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ABSTRACT

The Land Use Data and Analysis (LUDA) Program will provide a systematic and comprehensive collection and analysis of land use and land cover data on a nationwide basis. The initial nationwide collection of these data will be completed within a 5-year period. Individual land use/cover maps and their associated data will be released as they become available following compilation. Periodic revision of the data is planned.

Maps will be compiled at about 1:125,000 scale showing present land use/cover at Level II of a land use/cover classification system developed by the U.S. Geological Survey in conjunction with other Federal and State agencies and other users. For each of the land use/cover maps produced at 1:125,000 scale, overlays will also be compiled showing Federal land ownership, river basins and subbasins, counties, and census county subdivisions.

The program will use the advanced technology at the Special Mapping Center of the U.S. Geological Survey, high altitude NASA photographs, aerial photographs acquired for the USGS Topographic Division's mapping program and LANDSAT data in complementary ways.

INTRODUCTION

In the United States there has been no systematic and comprehensive compilation of land use/land cover maps and data similar to land use mapping carried out in Canada, Japan, the United Kingdom, and most other European countries. However, much mapping of land use has occurred in the metropolitan areas of the Nation. Much of this compilation of land use maps and data in urban America has been carried out with assistance from the U.S. Department of Housing and Urban Development.

Some States such as Connecticut,¹ New York,² and Minnesota,³ have, for some time, had maps of land use at scales ranging from 1:24,000 to 1:500,000, but in most cases these States have not been able to update their land use maps regularly. Therefore, they have decreasing utility. Some Federal agencies, such as the Forest Service, Soil Conservation Service, and Bureau of Land Management, collect some land use information, but it is generally collected for a specific need and it is generally difficult to adapt to other uses. In 1958, and again in 1967, a National Inventory of Soil and Water Conservation Needs was carried out by the U.S. Soil Conservation Service.⁴ The inventories have provided much useful information about land uses by counties, but since the inventory was based on a 2 percent sampling of the total area of the United States it is deficient with respect to specific geographic distributions of various land uses.

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Some of the major problems with these existing data sources are the lack of consistency, the age of the data, spotty coverage, and the use of incompatible classification systems. The data have been collected to meet specific limited needs using definitions of use classes which are appropriate only for that need. They have often been collected on a one-time basis so the data are of marginal utility for other applications at a later time. Furthermore, it is nearly impossible to aggregate available data because of the differing classification system used.

LAND USE - LAND COVER CLASSIFICATION

The Land Use Data and Analysis (LUDA) Program of the U.S. Geological Survey has been designed and funded to provide a systematic and comprehensive collection and analysis of land use and land cover data on a nationwide basis. The initial collection of these data is to be completed within a 5-year period. Individual land use/cover maps and their associated data will be released as they become available following compilation. Periodic revision of the data is planned.

A major necessary first step in establishing the Land Use Data and Analysis Program was to develop and test a land use classification system appropriate for use throughout the United States at the more generalized first and second levels. At the same time it was necessary to recognize the need for flexibility in meeting regional and local needs for land use/land cover maps and data.

A Land Use Classification System for Use with Remote Sensor Data published by the U.S. Geological Survey as Circular 671, 1972,⁵ and the revised circular now nearly ready for publication under the title, A Land Use and Land Cover Classification System for Use with Remote Sensor Data have been prepared to meet that need. In the preparation of these reports, the authors have had the benefit of extensive and extended discussions with informed persons from Federal, State, and local governmental agencies as well as from universities, professional societies, and elsewhere.

In developing the Geological Survey system of land use and land cover classification, several needs were kept clearly in mind. Some of these were:

1. Recognition of frequently used existing categories of land use and land cover in order to make it possible to have an adequate understanding of the general framework of the classification system. It was considered absolutely essential in order to attain a reasonable, though not necessarily ideal, level of standardization for land use mapping and data collection. Sophisticated but unfamiliar terminology was carefully avoided although a more refined approach to the classification of land use and land cover might be more acceptable to those seeking to institute a classification system which gives more attention to logic than to practicality.
2. Provision for adequate flexibility in using the proposed approach to standardization at the more generalized levels of classification was absolutely necessary. From the beginning it was recognized that what was one man's prime concern was another man's miscellany. Later I will illustrate how various users of the Geological Survey classification system have been able to achieve the flexibility needed in their respective programs.

3. Application of the available and rapidly expanding array of remote sensor technology was considered a prime consideration in developing a framework of land use and land cover classification. Funds for data collection are always scarce. Too often we fail to ask the important question: What is the minimum amount of data that is needed for planning, management, and regulatory purposes? We also generally fail to be realistic about the funds and time needed to obtain data for a specific need. Data not exactly applicable to a specific use may be available at a fraction of the cost of generating data sets for each highly specific use. Remote sensor data will definitely not supply all user needs for land use and land cover data, but remote sensing offers an efficient and timely approach to obtain much data to which data from other sources can be conveniently added.
4. Recognition of the need for objectivity is absolutely essential in providing benchmark or baseline data pertaining to land use and land cover. Without a means of quantifying the use and character of land resources on a consistent, repetitive basis, an important dimension of land use planning is sorely neglected. Unless careful attention is given to the selection and definition of land use and land cover categories, objectively assembled data will not be available for the measurement of changes in land use and land cover over time or from place to place.
5. Assignment of single use or cover designations to a given area of land seems necessary and preferable to the recognition of multiple uses which might be applicable to such an area. The multiplicity of uses can best be handled by employing the overlay method rather than by using combinations of use and cover categories. For example, when an area of forest land is used for the production of timber, grazing of livestock, recreation, and wildlife habitat, an additional map or maps is really needed to depict such a multiple use situation properly. To establish a category that would identify such a combination of uses in the basic data set creates specific problems in recovery of basic land use and land cover data for other purposes.

The words "land cover" have been added to the title of the USGS classification system being published in the revision of Circular 671 in order to indicate more clearly the intermixing of land use and land cover terminology in the classification system. To some this intermixture is undesirable. However, a careful evaluation of alternatives leads the authors to the conclusion that unfamiliar or infrequently used terms would need to be introduced if strict adherence to either land use or land cover terminology was observed

LAND USE DATA AND ANALYSIS PROGRAM

Turning now to the Land Use Data and Analysis (LUDA) Program of the U.S. Geological Survey, I would like to review briefly the main components of the program and to cite several examples of how land use/land cover data being compiled are being interfaced with third level categorization to meet specific needs of cooperating State, Federal and metropolitan agencies.

Maps are being compiled at a scale of approximately 1:125,000. For each of the land use/cover maps produced, overlays will also be compiled showing Federal land ownership, hydrologic units, counties, and census county subdivisions. State land ownership will be shown when information is made available to the U.S. Geological Survey by the appropriate State agency or agencies on a Statewide basis.

Land use and land cover data will be keyed to the combined black and blue color separation plates of the standard USGS 1:250,000 topographic sheets. The minimum mapping unit for urban and built-up uses, water areas, confined feeding operations, other agricultural land, and strip mines, quarries, and gravel pits is 10 acres. All other categories are being delineated with a minimum unit of 40 acres. Federal land holdings will be shown for tracts of 40 acres or larger.

Selected experimental demonstration land use and cover maps at scales from 1:24,000 to 1:100,000 are also being prepared in order to show how land use and cover mapping carried out at a regional scale can be related to more detailed land use and cover mapping at larger scales.

Computerized graphic displays and statistical data on current land use and cover will become available through this program for use in conjunction with other data. Statistical data will be compiled by counties, by areas of Federal ownership, by hydrologic units, and by statistical units such as census tracts or other census county subdivisions.

Land use and cover data will be digitized in polygon format (each individual land use/cover area comprising a polygon). Conversion of land use polygons to land use grid cells of varying sizes can be made when desired.

Because of the dynamics of land use, the emphasis in the preparation and distribution of all products is on supplying the information to the users in the shortest possible time. There are three stages of release of land use and land cover information.

- A) Maps will be available for advanced sale on ozalid paper, ozalifoil, semi-stable ozalid, cronar, and cronaflex materials. The standard land use/cover maps and accompanying overlays showing counties, hydrologic units, Federal land ownership, and census county subdivisions will be available at 1:250,000 on the materials just mentioned. However, these products will also be available upon request within a reasonable range of the compilation scale of approximately 1:125,000. For example, under the cooperative agreement with the State of Florida, land use/cover maps are being supplied at a scale of 1:126,720 in order to match the scale of county highway maps in common use in that State.
- B) Computer-generated maps and statistical data are to be made available upon request about 6 months after land use/cover maps and accompanying overlays have been made available as indicated above. Magnetic tapes will be available for sale. Documented software needed for the use of computer-generated data will also be available. Of course, computer-generated maps can be supplied at any scale compatible with the original compilation scale of approximately 1:125,000. (It is, of course, inappropriate to use land use/cover data compiled at that scale at such scales as 1:24,000 or 1:50,000 on the one hand or at such scales as 1:1,000,000 on the other hand.)
- C) Lithographed published maps in color.

The LUDA Program will use the advanced technology at the Special Mapping Center of the U.S. Geological Survey, high altitude NASA photographs, aerial photographs acquired for the USGS Topographic Division's mapping program, and other supplemental data necessary for the effective compilation of land use/land cover maps. LANDSAT data will be used in complementary ways.

As stated earlier the approach to land use and land cover mapping by the U.S. Geological Survey permits an aggregation of Level II categories into Level I categories. Even more important is the capability to add Level III categories desired by users. Such categories would represent further subdivision of Level II categories already compiled.

For example, under a cooperative agreement with the State of Florida, land use and cover data are being compiled at Level II. At the request of the Florida State Department of Planning, an overlay of selected Level III-type categories is being prepared. The cost of this overlay is being borne by the State. Some of the Level III categories being overlaid and fitted to the Level II categorization are:

1. citrus groves separated from other groves, nurseries, etc.
2. mangrove swamps and cypress bogs separated out of the Level II category "Forested Wetland"
3. mudflats separated out of non-forested wetland

One of the current cooperative agreements involves the Level II land use/land cover mapping for the area of the new 1:100,000 topographic base map of the Atlanta Region for the Georgia State Geologist. In conjunction with this mapping, certain additional Level III categories are being supplied at the request of the Atlanta Regional Commission for the eight-county area of its jurisdiction. These include the separation of single-family and multi-family residential units, the breakout of major institutional areas from the Commercial and Services category, the delineation of urban parks, and a further breakdown of areas classified as Mixed Urban or Built-up at Level II. In order to permit digital and statistical extraction and comparison of data for areas of local and regional interest, additional overlays depicting municipality boundaries and local watersheds are being compiled. These additional products and categorizations are examples of accommodations which make the techniques of a national program useful in a local context.

Separation of additional Level III-type categories such as saline and fresh-water marsh will generally require more extensive use of data acquired by other means than remote sensing. This flexibility is obviously needed to accommodate varying needs for land use data from place to place and agency to agency. Such flexibility even permits restructuring the emphasis in the generalization process so that a Level III category from a nationwide perspective can be elevated to Level I in a particular State or region. Compatibility with the U.S. Geological Survey mapping will be maintained if the categories which are added can be combined into Level II categories.

There has been considerable experimentation in the Geography Program on the potential of LANDSAT data for providing Level II land use/land cover information useable for land use mapping. This has included both visual and automated interpretation, and certain aspects of both procedures are being described in other

presentations from the USGS Geography Program at the Symposium by Alexander and Wray. General results of this interpretation of LANDSAT data indicate that most Level I categories can be obtained either visually or through automated classification of CCT spectral data. Although certain Level II categories usually can be obtained either visually or automatically, the entire range of Level II categories has not been obtained consistent with the definitions as specified in USGS Circular 671. More importantly, repetition of categories from scene to scene and region to region has not yet been achieved. The results of our research on the potential of LANDSAT data for land use and land cover mapping generally parallel the results obtained by other researchers concerned with similar problems. The several State land use maps that have been produced through conventional interpretation of LANDSAT data, such as the maps for Kansas,⁶ Nebraska,⁷ and Tennessee,⁸ are indicative of the problems of level of classification and consistency of definition. Similar problems have been encountered by those attempting to assign land use and land cover categories to LANDSAT spectral data.^{9,10,11}

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