Long-term Grazing Intensity Research in the Missouri Coteau Region of North Dakota: Effects on Plant Production and Composition - Final Report

Bob Patton and Anne Nyren
Central Grasslands Research Extension Center - NDSU, Streeter

The effects of grazing intensity on plant species and the sustainability of forage production have been monitored on 12 pastures at the CGREC since 1989. Plant responses to grazing fall into four groups: plants favored by no grazing, those that benefit from moderate grazing, those favored by heavy grazing, and invaders. The optimum stocking rate depends on objectives, but the greatest forage production falls between a light stocking rate (35 percent utilization) and a moderate stocking rate (50 percent utilization).

Summary

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 remained on the light, moderate, heavy and extreme treatments, respectively.

On loamy and loamy overflow ecological sites, the extreme grazing treatment produced the least forage ($P \leq 0.05$). On loamy ecological sites, the light treatment produced the most forage ($P \leq 0.05$). On loamy overflow ecological sites, the light and moderate treatments produced the most forage but were not significantly different from each other ($P \leq 0.05$).

Of the 167 plant species monitored on loamy ecological sites, 76 responded to grazing based on estimated weight, frequency, density or basal cover. Of the 179 plant species monitored on loamy overflow ecological sites, 66 responded to grazing.

Introduction

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.

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).

Procedures

Vegetation sampling began in 1988 and grazing on 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.

The grazing intensity study pastures after 18 years of treatment.
©2011 Google, Image USDA Farm Service Agency

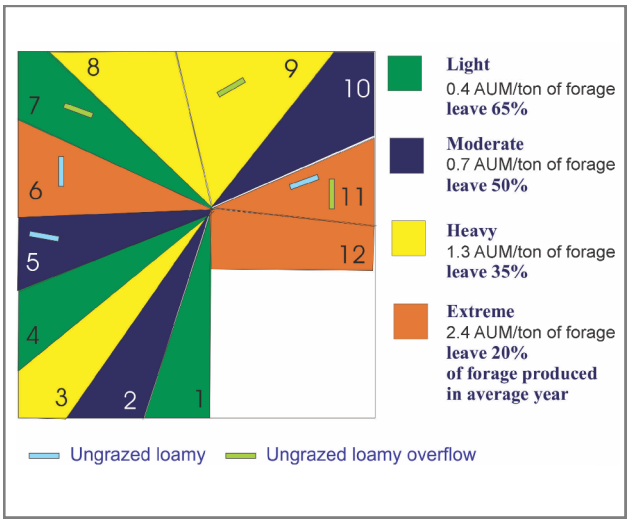


Diagram of grazing intensity treatments at the CGREC.

Table 1. 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.

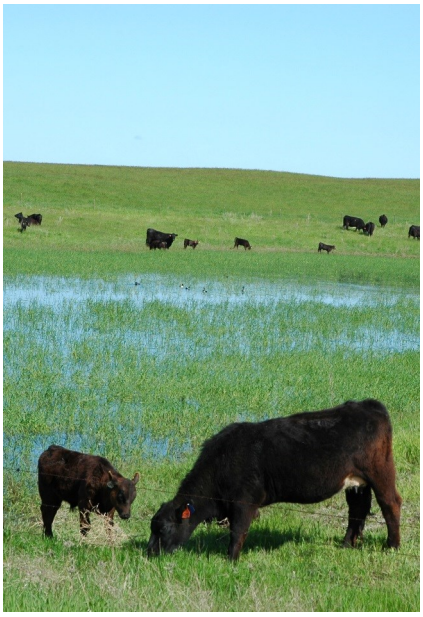
Grazing began each year in mid-May, and cattle were removed when forage utilization on half of the pastures had reached desired grazing intensity (approximately mid-October). Table 1 presents the stocking history of the study and Figure 1 (next page) shows how much forage remained at the end of the grazing season each year.

Monitoring locations were on loamy and loamy overflow ecological sites in each pasture, as were six exclosures for the ungrazed treatment. Frequency of occurrence of all plant species was monitored each year to determine changes in the plant community. Plant density of shrubs, forbs and bunch grasses was sampled in conjunction with the frequency sampling. Forage production and utilization were determined using the paired plot cage comparison method. While clipping plots at peak production, an estimate was made of species percentage by weight. All samples were oven-dried and weighed.

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.



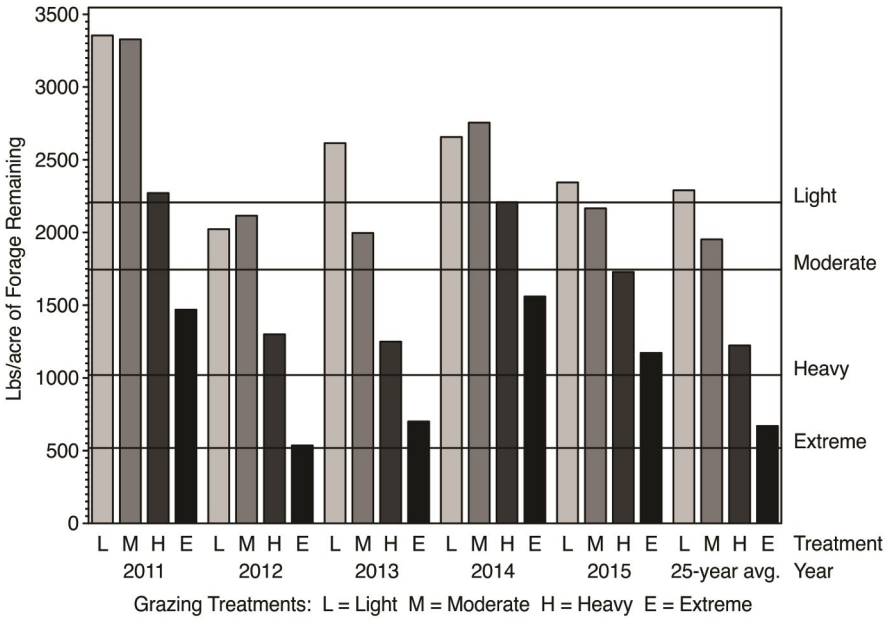


Figure 1. Forage remaining on each treatment at the end of the grazing season from 2011 to 2015 and the average forage remaining on each treatment over the last 25 years.

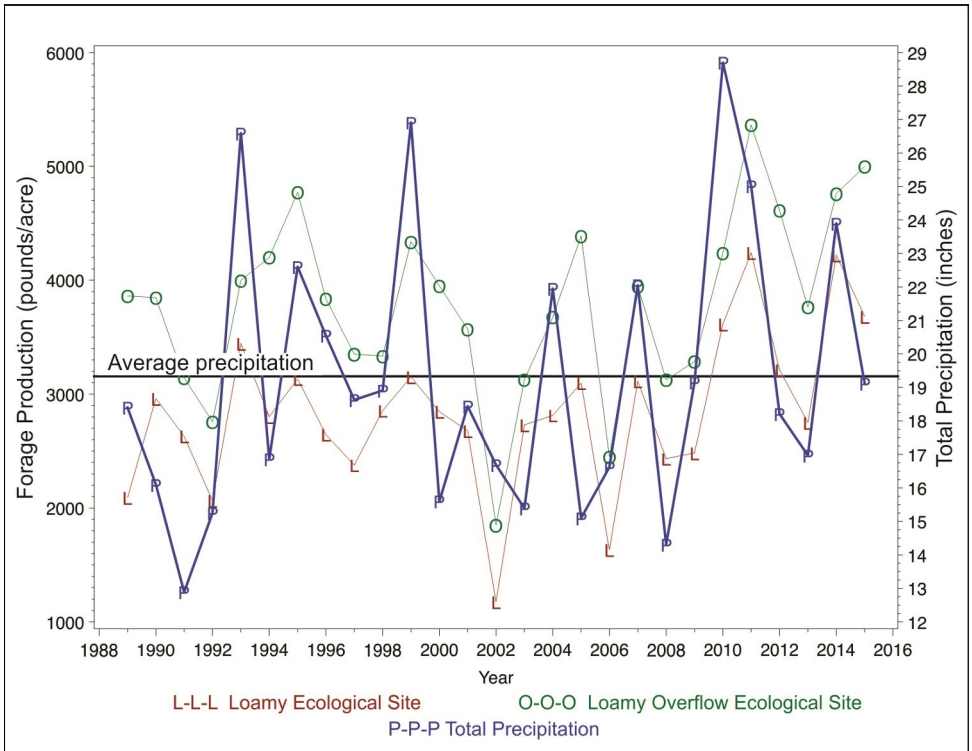


Figure 2. Total crop year precipitation (October 1 to September 30) and peak total above ground biomass production on loamy overflow and loamy ecological sites on the grazing intensity study from 1989 to 2015.

Table 2. Average above-ground biomass production by grazing treatment on **loamy** ecological sites from 1992 to 2015.

Treatment	Above-ground Biomass (lbs/acre)			
	Beginning of season	Middle of season	Peak yield	End of season
Ungrazed	1,265 b[1]	2,596 b	2,837 c	2,670 c
Light	1,340 a	2,961 a	3,400 a	3,286 a
Moderate	1,202 c	2,733 b	3,146 b	3024 b
Heavy	951 d	2,347 c	2,670 c	2,584 c
Extreme	767 e	1,995 d	2,364 d	2,304 d
LSD (0.05)	61	162	216	229

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

Table 3. Average above-ground biomass production by grazing treatment on **loamy overflow** ecological sites from 1993 to 2015.

Treatment	Above-ground Biomass (lbs/acre)			
	Beginning of season	Middle of season	Peak yield	End of season
Ungrazed	1,000 c[1]	3,394 c	3,547 c	3,076 b
Light	1,170 b	4,194 a	4,548 a	4,320 a
Moderate	1,257 a	3,843 b	4,310 ab	4,165 a
Heavy	1,231 ab	3,690 b	4,097 b	4,046 a
Extreme	837 d	2,394 d	2,833 d	2,769 c
LSD (0.05)	71	249	271	283

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

The average forage production by treatment is shown in Tables 2 and 3. On loamy ecological sites, the light grazing resulted in the highest production ($P \leq 0.05$). On loamy overflow ecological sites, no difference ($P > 0.05$) in forage production was found on light, moderate and heavy treatments in end-of-the-season forage production. The ungrazed treatment produced significantly less forage than the light treatment on the loamy ecological site and less than the light, moderate and heavy treatments on the loamy overflow ecological site ($P \leq 0.05$). The extreme grazing treatment produced the least forage ($P \leq 0.05$) on both ecological sites.

Year x treatment interactions ($P \leq 0.05$) have been found only at the beginning of the grazing season for both ecological sites. On loamy overflow ecological sites, the treatment with the most forage production at the beginning of the season was either the light, moderate or heavy treatment, depending on the year ($P \leq 0.05$). On loamy ecological sites at the beginning of the grazing season, the treatment with the highest forage production was ungrazed, light or moderate in different years, with the extreme or heavy treatments always having the lowest forage production ($P \leq 0.05$).

Plant Community Dynamics

Production by Species and Species Response

Figure 3 shows total forage production and estimates of production by species for the dominant plant species on the loamy ecological site in 2015. This includes any species estimated to exceed 10 percent of total production in 2015 on any treatment. Differences in species production due to treatment are reflected in this figure. However, the plant community changes dynamically through time due to grazing and growing conditions.

Table 4 lists the 10 most dominant plant species on the loamy ecological site as determined by average frequency of occurrence in 25- by 25-cm frames across the 28 years and five treatments. (A graph and photo of each species may be found by clicking on the scientific name.)

A total of 167 species have been found on the loamy ecological sites, and 76 have shown a response to grazing treatment based on frequency, density, basal cover or estimated production. Nine species are favored by no grazing (Table 5). Thirty-four species are favored by moderate grazing (Table 6). These are species that increase as grazing pressure increases from ungrazed to moderately grazed but decrease as grazing pressure increases from moderate to extreme. Twenty-seven species are favored by heavy grazing (Table 7). Six species are "invaders," or species that appear on the site only after heavy grazing (Table 8).

Figure 4 shows total forage production and estimates of production of dominant species on the loamy overflow ecological site in 2015. Table 9 lists the 10 most dominant plant species on the loamy overflow ecological site as determined by average frequency of occurrence in 25- by 25-cm frames across the 28 years and five treatments. Of the 179 species on the loamy overflow ecological sites, 66 have responded to grazing treatment. Six are favored by no grazing (Table 10), 22 are favored by moderate grazing (Table 11), 32 are favored by heavy grazing (Table 12) and six are "invaders" (Table 13).

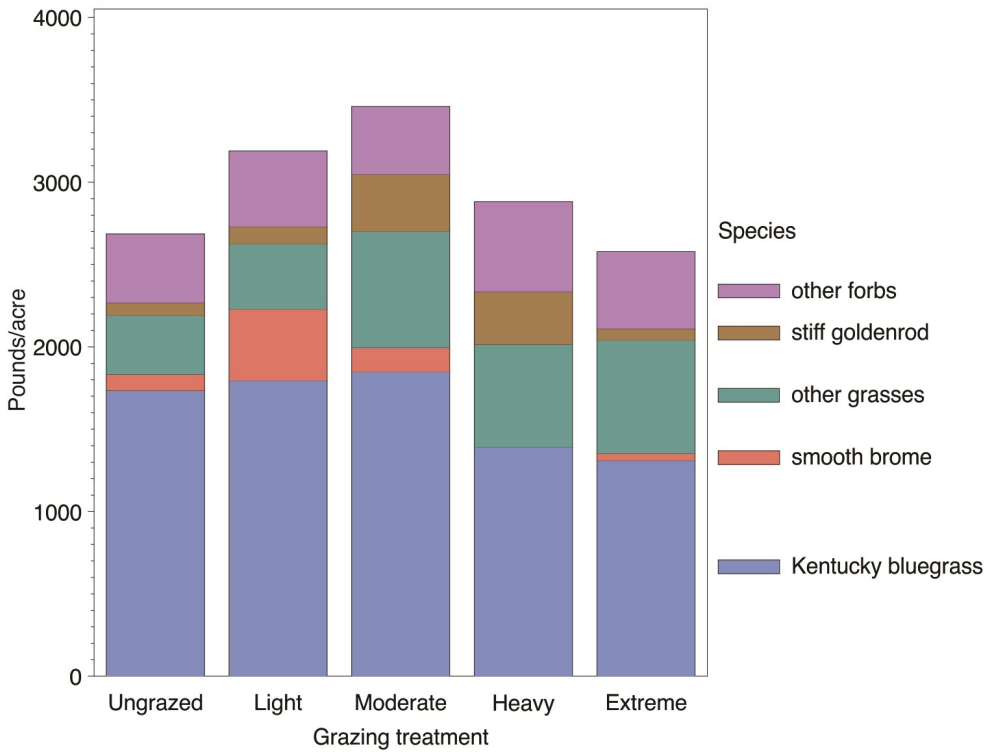


Figure 3. Total production and estimates of production of selected species and species groups on the **loamy** ecological site on the grazing intensity trial in 2015.

Table 4. The dominant plant species on the **loamy** ecological site: those with the highest average frequency of occurrence in 25- by 25-cm frames over the 28 years on the five treatments and their average frequency of occurrence in 1988 and 2015.			
Scientific name	**Common name**	**1988 average (percent)**	**2015 average (percent)**
Poa pratensis L.	Kentucky bluegrass	84	100
Pascopyrum smithii (Rydb.) A. Löve	western wheatgrass	51	74
Carex inops Bailey ssp. *heliophila* (Mackenzie) Crins	sun sedge	70	30
Symphyotrichum ericoides (L.) Nesom var. *ericoides*	heath aster	38	42
Artemisia ludoviciana Nutt.	cudweed sagewort	20	28
Nassella viridula (Trin.) Barkworth	green needlegrass	38	27
Carex obtusata Lilj.	obtuse sedge	13	31
Taraxacum officinale F.H. Wigg.	common dandelion	0	62
Achillea millefolium L.	western yarrow	4	41
Bouteloua gracilis (Willd. ex Kunth) Lag. ex Griffiths	blue grama	38	13

Table 5. Plant species which appear to have been favored by no grazing on the **loamy** ecological site.	
Scientific name	**Common name**
Poa pratensis L.	Kentucky bluegrass
Symphyotrichum ericoides (L.) Nesom var. *ericoides*	heath aster
Lotus unifoliolatus (Hook.) Benth. var. *unifoliolatus*	deer vetch
Lactuca tatarica (L.) C.A. Mey. var. *pulchella* (Pursh) Breitung	blue lettuce
Helianthus pauciflorus Nutt. ssp. *pauciflorus*	stiff sunflower
Artemisia absinthium L.	wormwood
Tragopogon dubius Scop.	goat's beard
Symphyotrichum lanceolatum (Willd.) G.L. Nesom var. *lanceolatum*	panicled aster
Pediomelum esculentum (Pursh) Rydb.	breadroot scurf-pea

Table 6. Plant species which appear to have been favored by moderate grazing on the **loamy** ecological site.	
Scientific name	**Common name**
Artemisia ludoviciana Nutt.	cudweed sagewort
Carex obtusata Lilj.	obtuse sedge
Oligoneuron rigidum (L.) Small *var. humile* (Porter) Nesom	stiff goldenrod
Ambrosia psilostachya DC.	western ragweed
Dichanthelium wilcoxianum (Vassey) Freckmann	Wilcox dichanthelium
Hesperostipa curtiseta (Hitchc.) Barkworth	western porcupine grass
Elymus repens (L.) Gould	quackgrass
Cirsium flodmanii (Rydb.) Arthur	Flodman's thistle
Ratibida columnifera (Nutt.) Woot. & Standl.	prairie coneflower
Hesperostipa comata (Trin. & Rupr.) Barkworth	needle-and-thread
Symphoricarpos occidentalis Hook.	buckbrush
Solidago mollis Bartl.	soft goldenrod
Pediomelum argophyllum (Pursh) J. Grimes	silver-leaf scurf-pea
Comandra umbellata (L.) Nutt.	comandra
Astragalus flexuosus Douglas ex G. Don	pliant milk-vetch
Elymus caninus (L.) L.	slender wheatgrass
Rosa arkansana Porter	prairie rose
Bromus inermis Leyss.	smooth brome
Artemisia dracunculus L.	green sagewort
Anemone cylindrica A. Gray	candle anemone
Carex filifolia Nutt.	thread-leaved sedge
Lithospermum incisum Lehm.	yellow puccoon
Calamagrostis montanensis Scribn. ex Vasey	plains reedgrass
Sisyrinchium montanum Greene.	blue-eyed grass
Asclepias ovalifolia Dcne.	ovalleaf milkweed
Arabis hirsuta (L.) Scop. var. *pycnocarpa* (Hopkins) Rollins	rock cress
Erysimum asperum (Nutt.) DC.	western wallflower
Heterotheca villosa (Pursh) Shinners var. *villosa*	golden aster
Solidago canadensis L.	Canada goldenrod
Physalis virginiana Mill.	Virginia groundcherry
Erysimum inconspicuum (S. Wats.) MacM.	smallflower wallflower
Orthocarpus luteus Nutt.	owl clover
Phleum pratense L.	Timothy
Polygala verticillata L.	whorled milkwort

Table 7. Plant species which appear to have been favored by heavy grazing on the **loamy** ecological site.	
Scientific name	**Common name**
Pascopyrum smithii (Rydb.) A. Löve	western wheatgrass
Carex inops Bailey ssp. *heliophila* (Mackenzie) Crins	sun sedge
Nassella viridula (Trin.) Barkworth	green needlegrass
Taraxacum officinale F.H. Wigg.	common dandelion
Achillea millefolium L.	western yarrow
Bouteloua gracilis (Willd. ex Kunth) Lag. ex Griffiths	blue grama
Artemisia frigida Willd.	fringed sagewort
Vicia americana Muhl. ex Willd.	American vetch
Grindelia squarrosa (Pursh) Dun.	curly-cup gumweed
Cerastium arvense L.	prairie chickweed
Astragalus agrestis Dougl. ex G. Don	field milk-vetch
Koeleria macrantha (Ledeb.) J.A. Schultes	Junegrass
Androsace occidentalis Pursh	western rock jasmine
Carex duriuscula C.A. Mey.	needle-leaved sedge
Oxalis stricta L.	yellow wood sorrel
Chamaesyce serpyllifolia (Pers.) Small ssp. *serpyllifolia*	thyme-leaved spurge
Hedeoma hispida Pursh	rough false pennyroyal
Plantago patagonica Jacq.	wooly plantain
Potentilla pensylvanica L.	Pennsylvania cinquefoil
Penstemon gracilis Nutt.	slender beardtongue
Geum triflorum Pursh	prairie smoke
Sphaeralcea coccinea (Pursh) Rydb.	scarlet globe mallow
Draba nemorosa L.	yellow whitlowort
Antennaria neglecta Greene	field pussy-toes
Bouteloua dactyloides (Nutt.) J.T. Columbus	buffalograss
Lepidium densiflorum Schrad.	peppergrass
Potentilla norvegica L.	Norwegian cinquefoil

Table 8. Plant species which appear only after heavy grazing on the **loamy** ecological site.	
Scientific name	**Common name**
Medicago lupulina L.	black medic
Agrostis hyemalis (Walt.) B.S.P.	ticklegrass
Melilotus officinalis (L.) Lam.	yellow sweetclover
Trifolium repens L.	white clover
Juncus interior Wieg.	inland rush
Polygonum ramosissimum Michx.	bushy knotweed

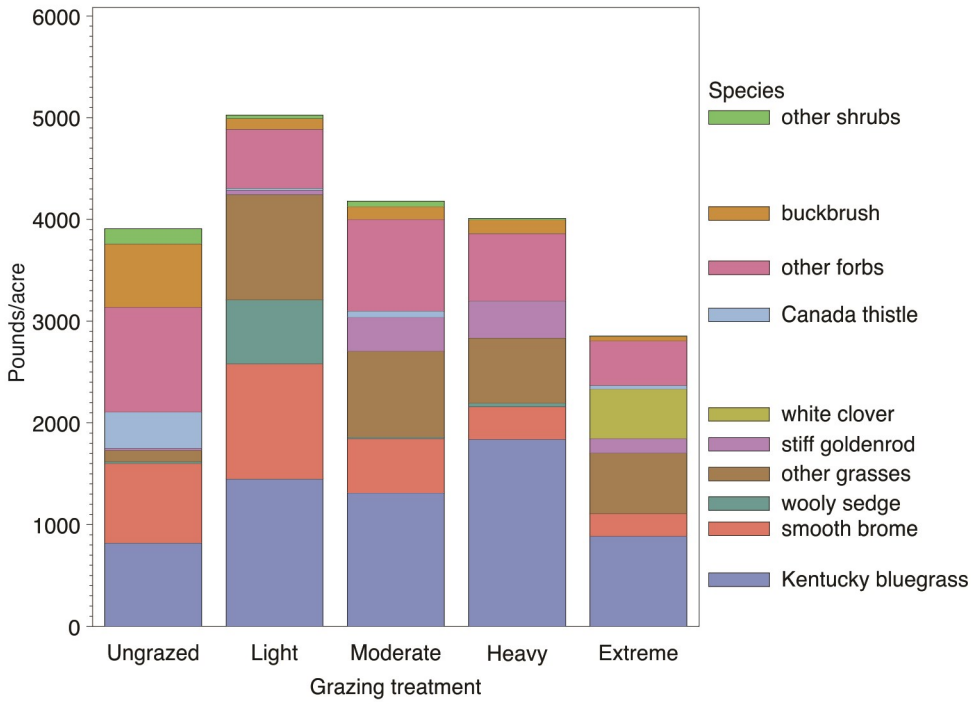


Figure 4. Total production and estimates of production of selected species and species groups on the **loamy overflow** ecological site on the grazing intensity trial in 2015.

Table 9. The dominant plant species on the **loamy overflow** ecological site: those with the highest average frequency of occurrence in 25- by 25-cm frames over the 28 years on the five treatments and their average frequency of occurrence in 1988 and 2015.

Scientific name	Common name	1988 average (percent)	2015 average (percent)
Poa pratensis L.	Kentucky bluegrass	66	96
Bromus inermis Leyss.	smooth brome	28	58
Symphoricarpos occidentalis Hook.	buckbrush	57	42
Oligoneuron rigidum (L.) Small var. *humile* (Porter) Nesom	stiff goldenrod	25	40
Symphyotrichum ericoides (L.) Nesom var. *ericoides*	heath aster	33	38
Artemisia ludoviciana Nutt.	cudweed sagewort	28	27
Carex obtusata Lilj.	obtuse sedge	20	29
Taraxacum officinale F.H. Wigg.	common dandelion	0	63
Achillea millefolium L.	western yarrow	5	38
Helianthus pauciflorus Nutt. ssp. *pauciflorus*	stiff sunflower	46	14

Table 10. Plant species which appear to have been favored by no grazing on the **loamy overflow** ecological site.	
Scientific name	**Common name**
Bromus inermis Leyss.	smooth brome
Symphoricarpos occidentalis Hook.	buckbrush
Helianthus pauciflorus Nutt. ssp. *pauciflorus*	stiff sunflower
Rosa arkansana Porter	prairie rose
Cirsium arvense (L.) Scop.	Canada thistle
Liatris ligulistylis (A. Nels.) K. Schum.	round-headed blazing star

Table 11. Plant species which appear to have been favored by moderate grazing on the **loamy overflow** ecological site.	
Scientific name	**Common name**
Oligoneuron rigidum (L.) Small var. *humile* (Porter) Nesom	stiff goldenrod
Ambrosia psilostachya DC.	western ragweed
Solidago canadensis L.	Canada goldenrod
Glycyrrhiza lepidota Pursh	wild licorice
Carex brevior (Dewey) Mack.	shortbeak sedge
Carex pellita Muhl. ex Willd.	wooly sedge
Solidago mollis Bartl.	soft goldenrod
Anemone cylindrica A. Gray	candle anemone
Spartina pectinata Bosc ex Link	prairie cordgrass
Carex praegracilis W. Boott.	clustered field sedge
Muhlenbergia racemosa (Michx.) B.S.P.	marsh muhly
Juncus arcticus Willd. ssp. *littoralis* (Engelm.) Hultén	Baltic rush
Juncus interior Wieg.	inland rush
Campanula rotundifolia L.	harebell
Helianthus maximiliani Schrad.	Maximilian sunflower
Sisyrinchium montanum Greene.	blue-eyed grass
Agrimonia striata Michx.	striate agrimony
Zizia aptera (A. Gray) Fernald	meadow zizia
Poa palustris L.	fowl bluegrass
Packera plattensis (Nutt.) W.A. Weber & A. Löve	prairie ragwort
Mentha arvensis L.	field mint
Puccinellia nuttalliana (Schult.) Hitchc.	Nuttall's alkaligrass

Table 12. Plant species which appear to have been favored by heavy grazing on the **loamy overflow** ecological site.	
Scientific name	**Common name**
Poa pratensis L.	Kentucky bluegrass
Symphyotrichum ericoides (L.) Nesom var. *ericoides*	heath aster
Artemisia ludoviciana Nutt.	cudweed sagewort
Carex obtusata Lilj.	obtuse sedge
Taraxacum officinale F.H. Wigg.	common dandelion
Achillea millefolium L.	western yarrow
Carex inops Bailey ssp. *heliophila* (Mackenzie) Crins	sun sedge
Oxalis stricta L.	yellow wood sorrel
Pascopyrum smithii (Rydb.) A. Löve	western wheatgrass
Cerastium arvense L.	prairie chickweed
Viola pedatifida G. Don	larkspur violet
Grindelia squarrosa (Pursh) Dun.	curly-cup gumweed
Elymus caninus (L.) L.	slender wheatgrass
Nassella viridula (Trin.) Barkworth	green needlegrass
Agrostis hyemalis (Walt.) B.S.P.	ticklegrass
Solidago missouriensis Nutt.	Missouri goldenrod
Androsace occidentalis Pursh	western rock jasmine
Astragalus agrestis Dougl. ex G. Don	field milk-vetch
Dichanthelium wilcoxianum (Vassey) Freckmann	Wilcox dichanthelium
Chamaesyce serpyllifolia (Pers.) Small ssp. *serpyllifolia*	thyme-leaved spurge
Conyza canadensis (L.) Cronq.	horse-weed
Pediomelum argophyllum (Pursh) J. Grimes	silver-leaf scurf-pea
Geum triflorum Pursh	prairie smoke
Antennaria neglecta Greene	field pussy-toes
Artemisia frigida Willd.	fringed sagewort
Penstemon gracilis Nutt.	slender beardtongue
Erigeron philadelphicus L.	Philadelphia fleabane
Bouteloua gracilis (Willd. ex Kunth) Lag. ex Griffiths	blue grama
Vicia americana Muhl. ex Willd.	American vetch
Erysimum inconspicuum (S. Wats.) MacM.	smallflower wallflower
Draba nemorosa L.	yellow whitlowort
Bouteloua dactyloides (Nutt.) J.T. Columbus	buffalograss

Table 13. Plant species which appear only after heavy grazing on the **loamy overflow** ecological site.	
Scientific name	**Common name**
Medicago lupulina L.	black medic
Trifolium repens L.	white clover
Polygonum ramosissimum Michx.	bushy knotweed
Lithospermum incisum Lehm.	yellow puccoon
Lepidium densiflorum Schrad.	peppergrass
Polygala alba Nutt.	white milkwort

Production by Functional Group

On loamy sites, total grass production generally has been greatest on the light treatment ($P<0.0001$); however, in some years, the ungrazed treatment was most productive. The extreme or heavy treatments always were the least productive ($P\leq0.05$) with respect to total grass production.

On loamy overflow sites, total grass production has decreased on the extreme grazing treatment ($P\leq0.05$). But the total density of non-rhizomatous grasses has increased on the extreme grazing treatment and decreased on the ungrazed treatment ($P\leq0.05$). Total shrub production has decreased during the course of the study ($P<0.001$), but it decreased most on the extreme treatment and least on the ungrazed treatment ($P\leq0.05$).

Density by Functional Group

Total forb density on loamy sites has become highest on the extreme treatment and lowest on the light and ungrazed treatments ($P\leq0.05$). Total non-rhizomatous grass density has decreased on the ungrazed and light treatments but has increased on the moderate, heavy and extreme treatments ($P\leq0.05$). Total shrub density has increased on the light treatment ($P\leq0.05$). Total plant density (including forbs, bunchgrasses and shrubs, but not rhizomatous grasses) has increased more on the extreme treatment than on the ungrazed or light treatments ($P\leq0.05$). Also, on loamy ecological sites, total plant basal cover decreased on all treatments, but it decreased less on the extreme than on the other treatments ($P\leq0.05$).

Total forb density on loamy overflow sites has increased with grazing intensity and has become greatest on the extreme treatment and least on the ungrazed ($P\leq0.05$). Total plant density also has increased with grazing intensity ($P\leq0.05$). Total plant basal cover has increased on the extreme and heavy treatments and decreased on the ungrazed and light treatments ($P\leq0.05$).

In addition to the changes listed for plant species, litter has decreased on loamy ecological sites under heavy grazing, and bare ground has increased on loamy and loamy overflow ecological sites also under heavy grazing ($P\leq0.05$).

Discussion

During the past 27 years, forage production on our loamy ecological sites has averaged 2,848 pounds/acre. If we assume that an optimum stocking rate would be 2.43 animal units per month per ton (AUM/ton) of forage, then in a year with average production, 0.29 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 0.70 acre. This emphasizes the importance of knowing how productive pastures are and being able to predict weather trends early in the grazing season.

Differences in biomass production among treatments indicate that grazing reduces the amount of carbohydrate reserves the plants are able to carry over to the next season. This was evident more on the loamy sites than the loamy overflow sites (Tables 2 and 3).

So instead of season-long grazing, we recommend a rotational grazing system at a moderate stocking rate to take advantage of higher forage quality found on the extreme grazing treatment (Patton *et al*. 2002) and still give plants a rest, thereby avoiding reduced production.

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.

This concludes this long-term study. (Editor's note: Bob Patton is retiring after conducting research at CGREC for 29 years.)

Literature Cited

Patton, B.D., P.E. Nyren, B.S. Kreft and A.C. Nyren. 2002. Grazing intensity research in the Missouri Coteau of North Dakota. North Dakota State University Central Grasslands Research Extension Center 2001 Grass and Beef Research Review, Streeter, N.D. North Dakota State University - Central Grasslands Research Extension Center. P. 12-16. Available online at www.ag.ndsu.edu/archive/streeter/2001report/Grazing_intensity_Intro.htm#TableofContents

Thurow, T.L. 1991. Hydrology and Erosion. In: Heitschmidt, R.K., and Stuth, J.W. (eds.). *Grazing Management: An Ecological Perspective*. Portland, Ore.: Timber Press. 259 pp.

Acknowledgments

We thank Dwight Schmidt, Rodney Schmidt, Rick Bohn, Cody Molle and former staff members, along with nearly 100 summer employees, who have contributed to this study during the past 27 years.

Photos by Rick Bohn, Fara Brummer and Janet Patton - CGREC