The GAP Analysis Program and the National Land Cover Characterization Database (NLCD)

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Abstract
The USGS Gap Analysis Program (GAP) has been a long-time collaborator of the MRLC Consortium (http://www.mrlc.gov/mrlc2k.asp). Originally, the coordination served GAP well by providing a cost-effective venue for the acquisition of satellite imagery critical to our biodiversity mapping. Today, we find that our programs, GAP and NLCD, have evolved in a way that complements each other. Numerous GAP projects discovered that stratifying states or regions ecologically lends itself to more efficient mapping and image processing. The classification protocols developed for the NLCD 2001 effort provide GAP mappers with useful tools for conducting such a stratification consistently across the US. In essence, this provides a first cut of broad vegetation categories that can be further classified into the finer, ecologically-based units. This finer, more detailed, classification can be used to do biodiversity assessments on vegetation patterns and to model habitat relationships for vertebrate species thus completing our biological database. Newly initiated GAP projects are coordinating with the EROS Data Center to incorporate methodologies and add these interim data layers to the NLCD dataset. Our program benefits from the coordination with other agencies, the expertise of the remote sensing staff at EROS, and the standardization of the outputs. Inevitably, we find ourselves in a better position to focus more on analysis and applications that can better inform land-management decisions.

Why GAP?
The extinction crisis is real and it is here. If we wait until species are endangered before we take steps to protect them, we will perpetuate the crisis. GAP's (p10901.jpg) mission has been to keep common species common. Our primary goal has been to evaluate the existing level of protection for animals and vegetation communities so that researchers and land management planners may make proactive decisions to protect all elements of biodiversity. In this way all managing entities may help to slow the tide of species added to the threatened and endangered lists.

What is GAP?
The GAP Analysis Program is designed to keep common species common by plugging the gaps in our network of lands managed for biodiversity. A GAP in this sense is any species or plant community which is not represented, or underrepresented, in the conservation network. Our program provides data that make that possible. While there is no magical threshold for what constitutes 'protected enough", gap analyses do provide a first cut towards understanding the big picture.

Each GAP Project generates the following spatial data layers (p10902.jpg). The land cover is mapped using TM satellite imagery. Numerous states have flown videography or air photos to augment existing plot data for training and accuracy assessment. Each project has attempted to map to the NVCS alliance level (dominant species). Newer projects are using "ecological systems" as their basis for vegetation classification which may prove to be more mappable from imagery.

The animal modeling is a three step process – delineating a coarse range, developing a species-affinity database, and finally predicting its distribution within its range. This is done for each vertebrate species known to occur in the project area (state or region). Accuracy assessments are done with existing occurrence data, or check sheets, not used for modeling.

Finally, each project has created a spatial stewardship database which identifies ownership (at broad agency and organizational levels), the entity of management (which may be different from ownership) and the level to which each parcel of land is managed to maintain biodiversity and natural processes. The gap analysis calculates the overlap between the conservation lands and each vegetation type and animal species. In this example, we have done a gap analysis for Sage Grouse across the western states. Only 6% of its predicted distribution overlaps with conservation lands.

GAP data can be used in a myriad of ways to inform land management decisions and leverage conservation dollars. Frequently, federal and state agencies need to conduct analyses beyond their political boundaries. With GAP data, managers and biologists can assess which agencies have the most amount of habitat for species of concern.

When they need to make decisions regarding which areas are the best for capturing suites of species or vulnerable plant communities, GAP data can provide the baseline information.

Typical questions that GAP data can be used to answer:

- What managing entity owns this land? Federal? State? County?
- Which land owner has the most potential to implement management that would protect this suite of species? This vegetation community?
- How much does my agencies' /organization's management add to the conservation of these species of interest?
- Where do these species predicted distributions overlap in my area of interest?

Managing for biodiversity is a complex issue. Land managers need information to help them evaluate which areas are best to use for general management such as timber or mining extraction, grazing, recreation, etc. Conversely then, which areas are the best to manage as conservation lands which would capture a full suite of species? Historically, our most protected areas are high elevation, inaccessible places, typically an alpine type habitat. Clearly, that would not provide protection for some suites of species, such amphibians and reptiles, that would more likely occur in lower elevation riparian areas.

Initially, our program focused on terrestrial vegetation and vertebrates (mammals, birds, amphibians and reptiles.) We have now implemented an aquatic component to GAP as well. We initiated several projects to test methodologies and analytical protocols. Our focus is primarily fish, with some projects including molluscs and crayfish. (p10903.jpg)

Expected outputs will be invaluable databases which link the physical stream characteristics to the biological component. Here is an example from Ohio where project staff have compiled point location data over the whole state so users can query the sampling records for each organism p10903b.jpg. Not only will this be the basis for predicting occurrence (p10904.jpg) beyond sampling locations but can help biologists to prioritize field sampling dollars more effectively.

How do GAP and NLCD mapping complement each other?

The GAP Program was a participant in the initial MRLC data buy. At that time many of the agencies were interested in acquiring the imagery for their own land cover mapping objectives. Coincident land cover mapping within the same agency may seem redundant, but the NLCD and GAP layers had different thematic objectives. NLCD implemented a coarser legend in order to get nationwide mapping done in a more expedient manner to serve their primary users. GAP strove to produce a more detailed map, state by state, where the vegetation units are a biological element to be evaluated alongside vertebrate species distributions. We would never have been able to implement our program nationally without this coordinated buy.

This map shows the current status of land cover mapping from the 1st Phase of GAP (p10905.jpg). All states in dark green are done and the data and report are available on CD or from our ftp site. The lighter green shows states which are basically done with a draft land cover and so it may be available from that state project. We have not started a GAP project in Alaska but all other states (including Puerto Rico) have a GAP project underway.

Now we are moving into a 2nd generation of GAP projects and the MRLC group and NLCD products are still very complementary to our program. The benefits we see are:

- 1st Phase GAP Projects evolved towards more stratified classification rather than scene-based protocols. Having learned this lesson, GAP will benefit from the implementation of map zone boundaries nationally.
- EDC mapzones represent a good combination of ecological, spectral and spatial units for GAP mapping activities.
- EDC methodological guidance adds efficiency to GAP modeling efforts so that we can focus more on finer scale mapping, applications and analysis of biodiversity.
- GAP has the opportunity to coordinate with other agencies with varying objectives for land cover mapping; this has proven to reduce time and cost by minimizing duplication of effort.
- GAP can produce NLCD deliverables (coarse land cover, imperviousness, tree canopy and accuracy assessments) for numerous mapzones as part of the GAP mapping process
- GAP will augment videography or aerial photo database for all MRLC members. Whenever we have captured these kinds of data we include it in the datasets. New projects will be developing websites to serve these data.

This is a glimpse at where we are starting for our second generation of GAP mapping (p10906.jpg). The Southwest has been underway for a few years. We hope to be able to provide NLCD land cover for the zones in those states. The Mid-Atlantic has been underway for a year for GAP level remapping. The Southeast Regional Project will be completing NLCD land cover mapping, imperviousness and tree canopy as well as complete GAP level mapping by 2006.

Where can GAP go from here?

Most of our efforts in GAP have been put towards generating the data, but we have had opportunities to facilitate analysis and understanding of biodiversity issues in numerous projects. A few examples are:

Socioeconomic Variables in the Hudson Valley Habitat Vulnerability Assessment

The goal of this project is to develop a CENSUS-based methodology which uses projected population growth information, census data, and physiographic restrictions to assign a habitat vulnerability index to individual census block groups. The Hudson River Valley (HRV) provides habitat for hundreds of migratory and resident species of wildlife. Recent data developed by the New York Gap Analysis (NY-GAP) project shows that over 80% of the terrestrial vertebrate species within NYS can be found in the HRV. The HRV is facing a period of re-industrialization and concomitant residential development. The ability to predict accurately the loci of that development and subsequently identify the ecologically and culturally sensitive areas, will empower decision makers with the knowledge necessary to take actions required to minimize impacts and maintain wildlife and fish habitat, biological diversity, and regionally significant historical/cultural sites.

The GAP Ecosystem Data Explorer Tool in the Roanoke-Tar-Neuse Cape Fear Ecosystem

Much like Refuge-GAP, an early decision support tool, the GEDE Tool is a customized ArcView (ver. 3.2) project that displays and manipulates GAP data through a series of dialog boxes and avenue scripts. The 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.

Using GAP data to assess the potential impacts of mountaintop mining in West Virginia

One of the first critical uses of the West Virginia GAP data was in an Appalachian-wide environmental assessment of the impacts of mountaintop coal mining. The environmental assessment that is being completed is comprehensive, focusing on aspects ranging from socioeconomic and community impacts to hydrologic and wildlife impacts. Areas that are potentially suitable for mountaintop mining were identified in associated GIS-based modeling efforts. These data then provided the base for estimating the impacts of potential future mining scenarios on land cover, land use, community development, and wildlife-assessments that relied primarily on the GAP-generated land cover and wildlife models that were developed.

Taking Refuge-GAP a step further: The GAP Ecosystem Data Explorer Tool in the Roanoke-Tar-Neuse-Cape Fear Ecosystem

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The Utah GAP Education Project CD-ROM

This project was developed for use in Utah's K-12 classrooms. What began as a GIS education project evolved into a multi-media presentation that used video, still photographs, text and maps for select Utah wildlife and their habitats, 13 designated wilderness areas and selected proposed wilderness sites, and a large selection of physical and human geography maps from the Utah Atlas.

Washington State's NatureMapping Program

The vision for NatureMapping is to create a national network that links natural resource agencies, academia and land planners with local communities primarily through schools. Their goal is to keep common animals common and to maintain our quality of life. The approach is to train individuals to become aware of their natural resources and to provide the tools to inventory and monitor their resources.

Participating states include Arkansas, California, Idaho, Indiana, Iowa, Michigan, Ohio, Oregon, South Carolina, Virginia, and Wisconsin.

Clearly, there are wide ranging applications for GAP data to facilitate analysis and decision-making in natural resources (p10907.jpg). Coordination with the NLCD effort has helped us to streamline data generation and allowed us to participate more in applying the results.
For more information about our program, visit our website at:
www.gap.uidaho.edu.

Acknowledgements

Many thanks to all the partners and collaborators who have made the GAP Program as successful as it is. The application examples were drawn from the GAP web page (www.uidaho.edu), and are literally just a few of the many fine applications we know about. The reader can visit our webpage and find links to these projects and many more. Specifically, thanks to Charlie Smith, Doug Ramsey, Steve Williams, Karen Dvornich, and Charlie Yuill for making us aware of these examples. The GAP program has truly benefited from its collaboration with the USGS/EROS Data Center and appreciate everything Collin Homer and Nick Van Driel have done to facilitate the MRLC.

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