Technical Report No. 131

COMPARISONS OF ABOVEGROUND PLANT BIOMASS ON UNGRAZED PASTURES VS. PASTURES GRAZED BY LARGE HERBIVORES, 1970 SEASON

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ABSTRACT

This report presents a comparison of floral composition (live above-ground biomass) between different grazing treatments at nine U.S. IBP Grassland Biome research sites. A similarity index developed by Shannon and Weaver (1949) is used to compare ungrazed pastures to those grazed by large herbivores based on data collected in 1970 at the nine sites. The data indicate that the proportional plant species composition is relatively unaltered by grazing at three of the sites while at five of the sites it is altered significantly. One site is intermediate to the two groups mentioned above.

DISCUSSION

This report presents a comparison of floral composition (live aboveground biomass) between different grazing treatments at nine U.S. IBP Grassland Biome research sites. Only within-site comparisons are covered in this report; for between-site comparisons, the reader is referred to Technical Report No. 83 (Grant 1971).

One of the major factors known to affect plant composition on grasslands that can be regulated by man is the grazing impact of domestic livestock. Quantitative knowledge of the effect of different intensities of grazing on the relative abundance of plant species is a prerequisite to effective decision-making to obtain maximum secondary productivity (via cattle, sheep, bison, antelope, deer, etc.) on a given land area. It follows that one of the major classification schemes by which U.S. IBP Grassland Biome studies have been categorized is based on the different grazing pressures to which the various study areas have been exposed.

Tables 1 through 9 contain data on the percent composition (oven-dry weight) by species of live aboveground biomass collected at the various research sites on the dates indicated [the rationale behind the selection of these dates is explained in Technical Report No. 83 (Grant 1971)]. The data were collected and compiled separately for the different grazing intensities. An information equation derived from Shannon and Weaver (1949) as described by Horn (1966) was used to compare the different grazing treatments within each site. The equation is written below:

$$R_o = \frac{\Sigma(x_i + y_i) \ln (x_i + y_i) - \Sigma x_i \ln x_i - \Sigma y_i \ln y_i}{(X + Y) \ln (X + Y) - X \ln X - Y \ln Y}$$

Table 1. Pawnee--July 16, 1970 collection date.

Species[a/]	Grazing Intensity			
	Ungrazed	Heavily Grazed	Moderately Grazed	Lightly Grazed
AGSM	.013	.000	.005	.012
ARFR	.023	.000	.022	.145
ARLO	.047	.004	.080	.138
ASTA	.000	.000	.000	.001
ASTR	.000	.002	.000	.002
ATAR	.010	.000	.000	.000
ATCA	.004	.000	.008	.000
BAOP	.033	.000	.012	.005
BOGR	.511	.488	.380	.303
BUDA	.033	.025	.033	.000
CAFI	.001	.001	.000	.005
CHLE	.000	.001	.000	.000
CHNA	.014	.000	.001	.014
CIUN	.000	.004	.000	.000
CRYP	.000	.001	.000	.000
ERBE	.003	.000	.000	.000
EREF	.000	.007	.000	.021
FEOC	.001	.008	.002	.001
GACO	.001	.001	.000	.002
GILA	.000	.000	.001	.000
GUSA	.010	.000	.001	.005
HASP	.001	.000	.000	.000
HYFI	.000	.000	.000	.001
LEDE	.000	.002	.000	.001
MAVI	.002	.000	.014	.002
MILI	.001	.001	.000	.000
MUTO	.004	.000	.085	.010
OECO	.001	.001	.003	.018
OPPO	.214	.400	.248	.228
ORLU	.001	.000	.000	.001
PEAL	.000	.003	.000	.000
PLPU	.000	.001	.001	.000
PSTE	.005	.000	.000	.013
SCBR	.004	.000	.000	.000
SCPA	.000	.005	.000	.000
SETR	.000	.003	.000	.000
SIHY	.005	.000	.000	.002
SPCO	.015	.014	.015	.022
SPCR	.000	.004	.029	.026
THME	.001	.000	.000	.002
THTR	.000	.000	.000	.006
TOGR	.001	.000	.000	.000
TROC	.000	.000	.000	.001

[a/] Species names are abbreviated for ease of data processing in the computer. Appendix I contains a list of all species names and their abbreviations.

Table 2. Cottonwood--July 6, 1970 collection date.

Species	Grazing Intensity	
	Ungrazed	Heavily Grazed
AGSM	.425	.033
ARFR	.011	.000
ARLU	.001	.000
BOGR	.133	.153
BRJA	.094	.006
BUDA	.206	.700
CAEL	.058	.026
FMUL	.000	.002
OPFR	.005	.070
PSCU	.002	.000
SPCO	.049	.010
STVI	.017	.000

Table 3. Bison--May 30, 1970 collection date.

Species	Grazing Intensity	
	Ungrazed	Heavily Grazed
ACMI	.025	.102
AGSP	.002	.190
ANMA	.005	.000
ANRO	.000	.024
ARFU	.051	.046
BRTE	.010	.000
CASU	.000	.018
CRAC	.000	.002
ERI	.000	.001
FESC	.633	.019
FFID	.041	.209
GETR	.007	.000
HIAL	.008	.000
KOCR	.000	.064
LIRU	.046	.000
LUSE	.142	.240
MINU	.028	.060
ZIPA	.003	.025

Table 4. Bridger--July 20, 1970 collection date.

Species	Grazing Intensity	
	Ungrazed	Heavily Grazed
ACMI	.027	.053
AGGL	.016	.006
AGSU	.225	.092
ARCO	.050	.047
CEAR	.040	.043
DAIN	.052	.117
ERSP	.029	.006
FEID	.340	.389
KOCR	.031	.026
LUAR	.189	.221

Table 5. Dickinson--June 22, 1970 collection date.

Species	Grazing Intensity	
	Ungrazed	Heavily Grazed
AGSM	.169	.033
AGTR	.003	.000
ALTE	.005	.000
ARLU	.120	.000
ASER	.005	.011
ASST	.059	.000
BOGR	.067	.228
CAFL	.048	.092
CALO	.050	.000
CAMO	.000	.127
CIUN	.006	.000
COLI	.005	.000
FEID	.000	.005
GACO	.005	.000
KOCR	.037	.034
LAPU	.002	.000
LIPU	.000	.013
SEDE	.007	.294
SPCO	.006	.000
STCO	.317	.163
TRDU	.082	.000
VINU	.007	.000

Table 6. Hays--June 16, 1970 collection date.

Species	Grazing Intensity	
	Ungrazed	Heavily Grazed
AGSM	.000	.017
AMCA	.033	.000
AMPS	.002	.016
ANGE	.266	.264
ANSC	.245	.000
ARLO	.000	.010
ARPU	.001	.000
ASAR	.000	.013
ASMU	.007	.011
ASOB	.003	.004
BOCU	.079	.208
BOGR	.000	.061
BRJA	.000	.015
BUDA	.000	.112
CIUN	.008	.000
ECAN	.017	.003
ERRA	.000	.004
GACU	.001	.000
GRSQ	.000	.001
GUSA	.000	.010
HOAN	.001	.000
LIPU	.000	.005
MACO	.000	.001
MEOF	.001	.000
OESE	.023	.004
PAVI	.030	.000
PEPU	.001	.000
PSCU	.000	.003
PSTE	.115	.143
RACO	.000	.005
SCRE	.002	.000
SCUN	.032	.003
SEUN	.005	.000
SOMI	.007	.005
SOMO	.001	.000
SONU	.065	.000
SORI	.037	.000
SPAS	.004	.000
SPPI	.007	.000
TEST	.006	.000
THGR	.001	.001

Table 7. Jornada--July 30, 1970 collection date.

Species	Grazing Intensity	
	Ungrazed	Heavily Grazed
ALIN	.000	.002
APRA	.000	.003
APSP	.000	.010
BAAB	.000	.002
BOER	.544	.065
CABA	.002	.008
CHIN	.006	.008
CRCO	.000	.017
CRCR	.004	.015
ERAB	.005	.004
ERPU	.001	.034
GUSA	.194	.556
GUSP	.000	.001
HELI	.001	.000
KRSC	.000	.002
KRSE	.000	.002
LIAU	.001	.000
NAHI	.000	.012
OIWI	.002	.000
PRJU	.000	.015
SAKA	.015	.130
SOEL	.000	.001
SPFL	.068	.115
YUEL	.154	.000

Table 8. Osage--July 16, 1970 collection date.

Species	Grazing Intensity	
	Ungrazed	Heavily Grazed
AMPS	.002	.000
ANGE	.000	.002
ANSC	.680	.339
FORB A	.082	.015
FORB B	.000	.002
FORB C	.031	.006
PAVI	.029	.239
POPR	.000	.010
SEDG A	.014	.003
SEDG B	.000	.003
SONU	.133	.113
SPAS	.030	.269

Table 9. Pantex--July 13, 1970 collection date.

Species	Grazing Intensity		
	Recently Ungrazed	Long-Term Ungrazed	Heavily Grazed
BOGR	.118	.402	.567
BUDA	.001	.012	.024
MAVI	.001	.000	.000
OPU	.878	.563	.403
RAT	.001	.019	.000
SPCO	.000	.000	.005

where x_i and y_i represent the proportions of the samples x and y composed of species i. When data are expressed as proportions, as is the case in these calculations, the denominator becomes the constant 1.3863 (= 2 ln 2). The value of R_o can vary from 0 to 1, with a value of 1 representing complete similarity with respect to proportional species composition by weight and a value of 0 representing completely distinct floral assemblages (no plant species in common).

A word about what is meant by *heavy grazing*, *moderate grazing*, *light grazing*, and *ungrazed* is in order. At Pawnee Site, data were collected on four different grazing treatments defined as follows (Don Jameson, personal communication): (i) ungrazed pasture--ungrazed by cattle for at least 30 years; (ii) lightly grazed--500 lb. per acre aboveground plant biomass (live and standing dead) remaining at the end of the grazing season; (iii) moderately grazed--400 lb. per acre aboveground plant biomass; (iv) heavily grazed--300 lb. per acre aboveground plant biomass. At the Comprehensive Network Sites, with the exception of Cottonwood, grazing intensities are not so clearly defined. The usual manner of expressing grazing pressure is in terms of animal-days grazed per year. For Cottonwood, a detailed record of grazing intensities on the various pastures is available for the past 29 years (Lewis 1970). But such records at the other network sites seem to be lacking.

The similarity values presented in Table 10 measure the extent to which the grazing pressure that was applied to a given grazing treatment at a particular research site affected the plant composition in that grazing treatment. It is assumed that what is called *heavy grazing*, *light grazing*, etc., is constant, even if quantitatively undefined, throughout the season

Table 10. R_o values comparing different grazing intensities within each site, based on species distribution of live aboveground plant biomass at one sampling period in 1970.

Site	Grazing Intensity	R_o Value
Pawnee	Ungrazed (treatment 1) vs. moderately grazed (treatment 3)	.90
	Ungrazed (treatment 1) vs. heavily grazed (treatment 4)	.88
	Moderately grazed (treatment 3) vs. lightly grazed (treatment 2)	.86
	Ungrazed (treatment 1) vs. lightly grazed (treatment 2)	.85
	Heavily grazed (treatment 4) vs. moderately grazed (treatment 3)	.85
	Heavily grazed (treatment 4) vs. lightly grazed (treatment 2)	.76
Pantex	Long-term ungrazed (treatment 1) vs. heavily grazed (treatment 3)	.96
	Recently ungrazed (treatment 5) vs. long-term ungrazed (treatment 1)	.90
	Recently ungrazed (treatment 5) vs. heavily grazed (treatment 3)	.81
Bridger	Ungrazed (treatment 1, 4 ft snow fence) vs. heavily grazed (treatment 3)	.96
Osage	Ungrazed (treatment 1) vs. heavily grazed (treatment 5)	.77
Cottonwood	Ungrazed (treatment 1) vs. heavily grazed (treatment 5)	.66
Jornada	Ungrazed (treatment 1) vs. heavily grazed (treatment 5)	.61
Hays	Ungrazed (treatment 1) vs. heavily grazed (treatment 5)	.56
Dickinson	Ungrazed (treatment 1) vs. heavily grazed (treatment 4)	.54
Bison	Ungrazed (treatment 1) vs. heavily grazed (treatment 2)	.47

and throughout the site so that all data within a site are comparable. This assumption cannot be extended to comparisons between sites. It is quite likely that a pasture at one site that is exposed to *heavy grazing* is grazed at a different intensity than is a pasture exposed to *heavy grazing* at another site. The point to be made is that there are too many unknowns to be able to state with any certainty what effect the same intensity of grazing has on the plant communities at two different sites in terms of changes in species composition. Ideally, the values in Table 10 would be comparable between sites and provide a measure of how a quantitatively defined intensity of grazing affects different grassland communities. Although it is impossible to make such quantitative comparisons, it is obvious from the similarity values (Table 10) that the floral response to grazing is qualitatively dissimilar at the different sites. Grazing by large herbivores appears to have no significant effect on the proportional plant species composition at Pawnee, Pantex, and Bridger (relatively high R_o values indicating similar plant species composition on the different grazing treatments), while at Bison, Dickinson, Hays, Jornada, and Cottonwood, grazing by large herbivores significantly alters the proportional plant species composition (relatively low R_o values indicating dissimilar plant species composition on grazed vs. ungrazed pastures). Osage, with an R_o value of .77, seems to be intermediate between the two groups mentioned above.

There is one further fact to be considered when comparing the R_o values of Table 10 with those presented in Table 3 of Technical Report No. 83. The between-site comparisons represented by the R_o values in Table 3 of Technical Report No. 83 were calculated by lumping together all grasses belonging to

the same tribe, all forbs belonging to the same family, and then lumping all sedges and all shrubs together as two additional groups. The R_o values in this report (Table 10) were calculated using individual species; no lumping was done. Thus, the failure of species in a single tribe or family to respond similarly to grazing (that is, to be eaten in similar quantities and then to regrow at similar rates) would add another source of error when comparing between-site to within-site R_o values.

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APPENDIX I

This appendix contains a list of all plant species whose four-letter computer codes appear in Table 1 through 9.

ACMI *Achillea millefolia* (L.)
AGGL *Agoseris glauca* (Pursh)
AGSM *Agropyron smithii* (Rydb.)
AGSP *Agropyron spicatum* (Pursh)
AGSU *Agropyron subsecundum* (Link)
AGTR *Agropyron trachycaulum* (Link)
ALDR *Allium drummondi* (Regel)
ALTE *Allium textile* (Nels.)
AMCA *Amorpha canescens* (Pursh)
AMPS *Ambrosia psilostachya* (T. + G.)
ANGE *Andropogon gerardi* (Vitman.)
ANMA *Anaphalis margaritacea* (L.)
ANRO *Antennaria rosea* (D. C. Eat.)
ANSC *Andropogon scoparius* (Michx.)
ARCO *Arenaria congesta* (Nutt.)
ARFR *Artemisia frigida* (Willd.)
ARFU *Arnica fulgens* (Pursh)
ARLO *Aristida longesita* (Steud.)
ARLU *Artemisia ludoviciana* (Nutt.)
ARPU *Aristida purpurea* (Nutt.)
ASAR *Aster arenosus* (Blake)
ASER *Aster ericoides* (L.)
ASFE *Aster fendleri* (Gray)
ASMU *Aster multiflorus* (Ait.)
ASOB *Aster oblongifolius* (Gray)
ASST *Astragalus striatus* (Nutt.)
ASTA *Aster tanecetifolius* (H.B.K.)
ASVI *Asclepias viridiflora* (Raf.)
ATAR *Atriplex argentea* (Nutt.)
ATCA *Atriplex canescens* (Pursh)

BAOP *Bahia oppositifolia* (Nutt.)
BOCU *Bouteloua curtipendula* (Michx.)
BOER *Bouteloua eriopoda* (Torr.)
BOGR *Bouteloua gracilis* (H.B.K.)
BRJA *Bromus japonicus* (Thunb.)
BRTE *Bromus tectorum* (L.)
BUDA *Buchloe dactyloides* (Nutt.)

CABA *Cassia bauhinoides* (Michx.)
CAEL *Carex elynoides* (Holm)
CAFI *Carex filifolia* (Nutt.)
CAHE *Carex heliophila* (Mack.)
CALO *Calamovilfa longifolia* (Hook.)
CAMO *Calamogrostis montanensis* (Scribn.)

CASU *Castilleja sulphurea* (Rydb.)

CEAR *Cerastium arvense* (L.)

CHLE *Chenopodium leptophyllum* (Nutt.)

CHNA *Chrysothamnus nauseosus* (Pallas)

CHVI *Chrysopsis villosa* (Pursh)

CIUN *Cirsium undulatum* (Nutt.)

COLI *Collomia linearis* (Nutt.)

CRCO *Croton corymbulosus* (Klotzsch)

DAIN *Danthonia intermedia* (Vasey.)

DIWI *Dithyrea wislizeni* (Engelm.)

DOCO *Dodecatheon conjugens* (Rybd.)

ECAN *Echinacea angustifolia* (D.C.)

ERAB *Eriogonum abertianum* (Nutt.)

ERBE *Erigeron bellidiastrum* (Nutt.)

ERIO *Eriogonum* spp. (Michx.)

ERPU *Erioneuron pulchellum* (Nash.)

ERSP *Erigeron speciosus* (Lindl.)

FEID *Festuca idahoensis* (Elmer.)

FEOC *Festuca octoflora* (Walt.)

FESC *Festuca scabrella* (Torr.)

FRPU *Fritillaria pudica* (Pursh)

GACO *Gaura coccinea* (Nutt.)

GETR *Geum triflorum* (Pursh)

GUSA *Gutierrezia sarothrae* (Pursh)

HASP *Haplopappus spinulosus* (Greene)

HECY *Heuchera cylindrica* (Nutt.)

HEPE *Helianthus petiolaris* (Nutt.)

HIAL *Hieracium albiflorum* (Hook.)

KOCR *Koeleria cristata* (L.)

LAPU *Lactuca pulchella* (Pursh)

LARE *Lappula redowskii* (Hornem.)

LASE *Lactuca serriola* (L.)

LEDE *Lepidium densiflorum* (Schrad.)

LIAU *Linum australe* (Heller)

LIPU *Liatris punctata* (Hook.)

LIRU *Lithospermum ruderale* (Dougl.)

LOAM *Lotus americanus* (Nutt.)

LUAR *Lupinus argenteus* (Pursh)

LUSE *Lupinus sericeus* (Nutt.)

MAVI *Mammillaria vivipara* (Nutt.)

MEOF *Melilotus officinalis* (L.)

MILI *Mirabilis linearis* (Pursh)

MINU *Microseris nutans* (Pursh)

MUTO *Muhlenbergia torreyi* (Knuth)

OECO *Oenothera coronopifolia* (T. + G.)

OENU *Oenothera nuttallii* (Sweet)

OESE *Oenothera serrulata* (Nutt.)

OPFR *Opuntia fragilis* (Nutt.)

OPPU, OPU *Opuntia polyacantha* (Haw.)

ORLU *Orobanche ludoviciana* (Nutt.)

PAVI *Panicium virgatum* (L.)

PEPU *Petalostemon purpureus* (Rydb.)

PLPU *Plantago purshii* (Roem.)

POPR *Poa pratensis* (L.)

PSCU *Psoralea cuspidata* (Pursh)

PSES *Psoralea esculenta* (Pursh)

PSTE *Psoralea tenuiflorum* (Pursh)

RAT *Ratibida columnaris* (Sims.)

SAKA *Salsola kali* (L.)

SARH *Saxifraga rhomboidea* (Greene)

SCBR *Scutellaria brittonii* (Porter)

SCRE *Scutellaria resinosa* (L.)

SCUN *Schrankia unicata* (Willd.)

SECR *Senecio crocatus* (Rybd.)

SEDE *Selaginella densa* (Rybd.)

SEPL *Senecio plattensis* (Nutt.)

SEUN *Senecio uintahensis* (A. Nels.)

SIHY *Sitanion hystrix* (Nutt.)

SOMI *Solidago missouriensis* (Nutt.)

SOMO *Solidago mollis* (Bartl.)

SONU *Sorghastrum nutans* (L.)

SORI *Solidago rigida* (L.)

SPAS *Sporobolus asper* (Michx.)

SPCO *Sphaeralcea coccinea* (Pursh)

SPFL *Sporobolus flexuosus* (Thurb.)

SPPI *Sporobolus pilosus* (Vasey.)

STCO *Stipa comata* (Trin.)

STIL *Stenosiphon linifolium* (Nutt.)

STVI *Stipa viridula* (Trin.)

TEST *Tetraneuris stenophylla* (Rybd.)

THGR *Thelesperma gracile* (Torr.)

THME *Thelesperma megapotamicum* (Spreng.)

TOGR *Townsendia grandiflora* (Nutt.)

TRDU *Tragopogon dubius* (Scop.)

VINU *Viola nuttallii* (Pursh)

YUEL *Yucca elata* (Nutt.)

YUGL *Yucca glauca* (Nutt.)

ZIPA *Zigadenus paniculatus* (Nutt.)