Mississippi Gap Analysis Project

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Introduction

The Mississippi Gap Analysis Project (MS-GAP) began in 1996 as an effort 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 vegetation types; (2) to map predicted distribution of terrestrial vertebrates; (3) to document the occurrence of inadequately represented vegetation types in special management areas; (4) to document the occurrence of inadequately represented terrestrial vertebrate species in special management areas; and (5) to make all information available to resource managers and land stewards in a readily accessible format.

MS-GAP was a highly interactive and cooperative endeavor that involved essentially all state and federal natural resource agencies, conservation organizations, and universities in the state. Further, many private landowner groups and individuals assisted by providing information and participating in working groups. The project encompassed all of Mississippi, a landscape of diverse geologic and natural history. The diverse array of biotic elements is partly attributable to a complex connection of biogeographic components from the southeastern United States, including the Mississippi Alluvial Valley, Hilly Coastal Plain, and Gulf Coastal Plain.

Data Development

Land Cover Classification and Mapping

MS-GAP used a three-stage process of development to complete the land cover. When our project began, the Stennis Remote Sensing Center (SRSC) was completing a circa 1992 land use/land cover project funded by the Environmental Protection Agency. The goal of the SRSC project was to determine the extent and distribution of wetlands within Mississippi. The final product consisted of 25 vegetation classes that approximately equated to Anderson Level 2 classes.

The development of the SRSC land cover was stage one of the process. Preparation of a statewide map of vegetation communities and other land-use cover types required a specific classification system in conjunction with interpretation of remotely sensed land cover data. We developed our land cover classification scheme in cooperation with the Mississippi Natural Heritage Program and in consultation with experts on Mississippi vegetation. MS-GAP obtained Landsat thematic mapper (TM) data (1991–93) at 30-meter pixel resolution from the Multi-Resolution Land Characteristics (MRLC) Consortium. Additional TM data (1992–93) were acquired from the Environmental Protection Agency (EPA). In total, 18 Landsat TM scenes were used for the project. Eight scenes had two dates for analysis, one during leaf-on and one during leaf-off. This seasonal coverage aided in the differentiation of National Vegetation Classification System (NVCS) alliances and alliance groups. Moreover, we used 273 color infrared aerial photographs, representing 6 percent of the state, to aid classification of satellite images.

Stage two of the land cover development process consisted of a pilot study to refine and enhance the SRSC product. Satellite imagery data were analyzed, clustered, and classified using ERDAS software, resource agency maps, vegetation experts, and selected ground site visits. Two satellite scenes, provided by the MRLC, were used to provide temporal vegetative changes. The objective of this pilot study was to enhance the SRSC land cover product and to attempt to classify the study scene to a level of precision as close to NVCS alliances as possible. Classes that were deemed sufficiently accurate and detailed were masked out of the scene. These included agriculture or cropland class, urban classes, transportation, and water/wetland classes. The transportation class was digitized from the imagery, as it could not be separated out spectrally; included were four-lane roads and airport facilities.

Our project team decided that remaining classes could be improved so they were recombined for reanalysis. Additionally, we considered developing specific procedures that would apply specifically to Mississippi and would facilitate the classification process, instead of simply repeating the process used by SRSC or using the methods of other GAP land cover projects. For generation of the land cover we used the Mississippi Transverse Mercator (MSTM) projection. Several other GAP projects examined used some form of data subdivision to reduce the variation within the satellite data set and enhance classification levels. In each case, subsets were believed to aid the final classification process. However, no tests were conducted to verify the results.

Benefits were gained by separating the cluster classes into subsets prior to reclassification and we decided to use an approach of separation based on soil characteristics. We decided to test whether subdividing the data on some parameter would be beneficial to the overall separation of classes and what level of subdivision would prove most useful. Instead of using soils alone, we decided to test the physiographic regions and provinces. The divisions were based on soils, geography, and existing land-use practices. To test for differences within a single cluster class across physiographic regions or across provinces, pine and

hardwood were used as distinguishing classes and split into the different regions present in the scene. Separation was based on the five Mississippi provinces, rather than the three regions designated by The Nature Conservancy (TNC). The provinces further subdivided the three TNC regions into five more detailed regions. We determined the ability to separate pine and hardwood within each region, within combined regions inside the same physiographic province, and within the entire scene.

Our results showed the highest separation existed within each of the 15 physiographic regions, followed closely by separation within the three physiographic provinces. Further efforts to improve class identification involved increasing the distinction between recently harvested timber areas and spectrally similar pastures, croplands, and grasslands. SRSC classes deemed to be poor in classification or too general for use were combined for reanalysis. These classes included pine forest, mixed forest, deciduous forest, pasture, grassland, upland scrub/shrub, barren land, and other land. Based on the analysis of several parameters, we selected a total of 50 classes. The final product of the pilot project scenes had a correct classification rate of 69 percent. The lowest accuracy was low-density pine class and the highest was mixed pine/hardwood. Hardwood uplands, water, recent timber harvest area, and wetland deciduous shrub classes had the highest user's accuracy, while bottom land hardwood, elm ash cottonwood, and medium-density pine classes had the lowest. Moreover, a 15 percent increase in accuracy over the original SRSC land cover map supported our methodology and classification advancements.

We defined high-density areas as pine stands of about 5–12 years in age, medium density as stands of 12–20 years, and low-density stands represented by older trees of 20 years and older. High-density areas consisted of dense stands with many small pines of even height and very little ground vegetation. Stands characterized by more open space between stems from thinning and minimal understory vegetation were representative of medium-density pine areas, while a stand with fewer (yet larger) pine trees with open canopies and moderate understory vegetation consisting mainly of hardwoods was representative of high-density pine areas. Hardwoods were also separated according to stand structural differences and classified into medium- and high-density categories. Structural distinction was based on clusters formed and information drawn from the aerial photographs. This development was a first for GAP programs and we believe it will prove important in differentiating wildlife habitat, especially for habitat specialists.

Stage three involved the conglomeration of information found in stages one and two, and the development of the final MS-GAP land cover map. With the SRSC map as the base, alliances that could not be mapped efficiently due to inaccuracy or confusion with spectrally similar classes were collapsed. Classification for the statewide land cover was conducted on a scene-by-scene basis, rather than on a whole state mosaic. Individual scenes were used because the satellite images across the state were taken at different times of the year and across multiple years. While MS-GAP benefited greatly from processes used or developed by other GAP projects, our project pioneered multiple techniques that not only increased the quality of the product, but contributed valuable information for wildlife habitat assessment and management. One of the major advantages discovered was our ability to accurately distinguish differences in structure within pine and hardwood types. During the pine class clustering process, three separate classes were detected. Further analysis showed a distinction between low-, medium-, and high-density pine areas.

Another development of MS-GAP was the separation of generalized urban classes into more descriptive and useful classifications. Typical GAP projects distinguish two to three urban classes. The medium-density urban class was more closely examined and reclustered into eight new urban classes with more specific vegetative land cover descriptions. We believe this advancement may increase the differentiation of vertebrate species-habitat predictions, particularly for those vertebrate species adapted to varying urban environments.

Predicted Animal Distributions and Species Richness

To develop our knowledge base for the predicted animal distributions, we initially consulted species lists of terrestrial vertebrates in Mississippi from several field guides. This list was cross-checked with the Mississippi Natural Heritage Program database for omissions and inclusions. We examined theses and dissertations available at Mississippi State University to populate our species-habitat database and supplement the information provided by field guides. We developed models for species designated as breeding in the state at least once in the previous five years.

Bird species range maps were initially delineated using available TNC information. However, we also incorporated collection records from major natural history museums around the country (e.g., the Smithsonian Institution and the American Museum of Natural History), as well as from prominent regional museums, (i.e., the Louisiana State University Natural Science Museum and the Mississippi Museum of Natural Sciences) into our avian range map database. We established a MS-GAP Bird Oversight Committee to refine species range maps and to align range maps along physiographic regions of the state, where appropriate.

The available information on mammal distribution was deficient in Mississippi as research had been limited to very few species, mostly of game management importance. The first examination of the species range was delineated from available sources in the state. Species records were then collected from museums with electronic databases and museum records were compared to available range maps. Any discrepancies were scaled to the greatest common denominator as a conservative measure. Range

maps were reviewed and edited by the MS-GAP Mammal Oversight Committee.

Extensive museum records were available for the diverse herptile fauna of Mississippi. Museum records were collected and mapped to the county level. Range maps were also selected from TNC data. Gross disparities in ranges from museum records were reported, and records were verified by museum curators for accuracy. We included all museum records in the range development regardless of date; however, records older than 30 years were excluded for a second comparison to prevent the inclusion of spurious records. Final species ranges were determined by the MS-GAP Herptile Oversight Committee.

The exponentially increasing size of intersected GIS coverages and processing time due to topological considerations involved with vector GIS greatly increased the time spent modeling animal distributions. Consequently, we intersected all coverages once, creating a hypercoverage whose polygons were unique combinations of seven land cover and physical coverages. A data file was created with rows representing hypermap polygons and columns denoting each animal's presence (1) or absence (0) for each hyperpolygon ID number. Use of a statewide hypercoverage exceeded our software capabilities so the hypermap was subdivided into three coverages. The first coverage (land cover hypermap) included all coverages except water buffers and slope. The second coverage (water hypermap) contained all data layers except land cover and slope. For these two coverages, the state was divided into nine tiles identical to the land cover map. The third coverage was statewide slope coverage. A species map was constructed by combining the three hypercoverages as pertinent.

The richest predicted areas in the state contained 223 of 306 vertebrate species, or 72.8 percent of the total. Overall, the richest areas for vertebrates in Mississippi were in the bottomland hardwood basins of the Pearl, Yazoo, and Pascagoula rivers. Herptile richness was greatest for the Mississippi coast. Accuracy for bird predictions was relatively high, especially for the De Soto and Delta National forests, approaching 80 percent. Omissions were primarily unusual species for which we had little evidence for inclusion in algorithms that intersected spatial coverages. Overall, errors of prediction for birds were a combination of edge-of-range detections and predictions of species that have relatively limited occurrence in that area. A limited historic survey of some areas of the state also appeared to influence errors.

Land Stewardship and Management Status

Land stewardship was mapped in two phases: (1) land ownership boundaries (with associated land use/land management information) were collected from various federal, state, and private sources; and (2) these boundaries were assigned one of four management status categories defined by national GAP standards as a measure of conservation afforded to biological diversity in that land tract (Status 1 = highest conservation class). The Mississippi Department of Wildlife, Fisheries, and Parks worked jointly with MS-GAP to produce a map of land ownership categories in Mississippi. Individual private parcels were not identified; private land was mapped only as a category. This digital map formed the basis of our land stewardship data layer, with additional data about specific stewardship boundaries incorporated from federal and state agencies, land trusts, and private landholders.

Before assigning management status categories to the stewardship boundaries, we collected information on how various groups and individuals statewide viewed management classification. MS-GAP made a concerted effort to contact public and private landholders to gather pertinent stewardship information. MS-GAP also made a special effort to identify private lands subject to special conservation provisions. We recognized that many private landowners practice good stewardship, and we made a substantial effort to include them; however, only conservation backed by legal enforcement, such as legislation or conservation deed restrictions, was considered in categorizing tracts for long-term maintenance of biodiversity.

Analyses

Private lands were a prominent category of stewardship; federal stewardship was dominated by the U.S. Forest Service and the U.S. Fish and Wildlife Service. We identified four general categories of land tracts represented in management status 1 and 2 lands. These categories included an array of federal, state, and private management entities associated as stewards and information sources. We estimated distribution of management status in Mississippi as 22,759 hectares of status 1 (0.2 percent), 98,708 hectares of status 2 (0.8 percent), 622,362 (5 percent) of status 3, and 11,630,095 hectares (94 percent) of status 4.

While analyses of animal species richness provided indicators of biologically valuable areas, they also involved confusion because areas with similar or identical richness values could actually contain different individual species. Therefore, these analyses should be viewed as a general perspective on areas to focus more detailed biological evaluation. We believe it is important for all future users of these data to recognize that some species primarily distributed on status 3 and 4 lands may adequately meet their biological needs within these areas.

Thus, while the majority of vertebrates we included had a limited distribution on the highest conservation status lands, judicious evaluation will be needed to determine which ones represent actual biological gaps. These data must be regionalized with other gap analysis projects to perform biological analysis across broader geographic distributions for many of these species. Moreover, MS-GAP data were produced solely with the goal of conducting a "coarse filter" assessment on distribution and

conservation status for plant communities and selected animal species. The project was conducted in a relatively short time frame with minimal resources, thus limiting data quality to that appropriate for large regional assessments. We specified a variety of limitations on data use in the report. We believe, however, that the data and analyses will be of use to many land planners, managers, and researchers who examine the data sets in detail and observe appropriate precautions regarding scale, the accuracy of remotely sensed data, the simplification inherent to predictive models, and the dynamics of biological populations.

MS-GAP Users and Applications

The long process of data acquisition and sharing developed a strong working relationship with MS-GAP cooperators. The Mississippi Final Report and all GAP data and products are available on the GAP web site <http://gapanalysis.nbii.gov> and on compact discs, which can be ordered by contacting the Cooperative Fish and Wildlife Research Unit at Mississippi State University. GAP data and products provide support to agencies in terms of applying spatial technologies and existing spatial data to help solve current natural resource problems. MS-GAP data are being actively used by many cooperators in the state and in nearby states, as well as by the general public. The Mississippi Department of Wildlife, Fisheries, and Parks (MDWFP) is using MS-GAP data in the state's Comprehensive Wildlife Conservation Strategy plan. The MDWFP Law Enforcement Division has made use of MS-GAP products to assess the distribution of game violations and conservation officers' sphere of influence. The MDWFP Natural Heritage program has incorporated MS-GAP into their species' database. The Mississippi Department of Marine Resources regularly makes use of the MS-GAP land cover for coastal zone assessments. The U.S. Department of Agriculture Animal and Plant Health Inspection Service (APHIS) has used MS-GAP products in piscivorous bird research and control programs. Moreover, MS-GAP data is being applied in species and ecosystem research and conservation efforts in the state. MS-GAP land cover data was applied to develop a spatially explicit model, derived from demographic variables, to predict attitudes toward black bear restoration in the state. More recently, MS-GAP data has been used to develop a spatial decision support system to assist county planning boards that integrates a Bayesian Belief Network with GAP data.

Conclusions

MS-GAP provided the first spatially refined data for the distribution of natural vegetation communities, animal species, and the conservation status of lands in the state. A variety of conservation assessments are now possible simply because these data now exist. However, these data sets could be further improved by (1) an updated and refined land cover map to more accurately inventory Mississippi's land surface resources and stewardship; (2) refined animal distribution predictions to differentiate between predicted potential distribution and actual distribution; and (3) a better assessment of conservation status of all lands in Mississippi that can better focus planning and management activities.

In summary, at least 50 natural land cover classes were identified in Mississippi. A small percentage of vertebrates were found having restricted occurrence on lands managed for long-term conservation of biological diversity. These restricted classes, especially wetlands and riparian areas, are under varied stewardship, including substantial private ownership. Most vertebrate species did not have substantial parts of their distribution on status 1 and 2 lands and occurred among a wide array of land stewards. Thus, the opportunity for conservation partnership is widespread, with upfront information that can easily focus attention and minimize contentiousness about what to accomplish and where.