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

**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, moderate or 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 remains 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 166 plant species monitored on loamy ecological sites, 66 responded to grazing based on frequency, density or basal cover. Of the 177 plant species monitored on loamy overflow ecological sites, 53 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 ongoing 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 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 was determined using the paired plot cage comparison method.

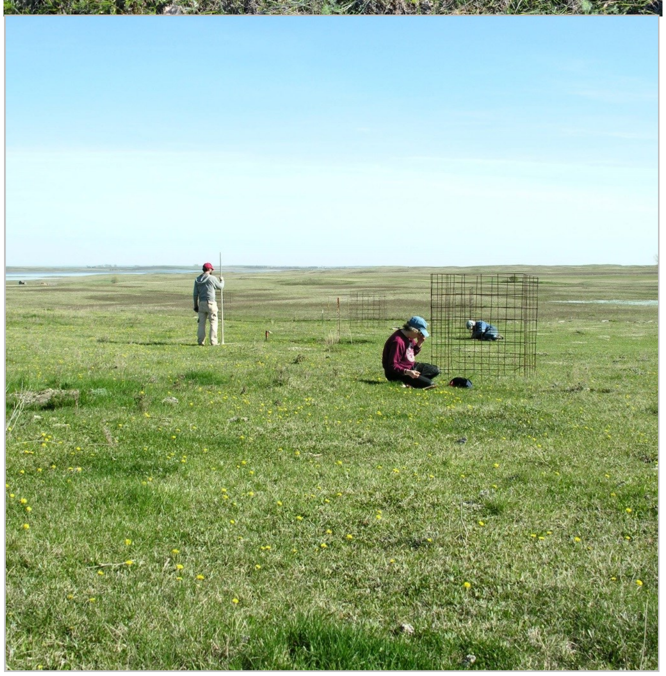

**Table 1.** Stocking history of the grazing intensity trial for 1989 through 2013 at Central Grasslands Research Extension Center, Streeter, N.D.

| 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 & 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 22 | Aug 28 | 98 |

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

## 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. Monthly precipitation for 2010 through 2013 is shown on page 48.

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 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 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 ($P \leq 0.05$).

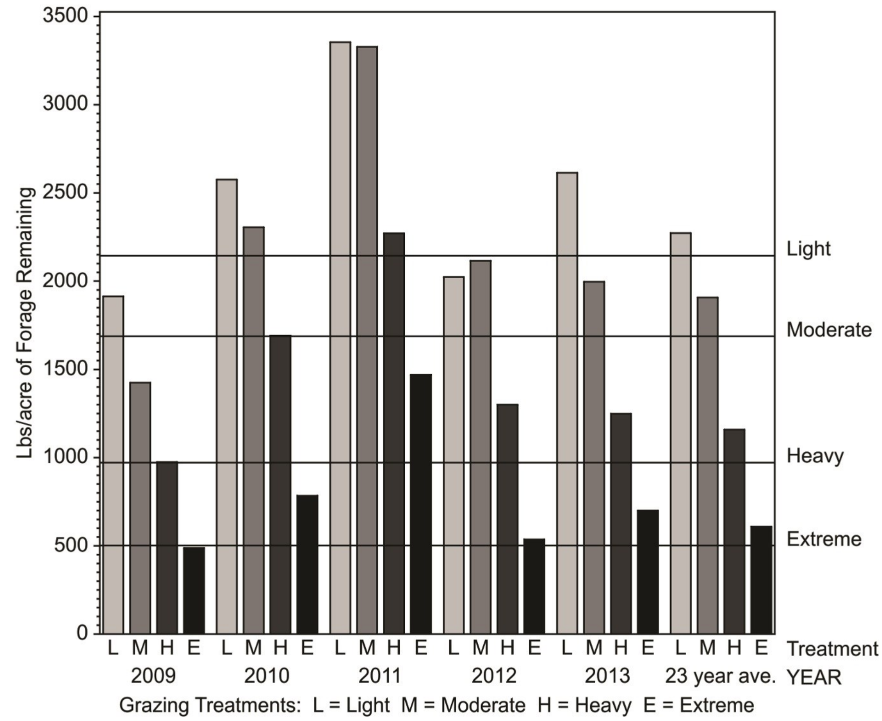


Figure 1. Forage remaining on each treatment at the end of the grazing season from 2009 to 2013 and the average forage remaining on each treatment over the last 23 years.

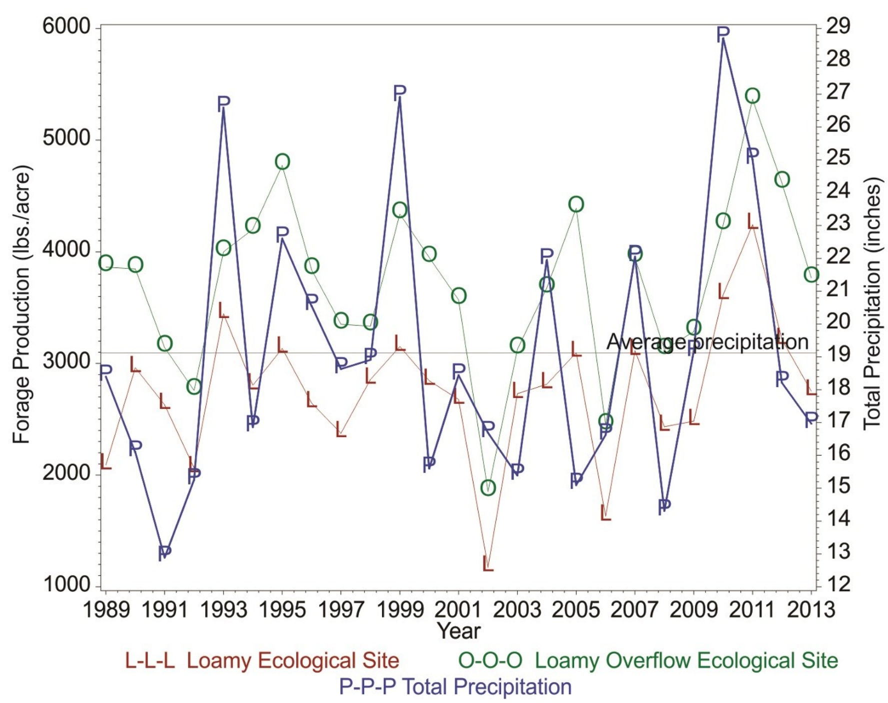


Figure 2. Total crop year precipitation (October 1 to September 30) and peak total above ground biomass production on loamy overflow and loamy ecological sites on the grazing intensity study from 1989 to 2013.

**Table 2.** Average above ground biomass production by grazing treatment on **loamy** ecological sites from 1992 to 2013.

| Treatment | Above-ground biomass (lbs/acre) Beginning of season | Middle of season | Peak yield | End of season |
|---|---|---|---|---|
| Ungrazed | 1,273 b[1] | 2,587 b | 2,829 b | 2,649 c |
| Light | 1,352 a | 2,906 a | 3,297 a | 3,172 a |
| Moderate | 1,201 c | 2,659 b | 3,019 b | 2,886 b |
| Heavy | 938 d | 2,261 c | 2,510 c | 2,416 d |
| Extreme | 751 e | 1,938 d | 2,278 d | 2,213 d |
| LSD (0.05) | 61 | 166 | 205 | 221 |

[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 2013.

| Treatment | Above-ground biomass (lbs/acre) Beginning of season | Middle of season | Peak yield | End of season |
|---|---|---|---|---|
| Ungrazed | 1,005 b[1] | 3,364 c | 3,511 c | 3,050 b |
| Light | 1,177 a | 4,127 a | 4,407 a | 4,156 a |
| Moderate | 1,249 a | 3,789 b | 4,226 ab | 4,067 a |
| Heavy | 1,219 a | 3,646 b | 4,009 b | 3,952 a |
| Extreme | 819 c | 2,310 d | 2,703 d | 2,633 c |
| LSD (0.05) | 74 | 255 | 269 | 284 |

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

*Plant community dynamics*. 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-centimeter (cm) frames across the 26 years and five treatments.

A total of 166 species have been found on the loamy ecological sites and 63 have shown a response to grazing treatment based on frequency, density or basal cover. Eight species are favored by no grazing (Table 5). Twenty-six 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).

Table 9 lists the 10 most dominant plants species on the loamy overflow ecological site as determined by average frequency of occurrence in 25- by 25-cm frames across the 26 years and five treatments. Of the 177 species on the loamy overflow ecological sites, 53 have responded to grazing treatment. Six are favored by no grazing (Table 10), 16 by moderate grazing (Table 11), 26 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 cm by 25 cm frames over the 26 years on the five treatments and their average frequency of occurrence in 1988 and 2013.

| Scientific name | Common name | 1988 average (percent) | 2013 average (percent) |
|---|---|---|---|
| *Poa pratensis* L. | Kentucky bluegrass | 84 | 98 |
| *Pascopyrum smithii* (Rydb.) A. Löve | western wheatgrass | 51 | 69 |
| *Carex inops* Bailey ssp. *heliophila* (Mackenzie) Crins | sun sedge | 70 | 40 |
| *Symphyotrichum ericoides* (L.) Nesom var. *ericoides* | heath aster | 38 | 45 |
| *Artemisia ludoviciana* Nutt. | cudweed sagewort | 20 | 33 |
| *Nassella viridula* (Trin.) Barkworth | green needlegrass | 38 | 29 |
| *Carex obtusata* Lilj. | obtuse sedge | 13 | 37 |
| *Achillea millefolium* L. | western yarrow | 4 | 45 |
| *Taraxacum officinale* F.H. Wigg. | common dandelion | 0 | 49 |
| *Bouteloua gracilis* (H.B.K.) Lag. ex Griffiths | blue grama | 38 | 19 |

**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 |
| *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 | goat's beard |
| *Pediomelum esculentum* (Pursh) Rydb. | breadroot scurf-pea |
| *Symphyotrichum lanceolatum* (Willd.) G.L. Nesom ssp. *lanceolatum* var. *lanceolatum* | panicled aster |

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

| Scientific name | Common name |
|---|---|
| *Symphyotrichum ericoides* (L.) Nesom var. *ericoides* | heath aster |
| *Artemisia ludoviciana* Nutt. | cudweed sagewort |
| *Ambrosia psilostachya* DC. | western ragweed |
| *Dichanthelium wilcoxianum* (Vassey) Freckmann | Wilcox dichanthelium |
| *Hesperostipa curtiseta* (Hitchc.) Barkworth | western porcupine grass |
| *Cirsium flodmanii* (Rydb.) Arthur | Flodman's thistle |
| *Elymus repens* (L.) Gould | quackgrass |
| *Ratibida columnifera* (Nutt.) Woot. & Standl. | prairie coneflower |
| *Pediomelum argophyllum* (Pursh) J. Grimes | silver-leaf scurf-pea |
| *Solidago mollis* Bartl. | soft goldenrod |
| *Comandra umbellata* (L.) Nutt. | comandra |
| *Rosa arkansana* Porter | prairie rose |
| *Bromus inermis* Leyss. | smooth brome |
| *Artemisia dracunculus* L. | green sagewort |
| *Carex filifolia* Nutt. | thread-leaved sedge |
| *Anemone cylindrica* A. Gray | candle anemone |
| *Lithospermum incisum* Lehm. | yellow puccoon |
| *Calamagrostis montanensis* (Scribn.) Scribn. | 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 |
| *Physalis virginiana* Mill. | Virginia groundcherry |
| *Erysimum inconspicuum* (S. Wats.) MacM. | smallflower wallflower |
| *Orthocarpus luteus* Nutt. | owl clover |

**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 |
| *Achillea millefolium* L. | western yarrow |
| *Taraxacum officinale* F.H. Wigg. | common dandelion |
| *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 only appear after heavy grazing on the **loamy** ecological site.

| **Scientific name** | **Common name** |
|---|---|
| *Medicago lupulina* L. | black medic |
| *Agrostis hyemalis* (Walt.) B.S.P. | ticklegrass |
| *Juncus interior* Wieg. | inland rush |
| *Trifolium repens* L. | white clover |
| *Polygonum ramosissimum* 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 cm by 25 cm frames over the 26 years on the five treatments, and their average frequency of occurrence in 1988 and 2013.

| Scientific name | Common name | 1988 average (percent) | 2013 average (percent) |
|---|---|---|---|
| *Poa pratensis* L. | Kentucky bluegrass | 66 | 97 |
| *Bromus inermis* Leyss. | smooth brome | 28 | 64 |
| *Symphoricarpos occidentalis* Hook. | buckbrush | 57 | 39 |
| *Oligoneuron rigidum* (L.) Small var. *humile* (Porter) Nesom | stiff goldenrod | 25 | 48 |
| *Symphyotrichum ericoides* (L.) Nesom var. *ericoides* | heath aster | 33 | 38 |
| *Artemisia ludoviciana* Nutt. | cudweed sagewort | 28 | 30 |
| *Carex obtusata* Lilj. | obtuse sedge | 20 | 26 |
| *Helianthus pauciflorus* Nutt. ssp. *pauciflorus* | stiff sunflower | 46 | 18 |
| *Achillea millefolium* L. | western yarrow | 5 | 38 |
| *Taraxacum officinale* F.H. Wigg. | common dandelion | 0 | 50 |

**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 |
| *Sonchus arvensis* L. | field sow 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 |
| *Solidago mollis* Bartl. | soft goldenrod |
| *Carex pellita* Muhl. ex Willd. | wooly sedge |
| *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 |
| *Campanula rotundifolia* L. | harebell |
| *Sisyrinchium montanum* Greene. | blue-eyed grass |
| *Agrimonia striata* Michx. | striate agrimony |
| *Poa palustris* L. | fowl bluegrass |
| *Packera plattensis* (Nutt.) W.A. Weber & A. Löve | prairie ragwort |

**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 |
| *Achillea millefolium* L. | western yarrow |
| *Taraxacum officinale* F.H. Wigg. | common dandelion |
| *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 hyemali*s (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 |
| *Chamaesyce serpyllifolia* (Pers.) Small ssp. *serpyllifolia* | thyme-leaved spurge |
| *Conyza canadensis* (L.) Cronq. | horse-weed |
| *Geum triflorum* Pursh | prairie smoke |
| *Artemisia frigida* Willd. | fringed sagewort |
| *Erigeron philadelphicus* L. | Philadelphia fleabane |
| *Penstemon gracilis* Nutt. | slender beardtongue |
| *Erysimum inconspicuum* (S. Wats.) MacM. | smallflower wallflower |
| *Draba nemorosa* L. | yellow whitlowort |

**Table 13.** Plant species which only appear 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 |

On loamy sites, total forb density has become highest on the extreme treatment and lowest on the light and ungrazed treatments ($P \leq 0.05$). 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 ($P \leq 0.05$).

From 1994 to 2001, total grass density decreased on the ungrazed and light treatments and has not recovered on those treatments, while a steady increase has occurred in grass density on the moderate, heavy and extreme 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 ($P \leq 0.05$). On loamy overflow sites, 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 forb density 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 under heavy grazing ($P \leq 0.05$).

## Discussion

During the past 24 years, forage production on our loamy ecological sites has averaged 2,759 pounds/acre. In a year with average production, 0.34 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 0.22 acre to requiring 0.79 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.

We plan to continue this research for a number of years because changes in forage production and plant species composition still are apparent in response to grazing intensity and weather. These factors, in turn, will affect animal response to the grazing treatments.

## Literature Cited


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