GIS by ESRI™

ESRI® Conservation Program

ESRI®
White Paper Series
November 1995

ENVIRONMENTAL SYSTEMS RESEARCH INSTITUTE, INC.

J-7091

ESRI Conservation Program Statement

Environmental Systems Research Institute, Inc.

Contents **Page**

Environmental Systems Research Institute, Inc. (909) 793-2853
380 New York Street, Redlands, CA 92373 Fax (909) 793-5953

Contents **Page**

J-7091

ESRI Conservation Program Statement

Environmental Systems Research Institute, Inc.

An Invitation to Participate

At the 1991 International User Conference, Environmental Systems Research Institute, Inc. (ESRI), announced the formation of a new Conservation Users Special Interest Group, now called the ESRI Conservation Program (ECP). This group is a membership organization consisting of local and international conservation organizations, geographic information system (GIS) hardware and software manufacturers, large GIS users interested in supporting conservation programs, and donors. Membership is open without charge to any individual representing or affiliated with such institutions, whether they use a GIS or not. This statement outlines the philosophy and goals of the program and reviews its progress to date. It will serve as the basis for a formal funding proposal to allow for expansion of these services to other conservation groups. This program is designed to serve the conservation community, so this statement is being circulated within the community to allow for review and comments and to invite partnerships prior to drafting a final, formal proposal.

The Biodiversity Crisis

The environment has become the single most important issue worldwide as we enter the twenty-first century. As human populations exceed the limits of biological resources everywhere, and greed for quick profits pushes exploitation without limit, the very fabric of our natural systems is threatened and human civilization itself lies in peril. If humans are to survive, we must become stewards of our home rather than demolishers. We have come to realize that biodiversity, the wide variety of living species, is a critical factor in the health of our planet. We live in a time of incredibly rapid change; even so, there are still opportunities for concerted action to protect and manage what remains of our natural heritage so that we may ensure the survival and enlightenment of future generations. To be effective, however, action must be based upon accurate information and continuous review.

The Information Crisis

Some have called this "The Information Age" since its progress and politics have been guided by control of information in the same way that development during the previous "Industrial Age" was guided by control over industry and mass production. The advent of the computer and huge databases inspecting every aspect of our lives has certainly made this appellation frighteningly real to many of us. Who controls access to information may become the principal social issue of the next decade as access itself becomes an important measure of political power. In some African countries, the private ownership of small computers was discouraged in the mid-eighties because they were perceived as subversive. Like most weapons, however, computers can cut both ways. The very power that allows them to control access to data can also be harnessed by individuals to collect and manage data independently. Historically, however, technology has often been a barrier to the free flow of information. The centralized use of computers in many institutions has often generated huge databases that are so complex and self-serving that no one, from the individual right up to the managers who operate it, can obtain useful information from them in a timely manner. As the saying goes, you start with raw data then ask meaningful questions of it to produce information, which is combined with human experience and wisdom to produce knowledge. Unfortunately, most large databases are exactly that, collections of raw data that still require a lot of questions and analyses before they can become information or be put to use as knowledge. In order to become knowledge, it is essential that data be controlled and managed by the users who depend on it for their day-to-day activities.

The Role of Information in Local Action

Perhaps the clearest illustration of the information crisis is in resources management. As industrialized countries increase their ability to peer at the planet and garner detailed resources information, they are frequently in the position of having better data than the resources management agencies in the countries themselves. This unequal access to information can lead to inequalities in control over the decisions made about the resources. The critical flaw in this is that the local occupants of any biotic system, especially indigenous people, usually know much more about how that system works than any national or international agency, since it is very often their livelihood. Because this knowledge is often informal, ranging from folklore and taboos to family tradition, it is often ignored when placed against the sort of high-tech presentations that large development projects can utilize. Unfortunately, large externally controlled development projects never seem to get it right since they often neglect long-term goals of sustainability. Africa is littered with the corpses of projects that failed for the most elementary of reasons. Local communities are frequently well aware of the history of development attempts in their area and can be quite lucid about why failure occurs and how to avoid it. Unfortunately, they are seldom consulted and local approval is seldom valued. This is ironic in that it is usually the locals who pay the most severe costs of overexploitation and bungled efforts.

The cooperation of local people is essential to the action that will be needed to protect and manage the earth's environment, and to achieve this, there must be ready access to resources information at the local level and well-established methods for incorporating local knowledge and priorities in any larger-scale decisions. The more widely such information can be shared, the more likely it is that all aspects of local knowledge will be included and the more likely a commonly agreed solution becomes. When computer tools are applied in these circumstances, great care must be taken to keep the focus on the human and not the tool. One of the most common mistakes illustrating this point is the tendency of computer programmers to assume that if a computer is involved then the normal usage by an individual will be in front of a screen punching keys, when in fact this is the least appropriate use. It is far more logical to think of the average user as getting their information as they always have, from a respected individual or a piece of paper or a map, while the computer's role is to drive the production of these various paper and other types of outputs for dissemination in the most appropriate manner possible. Finally, issues of local control over information and decisions are often politically sensitive, and a great deal of tact and sensitivity is required when outside agencies become directly involved in such processes. Rather than direct involvement, however, the ECP approach is to empower local people who are already showing some effectiveness in mobilizing local action.

Some of the most effective conservation programs are in Zimbabwe and Zambia where local people are given control over and management responsibility for wildlife species. Once wildlife is seen as a husbandry opportunity then vast numbers of would-be poachers are readily turned into active stewards and game scouts. The ECP already actively supports the Zambian program and will soon include the Zimbabwean program as well.

The Role of Information in Conservation

In a recent joint statement on world biodiversity, the world's major conservation organizations concluded the following:

- Nature is diverse.
- This diversity must be preserved.
- Knowledge about diversity is very inadequate because species and ecosystems are so numerous and the rate of progress in describing them very slow.

Conservative estimates give a figure of ten million species alive in the world today, yet in the past 230 years scientists have only managed to describe 1.4 million species. At this rate it would take over 1,600 years to finish the job. There is a clear need to protect as many unknown species as possible and a need for better, faster tools to assist in species and ecosystem description for those areas that cannot be protected. At current extinction rates, the next few years may provide the only opportunity to collect information on many species and habitats before they disappear forever.

GIS Is a Tool for Holistic Information Management

Solving these environmental information and management problems with local participation requires the ability to combine and integrate many different viewpoints and many different bodies of knowledge about the environment. The ecology movement taught us that the environment could only be understood if seen as an integrated system and studied in an interdisciplinary fashion.

GIS stands for geographic information system, and it is variously defined as a computer-based system for the storage, management, and analysis of geographic information and associated data. Perhaps its most important characteristic, however, is that it allows a wide variety of data to be integrated and combined in a formal, logical manner on the basis of spatial relationships. If a problem or data has a spatial component, then a GIS allows it to be analyzed and interpreted spatially, in ways never before possible with manual maps, tabular computer databases, or statistical techniques. The GIS is thus the first analytical tool that allows us to directly implement the ecological view of reality and to achieve a holistic information management capability, which is why it holds such promise in the struggle to solve the difficult biological and management problems that lie ahead.

This integrative capability derives directly from the advanced data processing abilities of the computer, so while many of the concepts of a GIS can be applied to manual map management systems, these are not true GISs. There are also computerized map databases and CAD systems that are only capable of graphic operations and amount to little more than a digital version of a paper map, easier to edit perhaps but definitely not a GIS since they lack any of the analytical and integrative functions. Among true GISs there has previously been a split between so-called "raster" and "vector" systems. Raster systems divide the world into a grid of cells, each cell receiving a value. Since remote sensing data come in this format, raster systems are essential for processing satellite images, and raster formats are better for some simple GIS functions. While limited, the raster model is simpler to write programs for custom and in-house GISs built upon this model. Unfortunately, raster systems have historically presented greater difficulties for relational database design since each spatial feature must be represented as a large number of cells rather than as a single exact feature. Vector systems derive from the formal mathematics of two-dimensional planar topology and relational algebra, and are generally better platforms for the sorts of complex spatial and statistical analyses that a GIS is often set up for in the first place. Since each spatial feature is represented as a single entry in each table, various relationships are easier to represent. ARC/INFO® was the first, and is still the leading, GIS system, and with the current release ARC/INFO integrates raster modeling capabilities with vector capabilities. Both of these tool sets are integrated with relational attribute tables. With this advance, the argument over which is better, raster or vector, becomes moot.

Role of Database Design

The capability for advanced analysis always carries a price. Data must be formally defined and structured or the products of the analyses will have no meaning. Database design is the process whereby raw data sources, database management methods and quality control procedures, and the desired analytical operations are all integrated into a formal plan that can guide the data entry and computer programming tasks, yet is still intelligible to the end users so they can control the tendency of computer programs and databases to whirl off into irrelevancy. Formally stated, a database design must define the following:

- Data structures—How the data will be partitioned into files and how these files will be related to one another.
- Integrity rules—What kinds and values of data are valid for this database? What relationships represent valid real-world phenomena? How is a quality control error defined?
- Operators—What analytical operations will this database support? What operations will produce garbage data and must therefore be prohibited?

These design activities are often carried out by specialist consultants and analysts. A GIS cannot reach its fullest potential for integration and data sharing without such a design, in the same way a car cannot achieve purposeful travel across unfamiliar terrain without a map.

Unfortunately, there is no easy fix for a good database design. Designs carried out apart from the users of the system are often worthless and irrelevant. Design activities carried out by outside agencies on behalf of an organization run the same risk. To be successful, the database design process must be viewed as an intimately cooperative effort among the users themselves, and a good database designer functions more as a facilitator between users, teaching them enough about the design process so they can control it directly, while providing an overview to help tie the different user requirements together. The idea of teaching users how to solve their own GIS problems rather than trying to build databases or conduct analyses for them is fundamental to the philosophy of a successful and self-sustaining GIS.

Basic Functions of a GIS

Data that become part of a GIS according to clear and well-structured design then become available for a wide variety of analytical functions. These functions can perform analysis of geographic phenomena and their relationships. Some examples of these tools include the following:

- Buffer—A buffer is a type of proximity analysis where zones of a given distance are generated around spatial features. The distances may be arbitrary or they may depend upon other attributes of the spatial feature such as sensitivity. Buffers are commonly used to establish minimum protective distances around environmentally sensitive features, or to establish zones of influence around environmentally disruptive phenomena.

- Overlay—An overlay is the process of combining two or more spatial databases (map layers) to produce a new third database, which contains the relationships defined by the overlapping intersection or combined union of the input databases. Overlay is the basic method for combining data on a spatial basis.

- Adjacency—Adjacency is the process of studying how spatial features interact with their neighbors. Habitat quality of individual sites is largely determined by the nature of surrounding areas whether urban, agricultural, or wild.

- Dissolve—This is the process of joining adjacent features that share a common characteristic, allowing a larger generalized view of a pattern.

- Select—Spatial features can be selected and analyzed separately using spatial methods such as all features within some arbitrary polygon or with some arbitrary distance of a point or line (buffer). The tabular data associated with this selection can be analyzed in parallel with standard statistical methods. Conversely, tabular selection processes can be applied to these tables such as all features with value x, and the linkage between this table and the spatial data allows an immediate map to be created of the selected records.

- Topographic surface—The GIS can automatically calculate point and line elevation data into contour maps, slope, aspect, watershed, and related analytical interpretations of terrain for three-dimensional display on terminals or other devices. Elevation, slope, and aspect are critical factors in the growth and success of many species and habitats. The ability to present any data set as three-dimensional patterns combined with geography is an important analytical and visualization tool.

- Network—Network refers to how linear features are connected together, like roads or streams. Network software tools allow paths to be followed through such networks according to any attribute such as blockage, flow rate, and toxicity. These tools are important in modeling migration routes and stream flows.

- Relation—Relation refers to the unlimited possibilities for associating tabular data with spatial features. Complex many-to-many relationships such as those found between species and sites (a species occurs on many sites and a site supports many species) can be represented and analyzed for spatial patterns.

- Model—A set of rules and procedures for conducting spatial analysis, drawing from all of the techniques listed above.

The Role of GIS in Conservation

The following is a list of actions and needs that a broad consortium of conservation groups have listed as being of the highest priority. With each action is listed the sorts of GIS capabilities that will be essential in resolving the problem. Most of these examples are taken from existing programs applying GIS methods to environmental problems, many of which are listed in the program review at the end.

Documentation

■ Major effort is required to document the world's biodiversity.

- Document species, basic inventory GIS coupled with remote sensing data, allow a crude classification and a rapid overall view of a large area. This view can then be used to focus field efforts into those areas most threatened. Remote sensing image classification is itself verified this way, but these same "ground-truth" methods can apply to complex analyses and classifications as well, such as predicting wildlife species occurrence on the basis of vegetation, slope, elevation, topography, season, land use, history, land management, and proximity to settlement and roads. All of these factors can be variously combined as measures of "habitat," defining the environment as it affects a particular species including human effects. Such analyses can be used to prepare putative species lists for little-known areas to help guide field efforts or to help sound the alarm if endangered species might be likely to occur in a little-known area threatened with destruction.

- Basic maps of flora and fauna—Used simply as a map management tool, GIS can help to organize a large collection of spatially referenced paper data by tying index maps into traditional bibliographic databases. As the next step, tabular data on each species characteristics, requirements, and status can be collected into a database and linked with the GIS to digitized maps. The relational power of the GIS allows data to be specifically maintained about each species at each site, such as its population status and protection status at that site, in addition to separate tables giving the overall global characteristics of a species such as biomass and life history. Once these links are made, it is then possible to conduct queries and prepare maps from questions like "map all fallbreeding mammalian species of large biomass and declining population status in less protected areas and then overlay with average autumnal rainfall and agricultural activity."

- Practical field taxonomic aids.

- Rapid inventory methods—GIS can combine physical data, such as soils, rainfall, and elevation, or use remote sensing data to plot out draft habitat maps that can be field-edited and verified more rapidly than a ground mapping program starting from scratch. As mentioned before, GIS can make crude predictions on the basis of habitat of which species might be present, a technique that has already proven useful in some tabular conservation databases.

■ Train more biologists and taxonomists.

■ Basic microcomputer programs.

Research

■ Perform ecological fieldwork to study how all the pieces fit together, using the following integrated interdisciplinary approaches:

- Effects of habitat loss and population fragmentation.

- Population dynamics.

- Habitat dependencies—Which physical and cultural factors are most correlated to observed species occurrence? Of course, such GIS research must be based on thorough knowledge of the species life history and natural history if it is to have any meaning.

- Explore interactions between species, habitats, and human activity.

- Explore why a species is where it is—Maps of actual species occurrence overlaid with present and former extent of suitable habitat form the basis of such analyses. Maps of human history, human activity, agriculture, other species, and physical environmental factors are all useful.

- Explore patterns of species reproductive success.

All of these efforts will rely extensively upon the integrative and modeling abilities of a GIS. The success of these efforts will depend mostly on the quality of the data obtained and the thoroughness and thoughtfulness of the database design.

Management

- Define the relative environmental sensitivity of areas—Buffering and overlays would be used to combine various measures of rarity, threat, and proximity in order to produce maps of environmental sensitivity.

- Determine which species and habitats are protected—Once species and habitat maps are combined with protected areas and human pressure maps, selection operations within the linked databases will reveal the percentage of range under threat for each species.

- Identify sites for protection—Modeling would be used as in the above examples to flexibly reflect the criteria for site protection.

- Manage these sites—A GIS used to manage baseline data can also model different management scenarios and help guide the search for ideal management options.

- Explore alternative conservation strategies.

- Compare undisturbed and disturbed habitats as groundwork for restoration.

- Explore how locals use the resources—The ability of a GIS to combine data from such disparate sources as vegetation community mapping and demographic maps allows analysis of local economies in ecological or bioregional terms. Patterns of local livelihood and their impact on local environment can be discerned and used as a guide in management plans.

Monitoring

Monitor changes in diversity, deforestation climate change, and pollution over large areas, and collate information on current status and trends in resources to support changes in policies.

Large spatial databases of the complexity needed to monitor environmental change would simply be impossible without the database management tools provided by a GIS. Most important among these is tiling, the ability to break large databases up into smaller manageable pieces linked together in a common spatial structure and a common database definition.

Application and Advocacy

Recent studies on the use and effectiveness of environmental information among government decision makers reveals that their most common unmet desire is to obtain information in a form that is useful to them, so that they can integrate it with the rest of their activities. The dual ability of a GIS to produce information in map form or linked tabular form gives it extraordinary flexibility. Maps are among the most useful formats for information since they represent spatial patterns directly and unambiguously, compared to tables or tabular databases.

- Establish local, sectoral, and national information management systems to ensure the *use* of information.
- Make information available to planners and decision makers in useful forms such as environmental status reports.
- Establish tropical research centers.
- Establish local action plans and local action centers.
- Establish national conservation strategies to define the basic agreed upon problems and lay out the agreed upon objectives via action plans, whose progress is monitored.
- Establish global strategies to set the framework for local and national efforts and set international priorities. "GIS has greatly simplified the preparation of integrated biodiversity conservation strategies."

- Demonstrate how various management or development options will impact environmentally sensitive areas.
- Prepare evidence for hearings and impact assessment.
- Study local resource use, how harvested, awareness of limiting conditions, possible alternate sources of income, and ethnic diversity. What incentives are needed to change behavior that negatively affects the environment?

ESRI Conservation Program Policy Statement

The overall goal of the ECP is to support conservation groups in acquiring, learning, and using GIS tools and methods. ECP has a particular focus on appropriate levels of technology for locally sustainable programs. Its goal is not to throw out one-off donations into a vacuum with no forethought, but to build permanent, locally based support structures that provide ongoing evolutionary growth in GIS skills.

Humans Are Still the Key

ECP will be human-based rather than tool-based in its approach to supporting conservation programs. Rather than inventing technical solutions and trying to flog them, the ECP will instead identify individual persons who are actively working on conservation programs at the local level, who have a strong dedication to that area, and who are making a clear difference because of their work. Once identified, the ECP will seek to support those persons with GIS and resources database problems in whatever way required, recognizing that the most important component of any database is the person running it. In this way, ECP activities are driven by the stated needs of its user community in a human-based manner. The present ECP concept is, in fact, based on just such feedback from the current network of conservationists interested in GIS.

Top-Down Training plus Bottom-Up Application

As humans begin the process of adopting and learning GIS tools and methods, ECP will provide specialist support in the complex problems of database design and management, recognizing that much of the top GIS design expertise in the world resides at ESRI. ECP will also make available whatever resources are needed to get new projects over the initial learning curve so they can begin to produce useful output as quickly as possible. This assistance will be provided solely on a user-demand basis. Whatever users need, ECP will attempt to provide. There is no ECP-centered development program for standard products or services thought to be of use to the community but developed separately at ECP. ECP is committed to providing what is required for successful GIS projects and no more.

The specific functions of the ECP are to

- Put GIS training, support, and tools into the hands of locally based conservation groups worldwide.

- Form partnerships with international and globally based conservation organizations for GIS technical assistance, global database design, development, and distribution.

- Help create locally sustainable GIS programs by developing cooperative agreements between local conservation groups to exchange technical support.

- Help create global networks of support by organizing an annual conservation GIS user conference, the first of which was held at the 1991 ESRI User Conference. Also, arrange for support and scholarships to help developing country participants attend.

- Develop direct sponsorship of local groups from larger institutions in the developed world, such as an adopt-a-user program where large GIS users agree to provide technical support and training to smaller users in developing countries. ECP has also arranged for conservation groups to have access to advanced equipment such as vectorization scanners and electrostatic plotters when needed.

- Encourage and facilitate the exchange of databases and applications. Help provide data conversion services and volunteer programming services, where needed. The ECP is working closely with ESRI on the ArcData℠ Publishing Program, which helps distribute the many GIS data sets already held at ESRI. The ECP is also organizing a "Country Starter Kit" program based on the Digital Chart of the World (DCW) Project. The DCW is a multiyear, ten million dollar ESRI project to produce the first 1:1,000,000-scale multilayer digital basemap of the world, contracted by an international consortium of government cartographic agencies headed by the U.S. Defense Mapping Agency (DMA). The DCW includes public domain display software and source code developed in the C language, and the database will contain topologically based vector data digitized from DMA's Operational Navigation Charts. The DCW project is also mandated to develop new international standards for the storage and interchange of digital map data. This Vector Product Format standard will serve as the standard for future digital products.

- Develop specific conservation GIS support programs within other companies, such as a conservation vacation program, where employees may spend their vacations volunteering for an approved international conservation program, or where leave without pay will be granted automatically for extended service to approved conservation programs without loss of benefits.

- Represent the GIS needs of the international conservation community to other donors including suppliers of hardware, software and imagery, and foundations and aid organizations.

- Assist conservation groups in securing donations for GIS programs and assist donors in evaluating the usefulness and long-term local sustainability of GIS donation requests received.

- Provide specialist advice to foundations and aid organizations in the potential for GIS and its appropriate application and management in developing country environments.

- Establish a quarterly newsletter to report on conservation GIS activities, notify donors of worthy projects, follow up on project progress for prior donations, report on availability of volunteers and services, and report on advances in conservation theory as it applies to GIS and new applications.

For further information, contact Charles Convis at ESRI, 380 New York Street, Redlands, California 92373-8100; telephone (909) 793-2853, extension 1529; fax (909) 793-5953.

Review of Existing Programs

Although it was announced at the 1991 ESRI User Conference, the ECP has actually been operating since 1989. Its origins lie in a series of missions carried out from 1986 to 1989 in Africa on behalf of the IUCN, with additional work in Asia and Central America. This review is part of an ongoing effort to determine which factors spell the difference between success and failure in attempting to utilize GIS tools and methods. This will result in a series of guidelines for the successful application of a locally sustainable GIS that will be distributed and used in planning for support. Among the trends already established:

- Adoption of a GIS takes a minimum of six months if starting with an individual already familiar with computers, database management programs, and paper maps. Otherwise a year is more reasonable. These times are based on one person working more or less full-time in a remote circumstance with limited access to outside help, aside from one to two weeks of GIS training. This time can be shortened with additional training classes at appropriate points or on-site visits by trainers, but there is no replacement for a local full-time person dedicated to getting the GIS off the ground. Since many projects cannot afford a dedicated GIS person, this often ends up being the principal investigator or a researcher with other duties. The ECP recognizes that with the extreme shortage of trained biologists it is undesirable for biologists to have to be computer programmers; therefore, one ECP goal is to shorten the start-up time for GIS projects by whatever means possible in such cases, so that biologists can go back to being biologists. As indicated before, however, this is never an excuse for abandoning local control and carrying out GIS work on behalf of projects at some remote location.

- It is usually possible to meet all hardware needs through donations but it is very time consuming to organize, and normal waiting times are six to nine months. Again, the ECP recognizes that biologists should not have to spend time chasing hardware donations.

- ARC/INFO is the most widely requested GIS software among conservation and planning groups. ARC/INFO is sometimes criticized as complex and difficult to learn. This complexity arises from its nearly 3,000 commands and great flexibility. In our experiences with the conservation groups listed, we have found that ARC/INFO is very straightforward and can be productively used to enter, edit, and output maps with only ten to twenty commands. It can be used and learned incrementally because of its modular design. In all cases, the difficulties in getting a GIS going in remote and developing country environments have been due to local politics, getting the required hardware and devices to work together, and getting a dedicated staff person. Difficulties in learning ARC/INFO have all been due to difficulties in learning basic geography, cartography, and relational database design, which would have to be learned regardless of the software and hardware used. ARC/INFO is as easy to use as any other GIS but in addition has the ability to keep up with the most complex and demanding tasks an advanced user might require. ArcView is another product in the ARC/INFO family that is completely graphic in operation, having no typed commands, and so is extremely easy to learn, with novices and even children able to begin making maps and displays within an hour. ArcView permits the existence of a separate community of data users with no formal training requirement, allowing the general public to benefit in the same way that literate readers benefit from the specialist efforts of authors and publishers. As already mentioned, ArcData is ESRI's own publishing program with a wide variety of global and national data sets available on CD–ROM.

Below is a review of selected organizations and conservation GIS projects supported by the ESRI conservation program.

World Conservation Monitoring Centre, Dr. Mark Collins

Dr. Collins is head of the World Conservation Monitoring Centre (WCMC), Cambridge, England. WCMC is a joint project of the World Wildlife Fund, the International Union for the Conservation of Nature, and the United Nations Environment Programme (UNEP), and is the world's largest repository of conservation data. The goal of the WCMC is to "support international programmes for conservation and sustainable development through the provision of information on the world's biological diversity." WCMC is the compiler and publisher of the Red Data Books, the principal authority on endangered species and their current status.

- **The Tropical Rain Forest Atlas—**A multinational, multiyear effort in collaboration with UNEP and Food and Agriculture Organization of the United Nations (FAO). It is based on ARC/INFO and Mundocart. A database of computerized maps of tropical forests is also being prepared in association with this atlas.

- **Biodiversity Map Library—**The Tropical Rain Forest Atlas is also serving as the foundation for a computerized world Biodiversity Map Library. ECP provided consultations, advice, and review on the Map Library Project in which ESRI's top database design experts donated their time to review and contribute to the database design proposals comprising the map library, drawing on ESRI's wide experience in designing large global GIS map libraries for other clients.

- **Antarctica Database—**WCMC conducted a joint venture with ESRI to publish the Antarctica Digital Database, a two-year compilation program by WCMC, the British Antarctica Survey, Scott Polar Research Center, and the Scientific Committee on Antarctic Research. This database is available on CD–ROM.

- **GIS Database of Wetlands**

- Future projects with GIS include mapping the global status of other ecosystems, preparing a global database of all tropical parks and reserves, and carrying out global analyses of gaps in the protection of critical habitats.

History of ECP Support to WCMC

- First PC ARC/INFO donation in 1989.
- WorkStation ARC/INFO donated in 1990.
- Two weeks of on-site volunteer support to set up the GIS lab and the WorkStation ARC/INFO.
- On-site training and self-paced educational materials.
- Scholarships to support WCMC attendance at the ESRI 1991 International User Conference and the parallel Conservation user conference.
- Four more PC ARC/INFO donations to support the map library, Tropical Rain Forest Atlas, and the Bird Biodiversity Atlas.
- WCMC GIS center now includes six PCs ranging in size from 80 to 340 MB and several UNIX workstations obtained with help from the ECP.
- Advanced training scholarships and support for attendance at the ESRI Training Center in Redlands.

Sierra Biodiversity Institute, Steve and Eric Beckwitt, Dr. Peter Morrison

The Beckwitts have been using a GIS and satellite data to map out remaining ancient forest stands in the California Sierra. This is a locally based program that has been successful in changing National Forest Service policy through the use of local knowledge presented as maps developed on ARC/INFO. Since the first donation of PC ARC/INFO in 1989, the Sierra Biodiversity Institute (SBI) has advanced rapidly in applying GIS techniques. This advanced capability has allowed them to carry out the following projects:

- **Identify old growth areas** in the Sierra Nevada threatened by logging. These GIS activities have been featured in a number of articles in the *Sacramento Bee,* the *San Jose Mercury News,* and on California television stations.

- **Organize local action** and present GIS maps in congressional testimony that resulted in withdrawing these areas from logging plans.

- **Sierra Biodiversity Project—**To begin to accurately inventory and analyze the threats to native ecosystems of the Sierra Nevada. Act to protect these resources throughout the United States Forest Service (USFS) utilizing the NEPA administrative appeals process at the regional and national level.

History of ECP Support to SBI

- First PC ARC/INFO donation in early 1989.

- WorkStation ARC/INFO donated in 1990.

- On-site volunteer consulting support.

- On-site training and self-paced educational materials.

- Assist with acquisition of remote sensing imagery.

- Scholarships to support SBI attendance at the ESRI 1991 International User Conference and the parallel Conservation user conference.

- ECP has worked closely with SBI in arranging equipment donations totaling over $50,000.

- Advanced training scholarships and support for attending the ESRI Training Center in Redlands.

- Logistical support for data processing and translation and electrostatic printing in preparation of materials for congressional presentations.

- Donation of the ESRI census analysis programs for use by SBI in assessing the socioeconomic impact of old growth preservation on northern California local economies.

The Wilderness Society, Susan Balikov

The Wilderness Society (TWS) is carrying out ancient forest mapping in Washington, Oregon, and northern California. TWS also lobbies extensively in Washington, D.C., for protection of wilderness areas and critical ecosystems throughout the USA. Since the first donation of PC ARC/INFO in 1989, TWS has carried out the following cooperative GIS and remote sensing projects:

- **Detailed GIS analysis of the Olympic Peninsula,** with maps from the GIS published in the *National Geographic* September 1990 article "Will We Save Our Own?". Several television documentaries have also used maps from GIS in stories about the ancient forest conflict.

- **Legislation—**TWS maps and data were referenced eighteen times in the U.S. Fish and Wildlife Service (USFWS) report recommending endangered species listing for the spotted owl. TWS maps have also been used to delineate federal habitat conservation areas and in the 1989 EPA Environmental Indicators Report.

- **Detailed GIS analysis** of eleven additional national forests in the Pacific Northwest, leading to the findings that proposed habitat conservation areas were inadequate to protect old growth. These maps have been widely used as they provide the only reliable and current information on the status of old growth forests.

- **Advocacy—**TWS GIS maps are regularly used in congressional testimony and in individual briefings of U.S. congressmen, senators, state legislators, and governor's staff.

- **Mapping the Ancient Rain Forests of Vancouver Island—**ECP is providing logistical support to help process data from other agencies into a compatible format.

- **Ancient Forest Mapping on the Okanogan National Forest**

- **Ancient Forest Reserve Design** in western Washington, Oregon, and northern California (in collaboration with the Sierra

Biodiversity Institute GIS mapping project). Studies of Pacific Salmon and the influence of land management practices on declining stocks.

History of ECP Support to TWS

- First PC ARC/INFO donation in early 1989.
- WorkStation ARC/INFO donated in 1991.
- On-site volunteer consulting support.
- On-site training and self-paced educational materials.
- Scholarships to support TWS attendance at the ESRI 1991 International User Conference and the parallel Conservation user conference.
- ECP organized special hardware donor meetings at the 1991 conference and, from these meetings, helped with a donation request to Sun Microsystems that recently resulted in a donation of $50,000 in hardware to TCW.
- TWS GIS center now includes five PC-based GIS workstations.
- Advanced training scholarships and support for attending the ESRI Training Center in Redlands.
- Logistical support for data processing and translation.

Future projects with GIS include comprehensive ancient forest mapping for coastal British Columbia, determination of logging rates on Vancouver Island in 1990–1991, assessing alternative old-growth management regimes and their implications on biodiversity, Pacific yew distribution and management, ecosystem assessment and protection across the Rocky Mountains, northeastern forests, southern Appalachians, and native grasslands.

CEDI—Ecumenical Center for Documentation and Information, Sergio Mauro Santos Filho

Ecumenical Center for Documentation and Information (CEDI) has been involved in defending the rights of the indigenous peoples of Brazil. They are currently using a GIS to map out native lands in Amazonia in order to protect them from incursion and to help the native Amazonians manage these lands. ECP is providing ARC/INFO, training, scholarships, assistance with hardware donations, scanning some initial maps, and support for attendance at the Conservation user conference.

Center for Conservation Biology, Dr. Paul Erlich, Dr. Stewart Weiss, Dr. Paul Rich

The Center for Conservation Biology (CCB) carries out research, education, and application of conservation biology principles in projects around the world. CCB is developing a GIS model linking microclimate and biodiversity as a tool for identifying critical habitats and predicting the potential effects of global warming. ECP is providing ARC/INFO, training, scholarships, assistance with hardware donations, and support for attendance at the Conservation user conference.

Conservation International, Andy Mitchell, Randy Hagenstein

Conservation International (CI) is a private nonprofit conservation group working to save endangered rain forests and other critical habitats worldwide, primarily through developing local capacity and empowering local people. CI is using an in-house GIS in its programs and has introduced ARC/INFO in its new Temperate Rainforests program. ECP is providing ARC/INFO, dedicated former employees, and support for attendance at the Conservation user conference. Recently, Sun Microsystems awarded a grant of $74,140 in hardware to support the Temperate Rainforests program at CI.

Development Alternatives, Ashok Khosla

Development Alternatives conducts research and carries out projects on sustainable development and appropriate technology in India and worldwide. They are planning to use GIS to help bring scientists and decision makers into a closer dialog to help resolve environmental conflicts. ECP is in the process of providing ARC/INFO to help start this project.

IUCN–Costa Rica, Mike Junkov, Guillermo Navarro

The IUCN Regional Office for Central America (ORCA) supports scores of conservation and sustainable development projects in the region, ranging from binational parks to locally based sustainable village forestry programs. ORCA plans to develop GIS databases for many of its projects and to apply GIS analysis methods for protecting Central American rain forests and introducing sustainable forest management practices. ECP is providing ARC/INFO, training, scholarships, assistance with hardware donations, scanning some initial maps, and support for attendance at the Conservation user conference.

Kenya Wildlife Service, Nairobi, Dr. Richard Leakey, Mrs. Tahareni Bwana

The Kenya Wildlife Service (KWS) is a new parastatal organization established in 1990 to manage and protect the national parks and wildlife of Kenya. KWS is planning to use GIS tools and methods to carry out integrated management of the nation's parks and wildlife areas and to increase involvement of local communities. ECP is providing ARC/INFO, training, scholarships, assistance with hardware donations, and support for attendance at the Conservation user conference. An ECP volunteer also provided two weeks of on-site training and support.

University of California, Dr. Michael Soule

University of California, Santa Cruz is in the process of forming a Conservation Biology GIS research center to support the application of GIS to locally based environmental action. ECP has provided ARC/INFO, training, and scholarships for this new effort.

World Data Center, John Kineman

The World Data Center (WDC) is using GIS to collect a variety of sample data sets to encourage wider distribution of geographic and resources databases. ECP provided PC ARC/INFO and training materials and support for attendance at the Conservation user conference, and it helped research problems on data format.

Zambia National Parks and Wildlife Department, Wildlands and Human Needs Program, Dr. Dale Lewis

This program is integrating the needs of villagers with the priorities of conserving wildlife by training villagers to be game scouts and take an active hand in managing wild areas. ECP provided ARC/INFO, assisted with hardware donations, and provided training in Redlands, local training materials, and use of the scanner to automatically digitize a basemap series covering the national parks and game areas of Zambia. ECP also arranged for the donation of hundreds of textbooks to help start a national network of conservation libraries in the game scout training centers. An ECP volunteer recently completed one month of specialized on-site training in remote sensing applications using ARC/INFO.

ESRI GIS SOLUTIONS

For over 25 years ESRI has been helping people manage and analyze geographic information. ESRI offers a framework for implementing GIS in any organization with a seamless link from personal GIS on the desktop to enterprisewide GIS client/server and data management systems. Our GIS solutions are flexible and can be customized to meet the needs of our users. ESRI is a full-service GIS company, ready to help you begin, grow, and build success with GIS.

ArcView® *software enables users to quickly select and display different combinations of data and to creatively visualize information from their desktops.*

ARC/INFO® *software is a high-end GIS with capabilities for the automation, modification, management, analysis, and display of geographic information.*

PC ARC/INFO® *software is a full-featured GIS for DOS and Windows™-based PCs.*

ArcCAD® *software links ARC/INFO, the world's leading GIS software, to AutoCAD®, the world's leading CAD software.*

SPATIAL DATABASE ENGINE (SDE™) *software is a high-performance spatial database that employs a true client/server architecture to perform fast, efficient spatial operations and management of large, shared geographic sets.*

For more information, call

1-800-447-9778 (1-800-GIS-XPRT)

Send E-mail inquiries to info@esri.com

Visit ESRI on the World Wide Web at http://www.esri.com

GIS by ESRI™

CORPORATE OFFICE

ESRI
380 New York Street
Redlands, California
92373-8100 USA
Telephone: 909-793-2853
Fax: 909-793-5953

U.S. OFFICES

Alaska
Telephone: 907-344-6613

Boston
Telephone: 508-777-4543

California
Telephone: 909-793-2853, ext. 1906

Charlotte
Telephone: 704-541-9810

Denver
Telephone: 303-449-7779

Minneapolis
Telephone: 612-454-0600

Olympia
Telephone: 360-754-4727

Philadelphia
Telephone: 610-725-0901

San Antonio
Telephone: 210-340-5762

St. Louis
Telephone: 314-949-6620

Washington, D.C.
Telephone: 703-506-9515

INTERNATIONAL OFFICES

ESRI-Australia
Telephone: 61-9-242-1005

ESRI-Canada
Telephone: 416-441-6035

ESRI-France
Telephone: 33-1-450-78811

ESRI-Germany
Telephone: 49-8166-380

ESRI-Italia
Telephone: 39-6-406-961

ESRI-South Asia
Telephone: 65-735-8755

ESRI-Spain
Telephone: 34-1-559-4375

ESRI-Sweden
Telephone: 46-23-84094

ESRI-Thailand
Telephone: 66-2-678-0707

ESRI (UK)
Telephone: 44-1-923-210-450

For the location of an international distributor, call 909-793-2853, ext. 1375

Printed in USA