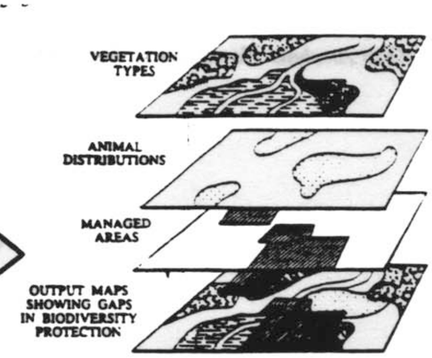
Gap Analysis Newsletter



Volume 1 Number 1 Spring 1991

Welcome

Welcome to the first issue of the *Gap Analysis Newsletter.* This is an informal product intended to share information among scientists and staff involved in the Gap Analysis Project and to foster coordination and cooperation among all participants.

The Gap Analysis Program is growing by leaps and bounds. Initially funded by the Idaho Department of Fish and Game, and the National Fish and Wildlife Foundation since 1989, major funding has come from the U.S. Fish and Wildlife Service with significant contributions from private and state cooperators. From that beginning only 3 years ago, we have seen the budget and the number of states involved expand dramatically. The President's FY92 budget includes funding for the program in the base for the first time. The number of states and other agencies seeking a Gap Analysis of their land is growing even faster than the budget. As the first real results are produced, we see the potential opportunities expand, and support for the concept grows seemingly exponentially, with them.

Our vision at this time is to complete the Gap Analysis nationwide before the end of the decade. The data gained will provide critical information for land and resource management and acquisition, with direct benefits to the protection of biological diversity, and can also serve as a baseline against which we can assess future change. To achieve these goals we need to maintain consistency, continuity, and communication. This newsletter will provide one means for that communication.

Best wishes on this exciting endeavor.

Ted LaRoe, Director
Cooperative Research Units Center
U.S. Fish and Wildlife Service

Director's Corner

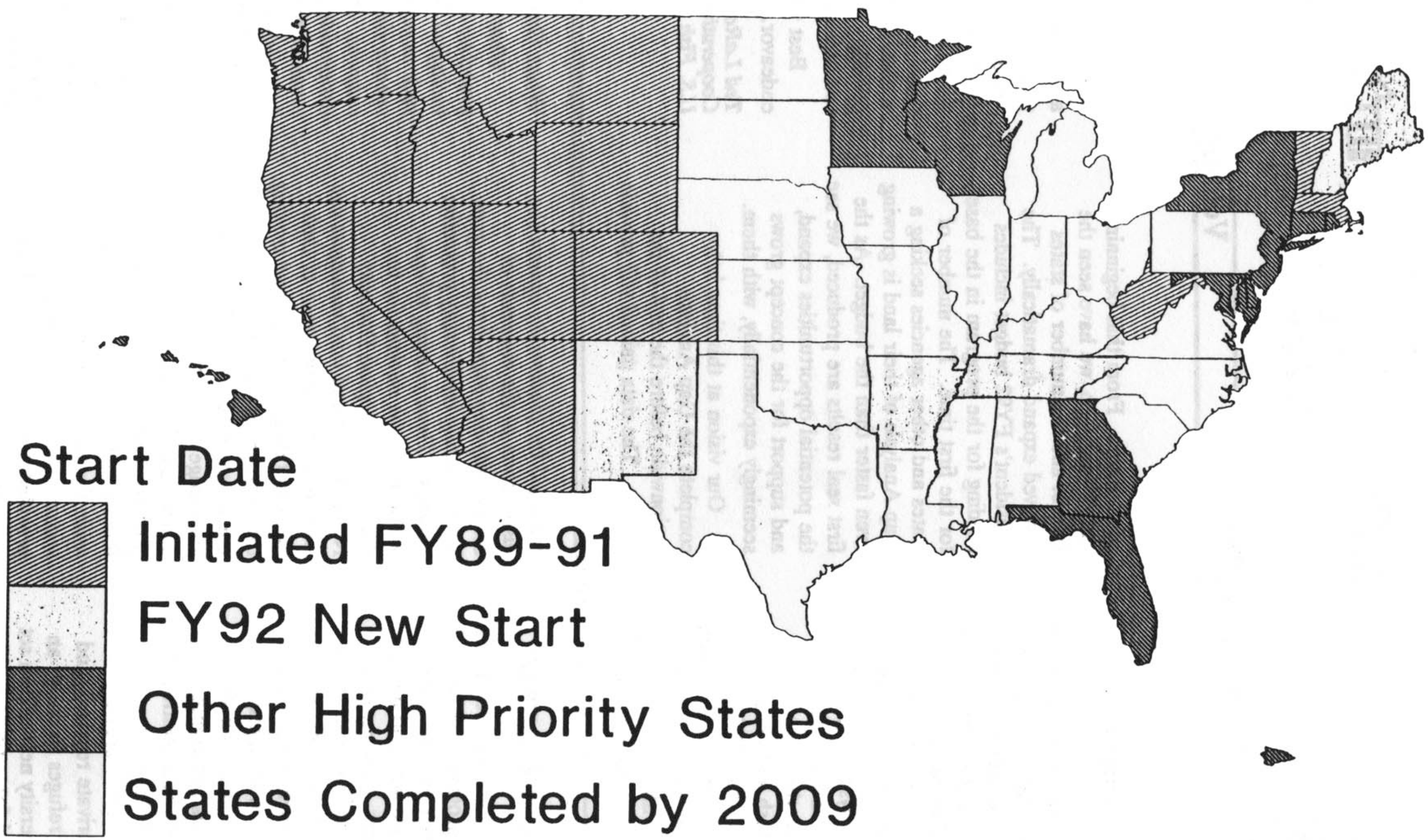
The information obtained during a Gap Analysis program can be used for a variety of purposes by state, federal and private land and natural resource managers. Gap Analysis provides us for the first time with a national scorecard on which we can determine how much of our nation's biodiversity we have managed for long-term survival in self-sustaining natural populations and communities. As a result, we are in a position to add to the already impressive collection of wilderness areas, national parks, private reserves, and national wildlife refuges to create an American biodiversity network: a set of areas managed for survival of this nation's natural heritage into the 22nd century.

This can be accomplished by examining the distribution of lands managed for biodiversity against the distribution of the elements of biodiversity and identifying the gaps in the existing biodiversity protective network. These existing refuges would form the nucleus for the American Biological Diversity Network. Federal land managers can then assess the importance of their lands to filling these gaps and making the appropriate changes in land management practices. With full knowledge of the distribution of the elements of biodiversity, gaps in the protective network that fall outside federal and state lands could be set aside through efforts of the private sector. Using the information provided, the American biodiversity network can be fully implemented with the minimum expenditure of dollars and land.

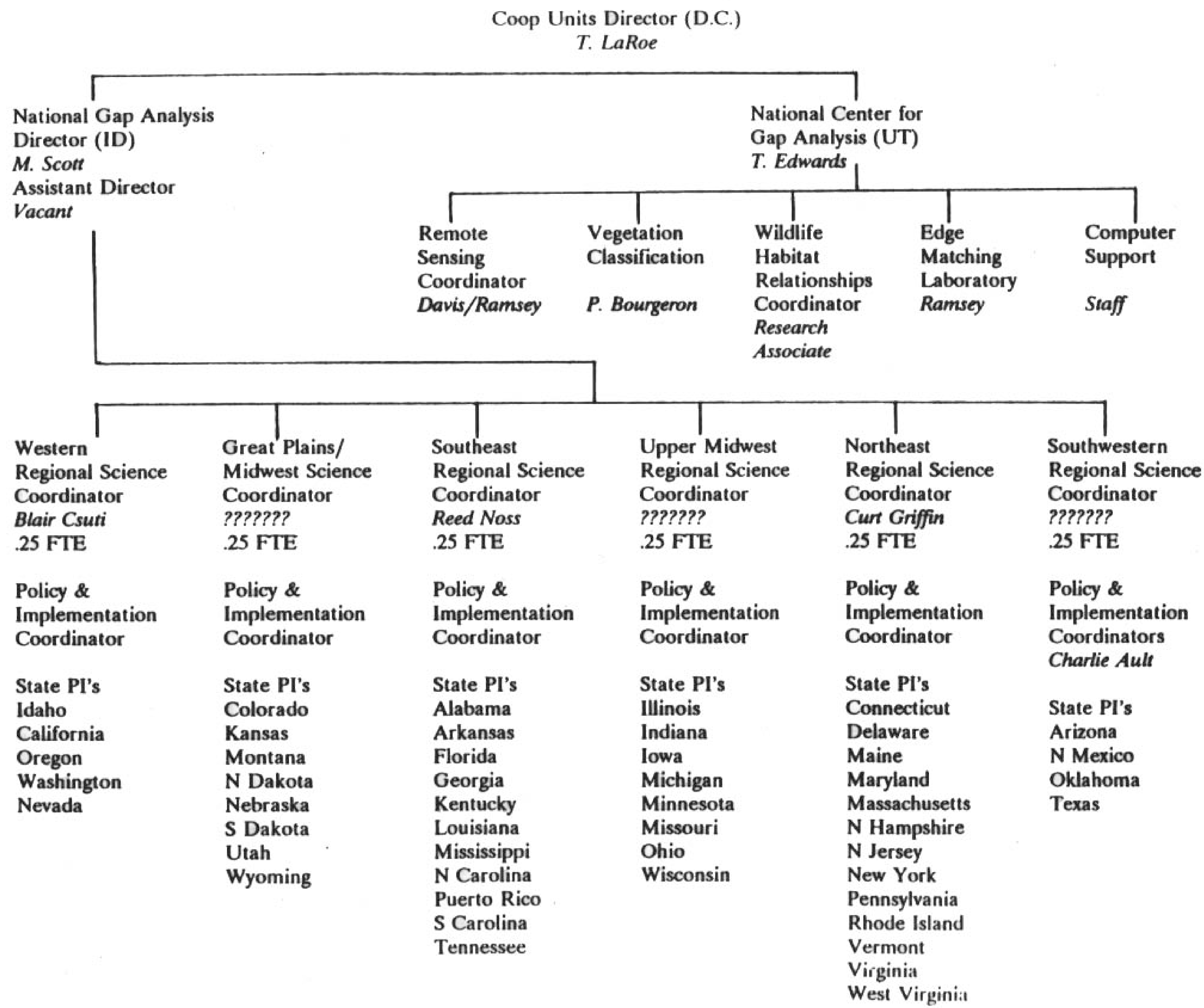
What Gap Analysis IS

What is Gap Analysis? It is a proactive approach to protecting biological diversity using surrogates such as vegetation type, vertebrate species richness and butterfly species richness. It is the first step in a nationwide program to assess how much of existing biological diversity falls within areas managed long-term for biodiversity. It builds on the strong programs initiated by the Nature Conservancy and individual states. It will provide focus and direction for efforts to conserve biological diversity. This is accomplished at landscape levels of resolution with scale ranging from 1:500,000 to 1:100,000 and minimum mapping units of 5-200 acres. Gap Analysis identifies and classifies biodiversity at the regional and state level and determines which components of biodiversity occur in

Status of Gap Analysis
($ 1 Million Base Only)



Completion 2 yrs after start.
Nation completed in FY2009 report to congress.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Southeast Regional Science Coordinator
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Curt Griffin
.25 FTE
Policy & Implementation Coordinator
State PI's
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Rhode Island
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Virginia
West Virginia
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Charlie Ault
State PI's
Arizona
N Mexico
Oklahoma
Texas

managed areas and which biodiversity components are not well protected.

Data layers included in a Gap Analysis include actual vegetation; terrestrial vertebrate distribution; areas managed for biodiversity; threatened, endangered and sensitive species distributions; butterfly distributions when available, and land ownership.

A map of actual vegetation is the backbone of any Gap Analysis. The purpose of the vegetation map is to identify the spatial distribution and protective status of major vegetation types, and to develop and refine range maps for individual species that can be used in wildlife habitat classification. Ancillary information used to map species distributions include elevation, distributional information on species from the Nature Conservancy, state wildlife information systems, U.S. Fish and Wildlife Service bird surveys, state atlases, and other published and unpublished distribution records.

What Gap Analysis is NOT

By combining modern technology (satellite imagery and Geographic Information Systems) with ecological concepts, Gap Analysis can provide a rapid, inexpensive and surprisingly reliable assessment of the distribution and status of biological diversity. However, every set of maps or computer databases has limitations and Gap Analysis is no exception. Here are some things Gap Analysis doesn't do:

Our vegetation maps do not show habitats smaller than the minimum mapping unit.

Many important wildlife habitats, like meadows or riparian areas in forests, are so small they don't show up on our vegetation. These habitats are critical for many wildlife species, but we can't depict them in our vegetation maps. We address them only as landscape components and predict their occurrence somewhere in a vegetation polygon, but not their precise location.

Our vegetation maps do not show stand age.

We are able to identify very early successional stages of forests (i.e., just after a burn or clearcutting), but it is difficult if not impossible to accurately determine stand age from satellite imagery.

The labels on vegetation polygons do not identify minor inclusions of adjoining habitat types.

The boundary between different vegetation types is rarely a sharp edge. There's usually a transition zone where patches of the two types change in frequency. A small sample plot in a transition zone may well have different vegetation than that predicted by our map label. This is an unavoidable by-product of cartographic generalization.

Our maps of predicted habitat distribution are not maps of species distributions.

Any distribution map is a generalized prediction of the presence of a species within its known distributional limits. Local populations may become established or die out on particular habitat patches. Gap Analysis predicted distribution maps are an application of the wildlife/habitat relationships concept to digital information storage and analysis. Comparisons of species lists from Gap Analysis data layers with those from well-studied field sites have been encouraging to date—with about 80% success in correctly predicting the species list. Just like any range map, the presence of a species on a site must be confirmed in the field.

Our maps of predicted habitat distribution do not reflect habitat quality or species density.

We make a prediction about the presence of a species in a landscape, but not about abundance. We predict a species to be present whether it is scarce or common.

Gap Analysis is not a substitute for threatened and endangered species recovery efforts.

Gap Analysis was designed to identify unprotected habitats and species before they become endangered. This knowledge will not help recover endangered species. We believe there are biological and ethical reasons to prevent anthropogenic extinctions and support efforts to rescue species that humans have jeopardized. We cooperate with state natural heritage programs to enter locations of threatened, endangered and candidate species into our GIS data layers. These localities can be used in conjunction with other data layers to develop fully integrated conservation strategy.

Gap Analysis is not a substitute for a national biological survey.

We need to improve our knowledge of the systematics, taxonomy and distribution of all species based on field observation and specimens. This will be a lengthy and expensive process, begun by the Bureau of Biological Survey in the nineteenth century. Because of rapid habitat loss, there is a need for a quick assessment of the probable distribution of species and communities for conservation purposes. Gap Analysis provides such an assessment. The distributional and ecological databases used in Gap Analysis will be improved as more of the nation's biological resources are adequately surveyed.

Practical Applications

When information on the distribution of the elements of biodiversity are combined with data on land zoning, predicted urban growth, urban and rural areas, and areas important for grazing, logging mineral activities and other exploitable natural resources, potential conflicts can be identified. This should facilitate preparation of long-term management plans for federal agencies, and to focus and prioritize land protection of private groups. As a result, it should be easier for resource managers to be proactive rather than reactive in their efforts to protect this nation's rich natural heritage.

Presently, Gap Analysis is being conducted in 13 states: California, Oregon, Washington, Idaho, Utah, Nevada, Arizona, Wyoming, Montana, Colorado, West Virginia, Vermont and Massachusetts. In addition, we are planning on developing and testing an aquatic Gap Analysis this year. The state in which the work will be conducted has yet to be selected. Gap Analysis of additional states will be initiated as funds and people become available. Building a regional and ultimately national map of biodiversity will start next fiscal year, and that work will be conducted at Utah State University in collaboration with researchers at UC Santa Barbara and the University of Idaho.

Finally, by providing for the protection of all elements of biodiversity, not just the rare ones, we will ensure that the greatest number of species and communities survive into the 22nd century as self-sustaining wild populations.

J. Michael Scott
U.S. Fish and Wildlife Service
National Gap Analysis Director
College of Forestry, Wildlife and Range Sciences
University of Idaho

State Reports

Arizona

The Arizona Gap project Statement of Work has been completed and been sent to the necessary authorities for signatures, so we are only a short time away from startup. In this interim period, Jim Walsh (Arizona Remote Sensing Center, UA) and I travelled to Phoenix. The purpose of the trip was to (1) address the AGIC council (Arizona Geographic Information Council) on the nature and status of the Gap project, and (2) meet with representatives from interested state cooperating agencies. The AGIC address went smoothly, and there seemed to be interest on the part of Council members in keeping track of Gap's progress. More important, Jim and I gathered quite a bit of useful information and support from people working with State Lands and State Fish and Game. These developments are summarized as follows:

1) Vegetation mapping: As predicted, the greatest amount of interest and controversy concerns this part of the project. In 1985, State Lands (primarily State Forestry) produced a land cover map of Arizona using Landsat MSS imagery. The major emphasis in this mapping project was aimed at forestry components of the landscape; hence, they used imagery from late summer, hence the criticism by some parties that rangeland/grassland communities were not adequately classified and mapped. Jim and I looked over their work and concluded that we probably couldn't do any better job on the forested areas using Landsat TM data. This allows us to acquire imagery from late spring (May), which will optimize the classification of rangelands. At the same time, we can acquire the GIS data set for the map State Lands put together to verify for changes and to compare the effectiveness of the two sources of imagery for vegetation classification. This is significant in that it should expedite and improve the product immensely. We obtained a copy of the vegetation classification used for the 1985 map and will distribute to the necessary parties.

We also have the support of Gary Irish, who is in charge of the state's GIS program. There is a significant amount of useful information to be gained from this database that will contribute to the success of Gap. The hydrologic and land ownership databases are currently being updated at 1:100,000-scale, complete with enhanced attribute coding. Both layers should prove useful to Gap.

2) Wildlife mapping: State Fish and Game is currently gearing up their GIS program. Gap will pay the salary of a technician to assist in updating the non-game Heritage database for 6-9 months. This database references all locations of species by some type of coordinate system (generally latitude/longitude) and will be useful in producing the wildlife habitat relationship maps. This database includes information on both plant and animal species, and so provides an avenue for extending Gap beyond the terrestrial vertebrate slant of the approach used in previous studies.

3) Data management aspects: In any large mapping study, there are problems to be addressed relative to data storage and retrieval. The state GIS program has also encountered these problems, and has devised library schemes for the geographic database that work for them. We plan to adopt a similar scheme for Gap, therefore assuring the databases we develop will meld nicely with those of the state.

The Gap project in Arizona is administered through the Arizona Cooperative Fish and Wildlife Research Unit and the Advanced Resource Technology (ART) program in the University of Arizona's School of Renewable Natural Resources. The ART program is geared toward developing, demonstrating, and transferring advanced technologies (including GIS, remote sensing, and GIS-based modeling) for more efficient resource management.

During January-February 1991, a series of meetings was held to introduce the Gap concept to Arizona resource managers and to identify potential cooperators. Dr. Lee Graham (ART/University of Arizona) is serving as Principal Investigator for Arizona Gap

Analysis. Dr. Graham is a systems ecologist with 7 years experience in GIS and remote sensing for forestry, wetlands, and wildlife applications. Co-investigators include Dr. Guy McPherson (UA plant ecologist, responsible for vegetation classification and mapping) and Mr. Jim Walsh (Arizona Remote Sensing Center, responsible for image classification and vegetation mapping).

Arizona already has a strong GIS program (ALRIS, Arizona Land Resources Information System), providing Gap with much of the required data and a strong base of people already familiar with GIS concepts and applications. A presentation to the Arizona Geographic Information Council (AGIC, consisting of representatives from state and federal land management agencies) stirred a great deal of interest in Gap. Additionally, we have enlisted the cooperation of Arizona State Lands Department (the agency that administers ALRIS) and the Arizona State Game and Fish (who maintains the game and non-game databases for Arizona).

Working with these cooperators, priority activities of the Gap project are summarized as follows. First, a need for enhancing the current vegetation map (completed in 1985 by the Forestry Division of State Land Dept.) was identified. This map was compiled from LANDSAT MSS imagery from late summer, is judged quite good for forested areas, but the classification is not sufficient for the lower elevation rangeland/grassland/-desert complexes. The Gap project will improve on this earlier effort by mapping from LANDSAT TM imagery from early spring, which will optimize the delineation of these vegetation classes. It will also allow us to map the Navaho Indian holdings, which were not included in the earlier map. Second, Gap will supply a technician to the Game and Fish to assist in updating the non-game Heritage database. Finally, initial mapping efforts will be concentrated in the San Pedro River watershed, an area of high interest to numerous state, federal, and conservation agencies. This pilot mapping project will also allow us to work out methodologies for using GPS-linked airborne video imagery for ground-truthing the vegetation layer. It will also help determine an acceptable vegetation classification scheme and minimal mapping unit.

Arizona is, of course, surrounded by other "Gap" states. Now that the framework for cooperation is established within the state, we will proceed with coordinating activities with our neighbors. Preliminary analysis indicates that there is a great potential of imagery-sharing with Utah.

Information on the Arizona Gap effort can be obtained by contacting Dr. Lee Graham (602/621-7270) or Dr. Eugene Maughan (602/621-1193).

Lee A. Graham, ART/SRNR, University of Arizona

California

Numerous efforts are underway by public and private groups in California to assess the status of biodiversity in the state. Most are being conducted at local to sub-regional scales, and many are focused on species or communities of special concern. Currently lacking is an overview of the protection status of species and communities both statewide and in the western U.S. as a whole. The California Gap Analysis project is aimed at providing this statewide perspective. It is a two-phase program, initially focusing on the southern half of the state (Phase I) and ending up with completion of the northern half (Phase II).

The California effort is using existing digital geographical data sets on land use, land cover, land ownership, topography, species ranges and locations of rare, threatened and endangered species. The effort is being coordinated by Dr. Frank Davis at the University of California, Santa Barbara, who, in cooperation with other groups such as the California Department of Forestry and Fire Protection, the California Department of Fish and Game, The Nature Conservancy, Southern California Edison and the State's Teal Data Center, is working to complete and/or to verify the accuracy of these data. Up-to-date maps of the distribution of vegetation and species habitats (Wildlife Habitat Relationships (WHR) Habitat Types) are being produced using Thematic Mapper satellite data. Upland vegetation mosaics will be mapped using a minimum mapping unit (mmu) of 100 hectares (247 acres). Major wetland areas will be mapped using a 40-hectare (99-acre) mmu. The accuracy of these maps will be tested and refined by extensive field reconnaissance and sampling.

Once the digital database is compiled, the WUR habitat relations models and digital species range maps will be applied to predict the current distribution of potential habitat for all native terrestrial vertebrate species in California (570 species), as well as patterns in potential species richness for selected groups. When possible, species distribution maps will be reviewed by specialists familiar with the taxa. They will also be compared to existing collection and sighting data.

The program has been underway since September 1990. Twelve graduate and undergraduate students are working on various aspects of the project. A mixture of hardware and software is being utilized, but the main platforms are DEC and IBM workstations running ULTRIX and AIX. Image processing software includes ERDAS, LAS and IPW (Image Processing Workbench). GIS software includes ARC/INFO, AUTOCAD and GRASS.

Several research issues are being addressed at the outset of this study, most importantly the appropriate techniques for mapping statewide vegetation, and the sensitivity of the biodiversity assessment to map scale and minimum mapping unit. A study of scaling effects in habitat models is underway based on a large set of vegetation transects located randomly across the southern half of the state. This study consists of mapping vegetation along 8-km x 125-m transects divided into 125-m x 125-m plots. One transect was located randomly in each cell of a 15- by 15-minute statewide grid. Vegetation along the transect is classified using 1986 high-altitude color infrared stereo photography and, where possible, field visits. Thus far, transects have been completed in 4 of 11 quadrangles (1:250,000) covering southern California: Bakersfield, Monterey and Santa Ana.

Tests of mapping methods are underway for a 1-degree by 1.25-degree region of the encompassing portions of the San Joaquin Valley, southern Sierra Nevada, Owens Valley and northern Mojave Dessert. Extensive ground data and more detailed geographic datasets for this region have already been collected. The project is currently comparing per-pixel digital image classification of TM data to photointerpretation of digital imagery using ARC/INFO and ERDAS in the live-link mode. Methods are being compared in terms of time, cost and the spatial detail and accuracy of the final products.

Frank Davis
UC Santa Barbara
Ken T. Smith
California Dept. of Fish and Game

Colorado

The U.S. Fish and Wildlife Service's National Ecology Research Center (NERC) in Fort Collins, Colorado, is developing the Colorado database for Gap Analysis. Work began in early March 1991 and is consequently in the early stages of database development. However, months of pre-planning allowed us to start as soon as budgets were approved and task orders were in place. This report will provide a brief overview of the procedures we will use to construct the Colorado database.

Digital Data Requirements

The base maps for Gap Analysis include land status and vegetation. The individual species range maps will be derived from the vegetation map.

Land Status Database

The land status information will be captured from the 1:100,000-scale series of land ownership maps published by the Bureau of Land Management (BLM). The BLM's Colorado State Office has agreed to provide us with the mylars for all 54 quadrangles needed for state-wide coverage. In addition, several quadrangles have already been digitized and we are working with BLM on data exchange formats that will allow us to import these data and transfer the final, completed database to BLM.

These maps contain the delineation for state, private, and federal lands. However, the location of preserves, whether they are private or federal, are not indicated. The NERC is working with The Nature Conservancy, the Colorado Division of Wildlife (CDOW) and other agencies to identify the locations of these protected areas.

Maps are being digitized in ARC/INFO which is running on a Prime super-minicomputer at the NERC facility. To date, approximately five quadrangles are complete. As adjacent quadrangles are completed, they are merged to check edge matching and eventually will be used to construct a statewide base map. We have found that using double precision results in very few problems with edge matching. We plan to maintain the final map in single precision because of the increased storage space required of double precision.

Vegetation Database

The vegetation database will be constructed at a scale of 1:250,000. Landsat Thematic Mapper (TM) digital satellite data will be acquired for full coverage of the state. The TM data will be processed for optimum enhancement of vegetation characteristics using image-processing techniques. The data will be geometrically corrected and subset to standard 1:250,000-scale quadrangles. A color photographic print will be produced from the enhanced digital image and standard, manual photo-interpretation techniques will be used to delineate the vegetation classes. Identification of the classes within each polygon will be made with the assistance of aerial photography, existing vegetation and timber maps, and ground surveys. It is anticipated that cartographic transfer to a stable base map will be unnecessary since the photo will be subset and warped to fit a standard quadrangle, and latitude/longitude tic marks will be included in the image for registration. A mylar overlay will be registered to the photo and the line delineation digitized directly from the overlay.

The Nature Conservancy has been contracted by the Idaho Cooperative Unit to develop a classification system for the western United States. A draft for Colorado is available and will be the classification system used in this project. However, relationships will be developed to other existing classification systems.

Sixteen full TM scenes are required to provide full coverage for the state. These scenes will be subset to match standard 1:250,000 scale map sheets. Each map sheet will be digitized and merged to adjacent quadrangles to complete a vegetation layer for the state as described for land status. The Colorado Division of Wildlife (CDOW) has several TM scenes which will be made available to the project and the first image for photo-reproduction will be completed in mid-April. Photo interpretation is scheduled to begin in early May on the first 1:250,000 scale photographic print.

Species Range Maps

The Colorado Wildlife Species Database (CWSDB) contains almost 200 fields of information for all species of mammals, amphibians, fish, birds, and reptiles found in Colorado. The information on habitat and environmental requirements will be used to select the appropriate vegetation classes in which a species is known to occur. The CWSDB also contains information on county of occurrence, which will be used to help delimit the range of a particular species. Once range maps are developed through habitat relationship analysis, they will be verified through field evaluations by CDOW regional personnel, historical records, and expert review. Further validation will be made by comparison of computer-generated ranges to locations obtained from reliable species inventories.

Frank D'Erchia
Technical Services Branch
National Ecology Research Center
Fort Collins, Colorado

Idaho

The Idaho project was the first Gap Analysis project designed and accomplished using GIS. Due to success with the technique and its results, additional Gap Analysis projects were started in the surrounding states. The Idaho Department of Water Resources (IDWR) is acting as the primary GIS production and coordinating facility for Idaho and Oregon.

In sum, most of the digital data required for Gap analysis of Idaho are complete except for a few loose ends which primarily involve editing. Specific data layers and their status on this date follow.

The vegetation layer shows actual vegetation types for the entire state. The latest edits were completed in mid-1990 to vegetation polygons in southwest Idaho, and some minor changes were made to vegetation groupings shortly after that.

Managed areas, also referred to as "reserves," display areas that have some special management purpose or constraint, and the degree to which biodiversity is protected (according to The Nature Conservancy protection status criteria). Managed areas were completed in early 1990 at 1:100,000-scale.

Ownership (Surface management), as coarsely defined by the BLM Surface management map series at 1:100,000-scale, is complete. The BLM maps simply identify ownership as private, state, and federal, which is broken down by eight agencies. Presently, the data layer is undergoing some last-minute edge-matching and accuracy checks. We have also received updated information from the BLM for a few panhandle quads.

Küchler's potential vegetation was completed in early 1990 from 1:3,168,000-scale source material (U.S. wall map).

Omernik's ecoregions (modified for Idaho by Caicco) was completed in early 1990 from 1:7,500,000-scale source material (U.S. map).

The digital hydrography (streams and lakes) layer of Idaho, at 1:100,000-scale, is near completion for the entire state.

With regards to wetlands, a contract is being approved to initiate a pilot project to assemble a wetlands layer from classification Landsat TM (Thematic Mapper) imagery.

Digital compilation of data layers required on the Oregon Gap Analysis Project began in July 1990 with the initial input of vegetation data. Currently the management areas are being digitized.

Vegetation for all of Oregon has been digitized and is now undergoing extensive editing. The compilation scale is 1:250,000.

The managed areas (reserves) theme, at 1:100,000-scale, for the Deschutes River Basin has been completed by the Oregon Water Resources Department. IDWR is digitizing the rest of the state.

The ecoregions layer has been digitized by the University of Idaho.

The remaining themes are planned for the Oregon project, but have not been started yet. They include wetlands, wildlife distribution models, ownership, T&E species, and hydrography.

Compilation of the wetlands layer on 1:100,000-scale maps from USFWS National Wetlands Inventory 1:24,000-scale maps is almost complete. It is due to arrive at our office shortly.

Butterfly distribution models. Digital compilation is complete for 1/3 of the state by the Oregon State Service Center for GIS. The Service Center is sending data to check. Compiling the data from butterfly location records maintained by the Xerxes Society is currently underway.

Approximately one-quarter of the state (the Willamette Valley) has been digitized at 1;100,000-scale for Ownership (surface management). The Oregon State Mapping Advisory Council (SMAC) has completion of this layer as a goal for mid-1992. Existing associated digital data include the USGS national map series at 1:2,500,000-scale, and it breaks down the theme into a few categories.

Threatened and endangered (information from Blair Csuti). Point data (latitude and longitude) are available from the Oregon National Heritage database. The Threatened & Endangered (T&E)/listed species coverage is complete. It was compiled from data supplied by Craig Groves at the Idaho Natural Heritage Program in late 1989 and early 1990. It includes areal, linear, and point distributions for 37 animal species at 1:500,000-scale. Three species, the Coeur d'Alene salamander, the mountain goat, and the piñon mouse, require further work before they are included.

Wildlife species models. The county-of-occurrence data set is complete and on file at the Oregon Natural Heritage database. Oregon

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Wildlife species models. The county-of-occurrence data set is complete and on file at the Oregon Natural Heritage database. Oregon

Department of Fish and Wildlife is preparing the wildlife-habitat relationships data set.

Hydrography (streams and lakes). Possible sources include the USGS 1:100,000-scale DLG (Digital Line Graph) series by quad and possibly the USGS Water Resource Division's data by basin (in Portland).

Hal Anderson: Chief, Technical Services Bureau
Robert Harmon: Senior GIS Analyst Resource Information Section
David Palmer: Digitizer, Resource Information Section

University of Idaho Contribution to Gap Analysis

In Idaho, we are well on our way to completing Gap Analysis. We have been at it for nearly 3 years. Along the way we have had many successes, made a few mistakes, and learned a lot. We have a lot to share with other states about concepts, techniques, and helpful hints. Through this sharing process we hope to nurture the development of compatible state-by-state Gap Analyses. Also, we may be able to prevent others from repeating some of our mistakes and produce an environment for a smooth conversion to regional Gap Analyses.

For this first Gap Analysis Newsletter, however, we are going to limit our material to an update of our progress. That will leave room for everyone to bring us all up to speed on their projects. Future editions of the newsletter will contain more in-depth material on Idaho Gap Analysis.

Our vegetation map was completed at 1:500,000, mostly from existing maps. Idaho Department of Water Resources digitized the vegetation map, in addition to building ownership, managed areas, hydrology, and threatened, endangered and sensitive species. Most of these data sets were started from scratch and it has been a time-consuming, thankless task to get them put together.

Free from the laborious task of developing those large data sets, the University of Idaho Cooperative Research Unit has concentrated on ancillary data sets, development of vertebrate distribution models, analysis, and communicating the concept and techniques of Gap Analysis.

Our biggest effort has been in development of vertebrate distribution models. A wildlife relations database was not available for Idaho, so we created our own from various general and scientific sources. Only the most general information was available for the majority of species. Each species was classified as present or absent in 34 broad vegetation classes.

We initially developed a simple county-of-occurrence and vegetation model for terrestrial species. We omitted waterfowl for the time being. We internally reviewed each species to catch major errors then plotted hard-copy maps of each. All maps have been reviewed once by an expert on each major taxonomic group.

While waiting for a second review of the maps, we compiled species lists of our simple model for several managed areas with established species lists. Those very preliminary tests indicated a 10.7% omission error rate and 21.0% commission error rate. Much of the omission error was due to rare and accidental species that we failed to identify. The high commission error is partially due to overestimates of certain taxa, particularly mammals, and partially due to incomplete area lists. For example, our sharp-tailed grouse model indicates a much wider distribution than commonly believed by biologists and Idaho Fish and Game documents. However, new surveys being conducted this spring by IDFG have found sharp-tails in new areas predicted by our model.

Other errors are due to our oversimplified model. We are currently finishing up a pilot test of more complex models that include climate, potential vegetation, hydrology, and wetlands. Early results suggest that most species can be modeled very accurately with rather simple models.

We are also completing initial gap analysis of the vegetation. To date the analysis consists of simple overlays of protected areas and vegetation types and descriptive statistics. We have identified 6 of 70 types completely unprotected, 3 other types with less than 100 ha protected, and 1 other with less than 1,000 ha protected. All of these represent under-protected areas.

We will be writing up a complete paper on our vegetation Gap Analysis for presentation at the Society for Conservation Biology meeting in Madison this June. Also, we are presently working on a manuscript to be submitted to *Science* that will detail the findings of Gap Analysis in Idaho.

J. Michael Scott
U.S. Fish and Wildlife Service
National Gap Analysis Director
College of Forestry, Wildlife and Range Sciences
University of Idaho

Massachusetts

The Massachusetts Cooperative Fish and Wildlife Research Unit is participating in Gap Analysis for New England in close conjunction with the Vermont, New York, and Maine Cooperative Fish and Wildlife Research Units. University of Massachusetts faculty members are drafting a Research Work Order and proposal through the Massachusetts Unit to apply Gap Analysis for southern New England (Massachusetts, Connecticut, and Rhode Island). Co-principal investigators are Curtice R. Griffin and John T. Finn. Also contributing to the databases and technical aspects will be UMass Digital Image Analysis Laboratory; Umass Resource Mapping/Land Information Systems Project; Massachusetts Division of Fisheries and Wildlife; Service's National Wetlands Inventory Mapping Unit at UMass; Connecticut

Department of Environmental Protection; Rhode Island Division of Fish and Wildlife; New England Office of The Nature Conservancy; University of Rhode Island; University of Connecticut; U.S.D.A. Forest Service Northeastern Experiment Station; Cape Cod National Seashore; Massachusetts Audubon Society; and U.S. Fish and Wildlife Service-Region 5.

Details on minimum mapping units and imagery

A meeting was held at the Regional Office on February 25, 1991, to brief Service and other agency staff on the concept, methods, and applications of Gap Analysis, and to allow Region 5 Units to coordinate and discuss details of Gap Analysis in the northeast. Attending the meeting were staff from the Regional Office; Units in Massachusetts, Vermont, Maine, West Virginia, New York, and Pennsylvania; The Nature Conservancy; Environmental Protection Agency; and the Massachusetts Executive Office of Environmental Affairs. A slide presentation on Gap Analysis was given by Curtis Griffin using material from J. Michael Scott, as well as additional slides and information specific to the issues in New England.

Rebecca Field, Unit Leader
Massachusetts Cooperative Fish and Wildlife Unit
Department of Forestry and Wildlife Management
University of Massachusetts

Montana

As of 1 March 1991, we have identified cooperators and consulted with representatives from the various groups regarding their specific interests and needs. We also have drafted a proposal and work order, and circulated the former to cooperators and collaborators for input. A three-year budget has been developed. We are preparing the final proposal and work order documents and expect to submit these formally within the next few weeks. At this point, we expect to use Landsat TM imagery, but we still have not decided between digital and manual classification methods. This decision will require further consultation with cooperators in-state as well as in Idaho and Wyoming.

Dr. Roland Redmond
Montana Cooperative Wildlife Research Unit
University of Montana

Oregon

The Oregon Gap Analysis program has been underway since late 1988, and is the first state program to use LANDSAT imagery as the basis for its vegetation map. Steve Caicco, who developed the Idaho Gap Analysis vegetation map, has collaborated with Jimmy Kagan, Oregon Natural Heritage Program Coordinator and Ecologist, to prepare a 1:250,000 vegetation map of Oregon from LANDSAT MSS false-color infrared positive prints. Vegetation polygon boundaries were drawn by photo-interpretation and we used ground-based, larger-scale vegetation maps to assist with labeling. Our minimum polygon size was 200 acres, but most polygons represent areas larger than several thousand acres. These methods kept cost down and allowed labeling at a very fine level in the vegetation classification hierarchy; however, our experiences led us to recommend use of digital thematic mapping imagery for future projects. We feel using TM imagery and digital classification will facilitate edge-matching data sets across state lines. We have prepared a manual describing 118 vegetation cover types in Oregon on the basis of their floristic dominant plant species in canopy, shrub and herbaceous layers. The 90 shrub and grassland types are described at a finer level in the classification hierarchy than forest types. We plan to address fragmentation in forest polygons with an attribute field.

Drafts of the digitized Oregon vegetation map were delivered in December 1990. Editing should be complete by June, and an agency review draft is expected by mid-summer 1991. We have also transferred the boundaries of about 800 managed areas to 1:100,000 BLM land status maps, and these are currently being digitized as part of our contract for GIS support with the Idaho Department of Water Resources. We have been cooperating with the Oregon Department of Fish and Wildlife to develop a statewide wildlife/habitat relationships database. Existing WHR documents have been cross-walked to our vegetation cover types, and the WHUR matrix is now being quality controlled. We have cooperated with Conservancy to complete their Vertebrate Characterization Abstract Database, which we will use to model the ranges of vertebrate species. We are also working with the Xerces Society to prepare distributional databases for butterfly species.

State experts on bird, reptile and butterfly distribution have agreed to review our draft animal distribution maps. We are also transferring the location of larger (>100 acre) wetland complexes from USFWS National Wetland Inventory maps to 1:100,000 BLM land status maps. This data layer will allow us to address the protection status of wetlands which may be important for many migratory and wintering birds as well as aquatic micro-habitat specialists like anurans. Depending on the time required for vertebrate map review, the Oregon Gap Analysis data set could be assembled in review draft form by the last quarter of 1991.

Blair Csuti, Oregon Principal Investigator
Idaho Cooperative Fish and Wildlife Research Unit

Utah/Nevada

Project Status

We hope to have the first analysis of a complete ecoregion (the Wasatch-Unita, after Omernik) by late summer. Analyses of the Basin and Range and Colorado Plateau ecoregions are not expected until summer 1992.

We have been extremely successful in incorporating into our database extant data sets, principally relating to vegetation, from a variety of sources. In addition, several of the National Forests in the Great Basin purchased the Landsat Thematic Mapper data (TM) imagery for us in return for "cut-outs" of the plant and animal data within their respective forest boundaries. Most forests also have promised to help us ground-truth both vegetation and animal distributions, thereby enhancing the quality of the database.

For groups just beginning gap analysis, we encourage you to strike whatever deals you can with management groups in your area. In most instances, we found public agencies eager to work cooperatively. Several, however, required hard sells, and several more are waiting for finished results before determining if the data will be of benefit to them.

We describe below three aspects of our ongoing analyses we feel might be of interest to those just beginning gap analysis. The first two discuss the rationale we used to decide which TM scenes to purchase and our protocol for standardizing reflectance values between different TM scenes. Last, we discuss the database used to develop the animal-vegetation associations. In subsequent newsletters we will discuss ways to ensure maximum flexibility for future applications and implementation of the gap analysis database, and describe a "user-friendly" menu system we are developing for public and private agencies wishing to use the database.

For further information, contact T. Edwards, 801/750-2529.

Remote Sensing Data Acquisition

Vegetation and habitat type mapping at regional scales will require remote sensing data collected from satellite. These data can be interpreted digitally or manually, depending on the requirements and capabilities of the agency or group providing the vegetation layer. At Utah State University, we have chosen to digitally classify TM across the Basin and Range, Wasatch-Unita, and Colorado Plateau Ecoregions (after Omernik). Regardless of the analytical method (digital or manual), certain factors need to be considered when purchasing or collecting remotely sensed data. These factors center on the need to match images across boundaries and to maintain a certain amount of consistency in the phenological character of the vegetation. For an area the size of the Great Basin, it is impossible to acquire imagery that is temporally identical or, in some instances, even similar. The rule of thumb we have used is to purchase images as phenologically close to the peak growing period as possible. This is very difficult in a region that varies in latitude and has drastic variations in topography, such as the Great Basin. Certain concessions were made in order to collect cloud-free imagery in as close a temporal spread as possible. We collected imagery of early summer (June) in southern latitudes, but as we moved north, the June period translated to snow at higher elevations. We therefore had to acquire late summer imagery (July and August) for northern latitudes.

Decisions between cloud-free and clouded imagery also required compromise. If the clouds were along the east or west overlap of adjacent orbital paths, and the adjacent imagery was cloud free, the clouded image would be purchased if the phenological period was more ideal than the cloud-free counterpart. In short, we felt it more important to have phenologically similar rather than cloud-free imagery, provided the area obscured by clouds could be recovered by overlapping cloud-free images.

For further information, contact D. Ramsey, 801/750-3783.

Matching TM scene brightness values

TM scene brightness values (BV) vary in both time and space due to solar elevation, phenological differences, and atmospheric conditions. Therefore, when creating mosaics containing several TM scenes, the BV need to be equalized to provide successful edge matching between two scenes having different dates. The method we have used is to select a "master" TM scene as the core scene used to adjust the BV of all other scenes. The ideal master scene has several attributes: 1) the acquisition date is representative or central to all project scenes; 2) the scene covers a broad spectrum of land cover classes (e.g., in Utah we chose a scene containing portions of the Wasatch Mountains, Basin and Range, and Colorado Plateau ecoregions to ensure a representative spectrum of brightness values); and 3) the scene is as geographically centered as possible, allowing the direct overlay of the maximum number of adjacent scenes.

Once a master scene is selected and rectified, bands 1-4 are atmospherically corrected to minimize the effect of atmospheric haze on these shorter wavelength bands. We used the regression/intersection method, which involves collecting a sample of very dark pixels (e.g., deep water or shadow) in bands 1-4 and finding the matching set of pixels in band 7. Because of the long wavelength of band 7, these pixels are assumed to represent true BV. The Y-intercept of the least squares equation is the amount to be subtracted from the image to remove the atmospheric bias. The master scene can then be used to "train" the brightness of the adjacent scenes. Our method samples the overlap pixels between adjacent scenes and calculates the BV mean for the overlap area in each of the scenes. The difference in the two means is used to bias the adjacent scene to the master scene by subtracting or adding the difference amount. The adjustment of the adjacent image is similar in nature to the histograph bias atmosphere correction method.

Other merge matching techniques do exist. However, they tend to stretch the entire histogram to match the master image. We feel that to maintain as much of the original nature of the image as possible, biasing the histogram to match the master image is preferable to stretching or compressing the entire histogram. Most of the original distribution is lost when the histogram is stretched, which may affect the ability to properly classify the image. We have found that a temporal difference of one year poses no problem in standardizing BV's if the scenes are within the same season, are phenologically similar, and the climate difference is small.

For further information, contact C. Homer, 801/750-1264.

Computerized Fish and Wildlife Information System

The Utah Division of Wildlife Resources has developed a Computerized Fish and Wildlife Information System (CFWIS) that is an automated reference library that can be manipulated for planning and informational purposes. The extensive CFWIS was developed in cooperation with a national effort by the Multi-State Fish and Wildlife Information Systems Project based in Blacksburg, Virginia, to establish rapid wildlife information management.

Utah's CFWIS was developed using the Advanced Revelation database management software. Some of the information categories for each species included are taxonomy, status, distribution, ecoregions, habitat associations, breeding and feeding guild information, food habits, beneficial and adverse management practices affecting each species, and extensive references for each field of information.

The purpose of the CFWIS is to establish a process of coordinating and compiling the diverse body of knowledge about fish and wildlife and colleges/universities, conservation organizations, professional societies and individuals into a comprehensive information system. The system is designed to enhance fish and wildlife coordination in the land use and development planning and management decision-making process by providing technically sound data on animal species in a timely manner. The system provides a procedure for:

1. Summarizing fish and wildlife species information in a standard format using standard information.

2. Establishing a focus for coordinating and compiling fish and wildlife information within the state fish and wildlife agency.

3. Developing a process for managing fish and wildlife information within an individual state.

By using the CFWIS in conjunction with the Gap Analysis process, information can be rapidly retrieved and used for reselection of species distribution on various parameters. Species distribution information can be searched in three areas of detail. The broadest category would be on an administrative distribution. This category would include species distribution in broad parameters of county, forest, park, or other administrative area.

Intermediate categories would include information on general habitat distribution, such as vegetation types, ecoregions, and the land use/land cover classifications. Narrow categories are those of specific preference, use, or season. This includes information on habitat relationships, in particular, specifics of use of those habitats. Since information in these areas is not available for all species, first generation distribution maps may be to the intermediate level of accuracy.

As image processing and vegetation maps are completed, the CFWIS is used to provide information for selection of vegetation patterns that most closely resemble individual species distribution. With the rapid search and retrieval capabilities of the automated database, this process should prove to be one of the minor obstacles of Gap Analysis.

For further information, contact D. Foster, 801/538-4859.

Thomas C. Edwards, Jr.
Utah Cooperative Fish and Wildlife Research Unit

Vermont

The Vermont Cooperative Fish and Wildlife Research Unit (VTCFWRU) is working with Units at the University of Massachusetts and the University of Maine to develop a coordinated strategy for a Gap Analysis of New England, with the intention of connecting with ongoing work in New York and elsewhere as additional states become involved in the program. The coordinated effort in New England aims at development of habitat classifications, species habitat associations, and other data layers that cross state boundaries, in order to avoid edge matching and resolution problems that could otherwise arise. The states of Vermont and New Hampshire are included within the geographic area of primary responsibility for the VTCFWRU. The Unit will assume a lead role in development of species distributions and species-habitat associations throughout New England. The Massachusetts Cooperative Research Unit has the lead in developing the vegetation map for New England.

The VTCFWRU is working with the state agencies, the state heritage programs, the University of New Hampshire and others to develop information bases for conservation areas, species ranges, and community distributions within both states. We also are developing a cooperative agreement with The Nature Conservancy to produce a region-wide crosswalk of habitat classes for the heritage programs in the Northeast. We anticipate that the crosswalk can be completed within the year. The development of distribution and species-habitat information at the VTCFWRU and the vegetation map at the University of Massachusetts will progress in parallel. Participants in the effort at the VTCFWRU include Ken Williams, Mary Watzin and Dave Capen in the School of Natural Resources, University of Vermont in Burlington, VT 05405.

Ken T. Williams
School of Natural Resources
University of Vermont

Washington

An evaluation of the protection of biodiversity (Gap Analysis) in Washington State will begin 1 October 1991. The 3-year project involves developing a vegetation map for the state and overlaying distributions of amphibians, reptiles, birds and mammals, and land ownership. Protection of areas of high species richness (plant or animal), or habitats critical to particular species or groups of species will then be assessed. The project is funded by the U.S. Fish and Wildlife Service through the Idaho Cooperative Fish and Wildlife Research Unit, and will be coordinated by the Washington Cooperative Fish and Wildlife Research Unit at the University of Washington. Although data analysis will not begin until the Fall, planning and coordination has been underway for several months. A number of cooperators are already involved in the project, including the University of Washington (College of Forest Resources; Department of Botany; Center for Quantitative Studies in Fisheries, Forestry and Wildlife; Olympic Natural Resources Center, and the Remote Sensing Applications Laboratory); Washington State University (Department of Zoology and the Digital Image Analysis Laboratory); the Washington Department of Wildlife; the Washington Department of Natural Resources; the University of Puget Sound; the U.S. Forest Service; and two private consultants. The majority of the data analysis will be conducted within facilities in the Center for Quantitative Studies in Fisheries, Forestry, and Wildlife at the University of Washington. The mammal distribution data layer will be developed by Washington State University. Specific working groups have been established to provide technical guidance for development of the vegetation map; vertebrate distribution data layer, and image processing and GIS. The next steps toward initiating the project will be (1) selection of a project leader, (2) identification of additional cooperators, (3) identification of data resources, (4) installation of hardware and software, and (5) selection of a pilot study area. The project is seeking assistance in obtaining or purchasing recent satellite imagery (TM data) to develop the vegetation map. Individuals or agencies interested in cooperating in the project should contact Christian Grue.

Gap Analysis Time Table for 1991:

6 May:	Announcement for Project Leader
20-25 May:	Third meeting of cooperators, preparation of RWO
5 June:	RWO due in Washington, D.C.
15 June:	Susan Freigen (WCFWRU) coordinates future meetings, information transfer, etc.; applications for Project Leader due
1 July:	Selection of Project Leader
15 July:	RWO (contract) established; Karen Dvornich (Project Assistant) begins GIS (GRASS/ARC-INFO) training
1 August:	Hardware and software in place; selection of TM data, pilot study area, and initial vegetation classification
1 October:	Project Leader and Assistant begin image processing and vegetation analysis on pilot study area, funding (subcontracts) initiated for bird and mammal data layers

Overview of Meeting of Cooperators on 18 March 1991:

Our meeting on 18 March focused the project budget, facilities, software, acquisition of TM and other data, and vegetation classification. It was also an opportunity for cooperators to meet and talk to David Stoms who the Unit was considering for the Project Leader position. Critical to being able to complete the project within the budget that has been discussed, is cost sharing by cooperators, particularly in the purchase of TM data. Steve West (COFR) reported that the Olympic Natural Resources Center has agreed to purchase the necessary TM data for the Olympic Peninsula. With the ongoing initiative by the Forest Service (National Forests) and the recently passed Growth Management Act, we are hoping that additional TM data will be made available, or others will purchase it for us. Much of the meeting was devoted to the availability of needed data and the group decided to form working groups that would address specific issues. The working groups outlined above are the result of those discussions. The following priorities were identified: (1) selection of a Project Leader, (2) identification of potential cooperators, (3) identification of data resources, (4) installation of hardware and software, and (5) selection of a pilot study area.

Goals for Working Groups by End of Next Meeting (week of 20 May):

Technical Advisory Committee - address the issue of which image processing software should be used and its availability, provide listing (evaluation of suitability, e.g., cloud cover) of recent TM data, provide guidance on GRASS/ARC INFO as GIS software.

Vegetation Classification Committee - identify classification information and models currently available for Washington State.

Vertebrate Distribution Advisory Committee - identify available information on vertebrate distributions in Washington State.

Total Group - review revised budget, identify potential pilot study areas and additional cooperators (names, addresses, phone numbers), identify land ownership data bases, select members for Coordinating Committee

Our next meeting is critical to the success of the Gap Analysis Project in Washington State. Much needs to be done. I hope that each of you will continue to devote the time and effort needed to make it a success. I look forward to seeing each of you during the week of 20 May.

Dr. Christian E. Grue, Leader
Washington Cooperative Fish and Wildlife Research Unit
School of Fisheries, WH-10
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(206) 543-6475

West Virginia

A Gap analysis project has been initiated for West Virginia involving investigators from the West Virginia Cooperative Fish and Wildlife Research Unit and a number of departments at West Virginia University. Participating cooperators will include the state Soil Conservation Service GIS Office, The U.S.D.A. Forest Service - Monongahela National Forest, The West Virginia Department of Commerce - Division of Natural Resources, and the Marshall University Remote Sensing Laboratory. Additional cooperators will be identified as the study progresses.

The project team is in the process of formulating a detailed work plan. A comprehensive search for appropriate imagery is presently underway. Initial plans call for establishing a base mapping scheme around 1:100,000 quadrangle maps. This database is being developed by the state Soil Conservation Service as part of their statewide GIS effort. 1:24,000-scale base mapping may also be used in certain areas for landscapes or potential habitats of special concern. Explicit cooperation with a number of allied statewide and regional mapping efforts is central to the work plan that has been developed. Landsat TM data are being evaluated for their suitability as the primary source imagery for the project. Manual vs. automated interpretation methods are being examined. MIPS, ERDAS and LAS image processing software are available as needed for use on the project. ARC-INFO, GRASS, and SPANS GIS software are available, though it is expected that most output mapping will be completed with ARC-INFO.

A flexible approach to data acquisition and use will be required. An initial search revealed no cloud-free (<10%) TM images available for north-central West Virginia for the last three years. So, quite possibly, a combination of new TM and MSS, older images, and high-altitude NHAP imagery may be required to complete vegetation mapping for various areas in West Virginia. The best available imagery will be used for vegetation mapping. Likewise, a flexible mapping scheme will be used, though initial plans call for an overall minimum mapping unit for vegetation mapping of approximately 40 acres, though smaller mapping units may be used in critical areas or in special forest/vegetation conditions.

Sue A. Perry
West Virginia Cooperative Fish and Wildlife Research Unit
College of Agriculture and Forestry
West Virginia University

Wyoming

Wyoming is at the initial stages of Gap Analysis. We have solicited comments from Dr. Scott and others on our general approach to Gap Analysis in Wyoming. We will be meeting with Frank D'Erchia to coordinate on regional data sharing and linkages at the end of March. We hope to "pick" Frank Davis' brain about the California experience when he is in Laramie the week of March 4th. Our initial efforts have been focused on identifying major cartographic data sources that are available for Wyoming and locating pertinent vegetative and vertebrate databases in the state. We will be cooperating with the Nature Conservancy, Wyoming Game and Fish and BLM, in our efforts. We have meetings scheduled to meet with the forest service folks about their participation.

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Viewpoint

When I joined the staff of Defenders of Wildlife in 1978 as Northwest Field Representative, the organization was preoccupied with issues like the federal animal damage control program, and with single species, especially large carnivores like wolves and grizzly bears. While we still work diligently to maintain these species in the wild, our programs have broadened considerably to reflect the ecological reality that everything is related to everything else, and saving the charismatic megafauna isn't enough. As many other conservation organizations have done, Defenders had recognized the importance of saving all of the pieces and maintaining natural processes—of protecting biodiversity.

Protecting biodiversity, however a lofty goal, is an elusive one. Far too abstract and complex for most, it's difficult to sell in an intensely competitive political marketplace. Although the "Gap Analysis" sounds more like dental work than wildlife conservation, it represents a breakthrough in public policy and has the potential to stimulate a paradigm shift within natural resource agencies. Because it's easily explained, relatively inexpensive, and has almost immediate practical application, it has been readily embraced by an unlikely cast of characters, including scientists, conservationists, land developers and politicians. By calling the project a "biodiversity inventory," Defenders and other organizations have been successful in securing federal and state appropriations and private funds to finance "Gap Analysis" projects in Idaho, Oregon, Utah, California and other states.

The FY 1992 $4 million appropriation request that Defenders of Wildlife proposed would allow Arizona, Colorado, Massachusetts, Nevada, Vermont, Washington, West Virginia and Wyoming to continue, and finance initiation of Gap Analysis in fifteen new states: Arkansas, Hawaii, Illinois/Iowa, Maine, Minnesota, Montana, New Mexico, New York/New Jersey, Rhode Island/Connecticut, New Hampshire, Tennessee and Texas.

One might wonder where this effort is heading and why it deserves so much attention. Most conservationists are now convinced that habitat loss, degradation and fragmentation are the most significant factors resulting in the decline of wildlife diversity worldwide. Clearly, a systematic approach to habitat protection at the landscape level is needed to avoid the hopelessness and inadequacy of attempting to conserve species one at a time, usually after it's too late.

Gap Analysis allows us to step back and determine which vegetation types are protected adequately in our existing reserves, and which ones aren't. The application of this data will enable us to design a national network of conservation lands to help prevent species from becoming endangered.

Designing this national network, however, is no small task. It will require careful attention to three strategic components:

1) Information exchange
2) Interagency cooperation, and
3) Funding

Under information exchange are three primary audiences: legislators with the interest and capability to make decisions about land conservation, the press, and the influential publics that want to protect lands identified by Gap Analysis. Reaching these groups requires easily understandable, non-technical audiovisual and printed materials that capture the imagination of the audience and give them a meaningful role in making the vision a reality.

One outstanding opportunity to publicize Gap Analysis is by integrating it with the "watchable wildlife" program. This effort has distinct recreational, educational and ecological components and the support of major natural resource agencies. It has the potential to reach a significant number of naturalists who purchase wildlife viewing guides and visit the viewing areas.

Effective implementation of Gap Analysis will mean acquisition of some lands, trading others, and will include a broad range of strategies to protect biodiversity on private lands. It will also mean changing the management of certain public lands. Since the Forest Service, the Bureau of Land Management, and the Department of Defense are major landholders, it is essential for them to be involved early, at every level in Gap Analysis projects. Their needs must be accommodated before they are likely to embrace the results.

Finally, creating a national network of biodiversity reserves will cost money. Experience has shown, however, that funds can be found for meritorious projects with a solid constituency backing them. Involving these constituencies in the early stages of the process will improve chances of securing their financial and political support later. Solicitation of this support is an appropriate role for organizations like Defenders of Wildlife, working closely with scientists and resource agencies.

Sara Vickerman

Methodology Update

Habitat Classification and Regionalization: Nightmare on Gap Street?

State Gap Analysis cooperators have long recognized that matching GIS data layers along state boundaries will present some problems. Most discussion of these problems has centered on edge-matching vegetation polygons. This will be especially difficult when adjacent states use different vegetation classifications or where they map at different levels in the classification hierarchy. We propose to address this by developing regional classifications and building a cross-walk to state classifications that can move up or down the classification hierarchy. Ultimately we aim for a national classification developed in cooperation with The Nature Conservancy.

We recognize that plant ecologists divide vegetation into more associations than the number of habitat types recognized by wildlife biologists (or animals!). To quote Chris Maser, Jack Ward Thomas, and Ralph G. Anderson (The relationship of terrestrial vertebrates to plant communities, USDA Forest Service GTR NNW-172, 1984), "When no demonstrated differences existed in animal communities between structurally similar plant communities, the communities were combined."

Since each state is developing its own wildlife/habitat relationship database, there's a strong possibility that species distributions modeled from these databases will not agree completely across state lines. The only solution to this problem may be to cross-walk each state WHR database to a national list of wildlife habitats developed from the national plant community classification. This will not be an easy task—but it may be easier than getting other state and federal agencies to acknowledge this National WHR Database. Of course, some team will have to take on this not insignificant task. Mighty oaks from little acorns grow.

Blair Csuti, Program Director
Idaho Cooperative Fish and Wildlife Unit

Gap Analysis and Migratory Concentration Areas

The basis for a Gap Analysis is a series of GIS data layers of the distribution of various elements of biodiversity. One benefit of GIS technology is the ability to carry out queries on combinations of these data layers. Several cooperators have expressed a desire to address the protection status of areas that are important to animals during migration. Since these are specific areas, we can't predict their distribution by modeling. Rather, we must create a separate data layer by digitizing maps of these important concentration areas.

There is a danger in capturing only a portion of a state's or a region's concentration areas—the favorite birding spots of one person may provide a biased sample of concentration areas. We also would like to quantify the importance of each area with some attribute fields and set up criteria for including such areas in the first place. One effort to identify very important concentration areas is the Western Hemisphere Shorebird Reserve Network (see J. P. Myers et al., *American Scientist*, 75:19-26, January-February, 1987). A hemispheric reserve must be used by more than 250,000 birds or 30% of a flyway's population of a species. Regional sites must be used by 20,000 birds or 5% of the flyway's population of a species. Over 90 sites meeting one of these criteria had been identified by 1987.

States electing to incorporate this data layer in their analysis should ensure that no major concentration areas are overlooked. Most of the more important concentration areas are well known by wildlife agencies or bird-watchers. These sources should be systematically polled for quantitative information that will allow concentration areas to be ranked by their contribution to state and regional biodiversity. Minimum criteria need to be established, and we would welcome suggestions. Small wetlands used by a few hundred birds may be locally significant, but don't contribute as much to national biodiversity as larger areas used by thousands of individuals of many species. No areas should be included without adequate quantitative documentation. For the moment, we propose adopting the criteria developed by the Western Hemisphere Shorebird Reserve Network.

Blair Csuti, Program Director
Idaho Cooperative Fish and Wildlife Unit

Standard Species Codes for Gap Analysis

Because the distribution of biodiversity rarely coincides with state lines, combining state-developed data layers for regional and national Gap Analysis will be necessary. This will be facilitated if each state uses the same names and coding conventions for species in their databases. Since taxonomy is a dynamic science, we need national standards for names and codes (based on accepted reference works like the AOU *Checklist of North American Birds*). Creating such a list can be both tedious and rancorous. We have already established a cooperative relationship with several state Natural Heritage Programs. In most states, these programs will supply both distributional databases on common species and specific latitude-longitude information for locations of candidate, threatened and endangered species. The Nature Conservancy developed and maintains a national list of codes and nomenclature for vertebrates, some invertebrates and plants for use by its Heritage Programs. I am enclosing a list of these codes for vertebrate animals with the request that you use them for your databases. The list of codes is updated periodically to reflect taxonomic changes, such as splitting the brown towhee into the California towhee and the canyon towhee. Your state heritage program can supply you with these updates.

Blair Csuti, Program Director
Idaho Cooperative Fish and Wildlife Unit

A Message From the Front: Qualifying Wildlife/Habitat Relationships

Gap Analysis uses space-age technology to apply a stone-age concept: animals are usually found in their appropriate habitats. If you draw a map of their habitats, you've also drawn a map predicting the distribution of species found in those habitats. We know quite a bit about the habitat preferences of a few species—game species and other species of special interest. We know far too little about the habitats of most species, especially at the level of discrimination we are able to map vegetation cover types.

I've just been reviewing the habitat associations for Preble's shrew, a species known from only a handful of specimens, but one which all authorities suspect is widely distributed across the northwestern tier of states. Some specimens have been taken in dense coniferous forests, but most come from sagebrush steppe or sagebrush openings in coniferous forests. Oddly, none are reported from juniper-sage woodlands, which form a transition between sagebrush steppe and montane forests. Based on the scanty evidence available, a GIS model of its distribution will skip over juniper woodlands and place the species in arid sagebrush and moist forest types. This may reflect our knowledge about the shrew more than its habitat associations or distribution. It may be prudent to attach a qualifier to our WHR data sets and predicted distribution maps reflecting the state of our knowledge about individual species. I'd rather not get into the business of quantifying an already fuzzy area (e.g., with a scale of 1-10, or 1-100), but we might want to state that habitat affinities are poorly known, somewhat known, or well known for each species.

Blair Csuti, Program Director
Idaho Cooperative Fish and Wildlife Unit

Proposed Automated Delineation of Hot and Cold Marginal Sites Within Vegetation Polygons

This summer we will begin research aimed at delineating hot and cold margins of vegetation polygons. Such information is crucial in making rational decisions in the advent of climate warming. For example, where are hot margins of vegetation zones where one might expect the detrimental changes due to climate warming to be easily measurable? Are there significant cold margins within vegetation polygons that could act as buffer regions during climate warming? Are there gaps that would make migration to colder zones improbable?

The delineation of hot and cold margins within vegetation polygons would be useful for many research questions concerning the affect of climate warming on communities. However, we have found little published research aimed at computer classification of hot or cold regions of vegetation polygons. This summer, we will begin research to evaluate three potential tools for this purpose: radiation indices, a mountain climate simulation model, and thematic mapper thermal data. All three methods have many technical problems that need to be addressed. We will initially validate the three methods by predicting hot and cold margins of polygons at the University of Idaho Experimental Forest and compare predictions with recorded min/max daily temperatures taken from the predicted hot/cold margins and from random sites within the vegetation polygon.

If any one has suggestions or questions concerning this research area, contact Dave Verbyla at (208) 885-7209.

David L. Verbyla, J. Michael Scott, Joseph J. Ulliman
College of Forestry, Wildlife and Range Sciences, University of Idaho

The Application of Gap Analysis to Land Use Planning: Initial Project Steps

The project was funded March 1, 1991, and this paper outlines some of the directions proposed for the initial phases of the project. The objectives of the project are listed below in order of priority.

Objectives

1. To develop a systematic methodology wherein the Gap Analysis databases can be applied to actual land management planning decisions.

2. Through the processes in objective one, develop databases which identify ecologically valuable lands in specific areas of Idaho and Oregon which can be made available to the planners and groups interested in the management of these lands.

3. Use the vegetation data from the initial geographic area to examine the problems that may arise when the vegetation maps from two different states are combined.

4. Work with University of Idaho faculty and Payette National Forest personnel to extend the Gap Analysis databases to development ecologically sound timber harvest strategies. This objective is in part contingent on additional funding for the above participants.

Geographic Focus

The initial geographic area this project will focus on is the Blue Mountains eco-region, an area of 866,662 ha (2,166,656 a) straddling the Idaho-Oregon border. This region contains the Hells Canyon National Recreation Area, a site of considerable interest because of problems associated with current land management practices and because of proposals by the Hells Canyon Preservation Council to establish a national park in the area. The Blue Mountains region will be considered a pilot test of an applications procedure. The lessons learned in that area will be subsequently applied to other areas of Idaho and Oregon.

Area Description

Lands data are presently available in the database only for the Idaho portion of the eco-region. There, over 50% of the lands are privately owned, while less than 7% of the lands are in a status that receives maximum protection (status classes 1 and 2). The majority of the publicly owned lands are managed by the Forest Service; in Idaho the Payette National Forest, in Oregon the Wallowa-Whitman National Forest. Twenty of the 34 vegetation types identified for Idaho are found in the eco-region. Only three of the 20 types occur on lands receiving maximum protection, while the remaining plant communities are found on lands receiving minimal or no protection. The Oregon vegetation data should be available soon. Oregon land status data will be incorporated as they become available.

Project Steps in the Project

Step 1. A table will be compiled showing all vegetation types and their occurrence in each land protection category for the eco-region. A similar analysis will be done for those same types in a zone 100 km around the eco-region. This will provide a basis for determining if it is necessary to preserve lands of a vegetation type that may be rare in the eco-region but well protected on lands in the larger zone. This comparison will, of necessity, be somewhat subjective and we will err on the conservative side.

Step 2. Initial analyses will focus only on those plant communities which occur on public lands classed as receiving minimal protection (status 3), and not eliminated in step 1. This will be done to avoid conflicts that will inevitably result when instituting conservation measures on private lands. The inclusion of private lands will be considered at a later stage in the project.

The region, when subdivided by land management status and ownership, contains roughly 1,300 land parcels. Various size groupings of the land parcels will be examined and a frequency distribution calculated. Depending on the particular vegetation type, we will examine the utility of focusing analyses only on land parcels greater than a certain size. The assumption being tested here is that for a given vegetation type, land parcels smaller than a certain size may have little conservation value. We will try and substantiate these decisions through the literature. The aim of this step is intended to narrow the scope of the effort, i.e., limiting the amount of lands of a given vegetation type that will be further analyzed for its conservation value.

Step 3. Databases (maps) of individual vegetation types developed in step 2 will be systematically combined with other, similarly derived databases of the other vegetation types. Species richness maps will be compiled for the complete assemblage of vegetation types. The specific species comprising the richness calculations will be listed, and those species which overlap more than one type will be noted and duplications eliminated. This will probably reduce the overall species richness for two adjacent vegetation types.

The aim of this step will be to identify clusters of status 3 vegetation types having the highest species richness of unique species. Isolated patches of vegetation types groupings which are low in species richness and which cannot be linked with other protected lands will be dropped from consideration. Again the aim is to narrow the scope of effort.

Step 4. The subset of lands identified in step 3 should represent those with the highest priority for receiving additional protection either through changes in land classification or changes in management activities. In this step a more in-depth analysis of the resources on each parcel will be undertaken. This will include, where available, the use of higher resolution mapped data, e.g., aerial photography or TM or SPOT imagery, and higher resolution land status data, e.g., management zones within the public lands.

One task at this time will be the formation of a working group of individuals knowledgeable about the area and its resources who can contribute expertise to the project. These will include federal, state, and university personnel such as those involved in the Payette National Forest project.

Depending on the extent of the lands remaining under consideration, a field validation of limited scope of the individual parcels within each of the selected vegetation types will be undertaken. Field work will include verification of the GIS data layers and the collection of additional data on stand parameters such as size, age class, and degree of canopy closure. Similar data may be collected by the Payette National Forest in their proposed inventory and could therefore be incorporated into this phase of the project.

Step 5. At this point, a map of the subset of lands suitable for consideration for additional protection will be produced and made available to agency planners and outside interest groups. It will be up to these individuals to provide further refinements for the analysis, such as the elimination of areas of high political or economic sensitivity.

Gerry Wright, Project Director
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Western U.S. Vegetation Classification and Regional Correlations

The proposal funded by the Idaho Cooperative Fish and Wildlife Research Unit, under its GAP project, is part of an ongoing project funded by The Nature Conservancy's Science Department. The project aims at building a regional ecological classification to identify and describe all plant communities, as well as defining the range of each one. A regional approach is necessary to ensure the standardization needed to compare vegetation and diversity patterns over entire landscapes and regions. Landscapes need to be divided in units that occur repeatedly in space and time. The regional classification is used to generalize the knowledge about a few samples to as many sites as possible. The units of a regional classification are used to produce the mapping units for GAP.

The vegetation is multiscaled (from the biomes to site-induced variations). Therefore, a functional ecological classification needs to recognize the various levels in the vegetation, levels matching the scales of processes responsible for them. Only if the structure and the processes acting upon it are matched will the classification have predictive power. Predictivity means the capacity of a classification to predict states of external variables. The theory has been developed and discussed over the years by many authors. A similar qualitative approach is used while developing the first cut of the western U.S. regional classification. The regional classification uses the UNESCO framework as a higher level umbrella, under which two additional levels are nested. The lowest is the plant association. The other level is similar to the European suballiance. The latter is the level more appropriate for regional mapping as needed by the Gap Analysis Project.

Working classifications have been completed and are being used in Arizona, Colorado, Idaho, Montana, New Mexico, Nevada, Oregon, Utah, Washington and Wyoming. Work continues in California and Alaska. Drafts exist for each state. A western community classification table has been compiled, mostly during three regional meetings of the Heritage ecologists. To date, this table contains the plant communities of Washington, Montana, and Oregon shared by at least two states, plus all of the communities of Colorado, Wyoming, New Mexico, and Idaho. Included in this table are known synonyms for each community.

Additionally, a global rank column has been added to the vegetation table. Global and state ranking has been completed for Montana, Idaho, Washington, Oregon, and New Mexico. Some state ranks were also inserted where known for Wyoming, Colorado, Utah, and Nevada. In late February, the latest version of the vegetation table was sent to each state ecologist in the western region for input on global and state ranks. Revisions will be made at a later date.

In our Source Abstract database, coding and keywording of the sources used in state classifications have begun. These codes will be an additional section at the end of the descriptions for each plant community. This information can then be transferred to the western vegetation table so that each community in the western United States has the sources where it is found listed next to it. This will also provide a complete bibliography of all sources used in the western classification. To date, sources have been coded for New Mexico, Idaho and Washington. Colorado is being done.

Work on the descriptions started with the coniferous forest communities, with emphasis on Utah, Oregon, and Idaho. The *Abies concolor* series descriptions for these states have been mostly completed. Work is ongoing for the *Abies grandis* series. Time was spent at the end of 1990 and beginning of 1991 writing descriptions in the *Abies lasiocarpa* series based upon the regional quantitative analysis conducted at the Western Heritage Task Force in association with the USFS on the spruce-fir forests of the Rocky Mountains.

The following is a list of completed community descriptions:

Abies concolor/Acer glabrum
Abies concolor/Archtostaphylos patula
Abies concolor/Cercocarpus ledifolius
Abies concolor/Erigeron eximius
Abies concolor/Juniperus communis
Abies concolor/Lathyrus arizonicus
Abies concolor/Physocarpus malvaceus
Abies concolor/Symphoricarpos oreophilus
Abies concolor/Vaccinium myrtillus
Abies grandis/Acer glabrum
Abies grandis/Asarum caudatum
Abies grandis/Calamagrostis rubescens
Abies grandis/Clintonia uniflora
Abies grandis/Coptis occidentalis
Abies grandis/Linnaea borealis
Abies lasiocarpa/Acer glabrum
Abies lasiocarpa/Actaea rubra
Abies lasiocarpa/Calamagrostis canadensis
Abies lasiocarpa/Lathyrus arizonious
Abies lasiocarpa/Mertensia ciliata
Abies lasiocarpa/Physocarpus malvaceus
Abies lasiocarpa/Ribes Montigenum
Abies lasiocarpa/Rubus parviflorus
Abies lasiocarpa/Vaccinium scoparium
**Abies lasiocarpa/Vaccinium scoparium* - Cascadian influence

*Picea engelmannii/Caltha leptosepala
*Abies lasiocarpa/Vaccinium scoparium I
*Abies lasiocarpa/Vaccinium scoparium II
*Abies lasiocarpa/Vaccinium scoparium III
Picea pungens/Amelanchier alnifolia/Cornus sericea
Acer negundo-populus angustifolia/Cornus sericea
Alnus incana/Equisetum arvense
Aquilegia fmicrantha/Mimulus eastwoodiae (Hanging gardens)
Carex nebrascensis-Catabrosa aquatica spring wetland
Eleocharis palustris wetland
Phragmites australis wetland
Populus angustifolia/Amelanchier alnifolia/Smilacina stellata
Populus deltoides ssp *wislizennii/Rhus trilobata*
Populus tremuloides/Pteridium aquilinum
Populus tremuloides/Tall forbs
Potentilla fruticosa series
Salix bebbiana (*S. depressa* ssp. *rostrata*)
Salix planifolia/Carex scopulorum
Sarcobatus vermiculatus/Distichlis spicata var. *stricta*
Typha domingensis wetland

*These descriptions were based on the quantitative work on the subalpine fir forests.

ALLIANCES

Core *Abies lasiocarpa/Vaccinium scoparium*

Patrick S. Bourgeron and Lisa D. Engelking

Gap Analysis Newsletter is published twice a year by the Idaho Cooperative Fish and Wildlife Research Unit, J. Michael Scott, Unit Leader. To receive the newsletter, write to:

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POSTDOCTORAL RESEARCH ASSOCIATE NEEDED TO STUDY BIODIVERSITY IN WASHINGTON STATE

The Washington Cooperative Fish and Wildlife Research Unit in cooperation with the U.S. Fish and Wildlife Service and the college of Forest Resources at the University of Washington in recruiting a postdoctoral research associate to study biodiversity in Washington State, October 1991 through September 1994. Salary will be $26,712 to $28,314 per year (12 months) plus benefits. The incumbent will be responsible for conducting an evaluation of the status and protection of biodiversity (GAP Analysis) within Washington State with primary responsibility for developing a vegetation map for the State from satellite imagery, and overlaying land ownership and vertebrate distributions. Training and project experience in remote sensing (image processing) and GIS is essential. The incumbent will be expected to work with a number of principal investigators, cooperators and support staff. A resume, three letters of recommendation, and college transcripts should be sent to: Dr. Christian E. Grue, Washington Cooperative Fish and Wildlife Research Unit, School of Fisheries, WH-10, University of Washington, Seattle 98195 (206-543-6475). Application deadline: 15 June 1991. The Washington Cooperative Fish and Wildlife Research Unit and the University of Washington are affirmative action/equal opportunity employers. Women and minorities are encouraged to apply.

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