Abstracts from National GAP 2000 Meeting

A conservation assessment of the freshwater ecoregions of North America.

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With nearly every freshwater system in North America suffering from some degree of degradation, and conservation resources limited, there is an urgent and practical need for priority-setting. Recognizing this, World Wildlife Fund-US, with support from the U.S. EPA, conducted a conservation assessment of freshwater ecoregions as an initial step in identifying those areas where protective and restorative measures should be implemented first.

The goals of this assessment were: 1) to identify freshwater ecoregions that support globally outstanding biological diversity and to emphasize our global responsibility to protect and restore them; 2) to assess the types and immediacy of threats to North American ecoregions; 3) to begin to identify specific sites within ecoregions where conservation activities may result in substantial benefits to biodiversity; 4) to identify important gaps in information that hamper an accurate evaluation of biodiversity; and 5) to provide a broad-scale framework so that conservation agencies and groups can position their activities within a continental and global context, resulting in more effective allocation of conservation resources.

Ecoregions are defined as relatively large areas of land or water that contain a geographically distinct assemblage of natural communities. The communities 1) share a large majority of their species, dynamics, and environmental conditions, and 2) function together effectively as a conservation unit. North America, defined here as Canada, the continental United States, and Mexico, was divided into 76 freshwater ecoregions. The freshwater ecoregions are, in most case, comprised of aggregations of catchments and are based primarily on fish species distributions.

We developed two indexes, biological distinctiveness and conservation status, to characterize ecoregions. Biological distinctiveness combines species richness, endemism, rarity of habitat type, and ecological and evolutionary phenomena. The species richness and endemism measures were based on the distributions of freshwater fish, unionid mussels, crayfish, amphibians dependent on aquatic habitats, and aquatic and semi-aquatic reptiles. The remaining criteria were evaluated using expert assessment. Conservation status combines seven indicators of current threats and degradation, all evaluated using expert assessment. We also considered future threats in the next 10-20 years, and modified the conservation status accordingly.

We used our analyses of biological distinctiveness and conservation status to suggest conservation targets for the next few decades and beyond. By integrating the results of these two analyses, we created a matrix that separates ecoregions into five priority classes. The priorities are intended to guide conservation action, focusing on those ecoregions where intervention has the best potential to achieve conservation gains at a continental and global scale. Twelve ecoregions received the highest priority in our analysis. We recognize the intrinsic value of all freshwater ecosystems at the national and local scales, and we provide site-based and more general recommendations for achieving conservation of freshwater biodiversity and habitats across North America.

A proposed ecosystem and habitat classification system for United States marine and estuarine waters.

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The Ecological Society of America and the United States National Oceanic and Atmospheric Administration's Offices of Habitat Conservation and Protected Resources sponsored a workshop to develop a national marine and estuarine ecosystem classification system. Among the participants were scientists who had developed various regional classification systems and federal managers who might ultimately use this system for conservation and management. The objectives were to: 1) review existing global and regional systems; 2) develop the framework of a national classification system; and 3) propose a plan to expand the framework into a comprehensive classification system. A consensus developed during the workshop that a classification system would provide a useful common language for description of habitat and a framework for interpretation of ecological function. However, all agreed that a system currently did not exist that was both broad enough in scope and fine enough in detail to be useful at the national level. Participants developed a classification framework that blended global scale systems with regional systems to provide a prototype classification system. The prototype system provides a descriptive approach, using a combination of physical and biological information, to classify Aecological units@ that ultimately represent the biological community or assemblage within a given habitat.

Managing museum collections using geographic information systems.

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At Texas Tech University mammal specimens in the National Science Research Laboratory are being labeled with bar code tags and the locations of all collection sites within the state of Texas have been georeferenced. Attribute data are stored in a relational database that can be linked to a GIS for modeling or mapping purposes. Storage of voucher specimen information in a relational database has facilitated error checking and increased data consistency and accuracy. A GIS permits the visualization of collection sites of voucher specimens and their related information. This has proven to be particularly useful for managing nomenclature changes, observing range contractions or extensions, and determining previously unknown relationships with environmental variables.

To date, these new tools have been used to identify 1377 voucher specimens (50 species) that needed to be reviewed by the mammalogists at Texas Tech University. Preliminary results indicate over 700 voucher specimens, representing 8, species had either undergone nomenclature changes or were initially misidentified. Our results indicate relational databases and geographic information systems are powerful tools that are expected to become increasingly important in the development of unforeseen applications.

Conceptual gaps in the conservation of aquatic biodiversity: perspectives from Virginia.

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Biological diversity is a much broader, more complex concept than imperiled species. In particular, biodiversity encompasses multiple organizational levels within multiple biotic hierarchies. Conserving substantial portions of biodiversity will require more comprehensive policy frameworks than those currently implemented, which focus largely on species-specific preservation. Conservation planners should carefully consider conservation goals and anticipate shortcomings in the ability of current policy to effectively conserve all biotic elements. The tools and strategies developed via gap analysis programs are sorely needed and may facilitate moving biological conservation beyond species-by-species approaches. However, to forge effective conservation programs, gap analyses must be integrated with policy that is more proactive and that incorporates current understanding of biodiversity issues. A major "gap" in the conservation policy of Virginia (and other states) is the lack of mechanisms to explicitly protect ecological communities and landscapes. This policy tacitly allows the extirpation of >90 distinctive types of fish communities and fails to recognize biotic homogenization as a basic form of biodiversity loss. Conservation planners should look beyond the obvious role of gap analyses as inventory and prioritization tools, and also use them as educational tools to effect more comprehensive conservation policy.

A voucher specimen based biological informatics program.

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Texas Tech University Museum has developed a biological informatics approach for the management, access, and multidisciplinary research use of voucher specimens. This approach involves the TTU mammalogists, as well as, specialists from elsewhere across campus. A bar code system developed by Richard Monk uniquely identifies voucher specimens employing a base TK number supplemented with a code identifying each part of a specimen including skins, skulls, post cranial skeletons, frozen tissues, etc. Bar codes are used for electronic cataloging, inventory, loan preparation and curation. Bar codes are assigned to specimens in the field using pre-printed tags and labels on archival quality stock as appropriate for specimen storage. UTM coordinates have been assigned to all voucher specimens through a software package developed by Oleksiy Knyazhnytskiy, so that geographic data can be examined in a geographic information systems (GIS) context. The collection can be searched online by species, collector, geographic locality and date. The goal is to have an electronic data set associated with voucher specimens that will be accessible to users. Voucher specimens are the central feature in a set of relational databases that scale up to global perspectives and down to specific aspects such as DNA sequences. Users include scientists, decision-makers, K-12 students, and governmental agencies. Additional information is on our homepage http://www.nsrl.ttu.edu.

Putting the pieces together: A rangewide perspective of vertebrate distribution modeling with GAP data.

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The Gap Analysis Program establishes core criteria for modeling predicted distribution (Scott and Jennings, 1998) for vertebrate species known to occur in each state. Researchers model distribution from local records, literature searches, range limits and expert knowledge. However, because the data and analysis are generated at the state level, the scientific knowledge of each species may vary from state to state. Thus, predicted distributions may not be consistent across state boundaries. Issues such as resolution of base data (i.e. land cover), minimum mapping unit, distribution models, and taxonomic classification, may further intensify the differences. I will compare some preliminary results from putting together numerous species over the eleven western states. We will see some examples of widely-ranging species, some species with narrow ecological amplitude and some which may be wide-ranging but have special features influencing their occurrence. I will summarize with some issues pertinent to mapping rangewide distributions from GAP data.

Directions in metadata.

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Metadata provide us with a way to standardize key information about data which can promote data sharing through data catalogs and clearinghouses. Just as importantly, metadata allow GAP projects to maintain our internal investment in the data. In this talk I will review the essence of the standards from FGDC and NBII and focus on required elements as they pertain to our GAP needs. I will show some examples of states which have produced thorough and comprehensive metadata. I will also give a brief overview of the National Office's direction with metadata: available software, the need to parse, and an update on our GAP node which will serve metadata to the NBII clearinghouse.

Metadata Clinic.

REE BRANNON (National Gap Analysis Program, 530 S. Asbury St., Suite #1, Moscow, ID, 83843. abrannon@uidaho.edu) and TOM SKLEBAR (BRD/Northern Prairie Science Center, 8711 37th St., SE, Jamestown, ND, 58401. Tom_Sklebar@usgs.gov)

Are you wondering just what you are supposed to be doing about metadata? Do you have specific questions about software, deliverable format, or how to handle that special data set? The Metadata Clinic will be just the place for you to bring your metadata ailments. Ree Brannon (National Office) and Tom Sklebar (North Dakota GAP) will be on hand to answer questions and run diagnostics on available computers. Meet with us on Wednesday morning, from 8-11:00, or schedule one of us to visit your regional breakout session.

Nature preserve planning in the urban-rural fringe of San Antonio/Bexar County, Texas: Integration of GIS, vegetation analysis, and ground-truthing to aid land acquisition and management decisions.

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Since Europeans first settled in the San Antonio region 300 years ago, agriculture, ranching, and urbanization caused great changes in the natural landscapes of Bexar County. Population growth and land development continue at a rapid rate with the result that only small remnant patches of natural and semi-natural communities remain. A number of species are no longer found in the county, though most still occur elsewhere. Existing nature preserves represent only one of the county's four ecoregions, furthermore, no comprehensive system of reserves currently exists to protect the native biodiversity of Bexar County. This study seeks to identify and classify areas or sites representative of and appropriate for designation and management as nature preserves. We delineated four ecoregions *a priori,* based on soils and their potential vegetative cover. These include Balcones Canyonlands (juniper-oak woodland/forest), Blackland Prairies (tall grassland), South Texas Plains (Tamaulipan thornscrub), and Oak-Hickory Woodlands (post oak woodland/forest). Riparian wetlands, either perennial or intermittent, are present in all of these, though there are no unmodified natural lentic wetlands. We prepared a selection matrix for nature preserve acquisition that included site size, ecoregion type, protection level currently afforded particular ecoregions, present ownership, and proximity to urbanized and urbanizing areas.

Using Envi, the authors performed an unsupervised classification of 1-meter digital orthophoto quarter quads (DOQQs) of Bexar County produced in 1995. Then we classified the resultant data to determine land cover types. These are comprised of urban, water, wetland, cropland, grassland, thornscrub, and woodland/forest. The pertinent land cover types are, grassland corresponding to the Blackland Prairies, thornscrub corresponding to the South Texas Plains, and woodland/forest correpsonding to either the Balcones Canyonlands or the Oak-Hickory Woodlands (depending on location in the county). The authors selected four representative DOQQs in each of the four ecoregions and ground-truthed samples to verify the land cover classification accuracy. We delineated sites of 50 acres or more in natural vegetation for consideration as potential preserve sites or as components of such preserves using ArcView. Additionally, localities of selected vertebrate and plant indicator species were overlaid on the land cover map to predict where these species are likely to occur.

Electronic development, review, and delivery of vertebrate distribution models at Kansas GAP.

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Development of more than 400 vertebrate distribution models for analysis in a geographic information system for Gap Analysis is a daunting task for every state. The need to maintain detailed metadata on every habitat selected for each species and to communicate this information to expert committee reviewers led us to develop a database/expert system in a commercial database program (Microsoft Access). Bibliographic data are maintained in a commercial bibliographic database program (Procite) which is linked, through a word processing program, back to the Access database. We presented an early example of the database/expert system at the 1999 Annual Gap Analysis Meeting in Duluth.

Since last year, we have made enhancements in the program to streamline model development and produce reports for expert reviewers. We also have developed a web-based review process that allows online review of proposed habitat distribution models and communication of experts_ responses. Review materials include a list of land cover classes with detailed literature or other citations, a county distribution map that displays the species_ known range in the state, and a GIS display of the proposed model.

When the expert finishes the on-line review, a hyperlink accesses a review form where the reviewer can accept the model as presented or make suggested changes on line. The review form includes choices to add or delete land cover classes as well as a window for ancillary comments. We require that all suggested changes to models be accompanied by supporting documentation which can include additional literature citations, reinterpretation of literature cited, personal observations, or other sources. When the review is complete, it is submitted to us via email with the click of a button.

Currently, the database/expert system is being used by state GAP projects in Iowa, North Dakota, South Dakota, and Kansas. Nebraska GAP is considering using the program, but also is considering some alternative vertebrate modeling systems. Kansas GAP is expected to be completed in FY 2001. We believe multi-state use of the program will facilitate developing a Great Plains Regional Gap Analysis as additional states finish their projects. Our presentation will demonstrate the linked programs and web-based review process.

Conservation biology and community-based land trusts.

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Myopia and isolation are the curse of most local conservation efforts. Inland Northwest Land Trust (INLT) has created a proactive approach to identify critical lands and strategic alliances spanning Spokane County, Washington. Conservation biology drives our identification of critical lands by using Gap Analysis Priority Habitats and Species data to delineate the "Threads of Hope" corridors linking larger habitat reserves. Our alliances with neighborhood grassroots groups have verified the choice of these corridors and assisted with contacting over 400 landowners representing over 20,000 ha. These data have united the land trust with government agencies and other non-profit groups to provide an array of options to conserve both private and public lands within the Threads of Hope, in part to protect species that migrate across administrative boundaries and to augment existing reserves. Land trusts are non-profit, non-governmental organizations operating at local and regional levels to preserve habitat. Nationwide, 1200 land trusts have conserved over 2 million ha. The same conservation biology and community-based approach will be used to prioritize INLT conservation efforts in seven other counties in eastern Washington and northern Idaho.

The role of ecological principles in refuge management planning.

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The framework of management planning on national wildlife refuges (refuges) is in a period of evolution, stemming from the National Wildlife Refuge System Improvement Act of 1997. Among the new legislated requirements are directives to (1) conserve and manage fish, wildlife, plants, and their habitat as the fundamental mission of the Refuge System; (2) maintain the biological integrity, diversity, and environmental health of refuges; (3) identify significant problems that may adversely affect fish, wildlife, plants, and their habitat on refuges and actions needed to resolve them; and (4) contribute to the conservation of the ecosystems of the United States through future growth of the Refuge System. Taken together, the above-listed directives provide the framework for melding traditional wildlife management with ecological restoration principles. The order of priority on refuges is clear: wildlife, habitat, ecosystem functioning. Nonetheless, growing emphasis is being placed on restoring ecosystem functioning as the primary means to restore natural habitat conditions, with restoration of these conditions being emphasized as the main approach to accomplishing the purposes for which a given refuge was established. Restoration of natural processes does not apply to all refuges, however. Case studies are used to show how the Fish and Wildlife Service is exploring ways to apply a broad range of ecological principles to management of individual refuges and the Refuge System. Some of the hurdles to be overcome in developing ecologically-sound conservation plans, including public resistance to changes in habitat management practices, are presented.

State and local government use of land cover data and GIS for planning.

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MoRAP is a soft-funded GIS and remote sensing lab that is supported by a consortium of state and federal agencies. As such we are keenly aware of the needs of the partners and the uses of digital data in natural resource management. We review several state and local government initiatives that have used land cover data and GIS analyses for planning. We helped produce Regional Management Guides for the Missouri Department of Conservation; the effort was the first time that remotely sensed data had been used as a primary basis for the creation of statewide natural resource plans. Use of the valuable data layer required agency buy-in, which in turn was ensured by involving more than 100 MDC biologist in gathering ground-based land cover data. The Missouri Department of natural Resources used different analyses of the same data to evaluate the distribution of forest in the Ozark Highlands in order to help set priorities for conservation. MDC used still more analyses to help set priorities for conservation in the Ozark Highlands ecoregion. Finally, Boone County used land cover as input for developing a natural resources conservation plan. We suggest that a standardized land cover data set and standard analyses will be useful for a variety of users, but that each scale of application will require difference types of additional data analysis.

New techniques for mapping urban sprawl in the southeast.

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The Metropolitan Atlanta region is one of the fastest growing urban areas in the country, and is often cited as the poster child for urban sprawl by the popular press. However, urban sprawl has become a national issue. Many communities across the country are initiating a number of practices to counter urban sprawl such as green space planning, alternative transportation, and more comprehensive land use planning. Often GAP data products are being incorporated into these local and regional land use planning activities. To assist in these planning activities in Georgia, Georgia GAP is attempting to increase the mapping accuracy of current urban land cover information. This paper compares two methodologies developed for mapping low-density residential areas, standard isodata clustering and a road buffering technique. These methods are being assessed for overall classification accuracy versus operator time expended. As with many processing techniques, the increase in the amount of time spent on the buffering technique results in an increase in accuracy.

Changes in black-tailed prairie dog towns on the Texas Panhandle determined by GIS.

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Historically, the largest expanse of the black-tailed prairie dog (Cynomys ludovicianus) occurred in Texas, whose distribution comprised more than one-third of the entire state. A recent estimation of the total remaining Texas prairie dogs predicted a decline of 61% in 2 decades or from 77,500 acres in 1973 to only 30,000 acres in 1991. Current distribution data for 29 counties in the Texas panhandle was obtained by viewing aerial photographs (color slides) taken biannually, available at the U.S. Department of Agriculture Farm Service Agency offices. Once examined for presence of prairie dog towns, these slides were digitally scanned and incorporated into a Geographical Information System (GIS). Current estimates of acreage and spatial distribution of prairie dog towns in 1998 will be compared to those from 1991. Additional GIS coverages such as playa lake distribution, soils, elevation, vegetation, and road proximity will be explored to describe prairie dog habitat and current localities of towns in Texas.

Developing predictive range maps of rare plant species in Wyoming.

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Resource managers are faced with a critical shortage of information on the potential distribution of rare plant species over large areas. Traditional dot distribution range maps may represent only a small percentage of a species' actual range and reflect sampling bias. An alternative is to model the potential range of a species by identifying correlations between the plant's known distribution and relevant environmental variables using geostatistical methods. Such models can be derived from herbarium or natural heritage program location records and state or regional-scale coverages of substrate, topography, and climate in a Geographic Information System (GIS).

As an example of this technique, I have developed models of the potential distribution of three rare, Wyoming endemic species of *Physaria* (Brassicaceae). These species occupy similar, semi-barren ridge and cushion plant habitats, but have discrete geographic ranges. Models for each species were developed using known presence and absence location data from the Rocky Mountain Herbarium and the Wyoming natural heritage program. Environmental attributes for each location were derived from digital coverages in Arcview version 3.1 and included PRISM mean monthly precipitation and temperature, 90m DEM land position, elevation, and aspect, bedrock and surficial geology, and Gap land cover data. Classification tree analysis in S-plus version 1.1 was then used to develop models of potential distribution using selected environmental variables as predictors. From the model output, I created a potential range map in arcview by intersecting the environmental values that best predicted the presence of each species. The models correctly identified 93-95% of known absence points in the model-building dataset and approximately 50% of known presence points in the validation dataset.

The predictive ability of these correlational models may be hampered by errors inherent in the input datasets. Imprecise location points, errors in converting map data to digital format, and horizontal and vertical errors in DEMs may all reduce prediction accuracy. Potentially useful environmental factors such as local soil pH, soil texture, or extremes in precipitation or temperature are unavailable in state-wide coverages or are masked when macroclimate data are averaged over diurnal cycles and monthly periods. Equally useful spatial data sets for the distribution of pollinators, seed dispersal vectors, predators, and soil symbionts are also unavailable. Spatial autocorrelation may also inflate the explanatory power of models when location points for a species are naturally clustered. Lastly, an inadequate number of sample points may be available for some extremely rare plants to meet the minimum data input requirements for a statistically useful model. Despite these caveats, GIS-based correlational models can be a powerful tool for developing cost-effective, testable, and ecologically meaningful distribution maps of rare species and for identifying or prioritizing areas of potential habitat for field surveys.

The National Biological Information Infrastructure.

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The National Biological Information Infrastructure (NBII), **http://www.nbii.gov**, is dedicated to the development of an electronic federation of biological data and information sources. The goal of the NBII is to provide swift user access to biological databases, information products, directories, and guides maintained by Federal, State, and local government agencies, non-government institutions, and private sector organizations in the United States and around the world. Typically, users come from both the public and private sectors; scientists, planners, and decision makers within various Federal agencies, State and local governments, industry, international entities, teachers and students, and private citizens. Diverse customer segments, the vast amount of biological information currently being produced, and the ever-changing rate of technology all factor into any information system or tool development effort that is undertaken. Addressing all facets of the biological information life cycle including the data collection, discovery, access, retrieval, and application of the data/information all present tremendous challenges to the computer and biological communities. This session will discuss the challenges and solutions that have been developed for the biological community by the NBII Program.

The cost of conservation: The consequences for GAP.

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Two of the most frequent questions for GAP managers are: What does the funding situation look like in the future? And when will we complete projects in all the states?

These are highly related questions, the first question normally has a hint of optimism and the second frequently borders on impatient. This talk briefly reviews the funding that has been provided for GAP projects over the years, and looks at trends, such as the cost of projects and support that comes from outside the USGS. It also compares funding for GAP to other programs that aim to generate data to support conservation and land management decisions. These issues are extremely important to the future of GAP. The Lower 48 states and Hawaii are underway, but core financial support for the program is unpredictable. The next year or two will be extremely important in charting the course for choosing projects. How far to go towards applications and implementation is not clear, nor is how to choose states to revise, and how far to go in these revisions.

Secondly, we review the political process that affects the operation of the program. The GAP program managers in the Washington DC area have spent the last year in a concerted effort to develop support for the program. Results and implications are discussed.

The National Vegetation Classification: Ongoing development and GAP conservation applications.

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The Association for Biodiversity Information (ABI) has worked with GAP to apply the US National Vegetation Classification (USNVC) and implement its use in the creation of an ecologically meaningful and consistent vegetation map of the United States. As we gain experience in mapping vegetation at a variety of scales and for different purposes, we are developing new tools, methods, and units that improve the utility of the USNVC for mapping, vertebrate modeling, and other efforts. This presentation is an update on the status of the USNVC and the ICEC (International Classification of Ecological Communities). This includes a summary of current cooperation between GAP and ABI to map ecologically meaningful groups of alliances; efforts to provide improved access to current USNVC data through the Internet; and the status of upcoming revisions to the Classification.

Ecoregional planning in The Nature Conservancy: Insights, lesson, and challenges from the first five years.

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Since 1996, The Nature Conservancy has been working to complete ecoregional plans for all 64 ecoregions in the contiguous United States. About 60% of the plans in the lower 48 will completed by October 2000, and the remaining plans are scheduled for completion by the end of 2002. Ecoregional planning is a major component of the overall 4-part Conservation Process within The Nature Conservancy: 1) Ecoregional Planning – identifying areas of biodiversity significance, 2) Site Conservation Planning – identifying threats and developing strategies to abate threats at these areas, 3) Conservation Action – implementing a variety of strategies and actions, and 4) Measuring Success – measuring health of conservation targets, abatement of threats to targets, and institutional capacity at important areas of biodiversity significance. Five major steps are involved in the preparation of ecoregional plans: identifying conservation targets (species, communities, ecological systems), setting goals for these targets, assessing the viability/integrity of these targets, designing a network of conservation areas, and developing multi-site strategies to conserve these areas. Information to prepare these plans is gathered from a wide variety of sources including Gap Analysis programs, Natural Heritage Programs, remote sensing, government agencies, and expert workshops. Conservancy scientists have worked collaboratively with scientists in a number of different institutions to develop innovative methods for setting conservation goals in communities and ecosystems, classifying and identifying aquatic communities and ecosystems primarily from physical variables, and developing flexible computer algorithms to assist in the design of networks of conservation area. Answering the question of "how much is enough?" remains the most significant challenge in these large-scale conservation plans. Identifying the highest quality remaining examples of conservation targets as well as evolving the planning process from one of identifying collections of important areas to true networks of conservation areas are also significant challenges. Through ecoregional planning, the Conservancy and its partners are placing greater emphasis on the conservation of communities and ecosystems and are focusing conservation work on the most functional landscapes remaining in these ecoregions.

Ecotourism and conservation biology in Texas: An application of GAP analysis.

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With a global human population of 6 billion and rising, the habitat for many species is being lost at an unprecedented rate. The 20 plus million residents of Texas are rapidly altering native habitat largely by removal or by fragmentation. An objective of the Texas GAP Analysis Project was to develop fine-scale distribution maps for terrestrial vertebrates of Texas. As a first step we examined published range maps to determine areas of high biological diversity (biodiversity) that would be of interest to ecotourists, conservationists, landowners, and natural resource managers. A map depicting the seven major geographic regions was used as a backdrop to analyze distribution of 908 terrestrial vertebrates of Texas. This map was part of a GIS including soils, vegetation, and elevations used to define habitat for terrestrial vertebrates. Species richness ranged from a low of 378 in the Piney Woods to a high of 514 in the South Texas Plains. These maps provide a guide to the biodiversity of Texas and therefore reflect the potential for expansion of ecotourism. Ecotourism is one means available to landowners to develop an economically sustainable lifestyle and yet conserve natural resources for generations to come. In a state with only 3.2% of its area in public ownership, the importance of private landowner stewardship to maintain biodiversity is essential. Access to accurate information on biodiversity is critical to economic development and conservation biology.

An overview of MRLC 2000.

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In 1992 a consortium of federal agencies called Multi-Resolution Land Characterization (MRLC) was created to optimize the purchase of Landsat 5 imagery. A second generation consortium called MRLC 2000 is now underway to create an updated pool of nation wide Landsat 7 imagery. This MRLC consortium offers several benefits to members including access to a nationwide pool of imagery at reduced cost, standardized processing and criteria based scene selection. Additional work at EDC is now exploring the application of MRLC 2000 imagery towards the development a land cover characteristics database. This multi-layer, multisource database would include a suite of landscape attributes and data elements that could serve as the supporting data required for users to produce second stage products – tailored land cover data – based on the specifications and requirements of individual programs and applications. This database in the future could be available to all GAP cooperators, and could provide standardized ingredients for local mapping of land cover. Components of the database will include source data, transformed data, interpreted data and documentation.

A comparison of 1st and 2nd generation GAPs.

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In 1991, the first Gap analysis project (GAP) was carried out in Idaho. Since GAP was a prototype project at the time, results were published extensively in peer-reviewed publications, but a final report for Idaho was never completed. Advances in remote sensing and modeling technology have allowed much higher resolution in mapping and led to a second generation GAP for Idaho. Our objective was to determine the management status of Idaho's land cover types and compare these results to those of the original Idaho GAP (reported by S.L. Caicco, J.M. Scott, B. Butterfield, and B. Csuti, 1995, Conservation Biology 9:498-511). The Landscape Dynamics Lab compiled the Idaho Land Cover Classification from Redmond et al.'s (University of Montana, 1997) Current Vegetation Map of Northern Idaho and Western Montana and Homer's (Utah State University, 1998) Idaho/Western Wyoming Landcover Classification. These sources were crosswalked and merged to produce a unified land cover map for Idaho. This coverage is stored as an ARC/INFO grid with a 0.09ha (30m) cell size and a 2ha minimum mapping unit. Thus, the new Idaho GAP land cover map is much more detailed than that of Caicco et al. (1995). In addition, the new land cover classification captures many smaller land cover patches (such as shrub-steppe inholdings within agricultural matrix), and results in a shift in the proportions of major land cover classes in the state. We also updated the 1991 Land Stewardship coverage with information provided by Idaho Conservation Data Center for Status 1 and 2 lands, and by contacting land management agencies for other ownership boundaries. These updates added almost 90 new protected areas ranging from 100-1000 acres and another 10 between 1000 and 10,000 acres. Despite the changes in the land cover and stewardship coverages, the cover type protection results were very similar.

Landcover change detection in Florida and application to the Florida Panther Habitat Model.

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In 1990, the Florida Fish and Wildlife Conservation Commission completed a project to map vegetation statewide in Florida. Landsat Thematic imagery dated 1985-89 (mostly 1986-87) was used to map 22 vegetation and land cover types. Over the last decade, we have used this vegetation base map to: (1) develop potential habitat maps for 130 rare and imperiled Florida vertebrates, (2) determine the conservation status of each species with respect to security on public lands, and (3) identify strategically located habitats that should be protected to ensure the long-term persistence of biodiversity in Florida. However, given the rapid growth of the human population in Florida, the vegetation map is becoming out of date. In an effort to update our previous work, we have undertaken a project to perform a change detection for all of Florida on a county by county basis. The change detection employs the following steps: (1) obtain 1996-97 Landsat imagery, (2) clip the imagery by county, (3) perform an unsupervised classification to identify lands with spectral signatures indicating disturbance, (4) overlay the disturbed lands layer on our original vegetation map to identify lands disturbed since the late 1980s, (5) determine which lands disturbed over the 10 year period were converted to urban uses and which were converted to agricultural uses by overlaying the newly disturbed lands grid on available land use/land cover data layers and digital ortho quarter quads, and (6) produce 30 m grids of newly disturbed lands and tabular reports of habitat loss by county for the study period. In five southwest Florida counties, disturbed lands covered 41% of the region in 1996, and 31% of disturbed lands had been converted from natural habitats to agricultural and urban uses between 1986-96 (a 46% increase in 10 years). Agricultural lands accounted for 76% of the natural habitats converted to human uses, and urban lands accounted for 24%.

We used the results of the change detection to evaluate the impacts of land use conversions on the habitat of the endangered Florida panther (*Puma concolor coryi*). The grid of lands disturbed between 1986-96 was overlaid on our model of Florida panther habitat (created from our original land cover map based on 1986 Landsat imagery). We found that 13% of lands mapped as panther habitat in 1986 had been converted to urban and agricultural uses between 1986-96. Most (77%) of the habitat lost was due to conversion of panther habitat to agricultural uses. Of equal concern, the map produced by this project showed that landscape linkages that provide for panther movements throughout the southwest Florida region are being severed by conversion of native habitats to intensive human uses. These are alarming results given that the population consists of no more than 60-70 individuals, and that at least half of the population occupies habitats on private property.

We anticipate that 18-21 months will be needed to complete the change detection project statewide. We intend to use our change detection results to: (1) evaluate the extent of habitat loss in Florida over a 10 year period, (2) update our potential habitat maps, and (3) reevaluate the habitat protection needs for Florida’s rare and imperiled wildlife.

A resource manaagement decision support system for the Upper Mississippi River System.

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During recent years, the Long Term Resource Monitoring Program (LTRMP) for the Upper Mississippi River System has increased its focus on developing information distribution mechanisms for use by resource managers, scientists, and decision-makers. The mechanisms include (1) development of a decision support system (DSS) concept that uses the ESRI Arcview® and MapObjects® GIS platforms and (2) use of the WWW. Our DSS facilitates an integrated, ecological, and pro-active scientific approach to management of UMR resources. The DSS framework provides for an adaptive management approach to decision-making and project evaluation. The DSS has been an effective information visualization and integration tool for briefing members of Congress, Federal and State agency leaders, and the public on the value and needs of the UMR. Moreover, Program scientists within all customer and cooperator agencies are beginning to compile environmental monitoring and research data into a common DSS platform. Application of the DSS is facilitating the planning and design of habitat rehabilitation and enhancement projects. A custom Arcview® script will be demonstrated to show how potential habitat maps, tables, charts, and metadata are being generated for over 450 species/guilds of invertebrates, unionid mussels, fish, reptiles, amphibians, birds, and mammals. Site specific monitoring and research data are used to provide corroboration of the potential habitat models for these groups.

Historical weather and natural resources in Texas.

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Surface water in the state of Texas (including every bay and arm of the Texas portion of the Gulf of Mexico) is considered state water. Water availability is a function of the temporal and spatial distribution of rainfall in Texas and density of the human population. The potential water-renewal per person in Texas was estimated using average rainfall for the period of 1880-1997 and population data from 1850-1990 with projections by decade to 2030. The total per capita precipitation was calculated by river basin, ecoregion, and the entire state of Texas. Kriging and co-kriging techniques were used to determine the spatial distribution of per capita precipitation for the period of 1850-2030. Kriged surfaces were overlaid with main river basins in Texas. Historical changes in water availability data were analyzed using a Geographical Information System (GIS). The study of the historical changes in precipitation per capita with projections to 2030 in Texas reinforces the need to develop water conservation programs for the state.

Building statewide data for Texas--GAP, framework, and beyond.

A. KIM LUDEKE* (Texas Parks and Wildlife GIS Lab Manager; Chair, Texas Geographic Information Council; 4200 Smith School RD., Austin, TX 78744.)

The Texas GAP Program is producing a number of statewide data sets including an updated vegetation map. Concurrent with this effort, the Texas Geographic Information Council has been producing a number of statewide maps under the Texas OrthoImagery Program (TOP) and the Strategic Mapping Program (StratMap). These digital products are being developed through an innovative partnership agreement with the USGS and meet or exceed the requirements of the Federal Geographic Data Committee. Further, Texas plans to develop the National Hydrology Dataset (NHD), complete statewide soils mapping, produce ten meter Digital Elevation Models (DEMs), develop 1:50,000 &/or 1:12,000 Land Use/Land Cover maps, update the vegetation map using the latest Landsat 7 imagery, and derive precision image maps using historical aerial photography.

A case study of the Southwest Gap Analysis Project.

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Classification of remotely sensed imagery for lance cover mapping across large, ecologically diverse, landscapes is a complex process of relating defined spectral clusters and biophysical information of landscape parameters to land cover types. A basic problem is that spectral clusters generated from imagery alone can be associated with multiple land cover types that have similar spectral characteristics. This problem is present at all scales, but increases as landscape size and mapping detail increases. Land cove classifications developed from digital imagery are often the result of a modeling process based on spectral response coupled with biophysical layers such as elevation, slope, aspect, precipitation, geology, and soils.

To help in the classification of land cover over large, diverse landscapes, ecologic variation of the landscape must be addressed. As a first cut, or preliminary, step in modeling we have used mapping zones to identify environmentally similar areas. Mapping zones are conceptually based on the ecoregion approach and divide large areas into ecologically and spectrally homogenous units, reducing landscape and land cover complexity and improving land cover mapping. The Southwest Gap (SWGap) analysis project is developing mapping zoned in order to assist in the multi-state mapping of land cover. This process not only attempts to address landscape variation, but also brings the focus of the 5-state SWGap collaborators to ecological unts and away from state boundaries.

The evolution of conservation planning in Tennessee: Failure, success, the future.

MARTY MARINA (Tennessee Conservation League; 300 Orlando Ave.; Nashville, TN 37209; phone: 615-353-1133)

Since 1991, the Tennessee Conservation (TCL), a private, not-for-profit organization, has pioneered a series of initiatives to promote the use of natural resource information, maps, and other tools for making land-use and land management decisions. The national Gap Analysis Program (GAP), TN-GAP and Partners in Flight's Neotropical Bird Conservation Plan provided the technical underpinning.

TCL partnered with citizens groups, industries, universities, NGO's, and state and local governments to foster the demand and refine the tools to realize this vision. As a result, the State of Tennessee is developing a state-of-the-art GIS, including a GAP component, and implementing Public Chapter 1101, which mandates all counties have a plan for growth that describes the long-term effects of urban expansion on agriculture, forest, recreation, and wildlife management.

Ten counties are already on the GIS and the Department of Economic Development is writing business plans for all 95 to sign on within five years. Counties are beginning to talk about protection of entire watersheds. Universities and government agencies are beginning to address what this means in terms of land use planning. An overview of the work – both successes and failures – will be provided with a discussion about what is left to do and TCL's role in getting there.

Conservation planning and implementation in the Bureau of Land Management.

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The U.S. Bureau of Land Management (BLM) is responsible for managing 264 million acres of public land, located in 23 States, more land than any other federal agency in the United States. Public land managed by the BLM is spread from the Alaskan tundra to the desert Southwest and is some of the most ecologically diverse areas in the western U.S. Land cover is highly varied with the majority reflecting the arid landscape that dominates the western U.S.

BLM public lands contain significant fish, wildlife and rare plant communities as well as important historical, cultural, and paleontological resources including over 200,000 miles of streams and rivers, 2.2 million acres of lakes, 2,000 miles of Wild and Scenic Rivers, 136 Wilderness Areas, an additional 622 Wilderness Study Areas, 8 National Conservation Areas, 4 National Monuments, and 739 Areas of Critical Environmental Concern. BLM managed lands support nearly 300 federally listed threatened or endangered plants and animals and an additional 1,000 sensitive species.

The BLM manages the public lands under the principles of multiple use for present and future generations with day to day management guided by land use plans that were developed by local field offices. The BLM currently has 162 existing land use plans that cover our land base.

Historical land-settlement patterns in the western U.S. left the BLM with a landscape of scattered management units from a few hundred acres to several million acres in size. Unlike other U.S. federal land management agencies, the majority of BLM administered land has some level of interspersed private and state land ownership. As a result of this pattern, coordinated planning and cooperation with other State and federal agencies, local governments, and private landowners has always been a guiding philosophy. However, in recent years with increasing numbers of federally listed T&E species, growing human populations in the West, and increasing demands on the public lands, BLM has recognized the need for broader landscape-level planning that looks at issues as they affect the landscape rather than just as they affect BLM lands.

In addition, technological advances in remote sensing, global positioning systems (GPS), and Geographic Information Systems have provided tools to land managers that are more readily available and affordable for planning purposes than a decade ago. The BLM's involvement in two regional planning efforts, the Northwest Forest Plan and the Interior Columbia Basin Ecosystem Management Project (ICBEMP) along with an overview of two new strategies for the conservation of multiple species in the sagebrush and prairie grassland ecosystems will be discussed.

Vegetation or vertebrate time scale? Incorporating vegetation structure into remotely sensed vertebrate modeling.

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In 1961, MacArthur and MacArthur stated an ornithologist could predict the presence of bird species in a forest by examining vegetation types alone. In doing so, he would use geographic location, vegetation species composition, and structure. Programs, such as Gap Analysis (GAP), that use remote sensing for their land classification in modeling of wildlife habitat traditionally use the first two components, but avoid the latter. Forested ecosystems of the eastern United States are characterized by historical and periodic disturbance. To adequately assess species habitat distribution, we must examine the impacts of disturbance on vegetation composition and structure. Predicting species distributions on potential rather than actual habitat may represent an inappropriate temporal scale. Vertebrate generation times and vegetation successional stages are not necessarily synchronized. Furthermore, terrestrial vertebrate species may have multiple generations during the course of one vegetation cycle (i.e., forest rotation). Species whose life histories are tied to a particular vegetation seral stage may remain vulnerable to population crashes and extinction vortices between cycles if reserves are planned based on potential rather than actual habitat availability. Vegetation mapping techniques have matured and increased in complexity and resolution over the years to the point where structural information such as age class groupings are discernable. Such information can and should be incorporated into vertebrate models to better represent the distribution of habitat specialist vertebrate species. In Mississippi alone, 3.0 million ha of potential pine habitat exists for the red-cockaded woodpecker (*Picoides borealis*). Closer examination reveals that 2.2 million ha of that habitat is not currently suitable to support any woodpeckers. Reserves are aimed at reducing the number of species that may shortly become threatened or endangered through land planning and management. Not incorporating structural data into planning reserves may allow some species to fall through the "gaps" of GAP.

Landscape indicators of aquatic habitat and ordination by habitat availability.
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Pennsylvania gap analysis included habitat modeling for fishes at a landscape level. Our primary concern for modeling fish species has been to ascribe habitat to sectors of landscapes that are large enough to be evident in regional mappings, but small enough to inform environmental and conservation analyses across landscapes. We considered stream reaches to be inappropriately fine scale with respect to both mapping and effort. Small watersheds constitute a next level of scale above stream reaches that can serve for purposes of landscape segmentation relevant to both hydrology and organisms. Small watersheds are also advantageous in mapping as area features rather than linear features, thus providing a tessellation.

Geomorphology, as reflected in physiographic provinces, controls development of drainage networks and character of streams, with influence extending also to physical and chemical properties of water. Drainage divides constitute zoogeographic barriers to movement of organisms that are wholly aquatic. Stream order can serve as a surrogate for stream size and discharge, which reflects macrohabitat for fish species. Median slope of a watershed indicates stream gradient, which reflects habitat factors along the longitudinal axis of a stream. Land cover can be used a surrogate for human disturbance, and well as providing an indicator of microhabitat diversity.

For the Pennsylvania context it is important to have a relatively objective way of analyzing the model results to determine which species are particularly insecure with regard to potential habitat, and also where there is notable co-occurrence among such insecure species. A special mode of analysis was conceived to meet these needs.

A *regional habitat insecurity index (RHII)* was formulated for joint ordination of species and landscapes with regard to comparative availability of potential habitat. The index combines overall habitat scarcity with scarcity of habitat in conservation areas and scarcity of habitat outside conservation areas. It lends particular emphasis to species that couple overall habitat scarcity with low representation in conservation areas and difficulty of finding habitat outside existing conservation areas by which to enhance the level of protection. A weighted spatial index of landscape importance was calculated for each taxonomic group by summing the RHII values for species having habitat in a given area. For each taxonomic group, a threshold was then determined for the composite RHII importance index. Areas above the threshold and not already having conservation status were designated as *leading landscapes* for conservation concern regarding that taxonomic group. The mappings of leading landscapes were also cross-compiled to show areas that constitute leading landscapes for multiple taxonomic groups. These latter areas are seen as being our *conservation gaps* for Pennsylvania gap analysis.

The land use history of North America and vegetation mapping programs.

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This presentation provides a general overview of two programs: the Land Use History of North America (LUHNA) Program and Vegetation Mapping Programs (VMP's). These two programs, along with the Gap Analysis Program, are biological characterization programs of the USGS Center for Biological Informatics (CBI).

Encompassing the time of pre-European settlement to the present, the LUHNA program seeks to understand the relationships between human land use and land cover change and works to assess future implications of these interactions. LUHNA studies, conducted by scientists across North America, begin to answer important questions such as "What types of land cover changes are occurring now, and how fast are they occurring?" "How do these changes compare with those in the past, and what does it all mean for future environmental quality and the habitability of the planet?"

CBI manages programs in support of the National Park Service and the U.S. Fish and Wildlife Service that classify, describe, and map vegetation communities. These programs classify vegetation at the association level of the National Vegetation Classification System, and map the vegetation communities using aerial photography at the highest possible resolution. The USGS-NPS Vegetation Mapping Program has completed work in eleven national parks and has work in progress in 19 others. The USGS-FWS Vegetation Mapping Program has started work in two national wildlife refuges. The vegetation information and data developed by these programs provide the structure for framing and answering critical scientific questions about vegetation communities and their relationships to environmental processes across the landscape. Access to these data provides resource managers with a consistent means to inventory and monitor plant communities and to characterize the biological components of different ecosystem units.

These programs complement GAP in terms of data collection, and future integration efforts among the programs will provide rich information and datasets for natural resource managers and policy makers.

More information about these programs can be found at CBI's homepage at http://biology.usgs.gov/cbi/index.html, or at the National Biological Information Infrastructure (NBII) at http://www.nbii.gov/.

TX-GAP and biological informatics products.

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The World Wide Web (WWW) is increasingly providing timely information to a wide array of users, including students, teachers, researchers, natural resource managers and legislators. TX-GAP products, maps, reports, and synthesized data will be prepared in hardcopy publications and on electronic media, such as computer disks and through the WWW. Currently, data on TX-GAP are available at http://www.tcru.ttu.edu/tcru/ and databases used to support biological informatics products are available through the Natural Science Research Laboratory at http://www.nsrl.ttu.edu/. Products available include Landsat thematic mapper scenes classified for vegetation; high-level aerial photographs (DOQQs), low-level videography, and site-specific ground-level photographs; distribution maps for vertebrates; The Mammals of Texas by Davis and Schmidly (1947 or 1994).

Urban sprawl in Texas: Past, present and future.

NICK C. PARKER, GUIRONG WANG*, SHERI HASKELL (USGS, Texas Cooperative Fish and Wildlife Research Unit; Texas Tech University, Lubbock, TX 79409-2120) and EVANS CURRY (Department of Sociology, Anthropology and Social Work; Texas Tech University, Lubbock, TX 79409-1012)

The goal of the Texas GAP Analysis Program is to develop statewide maps of landcover and distribution of vertebrates as tools to manage and maintain biodiversity. Landsat images from the 1970s, 1980s and 1990s provide the best landscape scale data for habitat and therefore vertebrate distribution. Correlation of historical demographic data with landcover of the 1970s-1990s provides a means to model landcover changes which may have occurred during the past century as the human population expanded. Landcover models liked to projected population growth could provide powerful tools of socioeconomic importance. Decisions based on these models could influence ecotourism, placement of parks and conservation areas, siting of agricultural industries such as feedlots, and siting of other developments. Zoogeography provides the back bone upon which ecotourism is based. Vertebrate distribution maps are used as guides for birders, hunters, fishers, and other ecotourists selecting sites to visit. The identification of area of high levels of biodiversity has both social and economic benefits. Other socioeconomic applications of these data sets could include modeling of air quality. For example, estimates of biomass (fuel) based on vegetation maps could be used to model potential aerosol contaminants that affect human health such as smoke and fine particulate matter from grass and forest fires. Numerous other models incorporating products of the Texas GAP Analysis Program would be developed to provide scientifically-based tools to better manage natural resources, economic development, and even public health.

Classification and optimization in land use planning algorithms.

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A natural application of GAP derived datasets is in land acquisition, reserve design and other land use planning exercises. Recently, some GAP projects have created tools that derive and ascribe various metrics and values to land parcels (e.g. biodiversity metrics, patch size, number of rare and endemic species on site, scenic value, etc). Once these classification procedures have been applied, it is often left to the stakeholders to decide which of the parcels are appropriate for the project in question. In Georgia, a recent governor's initiative on greenspace planning has prompted us to wonder if it would be possible, after assigning a set of values to land parcels, to write an algorithm to select an optimal subset of these parcels. The purpose of this talk to describe some of the ways to formalize the problem of optimal parcel selection, and to discuss the advantages and disadvantages of each approach. It also discusses what appropriate methods, if any, currently exist in the operations research literature that could be used to create such an algorithm.

Conservation planning for aquatic biodiversity: Experience from the Nature Conservancy's Freshwater Initiative.

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In the past, imperiled and vulnerable fish and mussel species have been the primary targets of many conservation planning efforts. However, recent analyses of the diversity and status of endangered freshwater species have shown that we must broaden these targets, and the number of sites we protect, to preserve the full range of aquatic biodiversity. We believe that identifying and targeting aquatic communities and systems will result in more comprehensive, proactive protection of aquatic ecosystems and their component biodiversity than will an approach based exclusively on species-by-species protection. The Nature Conservancy's aquatic classification framework helps us identify what types of communities and systems exist and where they are found. Once we know what the range of biodiversity is in a planning region (ecoregion), the next step involves identifying the best examples of aquatic species, communities, and ecosystems. Information on the quality of the occurrences of aquatic species and communities is obtained from Natural Heritage Programs and other sources to help us locate viable examples of these conservation targets. We also rely on experts' personal knowledge of high quality, viable hydrologic systems that represent the full range of aquatic biodiversity, and additionally refer to land use/land cover maps, water quality sampling data, and maps showing hydrologic alteration (e.g., dams and channelization). In some cases, high quality examples may not exist for a particular target, and it may be necessary to identify the best opportunities for restoration of natural aquatic systems. We will illustrate this process by presenting two recent ecoregional planning efforts that resulted in the identification of aquatic conservation priorities. We are currently working in nearly all states to apply the classification framework and help planners select conservation sites that represent the full diversity of aquatic assemblages and their environmental settings. The work to date has involved cooperative efforts among The Nature Conservancy's Freshwater Initiative, Central Ecology, Great Lakes Program, field offices, regional staff, as well as Natural Heritage Programs, university researchers, and state and federal natural resource agencies.

Role of classification in establishing bioassessment.

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In collaboration with the States, EPA is developing tools for biological assessment of aquatic systems in the U.S. Over the years, classifications have taken many forms and been developed for many different purposes. Our focus, in EPA, has become the role of classification in setting the expected conditions for aquatic biological resources. We have historically approached this from the development of geographic areas that we called ecoregions. Our more recent work indicates that the establishment of geographic regions alone is not sufficient. We need to account for more natural features, such as stream gradient, watershed size, and stream morphology in order to effectively get at the expected biological conditions. Clearly, in order to identify the signal produced by human disturbance, we must first account for differences due to natural features that change across the landscape. Examples of these concepts and how we have applied them to refining the various multimetric indices used for assessing fish and macroinvertebrates across the country will be presented.

The US National Vegetation Classification (USNVC) and its use by GAP Analysis Programs.

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The Association for Biodiversity Information (ABI) has worked with GAP to apply the US National Vegetation Classification (USNVC) and implement its use in the creation of an ecologically meaningful and consistent vegetation map of the United States. This workshop and discussion will provide access to some case studies demonstrating use of the USNVC in land cover and vegetation mapping projects, such as those conducted by state GAP programs. Approaches to evaluating existing data, and organizing the mapping process to effectively integrate multiple data sources will be highlighted. Examples will include the classification of satellite imagery through the use of videography for ground truthing and ancillary environmental data for modeling vegetation patterns. There will be discussion time for vegetation ecologists and land cover analysts from GAP programs and the Association for Biodiversity Information (ABI) to discuss these issues with an eye to continuing collaboration. Attendees are encouraged to bring their own maps or other examples of vegetation classification, modeling data or other items of interest.

Place prioritization for Texas using GAP data: The use of biodiversity, environmental surrogates in the presence of socioeconomic constraints.

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Texas GAP has collated biogeographic and localized socioeconomic data on the entire state of Texas represented as a set of 1183 hexagons. Ignoring local topographic details, these hexagons each have an average area of 649 sq. km. The attributes recorded for each cell include: (i) environmental attributes: area, average temperature, average maximum temperature, average minimum temperature, average rainfall, average snowfall, elevation, aspect, dominant soil type, and acreage of each of 46 soil classes; (ii) biodiversity attributes: dominant vegetation type, acreage of each of 38 vegetation types, and presence-absence of 657 animal species; and (iii) socioeconomic attributes including human population density.

Subsets of the environmental and biodiversity attributes were used to prioritize the hexagons and establish potentially reserved sets of hexagons. For prioritization targets of representation were set either as a specified number of representations for each attribute or a certain percentage of every attribute. Alternatively, a maximum cost or maximum area were set as targets. The surrogacy problem (which subsets of attributes, called “estimator-surrogates,” are good predictors of other subsets of attributes, called “true surrogates”) was investigated in the following way: a place prioritization was carried out using a set of putative estimator-surrogates and then compared to one carried out using the targeted true surrogates. Tentative results include the success of soil types as estimator-surrogates for biodiversity attributes. Prioritization results were overlaid on socioeconomic data to: (i) explore the potential social and economic costs of conservation regimes; and (ii) analyze the details of human impacts on biodiversity.

The place prioritization algorithms used are based on rarity, complementarity and richness; they can also incorporate adjacency requirements (where adjacent cells are preferred over non-adjacent ones) as well as cost and area constraints. These have all been incorporated into the "ResNet” software developed at the University of Texas at Austin in collaboration with the Commonwealth Scientific and Industrial Research Organization, Australia. The algorithms are initialized using: (i) a set of pre-existing reserved cells; (ii) the cell with the rarest attributes; or (iii) the cell richest in attributes. The iterative procedure uses complementarity (choosing the cell with the most representatives that are not yet adequately represented in the reserved set of cells) and then incorporates the adjacency, cost and area constraints as required.

Texas natural history: A century of change.

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From 1889 to 1905, a team of federal scientists from the U.S. Bureau of Biological Survey surveyed the flora and fauna of the state of Texas. These naturalists visited over 200 sites in all ten ecological regions of the state. Their goals were to determine the types of plants and animals native to Texas at the time, to map the distributions of these plants and animals, to estimate the abundance of each wildlife species, and to assess the economic relationship of birds and mammals to farming and ranching. When the survey was completed, over 1,000 photographs and over 500 survey reports, field journals, and catalogs of specimens collected were deposited in the National Archives of the Smithsonian Institution in Washington, D.C. These original field notes and photographs have now been compiled into a database program and in the near future will be accessible via the web site of the Natural Science Research Laboratory of Texas Tech University. This collection of field reports and photographs provides a virtual natural history picture of every region of the state as it existed a century ago and contains a wealth of detailed, historical natural history information never before available to biologists in Texas. This information will prove invaluable as baseline data to compare with the results of current natural history studies in the state to assess landscape and biotic change over the last century.

Comparison of vegetation classification using various clustering levels.

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One of the most significant sources of classification errors that occur in the assembly of large-scale, landscape sized remotely sensed vegetation maps is due to the unavoidable temporal variance of adjacent satellite imagery. Nine Thematic Mapper ("TM") digital scenes were used to create a continuous image of the Trans-Pecos region of Texas. The intent of this project is to develop a methodology that will reduce the effects of the temporal variability inherent in large satellite image archives. The storage space and CPU time required to view and work with these large image files encourage the use of data reducing techniques.

The individual scenes were joined together by feather mosaic and clipped to the boundary of Texas west of the Pecos River. The Tasseled Cap transformation was performed on the raw data (6 bands) to extract indexes of soil brightness, moisture, green growing biomass, and atmospheric haze. These indexes are then clustered (unsupervised classification) into groups of similar characteristics. Several clustering levels (5, 10,15, 20, 25, 30) will be explored in an effort to determine the optimal number of classes needed to map the vegetation of the Trans-Pecos.

Use of socioeconomic variables in habitat vulnerability assessment.

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New York State Gap currently has a project ongoing with New York State Department of Conservation to develop techniques for analyzing socioeconomic data to quantify an index of potential human impacts on biodiversity in the Hudson River Valley. The Hudson River estuary provides habitat for hundreds of migratory and resident species of wildlife while supporting almost half of New York State's human population. The Hudson River Valley region, north of New York City, is home to 2.6 million persons. Continued population growth and sprawling development will intensify pressure on biodiversity in the region.

The Hudson River Valley Habitat Vulnerability Assessment project is focused on developing a methodology for calculating and assessing a vulnerability index which quantifies the inverse relation between diverse habitats and areas of probable development. Land development fragments species habitat and increases the vulnerability of the landscape to loss of biodiversity. One approach to quantifying this process is to determine a vulnerability index for a specific geography within the region based on the relationship between quantities of land area developed within the specific geography at two different time periods. Expressed as a percentage, an increase in the index percentage for a specific geography in the current time period suggests an increase in habitat fragmentation and a subsequent reduction in the species-specific population viability.

A fundamental step in determining vulnerability is the identification of probable development areas. Traditional growth allocation models are heavily dependent upon the availability of information about land supply and demand, as well as transportation activities. This project is investigating an alternative to these traditional models. Population projections for smaller areas- such as neighborhood block groups - are best based on trends in land use, housing stock and the social composition of the resident households. A probabilistic model is used to translate county population projections into changes at the neighborhood level. Neighborhoods are classified by stages of growth and type of social composition. Using readily available data from the 1990 Census of Population and Housing we model residential development at the neighborhood level for the period 1985-90. Then test the model against development that has occurred since 1990. This method of growth allocation will free us from the labor intensive data requirement of the previously used land use / transportation models, permit the allocation of growth independent of minor civil divisions, and have statewide applicability.

Once the projected growth has been determined and allocated to a spatial geometry then the issue of a vulnerability index can be addressed. Through spatial analysis of the existing biodiversity areas and the projected growth areas, a vulnerability index for each neighborhood will be determined. Using the modeling process, balances between environmental and economic uses of each investigated neighborhood can be identified and recommendations provided.

Challenges and opportunities for biodiversity assessments in aquatic environments:

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Interest in the conservation of aquatic biodiversity has increased dramatically over the last five to ten years. However, rapid declines in the health of our nation's aquatic ecosystems necessitates that we move rapidly from the arm-waving stage to a more concerted nationwide effort to conserve these important resources. Such an effort presents several major challenges. Some of the most pressing challenges include (a) establishing a central forum for the exchange of ideas and information among the numerous resource agencies and aquatic resource professionals across the nation, (b) establishing a common coarse-filter assessment strategy to prioritize conservation efforts, and (c) establishing conservation strategies that effectively deal with the diffuse, diverse, and often distant threats to our aquatic resources. The National Gap Analysis Program is ideally situated to help us meet many of these challenges and the initiation of Aquatic GAP pilot projects in New York and Missouri are an important and necessary first step, but many challenges remain. Aquatic biodiversity conservation efforts also present some unique opportunities. For instance, our nation is mandated by law in the Clean Water Act to maintain the biological integrity of our nation's waters. This legislative mandate has the potential to be a powerful tool in the conservation of not just our aquatic, but also our terrestrial, resources. This presentation will briefly describe some of the major challenges to, and opportunities for, effectively conserving aquatic biodiversity in the United States. It will also cover the theoretical and technical aspects behind the coarse-filter assessment strategy that has been developed in the Missouri Aquatic GAP Pilot Project.

Application of WV-GAP results in the interagency environmental assessment of mountaintop mining in Appalachia.

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The size and scope of mountaintop removal/valley fill mining operations is increasing across the southern half of West Virginia and within other Appalachian states. The U.S. Environmental Protection Agency, U.S. Army Corps of Engineers, U.S. Office of Surface Mining, U.S. Fish and Wildlife Service, and the State of West Virginia are currently cooperating to prepare an Environmental Impact Statement to address the effects of mountaintop removal mining on fish, wildlife, and environmental resources in these areas. The interagency assessment process offers an opportunity to use the data and knowledge gathered by the WV-GAP project towards a practical, timely land use issue. This ongoing effort uses WV-GAP land cover data and wildlife habitat relationship models to explore the potential impacts of these particular mining techniques on wildlife resources. WV-GAP data may be used to identify local hotspots of biodiversity, species or communities at particular risk, or potential impacts of mining and reclamation procedures.

Oregon Biodiversity Project/Partnership.

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The Oregon Biodiversity Project was initiated and managed by Defenders of Wildlife's West Coast Office, beginning in 1994. it was inspired by the Gap Analysis Program, and designed to help build a bridge between the science and policy, leading ultimately to the implementation of a biodiversity strategy on-the-ground. The first stage of the project was structured as a private sector effort guided by a small steering committee. A science committee provided technical expertise, and an implementation committee offered practical advice from diverse perspectives. The Oregon Chapter of The Nature Conservancy and the Oregon Natural Heritage Program were primary partners in the project. Over forty other academic, governmental, conservation, and industry organizations participated at some level. Funding was provided by federal agencies, corporations, and foundations.

The staff used GIS data from GAP and other sources. Ultimately, it collected, evaluated, and processed hundreds of data layers in consistent format, and used them to identify forty-two "conservation opportunity areas", where ecological value and conservation potential converged. The project also developed extensive materials on stewardship incentives in response to strong encouragement from scientists, landowners, and managers who felt strongly that biodiversity could not be protected in reserves alone. After nearly five years, the products were released. They included a full color atlas-type publication containing the biodiversity assessment and strategy, a color poster and map showing the proposed conservation network, two books on incentives, a process report, and a CD-ROM with the GIS data sets, introductory information, and software for users to do their own analyses.

The implementation phase is through the Biodiversity Partnership, a loosely structured affiliation of organizations and agencies who are interested in working together to implement the biodiversity strategy. It addresses on-the-ground conservation projects like the protection and improved management of Oregon's endangered oak woodlands. It also serves as a forum for discussion of important policy issues, especially those relating to incentives and conservation investment priorities. The partnership has also tackled some thorny issues relating to information management – the need for improved coordination and cross-boundary cooperation.

Delivering wildlife information on the net: Examples and case studies.

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Conservation organizations and institutions have been involved in the development of fish and wildlife information systems for many years. The advent of the world-wide-web has renewed interest in techniques for designing, compiling, managing, and delivering information to decision makers, professionals, and the public. Gap analysis projects nationwide are developing fish and wildlife information bases that are useful to a wide variety of audiences from legislators to planners to school children.

This paper will address case studies of fish and wildlife information systems on the world-wide-web, highlighting 'best practices', suggesting fruitful areas of research, and summarizing the experience of past efforts to deliver information to various audiences.

Scaling up from field to region for wind erosion prediction on cropland using GIS.

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Factors that affect wind erosion such as surface vegetative and other cover, soil properties and surface roughness usually change spatially and temporally at the field scale to produce important field-scale variations in wind erosion. Accurate estimation of wind erosion when scaling up from fields to regions, while maintaining meaningful field-scale process details, remains a challenge. The objectives of this study were to evaluate the feasibility of using a field- scale wind erosion model with a geographic information system (GIS) to scale up to regional levels and to quantify the differences in wind erosion estimates produced by different scales of soil mapping used as a data layer in the model. We used a GIS in combination with a field-scale wind erosion model (Revised Wind Erosion Equation, RWEQ) to estimate wind erosion for two 50 km-square areas. Landsat Thematic Mapper satellite imagery from 1993 with 30 m resolution was used as a base map. The GIS database layers included land use, soils, and other features such as roads. The major land use was agricultural fields. Data on 1993 crop management for selected fields of each crop type were collected from local government agency offices and used to 'train' the computer to classify land areas by crop and type of irrigation (agroecosystem) using commercially available software. We overestimated the land area of the agroecosystems by 6.5 percent in one region (Lubbock County) and underestimated the land area by about 21 percent in an adjacent region (Terry County). The total estimated wind erosion potential for Terry County was about four times that estimated for adjacent Lubbock County. The difference in potential erosion among the counties was attributed to regional differences in surface soil texture. In a comparison of different soil map scales in Terry County, the generalized soil map had over 20 % more of the land area and over 15 % greater erosion potential in loamy sand soils than did the detailed soil map. As a result, the wind erosion potential determined using the generalized soil map was about 26 % greater than the erosion potential estimated by using the detailed soil map in Terry County. The natural variation in soils across a region and within the same region, but discernable at different scales of mapping make it evident that care must be taken when combining units as we scale up from fields to regions.