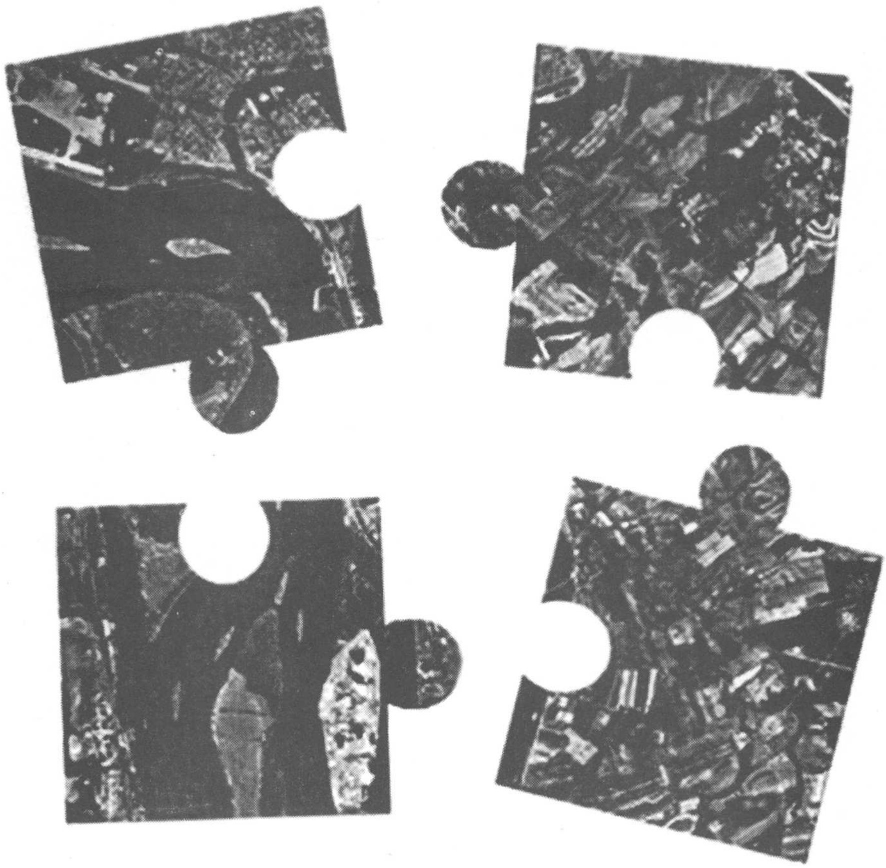
Forum on Land Use & Land Cover

Summary Report

Forum Co-hosted by the:

U.S. Environmental Protection Agency
U.S. Geological Survey



U.S. Geological Survey
Reston, Virginia
1992

FORUM ON LAND USE AND LAND COVER

SUMMARY REPORT

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U.S. ENVIRONMENTAL PROTECTION AGENCY
U.S. GEOLOGICAL SURVEY

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Donation, 6-15-93

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9:00	Technical Issue - Sensors, Preprocessing, and Image Processing - *Tom Loveland (USGS)*
9:20	Technical Issue - Accuracy Assessment - *Jerry Dobson (Oak Ridge National Labs)*
9:40	Technical Issue - Archiving and Data Transfer - *Robin Fegeas (USGS)*
10:00	Recap of issues and logistics for small group discussions - *John Montanari*
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12:00	**Lunch**
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2:50	Reassemble and recap by discussion chairmen
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4:00	Adjourn

Thursday, February 27, 1992 (For organizers, speakers, and session chairmen)

Moderated by Dick Kleckner (USGS) and Tom Mace (EPA)
8:00 to 1:00 Development of User Needs Assessment and follow-on activities

INTRODUCTION

This report includes the agenda and abstracts of presentations from the Forum on Land Use and Land Cover Data, cohosted by the U. S. Geological Survey (USGS) and the U.S. Environmental Protection Agency (USEPA), February 25-27, 1992 at the USGS National Center in Reston, Virginia. The Forum was conducted under the auspices of the Federal Geographic Data Committee (FGDC) and was attended by Federal and State managers of programs that produce and use land use and land cover maps and data in support of environmental analysis, monitoring, and policy development. The goal was to improve opportunities for Federal and State coordination, information exchange, data sharing, and work sharing in land use and land cover mapping.

The first day focused on selected Federal and State programs that have significant land use and land cover components. An open session on the agenda allowed participants to describe their programs' needs or applications of land use and land cover data. The second day highlighted technical issues in presentations and discussion groups led by national experts on each issue. Issues included land use and land cover classification; sensors and image processing; accuracy assessment; and archiving and data transfer. On the third day, forum organizers and speakers met to plan a national land use and land cover data needs assessment.

Significant findings from the forum are: (1)land use and land cover are among the most important and widely used environmental data sets and span a variety of levels of detail and support activities such as ecological monitoring, habitat assessment, wildlife management, enforcement, exposure and risk assessment, global change monitoring, environmental impact assessment, State and local planning, hazardous waste remedial action, and regulatory policy development; (2) use of land use and land cover data has grown significantly with the spread of GIS technology; (3) although a broad and varied clientele cannot be served by one standard land use or land cover product, an optimal standard could be developed to serve many clients who now generate their own data; (4) there is a need for a stronger Federal role in providing guidance on mapping methods and standards; and (5) State and Federal participants are willing to cooperate on mapping activities.

SUMMARY OF PRESENTATIONS - FEDERAL

NOAA COASTAL OCEAN PROGRAM

COASTWATCH
CHANGE ANALYSIS PROGRAM (C-CAP)

James Thomas
National Oceanic and Atmospheric Administration

Summary

The goal of the C-CAP is to develop a comprehensive, nationally standardized, information system for land cover and habitat change in the coastal region of the U.S. The purpose is to improve understanding of coastal uplands, wetlands and sea grass beds and their linkages with the distribution, abundance and health of living marine resources. The coastal region of the U.S. will be monitored every 1- to 5-years depending on the rate and magnitude of change in each region. The effort will emphasize a geographic approach including the use of geographic information systems (GIS), ground-based data, and remotely sensed data.

Data from Thematic Mapper (TM), other satellite sensors, and aerial photography will be interpreted and classified. The derived products will include: 1) spatially registered digital images, 2) hardcopy maps, and 3) tabular summaries. Land cover change will be detected in a pixel-by-pixel comparison from different time periods.

Operational protocols are being developed through a series of working group meetings focusing on coastal uplands and wetlands, submerged aquatic vegetation (SAV), and user products. Invited participants include technical and regional experts and representatives of key State and Federal organizations. The community of users and providers of coastal habitat information will be given an opportunity for review and comment.

The resulting information will enhance conceptual and predictive modes and support coastal resource policy analysis. A major contribution will be the determination of biomass, productivity, and functional status of wetlands.

Application

Timely documentation of the location, abundance and change in coastal wetlands is critical to their conservation and to effective management of marine fisheries. The rapid changes occurring in these valuable wetlands require monitoring on a 1- to 5-year cycle. Therefore, NOAA, within its Coastal Ocean Program, has initiated a cooperative interagency and State/Federal effort to map coastal wetlands and adjacent upland cover and change in the coastal region of the U.S. on a 1- to 5-year repeating basis. The specific program is called CoastWatch Change Analysis Program (C-CAP).

Background and Application

One of the principal impacts on estuarine and coastal living marine resources and their habitats is development in the coastal zone. A United Nations Environment Program (IMO 1990) report on The State of the Marine Environment states, "The coastal strip, encompassing the shallow-water and intertidal area along with the immediately adjacent land, is clearly the most vulnerable as well as the most abused marine zone. Its sensitivity is directly tied to the diversity and intensity of activities which take place there, and the threat to its future is related to the increasing concentration of the world population in this area. The consequences of coastal development are thus of the highest concern. They arise not only from the variety of contaminating inputs associated with great concentrations of people, commerce and industry, but also from the associated physical changes in natural habitats, especially salt marshes, sea-grass beds, coral reefs and mangrove forests."

Coastal wetlands with emergent and submergent vegetation [salt marshes, mangroves, macroalgae and submerged aquatic vegetation (SAV)] support a majority of marine finfish and shellfish resources in the coastal United States. Continued loss of these wetlands may lead to a collapse of coastal ecosystems and associated fisheries. Under the Magnuson Fishery Conservation and Management Act, the U.S. Department of Commerce, National Oceanic and Atmospheric Administration (NOAA) is directed to: 1) identify and describe the habitat requirement of fish stocks, 2) identify existing habitat conditions, 3) identify sources of pollution and degradation, 4) describe habitat protection and enhancement programs, and 5) recommend habitat protection and enhancement measures.

The Wetlands Policy Forum (Kean and others, 1988) says, "The United States...needs much better information on the condition of its wetlands resources, [and] the rate at which they are being altered...we need to make information more widely available to those involved in wetlands protection and management...accurate maps depicting where wetlands exist...[are needed]." Further, the report states, "...current survey efforts are too infrequent...Particularly in regions where wetlands are being lost rapidly, where they are under substantial threat, or where they are of unusual value, more frequent assessments...preferably every one or two years...are essential to an effective protection and management program...."

In response to these issues, NOAA, in 1990, began a program to develop a comprehensive, nationally standardized, information system for land/habitat cover and change in the coastal region of the U.S. using remotely sensed (i.e., satellite imagery and aerial photography) and ground-based information sources. The program will be standardized based on a series of regional protocol workshops held around the country during 1990-91, and on the results from a number of regional projects testing and resolving protocol issues. The coastal region covered by this program includes those land and water components of the various watersheds within the U.S., its possessions and territories, that most directly influence estuarine and coastal marine habitats utilized by living marine resources (LMR). The land/habitat cover includes those classes of vegetation and physical cover of ecological significance to LMR and/or their habitats. The major classes include submerged aquatic vegetation (SAV), emergent coastal wetlands and adjacent uplands. By change we mean all differences in land/habitat cover of approximately 1 acre or greater that occur between times, T_1 and T_2. Our planned time interval for repeated looks at the coastal region of the U.S. is every 1 to 5 years. Regions with little change or interest will be monitored every 5 years; areas of intense development, every 2 or 3 years; and areas disturbed by extreme events (e.g., oil spills, hurricanes), annually.

NOAA is responding to other issues as well. The Wetlands Policy Forum (Kean and others, 1988) notes the need to "develop methods enabling trend information to reflect losses of certain functions, particularly in regions subject to significant stress." A component of the program is being designed so that not just areal coverage is determined, but also functional health, whereby we could see a decline in the functioning of a coastal habitat prior to its loss in area.

The purpose of the program is to build a digital data base that when integrated with other data within a GIS ultimately will enable us to link development in the coastal region to the ecological and economic productivity of the coastal zone/coastal ocean, and particularly in the case of the NOAA/National Marine Fisheries Service, the abundance, distribution and health of LMR. Our rationale is that changes in land use and cover affect critical habitat required by LMR for spawning, feeding and survival. We believe that as these critical habitats are affected, so is the potential recruitment of larval and juvenile stages to estuarine and coastal fisheries, including those in the Exclusive Economic Zone. Further, we believe that it is necessary to monitor upland cover, as well as that of the critical habitats, because knowledge of the upland cover provides a significant determinant to the water quality affecting the critical habitats of LMR. As relationships between uplands, fishery habitat and LMR are better understood, improved long-term planning (and perhaps regulation) can be accomplished to sustain the productivity of the coastal zone/coastal ocean system.

Quicker, more frequent updates of land/habitat cover and change (i.e., location, type and magnitude) for the coastal region of the U.S. and the ability to see such data geographically arrayed in a geographical information system (GIS) in relation to other data will allow earlier warning and earlier, more focused management actions regarding loss or change in coastal wetlands and adjacent uplands, and potential impacts on coastal zone/coastal ocean productivity -- ecological, including fisheries, and economic. The ability to see specific mapped changes synoptically over large areas (i.e., 3,600 km^2 or greater) will enhance the research effort toward understanding the relationships between coastal wetlands (including SAV), adjacent uplands and LMR. These quicker, more frequent updates, it is hoped, someday will allow much better projections (i.e., very early warnings), based on predictive models, of the effects of future changes in coastal wetlands and adjacent uplands on LMR and coastal zone/coastal ocean productivity.

Relationship to Other Programs

NOAA's habitat mapping effort will work with and utilize data from other Federal and State agencies during all phases of the program. It will build upon and complement existing coastal habitat mapping programs and provide essential timeliness, synopticity and frequency of repetitive cycles not currently available. The 1- to 5-year monitoring cycle is critical to NOAA for effective coastal habitat management and research on a local, regional and national scale.

For additional information contact:

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Beaufort, NC 28516-9722 Phone: (919) 728-8724

GAP ANALYSIS OF BIODIVERSITY

J. Michael Scott
Idaho Fish and Wildlife Service

Frank W. Davis
University of California, Santa Barbara

The term "Gap Analysis" refers to the evaluation of the protection status of plant communities, animal species and vertebrate species richness by GIS overlay of biological distribution data on a map of existing biological reserves. After compiling statewide moderate resolution digital data bases, GIS capabilities are used to identify and map landscapes that contain large numbers of potentially unprotected vegetation types and vertebrate species of interest. Such areas can then be studied in more detail as candidates for additional preservation and protection efforts to fill gaps in the protection network. This approach allows conservationists to be proactive rather than reactive in their efforts to preserve biodiversity. The number of States in which gap analysis projects are underway has increased from 2 in 1988 to 25 in FY92, including most of the western States. The pilot project in Idaho is nearing completion.

The most crucial data layer in a Gap Analysis data base is the vegetation/habitat map. National standards are being established so that State-level products are compatible and can be aggregated for regional and national assessments. Recent Thematic Mapper (TM) satellite data is being interpreted as the source data for vegetation mapping. The classification system requires a mix of physiognomic and floristic characteristics, corresponding to the vegetation series level. Thus, communities are labeled according to their dominant overstory species. The minimum mapping unit will be 100-200 hectares at a mapping scale of 1:250,000. Critical cover types may be mapped at a finer resolution. An accuracy level of 80 percent is required for the entire map and 75 percent for individual cover types. Wildlife-habitat relationships models will use the vegetation cover map to predict the distribution of vertebrates and species richness. It is anticipated that gap analysis, including the vegetation cover map, will be updated within States on a 10-year cycle.

USES OF LAND USE AND LAND COVER INFORMATION– PERSPECTIVE OF THE NATIONAL WATER-QUALITY ASSESSMENT PROGRAM

William Wilber
U.S. Geological Survey

In 1991, the U. S. Geological Survey began a full-scale National Water-Quality Assessment (NAWQA) Program. The two long-term goals of the program are to: (1) describe the status and trends in the quality of a large, representative part of the Nation's surface-water and ground-water resources, and (2) provide an improved understanding of the natural and human factors affecting the quality of these resources. This information will provide water managers, policy makers, and the public with an improved scientific basis for evaluating historical as well as contemplated changes in land- and water-management practices.

Study-unit investigations are the principal building blocks of the NAWQA Program. The study units are large, ranging in size from about 1,200 to more than 60,000 square miles. Collectively, the 60 study units that constitute the full-scale program encompass about 45 percent of the land area of the conterminous United States, and about 60-70 percent of the Nation's total water use and population served by public water supply.

To make the program manageable, the assessment activities in each of the study units will be done on a rotational rather than a continuous basis. One-third (20) of the study units will be studied in detail at a given time. By including study units that are diverse and cover a large part of the United States, the NAWQA Program ensures that the most important water-quality issues can be addressed through comparative studies.

The national benefits of NAWQA primarily accrue in two ways. First, there is the simple accumulation of high-quality, consistent, perennial assessments of 60 key hydrologic systems of the Nation. Second, a major effort of the program will be focused on a national-scale synthesis of existing information and findings from the NAWQA study units to address specific water-quality issues of national interest and concern.

Information on land use and land cover is critical for achieving the goals of the NAWQA Program. The NAWQA Program needs current and consistent land use and land cover data for the Nation at a variety of spatial scales to support the analysis and interpretation of water-quality data at local, regional, and national-scales. These requirements for current, consistent, and multi-scale data are not unique to the NAWQA Program, but reflect the needs of hydrologists in general.

For hydrologic studies and for national assessments, a national land use and land cover program would:

- Provide information on land use and land cover based on current source materials with periodic updates;
- Provide information at a variety of spatial scales. For example, complete coverage of each NAWQA study unit would be desirable at an intermediate spatial scale (For example,1:100,000). Selected activities, targeted at parts of a study unit, may require land use and land cover information at larger spatial scales (For example,1:24,000).
- Include a hierarchical and flexible classification system to facilitate analysis at a variety of spatial scales, and to allow more detailed classification of land use and land cover tailored to the needs the users;
- Differentiate irrigated cropland from other agricultural land, and cropland from pasture at all classification levels.
- Facilitate comparisons betweeen current land use and land cover data and existing data from the Land Use Data Analysis Program so that users could assess trends of the extent of land use change;
- Provide both standard map products and digital data to users in a timely manner;
- Provide revisions to land use and land cover data at intermediate and national scales at 5-10 year intervals to support analysis of environmental trends.

USDA SOIL CONSERVATION SERVICE

NATIONAL RESOURCES INVENTORY PERSPECTIVE ON INVENTORYING EARTH COVER AND LAND USE

J. Jeffery Goebel
Robert E. Smith Jr.
USDA Soil Conservation Service

Summary

The SCS National Resources Inventory (NRI) is a multiresource inventory based on soil information and other resource data collected at scientifically selected, random sample sites.

Congress has authorized this national inventory be conducted within a 5-year cycle and determine the status, condition, and trends of the Nation's soil, water, and related resources.

The NRI cycles of 1977, 1982, and 1987 expanded on previous SCS inventories. Many improvements have been made in the data collection process. A 1992 NRI is currently underway. Data will be collected by the middle of 1993.

NRI's are the Federal Government's principal source of resources data on non-Federal lands in the United States. The sample sites are selected by a two-stage stratified area sampling on a county basis. Primary Sample Units (PSU's) 40 to 640 acres in size are established. Most data are collected at sample points within the PSU's.

Data collected include soil information, earth cover, land use, cropping conditions, irrigation, erosion, conservation practices, treatment needs, wetland and forest cover type determinations, wildlife habitat, rangeland conditions, conservation tillage systems, and potential for conversion to cropland. Linkage with the SCS Soil Interpretation Record data base is made to NRI data. Linkages with other data bases are being made.

The 1992 NRI data base will be used for trending analysis. It will contain data for 1982, 1987, and 1992 from 300,000 PSU's and nearly 800,000 points. By the end of the 1992 process, all sample points will be georeferenced.

SCS inventory activities are being coordinated with the Economic Research Service, the National Agricultural Statistics Service, EPA's EMAP Program, the Forest Service, and USGS. The Statistical Laboratory at Iowa State University contracts with SCS on sample design and selection, and data processing.

In the NRI program three separate schemes are used to collect information about land cover and land use. Seven major categories are included in the Earth Cover scheme. The Earth Covers are Artificial, Barren, Crop, Grass/Herbaceous, Shrub, Tree, and Water covers.

Ten types of land are recognized under the scheme referred to as Land Cover/Use. These types of land (including water) account for all the surface area of the United States. They are referred to as: Barren Land, Cropland, Forest Land, Other Cropland, Other Rural Land, Pastureland, Rangeland, Rural Transportation Land, Urban and Built-up Land, and Water Areas.

Seven major uses of land and water are also part of the NRI classification scheme; they are: Agricultural Production, Business/Commercial, Recreation, Residential, Reserved, Transportation, and Waste.

THE ENVIRONMENTAL MONITORING AND ASSESSMENT PROGRAM'S LANDSCAPE CHARACTERIZATION USING LAND COVER INFORMATION IN ECOLOGICAL MONITORING

Douglas J. Norton
U. S. Environmental Protection Agency

Scientists and policy makers throughout our nation are recognizing the need for better scientific information regarding the condition of our ecological resources. Over the past several years, the United States government has addressed this need by developing improved methods for monitoring the status and trends in its forests, wetlands, arid lands and other major ecosystems. An important contribution to this effort has been made by the U.S. Environmental Protection Agency (EPA) in establishing the Environmental Monitoring and Assessment Program (EMAP). This program has proposed and is currently testing a number of unique concepts in ecological monitoring design, selection of indicators of resource condition, landscape characterization, and integrated assessments. Due to its emphasis on interagency coordination, EMAP has also established an infrastructure of over 400 scientists from many Federal agencies, academic institutions, and private corporations.

The goals of EMAP are to monitor and report on the condition of the Nation's ecological resources, to evaluate the success of environmental policies and regulations, and to identify emerging problems before they become widespread or irreversible. To achieve these goals, three broad objectives have been established:

1. Estimate the current status, extent, changes, and trends in indicators of the condition of the Nation's ecological resources on a regional basis with known confidence.

2. Monitor indicators of pollutant exposure and habitat condition and seek associations between human-induced stresses and ecological condition.

3. Provide periodic statistical summaries and interpretive reports on ecological status and trends to resource managers and the public.

To address these objectives, EMAP has established monitoring teams to study status and trends in indicators of the condition of specific types of ecological resources, and coordination/integration teams to provide technical expertise in topics that cut across all resources. EMAP-Landscape Characterization (EMAP-LC), one of the several coordination/integration teams, is assigned to support EMAP's many types of spatial data needs with existing or new data.

Land cover information in particular is being evaluated for its potential to serve four main purposes for EMAP: a source for sampling locations; data for estimating areal extent and changes in abundance of resources; information on terrain characteristics that may be correlated with resource condition; and a basis for landscape ecology investigations. EMAP-LC will support these applications as both a user of existing data, where suitable, and a producer of new land cover data where needed. Consequently, EMAP not only uses existing land cover information produced by USGS, USFWS and State programs, but also is coordinating with agencies such as NOAA, USGS and States to revise and test classification and mapping protocols in land cover mapping pilot studies such as the Chesapeake Bay watershed.

Existing and new land cover mapping data may provide a source for EMAP resource groups to select sampling units for field visits and monitoring; the USFWS National Wetlands Inventory maps are an example. Methods are under development to evaluate land cover mapping as a source for estimating status and changes in resource extent and distribution, in cooperation with other Federal resource management agencies. In addition, land cover data at a number of scales and resolutions will play a role in identifying associations between resources in marginal or subnominal condition and adjacent human-made or natural stressors within, for example, the same watersheds. Moreover, land cover data will provide EMAP with opportunities to observe how the landscape itself is changing in pattern, composition and abundance of its components; EMAP will apply the principles of landscape ecology to explain how these ecological patterns and interactions influence the function and condition of landscapes as well as the resources of which they are composed.

The current status of land cover information in the Unites States is not suitable to meet all of EMAP's needs as described. The primary shortcoming is the absence of national consistency. Land cover mapping varies from place to place in classification system used, sensor source, spatial resolution, and date. Map accuracy is seldom tested and documented. As a result, the available land cover products fall short of the ideal for national ecological monitoring -- land cover information of known accuracy, produced using nationally common terminology and techniques and updated on a regular (e.g., 5-year) cycle.

In view of the current situation, EMAP-LC's strategy emphasized building support among Federal and State agencies for establishing a nationally consistent land cover data base through methods standardization and data sharing. A revised national classification system, based on familiar systems but including new improvements, is warranted. Guidance on the appropriate sensor systems and mapping protocols to apply this system at common scales would be valuable to all potential data producers and would increase the overall quality of many land cover products. Data archiving and transfer standards would facilitate cooperation and exchange of land cover data sets between agencies. Accuracy assessment guidance could aid the much-needed verification of land cover data quality. Coordination on these technical issues could help EMAP and many other programs reach their full potential, enhance Federal cooperation, and stimulate cost-efficient advancements in the mapping sciences.

LANDSAT PATHFINDER

Dr. James G. Lawless
National Aeronautics and Space Administration

Dr. Leonard Gaydos
U.S. Geological Survey

Mr. Edwin J. Sheffner
TGS Technology, Inc.

Because we are concerned with our survival as a species, we must respond to the indications that the biophysical world we inhabit is changing, and that it is changing as a result of actions and activities we control. If we are to respond in a manner based on the principles of science, then we must obtain better information on how the biophysical systems of the earth function on local, regional and global scales, and we must develop instruments and procedures to monitor those functions in a timely manner.

The United States has embarked on a research program to obtain such information. As part of that program, the National Aeronautics and Space Administration has designed a suite of new instruments and satellites, the Earth Observing System (EOS), that will supply data related to the function of a variety of critical biophysical processes.

The first EOS satellite will be launched before the end of this century, but the need for information is immediate. To fill the "data gap," i.e., to supply the user community with data suitable to address global change research issues in the pre-EOS era, NASA initiated the Pathfinder Program. The objective of the program is to make data from existing satellite systems available to the user community in quantities, formats, and at costs that will encourage application of the data to global change problems.

The Landsat Pathfinder is one of five elements of the NASA Pathfinder program. Sponsored by the Earth Science and Applications Division of the National Aeronautics and Space Administration with cosponsorship from the U.S. Environmental Protection Agency and U.S. Geological Survey, the goal of the Landsat Pathfinder is to develop medium to high resolution global data sets from the Landsat satellites multispectral scanner system (MSS) and make the data sets available to a broad-based user community. To meet the objectives of the program, the data sets must be multiyear (at least three acquisition epochs to detect change and rates of change), readily accessible, reasonably priced, truly global in coverage, applicable to both the science and nonscience communities, and applicable at various scales. Work toward those objectives began in August 1991 with the first meeting of the Landsat Pathfinder Users Working Group. Currently, the science requirements and the Landsat Pathfinder data products are being defined. The first regional data sets should be available to the community by the end of 1992.

Landsat MSS data have been acquired since 1972. Virtually the entire land surface of the Earth has been imaged by MSS at least once, and much has been imaged multiple times. The extent, duration, spectral sensitivity and spatial resolution of the MSS data set make it an ideal candidate for global change studies. The impediments to use of MSS data for global change research are being addressed in the Landsat Pathfinder. The program will demonstrate how existing, archived data can be combined with newly acquired data and new technological capabilities for data storage and processing to address, now, global change issues previously beyond the range of researchers.

NATIONAL WETLANDS INVENTORY PRODUCTS

Bill Wilen
U.S. Fish and Wildlife Service

Summary

The National Wetlands Inventory (NWI) provides wetlands data in map and digital forms. These data provide consultants, planners and resource managers with information on wetland location and type.

Available Product Coverage

NWI wetlands data are available in map form at 1:24,000 scale for approximately 75 percent of the conterminous U.S., Hawaii, and 24 percent of Alaska. Availability of maps at 1:100,000 and 1:250,000 scales is limited. A color, wall-sized map of the wetland resources of the United States at 1:3,168,000 scale is also available. Digital wetlands data are available for approximately 16 percent of the conterminous U.S. See graphics for current status of large-scale mapping, Alaska mapping, and digital data.

Information Content

The standard NWI map product is a 1:24,000-map of wetland point, line, and area features overlaid on a USGS 7.5-minute topographic map. Maps are compiled from National Aerial Photography Program (NAPP) 1:40,000 scale and National High Altitude Photography program (NHAP) 1:58,000- or 1:80,000-scale aerial photography with source dates ranging from the 1980's to the present.

All photo-interpretable wetlands are mapped. In the treeless prairies, 1/4 acre wetlands are mapped. In forested areas, small open water and emergent wetlands are mapped. In general, the minimum mapping unit is from 1 to 3 acres, depending on the wetland type and the scale and emulsion of the aerial photography. In regions of the country where evergreen forested wetlands predominate, wetlands larger than 3 acres may not be mapped. Thus, a detailed on-the-ground analysis of a single site may result in a revision of the wetland boundaries established through photographic interpretation. In addition, some small wetlands and those obscured by dense forest cover may not be included on the maps.

The wetlands are classified in accordance with the 'Classification of Wetlands and Deepwater Habitats of the United States' by Cowardin and others, published by the U.S. Fish and Wildlife Service in 1979 (FWS/OBS - 79/31).

The 1:3,168,000-scale national map should be used only as a graphic to approximate relative distribution and location of wetlands.

Digital wetland data are digitized from the 1:24,000-scale wetlands maps into topologically correct data files containing ground planimetric coordinates and wetland attributes.

Product Delivery Format

Wetland maps at 1:24,000 scale are available on paper or mylar, with or without the USGS topographic base map. Digital data, registered to the USGS 7.5-minute, 1:24,000-scale base map, are available in DLG-3 Optional, MOSS Export, and GRASS vector format on 9 track magnetic tape, 8 mm cassette, 1/4 inch cassette, and on floppy disk for small orders (fewer than 10 quads).

Technical, Ordering, and Availability Information

For wetland map and digital data information, telephone 1-800-USA-MAPS or contact the nearest Earth Science Information Center of USGS:

ESIC/USGS
National Headquarters
507 National Center
Reston, VA 22092
(703) 648-6045

ESIC/USGS
Building 3101
Stennis Space Center, MS 39529
(601) 688-3544

ESIC/USGS
Western Mapping Center
345 Middlefield Road, MS 532
Menlo Park, CA 94025
(415) 329-4309

ESIC/USGS
Rocky Mountain Mapping Center
Box 25046, Stop 504
Federal Center
Denver, CO 80225
(303) 236-5829

ESIC/USGS
4230 University Dr., RM 101
Anchorage, AK 99508-4664
(907) 786-7011

ESIC/USGS
Mid Continent Mapping Center
1400 Independence Rd., MS 231
Rolla, MO 65401
(314) 341-0851

For 1:24,000 wetland maps, contact the State Distribution Center for NWI Maps:

Alabama - (205) 349-2852
Arkansas - (413) 545-0359
Arizona - (413) 545-0359
Connecticut - (203) 566-7719
Delaware - (302) 739-4691
Florida - (904) 644-2883
Georgia - (404) 656-3214
Missouri - (413) 545-0359
North Carolina - (919) 733-2302
Nebraska - (402) 472-7523
New Hampshire - (603) 271-2155
New Jersey - (609) 777-1038
New York - (607) 256-6520
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Louisiana - (413) 545-0359
Massachusetts - (413) 545-0359
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Maryland - (301) 548-4774
Minnesota - (612) 296-4800
Mississippi - (413) 545-0359

Oklahoma - (405) 271-2521
Oregon - (503) 378-3805
Pennsylvania - (413) 545-0359
Rhode Island - (401) 277-6820
South Carolina - (803) 734-9100
Texas - (512) 463-8337
Vermont - (802) 244-6951
New Mexico - (413) 545-0359
Washington - (206) 459-6201
West Virginia - (304) 636-1767
Wyoming - (307) 777-6942

SUMMARY OF PRESENTATIONS - STATE

How does the environment look overall, globally? nationally? regionally? State-by-State? What is going on in a particular congressional district? How is my home affected?

Are our enforcement efforts concentrated where the worst pollution problems exist? What will happen if we do/do not shift enforcement emphasis to where areas of ecological/environmental vulnerability exist? Are statutes being enforced uniformly? Why? Are there particular sociotechnological practices that may be identified as critical in affecting environmental quality? How might pollution prevention incentives be more successful for a particular geographic area? Why?

How soon can the results of EPA and related regulatory activities be observed in the environmental quality?

Are EPA and related agency programs collecting data about the environment where it is needed? Are these areas in which current resources can be redirected to gain additional information?

Meta-data are also essential components of all data bases used in environmental policy analysis. Although GIS is a powerful enabling tool, many issues need to be disclosed to even the less technically trained user of geographic data. Before an informed policy decision can be made from the results of the analyses, OPPE needs to know the level of confidence which can be ascribed to these results. These include providing policy analysts with caveats on the reliability and limitations on the uses of the data. Spatial and temporal comparability, feature generalization and aggregation issues are specific examples of components of land cover and use data which can impact environmental policy results.

Elizabeth Porter, Environmental Results Branch, US EPA (202) 260-6129

LAND COVER AND USE DATA BASE REQUIREMENTS TO SUPPORT EPA POLICY STUDIES

Elizabeth Porter
U.S. Environmental Protection Agency

The Environmental Results Branch of the EPA Office of Policy Planning and Evaluation (OPPE) is conducting pilot studies applying GIS technology to support program evaluation and report environmental trends. The studies are integrating environmental indicator data with agency administrative data to evaluate the relationships between program activities and the resulting state of the environment. Environmental indicators measure the state of the environment through direct or indirect effects on the human or ecological health of an impacted community.

Ultimately, EPA intends to make regional and national scale assessments of program performance using indicator data in conjunction with activity measure data. OPPE recognizes that land cover and use data are essential companions to the environmental and administrative data used in geographically based policy analysis. OPPE is presently supporting efforts to assess and define requirements for land cover and use data to support evaluation of multiple impacts to surface water quality, as well as addressing risk and remediation issues in prioritizing Superfund hazardous waste sites. In addition to assessing spatial requirements, such as resolution and data content, temporal issues also need to be addressed. There is most probably a strong correlation between land use changes and changes in environmental quality. These relationships need to be well understood in order to conduct effective program evaluation.

The data requirements for land cover and use, as well as other data, are driven by the types of questions that EPA needs to answer in order to evaluate the effectiveness of its programs. Examples of questions environmental policy makers need to know include:

Where is the environmental quality the best, worst? Why? How has it changed over time? How fast? Why? How much localized variation occurs? How is the environmental quality related to regulatory action or to other socioeconomic or natural factors? What are the standards that determine good or bad environmental quality? Are these consistent from place to place? Have these criteria changed over time? Can we compensate for any variation in measurement standards to get a consistent environmental picture over time and space?

Where are Federal and State resources expended to address a problem area or prevent a problem from occurring? Are these successful?

THE MARYLAND PERSPECTIVE ON LAND USE AND LAND COVER CLASSIFICATION

William S. Burgess
Maryland Water Resources Administration

Introduction

Maryland has completed a wide variety of land use and land cover mapping programs. Each program was designed to meet the requirements of specific management issues and the end-users of the data. In many cases, the scale of map products and their distribution were criteria that were specified by the Maryland General Assembly. The collective map products have a wide range of utility and the mapping information is often transferrable from one product to the next. However, digital raster and vector mapping technologies often show flaws and accuracy problems in the various data sets after they are combined. Problems were not as significant in the past due to the transfer methods used, and the "art" involved in map making. These types of problems have been exaggerated due to the interaction of the various "older" regulatory programs with new programs.

With the advent of digital mapping technologies, an even greater potential exists for identification and/or development of data layers that are questionable due to poor production techniques and the knowledge of the production staff. Any computer operator can develop a map with no understanding of datums, projections, documentation or any of the other essential elements involved in the production of a cartographic product.

A final concern manifests itself when the end-users of the various map products do not understand issues regarding the accuracy, use and functionality of their maps. This can be typically seen when datums shift, and new maps are produced with no training programs for the end-users or data processing staffs. End-user problems may also be a function of pushing mapped information far beyond its production scale in order to meet the needs of local government.

I would be very surprised if nearly every local, State and Federal agency did not have each of the general problems that I have described above. There is a clear need for coordination and documentation of existing mapping efforts as well as production of one map series that will fit the needs of Federal, State and local agencies where possible. There is also a significant void in the training of our personnel that are expected to use these data sets.

Existing Land Use and Land Cover Map Programs

Office of State Planning - The Office of State Planning produces land use and land cover maps for the entire State of Maryland. The most recent map series (1985 and 1990) are in digital and hardcopy formats. They were produced at a scale of 1:62,500 for each individual county with a minimal mapping unit of 10 acres. There is also a minimal width of 500 feet for linear features. The classification system is a slightly modified Anderson Level II with the interpretations coming principally from NHAP or NAPP photography, although a variety of other data sources were also used. This is the only statewide data set of general land use and land cover. The Office of State Planning is working with Towson State University to create another series of land use and land cover maps based on Thematic Mapper data. This project will involve new classification of approximately one-third of the State this year. These products are distributed by the Office of State Planning according to published price schedules.

Department of Natural Resources - Several mapping programs have addressed terrestrial and subaqueous land use and land cover mapping efforts. A partial listing of the Department's mapping efforts includes:

Map Name	Scale	Base Map Series	Revision	Digital
Critical Areas (1,000' buffer from tidal wetlands based on 1971 maps)	1:7,200	Tax Maps	Upon petition	Yes
Public Lands Inventory	1:7,200	Tax Maps	Additions	Yes
Oyster Bar and Lease Charts	1:20,000	Unique	?	In Progress
1971 Tidal Wetlands (regulatory maps)	1:2,400	Uncorrected Photography	None	No
1989 Nontidal Wetlands (guidance maps)	1:24,000	7.5' Quads SPOT Pan.	None	Yes
Environmental Easement Areas	1:7,200	Tax Maps	Additions	Yes
Heritage Species Locations	1:24,000	7.5' Quads	Additions	No
Forest Inventory (TM Classification)	1:24,000	7.5' Quad SPOT Pan.	First Maps 12/92	Yes

The majority of the above maps have been prepared on the 7.5-minute quad map series or on State tax maps because of availability, common usage and generally adequate scale. We have found, however, that most users have always sought larger or smaller scale map products to display their information while working with the public or for use in meetings. The maps most frequently cited as being useful when working with the public are the 1" = 200' tidal wetlands maps. Anybody can find their house on these maps, assuming it was built before 1971. Given the variety of map products, and the need to better interface with the public, we set out in July 1989 to develop a new map series that would fill the need of most regulatory, management and planning agencies at the Federal, State and local levels. That map series appeared to be a color digital orthophoto quarter quad map produced at a 1:12,000 scale and based on NAPP specification leaf-off color infrared photography.

Map production started in 1991 after a 2-feasibility, planning and contracting process that was a combined effort between the Department of Natural Resources and Salisbury State University. The maps are prepared by establishing a control point network (approximately 9 points per 7.5-minute quad), and flying NAPP specification photography or SPOT photographs over the aerial targets. The photographs are plugged and an aerotriangulation solution is performed. A digital elevation model (DEM) is established, with a point collected every 300' on the ground. The image is scanned at 800 dots per inch and ortho-corrected to the DEM. The corrected digital image is output in three separate bands with a composite color image and an ASCII file containing the elevation data. Each separate band of the raster image is approximately 30 megabytes, resulting in a total file size of 120 megabytes for each quarter quad map. The contractor supplies the State with the above digital files and two copies of a 1:12,000 black-and-white mylar. One copy of the mylar map is given to the county government on a gratis basis and digital files are made available for the cost of reproduction.

These digital maps have a ground resolution of 4 feet per pixel. This provides good on-screen image quality to scales of 1:2,400. We are able to develop 10' elevation contours to meet National Map Accuracy Standards (NMAS), and can produce significant information about overland water flow direction, and watershed boundaries with pour seed points. The digital files can support production of specific contour intervals to map features such as backwater behind a proposed dam, or floodplain areas, although the accuracy only meets original production standards. It is likely that the existing contract will be modified to obtain continuous collection of elevation points in stream channels to enhance the watershed modeling capabilities. Although the initial file with ASCII elevation data is very small, the final surface fitting raster that is used for detailed work involving elevations is approximately 70 megabytes.

The primary purpose of the new maps is to delineate tidal and nontidal wetlands. Photographic interpretation for wetland features follows standard NWI protocols and uses the Cowardin, et. al. classification system. Our methods vary from most mapping programs in the method of data transfer to the base map. A zoom transfer scope is not used. The photo interpreter enlarges an interpreted mylar on a xerox, scans it into digital raster format, and converts the file to a vector that is "fitted" to the orthophoto image. Each line element is then turned-off, properly hand-fitted to the ground feature, and a label class is entered into the system. This work is done at an approximate scale of 1:4,800 and provides data that are useful at large and small scales. The minimal mapping unit is one-half acre with obvious smaller features mapped.

The interpreted data are plotted into a dithered 1:7,200 scale raster that is converted to a print file that is approximately 35 megabytes. Multiple copies of the black-and-white print file may be sent to the electrostatic printer and printed in approximately 8 minutes each. Each printed map contains over 440,000,000 pixels. We have recently found that suitable blueline copies can be produced from first generation electrostatic black-and-white paper prints. This provides reproduction costs of approximately $15.00 for electrostatic prints and $4.00 for blueline copies.

Recommendations for Future Coordination

Even though large-scale mapping programs are expensive for statewide and national application, a coordinated program to produce one base map that is acceptable at all levels of government will result in a net saving through less frequent base mapping efforts and shared production costs with improved ability to transfer data between agencies. It will also allow for standard import and export routines in the various software packages that are used for digital mapping purposes. Meetings and seminars need to be held between Federal, State and local agencies to determine if a standard base map can be developed over large regional areas.

README files need to be included with all transfers of digital data that detail the following information at a minimum: year of production, method of production, source materials (e.g., NAPP photography, etc.), scale of production, does the product meet NMAS, what agency or corporate entity produced the map, contact name and telephone number, and other information as required.

We cannot let today's hardware and software limitations dampen our efforts to develop better map products. When Maryland started the orthophoto quarter quad project, it was not possible to effectively handle the expected volume of data that was projected at nearly 30 gigabytes. With the advent of better erasable optical diskettes, jukebox changers and the decreasing costs of storage media, we have decided to retain the separate bands of the raster images, print files, and the elevation rasters that will be produced. The total storage requirements will be in excess of 225 gigabytes. We have always been confident that hardware and software manufacturers will continue to improve their product lines to meet the demands of digital mapping programs.

LAND COVER/USE DATA SOURCE COORDINATION: KEY TO RESPONSIVE FUTURE LAND POLICY

Dale Friedley
Manatee County, Florida

Introduction

Land use and cover represents one of the few elements in modern land information systems that has applicability across all levels of government and a substantial number of private sector disciplines. It also represents the most difficult element of any government land information system to precisely define. Its problems stem from the subjective nature of the term and the general applicability of the information that require it to be a servant to a wide variety of demanding disciplines. This briefing outlines the most critical classes of land cover data of interest to Florida public agencies and suggests a strategy for coordinating their development and integrating their contents.

There are three equally valid views of land use and cover information that are commonly applied in the public sector throughout Florida. The first is the view from space provided through the use of scanners that produce multispectral digital remotely sensed information obtained from airborne scanners or digitized photographic imagery. The second is the interpretation and classification of land use and cover based on manual review of hard or soft copy aerial photographs or digital remotely sensed imagery. The third is land use source information related to land records and represented as characteristics of ownership or other types of parcels.

Image Sources

The image sources of land cover data are developed through a series of elaborate analytical procedures on multispectral digital remotely sensed data. Resulting data bases classify regularly shaped cells of land into specific cover and use classes. A variety of techniques are also used to produce aggregate cell areas that represent a general trend for land cover in an area. These sources of data are biased toward land cover information, and when analyzed over smaller areas, tend to provide more discrete cover information than can be obtained from the other two sources. Image approaches are extremely poor at this time in identifying and classifying land uses, however. The sources also are prone to higher error rates in classification and are generally rejected by local government concerns due to their cartographic aesthetics. Methodologies for classification are also less standard since the techniques and classification systems can vary greatly due primarily to considerations of the season and the discipline performing the analysis.

Aerial Photographic Interpretation

Aerial photographic interpretation represents the most standardized approach of land use and cover analysis, with a wide variety of theory and standards already available to guide any similar data collection approaches. Photo interpreted use and cover data tends to be driven by the scale of the source imagery, the minimum mapping unit, the detail of the classification system used, the consistency of interpretation between individuals performing the work, and the rigor of the ground truthing strategies used in data validation. The resulting data bases provide more meaningful boundaries between use/cover areas than those offered from image sources. The detail and accuracy of the classification systems depend greatly on the quality of the interpreter and the source material. Though the land use data provided is superior to that offered from image sources, it in no way can assess use at details offered from land records. Though cartographically more pleasing than image data, local government agencies tend to shy away from these sources due to their inability to interpret based on parcel or other legal boundaries.

Land Record Data Sources

Land record data sources provide more discrete assessments of the cultural activity associated with individual parcels of land. Though the classification systems vary, they tend to be combinations of earlier cultural land use coding strategies such as the Standard Land Use Coding system (SLUC) and the Standard Industrial Classification system (SIC). These are generally useful for reclassification into urban planning classes similar to those used in the current and future land use maps available in Florida growth management plans. When related to automated parcel and zoning maps, these classifications become the best source of spatial land use information, providing a wide variety of legal and cultural information concerning a parcel. These data sources seldom consider the actual cover associated with a parcel and do not delineate the specific location of the cultural activity on larger parcels. The location and classification accuracy of the parcels tend to be more accurate, however.

Coordinated Use

Most applications of land use and cover information would tend to favor data from one of the three sources outlined above. There is ample evidence, however, that a combination of the data provided from these sources would provide more useful, and in many cases more accurate, information. The combination of photo interpreted urban land use classes and parcel-based uses would provide substantially more discrete classifications of the cultural activity associated with an industrial use polygon. The use polygon would also offer information that could more accurately pinpoint the location of the industrial activity on what is currently a large parcel of land. The combination of image-based cover classification data could delineate more discrete assessments of manually interpreted cover classes such as dominant species and stand health.

It is evident that land use and cover data from all three sources will continue to be developed. It is also true that available geographic information systems will continue to improve functions that can properly integrate spatial data from a variety of sources. For these reasons, the exercise of determining a national or statewide direction for land use and cover data should consider all three potential data sources and further begin a dialogue to determine appropriate methods for integrating these data sources. For these reasons, the following recommendations are offered:

1. Establish interdisciplinary teams to review and document appropriate strategies for developing image-, photo interpreted-, and land records-based land use and cover data sets. Develop guidelines for potential data base developers that outline appropriate existing classification systems, methods for feature delineation, and appropriate uses for each class of land use and cover data when applied separately.

2. Establish a series of classification standards and analytical methods proscriptions for image data based on the type of imagery, the season of the image, and the discipline using the results of an analysis. This catalog should highlight a general approach to land cover analysis that appears to have the greatest utility for the largest possible audience.

3. Enhance research in the areas of feature delineation for higher resolution imagery and consider possible integration of methods between high and low resolution digital image sources.

4. Document in a single source or recommend existing sources for standards related to aerial photographic interpretation of land use and its accuracy evaluation.

5. Establish discrete ground truthing mechanisms for each source of land cover information that lead to meaningful classification error assessments. Develop a protocol for communicating location and classification error to potential users of a specific land data set.

6. Provide guidelines to local governments developing multipurpose cadastres on how this data source can be used as a quality land use data base. Highlight existing cultural activity classification standards and recommend an initial national standard for urban land record-based land use similar to the standards available in the photo based interpretation.

7. Cross-pollinate the talent from the interdisciplinary teams to determine appropriate integration strategies among multiple sources of land use and cover data and document these methods as determined.

8. Establish both locational and classification error theory for the composite land use and cover sources that consider the unique error characteristics of each source.

Offer guidelines for the overall evaluation of error in composite land use and cover data bases.

9. Highlight restrictions for using composite land use and cover data sources. Restrictions should be documented both in concept and based on the probable error associated with each source use and cover data base employed in establishing the composite.

MASSGIS LAND COVER DATA

Christian Jacqz
State of Massachusetts

Data base Description

We have one statewide land cover vector data base, in ARC/INFO, at roughly 1:25,000 scale, which is based on 1971 and 1985 data. This coverage was generated by the Resource Mapping-Land Information Systems group under Prof. Wm. MacConnell at University of Massachusetts/Amherst. Land use updates for Cape Cod were completed in 1990. Elsewhere, 1991 NAPP imagery for land cover interpretation is now available for about 100 towns out of 351 towns in the Commonwealth. Additionally, DEP's Wetlands Conservancy Program has undertaken statewide mapping of wetlands at a 1:5,000 scale. Complete imagery for this project has been acquired for about 10 percent of the State; production of an orthophoto base map and compilation of wetlands is underway. No other compilation of vector data from this source is in production at the present time.

Source data:

(MacConnell)	summer 1971-2	1:20,000 B&W onto mylars
	summer 1984-85	1:25,000 color infrared photos
Cape Cod	summer 1990	1:25,000 color infrared photos
proposed	spring 1991-2	1:40,000 color infrared photos (NAPP)
(wetlands)	spring 1990 on	1:12,000 color infrared on base of 1:5,000 OQ

Minimum mapping unit:

(MacConnell)	1971-2	3 acres
	1984-5	1 acre
Cape Cod	1990	.5 acre
proposed	1991-2	1 acre
(wetlands)	1990 on	<.25 acre

Projection, coordinate system, datum:

All in State Plane coordinate system, based on NAD27 except for wetlands which is based on NAD83

Coincident features embedded in data base:

Only town boundaries

Size: Total size of statewide data base 130 mb
Size per 7.5-minute quad average .95 mb
Number of polygons total estimate 70,000

Update frequency:
When funding permits on a 5-year cycle for MacConnell
Scheduling of wetlands PI originally over 10-year cycle

Coding Details

Coding system:

CODE	CATEGORY	DEFINITION
AC	Cropland	Intensive agriculture
AP	Pasture	Extensive agriculture
F	Forest	Forest
FW	Wetland	Nonforested freshwater wetland
M	Mining	Sand, gravel & rock
O	Open Land	Abandoned agriculture, power lines, areas of no vegetation
RP	Participation Recreation	Golf, tennis, Playground, skiing
RS	Spectator Recreation	Stadiums, racetracks, Fairground, drive-ins
RW	Water Based Recreation	Beaches, marinas, Swimming pools
R0	Residential	Multifamily
R1	Residential	Smaller than 1/4 acre lots
R2	Residential	1/4 - 1/2 acre lots
R3	Residential	Larger than 1/2 acre lots
SW	Salt Wetland	Salt marsh
UC	Commercial	General urban, shopping center
UI	Industrial	Light & heavy industry
UO	Urban Open	Parks, cemeteries, public & institutional greenspace, also vacant undeveloped land
UT	Transportation	Airports, docks, divided hwy, Freight storage, railroads
UW	Waste Disposal	Landfills, sewage lagoons
W	Water	Fresh water, coastal embayment
WP	Woody Perennial	Orchard, nursery, cranberry bog

We propose to include **forested wetlands** in the 1990-91 update, to add seven classes and eliminate one, as follows:

Wetlands	(will now include forested wetlands)
Marinas	(previously part of Water-Based Recreation)
Power lines	(previously part of Open Lands)

Heath Lands	(previously part of Open Lands)
Cemeteries	(previously part of Urban Open)
Cranberry Bogs	(previously part of Woody Perennial)
Orchard	(previously part of Woody Perennial)
Nursery	(previously part of Woody Perennial)

The environmental impacts associated with the specific land cover types listed above are the primary reason for breaking them out into new categories. For example, herbicide application associated with power line rights of way would be of special concern.

Decision process for selection of MacConnell coding scheme:
The UMASS/RM-LIS project has been going on since 1950-51. Land cover classification scheme originally included 104 classes, including

11 agricultural
40 forest
11 wetlands
5 mining & waste disposal
22 urban lands
15 outdoor recreation

I have the complete listing if anyone is interested.

The original classification scheme was developed "for use in Southern New England" and uses "descriptive land use terms common to that part of the country." (MacConnell and Niedzwiedz, 1974.) The original scheme was aggregated for use with GIS when the photointerpretation of 1971-1985 change was done.

The classification scheme for the WCP wetlands data will include the following:

DM	Deep marsh
M	Shallow marsh, meadow or fen
SS	Shrub swamp
WS1	Wooded swamp, deciduous
WS2	Wooded swamp, coniferous trees
WS3	Wooded swamp, mixed trees
BG	Bog
CB	Cranberry bog
TF	TIdal flat
SM	Salt marsh
BE	Coastal beach
BB	Barrier beach
D	Coastal dune
RS	Rocky intertidal shore
OW	Open water
BA	Coastal bank, bluff
U	Upland

Additionally, 11 classes represent combinations of Barrier Beach and other classes; these represent a small total area, such as BB/D.

The rationale for this classification scheme is partly based on the regulatory purpose for which the mapping was undertaken and partly on commonly accepted principles of wetlands mapping. The classification scheme represents a combination of the USF&W scheme and the regulatory categories set up by the State's wetland protection legislation; it is intended to be more descriptive than just using the regulatory scheme would allow.

Investment

Dollar cost for MacConnell:

The estimated total cost for the current statewide land cover classification (including the State's $30,000 share of the flyover) is under $480,000 for the current round of photointerpretation. This would work out to about $3500 per quad. In today's dollars, therefore, the total investment would be over $1.5 million, since the original interpretation was more costly than the subsequent analysis of change.

Dollar cost for wetlands:

The total cost for orthophoto production, CIR imagery, and interpretation of wetlands is estimated at roughly $3 million, or $22,000 per quad.

Experiences

Coverage creation problems with the MacConnell land cover:

Methodology involved detection of change using disparate sources and consequently the creation of sliver polygons was a technical difficulty.

Successes and failures for the MacConnell:

The coverage has been extremely valuable and has well served a variety of applications (see below). However, the impossibility of photointerpreting forested wetlands from leaf-on photography in the current edition of the land cover data has been a severe limitation in some analyses. Another issue is the explicit identification of transitional areas such as pasture grown up into forest.

It is still early for discussion of wetlands project's successes and failures.

Typical Applications of MacConnell Land Cover Data

- The MassGIS Cohen bill analysis used the wetlands and other aggregated land use data to show that the impact of watershed protection buffer zones on local economic development would be much less than feared.

- Department of Environmental Protection air quality monitoring application used land use data to give analysts an overview of conditions surrounding a permit site.

- Department of Food and Agriculture analysis of the impact of proposed pesticide regulation depended on land use data to show that on average less than 5 percent of agricultural land use lies within DEP well-head protection zones.

- MassGIS recently assisted DEP's Solid Waste Division in using the land use data to perform a major overlay analysis of land use within a half-mile and one mile radius around landfill sites, with the purpose of prioritizing monitoring efforts and potentially reducing the regulatory burden on towns.

- Land use data have been used by Bays programs to characterize potential impacts of development on coastal ecosystems.

All of these applications were regional or statewide in scope, and the resolution of our current and proposed land use classification was perfectly appropriate for their purposes. Finally, this data layer is the one more requested by planners, environmental consultants and others outside EOEA for the general evaluation of development proposals and environmental impacts.

The obvious application of the wetlands data is in support of the Wetlands Protection Act. However, there are many ancillary applications for the base map and the derived products such as DEM's. These include facility mapping, forest stand mapping, recreational and open space planning, agricultural use classification, etc.

Dream World

We would be very happy to get funding just to continue doing what we see as a valuable program of GIS-based land use/land cover mapping in Massachusetts. We feel that **historical continuity** of the data is very important to understanding the patterns of development in our State, and we would like any future land cover mapping to be consistent with the classification system that has been developed over a 40-year period. However, if we had unlimited funds, we would probably:

- investigate the use of higher resolution imagery to reduce minimum mapping unit

- develop more classes especially for forest types, agriculture, recreational and urban

- use image processing software on scanned imagery to do some kinds of classification

We would like to integrate different sources of information, so that multispectral imagery could be used in conjunction with the vector data to enhance the information on ecosystem characteristics such as vegetation stress.

LAND USE AND LAND COVER MAPPING CHALLENGES, A CALIFORNIA PERSPECTIVE

Nancy Tosta[1]
U.S. Geological Survey

There have been numerous efforts in California to create land cover and land use maps. For many years some programs have been collecting data that are specific to agency missions. Other programs have been more generally oriented to the goal of creating a statewide land cover map. Relatively few efforts have involved multiple agencies, or multiple levels of government. Following is a synopsis of some of the California efforts, plus observations on some of the challenges of coordinating land use and land cover mapping programs.

The California Department of Water Resources has conducted land use surveys for decades. Land use, concentrating on agricultural lands, is mapped for one-seventh of the State annually by projecting 35 mm aerial photographs on the wall and transferring them to 7.5-minute quadrangles. Hence, the entire State is mapped every 7 years. Mapping minimums are about 5 acres. Lands that support agriculture, or are developed, are mapped with some classification detail, and other lands are labeled as "NV" or native vegetation. Some of these data are being digitized.

For decades the California Department of Forestry and Fire Protection (CDF) has had a mapping program, which is primarily responsible for delineating soils, but also maps the distribution of vegetation within soil polygons. The areas mapped are uplands in private ownership. Little of the State has been mapped. Mapping minimums are around 5 acres. Very few of these data have been systematically digitized. Some data sets have been digitally encoded for projects covering small areas. In the late 1970's, the CDF was also involved in a project with NASA to use Landsat multispectral scanner data to generate an "unsupervised" classification of land cover for the entire State. When the classification was complete in 1979, the CDF had no equipment to use the digital data. Since then the CDF has acquired GIS and image processing capabilities and is now undertaking further mapping, attempting to classify the entire area of forest and range land (about 85 million acres of the State) to a 40-acre mapping minimum. Some of this work is now being done in cooperation with the U.S. Forest Service. The CDF has also compiled the U.S. Geological Survey (USGS) 1:250,000-scale land use and land cover data into a Statewide digital data file.

The California Department of Conservation maps farmlands designated as "important,"

[1]Formerly Deputy Director, Teale Data Center, State of California

as defined by soil type. Mapping is conducted only where there are valid surveys that indicate potential, not actual, land use.

The California Department of Fish and Game tracks rare and endangered species and recently has become very interested in the distribution of habitat. The staff botanists have developed detailed vegetation classifications that are not easily mappable using photographic or image interpretation techniques. Extensive ground surveys would be required to generate cover type maps.

The U.S. Forest Service (USFS) conducts a forest inventory on private lands in the State and from this estimates the acreage of productive and unproductive forest land. There is no standard map because data are derived from photo interpretation of sample points. Many of the national forests have individual programs to map vegetation, some using Landsat thematic mapper data.

The Soil Conservation Service (SCS) conducts a National Resource Inventory and also estimates the acreage of forest, range, and agricultural land from their sample. There were efforts several years ago to integrate the SCS and USFS inventories, but given the different objectives of the surveys (and differences in the definition of forest land), the results were not successful.

The Environmental Protection Agency has been discussing some of their proposed Environmental Monitoring and Assessment Program (EMAP) activities with some of the State departments, but no cooperative agreement has resulted.

These examples do not cover all efforts to map land use or land cover, but as can be seen, there is much redundancy in the efforts to develop statewide cover-type data bases. Many efforts have been made to coordinate the activities. For the most part these have been ad hoc. A few partnerships have evolved, but most have not lasted. As groups try to work together the issues that arise most often are how to establish a boundary between mapping "wildlands" (the responsibility of Forestry, etc.) and developed or agricultural lands (Conservation and Water Resources), what classification system to use (all the way from detailed species descriptions to what a forest is), what the mapping resolution should be, what source data are best, how to conduct accuracy assessments, and how to derive a product that meets the needs of the organization (that is if you cannot delineate the limited unique cover types, can you protect biological diversity?).

Following are suggestions for trying to coordinate these efforts in the future. First, separate land use from land cover. In general, land use is easier to delineate than land cover. Boundaries tend to be sharper, and classes have more easily mappable edges (i.e., field, residential areas). Obviously, there are some gradations, but the task is often easier than delineating a boundary between a mixed conifer and a red fir stand. Probably more important, the communities that are interested in these data sets often differ and have very different objectives. Attempts to develop mapping programs for the entire State often ran into difficulties simply because the area of interest varies by user. For some, wildlands are more important, for others, agricultural areas. Letting each user community develop rules and an approach for their specific area of interest, and integrating the data sets afterwards, may work more efficiently than forcing everyone to adopt a common mapping approach.

Second, be flexible in classifications. There has been some discussion about the value of hierarchical, nested classifications, which can be aggregated from specific to gross levels. If everyone could agree on one hierarchical approach we might all benefit by one classification, but most agencies look at the world differently for management purposes. Agreeing on what something is to be called depends on what you think it is and how it is to be used. The timber company sees a forest differently than the botanist does. Institutionally, there is a better chance to "cross walk" classifications, perhaps in a relational sense, than to design one that meets everyone's needs. This is messier than a hierarchy, but maybe more realistic. Also, given that some approaches to mapping such as digital image classification can underestimate "unique" classes, recognize the need to match classification to mapping approaches.

Third, in determining about mapping resolutions, consider what decisions will be made with the data. (Also, consider cost!) Knowing a class for every acre may be necessary when trying to create a city plan, but probably doesn't work well for managing wildlife habitat, is expensive to gather, and results in a lot of data to manage. However, understanding what is going on in a forest for habitat purposes may be difficult if only 40-acre polygons are available. Try to understand the intended use of the data, and that use should determine the mapping resolutions. Consider varying the resolutions in different regions of the map to meet specific requirements.

Finally, collecting detailed ground control information to assess the accuracy of classifications can be very expensive. In many parts of California, access is a problem; no roads exist, or extensive tracts of land are in large private ownerships. Designing an accuracy assessment that provides enough information to be reliable, particularly in sampling small, unique classes, is very difficult. But as GIS technologies are used to integrate our spatial data, understanding the accuracy of the data becomes more important. Reliable, extensive accuracy assessments are going to increase the cost of cover-type mapping.

In general, coordinating land use or land cover mapping efforts should be approached flexibly. At the State level, the group of users and interested players is very diverse. Focusing on use of the data helps identify possible partners. Classifications and mapping minimums are more easily developed with specific applications in mind (even though the data will be used for a thousand other purposes). The goal of a national land use or land cover program is to lay a framework within which a variety of mapping activities can fit. The entire Nation may never be mapped to the same classification or resolution, but that may not be necessary. Standards are necessary to allow data to be aggregated to classes that are useful for national concerns, but these standards do not have to preclude local flexibility.

LAND USE AND LAND COVER FORUM: THE STATE OF ILLINOIS PERSPECTIVE

Warren U. Brigham
Illinois Natural History Survey

The Illinois Geographic Information System is based in the State's Department of Energy and Natural Resources (DENR) and has been operational for more than 10 years. Virtually all spatial processing utilizes ARC/INFO software, although ERDAS predominates for image processing. Migration from a network of PRIME minicomputers (4) to a network of SUN workstations (35) is virtually complete. Online data files now exceed 40 Gb, and include a broad range of statewide coverages of natural resource, socio-economic, and other data. The user community numbers around 250, with most coming from within DENR.

Information regarding land cover is important to most of our applications. Our original source of such information was LUDA. Despite its age, lack of resolution, and lumping of some important land cover types, LUDA still represents our only statewide source of land cover information. Although SPOT and TM scenes have given us newer, detailed information for selected regions of the State and special inventories, such as the Illinois component of the National Wetlands Inventory, have updated single resources statewide, we lack current, comprehensive statewide land cover data.

In spite of severe budget limitations, the State of Illinois recently began an assessment of critical trends in human health, ecosystem health, and other more nebulous attributes of "quality of life." Current land cover is essential to this assessment, as is our ability to detect changes in land cover. To this end, we have just purchased statewide TM coverage c. 1990 and plan to purchase similar data for c. 1982.

Issues before us now include selection of a classification scheme (applicable both to Illinois and EMAP?), a procedure for accuracy assessment (can we use areas already "done" for other projects?), and a procedure for change detection less resource-intensive than two full statewide classifications.

PERSPECTIVE OF THE GEORGIA MOUNTAINS REGIONAL DEVELOPMENT CENTER

David Nix
Georgia Mountains Regional Development Center

The Georgia Mountains Regional Development Center (RDC) is proud to be invited to participate in this forum, and we hope that through our relationship with the USGS Water Resources Division in Atlanta we have contributed to these efforts.

The Georgia Mountains RDC serves 13 counties in Northeast Georgia made up of 51 member governments with vital resources such as Lake Sidney Lanier, the most heavily visited Corps of Engineers reservoir in the nation, and the headwaters of the Chattahoochee River, which serves as the primary water supply for the City of Atlanta.

The Georgia Mountains RDC has worked with Bob Dyar and Jack Alhadeff with USGS for the past 3 years on a pilot project for Habersham County, located in northeast Georgia. The Georgia Department of Community Affairs chose our agency to crate a GIS application to serve as a model for incorporating the natural resources criteria of a statewide mandate for comprehensive planning at all levels of government. The 18 regional development centers in Georgia will be serving as the key agencies in utilizing GIS-related applications for satisfying the requirements of the Georgia Planning Act and assisting local governments in the implementation of GIS applications.

Among the requirements in the Georgia Planning Act is the requirement for an existing land use inventory and map and the creation of a future land use plan. For this purpose the Georgia Department of Community Affairs Office of Coordinated Planning, in conjunction with the State Mapping Advisory Board, developed a standardized land use classification system. The intent of this system was to provide a basis for better land use and economic analysis within and among local governments, to enhance local land records management, and to facilitate the establishment of a statewide GIS.

The classifications are: Residential, Commercial, Industrial/Mining, Agricultural and Forest, Institutional, Park/Recreational, and Undeveloped/Unused.

The State of Georgia is encouraging plans to go beyond these basic seven classifications to levels that correspond with standard industry classification codes.

The Federal/State Joint Funding Program was the vehicle for our tie with USGS as well as their interest to develop a localized application. Our goal has been to develop an application incorporating data from Federal and State agencies with an emphasis on natural resource and environmental management and protection at a refined scale which can be applicable to the local level. The result is the capability to perform analysis across multiple layers of environmental and resource data, including the NMD 1975 Land Use/Land Cover data to provide a tool to manage a treasured area of our country. Participants in our pilot project included the USGS, SCS, EPA, Forest Service, FEMA, the Georgia DNR, and others.

This project has been a tremendous learning experience for our agency in terms of approach and execution of a GIS-related project involving a cadre of agencies, and I personally believe the process has furthered the acceptance and development of GIS in the State of Georgia and the Nation. We have used the application as a training and demonstration tool for government officials, managers and planning officers.

Through the refined datum and scale of land cover and land use from the National Mapping Division, we will be able to perform comparisons with our field-checked data and the environmental scenarios we have created. Another source of data comparison will be the ERDAS land cover data developed for the Georgia Department of Natural Resources.

Our relationship with USGS has been one in which we have learned and grown in the development of standards and procedures that add utility and credibility not only to the maps we produce, but also to the decisions made as a result of the products.

I feel we are extremely fortunate that the area of our pilot study in Habersham County is a part of the NMD land cover update project and that the refined scale and timeliness of the data will allow us to expand the processes we have undertaken with the USGS and broaden the use of these data sets for environmental, natural resource and infrastructure management and preservation.

TECHNICAL REQUIREMENTS OF LAND USE AND LAND COVER DATA FOR NEW ENGLAND STATES**

Peter August
University of Rhode Island

Michael Mac Dougall
U.S. Environmental Protection Agency

On February 6-7, 1992, representatives of GIS programs in Connecticut, Rhode Island, Massachusetts, Vermont, New Hampshire, the United States Geological Survey (Water Resources Division), and the United States Environmental Protection Agency (Region I) met and discussed their needs for land use and land cover data. The goals of the workshop were to:

1 -- Exchange information on the status of land use and land cover (LULC) data development in each of the New England States and describe how these data have been used.

2 -- Identify common requirements in the development and use of LULC data.

3 -- Develop a consensus set of regional LULC data needs to be carried forward to the National Forum on LULC data to be held in Reston, Virginia on February 25-26, 1992.

Goal one was met by exchange of technical descriptions of each State's LULC data set and summary of major applications of LULC data. This document constitutes achievement of goals two and three and summarizes what the participants feel are the technical requirements and major issues associated with development of a national LULC data base. Section I reports the consensus position among the attendees on specific technical issues. Section II provides a review of regional needs with respect to certain elements of a national LULC data base.

**The New England Land Cover Workshop was sponsored by the Environmental Protection Agency, Region 1 and the University of Rhode Island Department of Natural Resources Science with support from the Rhode Island Cooperative Extension Service.

There was general agreement that a cooperative effort between the States and the Federal government to create land cover data was a positive notion and should be examined carefully. In this model, the States would be free to establish the detailed data they require within the constraint that the data set be generalizable to a condition that met national standards. In return, the Federal government would provide financial, technical, or other assistance to the States in support of their LULC data development programs. A national data set could be developed that was consistent among States, yet States would not sacrifice the ability to customize the data for their unique applications. This model would minimize redundant data base development and would, in the end, be far more efficient than having States and Federal agencies pursuing development of land cover data in a parallel fashion.

The main theme of this report is to detail what constitutes the minimum acceptable standards for a land cover data set that would serve the needs of the New England States. For example, a national land cover data set that was based on a minimum mapping unit of 10 acres and consisted of 9 land cover classes would be of very little value to the States. Conversely, a 30-class LULC data set of one acre minimum polygon size would be an extremely useful data base for State applications.

The States look to the USGS and EPA for leadership in developing standards, protocols, and coordination in the development of LULC data. We encourage government agencies to support research of new technologies that permit better, faster, and/or more accurate land cover assessment and digital data base development. The methods and tools in use today will certainly be of limited value at the end of the decade. The technology that is used to obtain, manage, store, and analyze LULC data changes rapidly. It is important to address data requirements in terms of application needs rather than what current technology can deliver.

Technical Requirements of a National LULC Data base

Land Cover vs Land Use, Definitions. Careful distinction should be made between land use and land cover. A low density residential area (= land use) in a rural landscape may be dominated by forest, turf, or orchard (= land covers). The two data sets are not interchangeable, and many applications require one but not the other. In New England, land use data are frequently required at large scales such as 1:5,000. The scale requirements for land cover data are typically in the vicinity of 1:24,000.

Minimum Mapping Unit. A minimum mapping unit of 1-acre for both land use and land cover data would satisfy most application requirements. Issues of minimum mapping unit are tightly bound to project costs and technical capability. As technologies change in the future, so will our ability to realistically expect smaller minimum mapping units.

Classification Systems. Land Use/Land Cover (LULC) classification schemes must be of a hierarchical structure and readily accommodate the need to generalize LULC classifications. There must be at least Anderson Level II detail (30+ categories). The classification used for a national LULC data set must be back-compatible with the Anderson system. The classification must be designed to permit customization for local data base requirements and applications.

Coincident (Embedded) Features. Coincident features are an important element of an LULC data set. However, each State has unique requirements and it is difficult to set a regional or national standard for which features (roads, hydrography, coastline) should form the template of an LULC data base. Issues of documentation, error budgets, and accuracy are tightly associated with discussions of embedded features. The issue demands careful consideration and study.

Source Data. It is important not to become too tied to a specific technology because changes in data sources and technical capabilities occur rapidly. It is important to consider the merger of technologies in LULC assessment; for example, to use data derived from aerial photography to enhance or expand a classification established from satellite imagery (SPOT or TM).

Accuracy. There is a need for a systematic, objective, quantifiable method of LULC data accuracy assessment. The process can be expensive and account for a significant proportion of the total cost of developing an LULC data set, but it is an essential component. There are two elements of LULC accuracy, positional (i.e., is the line in the correct location) and classification (i.e., is the polygon correctly identified), and both must be measured and explicitly reported to the users of the data. More attention must be given to distinguishing between hard (e.g., a pond edge) vs fuzzy boundaries (e.g., a groundwater aquifer) in LULC data. Which element of accuracy (positional or thematic) is most important is very much application dependent. An LULC data base project would be well served by a system where feedback from the users of the data can be incorporated into data base maintenance and update.

Datum. Datum and coordinate systems are not major issues because GIS software will be able to easily convert from one system to another. New data should be developed in NAD-83.

Revision Cycle Time. It is imperative that an LULC data development project include plans for regular update and revision. A 3-year update cycle would be ideal (assuming rapid dissemination of the revised data). A 5-year interval between updates is the maximum allowable duration. States would require some control over, or participation in establishing the timing for data revision.

Spatial Data Transfer Standards. All New England States maintain their GIS data bases in a topological structure that easily satisfies SDTS requirements.

Miscellaneous. Many of the technical requirements of an LULC data base are application specific. For example, a regional summary of land cover types does not require great positional accuracy in the source data; whereas, an assessment of potential nonpoint pollution sources with respect to groundwater reservoirs and recharge areas requires considerable positional accuracy of the data. It is therefore important to clearly define classes of applications when discussing technical requirements of land cover data.

What Land Use & Land Cover Data Would New England States Invest In: an Informal, Unscientific Survey

Each participant was asked to indicate whether they would invest in a national LULC data set with certain characteristics. The amount of money they would pay would be equal to what their State contributes to the National Air Photo Program (NAPP) cooperative agreement with the United States Geological Survey. On the average, this is approximately $28,000 per State. The purpose of the exercise was to determine where there was strong agreement, or disagreement, on various aspects of the development of a national LULC data set. It is clear that the description of a quality, useful LULC data set is a multivariate proposition. The questions posed here were, for the most part, univariate in nature and certainly simplify a somewhat more complex issue. There were 17 participants, and their responses are given as a percentage of this total. Each question should be preceded with the phrase

> "Would you pay (an amount equivalent of your State's share of NAPP) for a LULC data set that ..."

Is not based on the Anderson Classification scheme?
- Yes -- 74%
- No -- 13%
- Uncertain -- 13%

Comments and Implications -- The group is not tied to the Anderson scheme per se. They are, however, adamant that the scheme be hierarchical and back-compatible with Anderson.

Has a minimum polygon size of 100 acres?
- Yes -- 0%
- No -- 100%

Has a minimum polygon size of 10 acres?
- Yes -- 13%
- No -- 75%
- Uncertain -- 12%

Has a minimum polygon size of 5 acres?
Yes -- 41%
No -- 41%
Uncertain -- 18%

Has a minimum polygon size of 1 acre?
Yes -- 100%
No -- 0%

Comments and Implications -- There is complete agreement on the value of a 1 acre minimum mapping unit. There is mixed agreement on the value of a minimum polygon size of 5 acres. A minimum mapping unit of greater than 10 acres would not be of value to the States.

Is referenced to NAD-83?
Yes -- 100%
No -- 0%

Is referenced to NAD-27?
Yes -- 59%
No -- 12%
Uncertain -- 29%

Comments and Implications -- NAD-83 is the preferred datum.

An LULC data set that does not contain explicit, statistical reporting of measured accuracy?
Yes -- 12%
No -- 57%
Uncertain -- 31%

An LULC data set that has a measured classification accuracy exceeding 90% (i.e., no less than 90 percent of the land cover or land use features are correctly identified)
Yes -- 88%
No -- 6%
Uncertain -- 6%

Comments and Implications -- There is general agreement that the quality of LULC data must be systematically assessed and reported to the user. A classification accuracy level of 90 percent is suitable for most applications.

An LULC data set of classification detail akin to Anderson Level I (e.g., approximately 9 categories)?
Yes -- 0%
No -- 88%
Uncertain -- 12%

An LULC data set of classification detail akin to Anderson Level II (e.g., approximately 30+ categories)?
Yes -- 100%
No -- 0%

Comments and Implications -- 9 or so classes are too generalized and 30+ classes are suitable.

An LULC data set that is in vector format, is derived from Landsat Thematic Mapper imagery, is no less than 3 years old, contains Anderson Level II detail, and at least 90% correct classification accuracy?
Yes -- 100%
No -- 0%

An LULC data set that is based on TM imagery and supplemented with detail provided by aerial photography?
Yes -- 100%
No -- 0%

Comments and Implications -- There is no hesitation to accept LULC data based on satellite imagery.

An otherwise suitable (for your specific needs) LULC data set with no plans for future maintenance, revision, or update?
Yes -- 62%
No -- 12%
Uncertain -- 26%

Comments and Implications -- A revision is strongly preferred. If costs were higher or data of less quality, some users may not buy in to the project.

An LULC data set in raster format?
Yes -- 69%
No -- 0%
Uncertain -- 31%

Comments and Implications -- The States have the technical capability to accept LULC data in raster format. Many of the uncertain respondents were concerned over the pixel size of the data set; if it was too large, they might not be interested.

The following questions were asked to get a general sense of the group on several important issues.

Over the next 5-10 years do you see yourself working with data at a scale that is required for municipal applications (e.g., 1:5,000)?

Yes -- 69%
No -- 19%
Uncertain -- 12%

Comments and Implications -- There is a definite trend in integrating data from the community scale (e.g., 1:5,000 and larger) with data from the regional planning scale (e.g., 1:24,000 and smaller).

Would you adopt a national standard for LULC data?

Yes -- 75%
No -- 0%
Uncertain -- 25%

Comments and Implications -- There is general willingness to accept a national standard, as long as it has the flexibility to accommodate State/local requirements.

Would you accept a regional standard for LULC data that was developed by the regional GIS community?

Yes -- 82%
No -- 0%
Uncertain -- 18%

Comments and Implications -- There is a general willingness to adopt a regional set of standards for LULC data.

Would you provide data to users who might distribute them to others?

Yes -- 56%
No -- 12%
Uncertain -- 32%

Comments and Implications -- For many users, relinquishing control of data distribution is not a problem; however, those who voted "no" were adamant in their response and had significant misgivings over relinquishing distribution rights.

ATLANTA REGIONAL COMMISSION
LAND USE & LAND COVER PROGRAM

Connie Blackmon
Atlanta Regional Commission

Overview

Under cooperative agreements with the U.S. Geological Survey, the Atlanta Regional Commission (ARC) adapted the national Land Use and Data Analysis (LUDA) program to meet the needs of its regional planning program. The agreements covered: (1) the initial development of the 1975 Atlanta Region land use data base featuring third-level urban land uses and institutional boundaries, and (2) a joint technical effort to establish change detection procedures via an update of the regional data base to 1980. (The details of these agreements and ARC's implementation are described in the URISA '86 Proceedings, "Land Use Information System: Adaptation of the USGS System for Regional Planning.") Following these agreements, ARC refined the USGS software and completed a 1985 update of urban land uses. More recently, ARC has incorporated the land use/cover data base into the Atlanta Region GIS under ESRI's ARC/INFO software. The staff is now in the process of adding enhanced features to the data base while they complete their third update of urban land uses based on 1990 SPOT imagery and other resource materials.

Local & Regional Applications

Comprehensive data on land use and cover are an integral part of ARC's planning process. The data are used to prepare small areas forecasts, to assess regional growth trends, and to monitor implementation of the Commission's regional plans and policies. Land use data and maps also support a variety of special studies for transportation corridors, watersheds, and other environmentally sensitive areas such as the Chattahoochee River Corridor. In addition, ARC produces summary statistics and maps to meet the needs of local governments and developers for current information on land use patterns and trends.

Special Features and Achievements

The Atlanta land use/cover data base was originally compiled by USGS in 1975 as a LUDA demonstration project for a special 1:100,000 scale, 1° x 1 1/2° topographic map centered on Atlanta. In addition, land use/cover for 18 of the 96 component 7 1/2' quads was compiled at 1:24,000 scale. The three updates have been performed using a range of aerial photography products -- low- to high-altitude, contact prints and enlargements, color-infrared and black-and-white -- at compilation scales ranging from 1:100,000 to 1:14,400. The overall quality and resolution achieved by the Atlanta implementation have exceeded original expectations. Analysis of the 1975 file for Atlanta shows that urban land use areas of 2 hectares and rural areas of 4 hectares are the norm, compared to the standard minimum mapping units of 4 and 16 hectares, respectively. ARC has used the higher resolution units for all its edits and updates. USGS also specifies minimum width criteria that originally precluded mapping central portions of Atlanta's interstate system. They have now been added and the entire interstate system is classified as a separate third-level land use. The third-level categories used in 1975, 1980 and 1985 are:

112	High Density Residential
115	Mobile Home Parks
121	Intensive Institutional
125	Extensive Institutional
145	Limited Access Highways
171	Golf Courses
172	Cemeteries
173	Parks

Ownership boundaries of parks and major institutions have been used to delimit the coverage of 125 and 173 areas in order to support ARC's plans for public facilities and forecasts of land available for development. As a result of these refinements in resolution and coverage, ARC's land use data base has proven adequate for regional planning purposes and for some local applications as well.

Refinements in Process

As documented in the URISA '86 Proceedings, by 1986 ARC had adapted the USGS procedures and software to achieve a reasonably efficient method of tracking land use change over time. However, only with the implementation of the GIS has the agency established a practical approach for compiling a consolidated file of current land use. Formerly, the data base had a comprehensive file of 1975 land use/cover plus 1975 to 1980 and 1980 to 1985 change overlays. Under the GIS, ARC has consolidated 1975 land use with the change overlays to produce 1980 and 1985 land use coverages. Soon ARC will have 1990 land use/cover with 1985 to 1990 changes derived by polygon overlay. The GIS has also facilitated a comprehensive clean-up of slivers and other inconsistencies caused by the blind digitizing of changes.

The 1990 update in process is using a panchromatic SPOT image (10 x 10 meter resolution) covering a major portion of the nine-county Atlanta Region. In this area, the update involves interactive image tracing techniques recording changes observed between the 1985 land use coverage and the 1990 background imagery, working at a scale of 1:12,500.

Before this update, ARC staff established a coverage of control links showing where the 1985 land use boundaries differ from the imagery. The control link coverage was then used to adjust boundaries of the 1985 land use coverage to align with the true lines of demarcation seen in the imagery. These same adjustments will be applied to 1980 and other years as needed to provide consistent historical bases for modeling and analytical purposes. One other refinement involves the division of the low-density residential category into three levels (intown, suburban and rural) because the percent of impervious surface varies significantly. For stormwater modeling, each land use class will be assigned a factor estimating the percent impervious surface. Also for runoff modeling, land use/cover data will be adjusted to remove the estimated pavement coverage of streets and highways using ARC's street base and attributes related to road widths.

Recommendations for Future Improvements

A primary internal use of the land use data is support of the agency's small area forecasting process. In this modeling effort, ARC has discovered some problems with the classification system and compilation standards. The understatement of residential land in rural areas is a common problem because strip developments often fail minimum width requirements. ARC has added rural residential land in many areas that fall below USGS standards. Even so, comparison with census counts suggests that residential land is understated in the region's more sparsely settled census tracks.

More serious problems were encountered with high-density residential, commercial and industrial land. In particular, high-density residential land is understated in areas where apartment complexes are mid-to-high rise buildings. ARC plans to offset this problem by linking the land use to its data base on apartments and developing more precise density measures. In some commercial and industrial areas, interpretation fails to separate the classes properly. Also, the types of activities defined for each class do not correspond well with the Standard Industrial Classification (SIC). Since ARC's small area forecasts are based, in part, on correlations of land use by type to jobs by SIC, this problem is an area of continuing concern.

In addition to these classification concerns, ARC is extremely interested in any programs or coordinated efforts that would make digital imagery available at reasonable cost and in easy-to-use forms. For instance, to acquire satellite imagery covering its entire region, ARC must purchase at least four frames. Only one lies mostly within the Atlanta Region, and the others would extend far beyond its borders. The use of image tracing and related interactive techniques is a promising improvement in efficiency. However, ARC encountered a range of technical implementation problems, which are apparently not atypical. As these are resolved over time, it will be easier to justify the higher costs of digital imagery, but lower costs will promote more frequent monitoring of land changes.

Conclusion

Use of the LUDA-adapted system has provided ARC a flexible, easily replicated approach to maintaining a consistent, high-quality data base on land use/cover patterns and trends in the Atlanta Region. With the accuracy and resolution achieved by the cooperative efforts of USGS and ARC, the Atlanta implementation can serve as a model for land use/cover information systems shared among Federal, State and local agencies.

OHIO DEPARTMENT OF NATURAL RESOURCES REMOTE SENSING PROGRAM

Gary Schaal
Ohio Department of Natural Resources

The Remote Sensing Program inventories, maps and monitors changes in Ohio's land and surface water resources and their uses. The Program is utilized by all levels of government involved in resource management, protection and planning.

Aerial Photography - The Program provides aerial photography support for the Department and other State of Ohio agencies. Through April 1991, some 63,600 aerial photos have been taken covering Ohio's landscape, providing a permanent visual record of conditions for present and future reference. The photos are being used for pre land acquisition surveys, surface mining monitoring, reclamation monitoring, Lake Erie shoreline erosion studies, wildlife habitat assessment, land use mapping and economic development planning, among others. The photography is entered into a national data base (see ESIC) and becomes available for purchase to users throughout the U.S.

Photo Interpretive Services - The Program provides assistance to users in interpreting and extracting information from aerial photos. Examples include boat counts and type classification on several State-owned lakes, logjam locating for stream cleanups, floodplain delineation, boat dock counts, tree crown density mapping and disaster assessment.

Land Use Mapping - The Program enters into contracts with county officials for mapping current land use from aerial photography. This information is used by local officials in planning, development, and resource management as well as by the Ohio Capability Analysis Program for land capability analyses and current agricultural use valuations. Recently, counties are requesting 5- or 10-year updates. Forty-one counties have been mapped with nine more in progress or under contract.

Earth Science Information Center (ESIC) - The Program was selected by the U.S. Geological Survey's National Map Division to become the Ohio affiliate of their Earth Science Information Center. As such, the Program has access to a national data base of historic and current cartographic products including aerial photos, satellite data and maps. ESIC provides users with a one-stop-shop for these products. Since inception, 8,500 requests from public and private sectors have been handled, with an average of 150 per month and rising. Typical clients besides State of Ohio agencies include attorneys (legal purposes), bankers (loans on property), developers (land acquisitions), engineers (site development), and sportsmen (hunting and fishing sites). ESIC is a repository and distributor of U.S. Fish and Wildlife Service wetlands maps of Ohio.

Satellite Digital Image Processing - The Program operates an Earth Resources Data Analysis System (ERDAS). ERDAS is an image processing and geographic information system (GIS) which allows the State to utilize data from U.S. and French satellites. This capability allows timely analysis and mapping of land and surface water resources over regional and statewide areas. Current projects include inventorying and mapping the State's wetlands in cooperation with the Soil Conservation Service and ODNR's Division of Wildlife, nonpoint source pollution modeling to guide best management practices on agricultural land, assessment of reclamation success on abandoned mined lands, and tillage practice tracking. An additional project being considered is a statewide land use inventory and map.

Landsat Browse File - The Program maintains current micro catalogues and micro images of available Landsat (satellite) images. This facility enables users of Landsat data to select and view Landsat scenes prior to ordering. It is the only way to determine whether or not clouds obscure the area of interest.

Ohio Capability Analysis Program (OCAP)
Division of Soil and Water Conservation

The OCAP is a computer mapping and information storage, retrieval, and analysis system for natural resource data. Since its inception in 1973 OCAP has provided local government officials and others with resource maps and data to help improve land use and resource management decisions made at the county, township and municipal levels of government.

Mission Statement

One of OCAP's primary objectives is to create a digital natural resource data base for every Ohio county. To date a total of 50 county data bases have been created. A typical Ohio county OCAP data base includes soils, land use/land cover, surface and subsurface geology, groundwater availability, zoning, floodplain delineations, and various boundary data including watersheds, political jurisdiction lines, and parcel ownership tracts. A second objective of OCAP is to assist local government officials in using the digital data base to help evaluate and plan for different land uses such as sanitary landfills, residential subdivisions, and commercial, industrial, and recreational uses. OCAP's composite resource maps or land capability analyses are particularly useful to local officials when planning for a controversial but necessary land use such as a sanitary landfill. An OCAP composite resource map brings all of the pertinent, physical resource data together on one map so that local officials can more easily interpret the data. This information is ideal as an economic development tool to identify sites which meet the requirements of any proposed facility. By using OCAP maps local officials are more likely to arrive at an objective and rational decision that considers the limitations and potential of the physical resources of the planning area.

Resource Management Activities

The use of OCAP products is not limited to land use planning activities. Since 1982, when OCAP was administratively placed within the Division of Soil and Water Conservation, several agricultural applications have been developed to meet locally expressed needs. OCAP can now illustrate and compare soil erosion potential for different agricultural practices including no till, conservation and conventional tillage. This is a very valuable tool for local resource managers who must target scarce resources to implement important conservation efforts. In addition, OCAP has developed a capability analysis to illustrate where municipal sewage sludge can be safely applied to agricultural lands. The application of sewage sludge can improve soil tilth and lessen the need for expensive soil fertilizers. A well planned and monitored local application program can also save tax dollars by reducing sludge disposal costs.

Other OCAP agricultural applications include the mapping of prime farmland and hydric soils. These types of data are generally incorporated into local comprehensive development plans that identify areas that the community wants to preserve. Another OCAP agricultural application is the provision of soils and land use data on a parcel basis for implementation of the State's Current Agricultural Use Value (CAUV) Program. OCAP provides county auditors with a computerized record of parcel data that would be very difficult and expensive for them to produce manually.

For more information contact:

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OHIO LAND USE/LAND COVER CLASSIFICATION

- 1 Urban or Built Up Land
  - 11 Residential
    - 111 Single Unit
    - 112 Multiple Unit
      - 1129 Apartment Complexes
    - 113 Mobile Home Parks
  - 12 Commercial and Services
    - 121 Retail Trade
      - 1211 Junk Yards
      - 1212 Shopping Centers
    - 122 Institutions
      - 1221 Educational
      - 1222 Religious
      - 1223 Health Care
      - 1224 Correctional
      - 1225 Military
    - 123 Recreation
      - 1231 Marinas
      - 1232 Drive In Movies
      - 1233 Amusement Parks
      - 1234 Municipal Sports Facilities
      - 1235 Race Tracks
      - 1236 Fairgrounds
  - 13 Industrial
    - 131 Light Industries
    - 132 Heavy Industries
      - 1321 Electric Power Generating Plants
  - 14 Transportation, Communications, Utilities
    - 141 Transportation
      - 1411 Airports
      - 1412 Rail
      - 1413 Highways
      - 1414 Ports
    - 142 Communications
    - 143 Utilities
      - 1431 Electric
      - 1432 Gas
      - 1433 Water
      - 1434 Wastewater
  - 15 Industrial and Commercial Complexes
  - 16 Mixed Urban on Built Up Land
  - 17 Other Urban or Built Up Land
    - 171 Undeveloped
    - 172 Zoos
    - 173 Golf Courses
    - 174 Cemeteries
    - 175 Parks
    - 176 Landfills and Waste Dumps
    - 177 Water Control
    - 178 Campgrounds

● Categories added since last printing

- 2 Agriculture
  - 21 Cropland and Pasture
    - 211 Cropland
      - 2111 Row Crops
      - 2112 Cover Crops
      - 2113 Fall Plowed Land
    - 212 Pasture
  - 22 Orchards, Groves, Vineyards, Nurseries, and Ornamental Horticultural Areas
    - 221 Orchards and Groves
    - 222 Vineyards
    - 223 Nurseries and Ornamental Horticultural Areas
  - 23 Confined Feeding Operations
  - 24 Other Agricultural Land
    - 241 Farmsteads
- 3 Rangeland
  - 32 Shrub and Brush Rangeland
    - 321 Young Shrub & Brush
    - 322 Mature Shrub & Brush
- 4 Forest Land
  - 41 Deciduous Forest Land
  - 42 Evergreen Forest Land
  - 43 Mixed Forest Land
  - ●44 Clearcut Forest Land
- 5 Water
  - 51 Streams and Canals
  - 52 Lakes
  - 53 Reservoirs
  - 54 Bays and Estuaries
  - ●55 Ponds
- 6 Wetlands
  - 61 Forested Wetlands
  - 62 Non Forested Wetlands
- 7 Barren
  - 72 Beaches
  - 73 Sandy Areas Other Than Beaches
  - 74 Bare Exposed Rock
  - 75 Strip Mines and Other Surface Excavations
    - 751 Strip Mines
      - 7511 Active
      - 7512 Inactive Not Reclaimed
      - 7513 Inactive Partially Reclaimed
      - 7514 Reclaimed Not in Use
    - 752 Other Surface Excavations
      - 7521 Quarries
      - 7522 Sand and Gravel Pits
      - 7523 Borrow Pits
  - 76 Transitional Areas
  - 77 Mixed Barren Land

STATE OF CONNECTICUT PERSPECTIVE

Theron A. Schnure
State of Connecticut

Structure

The structure for developing land use and land cover parameters and data requires extensive involvement from States -- and as such, States should be represented in the discussions occurring among the USGS, USEPA, and other Federal agencies. It is in the national interest of the cognizant Federal agencies to involve States in any land use and land cover programs. In addition to Federal agencies, it is the States that are in a knowledgeable and key position to manage the development, use, and maintenance of land use and land cover data, especially land use data. To facilitate an interface in this effort, the States need to structure themselves to have representation in this effort, as through a committee or committees. The cognizant Federal agencies should pay expenses for committee representatives from the States to meet and develop with Federal agencies the parameters for land use and land cover data development which will be carried out by States and used by all.

We, the States, need to organize activities within our respective States so the subjects of consistency and compatibility can be addressed. Typically, a lead State agency for land use and land cover data would represent and respond to concerns or opportunities and facilitate communication and coordination within the State. It would also provide a point of contact in the Federal-State interchange regarding land data.

A viable organizational structure within each State and among States and Federal agencies is a prerequisite in developing a framework for land use and land cover data.

Compatibility

Any schemes which are developed for State and national applications must be flexible and compatible to the breadth of categories and detail common to all. Specifically, a scheme for land use categories needs to be in sufficient detail to satisfy the needs of municipal planning and management. I recognize that some State and national needs may not need or desire a fine level of detail, especially in recognition of the costs of preparing more detailed data. Regardless, the scheme for land use data at larger scales should provide for generalizing when detailed land use data is available and maintained.

As a side bar, I would note the Bureau of the Census, on a national scale, has a program of geocoding employer's sites, which is a rather detailed program in light of assumed broader or more generalized national interests.

We need to recognize there are needs for land use data at municipal levels and this detailed level of data can provide a basis for more generalized data at regional, State, and national levels. A "nesting" capability to assure compatibility of land use data at all levels is required.

Definitions

Any scheme developed needs to be compatible to the extent feasible with applications relating to land uses and applications relating to land cover. Data are generated from different approaches: a bottom-up procedure and a top-down procedure, respectively. We need to recognize the uniqueness of each of these data bases and the advantages or limitations of each. Land use data will be required for many other applications, and within the land use categories, there will be levels of detail. On the other hand, land cover data will serve many applications in a cost effective manner. The physical aspects of our land need to be associated with comparable socioeconomic data, for example. Definitions and support programs for each must be developed, agreed upon, and utilized as we enhance our availability and uses of land use and land cover data.

SUMMARY OF PRESENTATIONS - TECHNICAL ISSUES

A WETLAND/UPLAND LAND COVER CLASSIFICATION SYSTEM FOR USE WITH REMOTE SENSORS

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Abstract

An ecologically oriented land cover classification system for wetlands and uplands has been developed for use in current land cover mapping projects of several government agencies. The classification system has the following attributes: 1) it is designed for use with satellite remote sensor data, yet it is capable of incorporating aircraft and field data at lower levels; 2) the classes are defined primarily in terms of land cover, avoiding land use terms, to eliminate confusion and improve reliability of detection with satellite sensors; 3) the system emphasizes wetland, deepwater habitat and uplands categories to meet special requirements of the NOAA Coastwatch Habitat Change Analysis Program (C-CAP) and EPA's Environmental Monitoring and Assessment Program (EMAP); 4) it is compatible with the National Wetlands Inventory (NWI), and other mapping programs; and 5) the number of totally new classes has been kept to a minimum with most being similar or identical to those used in the Anderson and Cowardin Systems. The system was developed during joint meetings with representatives from key government agencies, including NOAA, USGS, EPA, USFWS, and COE, in order to satisfy the immediate needs of the NOAA Coastwatch Change Analysis Program (C-CAP) and the EPA Environmental Monitoring and Assessment Program (EMAP). Also, comments from five NOAA regional workshops were incorporated into the classification development process.

The goal of the NOAA Coastwatch Change Analysis Program is to develop a comprehensive, nationally standardized, information system for land cover and habitat change in the coastal region of the U.S. Satellite imagery (Thematic Mapper), aerial photography and surface level data are being interpreted, classified, analyzed and integrated within a geographic information system (GIS). The program will delineate coastal wetland habitats and adjacent uplands and monitor changes in these habitats on a cycle of 1 to 5 years. This type and frequency of information is required to improve our understanding of the linkages of emergent and submerged wetlands with adjacent uplands and with the distribution, abundance and health of living marine resources.

C-CAP Program products will strengthen conceptual and predictive models and improve coastal resource policy planning and analysis. Products will include: 1) spatially registered digital images, 2) hardcopy maps, 3) tabular summaries by State, county, and hydrologic unit, 4) quality control procedures, and 5) user documentation. The maps will be available at scales from local (1:24,000) to regional. Land cover change will be detected and mapped in a pixel-by-pixel comparison of different time periods. Remote determination of biomass, productivity, and functional status of wetlands will be tested, as well as new platforms and sensors as they become available.

The Environmental Monitoring and Assessment Program (EMAP) was initiated in 1988 by EPA to provide improved information on the current status and long-term trends in the condition of the Nation's ecological resources. The overall goal of EMAP is to provide a quantitative assessment of the current status and long-term trends in ecological condition on regional and national scales. In the short-term, EMAP will provide standardized protocols for measuring and describing ecological condition, provide estimates of condition in several regions, and develop formats for reporting porgram results. Trend detection will clearly require longer periods of data collection and evaluation, and therefore is an immediate goal. Diagnostic analyses, to identify or eliminate plausible causes for degraded or improved condition, is considered the long term goal of EMAP.

Three EMAP component programs are cooperating with NOAA's Coastwatch Change Analysis Program: EMAP-Wetlands, EMAP-Near Coastal Systems, and EMAP-Landscape Characterization. All three groups are involved in the effort to develop an interagency classification system. The EMAP resource groups are cooperating with NOAA in development of indicator measurements for coastal zone ecological systems, particularly estuaries and estuarine wetlands. EMAP-Landscape Characterization is working with NOAA C-CAP in mapping protocols development, accuracy assessment, classification, and pilot testing of these methods in the Chesapeake Bay area.

The NOAA contribution to this effort was supported by NOAA's Coastal Ocean Program (Sea Grant) under grant no. NA90AA-D-SG542.

MODIFIED WETLAND/UPLAND LAND COVER CLASSIFICATION SYSTEM FOR USE WITH REMOTE SENSOR DATA

Level 0	Level 1	Level 2	Level 3
Upland			
	1.0 Developed	1.1 High Intensity (Solid Cover)	1.11 Residential
			1.12 Commercial
			1.13 Industrial
			1.14 Transportation, Communications & Utilities
		1.2 Low Intensity	1.21 Residential
			1.22 Commercial
			1.23 Industrial
			1.24 Transportation, Communications & Utilities
			1.25 Rural Development
	2.0 Cultivated Land	2.1 Woody	2.11 Orchards/Groves
			2.12 Vine/Bush
		2.2 Herbaceous	2.21 Cropland
	3.0 Grassland (Herbaceous)	3.1 Herbaceous	3.11 Unmanaged
			3.12 Pasture
			3.13 Groomed
	4.0 Woody	4.1 Deciduous	4.11 Forest
			4.12 Shrub
		4.2 Evergreen	4.21 Forest
			4.22 Shrub
		4.3 Mixed	4.31 Forest
			4.32 Shrub
	5.0 Exposed Land	5.1 Soil	5.11 Transitional Developed
		5.2 Sand	5.21 Beach/Dune Complex
			5.22 Sandy, Other than Beach/Dune Complex
			5.23 Extraction Pits
		5.3 Rock	5.31 Outcrops
			5.32 Quarries/Mines
			5.33 Unconsolidated
		5.4 Evaporite Deposits	5.41 Dry Salt Flats
	6.0 Snow & Ice	6.1 Snow & Ice	6.11 Perennial Snowfields
			6.12 Glaciers
Wetland			
	7.0 Wetland	7.1 Marine (intertidal)	7.11 Aquatic Bed
			7.12 Reef
			7.13 Rocky Shore
			7.14 Unconsolidated Shore
		7.2 Estuarine (intertidal)	7.21 Aquatic Bed
			7.22 Reef
			7.23 Streambed
			7.24 Rocky Shore

Level 0	Level 1	Level 2	Level 3
			7.25 Unconsolidated Shore 7.26 Emergent 7.27 Scrub/Shrub 7.28 Forested
		7.3 Riverine	7.31 Rock Bottom 7.32 Unconsolidated Bottom 7.33 Streambed 7.34 Aquatic Bed 7.35 Rocky Shore 7.36 Unconsolidated Shore 7.37 Nonpersistent Emergent 7.38 Open Water
		7.4 Riverine (lower perennial)	7.41 Unconsolidated Bottom 7.42 Aquatic Bed 7.43 Rocky Shore 7.44 Unconsolidated Shore 7.45 Nonpersistent Emergent 7.46 Open Water
		7.5 Riverine (upper perennial)	7.51 Rock Bottom 7.52 Unconsolidated Bottom 7.53 Aquatic Bed 7.54 Rocky Shore 7.55 Unconsolidated Shore 7.56 Nonpersistent Emergent 7.57 Open Water
		7.6 Riverine (intermittent)	7.61 Streambed
		7.7 Riverine (unknown perennial)	7.71 Rock Bottom 7.72 Unconsolidated Bottom 7.73 Aquatic Bed 7.74 Rocky Shore 7.75 Unconsolidated Shore 7.76 Nonpersistent Emergent 7.77 Open Water
		7.8 Lacustrine (littoral)	7.81 Rock Bottom 7.82 Unconsolidated Bottom 7.83 Aquatic Bed 7.84 Rocky Shore 7.85 Unconsolidated Shore 7.86 Nonpersistent Emergent 7.87 Open Water
		7.9 Palustrine (wetland)	7.91 Rock Bottom 7.92 Unconsolidated Bottom 7.93 Aquatic Bed 7.94 Unconsolidated Shore 7.95 Moss-Lichen 7.96 Emergent 7.97 Scrub/Shrub 7.98 Forested 7.99 Open Water

Level 0	Level 1	Level 2	Level 3
Water and Submerged Land			
	8.0 Water and Submerged Land		
		8.1 Marine (subtidal)	8.11 Rock Bottom 8.12 Unconsolidated Bottom 8.13 Aquatic Bed 8.14 Reef 8.15 Open Water
		8.2 Estuarine (subtidal)	8.21 Rock Bottom 8.22 Unconsolidated Bottom 8.23 Aquatic Bed 8.24 Reef 8.25 Open Water
		8.3 Riverine (tidal)	8.31 Rock Bottom 8.32 Unconsolidated Bottom 8.33 Aquatic Bed 8.34 Open Water
		8.4 Riverine (lower perennial)	8.41 Unconsolidated Bottom 8.42 Aquatic Bed 8.43 Open Water
		8.5 Riverine (upper perennial)	8.51 Rock Bottom 8.52 Unconsolidated Bottom 8.53 Aquatic Bed 8.54 Open Water
		8.6 Riverine (unknown perennial)	8.61 Rock Bottom 8.62 Unconsolidated Bottom 8.63 Aquatic Bed 8.64 Open Water
		8.7 Lacustrine (limnetic)	8.71 Rock Bottom 8.72 Unconsolidated Bottom 8.73 Aquatic Bed 8.74 Open Water

DIGITAL LINE GRAPH - ENHANCED (DLG-E)

Keven Roth
U.S. Geological Survey

Digital Line Graph - Enhanced (DLG-E) is a new program that will provide the U.S. Geological Survey's (USGS) next generation of digital data. The DLG-E data model will provide a more comprehensive and flexible tool to capture and describe geographic data. While there are some differences between the categorization hierarchies of traditional land use and land cover (LULC) and DLG-E features, most existing LULC schemes can be mapped to the DLG-E model. DLG-E makes possible the integration of LULC and topographic mapping.

Early in the DLG-E development process, a decision was made that the content of current USGS products would form the basis for defining DLG-E features. A review of current specifications for graphic and digital products, including both topographic and LULC products, identified the geographic information included in these products. The current list of DLG-E features, attributes, and attribute values is a direct result of that review. We expect that the list will change over time, as technology changes and as new user requirements are identified.

DLG-E is a feature-based model, where one feature may be composed of multiple line, point, or polygon elements in the data file. The model distinguishes between features and the space in which they exist, which means that the locational information about a feature is held separately from the attribute information in the data file. The relationships between a feature and other features can be described without reference to the individual elements that make up the feature. DLG-E feature types are defined by form rather than function. Therefore, most DLG-E features describe land cover, rather than land use. Function or use, when significant, is usually considered an attribute of a DLG-E feature.

Traditionally, LULC mapping has considered the surface of the Earth to be one feature (land) that is further described by a set of attributes. This is the orientation of the Anderson classification scheme historically used by the USGS. In contrast, DLG-E describes homogeneous parcels of land as features in their own right, with further characteristics described with attributes. For example, DLG-E defines barren land, as a homogeneous parcel of land, as a feature. Distinctions based on earth composition (rock, gravel, mud, salt, etc.) are handled as attributes of the feature "barren land." These further distinctions do not create a different feature, just a different type of the same feature, barren land. However, grassland, as another homogeneous parcel of land, is considered a separate feature which can then have its own attributes.

In traditional LULC mapping, each parcel has a single category that describes that parcel uniquely and that may result in the loss of fine distinctions between similar things. For example, an area that is mostly commercial with some residential land may be attributed the same as another area that is mostly commercial with some industrial land, because only one category can be used for any given area. The possible categories may also include ones for "mixed" use or cover to handle areas where no one use or cover dominates. The mix of covers or uses is not defined, so that an area that is a combination of rock and sand is attributed the same as an area that is a combination of strip mines and transitional areas (mixed barren land).

DLG-E, on the other hand, allows features to have multiple values for a given attribute. For example, in DLG-E, areas of mixed forest land would be captured as "trees" with both "deciduous" and "evergreen" as values for the attribute "tree category." DLG-E also allows for complex characterizations by allowing multiple features to share the same space, for example, so that an area of grassland can overlap an area of residential use.

LAND COVER CLASSIFICATION WITH REMOTELY SENSED DIGITAL DATA

Thomas R. Loveland
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Data from Earth-orbiting satellites have been used for land cover mapping for nearly 20 years. The most common satellite systems currently used for land cover analysis are Landsat with the Multispectral Scanner (MSS) and Thematic Mapper (TM), SPOT with both panchromatic (Pan) and multispectral (MS) data, and NOAA Polar Orbiters with the Advanced Very High Resolution Radiometer (AVHRR). Each system fits a unique niche based on its spatial and spectral characteristics. Landsat TM and SPOT imagery, with 30-meter and 10- or 20-meter ground resolution respectively, can be used for detailed land cover mapping at scales from 1:100,000 to 1:24,000. Landsat MSS, with 80-meter resolution, is commonly used for mapping projects requiring data at 1:250,000 scales. AVHRR, with 1,100-meter resolution, is useful for national-level general land cover studies in which results at scales smaller than 1:2,500,000 are needed. Landsat TM offers an additional advantage for some studies because higher spectral resolution improves the identification of some land cover types.

Land cover classification using computer-assisted procedures is based on pattern recognition techniques. Pattern recognition requires a sample of representative land cover spectral properties to train statistical classifiers such as maximum likelihood and minimum distance methods. This phase of the pattern recognition process is typically automated and requires minimal analyst intervention. However, the remainder of the classification process, particularly the critical class labeling step, has many similarities to manual interpretation. It requires that an analyst determine the relationship between the computer-generated categories and land cover types using thought processes common to manual interpretation. Following labeling, most classifications now rely on postclassification refinement using ancillary data such as digital elevation or ecoregions to improve classification accuracy. This refinement is important in situations where disparate land cover types share common spectral properties.

Digital classification of either Landsat, SPOT, or AVHRR data offers several advantages over manual interpretation:

- Greater spatial detail can be achieved.
- Objective, repeatable techniques can be used.
- Generation and reproduction of results is automated.
- Data collection is cost-effective for large study areas.
- It is cost-effective to include in a GIS.

There are disadvantages, however, such as higher data costs for digital versus photographic products, larger investments in staff training and analysis systems, and inconsistent results in complex environments. Because digital image classification must rely on the statistical relationships among land cover types, spectral similarities among disparate cover types can cause significant reductions in classification accuracies.

Several factors should be considered when determining whether digital or manual interpretation should be used and in selecting the specific remotely sensed data appropriate for the mapping project:

- Study area size and characteristics
- Information requirements of users including spatial detail and land cover categories
- Accuracy requirements
- Available budget
- Time requirements
- Access to analysis systems and staff

The final results of digital classification will be affected by image quality, classification methods, environmental characteristics, and analyst conditions. Typically, automated classification of land cover results in 75- to 80-percent accuracies. Project design must include careful matching of information requirements, sensor types, and classification methods to ensure successful development of land cover products.

Robin G. Fegeas
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As our society and economy continue to be transformed by technology, there is a growing movement toward a National Information Infrastructure (for example, Dertouzos, 1991). This infrastructure, necessary for the easy and rapid interchange of many types of information, will include not only data (and a spectrum of organizations collecting data), but also systems for coordinating, storing, processing, managing, and distributing data.

Some reasons for this movement are quite simple. Many new technologies, on which we will increasingly rely for our continued well being, if not survival, have greatly increased needs for easier and faster access to accurate and current data. And the cost of creating much of this data, for each separate application, is excessive.

The use of geographic information systems and related technologies is an excellent example. With overlapping requirements and shrinking budgets, the need for a geographic or spatial data component to the National Information Infrastructure is becoming clear. Moreover, as noted in a 1990 *Spatial Data Needs* report from the Mapping Science Committee of the National Academy of Sciences, "Survival in an increasingly global economy, dominated by ever larger private/public sector coalitions in countries outside the United States, may be possible only if commitments are made in this country to a national policy for increased information development and sharing."

The fact that we are holding this land use and land cover forum is evidence of our growing need to share data. As we have come to recognize over the last few years, our missions and budgets demand that we coordinate requirements, consolidate resources, and share data.

So how do we go about sharing data? Unfortunately, as a community, we have had very little successful experience. For a number of reasons, even when we are able to overcome the NIH (not invented here) syndrome, we have been thwarted by the difficulties in accessing and using one another's data. Some reasons are political or economic--access is restricted by sensitivity or cost recovery issues. Other reasons derive from the fact that data are often collected for a single purpose, effectively limiting multipurpose use.

But even when we have wished to design data bases and exchange data for multipurpose use, a general lack of spatial data standards has often kept us from knowing how to do it. Standards come into play in a number of areas affecting data sharing. These areas are:

- data collection criteria involving content definition and accuracy,
- data modeling, structuring, processing and storage,
- data access and distribution policies,
- data access paths and exchange media and formats, and
- data quality reporting (often called "metadata"--data about data).

The Spatial Data Transfer Standard (SDTS), soon to become a Federal Information Processing Standard, addresses a number of the issues involving spatial data sharing. Currently undergoing testing and the development of implementation guidelines, SDTS is expected to become a useful tool for spatial data modeling, content definition, and data quality reporting, as well as data exchange, possibly as early as the end of this calendar year.

More work on SDTS and other standards is to be conducted by the Federal Geographic Data Committee (FGDC), commissioned by OMB in October 1990 in the revised *Circular No. A-16*: "A major objective of the Circular is the eventual development of a national digital spatial information resource, with the involvement of Federal, State, and local governments, and the private sector. This national information resource, linked by criteria and standards, will enable sharing and efficient transfer of spatial data between producers and users."

Although a large task, we must set about defining these criteria and standards. As Nancy Tosta concluded in her "Data Data" column in the April 1991 issue of *Geo Info Systems*, "The more of us there are in the geo-processing community, the more difficult cooperation and coordination become--but also the more necessary it becomes that we work together and the more benefit we are likely to derive from developing the ability to share data."

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SUMMARY OF SMALL GROUPS DISCUSSIONS

For the last part of the Forum, participants reconvened in small groups to address the technical issues related to (1) classification, (2) sensors, preprocessing, and image processing, (3) accuracy assessment, and (4) archiving and data transfer presented earlier. The purpose of these discussions was to identify issues for the follow-on User Needs Assessment, and to generate ideas that would help develop the questions for this analyses. The common issues permeating all discussions were interest in acquiring and sharing land cover/use data and the concern that communication and coordination is essential, especially at the Federal level. Immediately following the Forum, paper presenters, technical issue discussion leaders, and others met to begin the process of developing a User Needs Assessment. This follow-on assessment will be conducted during the Fall 1992.

APPENDIX A

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