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Soil and Land Cover Overlay Analyses

Land cover overlays, prepared from ERTS scanner data, and soil survey overlays, extracted from maps, were employed to characterize resources.

Abstract: *Soil survey data for Knox County, Tennessee, were coded in 2.68-acre cells registered to geodetic coordinates; land cover information classified from geometrically corrected* ERTS *scanner data was processed and assigned to geodetic cells of the same size through the use of a special computer program. Ground registration of data permitted overlay analysis which greatly enhanced the value of both data sets.*

Introduction

Land analysis processes generally involve three distinct phases: (1) inventory of basic resource data, (2) analysis of resource data, and (3) interpretation of analysis results. In a well-defined process each phase might be implemented independently; however, in many land analysis efforts, the three phases are performed concurrently.

Data collection involves the direct or indirect measurement of certain basic resource variables that are compiled into a data base. These data subsequently can be used to make inferences about the relative or absolute state of the resource, and about related resources for which no data were collected. In other words, a resource is characterized. The final phase entails interpreting the significance of the characterization with respect to land analysis objectives.

The process can be illustrated by the example of a forester marking a timber sale. The forester measures the diameter and height of each tree and then calculates the volume of wood in the tree. The particular tree is then interpreted as merchantable or unmerchantable, based on the characterization of volume. A more complex example would be the collection of surface reflectance data with a multispectral scanner, characterization of a spectral signature, and subsequent interpretation of land use.

A study in east Tennessee (Cox and Weber, 1974) showed that most characterizations needed in land management decision systems can be made with basic data in four categories: (1) soils, (2) cover, (3) topography, and (4) ownership. Many characteristics can be inferred with soils and cover data alone.

The Tennessee Valley Authority conducted an analysis in Knox County, Tennessee, using soil map unit data from published maps and land cover information classified from ERTS scanner data. Overlay analyses, combining both basic data items, provided resource characterizations for potential land management activities. These analyses provided resource characterizations for both forest management and urban planning activities.

Study Area

Knox County encompasses approximately 338,000 acres in middle-east Tennessee within the Ridge and Valley Province. Metropolitan Knoxville, located in the center of the county, is a major commercial and transportation hub for the east Tennessee region.

Knox County was selected as the study area so that data and interpretations could be utilized in ongoing TVA forest management projects. Research and utilization of the information could be coordinated with management and research activities of Oak Ridge National Laboratory, the Soil Conservation Service, local and regional planning agencies, and the National Park Service.

Data Collection and Processing

Four major constraints were considered in selecting data sources and processing techniques. These constraints were (1) data availability, (2) computer capability, (3) ease of registration, and (4) desired resolution.

Detailed Soil Conservation Service county maps were selected as the source of basic soil data, and ERTS multispectral scanner data were classified to provide land cover information. Techniques employed for data collection and processing were unique in both cases and each will be treated separately in discussion. The same general procedure, however, was followed in both cases although the techniques varied in the last two steps.

- Identification of data source in concert with needs.
- Selection of variables and levels within variables.
- Data registration and digitization.
- Data processing and analysis.

SOIL DATA

Basic soil information often is useful to land planning activity, because land use is usually dependent on land capability. This is especially true for agricultural and urban uses.

Data Source. Knox County soils data were digitized from detailed soil maps prepared by the Soil Conservation Service (1955).

Selection of Variables and Levels. Large numbers of interpretations are possible from the soil data, the exact number being dependent on the descriptions available and the knowledge of the local soil scientists. Variables selected for this analysis were (1) slope, (2) depth to bedrock, (3) flooding potential, (4) percolation rate, and (5) drainage.

The analysis technique allows flexibility in

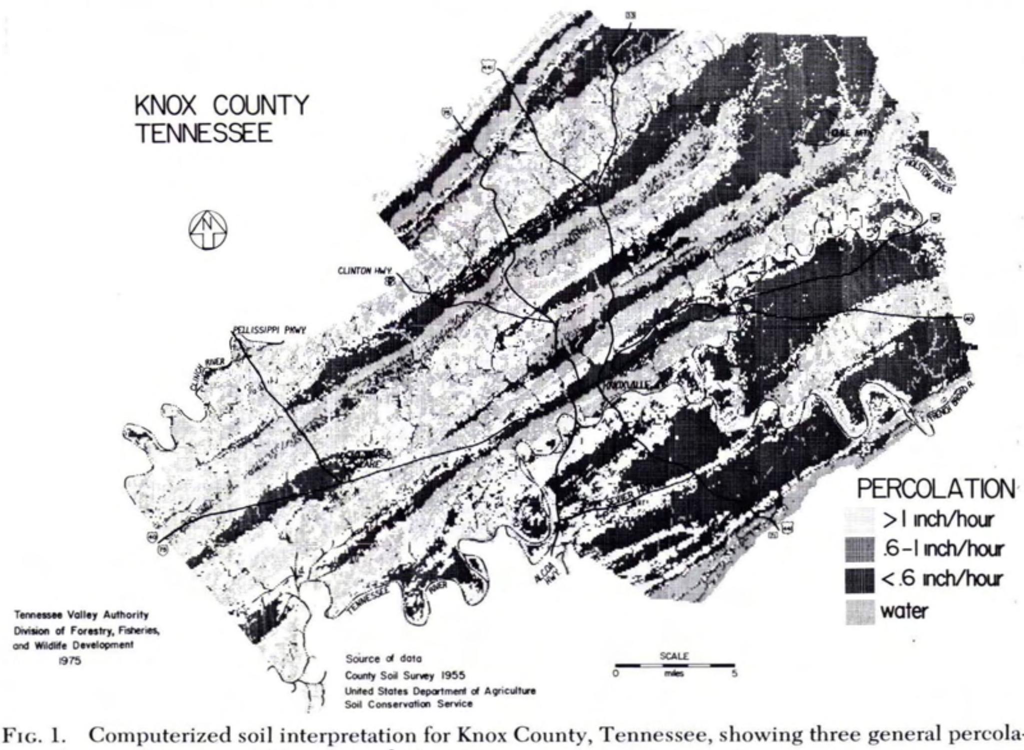

Fig. 1. Computerized soil interpretation for Knox County, Tennessee, showing three general percolation classes.—data are at 2.68-acre resolution.

the number of levels in each interpretation to meet analysis objectives. Figure 1 displays a soil interpretation in three general percolation classes for Knox County, although six classes could have been obtained.

Data Processing and Registration. Soil map unit data were digitized by using the mapping code symbol. A transparent mylar grid was fitted to each soil map, subdividing it into discrete data cells. Each cell of 2.68 acres (3.75 seconds on a side) was geodetically registered. Mylar grids were computer-drawn by the GRIDOT program (Durfee, 1975) to allow for cell size variation with latitude changes.

By using grid overlays, the alphabetic or alphanumeric symbol for each mapping unit was hand coded (digitized) for each cell and these data were transferred to standard forms for keypunching. A sampling method was used in digitization. The value assigned each cell was the soil map unit at the center of that cell. After error correction, interpretations were made by assigning each of the basic soil map units to a selected suitability or capability class. This information was supplied to a modified version of the GRID program (Sinton and Steinitz, 1971) to produce a single-factor analysis map. Interpretative maps were stored in digital form for future combination with other cellular information for the study area.

LAND COVER

Processing basic soil data provides interpretations of potential site productivity or land capability. Land cover information, however, greatly enhances the value of the soil data. Through composite or overlay analysis, characterizations of actual land use as well as land capability can be produced.

Data Source. Several different sources were available for obtaining generalized land cover data for Knox County, including various scales and types of aerial photography, field surveys, and multispectral scanner data.

ERTS-1 (LANDSAT) multispectral scanner data collected in October 1972 were selected as the data source because: (1) ERTS data, geometrically corrected by IBM for Oak Ridge National Laboratory and TVA, were readily available; (2) data were in digital form and geodetic registration could be performed by computer; and (3) cell size was similar to that used for digitized soil data.

Selection of Variables and Levels. The category of land cover was considered a separate variable and each cover type a distinct level. Five major types of cover occur in Knox County: trees, grass areas (nonforest and agricultural vegetation), constructed surfaces, bare soil, and water. Bare soil occurs infrequently and was included with constructed surfaces. Trees were subdivided into hardwoods and conifers. The levels used were constructed surfaces (and bare soil), hardwood, conifer, pasture and other (vegetation other than trees), and water.

Data Processing and Registration. By applying a supervised classification approach, the LARSYS software package (LARS, 1973) at LARS/Purdue University converted the raw multispectral scanner data to land cover information. Training areas were selected from 1:24,000 CIR photography taken in November 1973. Each area was subsequently field checked and land cover verified for the ERTS data (October 1972). Final classification results were stored on magnetic tape in a single array with each mapping unit of 0.64 acre having a unique land cover designation. The mapping unit size differs from the standard PIXEL size of approximately 1.1 acres because of the geometric correction process.

Registration was performed utilizing a computerized technique recently developed at the Oak Ridge National Laboratory (Mashburn, et al., 1975). The technique consisted of internally overlaying the appropriate geodetic grid on the classification results grid. Each geodetic cell was then assigned the appropriate land cover code based on dominant feature weighted by the LARSYS generated probability of correct classification.

Results and Discussion

The Fountain City 7½′ × 7½′ quadrangle (Figure 2) was chosen as a subset of the Knox County data base in order to demonstrate the concepts of resource characterization.

The computer process for developing resource characterizations for the Fountain City Quad is dependent on innovations in spatial computer display developed at the Harvard University Laboratory for Computer Graphics, and on additional developments in the handling and analysis of spatial data by the Systems Development and Data Processing Section of TVA's Division of Forestry, Fisheries, and Wildlife Development (Baxter and Cox, 1975).

Analysis of Soil and Cover Resources. Landscapes are characterized by combinations of a variety of biotic and physical features. Analysis of individual variables composing the landscape provides the user with a

FIG. 2. Fountain City, Tennessee, 7½-minute topographic quadrangle.

basic education of various categories independent of others. A map of a soil interpretation with its various levels is shown in Figure 3. The map and summary statistics provide a means of geographically locating various soil interpretative categories and determining the proportion of area in each class.

Land cover (Figure 4) was also analyzed independently in order to inventory forest, water, and other resources. Patterns of forest cover types are easily recognized in this map and follow the ridges. These independent variable maps provide analysts with a basic visual and statistical characterization for a single resource in an area. Resource interpretations, however, are greatly enhanced when variables can be combined (overlayed) to delineate management units.

The prerequisite for composite analysis is that all data, no matter what the source, be referenced to identical points on the ground. This was done with the soils and ERTS land cover data in this analysis effort. As a result, numerous overlay analyses were possible. Three analyses are given here as examples.

One analysis determined the proportion of land with wet or intermediate moisture soils and their associated cover type (Figure 5). Most of the drier soils (intermediate moisture) were in the constructed surface cover type, while wet soils had been left mainly in pasture due to limitations for development. This information can be useful, for example, to indicate potential wood duck habitat. Other possible characterizations include the effects of land-use changes on soil resources over a

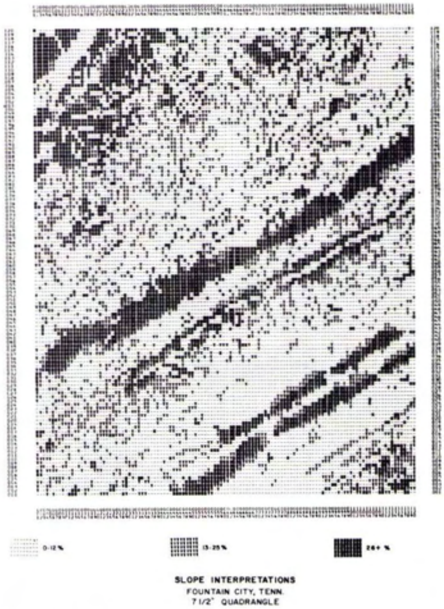

FIG. 3. Computerized soil interpretations for the Fountain City, Tennessee, quadrangle showing three general slope classes. Note the steep ridges characteristic of the Ridge and Valley Physiographic Province.

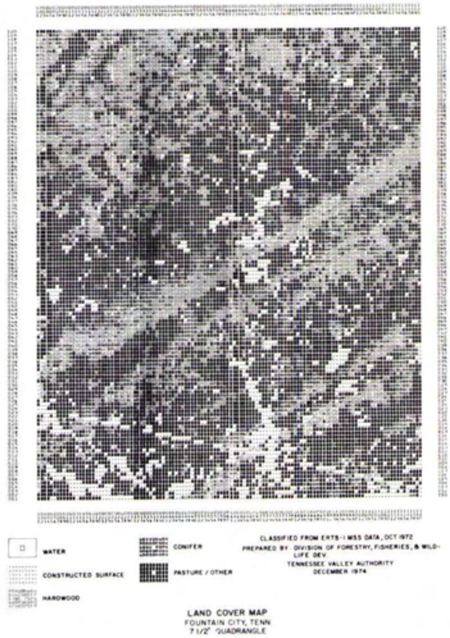

FIG. 4. Computerized land cover classified from ERTS-1 MSS data and assigned to 2.68-acre geodetic cells. This type of map shows the distribution of basic land cover categories. Statistical summaries also are available.

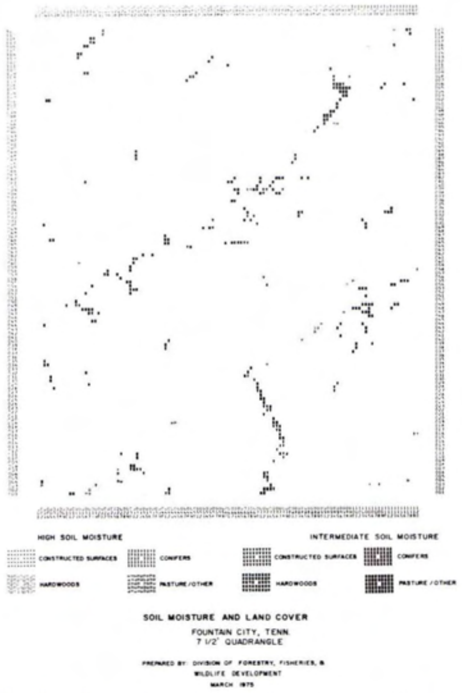

FIG. 5. Computerized overlay of two soil moisture classes and land cover. This map is a first attempt to characterize potential wood duck habitat that requires excessive soil moisture and hardwood vegetation.

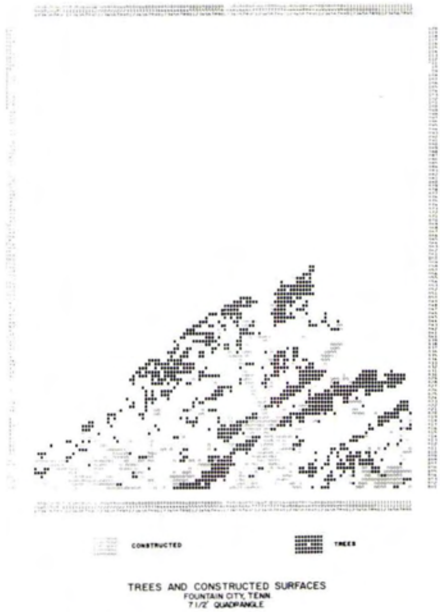

FIG. 6. Computerized overlay showing land-cover classes of constructed surfaces and trees within the city limits of Knoxville, Tennessee. The ratio of these two classes is important to city planners in hydrologic studies.

period of time by conducting additional overlay analysis with cover data at some future time.

Another analysis was conducted to determine the amount of forested and constructed surfaces within the Knoxville city limits area of the Fountain City quadrangle map (Figure 6). Of the 4,356 acres surveyed, 25 per cent (1,508 acres) is in constructed or impermeable surfaces, a very important statistic to the hydrologist. This analysis demonstrates that boundaries such as city limits, watersheds, etc., can be digitized to delineate the analysis area of the investigator's choice.

Of major concern in recent decades is the rate of change-of-use of agriculturally productive lands. Therefore, a soil interpretation representing lands that can produce at least 80 bushels of corn per acre was overlayed with the present cover type to characterize its use (Figure 7). A well-known fact is that most level and productive lands have the greatest pressure for development or other uses (highways, etc.). This analysis allows an estimate of the productive acreage that has probably been changed from agricultural use to constructed surfaces. By processing ERTS data in this manner, the potential exists to allow monitoring of these land-cover changes as frequently as necessary.

FIG. 7. Computerized soils and land cover overlay showing areas of high potential agricultural productivity. This analysis allows an estimate of productive acreages that has probably been changed from agricultural use to constructed surfaces.

Conclusions

Resource characterization by overlay analysis enhances landscape interpretations. Soil map units and land cover categories are important variables for characterizing land resource capability and use. Registration of data to ground coordinates permits the use of different data sources in analyses. Separate analysis of each variable provides a basic education about its characteristic independent of others, but registration allows the analyst to study the more natural combinations of variables by overlay analysis. The addition of other information, such as ownership, can further increase the power of the analyst to characterize a resource or project its likely future use.

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