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The Ornithogeography of the Great Plains States

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INTRODUCTION

It has long been recognized that the Great Plains represent a major transition zone in the distribution patterns of North American birds; field guides traditionally have treated the 100° W. longitude meridian as a convenient dividing line between eastern and western faunas. Furthermore, this line rather neatly bisects the political subdivisions of the Great Plains, namely the "plains states" extending from North Dakota southward through South Dakota, Nebraska, Oklahoma, and Texas. Of these, Texas is the least typical, its climate and fauna is strongly influenced by the Gulf Coast on the east and the Chihuahuan desert on the west. As a result of its size and ecological diversity Texas supports the largest array of breeding bird species of any state in the nation. Thus, in the present analysis it was decided to eliminate from consideration all but the northwestern "panhandle" of Texas, which consists of the grassland-dominated "staked plains." Further, to facilitate the faunistic analysis, limiting lines of latitude and longitude were selected that not only encompassed all five other states mentioned, but also parts of several adjoining ones. After some deliberation, it was decided to define the coverage of the analysis as extending from the U.S.-Canadian border (49° N. latitude) southward to 34° N. latitude in Texas, following this line eastward until it intersects with the Texas-Oklahoma boundary, and continuing eastwardly along the boundary to the eastern limit of Oklahoma. The western limit was defined as the 104° W. longitude meridian, which essentially conforms with the western boundaries of the Dakotas and the Nebraska "panhandle", and continues southward through the eastern portion of Colorado and New Mexico. The eastern limit was selected as the 95° W. longitude meridian, which includes the prairie areas of western Minnesota, the western edge of Iowa, and a small part of extreme northwestern Missouri. Where this line intersects with the Missouri River along the Missouri-Kansas border, the coverage was continued eastwardly to include the extreme eastern portions of Kansas and Oklahoma (Fig. 1).

The area thus enclosed includes all of five states, parts of six others, and comprises a maximum north-south distance of slightly more than 1,000 mi, as well as a maximum east-west distance of nearly 550 mi. The total surface area includes 502,000 mi^2, or 17 percent of the land area of the 48 contiguous United States. It lies almost entirely within the "grassland climax" as mapped by Clements and Shelford (1939), and perhaps represents about the largest land area south of Canada having a relatively uniform floristic nature that could be established for purposes of analysis. A very similar area was selected for an inventory of the Great Plains plant flora (Barkley 1977).

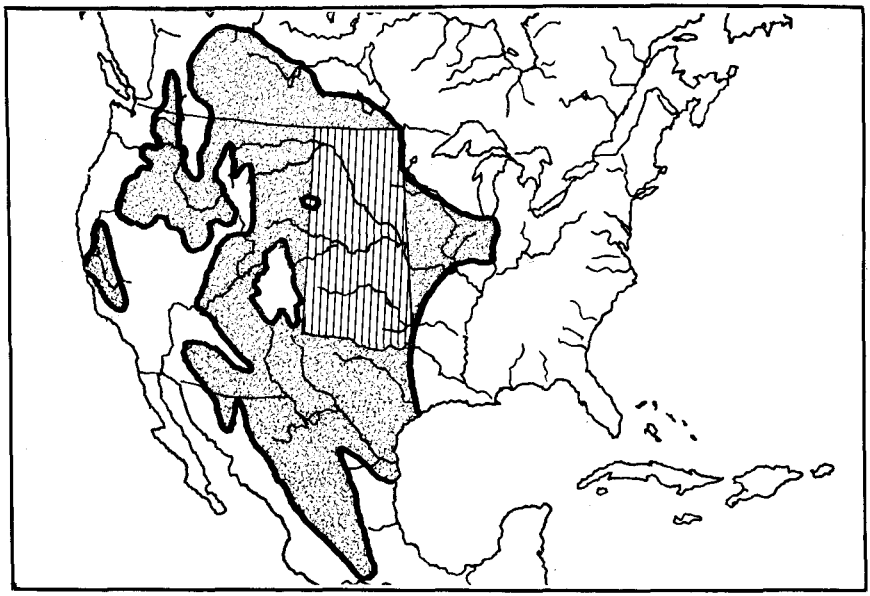

Fig. 1. The distribution of the grassland climax vegetation type as mapped by Clements and Shelford (1939) relative to the region selected for analysis (vertical hatching).

Although there are minor variations, the overall topography of this region is that of an inclined plain, which slopes downward from the west to the east at an average gradient of about ten ft. p. mi. The highest point in the region is Sierra Grande, in northwestern New Mexico, at 8,732 ft. above sea level, while the lowest point is in southeastern Oklahoma, at 323 ft. above sea level. To the north, the Black Hills of South Dakota provide a secondary montane influence, with a maximum elevation of 7,242 ft. provided by Harney Peak. Along the eastern limits the only highlands of significance are the Ouachita Mountains, a part of the Ozark Plateau, which attain a maximum height in excess of 2,000 ft. Over nearly the entire area, the general water drainage is to the southeast into the Missouri and Mississippi systems, but in North Dakota the Souris and Red Rivers are part of the Hudson Bay drainage system.

Approximately the northern half of the total region has been markedly affected by the action of glaciers, of which the most recent or Wisconsin age glaciation has had the strongest effect on present-day landforms. Most of eastern and northern North Dakota, parts of eastern South Dakota, and all of western Minnesota bear such glacial scars as ground moraine, dead ice moraines, and end moraines. The entire Red River Valley represents a lake plain that was once covered by glacial Lake Agassiz, and which drained and retreated northward less than 10,000 years ago. Likewise the Souris Lake plain of north-central North Dakota and several other smaller lake plains and areas of deltaic sands associated with glacial lakes provide similar evidence of glaciation. West of the Missouri River the uplands consist of many extensively eroded plains, with buttes, bedrock

valleys, and highly eroded "badlands" marked by dry valleys, steep and dry slopes, and sharp ridges, which provide excellent habitats for a variety of cliff-nesting bird species.

The pattern of rainfall throughout this region is relatively simple. In general, it increases from the northwest to the southeast, at the approximate rate of about one in. per 40 mi. at the northern edge of the region, and one in. per 10 mi. at the southern edge. The wettest locality in the region is Ouachita Mountains of southeastern Oklahoma, with more than 50 in. of precipitation annually, while less than 13 in. of annual precipitation occurs near Clayton, Union County, New Mexico. About three-fourths of the rainfall occurs during the growing season, which ranges from about 100 days in northern North Dakota to 240 days in extreme southeastern Oklahoma. However, evaporation rates also increase correspondingly as one proceeds southward. The highest rates of annual evaporation (as measured from lake surfaces) occur in the staked plains region, where evaporation rates more than four times greater than the annual precipitation rates are characteristic. Much lower evaporation rates are typical of the cooler and more northerly states, and thus parts of eastern North Dakota can support a lush tall-grass prairie vegetation with less than 20 in. of precipitation per year, while the same amount of precipitation on the staked plains allows only for the barest stands of buffalo grass and other xeric-adapted plants.

Although enormous changes have occurred in the vegetation of the region, numerous historical records and sufficient relict communites still exist to provide a reasonable basis for mapping the original distribution of vegetation types through the region. Largely on the basis of the vegetation map asembled by Küchler (1964), it is possible to estimate the relative abundance of major plant communities that once covered the land surface of the region under consideration. Using such criteria, it seems likely that the 502,000 mi.^{2} area was once 81 percent grasslands, 13 percent hardwood deciduous forest or forest-grassland mosaic, 3 percent sagebrush grasslands, and 2 percent coniferous forest or coniferous woodland. The remaining one percent is now covered by surface water, predominantly of recent origin resulting from river impoundments.

METHODS AND RESULTS

Using a variety of published and unpublished records, distribution maps were drawn for all of the species known to breed within the geographic limits established. These will be published later (Johnsgard, in press), but the data assembled indicate that a minimum of 324 species have recently bred or currently breed in the area under consideration. Five of these are introduced species, and were excluded from the analysis, and another seven species are either extinct or have been extirpated from the region. Of the 312 remaining species, about 260 are "regular" breeders. Thus well over 50 percent of America's continental breeding bird fauna is included within the region's geographic limits, in spite of the fact that it is less than a fifth of the total area of the U.S.A. excluding Alaska. This is a rather surprising statistic, since the endemic Great Plains bird fauna is known to be a relatively meager one, consisting of only some 32 (Udvardy 1958) to 38 (Mengel 1970) species, or about 5 percent of North America's total avifauna.

Bases for analyzing the zoogeographic categories were as follows:

Endemic: Largely limited to the grasslands or marshes of the Great Plains.

Pandemic: Having a large continuous or disruptive distribution pattern not clearly associated with specific major vegetational types.

Introduced: Added purposefully or accidentally to the fauna.

Northern: Having a breeding distribution generally associated with boreal forest areas to the north or northeast of the region in question.

Eastern: Having a breeding distribution generally associated with deciduous forest areas to the east or southeast of the region in question.

Southern: Having a breeding distribution generally associated with deserts or scrublands to the south or southwest of the region in question.

Western: Having a breeding distribution generally associated with montane forests to the west or northwest of the region in question.

The ecological distributional categories were as follows:

Grassland species: Having a breeding distribution generally associated with grasslands.

Arboreal species: Having a breeding distribution associated with deciduous or coniferous forests or woodlands.

Xeric Scrub species: Having a breeding distribution associated with sage or other arid-adapted and shrub-dominated vegetational types.

Limnic species: Having a breeding distribution associated with marshes, rivers, lakes, or other surface-water habitats.

Miscellaneous: Having a breeding distribution not specifically associated with any of the above categories.

Three additional categories relative to abundance are also included:

Accidental: One or two recent breeding records, but the normal breeding range is well beyond the limits of the area under consideration.

Extirpated: No longer breeds in the area under consideration but still exists elsewhere.

Extinct: The species evidently no longer exists elsewhere.

A listing of all the species included in this analysis, together with their geographic and ecologic affinities, may be found in Tables 1 to 5, and a numerical summary of these listing appears in Table 6. From these tables it is clear that the greatest single component of the breeding bird biota is provided by arboreal species, which represent more than half of the total bird fauna, although woodlands and forests occupy only 15 percent of the region's surface area. In contrast, although grasslands cover 81 percent of the area, grassland species comprise only 11 percent of the total bird faunal diversity. The small percentage of xeric scrub species (4%) corresponds closely with the approximate percentage (3%) of sagebrush grasslands relative to the total area. An estimate of the value of marshes and other surface water areas to breeding birds is provided by the fact that, although such habitats occupy only about one percent of the region's total area, limnic species make up 21 percent of the breeding bird fauna.

The zoogeographic influences of regions continuous to the Great Plains become evident when one considers the geographic affinities of the bird fauna, as summarized in Table 6. The largest single component (27%) is eastern, and as might be expected these are nearly all of deciduous forest species. The next largest component (23%) is of species having pandemic distributions, particularly forest and limnic species. Species with western affinities make up nearly a fifth of the total, and these are in large measure birds of the Rocky Mountain coniferous forests. Species with northern affinities comprise 17 percent, and most of these are birds of the coniferous boreal forests of Canada and the Great Lakes States. The influence of southern species is relatively low, consisting of 7 percent of the total, and many of these are xeric scrub or desert-adapted forms of the Chihuahuan aridlands. In spite of the vast area represented by the Great Plains grasslands, only 5 percent of its bird fauna may be considered endemic, half of which is comprised of grassland-adapted sparrows, while several others are shorebirds associated with low meadows or prairie marshes.

Although this overall pattern of affinities is in itself instructive, a more "fine-grained" analysis is obviously desirable for estimating the rate of change in faunal composition along gradients of longitude and latitude. For this purpose the region was subdivided into smaller segments. The 15 degrees of latitude were divided into four units, comprised of one northernmost 3° unit and three 4° units. The approximately 9 degrees of longitude were divided into five units, comprised of four 2° units and one easternmost unit that varies in width from 1° to nearly 2° at the southernmost limits (Fig. 2).

Using transparent overlay maps with the lines of latitude and longitude thus established, the distribution maps of all the extant and non-introduced species of birds were plotted, and a checkmark was made in each quadrant encompassing the species' breeding range. Single records of "accidental" breedings or extralimital breeding records beyond the species "normal" breeding range were ignored. In this manner, it was possible to establish patterns of distribution for the four primary ecological groups defined earlier (arboreal, limnic, grassland, xeric scrub) and for the four major zoogeographic categories (northern, eastern, southern, and western). For obvious reasons, pandemic and "miscellaneous" ecological affinities were excluded from the analysis, as was the endemic category.

Table 1. Species Associated with Woodlands and Forests

Eastern	Northern	Pandemic	Western	Southern
Mississippi Kite	Bald Eagle	Cooper's Hawk	Broad-tailed Hummingbird	Golden-fronted Woodpecker
Red-shouldered Hawk	Goshawk	Sharp-shinned Hawk	Northern 3-toed Woodpecker	Ladder-backed Woodpecker
Broad-winged Hawk	Merlin	Red-tailed Hawk	Lewis's Woodpecker	Scissor-tailed Flycatcher
American Kestrel	Spruce Grouse	Wild Turkey	Western Kingbird	Black-crested Titmouse
Bobwhite	Woodcock	Ruffed Grouse	Cassin's Kingbird	Black-capped Vireo
Black-billed Cuckoo	Saw-whet Owl	Mourning Dove	Ash-throated Flycatcher	Great-tailed Grackle
Barred Owl	Black-backed 3-toed Woodpecker	Yellow-billed Cuckoo	Say's Phoebe	Blue Grosbeak
Chuck-wills-widow	Olive-sided Flycatcher	Screech Owl	Western Flycatcher	Painted Bunting
Whip-poor-will	Yellow-bellied Sapsucker	Long-eared Owl	Dusky Flycatcher	
Chimney Swift	Gray Jay	Great Horned Owl	Western Wood Pewee	
Ruby-throated Hummingbird	Boreal Chickadee	Common Flicker	Scrub Jay	
Pileated Woodpecker	Brown Creeper	Hairy Woodpecker	Pinyon Jay	
Red-bellied Woodpecker	Winter Wren	Downy Woodpecker	Black-billed Magpie	
Red-headed Woodpecker	Veery	Willow Flycatcher	Plain Titmouse	
Red-cockaded Woodpecker	Hermit Thrush	Common Raven	Common Bushtit	
Eastern Kingbird	Swainson's Thrush	Common Crow	Red-breasted Nuthatch	
Great Crested Flycatcher	Ruby-crowned Kinglet	Black-capped Chickadee	Pygmy Nuthatch	
Eastern Phoebe	Golden-crowned Kinglet	White-breasted Nuthatch	Townsend's Solitaire	
Acadian Flycatcher	Solitary Vireo	House Wren	Mountain Bluebird	
Least Flycatcher	Philadelphia Vireo	American Robin	MacGillivray's Warbler	
Eastern Wood Pewee	Northern Waterthrush	Cedar Waxwing	Western Tanager	
Blue Jay	Palm Warbler	Loggerhead Shrike	Black-headed Grosbeak	
Fish Crow	Nashville Warbler	Warbling Vireo	House Finch	
Carolina Chickadee	Tennessee Warbler	Yellow Warbler	Lazuli Bunting	
Tufted Titmouse	Magnolia Warbler	Yellow-breasted Chat	Lesser Goldfinch	
Brown-headed Nuthatch	Cape May Warbler	Brown-headed Cowbird		
Bewick's Wren	Blackburnian Warbler	Northern Oriole		
Carolina Wren	Bay-breasted Warbler	American Goldfinch		
Mockingbird	Yellow-rumped Warbler	Rufous-sided Towhee		
Gray Catbird	Mourning Warbler	Chipping Sparrow		
Brown Thrasher	Canada Warbler	Song Sparrow		
Wood Thrush	Evening Grosbeak			
Eastern Bluebird				

Eastern	Northern	Pandemic	Western	Southern
Blue-gray Gnatcatcher	Purple Finch			
White-eyed Vireo	Red Crossbill			
Bell's Vireo	Pine Siskin			
Yellow-throated Vireo	Dark-eyed Junco			
Red-eyed Vireo	White-throated Sparrow			
Black and White Warbler				
Prothonotary Warbler				
Swainson's Warbler				
Golden-winged Warbler				
Blue-winged Warbler				
Northern Parula				
Black-throated Blue Warbler				
Black-throated Green Warbler				
Cerulean Warbler				
Yellow-throated Warbler				
Chestnut-sided Warbler				
Pine Warbler				
Prairie Warbler				
Ovenbird				
Louisiana Waterthrush				
Kentucky Warbler				
Hooded Warbler				
American Redstart				
Common Grackle				
Orchard Oriole				
Summer Tanager				
Scarlet Tanager				
Cardinal				
Rose-breasted Grosbeak				
Indigo Bunting				

Table 2. Species Associated with Limnic Environments

Pandemic	Western	Eastern	Northern	Endemic
Pied-billed Grebe	Western Grebe	Black Duck	Common Loon	Wilson's Phalarope
Double-crested Cormorant	Eared Grebe	Wood Duck	Red-necked Grebe	Franklin's Gull
Canada Goose	White Pelican	Hooded Merganser	Horned Grebe	
Green-winged Teal	Trumpeter Swan	Green Heron	Ring-necked Duck	
Mallard	American Wigeon	Little Blue Heron	Bufflehead	
Pintail	Gadwall	Yellow-crowned Night Heron	White-winged Scoter	
Blue-winged Teal	Cinnamon Teal		Common Goldeneye	
Northern Shoveler	Canvasback	Cattle Egret	Common Merganser	
Great Egret	Redhead	American Bittern	Greater Sandhill Crane	
Snowy Egret	Lesser Scaup	Least Bittern	Yellow Rail	
Great Blue Heron	Ruddy Duck	King Rail	Common Snipe	
Black-crowned Night Heron	Snowy Plover	Black Rail	Swamp Sparrow	
Virginia Rail	American Avocet	Common Gallinule		
Sora	Black-necked Stilt	Purple Gallinule		
American Coot	California Gull	Short-billed Marsh Wren		
Piping Plover	Ring-billed Gull			
Spotted Sandpiper	Yellow-headed Blackbird			
Willet				
Common Tern				
Forster's Tern				
Black Tern				
Least Tern				
Long-billed Marsh Wren				
Red-winged Blackbird				
Common Yellowthroat				

Table 3. Species Associated with Grasslands

Endemic	Western	Pandemic	Eastern	Northern
Pinnated Grouse	Ferruginous Hawk	Marsh Hawk	Eastern Meadowlark	Sharp-tailed Grouse
Mountain Plover	Swainson's Hawk	Short-eared Owl	Bachman's Sparrow	
Long-billed Curlew	Prairie Falcon	Horned Lark	Field Sparrow	
Marbled Godwit	Burrowing Owl	Bobolink	Henslow's Sparrow	
Upland Sandpiper	Poor-will	Savannah Sparrow		
White-necked Raven	Western Meadowlark	Grasshopper Sparrow		
Dickcissel	Brewer's Blackbird	Vesper Sparrow		
Baird's Sparrow				
LeConte's Sparrow				
Lark Bunting				
Clay-colored Sparrow				
Cassin's Sparrow				
McCown's Longspur				
Chestnut-collared Longspur				
Sprague's Pipit				

Table 4. Species Associated with Xeric Scrub

Southern	Western
Scaled Quail	Sage Grouse
Roadrunner	Rock Wren
Verdin	Canyon Wren
Curve-billed Thrasher	Sage Thrasher
Gray Vireo	Green-tailed Towhee
Brown Towhee	Brown Towhee
Rufous-crowned Sparrow	Brewer's Sparrow
Black-throated Sparrow	

Table 5. Miscellaneous, Accidental, Introduced and Extirpated or Extinct Species

Miscellaneous	Accidental	Introduced	Extirpated	Extinct
Turkey Vulture (P)*	Anhinga (E)	(successfully)	Blue Grouse (W)	Passenger Pigeon (E)
Black Vulture (S)	Tricolored Heron (E)	Ring-necked Pheasant	White-tailed Kite (S)	Carolina Parakeet (E)
Golden Eagle (W)	White-faced Ibis (W)	Gray Partridge	Swallow-tailed Kite (S)	Ivory-billed Woodpecker (E)
Osprey (P)	Fulvous Whistling Duck (S)	Rock Dove	Whooping Crane (N)	
Peregrine (P)	Mottled Mallard (S)	House Sparrow		
Barn Owl (P)	Caspian Tern (P)	Starling		
Common Nighthawk (P)	Harris's Hawk (S)	(uncertain status)		
White-throated Swift (W)	Great Gray Owl (N)	Chukar Partridge		
Belted Kingfisher (P)	Vermilion Flycatcher (S)			
Violet-green Swallow(W)	Gray Vireo (S)			
Tree Swallow (N)	Worm-eating Warbler (E)			
Bank Swallow (P)	Evening Grosbeak (N)			
Rough-winged Swallow (P)	White-winged Crossbill (N)			
Barn Swallow (P)				
Cliff Swallow (P)				
Purple Martin (P)				
Dipper (W)				

P—Pandemic, S—Southern, W—Western, N—Northern, E—Eastern

Table 6. Summary of Listings of Species in Tables 1 to 5 — Geographic Affinities of Species

Ecologic Affinities of Species	Eastern	Northern	Western	Southern	Pandemic	Endemic	Introduced	Totals
Woodland & Forest spp.	63	37	25	8	31	—	—	164(51%)
Limnic spp.	14	12	17	—	25	2	—	70(22%)
Grassland spp.	4	1	7	—	7	15	—	34(11%)
Xeric Scrub spp.	—	—	7	8	—	—	—	15(4%)
Other spp.	6	5	5	8	12	—	5	41(12%)
Totals	87	55	61	24	75	17	5	324
%	27%	17%	19%	7%	23%	5%	2%	

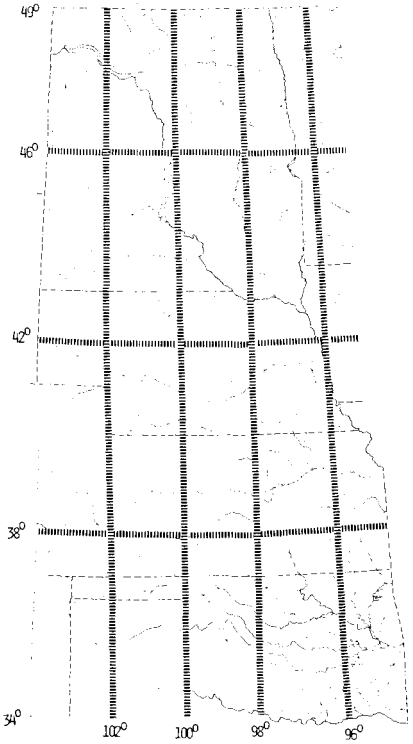

Fig. 2. The area encompassed by the analysis, and quadrants of latitude and longitude used for subdividing the region.

Perhaps the simplest method of presenting the resulting data is attained by recording the total number of breeding species having identified geographical or ecological affinities that are known to breed in each of the quadrants of latitude and longitude (Table 7). It may be noted that the species total not only varies between quadrants, but also that the totals reported for the geographical analysis are always less than those of the ecological analysis. This is because although some species listed as "miscellaneous" in their ecological affinities have distinct geographic affinities, a much greater number of the pandemic or endemic species can be classified as to their ecological affinites. This table also shows the strong influence of limnic and grassland-associated birds in the northern parts of the region, and the increasingly greater influence of forest-adapted birds toward the east and southeast. Throughout the region, the influence or xeric scrub remains relatively small. Likewise, the western montane influence is stronest in the quadrant comprising the Black Hills, the northern influence is strongly apparent in the northeasternmost quadrant, the eastern influence is greatest in the southeasternmost quadrant, and the southern influence is relatively low throughout, but is strongest in the quadrant including the Red River Valley of southwestern Oklahoma.

A more readily visualized method of presenting these results is to convert them into graphic form, plotting the numerical data according to gradients of latitude or longitude. After some experimentation, it was found that these ecological and zoogeographical trends might be effectively illustrated by converting the absolute numbers into relative ones, based on interactions of two essentially opposite trends. Thus, rather than plotting the changes in numbers of grassland-adapted species by zones of latitude (as can be readily done by extracting

Table 7. Numbers of Species with Directional or Ecological Affinities Breeding in Quadrants of Longitude and Latitude within Region

	Longitude				
	102-104°	100-102°	98-100°	96-98°	95-95°
Latitude					
46-49°					
Scrub	2	1	0	0	0
Grass	31	31	28	28	17
Limnic	32	42	44	49	38
Arboreal	48	53	57	62	100
Total	113	127	129	139	155
North	4	8	18	17	51
West	29	23	19	17	10
South	0	0	0	0	0
East	18	27	30	33	40
Total	51	58	67	67	101
42-46°					
Scrub	4	1	0	0	0
Grass	31	30	29	28	19
Limnic	27	32	39	37	40
Arboreal	83	56	59	66	58
Total	145	119	127	131	117
North	22	5	5	7	9
West	44	24	21	16	10
South	1	1	1	1	1
East	24	32	35	41	41
Total	91	62	62	65	61
38-42°					
Scrub	2	2	1	0	0
Grass	28	23	21	16	14
Limnic	28	28	30	27	23
Arboreal	46	63	58	72	80
Total	104	116	110	115	117
North	2	1	2	2	2
West	29	22	16	12	2
South	2	3	2	2	3
East	20	30	36	47	58
Total	53	56	56	63	65
34-38°					
Scrub	9	6	6	2	2
Grass	20	20	16	13	12
Limnic		18	25	20	19
Arboreal	59	58	77	81	81
Total	99	102	124	116	114
North	0	0	0	0	0
West	32	20	16	7	1
South	10	10	14	8	7
East	19	30	50	60	68
Total	61	60	80	75	76

the information in Table 7), it is more instructive to plot the percent of arboreal species, minus that of grassland forms associated with each of these quadrants. A number representing the excess of arboreal-adapted over grassland-adapted species occurring in each quadrant can thus be easily obtained, and plotted according to latitude or longitude (Fig. 3). Similarly, the excess of limnic-adapted over scrub-adapted species was determined (Fig. 4). The resulting patterns generally confirm the impression of relative environmental homogeneity and gradual ecological gradients in the Great Plains. The east-west gradient in species composition from arboreal to grassland-adapted is most uniform in the southern plains (34-38° latitude), and the demarcation is sharpest in the northern plains, where the primary "break" occurs between 95 and 98° longitude (Fig. 3). Likewise, the north-south gradient in species composition trends of limnic-dependent to scrub-adapted forms is a rather gradual one, especially between the 95th and 102nd meridians (Fig. 4). To the west, the influence of the Black Hills and Chihuahuan deserts become more apparent, and in the extreme east the overwhelming effect of the arboreal-adapted forms tends to obscure the trends.

The gradients of east-west and north-south zoogeographic affinities can be illustrated in the same manner (Figs. 5 and 6). In Figure 5, a plotting of the numbers of northern *versus* southern species is presented according to the five zones of longitude defined earlier. Once again, the most uniform and gradual gradients may be seen between the 96th and 102nd meridians, where a nearly straight-line gradient exists, while to the west the Black Hills produces a "bulge" of boreal-adapted species, and to the east the high incidence of northern forms in northern Minnesota is strongly illustrated. Interestingly, however, the zone of equality between species of northern and southern affinities remains constant, and occurs at about 40° N. latitude in all cases.

Lastly, the representation of the transition in dominance of eastern *versus* western species provides an interesting example of the zoogeographic gradients to

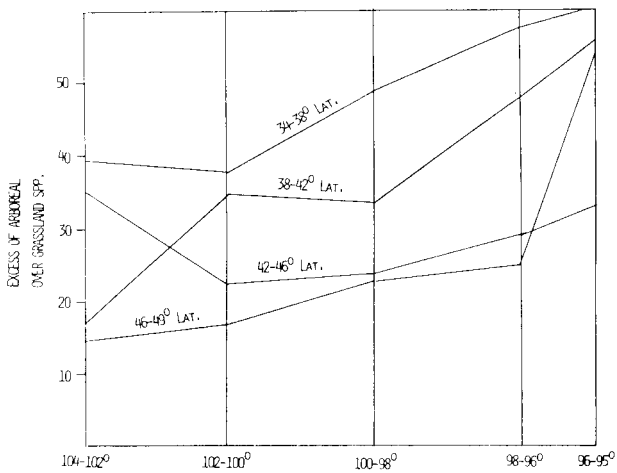

Fig. 3. The rate of change in arboreal relative to grassland species of birds along east-west gradients of latitude in the Great Plains.

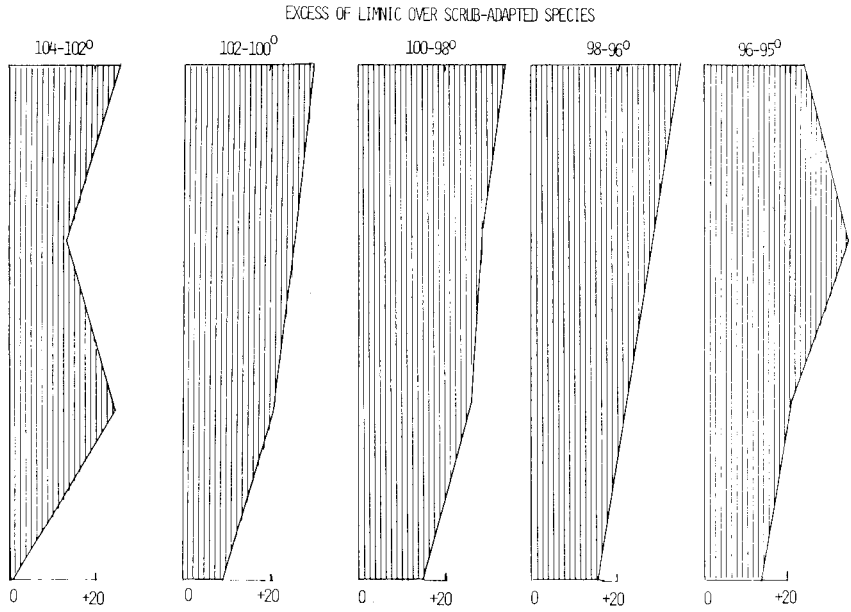

Fig. 4. The rate of change in limnic relative to scrub-adapted species of birds along north-south gradients of longitude in the Great Plains.

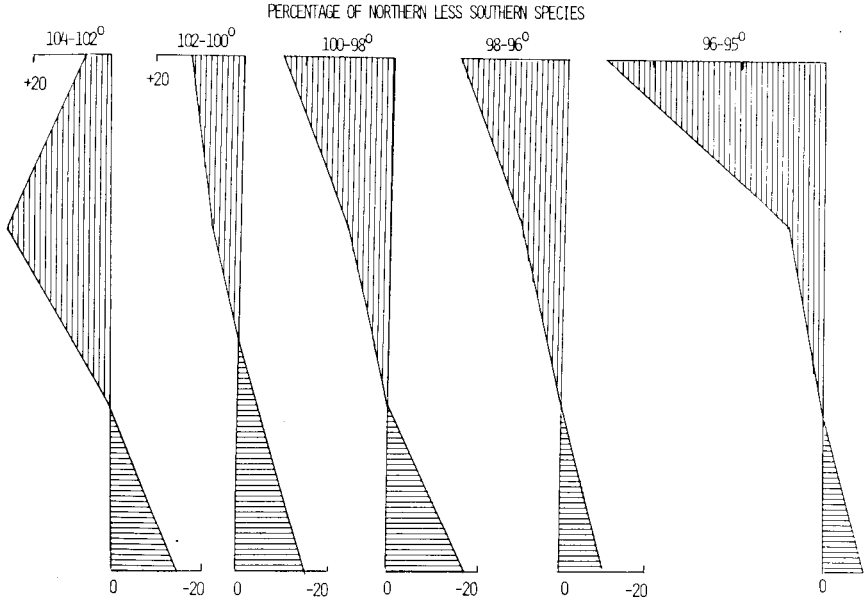

Fig. 5. The rate of change in northern relative to southern species of birds along north-south gradients of longitude in the Great Plains.

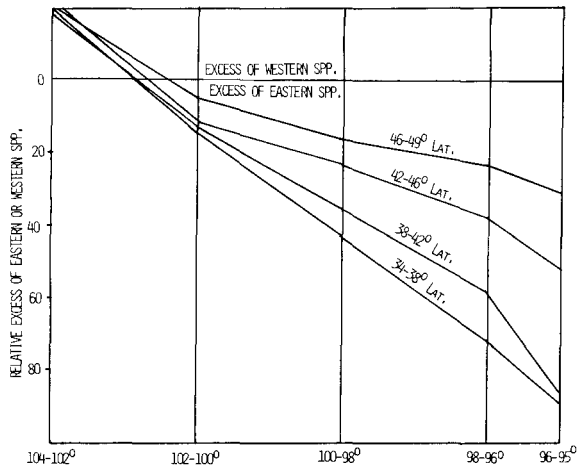

Fig. 6 The rate of change in eastern relative to western species of birds along east-west gradients of latitude in the Great Plains.

be seen in the Great Plains (Fig. 6). Over most of the region concerned, there is a predominance of species having eastern affinities, and only in the westernmost segment (102-104th meridian) is there an excess of western-associated species. At all latitudes the transition in dominance between eastern and western forms occurs at about the 102nd meridian, thus confirming the general dictum of the 100th meridian being a convenient dividing line for the two faunas. Interestingly, an analysis of wintering bird populations in the Great Plains states (Bock et al. 1977) also suggests that the vicinity of the 100th meridian represents a major biogeographic boundary between eastern and western bird faunas. The gradient of transition varies considerably to the east of this meridian, being most rapid at southern latitudes and is least evident at northern latitudes.

DISCUSSION AND CONCLUSIONS

Rather than regarding the Great Plains as a center of evolutionary diversity and speciation in birds, it is perhaps better regarded as a natural barrier or isolating agent in avian speciation, as is indicated by the relatively small number of endemic species associated with the plains. The Great Plains may thus be thought of as resembling an ocean, physically separating major faunas to varying degrees, but also acting like a semipermeable barrier to the bird faunas associated with Canada's boreal forest, the deciduous forest of the eastern and southeastern United States, the Rocky Mountain coniferous forests, and the aridlands of the American southwest.

Mengel (1970) has suggested that the central and southern parts of the Great Plains may have been periodically covered by savannah, pine parklands, and even boreal forests during periods of glaciation, which may have seriously interfered with speciation during those periods. Hubbard (1974) has also examined Pleistocene history as a possible basis for present-day distribution patterns and

speciation characteristics of birds in the southwestern aridlands. Rising's (1974) analysis of the summer birds of western Kansas produced similar results to mine, namely that a predominance (46 percent) of the breeding species exhibit arboreal adaptations and have their zoogeographic affinities with eastern North America, while the proportions of grassland and xeric scrub-adapted forms collectively comprise 23 percent, while limnic-adapted forms total 22 percent. My results for western Kansas agree quite closely with his for the same general region.

The general conclusions to be drawn from these analyses are that, ornithologically at least, the Great Plains represent a relatively homogeneous unit, without sharp zoogeographic breaks. Yet, within the plains area about 275 bird species reach the limits of some part of their breeding ranges, and the region is thus of extraordinary interest to ecologists and evolutionists. The region includes numerous cases of range contact or range overlap between eastern and western species pairs, and the 100th meridian closely conforms to the primary zone of hybridization in many of these species-pairs (Bock et al. 1977). A corresponding analysis of plant distribution gradients for the entire plains area is not yet available, but is feasible now that an atlas of Great Plains plants (Barkley 1977) has been published. In any case, it is known that a considerable number of eastern and western species of plants as well as animals come into contact east of the Rocky Mountains, and that this area may be the most active biological "suture-zone" in North America (Remington 1968).

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