Appendix B. Predicted distribution model development for 602 terrestrial vertebrate species of the Southeast Gap Analysis Project

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INTRODUCTION

The United States Geological Survey's (USGS) Gap Analysis Program (GAP) is a scientific method for identifying potential inadequate representation of conservation lands (so-called "gaps") for native vegetative communities and animal species. By mapping existing vegetation and land use; conservation land network boundaries and their degree of biodiversity management; and the predicted distribution of terrestrial vertebrates, GAP seeks to provide managers, planners, scientists, and policy makers with data to make informed decisions regarding the conservation of biological diversity (Scott et al. 1993).

Using gap analysis standard protocols (Csuti and Crist 2000), a list of species is assembled and their geographic range extents delineated. Species-habitat associations are then compiled outlining potential relationships with mappable data. Within the southeastern United States, 606 species were identified for inclusion in the Southeastern Gap Analysis Project (SE-GAP). A total of 613 digital range maps were created depicting species' breeding and/or wintering ranges (see Appendix A for methods describing digital range creation). Digital raster datasets of species' predicted distributions represented as presence/absence were developed for each of the 613 ranges.

METHODS

Wildlife-Habitat Relationship Database and Land Cover Data

A wildlife-habitat relationship database was developed to organize information describing species' habitat associations compiled from the primary literature, field guides, reports, and other published sources. The goal of these activities was to define, for each species, potential habitat available during the species' breeding and/or wintering periods in a way that enabled the automated production of maps predicting their presence and absence. The database maintained knowledge of relationships between species occurrences and multiple landscape descriptions via related data tables. Land cover descriptions were coded for species presence in order to add area to species maps where the species were predicted to occur. All species were linked to one or more land cover descriptions. These descriptions consisted of 245 unique classes based on NatureServe ecological systems (Comer et al. 2003), some of which were defined in consultation with SE-GAP personnel. For each species, land cover classes were coded as either a primary association (i.e., considered critical for nesting, rearing young, and/or optimal foraging) or auxiliary (i.e., considered complementary when in proximity to primary land cover classes).

Ancillary Data

Several other landscape descriptions were used as ancillary decision rules to reduce the area where species were predicted to occur. These were either separate datasets or derivatives of land cover data.

Elevation

Some species respond to environments directly related to altitudinal variation. Elevation is easily implemented in spatial modeling by limiting the model to minimum and/or maximum values explicitly stated in the literature. SE-GAP utilized the USGS compiled National Elevation Dataset (NED) as a primary source (USGS 1999a). However, because of the varying quality of the NED, it was necessary to incorporate other datasets to create an improved, region wide product. These included data from NASA's Shuttle Radar Topography Mission at 30 m resolution (Farr et al. 2007), Light Detection and Ranging data from the North Carolina Floodplain Mapping Program, and hypsography data from the USGS's Digital Line Graphs at 1:24,000 and 1:100,000 scales (USGS 1989, 1990). Areas of inconsistent, erroneous, or systematically flawed data were identified visually and "tagged" for fixing. A number of algorithms were then used to reassign elevation values using interpolations based on the higher quality data. This essentially promoted the best available information for a given area using a number of sources, as opposed to re-interpolating data from the same flawed source.

Hydrography

SE-GAP used a number of water related data layers to refine species models. These include water type (i.e. flowing or open/standing), distance to and from water, and stream flow and underlying gradient. Hydrographic data were based on a modified version of the USGS National Hydrography Dataset (NHD) (USGS 1999b). A number of researchers have noted inaccuracies and inconsistencies associated with the NHD and its source data (Morisawa 1957, Werritty 1972, Miller et al. 1999, Hansen 2001, Firman and Jacobs 2002, Heine et al. 2004). To address these issues, SE-GAP utilized the NED digital elevation model (DEM) to normalize feature representation through algorithms that incorporated topographic derivatives including, flow accumulation, flow direction, and slope. Flow accumulation algorithms using DEMs calculate flow direction and aggregation of each grid cell compared with its eight adjacent neighbors. SE-GAP divided the study region based on majority cell slope by watershed catchment in three categories: 0% slope, > 0 and < 30 % slope, and > 30% slope. These three categories roughly correspond to the Coastal Plain, Piedmont, and Mountain regions of the southeastern US. Stream delineation using flow accumulation grids is simply a matter of defining an accumulation threshold. In essence this threshold is akin to setting a minimum area required to initiate flowing surface water. Open water bodies (lakes, reservoirs, ocean, etc...) were represented using a conflation of NHD and land cover water classes.

Landforms

Species predicted distributions were occasionally restricted using one or more of 11 categories of landform. Landforms are derived from the modified NED, ecoregions and hydrography using a complex model of slope, aspect, location, elevation, flow direction and accumulation, a topographic relative moisture index, and a variety of other interpolated data. These are meant to incorporate a mixture of environmental inputs important for species. Landform categories included cliffs, steep slopes, slope crests, side slopes, upper slopes, flat summits, coves, slope bottoms, moist flats, dry flats, and wet flats.

Edge/Ecotones

The edge or ecotone between forested and non-forested environments can be a critical aspect of the habitat landscape. SE-GAP grouped land cover map units into forested, non-forested, and shrubland/woodland land cover types to create unique data layers. Aggregated map units were then compared and contrasted to identify areas of transition between these broad categories. They were also used to identify "core" areas or contiguous blocks of similar type (i.e. interior) through buffering procedures.

Anthropogenic Environments

SE-GAP created a three-tiered urban/avoidance data layer using a combination of road density and three land cover map units of development intensity. In effect, the derived data layer acts as an index for a species' intolerance to human environments. However, some species respond favorably to human habitats. In this later case, the data layer was used in an inclusionary manner.

Patch Size

The type and size of habitat clusters can be assessed with GIS and spatial modeling. As a final step to the distribution modeling process, SE-GAP used these parameters for species shown to require minimum amounts of habitat. This includes not only directly adjacent habitats, but those that are contextually adjacent. Both these parameters are utilized as the final step in a predicted distribution and therefore incorporate all other decision rules. The patch size decision rule was implemented in two different ways – either as contiguous or non-contiguous patches. The contiguous patch size rule limited occupancy predictions to patches defined by contiguous 'presence' cells exceeding a minimum size. The non-contiguous patch size rule limited occupancy predictions to 'presence' cells exceeding a specified density within a specified area (e.g., 20% within 10 ha).

LITERATURE CITED

Comer, P., D. Faber-Langendoen, R. Evans, S. Gawler, C. Josse, G. Kittel, S. Menard, M. Pyne, M. Reid, K. Schulz, K. Snow, and J. Teague. 2003. Ecological Systems of the United States: A Working Classification of U.S. Terrestrial Systems. NatureServe, Arlington, Virginia.

Csuti, B., and P. Crist. 2000. Methods for developing terrestrial vertebrate distribution maps for Gap Analysis. Version 2.0.0 (16 February 2000). A handbook for conducting Gap Analysis. Accessed 20 December 2007 from <http://www.gapanalysis.nbii.gov>.

Farr, T. G., et al. 2007. The Shuttle Radar Topography Mission. Reviews of Geophysics 45, RG2004, doi:10.1029/2005RG000183.

Firman, J. C., and S. E. Jacobs. 2002. Comparison of stream reach lengths measured in the field and from maps. North American Journal of Fisheries Management 22 (4), 1325–1328.

Miller, S. D. Guertin, and L. Levick. 1999. Influences of map scale on drainage network representation. Hydrology and Water Resources in Arizona and the Southwest 29, 7–15.

Morisawa, M. 1957. Accuracy of determination of stream lengths from topographic maps. Transactions, American Geophysical Union 38, 86–88.

Hansen, W. F., 2001. Identifying stream types and management implications. Forest Ecology and Management 143 (1-3), 39–46.

Heine, R. A., C. L. Lant, and R. R. Sengupta. 2004. Development and comparison of approaches for 71 automated mapping of stream channel networks. Annals of the Association of American Geographers 94 (3), 477–490.

Omernik, J.M. 1987. Ecoregions of the conterminous United States. Map (scale 1:7,500,000). Annals of the Association of American Geographers 77(1):118-125.

Omernik, J.M. 1995. Ecoregions: A spatial framework for environmental management. In: Biological Assessment and Criteria: Tools for Water Resource Planning and Decision Making. Davis, W.S. and T.P. Simon (eds.) Lewis Publishers, Boca Raton, FL. Pp. 49-62.

Paybins, K. 2002. Flow origin, drainage area, and hydrologic characteristics for headwater streams in the mountaintop coal-mining region of southwest Virginia, 2000-01. Water-Resources Investigations Report 02-4300, U.S. Geological Survey.

Scott, J. M., F. Davis, F. Csuti, R. Noss, B. Butterfield, C. Groves, H. Anderson, S. Caicco, F. D'Erchia, T. C. Edwards, Jr., J. Ulliman, and G. Wright. 1993. Gap analysis: A geographic approach to protection of biological diversity. Wildlife Monographs 123.

U. S. Geological Survey. 1989. Digital line graphs from 1: 100,000-scale maps—data user's guide 2: Reston, Virginia, U. S. Geological Survey, 88 pp.

U. S. Geological Survey. 1990. Digital line graphs from 1: 24,000-scale maps—data user's guide 1: Reston, Virginia, U. S. Geological Survey, 107 pp.

U. S. Geological Survey. 1999a. National Hydrography Dataset. Fact Sheet. Report number 106-99.

U. S. Geological Survey. 1999b National Elevation Dataset. Fact Sheet. Report number 148-99.

Werritty, A. 1972. Accuracy of stream link lengths derived from maps. Water Resources Research. 8 (5), 1255-1264.