SPECIAL ARTICLES

GEOGRAPHICAL INDEX NUMBERS

THE term geographical index number is a mathematical expression intended to represent the intensity of man's utilization of the environment or, as some would say, the quantitative determination of a geographical relationship. A hypothesis is established that a complete harmony between man and environment or a maximum geographical relationship has an index value of 100. Thus, in computing the geographical index numbers, the object is to determine and express in the form of a ratio what man is doing with what he should do in order to utilize most efficiently the environment. The word utilization is here defined to include the thought of control, adaptation or use of the environment.

Quite evidently, any attempt to measure quantitatively such variable components as man and environment is subject to conjecture. In fact, the supposition may seem unscientific because, in the opinion of some students, the nature of a geographical relationship or man's utilization of the environment will not lend itself to classification. The probable error of such quantitative determinations has been referred to as being so high that the results are scarcely more than personal judgments. These assertions may apply to the methodology or technique of measuring geographical relationships, but they do not exclude the possibilities of solving the problem within the limits of the probable error.

Apparently there has been very little attention directed towards quantitative analysis or synthesis of the reciprocal relationships between man and environment, if one can judge from known literature and discussions. The science has not advanced far beyond the descriptive stage—a situation, however, that does not reduce the significance of index numbers. In other social sciences, particularly economics, index numbers have a potent position. This should be equally true in geography. The effort to determine quantitatively the relationships between human activities and their settings represents time well spent, regardless of results. It fosters a greater interest in the classification, correlation, interpretation and application of geographical data, thus placing geography in the realm of a true science. The concentration of factors involved in a geographical relationship into one mathematical expression or figure necessitates careful weighing of the individual factors both human and environmental. The results are likely to be more representative and less misleading than when the same geographical relationship is expressed in a lengthy dissertation. Another salient feature of index numbers is their adaptability to maps. Geographical index numbers can be easily placed on maps, thus disclosing the nature of the environmental elements which in many cases can not be shown on one map. Through the addition of geographical index numbers physical maps may be converted into geographical maps.

The method of procedure in the determination of the geographical index number is as follows. In formula $\text{G. I. N.} = \frac{U^d \times 100}{U^m}$, G. I. N. represents the geographical index number; U^d represents present degree or intensity of utilization, and U^m represents maximum degree or intensity of utilization.

The values of U^d and U^m are expressed in terms of digits 1 to 10. Since the digit value of the maximum degree of utilization equals 100 per cent. the formula may be expressed in the form of a ratio as:

U^m (maximum utilization) : $100 = U^d$ (present utilization) : X (geographical index number).

The digit value of U^d and U^m are determined from the following expressions:

$$U^d = A^d \times P^d \text{ and } U^m = A^m \times P^m$$

(m) represents maximum
(d) " present degree
(P) " productivity
(A) " activity

Let us apply these equations to a given field in which the cultivation of corn is the major form of activity. A careful analysis of the human factors involved in the utilization of said field, such as method of cultivation, equipment, market conditions and transportation facilities, show that they have a digit value of 6. That is, each one of the human factors is graded on the basis of 1 to 10 as to degree of efficiency. Then the digit values of all human factors are added and the average determined. If the human side of the equation in the above illustration had been recognized as excellent then the digit value would have been recorded as 10. Thus the component (A^d), present activity, has a digit value of 6 in expression $U^d = A^d \times P^d$.

In the determination of (P^d), present productivity, such physical factors as soils, topography, climate and biological elements, and such locational factors as position, area and distance, are considered with reference to the growing of corn in the above illustration. The digit value of the physical factors is determined on a basis similar to that used in the determination of the human factors. The results show that the digit value of the physical factors is 8. Again, if the conditions had been ideal for the production of corn the digit value would have been 10.

Since $U^d = A^d \times P^d$, $\therefore U^d = 6 \times 8 = 48$; that is, the present degree of utilization of said field has a digit value of 48.

The next step in the determination of the geographical index number is to consider the digit value of the maximum degree of utilization. It may be repeated for the purpose of clearness that the most efficient utilization of a given area is recognized as the maximum utilization or geographical relationship. Again, referring to the above illustration, let us suppose that (A) activity has a digit value of 10 if cotton is grown, while the digit value for corn as stated above is 6. Thus the (A^m) maximum activity has a digit value of 10. It is also assumed the component (P) has a digit value of 10 for cotton and only 8 for corn. Thus, the (P^m) maximum productivity has a digit value of 10.

Since $U^m = A^m \times P^m$, $\therefore U^m = 10 \times 10 = 100$. In other words, it is much more advisable so far as the geographical relationship is concerned to grow cotton than corn because the digit value for corn is 48 as compared to 100 for cotton.

In completing the formula, G. I. N. $= \frac{U^d \times 100,}{U^m}$ or $= \frac{48 \times 100}{100} = 48$. Thus the geographical index number for the given field is 48. (It should be kept in mind that the digit value of the maximum utilization is always equal to 100 per cent and that a maximum geographical relationship is 100.)

The question undoubtedly comes to the reader as to how the digit values are determined. Are they largely personal estimates? However, after a careful consideration of maps, statistics, field work and consultation with specialists in the respective sciences the problem assumes a tone of encouragement. The satisfaction reaches the point where the results are above estimates, at least, more than personal opinions. As previously stated the attempt to place on a quantitative basis the factors involved is a worthy step towards the establishment of geography as a true science.

Another query about geographical index numbers pertains to the difficulty of determining what shall be recognized as the most efficient use of the land. Shall it be considered from the interests of an individual, a community, a state, a nation or society as the human race? With the tendency to consider geography as chorography, or a study of regions, it may be safe to say that the degree of utilization should be considered from the point of view of the occupants of the accepted region. There may be reasons at times to consider the problem from the interests of the individual or even nations. It all depends upon the objective.

In conclusion it may be said that geographical index numbers are intended to show the intensity of man's utilization of the environment or the geographical relationship. A low geographical index number suggests inefficient use of the environment. It may be the reader's interest to determine why a given region or area is not more effectively utilized. Areas of low geographical index numbers should disclose the future lands for human occupancy if the index numbers fulfil their purpose. Indeed, it is not assumed that it is always advisable for man to use his environs most efficiently. In other words, there are factors other than those classified as geographic that enter into the activities of man. Geography is not a science of determinism.

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OVERWINTERING OF THE FIRE BLIGHT PATHOGEN, BACILLUS AMYLOVORUS, WITHIN THE BEEHIVE[1]

IN a former article[2] the writer discussed the pioneer work of Merton B. Waite, who showed that the honey-bee is capable of acting as a carrier for the fire blight germ. Waite, as is well known, produced artificial epidemics of blossom blight by inoculating pear blossoms with pure cultures and then noting the relationship of bees in disseminating the pathogen from inoculated or diseased blooms to healthy ones.

Following Waite's work it has been commonly assumed that under natural conditions bees and other insects obtain the inoculum from drops of ooze or exudate that are extruded in the early spring from blight cankers located on diseased trees. In other words, while Waite had presented no evidence to show that under field conditions the insects obtain the inoculum from bacterial exudate originating in overwintered cankers, his findings of bacterial dissemination by bees from artificial infections has been used as a basis for the assumption that bees and other insects obtain the inoculum from oozing cankers. And, notwithstanding the fact that Waite[3] in his later articles makes no mention of bees as visitors or disseminators of primary inoculum from exuding cankers, though mentioning wasps and flies as acting in this capacity in one of his articles (a theory of Waite's for which no proof has been presented), it has been almost universally assumed up until recently

[1] Research paper No. 209, Journal series, University of Arkansas.

[2] SCIENCE, 70: 355, 1929.

[3] *Trans.* N. Y. State Agr. Soc., 1897: 779–790, 1898. Thirty-first Fruit Growers Conv. State Cal., 1905: 137–155, 1906. *Proc.* W. Va. State Hort. Soc., 1911: 66–73, 1912.