The Distribution of Slopes in Indiana

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Abstract

Slope maps of Indiana have been prepared from the 2 percent sample of the United States Department of Agriculture Conservation Needs Inventory. The Syngraphic Mapping Technique (a form of computer cartography) was used to generate maps of average slope, slopes between 0 and 2 per cent, and slopes 35 per cent and greater.

Introduction

The objective of this study was to develop a quantified slope map which would supplement and extend the work of Malott (2) on the regional geomorphology of Indiana. A subsidiary objective of the research was to provide a slope map, sufficiently detailed, to aid in the development of more precise morphometric measures to be used in studies of watersheds in Indiana.

The classical study classifying and describing the physiographic regions of Indiana was published by Mallott in 1922 (2). More recent summaries of the State's physiography are to be found in papers by Schneider (4) and Wayne (6). A quantitative approach to the physiography of the state is taken by Lewis (1) who used principal components analysis as a method of regionalizing 13 morphometric variables. His data were collected from a random sample of 60 fourth order drainage basins. The writers believe that Lewis is justified in concluding that his approach provides a more objective view of Indiana physiography. However, any examination of the benefits of objectivity as yielded by principal components analysis must be balanced by the fact that the physiographic regions, so produced, are rudimentary and not particularly informative.

In the geographic literature there are many reports of research dealing with state and regional maps of slope, though none of these studies use the mapping techniques and data sources of this paper. Good summaries of slope research are to be found in Miller and Summerson (3), and Zakrzewska (7).

Conservation Needs Inventory

It was recognized in the mid-1950's that changes in land-use patterns with their associated problems were taking place rapidly enough to necessitate the development of a data bank which could be used to monitor these changes. The response to the situation was the establishment, in 1957, of the Conservation Needs Inventory (referred to hereafter as the C.N.I.). The major objective of this Inventory was to provide the U.S. Government with up-to-date and detailed information

on the rural landscape. The scope of the data is indicated by the following variables which are included in the inventory: land ownership, soil type, slope, erosion, land use and treatment needs. The U.S. Department of Agriculture wanted the inventory, for the entire country, to be completed within 3 years of the starting date in 1957. To achieve these objectives, Taylor (5) designed a startified random sample, which used the quarter section (160 acres) as its standard sampling unit; a sampling rate of 2% was established that required the selection of 3 quarter sections per township. The Statistical Laboratory of Iowa State University in Ames, Iowa, is responsible for maintaining and periodically updating the Inventory which is stored on magnetic tape.

Analysis of the Data

The first task of this research was to change the order of the C.N.I. variables from a sequence based on soil types to one based on counties and townships. This strategy put the data into a locational form eminently suitable for computer mapping.

With the data in the new sequence it was possible to compute the average slope value for a township by using the following formula:

$$Y_i = \frac{\sum_{j=1}^{7} P_j \left(\sum_{k=1}^{N} q_k \right)}{S} \times 100$$

where, Y_i = average slope for the i^{th} township
N = number of soil mapping units in the i^{th} township containing at least one acre of slope class j
P_j = midpoint value of slope class j (%)
q_k = acreage of the k^{th} soil mapping unit
S = sample acreage of the i^{th} township.

The outer summation refers to the seven slope classes adopted by the C.N.I. for Indiana; these are 0-2; 2-6; 6-12; 12-18; 18-25; 25-35, and greater than 35% slope.

Computerized maps of the slope classes were then generated by using the Synagraphic Mapping Technique (SYMAP). The geographic center of the 1,270 townships used in the Inventory of Indiana served as the data points for the maps.

Slope Maps of Indiana

Four maps were selected for illustrating the variation of slope in Indiana. Included were two average slope maps, and maps of 0-2% slope and 35% and greater slope.

Average Slope Map 1

This map (Fig. 1) uses the slope class intervals adopted by the Conservation Needs Inventory for Indiana (these values vary from state to state). The feature that clearly emerges from the map is the division

of the state into two parts about a line drawn approximately east-west through Indianapolis. The slopes of the southern half of the state clearly reflect the physiographic divisions established by Malott (2). The Wabash and Scottsburg Lowlands are readily identified as are the higher average slopes of the Crawford, Norman, and Dearborn Uplands. The Mitchell Plain between the Crawford and Norman Uplands can be distinguished even though the pattern of low slope is broken into discontinuous units. The northern half of the map is dominated by 1-6% slopes reflecting the glacial modification of the landscape north of Indianapolis.

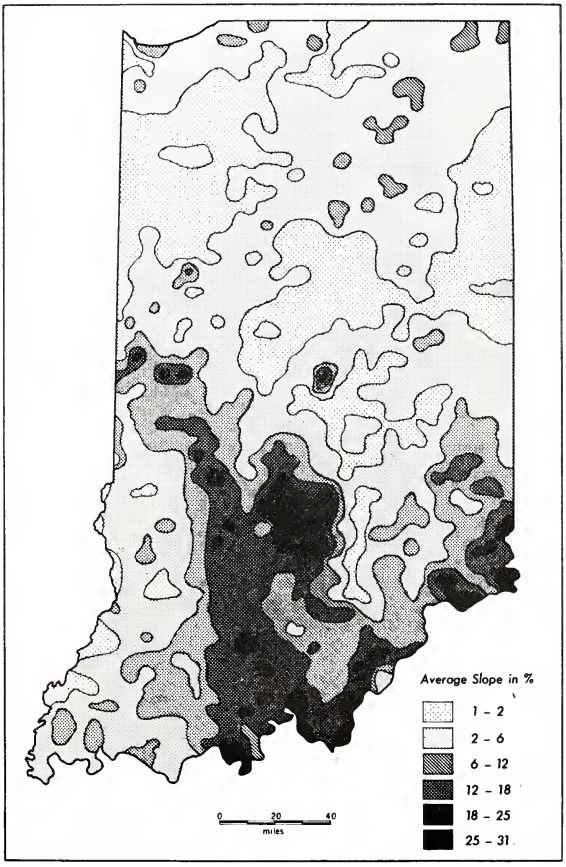

FIGURE 1. *The average slope map 1.*

The 0-2% Slope Map

The value of this map (Fig. 2) to the interpretation of Indiana physiography is the emphasis it gives to the occurrence of low slopes, which are indicated by the darker shadings on the map. For example,

the Calumet and Maumee Lacustrine Lowlands are clearly differentiated as well as the more extensive Tipton Till Plain to the south. The lowlands and floodplains associated with the Kankakee, Wabash and White Rivers are well defined areas of low slope. Other features that can be identified are the Valparaiso Moraine and the Steuben Morainal Lake Area.

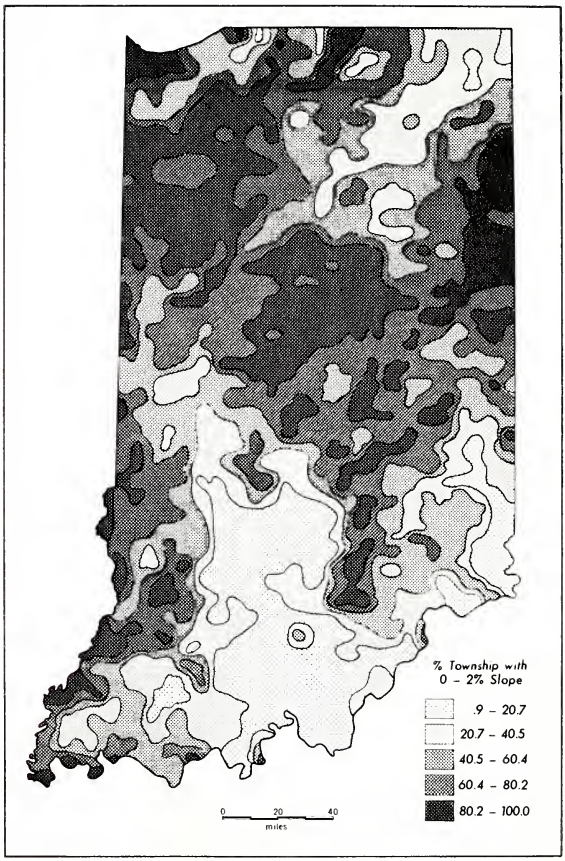

FIGURE 2. *The map of slope in Indiana based on the percentage of a township with 0-2% slopes.*

Average Slope Map 2

The class intervals for this map (Fig. 3) are changed from Figure 1 in that each interval represents an equal range of slope. It is apparent that the lowest class interval does not discriminate, very effectively, the slope variation in the northern half of the state. The concentration of high slopes in the southern uplands of Indiana is more clearly em-

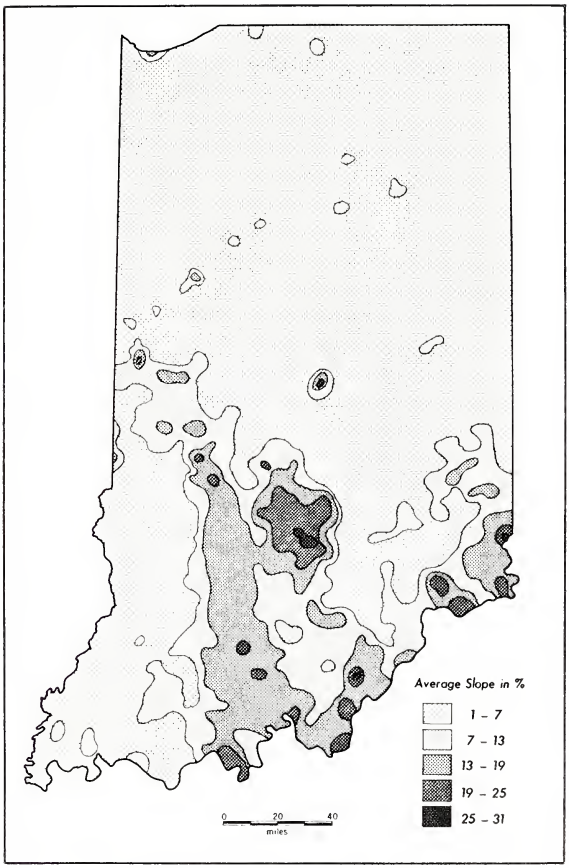

FIGURE 3. *The average slope map 2.*

phasized than on the previous map and, again, the Malott physiographic divisions are reaffirmed in this area.

The 35% and Greater Slope Map

The high slopes, on this map (Fig. 4), are spatially clustered into two groups. One group is associated with the bluffs of the Ohio River, while the other is a cluster extending NW-SE across the southwestern quadrant of the state. This trend line appears to reflect the occurrence of particularly high slopes in both the Norman and Crawford Uplands. An area of high slope in the central portion of the map reveals a problem of widely scattered data points in relation to the SYMAP algorithm. The data of one township with a high slope value located on the bluffs of the White River are expanded to influence a much larger area on the map than exists in reality. This difficulty can be overcome when the sample is areally dense enough to prevent the present situation of an isolated anomaly from arising.

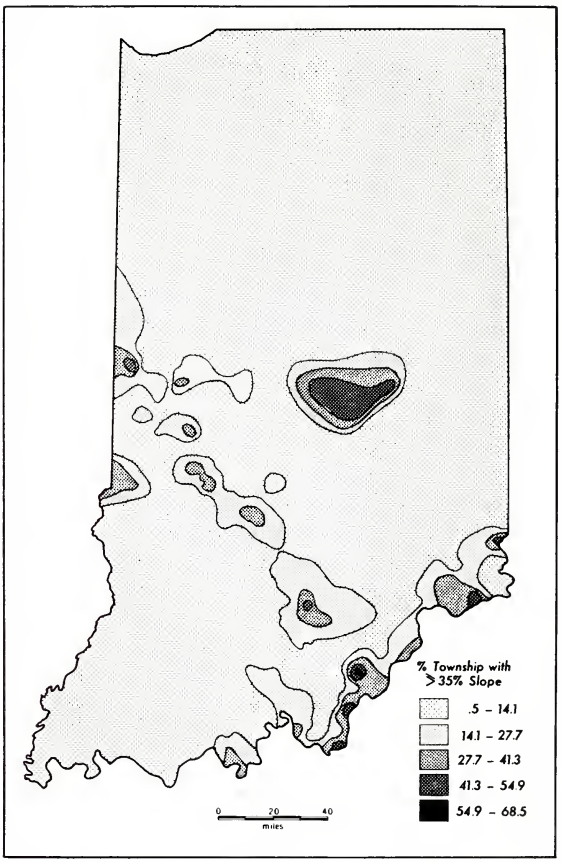

FIGURE 4. *The map of slope in Indiana based on the percentage of a township with* $\geq$ *35% slopes.*

Conclusions

The value of the C.N.I. to the physical geographer who is concerned with slope research has been demonstrated. The maps produced here give insight into the variation of landforms of Indiana for they show that physiographic regions are not uniform spatial units but, in fact, units possessing internal variations.

Acknowledgment

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Literature Cited

1. LEWIS, L. 1968. Analysis of surficial landform properties: the regionalization of Indiana into units of morphometric similarity. Proc. Indiana Acad. Sci. 78: 317-328.

2. MALOTT, C. A. 1922. The physiography of Indiana, p. 59-256. *In* W. B. BURFORD (ed.) Handbook of Indiana Geology. Indiana Dep. Conserv., Publ. 21, Pt. 2. 1120 p.

3. MILLER, O. M., and C. H. SUMMERSON. 1960. Slope-zone maps. Geog. Rev. 50:194-202.

4. SCHNEIDER, A. F. 1966. Physiography, p. 40-56. *In* A. A. LINDSEY (ed.) Natural Features of Indiana, Indiana Acad. Sci. Sesquicentennial Vol., Indianapolis, Ind. 600 p.

5. TAYLOR, H. L. 1958. Statistical sampling for soil mapping surveys. Statistical Lab., Iowa State Univ., Ames (reprinted 1962). 75 p.

6. WAYNE, W. J. 1966. Ice and land, p. 21-39. *In* A. A. LINDSEY (ed.) Natural Features of Indiana, Indiana Acad. Sci. Sesquicentennial Vol. Indianapolis, Ind. 600 p.

7. ZAKRZEWSKA, B. 1967. Trends and methods in landform geography. Ann. Assoc. Amer. Geog. 57:128-165.