Gap Analysis Bulletin No. 4

CONTENTS

DIRECTOR'S CORNER

Status and Directions of the National Biological Service's Gap Analysis Program in 1995

These are exciting times for GAP. By the end of the fiscal year, ten states will have completed Gap Analysis projects. They are also times of change. With the creation of the National Biological Survey (now the National Biological Service), GAP was placed in the Division of Inventory and Monitoring, and we are working very closely with John Moeller and John Mosesso of that Division to insure a smooth transition from the Division of Research. The administrative structure of the NBS is divided into Research, Inventory and Monitoring, and Information and Technological Services. With GAP, we have an unprecedented opportunity to demonstrate how a research activity can be fully integrated into all three areas of the Service.

The Research Arena

In the research arena, Bill Krohn from Maine, Curt Griffin from Massachusetts, and Lee Graham's group from Arizona have worked together using the Airborne Videography techniques developed in Arizona to help resolve the difficulties of mapping deciduous cover types in New England. Additionally, inventorying and monitoring efforts using GAP maps will assess changes in cover types back to 1972 through examination of three coregistered sets of multispectral scanner scenes. This change assessment will be led by EPA and USGS in the North American Landscape Characteristics Program, as part of NASA Pathfinder.

The Use of GAP Information

In the information transfer arena, the use of GAP by cooperators and others to help their efforts at land use planning has been exceptional. Specifically, Frank Davis at the University of California, Santa Barbara, collaborated with Ventura, Los Angeles, Imperial, Orange, Riverside, and San Bernadino counties (i.e., the Southern California Association of Governments or SCAG, a six-county coalition), to show the occurrence of communities at risk in areas zoned as open space and those occurring in areas zoned for development. The Utah Department of Fish and Game is using GAP for many research and management activities. The Idaho Department of Fish and Game has placed the data set in its Conservation Data Center, where it has been used to advise the Director on environmental values of a proposed bombing range. Dr. Blair Csuti is involved in an exciting collaborative effort with Dr. Pressey; Dr. Steve Polasky, economist at Oregon State University; Dr. Ross Kiester, U.S. Forest Service; and Ms. Melanie Kershaw, with the Institute of Zoology at the University of London. They are using the results of the Oregon Gap Analysis Project to compare different approaches to special management area selection questions, using various algorithms on the same data set. This should provide us with a better idea of the strengths and weaknesses of the various approaches.

One of the more exciting and, hopefully, long lasting developments for GAP has been the creation of private, state, and federal partnerships in Arizona, Oregon, and Tennessee to apply the findings of GAP. As the recently completed GAP users' survey and implementation strategy report indicated, there are three ways in which GAP information is used:

1. Situation-specific application which includes the use of data sets or individual data layers to answer questions about single species, sites, or management issues. Easy access to GAP data and some assistance in the interpretation of the information is needed by users for these applications.

2. Integration into existing land-use planning is another important application strategy. Included primary users are county planners, state and federal resource agencies, and large private industrial landowners like timber and utilities companies. Easy, efficient access to that data and some assistance with its interpretation is needed to facilitate this application.

3. Use in cross-boundary, ecosystem-oriented, landscape-level planning is another purpose for which GAP data is well suited. Given its meso scale, GAP is most useful for statewide, bioregional, and large

watershed planning. It provides a context for making more site- specific decisions. This application is the best opportunity to make decisions that will prevent species from being listed as threatened or endangered.

We are currently seeing major use of GAP data in specific situations and their integration into existing land use planning efforts. As the data sets become more widely available, we hope to see use of GAP in transboundary ecosystem application. To facilitate this, Frank Davis at UC Davis is going to create seamless vegetation maps for the Mojave, Sonoran, and Great Basin ecoregions in the next 12 months.

GAP has used a variety of ways to facilitate the transfer of its information. Brian Biggs, now at Utah State University, developed an on-line encyclopedia of Gap Analysis at the United Nations Environment Programme's Global Resource Information Database (UNEP-GRID), located at the EROS Data Center in Sioux Falls, South Dakota. Brian's work was done in conjunction with the U.S. National Biological Survey and was funded by NASA, through the Remote Sensing Research Unit at the University of California, Santa Barbara. It contains the GAP Monograph, manual, and data sets for Utah, California, and Idaho. Other state data sets will be added as they become available. Complete access instructions are available in this bulletin.

Allan Falconer and Tom Edwards at Utah State, in collaboration with the USGS, developed a hard copy (CD-ROM with ArcView 2 shell). Currently, prototype versions are available and were demonstrated in October by Brian Biggs and Mike Jennings at the First Federal Geographic Technology Conference in Washington, D.C., where the Mosaic home page and poster presentations were extremely well attended. Production copies will be available in March at the ACSM/ASPRS Convention.

A formal Memorandum of Understanding will be signed in November 1995 in recognition of the Multi-Resolution Land Consortium's (MRLC) unprecedented collaborative efforts to more fully integrate land cover mapping efforts by federal agencies. Congratulations to Denice Shaw (EPA), Mike Jennings, Don Lauer, Jim Sturdevant, and Tom Loveland at USGS for all their hard work on this project.

We have been invited by the American Society for Photogrammetry and Remote Sensing to present a section of papers on GAP at their annual convention. The conference is normally attended by several thousand individuals. The date of the symposium is 27 February - 1 March at Charlotte, North Carolina. More than 30 papers will be presented and later published as a proceedings. A more detailed program can be found in this bulletin.

Again, these are exciting times for GAP, indeed for all collaborative efforts. This year will see 36 states with Gap Analysis projects, with perhaps ten state projects scheduled for completion by the end of 1995. It is my hope that with more projects completed, we will see GAP data sets used in collaborative private, state, and federal efforts to resolve long-term land use issues. The SCAG's effort and the ongoing interagency Klamath Basin effort in California (including GAP data from California and Oregon) are just two examples of interdisciplinary multi-partnered planning efforts using GAP data sets.

Finally, congratulations to the folks in the Washington Gap Analysis project, especially Karen Dvornich and Chris Grue. Karen will receive Renew America's National Award for Environmental Sustainability in the "Wildlife and Habitat" category. The award activities include a White House visit and will be nationally televised.

I look forward to seeing all of you at this summer's meeting in Fayetteville, Arkansas.

J. Michael Scott, Director
National Gap Analysis Program

FEATURES

A Discussion of the Adoption and Diffusion of Gap Analysis as a Technical Innovation

The purpose of this discussion is to broaden the dialog of how to deliver the concepts, products, and results from Gap Analysis to society. As more and more state GAP projects near completion, the unavoidable question then becomes, "where does all this data go from here?" I briefly discuss the results of a review of some recent uses of GAP data to illuminate early uses of GAP as a technical innovation and, in that light, present some important tenets of the adoption and diffusion of technical innovations. I present these concepts as a framework to help those struggling with the issue of "implementing" GAP, especially at the state level.

GAP is on the verge of either becoming irrelevant to society or becoming an accepted basic tool for managing biological diversity across the broad array of related programs and activities, both private and public. The answer to which one of these will prevail hinges on how we go about the task of providing for its adoption and diffusion into society. Admittedly, we have until now had no choice but to focus on the development of GAP's science and technology, on the development of state projects, and on maintaining support for state projects. It's now time to focus on the long-term issues of how GAP can maximize its potential by bringing new knowledge to policy. The only way to do this is by providing individuals with information based on good science. This discussion is concerned with the "providing" part of this equation, or the delivery of GAP to society. The "good science" part has been and will continue to be dealt with as an integral part of GAP.

At this point, it's important to briefly reiterate the original vision and direction of GAP, because in the early adoption and diffusion of the concept among natural resources professionals, the desire for biologically sound land cover data has often overshadowed its deeper meaning, sometimes resulting in misunderstandings of what GAP is intended to do.

Gap Analysis is a scientific method for identifying the degree to which native animal species and natural communities are or are not represented in our present-day mix of conservation lands. Those species and communities not adequately represented in areas that are being managed for the long-term maintenance of native species constitute conservation "gaps." The purpose of the Gap Analysis Program (GAP) is to provide broad geographic information on the status of ordinary species (those not threatened with extinction or naturally rare) and their habitats in order to prevent future conservation crises. To achieve this, maps of natural land cover, vertebrate species distributions, and land management are required in specific formats. The method was originally intended as a first, coarse-scale step in the process of special management area identification and selection, rather than special management area design. Maximizing the use of GAP products for other uses is also important, and this has been central to the GAP philosophy of partnerships.

As it has turned out, GAP has served as an "information catalyst" around which natural resources professionals and their institutions are coalescing naturally. I hypothesize that this represents a major new phenomenon in resources management, made up of three parts. One part is simply a manifestation of the information age within the natural resources field - our newfound ability to model and visualize the living world using digital technology and telecommunications. A second part stems from advances in science, resulting in a better understanding of how the natural world works. For example, the mechanisms by which the different levels of biotic organization are linked - species, natural communities, and large landscapes - are much better understood; GAP is a management tool evolving from this science. Third, diminishing natural and fiscal resources are causing natural resources professionals, thus their institutions, to work together in a more dynamic fashion. This is greatly facilitated by having a common information base and having the ability to share their data. This emerging phenomenon fits, coincidentally, with the present-day trend of decentralized government. If state- level policy is to be effective, sound multi-state biogeographic information will be critical.

A Profile of Some Uses of GAP Thus Far

Recently, I reviewed 47 cases where GAP data were used for a specific purpose, and I stratified these uses into eight general categories. Of these cases, GAP information was used most often for direct land management purposes, such as siting a ski resort on public land or revising wildlife management plans. In most of the cases where GAP information was used for direct land management purposes, its users were driven by an immediate need for explicit landscape-level maps that provide contextual information on a variety of themes (such as the distribution of species or the distribution of habitat types relative to a proposed action or resource use decision). This underscores the demand and the need for large-area contextual biogeographic information for diverse applications, thus the use of Gap Analysis products for purposes beyond its original intended purpose.

The review of case histories also underscores the imperative for state GAP projects to track the uses of their data. If state projects do not yet have a database for tracking how their data are being used, they should construct one now. This topic should also be the focus for discussion among state project cooperators. Cooperators should agree to report back to the GAP principal investigator on how the data are being used, either broadly (used in everyday operations to maintain certain amounts of habitat types in a shifting mosaic) or specifically (used to evaluate a proposal to enhance bighorn sheep habitat across five townships).

One of the greatest problems, of course, is that data dissemination is not funded under state projects' research work orders. So, when a request comes in to a state GAP project, the data are provided pro bono, usually at the expense of completing the project itself. For many project staff, responding to requests for data is a distraction from the work of producing the data, and it is an unfunded demand. What is the solution?

For now, we ask that the project personnel respond to requests as best they can. Staff should make sure that the person requesting the information realizes and appreciates that the work is in progress and that because of this there are limitations to the degree of response. At the same time, please do not just turn a request down flat. Get those requesting the information to understand the present situation. If the data they are asking for is genuinely not ready for release, explain the details to them so that they understand, while giving them a picture of what is to come.

The question is often asked, "Where does GAP end?" The NBS role is to work in partnership with other organizations to develop, interpret, and disseminate scientific information about the nation's biological resources. How all of this is manifested is still developing. It is safe to say, though, that much will depend on the state cooperators.

Eventually, we will find permanent homes for state- level data as both dissemination and feedback nodes. Although the role that the NBS plays in the long term is still developing, there is promise in its incipient National Biological Information Infrastructure (NBII) effort, as well as its State Partnerships program, both of which are within the Division of Information and Technology. As of now, most of us involved with GAP envision state-level information nodes and continued research and development activities among the state project cooperators. Additionally, the EROS Data Center will serve as the long-term federal-level archive for GAP and MRLC data. Ultimately, exactly how the results from GAP are disseminated at the state level will depend largely on the ongoing cohesion of state agencies, non-government organizations, and universities within the states.

Within the NBS, GAP is one of the few programs that flows through each of the three operational divisions In this sense, GAP is contributing to the functional linkages among the NBS divisions.

There are still unsolved structural issues at the state level, such as where GAP data will live, who will pay, and exactly how updates will be done. These issues should be approached as the problems of adoption and diffusion of technical innovations. Because the degree to which GAP becomes useful to society is at stake, and because many who have been focused on the data development phase of GAP are not familiar with how technical innovations (GAP) spread through society, Below is a review of some of the basic concepts as articulated by Rogers (1983). These principles are the basis for the successful agricultural extension model, and they need to be the basis for any GAP extension work.

A Review Of Principles For The Adoption And Diffusion Of Innovations

Diffusion is the process by which an innovation is communicated through certain channels over time among the members of a social system. It is a special kind of communication because the messages have to do with new ideas. The diffusion of innovations is a complex social process.

The four main elements of the diffusion of innovations are:

1. The innovation
2. Communication about the innovation
3. The time, or rate of diffusion
4. The social system that adopts or rejects the innovation

The innovation's characteristics that explain the different rates of adoption are:

1. Perceived relative advantage: Not the proven or objective advantage that the innovation may offer, rather, this is the advantage that the potential user believes the innovation may provide, regardless of the bases for their belief.
2. Compatibility: The degree that an innovation is perceived as being consistent with existing values, experiences, and social systems of potential adopters. Adoption of an incompatible innovation may require prior adoption of a new value system.
3. Complexity: Perceived or real complexity will slow the rate of adoption. New ideas that are simpler to understand will be adopted more quickly than those that require new skills or new understandings.
4. Tryability: Innovations will be adopted more quickly that people can try out first before committing themselves.
5. Observability: The degree to which the results are visible. Innovations that are preventative in nature, such as health practices, are less immediately observable and slower to be adopted.

Most people do not evaluate an innovation on the basis of scientific studies, but depend on a subjective evaluation of the innovation conveyed to them from other individuals who are like themselves and who have had previous experience with the innovation.

This dependence on subjective peer-group communication strongly suggests that the heart of the diffusion process has more to do with who does the communicating than what or how it is communicated, although the what and how also remain important.

One of the most distinctive problems of diffusion is that those attempting to communicate to potential adopters are often not in the same peer group or do not have much in common with the potential adopters. They may not talk the same "language." This situation often results in the rejection of innovations.

The rate of adoption of an innovation by an individual has to do with the individual's (a) decision process, and (b) degree of innovativeness (there are innovative people and there are people who lag in adopting new innovations). An individual decision process for adopting an innovation has five time-related periods to it:

1. Knowledge: Gaining an understanding of the innovation's existence; what it is and how and why it works.
2. Persuasion: Formation of a favorable or unfavorable attitude about innovation; how will it help me solve my problems, etc.
3. Decision: Engaging in activities that lead to a choice to adopt or reject the innovation.
4. Implementation: Putting the innovation to work.
5. Confirmation: Reinforcing a previous decision about the innovation; an individual may reverse a previous decision if exposed to conflicting signals.

Individuals clearly have different degrees of innovativeness which can be characterized as innovators, early adopters, early majority, late majority, and laggards.

Innovators actively seek information about new ideas. They have wide interpersonal networks usually beyond their local system. They are able to cope with a higher level of uncertainty about an innovation. However, innovators are likely to be considered deviant from the target social system and often of low credibility to the system, frequently necessitating the use of change agents for the diffusion of their innovations. Early adopters generally do not depend upon subjective evaluations of an innovation from their peer group and are more likely to take risks.

The social structure of the target adopter group has a major bearing on how an innovation may be adopted. When the social system is oriented toward change, the "opinion leaders" may be innovative; when the social system's norms are opposed to change, opinion leaders are slow to adopt an innovation. Opinion leaders make up an informal leadership that can influence the attitudes of others. Their position is earned and maintained by the individual's technical competence, social accessibility, and conformity to the system's norms. Those who can successfully achieve adoption of an innovation by a social system are referred to as "change agents." Change agents work to influence adoption, or rejection, of an innovation most often by influencing the opinion leaders.

Conclusion

I hope this is the beginning of a dialog on a coordinated effort to deliver the results of GAP to society, whether original data sets or derivatives. The adoption and diffusion of GAP will by necessity be driven from the bottom up, yet to be effective, it will require a consistent and cohesive effort. Perhaps in the next GAP bulletin, we can print your thoughts on this.

Literature Cited

Rogers, Everett. 1983. The diffusion of innovations. Free Press, New York, 453 pp.

Portions of this article were excerpted from a presentation made at the fourth annual GAP workshop, July, 1994. Thanks to Gary Machlis and Sara Vickerman for their important contributions and ongoing efforts to foster the adoption and diffusion of GAP.

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Gap Analysis Program

The Aquatic Component of Gap Analysis

Since the very beginning of Gap Analysis, there has been discussion on the need to apply the method to aquatic environments. The effort was officially launched in early September of 1994 with the formation of an advisory group. The group established the goal for the application of GAP methodology to aquatic environments as:

> "To characterize aquatic biodiversity in the U.S. on a landscape scale for the effective management of land and water resources in ways that will preserve this biodiversity."

Dr. Patricia Heglund has been appointed as the coordinator for the aquatic GAP section. She recently moved to Moscow, Idaho from Alaska, where she had spent the past seven years as a research biologist (wetlands and waterfowl) for the U.S. Fish and Wildlife Service - Alaska Fish and Wildlife Research Center (now the National Biological Service - Alaska Science Center). Dr. Heglund currently holds affiliate faculty status in both the Department of Fish and Wildlife Resources and the Department of Biological Sciences at the University of Idaho.

Three prototype projects have been funded for 1995. These projects will be conducted in New York, Washington, and California. These pilot projects are predicated on the same fundamental tenets as the terrestrial component of GAP: 1) to identify places offering the best opportunities to conserve species while they are still common, through the identification of species and their habitats currently under-represented within our conservation network; 2) to provide a baseline for later biogeographic comparison; and 3) to provide landscape level spatial data useful for holistic resource management. These pilot projects will include lacustrine, palustrine, and riverine environments.

Our objectives for these prototype studies include:

1. Acquiring EPA River Reach File III data for use as base maps and catalogs of river basins at a scale of 1:100,000. Base maps will be registered with corresponding terrestrial GAP base maps and corrected for errors in River Reach data sets.
2. Mapping known distributions of fish, macroinvertebrates, amphibians, and reptiles (hereafter referred to as "elements") from museum collection records, agency records, published literature, and other sources.
3. Mapping general predicted ranges of each element from the published literature (e.g. Freshwater Fishes of Canada).
4. Mapping general habitat types, for example, aggregated from National Wetlands Inventory database.
5. Identifying habitat relations models for each element from existing literature.
6. Combining the steps listed above to generate maps for each water body or river reach of known or predicted occurrences of each element.
7. Reviewing predicted occurrences with experts and revising data layers as appropriate.
8. Developing attributes for each river reach, identifying its management status such as:

- county or state shoreline, or riparian management regulations,
- state fisheries management practices (fishing regulations, stocking, pesticide use, motorized/non-motorized boating regulations, etc.),
- state area-specific management designations (e.g., water quality, recreation, water withdrawals, aquatic vegetation management),

- federal designation and regulations (e.g., Wild and Scenic Act, Clean Water Act, navigation considerations, other licenses and permits such as NPDES or FERC, federal structures).

9. Showing relations between, a) species distributions and in-stream management, and b) species distributions and terrestrial land cover between successive watershed sizes (fourth to second order watershed).

10. Determining where the best opportunities are to achieve long-term avoidance of threatened or endangered species status by both in-stream and watershed management.

Analyses will be conducted a second time when adjacent river basins are completed and their information is integrated, allowing for comparisons across larger biogeographic regions.

One of the most exciting aspects in developing the aquatic component of GAP is the construction of data sets compatible with the terrestrial data. Through the GAP process, we will integrate aquatic and terrestrial environments for a variety of analytical applications. For example, the data will show land cover for all second-order watersheds upstream of any given river reach. Although we expect others to find many uses for the data, our current goals are to: 1) conduct an initial screening of large areas from which more specific planning and management options can be developed within a bioregional context, and 2) provide a logical starting point at the landscape scale for conservation problem-solving.

In discussions about both the terrestrial and aquatic components of GAP, the question frequently arises, "What about riparian areas?" Our current position is that although riparian areas are of enormous importance, they cannot be adequately treated by our current level of funding. Adequate treatment of riparian areas requires a level of effort similar to the National Wetlands Inventory program, in that they should be mapped at a scale of at least 1:24,000. Given our funding constraints, we believe it is more productive to focus on landscape elements that can be adequately treated and continue to articulate the needs of those elements that are currently beyond our means.

As with terrestrial GAP, the aquatic component is starting with no generally accepted community- based habitat classification system. As with the land cover mapping effort, we hope the aquatic projects will spur a consensus about the structure and substance for a national classification system and how the system can be maintained over time.

Michael D. Jennings, National Coordinator, Gap Analysis Program
Patricia J. Heglund, Aquatic GAP Coordinator, Gap Analysis Program

Steps in Strategies to Manage Biodiversity: Identification, Selection, and Design of Special Management Areas

Gap Analysis provides a regional perspective on the distribution of several elements of biodiversity, notably, plant communities and vertebrate species. The maintenance of much biodiversity will depend on balanced management of multiple-use wildlands. Special management areas however, are a necessary component of an overall biodiversity management strategy, since they serve as a haven for those species and communities incompatible with multiple use management and provide control areas to assess the success of various management prescriptions outside of special management areas.

In their 1994 book, Saving Nature's Legacy, Reed Noss and Allen Cooperrider conclude, "The United States has no national strategy to conserve biodiversity." Aside from the opportunistic protection of scenic wilderness, habitat protection in the USA largely has been focused on areas inhabited by game species or endangered species. Although the recovery needs of species on the brink of extinction are legitimate components of an overall strategy to maintain biological diversity, they must be complemented by a proactive approach to land use planning that ensures that the bulk of biodiversity never becomes endangered in the first place. In an ideal world, an objective consideration of the distribution of biodiversity would lead to the identification of priority areas which would then be managed for their natural values in order to minimize future anthropogenic extinctions. This, of course, has never been the case. In reality, most natural areas have been set aside because they have little economic value, because of their scenic appeal, and because the opportunity to designate them presented itself. The primary danger of opportunistic development of a special management area network is that options to establish new special management areas could be exhausted before all elements of biodiversity are represented in the special management area system.

Developing a natural area network is a multiple step process. First, the distribution of the known elements of biodiversity must be assessed. Next, a set of areas is identified in which all elements of biodiversity are represented. This is an exercise in applied biogeography. Then, potential natural areas are more intensively studied to determine their condition and the feasibility of special management area designation. Sites meeting criteria for natural areas are then chosen. This process is commonly referred to as special management area selection. Following special management area selection, the principles of conservation biology are applied to delineate natural area boundaries sufficient to maintain viable populations and ecosystem processes. This step is commonly referred to as special management area design and draws on the disciplines of ecology, population biology, hydrology, and natural areas management. The spatial questions involved in identifying natural area networks in which biodiversity will be completely represented should not be confused with the practical and biological questions that need to be addressed when designing individual natural areas for long term viability of their constituent biodiversity elements and processes.

This entire process is complicated because of our incomplete knowledge of the occurrence and abundance of the elements of biodiversity, as well as an incomplete understanding of ecological processes. Our lack of knowledge is basic. We do not even have names for all species. Although estimates vary, perhaps 90 % of the world's species are unnamed. It is only for some of the higher vertebrates (large mammals, birds) that we have reasonably complete record. For others, especially invertebrates, we have a much less complete list of species. When it comes to more detailed ecological studies, such as distribution, abundance, demographics, and habitat association, we are far more ignorant. The same is true for process. Thus, while ideally identification, selection, and design of special management area areas should be based on complete knowledge, we are hindered by our ignorance of taxonomy and ecology of the species and the ecological processes occurring in the systems in which they live. However, we must not use lack of complete information as an excuse not to act on what biologically defensible information we do have. If we fail to do so, we will lose much of what we have.

Special management area Identification

Rather than focusing on locations of rare species or difficult-to-classify landscapes, biodiversity can be most efficiently represented if maps of several biodiversity elements are examined in hierarchical manner. First, areas in which all plant communities are represented are identified, corresponding to the "coarse filter" approach of The Nature Conservancy.

Then, species-rich areas that are most complementary to one another are identified. Finally, areas containing species still unrepresented are located, a "fine filter" that catches species not represented in areas identified by the "coarse filter" approach.

A subset of areas from a state or region in which all biodiversity elements are represented can be identified using one of a variety of stepwise algorithms. This approach to conservation planning has been most fully developed in Australia. One algorithm, called the "greedy heuristic," proceeds as follows: The presence of plant communities or species becomes an attribute of an area; areas with the largest number of attributes are identified, then areas with the largest number of attributes not already present in the previous choice are identified, and so on. This stepwise approach maximizes complementarity in each successive selection and results in the efficient selection of a special management area network. Since many areas will share biodiversity attributes, alternative choices usually exist at each step, leading to the identification of different configurations of special management area networks, any one of which would be completely representative. Of course, areas containing unique attributes must be included in all potential special management area networks. These areas are irreplaceable (i.e., they must be included in all networks).

Designing and managing natural areas for the long term persistence of species and communities are important but fundamentally different issues than selecting potential special management area networks. No amount of management will maintain species or ecosystems not present in a natural area network in the first place. However, the presence of a species or natural community in an area implies nothing about the potential of the area to maintain that species or community.

Special management area Selection

Once potential areas containing target species or communities have been identified, further information about the quality of each area needs to be gathered and compared with the biological, physical, and spatial requirements for long term persistence of the target species or communities. There are many established protocols for sampling plant and animal populations, and the intensity of sampling necessary to select the best natural area has not been systematically investigated and is likely to differ between ecosystem types. In some cases, a rapid assessment by trained biologists will suffice, in others, multi-year sampling of a number of populations will be necessary.

Social and economic factors are often more critical than biological factors when selecting among a set of potential special management areas. Cost, community attitudes, and projected changes in human land use in surrounding areas all contribute to the selection process. Possible ways to integrate these factors into special management area selection are being explored by Gap Analysis Programs.

Special management area Design

Population, community, ecosystem, and landscape processes are all important factors in special management area design. Furthermore, beyond the physical and biological components of special management area design, the size and shape of a natural area have considerable relevance to practical details of special management area management. Four areas of special management area design become relevant after potential natural areas are selected: 1) minimum area requirements for viable populations; 2) community-level interactions; 3) patch dynamics and other ecosystem processes; and 4) interactions between special management area design and management.

1. Many initial discussions of nature special management area design centered on the viability requirements for populations of target species, including population dynamics, the effect of environmental variation, genetics, metapopulation structure, and the effects of habitat fragmentation. In simple terms, natural areas must be large enough and have a shape that will support viable populations of most animal and plant species for a relatively long period of time, usually at least 100 years. Population viability analysis (PVA) represents an effort to formalize estimates of population persistence, but rarely are sufficient data available for robust conclusions.

   Habitat quality varies spatially for most species, resulting in source and sink populations that interact as a metapopulation which experiences local extinction and colonization events. Habitat heterogeneity tends to increase with area, suggesting that larger natural areas offer more patches of high quality habitat which can carry a species through periods of adverse environmental conditions. Edge effects may result in negative population growth rates near natural area boundaries. Many species will occur in natural areas only when sufficient interior habitat is present. Edge is minimized and interior maximized as special management area shape becomes more compact.

2. The maintenance of essential community-level interactions and processes is the second major special management area design

consideration. At the most basic level, natural areas need to support trophic interactions between producers and consumers. Some exchange of energy and matter will occur between special management areas and surrounding areas, so boundary delineation should always consider the context of natural areas. Carnivores typically occur at lower densities than herbivores of equal body size and often play essential roles regulating herbivore density and diversity. Special management areas must therefore meet the spatial requirements of the most area-sensitive community member. Mutualistic relationships exist between many plants and their animal pollinators, including insects, birds, and bats. Insuring the continuation of community interactions, especially those involving keystone species, becomes a primary special management area design challenge.

3. The concept that natural areas represent eternal and unchanging examples of particular ecosystems is a widely held fallacy (Botkin 1992). Many ecosystems experience regular disturbances whose frequency and patch size is an integral part of ecosystem function. Disturbance events include fire, windstorms, floods, landslides, and volcanism. While some catastrophic events affect large areas, most disturbances are local and scattered throughout a landscape. Special management areas ideally include the "minimum dynamic area, the smallest area with a natural disturbance regime." Disturbances would then occur in a shifting mosaic pattern within a natural area, with various patches in different stages of succession. This arrangement would ensure that propagules for recolonization of disturbed areas are present on undisturbed portions of the special management area. In practice, ecosystem management activities (such as controlled burning) can be used to recreate a natural mixture of seral stages on a smaller scale where natural disturbance events are larger than the natural area.

4. The final guidelines for special management area design come not from conservation biology but from the more practical world of park management. The location of special management area boundaries influences essential management activities such as transportation, visitor control, fencing, and controlled burning. Special management area staff, visitors, and researchers all need to move about a special management area without damaging natural communities. Engineering constraints limit the placement and cost of roads and trails. Boundaries should be adjusted to avoid difficult obstacles (canyons, mountains, rivers) between portions of the special management area. Fire burns upslope; when controlled burning is an anticipated management

practice, special management area boundaries should follow ridge lines and other natural firebreaks. Many natural areas require fencing to exclude people, livestock, or exotic animals. The cost and ease of fence building is related to topography and soils. Adjusting boundaries to lower the cost of fencing, even if special management area size must be increased, may be cheaper than drilling post holes in lava or granite. Finally, visitor facilities and housing for managers need to be placed on less sensitive parts of nature special management areas. Additional land may be needed within special management area boundaries for buildings, parking lots, etc.

Natural areas are expected to maintain biodiversity for centuries. The long term expenses of management can easily outweigh the costs of special management area establishment. Making boundary adjustments to minimize management costs is as important to special management area viability as those necessary to maintain population, community, and ecosystem processes.

Conclusions

A clear understanding of the differentiation between identifying a representative natural area network and designing individual viable natural areas will assist development of a national strategy to conserve biodiversity. Regional biodiversity distribution data bases are not intended to convey information about population or ecosystem processes. By definition, these processes are dynamic and can be accurately described only for small areas and short time periods. Special management area designers use detailed information about these local processes to make determinations about the special management area size and shape they hope will endow long term viability on particular natural areas. Recognizing the distinction between biogeographic analyses for natural area network identification and the biological, ecological, and practical analyses that constitute special management area design is the first step toward a consensus for developing a national biodiversity conservation strategy.

Blair Csuti
Idaho Cooperative Fish and Wildlife Research Unit
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SPECTRUM - Satellite Image Interpretation with Automated Delineation: A Workshop-

SPECTRUM - Satellite Image Interpretation with Automated Delineation: A Workshop-based Assessment of SPECTRUM Software

Abstract

A workshop was conducted June 28-30, 1994 at the USGS National Center in Reston, VA by representatives of the MRLC (Multi-Resolution Land Characteristics) consortium for the purpose of learning and evaluating SPECTRUM image analysis software relative to joint goals of consortium programs. The software is reasonably user-friendly, and permits satellite image data (notably Thematic Mapper) to be approached in an interpretive mode for land-use/land-cover mapping without the necessity of painstaking feature delineations. Suggestions were developed for mapping strategy, a few inconveniences were noted, and recommendations made for possible future enhancements.

Introduction

SPECTRUM implements an unsupervised classification approach to multi-spectral image data. Unsupervised classification involves first "clustering" the image data to capture the major image information and then assigning clusters to categories of interest for mapping. The SPECTRUM version of the unsupervised approach was developed by Patrick M. Kelly and James M. White in the Los Alamos National Laboratory, Computer Research Group. The orginal context of development was defense intelligence. The clustering mechanism uses a nearest-neighbor algorithm giving results similar to the k-means program in the SAS statistical package, but utilizes several innovative strategies to improve speed and accommodate large data sets. A simple user's perspective for MRLC is that SPECTRUM provides a computer-assisted mode of "photointerpreting" satellite image data that is rapid, highly interactive, and does not require extensive prior experience in remote sensing. As is typical of more conventional photointerpretation, however, the quality of the final map improves with the analyst's knowledge of the landscape being mapped and with amount of ancillary information available.

A particular advantage of the system relative to clustering is that many more clusters are generated than typical for other versions of unsupervised analysis, thus capturing more of the scene information. This multiplicity of clusters is called "hyper-clustering," and enables reasonable reproduction of the scene from just the cluster information alone. Therefore, hyper-clustering also constitutes a method of image data compression. Another substantial advantage for MRLC users is that EROS Data Center will precluster the scene and provide this information in the manner of an additional image band. Thus, MRLC users need not be bothered with the clustering phase at all and can get right to the business of assigning clusters to desired map categories with the SPECTRUM software.

Mapping Scenario

One begins by loading the cluster image and associated cluster information into memory of a UNIX workstation computer. The next order of business is to select three "image bands" for display on the screen. In fact, the resulting display is an approximation of the original image as rendered through the spectral band means for the several clusters. Analysts with photointerpretation experience will probably choose either a band combination that gives a "color-infrared" view or a "conventional color" view. Each has advantages for interpreting particular types of landscape features. Various "indexes" such as greenness, brightness, wetness, and so on can also be displayed if the analyst is familiar their formulation as ratios or linear combinations of spectral bands.

The desired map legend is next entered as a set of category labels for landscape features of interest (e.g., land-cover classes). Along with specifying a category label, one chooses a color to appear on the screen for "pixels" which will be placed in that category. The actual process of assigning clusters to map categories then begins. A "zoom" window is opened, and a representative sector of the image is moved into the zoom window with the mouse- driven cursor. As the cursor is moved around in the zoom window, the number of the cluster in that pixel location is displayed. One chooses a pixel location for which the map category is known from ancillary information, "ground truth," or general "lay of the land" as seen in the image display. Double clicking the location brings up a window for assigning the particular cluster number to a map category. All other pixels belonging to the same cluster then appear in the designated category color thoughout the rest of the image. Clusters can be transferred from one map category to another if desired. For those with digital image analysis experience, this latter process is very much like "training set" selection in supervised analysis.

If one is interested only in a very general categorization (perhaps water, forest, agriculture, and other), the assignment can probably be accomplished without recourse to ancillary information according to the appearance of the landscape in the image. If one is interested in a more detailed categorization (perhaps vegetation community types), it becomes necessary to adopt the traditional photointerpreter's approach to convergence of evidence using ancillary information (topo maps, soils maps, airphotos, etc.). This involves a special "highlight" category in which each cluster is temporarily placed by itself so that the distribution of its member pixels over the landscape can be viewed readily. The cluster can then be examined in terms of elevation, aspect, soils, and so on, in order to determine its characteristics relative to criteria for map categories. Although more time-consuming, it may be appropriate to run a text editor as a separate process in a window so that the characterization for each cluster can be documented in the course of interpretation. A bit of counsel based on photointerpretation experience is that careful assignment is generally more than repaid by avoidance of frustration in correcting errors later.

We would advise that you carry a typical quarter- scene (TM) through the entire process, including verification, before proceeding with the rest of your imagery. This will alert you to the likely pitfalls for the remainder of work, give you a good sense of expected accuracy, and perhaps reveal some category confusion that simply cannot be resolved in this particular mode of mapping. In the latter case, you should plan on refining your draft map by subsequent exploitation of other sources of information.

Multi-Temporal Mapping

Phenology is very important in separating land- use/land-cover and vegetation classes on the basis of spectral information. The scene with which we experimented in the workshop was clustered as a composite of two images, one from early summer (June) and the other from fall (late in October). This is a particularly advantageous combination relative to phenology, and the composite clustering is much better than having the same two scenes clustered separately.

The composite gives rise to a large number of clusters, several of which are likely to represent the same map category. It is much easier, however, to assign several clusters to the same map category than to face the prospect of lack of separability between categories. A given forest type may be in different stages of fall color change as a result of elevation differences, giving several clusters for the same category. However, such changes also permit detecting conifers in mixture with hardwoods and induce crop differences associated with senescence or harvest. More ancillary information may be needed to account for phenological distinctions between clusters, but the distinctions at least become possible. Dual dates also allow working under clouds as long as the clouds do not coincide in both images.

Working with a multi-date composite will require the interpreter to alternate views of the image. It will be necessary to switch back and forth between early-season infrared and late-season infrared, perhaps along with conventional color for one or both dates. Multiple dates also increase the importance of learning expected spectral signatures, which are levels of differing reflectance between bands and dates for particular types of features. SPECTRUM makes available a signature profile (plot of band means) when an instance of a cluster number is pending category assignment.

Multi-date composites will complicate the prospect of preclustering at the EROS data center. EROS may find it logistically impractical to precluster in different combinations of years and dates. This will serve as motivation for user sites to undertake their own clustering.

Provision for Refinement

It would be unrealistic to expect that the foregoing SPECTRUM scenarios will adequately address all map categories for all thematic contexts. Thus, it is only prudent to anticipate possible need for further refinement after you have done your best in SPECTRUM. SPECTRUM itself does not currently embody substantial capabilities for on- screen map editing outside the cluster environment. There are several paths by which the results of SPECTRUM work can be carried into other software systems that are better geared to editing operations. Unfortunately, the transport utilities are also not currently part of SPECTRUM per se. You are referred to remote sensing personnel at EROS Data Center for determining the most expedient import/export capability relative to your favorite GIS.

Making Spectrum More Commodious for Interpreters

SPECTRUM developers have apparently done little in the way of multi-temporal interpretation themselves, else they would have made it unnecessary to keep repeating some of the interpretive operations. The most obvious instance involves switching of image views. It is presently necessary to associate a spectral band with each color plane of the computer display each time you want a different view. When you have once set up a view in this manner, it should be possible to "save" the view under some name so that it can be reselected easily when it is needed again. We strongly urge that such a capability be added to SPECTRUM in its next version.

Equally annoying is the need to specify a numeric level of color for each plane in assigning a color to a category. Susan Benjamin currently has a sheet of paper that associates color levels with color names. We wholeheartedly encourage the incorporation of name-based color selection as an option in SPECTRUM. However, the capability to specify colors by numeric level should also be retained.

We also view as practical necessity the ability to "quick save" and retrieve the status of category assignments along with cluster means by cluster and band number to/from an ASCII file. This would not only allow interruption/resumption of worksessions and going-back to prior stages, but also local programming of bridgework to statistical packages.

Procurement and Platforms

SPECTRUM was developed to run in the Khoros software environment on UNIX workstation computers. It is possible to obtain Khoros with SPECTRUM by anonymous FTP through the Internet. If interest lies solely in SPECTRUM, however, one should seek a stand-alone version from EROS Data Center.

It must also be noted that all UNIX workstations are not created equal relative to SPECTRUM. SPECTRUM saw its first intensive use on Data General platforms at the workshop. While individually and collectively instructive, the workshop was not thematically productive due to frequent lock-up of the DGs during SPECTRUM sessions. Such problems have not occurred on Sun workstations. Version 2.0 of SPECTRUM is due for release in September and will have been tested on DGs.

Wish List for Sophisticated Analysts

We would like to:

a) Have current cluster enter scatter plot last so that color/position is not obscured by plotting of other clusters;

b) Have optional scatter plots on principal component axes;

c) Examine the spectral heterogeneity of individual clusters (standard deviations to go with means);

d) Retain the seed for a cluster and examine its relation to the ultimate cluster mean;

e) Examine the spectral heterogeneity of clusters assigned to a thematic category;

f) Explore the prospective addition of clusters to a thematic class on the basis of spectral similarity;

g) Create supercategories of categories for spectral comparison;

h) Explore the intercluster spectral structure though higher-dimensional displays and/or collapsing dendrogram;

i) Create spatial partitions of a spectral cluster for separate labeling by polygonal enclosure with cursor;

j) Have capability for explicit seeding of clusters, including cluster means from other scenes that may not actually exist as a pixel in present scene;

k) Restrict Monte Carlo sampling with an exclusionary binary mask, i.e. cluster for multiple strata;

l) Display multiple spectral reflectance curves, ie. display curves for deciduous forest types to compare æcharacteristic' spectral signatures;

m) Save a library of spectral reflectance curves;

n) Build a menu of æstandard' indices or formulas, i.e. greenness, wetness, brightness, etc. so the user doesn't have to type them in.

Workshop Participants:

Wayne Myers, Penn State University
Gail Thelin, USGS-WRD NAWQA
Susan Benjamin, NMD NASA-AMES Research Center
Ann Raspberry, Maryland, DNR
Joy Hood, EROS Data Center
Paul Etzler, EMSL, Las Vegas, NV
Jim Majure, Iowa State University
John Brakebill, USGS-WRD Potomac NAWQA
Pat Green, EPA-EMAP Forest, RTP, NC
John Findley, USGS-NMD, Reston, VA

Notes

New GAP Handbook

The following is a brief overview of the topics covered in the GAP Handbook. The "Management" section points out the necessity of collaboration between many different organizations to conduct Gap Analysis. It explains the structure of the administration of state Gap Analysis projects, the roles of cooperators and principal investigators, and staffing needs. The section also covers sources and delivery of funding.

The section on "Imagery" examines purchasing, preprocessing, spectral clustering, and copyrights of satellite imagery The two different approaches to land cover pattern delineation are discussed and concerns over differences in resulting maps are addressed. Part of the article deals with the cooperative efforts of the Multi- Resolution Land Characteristic Consortium (MRLC) and the use of SPECTRUM software for spectrally clustered data.

The "Data Layers" section contains four articles; the first one covers the actual vegetation layer. It describes the required standards for map products and explains the two different methods available for mapping vegetation - computer-assisted classification (unsupervised or supervised classification) and visual interpretation. Potential sources of existing maps vegetation are listed. Finally, several limitation of Gap Analysis vegetation maps are pointed out.

The article on terrestrial vertebrate distribution maps first deals with the constraints for predicting species distributions from vegetation types. The general method for developing animal distribution maps is detailed step-by-step. The appendix gives specific procedures for mapping the distributions of amphibians, reptiles, birds, and mammals. For each order, a table is included that indicates the data layers that should be used for mapping each species.

In the article on land management categorization, guidance for the development of the land management data layer is provided. In states where digital management maps do not already exist, the land management layer must be synthesized from existing information in digital form or from hard copy maps. Incorporation into a single coverage containing all necessary attributes is stressed. The use of primary and secondary codes for attributing the coverage is explained, as well as assignment of one of the four management status codes.

The last article in the Data Layers section describes 33 sources of information that are nationally available, how they may be useful to Gap Analysis projects, and how to this information can be obtained.

The "GAP Standards" section provides a summary of standards for Gap Analysis state projects that apply to all products delivered to the national program. The four basic data layers are listed, and 28 general project standards are described in detail.

The section "Metadata" outlines metadata standards to be used by Gap Analysis cooperators. The paper explains what metadata are and why they are crucial for increasing the value, accessibility, usefulness, and defensibility of data. Appendix A describes the minimum metadata documentation required for Gap Analysis projects. Appendices B and C illustrate metadata construction with examples from the Utah Gap project. Appendix D lists standardized keywords to be used for queries of data sets.

The first article in the section "Validation" serves as a guideline for assessing the reliability of GAP vertebrate distribution maps and derived measures of species richness. After outlining the process of building vertebrate data sets, three methods for accuracy assessment and validation of vertebrate distribution maps (expert review, comparison with existing checklists, and field surveys) are described.

The report on assessing land cover map accuracy presents guidelines to establish the minimum acceptable level of accuracy assessment to be adhered to by all state projects. It describes uses of the GAP land cover maps and purposes of map accuracy assessment and reviews measures of accuracy and constraints on assessment methods. Sampling and measurement strategies developed by participants in the February 1994 workshop in Santa Barbara are presented. The appendix summarizes land cover mapping programs by other agencies and relates them to Gap Analysis.

The "Analysis" section of the handbook contains an article on special management area selection. The author reviews selection strategies employed in the past and looks at special management area selection at different levels in the biodiversity hierarchy. His recommendations for a Gap Analysis special management area selection strategy considers the status and protection needs of vegetation types and of individual plant and animal species. Finally, analytical tools available for selecting priority conservation areas are examined.

The last part of the handbook, titled "Literature," contains a list of Gap Analysis publications, samples of a cooperative agreement, a research work order and proposal, and a reprint of Kelly and White's paper on preprocessing remotely-sensed data. A copy of Wildlife Monograph No. 123 is included in the end pocket.

Elisabeth Brackney
Project Assistant, National Gap Analysis Program

Encyclopedia of Gap Analysis

An effort to bring together all aspects of Gap Analysis in one complete package has been undertaken by Brian Biggs at the United Nations Environment Programme's Global Resource Information Database in South Dakota. The goal is to facilitate communication and dissemination of useful information to any persons involved with Gap Analysis. With ideas and contributions from many people, the "Encyclopedia of Gap Analysis" was created and is available via the Internet through NCSA Mosaic. To access the Gap Analysis Home Page, use the following Universal Resource Locator (URL) address:

http://www.gap.uidaho.edu/

The Encyclopedia is a hypertext document containing links to the following sections:

1. "Overview" Here are general Gap Analysis documents. There are three introductions to Gap Analysis. One is the unabridged Wildlife Monographs pamphlet. There is also a section on United Nations and Biodiversity, and even an online slideshow!
2. "How-to Manual" Click here to find out all of the technical aspects of GAP. Here you can find out how to complete each stage of the process. There is also a list of National Gap Analysis Program standards, so you can be sure you're doing the right thing.
3. "Online Data Available" If you click on this link, you will find a map of the United States, and you can click on a state to find and download completed Gap Analysis data layers. Currently all of Utah, Idaho, Arizona, and parts of California are available.
4. "Bulletin Board" Click on this link to see what GAP people have to say about anything and everything. There are several bulletin boards ranging from "Notices," and "Meetings," to "Job Opportunities," and "Help and Advice." Click on "Post a message" and create a bulletin of

your own!

5. "Investigators and Collaborators" This is a complete list of individuals who are in some way related to Gap Analysis. It includes their addresses, phone numbers, and e-mail.
6. "References" Here are two sets of references. You can find almost any article ever written about GAP and biodiversity.

For further information about NCSA Mosaic, or the Encyclopedia, contact Brian Biggs at biggs@nr.usu.edu or (801)797-2792.

Brian Biggs
Geography Department,
Utah State University, Logan, Utah

GAP Electronic Bulletin Board

The GAP "Help and Advice" bulletin board is a great opportunity to communicate problems you may have and those you have solved, so that other PIs can take advantage of your experience. Let's only invent the wheel once! To access the GAP home page, you need to be connected to the Internet and have NCSA Mosaic loaded onto your system. The Mosaic executable can be downloaded by anonymous ftp at: ftp.ncsa.uiuc.edu. Then change the directory to Mosaic. Download the executable from the ftp site and have your system administrator load it into your system. Within Mosaic, click on "OPEN", and type in the URL

http://www.gap.uidaho.edu/gap

On the GAP home page, click on "bulletin" and select "post a message". For information on other GAP topics covered on Mosaic see Brian Biggs' article on the Encyclopedia of GAP in this issue.

Introducing the IDRISI System

It is clear that the data gathered and made available by the GAP Analysis effort will have application far beyond their original intended use. As land managers and land management interest groups become aware of and begin to access these data, they will need to know more about the range of potential applications and available software tools to assist them. One such tool is IDRISI, a powerful geographic analysis system that runs on common MS-DOS machines and is developed, distributed and supported on a nonprofit basis by the Clark Labs for Cartographic Technology and Geographic Analysis, a nonprofit organization within the Graduate School of

Geography at Clark University in Worcester, Massachusetts.

IDRISI provides a full suite of GIS and image processing capabilities. However, its decision support routines may be especially interesting to the extended community of GAP data users. Routines are available to facilitate the creation of multi-criteria suitability maps for land use activities, where criteria are weighted for importance by the user. A separate routine aids in the weighting process and provides a mechanism for arriving at group consensus on the weights. The result is a continuous suitability map for the activity, from which the most highly suited areas may be assigned to that activity, or the most unsuitable areas may be restricted from that activity.

When more than one activity is vying for the same area, the multi-objective land allocation procedure in IDRISI may be used to create maps of land allocation under different compromise and prioritized scenarios. One of these maps may then be chosen and implemented or, more likely, examination and discussion of the suite of results will lead the decision makers to further refine their selection of criteria, criteria weighting and compromise schemes. In this fashion, the GIS is used as a surrogate environment to iteratively approach the most desirable solution to the land management problem, before any on-the-ground implementation is initiated. An added advantage of this approach is that decisions leading to the results (selection and weighting of criteria, etc.) are fully documented in the process and may be opened to public comment and revision. In addition, the mechanics of the process are quite intuitive and understandable to those not familiar with GIS, allowing for the demystification of the computer-generated alternatives. For more information about IDRISI, contact the Clark Labs at: phone (508) 793-7526, fax (508) 793-8842, or e-mail idrisi@vax.clarku.edu.

Michele Fulk
The IDRISI Project
Clark University

The GLOBE Program

The GLOBE (Global Learning and Observations to Benefit the Environment) Program is an international environmental science and education program. Students will participate in environmental science experiments using personal computers connected to networks like the Internet. Their observational data will be shared with students at other schools through the creation of global environmental pictures of the world based on the student-acquired data.
Under this program, students in grades K through 12 or equivalent grades at

schools throughout the world will conduct scientific experiments. The students' environmental observations will be transmitted through the international Internet and direct satellite communications to a central processing site. At the central site, global environmental images will be created and relayed back to the students. The data acquired by the students will also be made available throught the Internet to environmental scientists throughout the world to support their research.

GLOBE will bring school children, educators, and scientist together to monitor the worldwide environment. Its goals are to enhance the collective awareness of individuals throughout the world concerning the environment and the impacts of human activities on it and to increase scientific understanding of the earth.

The GLOBE Program intends to build on environmental education activities and supporting computing and networking infrastructure that is in place or planned to the greatest extent possible. The addition of GLOBE environmental measurements, scientific instruments, global environmental image viewing capability, and educational materials to a program at a school might enable it to broaden its hands-on science program and simultaneously actively support GLOBE program goals.

The program is managed by an interagency team that includes NOAA (the host agency for GLOBE), NASA, the National Science Foundation, EPA, and the Departments of Education and State. GLOBE leadership also includes the White House Office on Environmental Policy and Office of Science and Technology Policy.

GLOBE will begin operation in a number of schools throughout the world on April 22, 1995, the 25th Earth Day. Over the following several years, thousands of schools are expected to participate in GLOBE.

Map products generated by GAP may be useful to the GLOBE Program. Additionally, you may be able to use the GLOBE network for part of your information gathering activities on occurrence of vegetation types and animal species. For further information, contact

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MEETING SUMMARIES

1994 National Gap Analysis Workshop

The 1994 National Gap Analysis Workshop was held in Silverdale, Washington, July 19-21. Thirty-two states, as well as British Columbia and Mexico, were represented, with 125 individuals participating. The workshop was separated into a first day overview, which included a national Gap Analysis perspective, as well as individual state status reports, followed by four technical sessions on the remaining two days.

Each of the four technical sessions was moderated by a session chair with committee members presenting short talks followed by open discussions. The first of the technical sessions included discussions pertaining to administrative logistics as well as cooperator networks and public relations. The second session reviewed processes, standards and validation of land cover maps. The final day of the workshop began with a session on Gap Analysis species distribution maps and a talk on modeling habitat relations. The closing session turned to the identification of gaps in the protection of biodiversity and included implementation and data dissemination discussions.

Each of the technical session presentors submitted an extended abstract which was published in the pre- conference packet each participant received. The discussions following the formal presentations have been captured in a meeting summary which will be made available to all meeting participants.

Chris Grue and Jane Cassady
WA Coop. Fish & Wildlife Research Unit
University of Washington, Seattle

Society for Conservation Biology Meetings

I attended the June 1994 meetings of the Society for Conservation Biology and was disappointed not to see GAP better represented. (As far as I could tell, I was the only one there associated with our program).

The meetings themselves were well attended (680 people) and spanned five days and about 450 papers and posters. There were about a dozen papers that dealt with geographic biodiversity management strategies, although most were at continental to global scales.

Two papers were especially germane to Gap Analysis: George Powell presented his "Gap Analysis of Costa Rica" based on Holdridge Life Zones and protected areas. He used the CAMRIS CAM system to develop some very impressive statistics and graphics. His project was carried out on a minimal budget but resulted in some compelling results. He's familiar with our projects up north. His work demonstrates what can be done with GAP. We should take note.

Melanie Kershaw, a doctoral student at the Institute of Zoology, London, carried out a biogeographic Gap Analysis of Natal using 155 1/4 degree grid squares as a sampling unit. She looked at richness of birds, mammals, reptiles, amphibians, and plants. She found taxa with high local endemism were not well represented in hot spots for other taxa. Her paper showed a sophisticated understanding of analysis of biogeographic patterns for conservation purposes, and again demonstrates the power GAP can bring to conservation planning.

In 1995, the meetings will be at Colorado State University. I hope GAP and NBS will not be embarrassed by our conspicuous absence.

Blair Csuti
ID Coop. Fish and Wildlife Research Unit
University of Idaho, Moscow, Idaho

Gap Analysis Symposium in Charlotte, NC

In conjunction with the ACSM/ASPRS Annual Convention and Exposition, a Gap Analysis Symposium will be held at the Charlotte Convention Center from February 27 through March 1, 1995. Following is an outline of topics to be addressed:

Monday, February 27

I. INTRODUCTION

A. The need for a hierarchical approach to conservation

J. Michael Scott, University of Idaho

B. Recent developments in ecological science theory: Hierarchy and scale

Robert V. O'Neill, Oak Ridge National Laboratory

C. The conceptual (not technical) development of Gap Analysis:

1. The application of hierarchical and spatially explicit concepts in Gap Analysis

Gerald Wright, University of Idaho

2. The philosophy of Gap Analysis, the utility of its databases, and the development of partnerships

Mike Jennings, University of Idaho

3. Relevant spatial, temporal, and taxonomic scales for Gap Analysis

Frank Davis, University of California - Santa Barbara

4. Extending Gap Analysis to include socioeconomic factors

Gary Machlis, University of Idaho

5. The analysis part of Gap Analysis:

a. Hierarchical Gap Analysis for identifying priority areas for biodiversity

Blair Csuti. University of Idaho

b. Iterative uses and queries of reserve location

Ross Kiester, U.S. Forest Service

D. Summary

Mark Shaffer, The Nature Conservancy

E. The National Biological Service perspective

Ron Pulliam, National Biological Service

II. TECHNOLOGICAL ISSUES OF GAP ANALYSIS

A. Issues of GIS: "database thinking" and database structure

Allan Falconer, Utah State University

B. Data access - an NBS overview

Phil Wondra, National Biological Service

C. Compiling a Gap Analysis Electronic Encyclopedia

Brian Biggs, Utah State University

D. Emerging technologies: Digital Aerial Photography - an overview

Tuevo Airola, Cook College - Rutgers University

Tuesday, February 28

E. Uses of aerial videography in Gap Analysis for deciduous forests in New England

Curtice Griffin, University of Massachusetts

F. Summary

Tom Lillesand, University of Wisconsin

III. LAND COVER MAPPING

A. An overview and history of the concept

Katherin Lins, U.S. Geological Survey

B. Land cover mapping

1. A protocol for satellite-based land cover classification in the Upper Midwest

Tom Lillesand, University of Wisconsin

2. Nomenclature and mapping units

Mike Jennings, University of Idaho

C. Multi-resolution land characteristics: Landsat thematic mapper processing

Joy Hood, Hughes STX Corporation

D. Today's land cover mapping processes

Len Gaydos, USGS National Mapping Division

E. Accuracy assessment: A critical component of land cover mapping

Russell Congalton, University of New Hampshire

F. Multi-resolution land characteristics monitoring system: Building collaborative partnerships

Tom Loveland, USGS EROS Data Center

1. Land cover mapping with SPECTRUM

Susan Benjamin, USGS EROS Data Center

2. MRLC: Comprehensive land characteristics database-building through collaborative partnerships

Denice Shaw, U.S. EPA

G. Summary

Don Lauer, USGS EROS Data Center

IV. PREDICTED DISTRIBUTIONS FOR VERTEBRATE SPECIES

A. An overview to predicted vertebrate distributions

Larry Master, The Nature Conservancy

B. Modeling vertebrate species distributions for Gap Analysis

Blair Csuti, University of Idaho

C. Species richness: Concepts, calculation, and its pragmatic meaning for conservation

J. Michael Scott, University of Idaho

D. Predicted vertebrate distributions from Gap Analysis: Considerations in the design of a statewide accuracy assessment

William Krohn, University of Maine

Wednesday, March 1

E. Summary

Kim Smith, University of Arkansas

V. USES OF GAP ANALYSIS DATA

A. Analyses of biodiversity conservation status:

1. A description of products and their formats, with examples of Gap results by state

Mike Jennings, University of Idaho

2. Applied Gap data for planning of land use and biological resources: Case studies

Frank Davis, University of California - Santa Barbara

a. Applications of Gap Analysis data in the Mojave Desert of California

Frank Davis, University of California - Santa Barbara

b. Arkansas Gap Analysis

Robert Dzur, University of Arkansas

c. State biodiversity plans

Sara Vickerman, Defenders of Wildlife

d. Examples of use by county governments and state and federal agencies

Kent Smith, McCollum Associates

e. Use of Gap Analysis in regional planning in Southern California

Richard Crowe, Bureau of Land Management

f. Applications for planning and expanding national parks

Gerald Wright, University of Idaho

g. Applied Gap Analysis for conservation planning in British Columbia

Peter Murtha, University of British Columbia

B. Summary

Jim Quinn, University of California - Davis

VI. CONCLUSION

A. A perspective on current trends in conservation and a vision for the future of biodiversity management areas

Jack Estes, University of California - Santa Barbara

B. Closing remarks

J. Michael Scott, University of Idaho

ANNOUNCEMENTS

1995 National Gap Analysis Workshop

Mark your calendars for the fifth annual National Gap Analysis Workshop, to take place from Monday, August 7 through Thursday, August 10, 1995. This year's meeting is hosted by the Center for Advanced Spatial Technologies at the University of Arkansas in Fayetteville, AR. The sessions will be held at the Fayetteville Hilton Hotel. A preliminary announcement will be mailed to each GAP P.I. shortly. The formal announcement will come out later in the spring. We will be contacting you about presentations at a later date. Hope to see you all in the Ozarks this summer!

Biodiversity Gap Analysis: Critical Challenges and Solutions

This report presents the findings of an Advanced Research Workshop held at Semiahmoo, WA in early 1994. Participants included experts in gap analysis, as well as human ecology, cartography, and GIS. The goal of the workshop was to stimulate further development of the gap analysis technique, particularly the integration of socioeconomic factors. The report describes some of the critical challenges facing gap analysis and their potential solutions. Three thematic areas are covered: theory, methods, and application. Copies of the report are available for $5.00 from Dr. Gary E. Machlis, Cooperative Park Studies Unit/Sociology, College of Forestry, Wildlife, and Range Sciences, University of Idaho, Moscow, ID 83844- 1133.

1994/1995 GAP Start-ups

- Kansas
- Nebraska
- Kentucky
- North Carolina
- New Jersey
- Iowa

GAP T-Shirts Available

The official logo for the national Gap Analysis Program, as featured on the cover of the GAP Handbook, is printed in full color on the front of these heavy-weight 100% cotton T-shirts. They are available in adult sizes S, M, L, XL, and XXL in either white or ash (a light grey). Get your entire staff outfitted! These shirts also make great gifts for friends and family. The shirts can be purchased for $12.00 (includes shipping and handling) through the Idaho Cooperative Fish and Wildlife Research Unit, University of Idaho, Moscow, ID 83844-141, phone (208) 885-6336, fax (208) 885-9080.

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1994 STATE REPORTS

Arizona

The Arizona GAP project is nearly completed. The state vegetation map is undergoing final modifications. In addition to generalizing the 30-m map that resulted from TM classification, riparian information compiled during PI Dr. Lee Graham's work with the Arizona Game and Fish Department (AZ G&F) is being incorporated.

All of the 550 vertebrate maps have been drafted and sent out for expert review. Some of the maps have already been returned with comments. These reviews are being used to revise the maps for final production. So far, reviewers have been very generous with their time and comments, and their input will definitely improve the final maps. Rich Glinski, biologist for AZ G&F and one of the reviewers, has inquired about the possibility of using GAP maps to illustrate a book he is editing on raptors of Arizona.

Preparation of metadata for AZ-GAP maps has commenced, only slightly hampered by lack of examples of metadata for vertebrate maps. While information on map parameters (scale, projection, lineage, etc.) required for metadata was described in great detail in the GAP Handbook, no guidelines were given for required information on animals. With those questions now answered, preparation of metadata is expected to be successfully completed soon.

Vicky Meretsky
University of Arizona, Tucson

Arkansas

Vegetation Map

Much effort has been focused on a GAP vegetation product that will be useful for both national and state cooperator needs. The Phase I draft vegetation map was completed in December 1994. Currently, nearly 90% of the state has been classified. The methodology has included tassel cap transformation of the full Landsat TM scenes and subsequent segmentation by SCS STATSGO map units. Segmented map units were then subjected to an unsupervised, per pixel classification. The classified images were further aggregated into vegetation map units using existing digital ground-truth data. Over the last year, the state-wide vegetation committee developed a scheme of 160 vegetation community types for Arkansas under UNESCO guidelines. Based on this larger framework, a subset of 53 vegetation cover types was targeted for use on the Arkansas GAP vegetation map.

In 1995, an intensive accuracy assessment of the vegetation product will be the main focus. Efforts have already been made to collect other digital vegetation reference data sets for accuracy assessment of the Draft I vegetation map. In addition, many federal and state resource management agencies are providing assistance with this assessment.

Vertebrate Maps

Birds - Data for this taxonomic group are the most complete. The source data for the book "Arkansas Birds" is being used as a starting point for the county distribution maps. "Holes" in these maps will be filled in by local ornithological experts. The data have been coded by season into a database. For each species, the distribution map will be tied to the vegetation map by a matrix of acceptable vegetation units. The maps will be ground-truthed by other databases that have been collected, including: Audubon Christmas Bird Counts, U.S. Fish and Wildlife Breeding Bird Surveys, Bird Banding Lab reports, and specimen collections from scientific institutions. The Arkansas Breeding Bird Atlas has just started its first year of field work and will be of use in the near future. Data collected at two BBIRD sites and one EMAP site in Arkansas may be used in Phase II of Arkansas Gap Analysis. Of the 356 birds that have been reported in Arkansas, 281 will be included in the Arkansas Gap Analysis.

Reptiles/Amphibians - Currently, there is no book on distributions of reptiles and amphibians in Arkansas. Large specimen collections at Arkansas State University and University of Arkansas, the Arkansas Game and Fish Commission's records for collections within the state, and the Arkansas Natural Heritage Commission's data for threatened and endangered species will be used to compile the county distribution maps for these taxa. These data sets will have to be split, and some will be used to "ground-truth" the Arkansas Gap Analysis for these taxa. Of the 114 reptiles and amphibians in Arkansas, sufficient information is anticipated to be available to include 106 species in the Gap Analysis.

Mammals - The book "Mammals of Arkansas" is of limited use as a source for Gap Analysis. Therefore, large university collections for the state and the Arkansas Game and Fish Commission's records on specimen collection, furbearing mammal records and scent station reports will be relied upon. Of the 74 species of mammals that have historically occurred in Arkansas, 70 species will be included in Gap Analysis.

Management Map

This digital layer is composed of management boundaries (polygons) in the following broad categories: state, federal, private, and other non-governmental organizations. Each polygon will be assigned a "level of management" value based on the National GAP guidelines. The following organizations have contributed their land management boundaries: Arkansas Game and Fish Commission, Arkansas Natural Heritage Commission, Arkansas Department of Parks and Tourism, Arkansas Forestry Commission, USDA Forest Service , U.S. Fish and Wildlife Service, Fort Chaffee (U.S. Army) and Camp Robinson (State Military Installation). Areas of current acquisition are the National Park Service and the U.S. Army Corps of Engineers.

Kimberly G. Smith
Dept. of Biological Sciences
University of Arkansas, Fayetteville

California

Regional Status

The analysis for the Southwestern California Region was published as a technical report in January 1994. Nineteen of 62 mapped communities appear to be "at risk", as determined by their poor representation in existing special management areas, parks, or wilderness areas. Communities restricted largely to the lower elevations, such as grasslands and coastal sage scrub types, are at considerable risk of conversion to agricultural or urban uses. Forty-two vertebrate species were also identified by Gap Analysis as being at highest risk from lack of habitat protection. For details on obtaining the full report describing the methods and results through Internet by ftp, send e-mail to biod@horton.geog.ucsb.edu. A hard copy of report #94-4 can be ordered by phone for $15.50 from the National Center for Geographic Information and Analysis at (805) 893-8224.

The California Gap Analysis project has teamed up with the Sierra Nevada Ecosystem Project (SNEP) of the U. S. Forest Service, which has contributed funding to GAP to analyze the Sierra Nevada Region. The mission of SNEP is to define the spatial extent and dynamics of key features of the ecosystem; identify the benefits humans draw from it; and identify management alternatives and their effects on ecosystem integrity and its sustained capacity to provide the full range of benefits. Frank Davis, the GAP PI, is also on the SNEP Science Team and is coordinator of SNEP's GIS database. Copies of the SNEP progress report can be obtained through the SNEP office at the University of California, Davis.

Vegetation mapping has been completed for the Sonoran and Mojave Desert regions. A master's thesis was produced from the analysis of these two regions, and a Ph.D. dissertation is in progress. The Mojave map was distributed as 1:100,000 scale paper quads to 15 botanists for review. Mapping of the Central Western and Modoc Plateau regions of California is nearing completion. Blair Csuti, the Oregon PI, compared the Oregon and California vegetation maps along the border in the Modoc Plateau region. Although the maps were compiled in different ways, the general consistency found in polygon boundaries and labeling across the border was encouraging. Minor revisions were made in both maps to incorporate shared information. (A technical report is available in postscript format from the ftp site; send e- mail to biod@horton.geog.ucsb.edu for instructions).

Wildlife Modeling

Two programs have been written to facilitate wildlife modeling for the GAP project. They provide graphical user interfaces to link the GIS data on habitat distribution with tabular data on species-habitat relationships without having to convert all files to ARC/INFO format. The first program, called Fauna-List, relates a wildlife database to a GIS habitat coverage to produce species lists, either by habitat polygon or a sampling grid. The second program, called Fauna-Map, allows a user to display the predicted distribution of a selected species. Anyone interested in these programs should contact Allan Hollander at adh@geog.ucsb.edu. A paper on the effects of grid size on species richness maps, using the Idaho GAP data, was published in a recent issue of The Professional Geographer.

Validation

GAP models the distribution of native terrestrial vertebrates by their known habitat preferences and overall range limits. Much of the existing field-based information is used in developing the habitat suitability relationships, making independent sources of data for validation scarce. Extensive new field sampling is prohibitively expensive and is of limited value because many species will not be observed during the short sampling period. One approach to validation is to compare species lists for managed areas, or other clearly delineated geographic areas, with model predictions. For the Santa Monica Mountains National Recreation Area, species modeling provided a robust technique for predicting the occurrence of terrestrial vertebrates. The same level of agreement was achieved using only the range maps without the habitat relationships models. A technical report is planned on the methods and results. In the future, we hope to conduct comparisons at 25-30 sites of varying size throughout California to determine the range of sizes at which GAP modeling is reliable for each taxonomic group.

Validating the vegetation layer for GAP has proceeded by a number of routes. It was compared to a very detailed map of a small spatial extent (a "maplet"). Results showed that most polygons were reasonably delineated and labeled at the GAP scale. It was compared for a set of random points to other maps and by polygons to a more detailed map of a single cover class. It was also compared to the target elements for Forest Service Research Natural Areas (which average about 300 ha in size). While these evaluations all led to the conclusion that the vegetation map for the Southwest California region is reasonably good, no formal statistical measures of accuracy could be provided. An in-state workshop in February, attended by GAP investigators and representatives from federal mapping agencies and The Nature Conservancy, developed preliminary guidance for a formal accuracy assessment protocol. The report of that workshop is included in the GAP handbook. The proposed protocol still needs to be reviewed and tested, however, before it can be adopted as a standard.

database Uses

With the guidance of the Carlsbad Office of the U.S. Fish and Wildlife Service and the Geography Department at U.C. Santa Barbara, a number of planning efforts are now recognizing the contribution the GAP database makes to planning over a regional domain. The U.S. Fish and Wildlife Service, in cooperation with the California Department of Fish and Game, is coordinating a major planning effort to address conservation of biological diversity on federal lands in the Southwestern California region. GAP data will be used to provide initial insights on those natural communities at risk and lead to more detailed studies and management recommendations for conservation throughout the region.

The Southern California Association of Governments (SCAG) has prepared a regional open space plan for a six county area that includes over 100,000 square kilometers. This plan includes an open space/conservation element that will provide guidance to the cities and counties regarding conservation and future land development. They have used the GAP data extensively to provide a regional overview of the current and future threats to major terrestrial plant communities. Regional conservation planning efforts are underway that will use the GAP database as a first assessment of the conservation status in two other areas.

David Stoms
University of California, Santa Barbara

Colorado

Colorado Gap Analysis efforts have been focused on two areas this past year: attribution of the vegetation/land cover base layer and development of collateral species distribution information for range/distribution modeling. Tom Thompson, under Dr. William Reiners' direction (Botany Department, University of Wyoming), has completed preliminary vegetation polygon attribution for about 60% of the 100K quad blocks for Colorado. Vegetation polygons for an additional sixteen 100K blocks (30% of Colorado) were delineated and attributed by the National Ecological Research Center of the U.S. Fish and Wildlife Service (now known as the Mid-Continent Environmental Science Center of the National Biological Survey). These vegetation polygons are currently being edge-matched and cross-walked to the work performed by the University of Wyoming group. Colorado Division of Wildlife (Schrupp and Cade) has prepared 100K plots of the draft classification maps, with 100K road networks overlaid, for distribution at regional interagency review meetings in September.

Assembling collateral information for species range/distribution modeling has involved major updates to the Colorado Wildlife Species Database. These include Partners-in-Flight information, processing of herptile observation records, and continuing support in assembling the geographic information system components of the Colorado Bird Atlas project. In the formative stages is a Great Outdoors Colorado project to develop the Colorado Wildlife Heritage Inventory data-set, in cooperation with Colorado State University and the Colorado Natural Heritage Program. A developing MOU is anticipated to leverage inventory data available through the Division's Wildlife Resource Information System and the Colorado Natural Heritage Program's Biological Conservation Database efforts.

The Colorado Gap Analysis land ownership data layer has been completed by the National Ecology Research Center. Therefore, Colorado can begin development of the land management/land status models this winter. Regional review teams will be relied on to facilitate these efforts.

Don Schrupp
Colorado Division of Wildlife, Denver

Delaware

(See Maryland/Delaware/New Jersey)

Florida

The Everglades and Florida Bay are the focus of national and international attention due to their unique environments and historical support of wildlife and fish populations. These environments have been critically stressed and fragmented by opposing land uses and hydrological alterations. Restoration of South Florida ecosystems is a pressing national issue requiring intense largeûscale efforts and cooperative research and management among many agencies and organizations. A federal interagency science task force has been established to address restoration of South Florida ecosystems. The Federal Geographic Data Commission has selected South Florida as a test case watershed for facilitating the transfer and use of spatial data between cooperating agencies for improved management. For these reasons, the Florida Biological Diversity Project (Florida GAP) is concentrating first on the subûecoregions of South Florida.

To maximize delineation of natural communities from satellite imagery, close to a year has been spent in preparing other types of coverages as masks and sources of a priori knowledge in association with the imagery. After nearestûneighbor rectification of the imagery, land use coverages from the South Florida Water Management District were corrected to the imagery and updated. The land use coverages are being used to mask out urban and agricultural lands before classification. These areas are sources of high spectral variability, and their presence adds to classification confusion. Land use coverages have been obtained for the rest of the state and are now being corrected to eastern Florida subûecoregions as well.

Digital National Wetland Inventory maps were prepared and aggregated to broad classes to further segregate the imagery and enhance the delineation of classes. The imagery is being masked by the aggregated NWI classes, therefore delineation of a smaller range of communities within a masked area is occurring. SCS Soil Series maps at a scale of 1:24,000 were also aggregated to broad classes of Xeric, Mesic Upland, Mesic Flatwoods, and Hydric. The soil classes will be used after classification to refine image separable classes into physiognomic positions (e.g. xeric, sandhill pine is a very different community from mesic, flatwood pine). Labeling of the classes generated by classification is proceeding, using aerial survey, aerial photography, and ground observation. Ground-truthing is greatly augmented by volunteer cooperators such as the Native Plant Societies and biologist from agencies and private firms.

Vertebrates. Mapping of the distribution of Florida's breeding mammals, birds, reptiles, and amphibians, including established nonûindigenous species, is occurring. Mammal distribution has been determined from a nationûwide survey of museums, bird distribution from the Florida Breeding Bird Atlas and Survey, and herpetofauna from a compilation of records from 49 local and national museums. Habitat relationships and additional information important for species modeling such as home range, limiting factors, etc., have been compiled for the mammals and herpetofauna utilizing >500 sources to date.

The inclusion and species richness mapping of nonûindigenous species (as a separate layer) is expected to reveal much about ecosystem health and intactness. Established breeding nonûindigenous vertebrate species number about 70 in Florida. Due to the migratory nature of many bird species, and because subûtropical Florida is an important wintering area for many birds, breeding bird distribution and wintering bird distribution are both being mapped. Nodes of high species richness may differ for breeding and wintering bird populations and may necessitate different management approaches. Among the invertebrates, butterflies and skippers (Lepidoptera and Formicidae) will be mapped. Because they may be more habitat restricted, invertebrates allow higher resolution biodiversity mapping with the Florida Biodiversity Project's 30 m resolution.

Leonard Pearlstine
University of Florida, Gainesville

Idaho

Idaho Gap Analysis is proceeding. New uses and procedures for GAP data are being explored. Digital land ownership and management status maps are complete, and wildlife habitat relation (WHR) models are being updated in collaboration with Montana-GAP. The pilot digital vegetation map for the state of Idaho is also complete. A new vegetation map based upon TM imagery is being compiled for Northern Idaho by Dr. Roland Redmond at the University of Montana, and the Southern Intermountain Sagebrush portion of the state will be developed by Utah State University. The completed data layers are available through the Internet at the Gap Analysis Home Page,

http://www.gap.uidaho.edu/gap

Edge-matching with the adjacent states of Oregon and Washington has begun. Vegetation classification schemes for the adjacent states are being correlated with Idaho's classification. Once the edge-matching is complete, the Gap Analysis will be performed over the ecoregions encompassing the Pacific Northwest.

Stan Sobczyk
ID Coop. Fish and Wildlife Research Unit
University of Idaho, Moscow

Illinois

As a result of a memorandum of agreement signed in January 1994, between the National Gap Analysis Project Office and the Illinois Natural History Survey, INHS has become an MRLC cooperating agency. Since October 1993, INHS personnel have assisted the National Gap Analysis Project Office, the EROS Data Center, and EOSAT Corporation in conducting the Landsat Thematic Mapper (TM) scene selection for the State of Illinois. Single-date, cloud-free coverage acquired during October of 1992 and 1993 is available statewide, and multitemporal coverage (mostly May-August of 1992-93) is available for 60 percent of the state. A total of twenty-three TM scenes, system corrected in EOSAT Fast Format, were received in April 1994. INHS has begun geocoding and analyzing these data.

Since the landcover database for Illinois will be largely developed utilizing a computer-based, unsupervised approach, a number of important ancillary databases have already been collected. The predominant landscape within the state is agricultural. To guide the classification, and assess the accuracy, of this spectrally diverse and spatially complex landscape, USDA-ASCS Crop Compliance information has been collected for a sample of thirty-seven counties. These data provide detailed crop and farm management information for each crop year since 1982 and were provided to INHS through the cooperation of the USDA- SCS state office. To characterize the more persistent landscape elements, an approximate ten percent sample of color-infrared 1988 NAPP photography has been obtained. In addition, complete statewide coverage of black-and-white 1988 NAPP photography is readily available from the University of Illinois Map and Geography Library, and 1993- 1994 black-and-white NAPP acquisition is currently underway. Lastly, existing land ownership, land management, and species digital databases have been identified.

Some innovative approaches are being utilized to develop the landcover database. U.S. Bureau of the Census 1992 TIGER data has been used to create block-level, urban- rural masks for the entire state. This mask is imposed upon the TM data during the unsupervised clustering and classification stages to improve the interpretation of the two quite diverse landscapes. In addition, experiments are underway to evaluate the use of vector field segmentation for the purpose of partitioning the original TM data into a set of regions which correspond to objects on the landscape. Initial results from a cooperative study between INHS and the University of Illinois, Department of Electrical and Computer Engineering, reveal that the potential exists for this technique to discriminate both spectrally and spatially homogeneous landscapes within a TM scene.

Mark Joselyn and Donald Luman
Illinois Natural History Survey, Champaign

Indiana

The absence of funding and satellite data have severely limited the project's ability to progress beyond the pilot project concluded in late December 1993. A minimum effort has been maintained at both Indiana State University (ISU) and Indiana University, School of Public and Environmental Affairs (SPEA) using borrowed funds. Indiana GAP is positioned to begin statewide Gap Analysis now that funding and satellite data have become available.

Accomplishments since January 1994 include: cooperative agreements signed with the Indiana Department of Natural Resources (IDNR) and developed with the Hoosier Environmental Council (HEC); coordination with other partners; numerous presentations about the Indiana Gap Analysis Project; the establishment and subsequent meeting of the Region 3 Intra-Regional Gap Analysis Coordinating Group; refinement of wildlife modeling, metadata, vegetation classification, and other components of the project; a meeting with The Nature Conservancy (TNC) and IDNR to discuss a butterfly data layer for Indiana-GAP; meetings and proposal development with the Purdue University Working Group for Woody Plant Ecosystems toward application of the basic Gap Analysis data; and discussions and a meeting with the Environmental Protection Agency's (EPA) Great Lakes National Program Office about a cooperative venture with Indiana-GAP.

Indiana Gap Analysis Pilot Project

In December 1993, the Indiana Gap Analysis Project formally concluded their pilot project with a plenary meeting of representatives from all groups involved. Preliminary partnership building and planning for the Indiana Pilot Project at the Department of the Army's (DOA) Jefferson Proving Ground (JPG) began in summer of 1992. A year later, Indiana received $10,000 from the National Center, $5,000 from the IDNR, and $5,000 from the DOA for the project. The construction phase of the pilot project occurred at ISU and SPEA. The actual vegetation and vertebrate data layers are developed by ISU, which has a strong Life Sciences faculty and extensive experience with remote sensing in their Department of Geography and Geology. SPEA houses the Midwest Center of the National Institute for Global Environmental Change that provided an outstanding facility to carry out GIS responsibilities for the Indiana Pilot Project.

Resources essential for Gap Analysis also exist within the IDNR. Endangered, threatened, and rare (ETR) species data and Managed Areas data were available from IDNR with whom a working relationship was established early in the pilot project. GAP partnership discussions were also initiated with the USFS, USGS, SCS, Indiana Department of Environmental Management, TNC, and the HEC and the 80 Percenters (state non-government environmental coalition groups).

The Indiana Pilot Project's primary goal was to serve as a system development trial run for the full state Gap Analysis. Therefore, the project was pursued as a small Gap Analysis in an attempt to address the approximately 70,000-acre study area in the same manner that Gap Analysis would be applied to the entire state. The secondary goal was to produce data relevant to the biological assessment for the base closure proceedings at JPG; in this sense, the Indiana Pilot Project has been application-based. This assessment had particular importance because of the outstanding wildlife habitat, especially endangered species and neo-tropical migrant habitat, within JPG. Both goals have been successfully achieved.

Summary of Accomplishments

1)compiled a vegetation map of the study area to the UNESCO Formation Group level of detail

2) designed a classification system based on UNESCO, Cowardin, and the draft TNC vegetation classification for Indiana

3) produced approximately 55 complete vertebrate models related to the preliminary vegetation map and made significant progress modeling to remaining Indiana vertebrates

4) acquired the IDNR's managed area database and incorporated study area data into the GIS

5) acquired the ETR species data from the IDNR's Heritage Database and incorporated study site data into the GIS

6) incorporated the NWI data into the GIS

7) acquired digital elevation data where extant for the state and incorporated that data and slope aspect data for the study area into the GIS

8) initiated a pilot project with the SCS to digitize soils to the series level for the study area (approximately 70% completed)

9) established and populated a metadata database within ARC-INFO for the data layers developed for the Indiana Pilot Project.

10) delivered preliminary data to the DOA relevant to the biological aspects of the base closure proceedings

Forest Clark
U.S. Fish and Wildlife Service, Bloomington

Kansas

To prepare for start-up during FY 1995, potential cooperators have been contacted and existing databases identified. This effort is being coordinated by the Kansas Biological Survey (KBS) at the University of Kansas (KU) and by Dr. Phil Gipson, Unit Leader, and Dr. Jack Cully, Assistant Unit Leader of the Cooperative Fish and Wildlife Research Unit at Kansas State University (KSU). PI Chris Lauver attended the Second Annual Southwest Region Gap Analysis Meeting in Albuquerque during November 1993 to learn about the progress of neighboring states.

Three state programs have been identified as instrumental for conducting KS-GAP. The staff and resources of the Kansas Applied Remote Sensing (KARS) program at KU will be involved in developing the vegetation map. KARS program personnel completed a statewide digital land cover database from classifying 1989-1991 Landsat TM imagery. The classification included general cover types (e.g. cropland, grassland, woodland), but the spatial resolution is high with a 2-acre minimum mapping unit. The original and classified data from this project will be a great asset in creating and evaluating the GAP vegetation map. The GAP map will adopt the modified UNESCO vegetation classification being developed by KBS's Kansas Natural Heritage Inventory. In addition, the Natural Heritage Inventory will provide animal distribution information from its Vertebrate Characterization Abstracts database and locality data on natural communities and rare species throughout Kansas for verification purposes.

Ancillary GIS data to facilitate building the three major GAP data layers are available through the Data Access and Support Center (DASC) operated by the Kansas Geological Survey. DASC maintains the central databases for the State of Kansas GIS Initiative. On-line databases include STATSGO soils, elevation models (DEM), hydrology, U.S. Census Tiger Files, and county boundaries.

In April 1994, Dr. J. Michael Scott visited KSU and KU. During two days of presentations and informal discussions, he offered support and advice for initiating KS- GAP. The meetings were attended by faculty, staff, and representatives from several key organizations.

Chris Lauver
Kansas Biological Survey
University of Kansas, Lawrence

Louisiana

The Louisiana Gap Analysis Project was initiated in FY '94. While resources are minimal for a project of this scope, progress is being made at a steady rate.

Vegetation Mapping

Louisiana GAP is primarily utilizing Landsat Thematic Mapper (TM) satellite imagery from Jan.-Feb. 1993 for the initial vegetation classification for 17 categories, which is about 60% complete. (This does not include ground- truthing, accuracy assessment, or assigning each polygon to a dominant/co-dominant species.) Finishing the image classification will require 1) classifying all subsets, 2) stitching subsets together for master file, 3) procedures for correcting stitch lines, and 4) aggregation to 40+ acre size units. Afterwards, the raster files will be converted to a polygon format. Creation of a UNESCO-type classification scheme, which will be linked back to the original Landsat TM classified data set, is underway.

Breeding Bird Atlas and Wildlife Mapping

A breeding bird atlas (BBA), which will take three years to complete, will be part of Louisiana GAP. In the first year, we have designed the mechanisms to create the BBA and have initiated year-one field sampling of approximately 200 different 7.5 quadrangles. This effort is primarily conducted by volunteers.

For the wildlife species range distribution, coverage is being created for all herps and mammals on a parish(county)-wide occurrence basis. Also, a database to associate priority habitats for each animal is being initiated. When the BBA is completed, the same procedures to create parish-wide coverages will be used for birds.

Land Management

Presently available in digital format are maps of federal and state wildlife refuges, wilderness areas, and National Forest regions. Rank criteria are being assigned to each area based on GAP's four levels of land management status. In addition, other applicable data sets for land management are being identified.

The USFWS is currently studying critical habitats for the black bear (bottomland hardwood forests), which may be revised to include all hardwood forests. The primary loss of this critical habitat is due to conversion to agriculture lands. To delineate these critical habitats, classified Landsat TM imagery from the Louisiana Gap Analysis Project were combined with USGS DLG data (hydrography and roads).

Future Projects

1) Complete classified land cover map for the original 17 categories (at full resolution of 25 meters square) merged with the existing 1988 NWI habitat data for the Louisiana coastal zone.
2) Aggregate final land cover map for Louisiana.
3) Complete parish-wide species occurrence maps for herps, mammals, and plants.
4 Complete database to associate priority habitats for each animal.
5) Finish the land management component and produce state-wide map of land management distributions using the 4-tier ranking scheme.
6) Continue BBA and start to compile parish- wide bird species occurrence maps.
7) Begin investigations into appropriate wildlife models.

Peter Bourgeois
EPA-NBS National Wetlands Research Center, Gulf Breeze, FL

Maine

Maine Statewide Gap Analysis has entered its third year. During 1994, predicted species distributions and richness maps are being developed. Ranges and habitat relations of amphibians and reptiles were reviewed, mammal distribution maps were submitted to experts, and bird synopses will go to review shortly. The conservation land ownership map of Maine is completed.

Vegetation Classification

University of Massachusetts (UMass) researchers are creating the vegetation map for the New England Gap Analysis project. Mapping existing vegetation using Landsat scenes has been difficult because many habitat types have indistinguishable spectral signatures. In response, the New England effort has reduced the number of classes being mapped to about 15 and is exploring the use of aerial videography for refining the vegetation map.

To assist UMass staff in creating the vegetation map, existing ground-truthed vegetation maps from 60 areas covering about 4% of Maine have been provided. Corresponding National Wetland Inventory maps and stereographic pairs of National Aerial Photography Program color-infrared photographs were also provided. In cooperation with the New Brunswick Department of Natural Resources and Energy, existing vegetation maps of known accuracy, for a 50 km swath of New Brunswick bordering northern and eastern Maine, were provided by Maine GAP. UMass acquired a similar data set for New Hampshire. Some of these data are being used to type vegetation within Maine, near its borders.

UMass researchers requested that preliminary existing vegetation maps be checked for all or part of four 1:100,000 scale quadrangles of Maine. Analyses were conducted to determine the accuracy of the maps, and UMass staff are currently addressing the problems identified.

Predicting species occurrence using maps with few habitat classes is problematic. To increase the accuracy and number of classes mapped, future plans include incorporating into the spectral analyses: 1) aerial videography; 2) available GIS information such as hydrography layers; 3) additional Landsat scenes; and 4) existing ground-truthed vegetation maps. Visual interpretation of National Wetland Inventory maps and reclassification of all of the wetlands within the USGS Land Use Digital Analysis database for Maine has been initiated.

Wildlife Ranges and Habitat Relations

For each terrestrial vertebrate species that breeds in Maine (n_300), a short synopsis that summarizes its range and ecology is being prepared. These synopses include a description of the model to be used in Gap Analysis, a matrix of species-habitat associations (including abundance information), and information that will be used to derive a risk of extinction. The synopses for amphibians and reptiles are being reviewed by experts throughout the state. Published and unpublished data on birds have been assembled, and writing of the synopses has been initiated. In 1994, finalization of the mammal synopses for submission to experts and completion of the bird synopses is planned.

The Maine Gap Analysis project continues to support data entry into the Maine Department of Inland Fish and Wildlife (MDIFW) Natural Heritage database. This year, MDIFW personnel have been concentrating on entering records of occurrence for mammals that are rare in Maine (e.g., Lynx canadensis).

Land Ownership and Management

The Maine State Planning Office has completed a revision of the Conservation Lands of Maine maps. The maps were produced at 1:250,000 scale and include all federal and state conservation lands and those owned by conservation groups. Updating the digital ownership map was completed in November. Codes are now being applied to the areas to represent levels of biodiversity conservation.

In cooperation with MDIFW, Maine GAP funded a project that entailed digitizing mapped deer wintering areas and waterbird habitats in south-central Maine. These areas, if regulated, can potentially contribute as much to biodiversity conservation as lands owned for conservation. This study will allow extrapolation of the extent of deer wintering areas and waterbird habitats and provide future assessments of how regulated versus fee-title lands contribute to the conservation of vertebrates.

William B. Krohn and Randall B. Boone
ME Coop. Fish and Wildlife Research Unit
University of Maine, Orono

Maryland, Delaware, and New Jersey

Maryland, Delaware, and New Jersey began a joint Gap Analysis Project late in FY '93. The Principal Investigator is Ann Rasberry (Maryland Department of Natural Resources). She is responsible for GIS and analysis components. Grace Brush (Professor, The Johns Hopkins University) is the lead scientist on habitat inventory and has a Ph.D. candidate, Rachel Shea, assigned to the project. Rick McCorkle (USFWS Delaware Bay Estuary Project) is responsible for the vertebrate distributions, assisted by GAP biologist David Hannah.

GAP project staff in each state have held a number of meetings with top ranking officials in their state's natural resources agency. A cooperator's meeting was held in Delaware, and 10-12 smaller meetings have been held in Maryland with groups such as the Partners in Flight Research Committee and Maryland Conservation Council. The March 1994 meeting in Annapolis, Maryland, that introduced the Multi- Resolution Land Characteristics (MRLC) Consortium was attended. A pilot MRLC cooperative landcover mapping effort which will include mapping of agricultural and urban areas is being implemented in EPA Regions 2 and 3, encompassing New York, New Jersey, Maryland, Delaware, Virginia, West Virginia, and Pennsylvania. Ann Rasberry and Wayne Myers represented GAP at the June 1994 MRLC workshop on SPECTRUM software for classifying TM imagery.

Personnel from The Nature Conservancy (TNC) met with project staff regarding use of the TNC field forms for field inventory and ground truthing. The Maryland Wildlife Division is also using these forms to inventory wildlife management areas. TNC is planning to assist with the EMAP hexagon data population through the Natural Heritage programs in Maryland and Delaware in FY '94. Ancillary data available include computerized fish and wildlife information systems (CFWIS), breeding bird atlases and breeding bird survey data, NAPP photography, digital ortho quarter quads and elevation models, Anderson Level II forest inventory, SPOT 30 m panchromatic imagery, NOAA C-CAP data, and habitat inventory assessments. National Wetlands Inventory (NWI) data is digitized for the project as is land ownership data.

In Delaware, a Natural Communities Survey Report for Kent County and a Wetlands Evaluation Pilot Project Report have been obtained. Four volunteers were recruited to survey selected areas for breeding birds, mammals, reptiles and amphibians, and habitat information. A data base of wetland habitats has been developed in order to map suitable habitat for wetland dependent species. NWI data and a pilot project initiated in Bombay Hook and Prime Hook National Wildlife Refuges were utilized in developing this database.

For all three states, lists of resident terrestrial species have been developed and ranked to determine whether habitat models will be derived or actual occurrence data used. Some modeling is being done for rare rails in Maryland, using NWI data in the absence of vegetation maps. Additionally, breeding bird occurrence and habitat association data is being obtained for hundreds of sites surveyed in Maryland as a part of a project conducted by the Patuxent Wildlife Research Center.
In June, the TM imagery for the project began arriving. Preliminary vegetation maps will be produced this winter.

Ann Rasberry
Maryland Department of Natural Resources, Annapolis

Massachusetts

The University of Massachusetts and the MA Cooperative Fish and Wildlife Research Unit are cooperating with the Vermont and Maine Cooperative Fish and Wildlife Research Units in the New England Gap Analysis Project. A primary focus of GAP activities in Massachusetts has been the development of the base vegetation map for the six-state New England region. The extensive forests of New England produce a landscape with 75% to over 90% forested land cover. Furthermore, there are a wide variety of forest types across the region. Many of these forest types are interspersed on the landscape and occur in relatively small stands. This is primarily the result of the land use history of the region. These regional vegetation characteristics in New England pose new challenges for developing a base vegetation map. Thus, an important objective of the New England Project has been to evaluate the applicability of the vegetation mapping procedures used in Gap Analysis programs in the western U.S. for New England.

There are two phases to the current vegetation mapping efforts for New England. Phase 1 focuses on completion of a base map that includes water areas, nonvegetated areas, and vegetated areas that include at least five forest types (deciduous, coniferous, mixed, clearcuts, and regeneration). In Phase 2, a high resolution Gap Analysis for a pilot area in southern New England will be conducted. The scene chosen for this pilot study includes almost all of central and western Connecticut and Massachusetts. Summer and fall TM imagery are available for the area as well as some limited ground-truth forest stand databases. However, additional ground-truth data will be needed to generate adequate numbers of data points to classify the seasonal TM imagery. The only feasible way to obtain adequate ground-truth data in this heterogeneous forested landscape is via aerial videography. Furthermore, seasonal videography will help to delineate additional forest types. The comparison of TM data from different dates in combination with seasonal aerial videography should permit a significantly higher vegetation resolution to be derived from the TM imagery. This should help in the production of a vegetation classification with significantly more vegetation categories than can be produced for the six- state vegetation map in Phase 1.

This additional phase will serve as a pilot study to evaluate the efficiency and efficacy of vegetation mapping methods for New England and for much of the eastern deciduous forest. These higher resolution products will provide the technologies and assessment capabilities for future efforts needed to fully complete the New England Gap Analysis.

With the cooperation of Dr. Lee Graham and Dana Slaymaker from the University of Arizona, complete aerial videography coverage of New England was obtained during late May and early June. UMass staff have been trained in video interpretation, and video analyses have begun. Complete aerial videography coverage of New England was completed in the fall. The results of this work have significantly increased the ability to discriminate among various vegetation types.

Co-principal investigator, Curt Griffin, is continuing cooperation with the Danube Delta Biosphere Reserve in Romania. With assistance from the World Bank, UMass will be training three Romanian scientists during the next 12 months in remote sensing and GIS technology. The goal is to develop and apply a Gap Analysis approach to inventorying biological diversity in the Danube Delta to assist in resource management and delta research programs.

Curt Griffin and Jack Finn

MA Coop. Fish and Wildlife Research Unit
University of Massachusetts, Amherst

Michigan, Minnesota, and Wisconsin (Upper Midwest Gap Analysis Project)

The Upper Midwest Gap Analysis Project (UMGAP) is in the initial stages of implementation. Cooperative agreements with all three states are in place. The Environmental Management Technical Center (EMTC), a National Biological Service science and technology center in Onalaska, Wisconsin, is coordinating this effort. The EMTC hired a biodiversity coordinator who is responsible for full- time coordination of UMGAP and development of the species range mapping component in affiliation with state and federal agency ecologists and biologists. UMGAP partners are listed in the back of this bulletin. The EPA's Great Lakes National Program Office contributed funding to UMGAP and was instrumental in initiating the project. The EPA's interest is in the Great Lakes Basin, and initial efforts to classify land cover will be concentrated in that area.

UMGAP's land cover mapping effort is being coordinated through the EMTC with the assistance of Dr. Thomas M. Lillesand, Director of the Environmental Remote Sensing Center at the University of Wisconsin-Madison. In conjunction with the Geo Services Division of the Wisconsin DNR, Dr. Lillesand has completed a pilot project to evaluate methods and to develop procedures for processing Landsat Thematic Mapper (TM) satellite data. A paper presented by Dr. Lillesand at the International Society for Photogrammetry and Remote Sensing Mapping and GIS Symposium in Athens, Georgia (June 1994), described the background and philosophies influencing UMGAP's developing protocol. In his presentation, Dr. Lillisand discussed the use of multi-date satellite data, "guided" clustering in the classifier training process, and the simultaneous collection of training and accuracy assessment data.

Several Landsat TM scenes have been received from the EROS Data Center under the multi-agency agreement embodied in the Multi-Resolution Land Characteristics Consortium. These Landsat TM scenes have been distributed to the UMGAP cooperator in each state for processing. A classification system that crosswalks to the modified UNESCO GAP classification system has been developed and will be standardized across the three states.

The state of Michigan developed a land cover database in the early 1970s at a scale of 1:24,000. A procedure will be developed to use current Landsat TM data to update the existing database, and land cover classes will be recoded to match the GAP classification system. UMGAP states will also develop and update their existing land ownership and managed area spatial databases.

The Upper Great Lakes Biodiversity Committee, consisting of representatives from the three UMGAP states, has been formed to promote cooperation in maintaining and restoring biological diversity on a regional scale. The intent of the committee is to initiate a regional overview of biodiversity status and needs in an effort to guide ecosystem management. This effort supports and enhances the GAP effort in the Upper Midwest.

Frank D'Erchia
Environmental Management Technical Center
National Biological Survey, Onalaska, Wisconsin

Minnesota

(See Michigan, Minnesota, and Wisconsin)

Missouri

The Missouri Biodiversity Council (MBC) is a group of fourteen agencies and organizations who have agreed to collectively address the conservation of biodiversity in Missouri. Over the past two years, working groups of the MBC and the Missouri Gap Analysis Project have been meeting to work on specific objectives in this regard.

In February 1994, the MBC Coordinating Committee recommended that the individual working group proposals be incorporated into a collective plan of action for the state. This committee specifically recommended the Gap Analysis Project be incorporated into the overall resource assessment and planning scenario. The Missouri Resource Assessment Project (MoRAP) is the result of that recommendation. MoRAP incorporates Gap Analysis and other projects into a comprehensive state-level resource assessment and planning process.

MoRAP proposes the development of a facility at an independent site to achieve the greatest degree of control and flexibility, the least impact on existing GIS programs, and participation by the greatest number of agencies. This approach would be more cost- effective than contracting out for services. MoRAP staff will coordinate database design and development in support of natural resource planning and management in Missouri. Some of the major projects (i.e. ecological classification system, current land cover, aquatic resources, statewide elevation contours) will be carried out by staff associated directly with the facility, while other projects and tasks will be carried out at other sites by MoRAP cooperators with technical guidance provided by the MoRAP staff.
The various data development projects, their relationship to the GIS facility and the production of Coordinated Resource Management and GAP products, are illustrated in the flow chart. The overall project timetable calls for the production of lower resolution, statewide products in the short-term (year 1). The higher resolution products necessary for implementation of resource management objectives will be developed for a pilot region (Lower Ozarks) in the first three years, and subsequently, for the entire state over the following three years.

The projected six-year MoRAP budget totals $9,916,000; $2,381,000 for the technical facility staff and equipment, and $7,535,000 for project work. Initial start- up costs are necessarily high and will be shared by MoRAP cooperators, as will overhead costs such as salaries and benefits. Cooperators will be free to participate in those projects which offer the greatest benefit to them or for which they have the greatest responsibility. Additional funding will be sought from outside sources.

The Research Work Order for MO-GAP is in place. TM imagery has not been received yet. In the meantime, preliminary work has focused on coordination among state agencies, establishment of a classification system, and animal/habitat relationship models.

Ron Drobney and Tim Haithcoat
Missouri Cooperative Fish and Wildlife Research Unit
University of Missouri, Columbia

Montana

The map of existing vegetation and land cover is being developed across Montana according to a two-stage digital process. Landsat TM bands 4, 5, and 3 are classified by an unsupervised method which seeks to mimic the visual appearance of the false-color composite. Pixel groups smaller than a 2 ha minimum map unit (22 pixels) are identified and then merged with their most similar neighbor according to a rule-based model. A sample of the resulting spectral polygons is then ground-truthed to provide training data for the second-stage supervised classification to label all polygons. The efficacy of this process was confirmed for two pilot study areas in forested portions of western Montana and a rangeland site in central Montana . It was also determined that an average TM scene contained more than 300,000 raster polygons representing 25-35 different spectral classes. Given these numbers and the fact that 31 TM scenes are required to cover the state of Montana, the ground-truthing challenge was fully appreciated!

During 1993-1994, three different ways to obtain sufficient ground-truth data were pursued. First, timber stand data from the U.S. Forest Service and Montana Department of State Lands were evaluated. Unfortunately, even when these sources were readily available in digital form, they required considerable manual effort to import and query in ARC/INFO. Another drawback is that these data were collected primarily from stands of merchantable timber on public lands; consequently, they are not representative of the landscape that MT-GAP is trying to map. A second approach was to produce map overlays of the unsupervised spectral classification scaled to 7.5 minute USGS topographic quads. Last field season, more than 80 of these "spectral quads" were taken into the field and ground- truthed by Forest Service personnel in western Montana. Because the Forest Service crews had other work to do, they were not able to collect as much data as had been hoped. Nevertheless, the quality of the data provided by these crews was consistently high, and their plots spanned a wide range of cover types.

A third approach was to evaluate the use of airborne videography. A contract with Lee Graham and Dana Slaymaker (Resource Mapping Systems, Inc., Tucson, AZ) allowed them to fly several transects across the pilot study area in the Seeley-Swan Valley and to provide georeferenced video imagery. The challenge with this method was how to reliably distinguish plant species composition on a video monitor. Fourteen different coniferous tree species occur in western Montana, and MT-GAP found that several species were very difficult to identify from the airborne video. In fairness to Lee Graham and Dana Slaymaker, not all options were explored before abandoning their method; it may be that a crew could have been trained to recognize different crown patterns. Another alternative developed which, though more costly and time-consuming, had certain strategic advantages - that was to join forces with the Forest Service, Northern Regional Office, and the Columbia River Basin Assessment Project to map existing vegetation and land cover across western Montana and northern Idaho. For this effort, MT-GAP is supplying approximately 500 spectral quads to 17 Forest Service field crews whose primary responsibility is to ground-truth all the different spectral classes in different landform groups. Data from 9,000 plots were obtained in 1994; another 10,000 are planned for 1995. Twenty percent of the data will be held aside for an accuracy assessment.

MT-GAP is working with two advisory groups to develop rules to predict the distributions of most threatened and endangered species. Models have been implemented and refined for several species based on the Seeley/Swan vegetation map. Considerable work remains to be done to complete the wildlife distribution models and to implement them in ARC/INFO. Finally, the 1:100K statewide ownership map should be completed by the BLM, Montana State Office by June 1995.

Roland Redmond
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Nebraska

Planning for the spring 1995 initiation of Gap Analysis in Nebraska is underway. The program is being jointly led by Dr. James W. Merchant (Center for Advanced Land Management Information Technologies, University of Nebraska-Lincoln) and Dr. Dennis E. Jelinski (Department of Forestry, Fisheries and Wildlife, University of Nebraska- Lincoln). Cooperators currently include the State Museum of Natural History, the Nebraska Game and Parks Commission, and the Nebraska GIS Steering Committee. A Nebraska Gap Analysis Workshop, designed to broaden participation in the GAP Program, is being planned for spring 1995. Landsat Thematic Mapper data covering the entire state have been obtained, and efforts to develop a land cover database for Nebraska are beginning.

James Merchant
University of Nebraska, Lincoln

Nevada

Nevada Gap Analysis is proceeding. Land ownership has been completed, and the first generation wildlife habitat relation (WHR) models are largely done. All training points for cover-type mapping have been collected and are being used to model cover-types. Nevada cover-types in 5 ecoregion blocks are being modeled in parallel. Anticipated completion date of the vegetation modeling is 1 June 1995. Per agreement, a copy of the information is transferred to the University of Nevada-Reno conservation biology program as it is completed. For further information contact biod@nr.usu.edu.

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UT Coop Fish and Wildlife Research Unit
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New Hampshire

(See Vermont)

New Jersey

(See Maryland, Delaware, and New Jersey)

New Mexico

Imagery Classification

Raw '93 imagery was obtained from EROS last May for the purpose of filling some substantial cloud holes. The process of conversion, geocorrection, tagging, and stitching the segments into the final map was completed in June. Eighteen urban areas with two classes were included. The final steps included two rounds of single pixel "majority filtering" and then eliminating all polygons <25 contiguous pixels; a "rubbersheeting" geocorrection to bring the entire statewide map into compliance with the 1:100,000 usgs dlgs. then a clean-up of elevation ranges was conducted on a regional basis, using information solicited from cooperators around the state. a 100 ha aggregation process was undertaken and completed. as with most states, the vegetation map production has been the most costly and frustrating aspect of the project, especially when problems arise that would be fairly easy to fix given more time and money.

Verification

The process is in place to begin shipping 1:100,000 maps to approximately 100 cooperators statewide for field assessment. All aspects of the process have been tested. However, the logistics of producing and shipping several hundred plots, coordinating the cooperators, and determining how much of the work the cooperators will actually complete are daunting tasks. Temporary staff was hired last fall to assess locations missed by the cooperators. New Mexico is the first state to complete a statistically valid field assessment of a "machine classified" TM vegetation map. If the project is successful, the results will be published.

Land Ownership and Management

The PLSS ownership data from EDAC at UNM has been received. It was produced as a joint project between the state and BLM. Assembly of management maps from all state and federal land agencies, some tribes, and large landowners (e.g., the Turner Ranches) is about 90% completed. A matrix of land management types with generic descriptors which combine Ownership Status, Level of Legally Mandated Management, and specific Land Types such as "National Park" has been developed. This has been mailed to approximately 25 people representing a broad spectrum of interests. The participants have been asked to match generic descriptors with specific land types and then categorize both to the national scheme, allowing for subcategories as they see fit. The results will be used to develop a standardized method of categorizing all possible land uses according to its management for biodiversity. This spring, the cooperator management maps and the categorization scheme will be used to attribute all 40-acre units of the PLSS.

Public Outreach

The project was presented to the Native Plant Society where more volunteers were brought on-board for field assessment of the vegetation map; it was also presented to the Los Alamos National Laboratory summer workshop for science teachers, and an article appeared in the December 1994 issue of the American Planning Association's "Environment and Development" newsletter.

Note on Imagery Acquisition

EOSAT has been contacting us with some question as to the legality of our cooperative purchase, namely, that the geocorrected data may not be different enough from the raw imagery to warrant broad distribution. In a recent communication from them it appears that as long as our cooperators are using the imagery for purposes directly related to ours, then we are in compliance.

Patrick Crist
New Mexico State University, Las Cruces

New York

A preliminary, unsupervised natural terrestrial vegetation cover classification for twelve Landsat Thematic Mapper scenes has been completed for New York State. Clustering algorithms in the ERDAS

ISODATA routine, specifying 100 clusters, were used for the preliminary classification. Cluster labeling has been completed. Edge matching and integration of TM data with other GAP data layers was undertaken in August 1994. Ground-truthing of completed scenes will continue through 1995 to improve classification accuracy. The preliminary vegetation classification coverage will be refined and field-checked in cooperation with EPA during 1995 and 1996.
ERDAS*.SBD files have been converted to ASCII format and imported into Quattro-Pro for computing band ratios so these ratios and individual band cluster statistics are available during the labeling process. In addition to the cluster statistics, NHAP aerial photographs are being used for reference during the labeling process. Clusters are being labeled according to Level III of the Jennings GAP classification scheme.

A reasonable amount of success is being realized in classifying TM scenes into the following categories: Natural Terrestrial Cover (forest, deciduous; forest, evergreen; shrub, deciduous), Natural Aquatic Cover, Water, and Developed Cover (cropland/pasture, urban). Categories of aquatic cover below Level I of Jennings are not classifiable. Spectrally, water looks like water whether it is in a river, estuary, or lake. Wetlands (palustrine) should be classifiable, but not without more field knowledge required to distinguish forested from non-forested wetland cover types. Difficulties have also been encountered in the classification of woodlands, mixed forest, and pasturelands.

To assist in refining the preliminary classification of TM imagery, several reference sites across New York State have been identified for which detailed vegetation inventories already exist. In addition, NY-GAP is cooperating with the New York Natural Heritage Program to obtain ground truth information from an ongoing project that is surveying the biodiversity of state wildlife management areas.

The following GAP-related coverages have been acquired in digital form or have been digitized during the course of the NY-GAP Project and are available at the Cornell facilities: national forest boundary, state and national parklands, state freshwater wetlands, sensitive/threatened/ endangered species (from NY Natural Heritage Program), butterfly distributions, breeding bird atlas database, mammal distributions, state wildlife management areas, and USGS digital elevation models (1:250,000). NYSDEC will be providing information from its amphibian and reptile atlas as it becomes available, and arrangements are underway to acquire or create state forest land boundary files. In addition, the soils geographic
database (STATSGO) and a growing degree-day (GDD) map for New York State have been compiled. The STATSGO and GDD maps will be combined with the digital elevation model and cluster statistics to define and delineate vegetation regions within the state. The degree to which these regions correspond to one of several versions of "ecoregions" within the state will be investigated.

Charles R. Smith, Stephen D. DeGloria, and Milo E. Richmond
Cornell University, Ithaca

Oklahoma

The Oklahoma Gap Analysis Project (OK-GAP) is up and running! The Oklahoma Cooperative Fish and Wildlife Research Unit (OKCFWRU) began preliminary work to initiate Gap Analysis in 1991. Since then, OKCFWRU staff have attended national and regional (Region 2) Gap Analysis meetings and conducted or participated in informal meetings with state and federal agencies and private groups in Oklahoma to develop a core of project cooperators.

In December 1992, the OKCFWRU conducted the first OK- GAP Cooperators Meeting. The purpose of the meeting was to provide an overview of the project and discuss its implementation in Oklahoma. Twenty-three people representing four federal agencies, six state agencies, two universities, and one private group attended the meeting. Potential cooperators were asked to define their anticipated level of cooperation from three categories: contractual (responsible for development of the data layers), contributing (willing to provide existing data), and consulting (willing to provide technical advice). A few cooperators expressed interest in a contractual arrangement. Many others indicated a willingness to be contributors or consultants.

The second cooperators meeting in February 1994 was attended by 18 people representing 12 government agencies, universities and private concerns. Groups separated by data layer discussed data standards, availability, sharing, and ownership. The coordinator for the Oklahoma Biodiversity Project, a planning effort funded by Weyerhaeuser through the Oklahoma Department of Wildlife Conservation, provided an update on the status of this three-year study. The goal of the study is to make recommendations for the conservation of Oklahoma's biodiversity and to integrate these with human uses of natural resources. A state Biodiversity Council, composed of private and public landowners and managers and interested science and conservation groups, will be responsible for overseeing the development and implementation of this biodiversity plan. OK-GAP will be coordinating with this research effort to help ensure the success of biodiversity conservation in Oklahoma.

Development of OK-GAP data layers will be a cooperative effort between the OKCFWRU, the Department of Agronomy at Oklahoma State University (OSU), and the Oklahoma Natural Heritage Inventory (ONHI). Staff at the OKCFWRU are coordinating the project as well as performing data analysis and interpretation. The Department of Agronomy currently has OSU's most up-to-date GIS and remote- sensing hardware and software and considerable technical expertise. Mark Gregory heads up this lab and will be responsible for preparing the vegetation and land ownership layers. The ONHI houses databases on many of Oklahoma's plants and animals, particularly threatened, endangered, and declining species. Dr. Mark Lomolino will be coordinating development of the animal distribution data layer for ONHI.

The results to date are exciting. Nine TM scenes have been received and are being processed. Unsupervised classification is used for the first cut; the second pass will be supervised, once videography data are obtained. A portion of the videography will be held back for accuracy assessment. Wildlife habitat models are being developed. The ownership layer is being digitized in cooperation with the Heritage Program. Substantial progress toward the creation of the vegetation and animal distribution data layers is anticipated this year.

Bill Fisher
OK Coop. Fish and Wildlife Research Unit
Oklahoma State University, Stillwater

Oregon

Although fine-tuning continues, the basic data layers for the Oregon Gap Analysis Project (vegetation, land ownership, and special management areas) are essentially complete. Work on the species distribution maps is being closely coordinated with the pilot program of the Biodiversity Research Consortium (BRC). First drafts of predicted species distribution maps have been generated with assistance from BRC cooperators and sent out for expert review. The Nature Conservancy has developed a software package using FOXPRO that allows on-screen editing of distribution by EMAP 635 km2 hexagons. Species are predicted to be present in appropriate vegetation polygons within a hexagon.

LANDSAT MSS 1:250,000 imagery was photo-interpreted to create the first Oregon vegetation map. The map depicts the distribution of 133 vegetation cover types and contains over 6,900 polygons. The Oregon Department of Fish and Wildlife (ODFW) has taken responsibility for upgrading the map with LANDSAT Thematic Mapper imagery to current national Gap Analysis standards. This two-year project began in July 1994. ODFW contracted with Dr. Lee A. Graham, Arizona Gap Analysis Principal Investigator, to provide low altitude airborne video photography for Oregon. Seven days of airtime in August and early September 1993 yielded about 19,000 georeferenced video frames which sample about 3% of the state. With appropriate ground validation, these images will be used for training sites, labeling, and accuracy assessment.

The Defenders of Wildlife has developed a proposal to prepare an Oregon Biodiversity Plan based on the results of Gap Analysis. The proposal calls for a two-year effort which would bring both scientific and policy representatives from state, federal, and private resource management interests together to review the analysis of the Oregon data layers and take action to conserve areas rich in underrepresented elements of biodiversity. The EPA's Environmental Research Laboratory has recently hired a programmer/statistician whose major responsibility will be analysis of the Oregon GAP data sets.

Other Accomplishments

1) Digital coverage for the wetlands data that show areas 100 acres or greater from the NWI has been completed. The other digital data layers have also been completed (i.e. managed areas, ownership, and vegetation); however, none of these maps have been field- verified.

2) A Star-Lan network with PC to UNIX workstation to allow digital TM Landsat scenes to be accessed and stored on an optical drive has been completed.

3) Oregon Species Information System (OSIS) has been updated to an SQL standard with Advanced Revelations 3.0. Distribution of species continues to be updated along with taxonomy, status, habitat associations, and life history. Currently, 40 copies of OSIS have been distributed within the state at ODFW, Bureau of Land Management, Forest Service, and U.S. Fish and Wildlife Service offices.

4) OSIS to ARC/INFO programming has been streamlined.

5) A Wildlife Habitat Map has been developed from a cluster analysis of the original 133 habitat types and their associated species data.

6) An initial assessment of biodiversity is being conducted using the existing vegetation map.

7) Eighteen of 23 TM Landsat scenes have been received and read.

8) An Aquatic Gap Analysis Proposal has been written and is being circulated to potential funding agencies.

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U.S. Fish and Wildlife Service, Portland
Thomas O'Neil
Oregon Department of Fish and Wildlife, Corvallis

Pennsylvania

Our first GAP product, called PENN for Pennsylvania Environmental Network Navigator, is environmental metadata as hypertext on a self-contained diskette for PCs. PENN will be distributed widely without charge and will be updated regularly. If you are interested in receiving this information, send us a high-density diskette.

The same shell used for PENN also supports a hyperforms system for tracking progress on Pennsylvania GAP species. Our taxeme is all vertebrates, both terrestrial and aquatic, that breed in Pennsylvania. Progress is being made on distributional information since range maps have been captured in digital form for all mammals, reptiles, and amphibians. The recent Pennsylvania Breeding Bird Atlas has Atlas-GIS as its host system. The Nature Conservancy has completed the EPA hexagon encoding for Pennsylvania fauna. That leaves fishes and habitat suitability models on the faunal side.

The first installment of MRLC Consortium TM data was received shortly before the 1994 GAP Investigators Meeting in Seattle. Staff participated in a MRLC Spectrum software workshop held in July in Reston, VA. PA-GAP plans to be among the first states to base their vegetation map on hyper-clustering with Spectrum. Resolution of about 5 ha is being targeted to satisfy needs of all MRLC interests. Therefore, intelligent generalization of thematic rasters becomes important; customized software will be developed. The G.P. Patil's Center for Statistical Ecologyand Environmental Statistics at Penn State is cooperating on advanced sampling approaches to quality assessment.

Objective approaches for defining centers of species richness are being initiated. New concepts for object- oriented approaches to virtual (in this case biotic) topographies received their first public exposure at the August joint statistical meetings in Canada.

Instead of seeking direct outside funding, Pennsylvania Gap Analysis is concentrating on convergence of programmatic efforts. The Delaware Water Gap National Recreation Area will be the testbed for high resolution vegetation mapping with Spectrum. The Pennsylvania Game Commission is supporting an intensive landscape ecological modeling project for bobcat. PA-GAP is playing an integral part in the effort to delineate ECOMAP down to the landtype association level. A variety of programmatic efforts are contributing ancilliary GIS layers. Liaison with neighboring states is being maintained to keep updated on their Gap Analysis work.

In summary, Gap Analysis is viewed more as a stepping stone in evolving landscape ecological understanding for Pennsylvania than as an endpoint. It also provides an ideal testbed for development of advanced approaches to spatial information. In this spirit, a re- interpretation of GIS as Geographic Inferencing Systems is advocated.

Wayne Myers, Gerald Storm, Robert Brooks, and Joseph Bishop
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Tennessee

Vegetation Mapping Currently, the Tennessee Valley, representing 54% of the state, has been classified to Anderson Level II. The remaining 46% of the state should be completed at this level by March 1995. Accuracy assessment of the classification was done by the Tennessee Valley Authority (TVA) using a stratified random sampling design for a majority of the sample points. Further image processing to distinguish plant communities will involve masking the image to select only the class of interest. The new classes will then be labeled using aerial photos, field checking, knowledge of natural resource managers, and ancillary data layers. The vegetation classification system used by The Nature Conservancy will be the basis for naming plant communities. A crosswalk between this system and the modified UNESCO classification scheme will be conducted. The accuracy of the completed vegetation map will be assessed by post- classification field checking.

The applicability of air-videography methodologies in Tennessee will be tested in cooperation with the U.S. Forest Service. In the spring of 1994, transects were flown every nine miles in an east-west direction in the Elk River watershed. A considerable amount of analysis remains to be done with the video that was obtained. If it is determined that this technique is applicable, more flights can be flown in the spring of 1995.

Vertebrate Species Mapping

Tennessee's native fauna includes approximately 65 amphibians, 55 reptiles, 170 breeding birds, and 70 mammals. Range maps have been produced with data from the Breeding Bird Atlas, Tennessee Animal Biographies (TABS), and Vertebrate Characterization Abstracts (VCA). Point data for rare animals was provided by Ecological Services (Tennessee Heritage Program). Comments on the maps are being solicited from biologists.

Habitat data resides in VCA and TABS. Updated information was obtained from the Fish and Wildlife Information Exchange Master Species Files. Paul Hamel's "Land Managers' Guide to the Birds of the South" will be used as the major source of avian habitat types. Habitat types in the GAP databases still need to be cross-walked to the vegetation classification once the satellite imagery processing has been completed. Graduate research focussing on trapping small mammals from a variety of habitats in the Catoosa Wildlife Management Area will test the predictions of species' presence or absence.

Land Ownership and Management

The Tennessee Wildlife Resources Agency's GIS system contains coverages of public lands and acquired wetlands. The public lands database is being updated through a cooperative effort between the Tennessee Department of Environment and Conservation Recreation Planning Division. This task should be completed by March 1995. A subcommittee of the Biodiversity Team has begun to categorize lands as to their management status. Proposed criteria to be used in Tennessee were reviewed by the Protection Planning Committee and will also be reviewed by a committee of state and federal agencies who own and manage land in Tennessee.

Clifton J. Whitehead
Tennessee Wildlife Resources Agency, Nashville

Texas

The Gap Analysis project in Texas was formally initiated in October 1993. Dr. Nancy Mathews, Assistant Wildlife Unit Leader of the Texas Cooperative Fish and Wildlife Research Unit, is the principal investigator of the project. Initial work focused on establishing a network of collaborators. Cooperators for the vegetation, vertebrate range and boundary layer maps have been identified and contacted. In close cooperation with the Mapping Sciences Lab at Texas A&M University, a new GIS Lab was established at Texas Tech University, specifically for the GAP program. Matching equipment funds were provided by the U.S. Army Corps of Engineers, Construction Engineering Research Laboratory.

In February 1994, Lloyd B. McKinney from the Mapping Sciences Lab, Texas A&M University, was hired as the temporary Assistant Texas Gap Analysis Coordinator. His charge was to design and set up the Gap Analysis Lab at Texas Tech University. Two Sun workstations, peripherals, software (including ARC/INFO and GRASS geographic information systems), and a digitizer were installed. Ancillary databases were loaded onto the workstations and included digital line graphs of road systems, soils, counties, and cities of Texas. Joy Winckel was hired as the full-time Assistant Texas Gap Analysis Coordinator in April 1994.

Vegetation Map

Vegetation mapping is in a startup phase. Because the State of Texas is so large and varied, the task of interpreting satellite imagery to prepare a draft vegetation map has been divided between Texas Tech University and Texas A&M University. A minimum mapping unit of 40 ha was chosen for the entire vegetation map with map accuracy being a minimum of 80%. Final maps will be produced at a scale of 1:100,000, although maps can be produced at 1:24,000. The first nine TM scenes (raw data) were received from EROS Data Center, as part of the nationwide acquisition, in late June 1994. By last fall, 27 TM scenes had been obtained. The estimated date of completion of the vegetation map of Texas is June 1997. A vegetation advisory board comprised of ecologists from agencies and universities has been assembled to guide vegetation mapping efforts. A vegetation classification scheme has been developed using the UNESCO format and vegetation series recognized by the Texas Natural Heritage Program.

Because over 90% of Texas consists of private lands, and access to these lands for ground truthing and correcting classified satellite imagery is problematic, airborne videography was chosen for truthing and accuracy assessment. The states of Texas and Oklahoma were simultaneously flown on flight lines spaced at 30 minute intervals. For Texas, the flights covered 9,978 miles and were completed in July 1994. Post-processing of videotaped transects includes extraction of single digital frames from the continuous video track, georectification of the image and writing the image to tape with a unique file identification number. Fully georeferenced images are then overlaid to the TM imagery or unsupervised output and queried for ground coordinates. A user interface program allows an operator to call up a video-frame image, query latitude/longitude positions for vegetation types displayed, and write both vegetation class codes and positions to a file. Image files are exported to 8 mm exabyte tape for transfer to the Sun workstations. The hardware required to operate the user interface includes a PC with SVGA graphics, a mouse, and an internal PC-NFS card to network with the Sun Sparc Server.

Vertebrate Range and Boundary Layer Maps

Cooperators have been contacted to determine their interest in compiling data on the vertebrate range and boundary layer maps. They include ecologists from universities and state agencies who are experts in their fields. Members of the advisory boards have been identified, and a meeting is tentatively planned for spring 1995. It is anticipated that mapping of these data layers will commence in FY '95 if adequate funding is available.

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Utah

Utah Gap Analysis is completed. All data are available through the Gap Analysis Home Page, http://www.gap.uidaho.edu/gap. Information available consists of the Gap-specified 100-ha MMU cover map, land ownership, wildlife habitat relation (WHR) models, and assorted reports. Ancillary information, such as DEMs, are not on-line but are available on request. Utah Gap information will be available on CD-ROM on February 27, 1995. A version of the Utah CD, containing all information plus limited interactive capabilities, is completed. All data dictionaries and metadata are completed and await the completion of the final report before they are published. Once completed, the final report will be released on CD and a series of four 1:500,000 scale maps printed by the USGS. Manuscripts on vegetation classification, WHR accuracy assessment, and cover map vegetation assessment are available on request. Further information can be obtained by contacting biod@nr.usu.edu.

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Vermont and New Hampshire

The GAP project in Vermont is part of a larger effort to map biodiversity throughout New England, in cooperation with the Massachusetts and Maine Cooperative Fish and Wildlife Research Units. Each unit involved in the project has region-wide as well as state-specific responsibilities. The Vermont unit is responsible for development of distribution maps of vertebrates and baseline species-habitat association matrices over the New England region. In addition, the Vermont unit is responsible for development of other Gap Analysis data layers for Vermont and New Hampshire. Though the New England project has experienced some delays in the acquisition and processing of Landsat data, the current phase of the overall project will be completed within the original timeframe. A final report is expected in spring 1995. Investigators will then be ready to begin follow-up work.

The second phase of data collection and analysis will focus on refinement of vegetation cover maps for the region, development of validation methods for the distribution of vegetation cover and vertebrate species, and refinement of mapping and spatial data analysis methods for these coverages. In preparation for these efforts, researchers with the Vermont Cooperative Fish and Wildlife Research Unit are evaluating aerial videography based on transects flown over Vermont and New Hampshire in 1994. In addition, system development has continued at the University of Vermont spatial data lab, with the objective of integrating GIS, photogrammetry, image processing of Landsat data, and analysis procedures for spatially registered data.

Land Ownership and Management

The Vermont unit has compiled maps of conservation lands in both Vermont and New Hampshire, in cooperation with the VT Department of Fish and Wildlife, the VT Department of Forests, Parks, and Recreation, the NH Department of Fish and Game, and the NH Office of State Planning. These maps identify land ownership and, in some cases, land use and protection status. More than 90% of Vermont and New Hampshire land is dominated by private ownership of small, disconnected parcels of land. Approximately 5% of the land is under federal ownership and another 5% owned by the states. Privately-owned lands with special protection status (e.g., TNC lands) constitute only a very small and highly fragmented component of the network of conservation lands in both states. Almost all federally-owned lands are in a few large tracts constituting the Green Mountain and White Mountain National Forests. Most of the state land holdings are in a few large state forests and recreation areas, along with a large number of small parcels. The latter are highly dispersed, geographically disconnected, and thus of limited value as corridors in a conservation network.

Vegetation Maps

The Massachusetts Cooperative Fish and Wildlife Research Unit is nearing completion of the vegetation mapping of New England and has delivered digital maps of Vermont and New Hampshire to the Vermont unit. The classification of upland cover in these maps is limited to deciduous, coniferous, and mixed classes, which allows only a limited refinement of vertebrate range maps for Gap Analysis. Additional resolution in vegetative cover maps will be a focus of follow-up investigations in Vermont and New Hampshire.

Vertebrate Maps

Ranges and habitat associations have been processed for approximately 380 terrestrial vertebrate species in New England, including 25 amphibians, 29 reptiles, 651 mammals, and 265 birds. Species names have been converted to a common coding scheme for species listed in the breeding bird atlases for all six New England states, and all breeding bird data have been converted to ARC/INFO format. The Nature Conservancy Natural Heritage databases for the New England states have also been converted. Data from 165 breeding bird survey (BBS) routes in New England have been summarized and digitized. Breeding Bird Atlas, Heritage program, BBS, and other data sources were used along with the EPA-EMAP hexagonal grid to produce standardized species range maps for New England.

Regional species-habitat association matrices have been produced from published associations for New England vertebrates, with refinements at the state level based on local information and data records. A number of matrices have been coded at several levels of resolution in land cover, thereby facilitating a Gap Analysis depending on the amount of refinement in the land cover classification. ARC/INFO AMLs have been developed to allow for refinement of species range maps based on the land cover classification, either collectively with groups of species, or on a species- by-species basis. An ARC/INFO user interface has been developed that allows user-friendly access to GAP databases, including vegetation cover maps, conservation land maps, and predicted species distributions.

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Virginia

Various stakeholders in Virginia were contacted in preparation for funding of the Virginia Gap Analysis Project (VA-GAP) in FY '94.

The following agencies/programs were briefed and have expressed an interest in participation:

Virginia Department of Game and Inland Fisheries (VDGIF),
Virginia Natural Heritage Program,
Jefferson National Forest,
Virginia Tech College of Forestry and Wildlife
Virginia Tech Department of Entomology
U.S. Army Ft. Pickett and Ft. A.P. Hill
Virginia Water Resources Center, and
Environmental Protection Agency

A long list of other potential cooperators will be contacted and invited to a state coordination meeting for the project. Staff will also be participating in the Multi- Resolution Land Characteristic Interagency Consortium for the Mid-Atlantic region.

VDGIF has agreed to be a contributing partner by providing a GIS systems analyst and equipment and has committed resources to updating existing wildlife information systems, particularly distribution and habitat relationships data. VDGIF has included VA-GAP in its long- term strategic plan for information systems and has agreed to maintain and distribute VA-GAP products at the close of the project.

To distribute fish and wildlife information in Virginia, including VA-GAP products, the Virginia Fish and Wildlife Information System has been revised and placed in a dial-up network for access by cooperators and the public. The system will enable any biologist in the Commonwealth to use a microcomputer and a modem to access all the data on distribution, ecology, scientific collections, and taxa- specific surveys for all vertebrates and selected invertebrates that occur in Virginia, as well as threatened or endangered plant and insect data compiled by the Virginia Department of Agriculture and Consumer Services.

Virginia has received GAP funding as of September 15, 1994 and looks forward to receiving its Landsat imagery. In the meantime, data on wildlife distribution and wildlife/habitat relationships are being prepared. Work on the land ownership data layer is being done by Virginia Commonwealth University. Through cooperation with the Virginia Department of Planning and Budget, SPOT Panchromatic data for the entire state may become available. The Department of Planning and Budget has also increased funding for VA-GAP. The excitement level is quite high in Virginia. Although the state has a long history of GIS and wildlife information system development, this project will be the first to pull together a statewide land use and vegetation coverage. With the exceptional support from VDGIF, the issue of implementation at the end of the project is already resolved.

Jeff Waldon
Fish and Wildlife Information Exchange, Blacksburg

Washington

In 1994, WA-GAP made significant progress toward a Gap Analysis for the State of Washington. A draft landcover map was completed using a hierarchical cover type classification based on the U.S. Forest Service's Ecoregion/Ecozone system. Nearly all vertebrate databases have been compiled, and efforts are being channeled into producing preliminary habitat association models for expert review. In addition, close contact has been maintained with WA-GAP's extensive cooperator network, working closely with individuals around the state to provide crucial last minute input for land cover and vertebrate distribution refinement.

Vertebrate modeling began in early August with the completion of the landcover map. Currently, 50 maps from the bird database have been completed. These are primarily east-side breeding birds which inhabit shrub-steppe and grassland habitats. Maps are being created using a combination of published data on habitat associations and location data from the Breeding Bird Atlas (approximately 100,000 records). Bird modeling was completed in December 1994 with the preparation of habitat association maps for 250 species. Mammal draft models (142 species) will be completed in January 1995. Approximately 3,600 point locations for the 51 herp species in the state have been digitized. The National Wetlands Inventory (NWI) files for Washington are already available in digital format. This information will be used in modeling the habitat associations of species, particularly amphibians, which utilize the micro-habitats included in the NWI, but which are smaller than the minimum mapping unit (100 ha).

In addition to meeting the obligations to the National GAP Program, WA-GAP is working on several

Gap Analysis related pilot projects. One project with Dr. Gary Machlis, from the University of Idaho, will incorporate socioeconomics into a Gap Analysis for the Puget Sound Region. Under this project, socioeconomic data will be overlaid onto the traditional Gap Analysis to determine socioeconomic zones of influence for identified gap locations. WA-GAP is involved in a pilot ecoregion analysis for the Nisqually and Turnbull National Wildlife Refuges. In addition, WA-GAP was awarded $100,000 by the Environmental Protection Agency to further delineate agricultural lands within the state. A preliminary Gap Analysis for the state will be completed early in 1995.

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West Virginia

In fiscal year 1993-94, the West Virginia GAP Project was fully funded for the first time. Significant progress was realized during the year in all aspects of the project. For example, a statewide GIS data base was completed for a variety of coverages - surface hydrology, historic land use/land cover, elevation and topography, transportation, watershed boundaries, wetlands, and soils. In addition, a variety of ancillary data have been incorporated into the project database (e.g. multiple AVHRR images and classifications, historic TM and MSS data, and derived climate rainfall and temperature data). Models of species/habitat relationships are under development and will be linked with available databases from a variety of state and federal agencies. The West Virginia project received the majority of its imagery in June 1994 as part of the Multi-Resolution Land Characteristics (MRLC) image acquisition. Prior to this, a mix of available historic imagery had been utilized.

Vegetation Analysis

In WV-GAP's remote sensing work over the years, it has been difficult to obtain suitably detailed vegetation classifications for the highly diverse forested landscapes of the central Appalachian Mountains. This has been particularly true for data such as Landsat TM, using traditional remote sensing techniques. Therefore, two different approaches that are promising for using multi- temporal (spring/fall) images have been explored.

The first approach is a variation on Ducks Unlimited's hybrid unsupervised/supervised clustering which was successfully used for delineating and classifying wetlands in the northern Great Plains. The second utilized the n-Dimensional Probability Function algorithm, as developed by Cetin and Levandowski (1991). The technique, while similar to traditional methods such as Principal Components, appears to be superior in its efficiency in processing numerous bands of data.

Work is proceeding on application of the n- dimensional algorithm to a pilot study area in one 1:100,000 map area that includes the most significant slope, elevation, soils, and vegetation gradients in West Virginia. The area also includes a wide sampling of vegetation communities and potential ranges for terrestrial vertebrates of special concern.

Species/Habitat Relationships

Development of a first-time data base of comprehensive habitat/species relationships has been underway since August 1993. Data are being input into the project habitat/species database which will include all bird, mammal, herptile, and butterfly species. Experimentation with alternative database designs that will efficiently satisfy the aggregate data needs of the project, while maintaining unaggregated data in forms useful to some of the in-state cooperators, is progressing.

Additional Data Development

The necessary public lands data for West Virginia have been collected and digitized from stable 1:100,000 and 1:24,000 base mylars. Coordination with other state and federal efforts has impacted the project in a variety of ways. For example, the GAP vegetation types for West Virginia are being coordinated with the Forest Service ECOMAP Project (which is using the Bailey hierarchical classification) and the Mid-Atlantic Highlands EMAP Project. Using a variation of the Arizona GAP approach, airborne videography will support image classification. About 8,000 video plots are planned along regular transects. These plots will be used to classify and field-verify cover types, treating them as ground training sites for supervised classification. In addition, a percentage of the plots will be reserved for verification of results and accuracy assessment.

Regular project updates are being produced for WV- GAP cooperators and interested parties. The first of these, a non-technical introduction to the project for study cooperators, was mailed to over 40 individuals during spring 1994. The second, which will be a technical introduction to project methods and results to date, is planned for distribution during spring 1995. Subsequent updates will address specific project components in greater detail.

Reference: Cetin, H. and D.W. Levandowski, 1991. Interactive classification and mapping of multi-dimensional remotely sensed data using n-dimensional probability functions (nPDF). Photogrammetric Engineering and Remote Sensing, 57(12): 1579-1587.

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Wisconsin

(See Michigan, Minnesota, and Wisconsin)

Wyoming

Wyoming Gap Analysis (WY-GAP) is now seeing the fruits of its hard work. Positive feedback was received from cooperators during the April 1994 Annual WY-GAP Meeting, which Mike Jennings attended. In 1994, the first iteration of a land cover map was produced following the methods used by California Gap Analysis. The map is based on 46 types which meet the National GAP Standards. Portions of the map are currently being field-verified by a number of cooperating agencies. The second iteration and its data dictionary are expected to be completed by the end of February 1995.

WY-GAP staff have also completed an initial draft of the land status map and data dictionary. Land status was digitized for approximately 70% of the state from paper maps at 1:100,000, and data was adapted for 30% of the state from the Bureau of Land Management's digitized data at 1:24,000. The digital map is generally available and has been distributed to a number of agencies for review.

Compilation of point data bases of vertebrate species distributions from across the state has been completed and includes some 660,000 data records. As part of the first phase of mapping species distributions, WY-GAP has adopted the Environmental Protection Agency's hexagon grid system and "populated" the hexagons for each terrestrial vertebrate species according to a ranking of confirmed, probable, or possible. The hexagon distributions of species are currently under review by state experts. Species distributions by cover types within hexagons is expected to be completed and reviewed by early 1995.

Staff: Tom Kohley, Ken Driese, Brad Ball, Margo Herdendorf, and Pete Gillard. Principal investigators are Evelyn Merrill, Department of Zoology and Physiology; William Reiners, Department of Botany; Stanley Anderson, WY Coop Unit, and Ronald Marrs, Department of Geology.

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