Using Ranges of Terrestrial Vertebrates to Analyze Patterns of Species Diversity in Kentucky

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ABSTRACT

To explore the diversity of terrestrial vertebrate species in Kentucky, we examined the distribution of species using richness (number of species) as an index of diversity. We evaluated species richness for amphibians, breeding birds, mammals, reptiles, and all terrestrial vertebrates combined using two different regional delineations from the United States Forest Service: ecoregions and physiographic provinces. We overlaid species ranges obtained from the literature, databases, and expert reviews with coverages of the ecoregions and provinces of Kentucky using a geographic information system (GIS). We also analyzed the geographic variation in species richness in relation to six environmental variables. Variation in elevation, temperature, and precipitation were the best predictors of the geographic variation in species richness within and among taxa. Among the ecoregions and provinces, mean species richness differed most for reptiles. Mean species richness for reptiles and breeding birds was highest in the Appalachian Plateaus and Cumberland Mountains of eastern Kentucky. In contrast, mean species richness was highest for amphibians and mammals in the Mississippi Alluvial Basin and Mississippi Embayment of western Kentucky. Management plans that protect areas of high species richness will be essential to the conservation of Kentucky's vertebrate biodiversity.

INTRODUCTION

Biodiversity is a major concern for natural resource managers and conservation biologists. Gap analysis was developed as a proactive coarse-filter approach to protecting biodiversity (Scott et al., 1993). As part of Vertebrate Kentucky GAP, we analyzed species richness of the terrestrial vertebrates as defined by geographic regions of Kentucky.

The purpose of our study was to map species richness and determine if there are differences in species richness between the different ecoregions and provinces of Kentucky. Species richness is calculated as the number of species (Ricklefs, 1997). Because of the ecological and geological variation across Kentucky, we expected that richness would vary across ecoregions and provinces. Here we analyze such relationships between geographic regions and species richness. The results may be useful for management of biodiversity in Kentucky.

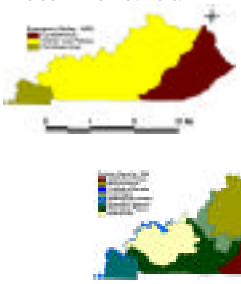
METHODS

The terrestrial vertebrate species included in our analysis were all native and current inhabitants of Kentucky. The species list was reviewed by biologists in and around Kentucky as part of the Kentucky Gap Analysis Project. The final list of species was comprised of 52 amphibian, 198 bird, 63 mammal, and 51 reptile species (364 species total). Due to inconsistencies between breeding and wintering bird ranges, we included only the 153 species of breeding birds in our analysis.

We used data from the scientific literature, state databases, and expert reviews to identify the ranges of terrestrial vertebrates within Kentucky. We then digitized the range data using Arc/Info version 7.0 (Environmental Sciences Research Institute, Redlands, CA). The result was a polygon coverage showing the geographic area of each species' range within Kentucky. We converted each range to a grid coverage with 600 x 600 meter pixels. Each pixel that included the range of the species was given a value of one. All other pixels were given a value of zero. We added the values for all the pixels associated with one of the four vertebrate taxonomic groups (amphibians, birds, mammals, and reptiles). The result was four different grids (i.e., maps) with all ranges added together for each taxonomic group. We also totaled the values for all taxonomic groups for an overall richness grid. Using the pixel values of each grid, we calculated the population (i.e., species richness) mean and variance for each vertebrate group and all groups combined for the ecoregions and physiographic provinces.

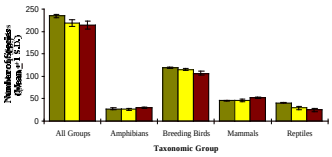
We examined the relationship between six environmental variables (temperature, precipitation, road density, distance to water, local topographic variation, and elevation) and species richness across Kentucky. The contribution of these variables to explaining geographic variation in species richness was determined using stepwise regression analysis (SAS, 1990).

1. THE REGIONS USED IN OUR ANALYSIS REPRESENTED TWO DIFFERENT CLASSIFICATIONS: ECOREGIONS AND PHYSIOGRAPHIC PROVINCES.



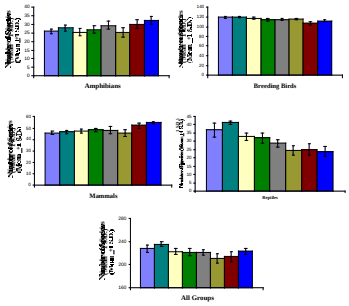
Bailey (1988) and Keys et al. (1995) described ecosystem classifications that could be used for economic and ecological inventories of natural resources. In our study, these classifications were named ecoregions and physiographic provinces, respectively. Geographic regions were classified into ecoregions and provinces using many different biotic and abiotic features (e.g., vegetation, soil, geology, surface form, etc.) to delineate boundaries.

2. MEAN SPECIES RICHNESS WAS SIMILAR AMONG ECOREGIONS FOR EACH VERTEBRATE GROUP EXCEPT REPTILES (SEE PANEL 1 FOR FIGURE LEGEND).



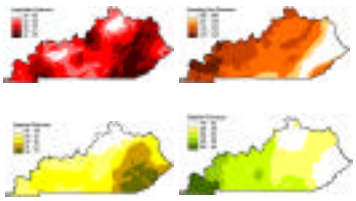
Mean species richness varied greatly for reptiles, being 66% higher in the Purchase Area and 19% higher in the Interior Low Plateau compared with the Cumberland ecoregion. Differences in mean species richness were much less for amphibians, breeding birds, and mammals, varying by only 9 - 13%. Total species richness was approximately 10% higher in the Purchase Area compared with the other ecoregions because of the relatively high number of reptiles, and to a lesser extent, breeding bird species in the western portion of the state.

3. MEAN SPECIES RICHNESS WAS MOST SIMILAR AMONG PROVINCES FOR BREEDING BIRDS AND LEAST SIMILAR FOR REPTILES (SEE PANEL 1 FOR FIGURE LEGEND).



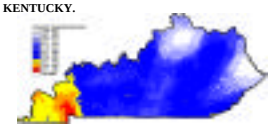
For breeding birds, mean species richness varied among provinces by, at most, 12%. In contrast, species richness for reptiles differed by a maximum of 73% among provinces. Mean species richness for mammals and amphibians followed very similar patterns among provinces. The maximum difference in mean species richness for mammals and amphibians among provinces was 20% and 27%, respectively. Total mean species richness varied by a maximum of 12% among the provinces, being highest in the Mississippi Embayment and lowest in the Bluegrass Region.

4. THE LOCATIONS OF HIGHEST SPECIES RICHNESS DIFFERED AMONG THE TAXONOMIC GROUPS.



Species richness of breeding birds and reptiles was greatest in western Kentucky, largely within the Mississippi Embayment and Mississippi Alluvial Basin. In contrast, species richness of amphibians and mammals was greatest in the Appalachian Plateau and Cumberland Mountain provinces of eastern Kentucky.

5. POCKETS OF HIGH SPECIES RICHNESS FOR ALL TAXONOMIC GROUPS COMBINED OCCURRED AT LOCATIONS IN BOTH EASTERN AND WESTERN KENTUCKY.



The largest area of high species richness occurred in western Kentucky, due primarily to high numbers of reptiles and secondarily, breeding bird species. In contrast, the pockets of high species richness in southeastern Kentucky were due to relatively high numbers of mammal and amphibian species.

6. ENVIRONMENTAL VARIABLES EXPLAINED 59% OF THE GEOGRAPHIC VARIATION IN SPECIES RICHNESS.

Taxa	Variable 1 (R^2)	Plus	Variable 2 (ΔR^2)	Six-Variable Model R^2
Amphibians	+Elevation (.15)		+Precipitation (.22)	.22 ($P<0.001$)
Breeding Birds	-Elevation (.43)		+Temperature (.49)	.51 ($P<0.001$)
Mammals	+Elevation (.34)		+Temperature (.45)	.48 ($P<0.001$)
Reptiles	+Temperature (.66)		-Elevation (.74)	.77 ($P<0.001$)
All Taxa	+Temperature (.55)			.59 ($P<0.001$)

It was not surprising, given the difference in climate and topography between eastern and western Kentucky, that of the six environmental variables examined temperature, elevation, and precipitation were the most important explanatory variables with respect to species richness. Distance to water, road density, and topographic variation were of little importance.

CONCLUSIONS

The mean richness of terrestrial vertebrate species was not distributed evenly across the state of Kentucky. The unevenness in distribution was especially marked in reptiles. As a result, total richness of vertebrate species was 10-12% higher in the western-most ecoregion and provinces. Variation in elevation and climate explained much of the geographic variation in species richness, especially for reptiles. The largest areas of high terrestrial species richness were located in two western provinces, the Mississippi Alluvial Basin and Mississippi Embayment, and in one eastern province, the Cumberland Mountains. Management plans that protect these and other "hotspots" of species diversity will be necessary if the biodiversity of vertebrates in Kentucky is to be maintained.

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