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Director's Corner

First of all, thanks to everyone for your understanding and patience during this very uncertain budgetary process we are going through. We hope that fiscal year '97 and the transition of the National Biological Service to the U.S. Geological Survey will be much easier.

As more states complete their projects, we will have increasing opportunities to test predictions of vertebrate occurrences at various thematic and spatial scales. We will also be able to examine representation of species and vegetation types in special management areas across their full range of geographical and ecological occurrence. In addition, our maps provide a sampling framework for more detailed mapping of biological structure and function and thus permit us to gather unbiased estimates of these features. Such efforts should contribute greatly to transboundary planning.

The accuracy assessment of GAP products is an important area in which we can, and have, made important contributions. It is important that we report the results of our work on accuracy assessment in the refereed literature (see Edwards et al. In press and 1996). A small workshop involving researchers from several GAP projects as well as from the U.S. Forest Service reviewed current methods used for accuracy assessment and identified those most appropriate for use with regional mapping efforts like GAP. The workshop was convened by Western States coordinator Patrick Crist in Denver this spring. He will report on the results of this meeting at our Key Largo meeting. In addition, we will continue to budget for further work on accuracy assessment issues. A request for proposals to address issues of accuracy, scale habitat relationships, and other topics that test the assumptions and products of GAP will be sent out October 1, 1996.

During the last five years, GAP investigators have developed new techniques for mapping land cover. It's time to review all that has been done. Jim Merchant will be documenting land cover mapping methods used by GAP investigators, comparing the different methods to identify strengths and weaknesses, costs, etc. and will host a workshop in March 1997. We hope that his findings will be useful to new GAP investigators as well as to our second-generation land cover mapping efforts. As one example of the lessons we have learned, recent land cover mapping efforts in New England and the Midwest have identified the importance of multiple dates for satellite coverage as an aid in obtaining more accurate and thematically more detailed vegetation maps. To meet the need for multiple dates, GAP is joining with its other Multi-Resolution Land Cover Consortium partners to purchase triple-date coverage of the coterminous United States. Scenes will be selected from available dates for summer 1995 to summer 1997. We believe that this second joint purchase of satellite scenes will greatly help coordinate interagency mapping efforts to develop a fully integrated, second-generation land cover map for the country. This map will be pixel-based with a MMU of 2 ha, a 50-fold higher spatial resolution than our current standard.

Ross Kiester and others used results of Idaho GAP to examine use of different algorithms to prioritize the selection of locations for conservation action and research and found complementarity rather than species richness to be the more defensible approach (Kiester et al. In press). Blair Csuti, working with research groups in England and Australia and the Biodiversity Consortium in Oregon, came to a similar conclusion based on a collaborative analysis of the Oregon data set (Csuti et al. In press).

Several GAP project investigators are testing the assumptions of the vertebrate models. Bill Krohn and his group are using information from the various accuracy assessments conducted to date to identify those species that we have difficulty reliably predicting, looking for commonality in life history, behavior, and demographics. It is hoped that this information can be used to develop more reliable vertebrate models. Of particular interest are any shared behavioral and/or life history or demographic characteristics that difficult-to-predict species may have.

Craig Allen, Wiley Kitchens, and the rest of the folks with Florida GAP have put together what promises to be a very interesting and stimulating program for the 1996 Annual GAP Meeting as well as some great field trips after the meeting. I look forward to seeing you in Key Largo!

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J. Michael Scott, Director
National Gap Analysis Program
Moscow, Idaho

Some Scales for Describing Biodiversity

One of the first principles of Gap Analysis is that the most efficient overall strategy for biological conservation is to complement intensive species-by-species management, necessary for those species now in danger of extinction, with management of habitat types or natural assemblages of plant and animal species that are still relatively common and viable (Scott et al. 1993). Adequate representation of the full complement of natural habitat types within a network of conservation lands is fundamentally required if we are going to conserve plant and animal species in their natural habitats rather than in zoos (Shaffer 1990).

Because of this, the relationships among and between (a) the pattern of dominant land cover types, (b) vertebrate species diversity, and (c) spatial scale are all critical for Gap Analysis. Measures of species diversity must be expressed relative to biogeographic units of a determined spatial scale if they are to be meaningful (Levin 1981). Unfortunately, confusion about the differences between types of diversity ("thematic resolution") and cartographic scale is persistent (e.g., Short and Hestbeck 1995, Davis 1995, Edwards 1995, Scott et al. 1995). Below, I briefly present some nomenclature that is useful when dealing with the issue of diversity and scale.

Whittaker (1960, 1977) suggested seven categories as a framework for describing species diversity in relation to ecological patterns and spatial scale (Table 1). The linkage between types of diversity and spatial scale makes this framework especially useful. Figure 1 (Stoms and Estes 1993) shows how four of these categories ("inventory diversities") are used to describe species diversity within sampling units of four approximate sequential sizes and corresponding with four hierarchical levels of biotic organization: a single ground sampling point (*point diversity*), a natural community (*alpha diversity*), a landscape (*gamma diversity*), and a large geographic region (*epsilon diversity*). Three other terms ("differentiation diversities") are used when comparing the amount of change in species composition between individual sampling points (*pattern diversity*), natural communities (*beta diversity*), and landscapes (*delta diversity*).

Inventory diversities	**Differentiation diversities**
1. *Point diversity*: A small, or microhabitat, sample of species diversity from within an alpha unit. Generally 10 to 100 sq meters.	
	2. *Pattern diversity*: The change in diversity between points within a community.
3. *Alpha diversity*: A single within-habitat measure of species diversity regardless of internal pattern. Generally 0.1 to 1,000 hectares.	
	4. *Beta diversity*: The change in diversity among different communities of a landscape; an index of between-habitat diversity.
5. *Gamma diversity*: The species diversity of a landscape made up of more than one kind of natural community. Generally, 1,000 to 1,000,000 hectares.	
	6. *Delta diversity*: The change in diversity between landscapes along major climatic or physiographic gradients.
7. *Epsilon diversity*: The species diversity of a broad region of differing landscapes. Generally 1,000,000 to 100,000,000 ha.	

Table 1. Levels and types of species diversity (Wittaker 1977, Stoms and Estes 1993).

The minimum thematic object that Gap Analysis is mapping is the Natural Community Alliance (Grossman et al. 1994). This corresponds most closely with the units of alpha diversity (a sample representing a community regarded as homogeneous despite its internal pattern) in order to conduct analyses at the beta, gamma, delta, and epsilon levels. As indicated by between-habitat diversity, a spatial depiction of beta diversity represents the pattern of landscape heterogeneity. For Gap Analysis, the central concept is that the structural and taxonomic characteristics of vegetation or, in the absence of vegetation, dominant land features, can be used systematically to delineate and map patterns of beta diversity. Models of these patterns are important for generating and evaluating landscape-level conservation options.

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Michael D. Jennings, National Coordinator
Gap Analysis Program
Moscow, Idaho

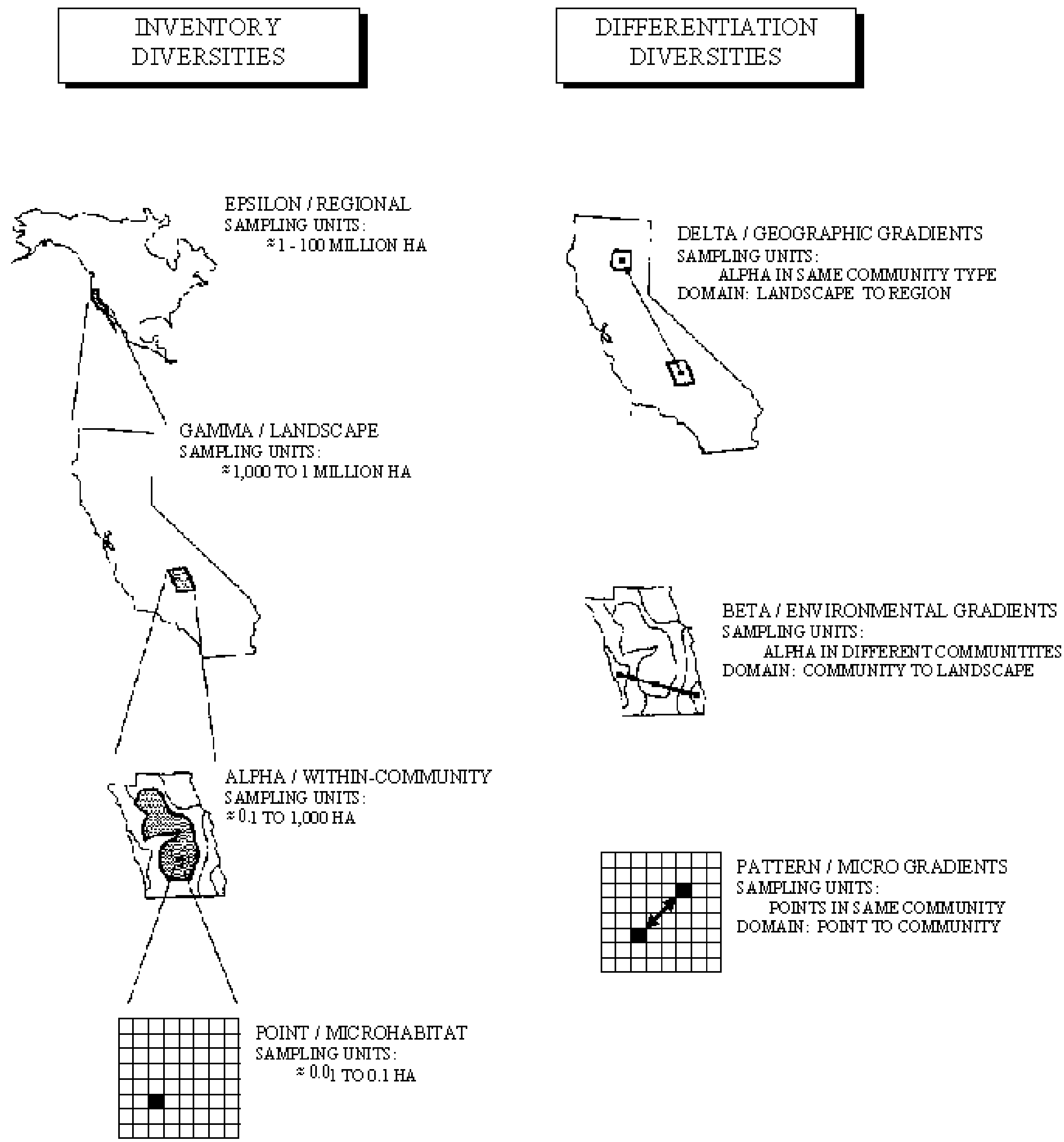

Figure 1. Diagram showing the levels of species richness defined by Whittaker (1977). The icons in the left hand column represent inventory levels of richness, while those on the right show differentitation levels or changes in composition across gradients. Sampling unit sizes indicate the approximate spatial dimensions for each ecological scale. (From Stoms and Estes 1993, with permission.)

GAP Implementation

So where are the gaps, and what should be done about them? When is a Gap Analysis finished, and what constitutes completion? Who are the users of GAP data, and what products do they need to apply the information? These fundamental questions cut to the heart of the Gap Analysis Program as many of the states begin moving from the data gathering and research phase of the program toward implementation.

What is GAP implementation? For the purposes of this discussion, it means application of Gap Analysis results to wildlife and habitat management and land allocation decisions. In the *Draft Recommendations for Implementing Gap Analysis: A Report to the National Biological Service* (Vickerman and Smith 1995), the authors identify three different ways for GAP to be implemented. It can be used in situation-specific applications, in which the data are used to help guide decisions about particular sites or species. It can be integrated into existing land use planning processes already in place and used by local governments and resource agencies. Finally, the information can be used for cross-boundary, ecosystem-oriented landscape-level planning. The authors suggest that this last application potentially makes the greatest contribution to the advancement of biodiversity conservation planning.

Unfortunately, there are few established programs with the responsibility to facilitate cross-boundary planning, although there is increasing interest in ecosystem management, and a number of pilot projects are under way that attempt to consider the broad distribution of ecological resources relative to human activities on the landscape. For example, President Clinton's Forest Plan (FEMAT) addressed all forest lands in the western Cascade Mountains of the Pacific Northwest. The Great Plains Initiative is another multistate effort to restore the biodiversity of the region.

Because of its stated goals, widespread geographic distribution, visibility, broad scale, and impressive list of cooperators from the public and private sectors, GAP is widely seen as an important tool in long-range planning for biodiversity conservation. Wildlife and land managers, policy-makers, private conservation and industry organizations are anxiously awaiting Gap Analysis results to help guide the new, innovative approaches to resource management. Several of these initiatives are described below. The list is not exhaustive, but it provides a few examples of potential applications for GAP data.

Initiated by Defenders of Wildlife, the **Oregon Biodiversity Project** is a public/private partnership working to develop a biodiversity strategy for the state. More than forty cooperators from academia, state and federal agencies, private industry, and conservation groups are involved. Project staff are compiling GAP and other data sets in GIS format to characterize the ecological and socioeconomic landscape and make specific recommendations concerning areas that should receive high priority attention. Emphasis is on the places where there are potential opportunities to accomplish conservation goals in a reasonable period of time and to avoid future "train wrecks." The strategy will be published in atlas format with full-color maps and a poster showing the priority areas in the state. The information will also be produced electronically on a user-friendly CD-ROM.

The **Tennessee Biodiversity Program** was also initiated by the private sector and involves a diverse group of government, academic, and private partners. Given the amount of private land in the state, a strong emphasis is placed on getting information on biodiversity to local land use planners. GAP has helped fund the development of county-level planning guides. The program has also sponsored a series of training workshops for educators and resource professionals.

The **Lower Mississippi Conservation** proposal was initiated by the director of the Tennessee Wildlife Resource Agency, whose vision is to integrate existing conservation efforts focused on species groups (i.e., fish, neotropical migratory birds, bears, and waterfowl) into a conservation plan for the entire lower

Mississippi River Valley. Gap Analysis data could be used to evaluate the distribution of vegetation and habitat types, to address endangered species issues, and to help design the overall strategy. The challenge for this program will be reconciling the different approaches and completion times for nine state GAP data sets.

Another program anxiously awaiting GAP data is the **Klamath Basin Ecosystem Office**. The office supports an interagency effort addressing a broad range of conservation issues in the Klamath province, which straddles the Oregon and California border. GIS data are being compiled at Humboldt State University. The Klamath Project is a high priority of the U.S. Fish and Wildlife Service because of the large number of endangered species and ecological problems in the region. It has a high political profile and could potentially serve as a model for interagency planning at the federal level.

One of the most democratic projects is the **Maine Forest Biodiversity Project**. A large and diverse group of interested parties meets regularly, and has agreed on a mission "to maintain viable representatives of existing native species and communities in Maine." The forest products industry is involved, in addition to academics, conservationists, and public officials. The group is working to identify principles to better maintain biodiversity on managed forest lands and to develop goals and techniques that might be used to achieve them. The focus is on the managed landscape, since most forest land in Maine is used for timber production. Although the project has completed its own biodiversity assessment, GAP data may be used at a later stage.

There are a number of issues common to most of the GAP implementation pilot projects that need to be addressed before Gap Analysis is fully integrated into resource allocation and management decision making. The "completion" timeline is critical. Does GAP provide a snapshot in time, or is it a process that accommodates new and finer-scale information as it becomes available, thereby helping managers implement adaptive management goals? If it is a one-time shot, what constitutes a final product? If it is seen more as a long-term process, then who is responsible for its continued funding and management? Missouri has a unique solution in MoRAP (Missouri Resource Assessment Partnership), designed to collect and update ecological data (including GAP) and socioeconomic information relevant to coordinated resource management planning.

Another important issue concerns the dissemination of information generated by GAP. Who are the target audiences, and what kind of information do they need? Many scientists and resource agencies have the capability to use and analyze electronic GIS data sets. However, most policy-makers, land-use planners, conservation organizations, and the media are more interested in hardcopy map products with spatially explicit recommendations about what areas are most important and why. There has been some understandable reluctance on the part of some principal investigators to provide these recommendations, but decisions are made with or without GAP, so users can become frustrated when the bottom line is so elusive. Utah GAP has produced the most elaborate "products" to date, but the report, CD-ROM, and four maps stop short of identifying specific areas that could be managed to conserve biodiversity.

What socioeconomic information is needed in Gap Analysis, and whose responsibility is it to compile it and integrate it into policy recommendations? Forester et al. (in press) have proposed a process in which "gap locations" are identified first as part of an ecological assessment, then a series of human activities on the landscape are evaluated to help policy-makers establish conservation priorities. Davis (1995) has incorporated a number of socioeconomic factors into an analysis of the Sierra Nevada bioregion. Cogan (1995) is working on models that link county planning and biodiversity indices. Vickerman (1996) describes the Oregon Biodiversity Project, which has collected data on a number of social, economic, and political factors in GIS format to help develop a pragmatic statewide conservation strategy. It is clear, however, that there is no standard approach to the integration of ecological and socioeconomic information in broad-scale conservation planning, and it is not at all obvious who should be responsible for the task.

GAP has gone a long way toward building a national framework for broad-scale analysis of wildlife and habitat conservation needs. It has made great strides in bringing together different disciplines, agencies, and interest groups. But the biggest challenges lie in making sure that the powerful information GAP can provide is ultimately both used and useful. The time to start dealing with implementation issues is now.

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Sara Vickerman
Defenders of Wildlife
Portland, Oregon

GAP Implementation Scorecard

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GAP Implementation Scorecard

Try this scorecard to see how prepared your state (or region) is to implement GAP. For each item, pick a number from zero to ten to characterize the current situation:

0 - 2	Not contemplated, no action
3 - 4	Some discussion taking place
5 - 6	Some actions taken, others under consideration
7 - 8	Significant progress has been made
9 - 10	Fully developed and operational

________ GAP data sets for land cover, species distribution, ownership, and management

________ Gap Analysis with spatially explicit recommendations

________ Socioeconomic factors identified and incorporated into recommendations

________ Agreement for long-term updating, management of data sets

________ User-friendly products and easy electronic access to data and GAP results

________ Public involvement opportunities, training, and outreach (i.e. citizens' monitoring)

________ Effective integration into multiscale planning

________ Statewide and/or bioregional planning framework

________ A willingness to consider biodiversity; a demand for the information

________ Funding available for implementation (i.e. landowner incentives, acquisition funds)

________ Total

Where do you rate?

0 - 25	Long, dusty road ahead
26 - 50	Good potential
51 - 75	Biodiversity has a chance
76 - 100	You must be dreaming...go back and recalculate

Sara Vickerman
Defenders of Wildlife
Portland, Oregon

The Indiana Gap Analysis Metaproject Approach

Introduction

Gap Analysis offers a science-based approach for evaluating biodiversity at regional and continental scales and for providing data necessary for the development and application of biodiversity management strategies (Scott et al. 1993). From the inception of the Indiana project, we recognized a design need for applications at a scale finer than continental. We have begun to address the challenges of implementing Gap Analysis by initiating cooperation with the principal Indiana natural resource agencies and key Indiana nongovernmental conservation organizations through the metaproject approach.

In part because of the importance of wetlands within the Indiana landscape, many of our initial metaproject proposals include a wetlands component. Whatever the focus (wetlands, forests, contaminants, agricultural land), an important consideration in implementing metaprojects is the evaluation of the utility of the Gap Analysis methodology. Particularly, its application to development and implementation of a landscape-scale conservation and restoration framework in Indiana has to be considered.

Indiana Landscape

In Indiana, nearly 80% of the nonfederal land (about 98% of the total) is used for cropland, pasture, and development. In Ohio, cropland, pasture, and developed land accounts for nearly 70% of the nonfederal land (about 99% of the total) and in Illinois nearly 88% of the nonfederal land (99% of the total). The figures for Kentucky and Michigan are approximately 54% and 46%, respectively (U.S. Bureau of Census 1993). Modification of the landscape on this scale produces some clearly identifiable problems related to biodiversity: 1) a human-dominated landscape, 2) habitat fragmentation and pollution (Steadman 1991), and 3) isolated populations of naturally occurring plant and animal species with many species depauperate of genetic diversity (Soulé and Wilcox 1980).

Wetlands (but also savannas and prairies) in the Midwest have been especially impacted by anthropogenic changes. Estimates of pre-settlement wetlands and information from the FWS National Wetland Inventory (NWI) suggest that Indiana has lost approximately 1.4 million ha or 86% of pre-settlement wetlands (IDNR 1989). The FWS compiled the following wetland loss estimates for the states surrounding Indiana: Illinois - 85%, Ohio - 90%, Kentucky - 81%, Michigan - 50% (Dahl 1990). Wetlands, moreover, have particular significance for biodiversity. A strong relationship exists between wetland loss and species listed as threatened or endangered. A 1991 National Wildlife Federation report indicates that 43% of the 595 plant and animal species listed by the U.S. Fish and Wildlife Service (FWS) as threatened or endangered in 1991 depend on wetlands (Hair et al. 1992).

Wetlands in Indiana and in the Midwest in general have been and still are key components for biodiversity in both the pre-settlement and modern landscapes. Approximately 2.3 million ha (5.6 million acres) of wetlands covered nearly 25% of Indiana before European settlement in the early part of the 19th century (IDNR 1989). Our experience has been that wetlands protection efforts, as an example of ecosystem level management, have proved to be expensive, difficult, and of questionable success.

Indiana Gap Analysis Metaprojects

Metaprojects are applications of Gap Analysis methodology or data in conjunction with data developed for a specific conservation project or group of projects. Metaprojects are sponsored by cooperating organizations that benefit from the infrastructure and data that exist as part of Indiana Gap Analysis. The fundamental concept is one of synergy among the Indiana GAP Project and partners interested in addressing landscape-scale problems of conservation or restoration.

The metaproject approach has some defined goals. These include establishing cooperative efforts to:

1. "jump-start" the application of the Indiana Gap Analysis methodology and data;
2. serve as pilot projects to evaluate Gap Analysis methodology and data in Indiana;
3. produce products useful in the conservation and restoration of Indiana's biodiversity;
4. solidify partnerships within and outside the Indiana conservation community.

Numerous Indiana Gap Analysis metaprojects are under way or in planning stages. Three metaprojects that reflect the Indiana landscape and the Indiana Gap Analysis approach to biodiversity problems are presented below.

The Nature Conservancy (TNC) Bioreserve Metaproject involves a cooperative effort to provide a landscape analysis of two of TNC's "Hoosier Landscapes." The Blue River in southern Indiana and the Pigeon River in northeastern Indiana are associated with important wetland habitat. Both are areas preliminarily identified by TNC as important for preserving biodiversity in Indiana. Indiana Gap Analysis will provide data through this metaproject to further evaluate TNC's assumption and to enable TNC land managers to approach management on a landscape scale. Cooperative analysis of data with TNC and other partners will function as a pilot for future statewide analysis.

A second metaproject applies a landscape approach to the FWS "Partners for Wildlife" wetland restoration program. The study area for this metaproject encompasses most of the Eel River watershed in north central Indiana. The goal of this pilot project is to identify restorable drained wetlands by watershed, using a combination of satellite imagery and ancillary data. This approach may improve efficiency and effectiveness of wetland restoration. Preliminary results of this project suggest that evaluation of satellite imagery in conjunction with ancillary data can identify poorly and very poorly drained sites. In addition, using the GIS, these data can be placed in context with important habitat features (Mausel et al. 1995).

The third Indiana Gap Analysis metaproject applies the Indiana Gap Analysis methodology and data to an environmental contaminants problem in southern Indiana. GIS is being used to plot the location of contaminants in the physical environment and to model their movement through the biota of several streams in five Indiana counties. Most of the data have been entered into the GIS, and preliminary analysis is under way. This project functions principally to evaluate the utility of the Gap Analysis Project vis-a-vis contaminants issues. Contaminants are ubiquitous in the environment, and the GAP methodology may be particularly useful in this area.

Conclusion

The natural landscape continues to change rapidly under the influence of human development. Biodiversity measured at both the species and ecosystem levels reflects a precipitous decline over the last 200 years (The Keystone Center 1991). Most existing efforts to protect species or even ecosystems lack sufficient breadth to protect and restore remaining biodiversity.

We propose to use Gap Analysis as an integral part of developing the requisite information to formulate the Indiana Landscape Protection and Restoration Framework (Indiana Biodiversity Vision Group's 1996 meeting to develop Phase I, Biodiversity Vision of an Indiana biodiversity protection framework; Bennett et al. 1995). What is more, the Indiana Gap Analysis Project has formalized an approach to implement restoration and protection efforts at a landscape scale. The metaprojects under way with various partners seem to be more efficient (cost effective) and efficacious than existing more traditional approaches.

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Forest Clark
Indiana Gap Analysis Project
U.S. Fish and Wildlife Service, Bloomington, Indiana

Expanding Roles for Gap Analysis Data in Arkansas

In Arkansas, the Center for Advanced Spatial Technologies (CAST) is just completing the production phase of Gap Analysis and will soon be entering the distribution and implementation phase. Efforts are now being directed to the usability of the Arkansas Gap Analysis data, for which the Utah Gap Analysis' prototype CD-ROM package provides an excellent sample methodology. This article concentrates on some extended uses of Arkansas Gap Analysis (AR-GAP) data in the private sector and some methods of information dissemination.

In Arkansas and many other states, Gap Analysis can be much more than "the only land cover mapping game in town" (Loveland 1995); it has the potential to establish or contribute to a framework that fosters statewide communication, data sharing, and exchange (Davis 1995). The National Spatial Data Infrastructure (NSDI) promotes the realization of data-sharing networks by providing policies and standards for transfer, production, and management of geospatial related data and technologies (see "The National Spatial Data Infrastructure" on the Web at http://fgdc.er.usgs.gov/nsdi2.html). Data sharing delivers obvious advantages of cost savings, efficient decision making, and communication among participating organizations. Nedovic-Budic (1995, p. 670) suggests that NSDI may likely follow a "bottom-up approach, building on local and already-established partnerships." Conceived as a bottom-up approach, Gap Analysis relies heavily on support from local state-level partnerships. The spirit of cooperation and sharing inherent in GAP provides an appropriate association with NSDI's mission.

As is the case in other states, AR-GAP is now serving as a mechanism for exchange of data among both private and public entities. AR-GAP, in its early development, forged institutional linkages first among mostly public organizations (Dzur et al. In press). Now, as map products from AR-GAP are being completed, those linkages are expanding to private sector organizations. Some reasons for use of Gap Analysis data by new organizations outside the initial Gap Analysis partnership structure are likely due to timing and acceptance of the technology. When Gap Analysis began in Arkansas, few organizations knew anything about the project. Moreover, few organizations knew much about the emerging technologies of Geographic Information Systems, Global Positioning Systems, and remote sensing. Today there is more awareness of both technology and Gap Analysis.

One of the first applications of GAP data by a private organization emerged from a previously established partnership with the Arkansas Highway and Transportation Department (AHTD). CAST supplied spatial data to an AHTD contractor for application as a framework for defining some EIS mapping goals. Their mapping goals emphasized forested wetlands, emergent vegetation, other wetland cover types, and ponds. Weyerhaeuser is another private entity using AR-GAP data products.

Weyerhaeuser manages close to 850,000 acres of forested land in Arkansas. GAP data were first acquired from CAST's digital spatial data catalog by Weyerhaeuser headquarters in Tacoma, WA. According to Scott Needham, "Our role here at Weyerhaeuser is to facilitate the procurement of spatial data and to redistribute it to our customers, the tree farm operations." In addition to some basic statewide data sets including land forms, geology, soils, and basins, AR-GAP ownership boundaries and spectrally clustered TM data were redistributed to Gary Arpin, GIS Analyst for Weyerhaeuser in DeQueen, AR. According to Arpin, the spectral data provide a regional perspective and show good correspondence with Weyerhaeuser's stand data. Although their pine plantations are identifiable from the data, Weyerhaeuser is not using spectral data for operational use since they rely on finer-scale digital aerial photo data. However, the ownership data are used on field maps. Weyerhaeuser officials acknowledge that data collection can be costly, and welcome organizations such as CAST that maintain digital spatial data archives. Monitoring the digital spatial data catalog via the World Wide Web (WWW) (see "Catalog of

Digital Data Available from CAST" at http://www.cast.uark.edu/local/catalog/arkansas), Weyerhaeuser officials indicated an interest in long-term analyses including mill-route surveys and school district level analyses that take advantage of some of CAST's other archived digital data layers.

CAST has been involved in stimulating and coordinating GIS development throughout Arkansas. The information exchange with both Weyerhaeuser and the AHTD contractor was of a traditional "one-way" and "one to one" mode. CAST is exploring other ways of making these data layers available to a wide array of persons and organizations over the WWW. Starting with a simple example of remote computing, the GIS Interactive Mapper home page (see http://www.cast.uark.edu/products/MAPPER/) will allow users to select a geographic region and produce maps with any combination of layers (raster, vector, and site data) available in the digital spatial data catalog. The resultant map can then be displayed on screen or downloaded to a remote site as a postscript file or gif image. While relatively simple and limited, Interactive Mapper fosters "one to many" information exchange that encourages exploration of a wide assortment of data sets, including GAP products, in an easy-to-use electronic environment.

The exact roles and permanent homes of state-level GAP data sets still require further investigation at both state and national levels. Development at the national level can be seen on the horizon with the advent of the National Biological Information Infrastructure (NBII). Taking a cue from NSDI, "NBII will provide information on and access to biological databases, information products, directories, and guides maintained by Federal, State, and local government agencies, and private organizations" (see "National Biological Information Infrastructure" at http://www.nbs.gov/nbii/ on the WWW).

Leadership at the state level is likely to come from a variety of sources including state universities and state agencies. In Oklahoma, for example, Senate Bill 722 was passed into law in 1994 and directs the Oklahoma Conservation Commission to develop a strategic plan for the implementation of GIS in state government (Danger 1995). The commission's stated objectives are to maximize data sharing between state agencies to avoid duplication of effort while improving public access to information (Danger 1995). Collaboration among agencies, private organizations, and nongovernmental organizations will be instrumental for achieving the mutual benefits of a distributed network of geospatial and biological information sources. Gap Analysis will likely hold a pivotal position in the network of data distribution helping to reduce the obstacles to public data access.

Gap Analysis has served as an "information catalyst" for natural resource professionals (Jennings 1995). Moreover, government downsizing underscores the important role of GAP as information catalyst and stimulus for private and public cooperation. Wide distribution and use of GAP data will help address some important issues, such as "How do we manage our biological resources and avoid crises?" To do so necessitates a broader understanding of relationships occurring at multiple scales of biotic organization and physical extent. New relationships and ideas may be formed and discovered through innovative applications of these data sets. "Where does Gap Analysis data end up?" Hopefully, it "ends up" in the hands of those people who need it most: regional planners, scientists, managers, educators - whoever can use, refine, and ask questions of the data to gain greater understanding.

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Rob Dzur
Arkansas Gap Analysis Project
University of Arkansas, Fayetteville

MRLC Update and New Rules for TM Access: The Landsat Program Management Agreement

Multi-Resolution Land Characteristics Consortium

In 1993, the Gap Analysis Program (GAP), together with four other federal programs, formed the Multi-Resolution Land Characteristics Consortium (MRLC) to create a venue for addressing issues related to land cover mapping. In 1995, the MRLC was formally recognized via a Memorandum of Agreement between the partner programs' parent agencies, including the National Biological Service (NBS), Geological Survey (USGS), Environmental Protection Agency (EPA), and the National Oceanic and Atmospheric Administration (NOAA). The goals of the MRLC include the generation of a flexible land characteristics database for the conterminous United States that meets the diverse needs of many users. The MRLC partners shared common requirements for a source of satellite data, preprocessing, spectral clustering, and ancillary data acquisition as well as data management, archiving, and distribution.

The MRLC partners could not afford to purchase the data from the Earth Observation Satellite Company (EOSAT) individually. Through the MRLC partnership, the joint purchase of Thematic Mapper (TM) imagery resulted in a direct saving of 4 million dollars with subsequent savings for image processing and data management, totaling 26 million dollars. USGS's EROS Data Center (EDC), a partner in the MRLC, is responsible for the execution of image processing and database management.

In February 1996, EDC completed processing the MRLC TM image data. Metadata for the TM imagery can be viewed using USGS's Global Land Information System (GLIS) which can be accessed via the MRLC home page (see "Multi-Resolution Land Characterization Consortium" on the Web at http://www.epa.gov/docs/grd/mrlc). Future TM imagery purchases by the MRLC partner programs will be directed toward expanding the multitemporal aspect of the original TM database and selecting satellite imagery for the "next generation" MRLC data set.

In order to build a flexible national land cover database of multiple spatial and temporal resolutions, the MRLC is pursuing better integration of the land cover projects that are being carried out by its members. Recently, MRLC completed a classified land cover mosaic encompassing the states of Pennsylvania, West Virginia, Virginia, Maryland, and Delaware. Produced by USGS's EROS Data Center using the MRLC TM imagery, this regionally-based land cover has 12 thematic classes. Our goal is to link this thematically coarser land cover data set with a seamless GAP vegetation layer for the mid-Atlantic states. This is a pilot project, and other regional land cover projects are planned. This thematically coarser but spatially more extensive land cover data set illustrates the importance for the GAP state projects throughout the country to agree on methodologies to successfully "edge-match" their land cover data with those of their neighboring states. The regional land coverages, linked with the GAP vegetation data, will be combined to form seamless multiresolution land cover data sets for the conterminous United States.

Landsat Program Management Agreement

The MRLC data purchase from EOSAT Corp. was bound by the terms and conditions of the original 1993 agreement. These terms and conditions limited MRLC TM data access to the partner programs and their cooperators. However, under the June 30, 1995 Landsat Program Management (LPM) Agreement between EOSAT, NASA, NOAA, and USGS, the original terms of the MRLC data purchase have become less stringent. This new agreement expands the availability of the MRLC Landsat data sets (original raw data from EOSAT and the terrain-corrected data) beyond the partner programs if certain conditions outlined below are met.

The LPM Agreement established the U.S. Government and Affiliated User (USGAU) purchaser group with EOSAT. The agreement defines the USGAU as "U.S. Government agencies; U.S. Government contractors; researchers involved with the U.S. Global Change Research Program and its international counterpart program; and other researchers and international entities that have signed with the U.S. Government a cooperative agreement involving the use of Landsat data for noncommercial purposes." Under the 1995 agreement, the USGAU will have unrestricted rights to reproduce and redistribute, within the USGAU, all unenhanced Landsat TM data purchased by the USGAU for noncommercial use, which includes future and previously purchased data by the USGAU, including the MRLC data.

This is taken to mean that all federal agency programs and their affiliates now have access to both the original 7-band data as well as the preprocessed data. Users must pay for the cost of reproducing the data at the EROS Data Center, which is about $70 per scene. While the MRLC TM database is not a classified land cover product, it is a data set that many programs are utilizing to work on land cover throughout the country. Expanding the availability to other qualified users will further efforts to develop consistent approaches to land cover classification and accuracy assessment and lead to establishing a framework for integrating multiresolution data sets into a national database structure.

For additional information about eligibility under the USGAU and the availability of the MRLC TM image data, contact Kent Hegge, EROS Data Center, at (605) 594-6976 or hegge@edcserver1.cr.usgs.gov.

Pete Campbell
MRLC Coordinator
U.S. EPA, Research Triangle Park, North Carolina

The Ecological Society of America's Vegetation Classification Panel

Changes in the natural resources fields (e.g., a shrinking natural resources base, societal shifts in values, etc.) are resulting in demand for an "ecosystems" approach to research, planning, and management (Jennings 1995). Yet, until recently, there was not a consistent set of defined categories for naturally occurring assemblages of species (Orians 1993) that can be reliably used as building blocks for characterizing ecosystems at alpha, beta, delta, and gamma scales of diversity (sensu Whittaker 1960, 1977). There has never been as much land cover mapping activity in the U.S. as there is today. Although the GAP state projects are the principal source of the increase, GAP overall is but one of several major efforts. With all this activity, the development of a broadly accepted classification system that is maintained within a scientific peer-reviewed arena and recognized by government agencies is critical.

At the Ecological Society of America's (ESA)1994 meeting, an ad hoc group of members met to discuss the circumstance of and need for a standardized vegetation classification system. This led to the establishment by ESA of a standing panel on vegetation classification, made up of about 20 ESA members and several nonmember experts. The panel is working under the aegis of and with staff support of the ESA Sustainable Biosphere Initiative (SBI).

The panel's mission is to provide a standardized, scientifically credible North American vegetation classification system, given the following objectives:

- provide a neutral forum for the review and discussion of vegetation classification;
- set standards for hierarchical structure, nomenclature, and definitions for a North American vegetation classification;
- establish a process for modifying the system as knowledge advances;
- establish a peer-review process for recognizing natural communities and natural community alliances;
- identify areas for further research and development;
- provide broad public access to a standardized North American vegetation classification system.

The panel held its first full meeting at the 1995 conference of the International Association for Vegetation Science and began by reviewing the standards being proposed by the Federal Geographic Data Committee's Subcommittee on Vegetation Classification (FGDC-VC). In summary, the ESA panel suggested that FGDC-VS adopt the following language regarding purpose and policy:

"The purpose for these standards is to foster consistency, precision, and clarity in the structure, labeling, definition, and application of a systematic natural land cover taxonomy for the United States. Consistency, precision, and clarity are critical for effective and efficient decisions about resources where the focus is on complex natural assemblages of biotic organisms.

These standards are intended for use by both federal agencies and other user groups, including those engaged in land use planning or management by county and state governments, teaching or research, and uses by the private sector. Widespread use of these standards will facilitate integration of land cover data collected by diverse users into a common national database, enhancing utility beyond single projects and establishing a long-term framework for the nation's natural land cover information."

The ESA panel went on to comment on and suggest changes to the assumptions, guiding principles, definitions, structure, requirements, and procedures for reaching closure on standards that were then being proposed by FGDC-VS.

At the panel's last meeting (March 17-19) agreement was reached to propose that ESA take lead in establishing the following:

- a standardized terminology for the floristically-based taxonomy and classification of natural communities and alliances of natural communities;
- a database network for all available plot and stand data from which statistical descriptions of natural communities and alliances can be compiled;
- a peer-review process for recognizing the names and attributes of natural communities and alliances, resulting in a brief standardized monograph for each type.

Descriptions of each of these components are now being developed and will be presented to the general membership at the annual ESA conference in August. For more information, contact Bruce Kahn at the SBI at bruce@esa.org or call (202) 833-8748.

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Michael D. Jennings, National Coordinator
Gap Analysis Program
Moscow, Idaho

Landscape Information Infrastructure in Pennsylvania

Statewide spring/summer coverage of Landsat Thematic Mapper (TM) data provided through the Multi-Resolution Land Characteristics Consortium (MRLC) is the foundation of the Pennsylvania-GAP landscape information infrastructure. This foundation consists of hyperclusters which are built with the ISODATA facility of ERDAS Imagine. First, every pixel in each scene is distributed directly among a set of 255 clusters, with no sampling whatsoever. Then complete bandwise signature information is compiled in conjunction with the clustering, and this is used to compute relative brightness measures for visible, infrared, and greenness.

Those brightness values permit us to construct cluster image mosaics across scene boundaries. The clusters, with their tables of averaged spectral attributes, permit us to render generalized image reconstructions—which are export-compatible with the ARC/INFO Grid facility and are free of proprietary restrictions on redistribution. Statewide cluster images will be transferred to CD-ROM as a distribution medium and made available on a cost recovery basis for production of the CD-ROMs. These cluster images preserve visual landscape pattern and are free of thematic focus.

The tables of scenewise cluster properties are kept separate from the CD-ROM on diskette, which permits the tables to be augmented as we proceed with landscape interpretations of the clusters. The first such augmentation is a text-field characterization for each cluster. Next follows cluster categorization according to a modified UNESCO classification of land use/land cover which is substantially compatible with Anderson. This is a northeastern states adaptation of physiognomy and formation levels from a provisional scheme set forth by The Nature Conservancy (TNC). Landscape interpretations of clusters are formulated photointerpretively using the suite of facilities available in ERDAS Imagine.

Floristic categorizations of forest clusters are then assembled as separate relational tables keyed to each cluster. Reference to supplemental information sources and assistance of cooperators is required in the floristic interpretation phase. The base floristic categorization will reflect Society of American Foresters cover types as a point of departure for classification of alliance types. It has been determined that spatial (patchwise) specificity comes later in the analytical scenario.

The first step toward patchwise specificity is contiguity-controlled spatial filtering to merge cluster patches less than one hectare with larger neighboring patches. Another reason for preferring ISODATA clusters is that their numbering and initiation protocols induce strong correlation between cluster number and multispectral composite brightness. Since major land use/land cover differences find expression in composite brightness, attribution criteria for spatial merger can be satisfactorily handled in terms of cluster numbers for micro-patch suppression.

After imposing a one-hectare minimum on patchwise occurrence of clusters, the clusters are next vectorized via the Vector module of Imagine. Imagine is particularly advantageous in this regard by virtue of using the same vector format as ARC/INFO and supporting interactive image-based editing of such coverages. The commonality extends to virtual identity of "Clean" and "Build" operations. The initial attributes for polygons are scene ID and cluster number. These, in turn, serve to index the relational tables of cluster properties and scene metadata.

Floristic categorization is obtained from "multiway" analysis. Categories for recognition are determined from cluster characterizations. Training sets and signatures are obtained directly from the TM image data classified at the pixel level in supervised mode. A supervised strategy is also used to label clusters by classifying the cluster's mean vectors. The map of labeled clusters and the direct supervised classification are then differenced in terms of category numbers. Where the difference map is zero, there is local agreement between cluster-based classification and direct supervised classification. Nonzeros in the difference map indicate localities of disagreement and thus uncertainty. Overlaying the cluster-patch polygons on the difference map shows problem areas for classification. These are investigated with the help of cooperators to determine how GIS variables can be used to formulate rules of reclassification that will treat landscape settings selectively. Appropriate GIS variables are transferred by overlay as cluster-polygon attributes. Reclassification takes place on a polygon-by-polygon basis via ARC/INFO macros. Any remaining problems are resolved by direct interactive editing. Since the rules of reclassification represent elements of landscape understanding, they are saved in text form as well as the AMLs.

Following vegetation analysis, any additional site-level GIS variables required by vertebrate habitat models are also transferred by overlay as attributes for the respective cluster-patch polygons. What results from this phase is a one-hectare minimum database of polygonal landscape segments corresponding to patches of clusters. Since more than one cluster may occur in a particular vegetation class, polygon boundaries are not necessarily vegetation boundaries. To produce a vegetation map, the polygonal database is processed to dissolve boundaries between polygons having the same attribute. This set of "cluster-patch" polygons, then, constitutes the primary framework for the landscape information infrastructure.

Next comes a series of criterion-based polygon aggregations to a coarser scale. The scale change factors, in terms of minimum polygon size, are 5-hectare, 10-hectare, 20-hectare, and 100-hectare minimum levels. One objective in this reductive rescaling is to retain a visual semblance of landscape pattern, corresponding to views from increasing altitudes. Selected mixture and diversity attributes due to rescaling will be computed and entered in polygon attribute tables (PATs). When transferred from coarser to finer scales, such attributes provide vicinity context.

Scale generalization by polygon aggregation ensures that segments from different levels are strictly nested. When landscape interpretations are extracted from imagery of different resolutions, there is usually at least some degree of nonagreement. To overcome this lack of agreement, direct on-screen photointerpretation of TM data at a 100-hectare resolution is being developed to further differentiate between human-caused and natural vegetation types. The two classes being recognized are woody successional matrix versus anthropogenically sustained herbaceous matrix. Islands of either type less than 100 hectares are not delineated. Boundary cutoffs in digitizing are likewise not considered significant if less than 100 hectares. This mapping speaks directly to high-level landscape fragmentation and provides a comparator for the strategy of polygon aggregation.

Each polygon data layer, representing a given scale, has a companion layer of indexing points. The layers of indexing points enable construction of polygon pyramids across scales. With the point indexing approach, pyramids can be constructed for hierarchies of imperfectly aligned polygons. It is also possible to adapt the point indexing strategy for "fuzzy" nesting.

Concurrently with Gap Analysis, a second major application of this Pennsylvania landscape information infrastructure is to formulate ecological land types and land type associations under the Bailey scheme being promoted as ECOMAP by the U.S. Forest Service. Deliberations en route to these formulations will add to the depth of landscape understanding.

Wayne Myers, Robert Brooks, Gerald Storm,
and Joseph Bishop
Pennsylvania Gap Analysis Project
Penn State University, University Park

Use of Gap Analysis Data to Establish Goals and Priorities for Individual Land Management Units - National Wildlife Refuges in Washington State

With demands on natural resources increasing, land managers need to adopt a landscape approach in developing management goals and priorities (Fig. 1). Whereas efforts in the past have focused on individual management units in isolation, Gap Analysis data provide a landscape context for land management units, irrespective of land ownership. In this paper, we describe the results of a preliminary analysis of the contributions of three National Wildlife Refuges (NWRs) to the conservation of biodiversity in the ecoregions in which they are located. This project, which will include all of the NWRs in the state when completed, is a cooperative effort between the Washington Gap Analysis Project, the U.S. Fish and Wildlife Service (FWS) Region 1-Refuges and Wildlife, and the FWS's field office in Vancouver, Washington. Our preliminary analyses include the Nisqually NWR in the Puget Trough ecoregion on the west side of the Cascade mountains, and the Turnbull and Little Pend Oreille NWRs in the ecoregion referred to as the Northeast Corner (ecoregional boundaries correspond to those described by Bailey [1980] as refined by the USFS and WAGAP). For each ecoregion, we identified the proportion of land in each vegetation zone, the actual land cover within each zone, and the proportion of each zone in each of five conservation status categories. The latter correspond to the National GAP guidelines, except that for this analysis we divided lands not managed for native species into public, e.g., DOD and tribal lands (conservation status 4) and private lands (status 5). We then identified those vertebrate species predicted to occur within the ecoregions and each of the refuges. Vertebrate distributions were based on each species' association with actual land cover. This allowed us to calculate the proportion of each species' predicted distribution on "reserves" (conservation status codes 1 and 2; lands managed for biodiversity) and to develop a "report card" describing the contribution of each NWR to the conservation of vertebrate biodiversity in their respective ecoregions. And finally, based on ecoregional context, we made recommendations as to the management goals and priorities for each NWR, both within and outside their boundaries.

Nisqually NWR

The Nisqually NWR, like most of the refuges in the Puget Trough ecoregion, is small and not connected to other areas managed for biodiversity. However, the refuge contains examples of most of the major habitat types within the Puget Trough ecoregion. This habitat diversity accounts for the high proportion of Trough vertebrates predicted to be present (see report card), but surrounding development threatens to reduce adjacent habitat patches to where they may not support viable populations of some species. Lowland forest (<2% in reserves) is particularly threatened within the Puget Trough ecoregion, and forested areas on the refuge are in danger of becoming isolated.

Based on modeled distributions, 45 of the ecoregion's native mammals are predicted to occur on the refuge, including 7 of 9 species listed as threatened or endangered by the state or federal government; 90 of the ecoregion's 144 native breeding birds, including 10 listed species; and 13 of the region's 22 native reptiles and amphibians.

The Nisqually River is the refuge's primary link to larger undeveloped areas. Compared to other large rivers within the Puget Trough ecoregion, the Nisqually has the least surrounding developed and agricultural land. Maintenance of this corridor to other protected areas in the watershed via land acquisition or land-use planning appears to be critical for ensuring the continued contribution of the refuge to the protection of biodiversity in this ecoregion.

Turnbull and Little Pend Oreille NWRs

The conservation status of vegetation zones varies considerably within the Northeast Corner ecoregion (see table below). Statewide, 49 percent of the Ponderosa Pine zone is privately owned. Three percent of this zone is managed for biodiversity in the Northeast Corner ecoregion, compared to 12 percent statewide. The Western Redcedar/Western Hemlock zone also has only 3 percent of its area managed for biodiversity in this ecoregion, but 70 percent of its total area is publically owned. In contrast, 44 percent of the Subalpine Fir zone occurs within "reserves," and only 3 percent of its total area in this ecoregion is privately owned.

Turnbull NWR is almost entirely within the Ponderosa Pine zone. One of its major assets is its status as one of the few conservation areas with this forest type. The refuge is, however, on a "peninsula" of Ponderosa Pine forest among agricultural lands and steppe, and development around Spokane threatens to isolate the refuge from other forests. Fifteen of the ecoregion's 16 reptiles and amphibians are predicted to occur on Turnbull NWR, as are 46 of 64 native mammals, and 105 of 160 species of breeding birds (see report card). Ten listed species of mammals and birds are predicted to occur on the refuge. Management recommendations from this preliminary analysis include maintaining existing grasslands and open canopy Ponderosa Pine woodland on the refuge and, if possible, preventing isolation from other forests to the north.

Little Pend Oreille NWR contains all of the major forest zones and forested habitats within the ecoregion. Not only is it the largest refuge in the state, it is bordered by national forest to the north and south. Because of its size and location, it has greater potential than smaller refuges to support large animals or those with large home ranges. Probably the refuge's greatest deficiency is its lack of connection to habitats along the Colville or Little Pend Oreille Rivers. Most of the reptile, amphibian, and mammal species in the ecoregion and 94 species of breeding birds are predicted to occur in the Little Pend Oreille NWR. Our preliminary analysis indicates that maintenance of a corridor to adjacent river valleys would help maximize the contribution of the refuge to biodiversity protection.

Overall, the three refuges are predicted to provide some habitat for 38 percent of the state's listed species and 80 percent of the remainder. We note that predicted presence does not necessarily mean that the species are confirmed as present or that the habitat on the refuge has been confirmed as suitable. More detailed field-level sampling is needed for the next stage of conservation planning. This analysis is an example of how to begin the planning at the ecoregion and landscape levels.

We believe our analysis, when completed, will serve as a model for the application of GAP data to the development of management goals and priorities within the National Wildlife Refuge System. Similar analyses for Fort Lewis and Camp Bonneville (both belonging to the U.S. Department of Defense) have been well received. The latter was recently considered for addition to the National Refuge System.

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Christian Grue, Kelly Cassidy, Michael Smith, Karen Dvornich, Jane Cassady, and Susan Fregien
Washington Cooperative Fish and Wildlife Research Unit
University of Washington, Seattle

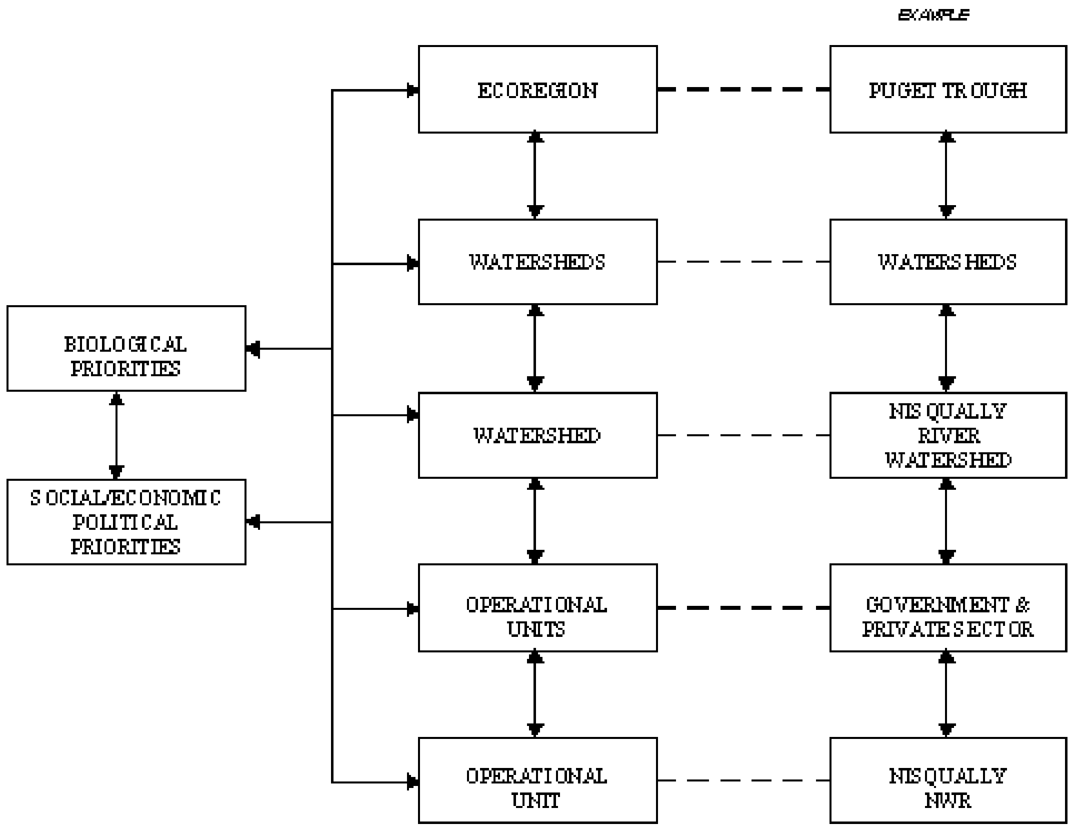

Fig. 1. Landscape approach to land unit management.

REPORT CARD FOR NISQUALLY, TURNBULL, AND LITTLE PEND OREILLE NWRs

	Herps		Birds		Mammals	
	Listed	Other	Listed	Other	Listed	Other
Puget Trough	6	16	21	123	9	41
Nisqually NWR	0	13	10	80	7	38
Norteast Corner	3	13	25	135	15	49
Turnbull NWR	3	12	10	95	10	36
Little Pend Oreille	3	10	11	83	10	43
State	21	24	55	172	31	70
3 NWRs	3	18	19	137	18	59

Listed Includes federal and state listed species

CONSERVATION STATUS IN WASHINGTON STATE FOR ZONES OCCURING IN TURNBULL AND LITTLE PEND OREILLE NWRs

	1	2	3	4	5
PIPO	2	1	25	23	49
PSME & AMGR	6	2	45	13	34
THPL & TSHE	2	1	67	0	30
ABLA & ALPINE	43	1	41	12	3
STATEWIDE	11	1	25	6	57

Numbers are percents.
PIPO = Ponderosa Pine, PSME & ABGR = Douglas-fir/Grand Fir, THPL & TSHE = Western Redcedar/Western Hemlock, ABLA = Subalpine Fir.

Modeling Grizzly Bear Habitat Suitability in Idaho

Many of the issues confronting wildlife managers and scientists are challenging the conventional spatial boundaries defined by administrative units. This holds especially true in the management of large carnivores such as wolverines, wolves, mountain lions, and grizzly bears. Individual grizzly bears range over 400 to 1000 square kilometers in a lifetime, while viable bear populations may require 10 to 30 times as much space. Such scales require a very broad view of habitat conditions. Not insignificantly, understanding these bears requires regional GIS databases that transcend state and even national boundaries.

Idaho is currently grappling with a number of issues related to grizzly bear management, including the potential reintroduction of a population into its central mountain wilderness areas and the management of humans in areas currently occupied by grizzly bears in the Panhandle and in the Yellowstone ecosystem. There has been reoccurring debate over the extent and location of "suitable" habitat. In addition, there are concerns about fragmentation and insufficient overlap between physically productive habitat and wilderness areas secure from substantial human intrusion. Scientists from the University of Idaho's College of Forestry, Wildlife, and Range Sciences GIS Lab and from the National Biological Service's Cooperative Park Studies Unit are trying to answer to these questions and develop a prototype for looking at the suitability of habitat for large carnivores elsewhere.

This research has drawn upon regional GIS databases, including GAP data for the state of Idaho, to model grizzly bear habitat suitability. These data were rasterized and combined in ARC/INFO grid format. Since grizzlies, like most other large carnivores, die primarily because humans kill them, a large part of this model deals with human-related features such as townsites, roads, and trails. This information is integrated into a measure of potential human activity for each map pixel and treated as an analogue of grizzly bear death rate. Information on vegetation, topography, and ungulate populations is integrated into seasonal measures of potential habitat productivity and treated as an analogue of birth rate. These two metrics are then combined in a way that culminates the analogy—by subtracting the standardized index of human activity from the standardized index of habitat productivity, the resulting measure is a direct analogue to population dynamics.

This model has already produced information of value to management deliberations. Maps have been produced that show seasonal habitat productivity for the entire state, as well as the location of "suitable" habitat defined by increasingly restrictive criteria. These maps show that, by most standards, there is abundant well-protected grizzly bear habitat in central Idaho that could potentially support a reintroduced bear population. They have also highlighted the potentially precarious status of existing grizzly bear populations, especially in the Panhandle. These results, as well as a description of the method, are parts of a manuscript that is currently being reviewed prior to submission to a journal for publication.

Even though significant progress has been made with this project, some major work remains ahead. In particular, we are prioritizing efforts to relate model outputs to parameters more directly relevant to management considerations, including actual grizzly bear birth and death rates. To date, we have partially confirmed the model by comparing outputs with delineations of currently occupied habitat and by assessing statistical relationships with bear sightings. We anticipate substantial future progress by extending the method to well-studied bear populations in areas such as the Yellowstone ecosystem and the northern Rocky Mountains of Montana.

David J. Mattson
National Biological Service
University of Idaho, Moscow

Point Sampling Surveys with GPS-logged Aerial Videography

Obtaining sufficient geographically unbiased data for verification and validation of vegetation communities is one of the greatest challenges in developing vegetation base maps for the Gap Analysis Program. These independent data are essential for classifying the Landsat Thematic Mapper (TM) imagery used in all Gap Analysis projects and for assessing the accuracy of the vegetation maps. Low altitude aerial surveys, combined with video data systems that tag each video frame with geographic coordinates from a global positioning system (GPS), provide a cost- and time-effective method for obtaining high resolution data on vegetation communities over large geographic areas. The Gap Analysis Program in New England is using this technology in conjunction with the hyperclustered, multitemporal Landsat TM imagery distributed through the Multi-Resolution Land Characteristics Consortium (MRLC) to produce its vegetation map of southern New England (Slaymaker et al. In press).

Aerial point sampling was developed to characterize the land cover of a region by interpreting a distributed sample of large-scale aerial images (Norton-Griffiths et al. 1982, Dunford et al. 1983). The Arizona Gap Analysis Program used this approach first to interpret its statewide Landsat TM coverage (Graham 1993), using aerial videography in combination with GPS-logged time code. The Arizona project used a Super-VHS camera flown at 2,000 ft above ground that covered 0.5 km at wide angle and zoomed to 15x magnification once every 10 seconds to collect a point sample image 30 m wide. The New England Gap Analysis Project modified Arizona's pioneering system by using two Hi8 band video cameras attached to a portable mount that can be operated from any highwing Cessna. The mount is clamped to the open window frame, then cranked out and adjusted to vertical with a bubble level. The video cameras are mounted vertically beside each other. One is set at wide angle, the other at 12x zoom, providing a swath of 30 m wide large-scale imagery down the middle of 0.4 km wide-angle coverage when flying 600 m above ground level. This approach provides more flexibility than a single camera in both the selection and density of sample points. Geographic position data are recorded in-flight from a GPS unit to a laptop computer using Geolink software. Flight lines can also be entered into this system for navigational purposes and will appear in correct relationship to the plane's position on the computer screen during filming. Time code is "sipped" from the GPS data stream by a Horita GPS time code generator to provide a matching SMPTE time code for the video tape recorders. SMPTE time code is the standard audible timing signal recorded to the audio track of professional video. Horita's time code generator substitutes GPS code for the normal internally generated signal, allowing each frame to be matched to a geographic position. In our system, time code is recorded directly onto the video images as well as the audio track, simplifying the synchronization of the two tapes during playback. We flew 10 - 24 km spaced transects of all six New England states (3,000 km) in the spring and fall of 1994, so as to capture both phenologies of our deciduous forests.

The video tapes from these transects are used to select and label sample Landsat pixel data. Two TV monitors, one each for the wide angle and zoom videos, are set up beside a computer monitor showing the corresponding portion of the Landsat image. The GPS flight data are overlaid on the Landsat image as vector points that can be queried for their time code, allowing the video frames to be matched to that image. As the video tape is interpreted and plant communities identified, specific pixels in the Landsat image are tagged with their forest type or vegetation class. These points are later extracted as a set of attributed coordinates and used as training sites in a supervised classification or, as in our case, systematically modeled for a set of inference rules to relabel the hyperclustered classification. Each selected pixel takes only seconds to tag, and we collect 18,000 or more points per image in a stratified sample by region and by topographic slope. One quarter of the sample points (stratified by vegetation type) are set aside and later used to access the accuracy of the final vegetation map. The remaining points represent only 0.06% of the total pixel population of a Landsat image, but this sample is sufficient for modeling of the probable vegetation types of each spectral class under different conditions of terrain and spectral mixtures.

The models for each vegetation type are developed with a set of Excel templates. The contingency tables sort the sample points by slope/aspect, frequency of appearance within a vegetation type, and the characteristics of their immediate neighborhood (25 pixel block) within those vegetation types. These data are then used in another set of Excel templates to construct inference rules that relabel each Landsat pixel to its most probable vegetation class for its location and spatial context. The templates are available on our World Wide Web (WWW) home page (see "New England GAP Analysis" at http://tove.fnr.umass.edu/gaphome.html, or ftp://tove.fnr.umass.edu/pub/gap), along with complete sets of our rules, a more detailed explanation of the process, and our initial accuracy assessments, which indicate a near 90% reliability for the seven forest types tested so far.

Technical assistance, including on-site workshops, acquisition of aerial video coverage, and assistance in setting up video interpretation stations, has been provided to a variety of Gap Analysis projects such as Colorado, Florida, Maine, Montana, Oregon, Tennessee, Vermont, West Virginia, and parts of California, as well as new applications of GAP methods in Madagascar, Mexico, and Portugal. Several GAP state projects now have aerial video camera systems and are using them cooperatively with other states. Contact Dana Slaymaker at the University of Massachusetts at (413) 545-4853 or dana@tove.fnr.umass.edu for additional information or technical assistance on aerial videography and interpretation of multiseasonal hyperclustered TM data.

Literature Cited

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Norton-Griffiths, M., T. Hart, and M. Parton. 1982. Sample surveys from light aircraft combining visual observations and very large scale color photography. University of Arizona Remote Sensing Newsletter 82-2:1-4.

Slaymaker, D.M., K.M.L. Jones, C.R. Griffin, and J.T. Finn. In press. Mapping deciduous forests in southern New England using aerial videography and hyperclustered multitemporal Landsat TM imagery.

Dana M. Slaymaker
New England Gap Analysis Project
University of Massachusetts, Amherst

Land Management Status Categorization in Gap Analysis: A Potential Enhancement

Gap Analysis as described by Scott et al. (*Wildlife Monograph* No. 123) and by *A Handbook for Gap Analysis* (National Biological Service and University of Idaho) requires that land tracts be categorized according to four status levels describing management for conservation of biodiversity. This component of Gap Analysis has been discussed and evaluated very little because, until recently, few projects had reached this point in the process. As we worked with the land management categories in New Mexico, we found the suggested methods and premises of the four categories to be somewhat inadequate to ensure repeatable results when there were several people involved, especially cooperators in our land categorization work group. This was particularly important in our project because we had spent much time seeking ways to better represent and categorize private lands managed for biodiversity. Thus, we wanted to enhance our categorization of lands of specific note to private interests.

Inconsistency Revealed

In New Mexico, we had 20 cooperators (representing private land holders, state and federal land management agencies, environmental organizations, and Native American tribes) assign land parcels to management categories. These individuals categorized 23 types of tracts by management status (e.g., status 2 - an area generally managed for natural values, but which may receive use that degrades the quality of existing natural communities) and 22 tracts by a name designation (e.g., national park) according to the published Gap Analysis category codes that we provided. While this quick assessment was not conducted as a controlled scientific survey, it did illustrate in general terms that land management categories may not be interpreted and applied similarly by all individuals. From the responses that we received, it was clear that the process of land management categorization was not a simple application of the four categories when attempted by a large group of cooperators. As important, we found that when we (the authors) attempted to settle on specific category assignments for distinct land tracts, we also sometimes made variable assignments. We found that we quickly sought a common way to identify information about tracts and to apply a repeatable process for category assignment.

A Different Approach

Ultimately, we developed a dichotomous key approach to meet this need (see below). This approach has two basic considerations. First, it requires the user to obtain simple information about each tract to be categorized (the revocability of protection; the existence of a specific management plan, policy, or regulation; the relative proportion of area subject to management; and the type of management). Second, it is structured to lead the user through relatively few decision steps that enhance consistent application by multiple users and, as importantly, by the same user if repeat categorization is attempted or requested for a previously categorized tract.

This key approach was described in a poster displayed at the National Gap Analysis meeting in Fayetteville, Arkansas, in August 1995. There was substantial interest in the approach, and discussion on the last day of the meeting indicated that the approach should have more extensive consideration among Gap Analysis projects.

An Opportunity to Participate

A small ad hoc working group of GAP principal investigators (coordinated by Bruce Thompson) was formed to examine this approach and other considerations in developing potential enhanced procedures for incorporation in the handbook. In advance of that group completing its review, there seemed to be a need for broader dissemination of this procedure and stimulation of evaluation and response by project personnel. So, take some time to apply the included dichotomous key to your individual GAP project. Does this key produce repeatability in addressing your land categorization challenge? Another issue seems to be whether there need to be more categories, or perhaps subcategories, such that individual projects can subdivide for their purposes while supporting consolidation to the basic categories nationally. Nonetheless, give this key a go and provide feedback to Bruce Thompson at (505) 646-6093 (office), (505) 646-1281 (FAX), or by e-mail at bthompso@nmsu.edu. Comments will be most helpful to the working group if received before May 15, 1996.

A Dichotomous Key (Draft)

This key is designed to be applied to any land tract, regardless of ownership, assuming that any management status category can apply to land parcels without consideration of public, tribal, private, or other ownership. Other assumptions are that the methods of protection listed are equal, regardless of ownership, and that written management plans are equivalent, regardless of who implements them. When categorizing a tract, recognize that mixed uses will occur; for instance, a natural area may have a visitor center and trails. Such uses need not influence the categorization if they represent 5% or less of the area of the tract. Also recognize that every type of management, ownership, or regulation can potentially be changed, but for this purpose, consider whether the intent infers permanence. When using the key, you may go back to a previous choice if the pathway has led you to an unsatisfactory option.

A-1:

If subject to statutory or irrevocable ecological protection from conversion to anthropogenic use of all or selected biological features by state or federal legislation, regulation, private deed restriction, or conservation easement intended for permanent status, GO TO B-1; if not, GO TO A-2

If ecological protection is revocable, temporary, or lacking but managed by a plan, GO TO A-3; if not, GO TO A-4

A-3:

Management to benefit biological diversity is provided by a written plan in place or in process under an institutional policy requiring a management plan - Status 3

A-4:

Not subject to an adopted management plan or regulation that promotes biological diversity - **Status 4**

B-1:

If total system in tract is conserved for natural ecological function, GO TO B-4; if conservation provisions apply only to selected features or species, GO TO B-2

B-2:

If management emphasizes natural processes including allowing or mimicking natural ecological disturbance events, but also allows low disturbance, renewable resource use, or high levels of human visitation on more than 5% of the tract - Status 2; if not, GO TO B-3

B-3:

Management allows intensive, human disturbance such as resource extraction, military exercises, or developed or motorized recreation on more than 5% of the tract, but includes ecological management for select features - **Status 3**

B-4:

If management strives for natural processes including allowing or mimicking natural ecological disturbance events - **Status** 1; if not, GO TO B-5

B-5:

Managed for natural processes, but some or all disturbance events are suppressed or modified - **Status 2**

Figure 1.

Patrick J. Crist, Julie S. Prior-Magee, and Bruce C. Thompson
New Mexico Cooperative Fish and Wildlife Research Unit
New Mexico State University, Las Cruces

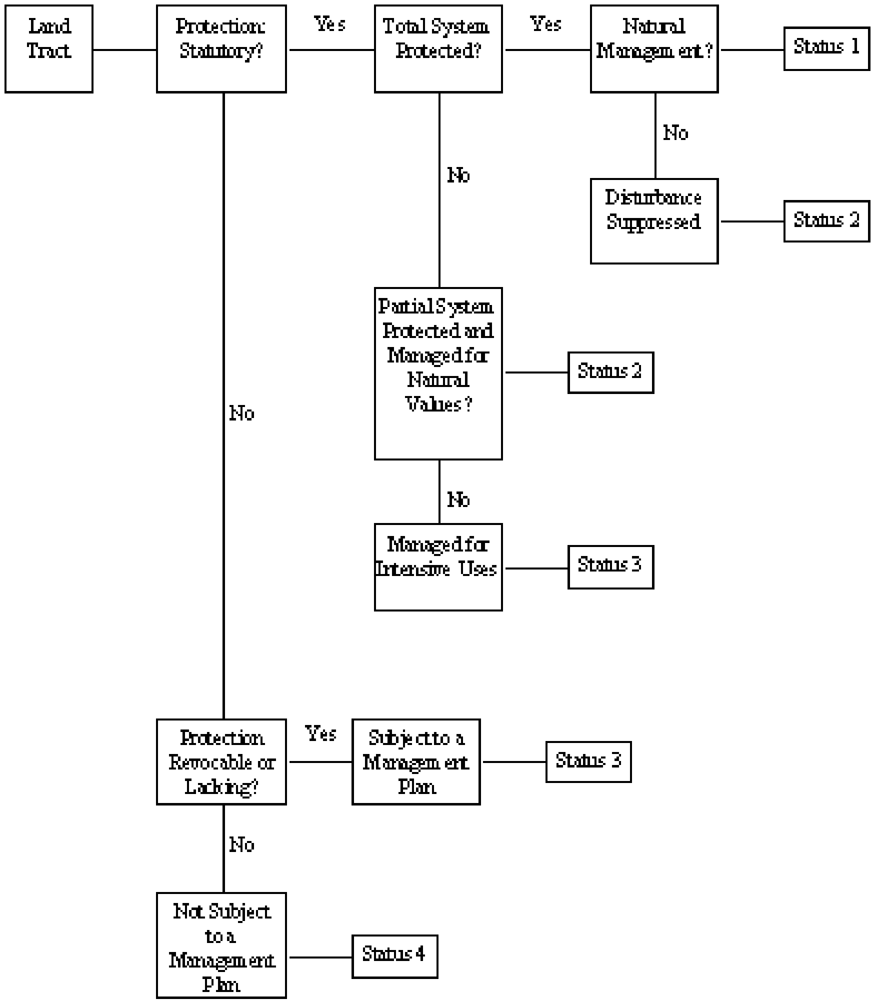

Figure 1. The dichotomous key flow chart for land management status developed by the New Mexico Gap Analysis Project (Crist et al. 1994).

A Preliminary Comparison of MMU Aggregation Procedures for Raster Data

Many Gap Analysis projects are challenged by the need to aggregate their base resolution land cover data to the 40- to 100-hectare minimum mapping unit (MMU) land cover product. Two creative solutions to this challenge have been developed by the Utah and Montana Gap Analysis Projects. In November 1995, the Arkansas GAP Project decided to face this challenge by evaluating these methods, along with some locally-developed procedures. Unfortunately, we encountered software problems with the Utah product that could not be corrected before our project's deadline, so attention was focused on evaluating the Montana method versus locally derived procedures. It became clear that the assumptions underlying the Montana method paralleled the image processing procedures used by the Arkansas project, and it was ultimately selected for statewide use in Arkansas. It is hoped that a more comprehensive comparison that includes the Utah product can be made in the future, but lessons learned to date may still be valuable to other GAP projects.

Before software problems were encountered in the Utah code, the Arkansas GAP team implemented a variety of testing procedures to evaluate both methods. We first tested the "rastelimqueen" program from the Utah Gap Analysis Project (UT-GAP). Rastelimqueen required an input ASCII raster file, a similarity matrix, and a minimum number of pixels in a group. The input and output products were then processed using GRASS GIS software. The ASCII raster files in addition to the existing binary raster files used by the Utah method are very large and require substantial disk space. The data were output from the GRASS binaries to ASCII form and provided as input to the module. The test data were processed successfully by the module, and the resulting ASCII output file was transformed using a conversion shell script to re-transform the header data to the GRASS format. The resulting file was then read into GRASS with the "r.i n.ascii" module. This process was regularly interrupted by an error message which noted that the "data conversion failed at row 1027, column 1878." Although the line with the error could be extracted, the extreme length of the line prevented examination of column 1878, even using a variety of UNIX tools that allow processing of very long lines. Without being able to input the ASCII data back to GRASS, the rastelimqueen program could not be fully tested.

Concurrently, we tested the Montana method. An advantage of the Montana program was that it did not require ASCII import. Instead, a binary cell matrix was used for input. The amount of area that could be processed at one time was an important element of the Montana method and was influenced by the amount of available memory. The work was conducted on a multi-CPU Sparc system with 100 megabytes of random access memory that were allocated to the process out of a total of 320 (mb RAM!). The Montana program utilized four variables that affected memory requirements: (1) number of columns, (2) number of cells, (3) number of categories, and (4) number of output polygons from each aggregation pass. Locally developed interfaces reclassed only those categories which were present in the section (then restored the original category numbers at the end of the process), constructed GRASS supporting files, and did other miscellaneous tasks. To overcome the memory limitations, the state pixel map was divided into seven subsections. Interfaces were written to the Montana program to derive similarity matrices for the seven subsections of the Arkansas map. With these interfaces and 100 megabytes of available RAM, six of the seven subsections were processed in one day. Testing was necessary to ensure that parameters would not exceed memory requirements.

Aggregation levels were 2, 10, 40, and 100 hectares. On some of the wider (more columns) subsections, additional aggregations at the 60 and 80 hectare level were required to further reduce the number of polygons so that the available memory was not exceeded. With the available hardware, the Montana aggregating method was very fast (probably 25 lines/second). At each larger aggregation unit the program was slower than the previous level, which was expected. According to the Montana team, the program can be run with as little as 16 megabytes of RAM, but this would limit the area (or other parameters) considered in each run. Testing in such a situation would be necessary to determine the maximum allowable four inputs to keep from exceeding the 16 megabytes of RAM.

Both the Montana and Utah approaches used similarity indices for intelligent decision-based aggregation. Montana's matrix was formed on the basis of multispectral data. Utah's matrix was a user-defined map classification similarity index defining which mapped categories were most alike (ecologically). This methodological distinction is quite significant, though each matrix can provide acceptable results. Evaluating the actual results from these aggregation methods poses another difficult task. Remember that any clump of cells can be subsumed and its identity changed if it is not large enough to remain at the current aggregation level. For example, cells that are classified as "oak," if not large enough, could be aggregated with other cells into a larger polygon classed as "cedar."

In the Montana method, aggregation occurred on a similarity matrix derived from the underlying spectral values. Thus, pixel groups that do not meet the minimum size limit would be aggregated with adjacent cells that had the most similar spectral properties. In the Utah method, aggregation would occur on the assessment of "similarity" of botanical character. While at first blush the Utah method would seem superior, and it may very well be in some situations, it means that the accuracy of the classification of the spectral class to the information class is central to the success of the aggregation that takes such assignments as a "given." Both techniques permit the "reservation" of certain classes, so that they are not forced into adjacent classes. Water, for example, can be blocked from being aggregated with other classes.

The two techniques reflect quite different underlying assumptions, and it is likely that each can yield successful results but in different mapping strategies. Utah's suite of aggregation algorithms, for example, also included a vector-based aggregation method which is based on the information class assignment and not the underlying spectral class. This is by no means a comprehensive comparison and, while the Arkansas team is satisfied with the results of the Montana method, we have not been able to perform a comprehensive, direct comparison of the two. It is clear that the mechanics of data aggregation are complex and depend on underlying image processing, GIS mapping strategies, and the assumptions that are made about similarities and classification. It is likely that there is no single best method, and what may be most appropriate in one situation may not be in another. More work is needed before these two methods (and perhaps others) can be said to be compared fairly.

Richard Thompson, Robert Dzur, and W. Fredrick Limp
Center for Advanced Spatial Technologies
University of Arkansas, Fayetteville

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Status of Spectrum Software

TX-GAP was able to compile Spectrum version 2.0.2 for Sun Workstations (with operating systems Solaris 2.4 and SunOS). Initial work with Spectrum revealed that the program could not integrate external data (e.g., videography output from SkyKing software, UTMs and vegetation types from ground verifications). As a result, we contacted the developers of Spectrum in August/September 1995 to investigate the possibility of adding some command language and allow input of external data (see Khoral Research contract, below). An additional problem with Spectrum 2.0.2 was encountered while attempting to load a file previously saved in Spectrum into Spectrum. All attempts at loading such a file caused the program to crash. This problem was encountered at both Texas A&M and Texas Tech Universities. Rick Hammer of the Texas GAP Lab contacted programmers at Khoral Research. An enhanced version of Spectrum 2.0.2 was made available to TX-GAP. The problems with loading a saved file have been corrected in this version. The enhanced version of Spectrum 2.0.2 will soon be available from the GAP home page.

Khoral Research Contract

TX-GAP established a contract with Khoral Research, Inc., the developers of Spectrum, to add command language that will allow Spectrum to integrate external data. As part of our contract with Khoral Research, TX-GAP has agreed that the enhancements paid for in our contract will be released to the general Khoros user community, free of charge, via anonymous ftp (or CD, etc.) at the next release of Khoros 2 (Spectrum is a part of Khoros).

Raymond Sims and Rick Hammer
Texas Cooperative Fish and Wildlife Research Unit
Texas Tech University, Lubbocknia-Santa Cruz

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1995 Annual GAP Meeting

Thanks to everybody who helped make the Annual Meeting in Fayetteville a success - especially the Arkansas crew! Below is the list of 13 "to do" items that came out of the meeting, along with annotations on the progress that has been made in addressing each.

1. Review the manual guidelines for modeling prediction of vertebrate distribution.
   - Several research projects on this topic are ongoing. Bill Krohn (ME-CFWRU) is identifying species whose distribution can be easily predicted versus those difficult to predict. John Ratti (ID-CFWRU) will be conducting a study of "The impact of land use practices on vertebrates of Western states." Chuck Peterson (Idaho State University) is upgrading models for herps.
   - Patrick Crist sent a request for methods statements to all GAP PIs. He will extract the most practical methods and develop new standard methods that will be reviewed by a working group.
2. Utah and Montana researchers have developed algorithms for aggregating the land cover maps from 30 m pixels to 100 hectare polygons.
   - Fred Limp of the Arkansas project has made a preliminary comparison of the two methods (see page 22, this volume).
3. Idaho, Utah, and Massachusetts have all developed accuracy statements of their vegetation maps, and guidelines for accuracy assessment are detailed in the GAP Handbook. However, more work is needed. A workshop will be held to make progress on developing one standard technique for accuracy assessment.
   - A regional accuracy assessment meeting was held April 9-10, 1996 in Denver to review the experience of states that have done accuracy assessment and to advise new start-ups.
4. GAP researchers have been at the cutting edge of developing and improving techniques for pattern delineation and polygon identification of land cover maps. How can the wide variety of experiences be "harvested" for better, more consistent results?
   - One of GAP's objectives in 1996 is to review and synthesize this experience. The evaluation of all methods used by GAP projects for land cover mapping will be spearheaded by Jim Merchant of NE-GAP.
5. The four land management categories used for the Gap Analysis project may be too limited. There is a need to revisit our thinking on land management categories and provide more detailed guidelines for designation of land use categories. NM-GAP developed a dichotomous key that could possibly serve as a basis for development of finer levels of land management categories.
   - Bruce Thompson is chairing a working group to prepare revised guidelines for the GAP manual (see page 20, this volume).
6. A standardized state project final report outline needs to be developed.
   - The standard report outline is done. A disk with the outline and all boiler plate text is available from the National GAP Office by request.
7. Aquatic guidelines: Dr. Pat Heglund of the University of Idaho and Mike Jennings developed a draft copy of an aquatic manual for GAP. Mike Jennings presented its contents at the meeting. These guidelines will be revised based on comments received at the meeting and circulated for further review.
   - Pat Heglund is completing work on the guidelines for Aquatic GAP.

8. The GAP Handbook chapter on metadata was revised to include more detailed examples.
    - The updated version was distributed to handbook recipients and is also available on the GAP home page.
9. Regionalization of state land cover maps by Bailey's ecoregions is currently under way for the Mojave and Great Basin ecoregions. New regionalization efforts will focus on the Colorado Plateau, Sonoran, Arizona, and New Mexico mountains and semi-desert.
    - Regionalization between Colorado and Utah land cover maps was recently completed. Tom
10. Thompson shared his experience on the GAP Bulletin Board. Efforts in other states are ongoing.
    - The National GAP Office is obtaining Bailey's subsection boundaries from ECOMAP that may be used to segment the landscape for ecoregion analysis. These will be available by request.
11. A digital copy of the TNC master list of animal names and codes will be distributed to all GAP principal investigators.
    - Completed (see page 48).
12. Several PIs indicated that they were unable to get a crisp, sharp version of the GAP logo from the GAP home page.
    - The logo has been enhanced and can be downloaded from the home page. The logo is available in ARC/INFO.gra form as well as in raster form.
13. Edge-matching of vertebrate distributions for the different states will be conducted on an ecoregion basis, with the first ecoregion matching done for the Sonoran and Great Basin ecoregions.
    - Tom Edwards and Blair Csuti are working on edge-matching of vertebrate distributions. Tom O'Neil, with Blair Csuti and Chris Grue, is updating Jack Ward Thomas's paper on the Blue and Wallowa Mountains, Oregon.
14. The home page will be reviewed and a variety of new discussion sections set up for regions and topics of interest.
    - The home page has been reviewed and modified. Further improvements are forthcoming.

The results or status of all these action items will be presented at the next annual GAP meeting. There will be an opportunity for further discussion on how to best accomplish these goals.

Mike Jennings and Elisabeth Brackney
National Coordinator and Program Assistant

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GAP Symposium at ASPRS Annual Meeting

In 1994, Maury Nyquist, then President of the American Society for Photogrammetry and Remote Sensing, invited the Gap Analysis Program to present a symposium at their 1995 annual meeting in Charlotte, North Carolina. We saw this as a great opportunity to build a stronger relationship with the remote sensing community. During the symposium, 28 papers were presented under five general headings: Scale and Content of Gap Analysis; Land Cover Mapping; Modeling Vertebrate Distributions; Practical Applications of Gap Analysis; and Technological Issues. Dr. Ron Pulliam made the introductory remarks in which he challenged those of us working with GAP to make greater use of the data sets in developing and testing demographic models for vertebrates and to reach out to more partners. Dr. Jack Estes, the Senior Visiting Scientist with the Mapping Division of the U.S. Geological Survey, summarized the history of GAP and identified present and future challenges to the program. After peer review of the papers, they were sent to the editorial office of the Society for Remote Sensing and Photogrammetry for final editing. We anticipate publication in early May. Following is the full citation:

Scott, J.M., T. Tear, and F. Davis, editors. 1996. Gap Analysis: A landscape approach to biodiversity planning. American Society for Photogrammetry and Remote Sensing, Bethesda, Maryland.

J. Michael Scott, Director
National Gap Analysis Program

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1996 Gap Analysis Annual Meeting

The sixth annual meeting will be hosted by the Florida Biodiversity Project. The meeting will be held from Monday, July 15 through Friday, July 19, 1996 in Key Largo, Florida. The preliminary agenda has been mailed out; registration and hotel information will follow. All state GAP projects are encouraged to present a poster to share their experience. To submit poster abstracts and for further information, contact: Craig Allen FL Coop. Fish and Wildlife Research Unit University of Florida P.O. Box 110450 Gainesville, FL 32611 e-mail: craigr@gnv.ifas.ufl.edu

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WELCOME Patrick Crist and Becky Sorbel to the National GAP Office!

In late summer 1995, Patrick and Becky joined the National GAP staff. Patrick is a full-time coordinator focusing on the Western states and comes to us from the New Mexico GAP Project. Becky is now the GAP secretary and comes to us from Washington State University's Department of Agricultural Economics. This is an exciting development for us because we can now serve state projects and national partners better. To contact either of them: Patrick Crist, pcrist@uidaho.edu, (208) 885-3901; Becky Sorbel, rsorbel@uidaho.edu, (208) 885-3555. You can contact anyone at the GAP national office by e-mail at gap@uidaho.edu or by mail at 530 S. Asbury, Suite 1, Moscow, ID 83843.

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Award for NatureMapping

Congratulations to Karen Dvornich, who recently received a certificate of environmental achievement from Renew America for her development of NatureMapping. This is the fourth national environmental award the program has received since its initiation in September 1993. NatureMapping is an educational outreach program that involves the general public and school children in field-testing maps and generating new information for Gap Analysis. A collaborative effort between the Washington Gap Analysis Project and the Washington Department of Fish and Wildlife, the program has grown to involve an estimated 50,000 people, including 500 teachers. The goal of NatureMapping is to facilitate exchange of information between natural resource agencies, academia, land use planners, local communities, and schools through public education and participation in data acquisition. The Oregon Biodiversity Project and Virginia Fish and Game are now getting started on NatureMapping, nine other states have expressed interest in beginning the program. For more information on NatureMapping, contact Karen Dvornich at (206) 685-4195 or kgap@salmo.cqs.washington.edu. The contact person for Oregon's NatureMapping program is Wendy Hudson, (503) 697-3222 or whudson@defenders.org.

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ASPRS's Award for Best Scientific Paper

Zhenkui Ma and Roland Redmond of the Montana GAP Project won the 1995 ERDAS Award for Best Scientific Paper in Remote Sensing from the American Society for Photogrammetric Engineering and Remote Sensing for their paper entitled "Tau Coefficients for Accuracy Assessment of Classification of Remote Sensing Data" (*Photogrammetric Engineering and Remote Sensing* 61:435-439). Dr. Ma accepted the award at the society's annual convention in Baltimore, MD, in April and presented a separate paper entitled "Integrating Remote Sensing and GIS to Map Land Cover Across Large Areas".

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Recent GAP Publications

The following list of citations is a brief sampling of recent publications related to GAP that may be of interest to you.

Caicco, S.L., J.M. Scott, B. Butterfield, and B. Csuti. 1995. A gap analysis of the management status of the vegetation of Idaho (U.S.A.). *Conservation Biology* 9:498-511.

Davis, F.W., P.A. Stine, D.M. Stoms, M.I. Borchert, and A.D. Hollander. 1995. Gap Analysis of the actual vegetation of California - 1. The southwestern region. *Madroño* 42:40-78.

Edwards, T.C., Jr. 1995. Protection status of vegetation cover-types in Utah. Pages 463-464 in E.T. LaRoe, G.S. Farris, C.E. Puckett, P.D. Doran, and M.J. Mac, editors. Our living resources. National Biological Service, Washington, DC.

Edwards, T.C., Jr., E.T. Deshler, D. Foster, and G.G. Moisen. 1996. Adequacy of wildlife habitat relation models for estimating spatial distributions of terrestrial vertebrates. *Conservation Biology* 10:263-270.

Jennings, M.D. 1995. Gap analysis today: A confluence of biology, ecology, and geography for management of biological resources. *Wildlife Society Bulletin* 23:658-662.

Jennings, M.D. 1995. Habitat assessments: Overview. Pages 461-462 in E.T. LaRoe, G.S. Farris, C.E. Puckett, P.D. Doran, and M.J. Mac, editors. Our living resources. National Biological Service, Washington, DC.

Loveland, T.R., and H.L. Hutcheson. 1995. Monitoring changes in landscapes from satellite imagery. Pages 468-473 in E.T. LaRoe, G.S. Farris, C.E. Puckett, P.D. Doran, and M.J. Mac, editors. Our living resources. National Biological Service, Washington, DC.

Ma, Z., and R.L. Redmond. 1995. Tau coefficients for accuracy assessment of classification of remote sensing data. *Photogrammetic Engineering and Remote Sensing* 61:435-439.

Merrill, T., R.G. Wright, and J.M. Scott. 1995. Using ecological criteria to evaluate wilderness planning options in Idaho. *Environmental Management* 19:815-825.

Stoms, D.M., and F. Davis. 1995. Biodiversity in the southwestern California region. Pages 465-466 in E.T. LaRoe, G.S. Farris, C.E. Puckett, P.D. Doran, and M.J. Mac, editors. Our living resources. National Biological Service, Washington, DC.

Stoms, D.M., F.W. Davis, and A.D. Hollander. 1996. Hierarchical representation of species distribution for biological survey and monitoring. Pages 445-449 in M.F. Goodchild et al., editors. GIS and environmental modeling: Progress and research issues. GIS World Books, Ft. Collins, Colorado.

Wright, R.G., J.G. MacCracken, and J. Hall. 1994. An ecological evaluation of proposed new conservation areas in Idaho: Evaluating proposed Idaho National Parks. *Conservation Biology* 8(1):207-216.

Yang, X., P.W. Mausel, and F. Clark. In press. Identification of drained wetlands for wetland restoration in the Eel River watershed of Indiana using remote sensing and GIS analysis.

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