



Long-term Grazing Intensity Research in the Missouri Coteau Region of North Dakota: Effects on Plant Production and Composition - 2014

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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.

Thus far, 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, 74 responded to grazing based on estimated weight, frequency, density or basal cover. Of the 179 plant species monitored on loamy overflow ecological sites, 65 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

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.

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 (next page) presents the stocking history of the study and Figure 1 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 is made of species percentage by weight. All samples are oven-dried and weighed.



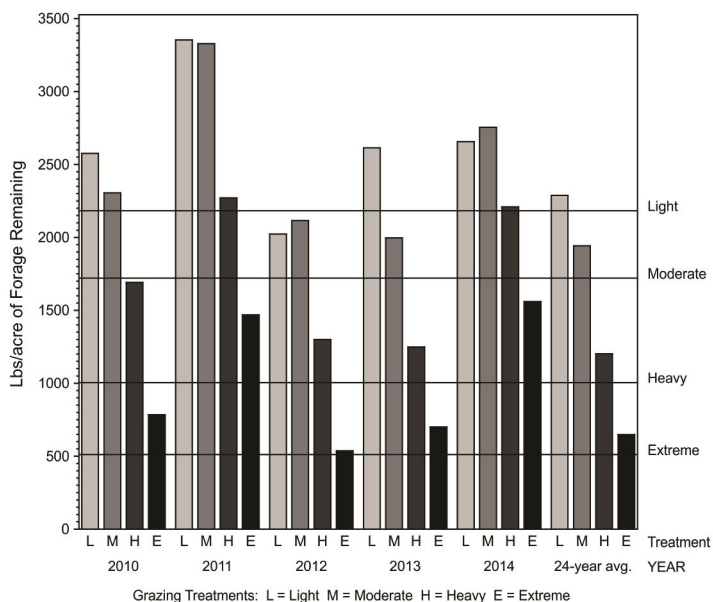


Figure 1. Forage remaining on each treatment at the end of the grazing season from 2010 to 2014 and the average forage remaining on each treatment over the last 24 years.

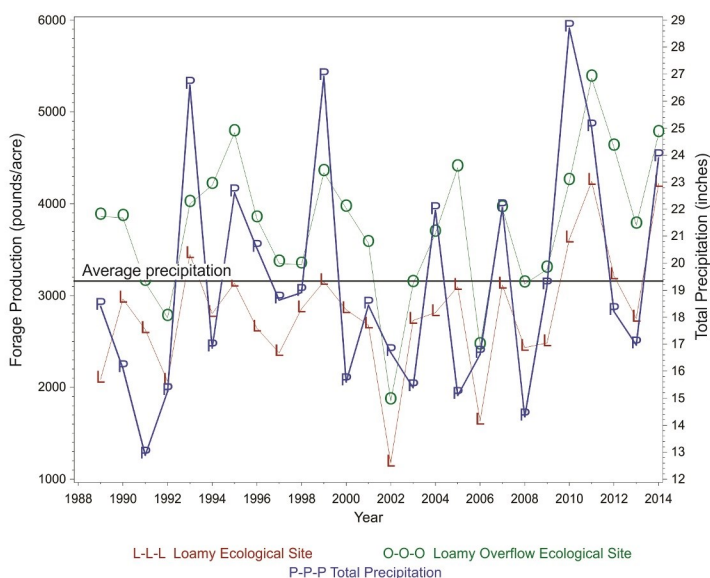


Figure 2. Total crop year precipitation (October 1 to September 30) and peak total above ground biomass production on loamy overflow and loamy ecological sites on the grazing intensity study from 1989 to 2014.

Results

Forage Production

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.

The average forage production by treatment for the past 21 years 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

Table 1. Stocking history of the grazing intensity trial for 1989 through 2014 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

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

Table 2. Average above-ground biomass production by grazing treatment on loamy ecological sites from 1992 to 2014.				
Above-ground Biomass (lbs/acre)				
Treatment	Beginning of season	Middle of season	Peak yield	End of season
Ungrazed	1,265 b ¹	2,592 b	2,844 c	2,670 c
Light	1,340 a	2,951 a	3,365 a	3,246 a
Moderate	1,202 c	2,701 b	3,094 b	2,967 b
Heavy	951 d	2,324 c	2,620 d	2,531 c
Extreme	767 e	1,970 d	2,320 e	2,258 d
LSD (0.05)	61	162	207	222
¹ Means in the same column followed by the same letter are not significantly different at $P=0.05$.				

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 light, moderate or heavy, but different treatments produced the most forage in different years ($P \leq 0.05$). 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 2014. This includes any species estimated to exceed 10 percent of total production in 2014 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 plants species on the loamy ecological site as determined by average frequency of occurrence in 25- by 25-cm frames across the 27 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 74 have shown a response to grazing

Table 3. Average above-ground biomass production by grazing treatment on loamy overflow ecological sites from 1993 to 2014.				
Above-ground Biomass (lbs/acre)				
Treatment	Beginning of season	Middle of season	Peak yield	End of season
Ungrazed	1,000 c ¹	3,371 c	3,511 c	3,049 b
Light	1,170 b	4,156 a	4,466 a	4,227 a
Moderate	1,257 a	3,827 b	4,267 ab	4,116 a
Heavy	1,231 ab	3,675 b	4,047 b	3,993 a
Extreme	837 d	2,373 d	2,788 d	2,721 c
LSD (0.05)	71	247	264	278
¹ Means in the same column followed by the same letter are not significantly different at $P=0.05$.				

treatment based on frequency, density, basal cover or estimated production. Nine species are favored by no grazing (Table 5). Thirty-three 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). Five 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 2014. 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 27 years and five treatments. Of the 179 species on the loamy overflow ecological sites, 65 have responded to grazing treatment. Six are favored by no grazing (Table 10), 23 are favored by moderate grazing (Table 11), 31 are favored by heavy grazing (Table 12) and five are “invaders” (Table 13).



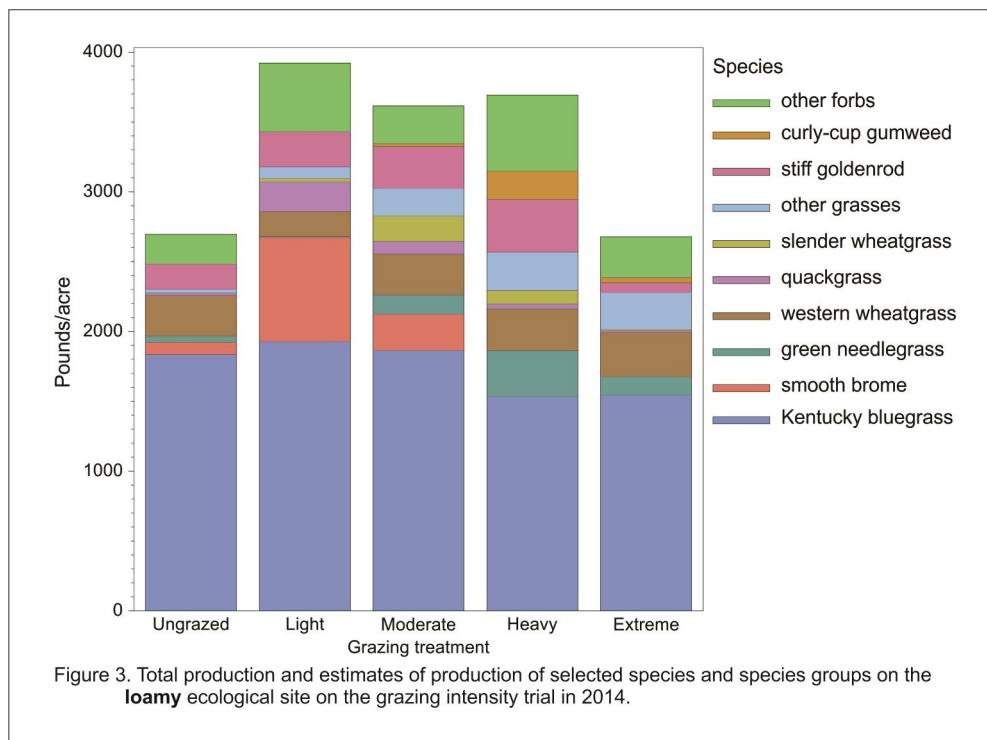


Table 4. The dominant plant species on the **loamy** ecological site: those with the highest average frequency of occurrence in 25- by 25-cm frames over the 27 years on the five treatments and their average frequency of occurrence in 1988 and 2014.

Scientific Name	Common Name	1988 Average (percent)	2014 Average (percent)
<i>Poa pratensis</i> L.	Kentucky bluegrass	84	99
<i>Pascopyrum smithii</i> (Rydb.) A. Löve	western wheatgrass	51	73
<i>Carex inops</i> Bailey ssp. <i>heliophila</i> (Mackenzie) Crins	sun sedge	70	44
<i>Symphyotrichum ericoides</i> (L.) Nesom var. <i>ericoides</i>	heath aster	38	43
<i>Artemisia ludoviciana</i> Nutt.	cudweed sagewort	20	28
<i>Nassella viridula</i> (Trin.) Barkworth	green needlegrass	38	30
<i>Carex obtusata</i> Lilj.	obtuse sedge	13	43
<i>Achillea millefolium</i> L.	western yarrow	4	41
<i>Taraxacum officinale</i> F.H. Wigg.	common dandelion	0	55
<i>Bouteloua gracilis</i> (Willd. ex Kunth) Lag. ex Griffiths	blue grama	38	16

Table 5. Plant species which appear to have been favored by no grazing on the **loamy** ecological site.

Scientific Name	Common Name
<i>Poa pratensis</i> L.	Kentucky bluegrass
<i>Symphyotrichum ericoides</i> (L.) Nesom var. <i>ericoides</i>	heath aster
<i>Lotus unifoliolatus</i> (Hook.) Benth. var. <i>unifoliolatus</i>	deer vetch
<i>Lactuca tatarica</i> (L.) C.A. Mey. var. <i>pulchella</i> (Pursh) Breitung	blue lettuce
<i>Helianthus pauciflorus</i> Nutt. ssp. <i>pauciflorus</i>	stiff sunflower
<i>Artemisia absinthium</i> L.	wormwood
<i>Tragopogon dubius</i> Scop.	goat's beard
<i>Pedimelum esculentum</i> (Pursh) Rydb.	breadroot scurf-pea
<i>Symphyotrichum lanceolatum</i> (Willd.) G.L. Nesom var. <i>lanceolatum</i>	panicled aster

Table 6. Plant species which appear to have been favored by moderate grazing on the loamy ecological site.

Scientific Name	Common Name
<i>Artemisia ludoviciana</i> Nutt.	cudweed sagewort
<i>Symphoricarpos occidentalis</i> Hook.	buckbrush
<i>Ambrosia psilostachya</i> DC.	western ragweed
<i>Dichanthelium wilcoxianum</i> (Vassey) Freckmann	Wilcox dichanthelium
<i>Hesperostipa curtiseta</i> (Hitchc.) Barkworth	western porcupine grass
<i>Cirsium flodmanii</i> (Rydb.) Arthur	Flodman's thistle
<i>Elymus repens</i> (L.) Gould	quackgrass
<i>Ratibida columnifera</i> (Nutt.) Woot. & Standl.	prairie coneflower
<i>Hesperostipa comata</i> (Trin. & Rupr.) Barkworth	needle-and-thread
<i>Pediomelum argophyllum</i> (Pursh) J. Grimes	silver-leaf scurf-pea
<i>Solidago mollis</i> Bartl.	soft goldenrod
<i>Comandra umbellata</i> (L.) Nutt.	comandra
<i>Astragalus flexuosus</i> Douglas ex G. Don	pliant milk-vetch
<i>Elymus caninus</i> (L.) L.	slender wheatgrass
<i>Rosa arkansana</i> Porter	prairie rose
<i>Bromus inermis</i> Leyss.	smooth brome
<i>Artemisia dracunculus</i> L.	green sagewort
<i>Carex filifolia</i> Nutt.	thread-leaved sedge
<i>Anemone cylindrica</i> A. Gray	candle anemone
<i>Lithospermum incisum</i> Lehm.	yellow puccoon
<i>Calamagrostis montanensis</i> Scribn. ex Vasey	plains reedgrass
<i>Sisyrinchium montanum</i> Greene.	blue-eyed grass
<i>Asclepias ovalifolia</i> Dcne.	ovalleaf milkweed
<i>Arabis hirsuta</i> (L.) Scop. var. <i>pyncocarpa</i> (Hopkins) Rollins	rock cress
<i>Erysimum asperum</i> (Nutt.) DC.	western wallflower
<i>Heterotheca villosa</i> (Pursh) Shinnars var. <i>villosa</i>	golden aster
<i>Solidago canadensis</i> L.	Canada goldenrod
<i>Potentilla norvegica</i> L.	Norwegian cinquefoil
<i>Erysimum inconspicuum</i> (S. Wats.) MacM.	smallflower wallflower
<i>Physalis virginiana</i> Mill.	Virginia groundcherry
<i>Orthocarpus luteus</i> Nutt.	owl clover
<i>Phleum pratense</i> L.	Timothy
<i>Polygala verticillata</i> 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
<i>Pascopyrum smithii</i> (Rydb.) A. Löve	western wheatgrass
<i>Carex inops</i> Bailey ssp. <i>heliophila</i> (Mackenzie) Crins	sun sedge
<i>Nassella viridula</i> (Trin.) Barkworth	green needlegrass
<i>Achillea millefolium</i> L.	western yarrow
<i>Taraxacum officinale</i> F.H. Wigg.	common dandelion
<i>Bouteloua gracilis</i> (Willd. ex Kunth) Lag. ex Griffiths	blue grama
<i>Artemisia frigida</i> Willd.	fringed sagewort
<i>Vicia americana</i> Muhl. ex Willd.	American vetch
<i>Grindelia squarrosa</i> (Pursh) Dun.	curly-cup gumweed
<i>Cerastium arvense</i> L.	prairie chickweed
<i>Astragalus agrestis</i> Dougl. ex G. Don	field milk-vetch
<i>Androsace occidentalis</i> Pursh	western rock jasmine
<i>Koeleria macrantha</i> (Ledeb.) J.A. Schultes	Junegrass
<i>Carex duriuscula</i> C.A. Mey.	needle-leaved sedge
<i>Oxalis stricta</i> L.	yellow wood sorrel
<i>Chamaesyce serpyllifolia</i> (Pers.) Small ssp. <i>serpyllifolia</i>	thyme-leaved spurge
<i>Hedeoma hispida</i> Pursh	rough false pennyroyal
<i>Plantago patagonica</i> Jacq.	wooly plantain
<i>Potentilla pensylvanica</i> L.	Pennsylvania cinquefoil
<i>Penstemon gracilis</i> Nutt.	slender beardtongue
<i>Geum triflorum</i> Pursh	prairie smoke
<i>Sphaeralcea coccinea</i> (Pursh) Rydb.	scarlet globe mallow
<i>Draba nemorosa</i> L.	yellow whitlowort
<i>Antennaria neglecta</i> Greene	field pussy-toes
<i>Bouteloua dactyloides</i> (Nutt.) J.T. Columbus	buffalograss
<i>Melilotus officinalis</i> (L.) Lam.	yellow sweetclover
<i>Lepidium densiflorum</i> Schrad.	peppergrass

Table 8. Plant species which only appear after heavy grazing on the **loamy** ecological site.

Scientific Name	Common Name
<i>Medicago lupulina</i> L.	black medic
<i>Agrostis hyemalis</i> (Walt.) B.S.P.	ticklegrass
<i>Juncus interior</i> Wieg.	inland rush
<i>Trifolium repens</i> L.	white clover
<i>Polygonum ramosissimum</i> Michx.	bushy knotweed



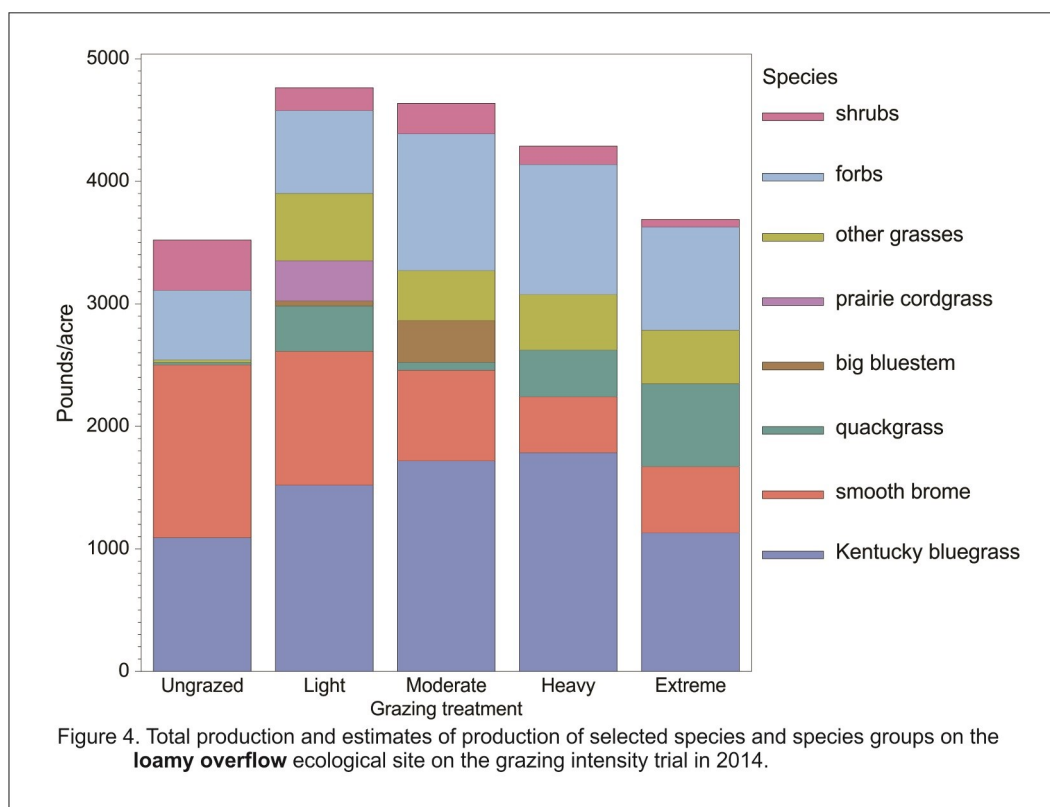


Table 9. The dominant plant species on the loamy overflow ecological site: those with the highest average frequency of occurrence in 25- by 25-cm frames over the 27 years on the five treatments and their average frequency of occurrence in 1988 and 2014.				
Scientific Name	Common Name	1988 Average (percent)	2014 Average (percent)	
<i>Poa pratensis</i> L.	Kentucky bluegrass	66	99	
<i>Bromus inermis</i> Leyss.	smooth brome	28	61	
<i>Symphoricarpos occidentalis</i> Hook.	buckbrush	57	39	
<i>Oligoneuron rigidum</i> (L.) Small var. <i>humile</i> (Porter) Nesom	stiff goldenrod	25	47	
<i>Symphyotrichum ericoides</i> (L.) Nesom var. <i>ericoides</i>	heath aster	33	37	
<i>Artemisia ludoviciana</i> Nutt.	cudweed sagewort	28	26	
<i>Carex obtusata</i> Lilj.	obtuse sedge	20	35	
<i>Achillea millefolium</i> L.	western yarrow	5	41	
<i>Taraxacum officinale</i> F.H. Wigg.	common dandelion	0	63	
<i>Helianthus pauciflorus</i> Nutt. ssp. <i>pauciflorus</i>	stiff sunflower	46	16	

Table 10. Plant species which appear to have been favored by no grazing on the **loamy overflow** ecological site.

Scientific Name	Common Name
<i>Bromus inermis</i> Leyss.	smooth brome
<i>Symphoricarpos occidentalis</i> Hook.	buckbrush
<i>Helianthus pauciflorus</i> Nutt. ssp. <i>pauciflorus</i>	stiff sunflower
<i>Rosa arkansana</i> Porter	prairie rose
<i>Sonchus arvensis</i> L.	field sow thistle
<i>Liatris ligulistylis</i> (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
<i>Poa pratensis</i> L.	Kentucky bluegrass
<i>Oligoneuron rigidum</i> (L.) Small var. <i>humile</i> (Porter) Nesom	stiff goldenrod
<i>Artemisia ludoviciana</i> Nutt.	cudweed sagewort
<i>Ambrosia psilostachya</i> DC.	western ragweed
<i>Solidago canadensis</i> L.	Canada goldenrod
<i>Glycyrrhiza lepidota</i> Pursh	wild licorice
<i>Carex brevior</i> (Dewey) Mack.	shortbeak sedge
<i>Carex pellita</i> Muhl. ex Willd.	wooly sedge
<i>Solidago mollis</i> Bartl.	soft goldenrod
<i>Anemone cylindrica</i> A. Gray	candle anemone
<i>Spartina pectinata</i> Bosc ex Link	prairie cordgrass
<i>Carex praegracilis</i> W. Boott.	clustered field sedge
<i>Muhlenbergia racemosa</i> (Michx.) B.S.P.	marsh muhly
<i>Juncus arcticus</i> Willd. ssp. <i>littoralis</i> (Engelm.) Hultén	Baltic rush
<i>Campanula rotundifolia</i> L.	harebell
<i>Helianthus maximiliani</i> Schrad.	Maximilian sunflower
<i>Sisyrinchium montanum</i> Greene.	blue-eyed grass
<i>Agrimonia striata</i> Michx.	striate agrimony
<i>Zizia aptera</i> (A. Gray) Fernald	meadow zizia
<i>Poa palustris</i> L.	fowl bluegrass
<i>Packera plattensis</i> (Nutt.) W.A. Weber & A. Löve	prairie ragwort
<i>Mentha arvensis</i> L.	field mint
<i>Puccinellia nuttalliana</i> (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
<i>Symphotrichum ericoides</i> (L.) Nesom var. <i>ericoides</i>	heath aster
<i>Carex obtusata</i> Lilj.	obtuse sedge
<i>Achillea millefolium</i> L.	western yarrow
<i>Taraxacum officinale</i> F.H. Wigg.	common dandelion
<i>Carex inops</i> Bailey ssp. <i>heliophila</i> (Mackenzie) Crins	sun sedge
<i>Oxalis stricta</i> L.	yellow wood sorrel
<i>Pascopyrum smithii</i> (Rydb.) A. Löve	western wheatgrass
<i>Cerastium arvense</i> L.	prairie chickweed
<i>Viola pedatifida</i> G. Don	larkspur violet
<i>Grindelia squarrosa</i> (Pursh) Dun.	curly-cup gumweed
<i>Elymus caninus</i> (L.) L.	slender wheatgrass
<i>Nassella viridula</i> (Trin.) Barkworth	green needlegrass
<i>Agrostis hyemalis</i> (Walt.) B.S.P.	ticklegass
<i>Solidago missouriensis</i> Nutt.	Missouri goldenrod
<i>Androsace occidentalis</i> Pursh	western rock jasmine
<i>Astragalus agrestis</i> Dougl. ex G. Don	field milk-vetch
<i>Chamaesyce serpyllifolia</i> (Pers.) Small ssp. <i>serpyllifolia</i>	thyme-leaved spurge
<i>Conyza canadensis</i> (L.) Cronq.	horse-weed
<i>Pediomelum argophyllum</i> (Pursh) J. Grimes	silver-leaf scurf-pea
<i>Geum triflorum</i> Pursh	prairie smoke
<i>Antennaria neglecta</i> Greene	field pussy-toes
<i>Artemisia frigida</i> Willd.	fringed sagewort
<i>Penstemon gracilis</i> Nutt.	slender beardtongue
<i>Erigeron philadelphicus</i> L.	Philadelphia fleabane
<i>Bouteloua gracilis</i> (Willd. ex Kunth) Lag. ex Griffiths	blue grama
<i>Juncus interior</i> Wieg.	inland rush
<i>Vicia americana</i> Muhl. ex Willd.	American vetch
<i>Erysimum inconspicuum</i> (S. Wats.) MacM.	smallflower wallflower
<i>Draba nemorosa</i> L.	yellow whitlowort
<i>Bouteloua dactyloides</i> (Nutt.) J.T. Columbus	buffalograss
<i>Polygala alba</i> Nutt.	white milkwort

Table 13. Plant species which only appear after heavy grazing on the **loamy overflow** ecological site.

Scientific Name	Common Name
<i>Medicago lupulina</i> L.	black medic
<i>Trifolium repens</i> L.	white clover
<i>Polygonum ramosissimum</i> Michx.	bushy knotweed
<i>Lithospermum incisum</i> Lehm.	yellow puccoon
<i>Lepidium densiflorum</i> Schrad.	peppergrass

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 ($P \leq 0.05$) with respect to total grass production.

On loamy overflow sites, total grass production has decreased on the extreme grazing treatment ($P \leq 0.05$). But the total density of non-rhizomatous grasses has increased on the extreme grazing treatment and decreased on the ungrazed treatment ($P \leq 0.05$). Total shrub production has decreased during the course of the study ($P < 0.0001$), but it decreased most on the extreme treatment and least on the ungrazed treatment ($P \leq 0.05$).

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 ($P \leq 0.05$). Total non-rhizomatous grass density has decreased on the ungrazed and light treatments but has increased on the moderate, heavy and extreme treatments ($P \leq 0.05$). Total shrub density has increased on the light treatment ($P \leq 0.05$). 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 ($P \leq 0.05$). 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 ($P \leq 0.05$).

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 ($P \leq 0.05$). Total plant density also has increased with grazing intensity ($P \leq 0.05$). Total plant basal cover has increased on the extreme and heavy treatments and decreased on the ungrazed and light treatments ($P \leq 0.05$).

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 ($P \leq 0.05$).

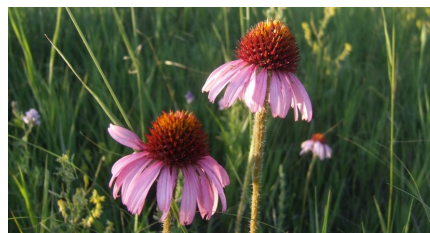
Discussion

During the past 26 years, forage production on our loamy ecological sites has averaged 2,815 pounds/acre. If we assume that an optimum stocking rate would be 2.53 animal units per month per ton (AUM/ ton) of forage, then 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.

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.



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