Identification of Conservation Priority Areas in Georgia

Liz Kramer[1] and Matt Elliott[2]
[1]Natural Resources Spatial Analysis Laboratory, Institute of Ecology, University of Georgia, Athens, Georgia
[2]Georgia Department of Natural Resources, Wildlife Resources Division, Georgia Natural Heritage Program, Social Circle, Georgia

Introduction

Congress is requiring all state agencies that receive funding through the State Wildlife Grants program to develop a statewide Comprehensive Wildlife Conservation Strategy (CWCS). The goal of this program is to create partnerships and provide a forum for coordinating conservation activities throughout each state. The CWCS process requires a landscape and ecosystem approach to planning for the protection of biodiversity.The Gap Analysis Program (GAP) provides landscape-scale information that can act as a coarse filter for identifying large areas of intact natural vegetation and habitats. It also provides information on the extent of existing conservation protection. GAP data include a land cover and vegetation map of the state, maps of the potential distribution of the terrestrial vertebrates found in the state, and a map of the distribution of conservation lands in the state.

In Georgia, GAP data allow us to identify coarse-scale habitat patterns, which play a key role in the long-term maintenance of wildlife populations. Habitat fragmentation is a key contributor to the decline in many wildlife species (Farhig 2003). By using spatial pattern analysis tools, large intact areas of vegetation can be identified and prioritized for the CWCS process.

The purpose of our project is to use GAP and other data to evaluate areas across Georgia for potential conservation opportunities. Products include new data that identify areas of natural vegetation that have been minimally fragmented. Additionally, these areas are evaluated to determine if they contain or are likely to contain rare species, how well these species are protected by the current conservation network, and whether they may be threatened by human encroachment. The different data sets may be used individually or in combination to determine which natural areas may need conservation protection.

Methods

Natural Vegetation

The primary data set for much of this project is the Georgia Gap Analysis Project (GA-GAP) 1998 vegetation map. This vegetation map was recoded to produce a map of natural vegetation. Table 1 lists the classes that were categorized as either natural vegetation or nonnatural. Although several classes not classified as "natural" for this project could certainly be considered so under a variety of circumstances (open water, clear-cut/sparse vegetation, open-loblolly-shortleaf pine, loblolly-shortleaf pine, loblolly-slash pine), in most cases in Georgia they are in very active management (reservoirs, clear-cuts, pine plantations, etc.). We believe that excluding them results in a more accurate depiction of lands in a natural state.

For more detailed descriptions of GA-GAP vegetation classes and the methods used to map them, refer to Kramer et al. (2003).

Spatial Pattern Analysis

The primary analysis of Georgia's natural vegetation was conducted in Fragstats 3.3. "Fragstats is a spatial pattern analysis program for categorical maps" (McGarigal et al. 2003). It allows for the computation of metrics that describe the distribution and character of patches of habitat across the landscape, thus it was ideally suited for analyzing natural vegetation in Georgia.

Several factors were deemed to be most important in describing the distribution, context, and character of Georgia's patches of natural vegetation: these are size, shape, internal cohesiveness, distance from nonnatural habitats, and distance from other patches of natural vegetation. When combined, these factors may allow for an overall evaluation of patches of natural vegetation for biodiversity protection and conservation potential.

A significant limitation of Fragstats is the size of digital file that can be processed. A 30-meter grid of the natural vegetation of the entire state of Georgia, even when recoded to values of 1 and "No Data," proved far too large and complex for calculation of the pattern metrics we desired. There were two potential solutions to this problem: resample the grid to a larger grain size (or more coarse resolution), or divide it into smaller areas. We decided to do both.

The initial 30-meter grid of Georgia's natural vegetation was resampled, using a nearest neighbor function, to a 180-meter resolution. Although there were several problems with the results of doing this, most notably the coalescing of a number of larger patches that should probably be analyzed separately, they still proved useful. We calculated the Fragstats metrics of area, contiguity, core area, and proximity at a grain of 180-meters. Area simply measured the surface extent of clumps using a 4-pixel adjacency rule. Core area was similar, but restricted the surface measurement to areas of natural vegetation more than (in this case) 180 meters or 1 pixel from an edge. Contiguity is an indicator of shape, and describes the spatial connectedness or cohesiveness of cells within a patch; it is expressed as an index from 0 to 1, with higher values representing more cohesive patches. These areas are often represented by long continuous riparian forests.

The four indices calculated at a 180-meter resolution were recoded to nine ranked classes. The recoded indices were then added to create a summed index, which may serve as an overall patch quality evaluation. Using this summed index, we drew a series of 12 ecologically similar zones across the state, taking care to minimize splitting significant contiguous areas of natural vegetation (Figure 1). The goal of this exercise was to include large patches that crossed ecozones, which are normally divided along ecoregional boundaries. These zones became the basis for a new pattern analysis calculated at a 30-meter resolution.

Table 1. Distribution of GAP vegetation and land cover classes into the natural vegetation and nonnatural classes for the natural vegetation map.

Natural Vegetation	Nonnatural
Beaches, dunes, mud (coastal areas)	Beaches, dunes, mud (noncoastal areas)
Coastal dune	Open water
Rock outcrop	Transportation
Mesic hardwood	Utility swath
Submesic hardwood	Low-intensity urban —nonforested
Hardwood forest	High-intensity urban
Xeric forest	Clear-cut/sparse vegetation
Deciduous cove hardwood	Quarries, strip mines
Northern hardwood	Parks, recreation
Live oak	Golf courses
Xeric pine	Pasture, hay
Hemlock-white pine	Row crop
White pine	Forested urban—deciduous
Montane mixed pine-hardwood	Forested urban—evergreen
Xeric mixed pine-oak	Forested urban—mixed
Mixed cove forest	Open loblolly-shortleaf pine
Mixed pine-hardwood	Loblolly-shortleaf pine
Shrub bald	Loblolly-slash pine
Sandhill	
Coastal scrub	
Longleaf pine	
Cypress-gum swamp	
Bottomland hardwood	
Salt marsh	
Shrub wetland	
Evergreen forest wetland	

For the 30-meter evaluation, we used slightly different indices. Core area and proximity were calculated again, but perimeter-to-area ratio and core area index replaced area and contiguity. Like contiguity, perimeter-to-area ratio is an indicator of shape. It is a simple index, perimeter/area, and describes the compactness of a clump or patch. Lower values indicate more compact shapes, and because area is in the denominator, it is inherently biased toward larger clumps when other factors are equal. For this reason, and the fact that we were already using core area, we did not feel that it was necessary to retain the area calculation. For the fourth index, we chose core area index. This simply calculates the

Figure 1. Ecologically similar zones delineated from an analysis of natural vegetation using 180-meter pixel size. The zones were identified by combining the results of spatial pattern analysis measures of area, contiguity, core area, and proximity run on a map of natural vegetation developed from the GAP vegetation map. These areas were defined to remove biases along ecoregion boundaries.

percent of a clump that is defined as “core area” (> 60 meters, at the 30-meter grain). It produces an evaluation of internal cohesiveness that is similar to contiguity.

As with the 180-meter analysis, these four indices were recoded to nine classes and ranked. The recoded indices were then added together to create a summed index, which serves as an overall patch quality evaluation.

Element Occurrence Data

The Georgia Natural Heritage Program (GNHP) tracks occurrences of a list of “Special Concern” plants and animals. This database is known as the element occurrence database. A complete list of tracked species is available at <http://georgiawildlife.dnr.state.ga.us/content/specialconcernanimals.asp>.

Besides quantifying the distribution, context, and character of Georgia’s patches of natural vegetation, we also sought to illustrate their relationship to known occurrences and potential habitat for GNHP-tracked species. To do this, we generated several indices across clumps of natural vegetation.

Based on a scheme devised by GNHP that we modified slightly for this project, element occurrences were weighted based on global and state status rankings by NatureServe. (Note: an explanation of NatureServe G-ranks and S-ranks may be obtained at the web link cited above.) Table 2 shows the original GNHP scheme. Our modification of this weighting scheme multiplies each “A” element occurrence by 3, each “B” by 2, and each “C” by 1. The most basic calculation we performed was a simple calculation of the total number of element occurrences per patch of natural vegetation. We also calculated a weighted density of individual points for each clump of natural vegetation by dividing the weighted total by the area. In addition, we generated a weighted density of element occurrences across the state (per 10,000 square meters or 1 hectare), and calculated the average weighted density per clump of natural vegetation.

A final use of the GNHP weighting scheme for Species of Concern involved incorporating them into the GA-GAP vertebrate models. These models are binary predictions of habitat/nonhabitat for all of Georgia’s 405 amphibians, breeding birds, nonmarine mammals, and reptiles. GAP vertebrate models included all species/subspecies from these taxa that are on the GNHP Species of Concern list (see <http://georgiawildlife.dnr.state.ga.us/content/specialconcernanimals.asp>) except the following: limpkin (*Aramus guarauna*), ivory-billed woodpecker (*Campephilus principalis*), green sea turtle (*Chelonia mydas*), leatherback (*Dermochelys coriacea*), black-billed cuckoo (*Coccyzus erythropthalmus*), Chamberlain’s dwarf salamander (*Eurycea chamberlaini*), Florida panther (*Felis concolor coryi*), Eastern cougar (*Felis concolor couguar*), Sherman’s pocket gopher (*Geomys pinetis fontanelus*), black rail (*Laterallus jamaicensis*), Kemp’s ridley (*Lepidochelys kempii*), Blackbeard’s whitetailed deer (*Odocoileus virginianus nigribarbis*), Suwannee River cooter (*Pseudemys concinna suwanniensis*), Sherman’s fox squirrel (*Sciurus niger shermani*), Florida brown snake (*Storeria dekayi victa*), Bewick’s wren (*Thryomanes bewickii*), and Bachman’s warbler (*Vermivora bachmanii*). This was a total of 109 species. For a complete list of GA-GAP vertebrate models and their methods, see Kramer et al. (2003).

The GA-GAP vertebrate models for the 109 Species of Concern were multiplied by their GNHP weighting scores and added together, creating a weighted species richness grid. The mean and the maximum richness score were calculated for each clump of natural vegetation.

Conservation Lands

A third GA-GAP data set, the conservation lands database, was used in an analysis of how well the current conservation network protects patches of natural vegetation in Georgia. For each clump of natural vegetation, we calculated the percent of its total area that is currently under some sort of conservation protection. All lands in the conservation network were treated equally; we did not adjust for GAP codes in this study.

Table 2. Weighting scheme for the element occurrence data obtained from the Georgia Natural Heritage Program.
*Note: All state-protected species are automatically “bumped up” one rank.

Category	Designation	Weight
All federally protected species, all G1 or G2 species, G3/S1	A	3
G3/S2, G3/S3, G3/SH, G4/S1, G4/S2, G5/S1	B	2
G4/SH, G5/SH, G4/S3, G5/S2, G5/S3	C	1

Human Influence

Human influence may be considered a threat to natural vegetation through land-use conversion, the degradation of resources due to overuse, the introduction of exotic species, and other factors. We attempted to quantify this negative influence using two data sets: human population density, calculated from U.S. Census data, and road density. Roads may serve as an indicator of human influence because they facilitate development and provide access to areas.

Our calculation involved creating a population density grid by census block group (U.S. Bureau of the Census 2001) and reclassifying this grid by quantiles into nine classes. Using a statewide roads coverage (University of Georgia–Information Technology Outreach Services 1997), we created a grid of road density, calculated as linear meters per hectare, and reclassed this into nine classes using Jenks's natural breaks (Brewer and Pickle 2002). We multiplied the reclassed road density by two and added this to the reclassed population density. We then calculated the average value of this surface per clump of natural vegetation. Especially when combined with the conservation lands assessment, this value may be considered a threats assessment for significant areas of natural vegetation in Georgia.

Results and Discussion

Natural Vegetation

Based on our classification, approximately 36 percent of the state is covered by vegetation in a natural state (Figure 2). The Blue Ridge ecoregion has 78 percent of its land area in natural communities, whereas the Piedmont and Coastal Plain are 35 and 33 percent, respectively.

Pattern Analysis

The 180-meter resolution analysis resulted in the coalescing of many clumps of natural vegetation (Figure 3). For this reason, it is probably more valuable for broad-scale viewing than actual analysis and ranking of individual patches. The total index for the 30-meter scale analysis is found in Figure 4.

The results of the core area analysis highlight intact patches where "edge effect" is minimized (McGarigal et al. 2003). Many species of concern respond negatively to increased edges, especially those in urban areas (Collinge 1996). Patches with a large core area can provide havens for these species where they are less likely to suffer predation, brood parasitism, human

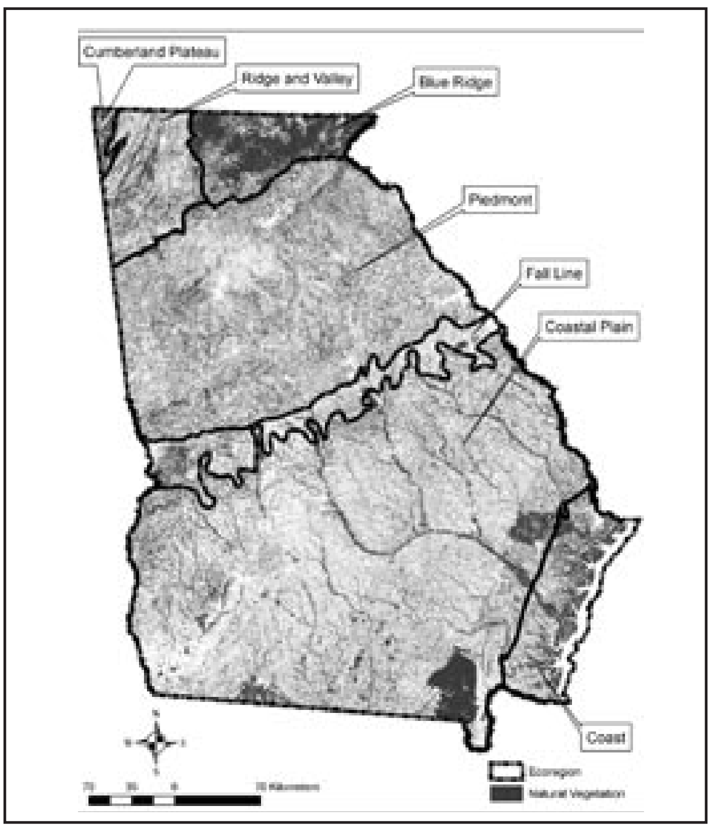

Figure 2. Natural vegetation classification of Georgia resampled to 180-meter pixel size. Derived from the GA-GAP vegetation map. The six major ecoregions of Georgia are shown in this figure.

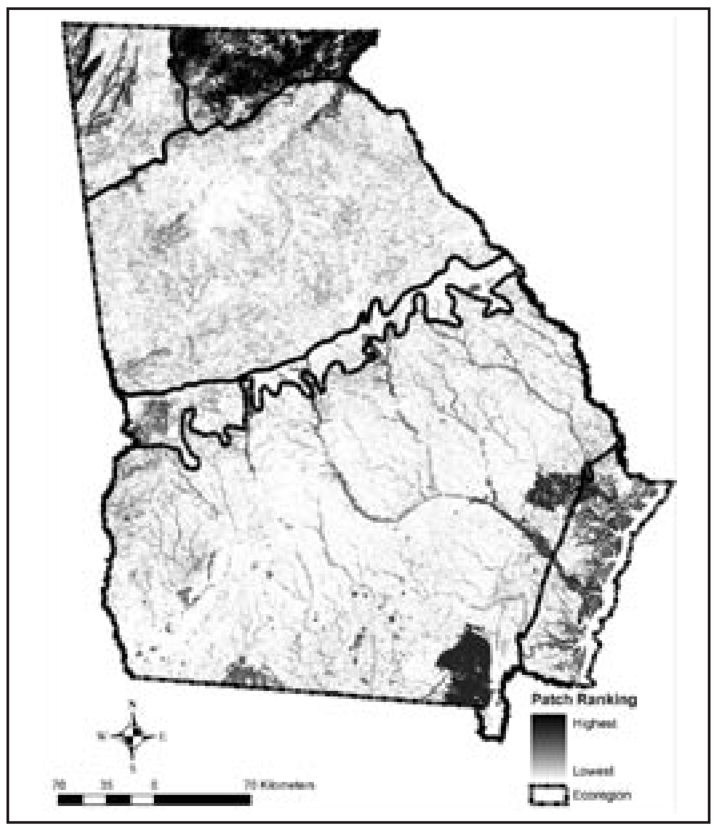

Figure 3. Index of patches of natural vegetation at 180-meter resolution. The index is derived by adding outputs of patch core area, contiguity, perimeter-to-area ratio, and proximity spatial pattern metrics into a single layer. Pattern metrics were derived using Fragstats software.

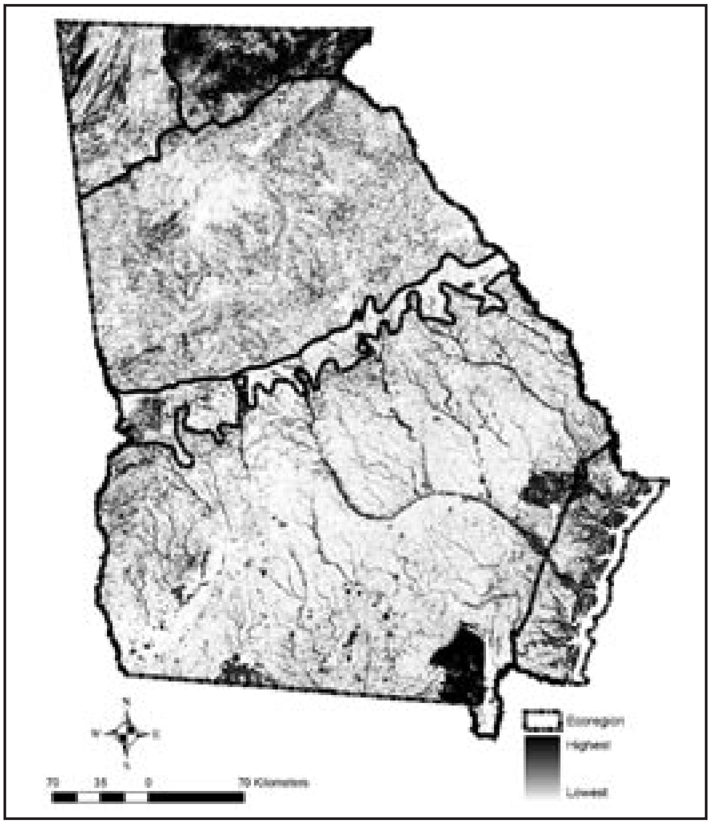

Figure 4. Sum of metric pattern metric rankings developed at 30-meter resolution. The metrics include core area, proximity, core area index, and contiguity. These metrics were derived from the natural vegetation map using Fragstats software.

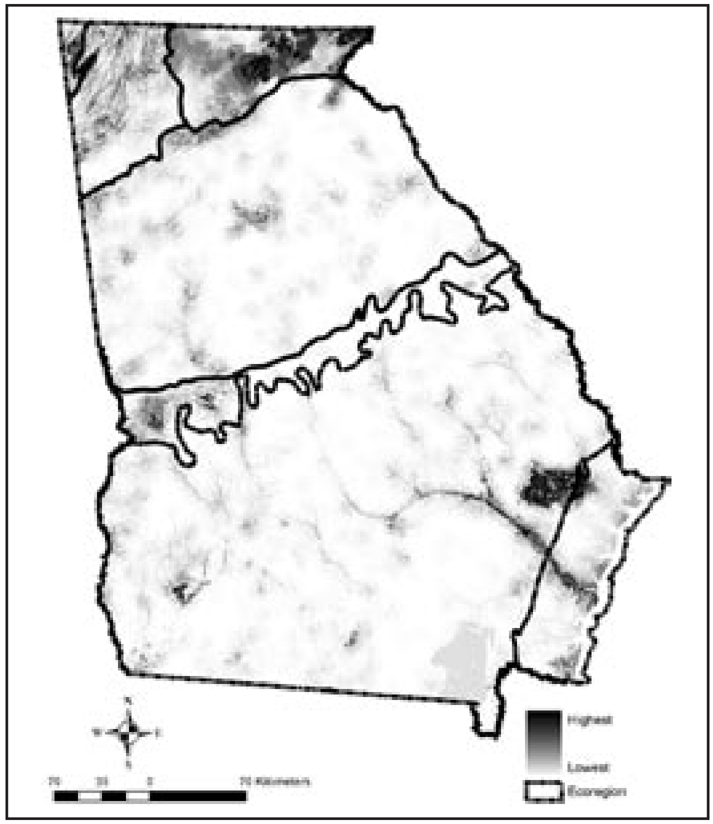

Figure 5. Average weighted density of element occurrences per patch of natural vegetation, calculated per 10,000 square meters. This map was derived using the Georgia Natural Heritage Program's element occurrences database. This database includes aquatic as well as plant and animal point data.

encroachment, or other negative factors (McKinney 2002). Core area index is similar, but as a percentage is not biased toward larger parcels and provides a means for evaluating the internal integrity of parcels of any size (McGarigal et al. 2003). Contiguity and perimeter-to-area ratio both measure shape; perimeter-to-area ratio is useful for finding large, compact patches, while contiguity focuses on internal cohesiveness and may highlight intact corridors (McGarigal et al. 2003). Proximity is best used as part of an overall index (such as the summed index calculated here); it provides a measure of a patch's place within the landscape (McGarigal et al. 2003). Because it considers so many different factors, the sum of the individual measures may be the most useful data set for determining the quality of patches of natural vegetation.

It should be noted that these rankings are not necessarily a prioritization scheme for land protection in Georgia. For example, the dearth of high-ranking patches in the Piedmont, especially when compared to a region such as the Blue Ridge, does not mean that there are no lands worth conserving in the Piedmont. Priorities within the Piedmont may be different from those in the Blue Ridge, and parcels within the region may be evaluated relative to one another, rather than across regions.

Many of the high-ranking patches are already part of the existing conservation network. Although a separate analysis looks at the conservation status of individual parcels, it is also informative to view the pattern analysis as it visually relates to the conservation lands of Georgia.

<u>Element Occurrence Data</u>

The different uses of GNHP element occurrences for this project illustrate slightly different values for individual patches, none necessarily better than another. The total number of GNHP element occurrences per patch appears to be somewhat biased toward large patches. However, this is not necessarily an unfair bias, as large patches may indeed be more likely to harbor a greater number of rare species than small patches. The weighted density of points per patch (total weighted value/area) highlights many small patches and a few larger ones that may be important for rare species. The average weighted density per patch illustrates a more even prediction across the landscape, emphasizing more broad-scale processes (Figure 5). Since the results of each analysis are so different, they should be seen as alternative views, each capturing a different conservation need.

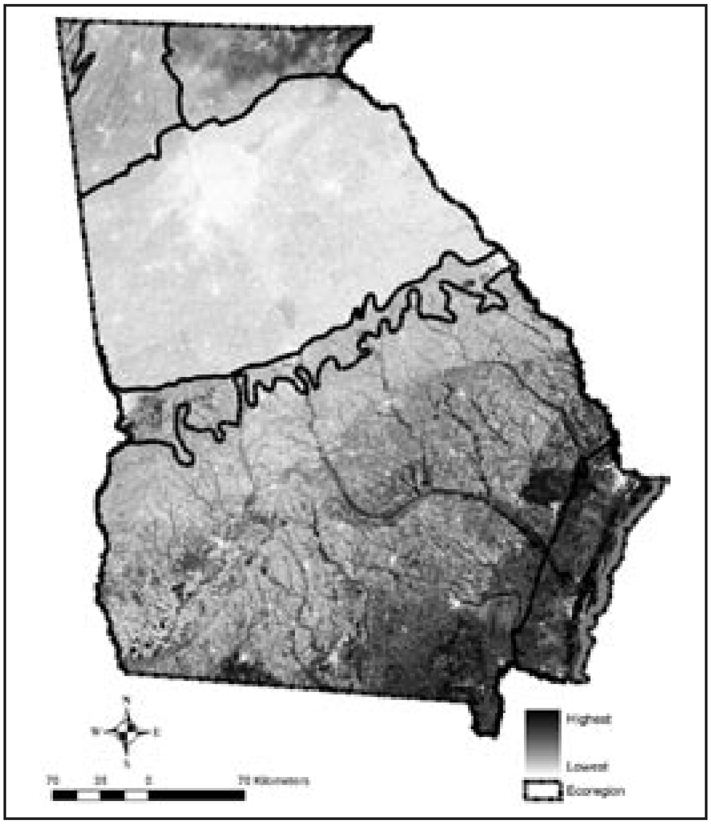

Figure 6. Weighted species richness of GNHP Species of Concern—amphibians, breeding birds, terrestrial mammals, and reptiles—at 30-meter resolution. These data were derived from the vertebrate model maps produced for GA-GAP.

Figure 7. Percent of patches of natural vegetation in current conservation network. These data represent the percentage of natural vegetation that makes up each property in the Georgia GAP Stewardship database.

The weighted species richness grid, calculated from amphibians, breeding birds, terrestrial mammals, and reptiles on the GNHP Species of Concern list, presents a completely different way of looking at biodiversity (Figure 6). Species richness was also evaluated at the patch level, both as an average and as a maximum across each patch of natural vegetation. The average tends to capture landscape-level trends, while the maximum focuses on specific areas of important habitat.

Conservation Lands

The conservation lands analysis provides an indication of how well the current conservation network is protecting natural vegetation (Figure 7). Significant patches that are lighter may be seen as being more threatened than darker colored patches. Under this scenario, significant lighter colored patches might be seen as conservation targets.

Human Influence

We calculated human influence at the natural vegetation patch scale to illustrate threats to individual patches, or perhaps targets for restoration (Figure 8). It is important to note that in areas of high human influence, patches of natural vegetation will be small, whereas in areas with low human influence, we find larger patches. This is just one way of looking at this factor. As part of future analyses, another way that might prove valuable would be to examine human influence within the neighborhood surrounding each patch. This would perhaps gauge future threats more accurately.

Limitations

The process outlined above provides a coarse-filter approach to land conservation. Because the GAP mapping process makes a number of assumptions, these assumptions must be carried through when evaluating the results of these analyses. For example, GAP data does not take into account any measure of habitat quality and in fact uses vegetation communities as a surrogate for habitat. This method does not take into account the distribution of invasive species or other changes in a vegetative patch that might be modified by human management. The process only looks at natural or seminatural vegetation, thus removing some potential habitat that can be derived from agricultural areas, as well as managed pine plantations.

In addition to the limitations of GAP data, the distribution of element occurrence data used in this study has a number of limitations. The collection of these data is often biased to public

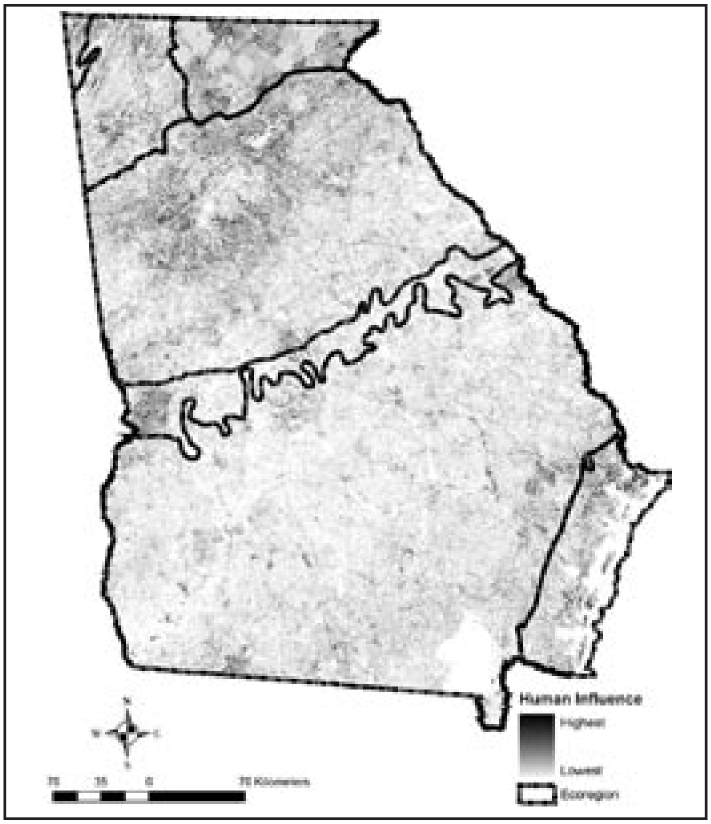

Figure 8. The average relative human influence per patch of natural vegetation. The map intersects areas of high human influence with natural vegetation. Metropolitan areas ranked high in human influence but low in natural areas and therefore do not appear on this map. These rankings represent areas where there is a combination of human influence and natural areas in close proximity.

lands and often to areas of high research interests, such as coastal and mountain areas. The element occurrence data does have an aquatic component; however, this exercise did not attempt a systematic approach to evaluating aquatic systems. This is particularly critical to the southeastern United States, which has a high distribution of aquatic biodiversity.

Conclusions

Approximately 36 percent of Georgia is covered by "natural vegetation." Although there has been no long-term analysis of natural vegetation, the acreage of nonevergreen forest types has declined throughout most of the state since 1974, while acreages for urban uses have increased sharply (Natural Resources Spatial Analysis Laboratory 2001). It is critical that Georgia complete an analysis of its remaining biological resources. GA-GAP was a first step toward this goal. Using our analysis as a guideline, biologists may begin to evaluate high-quality patches at a finer scale, such as the field data collection inventories. In addition, further analysis of the land-use trends data or historic vegetation distributions may provide additional information on sites for potential habitat restoration.Together these methods should lead to the development of sound conservation plans for Georgia.

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