NORTH CAROLINA GAP ANALYSIS PROJECT AND PRODUCTS

North Carolina Gap Analysis Program

The Gap Analysis Program (GAP) is a national program of the US Geological Survey (USGS) Biological Resources Division whose goal is to work with partners to develop data and conservation plans that serve to keep common species common. The North Carolina Gap Analysis Project (NC GAP) is the state level representative of the National Gap Analysis Program.

The datasets created by state GAP projects and central to their conservation assessments include:

- Detailed land cover including vegetation types

- Species distribution models – terrestrial vertebrates (birds, mammals, reptiles and amphibians) that are known to breed (5 of the last 10 years) and that are regularly occurring non-accidentals in North Carolina

- Stewardship analysis – assessing the amount and degree of protected lands in North Carolina

We were fortunate in that the NC GAP project was completed in time for us to include the results in our Plan. We used their data in the four ways described below.

1. **Habitat mapping** – We used 1992 NC GAP land cover data to create our habitat maps. First we identified major habitat types in the state (derived from NCNHP 2001 and Schafale and Weakley 1990). We then built a cross-walk between the NC GAP land cover data and those habitat types, where the mapped land cover type corresponded to one of the habitats (see Appendix F for the cross-walk). The data was then recoded to create the habitat maps referenced in the terrestrial habitat sections in Chapter 5A. See McKerrow et al. (in prep.) for NC GAP land cover mapping methods.

2. **Species distribution models** – One of the key datasets for GAP projects are predicted distribution models for terrestrial vertebrate species that occur regularly in the state during the breeding season. Distributions for the NC GAP project were developed by mapping the known ranges of the species, creating a habitat affinity database, and identifying additional spatial parameters that could used to model where the species is likely to use habitat within the state. These predicted distributions represent a model of the presence of suitable habitat. For this report, the NC GAP staff provided their data on the subset of our priority species that they modeled as a part of their efforts (Table K1 and Map Series K1-4).

Table K1. Priority species mapped by NC GAP.

Taxa group	# of priority species	# of priority species mapped by NC GAP
Birds	92	81
Mammals	38	33
Amphibians	41	38
Reptiles	43	41
Total	**214**	**193**

Those priority species that were not mapped by NC GAP are species that did not meet the GAP guidelines for inclusion (Table K2). This guideline was designed to exclude species that would be modeled poorly due to their unpredictable distribution.

Table K2. Priority species not mapped by NC GAP.

Group	Scientific name	Common name
Birds	Ammodramus caudacutus	Saltmarsh Sharp-tailed Sparrow
	Ammodramus nelsoni	Nelson's Sharp-tailed Sparrow
	Asio flammeus	Short-eared Owl
	Calidris alba	Sanderling
	Calidris canutus	Red Knot
	Cistothorus platensis	Sedge Wren
	Coturnicops noveboracensis	Yellow Rail
	Dendroica magnolia	Magnolia Warbler
	Elanoides forficatus	Swallow-tailed Kite
	Mycteria americana	Wood Stork
	Porzana carolina	Sora
Mammals	Lasionycteris noctivagans	Silver-haired Bat
	Lasiurus cinereus	Hoary Bat
	Lasiurus intermedius	Northern yellow Bat
	Myotis grisescens	Gray Bat
	Trichechus manatus	Manatee
Amphibians	Eurycea sp 1	Sandhills Salamander
	Pseudacris brachyphona	Mountain Chorus Frog
	Rana heckscheri	River Frog
Reptiles	Eretmochelys imbricata imbricata	Atlantic Hawksbill Seaturtle
	Opheodrys vernalis	Smooth Greensnake

Of the 193 priority species being mapped by NC GAP, 25 species did not have an exact match to the NC GAP list (Table K3). This was primarily caused by the subspecies epithet not being used by NC GAP. However, 12 of those species did not have any other subspecies present in North Carolina, and therefore, do not represent a mismatch of the species concept (see ** in Table K3). Of the remaining 13 species, 11 are multiple subspecies represented in the NC GAP data as a single full species. Two species (the shovel-nosed salamander and the crevice salamander) have been redefined taxonomically since NC GAP developed their database. For these 13 species true mismatches of the species concept exists between our priority species and NC GAP species, and as such, the predicted distribution maps will not be representative of our species concepts.

Table K3. Priority species mapped by NC GAP that do not match up exactly (** indicates species that don't have any other subspecies present in North Carolina).

Group	Scientific Name (as per priority list)	Common Name (as per priority list)	NC GAP-Listed Scientific Name	NC GAP-Listed Common Name
Birds	*Dendroica virens wayne*	Wayne's Black-throated Green Warbler	*Dendroica virens*	Black-throated Green Warbler
Mammals	*Corynorhinus townsendii virginianus***	Virginia Big-eared Bat	*Corynorhinus townsendii*	Townsend's Big-eared Bat
	Peromyscus leucopus easti	White-footed Mouse (coastal subsp.)	*Peromyscus leucopus*	White-footed Mouse
	*Sorex hoyi winnemana***	Southern Pygmy Shrew	*Sorex hoyi*	Pygmy Shrew
	Synaptomys cooperi helaletes	Southern Bog Lemming (coastal subsp.)	*Synaptomys cooperi*	Southern Bog Lemming
Amphibians	*Desmognathus marmoratus*	Shovel-nosed Salamander	*Desmognathus quadramaculatus*	Blackbelly Salamander
	Plethodon chattahoochee	Chattahoochee Slimy Salamander	*Plethodon glutinosus*	Slimy Salamander
	Plethodon glutinosus sensustricto	Northern Slimy Salamander	*Plethodon glutinosus*	Slimy Salamander
	Plethodon longicrus	Crevice Salamander	*Plethodon yonahlossee*	Yonahlossee Salamander
	*Pseudacris nigrita nigrita***	Striped Southern Chorus Frog	*Pseudacris nigrita*	Southern Chorus Frog
	*Siren intermedia intermedia***	Eastern Lesser Siren	*Siren intermedia*	Lesser Siren
Reptiles	*Apalone spinifera aspera*	Gulf Coast Spiny Softshell	*Apalone spinifera*	Spiny Softshell
	Apalone spinifera spinifera	Eastern Spiny Softshell	*Apalone spinifera*	Spiny Softshell
	*Cemophora coccinea copei***	Northern Scarletsnake	*Cemophora coccinea*	Scarlet Snake
	*Farancia abacura abacura***	Eastern Mudsnake	*Farancia abacura*	Mud Snake
	*Farancia erytrogramma erytrogramma***	Common Rainbow Snake	*Farancia erytrogramma*	Rainbow Snake
	*Lampropeltis calligaster rhombomaculata***	Mole Kingsnake	*Lampropeltis calligaster*	Mole Kingsnake
	Lampropeltis getula getula	Eastern Kingsnake	*Lampropeltis getula*	Common Kingsnake
	Lampropeltis getula sticticeps	Outer Banks Kingsnake	*Lampropeltis getula*	Common Kingsnake
	Lampropeltis triangulum elapsoides	Scarlet Kingsnake	*Lampropeltis triangulum*	Milk Snake
	Nerodia sipedon williamengelsi	Carolina Watersnake	*Nerodia sipedon*	Northern Watersnake
	*Ophisaurus attenuatus longicaudus***	Eastern Slender Glass Lizard	*Ophisaurus attenuatus*	Slender Glass Lizard
	*Pituophis melanoleucus melanoleucus***	Northern Pinesnake	*Pituophis melanoleucus*	Pine Snake
	*Thamnophis sauritus sauritus***	Common Ribbonsnake	*Thamnophis sauritus*	Eastern Ribbon Snake
	*Virginia valeriae valeriae***	Eastern Smooth Earthsnake	*Virginia valeriae*	Smooth Earth Snake

The complete set of NC GAP vertebrate distribution models, as well as the full report including methods, will be included in the standard GAP distribution formats (McKerrow et al. in prep., www.gap.uidaho.edu).

3. Species richness analyses – For the priority species that were included in the NC GAP effort, a series of maps of species richness by taxa were developed specifically for inclusion in this report (Figures K1–4). The richness maps will underestimate richness in areas of overlap in the ranges of subspecies. The development of each of the individual species predicted distributions and the richness maps are described in McKerrow et al. (in prep.).
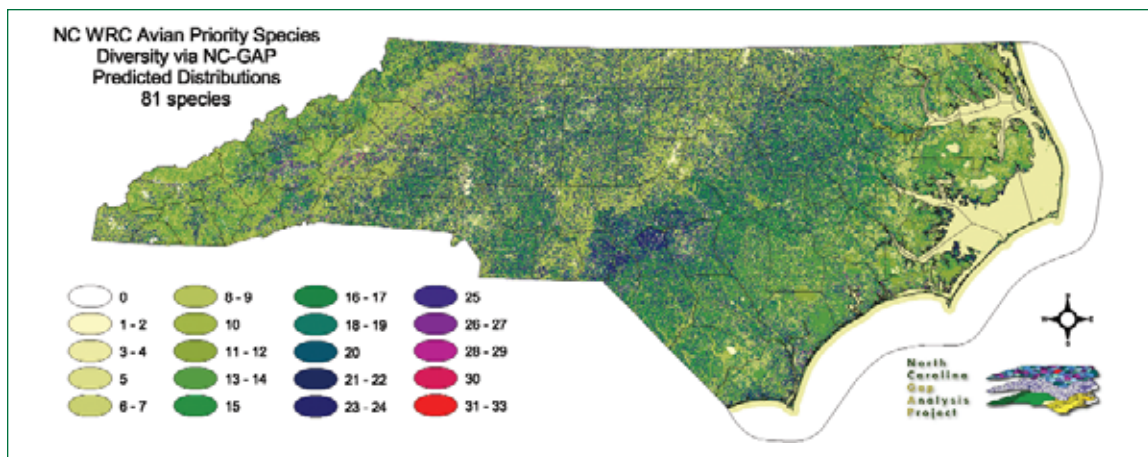

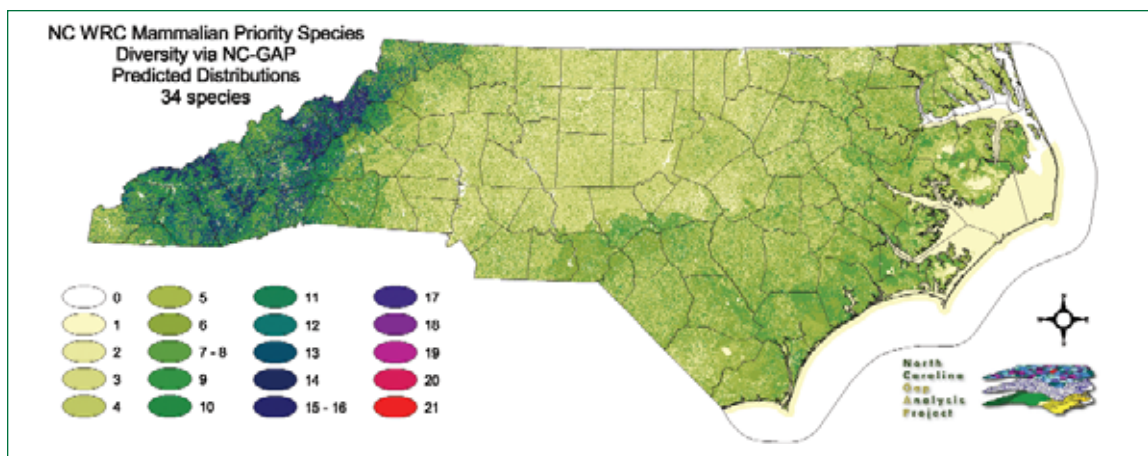**Figure K1.** Avian priority species diversity according to NC GAP predicted distributions.

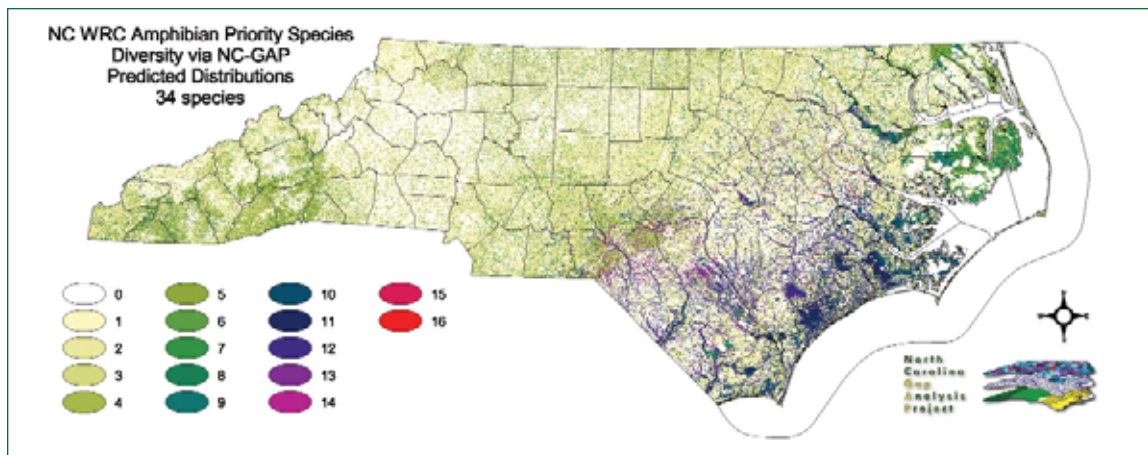**Figure K2.** Mammalian priority species diversity according to NC GAP predicted distributions.

Figure K3. Amphibian priority species diversity according to NC GAP predicted distributions.
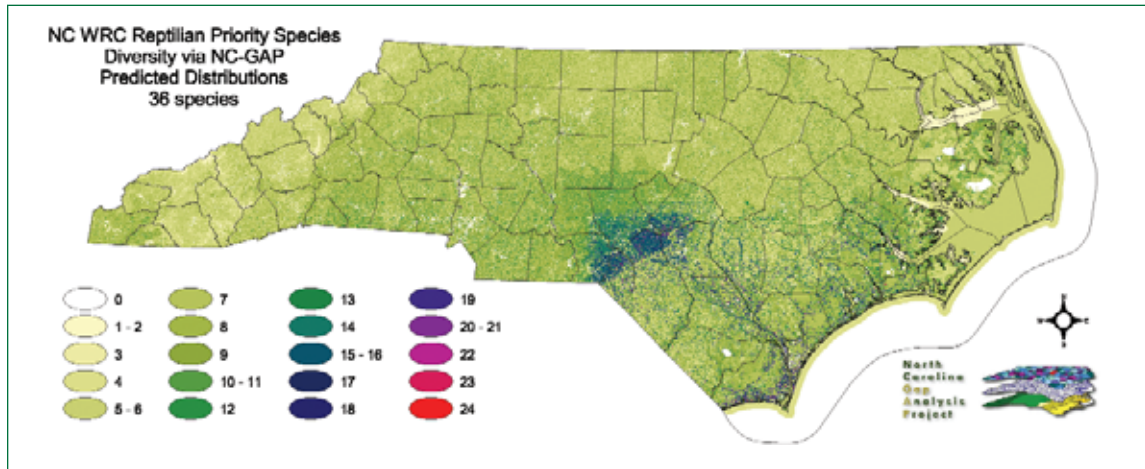
Figure K4. Reptilian priority species diversity according to NC GAP predicted distributions.

The figures above identify richness across the state for the subset of priority species modeled by NC GAP. For the 81 bird species, the Sandhills region of the upper coastal plain and the Blue Ridge Escarpment stand out as important areas (Figure K1). High elevations throughout the central Southern Blue Ridge region represent the hotspots for the mammalian species mapped (Figure K2). Amphibian diversity is very closely tied to Coastal Plain riverine and wetland systems, according to the NC GAP models (Figure K3). The pattern highlights the role of the Carolina bays and peatland pocosins in providing habitat islands in the southern outer Coastal Plain and the role of riparian wetlands in the northern outer Coastal Plain and in the Sandhills. Reptile species richness is closely tied to the Sandhills region of the upper Coastal Plain, as well as xeric pine woodlands (Figure K4).

These analyses point to the need for statewide conservation planning and management if the priority species identified in this Plan are to be maintained. The overlap in species use of Sandhills region habitats by birds, reptiles, and amphibians reinforces ongoing conservation efforts in that region, as does the importance of the wetlands of the outer Coastal Plain to the priority amphibian species. The concentration of priority mammals in the Southern Blue Ridge supports the need for a concerted inventory, research, and monitoring effort there. Even the highly fragmented Piedmont seems to be supporting a fair number of bird species, although the question of habitat quality in this landscape is difficult to assess. The potential for habitat conversion is greatest in the Coastal Plain and Piedmont regions. That fact makes the role of the Piedmont for those priority bird species worth exploring in greater detail.

4. Stewardship "gaps" – In order to assess the conservation status of a species within the state, NC GAP developed a statewide land management status dataset or stewardship map. They pulled together several disparate data sets that contain the boundaries of public lands and reviewed each parcel of land with respect to its ownership and management status. Using standard criteria described below, each parcel was then assigned a stewardship code between 1 and 4 to designate the level of protection afforded to biodiversity. A status of "1" denotes the highest, most permanent level of maintenance, and "4" represents no biodiversity protection or areas of unknown status. The characteristics used to determine status are as follows:

- **Permanence** of protection from conversion of natural land cover to unnatural (human-induced barren, arrested succession, cultivated exotic-dominated).

- **Amount** of the tract protected, with 5% allowance for intensive human use.

- **Inclusiveness** of the protection, i.e., single feature such as wetland versus all biota and habitat.

- **Type** of management program and degree that it is mandated or institutionalized.

The four status categories utilized can generally be defined as:

Status 1: An area having permanent protection from conversion of natural land cover and a mandated management plan in operation to maintain a natural state within which disturbance events (of natural type, frequency, and intensity) are allowed to proceed without interference or are mimicked through management.

Status 2: An area having permanent protection from conversion of natural land cover and a mandated management plan in operation to maintain a primarily natural state, but which may receive use or management practices that degrade the quality of existing natural communities.

Status 3: An area having permanent protection from conversion of natural land cover for the majority of the area, but subject to extractive uses of either a broad, low-intensity type or localized intense type. It also confers protection to federally listed endangered and threatened species throughout the area.

Status 4: Lack of irrevocable easement or mandate to prevent conversion of natural habitat types to anthropogenic habitat types. Allows for intensive use throughout the tract. Also includes those tracts for which the existence of such restrictions or sufficient information to establish a higher status is unknown.

A relatively small proportion of the state is under any sort of protection in order to maintain biodiversity (Figures K5 and K6). In fact, NC GAP found that approximately 10% of the state's area was under management, with the majority of that (7.6%; 969, 940 hectares) being federally managed. State management represented 2.2% of the state's area (277,064 hectares). A total of 37,413 hectares of non-governmental organization lands had been mapped through a variety of mapping projects and included in this dataset, but we know that 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 mid- to high-elevation mountains. See McKerrow et al. (in prep.) for methods.
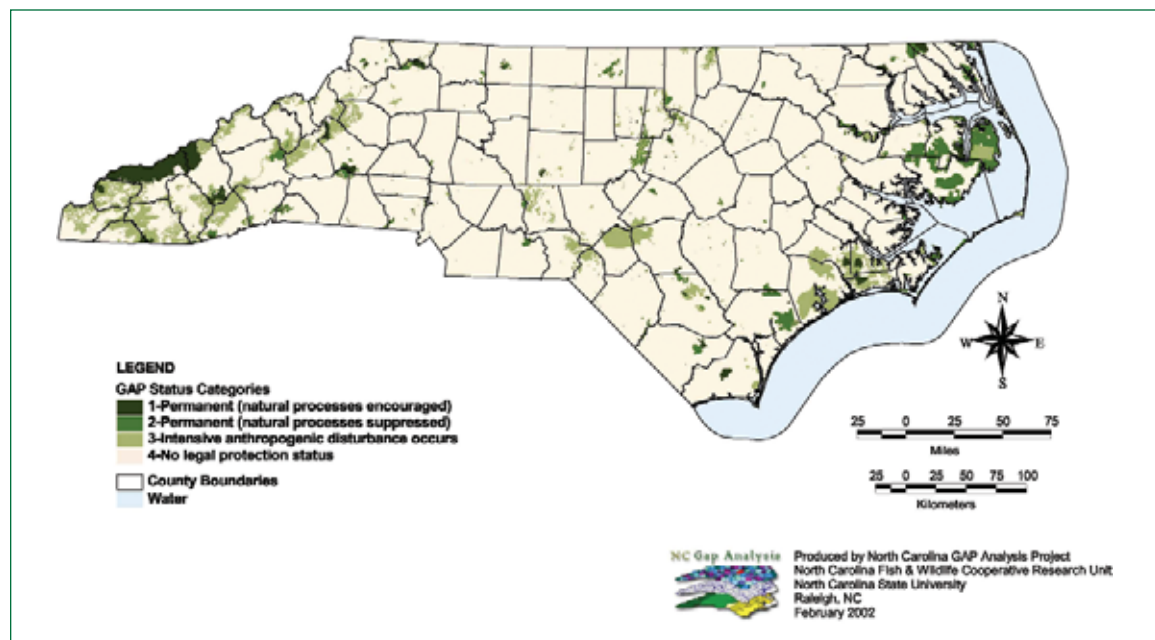

Figure K5. North Carolina stewardship map by GAP status.

Figure K6. North Carolina stewardship map by ownership type.

The Gap Analysis Program defines species with a critical lack of long term protection as those species with less than 1% of their predicted distribution on GAP status 1 and 2 lands. Of the 193 priority species modeled by NC GAP, 24 have less than 1% of their predicted distribution on lands with long term protection of biodiversity one of their primary goals (Table K4).

Table K4. Number of priority species in categories of percent of predicted distribution on GAP Status 1 and 2 lands.

	0 – 1 %	1 – 10 %	10 – 20 %	20 – 50 %	> 50 %
# of Species	24	96	32	31	5

Sixteen of those 24 species are avian species, many of which are associated with grassland habitat (Table K5). This highlights the lack of grassland habitat in long term protection status.

Table K5. Priority species with <1.0 % of predicted distribution on GAP Status 1 and 2 lands.

NC-GAP Common Name	NC-GAP Scientific Nomenclature	NC State Status	Federal Status	% Predicted Distribution on GAP Status 1 & 2 Lands
Mississippi Kite	*Ictinia mississippiensis*	SR		1.0
American Kestrel	*Falco sparverius*			1.0
Northern Bobwhite	*Colinus virginianus*			0.6
Chimney Swift	*Chaetura pelagica*			0.5
Willow Flycatcher	*Empidonax traillii*			0.7
Horned Lark	*Eremophila alpestris*			0.4
Loggerhead Shrike	*Lanius ludovicianus*	SC		0.3
Prairie Warbler	*Dendroica discolor*			0.9
Dickcissel	*Spiza americana*			0.3
Bachman's Sparrow	*Aimophila aestivalis*	SC		0.6
Field Sparrow	*Spizella pusilla*			0.9
Lark Sparrow	*Chondestes grammacus*	SR		0.5
Grasshopper Sparrow	*Ammodramus savannarum*			0.4
Henslow's Sparrow	*Ammodramus henslowii*	SR		0.8
Eastern Meadowlark	*Sturnella magna*			0.5
Orchard Oriole	*Icterus spurius*			0.9
Oldfield Mouse	*Peromyscus polionotus*	SR		< 0.1
Bog Turtle	*Clemmys muhlenbergii*	T	T(S/A)[1]	0.7
Loggerhead Musk Turtle	*Sternotherus minor*	SC		< 0.1
Slender Glass Lizard	*Ophisaurus attenuatus*			0.6
Southern Hognose Snake	*Heterodon simus*	SR		1.0
Coachwhip	*Masticophis flagellum*	SR		0.7
Smooth Earth Snake	*Virginia valeriae*			0.9
Eastern Coral Snake	*Micrurus fulvius*	SR		0.9

Future Directions for the National Gap Analysis Program

State-based GAP products are currently available for 46 states. Of the remaining four states, a pilot project has been initiated in Alaska while full scale projects are underway in Hawaii, Ohio, and Alabama. In addition, Puerto Rico is nearing completion of GAP as well. These state-based projects have provided many states with their first vegetation maps, their first databases and distribution models for their vertebrate species, as well as their first stewardship data layer. The strengths of the state-based project model included capacity building, rapid technological advancements, and the advancement of GIS as a powerful tool for conservation. Its main weakness lies in a lack of consistency of products from state to state. Several factors contributed to interstate inconsistency including different budget cycles, available technology, as well as different standards set, in part, by state cooperators. Now that all of the state datasets are nearly complete, the National Gap Office is refocusing its efforts on regionalization by establishing several Regional Gap Projects. Regional Gap Projects seek to take the best efforts from the preceding state projects and develop seamless, high quality regional datasets that will not only provide a more timely product, but also one that can used to address regional concerns. This is a major advancement for not only traditional conservations agencies (US Fish & Wildlife Service, US Forest Service, National Parks Service, etc.), but also can serve as a common basis to support state Wildlife Action Plans for adjoining states. Partnerships will play an increasingly important role as agencies are asked to be more efficient with their conservation dollars. Currently, there are three ongoing Regional Gap Projects: Southwest, Eastern

[1]T (S/A) - Threatened by Similarity of Appearance.

States, and Northwest. For more information on the National Gap Analysis Program, existing data, regional projects, and other activities throughout the country, please visit their website (http://www.gap.uidaho.edu). For more information on the Southeastern Regional Project see below.

Gap Analysis in the Eastern United States

In the east the Gap Program will be working on a series of regional projects to develop the seamless datasets. The Southeast Gap Analysis Project is a regional project with the goal of developing datasets and tools for use in conservation planning. The primary objective is to create detailed land cover and animal modeling datasets that are consistent across the region. GAP has moved from a state-based model to a regional one in order to facilitate consistency in all of the data being produced. The current project extent intersects 14 states, with nine states being completely mapped (VA, NC, SC, GA, FL, AL, MS, TN, and KY) and four others (LA, IN, OH, and WV) having at least a portion of their states included (Figure K7). Soon we will be adding mid-Atlantic states to the project study area. For now the work we are describing is specific to the Southeast Gap Project.
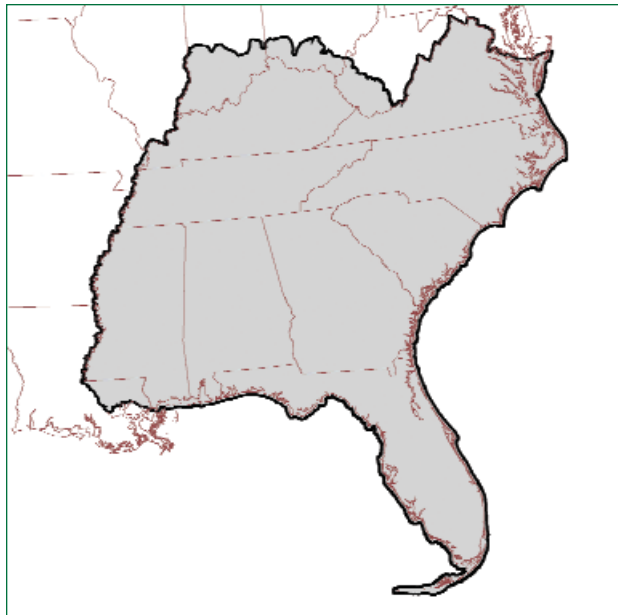

Figure 7. Southeast portion of the Eastern States Gap Analysis Project Area.

Approach

Land Cover Mapping

Southeast GAP is currently working on a series of land cover mapping products, including:
1) General land cover map (21 map units) based on 2001 era imagery,
2) Detailed land cover map (140+ map units) based on 2001 era imagery,
3) Impervious surface estimates, and
4) Canopy closure estimates.

GAP is working in parallel with several agencies to complete the 2001 National Land Cover Dataset (NLCD) (Homer et al. 2002) for southeastern states, which include the general land cover map, impervious surface and canopy closure estimates. All groups involved in NLCD mapping are using the same approach with LandSat satellite images, decision tree classification methodology, and a standard classification scheme, all provided by US Geological Survey EROS Data Center. Detailed land cover map units (being mapped by Regional Gap Projects) will be based on Ecological Systems as described by NatureServe ecologists as well as other land use classes derived from the general land cover map.

Vertebrate Modeling

Six hundred and fourteen terrestrial vertebrate species will be included in the Southeast Regional Gap Project (Table K6). The majority of the species being modeled are those that use habitat during their breeding season, although wintering waterfowl and bats have also been included. The Southeast GAP approach to modeling the animal distributions requires several key datasets including:
1) Species specific range maps (Figure K8),
2) Habitat affinity database, and
3) Ancillary datasets (hydrology, elevation, road density, etc.).

Table K6. Number of species being modeled by Southeast GAP by taxa.

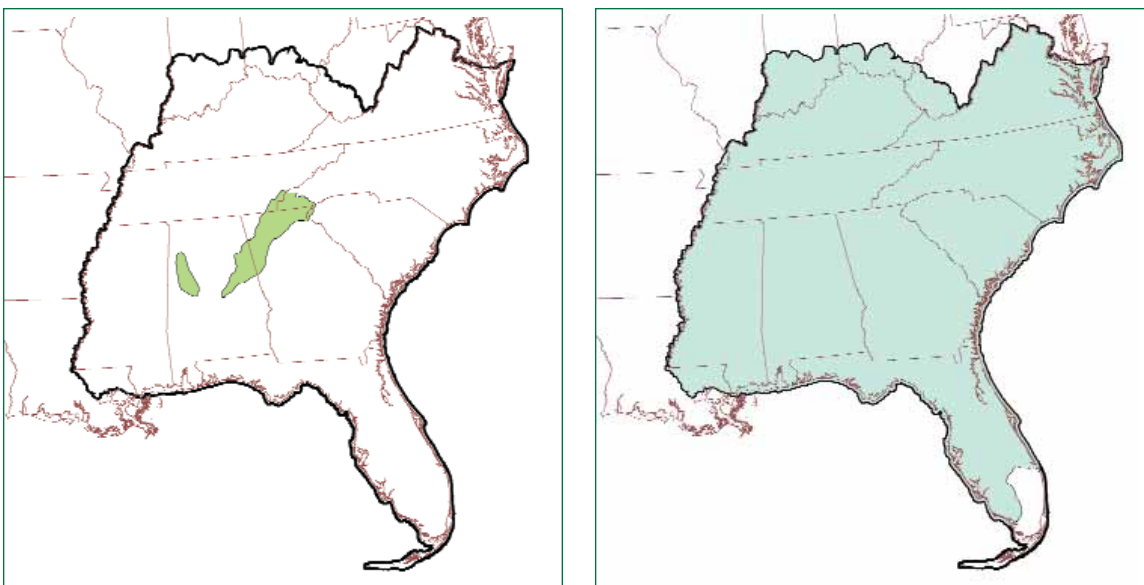| Taxa	Number of Species
Amphibians	133
Reptiles	124
Birds	258
Mammals	99
Total	**614**

Figure K8. Sample range maps for seepage salamander (*Desmognathus aeneus*) (left) and northern parula (*Parula americana*) (right).

Analyses

In addition to the standard analysis of 'gaps' (lack of protection) for each of the land cover types and species, a variety of applications and agency specific analyses will use these datasets. For example, the priority species analyses in this state report will be available across the region upon completion of the project. Currently, Southeast GAP is working with the US Fish & Wildlife Service on use of GAP data in modeling Partner in Flight Priority bird species. For the vertebrate species endemic to the Southeast this data will provide a basis for range-wide analysis of protection for Southeastern endemic vertebrates.
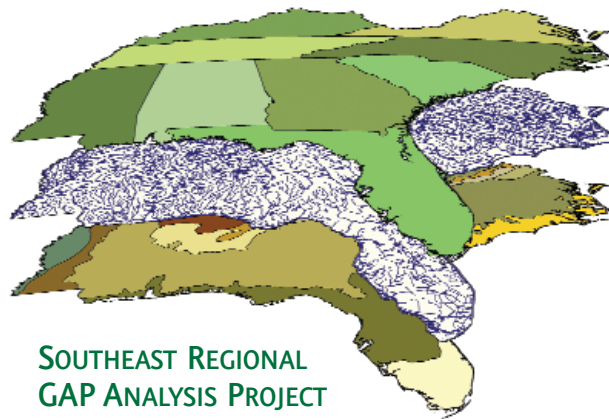
Products and Timeline

Component	Estimated completion date
Land Cover	
Impervious Surface Estimates (%)	June 2005
Canopy Closure Estimates (%)	June 2005
General Land Cover (21 cover classes)	June 2005
Detailed Vegetation (135+ vegetation types)	June 2006
Vertebrate Modeling	
Draft Species Range Maps (614)	Sept. 2004
Habitat Affinity Database	Dec. 2005
Ancillary Datasets Complete	June 2006
Species Distribution Maps (614)	June 2006
Biodiversity Analysis and Final Report	Sept. 2006

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SOUTHEAST REGIONAL
GAP ANALYSIS PROJECT

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