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A NUMERICAL ANALYSIS OF GRASSLAND FAUNAL RESEMBLANCES

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GRASSLAND BIOME

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ABSTRACT

Species lists of small mammals at eight grassland sites were compiled. Coefficients of Community among the sites were computed and subjected to cluster analysis. The resulting relationships are discussed and suggestions are made for additional and expanded study.

Terrestrial ecosystems are generally subdivided on the basis of dominant vegetative form and accompanying fauna. Major ecosystems are commonly referred to as biomes. The principal biome of central North America is grassland, westwardly characterized by shortgrass prairie and grazing animals.

This study considers the application of zoogeographical concepts to selected locations within the grasslands of the western United States. Faunal resemblances among eight research sites (of the US International Biological Program) are quantified through the use of statistical techniques.

GEOGRAPHIC REGION

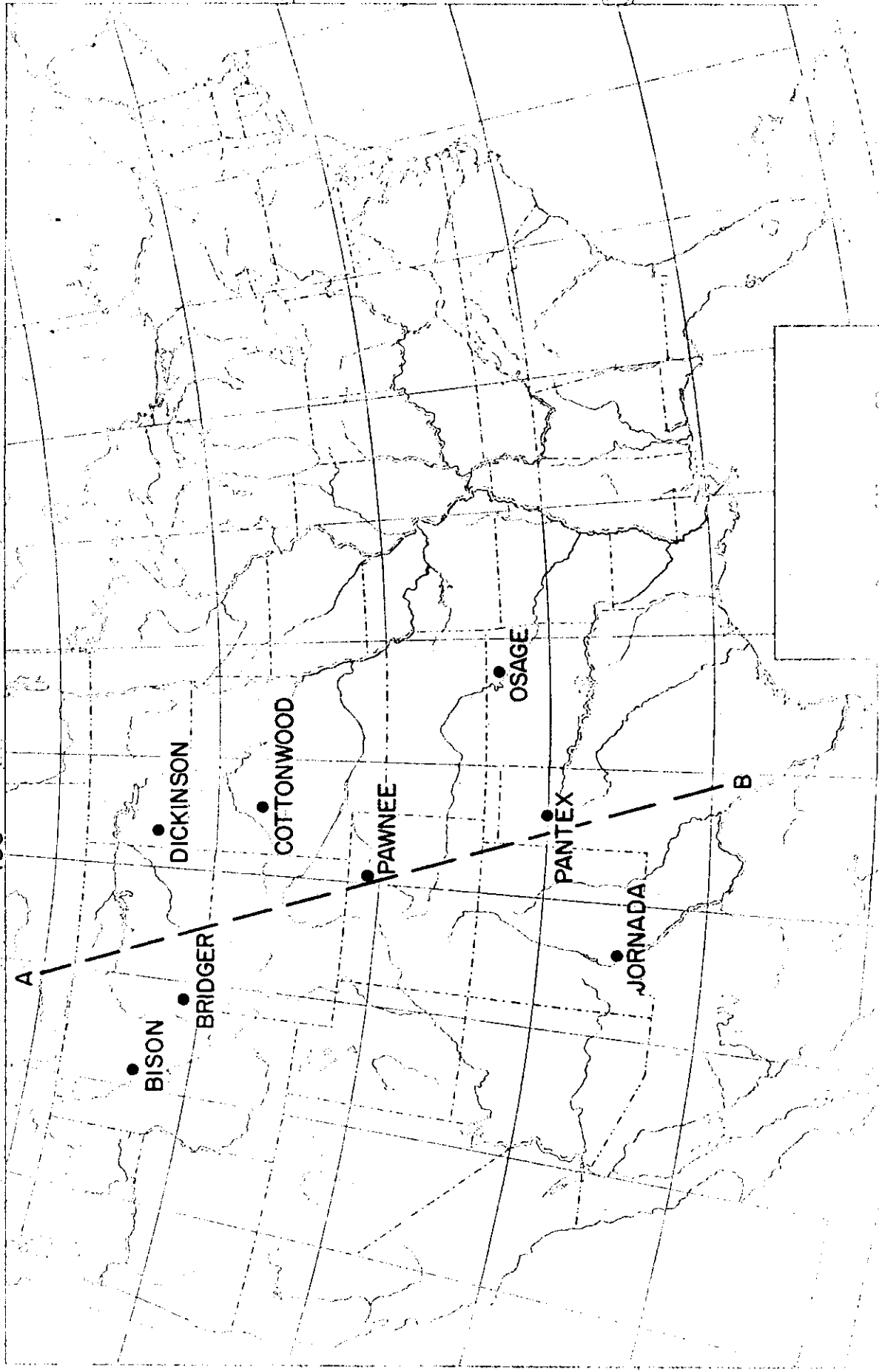
The zoogeographic area examined is the geographic region of the western United States extending from Montana to New Mexico and from the Rocky Mountains to eastern Oklahoma. The region encompasses about 14° longitude and 18° latitude. Individual site locations within the region are indicated in Fig. 1.

BASIC DATA

The basic data for the study consists of faunal species lists for each site. The lists were compiled principally from trapping results, but also include visual spottings and are limited to small, terrestrial mammals. A total working fauna of 50 species in four orders was generated. A composite list occurs in Table 1 and a list by site is presented in Table 2.

The list for the Pawnee site was compiled by the author on the basis of conversations with several individuals associated with various research projects at the site. It might be noted that only the Pawnee list is devoid of shrews. Though the list may in fact be accurate, it is also possible an omission exists as a function of a less than thorough examination of the area.

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Fig. 1. Locations of eight sites in the Grassland Biome

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Table 1. Small mammals occurring at eight sites in the Grassland Biome.

	Bridger	Bison	Dickinson	Cottonwood	Pawnee	Pantex	Osage	Jornada
Marsupialia								
<i>Didelphis marsupialis</i>							x	
Insectivora								
<i>Sorex cinereus</i>			x	x				
<i>S. vagrans</i>	x	x						
<i>Blarina brevicauda</i>							x	
<i>Cryptotis parva</i>						x	x	
<i>Notiosorex crawfordi</i>								x
Lagomorpha								
<i>Sylvilagus floridanus</i>							x	
<i>S. nuttallii</i>		x						
<i>S. audubonii</i>						x		x
<i>Lepus americanus</i>	x							
<i>L. townsendii</i>			x	x	x			
<i>L. californicus</i>					x	x	x	x
Rodentia								
<i>Eutamias amoenus</i>	x							
<i>Ammospermophilus interpres</i>								x
<i>Spermophilus tridecemlineatus</i>			x	x	x	x	x	
<i>S. pilosoma</i>								x
<i>S. variegatus</i>								x
<i>Cynomys ludovicianus</i>					x			
<i>Tamiasciurus hudsonicus</i>	x							
<i>Thomomys talpoides</i>		x	x	x				
<i>Geomys bursarius</i>						x		
<i>G. arenarius</i>								x
<i>Perognathus faciatus</i>			x					
<i>P. flavescens</i>						x		
<i>P. merriami</i>						x		
<i>P. flavus</i>								x
<i>P. hispidus</i>						x		
<i>P. penicillatus</i>								x
<i>Dipodomys ordii</i>					x			x
<i>D. spectabilis</i>								x
<i>D. merriami</i>								x
<i>Reithrodontomys montanus</i>				x		x	x	

Table 1. (Continued).

	Bridger	Bison	Dickinson	Cottonwood	Pawnee	Pantex	Osage	Jornada
Rodentia (Continued)								
<i>R. megalotis</i>				x	x	x		x
<i>Peromyscus eremicus</i>								x
<i>P. maniculatus</i>	x	x	x	x	x	x	x	x
<i>P. leucopus</i>				x		x	x	
<i>Onychomys leucogaster</i>			x		x	x		x
<i>Signodon hispidus</i>						x	x	x
<i>Neotoma micropus</i>						x		x
<i>N. albigula</i>								x
<i>N. cinerea</i>	x							
<i>Clethrionomys gapperi</i>	x							
<i>Microtus pennsylvanicus</i>		x	x	x				
<i>M. montanus</i>	x	x		x				
<i>M. ochrogaster</i>				x	x		x	
<i>Lagurus curtatus</i>			x					
<i>Ondatra zibethicus</i>				x				
<i>Zapus hudsonicus</i>			x					
<i>Z. princeps</i>	x							
<i>Erethizon dorsatum</i>				x				

Table 2. Eight sites in the Grassland Biome and small mammals occurring at each.

Bridger*	Bison*
<i>Sorex vagrans</i> <i>Lepus americanus</i> <i>Eutamias amoenus</i> <i>Tamiasciurus hudsonicus</i> <i>Clethrionomys gapperi</i> <i>Peromyscus maniculatus</i> <i>Neotoma cinerea</i> <i>Microtus montanus</i> <i>Zapus princeps</i>	<i>Sorex vagrans</i> <i>Sylvilagus nuttallii</i> <i>Thomomys talpoides</i> <i>Microtus pennsylvanicus</i> <i>M. montanus</i>
9 TOTAL	6 TOTAL
Dickinson*	Cottonwood*
<i>Sorex cinereus</i> <i>Lepus townsendii</i> <i>Spermophilus tridecemlineatus</i> <i>Thomomys talpoides</i> <i>Perognathus fasciatus</i> <i>Peromyscus maniculatus</i> <i>Onychomys leucogaster</i> <i>Microtus pennsylvanicus</i> <i>Lagurus curtatus</i> <i>Zapus hudsonicus</i>	<i>Sorex cinereus</i> <i>Lepus townsendii</i> <i>Spermophilus tridecemlineatus</i> <i>Thomomys talpoides</i> <i>Reithrodontomys montanus</i> <i>R. megalotis</i> <i>Peromyscus maniculatus</i> <i>P. leucopus</i> <i>Microtus pennsylvanicus</i> <i>M. montanus</i> <i>M. ochrogaster</i> <i>Ondatra zibethicus</i> <i>Erethizon dorsatum</i>
10 TOTAL	13 TOTAL

*Compiled from Jones, J. Knox, Jr., Curator of Mammals, Museum of Natural History, University of Kansas, Lawrence. Preliminary report on mammal studies at Comprehensive Network Sites. September 30, 1970. To Dr. Norman R. French, Natural Resource Ecology Laboratory, Colorado State University, Fort Collins.

Table 2. (Continued).

Pawnee*	Pantex**
<i>Lepus townsendii</i>	<i>Cryptotis parva</i>
<i>L. californicus</i>	<i>Sylvilagus audubonii</i>
<i>Spermophilus tridecemlineatus</i>	<i>Lepus californicus</i>
<i>Cynomys ludovicianus</i>	<i>Spermophilus tridecemlineatus</i>
<i>Dipodomys ordii</i>	<i>Geomys bursarius</i>
<i>Reithrodontomys megalotis</i>	<i>Perognathus flavescens</i>
<i>Peromyscus maniculatus</i>	<i>P. merriami</i>
<i>Onychomys leucogaster</i>	<i>P. hispidus</i>
<i>Microtus ochrogaster</i>	<i>Reithrodontomys montanus</i>
	<i>R. megalotis</i>
	<i>Peromyscus maniculatus</i>
	<i>P. leucopus</i>
	<i>Onychomys leucogaster</i>
	<i>Sigmodon hispidus</i>
	<i>Neotoma micropus</i>
<hr/> 9 TOTAL	<hr/> 15 TOTAL

*Knowledge of the author.

**Compiled from Robert L. Packard, Department of Biology, Texas Tech University, Lubbock. Personal communication. October 26, 1970. To Dr. Norman R. French, Natural Resources Ecology Laboratory, Colorado State University, Fort Collins.

Table 2. (Continued).

Osage*	Jornada**
<i>Didelphis marsupialis</i>	<i>Notiosorex crawfordi</i>
<i>Blarina brevicauda</i>	<i>Sylvilagus audubonii</i>
<i>Cryptotis parva</i>	<i>Lepus californicus</i>
<i>Sylvilagus floridanus</i>	<i>Ammospermophilus interpres</i>
<i>Lepus californicus</i>	<i>Spermophilus spilosoma</i>
<i>Spermophilus tridecemlineatus</i>	<i>S. variegatus</i>
<i>Reithrodontomys montanus</i>	<i>Cynomys ludovicianus</i>
<i>Peromyscus maniculatus</i>	<i>Geomys arenarius</i>
<i>P. leucopus</i>	<i>Perognathus flavus</i>
<i>Sigmodon hispidus</i>	<i>P. penicillatus</i>
<i>Microtus ochrogaster</i>	<i>Dipodomys ordii</i>
	<i>D. spectabilis</i>
	<i>D. merriami</i>
	<i>Reithrodontomys megalotis</i>
	<i>Peromyscus eremicus</i>
	<i>P. maniculatus</i>
	<i>Onychomys leucogaster</i>
	<i>Sigmodon hispidus</i>
	<i>Neotoma micropus</i>
	<i>N. albigula</i>
15 TOTAL	20 TOTAL

*Jones 1970.

**Packard 1970.

Finally, it must be pointed out that although the lists are valid to the extent that they represent the most accurate available data, they are not assumed to be completely comparable. The areas over which collections and observations were made are not strictly defined. Consequently, the lists must be assumed only to reflect the fauna of the "general area" around each of the research sites.

ANALYSIS OF SITES

The number of species occurring at each site and the number in common with each other site is graphically represented in Fig. 2. Totals range from 6 at Bison to 20 at Jornada, with a mean of 11.6. Shared numbers range from one to seven with a mean of three. The number of sites occupied by a species involves a highly skewed distribution in that 30 of the 50 species occur at single sites while only one species, *Peromyscus maniculatus*, is present at all sites. Species which occur at single sites are shown in Table 3.

The degree of faunal resemblance among the eight sites was quantified by employing Jaccard's Coefficient of Community (CC) according to Udvardy (1969).

$$\frac{100 \times c}{a + b - c} = R$$

where a is the number of species in the larger of two compared faunas, b is the number in the smaller, and c is the number in common. The formula provides the percentage of common species, expressed as faunal resemblance, R . The affinity of each site for each of the other sites was calculated, yielding 28 Coefficients of Community.

Cartocraft Desk Outline Map, United States (No. 1773)

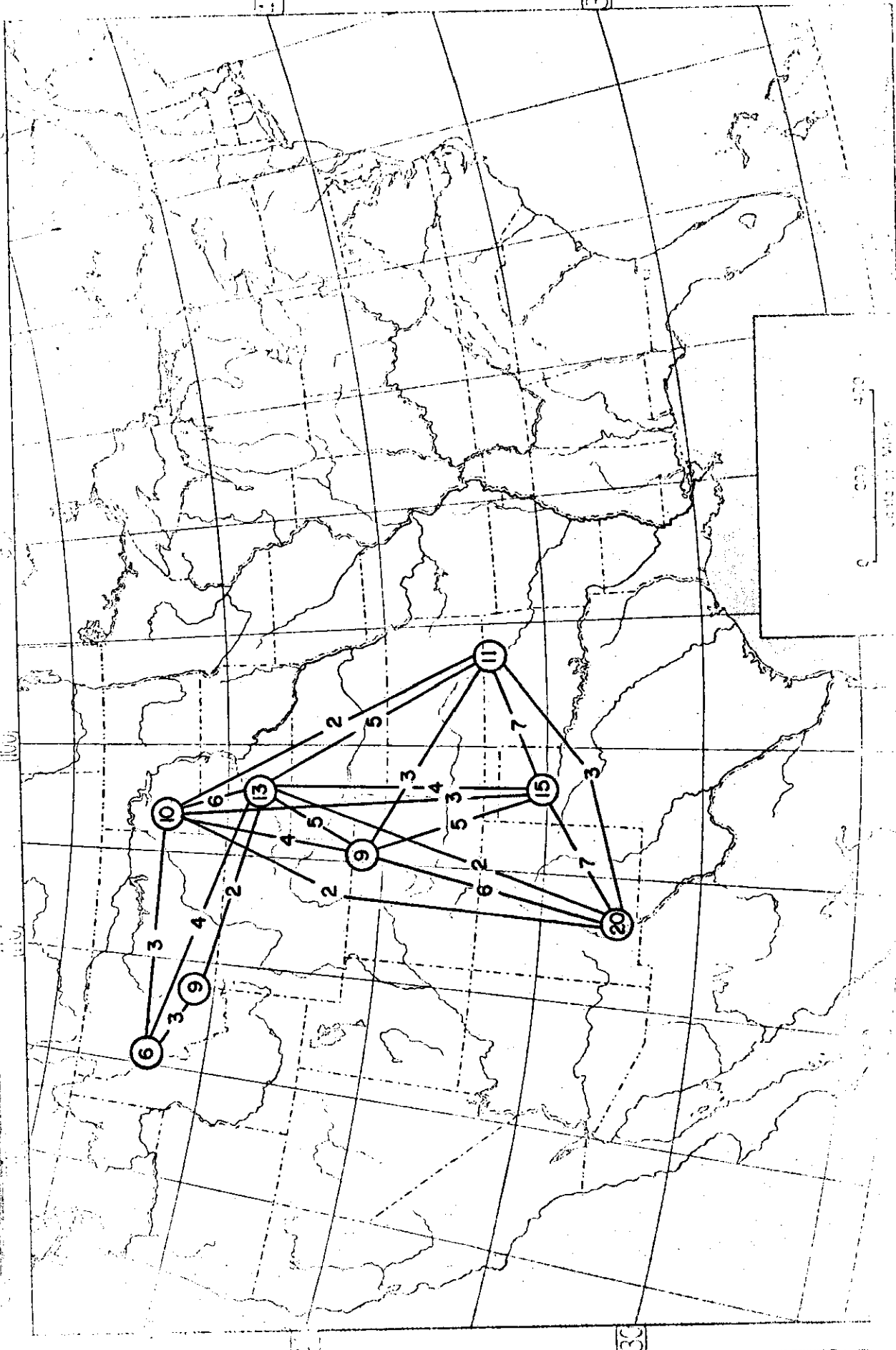


Fig. 2. Faunal resemblances among eight sites in the Grassland Biome. The numbers of small mammal species common to the sites are indicated in circles. The numbers of species common to sites are shown

Table 3. Eight sites in the Grassland Biome and small mammal species characteristic of each.

Bridger	Bison
<i>Lepus americanus</i>	<i>Sylvilagus nuttallii</i>
<i>Eutamias amoenus</i>	
<i>Tamiasciurus hudsonicus</i>	
<i>Neotoma cinerea</i>	
<i>Clethrionomys gapperi</i>	
<i>Zapus princeps</i>	
6 TOTAL	1 TOTAL
Dickinson	Cottonwood
<i>Perognathus faciatus</i>	<i>Ondatra zibethicus</i>
<i>Lagurus curtatus</i>	<i>Erethizon dorsatum</i>
<i>Zapus hudsonicus</i>	
3 TOTAL	2 TOTAL
Pawnee	Pantex
(None)	<i>Geomys bursarius</i>
	<i>Perognathus flavescens</i>
	<i>P. merriami</i>
	<i>P. hispidus</i>
0 TOTAL	4 TOTAL
Osage	Jornada
<i>Didelphis marsupialis</i>	<i>Notiosorex crawfordi</i>
<i>Blarina brevicauda</i>	<i>Ammospermophilus interpres</i>
<i>Sylvilagus floridanus</i>	<i>Spermophilus spilosoma</i>
	<i>S. variegatus</i>
	<i>Geomys arenarius</i>
	<i>Perognathus flavus</i>
	<i>P. penicillatus</i>
	<i>Dipodomys spectabilis</i>
	<i>D. merriami</i>
	<i>Peromyscus eremicus</i>
	<i>Neotoma albigula</i>
3 TOTAL	11 TOTAL

Faunal affinities were subjected to cluster analysis. The technique employed (after Sokol and Sneath 1963, and Hagmeier and Stults 1964) was the weighted pair-group method, using simple averages for recomputation of coefficients. From a matrix containing all CC's, pairs of sites having the greatest CC's were pooled and treated as clusters. Average CC's between clustered and unclustered sites were calculated and a new matrix formed. The process was repeated four times, after which all eight sites were grouped into a single cluster. The results are both a quantitative evaluation of the faunal resemblances among sites and an ordering of the sites based on the obtained resemblances, and are presented in Fig. 3 and 4 (after Hagmeier and Stults 1964). Fig. 3 is a similarity matrix indicating Coefficients of Community and ordering of sites. Fig. 4 is a dendrogram depicting relationships among sites.

Hagmeier and Stults (1964) and Hagmeier (1966) examined the distributional patterns of North American mammals and determined areas of greatest faunal homogeneity which they designated mammal provinces. Provinces which include sites considered in this study are shown in Fig. 5.

The following consistencies occur between the above two studies and this one (see Fig. 4 and 5 with Hagmeier 1966: Fig. 3 and 4): On the basis of cluster analysis of Coefficients of Community, the Bridger and Bison sites separate as a cluster from the other sites and show a high degree of mutual affinity, as do the Coloradan and Montanian provinces of Hagmeier. Of the remaining sites, Dickinson, Cottonwood, and Pawnee show a high degree of similarity of small mammal species. All fall in the Kansan province. Pantex and Osage are similar, as are the corresponding provinces Texan and Balconian. These two sites show the greatest degree of similarity of all pairs of sites considered here. The Jornada site shows little affinity for other sites,

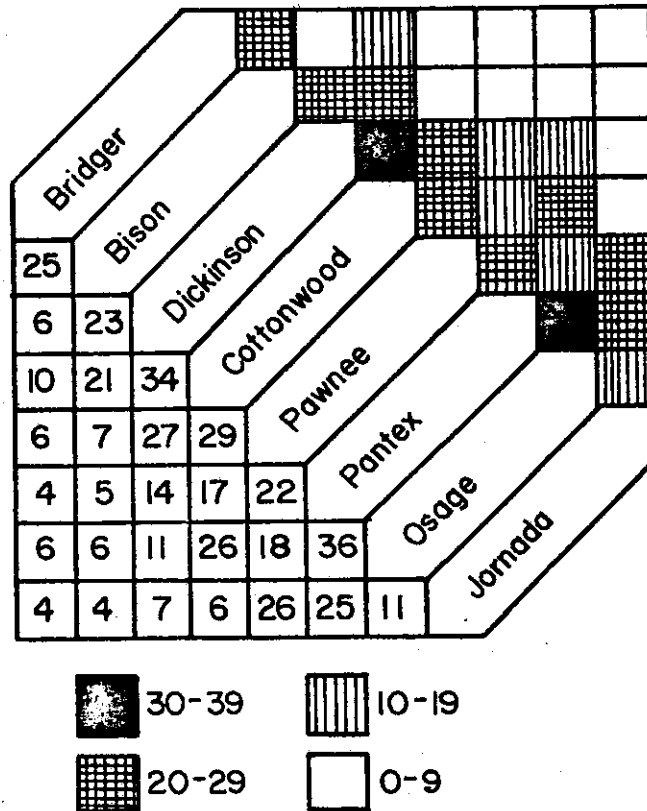


Fig. 3. Similarity matrix indicating Coefficients of Community between site pairs. Ordering of sites is the result of cluster analysis. Classes of shading were arbitrarily chosen. (After Hagmeier and Stults 1964).

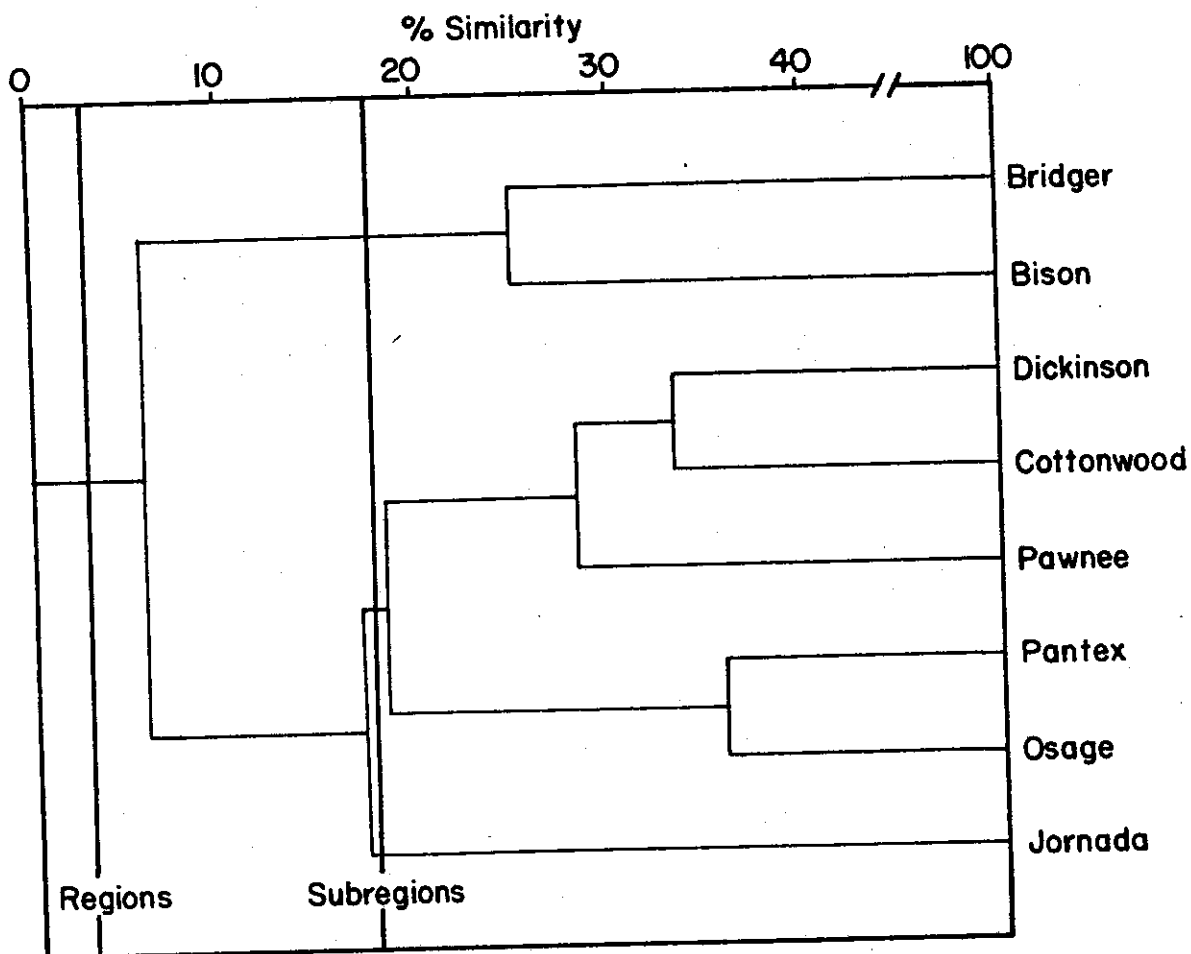


Fig. 4. Dendrogram depicting affinities among the eight sites resulting from cluster analysis. Coefficients of Community are represented by percent similarity. (After Hagmeier and Stults 1964).

Cartocraft Desk Outline Map, United States No. 1720, Exact Scale, 1:1,000,000

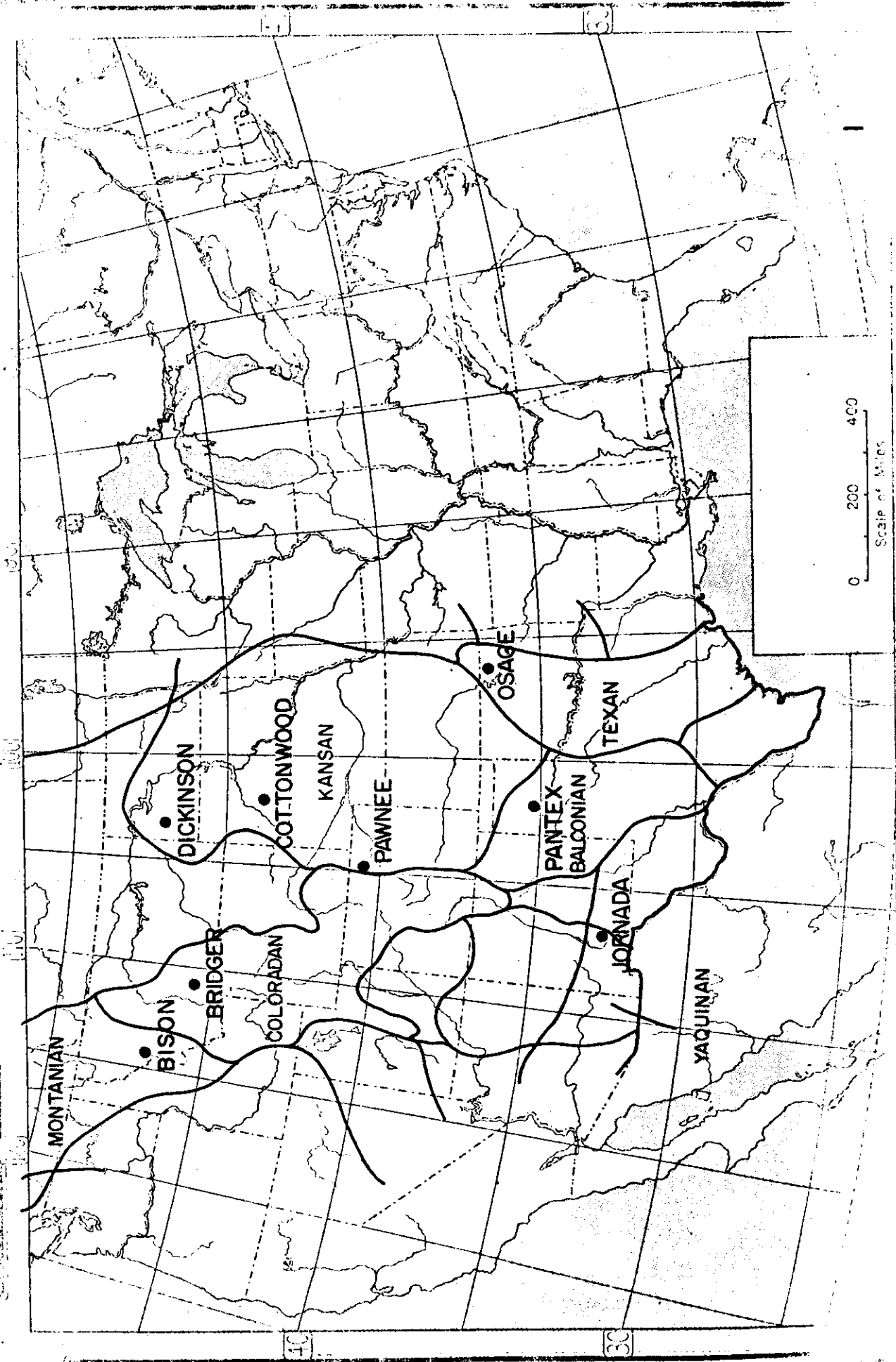


Fig. 5. Locations of eight sites in the Grassland Biome, including mammal provinces which include the sites.

and the corresponding Yaquinan province has only a slight affinity for the mentioned provinces.

An additional similarity which follows from the above is the designation of zoogeographic subregions. Hagmeier and Stults (1964) and Hagmeier (1966) apply the concept, dividing the Nearctic region into four such subregions by drawing a line across their dendrogram at a suitable level. A line across the dendrogram of Fig. 4 produces subregions consistent with theirs. Three subregions including the eight sites are shown in Fig. 6.

It may be observed that the percent similarity relating provinces in the mentioned studies is considerably greater than that relating sites in this study. The explanation reasonably lies in the fact that in the former much greater geographical areas and larger faunas are examined, resulting in higher Coefficients of Community.

In analyzing species densities of mammals, Simpson (1964) found only an irregular north-south gradient along a line approximately following the western axis of the United States. Along the 100th meridian, through the central portion of the United States, no increase in species density was evident. Line A-B of Fig. 1 is approximately parallel to the Rocky Mountains. Species' densities at the eight sites, projected along line A-B, are represented in Fig. 7. In Fig. 8 the same densities are projected along the 105th meridian, approximately through the center of the geographic area bounded by the eight sites (Fig. 7). Similar to Simpson's data, Fig. 7 and 8 show no regular north-south gradient in species' densities. However, with the fauna considered here, an overall increase in species' density along the two lines is suggested.

When the sites are ordered along line A-B of Fig. 1, the sequence associates those which are geographically closest to one another in a north-south

Cartocast Desk Outline Map, United States No. 17001 Excluding Alaska and Hawaii

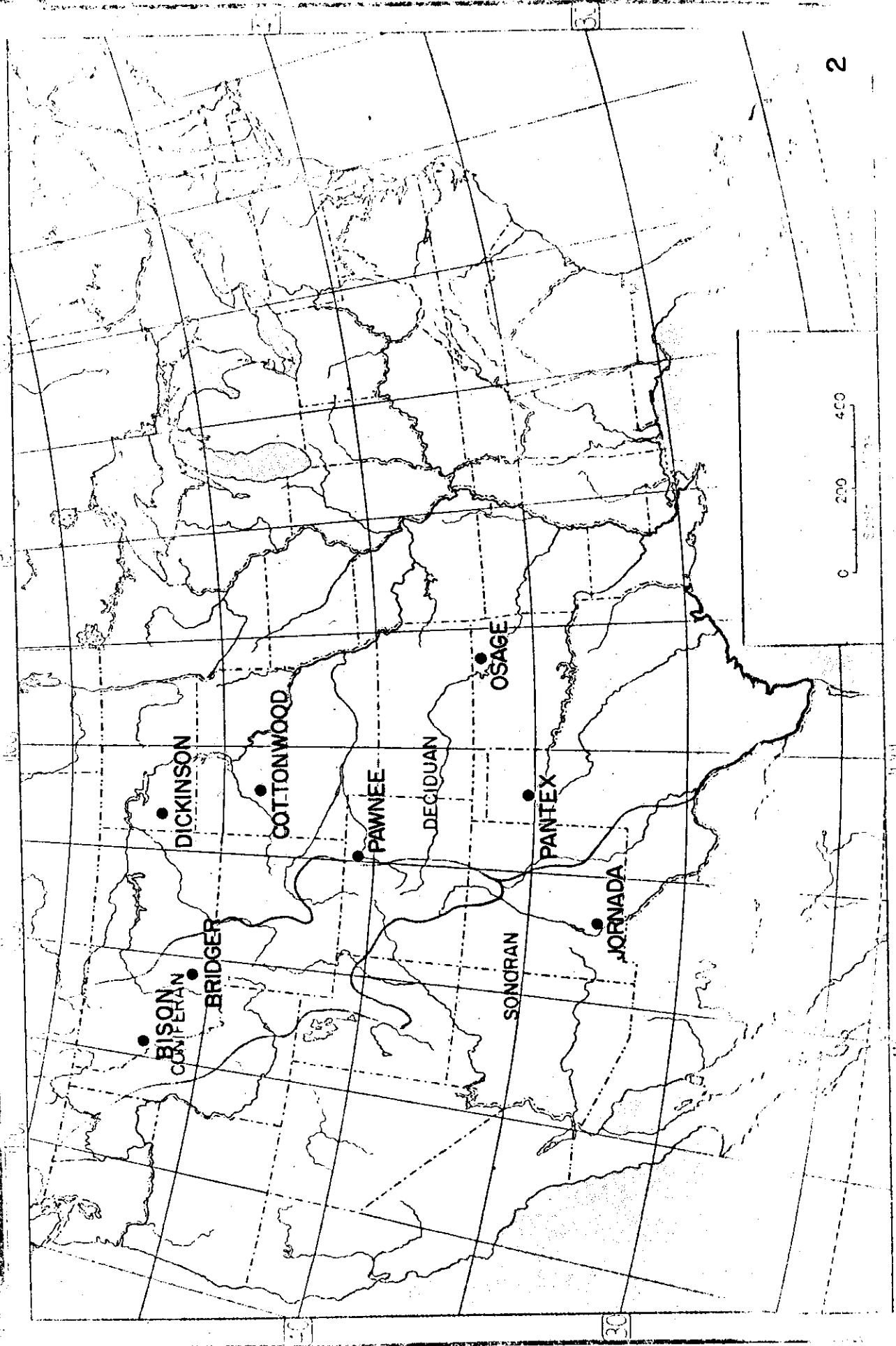


Fig. 6. Locations of eight sites in the Grassland Biome, indicating Nearctic subregions of Hagmeier (1966).

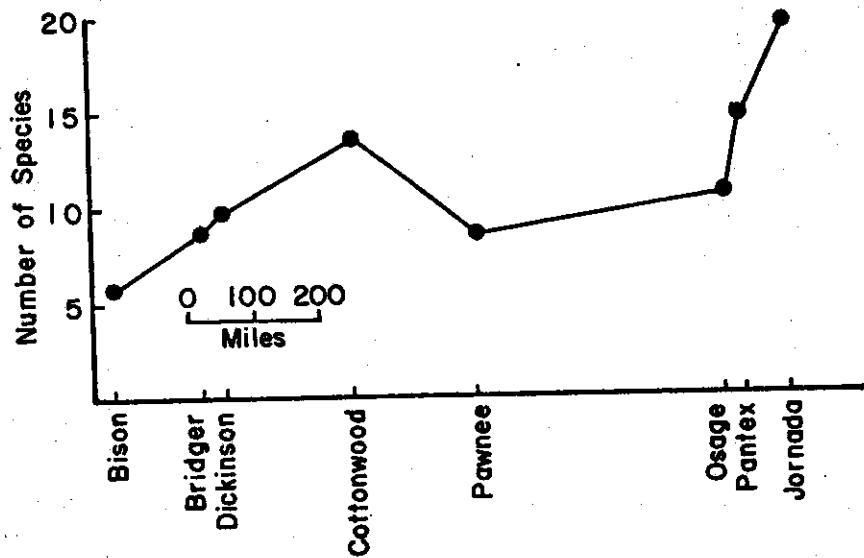


Fig. 7. Species densities at eight sites in the Grassland Biome projected along a line approximately parallel to the axis of the Rocky Mountains (line A-B of Fig. 1).

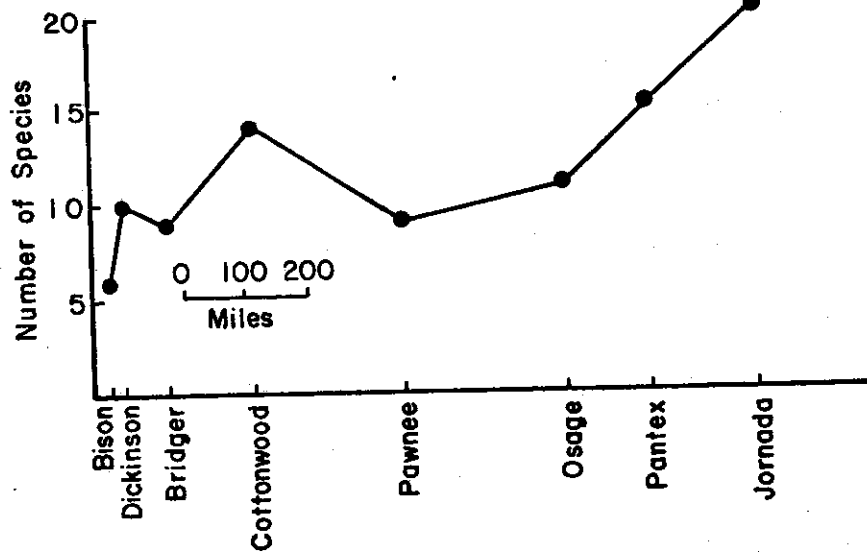


Fig. 8. Species densities at eight sites of the Grassland Biome projected along the 105th meridian (Fig. 1).

direction. Coefficients of Community so ordered are shown in the similarity matrix of Fig. 9. In the column at the left, CC's decrease as the northernmost site, Bison, is compared with sites progressively farther south. Examination of other columns in the matrix indicates that the relationship holds to some extent for other north-south sequences.

DISCUSSION

The principal criticism of the study must be the limited faunal lists which have been used. A more accurate understanding of the resemblances among sites seemingly would result if the total mammalian fauna around each site was considered. With the production of accurate lists, including Chiroptera, Carnivora, and Artiodactyla, such a fuller comparison will be possible. It is perhaps noteworthy that relationships among sites which have been demonstrated are analogous to provincial relationships described by Hagmeier (1966). Such similarities, in light of the extensiveness of Hagmeier's study, would seem to support the feasibility of identifying significant relationships among relatively small geographical areas. With respect to the comparability of the faunal lists, stricter definition will need to be made of the area sampled around each site.

Only those grassland sites of the US International Biological Program for which data was available have been compared. Data from additional sites in the United States, as well as those in Canada and Mexico, as obtainable, should be incorporated.

In addition to comparison of faunal lists, such a study might be extended to include faunal characteristics such as biomass, dormancy, and life form, as well as other data of ecological significance describing climate, vegetation, and soil (as suggested by Hagmeier and Stults 1964).

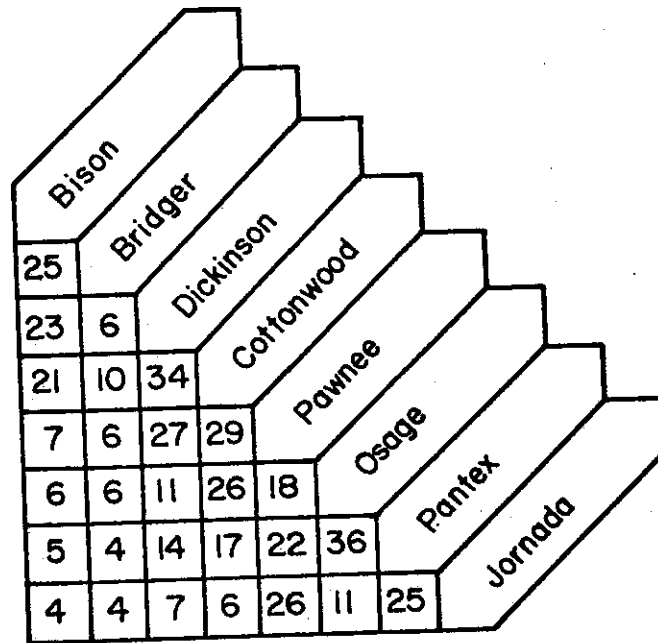


Fig. 9. Similarity matrix indicating Coefficients of Community. Ordering of sites is along line A-B of Fig. 1.

The data which have been employed are limited and incomplete, and in that sense erroneous. However, the study may be seen to have merit if viewed as the basis for similar, but more complete and expanded examinations of the relationships among various areas within the Grassland Biome.

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