CAPABILITIES OF COMPUTERIZING COMPOSITE MAPPING FOR SIMULATING LOCATION ZONES FOR SELECTED ECONOMIC ACTIVITIES AND PUBLIC SERVICES

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ABRIDGMENT

•A NEW composite mapping system (CMS) has been developed for land use modeling in states and regions and is specially designed for locating "efficiency gradients" or optimal zones for selected industries, major public facilities, and the like. The new process can readily handle a great variety of geographic data, local economic data, and transportation and social service phenomena. It can accept inputs of any form—tabular, printed maps, or sketch maps. Its outputs are cartographic and statistical. It permits any combination of spatial data to be overlaid, with various weights, and readily composed into simulated patterns called "composite maps."

This particular process, developed in the Economic Development Administration (EDA) of the U. S. Department of Commerce, is not the only or best computer program for simply displaying geographic factors. Various other line and symbol printing programs have been developed, some using special equipment. This one requires only a medium memory capacity and a conventional high-speed printer.

The particular capabilities for which CMS was developed are national grid coverage; automatic retrieval, mapping, and display of EDA's vast variety of socioeconomic data; ability to mix any number of desired factors and forms that come up in ordinary practice; and ability to harness statistical packages such as multiple regression for weighting a number of interacting factor maps and explaining "dependent" maps of social or economic change.

Thus, CMS is a kind of "hopper" for mixing all sorts of factor maps into any weighted combination, either with given weights or with weights derived by running dependent factor maps through standard statistical routines.

The present map matrix covers the United States with a grid of approximate 4 square mile cells (more accurately, 2 min of latitude by 2 min of longitude). Any states or desired geographic regions may be selected and implemented with geographic detail. It is not necessary to specify coordinates for introducing new maps or data for census areal units, for their locations and boundaries either are precoded in the map matrix or may be projected onto the blank grid of the county or any sector of it.

EDA's computer mapping laboratory has created map matrices (coded maps) of all counties of the coterminus United States at a scale of 1:500,000 in standard sectors of 240 x 240 miles and cells of 2 x 2 miles (Fig. 1). Each county is identified by a unique 3-character code that constitutes the map dictionary and that makes possible automatic mapping of any data given in tables of counties. Where finer subdivisions are necessary, another map matrix at the same scale has been built for minor civil divisions (MCD); at present, this matrix covers 4 western states having extremely large counties. Since the fourth count data of the 1970 census will have some 125 characteristics by minor civil divisions, this MCD matrix can be developed for any part of the country. The heart of the system must be an adequate map file that may ingest data from original county or other fixed geographic units, may take free form maps, or may create hypothetical patterns.

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CMS has been used by EDA for regional and national economic and social data mapping and composite mapping. The Four Corners Commission in the states of Utah, Arizona, New Mexico, and Colorado has used it for searching out optimal locations for 29 categories of industrial growth (1). It is now being used in Utah for industrial location planning. It is being adapted in Colorado for analyzing patterns of social statistics. It is used in Arizona for locating health and other public facilities with respect to social and geographic factors. It is being studied by federal interagency planning groups in the West for handling a vast variety of geographic factor maps. And it is being considered for analyzing patterns of energy-producing and energy-consuming locations in the Rocky Mountain Region. It may be of special interest to coastal states, for the grid pattern extends out over the continental shelf, where it may be used for maritime, fishery, or mineral studies that may need to combine numerous factors of climate, season, oceanography, and geology.

CMS itself does not embody analytic models. The art of using CMS revolves around selecting and weighting factors. Land use modeling requires a knowledge of industries and location theory; socioeconomic index mapping requires a knowledge of social phenomena. The appropriate model for each use depends on this depth perspective and the analyst's style.

Socioeconomic data are usually given by counties, minor civil divisions, and places, here called block maps (Fig. 2). They may be taken in directly from tape or tables by county or any location code. There is an infinite variety of such data around from the censuses—population, agriculture, or industry—and business reporting series of various kinds. EDA's data bank contains more than 6,000 such characteristics for counties alone, and these are automatically convertible to maps.

Many important variables for land use planning may be found in the form of free form maps, such as mineral zones, water supply systems or zones, gas supply systems or zones, rail patterns or accessibility zones, or regional market densities. These differ from the block maps in being conformal, physical, and more precise.

Special qualitative maps may also be introduced, such as regional "business climate factors," tax variation, community attitude variation, positive to negative promotional policies for a given objective, or differences in quality of living. It is apparent that these can be very useful in certain locational studies. The CMS program converts all these forms into grid maps at uniform scale, and this makes it possible to mix the different map forms into composite maps.

The practical applications of CMS are the following.

1. From any tabular or tape input data on population, agriculture, minerals, manufacturing, business, or housing, CMS can record and display quickly, at very low cost, patterns of any socioeconomic statistics over large regions.

2. Socioeconomic condition mapping is possible by a composition of relevant maps. For example, an index map of social conditions at one or several dates may be obtained by superimposing maps of unemployment, labor participation rate, population change, educational achievement, housing defects, or infant mortality (Fig. 3).

3. Mapping of intercensus change may be very useful. Significant changes over time in variables such as value added in production by a certain industry or change in labor occupational categories can be mapped automatically. A very meaningful application, for example, is to show intercensus rate of change in a map of socioeconomic conditions.

4. Efficient locations of an industry or a major public facility can be tested by a composition of a set of factor maps. This sort of simulation requires careful selection and weighting of factors. The purpose and limitations must be determined. The location of a given industry may signify only the within-region optimal location after an economic study has determined the between-regions feasibility of the industry; i.e., the optimal location map reflects only the resources and the distributive networks of this region. For example, in Utah's initial test model, economists first selected certain industries that were feasible within the state's resource-cost characteristics. One of the industries was furniture production, and the main location factors and weights were obtained from technical literature, as follows:

Figure 1. U.S. map matrix used in CMS and example factor map detail.

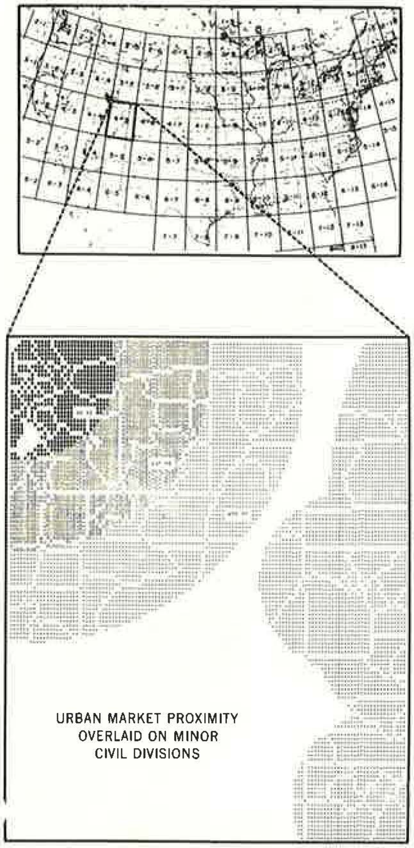


Figure 2. Development of CMS maps.

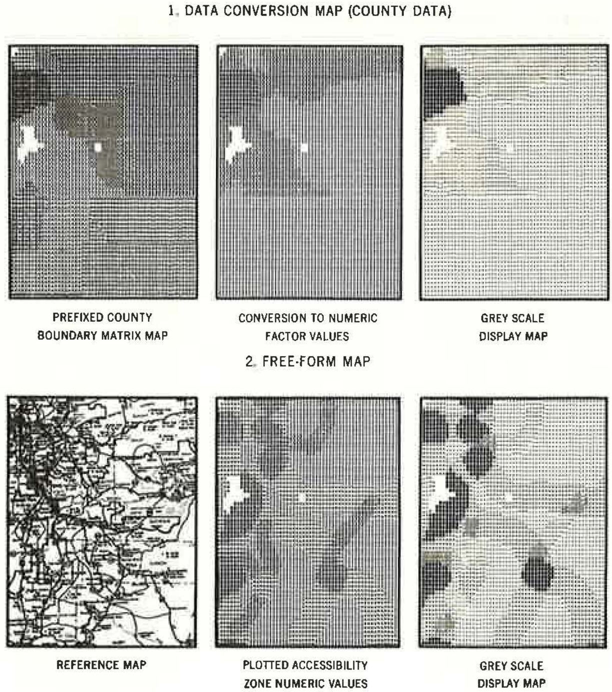


Figure 3. Composite map of social conditions.

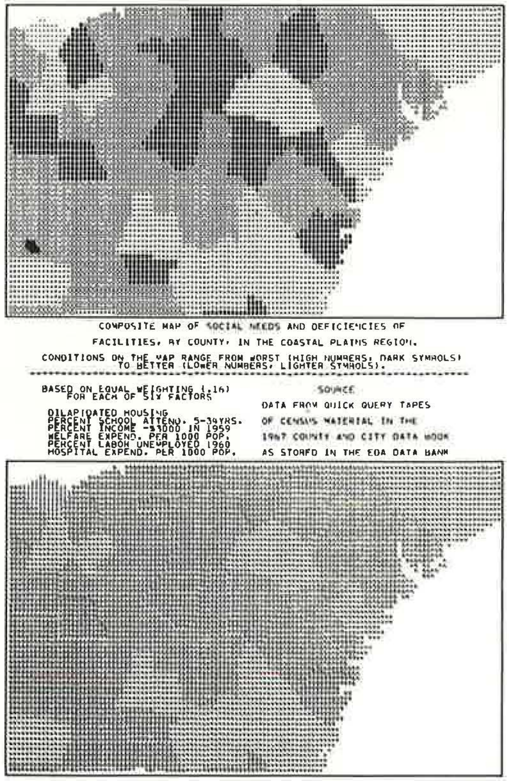
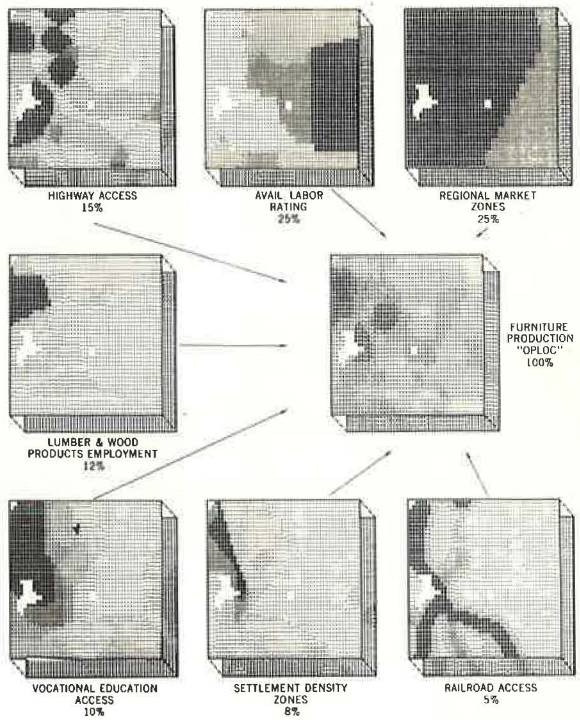
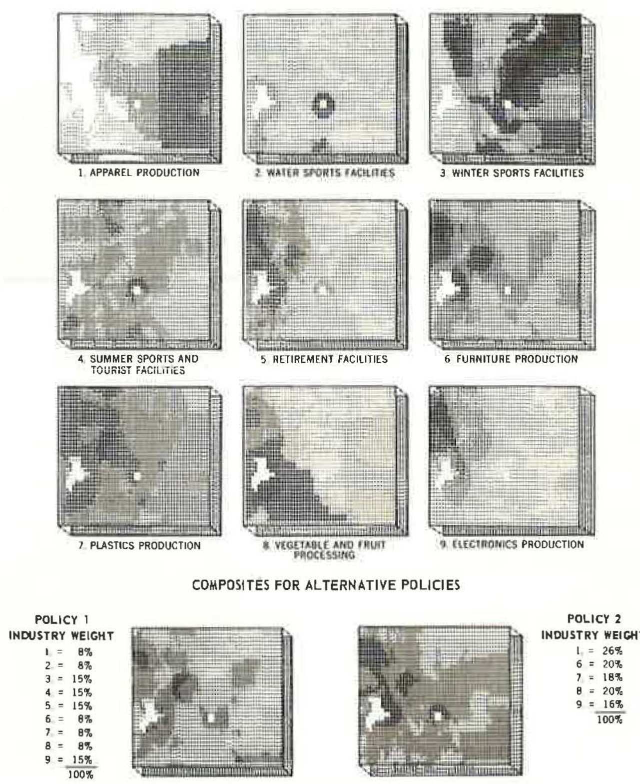


Figure 4. Seven-factor composite mapping of optimum location of furniture production industry.



These examples show only a small portion of Utah, so that digital detail can be seen in this reduction. The necessary area of search must cover a larger field, i.e. state or interstate region.

Figure 5. Composite mapping of favorable multiple-industry locations.



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Factor	Weight
Lumber and wood products	0.12
Federal and state highway accessibility	0.15
Railroad accessibility	0.05
Local settlement density	0.08
Regional market zones	0.25
Vocational training accessibility	0.10
Labor availability rating (a special map of 5 conditions)	0.25

The resulting furniture optimal location map is shown in Figure 4. According to the report (2), "Salt Lake City emerges as the most likely spot within the State, but is followed closely by Heber, Provo, and Payson. Slightly less attractive, but still significant, are Brigham City, Logan, Vernal, Nephi, Manti, Green River, Orangeville/Castledale, Richfield, Fillmore, Delta and Kanab."

There are several ways to approach the question, What are the relevant influences and weights?

1. Industrial management judgment may initially indicate the main inputs, relative costs, locational prerequisites, marketing characteristics, and a rough ranking of factors considered important for the industry's location.
2. Relevant literature on specific industries exists in business publications, state bureaus of economic research and federal agencies, studies by EDA, various metropolitan studies, and economic and geographic journals.
3. National or state input-output tables can be interpreted to rank important component costs. They overlook certain geographic variations and business "climate" factors, but these must be sought from sources 1 and 2.
4. Factor weights may be estimated by multiple regression where the reference "universe" is the larger region or another region comparable to the subject region. The target industry map constitutes the dependent variable, and all the locational factor maps constitute the independent variables. All of these maps will run through a multiple regression routine that reads the digital values of all identical cells, map by map.
5. Any number of individual industry optimal location maps may be combined into a multi-industry optimal location map (Fig. 5), which shows relatively strong zones of industrial potential, i.e., "growth areas." This is a common problem in development planning. CMS offers a way to rank industries and their locational propensities and to illustrate "policy" in geographic form. The selected industries may be differently weighted for alternate policies such as quickest labor absorption or lowest capital-job ratio.
6. If the problem requires finer location, it may be worked out by a sequential optimal location process. First, individual industries may be ranked by dominance or independence or both in the desired industrial mix. Then the dominant industries are located first. These locations are taken as given factors for the locations for other industries. A valuable purpose of this is to tailor expensive infrastructure to the most efficient locations and the sequential timing of a time-phased plan. Thus, by trial and feedback, it is possible to approach optimal regional combinations of industry and infrastructure.

REFERENCES

1. Hachman, F., et al. Application of Computer Composite Mapping in Four Corners Region. Bureau of Business and Economic Research, Univ. of Utah, Jan. 1972.
2. Bigler, C. Using Composite Mapping in Optimum Location, a Preliminary Test With Nine Industries in Utah. Office of State Planning Coordination, Salt Lake City, Nov. 6, 1970.