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SUBTLE RECENT DISTRIBUTIONAL SHIFTS IN GREAT PLAINS BIRD SPECIES

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ABSTRACT—Changes in geographic distributions of 5 bird species endemic to the Great Plains of North America were examined over the last few decades based on the United States Breeding Bird Survey. Examining the mean latitude of individuals of each species, 3 species showed significant or near-significant northward shifts, and 1 a significant shift southward. Over all 5 species examined, colonization events were concentrated in the northern part of the distributions of the species; in 3 species, extinctions were concentrated in the southern part of the distributions of the species. The conclusion is that significant distributional changes have taken place, but they have been subtle, and might be associated with global climate change.

RESUMEN—Se examinaron los cambios en la distribución geográfica de 5 especies de aves en las Grandes Planicies de Norteamérica a través de las últimas décadas con base a datos del United

States Breeding Bird Survey. Examinando la latitud promedio de individuos de cada especie, 3 especies mostraron traslaciones significativas o casi-significativas hacia el norte, y 1 significativa hacia el sur. Para las 5 especies, colonizaciones se enfocaron en la parte norteña de las distribuciones de las especies, y en 3 especies las extinciones se enfocaron en la parte sureña de sus distribuciones. La conclusión es que han habido cambios distribucionales significativos, pero sutiles, posiblemente asociados al cambio de clima global.

Global climates are in the process of rapid change, apparently owing to the effects of human activities on the Earth's atmosphere (Houghton et al., 1995). Although subtle when observed over short time-spans (Hulme et al., 1999), changes are real. Indeed, significant effects on elements of biodiversity have already been documented, including distributional and phenological shifts in species and ecosystems (Parmesan, 1996; Allen and Breshears, 1998; Visser et al., 1998), among other examples. However, the magnitude and commonness of such effects are only now being appreciated. This note documents subtle northward colonization and southern extinction in bird species in North America.

The United States Breeding Bird Survey (BBS) data represent an extremely valuable source of information on bird distributions, especially in that they comprise long time series of repeated, standardized surveys. I chose for analysis bird species endemic or at least concentrated in the portion of the Great Plains well covered by the BBS (the United States and southernmost portion of Canada). I further reduced the study area to coincide with areas known to have experienced a fairly uniform increase in annual mean temperatures over the past 3 decades (Karl et al., 1996). To focus on whole-distribution effects, I eliminated Great Plains species with significant populations farther east (e.g., upland sandpiper, *Bartramia longicauda*), west (e.g., Brewer's sparrow, *Spizella breweri*), north (e.g., longspurs, *Calcarius*), or south (e.g., greater roadrunner, *Geococcyx californianus*). Hence, 6 species remained for analysis: ferruginous hawk (*Buteo regalis*), lesser prairie-chicken (*Tympanuchus pallidinuchus*), mountain plover (*Charadrius montanus*), scissor-tailed flycatcher (*Tyrannus forficatus*), lark bunting (*Calamospiza melanocorys*), and Cassin's sparrow (*Aimophila cassinii*). Although ferruginous hawk does have populations farther west, the clear concentration of its abundance is in the central and northern Great Plains, hence its inclusion. One species (lesser prairie-chicken) had to be eliminated because too few BBS routes had recorded it, leaving just 5 species for analysis.

BBS routes with continuous coverage over the past 25 years were chosen for analysis. This quality-control measure left 1,331 routes in the Great Plains region for analysis. Data from these routes were divided into 5 categories of 5-years for analysis: 1971–1975, 1976–1980, 1981–1985, 1986–1990, and 1991–1995. Species were tallied as present or absent, and average numbers recorded were calculated for each 5-year sample for each route.

One analytical approach was that of regressing average latitudes of occupied sites, or average latitudes of individuals of a particular species (i.e., weighting sites occupied by numbers present), on time period (Table 1). Whereas the conservative sites-occupied analysis produced no significant regressions (all $P > 0.225$), 3 species showed significant or near-significant movement of average positions of individuals: Cassin's sparrows moved northward at approximately 0.6° latitude per decade (regression slope $m = 0.328$, $R^2 = 0.865$, $P = 0.022$), mountain plovers apparently moved northward at 0.4° per decade ($m = 0.212$, $R^2 = 0.695$, $P = 0.079$, near-significant), and scissor-tailed flycatchers moved southward at 0.4° per decade ($m = -0.231$, $R^2 = 0.921$, $P = 0.010$). Regression slopes were positive (northward movement) in 4 of the 5 species analyzed. However, these analyses were confounded by nonindependence of samples in different time periods, making interpretation of statistical significance complex.

Because samples were not independent with respect to time periods, I reanalyzed the data focusing on actual colonizations and extinctions of populations. I defined colonizations as routes on which a species was absent in the first 5-year period, but present in the last, and extinctions as those routes on which a species was present in the first 5-year period, but absent in the last. I then tallied colonizations and extinctions north and south of the median latitude

TABLE 1—Summary of colonizations (newly occupied sites) and extinctions (sites no longer occupied) north and south of median latitudes for 5 bird species in the Great Plains, and regression analyses assessing trends in average latitudes of occupied sites and total individuals for each species.

Species	Colonization		Extinction			
	North	South	North	South	Occupied sites	Numbers
Buteo regalis	27	22	9	9	$m = 0.109$	$m = 0.059$
					$R^2 = 0.165$	$R^2 = 0.041$
					$P = 0.497$	$P = 0.743$
Charadrius montanus	3	2	1	2	$m = 0.462$	$m = 0.212$
					$R^2 = 0.434$	$R^2 = 0.695$
					$P = 0.226$	$P = 0.079$
Tyrannus forficatus	12	3	8	6	$m = 0.025$	$m = -0.231$
					$R^2 = 0.270$	$R^2 = 0.921$
					$P = 0.369$	$P = 0.010$
Calamospiza melanocorys	8	7	14	18	$m = 0.116$	$m = 0.050$
					$R^2 = 0.190$	$R^2 = 0.012$
					$P = 0.464$	$P = 0.859$
Aimophila cassinii	13	6	5	8	$m = -0.011$	$m = 0.328$
					$R^2 = 0.009$	$R^2 = 0.865$
					$P = 0.879$	$P = 0.022$

for the species in question (Table 1). In all 5 species, colonizations were focused in the northern half of the distribution of the species (5 of 5 species; binomial test, $P = 0.031$), whereas extinctions tended to be in the southern half of distribution of the species (3 of 5 species; binomial test, $P = 0.125$). Hence, species are moving northward via colonization, and populations at the southern extreme are either persisting or are going extinct more slowly than colonization occurs.

To provide additional detail on population processes, I examined temporal trends in different sectors of the geographic distributions of each species. Separating BBS routes into those north and south of the median latitude of sites occupied for a particular species, I calculated linear regressions between population trends and time, and summarized differences between northern and southern sectors of the distribution of the species across 25 yr (Table 1). Several species showed concentrations of declining populations in the southern part of their geographic distributions (e.g., Cassin's sparrow, mountain plover), and others showed increasing populations in northern sectors (e.g., ferruginous hawk, lark bunting, mountain plover). These patterns of population decline and increase, although preliminary in nature, are consistent with the effects of a warming climate, in which southern areas become uninhabitable and northern areas become increasingly suitable.

Climatic warming in the Great Plains has been subtle, but measurable (Karl et al., 1996); bird distributions have also been moving northward. Conclusions as to causal links, such as that climate change caused the northward distributional shifts, are difficult, perhaps requiring physiological measurements or studies of habitat distributions and resource availability not within the scope of the present study. All the same, few other plausible explanations are available; human influence on landscapes is distributed fairly evenly across the Great Plains landscape, and, hence, is not likely to have caused the shifts observed.

Especially notable regarding the shifts documented herein is their magnitude. The distribution of Cassin's sparrows is moving northward at more than half a degree of latitude per decade, which, if true, would translate into more than 5 km per year of northward shift. This rate of movement is similar to those documented in other habitat types in apparent response to climate change (Allen and Breshears, 1998). These shifts suggest that coming decades of continued climatic change will shift avian distributions in North America significantly northward. Ecological and evolutionary

ramifications of these changes (e.g., Holt, 1990) are numerous, serious, and poorly understood, thus emphasizing the importance of careful monitoring of avian populations and distributions to document such distributional changes in detail.

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EFFECTS OF TORNADO DAMAGE ON FOREST BIRD POPULATIONS IN THE ARKANSAS OZARKS

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Abstract—Breeding bird populations were studied in forests recently damaged by tornados and in adjacent undamaged forests in the Ozark National Forest, Arkansas. During 1999 and 2000, surveys were undertaken at 6 points in forest moderately damaged by a tornado in 1996 and at 6 points in nearby undamaged forest. An additional 18 counts, 6 each in undamaged, moderately damaged, and heavily damaged forest, were undertaken in 2000 in an area affected by a 1999 tornado. Typical forest species, such as red-eyed vireo and ovenbird, were significantly less abundant in tornado-damaged forest than in undamaged forests, while edge species, such as indigo bunting and white-eyed vireo, were more abundant in damaged forest than in undamaged forest. Surprisingly, abundances of some species, such as black-and-white warbler, did not differ significantly between damaged and undamaged forests. Species composition differed between heavily damaged forest and moderately damaged or undamaged forest, with a number of species occurring only in the heavily damaged forest type. The congeneric summer tanager and scarlet tanager seemed to show habitat segregation in the study sites, with summer tanagers occurring in tornado-damaged forest and scarlet tanagers occurring in undamaged forest.

Resumen—Muestreamos poblaciones de aves reproductivas en bosques recientemente afectados por tornados y en bosques adyacentes intactos en el Ozark Nacional Forest, Arkansas. Durante