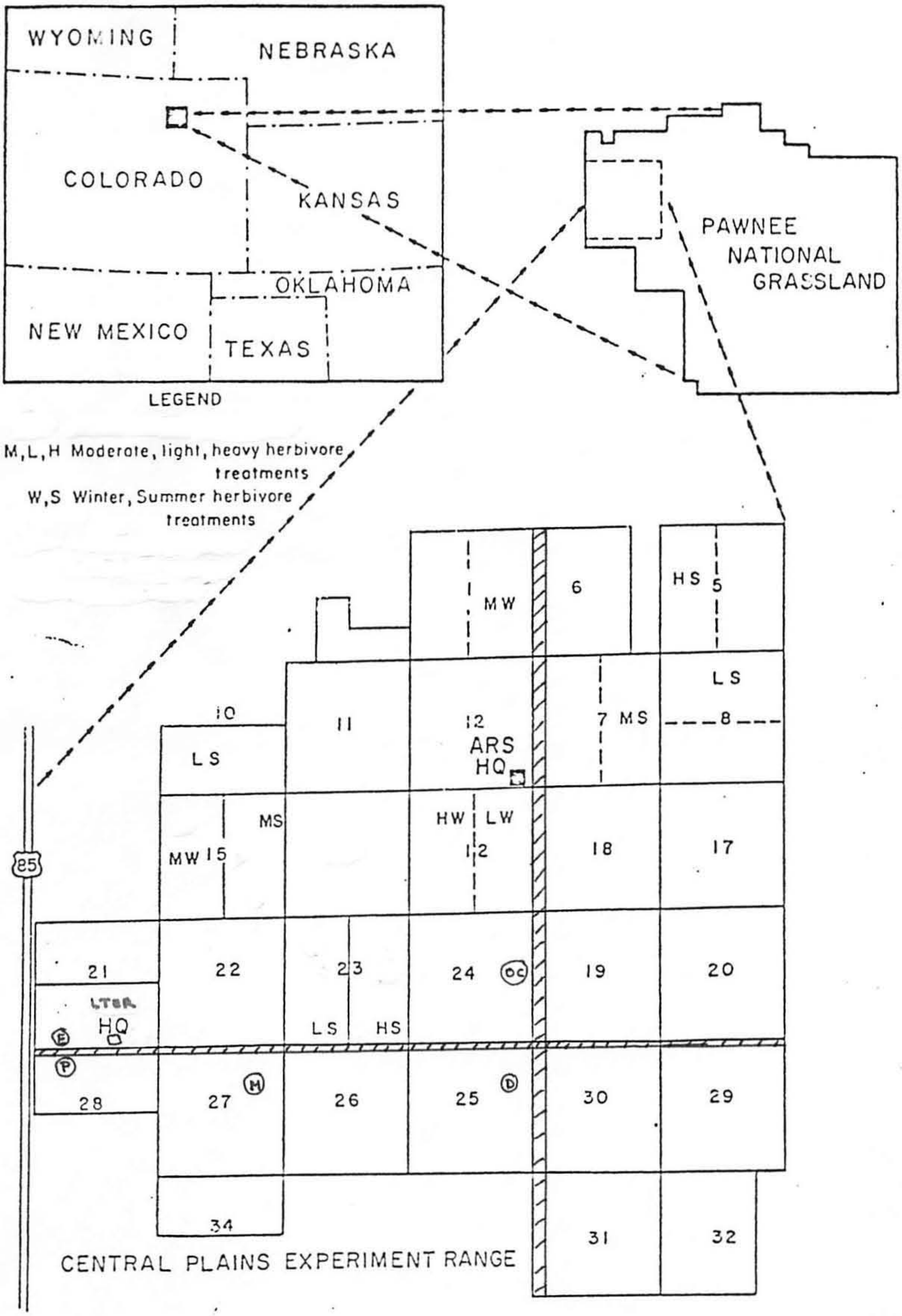
LANDSCAPE ECOLOGY SYMPOSIUM
FIELD TRIP

Central Plains Experimental Range
Long Term Ecological Research Site

March 16, 1989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M,L,H Moderate, light, heavy herbivore treatments
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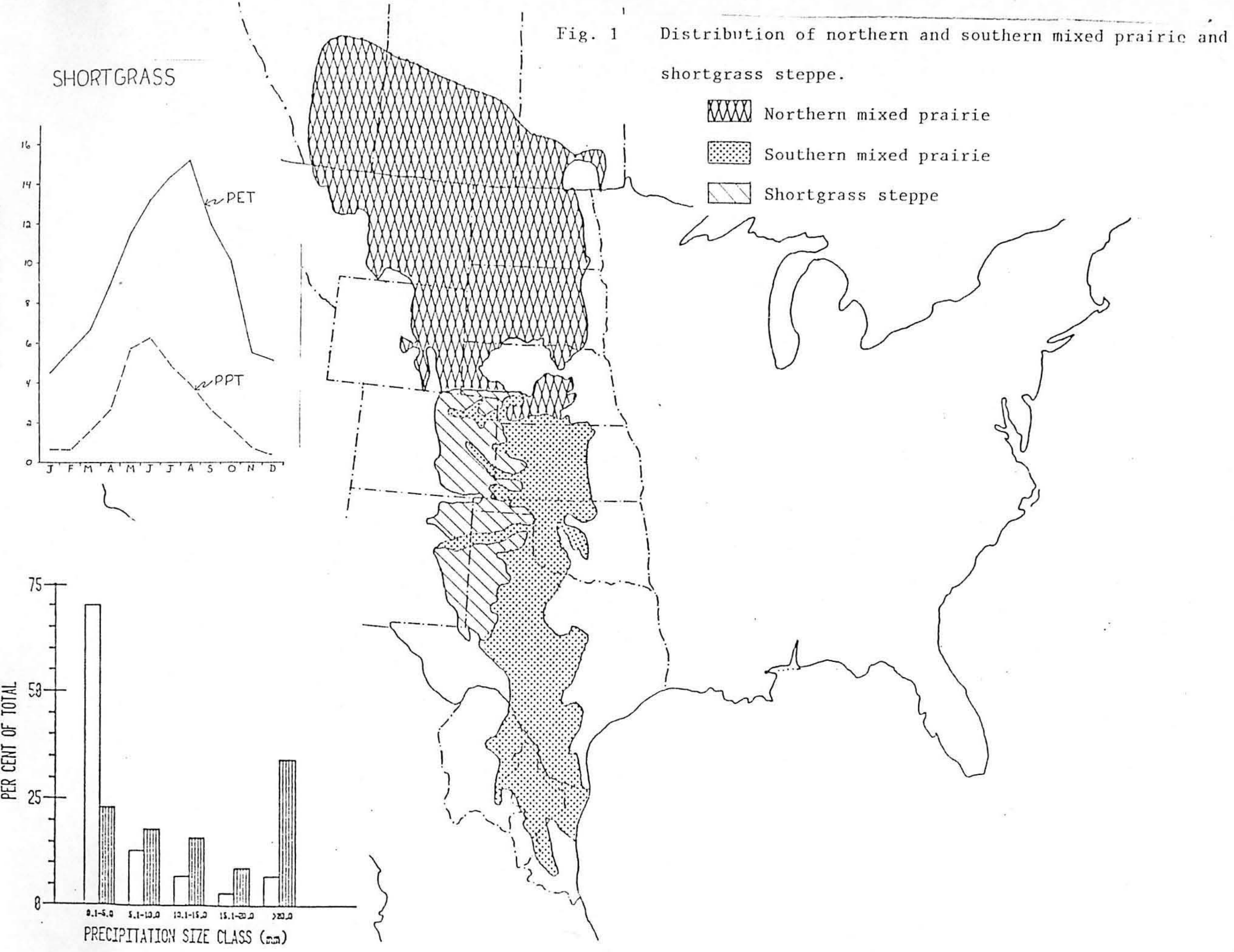
CENTRAL PLAINS EXPERIMENT RANGE

Fig. 1 Distribution of northern and southern mixed prairie and shortgrass steppe.



CHARACTERISTICS OF THE SHORTGRASS STEPPE

AREA: 280,000 Square Kilometers

LOCATION: West-Central Great Plains of the U.S

CLIMATE: Temperate Semiarid

LAND USE: Rangeland (50%) and Cropland (50%)

- Rangeland dominated by native shortgrasses
- Cropland divided between dryland and irrigated

VEGETATION OF THE SHORTGRASS STEPPE

UPLANDS: Bouteloua gracilis
Buchloe dactyloides
Opuntia polyacantha

SWALES: Bouteloua gracilis
Buchloe dactyloides
Opuntia polyacantha
Agropyron smithii

SANDHILLS: Artemisia filifolia
Calamovilfa longifolia
Andropogon hallii
Schizachyrium scoparius

CROPLANDS: Winter wheat
Alfalfa
Corn
Cotton

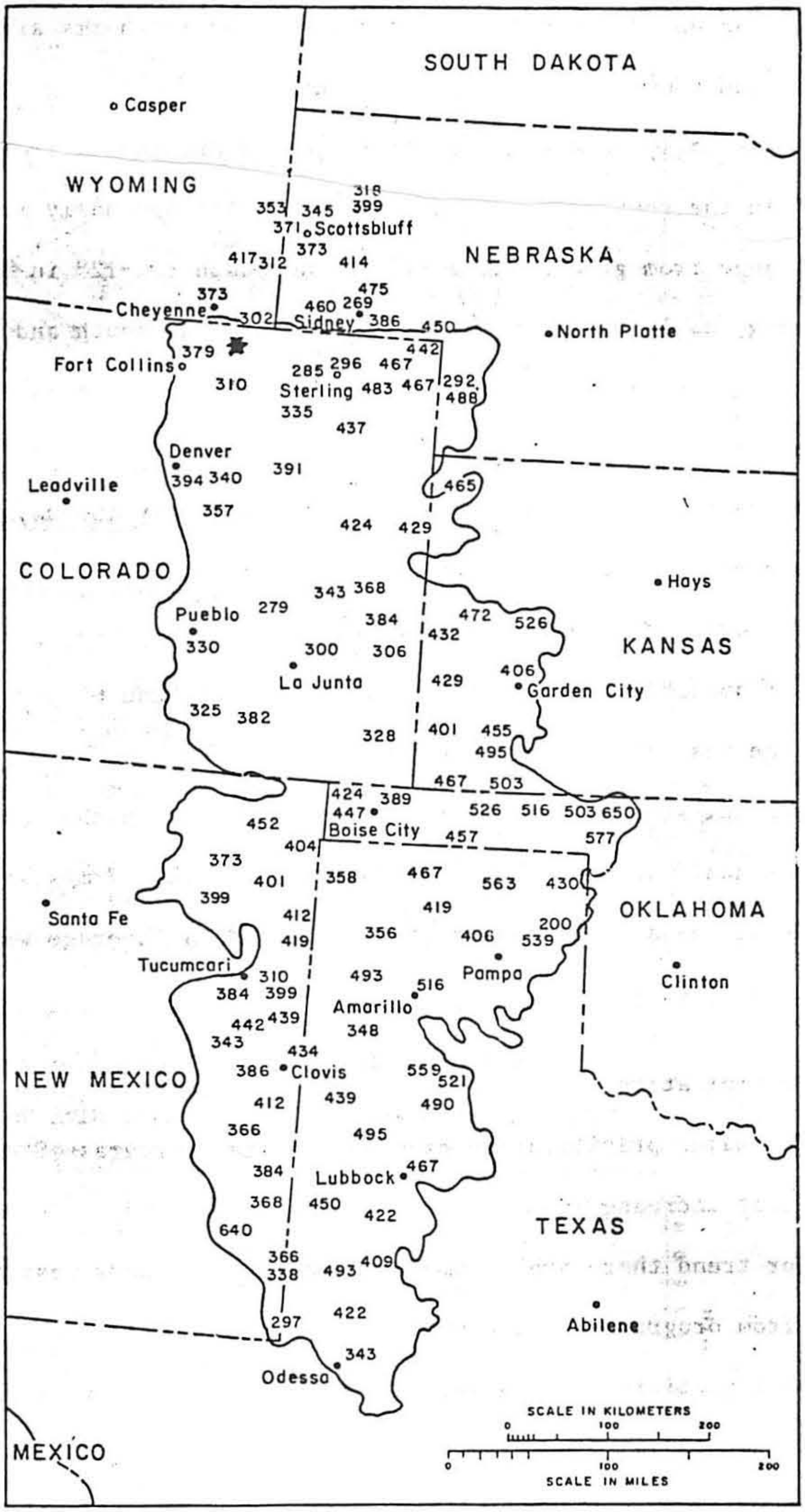


Fig. 2. Geographic distribution of amounts of annual precipitation in the Shortgrass Steppe region

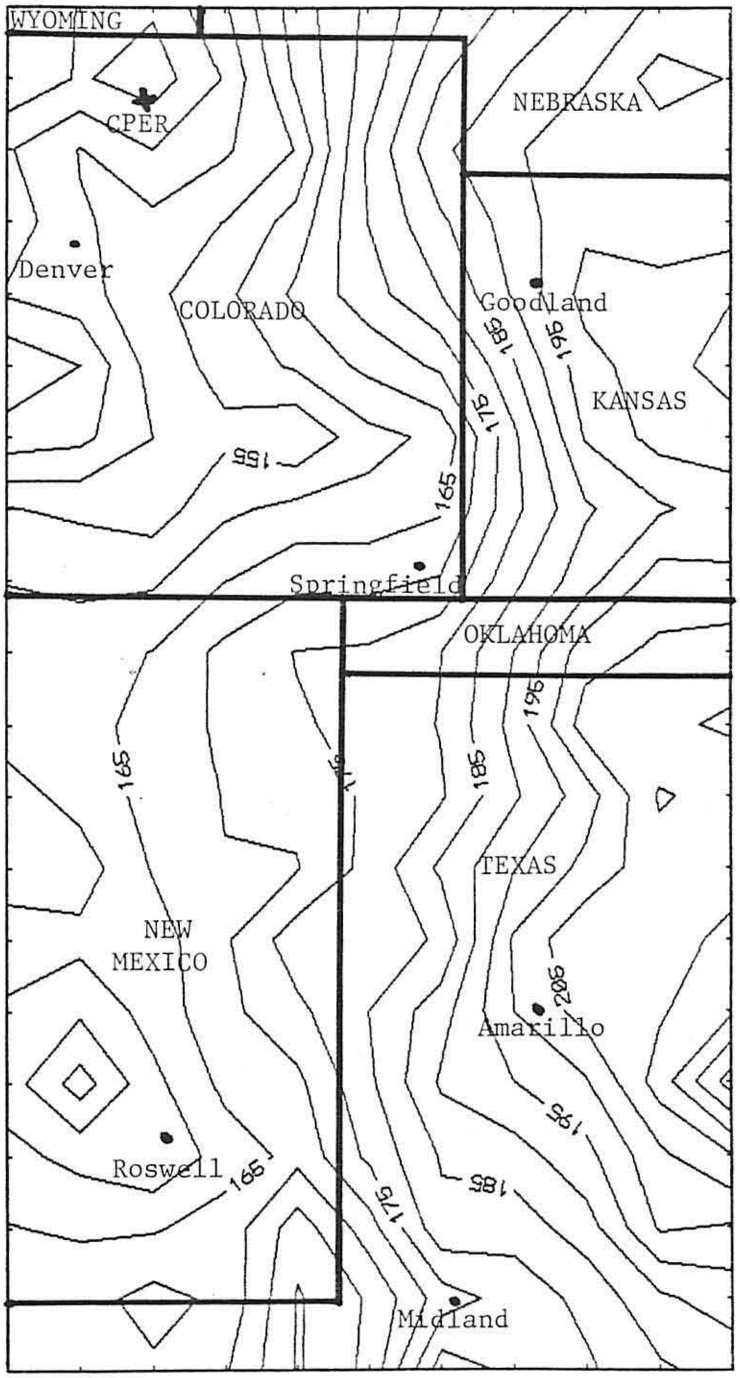


Fig. IV.1. Isolines of aboveground net primary production for the Shortgrass Steppe region.

APPENDIX 4

DESCRIPTION OF THE CENTRAL PLAINS EXPERIMENTAL RANGE

Location

The LTER project at Colorado State University is located at the Central Plains Experimental Range (CPER) in the western division of Pawnee National Grassland (Fig. 1). The western division of the Pawnee National Grassland is 42,700 ha and the CPER encompasses 6,280 ha.

The CPER is 19 km northeast of Nunn, Colorado, and 40 km south of Cheyenne, Wyoming. The Range was established in 1939 to answer questions which were important as a result of the drought of the 1930's. A number of pastures were set aside for long-term experiments, and a large number of scientific publications have resulted. Twelve half-section (129 ha) pastures were assigned four each to heavy, moderate, and light summer grazing. In 1958 two of the replicates were changed to winter grazing. Each of these and several other pastures also have at least one exclosure of 0.5 to 2 ha excluding livestock grazing since 1939. Permanent quadrats have been established in these pastures, and in most years composition of vegetation has been measured.

All of the Central Plains Experimental Range is available for use in the LTER Program, but some is dedicated to ongoing studies conducted by the Agricultural Research Service (ARS) (Appendix 7). The Pawnee National Grassland, as mentioned above, is available for extensive studies which require a great deal of land area but do not require rigid control for experimental purposes. The LTER program will assist investigators in securing cooperative agreements with the U.S. Forest Service for use of these lands. The CPER, on the other hand, may be utilized for intensive studies which require greater control.

A broad form of cooperative agreement has existed between the ARS and Colorado State University (CSU) for many years. Under this agreement CSU scientists have cooperated in many research projects on the CPER.

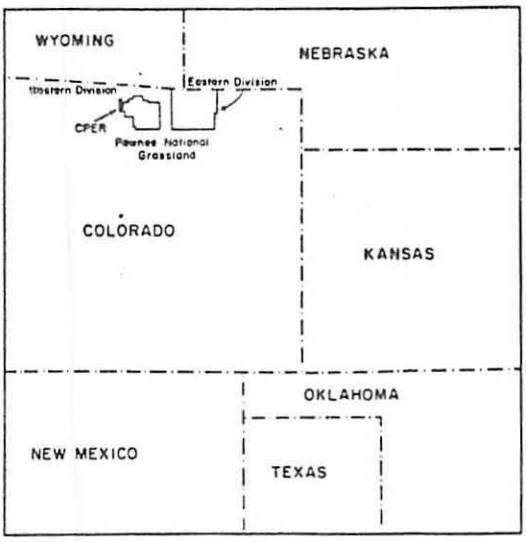


Fig. 1. Map showing the regional location of Pawnee National Grassland.

Within the CPER was located the Pawnee Site of the International Biological Program (IBP) Grassland Biome study. From 1966 to 1974 the IBP Program was involved in ecosystem research at the CPER.

In 1968, a cooperative agreement was signed among ARS, CSU, and the IBP's Grassland Biome Program (see Appendix 7). The agreement permitted IBP to conduct grassland research on a portion of the CPER and provided for mutual cooperation. The agreement also permitted the construction of needed facilities on the CPER. These included an office-lab-cafeteria, storage shed, dormitory, residence, barn, and corrals. This agreement was amended in 1975 when the IBP program was phased out and is currently the agreement of record.

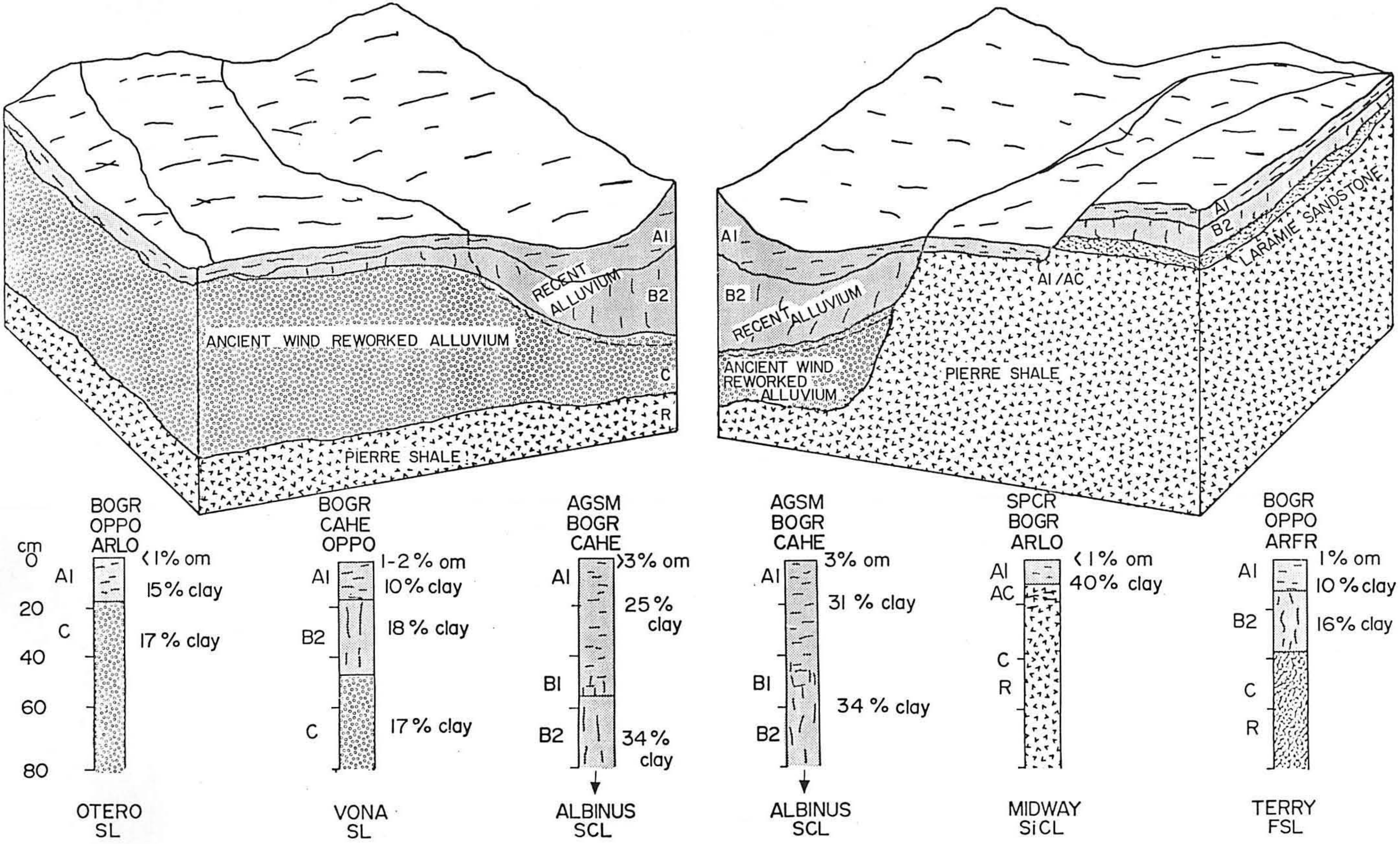
Under the auspices of the US/IBP Grassland Biome study and subsequent NSF funding, interdisciplinary teams have analyzed the fundamental structural and functional characteristics of the shortgrass steppe ecosystems at CPER. These studies included measurements of the structural aspects of all trophic compartments, their variation through time, space, and under stress (grazing, water, mineral nitrogen, herbicides, pesticides) as well as a broad array of studies relating to ecosystem processes such as primary production, secondary production, energy flow, nutrient cycling, and abiotic and biotic control.

Climate

The precipitation variability (in time and space) is probably the outstanding characteristic of the semiarid continental climate. The mean annual precipitation is 309 mm (12.2 inches) based on 30 years of data. May, June, July, and August tend to be the wettest months. These 4 months usually account for more than 50% of the annual precipitation. Through regression analysis it has been found that summer precipitation explained 89% of the variance in annual precipitation while winter precipitation accounted for the other 11%. This variation is explained by the frequent occurrence of convective activity in the area during summer months. Northerly flow of maritime tropical air combines with intense solar heating and orographic influence over the mountains to generate thunderstorms which move in an easterly direction over the grasslands beginning around noon each day. The winter climate is dominated by the presence of continental polar air masses and very few storms moving over the area. Storms which pass over the Rocky Mountain region lose most of their moisture over the mountains; consequently, dry, sunny days are common in winter. The winter storms which do occur have little effect on the mean water balance of the region. This is so because high insolation, moderate to high winds, and warm daily air temperatures combine to sublimate much of the snow. Major storms, defined as greater than 2.54 cm (1 inch) of precipitation, account for 74% of the variance in summer precipitation and only 16% of the variance in winter precipitation.

The large diurnal variation in air temperatures is a notable characteristic of the steppe climate. Average diurnal variations are between 17° and 20°C (30° and 35°F), with variations up to 34°C (60°F) possible in late summer. The lowest average monthly maximum temperature is 7°C (44°F) (January and December) for approximately 30 years of data. The highest average monthly maximum temperature is 31°C (88°F) (July). The lowest and highest average monthly temperatures are -12°C (11°F) (January) and 12°C (54°F) (July), respectively. The median frost-free period is 128 days.

Another important characteristic of the grasslands climate is the presence of moderate to high winds throughout much of the year. The period December to May experiences noticeably higher winds than the remaining months. This characteristic plays an important role in the redistribution of snow following winter storms and the resulting winter water balance of the region.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RECENT ALLUVIUM
B2
ANCIENT WIND REWORKED ALLUVIUM
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PIERRE SHALE
AI
B2
LARAMIE SANDSTONE
cm
0
20
40
60
80
BOGR OPPO ARLO
AI
C
<1% om
15% clay
17% clay
OTERO SL
BOGR CAHE OPPO
AI
B2
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10% clay
18% clay
17% clay
VONA SL
AGSM BOGR CAHE
AI
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B2
>3% om
25% clay
34% clay
ALBINUS SCL
AGSM BOGR CAHE
AI
BI
B2
3% om
31% clay
34% clay
ALBINUS SCL
SPCR BOGR ARLO
AI
AC
C
R
<1% om
40% clay
MIDWAY SiCL
BOGR OPPO ARFR
AI
B2
C
R
1% om
10% clay
16% clay
TERRY FSL

Table 3. Species comprising the functional groups

Cool season grasses	
Agropyron smithii Rydb.	Western wheatgrass
Carex eleocharis Bailey	Needleleaf sedge
Festuca octoflora (Walt.) Rydb.	Common six-weeks grass
Sitanion hystrix (Nutt.) J.G. Smith	Bottlebrush squirreltail
Stipa comata Trin. and Rupr.	Needle-and-thread grass
Warm season grasses	
Aristida longiseta Steud.	Red three-awn
Bouteloua gracilis (H.B.K.) Lag.	Blue grama
Buchloe dactyloides (Nutt.) Engelm.	Common buffalo grass
Munroa squarrosa (Nutt.) Torr.	Common false buffalo grass
Muhlenbergia torreyi (Kunth) Hitchc.	Ring muhly
Schedonnardus paniculatus (Nutt.) Trel.	Tumblegrass
Sporobolus cryptandrus (Torr.) A. Gray	Sand dropseed
Cool season forbs	
Allium textile A. Nels and Macbr.	Prairie onion
Astragalus drummondii Dougl.	Drummond milk vetch
Astragalus gracilis Nutt.	Slender milk vetch
Astragalus missouriensis Nutt.	Missouri milk vetch
Astragalus mollissimus Torr.	Woolly milk vetch
Cryptantha minima Rydb.	Cryptantha
Cymopterus acaulis (Pursh) Raf.	Stemless spring parsley
Descurainia pinnata (Walt.) Britt.	Pinnate tansy mustard
Erigeron bellidiastrum Nutt.	Fleabane
Lappula redowskii Hornem.	Redowski's stickweed
Lepidium densiflorum Schrader	Prairie pepperweed
Leucocrinum montanum Nutt.	Common star lily
Lithospermum incisum Lehm.	Narrow-leaf gromwell
Lomatium orientale Coult. and Rose	White flowered lomatium
Lupinus pusillus Pursh	Rusty lupine
Musineon divaricatum (Pursh) Nutt.	Leafy musineon
Oxytropis sericea Nutt.	Silky loco
Penstemon albidus Nutt.	White penstemon
Penstemon angustifolius Nutt.	Narrow-leaf penstemon
Plantago patagonica gnaphaloides (Nutt.) Gray	Woolly Indian wheat
Senecio tridenticulatus Rydb.	Plains groundsel
Sisymbrium altissimum L.	Tumbling hedge mustard
Sphaeralcea coccinea (Pursh) Rydb.	Scarlet globemallow
Taraxacum officinale Weber	Common dandelion
Thelesperma filifolium (Hook) Gray	Greenthread
Townsendia exscapa (Rich.) Porter	Stemless townsendia
Tradescantia occidentalis (Britt.) Smyth	Prairie spiderwort
Tragopogon dubius Scop.	Yellow salsify
Viola nuttallii Pursh	Yellow prairie violet
Warm season forbs	
Bahia oppositifolia (Nutt.) DC.	Plains bahia
Chenopodium album L.	Lambsquarters goosefoot
Chenopodium leptophyllum Nutt.	Narrow-leaf goosefoot
Chrysopsis villosa (Pursh) Nutt.	Hairy gold aster
Cirsium arvense (L.) Scop.	Canadian thistle
Cirsium undulatum (Nutt.) Spreng.	Wavy-leaf thistle
Conyza canadensis (L.) Cronquist	Canada horseweed
Euphorbia glyptosperma Englem.	Ridge-seed spurge
Evolvulus nuttallianus R. and S.	Nuttall evolvulus
Gaura coccinea Nutt. ex Pursh	Scarlet gaura
Gilia laxiflora (Coult.) Osterh.	Gilia
Grindelia squarrosa (Pursh) Dunal	Curly-cup gumweed
Haplopappus spinulosus (Pursh) DC.	Iron-plant goldenweed
Helianthus annuus L.	Common sunflower
Helianthus petiolaris Nutt.	Prairie sunflower
Hymenopappus filifolius Hook.	Fine-leaf hymenopappus
Kochia scoparia (L.) Schrad.	Fireweed summer cypress
Lactuca pulchella (Pursh) DC.	Chicory lettuce
Lactuca serriola L.	Prickly lettuce
Liatris punctata Hook.	Dotted gayfeather
Lygodesmia juncea (Pursh) D. Don	Rush skeleton plant
Machaeranthera tanacetifolia (H.B.K.) Nees	Tansyleaf aster
Mirabilis linearis (Pursh) Heimerl.	Narrow-leaf four o'clock
Oenothera albicaulis Pursh	Prairie evening primrose
Oenothera coronopifolia T and G	Cutleaf evening primrose
Orobanche fasiculata Nutt.	Purple broomrape
Orobanche ludoviciana Nutt.	Louisiana broomrape
Portulaca oleracea L.	Purslane portulaca
Psoralea tenuiflora Pursh	Slimflower scurf pea
Ratibida columnifera (Nutt.) Woot. and Standl.	Upright prairie coneflower
Salsola kali tenuifolia Tausch.	Tumbleweed Russian thistle
Solanum rostratum Dunal	Buffalo bur nightshade
Sophora sericea Nutt.	Silky sophora
Stephanomeria pauciflora (Torr.) A. Nels.	Wire lettuce
Talinum parviflorum Nutt.	Fameflower
Thelesperma megapotamicum (Spreng.) Kuntze	Greenthread
Tribulus terrestris L.	Puncture vine fever plant
Verbena bracteata Lag. and Rodr.	Big bract verbena
Half-shrubs	
Artemisia frigida Willd.	Fringed sagewort
Chrysothamnus nauseosus (Pall.) Britt	Rubber rabbit brush
Eriogonum effusum Nutt.	Rush wild buckwheat
Gutierrezia sarothrae (Pursh) Britt. and Rusby	Broom snakeweed
Succulents	
Echinocereus viridiflorus Englem.	Hedgehog cactus
Mammillaria vivipara (Nutt.) Haw.	Purple mammillaria
Opuntia polyacantha Haw.	Plains pricklypear
Pediocactus simpsonii (Engelm.) Britt. and Rose	Hedgehog cactus

Table 2. Areal extent of PUs, and percentage of CPER occupied by each.

PU	Lowland		Slope		Upland	
	Area	% of total	Area	% of total	Area	% of total
	ha		ha		ha	
1	38	2	171	9	1689	89
2	27	5	95	18	408	77
4	471	32	795	54	206	14
5	53	31	24	14	94	55
6	375	43	323	37	174	20
9	152	74	54	26	0	0
Total	1116	22	1462	28	2571	50

1979). Radiocarbon dates were determined for two paleosols after removal of all light-fraction material in an NaI solution of specific gravity 1.8. This was assumed to remove all modern roots and detritus. No further fractionation was performed. Radiocarbon age was determined by Geochron Lab., Cambridge, MA.

The distribution of organic C mass is presented in terms of three general landscape components, herein referred to as uplands, slopes, and lowlands. Uplands included level upland plains and the summit portion of toposequences; slopes included the area between the shoulder and footslope portions of toposequences and terrace escarpments; and lowlands included toeslopes, broad ephemeral stream courses, and other level, low-lying areas.

An electronic distance measure (EDM) was used to obtain the distance between sites and across physiographic units. These data were used to estimate proportions of uplands, slopes and lowlands within each unique PU (Table 2). The area within each PU was estimated using a dot grid overlay of a 1:24 000 map, at a resolution of 10 dots cm^{-2}. Hectares of uplands, slopes, and lowlands were derived for each PU from the latter two estimates by multiplying the proportion of each position along the transect by the total area of the PU.

RESULTS AND DISCUSSION

Patterns of Organic Carbon Concentrations

Organic C concentrations in surface horizons of CPER soils averaged 9.8 g kg^{-1}, with minimum, maximum, and standard deviations (SD) of 1.3, 35.9, and 3.2, respectively. Some variation was due to slope position, although differences between positions of a given toposequence may not be striking (Fig. 2). Typically, surface (A) horizon organic C concentration did not vary systematically among positions of a given toposequence. Although toeslopes nearly always had higher concentrations than corresponding summits, organic C concentration did not decrease at the shoulder or increase systematically downslope in most cases (Table 3). Similarly, surface horizon texture and thickness were not well differentiated across toposequences. These results are in contrast to other findings (Aandahl, 1948; Aguilar, 1984; Kleiss, 1970; Malo et al., 1974) and suggest that the role of water as the agent of differentiation is minimized in the present-day environment. Further evidence for the importance of eolian processes within the shortgrass steppe was presented in Schimel et al. (1985b), where the increase in fines downslope was found to result from the combined effect of an eolian footslope deposit and a recently denuded summit. Although some flow downslope apparently occurred at that site, wind was the overall dominant process in determining soil distribution.

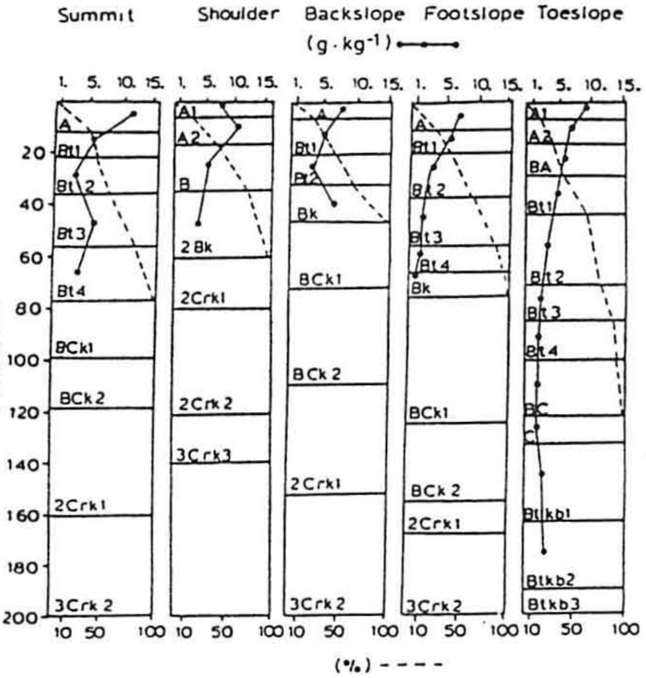

Fig. 2. Organic C concentration and cumulative percent of organic C mass as a function of depth for a selected toposequence.

The decrease in organic C concentration with solum depth (Fig. 2) was uniform except where perturbed by recent eolian deposition, buried soils, or lithologic discontinuities. All of these conditions were common at the shortgrass steppe site; two were reflected in the soils of Fig. 2. The A1 horizon at the shoulder contained less organic C and more sand than the A2, suggesting a more recent deposit, which has not accumulated an organic C concentration comparable with that of the A2. Although not dramatic in this example, the increase in organic C concentrations in the Btkb1, Btkb2, and Btkb3 horizons of the toeslope soil reflects the influence of buried horizons, which were often found relatively deep in the profile. Organic C concentrations in buried horizons were typically higher

Table 3. A horizon organic carbon (OC), sand content, and horizon thickness by slope position for each physiographic unit sampled.

PU	Summit			Shoulder			Backslope			Footslope			Toeslope		
	OC	Sand	Thickness	OC	Sand	Thickness	OC	Sand	Thickness	OC	Sand	Thickness	OC	Sand	Thickness
	g kg^{-1}	%	cm	g kg^{-1}	%	cm	g kg^{-1}	%	cm	g kg^{-1}	%	cm	g kg^{-1}	%	cm
1	7 ± 2 (7)	74 ± 5	9 ± 3	7 ± 2 (7)	71 ± 2	9 ± 5	9 ± 3 (7)	71 ± 7	15 ± 14	9 ± 2 (7)	63 ± 13	8 ± 6	13 ± 5 (6)	54 ± 18	9 ± 6
2	7 ± 2 (2)	69 ± 13	13 ± 11	10 ± 3 (2)	60 ± 17	14 ± 1	8 ± 1 (2)	58 ± 14	10 ± 6	11 ± 3 (2)	61 ± 2	12 ± 4	19 ± 14(2)	52 ± 22	10 ± 8
4	8 ± 2 (4)	68 ± 7	9 ± 5	8 ± 1 (5)	66 ± 6	10 ± 4	8 ± 2 (5)	64 ± 9	12 ± 4	9 ± 4 (5)	69 ± 3	12 ± 3	12 ± 5 (5)	60 ± 8	17 ± 7
5	15 ± 4 (2)	57 ± 4	9 ± 4	10 ± 3 (2)	67 ± 2	14 ± 2	8 ± 0 (2)	65 ± 6	9 ± 2	7 ± 2 (2)	70 ± 4	14 ± 5	8 ± 2 (2)	68 ± 4	14 ± 3
6	8 ± 2 (5)	58 ± 16	11 ± 11	6 ± 3 (6)	60 ± 15	12 ± 8	8 ± 3 (6)	55 ± 17	10 ± 4	7 ± 1 (6)	60 ± 7	8 ± 2	10 ± 4 (6)	52 ± 8	8 ± 1
9	8 (1)	61	7	8 ± 3 (2)	66 ± 5	9 ± 6	7 ± 1 (2)	64 ± 10	5 ± 1	7 ± 7 (2)	62 ± 7	7 ± 4	11 ± 8 (2)	57 ± 15	6 ± 3

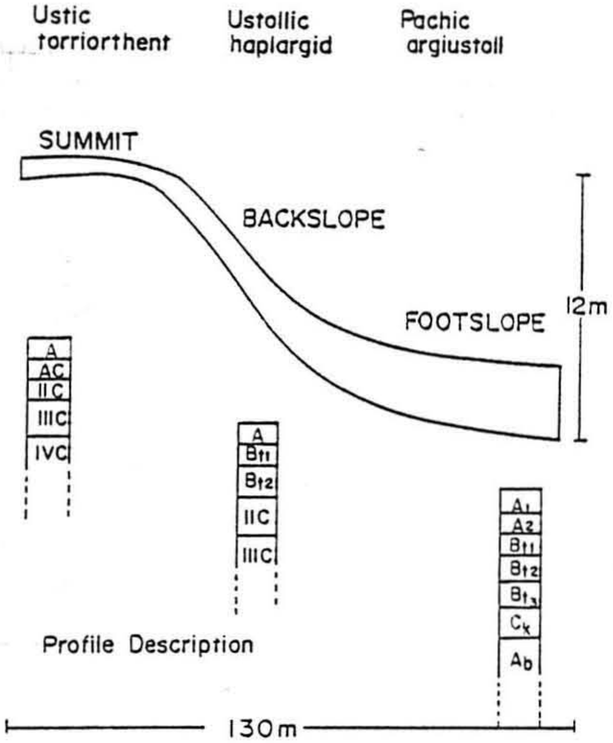

FIG. 1. Horizonation of soils and topography of a shortgrass steppe catena.

are also found. These are generally saline or sodic and have distinctive vegetation. Large variations in soils occur along shortgrass steppe catenas, with as many as six soil series and three soil orders occurring along 120–130 m slopes. Sorting of particles often occurs along catenas, with sandy soils on ridgetops and clay loams in lower slope positions, although aeolian deposits frequently complicate this pattern. The area is ideal for studies of biogeochemical cycles in a landscape context.

The objectives of this study were (1) to describe the nutrient and organic matter content of soils in relation to topographic position, and (2) to identify the mechanisms through which erosion and runoff affect nutrients and organic matter.

MATERIALS AND METHODS

Study site

All studies were conducted at the United States Department of Agriculture–Agricultural Research Service Central Plains Experimental Range (CPER). CPER is located north of Nunn, Colorado, in Weld County (latitude 40°48′23″N, longitude 104°45′15″W). Average precipitation is 310 mm/yr and mean monthly temperatures range from −5°C in January to 22° in July. The site chosen was a north-facing hillside near the head of a narrow drainage located in Range 66W, Township 10N, Section 26. The base elevation of the hillslope was 1641 m, with 12 m relief from base to summit. The slope was 130 m long. The site was fenced to exclude cattle in May 1980.

Three soils were found along the hillside (Fig. 1). The summit was a Ustic torriorthent formed in ancient coarse alluvium. The backslope was a Ustollic haplargid, also formed in ancient coarse alluvium. The footslope was a Pachic argiustoll, formed in recent fine-textured alluvium. Terminology for slope morphology follows Ruhe and Walker (1968).

The vegetation also varied along the catenary sequence (Stillwell 1983). Percent ground cover ranged from 90–100% on the footslope to 30–40% on the ridge-top. The perennial vegetation on the ridgetop was dominated by *Opuntia polyacantha* (starvation cactus), *Aristida longisetum* (red three-awn), and *Bouteloua gracilis* (blue grama). Patches of *Muhlenbergia torreyi* (ring muhley) and *Stipa comata* (needle-and-thread) also occurred. The backslope was dominated by *Opuntia*, *Bouteloua*, and *Buchloe dactyloides* (buffalo grass). The dwarf shrub *Guterrezia sarothrae* (snakeweed) also occurred. The footslope was dominated by intermixed stands of *Buchloe* and *Bouteloua*, with large amounts of *Carex filifolia*. An unusual growth of the biennial forb *Thelosperma filifolia* occurred on the ridgetop and backslope sites but was not found in the footslope.

Soil and vegetation sampling and analysis

Aboveground live and dead vegetation on three 180 cm diameter circular plots was clipped on 26 June 1980 for aboveground biomass determination on each of three slope positions. Roots and detritus were removed from three 10 cm diameter, 20 cm deep cores per plot by repeated flotation and filtration through a 1-mm mesh screen. This depth increment included >90% of total root mass. We did not attempt to separate live from dead roots.

Three replicate 5.1 cm diameter soil cores spaced 20 m apart were taken for chemical and physical analysis from each of three slope positions. Cores were subdivided by genetic horizon as distinguished in the field, and were taken to as great a depth as could be obtained.

Total N in soil and plant samples was determined following Kjeldahl digestion using a block digestor (Nelson and Sommers 1980). Digests were analyzed for NH_3^0 colorimetrically. Organic P was determined by the method of Saunders and Williams (1955), in which paired samples are extracted with 1 mol/L H_2SO_4. One of the pair is ashed at 400°C prior to extraction, and the difference between the two is organic P. Total P was determined by NaOH fusion (Smith and Bain 1982). Available P was estimated using an $NaHCO_3$ extract (Olsen et al. 1954). After removal of carbonates with H_2SO_4, soil organic carbon was determined by wet oxidation with $K_2Cr_2O_7$ in a concentrated H_2SO_4–H_3PO_4 mixture in sealed culture tubes containing an alkaline CO_2 trap (2 mol/L NaOH). The wet oxidation

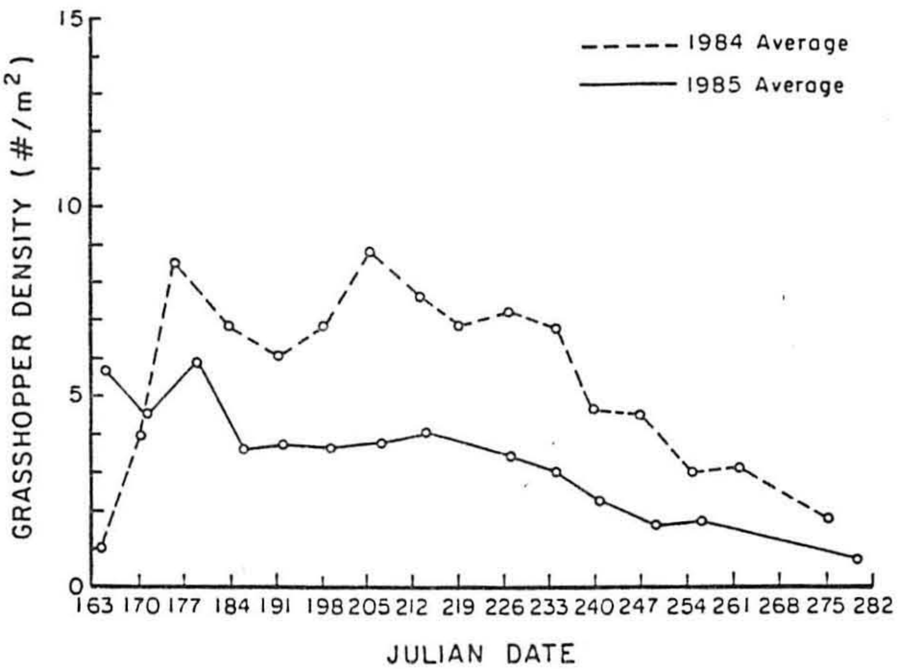

Fig. II.13. Grasshopper densities (#/m^2) during the 1984 and 1985 growing seasons.

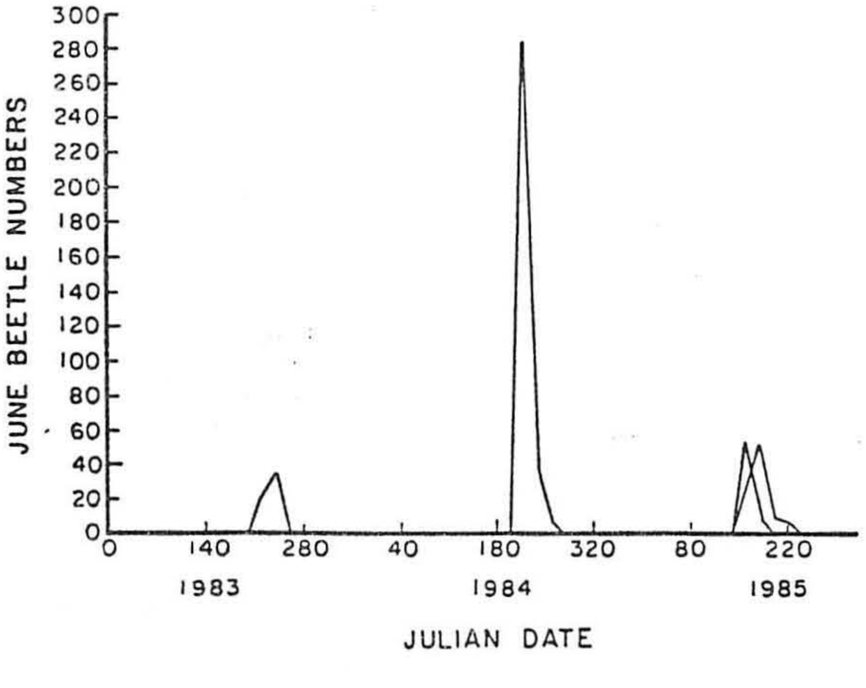

Fig. II.14. June beetle numbers (#/trap period) for 1983 through 1985.

I. INTRODUCTION

Meaningful analyses and explanations of spatial heterogeneity, its temporal counterpart and the relationships among the various scales of each, are prime deficiencies currently impeding the progress of ecosystem ecology. What is the origin of the spatial patterns in landforms, soils, and vegetation that exist in the Shortgrass Steppe? How are those patterns maintained? Which processes are primarily pattern generators? Which processes are primarily pattern neutralizers? What are the roles of punctual versus gradual processes in the origin and maintenance of patterns? How are the answers at one time or space scale related to the answers for a different scale? The spatial and temporal scaling issues inherent in these questions will guide the Central Plains Experimental Range (CPER)/LTER program for the next four years.

LTER I was organized around the theme of the interplay among geomorphological, pedological, and biological processes in shaping the structure and dynamics of Shortgrass Steppe landscapes. Current work was woven into a foundation provided by the 5 Core Topics from the LTER Request for Proposals. We expanded these 5 topics under LTER I to include: (1) Interrelations among geomorphology, landscapes, soils, and vegetation structure; (2) Weather and atmospheric deposition; (3) Erosion and sedimentation; (4) Soil water dynamics; (5) Primary production and plant nutrient dynamics; (6) Elemental cycling and organic matter; (7) Secondary production and population dynamics of selected consumers; and (8) Specific disturbances.

Results from the first four years have, in the balance, raised more questions about spatial and temporal pattern than they answered. Our original catena model[1] was based upon classic soil science concepts and proved to be too simple. While we found textbook examples of catenas at several locations, soils and vegetation at other

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[1] Webster's definition of catena is a connected series of related things. In our usage the related things are soil types and associated vegetation.

locations refused to fit the model. Our ideas about the fluvial origin of landforms at the CPER have also proven difficult to substantiate with data. Finally, the relative uniformity of A horizons from location to location is a puzzle. The resolution of these instances of lack of fit with current models was a major breakthrough for our concepts about semiarid regions. Research proposed under LTER II is planned to reconcile these differences over a range of spatial scales.

An important feature of the vegetation at the CPER and throughout the shortgrass region is the conspicuous pattern at small (0.1 m^2) to medium (several m^2) scales. Analyses of this pattern during LTER I could not link it to soils. If spatial variability in soils is not the explanation for these patterns, what is? Current patch dynamics theory (Watt 1947, Shugart 1985) suggests the idea of gap phase replacement and small-scale events, which result in the killing of individuals of Bouteloua gracilis (blue grama), as a likely source of this pattern. Does the killing of an individual of B. gracilis initiate a sequence of events belowground in a shortgrass plant community, that is analogous to the events that occur aboveground in forests? Is the pattern that is so obvious in shortgrass plant communites the result of gap dynamics? We propose to test this idea under LTER II and evaluate the range of spatial scales over which gap phase replacement is an important pattern-generating process.

This proposal is organized around nested hierarchies. The long-term nature of the project defines a nested hierarchy of time (viz., decades within centuries, years within decades, months within years, etc.). Because we are dealing with a range of time scales, we are compelled to consider a range of spatial scales. These too, have been conceptualized as a nested hierarchy (Fig. III.1). Finally, we have organized our ideas and hypotheses around the Core Topics for LTER. Within each of the Core Topics the organization is according to spatial scale. The conceptual development for the temporal and spatial scales is contained in Section III.