A PROPOSED APPLICATION OF DIGITAL ELEVATION AND SOIL DATA IN DELINEATING MICRO-LANDFORM REGIONS OF SHELBY COUNTY, TENNESSEE

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ABSTRACT

This study analyzes the land surface form characteristics for Shelby County, Tennessee, through the use of computer techniques. The regionalization of the landforms in the study area will facilitate better resource management and planning processes. The study will lead to development of an environmental data bank and management in the Mid-South region.

In this study, landforms are characterized by the following geographic variables: (1) elevation, (2) slope, and (3) flooding potential. Assemblage of these features permit regions to be delineated and evaluated for human use. The specific problems involved for the research are twofold; first, the identification and measurement of the physical characteristics and, second, development of a suitable computer-compatible environmental data base for analysis and display for the land surface forms. The utility of such a data base can be readily appreciated when one considers the need for siting landfills for toxic chemical wastes, critical erosion areas, and floodable lands, for example.

INTRODUCTION

Numerous studies have documented the significance of landforms on physical and cultural phenomena. Topographic control over the location of cultural features is exerted mainly through the agency of slope supplemented by relief and surface profiles. The more gentle the slope, the more cropland and mechanized agriculture; and the steeper the slope, the greater the percentage of farmland in pasture and wooded areas. In south central Ohio, for example, the plateau areas were characterized by more relief, finer texture, steeper slopes, less flat land, a denser drainage network, less fertile soils, and more woodland than the plain areas (Shaudys, 1956). The plateau areas had fewer people per square mile, poorer housing, and a smaller area in farms than did the plains. The value of farms and buildings was lower, acreage in crops and yields per acre were lower, there were almost no incorporated urban areas, no industry (except lumbering), no railroad and bus lines. The economy of the plateau areas was highly subsidized by government, while in the plain areas the appraised value of all real estate, public utilities, and personal property was much greater than in the plateau areas.

The relationships of landform to other physical phenomena such as air pollution, basin hydrology, climate, vegetation, and soil have been illustrated abundantly. Garnett (1935, 1937) studied the effect of relief, slope inclination, and slope aspect on the distribution of insolation and, in turn, on human land use in the Alpine regions. Salisbury (1965) in a number of studies attempted to analyze the specific relationship between landforms and lithologies. The relationships between vegetation and landform in a selected environment have been analyzed by Vann (1959). Detailed studies of this type lead to greater understanding of the role of landforms in the development of specific physical landscapes (Vann, 1959).

To portray the total character of the land surface, data defining characteristics of individual landform elements must be combined into a meaningful regional synthesis.

The study of regional geomorphology was very popular in the late 1940's through the early 1960's. Most of the regional landform classifications in the United States were based on descriptive genetic approaches such as those of Raize, Lobeck, Powell, Fenneman, and Hunt. In the late 1950's and early 1960's, Hammond began a systematic, non-genetic, quantitative approach to the classification of landform regions of the United States that was a milestone in landform geography (Hammond 1954, 1957, 1962). The basic procedures followed by Hammond in the preparation of the quantitative landform map were: (A) selecting those inherent landform elements (slope, local relief, and surface profile) which provide the best differentiating characteristics; and (B) choice of the size and shape of the sampling grid to be used on the topographic maps. Landform within each grid unit is analyzed objectively and systematically in terms of all differentiating elements. Before this information can be organized into a coherent synthesis, a hierarchy of elements must be established and the data must be grouped into classes (Hammond, 1964).

Landform geography is emerging slowly (Hammond, 1965) and its accomplishments during the last quarter of a century have been small. Four problems have prevented more rapid progress in this field according to Zakrzewska (1967):

(A) The extremely tedious and time-consuming process of data collecting resulting from the inherent complexity of landforms and the unavailability of good-quality, large-scale, continuous map coverage;

(B) The lack of adequate and universally applicable methods for collecting descriptive data;

(C) The lack of systematic approaches to data collecting, data analysis, and data presentation; and

(D) The insufficient number of case studies from which theory can be deduced.

Most landform studies and classifications before mid-1960 were focused upon large area surface characteristics. Few studies were concentrated on detailed analysis of a small area, such as a county, and computer techniques were not widely applied. The intent of this study is to formulate a method capable of explaining the detailed characteristics of landforms, the patterns of variation of landforms through space, and their contribution to the total spatial variation existing on the earth's surface.

PURPOSE

This study is focused upon environmental information, emphasizing land surface form within small areas using the following geographic variables: (A) elevation, (B) slope, (C) local relief, and (D) flooding potential. Assembling these features permits regions to be delineated and evaluated for human use. Using a portion of Shelby County as a "pilot," the study proposes to develop a computer-compatible environmental data base for regionalizing and integrating the four landform characteristics.

There are two tasks involved in this research: first, to quantify the physical elements of the landform, and second, to develop a suitable computer-compatible environmental data base for analysis and display of the land surface form. The procedures and results developed for a portion of Shelby County are universal and can be applied to the remainder of the county or to other areas, for identification of suitable sites for development, and to facilitate better land use planning and resource management. The utility of such a data base can be readily appreciated when one considers the need for siting land fills for toxic chemical wastes, critical erosion areas, and floodable lands.

Study Area

Portions of north and northwest Shelby County are selected for intensive analysis for the establishment of an environmental data base and for delineation of landform regions. The study area consists of the area found on the Locke and Millington, U.S. Geological Survey 7 1/2 minute topographic quadrangle maps (approximately 130 square miles). The reasons for selecting this area are: (A) the complexity and variations of the physical environmental elements, such as slope, elevation, local relief, and soil characteristics, can be expected to produce significant differences in landform characteristics; (B) the ready accessibility of this area allows intensive field work and data collection; and (C) floods frequently occur along Mississippi flood plain west of the Chickasaw bluff and along Loosahatchie River. Basic information and data such as the topographic maps (U.S.G.S. 7 1/2 minute topographic maps) and soil maps are readily available (U.S. Dept. of Agriculture, 1970).

Methods and Procedures

Although soils and topographic maps are available for the study area, proper analysis and interpretation still need to be made in order to establish a sound environmental data base and to delineate the landform regions. Two approaches will be used in this study and the results will be compared for accuracy and representation of the landform characteristics. They are (A) manual measurements and analysis of the topographic and soil maps; and (B) computer assisted data handling techniques.

(A) *Manual measurement and analysis:* Among the major considerations in collecting landform and soil data from maps are map reliability, map scale, factors determining overall nature of area, and class intervals appropriate to the values collected.

Topographic maps of the U.S. before World War II are generally not reliable sources of information. Contour lines are highly generalized and slopes and elevations are not shown correctly. However, most large-scale (1:24,000) U.S.G.S. topographic quadrangle maps after World War II are more reliable. Recent topographic maps of 1:24,000 scale of the study area, therefore, have been selected for analysis of landform elements. The problem of size and shape of the sampling grid necessary for quantitative analysis of terrain is a very complex task. A grid unit of 2.68 acres will be applied systematically throughout the study area. This approach avoids the subjective drawing of areas of landform characteristic boundaries. Grouping of values or class intervals and boundary values will be determined on the basis of the nature of the landform data collected and analyzed in the study area as shown on Table 1.

(B) *Computer assisted data handling techniques* will be used to establish an environmental data base and for delineation of the landform regions. This technique has been tested in several government agencies (Calkins, 1980; Coppelman, 1976; Peucker, 1972; U.S. Dept. of Interior, 1976; Voelker, 1975), but due to its complexity, cost, and not-universally-adaptable software package, the technique is emerging slowly and has not been widely accepted nor applied to many areas. One of the major goals of this study is to modify and convert the IMGRID programs (version 3.5, Tennessee Valley Authority) originally designed for the use on the IBM computer (TVA, 1976) to the Memphis State University UNIVAC computer system. This will enable the environmental data base to be easily established for the Mid-South region. In addition, grouping values and class intervals will be evaluated and determined for the study area.

Study areas on each map sheet will be grided and data associated with that grid system will be represented in digital form for use in the computer (Durfee, 1976). A grid is a row and column matrix of regular zones or cells. The location of each cell within the grid is determined by its row and column address which in turn is related to a coordinate system. It is chosen because of its advantages over other structures in terms of: (A) flexibility, the ability to manipulate data after it is put into the system from maps or other sources; (B) comparability, the ability to combine different types of geographically referenced information; and (C) topology, the position of a geographic entity in relation to its neighboring entities.

Once data for a quadrangle sheet is complete, the information on the coding sheet is keypunched and then read into the computer and stored on a magnetic tape so that the data can be accessed for analysis.

% Slope
1 = 0-2 (Low Bottoms)
2 = 2-5 (Undulating)
3 = 5-8 (Rolling)
4 = 8-12 (Hilly)
5 = 12 & Up (Steep)

Depth to Seasonal High Water Table
1 = 0-1.5′
2 = 1.5-2.0′
3 = 2.0-2.75′
4 = 2.75-6.0′
5 = Greater Than 6.0′

Permeability (In./Hour)
1 = Less Than .06
2 = .06-.6
3 = .6-2.0
4 = 2.0-6.0
5 = 6.0 & Up

Flooding Potential
1 = None
2 = None-Rare
3 = None-Common
4 = Rare-Common
5 = Common

Drainage Class
1 = Poorly Drained
2 = Somewhat Poorly Drained
3 = Moderately Well-Drained
4 = Well-Drained
5 = Extremely Well-Drained

Table 1. Class Intervals for the Land Surface Form Characteristics.

Results and Conclusion

Several single-factor maps were generated by using the computer mapping techniques through conversion of IMGRID program and interpretation of digital Shelby County soil data file. These maps include KSL-erodability, slope distribution, depth to seasonal high water table, soil permeability, surface drainage, and flood frequencies for the study areas. Composite maps are derived from several different land surface form characteristics by integrating them into matrices. Matrices (Table 2 and Table 3) and composite maps of septic tank suitability and land development potential are produced. The same approach can be easily applied to delineate the micro-landform regions of the studied areas. For the areas studied, the land surface form characteristics (elevation, local relief, slope distribution, and flooding potential) are

	Slight	Moderate	Moderately Severe	Severe
Slope	0-5%	5-8%	8-12%	G.T. 12%
Depth to Water Table	G.T. 6′	2.75-6.0′	2.0-2.75′	L.T. 2′
Permeability	G.T. 2″/Hr.	.6-2.0″/Hr.	.06-.6″/Hr.	L.T. .06″/Hr.

Table 2. Sewage Tank Limitations.

	Severely Limited	Moderately Limited	No Limitation
Slope	G.T. 12%	5-12%	L.T. 5%
Flooding Frequency	Common (5)	Occasionally (3 and 4)	None-Rare (1 and 2)
Drainage Class	Poorly Drained (1) Ex. Well-Drained (5)	Somewhat Poorly Drained (2) Well-Drained (4)	Moderately Well-Drained (3)
Depth to Water Table	L.T. 4′	4′-6′	G.T. 6′

Table 3. Capability for Development.

categorized into several classes and then integrated and regrouped into four micro-landform regions (Table 4) such as plain, low hill, high hill and open low hill. A composite map of micro-landform regions with the above selected landform characteristics, therefore, can be generated. The previous studies of macro-scale landform regions of the U.S. by Fenneman, Hunt, and Hammond have designated the areas studied into the Mississippi Alluvial Plain, or Gulf Coastal Plain. This study provides a detailed, quantitative, or more objective view of the micro-landform regions in northwest Shelby County.

In conclusion, a regionalization of the landform, septic tank suitability, and land-capability analysis for potential development from the selected natural environmental factors can be approached through the use of computer-aided techniques, and the creation of the environmental data base will have utility within the community.

Plain	
Elevation	< 250 ft
Slope	< 5%
Local Relief	< 20 ft
Flood	Common

Hill	
Elevation	250-300 ft
Slope	5-20%
Local Relief	20-40 ft
Flood	Rare-None

High Hill	
Elevation	> 300 ft
Slope	> 20%
Local Relief	> 50 ft
Flood	Rare-None

Open Low Hill

Any land surface configuration not conforming with Plain, Hill and High Hill will belong to this category.

Table 4. Scheme of Classification of Micro-Landform Regions.

LITERATURE CITED

Calkins, H., and D.F. Marble. 1980. *Computer Software for Spatial Data Handling,* Volume 1, Full Geographic Information Systems, (Ottawa, Ontario: International Geographic Union, Commission on Geographic Data Sensing and Processing).

Coppelman, Lee E. 1976. *A Methodology to Achieve the Integration of Coastal Zone Science and Regional Planning.* Nassau-Suffolk Regional Planning Board, Hauppauge, Long Island, NY.

Durfee, Richard C. 1976. *GRIDOT, An Automated Plotting Program to Produce Sampling Grids for Map Digitization,* unpublished ORNL-NSF-EFP report, (Oak Ridge, Tennessee: Oak Ridge National Laboratory).

Garnett, A. 1935. "Insolation, Topography and Settlement in the Alps," *Geographical Review,* Vol. 25, pp. 601-17.

Garnett, A. 1937. "Insolation and Relief: Their Bearing on the Human Geography of Alpine Regions," *Transactions, Institute of British Geographers,* No. 5.

Hammond, E.H. 1954. "Small Scale Continental Landform Maps," *Annals,* Association of American Geographers, Vol. 44, pp. 33-42.

Hammond, E.H. 1957. "On the Place, Nature and Methods of Description in the Geography of Landform," *Technical Report No. 1, ONR Project 1202 (01),* pp. 18-19.

Hammond, E.H. 1962. "Land Form Geography and Landform Description," *California Geographer,* Vol. 3, pp. 71-72.

Hammond, E.H. 1964. "Analysis of Properties in Land Form Geography: An Application to Broad-Scale Land Form Mapping," *Annals,* Association of American Geographers, pp. 11-19.

Hammond, E.H. 1965. "What is a Landform? Some Further Comments," *Professional Geographer,* Vol. 17, No. 3, pp. 12-14.

MAPCLAS program developed by Dr. Charles W. Smart, TVA Division of Forestry, Fisheries and Wildlife Development, Norris, Tennessee, 1976.

Peucker, Thomas, and Nicholas Chrisman. 1972. "Cartographic Data Structures," (Cambridge, Massachusetts: Harvard University, Laboratory for Computer Graphics and Spatial Analysis).

Salisbury, N. 1965. "Landform-Lithologic Relationships in Portions of the Mississippian Plateaus of Kentucky," paper presented at the annual meetings, Association of American Geographers, Columbus, Ohio.

Shaudys, V.K. 1956. "A Study of Selected Geographic Factors Adjacent to Topographic Boundaries in South Central Ohio," unpublished Ph.D. Dissertation, Ohio State University.

U.S. Department of Agriculture, Soil Conservation Service. 1970. *Soil Survey of Shelby County, Tennessee,* (Washington, D.C.: U.S. Government Printing Office).

U.S. Department of the Interior, Office of Land Use and Water Planning. 1976. *Information/data Handling: A Guidebook for Development of State Program,* unpublished draft.

Vann, J.H. 1959. "Landforms-Vegetation Relationships in the Atrato Delta," *Annals,* Association of American Geographers, Vol. 49, pp. 345-60.

Voelker, A.H. 1975. "Assessing Data Needs and Related Criteria: Discussion of Environmental Data," presented as a conference on Environmental Analysis Techniques and Procedures for Siting Utility Systems, University of Wisconsin, Madison, Wisconsin.

Zakrzewski, Barbara. 1967. "Trends and Methods in Land Form Geography," *Annals,* Association of American Geographers, Vol. 57, NO. 1, p. 128-165. Lawrence, Kansas.

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