Challenges to Managing Natural Resource Information

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***Abstract**—One of the most important issues facing resource managers today is that of information. In order to handle the numerous and diverse requirements for information, landscape-scale information management systems are needed that allow individual land management units to view their resource information in a regional context. The characteristics of such a system are: (1) the storage of basic data sets and GIS layers, (2) the development of Internet software tools and protocols to facilitate data sharing, (3) personnel to operate and maintain the system, and (4) system coordination and training to develop and support cooperators and users.*

Introduction

Numerous efforts are underway by both public and private groups to assess the status of biodiversity on the landscape. The National Park Service, USDA Forest Service, Environmental Protection Agency, and others have national monitoring programs for significant natural resources. The USGS has a program to assess the status and trends of the nation's biological resources (Mac et al. 1998). These are indications that government agencies and society now recognize a close link between natural capital (ecosystem assets) and broader socioeconomic goals. There is also growing understanding that in order to do a better job of managing ecosystem assets there is a need to better understand the interdependence of economies and environment, how to conserve biodiversity, how to protect natural ecosystems, and in some cases how to restore natural systems, in order to add to the quality of life. To facilitate these societal goals, it is necessary to have ever better natural resource information management systems. In the past there have been many efforts to gather data about natural resources. The results of these research efforts have typically ended up in reports or publications with data relegated to obscure locations on shelves, in drawers, or in boxes of information that are now not accessible to anyone. As scientists and managers we now have more information than we've ever had, yet we struggle. Struggle to apply relevant data to pressing issues and struggle to locate information that we know we have, somewhere. In order to do proper assessments and make appropriate management decisions, we have to apply the best scientific understanding possible. Even though there is more information available than any of us can handle, most of the time a new question is asked, the immediate response is, "I need more information!" When we talk about information management, we are in a world where we know where we want to go (having information readily available in a readily accessible form for any question about resource management), but where we want to go is a quantum leap away from where we are.

The ability to provide top quality, relevant information depends on our solving problems associated with scale, format, classification systems, hardware, software, and keeping data up to date. Further, a cultural shift needs to be made in our business of science. That is, to hire people who know electronic data management systems—from a mechanic's perspective and from a data perspective—in order to handle the great volume of data with which we need to deal. We need to develop information management systems that will allow researchers and managers to obtain natural resource information for a region, a State, a county, a local management unit, etc., and be able to readily update that information as appropriate.

Issues Related to Managing Information

System Outputs

When developing an information management system, it is helpful to have in mind what the outputs from that system might be. A very simple system might consist of a database and a report (Swantek et al. 1999). Sometimes data collection systems are developed without a clear purpose or intention of synthesis (Ward and McBridge 1986). These lead to data being collected that fill files and even boxes, but are not very useful over time. A more complete system will provide raw data; synthesized data, data documentation, and maps; in depth state-of-the-art reports and publications; skills training; and personal consultation.

Cost

The primary cost will be in personnel with data managers, information creators, and systems managers being added to the research specialists that are currently conducting individual projects, usually funded through research contracts of one sort or another. These projects typically result in data collection, data synthesis, data analysis, report writing, and infrequently, publications, but do not go beyond that. A secondary cost will be the upkeep on system changes that are becoming increasingly important as hardware and software get increasingly complex through time and with the addition of new raw and synthesized data.

Complexity

The more we know, the more we understand that the world is more complex than we previously thought. Some indications that things are getting more complex: papers written by 10-12 authors, the credit lines for movies, the increased focus on interdisciplinary studies. Other hurdles that need to be overcome: research evaluation systems that still reward scientists for being primary authors on peer-reviewed publications, individuals who will not share data, the use of multiple data collection and classification systems being used, and many different data analysis systems being used (e.g., GAP vegetation coverages that are incompatible across State boundaries).

Quantity, Format, and Scale of Information

Many data sets are still not available digitally, and often unique, "hard copy" information gets thrown out because it is "too old" or there is not enough space to store it any longer. Billions of dollars are being spent every year on collecting information, but there is no plan of what to do with the data and information after the project report is written (other than perhaps "archiving" the data). There is too much. Data are collected in most systems faster than those systems can handle it. Even so, almost always is heard, "I need more information to answer that;" "more research needs to be done on this topic;" and "the more you know, the more you don't know." Now we are hearing statements such as trying to deal with the quantity of information coming past me is like trying "to get a drink from a fire hose."

Data Evaluation

Another need that has arisen is to make sure that data are accurate and meaningful. With the quantity of data coming in, the accuracy assessments, quality assessments, and quality control are getting out of hand. No one can keep up with the volume that most systems are presented with.

Technology

Computer "crashes" lead to lost data and information. Hardware and software upgrades often make data and information exchanges difficult and sometimes impossible. Technology upgrades are a constant battle—how to pay for them and especially how to make them happen in such a way that all the data and information in the system is brought along.

Information Strategy

We all deal every day with a lack of information strategy, from the researcher who plans too little time for handling the data and writing reports after field collecting, to the agencies that still think that information management is accepting the research or management report and putting it on a shelf. Coordination is lacking between monitoring agencies with respect to objectives, protocols, timing of monitoring activities, data analysis, and/or data utilization. This often leads to time and money being wasted (Mogheir and Singh 2002). In a recent study to reestablish and restudy "permanent" study plots that were established in the early 1960s and studied by one person from the early 1960s until the early 1980s, investigators found that the contents of the original researcher's office relating to the study were not well described; there was no overall description of the permanent plots or the nature or purpose of several of the measurements taken; there were photographs of most, but not all of the study plots; and the data were on computer punch cards, 9-track tapes, and computer printouts, all of which needed to be translated onto modern computer media before the project could even begin (Webb et al. 2003). A paradigm shift needs to take place to an understanding that biological data need to be georeferenced and entered into a database that can be related to maps. Not just in an individual lab situation, but into a collaborative, integrated database management system. This needs to start first with the investigator, but the agencies also need to have computer systems and operators to handle the data as it is passed off from the investigator. Fortunately technology has advanced well enough to make this possible.

We also need to be considering that our information management systems need to be set up so that data can be shared through the levels of each agency and across agency boundaries. The level of commitment for this today is analogous to having a fleet of propeller airplanes trying to keep up in a jet engine world. We will not come close to solving this dilemma until the agencies make a commitment to purchase the new equipment, hire and train operators to "fly" the new systems, and hire mechanics to make sure they keep going. It is a commitment that is seemingly still not even in the kitchen, let alone on the back burner.

Where We Are Today

Regional and National Systems

Library systems that collect names and locations of libraries of data—A regional or national system that only tells folks where they can go get data, i.e., a catalog of data sources (National Spatial Data Infrastructure 2004). The biggest problem in this type of system is on the delivery end. If I am a scientist who gets in the system, then some percentage of my time has to be spent on maintaining a computer connected to the Internet that will deliver the data that I have reported that I have. I will also be spending more time answering all the questions that get asked—even if I did put in 30 pages of metadata.

Library systems that collect and archive data—A centralized data collection center or network. This amounts to a digital library that in most cases is managed by one to a few people because upper level managers have a mistaken idea that the computers can do all the work. This type of system can fail rapidly because the funds to maintain it are usually not sufficient and because the site only serves data that are not updated. One of the current sites that goes against this pattern and is well maintained with plenty of up-to-date information is http://www.natureserve.org.

The Future

An effective approach to meeting the information management challenge would employ a combination of expertise in information management systems, geographic information systems, natural resource modelers, population and vegetation biologists, and librarians to develop a Statewide Internet digital interactive library that is a node on a larger international system. This digital library would have the capability to collect, store, and manage information and data from multiple studies at multiple scales (e.g., population, individual species, individual management units, County, State, political or biogeographic region, Nation, or Continent) in a system that is inter-relational. That is, the system would be able to integrate, combine, and synthesize data and information from different sources so that it can be shared with a variety of users (Ram 2000; Ram et al. 1999). Data would be used to produce the usual reports, publications, and presentations, and would be delivered through different filters to those that need it: researchers, managers, NGOs, schools at all levels, and the general public. The system would make it possible for people to use the Internet to obtain complementary information such as a picture of a species or plant community/habitat, a distribution map, and information about species biology, including which collections have specimens of the species. This integrated tool would be extremely valuable for an evaluation focused on a particular location. It would also make it possible for people to obtain information about various management units such as wildlife refuges or units of the National Park Service.

To deal with the problem of serving out dated information, such a digital library of the future, would have the capability to upload new data to the system. That is, a researcher would be able to take from the system information that she needs for her project, collect additional data, conduct analyses and write reports, and then contribute back to the system so that the database is updated. This digital library would also maintain archives of databases so that as databases are updated and changed, an historical record is kept whereby trend analyses could be done.

Any effective electronic library and data delivery system will need systems people to run it. Just as FedEx, UPS, DHL, etc., have truck drivers and mechanics, pilots and airplane mechanics, etc., to run their systems, the information management system of the future will not run with researchers doing it as part of their responsibilities, or by their using research technicians with more computer savvy. The greatest challenge to managing natural resource information in the future will be a shift in culture that allows the equivalent of truck drivers and airplane pilots, truck and airplane mechanics, etc., into the business of science. We have only taken the first few baby steps along this path, but the speed of technology change, the large number of people looking for information, and the large amount of information available and coming in on a daily basis will speed us on our way.

Acknowledgments

Thanks to Mike Kunzmann, Andy Honoman, Craig Wissler, and Patrick Barabe for many hours of discussion relative to managing data and for lots of help in working on the integrated system of the Sonoran Desert Research Station and the School of Natural Resources, Advanced Resource Technology Group. Thanks also to Criag Wissler, Andy Hubbard, and Brooke Gebow for helping to improve this paper through their reviews.

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