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Annual variability of species richness and composition of breeding birds in the central Great Basin

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INTRODUCTION

Desert ecosystems are thought to be highly responsive to environmental changes, including shifts in temperature and precipitation, invasion by nonnative plants, and altered disturbance regimes (Sala et al. 2000, Smith et al. 1997, 2000). For example, declines in species richness and changes in species composition of native animals and plants in the Great Basin are anticipated if recent predictions of climatic changes by 2100 - 2–3Þ C increases in temperature, a 10 percent decrease in summer precipitation, and a 15–40 percent increase in precipitation during other seasons (US EPA 1999) - prove accurate (McDonald and Brown 1992, Murphy and Weiss 1992, Grayson 2000, Fleishman et al. 2001). Several active partnerships among interdisciplinary teams of researchers and land mangers are working toward understanding - and hopefully mitigating - the effects of major short-term and long-term environmental changes in the Great Basin (e.g., Chambers and Miller 2004).

Detection of faunal responses to environmental change on the order of years to decades typically is based on surveys. Ideally, one would monitor taxonomic groups of concern across large areas and multiple years in order to infer whether communities are being modified by known environmental changes and to evaluate whether management strategies are meeting their objectives. Extensive monitoring data from areas that have not been subject to manipulative experiments, for instance, increase our ability to evaluate whether changes in biodiversity measures result from those treatments (e.g., prescribed fire, revegetation) or simply reflect background variability (Berry et al. 1998, Link and Sauer 1998). However, time and money for biological surveys and monitoring are limited. Therefore, it is useful to examine whether one-year "snapshots" of species richness and composition accurately reflect longer-term patterns (Hanski 1999, Moilanen 2000). If there is considerable "noise" in fundamental measures of biodiversity from year to year, then it may prove more challenging to recognize the "signal" of an ecologically significant faunal response. In this paper, we explore the extent to which species richness and composition of breeding birds in the central Great Basin varies between years and at different spatial levels of resolution. These are the types of data that are most likely to be collected over relatively large areas and long periods of time given current and projected levels of funding for biological monitoring on public lands in the western United States. Such data also complement studies by other workers that examine distribution patterns over a much larger area (e.g., Parmesan 1996, Parmesan et al. 1999, Thomas et al. 2001) and attempt to determine whether the ranges of individual species are expanding or contracting.

Breeding birds are biologically well understood, relatively easy to study and monitor, and have been suggested as surrogate measures of various species-level and ecosystem-level parameters (Temple and Wiens 1989, Mac Nally 1997, Blair 1999, O’Connell et al. 2000). Because we currently have data from just two years of surveys, our results and inferences should be considered preliminary. Nonetheless, our limited sample size allows us to increase our knowledge of spatial and temporal variation in bird communities in the Great Basin and to develop working hypotheses that can be revisited as more data accrue. Insight into signal-to-noise ratios is essential for understanding the circumstances in which survey data can be used to make inferences about the biological effects of environmental change.

METHODS

We surveyed birds in 2001 and 2002 in three adjacent mountain ranges in the central Great Basin (Lander and Nye counties, Nevada, U.S.A.). The ranges are similar in terms of their regional climate, biogeographic past and ancestral biota, and human land-use histories (Wilcox et al. 1986, Austin and Murphy 1987, Grayson 1993). Work was conducted in five canyons in the Shoshone Mountains (approximate north-south boundaries 39Þ14’19" to 38Þ57’32") and Toiyabe Range (approximate north-south boundaries 39Þ54’00" to 38Þ30’00") and six canyons in the Toquima Range (approximate north-south boundaries 39Þ17’50" to 38Þ29’9"). We divided canyons into multiple segments from base to crest. Each segment was 150 m wide and long enough to span a 100-m change in elevation (Fleishman et al. 2002). Our work covered an elevational range of 1921–2691 m. Mean segment length was 1.5 km; more than two-thirds of the segments were >1 km long. Segment area ranged from 1.5–44.4 ha. We conducted surveys in 25 segments in the Shoshone Mountains, 31 in the Toiyabe Range, and 28 in the Toquima Range (84 total).

We followed standard survey methods for birds in temperate regions (Bibby et al. 2000). Birds in each segment were surveyed during the breeding season (late May through June) using two or three 75-m fixed-radius point counts. Within a segment, points were located in each of the dominant vegetation types (e.g., aspen, willow, piñon-juniper, wet meadow, sagebrush) to account for the influence of variables such as tree species composition, tree size, and water availability on avian species richness and abundance (Betrus 2002, Poulson 2002). Each segment included at least two point-count locations even if there was only one major vegetation type. Segments included three point-count locations when there were three different vegetation types within the segment. Point count locations were at least 200 m apart. We surveyed a total of 175 points - 51 in the Shoshone Mountains, 69 in the Toiyabe Range, and 55 in the Toquima Range.

Each time a point was surveyed, we recorded all birds actively using terrestrial habitat within a 75 m radius. Each point was visited three times during the breeding season for five minutes per visit. Three surveys are considered sufficient to determine which species of birds are present at point count locations (Siegel et al. 2001). In addition, point counts have been shown to be an effective method of sampling birds in riparian areas in the Great Basin (Dobkin and Rich 1998). In our work, species accumulation curves for birds at the segment and canyon levels generally approached an asymptote by the third round of surveys.

Point counts were conducted only under fair skies. Each point received at least one count within two hours of dawn and at least one count between two and three and a half hours after dawn. No counts were conducted more than three and a half hours after dawn. Although occurrence data provide little information on species viability, adequate time and money rarely exist to collect unbiased data on bird abundances (Droege et al. 1998, Link and Sauer 1998). Therefore, only occurrence data are presented here.

To compare similarity of species composition between years, we used the Jaccard index, $C_J = j/(a+b-j)$, where j is the number of species found in both years in a given location and a and b are the number of species in year 1 and year 2, respectively. C_J approaches 1.0 when species composition is identical between years and 0.0 when there are no species in common (Magurran 1988).

RESULTS

We recorded a total of 83 species of breeding birds from our study locations in 2001 and 2002 (see Appendix under Supplementary Data at http://www.gbbo.org/gbb.htm). Montane canyons in the Great Basin provide an ideal location for migrant and resident songbirds to breed during the late spring and early summer. Surface water, a wide array of avian food sources, and complex and heterogeneous vegetation structure are often concentrated in these canyons. During our inventories, birds displayed a variety of breeding behaviors including frequent song-repetition by males, collection of nest material, nest building, incubation, parental care, and territorial defense.

Further results refer to the 76 species of birds that were recorded during point counts. At the mountain range level, total species richness was greatest in the Toiyabe Range (65 species) and lowest in the Toquima Range (50 species) (Appendix on websidte). Fifty-four species were recorded from the Shoshone Mountains. Species richness (number of species) across the landscape changed little between years - 65 species in 2001 versus 66 in 2002. At the mountain range

Table 1. Mean similarity of species composition of breeding birds between years (2001 vs. 2002). Values are Jaccard similarities.

spatial level	all ranges	Shoshone Mountains	Toiyabe Range	Toquima Range
points	0.357	0.358	0.406	0.294
canyon segments	0.411	0.400	0.461	0.365
canyons	0.509	0.547	0.550	0.442
mountain ranges	0.691			

level, however, species richness was greater in 2002 than in 2001. Species richness increased from 44 to 50 species in the Shoshone Mountains, from 50 to 56 species in the Toiyabe Range, and from 40 to 45 species in the Toquima Range.

Between years, species composition of birds was more variable than species richness of birds. The only species whose presence was somewhat surprising was Indigo bunting (*Passerina cyanea*). The latter species, recorded from the Toiyabe Range in 2001, is considered rare in the Great Basin (National Geographic Society 2002). At the landscape level, ten species were recorded in 2001 but not in 2002, and 11 species were recorded in 2002 only (Appendix). Thus, similarity of species composition across the landscape between years was 0.724. Similarity of species composition between years tended to increase as the spatial level of analysis increased. For example, mean similarity of species composition between years at the point level was only 0.357, while mean similarity at the level of mountain ranges was 0.691 (Table 1).

DISCUSSION

We found that species richness of breeding birds in the central Great Basin was relatively consistent between years, especially at the landscape level, although there was considerable turnover in species composition. Similarly, Brown et al. (2001) found that species richness of birds in northern Michigan and rodents in the Chihuahuan Desert remained fairly constant over the long term (22 years and 50 years, respectively) despite large changes in species composition, climate, and other environmental conditions.

At the mountain range level, species richness in the Toiyabe Range in both 2001 and 2002 was greater than in the Shoshone Mountains or Toquima Range. Even within the same biogeographic subregion, there is some variation in topography, microclimate, and vegetation structure and composition among mountain ranges; the Toiyabe Range is somewhat larger and less arid than many other mountain ranges in its biogeographic subregion (Fleishman et al. 1999, 2000). A majority of the canyons that incise the slopes of the Toiyabe Range have ephemeral, if not permanent, streams. A regular supply of water helps to support an unusually diverse vegetational community in terms of both species richness and structure. As a result, a high proportion of the birds present in the Toiyabe Range may be able to persist in the "average" Toiyabe Range canyon. In the Toquima Range, by contrast, resources for birds are both more limited and more patchily distributed than in the Toiyabe Range. While the diversity of resources in the Shoshone Mountains does not appear to be particularly high, the distribution of those resources may be relatively homogenous among canyons (Tausch and Tueller 1990). Similar patterns of species richness at the mountain range level have been observed for other taxonomic groups, including butterflies (Fleishman et al. 1999, 2001, 2002).

We found substantial variability in species composition between years, particularly at relatively fine levels of spatial resolution (<50 ha). Do data from 2001 and 2002 represent an "average" level of annual variation in species composition, or was turnover in those two years unusually high? To address those questions, we plan to repeat surveys in all locations in at least 2003 and 2004. In the meantime, data on precipitation, which may influence resource availability for breeding birds, may provide some insight. Weather patterns in the Great Basin, as in many arid ecosystems, are both severe and unpredictable (Houghton et al. 1975, Grayson 1993). Precipitation for the six months preceding the 2001 and 2002 breeding seasons (i.e., November 2000–April 2001 and November 2001–April 2002, respectively) in Austin, Nevada (roughly parallel to and equidistant from the northern end of the Toquima Range and Shoshone Mountains) was fairly consistent - 195 mm prior to the 2001 season and 213 mm prior to the 2002 season (Western Regional Climate Center 2002). Precipitation during both blocks of time was slightly greater than the long-term mean of 192 mm for the 111-year period of record (Western Regional Climate Center 2002). Thus, it does not appear that precipitation was the cause of variation in species composition between 2001 and 2002. In diverse ecosystems, turnover in species composition seems to be common, even when species richness remains relatively constant (Brown et al. 2001).

In related work, we have addressed species composition in space as opposed to time. It does appear that species composition in space is somewhat predictable in a given year. For example, in both 2001 and 2002, distributions of birds within canyon segments in each mountain range were significantly nested (Fleishman et al. 2002). A nested biota is one in which the species present in depauperate locations are subsets of species present in locations that are richer in species (Patterson and Atmar 1986). Turnover in species composition among years is not inconsistent with the existence of a nested pattern each year.

Our results underscore the widely recognized fact that evaluation of the effects of land use, management treatments, and other environmental changes on biological diversity should consider both species richness and species composition. Our work also suggests that in this system, one-year snapshots of species occurrence may not provide an accurate representation of longer-term species composition.

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