# North Carolina Gap Analysis Project

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## Introduction

The North Carolina Gap Analysis Project (NC-GAP) was begun in January 1996 to assess the distribution and conservation status of biodiversity in the state under existing land ownership and management regimes. Our objectives were (1) to map the land cover of North Carolina; (2) to map the predicted distributions of native terrestrial vertebrates that use habitat in the state for breeding; (3) to map the network of conservation lands in the state; (4) to assess the conservation status of both the terrestrial vertebrates and the natural vegetative communities of the state; and (5) to provide that information to natural resource agencies so they can use it in their planning efforts.

## Land Cover

A map of North Carolina's land cover was developed using Landsat thematic mapper (TM) imagery acquired in 1991 and 1992. Processing was completed on each of 13 mapping zones, which were created by intersecting the Ecoregional Provinces at the section level (Bailey et al. 1994; Keys et al. 1995) with the Landsat TM paths and rows. The Sandhills subsection was mapped independently of the larger Coastal Plain section to accommodate the relatively unique vegetation types found there. For each mapping zone, reference data were developed from aerial survey or field reconnaissance, or from existing data sets. These data were used to guide the development of decision rules for the detailed land cover mapping. General land cover types, including water, row crops, pasture, urban, and barren, were integrated from the National Land Cover Data set (USGS 1997). Throughout image processing and classification, the 30-meter (0.09 ha) resolution data were maintained. The minimum mapping unit for the land cover data set is 2 ha, approximating the area of a 5 X 5 pixel area.

The North Carolina Gap Land Cover classification includes 69 map classes, 59 of which represent natural and seminatural land cover classes dominated by vegetation. Natural vegetation map units were based on a classification system that was intermediate between the National Vegetation Classification System (NVCS) (Grossman et al. 1998) and the NatureServe Ecological Systems Classification (Comer et al. 2003). Upland forests, including deciduous, mixed, and evergreen types, represent 51 percent of the total area mapped. A fourth of the land cover is the cultivated herbaceous category, the majority of which is row crop. Ten percent of the state was classified as wetland, the vast majority being the wetland forests of the Coastal Plain region. Statewide, the two most extensive natural/seminatural cover classes are the Piedmont Dry–Mesic Oak Hardwood Forest (7 percent) and Coniferous Cultivated Plantations (7 percent), which cover 981,400 and 966,200 hectares, respectively. The most extensive wetland forest type was the Pocosin Woodland and Shrubland, which represented 3 percent of the area.

## Accuracy Assessment

Both spatial and thematic accuracy assessments were completed for the statewide land cover data set. The 95 percent confidence interval for the total spatial error in the land cover map is 20.6 ± 5 meters (Easting 38 ± 5 meters, Northing 27 ± 5 meters). Thematic accuracy was tested at two levels of thematic detail: a general classification based on cross-walking the detailed cover classes into 15 categories, and for the detailed land cover all classes were assessed. Overall accuracy for the generalized land cover was 87.7 percent with a 95 percent confidence interval of 84.9 to 90.6 percent. The calculations for per class and overall thematic accuracy are based on the known map category marginal frequencies (Card 1982), which normalizes the error calculations based on both the number of samples within a stratum and the proportion of the map represented in each cover class. The estimated accuracies in the detailed cover classes were highly variable. The overall accuracy for the full 69 class land cover map is 58.5 percent with a 95 percent confidence interval of 57.1 to 59.9 percent. This is based on the 10,620 interpreted points. The estimated Kappa statistic for the detailed land cover is 0.73.

## Terrestrial Vertebrate Distributions

Potential distribution maps were developed for 414 terrestrial vertebrate species comprising 193 species of breeding birds, 75 species of mammals, 76 species of amphibians, and 70 species of reptiles. Range limits of each species were delineated on a grid of 258 hexagons encompassing the state (White et al. 1992). Point data used to create range limits included 748 point localities from the North Carolina Museum of Natural Sciences (NCMNS), 2,028 points from the North Carolina Natural Heritage Program (special concern species only), and 27,210 point localities that were newly mapped for this project. The newly mapped points include 25,001 records from the North Carolina Breeding Bird Atlas data set, along with NCMNS specimen records for birds (193 points), mammals (627 points), and herptiles (1,389 points).

The accuracy of the vertebrate potential distribution models was assessed by comparing available species lists for national wildlife refuges, national seashores, and national parks, as well as North Carolina state parks and preserves. The percent agreement averaged 78.8 percent, 64.4 percent, and 72.8 percent for birds, mammals, and herptiles, respectively. While species lists were readily available for birds throughout the state (11), very few

compiled lists exist for mammals and herptiles (3). Error rates were low for omission (5.6 for birds, 3.1 for mammals, and 2.1 percent for amphibians and reptiles), whereas commission rates were significantly higher (15.6, 32.4, and 25.1 percent, respectively).

## Land Stewardship

The stewardship analysis showed that a relatively small proportion of the state is under any sort of protection to maintain its biodiversity. In fact, the North Carolina gap analysis found that approximately 10 percent of the state's area was under management, with the majority of that (7.6 percent, or 969,940 hectares) being federally managed. State management represented 2.2 percent of the state's area (277,064 hectares). A total of 37,413 hectares of nongovernmental organization (NGO) lands had been mapped through a variety of mapping projects and were included in this data set, but we know that this is an underestimate for the state and that those lands will become increasingly important for natural resource management over time. The pattern of land ownership is highly skewed across the state, with the vast majority of public lands being in the outer coastal plain and in mid- to high-elevation mountains.

Slightly over 4 percent (213,841 ha) of North Carolina's land was categorized as status 1 or 2. Federal management, specifically the National Park Service (Great Smoky Mountains National Park), the U.S. Forest Service wilderness areas, and the U.S. Fish and Wildlife Service refuges and wilderness areas accounted for the majority of the status 1 and 2 lands. Status 3 lands were managed predominantly by the U.S. Forest Service (459,081 ha) and the Department of Defense or the Department of Energy (153,363 ha).

## Gap Analysis

Six of the natural cover types in the state have less than 1 percent of their distribution on conservation lands. These types include four cover types of the Coastal Plain: the Xeric Longleaf Pine Woodland, the Coastal Plain Xeric Oak–Pine Forests, the Coastal Plain Mesic Hardwood Forest, and the Coastal Plain Dry to Dry Mesic Oak Forests. The other two cover types are Piedmont types; these include the Piedmont Mixed Successional Forests and the Oak Bottomland Forests and Swamps. Another 25 natural cover types in the state have less than 10 percent of their mapped distribution in status 1 and 2 lands. The Spruce-Fir Forests have over 69 percent of their mapped distribution in status 1 and 2 lands; unfortunately, the distribution of this cover type is dwindling due to causes other than habitat conversion (acid deposition, disease). It is important to note that the gap analysis for existing vegetation does not account for the previous losses in acreage, which for some of these systems represent a severe decline in representation (Noss et al. 1995; Frost 1993).

Of the 414 species modeled, 45 have less than 1 percent of their predicted distribution on lands with long-term protection for biodiversity (GAP status 1 and 2). Thirty of these are birds, six are mammals, and nine are reptiles. In addition, NatureServe and the North Carolina Natural Heritage Program rank 14 of the 45 species as either critically imperiled (SRank 1), imperiled (SRank 2), or vulnerable (SRank 3) in the state.

Overall species diversity is concentrated along the outer coastal plain, with other high-ranking areas including the sandhills and the Asheville basin. Diversity in the sandhills and coastal plain seems to be tied to wetland habitats, whereas the Asheville basin probably is highlighted due to the range in elevation, topography, and land use of the area. For avian species, the blue ridge escarpment and the outer coastal plain stand out as areas of high diversity. High elevations throughout the southern blue ridge represent hot spots for mammalian species diversity. Amphibian species diversity is very closely tied to the coastal plain riverine and wetland systems. This pattern highlights the role of wetland habitat in the outer coastal plain and sandhills. For reptiles, the sandhills region, as well as the xeric pine woodlands in the coastal plain, stand out as the hot spots.

## Outreach

To get the information gathered as part of the North Carolina Gap Analysis Project into the natural resource managers' hands, we worked in cooperation with U.S. Fish and Wildlife Service personnel on the Roanoke-Tar-Neuse-Cape Fear Ecosystem team to build a decision-support tool. The GAP Ecosystem Data Explorer (GEDE) tool allows non-GIS-savvy users to quickly view data and conduct advanced queries with a few simple clicks. While the GEDE tool has been designed to be accessible to a broad audience, it is based on a full implementation of ArcView with Spatial Analyst, and thereby provides an advanced GIS platform for those who wish to expand the complexity of their queries and analyses. The central scripting used in the tool allows us to import our statewide data, as well as other state GAP products, into the tool so they can be used by a broad audience. In addition to the tool, an interactive web site, including download options for county, watershed, and state data sets, should facilitate the distribution to agencies and managers.

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