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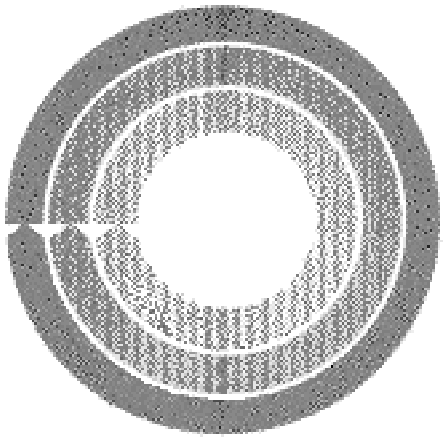

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CONGRESS ON APPLICATIONS OF GEOGRAPHIC INFORMATION SYSTEMS TO THE SUSTAINABILITY OF RENEWABLE NATURAL RESOURCES

RENEWABLE RESOURCES JOURNAL
SPECIAL REPORT

RENEWABLE NATURAL RESOURCES FOUNDATION

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SPECIAL REPORT: CONGRESS ON APPLICATIONS OF GEOGRAPHIC INFORMATION SYSTEMS TO THE SUSTAINABILITY OF RENEWABLE NATURAL RESOURCES

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Foreword

It is significant that the 20 member organizations of the Renewable Natural Resources Foundation decided many months ago to authorize a national meeting on geographic information systems (GIS) and sustainability. The selection and joining of these subjects, from the many considered, was significant recognition by this scientific community of the increasing importance of GIS to advancing sustainability.

This report describes an important interdisciplinary gathering of more than 100 professionals, scientists and educators at Jackson Lake Lodge in Grand Teton National Park, Wyoming, September 11–14, 1996. Delegates to this national congress on "Applications of Geographic Information Systems to the Sustainability of Renewable Natural Resources" were nominated by RNRF's 20 member organizations. The synergy created by this diverse group of delegates—from different employment sectors, from across the continent, and trained in the biological, physical and social sciences—resulted in numerous insightful recommendations to guide our future efforts.

GIS is a technology that can empower communities to participate more knowledgeably in local and regional land-use and other natural resources decisions. It is a technology that promotes interdisciplinary approaches to natural resources management—something in which RNRF members believe. Finally, GIS is an important tool in analyzing and visualizing complex problems. Using this technology increases the probability of making better decisions.

This report outlines what needs to be done to realize the potential of GIS in promoting the sustainability of renewable natural resources. And, there is plenty to be done. As you will note, important implementation responsibilities must be borne by private companies, communities, nonprofit organizations, educational institutions, and county, state and federal agencies.

Before closing, I am delighted to recognize the efforts of many who contributed to the success of this program. First, Gale W. TeSelle, chair of the Congress Program Committee, and the other 15 volunteers who served with him deserve an enormous amount of credit (see the committee roster on page 3). They took the general concept for the meeting, approved by the RNRF Board of Directors, and gave it depth and substance.

Another important contribution was made by the faculty, graduate students, and other personnel of the College of Natural Resources at Utah State University. The college hosted a wonderful opening session, with welcoming remarks from Provost Jay Gouge. During the three-day congress, faculty members served as working group chairs, and graduate students served as working group reporters. We could not have succeeded without them.

Finally, a very special thanks goes out to the federal agencies which recognize the importance of this interdisciplinary work by providing financial support. Our federal partners are listed on page 3.

Richard L. Duesterhaus
Chairman, Board of Directors
Renewable Natural Resources Foundation

Introduction

Peter M. Morrisette

In recognition of the critical role that geographic information systems (GIS) play in resource management, the Renewable Natural Resources Foundation (RNRF) convened a national meeting of GIS and resource management professionals to explore the use of GIS as a tool for promoting the sustainability of renewable natural resources, particularly at the community level. The meeting, entitled "Applications of Geographic Information Systems (GIS) to the Sustainability of Renewable Natural Resources," was held at the Jackson Lake Lodge in Grand Teton National Park, Wyoming, on September 11-14, 1996.

The purpose of the meeting was based on the premise that resource managers and local communities need and demand quality information about what resources are available and where they are located. This information must be accurate, consistent, timely, and shareable. As the management of natural resources becomes increasingly community oriented and the public seeks more information and accountability, GIS should be considered an essential analytical tool for quickly accessing and communicating land-and resource-planning information among resource specialists and local communities.

RNRF member organizations believe that GIS is being underutilized by resource managers and by local communities. In order to remedy this problem, RNRF brought together over 100 delegates from across the United States and Canada to reach a greater understanding of the uses and applications of GIS as a tool for promoting sustainable resource management among the professional, scientific, educational, resource management, and policy-making communities.

The delegates were nominated by the 20 member organizations of RNRF. RNRF made considerable effort to achieve a broad spectrum of disciplines and backgrounds among the delegates who represented many different local, state, and federal resource management and planning agencies, academic institutions, non-governmental organizations (NGOs), and the private sector. Many of the leading authorities in resource management and GIS attended the congress. However, it was not a forum only for "experts" in GIS; RNRF made a concerted effort to include professionals from diverse fields who would benefit from attending the meeting regardless of their background in GIS. Indeed, one of the primary objectives of the congress was to promote the future use of GIS among planning and resource management professionals who have had little experience with the technology. A list of delegates is provided in the appendix.

The congress had three specific objectives: 1) provide a forum for an interdisciplinary dialogue and examination of the applications of GIS for resource sustainability in the planning, management, decision-making, and conservation of renewable natural resources; 2) determine the priority issues concerning the accessibility, accuracy, consistency, and capability of the information that can be utilized through GIS tecnnology, and consider future applications of GIS technology in resource analysis, integrating and managing data, and in communicating possible solutions to complex environmental problems; and 3) recommend approaches or actions that need to be taken by federal and state governments, universities, private enterprises, and the natural resources professions to better utilize GIS and its potential benefits to community-based decision making in land and resource planning.

Six broad topics were the focus of discussion. Working groups were organized around each of these topics. The topics were identified by the RNRF Congress Program Committee as key issues that confront resource managers and planners in furthering the use of GIS as a tool for promoting the sustainability of renewable natural resources. The six topics and working groups were:

The author of this report, Peter M. Morrisette, formerly a member of the RNRF Board of Directors, has a Ph.D. in geography and works as a research consultant based in Victor, Idaho. He has held positions with Resources for the Future (RFF) and the Consortium for International Earth Science Information Network (CIESIN).

1. RESOURCE SUSTAINABILITY DATA AND INFORMATION TECHNOLOGY REQUIREMENTS

The focus of this group was to address the data and technology requirements of communities for effectively managing and sustaining renewable natural resources. This group, which had to tackle both the concept of sustainability and community, had perhaps the broadest scope of the six working groups. Specifically, participants in this working group assessed the data and technology needs of communities for utilizing GIS, the community level indicators of resource health and the data needed to support those indicators, the ways in which a local community assesses its resource sustainability goals within the context of state and national goals, and the ways in which GIS technology can support the decision making process.

2. GIS AND TELECOMMUNICATIONS TECHNOLOGY

This group addressed the technology issues that both enable and limit a community's access to information, data, and tools for using GIS in the management of renewable natural resources. With revolutionary changes in software and hardware, and the explosive growth in use of the Internet and the World Wide Web, this group had to tackle some very timely and difficult issues. Questions that participants considered included the limitations that restrict community access to GIS technologies, the extent to which cost is a factor, the extent to which more research and development could aid in solving the problem, and other actions needed to increase accessibility to GIS technology at the community level.

3. DATA AND DATA MANAGEMENT

Identifying data needs and assessing the adequacy of existing data for communities to engage in sustainable natural resources management was the issue addressed by this working group. Data lie at the heart of GIS, and this group had the task of exploring the data needs of local communities for effectively utilizing GIS technology. Participants in this working group considered whether there are adequate means for knowing what data exist, whether they are useful at the community level, and whether there are adequate standards in place for sharing data. Participants also addressed questions of data integration, privacy, and legal liabilities.

4. EDUCATION AND AWARENESS

Fostering an awareness of GIS technology as a tool for achieving the sustainable management of renewable natural resources, particularly at the community level, was the focus of this working group. Participants considered the relationship between GIS technology and sustainability, the steps needed to increase awareness of GIS, what different user groups need to know about GIS, the practical applications of GIS in resource management and economic development, and the role of formal education at all levels in increasing awareness of GIS.

5. ROLES AND RESPONSIBILITIES OF THE FEDERAL, STATE, LOCAL GOVERNMENT SECTORS, NON-GOVERNMENTAL ORGANIZATIONS, PRIVATE, AND ACADEMIC SECTORS

What are the roles of government at all levels, universities and the research community, non-governmental organizations, and the private sector in promoting the use of GIS as a tool for achieving sustainability of renewable natural resources? This was the question addressed by this working group. Specifically, this group focused on issues concerning how these large and diverse institutions and organizations could effectively work together, the specific roles of the private and public sectors in database management, and the adequacy of existing mechanisms for coordination. In addition, working group members considered the role of RNRF member organizations in enhancing the application of GIS technology to resource sustainability.

6. CASE STUDIES, APPLICATIONS, AND WORKING MODELS

The focus of this working group was to identify and explore examples of effective resource sustainability that could serve as models for others. Specifically, participants in this working group considered models at the federal or state level that might be useful to local communities, and examples at the community level that could serve as a model at the state and federal level. How do you evaluate case studies, what are the indicators of success, and how do you initiate support for projects at the community level were other issues considered by this group.

Delegates were assigned to working groups based on preferences that they identified on their meeting registration forms. RNRF made every effort to both meet the preferences of delegates and achieve a balance of disciplines and perspectives in each working group. Using a model developed at its 1992 Congress in Vail, Colorado, RNRF rotated delegates among different working groups. Each working group met for four two-hour sessions. Only the chair and recorder remained the same for each session of a working group. Working group chairs and recorders were from the College of Natural Resources at Utah State University. This model of rotating delegates among four of the six working groups provided an opportunity for delegates to comment on an array of issues, and for each working group to incorporate ideas and

concepts discussed in other groups. A set of questions was distributed to delegates at the start of each working group session. The questions, developed by the RNRF Congress Program Committee, were intended as an aid to structure the discussion of the group.

The congress opened with an evening reception on September 11 hosted by the College of Natural Resources at Utah State University. The first full day of the meeting (September 12) began with plenary sessions in the morning and early afternoon. Delegates then met in the first of four working group sessions. Working group sessions continued all day on September 13, and the congress concluded on the morning of September 14 with a final plenary session where summary reports of the working group findings were presented.

To set the context for the working group discussions, the congress opened with three plenary talks and the presentation of two case studies. In the first plenary, Robert D. Day, executive director of RNRF, presented an overview of the concept of sustainable development utilizing the recent report of the President's Council on Sustainable Development. Day noted that the concept of sustainable development can be viewed as a natural evolution from the traditional concept of resource conservation to one that more fully includes human values. Sustainable development is not necessarily an intractable problem. Managers need to approach it from an incremental perspective in which they breakdown large complex issues into smaller individual problems that have workable solutions. Day views GIS as an enabling technology that will help resource managers at the community level develop these workable solutions contributing to sustainable development and the sustainability of natural resources.

In the second plenary presentation, Jack Dangermond, founder and CEO of Environmental Systems Research Institute, presented an overview of the history and uses of GIS technology and some insights on its future potential. Dangermond explained that GIS provides a holistic method for examining resource sustainability issues that allows for a cross-cutting look at problems and solutions. Technology is becoming less of a limiting factor. The focus now is on issues of data and science. He noted the growing reach and pervasiveness of GIS. GIS tools are now embedded in other software and available over the Internet. The trend, according to Dangermond, is clearly toward more transparent technologies and more users. He believes that the Internet will be the future home of GIS technology, and it will displace traditional desktop uses. He notes that the age of "maps and apps" is already upon us, where we download a map and an application from the Internet. Dangermond is concerned, however, that with the growing pervasiveness and transparency of GIS technology, we run the risk of simplifying problems and solutions and becoming lost in a world of virtual reality. We must be careful not to lose touch with the real world. Nevertheless, GIS is one of the best tools we have for integrating information and data, and we must strive to make the most comprehensive use of it.

In the third plenary talk, John J. Moeller who is the staff director of the Federal Geographic Data Committee (FGDC), provided an overview of federal data coordination activities. Moeller explained the role of the FGDC, National Spatial Data Infrastructure (NSDI), and the National Data Clearinghouse. These programs are aimed at building partnerships for sharing geospatial data and for establishing shared standards. In addition to these three plenary talks, there also was an evening presentation on the evolution of the GIS profession by John C. Antenucci of Plan Graphics, Inc.

The two case-study presentations provided delegates with some real-world examples of how GIS is being used by communities to solve problems of resource sustainability. The first case study focused on efforts to use GIS technology in the Greater Yellowstone Ecosystem. The Greater Yellowstone Ecosystem includes over 20 million acres centered on Yellowstone National Park and the seven national forests that surround it. A panel discussion was organized by Frederic H. Wagner of the College of Natural Resources at Utah State University. The panelists included Anthony Barnosky of the Mountain Research Center at Montana State University; Dave Heilig of the USDA Natural Resources Conservation Service; Marshall Mayer, CEO of Desk Top Assistance; Jerry Reese, supervisor of the Targhee National Forest; and John D. Varley, director of the Yellowstone Center for Resources, National Park Service. The panelists represented diverse backgrounds and interests, and presented numerous examples of how GIS is being used by state and federal agencies, local governments, researchers, and NGOs to address questions of resource sustainability in the Greater Yellowstone Ecosystem. The panelists noted several successful applications of GIS to resource sustainability; however, they also underscored the need for more cooperation in data collection and sharing.

The second case study focused on efforts by the New Jersey Department of Environmental Protection to incorporate GIS into all of its permitting and monitoring activities. The presentation was made by Henry Garie, director of the Office of Information Resources Management for the New Jersey Department of Environmental Protection. Garie noted that New Jersey is using GIS to help strike a balance between environmental protection and economic development. He illustrated how GIS is used throughout his agency to integrate data and make day-to-day management, monitoring, and permitting decisions. Garie also noted how his

agency has worked with NGOs to improve public access to environmental information in New Jersey.

The remainder of this report presents the discussions, findings, conclusions, and recommendations of the delegate working groups from the congress. The report is structured around these six working groups. This report is based on the official recorder notes for each session, and on notes provided by session chairs and by volunteer recorders who were selected from among delegates attending each working group session. This overview report would not have been possible without the high–quality notes provided by these individuals.

No formal effort was made at reaching a consensus among all the delegates on all the issues. Each working group had its own dynamic and incorporated different approaches for structuring discussions and reaching conclusions. There also were variations from session-to-session within working groups. This report attempts to accurately portray the content and spirit of the discussions that took place within the individual working group sessions. The findings, conclusions, and recommendations reached at the congress, and included in this report, represent the opinions and ideas of the delegates attending the congress and not necessarily those of the Renewable Natural Resources Foundation and its member organizations, the agencies and organizations that provided financial support, or the author.«

Resource Sustainability Data and Information Technology Requirements

To effectively use GIS as a tool for sustainable natural resources management, local communities need access to data and information about their natural resources and the condition of their environment. These data and information must be assessed and utilized in a complex social and political environment in which local values and goals may not mesh well with the goals and values of outside organizations and institutions (e.g., state and federal agencies or environmental groups). Delegates in this working group considered the environmental data and information needs of local communities, the efforts needed to meet these data and information needs, and the means for addressing local community needs in the context of state and national goals for sustainable development. The following seven questions were provided as a basis for discussion:

1. What data are required for a community to effectively discuss, plan, and engage in efforts to sustain renewable natural resources?
2. How can a community go about establishing indicators of resource health?
3. What are the data needs and resource-health indicators for a state or nation to support its goal of sustaining renewable natural resources?
4. How does a community assess the relationship between its resource-health indicators and state or national goals?
5. What natural resource inventories and monitoring data are needed to measure indicators of resource health?
6. What information technologies are needed by communities to support decision making processes related to efforts to sustain natural re-sources?
7. What decision-support systems and technologies need to be accessible to a broad range of citizens in a community?

For most delegates, addressing these questions first required an attempt at defining what community and sustainability mean. This was an issue raised by all four working group sessions and formed the basis for much discussion. In general, delegates agreed that communities exist at more than one scale, and can be centered on a place or defined by shared values and interests. However, most of the focus was on the idea of community as a local place. Within that place, there can be divergent values and interests, and local places fit into a larger state and national context.

Most delegates agreed that sustainability must be defined within the context of the goals and values of a local community. However, a local community does not exist in isolation, we also need a shared national concept of sustainability. Ideally, goals and values at the local level would mesh with those at the state and national levels, but often this is not the case. Cooperation in the collection, sharing, and analysis of environmental data is a good place to begin to build a shared concept of what sustainability means to a community and to the nation. Ecosystem health and management are other useful concepts for defining and guiding sustainability at the community level. Respect for community values is important in developing a concept of what sustainability means at the local and national level.

Spatial scale was a cross-cutting factor for all the issues discussed in this working group. Delegates spent a great deal of time trying to come to terms with how concepts of community and sustainability might differ at various scales–local, regional, national and global. Data needed for effective resource management and indicators of sustainability and ecosystem health also differ by scale. Again, cooperation in the collection, sharing, and analysis of environmental data is a good place to begin to resolve problems of scale and to develop shared concepts of sustainability and ecosystem health.

Delegates agreed that data needs define themselves on a problem or issue basis (i.e., data needs are locally defined), but there is a clear need for good

baseline and inventory data on the condition of natural resources and the health of the environment at all scales. Despite the wealth of data that already exists, we still do not have a good understanding of the condition of our natural resources. We need baseline data sets that can be meshed or integrated, but because there are few standards that guide data collection, often it is difficult to combine two or more data sets. We need better and standardized metadata (background information about data) that addresses the problem of data integration and informs users about appropriate applications of a data set. We also need to be collecting good social and economic data along with natural resources data. Finally, delegates in one session noted that information about ecosystem processes is as important as spatial pattern data, and that not all natural resources and data are equal–some factors are better indicators or stronger causative agents of what is happening in a given environment.

In the discussion about indicators of ecosystem health, delegates noted many of the same issues (e.g., scale, standardization of data) raised during the discussion of data needs. Most delegates agreed that indicators of resource sustainability need to be bottom-up; that is, they need to have relevance at the local community level. These local indicators also need to be developed in the context of national indicators of sustainability. There was little agreement on what are the important local indicators. Most delegates believed that these indicators would define themselves based on the particular issues and problems. There was agreement that the report of the President's Council on Sustainable Development was a good starting point for developing national indicators of sustainable development, but that much more work was needed. We need more research to identify the proper indicators, and we need to better understand the relationship between indicators and ecological concepts such as thresholds and carrying capacity.

Environmental data does little good if local communities do not utilize it. Indeed, promoting the use of environmental data is a good way to start local communities thinking about issues of sustainability and how their natural resource management goals can mesh with state and national goals. Access to GIS technology and to data are barriers to incorporating environmental information into local decision-making. Cost is a factor limiting access to technology and data. More significant limiting factors are the lack of knowledge about the applications of GIS and training in how to use this technology. In addition, we need to teach more about ecosystem management and spatial analysis. Providing technology and data are not enough, local resource managers need to know how to make use of the information that these technologies and data are unearthing. Nevertheless, there was agreement that local communities would benefit greatly from better access to GIS technology, the Internet, and environmental data.

Delegates agreed that it was important for local communities to be part of the decision-making process. For GIS to be an effective tool for local resource managers, these managers need to be partners in the application of GIS to environmental management issues in their communities. It is too often the case that state or federal governments own the technology and data, and that there is little participation from, and consultation with, local communities. State and federal agencies need to be more sensitive to the needs of local communities. Delegates also noted a need for more and better efforts at conflict resolution. Indeed, the ability of GIS to help integrate and visualize complex sets of environmental data make it a very useful tool for conflict resolution, but all the stakeholders need to believe that the process for using this GIS is legitimate.

Finally, two suggestions where made that seemed to cut across many of the issues discussed by the delegates in this working group. The first is the need for a handbook to help communities understand the concepts of natural resource inventories and assessments, and the use of information technology to support ecosystem management and resource sustainability. This handbook would contain information about how to collect data and establish indicators for community sustainability, as well as information about where to find and how to use GIS and other information technologies for resource planning and decision making.

The second suggestion concerned the value of case studies as a learning tool. There is a wealth of good case-study material available. We need to make better use of this material, and we need to improve methods for integrating case studies and drawing generalized conclusions that are applicable to other problems.

This working group grappled with many far reaching and difficult issues regarding communities and sustainability, not the least of which was trying to come to terms with what community and sustainability mean. Delegates agreed that meaningful concepts of community and sustainability must have local roots, but that these local places also were part of larger state, national, and global communities. Resource managers at all administrative levels need to make a better effort at understanding each other's values and needs. Cooperating in the development and use of baseline data sets, indicators of resource health, and applications of GIS technology can help resource managers address issues of resource sustainability in a manner that cuts across scales. We need to bring local communities more fully into the process of developing data sets and using GIS technology.«

GIS and Telecommunications Technology

GIS technology is a powerful tool for assembling, integrating, and visualizing natural resources data, and can contribute in significant ways to the development and implementation of sustainable resource management strategies. However, for GIS to make a useful contribution, resource managers and policy makers must have access to the technology. This working group examined how to improve access to GIS technology, particularly by local resource managers and the public. Delegates participating in this working group considered five questions:

1. Are there limitations that significantly restrict the accessibility and usefulness of GIS and tele-communications technologies to communities that want to be involved in decision-making processes pertaining to management of renewable natural resources? What are these limitations?
2. Are there adequate industry standards in place to support universal and open access to data through common formats and command languages?
3. Is more research and development needed, and if so, in what areas?
4. Are the costs involved in using technologies reasonable to provide adequate public and community access?
5. What actions can be taken to increase general use and accessibility?

Delegates participating in the four sessions of this working group tackled these five questions in order. The discussions for each question certainly overlapped; however, the delegates reached some very specific conclusions and suggestions for each question which are summarized below.

LIMITATIONS TO ACCESSIBILITY AND USEFULNESS OF GIS

A wide-ranging discussion occurred in all four sessions regarding the question of limitations to the accessibility of GIS technology. Access to both technology and data is a limiting factor for everyone working with GIS, whether they are at a university or work for a federal agency. However, access is a particularly acute problem for local resource managers. Cost is a big part of the problem, but lack of training and knowledge about the applications of GIS and where to find data are also very significant limiting factors.

Delegates saw a pressing need for more and better education about GIS. Many local resource managers and much of the public do not know about GIS. Efforts at improving awareness of GIS applications and improving education and training in the use of the technology will lead to better access to the technology. People need to know about the technology before they can use it. Many delegates believed that when more resource managers and the public are exposed to GIS and understand its benefits, they will demand better access. Several delegates noted that education and training must focus on how to use the information that GIS makes available, and not just on how to manipulate GIS technology.

Making GIS technology easier to use or more "user friendly" was another common suggestion. Many people shy away from GIS technology because it is perceived to be too complicated. New technologies that embed GIS into other software applications, and the availability of GIS tools over the Internet, already are increasing access to the technology. Also, many users may not need large datasets and the software to handle them. Representing basic data on a map is all that many local planners need. The Internet is a powerful tool for providing access to GIS applications and to data. It is an easy-to-use and cost-efficient delivery system, but some delegates noted that the Internet also has limitations. Access to the Internet in rural areas still is a problem, and it is slow and often not reliable. Delegates agreed, however, that better, easier-to-use GIS tools that utilize the Internet and other new technologies will attract more users.

Issues concerning privacy of data, data security, proprietary ownership of data, and liability from the use of data are other important factors that limit the use of GIS technology. These factors often are not well understood by users. Cost, of course, is a key factor limiting community access to GIS (this issue is covered in greater detail in the section

on Education and Awareness). Limitations in the telecommunications infrastructure, particularly available bandwidth, also curtail access.

ADEQUACY OF INDUSTRY STANDARDS

Many delegates thought that lack of standardized metadata (information that explains the origins and uses of the data) is a problem, but numerous agencies, professional organizations, and industries are trying to address this issue. There was some concern that the current FGDC metadata standards are overly complex and should be refined. In addition, metadata standards need to better address issues of scale and layering so that different data sets can be integrated. There also was discussion over how open the process of standard setting should be. Delegates agreed that GIS hardware, software, and telecommunications standards will likely come from industry, and data standards from the professions. Delegates further noted the need for coordination among federal, state, and local agencies in establishing data standards.

Finally, there was much discussion about the different roles of public agencies and the private sector in establishing metadata standards and developing data. This discussion centered on the issue of who pays for and should have access to data. Most delegates agreed that data collected by public agencies should be available to the public, and that private industry has a proprietary right to data that it has developed.

NEED FOR RESEARCH AND DEVELOPMENT

Most delegates noted a need for more data, particularly baseline or inventory data that are useful to a wide audience. The need for improvements in data accuracy and the development of methods for addressing problems of data inaccuracy were noted by several participants. The trend away from public data development and toward private data development concerned some delegates. Access to data could be a problem. Other delegates noted a need for better data archiving methods. They were concerned that changes in technology and standards might make data archived today obsolete in five or ten years.

Technological change was a major topic of discussion. There was discussion but no agreement over whether needs and uses were outpacing developments in GIS technology, or whether the technology was being underutilized. There was agreement, however, that the Internet and World Wide Web will be an important part of future technological developments. Many delegates noted the need for improvement in getting reliable, useable information into the hands of users quickly. The development of more user-friendly GIS applications and expanded use of the Internet as a delivery system are potentially powerful tools for accomplishing this goal.

Finally, there is a need for research into the effect that GIS is having on resource management decision making. We need to understand how GIS has changed the way resource management decisions are being made, and the impacts of those changes on landscapes and people.

COSTS OF USING GIS TECHNOLOGIES

Delegates agreed that cost is a key factor limiting the use of GIS by local governments, schools, and libraries. These costs involve not only hardware and software, but also data, training, and salaries. Indeed, data and personnel costs often are much greater than hardware and software costs. We need to develop low-cost and easy-to-use GIS products, and we need to demonstrate the cost effectiveness of using GIS. In addition, the public, not just local governments, needs to be made aware of the usefulness and cost effectiveness of GIS.

Demonstrating cost effectiveness is critical. Local governments are concerned about whether they will get their money's worth out of GIS. These concerns are based not only on issues of direct costs such as software and hardware, but also on whether the technology is useful and accurate. Using county extension agents was suggested as one means of demonstrating the usefulness and cost effectiveness of GIS to local governments. Delegates also discussed whether it was appropriate for local governments to charge the public for data and GIS services. Cost recovery is an important issue that needs to be considered by local governments.

ACTIONS NEEDED TO INCREASE ACCESSIBILITY

Better efforts at building awareness of GIS and educating people about how to use the technology are important steps to improving access and use. GIS education at the K-12 level was stressed by many delegates. Education needs to focus both on how to use GIS and how to think spatially. Teachers need to be trained about GIS and spatial analysis and how they can be used in the classroom. We also need to place more emphasis on natural resources and environmental education so that people know how to interpret and understand the information that is produced using GIS. Delegates agreed that once people know what GIS can do for them, they will want to use it.«

Data and Data Management

Data collection and management are key elements in developing a GIS system for managing natural resources. GIS technology is not of much use if there are no available data. Do we have good data, particularly at the community level, for managing natural resources in a sustainable manner? This question was the focus of discussion for this working group. Delegates examined a wide range of issues concerning the availability and quality of data, the adequacy of metadata standards, and problems of privacy, accuracy, and liability. Discussions in this group addressed eight specific questions:

1. Are there adequate means of knowing what data exist and whether the data are useful for purposes of community efforts to sustain natural resources?
2. Are there certain fundamental databases that are most important and that should receive highest priority for development?
3. Are there adequate standards in place for renewable natural resources data and related data so that integrated use and data sharing can occur?
4. Do we have adequate understanding of the relationship between natural resources and environmental-health indicators and the inventories of data holdings in these areas that are currently available?
5. What is the best way to accomplish data integration for project-level use?
6. Who should maintain currency and accuracy of data?
7. How should concerns of privacy of information be handled in a community-based project?
8. Are there legal liabilities likely to result from using data that are in error or inaccurate?

Each session of this working group focused its discussion on a different set of these questions, and none of the working groups had enough time to address all eight questions. For example, metadata standards and indicators were the focus of one session, while another session spent more time with the problem of data integration. Privacy was an issue that all four sessions addressed. The summary below is organized around five topics: data and metadata, fundamental databases, indicators, data integration, and privacy, accuracy, and liability.

DATA AND METADATA STANDARDS

Most delegates agreed that current metadata standards need to be simplified and refined. Metadata is the information that explains what a specific data set is, how the data were collected, and how the data should be used. Some delegates felt that quality of metadata was not as much of a problem as the fact that users seem to ignore metadata. Others argued that metadata was too complex or not easily available, and that is why users tend to ignore it. Regardless of these differences, delegates agreed that current metadata standards are inadequate.

Delegates agreed that there is a need for a common, minimum standard for metadata that everyone follows. Developing a common, minimum standard will not be easy. Clearly there are important roles here for the federal agencies and other data organizations, but the process must also include local communities and users. One suggestion was to develop a certification process for metadata. This process would certify that a specific data set contains metadata information in accordance with at least the minimum standard. There is also a need for better education of users about the role and importance of metadata. Users need to know what metadata is and how to use it. In addition, it is important that metadata is delivered as part of the package that contains the data.

Access to data and metadata was another issue discussed by delegates. Everyone agreed that there are important roles here for the Internet, data catalogs, and data clearinghouses. We need to improve our ability to let users know what data and metadata are available, even if the information being provided is incomplete. Libraries and librarians should be a part of the process. Several delegates cited examples (from Montana and Pennsylvania) of the valuable role of libraries in providing access to, and information about, data. There also is a need for better metadata browsers that incorporate improved search services and pathways for locating data.

FUNDAMENTAL DATABASES

There was a wide-ranging discussion over the issue of what constitutes complete, fundamental resource-inventory data sets. Some key types of data were cited as essential (e.g., soils and demographic data), but delegates agreed that data needs vary based on the needs of a community and the issue being addressed. Still there was agreement on the need for complete, baseline or inventory data sets. In addition, standards need to address issues related to scale, layering, and integration. Problems with matching, overlaying, and integrating data are a barrier to developing baseline data sets. Digital orthophoto quads (DOQs) were cited as a good base to work from to develop baseline data sets.

INDICATORS OF ENVIRONMENTAL HEALTH

Delegates noted that we do not have an adequate understanding of the relationship between natural resources data and environmental-health indicators. Indeed, we do not know much about environmental-health indicators, or what constitutes a healthy ecosystem. Delegates agreed that environmental-health indicators will vary among communities, and that developing standards for indicators will be very difficult. Historical data, such as data on land-use/cover change, were cited as valuable information for developing indicators of environmental health.

DATA INTEGRATION

Data integration is essential but often very difficult because of lack of standards, lack of a common base maps such as digital orthophoto quads, and problems with scale and layering. Different data sets do not match up well. Delegates noted the need for coordination and collaboration among users and developers so that issues of data integration can be resolved. Some delegates believed that the only way to resolve the integration of natural resources data such as soils, land cover, hydrology, and geology is to conduct integrated, multi-agency collaborative field resource-inventory and mapping projects using the same base map at the same time interval and scale.

ACCURACY, LIABILITY, AND PRIVACY

The issues of accuracy, liability, and privacy sparked a lively discussion among the delegates. Everyone agreed that these are very important issues. Many delegates were concerned about legal liabilities resulting from issues of data accuracy. Developing accuracy standards might help address this issue, but users still need to take responsibility for using data correctly. Misuse of data will be a problem regardless of accuracy; therefore, the issue of liability is not likely to go away any time soon. Delegates did agree that the best way to avoid legal liabilities is to fully describe the data uses and limitations in the metadata record. Regarding the privacy issue, delegates agreed that some data should remain private. Delegates also felt that as more data becomes available, and the use of GIS technology becomes more widespread, privacy will increasingly be raised as an issue. We need to be able to address the privacy question when it is raised.

SYNTHESIS

The need for establishing minimum standards was a common theme in the discussions throughout this working group. There is a need for standards for addressing issues of accuracy, privacy, data integration, environmental-health indicators, data development, and metadata. The process of developing standards needs to involve agencies, local communities, data users and developers, and the public. Many delegates suggested the need for a database certification process for adherence to metadata and data content standards.«

Education and Awareness

One of the cross-cutting themes throughout the meeting was how to improve education and awareness about GIS. All the working groups touched on this issue in one form or another. Many of the recommendations that came from the working groups addressing data, technology, and resource sustainability issues called for more and better efforts at educating students, professionals, and the public about GIS. Foreseeing the importance of efforts to improve education and awareness of GIS, the congress organizers specifically set up a working group to explore this critical issue. Delegates participating in the working group considered five questions:

1. How does GIS technology relate to renewable natural resources sus-tainability?
2. What steps need to be taken to foster increased use and awareness of GIS technology?
3. What specific user groups need to be better informed about the technology and its relationship to resource sustainability?
4. What are the practical applications and uses of GIS technology related to decisions that address resource management issues in conjunction with economic and quality of life concerns?
5. What are the various roles of K-12 schools, community colleges, uni-versities, adult education, extension and the private sector in providing education to potential GIS tech-nology users and increasing aware-ness in the broader community?

Discussions in this working group covered all five questions but tended to focus on the first two, which for most delegates seemed to encompass the key issues. The summary below attempts to capture the breadth of ideas discussed by the delegates, and is organized around two themes: the relationship between GIS and natural resource sustainability, and the steps needed to improve education and awareness of GIS.

GIS AND SUSTAINABILITY

Most delegates agreed that there is an important relationship between GIS technology and efforts at developing strategies for the sustainable management of natural resources, but they underscored the need for caution and care in using GIS as a decision-making tool. GIS is an excellent tool for organizing, integrating, and displaying environmental data, and therefore, it can contribute to better informed decisions about resource management. Furthermore, because GIS can integrate and display data in ways that were previously not possible, it can also foster new and innovative approaches to sustainable resource management.

Many delegates noted that one of the strengths of GIS as a decision-making tool is its contribution to fostering compromise among competing interests. GIS is a powerful tool that can help decision makers better understand ecosystem patterns, and the specific relationship between uses and impacts. The ability of GIS to integrate and display data provides decision makers with a new way to assess the implications of specific resource uses and associated impacts, and for identifying solutions. Interests on different sides of a resource issue can use GIS to reach a consensus about how to manage and minimize impacts on that resource.

The ability of GIS to display information makes it a very persuasive tool, but it is imperative that it be used in a careful and informed manner. GIS is only a visualization tool; it does not produce solutions on its own. GIS usage must be rooted in a thorough knowledge and understanding of specific problems and the inherent limits of the data available to assess those problems.

Quality data is a critical need. The information produced by a GIS application is only as good (or accurate) as the data used to derive that information. In addition, users of GIS must understand how to ask the right questions–that is, they must understand the types of problems and issues that GIS is an appropriate technology for addressing. Delegates were very concerned about problems that emerge from inaccurate data and the misuse of GIS technology. Resource managers, decision makers, and other users of GIS must be responsible and informed about the natural resource problem being studied to be intelligent users of the technology.

Some delegates also felt that GIS can make a valuable contribution to participatory democracy (particularly at the local level), by providing the public with more and better information about environmental issues. The public can now use GIS tools provided over the Internet and embedded in CD ROM

technology to access and manipulate environmental data and information that was previously unavailable. Delegates noted examples of public participation illustrated in the Greater Yellowstone Ecosystem and New Jersey case studies presented during the congress plenary session. However, there was concern among some delegates that the decision-making process could be overwhelmed by all the new information that GIS technology will make available.

STEPS FOR IMPROVING GIS EDUCATION AND AWARENESS

Information by itself does not equal understanding. Delegates agreed that there is a pressing need to improve awareness of GIS, but this must be coupled with efforts to improve environmental and geographic education. The world of GIS users is broad–it includes professional resource managers and planners, researchers, NGOs, and the public. All of these users need to be educated about how to use GIS technology and the information that it produces. Delegates in all four sessions underscored the need for more and better efforts at teaching spatial analysis and critical thinking skills to students and professionals at all levels. Underlying this recommendation was a belief that just teaching people how to use GIS was not enough, and would be irresponsible. Individuals trained in GIS also need to be trained in how to interpret and judge the information that GIS produces.

Increasing awareness of the benefits of using GIS technology among planning and resource management professionals and the public is another critical need. Many professionals in resource management and planning still do not understand how GIS can benefit them, and the public has little or no understanding of the technology. Delegates suggested continuing education programs and university extension services as a way to reach professionals and the media as a means to introduce the public to GIS. However, before this can be accomplished, educators and the media need to be made aware of GIS as well. Delegates felt that there is a role here for RNRF and the professional resource management societies. The professional societies need to take a lead role in educating their members, the media, and the public about GIS.

Some delegates felt that GIS technology is still too complex and needs to be more user-friendly before it will gain widespread use. Delegates also felt that the products need to be simplified. Users are still overwhelmed by the technology and the intricacies of the information that it produces. There was a feeling, however, that this was an iterative process–increased exposure to and use of GIS will lead to a higher comfort level among users and a better understanding of GIS applications. In addition, the emergence of simple GIS applications on the World Wide Web is indicative of a move toward more user-friendly products.

There was substantial discussion in this working group on the role of K-12 schools, community colleges and universities, and other forms of formal education and training as a means of increasing awareness about GIS. Delegates underscored the need for education in spatial analysis, geography, and ecology in addition to teaching GIS skills. Few high school students are required to take a geography class, and university programs in resource management are weak in spatial analysis. Math and science requirements should also be increased for both K-12 and undergraduate college students.

Several delegates noted examples from their home states (e.g., Utah, North Carolina, and Florida) of how GIS, spatial analysis, and environmental studies are being incorporated into the K-12 curriculum. Government agencies, non-profit organizations, and private businesses are working with schools across the country to incorporate GIS into school curriculums. Educating teachers about GIS and making the technology available to schools are key factors in introducing GIS to K-12 education. The Geographic Alliance sponsored by the National Geographic Society, and Vice President Albert Gore's Globe Project are good models of how to work with schools, teachers, and students at the K-12 level to increase awareness of GIS and geography. The effort by Environmental Systems Research Institute to bring GIS software into K-12 classrooms is another model program.

GIS and spatial analysis also need to be an integral part of the resource management and environmental planning curriculums at universities. Delegates noted that this already is the case in many university programs, but there is room for improvement. Lack of funding and a crowded curriculum are barriers to adding additional courses in GIS. Several delegates who were members of university faculties noted that in resource management programs students have few electives and little flexibility in their curriculum requirements. Adding more GIS training would mean dropping something else. They explained, however, that GIS can be, and is, taught within existing courses (e.g., resource planning or field methods). Delegates agreed that better GIS training in universities was needed. However, delegates also stressed the need to teach core classes in science, math, ethics, and critical thinking. We need to teach students of resource management and planning how to be good professionals, as well as skilled users of GIS technology.

Delegates agreed that there is a critical need for GIS training among mid-career professionals. Many of these professionals graduated from college before GIS training was widely available within universities. Continuing education programs are needed to train mid-career professionals about GIS.

State and federal resource management agencies need to develop programs to train their employees in GIS applications. An example was provided of how one Forest Service office already is retraining many of its employees in the use of GIS technology. Small communities, however, often cannot afford the cost of training. Delegates suggested using university extension services as a way to reach small communities. Delegates also believed that the professional societies should play a major role in promoting efforts at retraining mid-career professionals.

Delegates also noted the need for trained technicians to perform the important data entry requirements of GIS. Currently, there are not enough skilled people available for data entry. Low pay is one reason for the lack of skilled workers, but lack of proper training in data entry is a consistent problem. Delegates thought that community colleges were good places to develop training programs in data entry. A good data entry training program should include spatial analysis, in addition to GIS and data entry skills.

Finally, delegates agreed that the member organizations of RNRF need to become more involved in supporting GIS education. Suggested actions for RNRF and its member organizations included promoting awareness of GIS among the resource management professions and the public, and developing guidelines and standards for GIS training and education programs.«

Roles and Responsibilities of the Federal, State, Local Government Sectors, Non-governmental Organizations, and Private and Academic Sectors

What are the roles and responsibilities of the different actors and sectors who have an interest in or benefit from GIS technology? Who should bear the cost of developing data? Who should develop professional standards? Are there different roles and responsibilities for the public and private sectors? How can cooperation and coordination be improved? These questions and other issues concerning professional roles and responsibilities were the focus of discussion in this working group. Because the issue of roles and responsibilities is so broad, delegates were asked to consider six specific questions:

1. How can federal, state, and local government sectors best work together to enhance the applications of GIS technology to resource sustainability?
2. What roles can individual organizations of the Renewable Natural Resources Foundation play in efforts to enhance the applications of GIS technology to resource sustainability?
3. What role should the private sector play in database management and proprietary ownership of data-bases?
4. What role should the public sector have in database management and proprietary ownership?
5. Which organizations or sectors should assume financial responsibility for development and maintenance of databases?
6. Are the coordination mechanisms that currently exist adequate for the future coordination of geospatial data, GIS technology, telecommunications, etc. among the various organizations and sectors that are likely to be involved in community-based sustainable development initiatives?

These six questions stimulated a wide-ranging discussion in the four working group sessions. Each session approached these questions from different premises, and sometimes came to conflicting conclusions. Nevertheless, several key conclusions resulted from working group discussions. All four sessions devoted a great deal of time discussing the first question, and tended to combine questions three, four, and five into a single question about the different roles and responsibilities of the public and private sectors. The summary presented below is organized around four themes: 1) federal, state, and local cooperation, 2) the role of RNRF member organizations, 3) the role of the public and private sectors, and 4) mechanisms for coordination.

FEDERAL, STATE, AND LOCAL COOPERATION

Delegates agreed that cooperation among federal, state, and local agencies is the key to improving the application of GIS technology to problems of resource sustainability. They also agreed that there are many barriers to effective cooperation among the government sectors. There was much discussion among delegates on who should initiate efforts at coordination and the specific roles and functions of different agencies and organizations. Delegates stressed that no single approach or model will work for everyone, and they warned against becoming totally committed to any single formula. Approaches to cooperation and coordination will vary among communities and problems.

In general delegates thought that the initiative or motivation for coordina-

tion needs to start at the local level–it needs to be bottom up rather than top down. Federal agencies should have in place appropriate structures for responding to the needs of local communities. Delegates stressed the need for federal agencies to be sensitive to local issues and concerns. State agencies need to play the role of coordinator between federal programs and local activities. The state agencies are in the best position, it was believed, to bring local governments and federal agencies together to address common needs and problems. Communicating needs and building partnerships are key elements to effective cooperation among agencies.

How do you develop local initiatives for using GIS technology? Many delegates believe that the local initiative often comes from visionary leadership. Some individual or local organization perceives a need for GIS technology and starts the process of communication with state and federal agencies. Delegates stressed the idea that there must be a local "felt need" for GIS technology, and that efforts at cooperation among local, state, and federal agencies must be mutually supported. Delegates also noted that grassroots NGOs can play an important role by identifying a need for GIS technology, and coordinating efforts among local, state, and federal agencies.

Many delegates perceived a lead role for state agencies in facilitating coordination and cooperation. The state agencies often are in a better position to communicate with local governments than are federal agencies. In addition, federal funding for local activities often is channeled through state agencies. The states also are in a better position to identify needs and provide local training than are federal agencies.

Federal agencies should be in a position to support state and local technical and data needs, and to provide appropriate funding. Delegates also thought that universities could serve as clearinghouses for data and information. They noted that universities often have a good relationship with federal, state, and local agencies.

Delegates also agreed that federal agencies need to improve coordination and cooperation among themselves. In particular, federal agencies need to improve efforts at sharing data. Agencies often do not always recognize that their data may have wide applications beyond the specific purposes for which they were collected. Delegates agreed that the recently established Federal Geographic Data Committee (FGDC) was a positive step toward fostering more inter-agency cooperation. Delegates also agreed that federal agencies along with the FGDC should take the lead in establishing metadata standards and developing base-line data sets. Federal agencies are in a better position to undertake these tasks than are state and local agencies.

Finally, delegates warned against placing too much emphasis on technology and losing sight of the main issue, which is promoting sustainable management of natural resources. Sustainability is a value-based concept that is rooted in place. GIS is merely a tool for assessing spatial/temporal changes in the environment. The goal of coordination is to promote and develop sustainable resource management policies that have strong community support. GIS can be a very useful tool for achieving that goal.

ROLE OF RNRF MEMBER ORGANIZATIONS

Delegates agreed that the professional, scientific and educational organizations that comprise the Renewable Natural Resources Foundation can play a very important role in promoting education and awareness about GIS. Delegates suggested eleven specific actions that RNRF member organizations should consider. These include:

- Develop guidelines for incorporating GIS into undergraduate and graduate curriculums for their respective professions.
- Develop and promote programs for retraining mid-career professionals about GIS. This could include sponsoring workshops and developing short courses.
- Promote interdisciplinary work on the development and application of GIS technology.
- Promote public awareness about the uses of GIS.
- Develop an Internet website for providing information about GIS and its applications to resource sustainability.
- Establish professional and ethical standards for using GIS technology.
- Work with other organizations to establish metadata standards.
- Publish more GIS articles in professional journals and sponsor more sessions on GIS at professional meetings.
- Develop an online GIS journal.
- Emphasize the need for quality peer review as a means to ensure accuracy and responsibility in the use of GIS technology.
- Become an advocate for the use of GIS technology.

ROLE OF THE PUBLIC AND PRIVATE SECTORS

Exploring the roles and responsibilities of the public sector versus the private sector led to a wide-ranging discussion, and the expression of many diverse views. Everyone had an opinion on this topic, but the breadth of this discussion also reflects the fact that the private sector is playing an increasingly important role in developing key natural resource data sets. In addition, efforts at cost cutting by federal agencies likely will lead to an even larger role in

data development for the private sector in the future. Much of the discussion on this topic focused on the issue of who has proprietary rights to data.

Delegates were quick to distinguish between data developed under a government contract and data developed by a company using its own money. There is no question that a company has a proprietary right to data that it developed with its own money, but data developed by the private sector with public funds is in the public domain. A company can sell data that is in the public domain if it has added to the value of that data in some way. Several delegates noted that while public agencies are good at developing data, the private sector is often much more efficient at making useable products out of those data. They further noted that this is a good and useful relationship. Most delegates also agreed that the public sector could charge for data in the public domain to recover costs, but there was no agreement among delegates on whether the public sector should make a profit from its data. Some delegates believed that all public data should be available free of cost.

Delegates expressed concern about the assurances of quality data developed by the private sector. They noted the need for shared metadata standards between the public and private sector, and for some type of peer-review system for assessing data available from the private sector. The concern here is that the consumer needs to have some way to judge the quality of data that is available from the private sector. Delegates also noted that there are good opportunities for public-private partnerships in data development, but regulations and conflict-of-interest issues often make it difficult to pursue these opportunities.

Finally, there was discussion about the role that the market should play in driving data development. Clearly, the private sector will respond to the market by developing data products that are profitable. The role of the public sector is to develop data that meet a public need–even if the private sector is developing data in this area as well. For example, weather data or data on air and water quality should be developed by the public sector. The role of government in data development is to serve the public interest.

COORDINATION

Most delegates agreed that existing mechanisms for coordinating GIS activities were not adequate, but there was little consensus on how one establishes adequate mechanisms for coordination. Numerous efforts and activities aimed at improving coordination already exist, and it is not clear what new actions will add. More can be gained by working with and improving mechanisms that already are in place such as the Federal Geographic Data Committee. In this light, a suggestion was made that the member organizations of the Renewable Natural Resources Foundation consider adopting a resolution supporting the coordination efforts of the Federal Geographic Data Committee.«

Case Studies, Applications and Working Models

Examples of how GIS has been used by state and federal agencies, local communities, and non-governmental organizations to support sustainable resource management were the focus of this working group. Delegates brought a diversity of backgrounds and experiences to bear on this issue, and offered an array of case studies and models of how GIS is being used by communities. Five questions were provided to delegates for discussion:

1. What examples can you point to of approaches and projects sponsored by a federal or state program that can serve as role models for other agencies or organizations attempting to pursue sustainable development initiatives at the watershed and/or community level?
2. What examples can you point to of approaches and projects that are working at various community (watershed, county, township, etc.) levels that can serve as role models for other agencies or organizations attempting to pursue sustainable development initiatives at the watershed and/or community level?
3. What are the examples of improved decision making and protection of resources that have occurred as a result of these models?
4. What lessons have been learned from these examples?
5. What are the steps that should be taken to initiate broad-based community support for projects?

Delegates did not focus on individual questions; rather, they approached these five questions as a single problem–what are successful (and unsuccessful) examples of using GIS, and what constitutes a successful project or program. Each session began with delegates relating stories and examples from their experiences. These examples came from every region of the United States, and underscored the point that there is no single approach or model that agencies and communities are following, and no single pathway to success. Several of these examples are highlighted in the list below:

- Two examples of successful statewide programs were provided from Wisconsin. The Wisconsin Initiative for Statewide Cooperation on Landscape Analysis and Data (WISCLAND) is a voluntary partnership among federal and state agencies, local communities, and private landowners to develop databases. The Wisconsin Land Information Program is a program that provides grants to counties and municipalities for modernizing land information programs. The state collects a fee from every land transaction and passes the money on to local communities.
- Two examples of local community initiatives were provided from Oregon. The first involves the Clackamas River Basin Project in Portland. This project is funded by the Environmental Protection Agency, and is under the coordination of a multi-county land-use council. It also includes participation from the USDA Forest Service and U.S. Bureau of Land Management. The project uses high school students to monitor river conditions. In the second project, the Umpqua River Land Exchange, industry and university researchers are using GIS to develop a process for making decisions regarding potential private/public land exchanges that would promote preservation of fragile lands.
- In another example from Oregon, advisory councils established under the Northwest Forest Plan bring together representatives from federal agencies, industry, NGOs, state agencies, and local governments to discuss land management options. GIS is used to increase awareness about, and opportunities for, holistic management approaches for protecting and restoring water quality and wildlife habitat.
- An example of a community-based conservation project was provided

in which The Nature Conservancy (a private, non-profit conservation organization) is working with local farmers in the Mackinaw River watershed in Illinois to protect fragile aquatic ecosystems. The project uses GIS to map non-point-source water pollution and erosion. Maps that are produced are used to help make decisions about how to reduce agricultural impacts on aquatic ecosystems.

Working from these examples and many others that were described during the four working group sessions, delegates identified a set of factors that are common to most successful applications of GIS to community-based resource sustainability projects. These factors are:

- Strong and visionary leadership is important for keeping a project focused. In some cases, a benevolent dictator is necessary to get a project started and to keep people and agencies working together.
- Building an effective partnership among all the agencies and organizations that are involved in the project is essential. This partnership must be based on open and ongoing communications. All interested parties must be involved in the project from the start. The process is as important as the outcome–if the process is not seen as legitimate, the results will not be accepted.
- Open access to data is critical. Data must be easily and equally available to all parties involved in the project. Proper metadata also is essential. Project personnel need to understand appropriate uses and limitations of the data that are available.
- Long-term data management is a key issue. Projects need to develop procedures and structures for the long-term maintenance of databases.
- Adequate, long-term funding is essential. Participants need to know that funds will be available to support the project in the long run before they will make long-term commitments. Long-term funding also is necessary to insure proper maintenance of databases.

Projects often fail when some combination of these factors is not present. In particular, delegates noted that failure is common when working partnerships are not in place, or there is little or no local commitment to a project. All parties need to "buy in" to a project in order for it to be successful. Failure also results from a lack of adequate funding. Sometimes projects are poorly planned or implemented. If there is no obvious link between the data that are being collected and efforts at promoting sustainable development, the project is likely to fail.

Even if all components for a successful project are in place, success is not guaranteed. There still will be problems to resolve. For example, lack of good data is frequently a problem. Sometimes the data may be available but there are proprietary, or scale, resolution, or accuracy problems. Lack of common standards regarding scale and integration is a reoccurring problem that must be addressed. Finally, the public may not understand the project, or they may misuse the maps and other materials that are produced.

The examples and models discussed in this working group are strong evidence that much good work is being done by communities using GIS as a tool in sustainable resource management. But these examples are only the beginning. There are thousands of counties and municipalities in the United States, and many of them have had little exposure to GIS. The task for natural-resource and GIS professionals is to build on these successful examples so that other communities can learn how to use GIS technology.«

Synthesis: GIS Technology and Sustainable Resource Management

Delegates attending the RNRF Congress on Applications of GIS to the Sustainability of Renewable Natural Resources participated in a remarkable three-day discussion. They explored how GIS can be used to facilitate and promote community-based sustainable development of renewable natural resources.

Many of the nation's leading experts on GIS and resource management attended the congress. This report reflects their ideas and recommendations. The heart of the congress was the day-and-a-half that delegates met in six working groups to discuss many of the key issues and problems that resource managers, community planners, and educators confront everyday.

Delegates addressed many difficult issues such as how to define sustainability, what is a community, what constitutes a baseline data set for natural resource management, what are indicators of environmental health, what standards need to be developed to guide data development, what are the roles of the private and public sectors in data development, how to improve education and awareness about GIS, and how to improve coordination and cooperation among federal, state, and local agencies.

Many ideas, opinions, and recommendations were expressed by delegates attending the working group sessions. In this report we have captured and distilled those ideas and recommendations as accurately as possible. Taken together, these ideas represent an informal consensus of the resource management and GIS professions on what actions are needed to improve the applications of GIS to community-based resource management efforts. Four general themes emerged out of the working group discussions, and are reviewed below.

SUSTAINABILITY IS A COMMUNITY-BASED CONCEPT

Delegates in all six working group sessions agreed that meaningful concepts of sustainability must be rooted in local communities. Sustainability is tied to values of place, and these values will vary from community to community. Local communities, however, do not exist in isolation. Local values are part of a national culture that binds communities together. Delegates recognized that local community values will not always mesh with the goals of non-local institutions such as state or federal agencies, or national environmental organizations. Nevertheless, it is critical to recognize and appreciate local values and needs when implementing community-based sustainable development programs.

Delegates agreed that there is an important relationship between GIS technology and efforts at developing community-based sustainable resource management strategies. However, delegates also were very careful to underscore the fact that GIS is only a tool, and incapable, by itself, of providing answers or solutions. The use of GIS must be rooted in a thorough understanding of specific problems and the limits of available data. Delegates agreed that a strength of GIS—as a decision-making tool—is its ability to foster compromise. Because GIS can integrate and display data in ways that previously were not possible, it can shed light on new and innovative approaches to sustainable resource management. However, in order for GIS to be an effective decision-making tool, local communities must know that they are partners in the decision-making process, and state and federal agencies need to be sensitive to local needs and values. Delegates provided many good examples and models of successful GIS programs from around the country.

Delegates noted that the cost of GIS technology, and particularly the lack of awareness about the benefits of GIS, were barriers to effectively using GIS for community-based resource sustainability projects. They recommended improved efforts by state and federal agencies, educational institutions, and the member organizations of RNRF to breakdown these barriers. Delegates also recommended developing a handbook that could help communities un-

derstand the concept of sustainability and the potential applications of GIS technology.

COOPERATION AND COORDINATION

Federal and state agencies, local governments, non-governmental organizations, and the private sector must work to improve cooperation and coordination in the use of GIS technology, and to limit duplicative efforts. Delegates in all working groups stressed the problems and frustrations that arise from poor coordination and lack of cooperation in collecting data, establishing metadata standards, and implementing GIS projects. Delegates agreed that the initiative for coordination should come from local communities. State agencies are in the best position to act as facilitators between local communities and federal agencies. The federal role should be focused on coordinating funding and expanding technical assistance. Communicating needs and building partnerships are key elements to effective cooperation among all involved. In addition, delegates noted the need for improved coordination and cooperation among federal agencies, particularly regarding data collection and development of metadata standards. Rather than establish new mechanisms for coordination, delegates recommended that agencies and professionals commit themselves to utilizing existing mechanisms such as the Federal Geographic Data Committee. Finally, delegates also concluded that the role of the private sector in data development and management will increase in the future as data needs grow and federal and state budgets shrink. Delegates identified a need for more public/private partnerships in data development, and a need for the private and public sectors to cooperate in the development of shared metadata standards.

BASELINE DATA SETS, METADATA STANDARDS, AND NEW TECHNOLOGIES

Delegates stressed the need for fundamental baseline natural resources data sets. Despite the wealth of data that already exists, we still do not have a good understanding of the condition of our natural resources. Delegates agreed that federal agencies should take the lead in developing baseline data sets, but states and local communities need to be full partners in the process. Standards need to be established to guide the development of baseline data sets. These standards must address the issues of scale, layering, and data integration. Delegates were more concerned with establishing a process for developing baseline data sets than with identifying what types of data should be included. The underlying reasoning was that once the process was established, issues of content could be addressed. Delegates believed that establishing the process is the bigger challenge. Similarly, delegates agreed on the need for a process to identify indicators of environmental health and sustainability.

The need for better metadata standards was another common request among delegates. Delegates were concerned about the lack of common guidelines governing development of metadata, poor access to metadata, and the tendency of users to ignore metadata. Delegates underscored the need for improved and coordinated efforts at developing metadata among data developers in federal, state, and local agencies, and in the private sector. Educating users about the critical function of metadata was strongly recommended. Delegates also stressed the need to make better use of data clearinghouses and public libraries as access points for data and metadata.

Delegates were both excited and concerned about the potential of new technologies (e.g., the Internet and embedded software applications) to simplify the use of GIS applications and to greatly increase the number of GIS users. Delegates recognized the potential of the Internet as a delivery system for data and for simplified GIS applications. However, delegates also recognized that greater access to data and GIS applications only underscored the need for better metadata and more education about the appropriate uses of GIS.

EDUCATION AND AWARENESS

Delegates agreed that there is an urgent need to increase awareness about GIS, and that this must be coupled with efforts to improve geographic and environmental education. Simply teaching GIS application skills is not enough. Users of GIS technology must understand how to interpret and judge the information that GIS produces.

Teaching spatial analysis and critical-thinking skills was strongly supported by the delegates, who made many specific recommendations regarding K-12 and college-level curriculums. For example, delegates recommended adding more GIS courses to university curriculums, and teaching spatial analysis skills to resource management and environmental planning students. At the K-12 level, delegates recommended adding more geography and environmental education courses, and placing a stronger emphasis on the teaching of math and science. Delegates also recognized that there is a critical need for GIS training for mid-career professionals who were not introduced to GIS when they were in college. Agency supported training programs and university continuing education programs were suggested as the means for retraining mid-career professionals.

Delegates also thought that the member organizations of RNRF take a lead role in promoting GIS awareness and education. Delegates recommended that RNRF and its member organizations develop guidelines for incorporating

GIS in university curriculums, develop programs for retraining mid-career professionals, and promote professional and public awareness about the uses of GIS and the concept of sustainable development.

THE NEXT STEP

In the months following this congress, RNRF will undertake two formal actions to build on and expand the work accomplished at the congress. First, RNRF will sponsor a congressional forum. Lawmakers, their staff members, and representatives of NGOs will be invited to a meeting that RNRF will organize on Capitol Hill. The recommendations and conclusions of this meeting along with copies of this report will be presented to those attending this forum.

Second, RNRF will hold a meeting of representatives of its 20 member organizations. The purpose of this meeting will be to review the findings and recommendation of the RNRF congress, and to determine what future actions the member organizations of RNRF can implement to further the goals and recommendations outlined in this report.

These actions by RNRF and its member organizations are only one outcome of the congress. The more than 100 delegates who attended the congress will take the knowledge and experiences that they gained at this meeting back to their organizations and institutions. It is the delegates, working within their professions and disciplines, who can make the greatest contribution to advancing the goals and recommendations outlined in this report.«

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About RNRF

PURPOSES

The Renewable Natural Resources Foundation (RNRF) was incorporated in Washington, D.C., in 1972 as a nonprofit, public, tax-exempt, operating foundation. It was established to: advance sciences and public education in renewable natural resources; promote the application of sound scientific practices in managing and conserving renewable natural resources; foster coordination and cooperation among professional, scientific and educational organizations having leadership responsibilities for renewable natural resources; and develop a Renewable Natural Resources Center.

The foundation represents a unique, united endeavor by outdoor scientists to cooperate in assessing our renewable resources requirements and formulating public policy alternatives.

MEMBERSHIP

RNRF's members are professional, scientific and educational organizations that have, among their primary purposes, the advancement of sciences and public education in renewable natural resources and/or the application of scientific knowledge to the management of renewable natural resources. Each member organization is represented on the board of directors. Also, "public interest members" may be elected to the board.

Individuals who support the foundation's purposes and programs may become "associates."

PROGRAMS

RNRF conducts conferences, symposia and congressional forums on renewable natural resources issues, and roundtable sessions for public/government affairs staffers of RNRF member organizations. RNRF also conducts annual summits of elected and appointed leaders of its member organizations.

The foundation has two annual awards to recognize outstanding achievements in the renewable resources fields, with an emphasis on interdisciplinary aspects. The "Outstanding Achievement Award" recognizes a project, publication, legislation, or similar accomplishment. The "Sustained Achievement Award" recognizes a long-term contribution and commitment by an individual or small group.

The *Renewable Resources Journal* promotes communications among RNRF's represented disciplines, and is provided to all members of the governing bodies of RNRF member organizations. *Renewable Resources Journal* also is provided to members of the U.S. Congress and staff members of congressional committees with jurisdiction over natural resources.

CENTER DEVELOPMENT

The Renewable Natural Resources Center is being developed as an office park complex and environmental center for RNRF's member organizations. The Center is located on a 35-acre site in Bethesda, Maryland, where lawns and forested buffer provide an exceptional work environment.

The county-approved site plan authorizes the construction of six new office buildings and a conference facility, with a combined area of 300,000 square feet.

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