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Effects of short duration and high-intensity, low-frequency grazing systems on forage production and composition

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Abstract

Research was conducted at the Sonora Research Station during a 4-year period (1984 to 1988) to measure differences in herbaceous vegetation response between two 7-pasture 1-herd grazing systems. Grazing tactics were short duration (SDG-7 days graze, 42 days rest) and high intensity, low frequency (HILF-14days graze, 84 days rest). Stocking rate for the 2 treatments was 10.4 ha/auy. Total aboveground net primary production (ANPP) varied significantly among years but not between grazing treatments. Significant, divergent shifts in composition did occur over the 4 years as a function of grazing treatment. Shortgrass production in the SDG pastures increased from 45% of the total ANPP for year 1 to 74% for year 4. Shortgrass ANPP in the HILF pastures comprised 44% of the total herbaceous production for year 1 and 51% for year 4. Midgrass ANPP in SDG pastures comprised 3.8% of the herbaceous production for year 1 and 13.6% for year 4. Midgrass production in the HILF pastures represented 4.7% for year 1 and 33.9% for year 4. Our data indicate the SDG system did not promote secondary succession from shortgrasses to midgrasses as effectively as did the HILF system.

Key Words: vegetation change, standing crop, primary production

Grazing systems are a specialization of grazing management which defines systematically recurring periods of grazing and deferment for 2 or more pastures or management units (Soc. for Range Manage. 1989). Developmental research on several systems was initiated at the Sonora Research Station in 1939. The basic impetus underlying this research was to assess their effectiveness in reducing sheep death losses to poisonous plants. Modification of the early systems eventually led to the development of the Merrill [4 pastures, 3 herds, 12 month graze, 4 month rest] grazing system in 1949 (Merrill 1954). Subsequent research has documented the benefits of the Merrill grazing system to both livestock and vegetation (Kothmann and Mathis 1970; Kothmann et al. 1971, 1978; Reardon and Merrill 1976; Taylor et al. 1980; Taylor 1989). Multipasture, 1-herd grazing system research was initiated at the Sonora Research Station in 1970. The initial design consisted of 7 equal-sized pastures and 1 herd of livestock, with 21 day graze and 126 day rest periods. Livestock movement was based on a calendar date and stocking rate was set to achieve moderate use. The 2 dominant successional mid-grasses, (sideoats grama [*Bouteloua curtipendula* (Michx) Torr.] and Texas cupgrass [*Eriochloa sericea* (Scheele) Munro] responded favorably to the grazing system, but livestock performance was reduced, especially at heavier stocking rates and during periods of limited plant growth (Taylor et al. 1980). About 7 years after this high-intensity, low-frequency (HILF) type grazing system was established, grazing and rest periods were reduced to 7 and 42-days, respectively (i.e., short-duration grazing system (SDG)). It appeared that midgrasses decreased and shortgrasses increased under SDG grazing but it was uncertain as to whether this was grazing system or year effects.

Previous studies on the Sonora Research Station (Merrill and Young 1959), reported that clipping commonly curly mesquite-grass [*Hilaria Belangeri* (Steud.)Nash] at 4-week intervals produced higher forage yields than other less frequent clipping treatments. Commonly curlymesquite, a stoloniferous shortgrass, is often the dominant grass on Edwards Plateau rangeland in the lower range condition classes. It is very competitive and can prevent the establishment of midgrasses (Smeins 1988). This study tested the hypothesis that longer rest (and grazing) periods of a HILF system would result in greater forage production and be more effective in promoting secondary succession from shortgrasses to midgrasses than an SDG system.

Methods

Study Area

The study was conducted on the 1,377-ha Sonora Research Station located (31° N; 100° W) on the southern edge of the Edwards Plateau resource region. Elevation is about 640 m. The average growing season is about 240 days (from March through October). Long-term average annual precipitation (1918–1988) is 60.9 cm. Peak precipitation months are May, June, and September. Growing season precipitation averaged 40.9 cm over 70 years. Growing season precipitation totaled 43.3, 45.3, 49.5, and 52.4 cm for the years 1985, 1986, 1987, and 1988, respectively. Growing season precipitation totaled 26.6 cm in 1983 and 15.2 cm in 1984 (Fig. 1).

The predominant soils at the station are Tarrant silty clay and Tarrant stony clay (members of the clayey-skeletal, montmorillonitic, thermic family of Lethic Haplustalls), with some Kavett silty clay soils in the low-lying areas. These soils overlay a fractured limestone substrate. Vegetation is a complex mixture of grasses, forbs, and woody species. Dominant midgrasses are sideoats grama, cane bluestem [*Bothriochloa barbinodis* (Lag.) Herter], Texas cupgrass and Wright threeawn (*Aristida wrightii* Nash). The dominant cool-season grass is Texas wintergrass (*Stipa leucotricha* Trin. & rupr.). Dominant shortgrasses are common curlymesquite, red grama (*Bouteloua trifida* Thurb.), hairy tridens [*Erioneuron pilosum* (Buckl.)Nash] and hair grama (*Bouteloua hirsuta* Lag). Dominant woody species are live oak [*Quercus fusiformis* (Small) Sarg], juniper (*Juniperus* spp.), Mexican persimmon (*Diospyros texana* Scheele) and honey mesquite (*Prosopis glandulosa* Torr. var *glandulosa).* For a complete description of the

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climate, soils, and vegetation at the research station see Smeins et al. (1976).

Treatment and Sample Plots

The study site was the 7 HILF (1970–77) and SDG (1977–80) pastures (32.4 ha/pasture) discussed earlier. In 1980 the 7 pastures were subdivided into 14 pastures of 16.2 ha each. The 14 pastures were managed as a 1-herd SDG system until 1984 when two 7-pasture, 1-herd grazing systems (SDG and HILF) were initiated. The graze/rest periods for the SDG treatment were 7 and 42 days, compared to 14 and 84 days for the HILF treatment. Each treatment was grazed with a combination of heifers, ewes, and nannies at a ratio of 1:1:1 animal unit equivalents. Stocking rate for the 2 treatments was 10.4 ha/auy for the 4-year study.

One Low Stony Hill and 1 Valley range site within each of 2 paired pastures per grazing treatment were selected for study. Valley sites are characterized by Kavett silty clay soils with slopes <1% overlying a fractured caliche layer and limestone substratum. Low Stony Hill sites are characterized by Tarrant soil series consisting of very shallow soils derived from limestone with slopes from 1 to 5%.

Vegetation Sampling

Herbage standing crops were estimated throughout each growing season. Immediately prior to each grazing event, 5 sets of three 1-m^2 paired quadrats were randomly located within each range site for each of the 4 pastures. The first quadrat in each set was located randomly and the remaining 2 quadrats were located near the first in areas with similar standing crop and composition. Quadrats to be clipped prior to and after grazing and to be caged and clipped after grazing were randomly selected. Vegetation was harvested to ground-level and separated into 6 forage categories: warm-season midgrasses (e.g., sideoats grama, cane bluestem, and Texas cupgrass); warm-season shortgrasses (red grama, hairy tridens, hair grama, and curly mesquite); cool-season grasses (Texas wintergrass); threeawns (*Aristida* spp.); annual grasses and forbs. Following drying (60° C) and weighing, live/dead and leaf/stem ratios were estimated by scattering subsamples of each forage category over a 30 × 60-cm board with permanently marked transect lines and recording intercepts as either live or dead or leaf or stem. The mulch remaining in quadrats after clipping was collected with a vacuum cleaner, sifted through a mesh screen to reduce soil contamination, then oven-dried and weighed.

Aboveground net primary production (ANPP) was calculated by forage class by summing the incremental increases in the live component or the sum of both live and dead components (Wiegert and Evans 1964, Heitschmidt et al. 1982). Live/dead and leaf/stem ratios were determined only on the grass component of the vegetation and for the first 3 years of the study.

Data Summarization and Statistical Analyses

Total and individual forage class standing crop estimates were subjected to analyses of variance utilizing a split block model (Hicks 1973). Main effects were grazing system (fixed), site (fixed), and year (random). Pastures within grazing systems were considered replications (random). Grazing system and site were whole plots with year as the split plot. The error term for testing significant effects of grazing system (GS) was pastures (P) within grazing system plus year (Y) × grazing system – year × site (S) × pasture within grazing system (i.e., error term = P(GS) + Y*GS – Y*S*P(GS). Error term used for testing site was S*P(GS) + Y*S – Y*S*P(GS). Error term used for testing year effect was Y*P(GS). Residual was used to test for Y*S, Y*GS, Y*P(GS), and S*P(GS). Duncan's multiple range test was used for mean separations where appropriate (Steel and Torrie 1960). Percent live/dead data were transformed using the square root, arcsine procedure (SAS 1985).

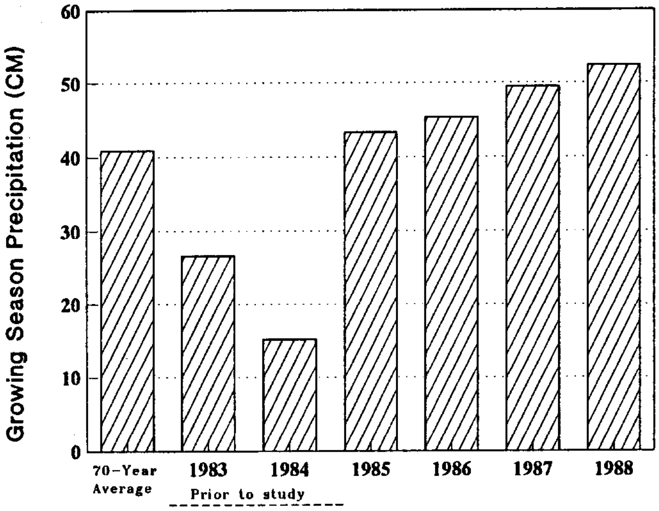

Fig. 1. Precipitation (March through September) for a 70-year average, 1 and 2 years prior to and 4 years of the actual study.

Results and Discussion

ANPP

These data show that total ANPP (grass and forbs) increased for both grazing treatments during the 4-year study. This increase was relatively uniform and was the result of above-average precipitation during the 4 growing seasons. Below-average growing season precipitation during the 2 years preceding this study along with previous heavy stocking had severely reduced the standing crop of herbaceous vegetation. Once favorable precipitation returned, the vegetation responsed with increases in production from both grazing systems.

Total ANPP (grass and forbs) varied significantly among years (P=0.05) but not between grazing systems (Table 1). Total ANPP ranged from 231 g/m^2 in 1987 to 103 g/m^2 in 1985. Total ANPP averaged 163 g/m^2 for the SDG treatment and 154 g/m^2 for the HILF (P=0.50). Total ANPP of grasses also varied significantly among years (P=0.05) ranging from 169 g/m^2 in 1988 to 59 g/m^2 in 1985. Total grass production averaged 128 g/m^2 for the SDG compared to 122 g/m^2 for the HILF (P=0.67); thus, the hypothesis that grazing system would increase ANPP was rejected.

Table 1. Annual growing season (March–October) aboveground net primary production (ANPP) from species/species groups by years and treatments.

Species/	Years				Treatments	
Species groups	1985	1986	1987	1988	SDG[1]	HILF[2]
	g/m^2					
Grass + Forbs	103^{c3}	125^{c}	231^{a}	177^{b}	163^{a}	154^{a}
Grass	59^{c}	118^{b}	154^{a}	169^{a}	128^{a}	122^{a}
Forbs	44^{a}	7^{b}	76^{a}	8^{b}	36^{a}	32^{a}
Midgrass	4^{b}	6^{b}	27^{ab}	43^{a}	8^{a}	32^{a}
Shortgrass	45^{b}	106^{a}	100^{a}	109^{a}	109^{a}	71^{b}
TWG[4]	6^{ab}	2^{ab}	19^{a}	12^{ab}	5^{a}	15^{a}
3-awn	3^{ab}	4^{ab}	9^{a}	6ab	6^{a}	5^{a}
Litter	17^{c}	38^{c}	68^{b}	105^{a}	53^{a}	73^{a}

[1]SDG (Short duration grazing)
[2]HILF (High-intensity, low-frequency)
[3]means of species/species groups within rows by years and within rows by treatments not followed by the same letter differ significantly ($P<0.05$).
[4]TWG (Texas Wintergrass).

Total ANPP was greater for the deep range site 208 g/m^2 com-

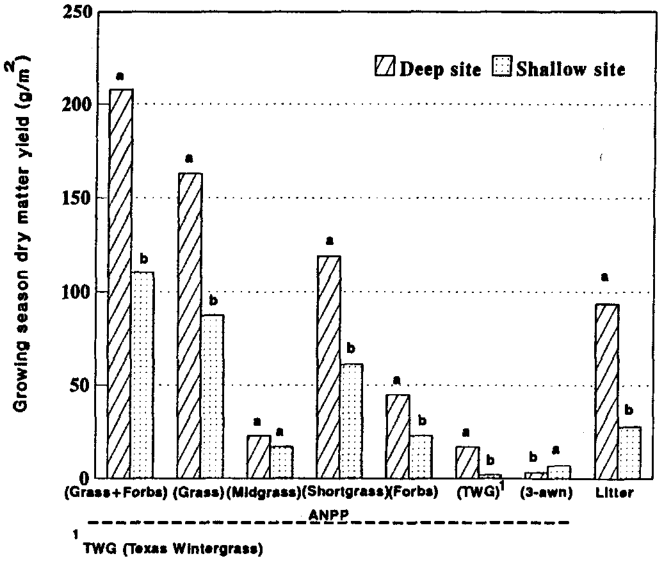

Fig. 2. Growing season (March–October) aboveground net primary production (ANPP) from species/species groups from different range sites. Values with different letters within species/species groups differ significantly at p=0.05 according to Duncan's multiple range test.20

pared to 111 g/m² for the shallow range site (P=0.04). Grass production averaged 163 and 88 g/m² for the deep and shallow sites, respectively (P=0.05). Midgrass production was not significantly different between sites (Fig. 2) but varied significantly among years (Fig. 3), from 4.3 g/m² in 1985 to 43 g/m² in 1988. Production of shortgrasses, forbs, and Texas wintergrass production was significantly greater from the deep sites compared to the shallow sites (Fig. 3); however, three-awn production was greater

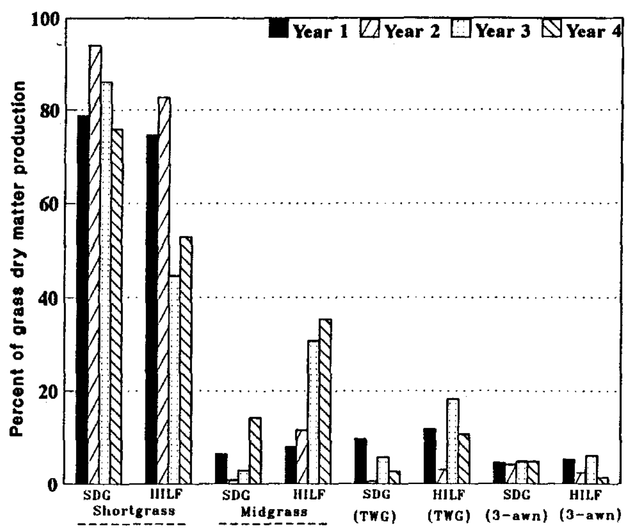

Fig. 3. Aboveground net primary production (percent of total grass production) from grass species/grass species groups.

on the shallow sites. Forb production was influenced by fall and winter precipitation and varied significantly among years (P=0.01) from 7 g/m² in 1986 to 76 g/m² in 1987 (Table 1). Forb production was similar for the 2 grazing systems (P=0.85).

Warm-season perennial shortgrass production was significantly greater (P=0.05) for the SDG system (109 g/m²) compared to the HILF system (71 g/m²). Warm-season perennial midgrass production averaged 32 g/m² for the HILF treatment compared to 8 g/m² for the SDG treatment but these means could not be compared due to a significant (P=0.05) pasture within grazing system interaction.

The significant pasture within system effect for the midgrass analysis occurred because one of the pastures in the HILF system did not respond with a major increase in production from the midgrass component. For year 1 warm-season midgrass production in the HILF system represented 5.2 and 6.2% of the total herbaceous vegetation for pastures 2 and 4, respectively, and 7.5 and 6.8% for pastures 1 and 3 in the SDG system, respectively. For year 4 warm-season midgrass production represented 9.6 and 45.9% of total vegetation production for HILF pastures 2 and 4 and 3.1 and 16.8% for SDG pastures 1 and 3, respectively. Pasture 2 (HILF) and pasture 1 (SDG) had been equal parts of 1 pasture for over 75 years prior to the initiation of this study. Pasture 3 (SDG) and pasture 4 (HILF) had originally been 1 pasture for approximately the same period of time. Because of past differences in grazing treatments, pastures 3 and 4 were in better range condition at the start of this study and the vegetation was able to respond to the current grazing treatments faster than vegetation in pastures 1 and 2.

Percent composition of herbaceous vegetation in the SDG system changed to a greater dominance of shortgrasses over the 4-year study while composition of grasses in the HILF system changed to a greater dominance of midgrasses. Shortgrass production in the SDG pastures represented 45% of the total herbaceous production in 1985 and 74% in 1988. Shortgrass production in the HILF pastures represented 44% of the total herbaceous production in 1985 and 51% in 1988. Midgrass production in the SDG pastures represented 3.8% of the herbaceous production for 1985 and 13.6% for 1988. Midgrass production in the HILF pastures represented 4.7% for 1985 and 33.9% for 1988.

Previous research on the Sonora Research Station revealed that midgrass cover was maintained under a moderately stocked HILF grazing strategy but declined under heavily stocked SDG grazing (Thurow et al. 1988). Midgrass composition was also reduced at moderate stocking rates under SDG grazing (Ralphs et al. 1990).

Litter was highly variable among years (P=0.02). Litter ranged from 17 g/m² in 1985 to 38, 68, and 105 g/m² for 1986, 1987, and 1988, respectively. Litter averaged 94 g/m² for the deep site and 28 g/m² for the shallow site (P=0.16). Litter in the HILF system (73 g/m²) and in the SDG system (53 g/m²) were not significantly different.

Harvest efficiency for this study averaged 22% for both grazing systems based on estimated animal demand and growing season forage production, well within the range of moderate stocking. A moderate stocking rate is that level when 25% of the current vegetation production is consumed by grazing animals (Kothmann 1984).

Percent Live/Dead-Leaf/Stem

Total grass live leaf, dead leaf, live stem, and dead stem averaged 36, 40, 10, and 14%, respectively, for the 3-year period. SDG pastures had (P=0.03) more live grass leaf than HILF (P=0.03), but there was no difference in percentages of dead leaves. Total leaf percentage (live+dead) was greater (P=0.08) for the SDG than HILF system. Total percentage of stems was significantly greater for HILF than (P=0.08) SDG pastures.

Sod grasses from HILF had greater (P=0.11) amounts of dead leaf and dead stems than sod grasses from the SDG system. Midgrass live leaf (38%) and total leaf (76%) was greater (P=0.04) from SDG than from HILF system (33 and 72%, respectively). Percent dead leaf was similar for both grazing systems (P=0.72). Percent live stem, dead stem and total stem were greater (P=0.16, P=0.07, and P=0.04, respectively) for midgrasses in the HILF system than the SDG system.

Conclusions

Dynamics of midgrass production from the HILF system resulted from 2 major influences: (1) The favorable growing season precipitation for each year of the study; and (2) the long rest periods.

Midgrasses in the SDG system had proportionally more total leaves and fewer stems than midgrasses in the HILF system. Apparently the shorter rest period of the SDG system allowed a more frequent harvest of the midgrasses, thus maintaining them in a more vegetative than reproductive state.

SDG systems may not improve range condition (Pitts and Bryant 1987, Skovlin 1987) and may even be detrimental to midgrasses. Ralphs et al. (1990), documented a significant decrease in midgrass production in a grazing system with 3-day grazing and 50-day rest periods at both moderate and heavy stocking rates.

Palatable species that are not abundant (i.e., midgrasses for this study) may receive excessive use and therefore may require longer rest periods than shortgrasses to recover. Optimum length rest periods for common curlymesquite in the SDG system may have enhanced the competitive ability of shortgrasses at the expense of midgrass production.

Management Implications

Expectations of rapidly improving deteriorated rangeland using SDG grazing tactics is a false perception for Edwards Plateau rangeland. Regeneration of preferred species is a slow process due to the presence of competing vegetation, and influenced by precipitation, soil type, intensity, and frequency of grazing, and length of deferment.

Grazing systems implemented on rangelands have generally been designed to improve or maintain range condition. Certain criteria must be met before grazing systems can accomplish this goal. Two important criteria are: (1) Grazing cycles (i.e., HILF with at least 80–90 days of rest) should be implemented during the major part of the growing season (approximately mid-April through September for the Edwards Plateau); (2) Moderate rates of stocking should not be exceeded (i.e., forage harvested by grazing animals should not exceed 25% of current forage growth).

Literature Cited

Heitschmidt, R.K., D.L. Price, R.A. Gordon, and J.R. Frasure. 1982. Short duration grazing at the Experimental Ranch: Effects on aboveground net primary production and seasonal growth dynamics. J. Range Manage. 35:367–372.

Heitschmidt, R.K., and C.A. Taylor, Jr. 1991. Livestock Production. *In:* R.K. Hietschmidt and J.W. Stuth. Grazing management: An ecological perspective. Timber Press.

Hicks, C.R. 1973. Fundamental concepts in the design of experiments. Holt, Rinehart and Winston, New York, N.Y.

Kothmann, M.M., G.W. Mathis, and W.J. Waldrip. 1971. Cow-calf response to stocking rates and grazing systems on native range. J. Range Manage. 24:100–105.

Kothmann, M.M, W.J. Waldrip, and G.W. Mathis. 1978. Rangeland vegetation of the Texas Rolling Plains: Response to grazing management and weather. p. 606–609. *In:* Proc. 1st Int. Rangeland Congress.

Kothmann, M.M. 1984. Concepts and principles underlying grazing systems: A discussant paper. *In:* Developing strategies for rangeland management. Res. Counc./Nat. Acad. Sci. Westview Press, Boulder, Colo.

Merrill, L.B. 1954. A variation of deferred rotation grazing for use under Southwest range conditions. J. Range Manage. 7:152–154.

Merrill, L.B., and V.A. Young. 1959. Response of curly mesquite to height and frequency of clipping. Bull. MP-331. Tex. Agr. Exp. Sta., College Station.

Pitts, J.S., and F.C. Bryant. 1987. Steer and vegetation response to short duration and continuous grazing. J. Range Manage. 40:386–389.

Ralphs, M.H., M.M. Kothmann, and C.A. Taylor, Jr. 1990. Vegetation responses to increased stocking rates in short-duration grazing. J. Range Manage. 43:104–108.

Reardon, P.O., and L.B. Merrill. 1976. Vegetative response under various grazing management systems in the Edwards Plateau of Texas. J. Range Manage. 29:195–198.

SAS Institute Inc. 1985. SAS users: Statistics, version 5 edition. SAS Institute, Inc. Cary, N.C.

Skovlin, J. 1987. Southern Africa's experience with intensive short duration grazing. Rangelands 4:162–167.

Smeins, F.E., T.W. Taylor, and L.B. Merrill. 1976. Vegetation of a 25-year old exclosure on the Edwards Plateau, Texas. J. Range Manage. 29:24–29.

Smeins, F.E. 1988. Range improvement: When does it happen? Tex. Agr. Exp. Sta. Tech. Rep. 88-1. Sonora.

Society for Range Management. 1989. A glossary of terms used in range management. Edison Press. Denver, Colo.

Taylor, C.A., Jr., M.M. Kothmann, L.B. Merrill, and D. Elledge. 1980. Diet selection by cattle under high-intensity, low frequency, short-duration, and Merrill grazing systems. J. Range Manage. 33:428–434.

Taylor, C.A., Jr. 1989. Short-duration grazing: Experiences from the Edwards Plateau region in Texas. J. Soil Water Conserv. 44:297–302.

Thurow, T.L., W.H. Blackburn, and C.A. Taylor, Jr. 1988. Some vegetation responses to selected livestock grazing strategies. Edwards Plateau, Texas. J. Range Manage. 41:108–114.

Wiegert, R., and F.C. Evans. 1964. Primary production and the disappearance of dead vegetation on an old field. Ecology 45:49–63.1