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COMMENTARY

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SOME CONSIDERATIONS ON THE USE OF ECOLOGICAL MODELS TO PREDICT SPECIES' GEOGRAPHIC DISTRIBUTIONS

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Abstract. Peterson (2001) used Genetic Algorithm for Rule-set Prediction (GARP) models to predict distribution patterns from Breeding Bird Survey (BBS) data. Evaluations of these models should consider inherent limitations of BBS data: (1) BBS methods may not sample species and habitats equally; (2) using BBS data for both model development and testing may overlook poor fit of some models; and (3) BBS data may not provide the desired spatial resolution or capture temporal changes in species distributions. The predictive value of GARP models requires additional study, especially comparisons with distribution patterns from independent data sets. When employed at appropriate temporal and geographic scales, GARP models show considerable promise for conservation biology applications but provide limited inferences concerning processes responsible for the observed patterns.

Key words: avian distribution patterns, BBS, GARP models, North American Breeding Bird Survey, predictive distribution models, roadside surveys.

Algunas Consideraciones del Uso de Modelos Ecológicos para Predecir la Distribución Geográfica de las Especies

Resumen. Peterson (2001) usó Modelos de Algoritmos Genéticos para la Predicción de Reglas (GARP) para predecir los patrones de distribución de los datos del Censo de Aves Nidificantes (BBS). Las evaluaciones de estos modelos deberían considerar las limitaciones propias de los datos del BBS: (1) los métodos del BBS pueden meustrear especies y hábitats de modo diferente; (2) usar los datos del BBS tanto para desarrollar los modelos como para probarlos puede evadir el pobre desempeño de algunos modelos; y (3) los datos del BBS pueden no proveer la resolución espacial deseada y capturar los cambios temporales en la distribución de especies. El valor predictivo de los modelos GARP requiere estudios adicionales, especialmente comparaciones con patrones de distribución obtenidos de bases de datos independientes. Cuando los modelos GARP son empleados a las escalas temporales y geográficas apropiadas muestran aplicaciones promisorias para biología de la conservación, pero proveen inferencias limiadas sobre los procesos responsables de los patrones obervados.

Peterson (2001) employed a Genetic Algorithm for Rule-set Prediction (GARP) approach to develop innovative models for predicting distribution patterns for 34 bird species. Data collected for the North American Breeding Bird Survey (BBS) were used to develop and test these models, because BBS data provided adequate sample sizes for these passerine species at an appropriate geographic scale for this study.

The BBS was created to monitor bird population trends across North America north of Mexico (Robbins et al. 1986), although these data have also served as the basis for mapping avian distribution and relative abundance during the summer months (Price et al. 1995, Sauer et al. 2000). Several aspects of the BBS seemingly reduce its suitability for depicting the distribution patterns for a number of bird species. The BBS is based on randomly located roadside survey routes, and whether data collected from roadsides are representative of the entire landscape remains a subject of debate (Hanowski and Niemi 1995, Keller and Scallan 1999). Bird populations are sampled using a series of 3-min point counts, a technique with known deficiencies for sampling bird species with equal levels of detection probabilities and precision (Verner 1985). Point counts provide incomplete counts of individuals present in an area, and within-count variability can be confounded with ecologically meaningful variation (Barker and Sauer 1995). Thousands of observers conduct these surveys each year and significant biases associated with changes in bird identification skills complicate the analyses of BBS data (Sauer et al. 1994, Kendall et al. 1996).

Despite these limitations on the use of BBS data, Peterson (2001) found impressively significant predictions for the 34 species tested. Perhaps the large sample sizes available in the BBS data set mitigate these potential limitations. However, additional studies may be needed to convince scientists that these predictive models have broader applications than the BBS, especially since BBS data were used to both develop and test these models. The assumption of independence between training and test samples can be challenged if one accepts the theory of source-sink population dynamics (Pulliam 1988). While the application of source-sink dynamics to passerine populations is still rather poorly understood, the existence and distributions of source populations are more likely to reflect prevailing ecological conditions than political bound-

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aries, and the presence of a source population in one state could influence the detection of a species in adjacent states.

Applying models developed from BBS data to other large-scale bird data sets might provide stronger supporting evidence that these models are predicting ecologically meaningful patterns of distribution. An alternative approach would be to test results from these predictive models against distribution patterns documented by data collected independently by Breeding Bird Atlas (BBA) projects. These atlases are conducted at similar geographic scales, usually at the level of states and provinces (Laughlin 1982). They are based on coverage of all habitats present within a defined geographic area, usually 25-km^2 blocks, and an area-search method is employed to detect the breeding birds present within each block. Although there are limitations in the BBA data sets for some species (Laughlin 1982), these projects are not encumbered by the limitations of point count methods and the potential roadside biases associated with the BBS. If these GARP models prove equally powerful predicting distributions when compared to data from BBAs as they were with the BBS data, then confidence that these models demonstrate ecologically meaningful information would be enhanced.

The predictive power of Peterson's (2001) models reflects the large sample sizes available within the BBS database for species in these four passerine genera and the suitability of the BBS for detecting individuals of these species. His approach would likely be less successful for species that are poorly detected by the BBS point-count methodology and are likely to be missed even when they are present, resulting in considerable rates of omission errors within the predicted species distributions. Owls, secretive marsh birds, and other species poorly sampled by the BBS would require other data sets for the development of suitable predictive models using this technique.

Another consideration is awareness that the predictive value of the distributions developed by the GARP models may diminish as the geographic scale changes. For example, predicted distributions based on the BBS or other large-scale data sets may not be very informative on predicting the presence of Brown Thrashers (*Toxostoma rufum*) in a field at the Patuxent Wildlife Research Center in Maryland. Conversely, a small sample of specimen data from a limited geographic area may provide limited predictive value of the range-wide distribution of a species. Errors of commission will tend to increase as one moves downward in geographic scale while errors of omission will likely increase as this scale changes from small to large. Knowledge of the geographic scale of the data set(s) used to develop these predictive models is important for the successful implementation of this approach. Whether fragmentary data obtained from multiple data sets operating at multiple geographic scales can be combined to produce informative distributional models remains to be established.

Temporal aspects to avian distribution patterns should also be considered in the development of these predictive models. Distributional shifts are regularly documented within many bird populations. Some avian range changes reflect movements associated with shifts in the distributions of the vegetative communities to which species are adapted (James et al. 1984, Root and Schneider 1995), while other range changes reflect a shift into different vegetative communities and interactions with new species associations (Martin 2001). Some distributional shifts occur over a period of a few decades, for example the expansion of invasive species (Cabe 1993, Hill 1993), while other shifts occur over longer periods such as the expansion and subsequent contraction of Bachman's Sparrows (*Aimophila aestivalis*) in the eastern United States during the nineteenth and twentieth centuries (Brooks 1938, Dunning 1993).

Potential pitfalls occur when these predictive models use data from one time period to draw inferences about distributional patterns during another period, for example using nineteenth century specimen records to predict current distribution patterns. Temporal shifts in distribution, especially shifts associated with changes in the factors influencing habitat selection by a species, may be poorly represented if the biotic and abiotic factors defining habitat selection are not accounted for in the algorithms used to develop the predictive models. Under these circumstances, these models risk the inaccurate representation of some distributional shifts that have occurred.

When used with appropriate geographic and temporal considerations, the GARP models represent a considerable advancement over previous predictive models of species' distributions. Their full potential remains to be realized and this approach has considerable promise for use in conservation biology applications. But GARP algorithms create descriptive models that will only allow relatively weak inferences to be made about the underlying processes responsible for the observed patterns, and experimental studies will still be necessary to conclusively establish the factors defining the patterns of distribution and abundance for most bird species.

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