gains were therefore much higher than in the previous years of the study, and could not be compared.



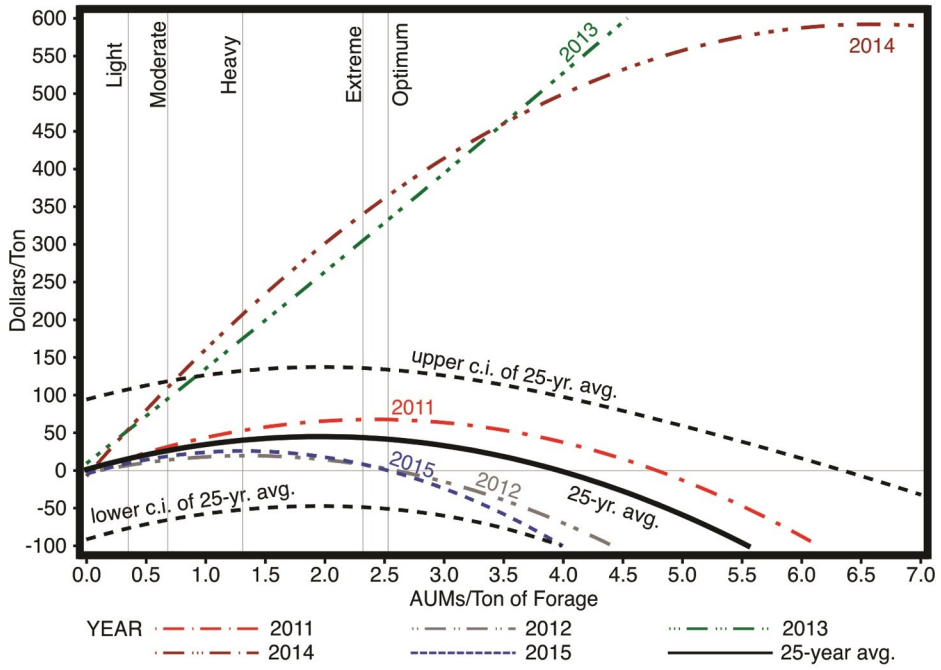


Figure 5. Relationships between returns to land, labor and management and stocking rate on the grazing intensity trial for 2011 to 2015 and the 25-year average with 95 percent confidence intervals.

Economics

Figure 5 shows the relationship between stocking rate and economic return. Costs for land, labor and management are not included because these values vary greatly from one operation to another. If cattle prices were steady, then return/ton would peak at a stocking rate somewhere below maximum gain/ton, with the exact point depending on carrying costs. However, when cattle are worth more per hundred-weight in the spring than they are in the fall, the point of maximum return/ton occurs at a lower stocking rate. When the cattle are worth more in the fall, the maximum return/ton occurs at a higher stocking rate (Hart 1987).

Table 5. Comparison of return to land, labor and management from selected stocking rates.

	A			B			C		
	Stocking rate in AUMs/ton of forage that would result in the maximum returns/ton to land, labor and management in each year.			Stocking rate in AUMs/ton of forage that if held constant would result in the maximum returns/ton to land, labor and management during the 24-year period.			Returns/ton to land, labor and management over the 24-year period if stocking rate where held constant at 0.68 AUMs/ton of forage, the average of the moderate treatment over this period.		
Year	**AUMs/ ton of forage**	**Dollars/ ton**	**Gain/ ton**	**AUMs/ ton of forage**	**Dollars/ ton**	**Gain/ ton**	**AUMs/ ton of forage**	**Dollars/ ton**	**Gain/ ton**
1991	0.41	1.77	18.0	2.53	(18.91)	56.43	0.68	1.41	27.13
1992		*		2.53	101.64	151.71	0.68	34.52	55.68
1993	1.41	59.10	91.8	2.53	22.87	97.32	0.68	43.52	53.09
1994	0.33	1.19	13.9	2.53	(27.86)	34.49	0.68	0.43	24.84
1995	0.89	0.84	35.0	2.53	(17.42)	60.29	0.68	0.55	28.34
1996	2.57	32.69	58.7	2.53	32.68	58.72	0.68	14.43	26.14
1997	1.12	15.84	69.2	2.53	(15.56)	94.43	0.68	12.77	46.04
1998	0.65	0.52	37.9	2.53	(25.27)	72.39	0.68	0.51	39.67
1999	3.55	55.94	108.2	2.53	51.10	100.16	0.68	18.17	36.57
2000	2.04	16.04	66.1	2.53	15.01	70.46	0.68	8.08	30.01
2001		*		2.53	53.50	108.58	0.68	17.91	36.12
2002	0.00	12.94	32.0	2.53	(19.82)	108.30	0.68	(3.58)	38.82
2003		*		2.53	117.43	78.01	0.68	36.24	28.47
2004	2.00	85.65	68.6	2.53	78.81	31.38	0.68	42.69	48.79
2005	1.58	14.34	42.1	2.53	8.89	48.21	0.68	9.51	22.47
2006		*		2.53	89.78	34.77	0.68	27.32	15.12
2007		*		2.53	76.90	111.43	0.68	23.84	34.28
2008	1.74	52.68	79.9	2.53	40.87	70.57	0.68	31.37	45.53
2009	1.24	19.46	78.1	2.53	1.75	94.39	0.68	16.11	53.18
2010	0.97	12.13	49.5	2.53	(35.93)	55.95	0.68	10.49	37.33
2011	2.41	67.72	82.4	2.53	67.57	82.42	0.68	31.72	37.84
2012	1.35	19.62	51.8	2.53	2.01	63.76	0.68	13.97	29.88
2013		*		2.53	332.00	93.71	0.68	95.38	33.76
2014		*		2.53	364.20	114.48	0.68	110.80	42.55
24-year Average	**1.43**	**27.56**	**57.8**	**2.53**	**54.01**	**78.85**	**0.68**	**24.92**	**36.32**
2015[1]	1.31	25.91	126.8	2.53	0.17	217.5	0.68	18.96	69.3

* The regressions for 1992, 2001, 2003, 2006, 2007, 2013 and 2014 were not suitable to project the peak in returns to land, labor and management.

[1] Cattle in 2015 were supplemented dried distiller's grain at 0.3 percent of body weight per day. Costs were therefore higher than in previous years of the study.

Table 5 shows the optimum return/ton for each year if stocking rates were set for the optimum for that year, a constant optimum rate and the moderate rate. The peaks of the curves in Figure 5 correspond to these optimum stocking rates.

The constant stocking rate with the maximum return/ton during the 24 years, 1991 to 2014, would be 2.53 AUMs/ton. This is the point labeled "Optimum" in Figure 5. In 2012, cattle prices were higher in the spring than in the fall for cattle weighing less than 875 pounds. This, coupled with the lower rate of gain on the higher stocking rates, would put the maximum return for 2012 at $19.62/ton if stocked at 1.35 AUMs/ton.

In both 2013 and 2014, cattle prices were higher in the fall than they were in the spring, so the heavier you could stock, the more money you would have made, provided the cattle did not lose too much weight. Therefore our pastures were not stocked heavily enough to determine the stocking rate with the maximum return. In 2015, cattle prices were higher in the spring than in the fall for cattle weighing less than 1100

pounds. This plus the added cost of supplementing with dried distiller's grain, would put the maximum return for 2015 at $25.91/ton if stocked at 1.31 AUMs/ton.

Although the average return/ton is higher under the optimum stocking rate, seven years had negative returns, while only one year had a negative return under the moderate stocking rate. Comparing Tables 4 and 5, the stocking rate with the greatest economic return was less than the rate with the greatest gain per ton of forage in all but three years (1996, 1999 and 2004).

Discussion

The objective of this study was to determine what stocking rate would result in the greatest economic return to the livestock producer in the long run. The slope of the decline in average daily gain with increase in stocking rate varies greatly from year to year. These differences may be due to variation in forage quality or quantity, the effect of weather on the animals, the animals' initial weights or their potential to gain.

Results indicate that for 24 years, 1991 to 2014, the optimum stocking rate would have been 2.53 AUMs/ton of forage. This is equal to 791 pounds of forage for one AUM.

During the past 25 years, forage production on our loamy ecological sites has averaged 2,848 pounds/acre. In a year with average production, 0.28 acre of this ecological site would be enough to supply this amount of forage for a month. However production has varied through the years from being able to supply this amount of forage with 0.19 acre to requiring 0.67 acre. This emphasizes the importance of knowing how productive pastures are and being able to predict weather trends early in the grazing season.

Although 2.53 AUMs/ton of forage would have provided the best economic return during the 24 years, we found a number of reasons to consider a lighter stocking rate. First, the extreme and heavy pastures have been deteriorating in condition through the course of the study and may not be able to support the rates of gain we have seen in the past. Also, profits and losses are higher at higher stocking rates, depending on the difference between spring and fall livestock prices. The producer would experience more years with negative returns at the higher stocking rates.

The moderate stocking rate may be too conservative if maximizing profit is the objective. In only four out of 25 years, returns would have been higher with a stocking rate less than the moderate rate of 0.68 AUM/ton of forage. In all other years, a higher stocking rate would have resulted in higher returns. For a stocker operation in this area, the optimum stocking rate would fall in the range of 0.68 to 2.53 AUMs/ton of forage.

Also, a light or moderate stocking rate is better than a period of rest that is too long. The low level of production on the ungrazed treatment likely is due to litter buildup that prevents rainfall and sunlight from reaching the ground.

Any stocking rate a livestock producer chooses will be a compromise between higher, variable income and lower, steadier income. It also will be a compromise between individual animal performance and total gain from the pasture, and between animal production and other products from the rangeland.

This is the last year of this study. (Editor's note: Bob Patton is retiring after 29 years of conducting research at CGREC.)

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