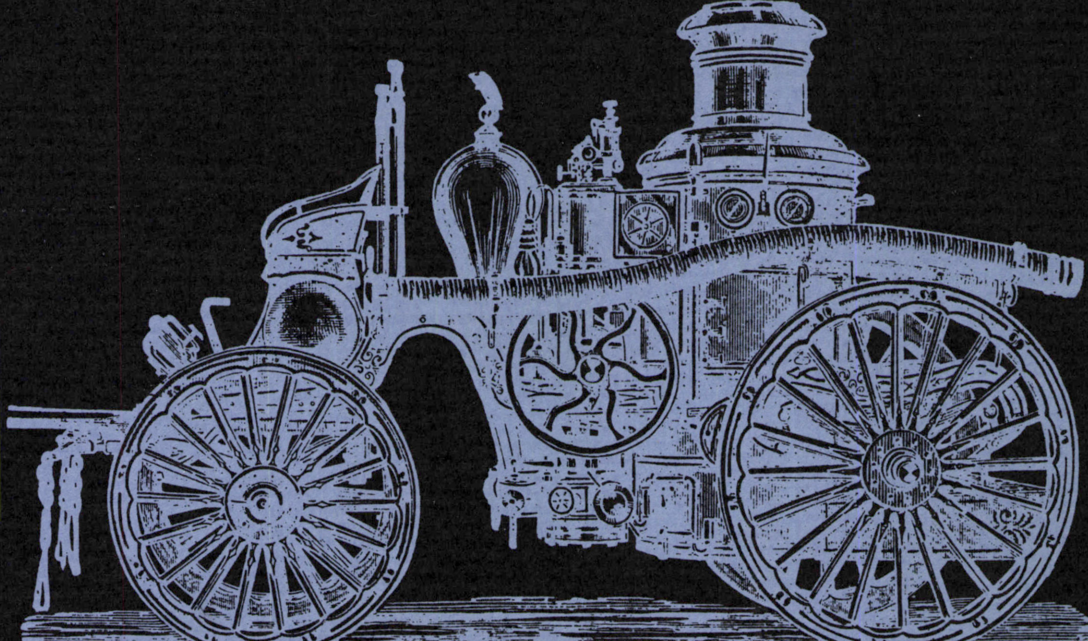
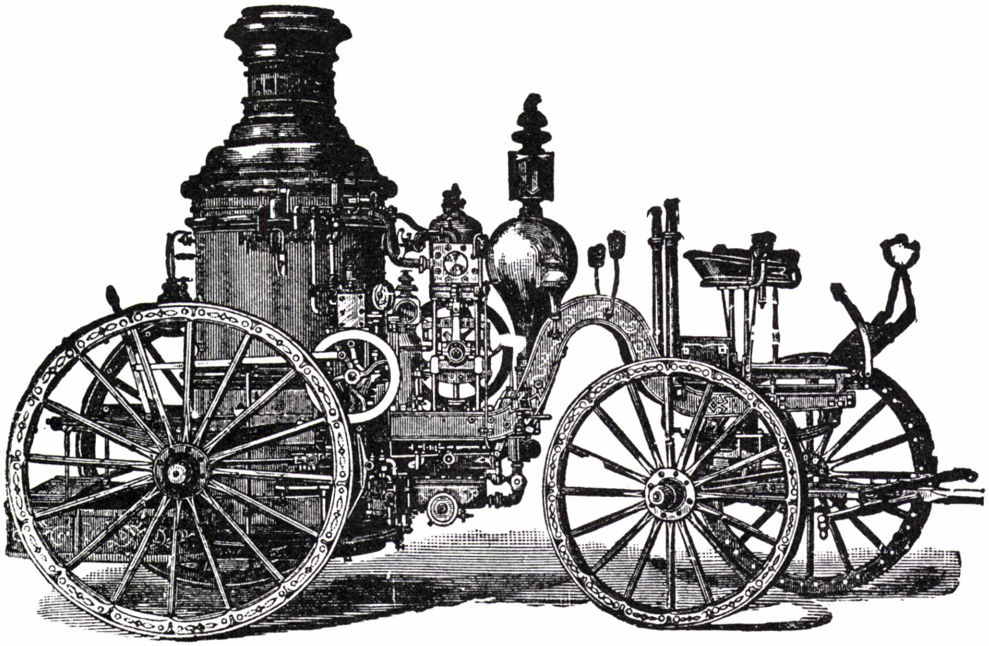
Student Publication



of the School of Design · Volume 15:2

TABLE OF CONTENTS



Peter Batchelor
CLASSICAL ECOLOGICAL AND SYSTEMS ANALYTICAL MODELS IN ENVIRONMENTAL RESOURCE ANALYSIS

Introduction

Multiple use planning is a combination of the following factors:

1 Determination of the appropriate use to which a piece of land should be put on the basis of both ecological and cultural characteristics;
2 Projection of anticipated resource needs for the future;
3 Anticipation of changes in the current socio-economic structure which would influence the fundamental value systems by which decisions are made as well as the demand for resources;
4 Identification of the factors which influence the suitabilities of land for particular uses; and
5 Understanding the political and economic decision processes within their respective jurisdictions as they influence Federal Lands.

From the five points listed above, one may infer that a logical system of multiple use planning must necessarily be extremely complex. Indeed, the techniques for dealing with problems of the magnitude of the Appalachian Forest Region are only just beginning to emerge from the interdisciplinary sciences dealing with land planning. This paper will attempt to identify some of the theoretical constructs which are being utilized in the determination of land uses in urban-oriented fields, with particular reference to the pressures of urbanization on non-urban land.

Assumptions

It is assumed here that the Forest Service of the Department of Agriculture is seeking a level of comprehensiveness in their planning that enables them to evaluate decisions at many different scales of activity, and to possess a means of evaluating these decisions in social and economic terms before proceeding with the allocation of land to a specific use or set of uses. Decision processes involving management plans for vast tracts of land require that large amounts of data processing and analytical capability be supplied by modern information processing technology. Therefore, it is also assumed that operational methods of multiple use planning are dependent upon quantification and description in other than graphic terms.

Basic Concepts Associated with Planning Models

At the most fundamental level, models are experimental designs based on realistic events or phenomena. *Iconic models* are large or small scale representations of states, objects, or events and play a basic role in the description of natural and ecological features. *Analogic models* are often utilized to represent one state by another, such as the description of evolutionary processes in ecological systems in terms of energy flows. *Symbolic models* utilize symbolic representation of properties, states, or processes, a good example being a mathematical formulation of the relationship between one part of a natural system and another. *Simulation models* are not *"models"* in the strictest sense, but rather imitations of natural phenomena. In addition, models may be *normative* or *descriptive* or some mixture of both. Since most of the models utilized in current planning methodologies fall into the categories of symbolic and simulation models, this paper will confine itself to an evaluation of current land use planning concepts in these two areas. In this paper *"classical"* refers to the widely accepted theoretical constructs of a number of symbolic models, while *"contemporary"* refers to a number of ecological and simulation models which have attracted considerable attention in recent years.

Classical Models for Land Use Planning

MECHANICAL MODELS Many land use planning agencies have developed comprehensive plans based on an incremental determination and adjustment of current needs. Most metropolitan area plans are, in fact, derived from adding projected land-use needs to an inventory of current uses, modified by normative standards relating to density and suitability for specific uses. The Research Triangle Regional Planning Commission's *Development Guide* is an example of the mechanical assessment of rural land capabilities for urban development based upon *deterministic* (as opposed to *probabilistic*) concepts of density and use suitability.

ECONOMIC MODELS As its title suggests, an economic model is based upon predictable economic patterns of behavior on the part of individuals, classes of individuals, economic sectors (such as industrial, agricultural), or firms.

Classical economic models had their origin in agricultural and urban land rent theory, and the basic concepts remain generally true today. Typically, an economic model assumes that a fixed amount of resource will be distributed according to a set of preferences which are interrelated. A *budget equation* describes the relative values of individual resource components in terms of the total economic resource available; an *indifference surface* describes the permissible trade-offs between resource components which are equally satisfying to the individual, firm or sector. Alonso's famous budget equation states that the income of individuals is a function of expenditure among household goods and services, living space, and transportation. Other economic models of behavior can be built on different assumptions, yet the effect is essentially the same: to distribute expenditures among a group of resources according to a fixed economic input. In general, economic models of behavior are easily applicable to natural environments. Thus, the revenue from timber sales could be described as a combination of permissible board-footage in a given area, its labor and transportation components, and other items such as reforestation. In a similar manner, the total income available for recreation on the part of a class of individuals might be distributed among the transportation costs and other competing costs of a variety of household goods and services.

MODELS OF INTERACTION A considerable amount of land use planning is based upon two well-known mathematical concepts: The *gravity* model and the *potential* model. Both are based on the phenomenon of interaction which states that the amount of activity among two population groups is a direct function of the size of these groups and an inverse function of the distance between them. Stated mathematically, interaction models have the following structure:

$$I_{ij} = K \left[\frac{P_i \quad P_j}{d_{ij}e} \right]$$

Iij represents the interaction between population *Pi* and *Pj* at a distance *dij* apart, *K* is a constant, and *e* is an exponent.

Models of this type are used extensively to determine the location of highway routes and the size and location of shopping centers. Dr. Larry Tombaugh of the School of Forestry at North Carolina State University has proposed that the location of vacation homesites can be described by models of spatial interaction where the factors of attraction are stated in terms of preferred vacation site features such as bodies of water, shorelines and so on. Thus, models of interaction are especially useful where populations create pressures on natural areas and where such pressures may force the conversion of one land use to another.

MATHEMATICAL PROGRAMMING MODELS Linear, dynamic, heuristic and stochastic programming all describe models whose basic property is to allocate resources according to quantifiable relationships and constrainits. Linear programming is especially useful in determining the optimum combination of resources or the optimum size and location of a specific land use or industry when relationships between variables, minima, maxima and objective functions are known. However, non-economic problems are fairly difficult to specify in terms of mathematical programming models, and it has been found that only relatively specific and clearly-defined problems can be handled in this manner. Thus, resource allocation as a mathematical programming problem is best handled as the seeking of a solution for specific industries rather than a general distribution for unspecified firms.

Shortcomings of Classical Models in Environmental Resource Analysis

Most of the models and methods described thus far possess some degree of usefulness in solving problems relating to natural landscapes. However, their dependence upon the definition of a few major variables in quantifiable terms, or on sets of mathematical relationships, render them relatively ineffective when dealing with complex and interacting ecological systems. Also, the necessity to quantify relationships for computational purposes makes some of the mathematical models inapplicable to geo-specific phenomena. Finally, classical models are most effective at a very large scale, except for mathematical programming models which can be applied to specific site situations as well as to large regions.

Ecological Models of Land Use Planning

Historical research reveals that unformalized ecological concepts have been the focus of attention for land planning purposes for many thousands of years. These concepts were formalized by 18th and 19th century naturalists and landscape architects such as Humphrey Repton, "Capability" Brown, F. L. Olmstead, George Perkins Marsh, and others. Currently operational methods of land use planning are combinations of *deterministic* models involving soil associations, plant and animal associations, and various attempts to define appropriate morphologies in terms of a complex array of natural characteristics. These models employ the characteristics of use suitability, use feasibility, use compatibility, and use capability. Another set of common characteristics is the breakdown of land into regions, types, classes, and units, together with a corresponding change in the structure of analytical information. There are many ecological models in existence today, although three of them account for the bulk of methodological variation. These models are named after their authors: G. Angus Hills, Philip H. Lewis, and Ian L. McHarg.

G. ANGUS HILLS. Hills' methodology originated in the study of soil associations for general land use planning. In time, this shifted to an analysis of landforms and geology in order to reveal a *parent* material and a structure for soils. Finally, he utilized vegetation and forest ecology to detect variations in soils. Out of this comprehensive approach grew a sophisticated notion of land classification and analysis which is widely utilized today. In general, Hills' method consists of three phases. The first phase proceeds with breaking down of land into consecutively smaller units of physiographic differentiation until the smallest unit with any homogeneity in landscape features is identified. This smallest unit, a *physiographic site type*, is then related to a set of land-use categories. The second phase consists of a ranking of the potential or limitation for each use or activity on the land identified in phase one. Finally, the relative potential of the units for dominant and multiple use is considered, and these units are grouped into larger units for the purpose of defining an appropriate management policy. Hills considers four land use activities—agriculture, wildlife, forestry and recreation—but usually ignores the influence of urbanizing land. Use potential is ranked at the local level (i.e. local physiography) in areas of 5 to 100 acres in extent, and at the community level in areas of 16 square miles or more.

PHILIP H. LEWIS Lewis' work in environmental resource analysis is concentrated primarily in the area of recreation analysis. From his work for the State of Wisconsin he evolved a methodology for defining *environmental corridors* which contain 90% or more of the resources required for recreation. He approaches the task by dividing resource patterns into those possessing *intrinsic* values and *extrinsic* values. Intrinsic values relate largely to the perceptual qualities of natural environments, while extrinsic values relate to those created by man-made changes or adaptations within the natural environment. Lewis then develops an inventory of resources and soil associations and analyzes them by grouping them into visually coherent patterns through the use of transparent overlays (this is often referred to as the sieve-mapping technique, or its converse, density mapping). The emergent and coherent patterns then become corridors and help to establish a geographic framework which is understandable to public and governmental officials. However, the complexity introduced by superimposing a large number of overlays requires a numerical method for defining the concentrations of resources. In the final stage Lewis develops a series of priorities based on specific activities by incorporating detailed ecological studies and field checks into case study areas. His work may be confined to recreation resource analysis, but it does tend to introduce some of the cultural influences of man on the landscape.

IAN L. McHARG *Ecological Determinism* is a phrase coined by McHarg to express a deterministic approach to defining the appropriate morphology for land. There are six major elements in McHarg's approach:

1 Ecosystem inventory;

2 Description of natural processes;

3 Identification of limiting factors;

4 Attribution of value;

5 Determination of prohibitions and permissiveness to change;

6 Identification of indications of stability and instability.

The first two elements of this methodology are descriptive; they refer to the collection of data pertaining to plants and animals within a prescribed physiographic region, and to the processes which describe the interdependence of these living organisms. Identification of limiting factors refers simply to establishing those factors which ensure the perpetuation of any ecosystem (such as topography, water regimen, and so on). Attribution of value covers four levels: intrinsic value, productive value, value as work performed, and negative value or constraint to use. Determination of prohibition or permissiveness to change requires a series of judgment related to the tolerance for human use or habitation which any given element in an ecosystem possesses. Finally, indications of stability and instability allows for evolution within the system. Thus, ecological successions, erosion phenomena, and other agents of change are included in this methodology.

McHarg works with major physiographic regions—usually within a river basin or watershed framework—to establish a macro pattern of land use. He then searches for prototypical elements within these macro units on the basis a more restricted physiographic definition. These prototypical elements are then treated as replicable units within a macro physiographic region. However, it should be noted that McHarg's smallest scale of investigation is still too large for detailed site analysis, and that his methodology rarely produces site-specific conclusiveness.

Shortcomings of Current Ecological Models in Environmental Resource Analysis

In general, the chief drawbacks associated with current ecological models fall into two realms: analytic scale, and methodological rigour. The problem of investigative scale forces each methodology into a set of areal classification schemes which do not allow their replication, expansion or contraction into different scales. That is to say, they are non-modular and are therefore difficult to compare and evaluate. This leads in turn the second major drawback: lack of analytical rigor. Enormous quantities of site-related information are requires for even comparatively small areas, so that *case studies* or prototypes must be developed as an alternative to comprehensive studies. This raises questions as to the accuracy of generalized *prototypes* of land use classification in situations where site-specific information reveals, as it always does, its uniqueness. One final point may be made with respect to current ecological models. Only one of the three discussed above manages to deal with urbanization as a phenomenon. This is one of the reasons why both McHarg's and Hills' approaches to land use planning are unable to resolve the problem of urban versus rural trade-offs in the process of development at the urban fringe.

Systems Analytic Models of Land Use Planning

During the last decade there has been a growing body of literature dealing with systems analysis. This may be described as a generalized methodology dealing with the identification of relevant parameters and variables and the relationships which exist between them within a particular system. A working model of a system is created by organizing the total system into a series of sub-systems and by adding factors of change to equilibrium conditions. Steinitz and Rogers created a working model of the urbanizing region around Boston which included five allocation models—industry, residence, open space and recreation centers, and transportation—and four evaluation models dealing with local politics, local finances, visual acceptability, and pollution abatement. Each separate model represents an explicit description, in quantifiable terms, of the relationships which exist between the components of the system. By making an assumption about rate of change for the whole region one is able to study the effect of growth, or decline, in each of nine models listed about.

Current systems analytic models are usually based on a geometric module as a unit of investigation. However, the Boston region model operates effectively only at one scale—in this case a grid cell of about a ½ mile square. The author has devised a systems simulation technique for analyzing a grid-cell system of expanding modular units ranging from 100′ x 100′ and 1000′ x 1000′ to 5000′ x 5000′ and beyond. The technique, which is based on determining the spatial evolution of cities, is easily adaptable to a modular analysis of natural areas. At present, the major variables and parameters are grouped as follows:

1 NATURAL SITE CHARACTERISTICS
a Topography.
b Water regimen (creeks, flood plains, marshes).
c Soil characteristics (permeability, bearing capacity).
d Vegetation.
e Wildlife and game features.

2 ACCESSIBILITY—RELATED FACTORS
a Accessibility to schools.
b Accessibility to employment.
c Accessibility to shopping centers.

3 PROPERTY-RELATED FACTORS
a Ownership (public, private).
b Land value.
c Land-use controls.
d Sewers.
e Roads.
f Current use of property.
g Age, if residential.
h Structural condition, if residential.

4 POPULATION CHARACTERISTICS
a Median family income level
b Race/ethnicity concentrations

The simulation system distributes growth and change to land units of 22 acres or larger as currently conceived, but the actual scale of analysis can be brought down to the level of one acre.

Shortcomings of Systems Simulation Models

In general, both ecological models and systems analytic models deal with the concept of a set of interrelated phenomena. Ecological models, however, operate on the basis of individual inspection, while systems analytic models rely upon the analysis of massive amounts of data. Thus, the largest single problem associated with the systems approach is in the securing of sufficient resources to develop and maintain an inventory of information. It is considerably easier to map natural characteristics and to compare them by using transparent overlays, as in Philip Lewis' approach to land use planning, than it is to convert them to numeric codes for computational purposes. Nevertheless, remote-scanning methods are already being employed to generate computerized data from aerial surveys. Another problem inherent in the systems approach is the need to utilize very large and powerful computers, thus raising the costs of planning analysis. However, it is anticipated that systems analysis will be used on a large scale by the late 1970's and that this usage will bring with it a nationwide demand for a coordinated information network.

Conclusion

The advantages and disadvantages of each methodology or model have been appraised in the previous material. For the present, it seems that the Forest Service would be best advised to create a *modular* system of land classification which could be used with any of the current ecological models. This modular system would possess the capability of conversion to any computational methodology, such as the systems analytic models, while still retaining its relevance to specific site analysis. The system should be as flexible as possible, allowing for the basic module to be grouped into larger units, or subdivided into smaller ones. In this way, the Appalachian region may be treated comprehensively, while specific sites can be examined in detail.

1. CLASSICAL MODELS AND CONCEPTS

Surveys of Theories and Models

Chapin, F. Stuart, Jr. "Review Article: Selected Theories of Urban Growth and Structure." JAIP.* Vol. 30, Feb. 1964, pp. 51-58.

Harris, Britton. "Plan or Projection: An Examination of Models in Planning." JAIP. Vol. 26, Nov. 1960, pp. 265-272.

*JAIP means JOURNAL OF AMERICAN INSTITUTE OF PLANNERS; PPRSA means PAPERS AND PROCEEDINGS OF THE REGIONAL SCIENCE ASSOCIATION.

Harris, Britton, Ed. "Urban Development Models: New Tools for Planning." JAIP. Vol. 31, No. 2, May 1965 (entire issue).

Lowry, Ira S. "A Short Course in Model Design." JAIP. Vol. 31, May 1965, No. 2, pp. 158-166.

Olson, Gunnar. DISTANCE AND HUMAN INTERACTION. Regional Science Research Institute, Philadelphia, 1965. (Bibliography series no. 2).

"Selected Bibliography on Land Use and Traffic Models". JAIP. Vol. 25, May 1959, P. 104.

Urban Development Models. Washington, D. C. Highway Research Board, National Research Council, 1968.

Voorhees, Alan M., Ed. "Land Use and Traffic Models: A Progress Report—Special Issue". JAIP. Vol. 25, May 1959, pp. 55-104.

Voorhees, Alan M. "The Nature and Uses of Models in City Planning." JAIP. Vol. 25, May 1959, pp. 57-60.

General Conceptual Models

Alonso, William. "The Form of Cities in Developing Countries". PPRSA.* Vol. 13, 1964, pp. 165-173.

Chapin, F. Stuart, Jr. "Activity Systems and Urban Structure." JAIP. Vol. 34, No. 1, January 1968, pp. 11-18.

Chapin, F. Stuart, Jr. URBAN LAND USE PLANNING. Urbana, University of Illinois Press, 1965 (2nd edition).

Chapin, F. Stuart, Jr. and Shirley F. Weiss. FACTORS INFLUENCING LAND DEVELOPMENT. Chapel Hill, Institute for Research in Social Science, 1962.

Chapin, F. Stuart and Shirley F. Weiss, Eds. URBAN GROWTH DYNAMICS. New York, John Wiley and Sons, Inc., 1962.

Dyckman, John. "City Form and the Geometry of Structures". Unpublished Paper for Conference of Joint Center for Urban Studies, MIT and Harvard University. June 1961, Mimeo.

Guttenberg, Albert Z. "Urban Structure and Urban Growth". JAIP. Vol. 26, May 1960, pp. 104-110.

Hansen, Walter G. "How Accessibility Shapes Land Use". JAIP. Vol. 25, No. 2, May 1959, pp. 73-76.

Harris, Britton. "The City of the Future: The Problem of Optimal Design". PPRSA. Vol. 19, 1967, pp. 185-195.

Harris, Britton. NOTE ON ASPECTS OF EQUILIBRIUM IN URBAN GROWTH MODELS. Philadelphia, Institute of Environmental Studies, 1966 (Unpublished MS).

Harris, Britton. QUANTITATIVE MODELS OF URBAN DEVELOPMENT. Philadelphia, Institute of Environmental Studies, 1967.

Harris, Britton. "The Uses of Theory in the Simulation of Urban Phenomena". JAIP. Vol. 32, No. 5, Sept. 1966, pp. 258-273.

Harris, C. D., and E. L. Ullman. "The Nature of Cities". ANNALS OF THE AMERICAN ACADEMY OF POLITICAL AND SOCIAL SCIENCE, Vol. 242, November 1945, pp. 7-17.

Loewenstein, Louis K. THE LOCATION OF RESIDENCES AND WORK PLACES IN URBAN AREAS. New York, Scarecrow Press, 1965.

Lynch, Kevin, and Lloyd Rodwin. "A Theory of Urban From". JAIP., Vol. 24, No. 4, Nov. 1958, pp. 201-214.

Meier, Richard L. A COMMUNICATIONS THEORY OF URBAN GROWTH. Cambridge, M.I.T. Press, 1962.

Row, Arthur, and Ernest Jurkat. "The Economic Forces Shaping Land Use Patterns." JAIP. Vol. 25, May 1959, pp. 77-81.

Ward, Benjamin. "City Structure and Interdependence". PPRSA. Vol. 10, 1963, pp. 207-221.

Webber, Melvin M., Ed. EXPLORATIONS INTO URBAN STRUCTURE. Philadelphia, University of Pennsylvania Press, 1963.

Williams, Robert M. "Fluctuations in Urban Growth: Some Comparative Data and Analysis." PPRSA. Vol. 1, 1955, pp. E-1—E-14.

Winger, Alan R. "Supply Oriented Urban Economic Models". JAIP. Vol. 35, No. 1, January 1969, pp. 30-34.

Wurster, Catherine Bauer. "Form and Structure of the Future Urban Complex". CITIES AND SPACE—THE FUTURE USE OF URBAN LAND. Baltimore, Johns Hopkins Press, 1963, pp. 73-101.

Symbolic Models

Alonso, William. LOCATION AND LAND-USE. Cambridge, Mass. Harvard University Press, 1964.

Alonso, William. "A Theory of the Urban Land Market." PPRSA. Vol. 6, 1960, pp. 149-157.

Berry, Brian J. L. "Cities as Systems within Systems of Cities". PPRSA. Vol. 13, 1964, pp. 147-163.

Berry, Brian, J. L. and William L. Garrison. "Recent Developments of Central Place Theory." PPRSA. Vol. 4, 1958, pp. 107-120.

Hamburg, John R. and Roger L. Creighton. "Predicting Chicago's Land Use Pattern". JAIP. Vol. 25, May 1959, pp. 67-72.

Hansen, Walter G. "How Accessibility Shapes Land Use". JAIP. Vol. 25, May 1959, pp. 73-76.

Hoover, Edgar M. THE LOCATION OF ECONOMIC ACTIVITIES. New York, McGraw-Hill, 1948.

Isard, Walter. LOCATION AND SPACE ECONOMY. New York, Technology Press M.I.T., and John Wiley, 1956.

Isard, Walter, METHODS OF REGIONAL ANALYSIS: AN INTRODUCTION TO REGIONAL SCIENCE. Cambridge, Mass., M.I.T. Press, 1963.

Lowry, Ira S. A MODEL OF METROPOLIS. Santa Monica. The Rand Corporation, August 1964.

Lowry, Ira S. "A Model of Metropolis". JAIP. Vol. 31, No. 2, May 1965, pp. 175-176.

Meier, R. L. A COMMUNICATIONS THEORY OF URBAN GROWTH. Cambridge, Mass., M.I.T. Press, 1965.

Morrisett, Irving. "The Economic Structure of Cities." PPRSA. Vol. 4, 1958, pp. 239-256.

Olsson, Gunnar, and Stephen Gale. "Spatial Theory and Human Behavior." PPRSA. Vol. 21, 1968, pp. 229-242.

Taieb, F. et al. METHODOLOGICAL PAPER ON A MODEL OF SPATIAL DEVELOPMENT. Paris, Centre d'Etudes et de Recherches sur l'Aménagement Urbain, 1967.

Wendt, Paul F. "Theory of Urban Land Values." LAND Vol. 33, No. 3, August, 1957, pp. 228-240.

Wingo, Lowdon, Jr. TRANSPORTATION AND URBAN LAND. Washington, D. C., Resources for the Future, Inc., 1961.

Zipf, G. K. HUMAN BEHAVIOR AND THE PRINCIPLE OF LEAST EFFORT. Cambridge, Mass., Addison-Wesley, 1949.

2. ECOLOGICAL MODELS AND CONCEPTS

ARCHITECTURE, ECOLOGY AND FORM. Mimeo for Architecture 153, University of Pennsylvania, Fall Term, 1965 (23 pp.).

Bureau of Outdoor Recreation and Smithsonian Institution Science Information Exchange. OUTDOOR RECREATION RESEARCH. Washington, D. C. U. S. Department of the Interior (Periodic Publication of on-going research activities).

"The Ecology of the City." AIA JOURNAL. November, 1962, Vol. 38:5 (pp. 101-103). Paper presented at the 1962 AIA-ACSA Seminar, Cranbrooke, Academy of Art.

Fine, I. V., and Hovind, Ralph B. THE LAKE SUPERIOR REGION RECREATION POTENTIAL (Preliminary Report). Madison, Wisconsin Department of Resource Development, 1962 (66 pp.)

THE GRIFFITH, INDIANA PARK AND RECREATION PLAN. Urban Planning Consultants, Chicago, Illinois, June, 1967.

Harris, C. W., and Ann Satterthwaite. THREE APPROACHES TO ENVIRONMENTAL RESOURCE ANALYSIS. Washington, D. C. The Conservation Foundation, 1967.

Hills, G. Angus. "The Classification and Evaluation of Land for Multiple Uses". FORESTRY CHRONICLE, June, 1966. (pp. 1-25).

Hills, G. Angus. THE CLASSIFICATION OF FOREST PRODUCTIVITY SYSTEMS (SITE, ECOSYSTEM, BIOGEOCOENOSE). Special paper presented at Fifth World Forestry Congress, Seattle, Washington, August/September, 1960.

Hills, G. Angus. THE CLASSIFICATION OF LANDS IN ONTARIO ACCORDING TO THEIR POTENTIAL FOR AGRICULTURAL PRODUCTION IN AN ECONOMY OF MULTIPLE LAND-USE. Maple: Ontario Department of Lands and Forests, 1956.

Hills, G. Angus. COMPARISON OF FOREST ECOSYSTEMS (VEGETATION AND SOIL) IN DIFFERENT CLIMATIC ZONES. Forest Ecosystem Symposium, IXth International Botanical Congress, Montreal, 1959. Silva Fennica, 105.

Hills, G. Angus. A CONSIDERATION OF THE TIME FACTORS WHICH DETERMINE THE SATISFACTORY USE OF RENEWABLE LAND RESOURCES. Paper presented at a seminar on Land-Use Problems in Ontario, sponsored by the Conservation Council of Ontario, November 26-28, 1958, Vineland, Ontario.

Hills, G. Angus. DEFINITION OF CAPABILITY CLASSES AND BENCHMARK SITES FOR THE RECREATIONAL LAND INVENTORY. Unpublished mimeo, January 21, 1966. (37 pp.)

Hills, G. Angus. THE ECOLOGICAL BASIS FOR LAND-USE PLANNING (Research Report No. 46) Toronto, Ontario Department of Land and Forests, 1961.

Hills, G. Angus, and Pierpoint, G. FOREST SITE EVALUATION IN ONTARIO. (Research Report No. 42) Toronto, Ontario Department of Lands and Forests, 1960.

Hills, G. Angus and Portelance, R. THE BLACKMEYER REPORT OF MULTIPLE LAND-USE PLANNING. Toronto, Ontario Department of Lands and Forests, 1960.

Hills, G. Angus. RANKING THE RECREATIONAL POTENTIAL OF LAND UNITS BY GRADIENT ANALYSIS; A PHYSIOGRAPHIC CLASSIFICATION OF LAND FOR RECREATIONAL USE. Ottawa, Proceedings of the National Meeting on Land Capability Classification for Outdoor Recreation, February 23 and 24 1966.

Hills, G. Angus. "Regional Site Research". FORESTRY CHRONICLE. December 1960, pp. 401-423.

Hills, G. Angus. "The Soils of the Canadian Shield." AGRICULTURAL INSTITUTE REVIEW. March 1960.

Hills, G. Angus. THE USE OF LAND-TYPE MAPS IN LAND-USE PLANNING. (Section Report (Site) No. 31) Maple, Ontario, Department of Lands and Forests, 1960.

Hills, G. Angus. "The Use of Site in Forest Management". FORESTRY CHRONICLE, Vol. 29 No. 2, 1953, pp. 128-136.

Hough, Michael. NATURAL PROCESS AS A BASIS FOR LAND-USE PLANNING. Unpublished mimeo (12 pp).

Lacate, Douglas S. "A Review of Land Type Classification and Mapping." LAND ECONOMICS, August, 1961. pp. 275-277.

LANDSCAPE ANALYSIS I: LAKE SUPERIOR SOUTH SHORE AREA. Madison, Wisconsin Department of Resource Development, 1963.

Lewis, Philip H. "Environmental Design Concepts for Open Space Planning in Minneapolis and its Environs." University of Illinois, PARKS AND RECREATION IN MINNEAPOLIS, Vol. III, Minneapolis Board of Park Commissioners, December, 1965. (33 pp.)

Lewis, Philip H. ENVIRONMENTAL VALUES IN THE PATHS OF PROGRESS. Madison, University of Wisconsin, 1965 (?), 5 pp.

Lewis, Philip H. THE OUTDOOR RECREATION PLAN. (Wisconsin Development Series) Madison, Wisconsin Department of Resource Development, 1966.

Lewis, Philip H. RECREATION IN WISCONSIN. Madison, Wisconsin Department of Resource Development, 1962.

McHarg, Ian. L. DESIGN WITH NATURE. Garden City, New York. The Natural History Press, 1969.

McHarg, Ian L. ECOLOGICAL DETERMINISM. Unpublished mimeo, 1965 (?), 22 pp.

McHarg, Ian L. "An Ecological Method for Landscape Architecture" LANDSCAPE ARCHITECTURE. Vol, 57, Number 2, 1967, pp. 105-107.

McHarg, Ian L. "Regional Landscape Planning." Scheffy, A. J. W., ed. RESOURCES, THE METROPOLIS, AND THE LAND-GRANT UNIVERSITY, pp. 31-35.

McHarg, Ian L. TOWARDS A COMPREHENSIVE LANDSCAPE PLAN FOR WASHINGTON, D. C. Prepared by Wallace, McHarg, Roberts, and Todd for the National Capital Planning Commission, April 1966, 97 pp.

McHarg, Ian L. and Wallace, David A. "Plan for the Valley vs. Spectre of Uncontrolled Growth." LANDSCAPE ARCHITECTURE QUARTERLY. April 1965, pp. 179-181.

METROPOLITAN OPEN SPACES FROM NATURAL PROCESSES. Philadelphia, University of Pennsylvania, 1964.

Moeller, John. STANDARDS FOR RECREATIONAL AREAS. Chicago, Illinois, American Society of Planning Officials, January 1965.

NATIONAL RECREATION SURVEY. Outdoor Recreation Review Commission. ORRC STUDY Report Series No. 19, Government Printing Office, Washington D. C., 1962.

1965 NATIONAL SURVEY OF FISHING AND HUNTING. U. S. Department of the Interior, Fish and Wildlife Service, Bureau of Sport Fisheries and Wildlife. Government Printing Office, Washington, D. C., 1966.

OPEN SPACE COMMUNITIES IN THE MARKET PLACE. Carl Norcross. Urban Land Institute (Technical Bulletin No. 56). Washington, D. C., December, 1966.

OPEN SPACE FOR URBAN AMERICA. U. S. Department of Housing and Urban Development, Urban Renewal Administration. Government Printing Office, Washington, D. C., 1965.

OUTDOOR RECREATION FOR AMERICA, Outdoor Recreation Resources Review Commission. ORRC Study Report Series No. A. Government Printing Office, Washington, D. C., January, 1962.

PARKS FOR AMERICA. U. S. Department of the Interior, National Park Service. Government Printing Office, Washington, D. C., 1964.

PARTICIPATION IN OUTDOOR RECREATION: FACTORS AFFECTING DEMAND AMONG AMERICAN ADULTS. Outdoor Recreation Resources Review Commission. ORRC Study Report Series No. 20, Government Printing Office, Washington, D. C., 1962.

"The Place of Nature in the City of Man." THE ANNALS OF THE AMERICAN ACADEMY OF POLITICAL AND SOCIAL SCIENCE. Vol. 352, March 1965, pp. 1-12.

Potomac Planning Task Force. THE POTOMAC. Washington, U. S. Government Printing Office, 1967.

PUBLIC EXPENDITURES FOR OUTDOOR RECREATION. Outdoor Recreation Review Commission. ORRC

Study Report Series No. 25. Government Printing Office, Washington, D. C., 1962.

RECREATION AND OPEN SPACE IN ILLINOIS. Urbana, University of Illinois Department of Landscape Architecture and Bureau of Community Planning, 1961.

REGIONAL RECREATION AREAS PLAN. County of Los Angeles, Los Angeles Planning Commission. Central Duplicating Bureau, County of Los Angeles, Los Angeles, California, 1967.

STATE OF INDIANA, DEPARTMENT OF NATURAL RESOURCES: MASTER PLAN FOR ACQUISITION AND DEVELOPMENT FOR CONSERVATION AND RECREATION. Vollmer Associates, Engineers and Landscapes Architects, Indianapolis, 1964, 1965.

STATE PARK STATISTICS. U. S. Department of the Interior, National Park Service, Division of Recreation Resource Planning. Government Printing Office, Washington, D. C.

Wallace-McHarg, Associates. A MEMORANDUM ON A METHOD FOR UNDERTAKING A COMPREHENSIVE PLAN FOR THE HUDSON RIVER BASIN. Unpublished professional proposal, 1967 (32 pp.)

Wallace-McHarg, Associates. PLAN FOR THE VALLEYS. Green Spring and Worthington Valley Planning Council, Incorporated, no date. (62 pp.)

3. SYSTEMS ANALYTICAL MODELS

Batchelor, Peter. "Residential Space Systems: Generic and Specific Concepts of Urban Structural Analysis" (Paper given to the Environmental Design Research Association Conference, Chapel Hill, June, 1969).

Chapin, F. Stuart, and Shirley F. Weiss. FACTORS INFLUENCING LAND DEVELOPMENT. Chapel Hill, North Carolina, Institute for Research in Social Science, 1962.

Chapin, F. Stuart, Jr. and Shirley F. Weiss. SOME INPUT REFINEMENTS FOR A RESIDENTIAL MODEL. Chapel Hill, North Carolina, Institute for Research in Social Science, 1965.

Donnelly, Thomas G., F. Stuart Chapin and Shirley F. Weiss. A PROBABILISTIC MODEL FOR RESIDENTIAL GROWTH. Chapel Hill, North Carolina, Institute for Research in Social Science, 1964.

Forrester, Jay W. URBAN DYNAMICS. Cambridge, Mass., M.I.T. Press, 1969.

Hamilton, H. R., et al. SYSTEM SIMULATION FOR REGIONAL ANALYSIS: AN APPLICATION TO RIVER BASIN PLANNING. Cambridge, Mass., M.I.T. Press, 1969.

McLoughlin, Brian J. URBAN AND REGIONAL PLANNING: A SYSTEMS APPROACH. London, Faber and Faber, 1969.

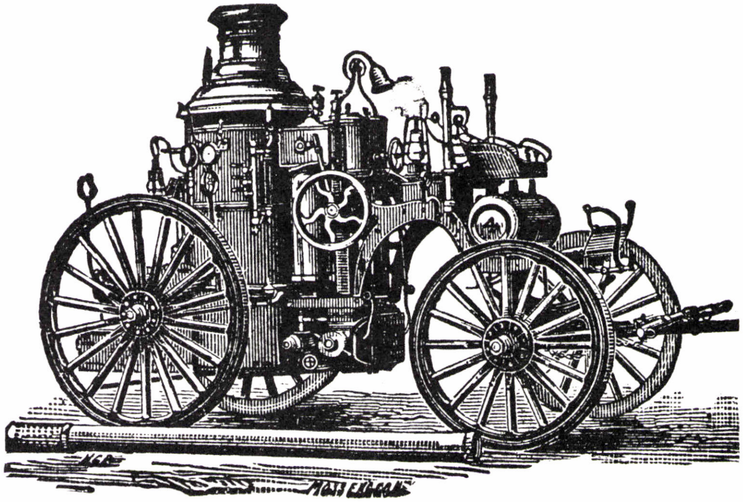
"Simulation Models". COMPUTER METHODS IN THE ANALYSIS OF LARGE SCALE SOCIAL SYSTEMS, James M. Beshers, ed., Cambridge, Mass., M.I.T. Press, 1969.

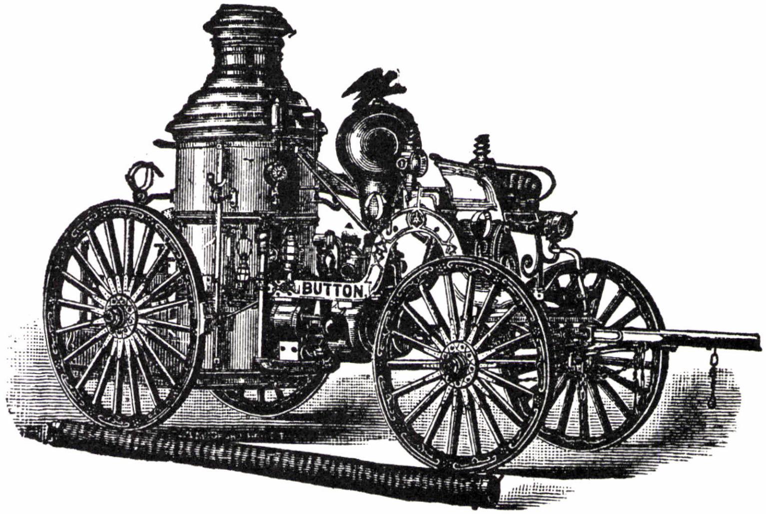
Steinitz, Carl, and Peter Rogers. A SYSTEMS ANALYSIS MODEL OF URBANIZATION AND CHANGE: AN EXPERIMENT IN INTERDISCIPLINARY EDUCATION. Cambridge, Mass., Graduate School of Design, Harvard University, 1968.

Taieb, Francoise, A. Danet, and G. Mercadal. METHODOLOGICAL PAPER ON A MODEL OF SPATIAL DEVELOPMENT. Paris, Centre, d'Etudes et de Recherches sur l'Aménagement Urbain, 1967.

Walsh, Brian F., and Sigurd Grava. "A Dynamic Land-Use Allocation Model." PAPERS. 4th Annual Symposium on The Application of Computers to the Problems of Urban Society, 1969, pp. 72-95.

Wolfe, Harry B., and Martin L. Ernst. "Simulation Models and Urban Planning". OPERATIONS RESEARCH FOR PUBLIC SYSTEMS, Philip M. Morse, Ed. Cambridge, Mass., M.I.T. Press, 1967.





Peter Batchelor
DESIGN FOR A SYSTEM ANALYTICAL MODEL OF URBAN GROWTH AND CHANGE

Introduction

The diagrams presented on the following pages represent a schematic outline of a process for stimulating urban growth and change. While the process is designed for application to urban situations, it is nevertheless applicable to rural areas and metropolitan regions. It is based on the assumption that growth variables are determined through scale of analysis; that is to say, the characteristics of growth at a large scale are not the same as those at a smaller scale, and that some form of modular relationship may be used to pass from one set of variables and parameters to another. These diagrams describe a two-phase algorithmic process in terms of sectors and cells and show how some major urban variables may be included.

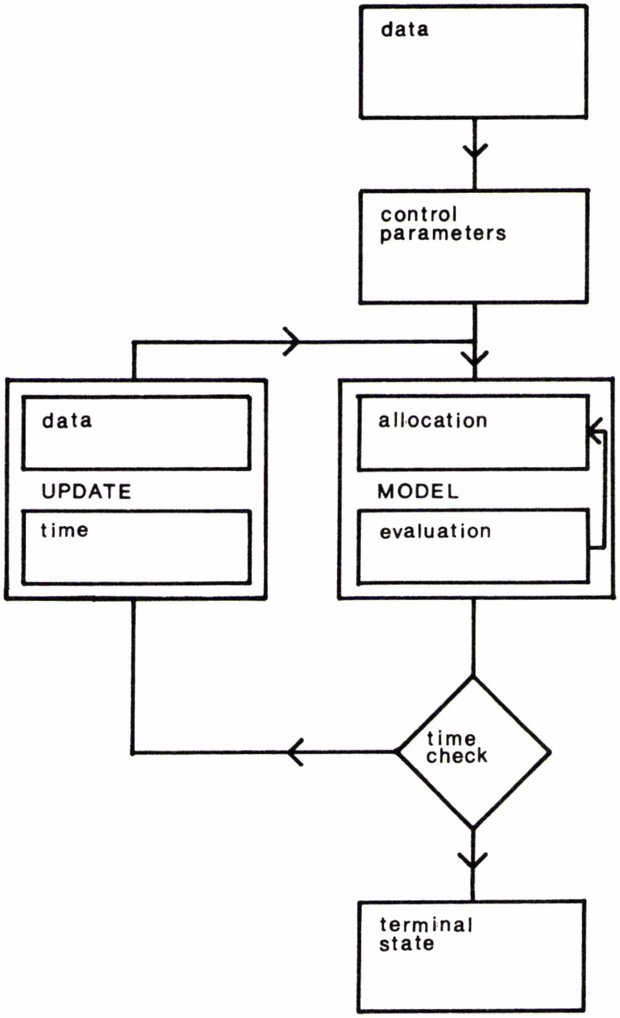


Figure 1

Most similation studies tend to follow the general process indicated above. The major differences occur in the number of urban activities treated and the allocation and evaluation methods. By relaxing the control parameters, it is possible to convert simulation programs of this kind into gaming simulation studies.

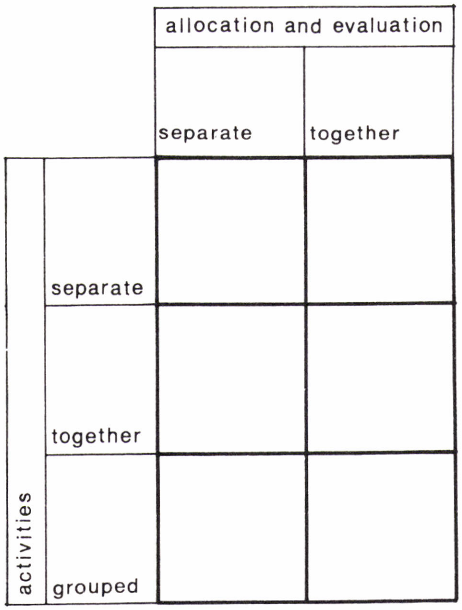


Figure 2

All of the major variations of the model shown in figure 1 appear here. At least six kinds of basic models arise out of the methods of handling activities in conjunction with allocation and evaluation processes.

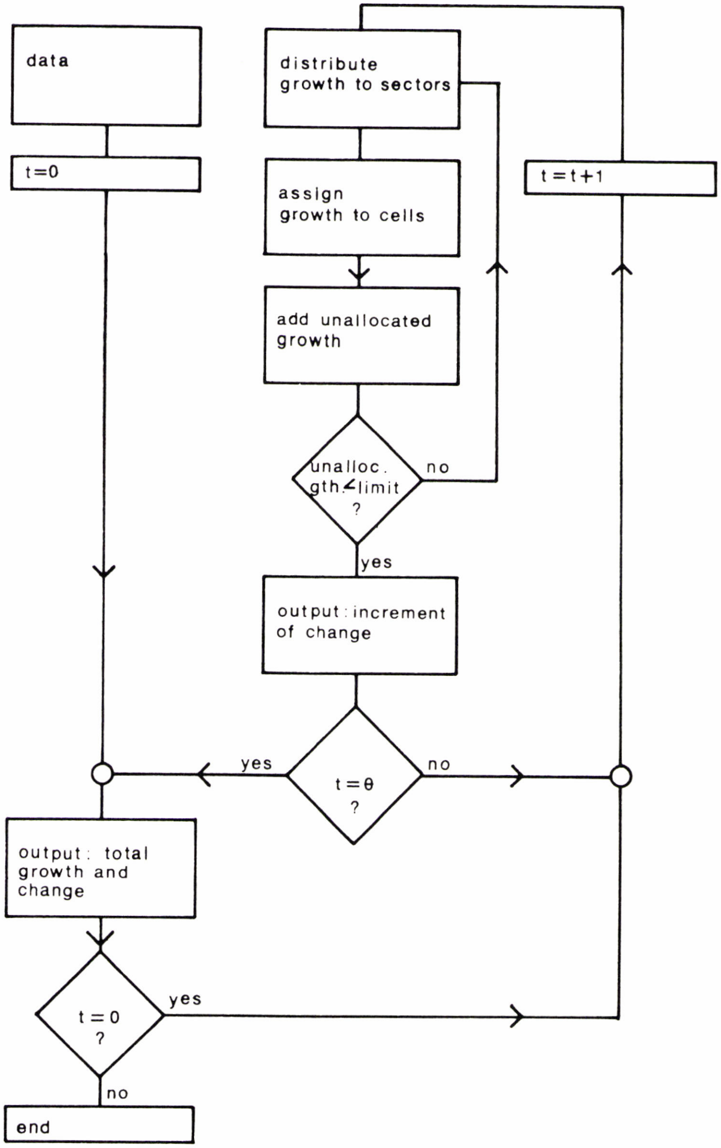


Figure 3

This is the basic process on which the algorithm is built. It consists of a distribution of growth increments to sectors of differential growth followed by assignment to specific locations.

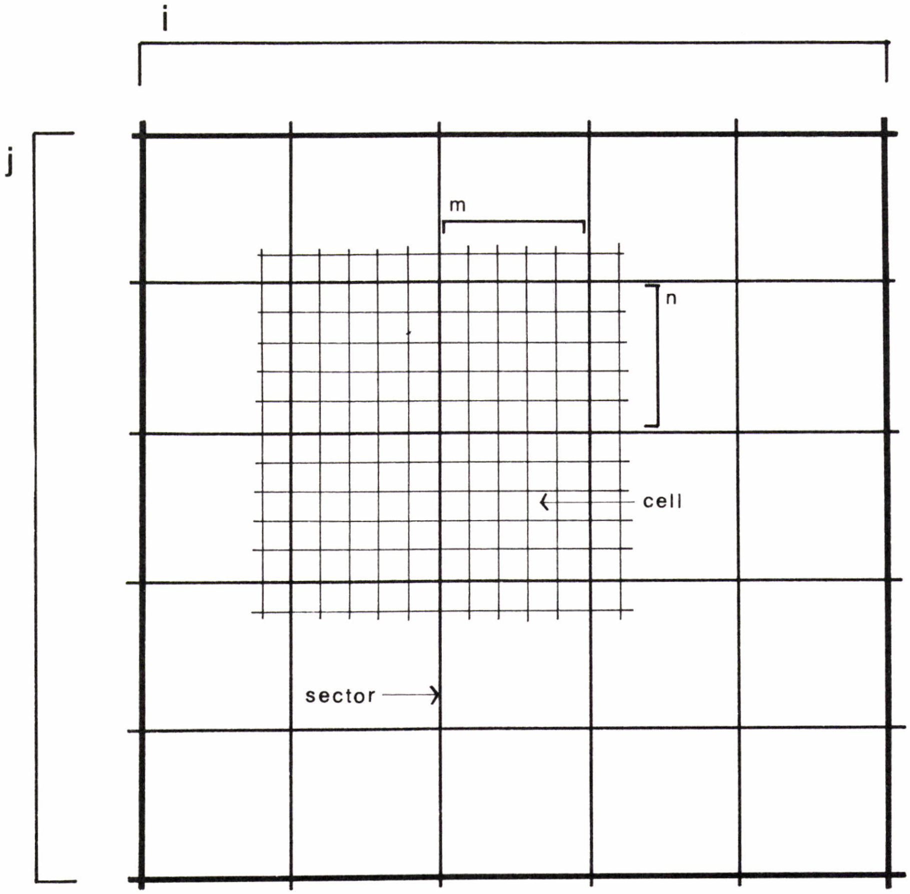


Figure 4

The study region is divided into a grid-cell system consisting of cells and sectors as shown. Determination of growth rates would bring about a refinement of the arbitrary sector shown here.

0.5 1	0.6 2	0.8 2	0.9 1	0.0 0
0.3 2	0.6 4	0.8 7	0.4 2	0.0 0
0.0 0	-0.1 1	-0.1 -1	0.1 3	0.2 1
0.0 0	-0.2 -1	-0.2 -2	0.1 1	0.2 2
0.3 2	0.3 1	0.4 2	0.2 3	0.0 0

Figure 5

Each sector exhibits two growth characteristics: A simple, yearly growth rate, and an annual rate of change.

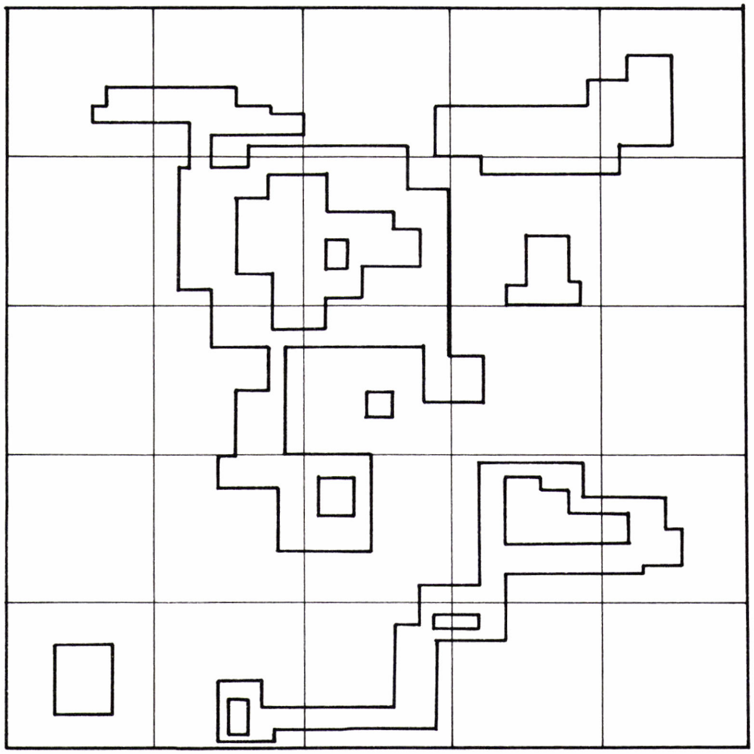


Figure 6

Under normal circumstances analysis would reveal that the sectors are, in fact, quite irregular and that the boundaries do not conform to the regular grid pattern shown in figures 4 and 5.

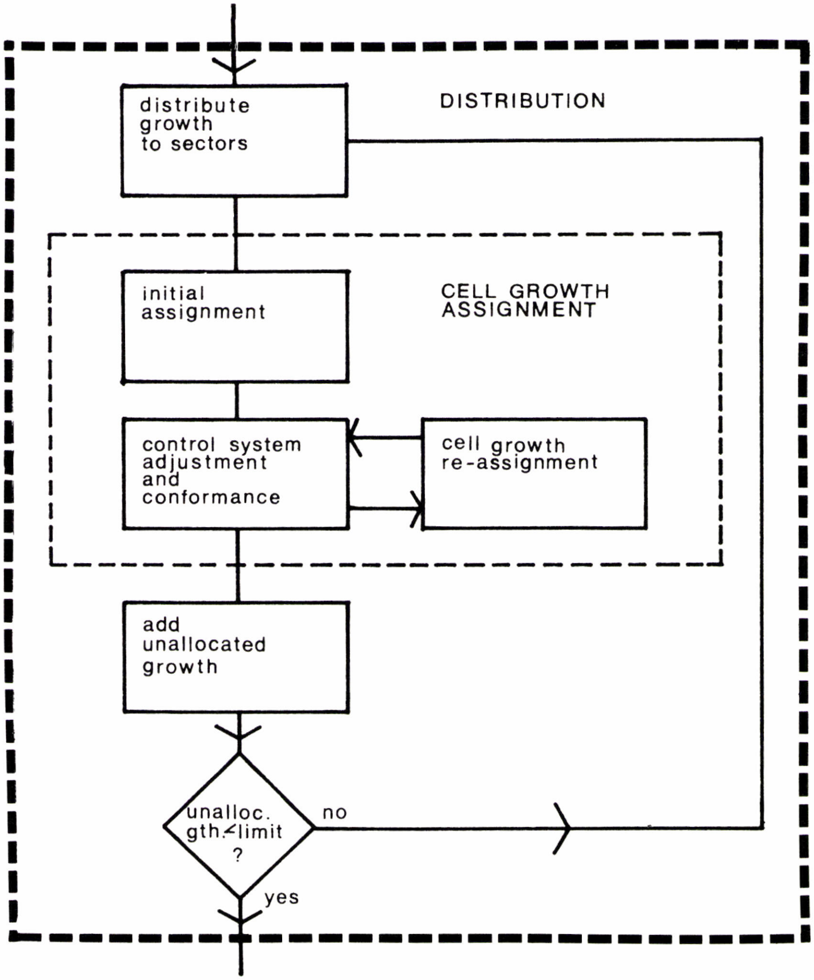


Figure 7

This portion of the basic process shown in figure no. 3 illustrates the major structure of the algorithm: A double-stage distribution process within sectors. The underlying assumption is that differential growth rates for sectors within an urbanizing region can be built into the simulation process.

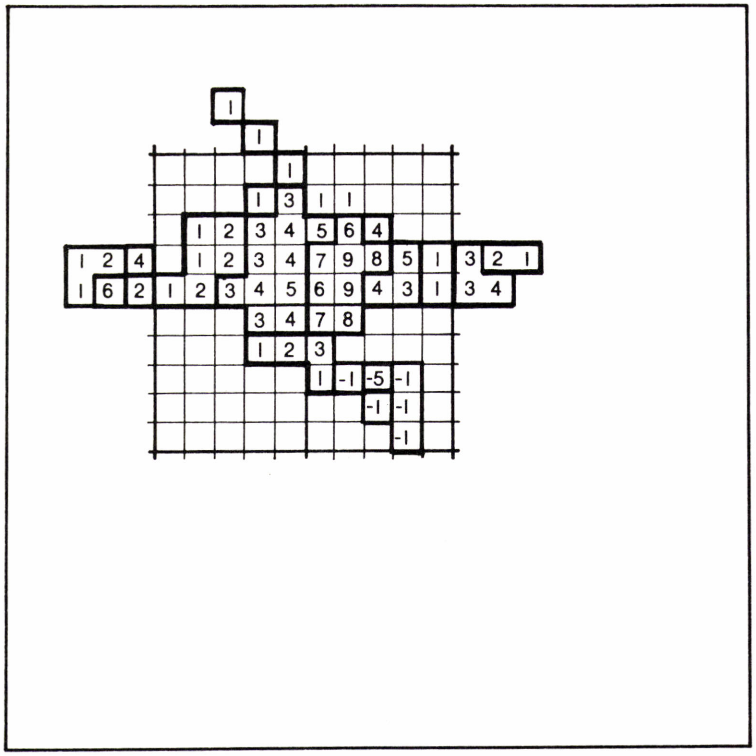
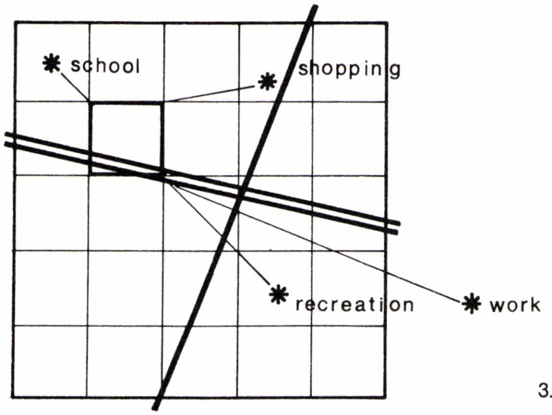
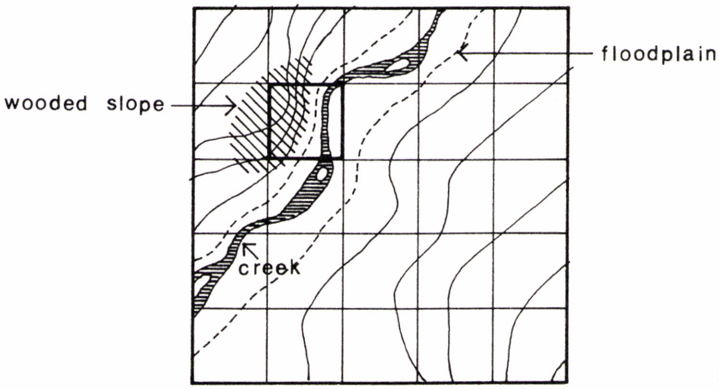


Figure 8

It can also be shown that probabilities of development apply to each cell, and that the aggregate of these probabilities is representative of the probability of a whole sector. At those times when a sector is too coarse for accurate measurement (as in high density urban situations), cell probabilities may be the best way to arrive at spatial development.



3.4a



3.4b

Figure 9

This demonstrates some of the essential difference between two kinds of information utilized to estimate the probability of development for a given cell. The upper diagram illustrates relational kinds of information, while the lower diagram shows site-specific information. A weighted aggregate of these characteristics is used to set up the final development probabilities for a given cell.

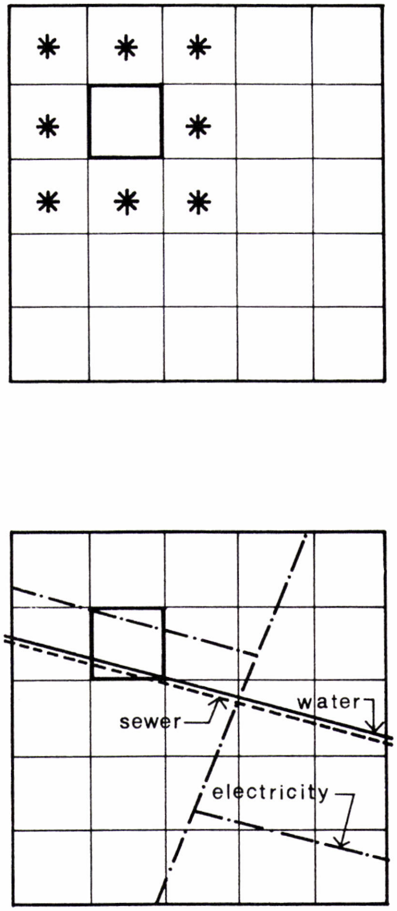
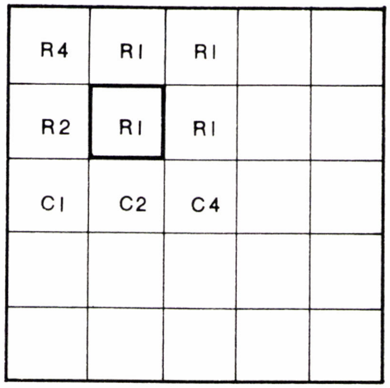
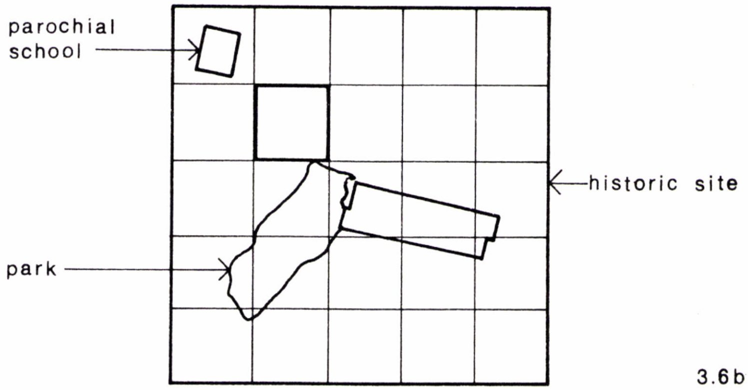


Figure 10

Both illustrations demonstrate the value of physical improvement to a given site. In the upper diagram value is a function of surrounding development, while in the lower diagram value is a function of services provided.



3.6a



3.6b

Figure 11

The constraining effect of land-use control systems and of sites pre-empted for public purposes are shown here. Adjustment and conformance to control systems is a fundamental part of the algorithmic process.

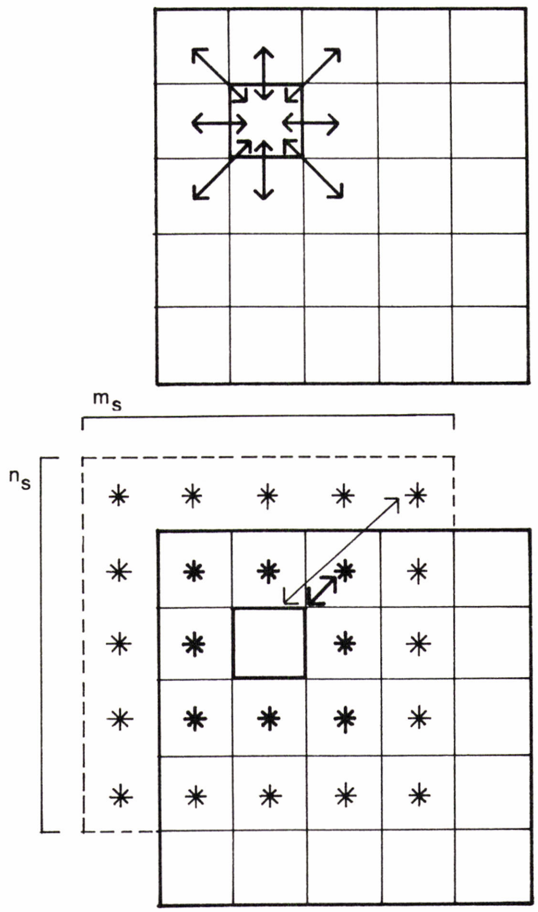


Figure 12

The concept of development pressure -- i.e. inward pressure on enclosed land, or outward pressure on open space -- is made part of the process by the creation of a search radius to examine characteristics of property for development purposes.

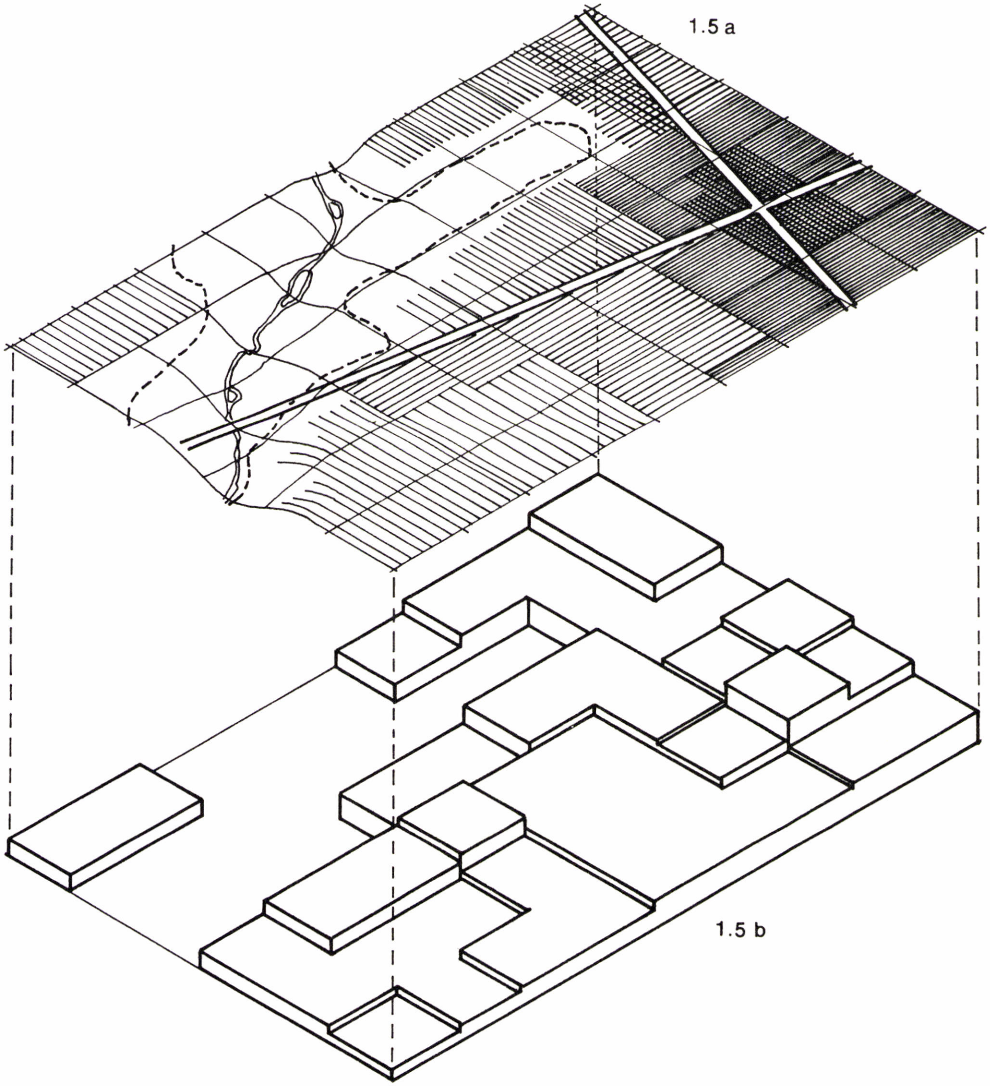


Figure 13

The terminal stages of the basic process posses the potential for several kinds of computerized output. The upper diagram shows a digital map of varying densities against a background of natural and man-made features, while lower diagram shows a topological interpretation of the varying density.

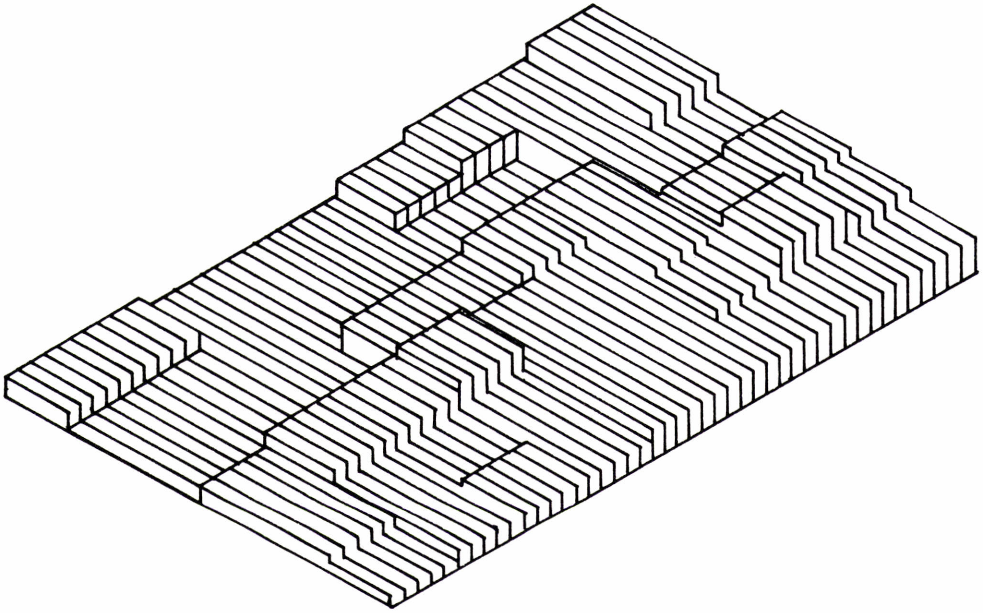
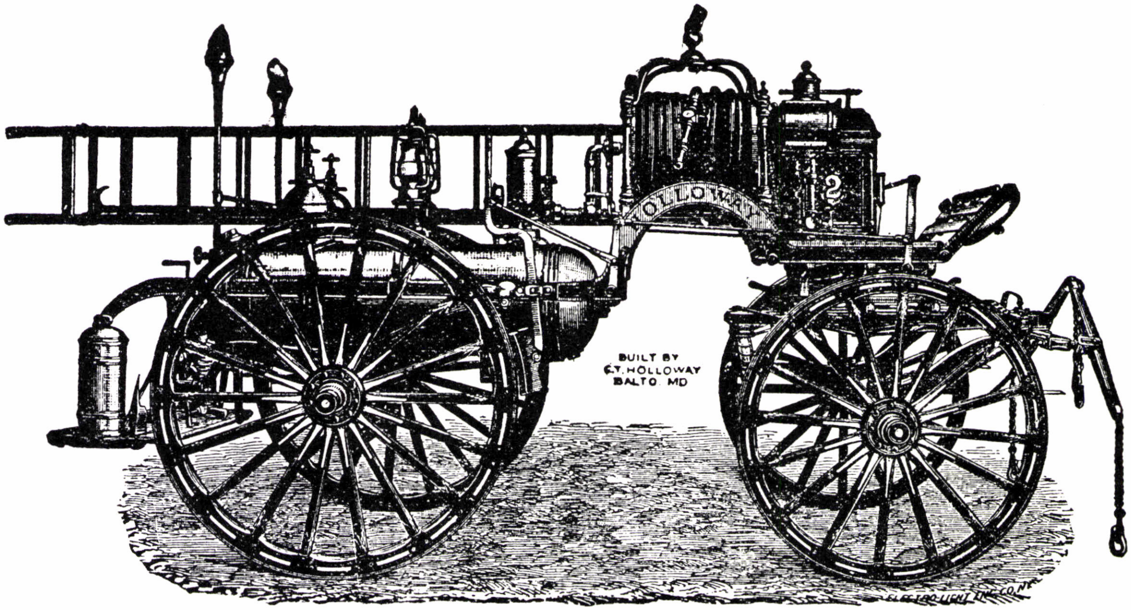


Figure 14

This map is a variation of the previous topological interpretation of varying density and demonstrates one of many possibilities for the computerized output of spatially distributed phenomena.



Richard R. Wilkinson
Warren J. Ranney

A LANDSCAPE BASIS FOR RESOURCES MANAGEMENT

Public land management is increasingly subject to changing demands and pressures. As a model for management devices that have application in the private arena, it is free from two major constraints; the public domain is not real estate and theoretically there is a continuous management capability. As real estate, private land is subject to a progressive deterioration in scale through division of ownership rights. As the rights are divided into smaller and smaller units the potential for management decreases. Real estate relates to its own logic and criteria and has no relationship to natural systems or change management. The public lands are free from this constraint although they are subject to many of the same pressures for use as private land.

It is reasonable to expect that progressive deterioration, irreversible degradation and uncontrolled consequences of use would not be a factor in public land management. To date they have not been, but as pressures for more diverse use is placed on them, the system by which they are managed must evolve in such a way that new uses can be accommodated.

In the past, land management agencies have had the responsibility of meeting diverse objectives with regard to the use of the national public lands. Wood and fibre production, watershed management, wildlife management, and range management today appear to be successfully established and managed. However, because of increasing social and economic pressures the management agencies are now responsible for additional uses which have not been seriously considered in the past. They not only face the problem of integrating new objectives into management plans but it also must fit new land uses into the public domain in such a way that the national lands, as a resource, act as a more positive influence in local and regional areas. Some of the categories which the agencies now consider are (1) uses requiring special permits, (2) scenic management and (3) recreation development, urban development, and other services. Attempts have been made to accommodate these newly important uses on a project by project basis, creating more problems than have been solved both within and without the public lands. With this in mind, these questions should be asked:

1. Why have the multiple use management guidelines not been able to accommodate new and diverse objectives and why is there not more benefit to the community from public land functions?

2. What can be done to correct the complexity and confusion, while providing the highest sustained benefit from the public land resource to the local, regional, and national community?

3. How can corrective or benefiting measures be formulated, adapted and implemented?

MANAGEMENT PROBLEMS: The United States Forest Service is the most proficient land management agency, and has created a suitable management structure for their present objectives.

Looking back at the way the source integrated its objectives for forests, watersheds, ranges, and wildlife, each one of these areas had its own individual objective. Each could be defined and was broken down to many levels of detail in order to breach the gap between the broadest, most abstract, objective level and the on-site level where physical change occurs. In addition, when something was to be done in one area (forestry, for example,) at a given level of detail, it could be compared directly to the other areas (watersheds, ranges, wildlife) at the same level of detail. This made it very easy to compare the objectives of different uses and to permit their resolution.

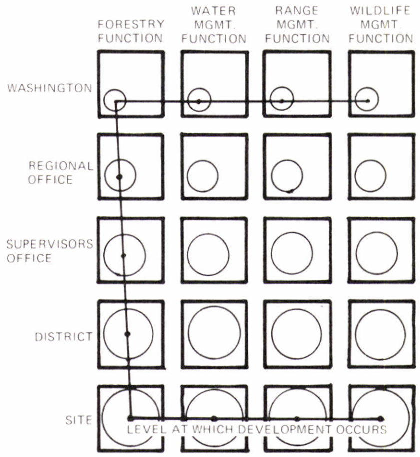


FIGURE 1. - Activities within the various functional categories are compared at the same level of detail throughout the system. This affords the means for evaluating and comparing the consequences of operations. In this way standard practices of activity for one function can be modified to assure results acceptable for other functions.

Today, however, new objectives with associated land uses brought into the public lands have not been sufficiently broken down and compared at common levels of detail. For example, it is hard to understand the relationship between the special use permit policies and urban type development without either broadening the scope of extra-agency involvement or narrowing the scope of special use permits. When land uses cannot be compared at similar detail levels, projects take on the appearance of being independent, somewhat unrelated, and confused from the regional or even district policy standpoint.

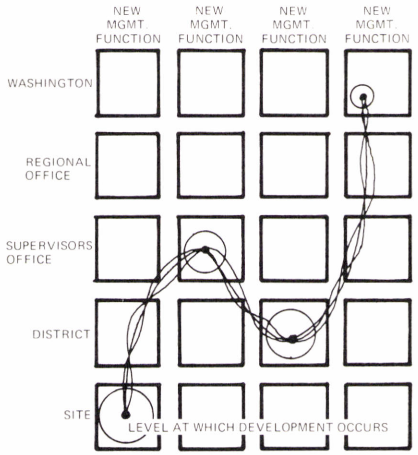


FIGURE 2. - When new functions are incorporated into the management framework without a backlog of experience and knowledge of environmental tolerances, the impacts are compared indiscriminately and confusion results.

MANAGEMENT CONSIDERATIONS

In order to facilitate the integration of various land uses (or land use objectives) it is necessary to maintain an overview of the entire jurisdiction or region to which similar general land use objectives will be applied. In this way, objectives imposed on public lands may show the necessary degree of continuity prerequisite in regional planning. Consistent with this, the overall objectives would also be of a similar detail level for comparison and integration. The second factor vital to the planning and integration of land use is the breakdown of land use objectives. Each level of breakdown should be the same for all objectives so that they may be compared with each other at any common level and consequently integrated. Each objective at any level can then be viewed not as an isolated entity but as an integral part of the entire region or planning process.

In order to breakdown land use objectives, it is necessary at some point to choose a factor, condition, or scale which is common to all objectives and can itself be broken down. This common character can then be the guide by which all land use objectives can be divided into common levels of detail. There are many "common denominator" characters which one can apply in land use detail levels such as time, acreage through grid patterns (excellent for computers), administrative boundaries, physical barriers, etc. However, since we are dealing with the integration of land uses, some of which are governed by land productivity, land form, and environmental quality it appears that ecological-physiographic conditions should guide the breakdown of land use objectives. The land, broken down into successively smaller units as governed by existing natural conditions (topography, soils, drainage, vegetation, climate, etc.) is extremely versatile as to land division sizes desired. Once the physiographic characters are identified which divide the land in a way that best fits administrative capabilities, use objectives can be broken down accordingly.

Literature research has shown that there are many different formats for environmental analysis following the physiographic or ecological breakdowns. The differences usually are either a function of how the raw information was collected or how the raw information was analyzed. For example, G. A. Hills collects bench marks or extremes in the environment, determines the gradient between extremes and using use capability, suitability, and feasibility, selects "proper" land uses. P. H. Lewis in his analysis procedure places particular importance on "environmental corridors" as a basis for land use planning. The general analysis procedure recommended by the authors is very similar to Ian McHarg's ecological determinism procedure. This last procedure requires the collection and mapping of large amounts of environmental information (as opposed to Hill's procedure). Once the information is mapped, however, it can be interpreted and re-used for any land use, or land development analysis as to suitability, capability, and feasibility. Once the maps are interpreted and overlayed (using a filter mapping process), potential development can be evaluated and planned. The level of detail in McHarg's procedure is sufficiently fine to evaluate single projects, if it can be consolidated into consistent management units.

ECOLOGICAL BREAKDOWN: A means of establishing decision levels and planning criteria.

In McHarg's analysis procedure, major natural and cultural features are inventoried such as climate, geology, physiography, hydrology, soils, plants and animal associations, and land use. These features can then be evaluated according to desired general land uses giving those areas with the most desirability the darkest tones. Overlaying the maps then reflects the most desirable conditions as the darkest areas, the least desirable, the lightest. This land breakdown is only good down to a scale considerably larger than the single building site. Eventually the desired land use objectives for an area can be put into a matrix as a way to determine their intercompatability. This, combined with the land use analysis map, then determines where certain land uses can be placed. The actual placement of land uses however is subject to analysis of other economic and social factors.

This breakdown by McHarg offers little in the small scale breakdown of the land in a way that can influence site-by-site development. Since development is generally a project by project (site by site) aggregation over time, an addition to the environmental analysis breakdown has to be made. This can be done using *single* physiographic features. For example, topography could be used to identify replicated land features such as hills of perhaps 500 to 1,000 acres in size. These hills, or units, could be further divided by topography to identify smaller three-sided hills of perhaps 50 to 100 acres. Beyond this, topography may not work. One may then have to shift to another physiographic characteristic such as soils or vegetation. The actual characteristic used does not greatly matter. For example, when dividing land into 50 acre sites, one would go down the scale of land characteristics until that feature which will divide the land into the range of 50 acre sites is reached. If, for instance, an area could be divided into 50 acre sites by soils but eventually in traversing areas this classification (using soils) becomes too large or small, one can use the next land characteristic on the scale (either up or down). Also the next scale could use the same feature but at a finer scale (such as topography as mentioned above).

Topography	100 acres
Soils	50 acres
Topography	10 acres
Vegetation	1 acre
Microclimate	0.5 acre

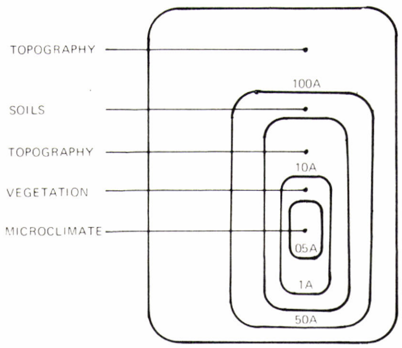


FIGURE 3. - .Physiographic characteristics vary in their constancy. At each level of detail they can be plotted to differentiate and compare characteristics and capabilities for determining their suitability for use.

DECISION LEVELS AND MANAGEMENT

Breaking land down to sites small enough for site planning permits the planner or land manager to compare desires with those of a developer on a one-to-one basis at the site or land unit level. In this way, as the manager breaks his objectives down from the highest to the lowest levels he can tell the developer exactly what criteria he must use to satisfy finite considerations. In this respect the land form is a determinant of both development practices and resource management. Alterations in resource quality are directly attributable to development and specific trade offs can be made that recognize the long term use of the site in its larger context, the land unit. The land breakdown is the key to guiding land development by permitting land use objectives to be expressed at a level developers can respond to. After all, development is predominantly the accumulated product of developer's decisions at the site level. An additional check on land use and development can be expressed in the terms of "ecological indicators" which are sensitive to land change. For example, stream quality or quantity characteristics are excellent interpreters of the treatment of a watershed. Quality or quantity standards (as set by social or economic conditions) could not only limit certain types or extent of land modification but could also express itself in terms of individual site plans. Improved site treatment would mean the possibility of more intensive development while at the same time maintaining the quality of the ecological indicator.

Because of the incremental breakdown of land use objectives and land units, three factors can now be related on a one-to-one basis. These factors are the isolates (scenic management, special use permits, recreation, forestry, etc.), management of the resource (the combined effect of the isolates), and the physiography or land base. Concessions, compromises, and the integration of objectives can thus be combined into a viable planning approach with regard to those who express sufficient interest in their community or region.

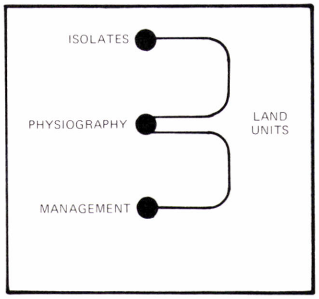


FIGURE 4. - Comparison of the isolates and their combined or interacting impact on the physiographic systems of the environment can be managed under a system that uses them as a management resource.

The purpose of this approach is to establish a format which will permit management control. In privately financed developments on private land it has not been a central objective of the manager to assume responsibility for the external consequences of actions. In the case of the public manager this is an integral part of his duties. It is not always possible to fulfill the responsibility unless provisions are integrated throughout the entire planning and development process.

Development in most cases proceeds on a project by project basis. Public managers tend to model their methods of control on the private sector and treat each project as a separate and distinct entity. Rather than try to integrate the projects over time they are segregated into different sites. Through this process the infill of land use proceeds much the same as it does on an urban strip development.

This is a product of seemingly non-reconcilable ownership and taxation problems. Public lands are not subject to these problems and experimental forms of management can be explored as a testing ground for ultimate private adaption.

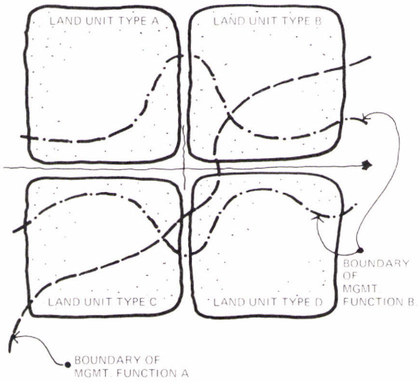


FIGURE 5. - Conflicting boundaries of functional management areas confuse efforts to integrate and control new objectives and their environmental consequences.

The existing process is a form of disjointed incrementatalism. As a process it involves the creation of a larger entity, such as a community, out of a series of unrelated projects which are not considered to have serious or long term consequences to the environment. As each is established it is considered complete and management seeks new and equivalent opportunities. As these are added the external effects compound into an unmanageable situation. Control of consequences is a vital objective for public management and the methods necessary to institute this are inherent in the land modularization process.

Urban managers divide their jurisdictions into Euclidian zones, each of which has an end capacity assigned to it. There is no inherent resource or environmental objective involved, other than the preservation of property values. In the public land situation this is not an issue, but the maintenance of environmental systems is, or should be.

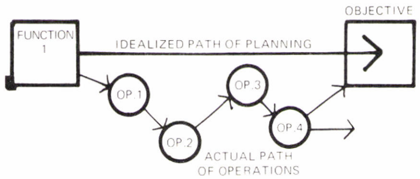


FIGURE 6. - Each operation in accomplishing an objective is subject to external pressures and in turn produces consequences that are beyond the scope of management and its linear objective framework.

The central issue involves the capacity to manage. This is based on being able to assess the limits of management in a realistic manner and divise programs that do not exceed that capacity. The key lies in relating the carrying capacity of the natural environment with the generative ability of management to produce and control change. By structuring a situation in which the impact of change is read directly through the monitoring of the natural environment.

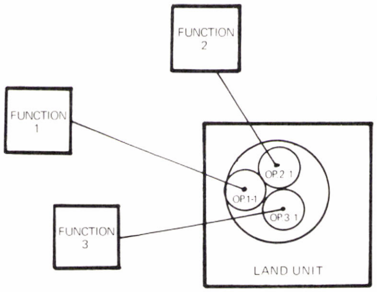


FIGURE 7. - Operations of various functions can be evaluated and integrated within the context of physiographic units. The units can be the basis of management control. Problems and consequences arising from operational programs can be compared with the limits and capacity of the unit to sustain change without destroying its internal structure or producing unacceptable consequences beyond its boundaries.

By setting limits, which is common, for the quality and quantity of change considered tolerable management can work backward through the development process. This is impossible, however, if each project is treated separately as it arises, and abandoned to managerial limbo upon completion. The sheer number of project by project impacts increases beyond control and no technique or skill exists to go back and enfold past accomplishments into the ongoing scheme.

The need is to retain continuous control and asess the impact of new plans in concert with past change. This requires that an alternative to site by site development of land be created. The obvious solution is the land unit. As described, it is intrinsically related to and controlled by natural processes. It has no finite limit for use of any one type, but it does have a capacity for change based on a given technology and management priority scale. If land is altered by a given process the change can be detected. If the purpose for making the change can be met by another method which makes less of an impact, and is feasible in other terms, then it should be used.

In most current instances this does not happen. The scale optimatization generally necessary for innovation is precluded by prior site categorization, or the existing aggregate impact of previous piecemeal change, which is irreversible.

Proper management can, if it controls all the circumstances of its action, increase the capacity of use, and relate physically, uses which were previously incompatible. Management must keep its opportunities before it and never relinquish control to excess. By relating all eventualities for change to a common base and never exceeding the capacity of that base to sustain change it can build on past actions and increasingly maximize its capability.

SELECTED REFERENCES

1. Anderson, R. C. 1970. AN OUTLINE FOR MULTIPLE-USE PLANNING. J. Forestry 68:558-560. In order to properly implement multiple-use planning in the forest environment, one should consider the "total" of the earth's "basic amenities and resources" and anticipate consequences arising from their use or management.

2. Batchelor, P. 1967. THE NATURAL ENVIRONMENT AS A DETERMINANT FOR URBAN FORM. Doctoral Program: Determinants of Urban Form, Paper No. 8, N. C. State Univ., Raleigh. 59 p. The author describes how features and perceptions of the natural environment affect the form of buildings, and the relationships between buildings. This is also discussed with respect to man's systems such as circulation and open space.

3. Blank, U. and Clare A. Gunn. 1966. GUIDES LINES FOR TOURISM-RECREATION IN MICHIGAN'S UPPER PENINSULA. A report to the Upper Peninsula Committee on Area Progress, Upper Michigan Tourist Association, University Extension Service Michigan State Univ., 105 p. Use of the idea of breaking the landscape down according to the extent of development and recreation potential was described. Following this, recreation development suggestions were laid out in a way to maximize their potential. Unusual resource features (both natural and man-made) were respected or improved.

4. Board of Water and Air Resources. 1970. CLASSIFICATIONS AND WATER QUALITY STANDARDS APPLICABLE TO THE SURFACE WATERS OF NORTH CAROLINA. Dept. Water and Air Resources, Raleigh. 20 p. The publication contains rules and regulations pertaining to water quality where stream standards have already been implemented. This can provide insight on using streams as ecological indicators and what can be done with this type of indicator in guiding land use.

5. Brower, David. 1969. ENVIRONMENTAL ANALYSIS IN LOCAL DEVELOPMENT PLANNING. Appalachia, November-December, pp. 1-11. The type of environmental information needed by Appalachian Regional Development District planners as described by the author is presented. The article appears to be a follow-up of McHarg's environmental determinism carrying the development decision level to the site level.

6. Chapin, F. S., Jr. 1965. URBAN LAND USE PLANNING. Univ. Illinois Press; Urbana, Illinois. 498 p. A textbook in the theory and techniques for urban land use planning.

7. Ciriacy-Wantrup, S. V. 1963. RESOURCE CONSERVATION, ECONOMICS AND POLICY. Univ. Cal., Berkeley Div. Agric. Sci., Agric. Exp. Sta. 395 p. Discussed are factors influencing and being influenced by conservation. The factors cover an extremely wide range of subjects such as social, economic and legal factors.

8. Downs, A. 1970. CREATING THE INSTITUTIONAL FRAMEWORK FOR ENCOURAGING NEW CITIES, IN REGIONAL NEW TOWNS; ALTERNATIVES IN URBAN GROWTH. Metropolitan Fund Inc, Detroit, M. Downs' article describes the inherent constraints to large scale change management inherent in our present system of development.

9. ________. 1961. CONSERVATION EASEMENTS AND OPEN SPACE CONFERENCE. Dept. Resource Development and the State Recreation Committee, Madison, Wisconsin. 127 p. Open space laws and policies surrounding land easement acquisition and costs are discussed. Mention is also made of possibilities of coordinated easement programs.

10. Darling, F. F. and J. P. Milton (Ed.). 1966. FUTURE ENVIRONMENTS OF NORTH AMERICA. The Natural History Press, Garden City, New York. pp. 526-538. McHarg gives a good description of his concept of ecological determinism or the "health environment" resulting from examining components and valuations of the environment in which we must live. He looks at (1) ecosystem inventories, (2) natural processes, (3) limiting factors, (4) the attribution of value, (5) prohibitions and permissiveness to change, and (6) indicators of the environment's stability or instability.

11. Daubenmire, Rexford. 1968. PLANT COMMUNITIES. Harper and Row, N. Y. 300 p. The book is a text of the relationships of plant communities as components of the ecosystems, their origin, development, and maintenance.

12. Davis, K. P. 1969. WHAT MULTIPLE FOREST LAND USE AND FOR WHOM? J. Forestry, 67: 718-721. The author looks at land ownership and the rights of management that go along with it. Different land owners have different management objectives and thus may misunderstand each other due to their management differences. For "multiple use" as is discussed in the article, "better valuation of land use alternatives is necessary."

13. Dearinger, J. A. 1968. ESTHETIC AND RECREATIONAL POTENTIAL OF SMALL NATURALISTIC STREAMS NEAR URBAN AREAS. Univ. Kentucky, Water Resources Institute, Lexington, Kentucky. Research Report No. 13. The report is an inventory and evaluation of natural and cultural features of a landscape. Ways for evaluating the desirability of features for meeting cultural recreation demands are discussed.

14. Deese, L. K., J. Hill, and R. Covington. 1969. A SYSTEMS APPROACH TO RECREATION LOCATION. An unpublished report for a landscape design class at N. C. State Univ., Raleigh. 13 p. The report is a short example of systematic location procedures used for specific land uses which in general relies on the map filtering process (see Forbes).

15. Dept. City Planning and Landscape Architecture, Univ. Illinois. 1961. REGIONAL LANDSCAPE PLANNING. Allerton House, Urbana, Illinois. 106 p. The book is a combined series of lectures given in a symposium on regional landscape.

16. Dept. Landscape Architecture. 1967. School of Natural Resources, Univ. of Mich., A DESIGN APPROACH TO RECREATION DEVELOPMENT. Ann Arbor. 125 p. The organization of physical development on a natural base has been examined and described at several levels of detail with respect to the distribution and intensity of activities, corridors, and the realization of recreation potential when considering the natural amenities.

17. Forbes, Jean. 1969. A MAP ANALYSIS OF POTENTIALLY DEVELOPABLE LAND. Regional Studies 3: 179-195. The "sieve map" which is an overlay of many maps can be used to determine land suitability for various development types. Its accuracy for selecting areas for development according to the article seems to be best at a large scale (large general areas). However, the author shows how the many overlays may be converted to a single numerical system for easy interpretation (threshold analysis).

18. Forest Service Handbook. 1964. MULTIPLE USE MANAGEMENT GUIDE. Forest Service, U. S. Dept. Agric. The handbook describes general policy statements of multiple use management methods.

19. Huron River Recreation Resources Study Group. 1967. HURON RIVER RECREATION RESOURCES STUDY, Huron River Recreation Resource Study Group, Ann Arbor, Mich. 102 p. Site descriptions according to natural features are inventoried and analyzed for recreation potential or limitation with subsequent recommended activity levels. In addition there is examination of land use and demography on an area compsing of many sites.

20. Kennedy, F. D. 1968. BASIC CONCEPTS REQUIRED IN THE DEVELOPMENT OF A PLANNING INFORMATION SYSTEM. State Planning Task Force, Dept. of Administration, State of North Carolina, Report No. P 64.03. A look at what one must consider when collecting information for specific projects such as organizational and resource inputs required to obtain the level of information desired is accomplished by the report.

21. Knowles, Ralph. 1969. OWENS VALLEY STUDY. National Endowment for the Arts and the Univ. S. Cal. An in depth study of the ecological balances of Owens Valley, California and its implications in development.

22. Landscape Architecture Research Office. 1967. THREE APPROACHES TO ENVIRONMENTAL RESOURCE ANALYSIS. Grraduate School of Design, Harvard Univ. The article looks at three approaches to identification, analyzation, and evaluation of environmental resources for planned development. In part it is a critical review and comparison of resource analysis done by A. Hills, P. Lewis, and I. McHarg.

23. PUBLIC LAND POLICY AND THE ENVIRONMENT PART III. Public Land Law Review Commission 1730 K Street, N.W. Washington, D. C. 1970. The article seeks patterns of landform influencing quantites and qualities of resource applying to land. Emphasizes use of existing personnel and administrative structures as well as analysis of known information.

24. Lewis, P. H., Jr. 1961. RECREATION AND OPEN SPACE IN ILLINOIS. Division of Landscape Architecture and the Bureau of Community Planning, Univ. Illinois; Urbana, Illinois. Lewis makes a natural reconnaissance of Illinois for future planning to accommodate recreation and openspace needs.

25. Litton, R. B., Jr. FOREST LANDSCAPE DESCRIPTION AND INVENTORIES—A BASIS FOR PLANNING & DESIGN. Paper PSW-49, U. S. Dept. Agric., Pacific Southwest Forest & Range Experiment Station, Berkeley, Calif. The author is concerned with recognition of scenic resources of forests, delineating scenic analysis, and compositional types of landscapes.

26. Marans, R. W. 1967. ENVIRONMENTAL STUDY FOR DESIGN RESOURCES. Metropolitan Area Regional Planning Commission, Detroit, Mich. 64 p. The author examined the identification and

assessment of environmental resources and the consequent synthesis of the resource information into design system forms.

27. Murry, A. C. (Ed.). 1967. SYMPOSIUM: METHODS OF LANDSCAPE ANALYSIS. Landscape Research Group, London. 55 p. The symposium presents a description of many varied techniques involved in landscape analysis such as visual analysis, human perceptions of landscape forms, discussion of basic landscape design guidelines, and natural and cultural land character breakdowns.

28. North Cascades Study Team. 1965. THE NORTH CASCADES. U. S. Dept. of Interior. The report is an examination of management and administration of Federal lands in the North Cascades.

29. ________. PLANNED UNIT DEVELOPMENT. Land Planning Bull. No. 6., FHA. 1st edition. The article is FHA's policy bulletin on land planning for urban development.

30. ________. 1966. PROCEEDINGS: NATIONAL COMMITTEE ON FOREST LAND. Dept. Forestry of Canada, Information and Technical Services Div., Ottawa, Canada. 148 p. The proceedings study several views on the classification of land for multiple land use considering predominantly the biological productivity of the land uses; however, recreation is also considered.

31. Roggenbuck, J. W. 1969. EVALUATION OF RECREATION RESOURCE INVENTORY AND ASSESSMENT SYSTEMS AND THEIR APPLICABILITY IN DEVELOPING COUNTRIES. Unpublished dissertation for Master of Sci. degree at Univ. Mich., School of Natural Resources, Ann Arbor. 208 p. The author goes through the evaluation of recreational land classification systems and the application of one system in the framework of developing countries.

32. ________. 1970. SENATOR HATFIELD OUTLINES PROPOSALS FOR THE AMERICAN FORESTRY ACT OF 1971. Forest Industries, Sept., p. 7. The article gives a quick look at the need for a coordinated national land use policy to help correct some of the nation's ills. As described by Turnbull in the article, "(t)he lack of a national land use policy lies at the root of many urban problems and the decline of rural populations. . . ."

33. Smith, D. M. 1962. THE PRACTICE OF SILVICULTURE. John Wiley and Sons, Inc., N. Y. 578 p. The book is a general text on techniques and theories of silviculture.

34. ________. 1967. SOIL, WATER AND SUBURBIA. U. S. Dept. Agric., Dept. Housing and Urban Development Conference Proceedings, Washington, D. C. The proceedings examine the transition of land from open stable uses to suburban uses, the effects on soil and water, and possibilities for planning, developing and managing new urban areas. Examination of land use intensities, resource mapping, advantages and disadvantages in development layout in the overall land picture is included in the proceedings.

35. Spurr, S. H. 1964. FOREST ECOLOGY. The Ronald Press Co., N. Y. 352 p. Spurr studies forest dynamics and the variables affecting forest development. He also identifies ways of dividing forests into stands or sites analytically, descriptively, or through indices.

36. PUBLIC LAND POLICY AND THE ENVIRONMENT, PART III. Public Land Law Review Commission 1730 K Street, Washington, D. C. 1970. Looked at are approaches towards increasing understanding the function of environmental systems, increasing the ability of decision makers to predict relationships, and improving methods of control.

37. THE STUDENT PUBLICATION OF THE GRADUATE SCHOOL OF FINE ARTS. "Ecology and Design." Univ. Pennsylvania, Phila., Penna. The publication is a series of articles concerned with ecology and its use in design methods.

38. AN ECOLOGICAL STUDY OF THE TWIN CITIES METROPOLITAN AREA. Metropolitan Council of the Twin Cities. 1968. Office of Wallace, McHarg, Todd, Roberts & Assoc., Philadelphia, Pennsylvania. The study is an example of ecological determinism through ecological inventories and interpretations. Through applying natural constraints or amenities to possible uses of land for man's benefit, "health" environments can be planned.

39. Wallace, D. A., McHarg, Roberts, and Todd. PLAN FOR THE VALLEYS. Green Springs and Worthington Valley Planning Council, Md. This brochure is an example of planning through ecological determinism. Several major valleys near Baltimore are examined for development planning purposes while the natural systems in the area may be maintained in the best possible way.

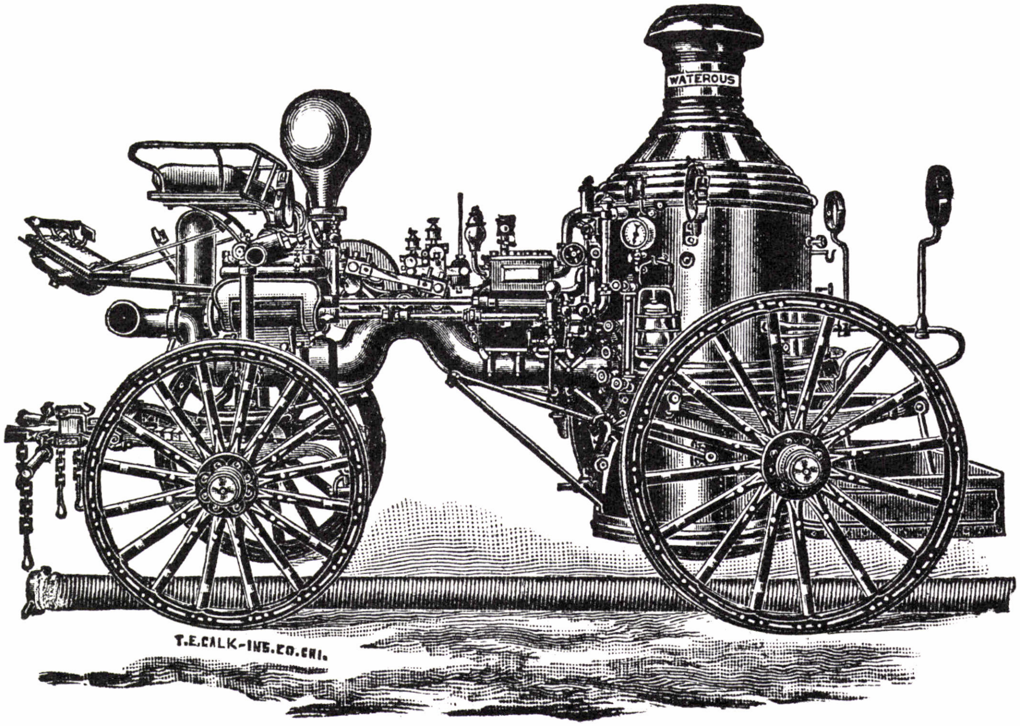
40. Watt, K. E. F. 1968. ECOLOGY AND RESOURCE MANAGEMENT. McGraw-Hill Book Co., N. Y. 450 p. The book is a study into resource management (land use) which is

multi-disciplinary. The focus in on how land use alternatives may be evaluated according to ecological principles (use is made of mathematics, statistics, and computers).

41. ________. 1968. WHERE NOT TO BUILD, A GUIDE FOR OPEN SPACE PLANNING, Tech. Bull. No. 1. U. S. Dept. of Interior, Bureau of Land Management, Washington, D. C. Included is a description of what open space and open space systems really are, a classification for open space and guides for open space planning and planning application at many levels. Also, the bulletin has a case study example with natural and cultural land character breakdown for closer analysis. The breakdown reaches the county level of detail.

42. Whitman, Ira L. 1968. USES OF SMALL URBAN RIVER VALLEYS. Corps of Engineers, Baltimore District, Baltimore, Md. 310 p. Various treatments and possibilities of small streams as landscape features is reviewed. Looked at are effects of land use types, use intensities, spatial arrangements, and the way it interferes with natural elements as looked at from the total valley environment.

43. Whyte, W. H. 1964. CLUSTER DEVELOPMENT. American Conservation Assoc., N. Y. 130 p. This book contains the description and evaluation of many possibilities or types of cluster development and its relationship to open space distribution.



William Perry D. White

LOCATIONAL DETERMINISM AS A FORCE IN PLANNING

PART I: LOCATION THEORY AND INDIVIDUAL PREFERENCES

One of the major problems to be faced in urban development is that of establishing a set of priorities for area renewal and new development. The process of renewal is normally initiated after existing areas have become both physically and economically deteriorrated. Changing needs, and outmoded uses provide a basis for renewal in central areas, while outward growth appears to be based on a dynamically speculative real estate market. Where the former depends heavily on visual recognition of conditions, the latter is more dependent upon accessibility and potential for extension of existing urban services.

Priorities for development are established through long range plans for the urban area, which in turn are determined by a "comprehensive" planning approach.[1] Comprehensive planning normally presents the community with a single set of objectives and goals, with policies for development aimed at achievement of the set. The more dynamic approach of a constantly updated inventory of conditions and uses presents a more realistic approach to planning, allowing minor changes to be initiated without compromising long range goals, while adapting these goals to trends of development in the city. Information concerning condition of facilities and arrangements should be incorporated in a dynamic long range plan, i.e. one which is changing constantly according to two major variable areas. The first, condition and arrangement of facilities, can often be usefully described by visual evaluation techniques. The second, planning criteria, is predicated upon needs and cultural norms of society, which change over time.

The objective of this study is to develop a series of explorative models for establishing a spatial disposition of urban development schemes based on visual evaluations of the condition and arrangement of facilities. The study will be described in three parts: first a theory of "optimal location" of facilities will be developed; then a demonstration of the application of this theory to urban development needs will be presented, and lastly, a discussion of the effectiveness of each application, along with its relative potential as a plan-monitoring device.

In the same way that people choose living places using relevant parameters such as proximity to employment, shopping, recreation, and schools, planners and urban designers use these criteria to choose areas in a city or urban area such that there will be a flexibility of choice for their "clientele", the population. But where individuals tend to choose on the basis of a static situation, planning must deal with the more dynamic aspects of choice. Over periods of time, urban areas change in environmental quality; this change may be toward improving or declining conditions. The ultimate goal of planning is to correct the declining condition through conscious design, making all the parts fit. The effects of planning and urban development are the result of subjective prediction of "better states" or conditions in cities. We may understand, for example, the relationships between owner occupancy and housing quality, or between rental housing and community spirit; these relationships extract very subjective information from objective data, implying "better states" which might be available. What we don't fully understand is how these relationships may be converted into design programs which achieve desired ends. Attempts to feed behavioral preference into design criteria do not generally provide a strong means for converting program information into a physical design.

In part, Central Place Theory represents an attempt to explain the geographical distribution of economically viable urban units. Central Place Theory is "the theory of the location, size, nature, and spacing of . . . . clusters of activity", and has provided a basis for much speculation on growth potential, location and hierarchies of economic units.[2] The physical arrangement of economic units seems to obey certain rules of hierarchy, distance, and catchment. The resulting arrangement is described as the "economic landscape" in which facilities are deployed over space in obedience to theorems of interaction of productivity and consumption, along with the utilization of available resources.[3] Behavioral preferences do not normally play a vital role in locational decision making.

Most Central Place Theory practitioners use the wealth of modern mathematical models made available to them by expansion of the theoretical base. The basis for variation in most models is usually the means of measurement used to determine the extent or realm of the "trading area". The trading area is usually conceptualized as a series of regional (or local, depending on hierarchial scale) patterns, either systemically geometric or non-geometric. Christaller, for example, develops a set of intricate hexagonal relationship diagrams to exhibit hierarchial orders of trade centers, based upon levels of economic interaction.[4]

---

1. The comprehensive planning goals approach is discussed in Altshuler, A: "The Goals of Comprehensive Planning", in JOURNAL OF THE AMERICAN INSTITUTE OF PLANNERS, August, 1965, pp. 186-197.

2. Berry, B. J. L.: A GEOGRAPHY OF MARKET CENTERS AND RETAIL DISTRIBUTION, Prentice-Hall, Englewood Cliffs, New Jersey, 1967.

3. Lösch, A.: THE ECONOMICS OF LOCATION. New Haven, Yale University Press, 1954.

4. Christaller, Walter: DIE ZENTRALEN ORTE IN SUDDEUTSCHLAND. Translated by C. Baskin. Englewood Cliffs, New Jersey. Prentice Hall, 1966.

Clearly, an understanding of the efficiencies of one system compared to inefficiencies of another provides a means for implementing conscious change measures in the inefficient system. In terms of "beefing up" one system to make its retail trade, gross production, or capacity to serve commensurate with others of its hierarchial level, economic designers can specify a program for upgrading the inefficient economy.

Location theory may broadly be described as an attempt to define spatially interactive segments of society, and to develop a deeper understanding of the factors or forces which influence and induce firms or individuals to locate in any given place.[5] Traditionally, Location Theory has also suggested that city size and region size are not determined exogenously, but from laws of optimality and hierarchy[6] It has also suggested that firms or individuals make choices on the basis of a series of criteria aimed roughly at maximal efficiency, equity, and utility. Pursuing this, choices are made normatively, and consciously of levels of satisfaction with returns from existing and new or anticipated locations or sites. Satisfaction is primarily an optimization process in which discrete cutting-off points determine the choice from among alternative courses of action; these cutting-off points are usually determined on the basis of what is acceptable from a marginal increase standpoint—what one has from moving to a new location will be marginally better than what one has at present. Alonso suggests that satisfaction is the relevant criterion of optional location of households, unlike other locational concerns.[7]

Most of the theory reduces reality to conceptual systems through a set of operating assumptions.[8] First, transportation is assumed to provide equal access in all directions, eliminating any real world constraints on choice of direction, and denying the fact that transportation in the form of accessibility and mobility is never unconstrained for a given route. Second, technology is assumed to be constant, or the ability to develop new means for overcoming obstacles to free choice is limited, denying man's ability to overcome problems in his environment and to manipulate the environment to exert his will. Third, resources are assumed to be evenly deployed over space, implying that every place has an equivalent endowment, and denying the geographical and geological advantages held by various contiguous areas. Lastly, in economic terms, a series of assumptions are built upon single producer, single market and constant labor skills, abstracting reality to devise conceptual models of the flow of labor and capital within and between trade areas.

The abstraction of reality through these assumptions creates models of regional or spatial interaction which shed light on the complexities of the economic process and allow a greater potential for the understanding of policy effects by altering one assumption while holding the rest constant. But implicit to most of these assumptions is the exercise of choice or preference on the part of most firms or individuals. It is clear that most urban residents trade off satisfaction on one need for an increase in satisfaction on another. For example, in transportation, people select the route to work which minimizes time of access, and consequently narrows the range of locational positions for residence to suit a minimum transportation need. Over an urban area, there are many locations which satisfy any or all of a set of needs in varying degrees: the chooser is indifferent to these locations up to a point. His choice is usually made intuitively as to the site which offers the greatest sum of all his choice criteria.

It is reasonable to assume that all movers, or migrants, to an urban area exhibit this type of preferential behavior. The degree to which they actually search on the basis of a set of criteria, and weigh each site in terms of discrete criteria analysis is a matter to be empirically determined, but I suspect it is not a vigorous mathematical process for most individuals. The view or image most in-migrants have of their urban area is by and large determined through the real estate market, e.g., where an agent helps them to find a home in the new place. Clearly, there are various classes of migrants, many of whom never contact agents, but deal for housing through friends or personal initiative. But their choice or preference of place is normally based upon similar, but socio-economically categorized criteria. A lower class person will choose whatever residence he finds which suits his means; this choice is abnormally limited in our society. Middle and upper class persons choose for similar reasons, but their choice range is more open, primarily due to freedom of movement in the city and to a lack of financially related constraints. However individuals find their place of residence, it is normally part of a process of becoming familiar with the spatial arrangement of spaces and functions in the

5. For a discussion of location theories, see Lösch, *op. cit.*; Christaller, *op. cit.*, and Isard, W.: LOCATION AND SPACE ECONOMY. MIT Press, Cambridge, Mass. 1956.

6. Zipf, G. K.: HUMAN BEHAVIOR AND THE PRINCIPLES OF LEAST EFFORT. Addison Wesley, Cambridge, Mass., 1949. It is conceptually correct but realistically untenable to expect that a city will order itself in the rank size hierarchy due to the set of limitating assumptions in the following paragraph. It is true, however, that cities or towns in a bounded area exhibit some constancy between their size (pop.) and their rank as defined by Zipf and Beckmann.

7. Alonso, W.: "A Theory of the Urban Land Market", in URBAN ECONOMICS, Leahy, W. H., McKee, D. L., and Dean, R. D., editors. The Free Press, New York, 1970.

8. These assumptions are taken from studies which attempt to treat the spatial character of the economy, (Lösch, Isard, et. al. *op. cit.*) and aim at positing a situation in which inter-regional or inter-urban flows of capital and labor might be studied.

city, regardless of its size. In part II, I will attempt to describe the factors which influence their choice, and which consequently provide an insight into growth potential in the city.

The preferences of individuals in locating and settling in various spatial areas of a city is a primary determinant of the spatial distribution of activity in cities, and of the resultant patterning of physical growth of cities. Locational preferences are conditioned by the state of the city at a point in time, in the sense that choices are made from what is currently available to the individual in terms of facilities, activities, and the quality of accessibility to and from these. Preferences are also conditioned by cultural norms, which have a vastly different effect on the spatial deployment of city functions. In England, for example, there is a lesser dependence upon vehicular modes of movement, and pedestrian communities are not uncommon.[9] Consequently, distances between residence and places of economic, recreational, and cultural activity are reduced and communities become more compact socially and physically, with a higher dependence on public systems of transport between centers of activity. Although economic conditions have played a large part in emphasis on public transport throughout Europe, it seems reasonable to conclude that preference structure has had much to do with the continuance of the pedestrian community.

Despite the success of location theorists in describing the behavior of individuals in the economy, most of the theories leave out one essential criterion for location. Designers have long pointed out that the aesthetic quality of the physical environment is a determinant of behavior and of mental health in urban dwellers.[10] Many empirical studies have demonstrated that behavior is very much dependent upon physical space, and efforts to improve the quality of the environment have directed the design professions to study and explore spatially determined behavior. Such studies have ranged from experimental to intuitive, attempting to create a laboratory for aesthetic phenomena in which behavior might be observed and related to design criteria. Essential to understanding the behavior of individuals is the exercise of spontaneous choice (as opposed to controlled or directed choice) of activity modes and environments. Spontaneous choice is perhaps a misnomer, since most people exhibit a tendency to act according to previous experience, according to a mental "set" which has been developed and ingrained or imprinted on the memory throughout the individual's lifetime.[11] Following their mental "set", individuals subconsciously choose environments in which they feel a sense of satisfaction experientially, predicating their choice on previous experience, and pursuing patterns of behavior which "fit" their needs. Needs are not genetically determined but are based upon recurrent and positively reinforcing stimuli, and the individual "spontaneously" seeks such stimuli.[12]

The choice or preference for one location over another is based upon a spontaneous search for psychic rewards of familiarity, confidence, or convenience arising from a reasonable arrangement of activities and behavior between place of residence, place of work, and places of shopping, recreation, and cultural pursuits. Psychic rewards describe the levels of satisfaction and cutting-off points inherent to the choice structure the individual uses to process alternative site possibilities. Psychic rewards derive from being close to a large shopping center, in a decent neighborhood, in the district of the finest school facilities, or within easy reach of the job or place of daily work. But they also derive from a more qualitative consideration, manifested in the condition of the "personal space" or the territory of the individual.[13] People seek actively to "exert a measure of control over their environment through the ordering of objects and activities to suit individual needs; generally this can only result where there is some measure of proprietorship over environmental effects. The converse of psychic rewards would be psychic costs, where the individual trades off levels of satisfaction or proprietorship to achieve or accomplish certain goals.

9. This observation is based upon firsthand experience in living and traveling in England where I observed that many new towns have been designed to reduce dependence on automobile transport, utilizing Radburn-type neighborhoods, and Garden City-type layouts, with central areas which successfully separate pedestrian and vehicular movement.

10. Relevant readings are to be found in Proshansky, H. M.; W. H. Ittelson, and L. G. Rivlin: ENVIRONMENTAL PSYCHOLOGY. Holt, Rinehart and Winston, New York, 1970. See also Craik, K.: "Environmental Psychology" in NEW DIRECTIONS IN PSYCHOLOGY IV. Holt, Rinehart, and Winston, New York, 1970.

11. See Parr, A. E.: "Psychological Aspects of Urbanity" in JOURNAL OF SOCIAL ISSUES. Vol. 22, No. 4. 1966, pp. 39-45. ____: "Design for Eye and Mind", in INDUSTRIAL DESIGN: Vol. 16, No. 7. September, 1969. ____: "Lessons of an Urban Childhood", in AMERICAN MONTESSORI SOCIETY BULLETIN. Vol. 5, No. 4, 1969.

12. Recurrent Behavior is discussed at length in Kojala, J.: SOCIAL SYSTEM AND TIME AND SPACE (Duquesne University Press, Pittsburgh, Pa., 1969). Individuals develop mental "maps" of social or physical acts, and bring these acts to bear on new situations, allowing their previous "map" to determine their behavior recurrently. See also: Stea, D.: "Environmental Perception and Cognition: Toward a Model for 'Mental Maps'", in RESPONSE TO ENVIRONMENT, Coates and Moffett, eds., North Carolina State University, Raleigh, North Carolina, 1969, pp. 63-76.

13. Territoriality is defined as "an area of space . . . . . which an animal or group of animals defends as an exclusive preserve", in Ardrey, R.: THE TERRITORIAL IMPERATIVE. Dell Pub. Co., New York, 1966. Personal space is a concept developed by R. Sommer: PERSONAL SPACE. Prentice Hall, Englewood Cliffs, New Jersey, 1969.

Psychic rewards may be linked to physical patterns of growth in cities where the demand for new locations exceeds its supply and vice versa. Whatever the deployment of city functions, there are portions of the urbanized environment which are more or less efficiently developed which will offer individuals new location possibilities, regardless of socio-economic class or means. There is also a ring of undeveloped land on the periphery of every city in which conditions are more or less suitable for future expansion of the urban area. Both present possibilities for individuals to choose from in settling and offer psychic rewards as stimuli; as such they also present two areas for study of the phenomena of urban physical growth, which will be developed in this study.

Most models of urban growth, of location, and of preference are based upon as many factor relationships as adequately can describe the phenomena being modeled. Models of transportation systems treat every conceivable contribution to movement in cities as a part of the overall system, projecting these to produce quantities of various modes of transport required to satisfy future needs. But they do not treat the physical quality of the environment as a necessary constraint on the types and amounts of transport modes needed. Models of urban growth attempt to link the transport system with activity and land use patterns, but never seem to include the amenity value of the physical environment as stimulus or restraint on future growth. One major reason for this has been the problem of quantifying what are essentially aesthetic criteria in which individual judgments must prevail. Architects and designers hold themselves to be capable of making these judgments, yet each and every one of them has a different view and appraisal of the subjective quality of physical arrangements of objects in space. Still, studies have indicated that architects do tend to appraise the qualities and character of spaces and buildings in a similar fashion,[14] suggesting that this set of professionals might make a contribution of the necessary qualitative judgments to the process of modeling urban phenomena. The problem lies in the development of techniques which standardize such judgments, while allowing them to retain the full range of aesthetic values.

The purpose of this paper is to attempt to devise a beginning—the development of a model is a long-term process, and if the model is to be tested on a real world situation, it must be tested at several points in time. Moreover, since many of the inputs to this model are variables in the subjective sense, due to their aesthetic judgment nature, it is essential that they be tested on a variety of situations. Two such projects have been carried out. First, data has been collected for a city of 100,000 and this has been computerized and stored for manipulation and analysis. All of the data has been collected using on-site aesthetic judgment procedures. The purpose of the project was to organize and institute an inventory of amenity value and physical quality of relationships in the city's environment which could be constantly updated as developmental changes occur, but which also would present a rough indicator of trends in growth and potential for future growth.

The second project, completed two years ago, was a static location analysis, designed to determine a single "best" location for a major freeway in a highly urbanized setting. The framework for the study incorporated many of the determinants of location used in the above study, but these were not projected forward in time or updated. With such a discrete objective, the study could be formulated, and concluded within a short period. Like the city study, this highway location project utilized aesthetic judgments and on-site appraisals to determine the environmental impact of the highway, with a major outcome that of using the highway to stimulate redevelopment and renewal zoning rather than locating it in "twilight" or "grey" agreas of the city. This project was instrumental in rerouting the highway from a high quality environment to a new location based upon aesthetic judgment *before* the highway was built, avoiding great financial costs, but also preventing a great psychic loss to the community.

Hopefully the two projects will exhibit the potential for aesthetically judged criteria as a determinant of future development of cities. It should fit easily within the context of existing models of location and urban growth. Stressing that it is an ongoing area of involvement, I would solicit suggestions and criticisms of the process as well as insights for analysis. In the next part I will describe the factors which affect location of individuals or developments, using those factors which have been determined mostly from aesthetic judgments, and observed relationships in the urban environment.

PART II: FACTORS AFFECTING LOCATION

Of all the determinants of physical location for individuals in cities, those which establish a distance or time relationship between home and the various activities are those which are usually considered first in location models. Psychic reward is likely to result from being close to a good shopping center or the place of employment. Similarly, psychic rewards are to be found in being able to locate in areas where lot size and neighborhood arrangements are such that open space is a recreational amenity as well as a factor of community appearance. Until we can distinguish empirically between

14. White, W. P. D.: "The Meaning of Character in Architectural Spaces", unpublished thesis, N. C. State University, Raleigh, N. C., 1967.

the more important ones, these relationships, or locational factors are weighted equally in both studies.

The factors which determine the attractiveness of a given location in a city can be categorized roughly as those of accessibility, availability of land in the real estate market, and the classifications of land use functions and their relative stability. Each category suggests amenity or disamenity depending on the psychic rewards or costs inherent to each. Each category also suggests the need for some means of quantifying values in order to build ratios or indices of attractiveness for any location in the city. Taken over every census tract, the indices produce maps of areas in which, for a given category, the locational advantage of one tract over another is explicit. A site with a high advantage would combine high levels of accessibility, quality land available, and stability of land use. The problem in developing a model of locational advantage is to derive indices for each advantage which are compatible with the goal of the study, i.e., that of using aesthetic judgments to determine potential for future urban growth trends.

Accessibility is a function of the relative ease of movement over the transport network, and of the distance to those places in the urban community to which individuals desire access. Different types of roads afford different speeds of movement; congestion notwithstanding, the speeds are related to ease of accessibility. Thus for any site in a city, it is possible to develop an index of accessibility to any other site simply by summing the time-distance relationships between a given site and each and every other site, with corrections for congestion. This is an essential task, because such an index is necessary; but impractical, because access to *all* other sites is unwarranted. Three activities require access: employment, shopping, and cultural, where the latter includes recreation, school, and social functions.

The best way to develop an index of accessibility is to determine the possible places of employment, of shopping, and of socio-cultural activities. But in the latter, recreation is essentially a non-urban function, requiring access to points outside the city; school sites are predicated upon location, and most schools are assumed by this model to be equal in quality; and social patterns are unpredictable and widely dispersed. For these reasons the latter is excluded, and two accessibility models are presented as a form of trip-generator analysis. The first, employment, defines the major employment centers of the city, and the major roads network, and sums time-distance relationships for every tract in the city. An underlying assumption is that the majority of persons will work in centers of employment, such as industrial areas, shopping centers, downtown areas, and so on. The model is based primarily upon the spatial intensity of employed activity, assuming that this will be sufficient to define the attractiveness of any site relative to its proximity to such spatially dispersed centers.

The second, shopping, is defined in exactly the same manner: the major shopping areas are related to the major roads network through time-distance sums, and census tracts are indexed according to their relative proximity or accessibility to shopping areas. If this method proves viable, the index of accessibility for either activity will produce a map of values which represent the spatial pattern of desirable locations with respect to the particular activity.

A third accessibility index can be developed by determining a discrete number of activity centers or major points, which represent the non-employment and non-commercial activities settings provided by cities. Frequently these coincide with commerce centers or employment centers, as in the case of theatres, sports centers, or institutions. A list of such activity centers, all "imageable" in the Lynch notation[15], provides a third model of accessibility which is derived using the same procedure as the first two. Once again the resultant spatial pattern of desirable locations is a function of ease of access and the spatial deployment of such functions.

Each of the three models is dependent upon the spatial disposition of activities and the relative ease of accessibility to such activities. In a city where these are concentrated centrally, the resulting pattern of attractive residential locations will resemble a contour map in which the major roads are ridges, or high points, and more distant secluded residential areas are valleys or low points. In a city where activities are dispersed generally over the urban area, the resulting pattern will resemble concentric rings of relative accessibility. For the individual, the most attractive location will be the one with the highest index located closest to the center of the city. This is an optimal condition; it is conditional upon certain social norms, land use patterns, and the preference in our culture for suburban living areas.

The real estate market is the second locational determinant. Location of residence is a function of the availability of land in the urban area, whether developed or undeveloped. Urban area models of the real estate market suggest that the existing stock of housing is in a dynamic state of change, with older units obsolescing, and with newer units changing hands. Older housing is vacated by families searching for better, or new accommodations, and is either renewed or occupied by upwardly mobile families. In the center of the city there is usually a substantial inventory of available housing, but in certain areas

15. Lynch, *op. cit.*

tenure is more stabilized than others, due to social or physical conditions. In the outer areas, there is a similar inventory of housing which supports a different class of people, whose tenure is more likely to be stabilized than center city residents. Lastly, on the growth threshold of the city, undeveloped areas present themselves on the market, either through speculative development or through individual transaction. The trend in recent times has been toward the development of "shopping communities" on the edge of the city, a phenomenon which has provided positive directional growth stimulus to the city as a whole.

Psychic rewards are associated with the evidence of basic desire on the part of residents for semi-urban sites, good quality low density housing, a yard for the children to play in, and neighbors with similar socio-economic status and means. The availability of locational possibilities for residences is determined by economic means of certain social classes; in middle and upper classes this involves the more distant areas from the city center. For lower classes, mobility is not easily achieved, and residents are "chained" to the areas they currently reside in. In spatial terms, this leads to two models of locational possibilities: the first is couched in terms of the redevelopment—rehabilitation potential of presently urbanized areas, while the second is couched in terms of undeveloped land which enters the market in adjacent areas of the city.

The potential of the currently urbanized area to present new location possibilities is limited by the stability of present uses, and by the settlement pattern of socio-economic groupings within the city. Stability is determined in part by land uses, in part by the quality of physical structures, and in part by ownership conditions for any given site. Industrial and institutional properties are generally considered to be stable, while low-income rental housing areas are considered to be highly unstable, with other uses falling in between. Areas which are semi-unstable or unstable suggest possibilities for redevelopment or renewal, creating potential locations for functions other than residential in the process; these do not always occur in the center city, but can occur in outlying (but not remote) housing areas as well. The first input is a representation of the relative stability of urban functions, in which the index is a simple ordinal scale of values.

The second input, binary in nature, is determined from land ownership conditions also, but here the criterion is ownership of open space which is next in line for "annexation" to the urban area. Some lands are publicly owned; these will remain undeveloped insofar as this study is concerned. Other lands are privately owned; if accessible, these will provide the areas for future outward growth. If inaccessible, roads normally are built to link them to the urban system. An underlying assumption here is that services to the site can be built when the site is ready for development.

Socio-economic groupings are relevant to both models: in the first, they influence the location of individuals within the existing patterns; in the second, it is likely that suburban developments will maintain the socio-economic levels attained in existing developments at the edge. Lastly, population density is related to the first model, insofar as density conditions are a function of zoning, and as new development or rehabilitation must work within the zoning ordinances. For both socio-economic status and density of population information can be converted to ordinal scales.

Eight basic maps of factors affecting locational possibilities for any given urban area have been described. To summarize, these are as follows: urbanized area, land use stability, accessibility of shopping, accessibility of employment, accessibility of cultural or activity points, availability of open space, socio-economic groupings and population density. Each is developed as a sub-model, and in index or relative number terms; each is the result of research and qualitative judgments. There are two basic ways in which these can be fitted together to determine the probability of growth of the urban area. The first is written around the potential for the existing or currently developed urban area to support extensive further development through renewal, infilling, or change in zoning; this is termed "vertical" growth. The second, "horizontal" growth, is a consideration of the potential of the currently undeveloped peripheral land to provide new areas for residential development; it is primarily a function of the ownership and costs of acquisition of open space around the city. This study assumes that both forms of development are carried on conjunctively. The locus of areas which provide physical growth potential in the city is a function of vertical and horizontal growth phenomena linked with the preference of individuals in the city for the highest personal satisfaction measured subjectively as psychic rewards. The probability of future growth of the city as a whole is taken to be those areas estimated to provide the greatest amount of psychic reward to inhabitants on the basis of their personal needs or strivings.

The eight base functions can be combined mathematically in an infinite number of ways. A city is considered to be a spatial array of information in material form; every cell of area contains the eight indices of locational factors. Various combinations of the factors produce visual displays which describe the potential future growth areas of the city, for the set of input factors specified. The overall model of growth is static, or based upon conditions present in the city at a point in time; as such it provides an indication at any time of the growth trends present in the city. Only time can bear out the validity of this predictive device: at a second point in time, we can collect the same information and observe whether vertical and horizontal expansion has taken place as estimated from the first. It is possible, however, that the information gleaned from the initial study would provide planners with an indication of the needs of their constituents, and enable them to alter the future outcomes through concentration of efforts on those trends deemed inadequate, or those which deny certain classes a reasonable range of location possibilities.

In the next two sections two applications of this model of locational preference and future growth definition are presented.

PART III: THE RALEIGH STUDY. LOCATIONAL DETERMINANTS OF URBAN GROWTH

This project was conducted while acting as a critic and assistant to a studio in Urban Design at North Carolina State University from September to December, 1969. The brief in this instance was to formalize the approach to initial analysis of a city and to develop a framework from which a meaningful plan for physical growth and expansion could take place.

Raleigh, a city of approximately 100,000, provides a good study field for the pilot effort, for reasons of size, accessibility, and degree of urbanization. The entire urban area can be perceived and inventoried over a reasonably short period of time, and there is a good source of supplementary information available from the local planning agency. Moreover, two-dimensional documentation is substantial, up-to-date, and also readily available.

In this study, the approach to developing a land use inventory is through "windshield survey" and map analysis. The initial objective is to build an information base of maps from which diagnostics may be made to determine those areas of the city which offer potential for future growth or indicate a need for change. Changes are to be specified from observed deficiencies in the information. Every map would contain a single "bit" of information for every area covering the city and for a substantial portion of the outlying area as well.

Due to the availability of the SYMAP and GRID program,[16] the two-dimensional format of the study was adapted for submission to these programs. A map of Raleigh (1″ = 1 mile) was gridded off into 1/2″ increments, each of which was considered to be reasonably close to the size of the existing census tracts in the city. Where the census tracts are essentially irregular in shape, it was concluded that these were unimportant because the basic information was not to be highly dependent upon census information; conversely, where information was derived from the census, a "rounding-off" process was used to convert the census tracts into gridded form.

Raleigh has shown a pattern of growth which is essentially bi-directional over the past 20 years. Following the stimulus of a major shopping center, it has extended its urbanized residential area some 8 miles to the north, along former rural roads, adding low density, medium and high cost developer tracts to the urban fabric. This initial thrust has attracted other shopping centers, infilling with residential areas as much as available land would allow. The other direction, to the southwest and west, has not had the advantage of the shopping center stimulus, but evidence suggests these stimuli are emerging as the pressure for more and more residential area intensifies.

Perhaps due to heavy institutional ownership of land to the south, there has not been a noticeable trend of growth in this direction. Similarly, to the east, the total directional growth has been negligible, probably due to barriers in the form of socio-economic conditions in the more central areas and to the lack of clearly articulated transportation systems.

The major road network in Raleigh has had a pronounced effect on growth. The Beltline, not yet completely encircling the urban area, runs from the southwest across the north and terminates due west. It is scheduled for completion in the next decade; but, for the present, it has served only the two directions described as a growth stimulus. There are six major radial routes, two entering the city from the west, one from the northwest, one from the north, and one from the east. The south radial has only served as a locator for various industries and business enterprises which find it convenient to be located on a major road. To facilitate understanding of the physical layout of Raleigh, a skeleton roads system map is presented in Figure 2.

The first step in analysis of the Raleigh urban area was to develop the eight base functions described in the previous section. These base functions are then combined in eight study maps which aim at determining the likelihood or probability of future expansion on the basis of hypothesized relationships between base functions.

A. The Base Functions

1. Urbanized Land (See Fig. 3) This map contains 5 values which express the

16. SYMAP is a computer mapping program developed by the Laboratory for Computer Graphics, Harvard University, Cambridge, Massachusetts. GRID is a similar program developed by the same group.

degree to which the study area has been built up, with the lowest value represented by an asterisk (*), the lightest tone; and the highest by a "9", or the darkest tone. The degree of urbanization assumes stability of current land use, and is thus expressed as a percentage of the total area in each cell which has already been developed. The five figures represent quartile intervals, i.e., 0%, 25%, 50%, 75%, and 100%. Thus, where a "3" occurs in a grid cell, between 25% and 50% of the land has already been developed, but up to 75% may still be acquired and built upon, depending upon ownership and zoning constraints. Urbanized land is simply a description of the built-up area of Raleigh, abstracted from the land uses and zoning regulations which exist. It is a determinant of the potential for a given cell to support vertical (increased density) *or horizontal* (new site) *development.*

2. Land Use Stability (Fig. 4) Land Use Stability is essentially an index of the relative stability of a given land use. It is determined from an existing land use map, the age and physical condition of the structures in each use and the observed aesthetic quality of the physical development in that tract. Generally, certain land uses are more stable than others, such as institutions and buildings of government. Upper-income and middle-income housing is normally semi-stable to semi-unstable depending upon age and condition. Low grade commercial areas and absentee-ownership housing are semi-unstable, undergoing frequent changes of use, and other low-income housing is unstable. Outmoded factories are unstable, while producing industrial areas are semi-stable or highly stable.

The purpose of the land use stability map is to define the probability, an index, of a change in use or redevelopment, within the urbanized area, giving insight into the potential for vertical expansion of the city.

3. Proximity to Shopping (Fig. 5) This map represents an index of the distance-time relationship or relative accessibility of each cell in the urban area to shopping-intensive centers. It is developed by tracing the speed-constrained paths *from* each of 12 shopping areas along the major roads network and from there to the outermost edges of the study area. At the scale of the maps (1″ = approx. 1 mile), an individual can move 2 cells in one minute at 60 mph., 1 cell at 30 mph., one cell in 2 minutes at 15 mph., and so on. A circle with a radius whose length is determined by the level of shopping activity is drawn using each shopping center as a center respectively, defining the radius of catchment for that shopping center. A neighborhood grocery will have a small radius; a regional shopping center, a large radius; downtown Raleigh and North Hills and Cameron Village are the top shopping areas in the city. A household residing somewhere equidistant to these would therefore be considered to have excellent access to a variety of shopping areas and are represented by the darkest tones on the map.

4. Proximity to Employment (Fig. 6) Employment centers provide the same relative accessibility index as in Proximity to Shopping, but not necessarily with the same spatial distribution. Using 20 areas of intensive employment, such as N. C. State University, the Fayetteville Street area of downtown, the government complex, the Downtown Boulevard industrial "wedge", the index was again determined using radii of catchment and time-distance relationships. Comparison of figures 5 and 6 demonstrate that there are substantial differences in the spatial distribution of areas with good shopping proximity and those with good employment proximity.

5. Open Space Availability (Fig. 7) This map identifies lands which are owned by institutions or the public, and effectively removes them from the real estate market. Building on information from the Urbanized Land map, the function attempts to identify all areas in which some open space undeveloped land remains available for future development. Some cells contain development—these still offer potential for development in the following degree, stability of land use held constant: 0%, 33%, 67%, and 100%. On the map, the lightest tones represent public owned, non-available lands, while the progressively darker tones represent degrees of availability. Comparison with figures 2 and 3 demonstrate the effect of publicly owned land on the potential location of sites for development outside of and on the edge of the existing urban area.

6. Major Points Accessibility (Fig. 8) In this map 30 major attraction points, such as activity centers for social, cultural, or recreational pursuits, were identified, and these points were linked to the major roads network using a time-distance parameter. The accessibility of any cell on the map is therefore determined by ease of access to the major network and, thence, to all of the set of major activity points, using shortest time or distance as a path determinant. Once again, the values are calculated as an index in which the number represents the relative amount of time to move from any cell to all major points. The range is from 14 to 90 with 96 being an assigned value to those cells in which there are no means of vehicular access available represented by the darkest tones.

7. Socio-Economic Groupings (Fig. 9) This map is determined by census and demographic information, though no information on incomes, either per capita or per household, was available. For this reason, the standard classification scheme, levels of income, has not been used; but an estimation of the value of houses on the real estate market has been used as a surrogate measure. This was acquired from the Real Estate Brokers' Multiple Listing Service for 200 houses picked from the listing, ordered in value from $9,000 to $74,000; the location of each was pinpointed on a map. From visual reconnaisance it was verified that groupings of houses within a given value range do occur, and from this socio-economic status levels were inferred. On the map the darker tones represent undeveloped land, while five levels of socio-economic status are represented with the asterisk (*) representing the lowest class and the number 4 representing the highest. These classes correspond roughly to value ranges for houses in each cell.

8. Population Density (Fig. 10) Using census and demographic sources, population density arranges relative values from 1 to 10 in which the actual density ranges from no dwelling units per acre to 20, the maximum allowed in the zoning ordinance. There are some cases where the value exceeds 20, but the scale of the study is too gross to include these isolated examples.

These are the eight base functions. The computer program is written so that the values for any map can be combined algebraically with those of any other, retaining the format of the array in the process. In the course of the study, I attempted over 50 such combinations, striving to use the two basic types of growth, vertical and horizontal, as a guide. Eight of the more meaningful combinations are presented here.

B. Combination Maps

For each map an equation is required which algebraically combines base functions into more meaningful arrays of data. In each map efforts have been concentrated on relating combinations to subjectively predictive "pictures" of the potential for future growth of the urban area. For each picture I will describe the producing equation and, for the sake of brevity, summarize the anticipated result. The eight base functions have been assigned the following mathematical notation for convenience.

U_{ij} = Urbanized Land Index

L_{ij} = Land Use Stability Index

Ps_{ij} = Proximity to Shopping Areas

Pe_{ij} = Proximity to Employment Areas

O_{ij} = Open Space Availability Index

A_{ij} Major Points Accessibility Index

G_{ij} = Socio-economic Groupings

D_{ij} = Population Density

1. Vertical Growth I (Fig. 11):

$$V_{ij} + L_{ij}$$

This map combined urbanized land and stability of the current land use to determine the potential of urban areas to sustain or support future growth development. Unstable areas will redevelop, while stable areas will remain. On the map, the darkest areas are most stable, while the lightest areas are unstable. Areas marked with a asterisk(*) are not urbanized. The map suggests that future vertical growth will take place largely around the edges, but some centralized areas south and west of Fayetteville Street are capable of future growth.

2. Vertical Growth II (Fig. 12):

$$[Ps_{ij} + Pe_{ij}] \times A_{ij}$$

Here I combined the two proximity functions with the major points accessibility index to determine the attractiveness of locations on the basis of their general access to jobs and shops. The range of values on the map is from 1 to 5, the darkest values being attributed to technical errors. Areas designated by asterisks are outside the urban area; values of 1 represent high accessibility to jobs and shops; values of 4 represent diminished accessibility. The indication from this map is the potential for a new large scale shopping center in the southeastern quadrant of the city, and accessibility could be increased by upgrading the major roads network in this sector.

3. Horizontal Growth I (Fig. 13):

$$O_{ij} \div A_{ij}$$

Specifically, this model represents the combination of available open space with major points accessibility, where the closest "available" cells would have the highest degree of accessibility, and, thus, be most attractive for location. Due to some technical errors arising from the incompatibility of the two indices in their present form, the results are difficult to interpret. But from the edge of the urban area, results are valid (see line drawn on the map). Darker areas are most attractive, while lighter areas are too distant or unaccessible or even unavailable. The indication is, once again, that Raleigh has a considerable amount of land at certain specific edges which will present opportunities for future development. With some changes in the roads system, this picture could be considerably altered; for example, extension of the Beltline across the southern half of the city would open up a large market in real estate in the Lake Wheeler and Lake Benson areas.

4. Vertical Growth III (Fig. 14):

$$Ps_{ij} + Pe_{ij} + [D_{ij} \times A_{ij}]$$

to Vertical Growth II with the primary difference that of the inclusion of Population Density. The hope was to see if numbers of people exerted any changes in the first formulation. The same ranges apply, and comparison suggests that the conclusions remain the same as in the first effort. Density simply refines the result, making the outcome preferable as a combination to figure 12.

5. *Combined Growth (Fig. 15):*

$$\frac{[P_{sij} + P_{eij} + O_{ij}]}{[U_{ij} + L_{ij}]}$$

This model represents an effort to combine effects of vertical and horizontal growth. Proximity to shopping and employment areas is linked to available open space, conditioned by stability of urbanized land. Two significant effects result: first, the attractiveness of areas adjacent to the southern half of the city is pronounced; and increased accessibility should cause these areas to develop rapidly. Second, areas designated by the asterisk(*) may not develop due to ownership conditions. Of all other areas, designated 1 and 2, values of 1 represent areas which are most likely to develop further, both inside the city and outside.

6. *Vertical Growth IV (Fig. 16):*

$$D_{ij} + A_{ij}$$

The effort here was directed toward determining numbers and spatial dispersion of people who have good or bad accessibility to major points in the city by virtue of their specific location and the roads network. Curiously in this map, the accessibility index caused some quirks in the results, due to faculty programming and formulation. But the interpretation is as follows: Values of 1 and 2 on the road network have good access but low-density population. Values of 3 through 8 inside the city limits have high densities and excellent access, while similar values outside the city have moderate densities but poor access. In the map the results are somewhat nebulous due to incompatibilities in the index values. But the indication is that general patterns of accessibility can be increased for large numbers of residents living in low-density areas outside the city. Further, future roads development policy should be based on an objective of servicing the largest numbers of inhabitants currently living in disadvantaged access areas.

7. *Horizontal Growth II (Fig. 17):*

$$G_{ij} \div A_{ij}$$

This map describes the locations in the outer area of unoccupied land which should be attractive to the various socio-economic groups. Tones inside the urbanized area are meaningless and should be disregarded. The higher values represent the higher income groups, where current trends indicate costs of land will increase due to the status of residents in adjacent developments. The more remote lands will be attractive to low-income residents due to lower costs; this is paradoxical because their means of personal mobility is limited. In any case, the lower values occur less frequently, due to the smaller numbers of lower class inhabitants of Raleigh. This trend can be reduced by policies of income redistribution, mass transport, and price stabilization in the real estate market through FHA and rent subsidy programs.

8. *Horizontal Growth III (Fig. 18):*

$$O_{ij} + A_{ij}$$

18) Similar to figure 12, this model is perhaps the most telling of the horizontal growth models, overcoming the technical deficiency described in the first attempt. The darkest values (9) are currently inaccessible, while the rest of the values are concentrically contoured outward from the center of the city. The bulk of available land which is reasonably accessible is concentrated in the southern half of the city, supporting the view that development in these areas is imminent. Even so, with radical changes in the roads system, the overall trend is toward concentric growth in the city. Once the effect of accessibility change abates, the phenomenon of concentric growth will probably resume.

C. Analysis and Conclusions

In spite of the technical errors evidenced in the combined models, it is clear from certain combinations that further formulation is necessary to adequately define the relationships between the base functions. The base functions constitute a reasonable way of organizing the factors of location so that they can be used as an instrument of description and of prediction. Problems exist in deriving the indices, but this can be model. The organizing model (fig. 1) might also be subject to change; this too is being studied.

The importance of this exercise lies in the attempt to place the emphasis on qualitative aspects of individual preference for certain relationships which exist, but are not always maximal, in the urban environment. It appears that inclusion of the preferences of individuals can, and sometimes does, play an important role in contributing to the physical planning of urban facilities and their arrangements. Location possibilities are currently manipulated by planners with very little attention to the personal nature of choice. One question which arises is whether it is possible to maximize choice and resultant psychic rewards for all inhabitants of the city. If plans were developed with such psychic returns as a prime objective, future development outcomes might improve the choice of locations to individuals.

From the preceding analysis, several observations might be made relevant to future studies of this nature. First, the study is largely descriptive, although it aims at predictivity. Suggestions for development policy arising from the combination models could be implemented, and after five or ten years, the effects observed by repeating the initial data collection process. It would then be possible to determine if the implementation of the policy had the desired growth effects. There is an advantage to be gained from the data collection procedure: it is quick, and can be carried out by an individual working over short periods of time; and much of the index materials come from map analysis and from basic census material. There is also an advantage to be gained in looking at the city and its surrounding area or hinterland as a whole rather than by individual areas in greater detail. Much wasteful time can be spent in analyzing areas which do not require concentrated efforts. The problems of some areas can be solved by measures designed to improve the operation of city-wide systems; conversely, analysis of city-wide systems often indicates large-scale problems of smaller areas which cannot be perceived at the local level.

At the scale of this study, only rough decisions can be made regarding requirements for future development. Clues to needs can be found at such a scale, but these clues should dictate a more intensive study of social and physical conditions which prevail. Certainly more detailed study of the southern areas of Raleigh is warranted to effectively and efficiently plan its growth. Since this growth trend is indicated by the study, it would be advantageous for planners to develop a detailed plan for the physical and social development of that area before it develops in the sprawling hodgepodge fashion of recent growth in cities. Certainly in the process of planning it would be possible to include some forms of development which maximize social and environmental rewards.

Most of the location factors as presented can be designed for. Employment areas and shopping areas are spatial effects; should they occur randomly as happens in the world of private development, or should they be concentrated to afford easy access and convenience to users? Although much of the available open space will ultimately go into the private development sector, should cities begin to acquire parts of these areas to assure a plentiful amount of amenity recreation space for future areas of development? What are the implications for certain social groups of increased accessibility—will a new freeway improve or destroy the living styles of lower classes who may never be able to benefit from increased access due to limits on transportation? These questions, and others, arise through the concept of psychic rewards. And yet most such rewards are carefully monitored by public policy. Alterations in policies toward physical development and the allocation of resources have substantial implications for the increasing of such rewards to all citizens.

Hopefully, a more cautious approach toward location of facilities, in terms of maximum economic efficiency, which includes some measures of psychic returns, will be a trend of planning in the future. Vertical growth in cities should aim at improving the quality of life, not for the daily users of the central areas, but for those who live in poverty within walking distance. Horizontal growth should be carefully structured so that 25 or 50 years from now we have some land left to enjoy. The location of physical facilities must follow some optimal rules; these rules are of the utmost importance when we realize that the resulting patterns of development might create an environment that twice as many people will have to live in and derive their psychic rewards. The primary conclusion of this study is the need for careful monitoring and structuring of the physical development of Raleigh to conform to societal goals of which psychic rewards are an essential right.

PART IV: THE LONDON STUDY, LOCATIONAL DETERMINANTS FOR METROPOLITAN HIGHWAYS.

This project was conducted over a period of approximately six months while working at the Greater London Council, London, England. The specific brief was to determine factors which affect the locations of highways in densely developed urban areas. Policy toward location had seemingly been approached at the wrong scale, and had been derived from policies such as "location in open spaces has a high priority."[17] Early in the study we decided that if one views change in urban areas as being integrative rather than adaptive, such a priority system would result in loss of open and recreation spaces which are essential to man's survival in high density situations.

The problem thus became one of examining the physical potential of the built environment to find areas in which change might prove to be a catalyst for upgrading the overall environment while reducing the impact of major highways on existing development. This shift in emphasis necessitated a reexamination of the inputs to studies of highway location in the GLC to determine if a new set of environmental priorities could be established.

Definition of pertinent and available data required about four weeks; supplementary data was acquired from "windshield survey", requiring about four more weeks. Graphic analysis and synthesis required the major portion of remaining time, while appropriate allocation was retained for changeover to comparison studies. The study was conducted in South London, in a study area of about 20 square miles or, specifically, 36 square kilometers. Comparison studies took place in selected parts of London, with the specific intent of reexamining and subsequently, rejustifying the location of the Motorway Box, an urban ring road, along its entire proposed route.

17. From an article in the LONDON EVENING STANDARD, which described the factors which determined the location policy for such highways, notably, the Motorway Box. The article was aimed at reducing the fears of the populace, which were generated by announcements of large numbers of displaced families as a result of the new development proposal.

As the particular study was a pilot study, there are present in it some minor changes from the proceeding theory—this is largely due to inappropriate chronology, and to expansion of the study after the pilot activities.

A. Environmental Factors of Location of Primary Routes and Motorways

This study was an analysis of urban design aspects that should be considered in the urban motorway program. It consisted of a broad statement of the techniques used at both the policy and design levels in determination of motorway or primary route alignment locations. It was important that environmental criteria be introduced in the study at a broad strategic level, and be carried through subsequent stages; therefore, the stage sequence serves as a structure for developing appropriate studies of locational determinants for highway locations in any situation.

The object of the technique was to determine those factors which affect and determine the receptivity or non-receptivity of urban areas to motorway development; specific policies toward location were defined to establish enabling and deterring criteria of highway receptivity. Reconnaissance maps and statistics of various conditions in the study area form the basis of the technique; the following information maps were considered necessary:

1. Environmental Quality
2. Activity Intensity
3. Landscape Amenity
4. Identity Areas
5. Communications Systems
6. Accessibility Areas
7. Planning Commitments

These survey maps were combined and superimposed using a graphic analysis and synthesis technique: areas in which there were no objections to motorway development on the basis of synthesis of the seven information maps were termed "receptive", and, conversely, areas in which there were many objections are termed "non-receptive". The receptive area was converted into a corridor within which it would be most logical to locate a proposed motorway link. It was anticipated that this corridor would provide an area in which many alignments are possible and feasible; it was also anticipated that more detailed studies within the corridor would be required to determine the best "engineered" alignment. The function of this study was to eliminate time-consuming analysis of unlikely alignments, by using the physical and visual amenity of the environment as a primary determinant.

Areas of receptivity can be defined on the basis of purely subjective information unless sources permit analysis of more objective information instead. In order to produce a reasonable result over a short period of time, emphasis was concentrated on simple methods for quantifying. The location of corridors was based upon analysis of receptivity; more detailed decisions may be based upon more thorough evaluation studies of receptive areas.

Context studies made at several levels of consideration are required for deciding motorway locations, since criteria justifying a regional link will differ significantly from those justifying links between sub-centers in urban areas. To serve or link two predetermined points in geographic space, an infinite number of alignments are possible; knowledge that a motorway is to traverse a given area should indicate the need for a set of studies to isolate reasons for or against any given alignment.

If essential factors are ignored at one scale, their absence becomes increasingly noticeable at subsequent levels. Each level of consideration requires a different operational technique and procedure for design, assessment, and evaluation. Once defined, such techniques will yield a systematically comprehensive treatment of problems of motorway location—one which is sensitive to factors of location at each level. To test this hypothesis, techniques must be designed and applied for the coordination of information utilized at each of the levels described below. This study is an amplification of one such technique made under "Metropolitan Analysis."

Regional Analysis The need to reduce cross-city traffic impact on the central area, and to ease point-to-point movement within the city strongly suggested the creation of a motorway system around London based upon the concept of three concentric rings connected to other urban areas by radial routes. This 'concentrics and radials' theory resulted from considerations of needs, and from construction of a hypothetical geometry, or the application of information to pattern, and led to a generally accepted concept for the primary roads system in London. (This concept has been altered since its first presentation.) Regional criteria considered at this broad level should establish the general concept of the motorway network, points of interchange, and the areas and localities it is to serve.

Metropolitan Analysis The second level of consideration implemented a generalized scheme established under Regional Analysis to define subregional areas where the motorway can be located. Selecting two points from among designated interchange points, it was the objective of this study to define a 'corridor' of land suitable for motorway development. Such a corridor need not be continuous, nor of a fixed dimensional width, but it should clearly demonstrate areas of receptivity without suggesting a preferred or exact alignment. It should also indicate areas in which a more detailed assessment of the physical and environmental conditions is necessary.

Urban Analysis The urban level of consideration was a more detailed survey and analysis of the corridor. It was devised to bring levels of detail into consistency with scales of consideration, and to suggest alternative 'strip' routes. It should combine information concerning social, physical, and fabric study factors within the corridor, with the primary objective that of establishing a preferred alignment. Criteria for decision-making can be based upon visual assessment and survey, demographic, and statistical data. In order to develop a comprehensive understanding of the character, amenities, and conflicts of the study area, information was structured and manipulated to clarify criteria and produce useful "insight" into relevant relationships. Suggestion of a strip does not imply a rigid, fixed alignment; the precise route can be determined from detailed engineering studies.

These studies should develop a strip location by making a detailed assessment of impact on smaller scale areas. Impact assessments should be carried out along the entire corridor suggested at this level. Efforts should be directed at resolution of environmental, social, physical, financial, psychological, and functional factors which affect final locational decisions.

When completed, these studies should present one clear alternative—a fixed alignment—which represents the best interests for study area, motorway location, and urban design objectives.

Architectural and Engineering Analysis At the final level of consideration, architects and engineers take over an alignment fixed by the previous levels, and convert it into design, working drawings, and contracts. Studies made at this level should conform to the brief as established by planning, urban design, highway planning, and valuation. Changes to the program should be incorporated speedily and efficiently, so as not to slow the progress of design development.

Summary

Regional Analysis *establishes general locations and points of interchange, relating these to regional need.*

Metropolitan Analysis *takes the points and locations, and determines corridors of receptivity requiring further and more detailed analysis of alignment and interchange.*

Urban Analysis *examines alternatives within the corridor and determines a preferred alignment, examines the impact of this alignment at the local level, establishes receptivity, and firmly fixes the alignment.*

Architectural and Engineering Analysis *develops the physical design, drafts the working drawings, and administrates the construction phase of the project.*

It should be noted that this sequence was not to be restricted to motorway or primary roads; any roads improvement scheme should fit into the structuring sequence with reasonable ease.

B. The Study Area

Having established the broad conceptual framework, the pilot study undertook to develop a technique for metropolitan analysis: the Streatham Vale (A23) to Southend (Lewisham, A21) section of 'Ringway 2' was chosen because the two intersection points had been precisely located, but the alignment between them was undetermined (Fig. 19). The study aimed at demonstrating possible corridors of land receptive to motorway development, rather than specific routes. The study area was defined on a base map (ordinance survey) allowing consideration of any possible route location area between the two points.

At this stage, techniques involved study of land use, general urban fabric, communications and accessibility and physical structure. Observations of relationships between these factors yield substantive and subjective assessments of environmental quality and content. The study was conducted at the Metropolitan Analysis stage, with the objective that of determining the strip location within a corridor of feasible or receptive locations.

C. Information and Filtration

A series of filter maps were drawn from each of the survey information base maps, based upon positive or negative estimation of the effect of the motorway upon the existing environment, thus abstracting areas of receptivity and non-receptivity.

The method was dictated partly by the immediate limits of available sources and time within which decisions must be made. Therefore the study aims at a high level of information quality, but a low level of detail. There was no attempt to provide an exhaustive search into sources, as the main objective of the study is to develop a technique for converting the information into a potential locations corridor.

Following is a discussion of the filter information, and "rules" determining receptivity on each of the six filter maps.

Map No. 1: Assessment of Environmental Quality (Figs. 20, 21) The objective was to define good environmental areas in terms of identifiable factors perceived in the area studied. A 'good' environmental area was defined as one in which there is a pleasant atmosphere or character, combined with neatness of landscape, building form, space sequence, and planting. A 'bad' environmental area was defined as one in which there is an unpleasant character, combining factors of dereliction, dilapidation, poor environmental conditions, and elements of visual intrusion. Quantified weights assigned to various conditions depended heavily upon intuition and visual perception during reconnaissance.

The assessments were made from visual reconnaissance (windshield survey), searching for indicators or "signals" of quality in an attempt to objectify an extremely intuitive subject. It is possible to assess relative quality of an area by the presence of elements considered "good" or "bad" and to assign values to areas on the basis of such assessments. The "signals" were conceived of as a series of easily recognizable indicators of environmental conditions in a given area. Examples might be rubbish or litter, unkept yards, and dilapidated buildings on the negative side; and nice gardens, well painted trim on houses, and good relationships between land use functions on the positive side.

Evaluation or assessment resulted in a scale of "quality values" ranging from 1 for lowest quality, to 5 for highest. On the maps these are interpreted in tone contours, using white for lowest quality, through black for highest. In simple terms, the grading was based on the following magnitude scale.

MAGNITUDE QUALITY CHARACTER

1 . . . *Poor environmental area; indicators of dereliction, monotony, lack of attractiveness, poor land use relationships; area requiring redevelopment to renew the total environment.*

2 . . . *Fair environmental area, quality on downgrade; requiring face-lifting, rehabilitation to retrieve original quality.*

3 . . . *No distinguishing characteristics, no sign of active deterioration or downgrading, no sign of positive elements; or a balance of both.*

4 . . . *Good environmental character; some negative factors intruding; overall positive quality.*

5 . . . *Excellent environmental quality; mostly positive quality elements; no negative elements.*

From the five magnitudes of environmental quality, estimations were made relating the quality magnitude of an area to its receptivity to motorway development. The following policy toward location was derived from studies of environmental quality:

1. Avoid high quality (magnitudes 3, 4, 5) environmental areas; they are not receptive to highway location.

2. Low quality areas are considered receptive and warrant total renewal consideration.

3. Middle quality areas may accept motorway development; care must be taken to minimize intrusion and disruption in such areas.

4. Design highway locations to reinforce or upgrade environmental quality in low magnitude areas.

Map No. 2: Activity Areas (Figs. 22, 23)
This study defined areas where there is a recognizable level of activity, distinguishing between those types of specialty or seasonal activities, and those where there is always some recognizable level or intensity.

Activity levels that reflect busy environmental areas were considered to be highly sensitive to the effects of motorway location. Areas which attract people for various activities were considered worth maintaining as areas for human contact, in which the present level of congestion should be reduced to allow such contact to take place freely. Areas of activity conflict were keyed as areas requiring special attention; in some cases, motorway location can be combined with other development proposals to alleviate conflict conditions. Where activity levels were low or non-existent, there may be undefinable factors contributing to absence of community spirit, pride, and responsibility.

A broad study of activity levels and generators was considered essential, and because of social conditions that might be involved, results were interpreted carefully to determine the nature, type, and time of activity. Urban activity areas usually contribute strongly to the character of an area, and help to define community and physical structure.

In order to make a rapid assessment, calibrations and detailed counting methods were not utilized. Areas were assessed by observation and inference, and the intensity, type, and quality of activity were noted. The assessment magnitudes of perceived activities were made as follows:

MAGNITUDE CONDITIONS AND TYPE OF ACTIVITY

1 *Heavy traffic congestion; heavy pedestrian activity; concentrated commercial or industrial outlets; main shopping areas; high noise levels.*

2 *Moderate traffic; moderate pedestrian activity; shopping areas, com-*

mercial areas, business areas; constant noise levels.

3 *Light traffic; moderate pedestrian activity; local area shops, businesses; no unusual noice problems.*

4 *No perceptible acvitity; residential areas closed to through traffic; no noice.*

Activity restricted to special times of the day or week, operating at various levels of magnitude; parks, open spaces, recreational spaces, schools, hospitals, rail stations, etc.

From these magnitudes decisions relating activity intensity to motorway locations were based upon the following set of policies:

1. Avoid central area activities, or areas with a perceptible level of activity due to a clustering of activity generators, such as shopping center, civic centers, etc.; they are not receptive to motorway location.

2. Avoid specialized local activity generators and public facilities such as hospitals, schools, churches.

3. Avoid amenity areas used part-time such as recreation grounds, parks, open spaces.

4. Locate access/egress points to influence existing activity areas positively, avoiding further disruptance.

5. Avoid quiet areas of residential quality, and areas where there might be a disruptive effect on an otherwise low activity area.

Map No. 3: Topographic and Open Space (Figs. 24, 25) In this section, information was gathered on the distribution of landscape elements without attempting to assess the quality of the elements, as this was included in the environmental quality study. Generally, policy toward retention and provision of open spaces and landscape amenity was guided by our feeling that open spaces are essential as urban features and should be retained wherever possible in a highly urbanized setting.

Motorway-sensitive areas were determined by open spaces of positive character, topographical changes affording experiential variety, woodlands and water areas. The landscape of open areas of poor quality, such as areas in which there are allotment gardens (open space parceled out to private gardeners), sewage plants and outfalls, etc., are not adversely affected by motorway location. The motorway should be integrated into the landscape as a positive redesign element, forcing areas of lower quality to redevelop positively, and avoiding landscape areas of high quality. It should have built-in or natural features alongside to maintain a driver's interest without distracting. Open space amenity areas and viewpoints should be used to best advantage, and wherever possible, alignment should avoid land use areas which cannot be replaced or renewed or which are essential to public recreation and relaxation.

Map No. 4: Community Identity (Figs. 26, 27) The objective of this study was to develop a method for distinguishing between areas which have a sense of 'identity', and for defining the boundaries of such areas. Since major routes tend to define 'environmental areas'[18] motorway location can have a disruptive effect on existing community structure. Suggestions for location may break up areas where there is a strong sense of identity, or may be structured to create new 'identity areas'.

The concept of 'identity areas' may bear some relationship to Buchanan's 'environmental areas', but Buchanan admits to lacking one of the fundamental ideas implied by identity when he says, "No sociological content is implied in this concept. . . ." Lynch appears to be much closer to the intended meaning:

By appearing as a remarkable and well-knit place, the city (or its parts, in the case of a city-region or large urban agglomeration) could provide a ground for the clustering and organization of these meanings and associations. Such a sense of place enhances every human activity that occurs there, and encourages the deposit of a memory trace.[19] *(parentheses added)*

The process of constructing an 'image of places' in a given area may provide an important clue to social structuring in the area. It should be possible to define sub-areas in which there is a sense of place as determined by nodes, views, topography, parks, housing areas, etc. A sense of place, or identity, may be fostered in a given area by attachments to the name of the place, such as "Mayfair", "Soho", or "Broadway" and the relative importance of, and hence the degree of which a place has an identity, may depend upon how well it is known both inside and outside its surrounding area. Often such an 'identity area' has undefined and intangible boundaries.

In the pilot study, information was obtained from visual survey and ordinance survey maps. Although subjective assessments may prove to be unreliable and thus unrealistic, it seemed to establish boundaries and barriers that contribute physically to define areas

18. Buchanan, Sir Colin, TRAFFIC IN TOWNS. Her Majesty's Stationery Office, London, 1963.

19. Lynch, Kevin: THE IMAGE OF THE CITY. MIT Press, Cambridge, Massachusetts, 1960.

with a sense of place. Factors such as patterns of topography, grain, streets, and planting were noted during reconnaissance survey. Other factors such as grouping (social if possible), proportion, elements of 'place' and name association, were also examined in the search for environmental divisions.

An estimation of 'environmental identity' was made on the basis of visual survey, and verified against ordinance and aerial survey maps, then verified again by re-survey. The information can only reflect existing conditions and is not to be interpreted as more than a "sketch" social indicator. It is possible that studies of social activity might be linked to "sense of place" studies to indicate the presence of community identity.

Motorway location can be used as positive influence on identity areas and community structure, and may be useful in re-structuring community boundaries to create areas with cohesive identity. Re-structuring is not conceived as the sole operation; in order to create identity areas it should be linked to comprehensive development schemes and long range plans.

In the pilot study, 'Crystal Palace' announces the place regionally, while locally, Upper Norwood is the best example of place identity, probably due to its unique geographical condition. South Norwood, Streatham Vale, Elmers End, Anerley, and Southend have decreasing degrees of perceptible identity. Decisions relating identity areas to motorway location were based upon the following policies:

1. Avoid areas with well-defined identity boundaries which might be disrupted by motorway location.

2. Areas with no tangible or perceivable identity should be considered receptive, development should strive to create identity areas in new proposals.

3. Treat areas where there is potential for creation of identity areas, or a sense of place, in the design brief. These areas should be safeguarded from disruption through motorway location.

Map No. 5: Communications (Transportation Systems) (Figs. 28, 29) This study had a twofold object: first, to provide a picture of the existing communications structure of the survey area, and second, to provide information pertaining to a study of accessibility. The existing structure was likely to be a relevant factor, since the new motorway would become a part of the communications system. Existing rail lines and roads were expected to influence alignment proposals. Most existing primary roads produce barriers due to congestion, and in general railways produce both noise and visual conditions which could be modified positively through design.

In certain areas, railway lines have produced a pattern that is highly receptive to linear design (such as motorways), but in considering these lines as receptive, care must be taken to prevent intensification of an existing negative condition, such as uninterrupted linear elements. At every level of design there are likely to be problems of amplification, for example, direct egress from the C-ring to the present A23 road would produce an increase over present traffic loads, resulting in unbearable environmental conditions of congestion.

Decisions relating communications to location were guided by these policies:

1. Existing railway lines provide an opportunity to locate motorways because of provided breaks in the urban pattern.

2. Avoid existing communications congestion areas; alleviate congestion through design developments if possible.

Map No. 6: Accessibility (Figs. 30, 31) The basis for this study was the initial assumption that accessibility to public transport systems can be directly affected by a motorway barrier. In a country where private car ownership is low, accessibility to public transport is a critical problem. This assumption produced a secondary assumption: that of a relationship between accessibility and environmental quality. It may be possible to define non-receptive areas as those in which accessibility to the various transport systems modes is limited.

In the pilot study, all parts of the study area were served equally well by bus services, so measurement was confined to the rail services in the area, and the accessibility through these services to other centers, such as Central London, Croydon, etc. Local accessibility was assumed to be constant, and of high quality.

Accessibility areas were drawn up using a time-distance scale. A walking radius of one-half mile was regarded as reasonable for catchment areas from local stations; areas which were not in such catchment areas were considered inaccessible. Any area served by two or more services was rated high in accessibility.

D. Graphic Analysis and Synthesis

These study maps were combined using a "sieve" process involving graphic analysis and synthesis. Areas defined as receptive were established using policy guidelines and the areas so defined were drawn onto overlay maps, called 'filters'. For each study map, the filter map defines areas which are receptive to motorway location for that study only. The six resulting filter maps were then superimposed, and a map showing contours of receptivity was drawn. This map is made up of six contoured tones, each representing the number of filtered objections or degrees of receptivity by area. Tones on this map represent non-receptive (dark) to receptive (light). Thus graphic synthesis of the six filter maps resulted in a single map of receptivity contours, indicating those sub-areas in the study area that are most suitable for motorway (and urban design) location (Figs. 32, 33, 34).

As a historical note, the Greater London Council later voted to accept the recommended "strip" location determined by this process. The Council recognized that the most important single consideration in determining locations of major highways in urban areas is that of impact on and disruption to the physical environment. It also recognized the need for development of techniques which insert environmental considerations into the process of deciding highway locations, and stimulated a series of re-evaluations of motorway proposals which had not yet reached the implementation stage to examine the environmental impact. The pilot study was used to verify a portion of the Motorway Box proposal, but no major alignment alteration was made.

The effectiveness of the study can be judged in these terms. The intuitive nature of the study came under fire from rational (cost-benefit) process advocates, but as a tool for determining highway locations the study was considered valid. Some of the more judgmental criteria might be made more explicit and sophisticated, but the relatively intuitive examination of locational factors seemed to be compatible with the need for environmental determinism at the level of Metropolitan Analysis.

PART V: CONCLUSION

The major differences between the London and Raleigh studies arise in the technique used for analysis and in the locational objectives of each study. Where the London study is essentially a manual process, it aims for a very specific conclusion, and the relation between the determinants is also made specific. The Raleigh study is more an exploratory model, which enables the user to specify in advance the relationship between the determinants, and to search for problems using a trial and error approach. Both models are descriptive, but the London study describes a static equilibrium state, while the Raleigh study seeks to allow for a more versatile, dynamic, and non-equilibrium state.

Since the computer program was not used in the London study, comparison is made difficult; but the potential for the study to utilize the program is implicit. The GRID program allows a considerable flexibility in manipulating data, since factors can be combined algebraically at the user's discretion. The next stage of this type of study would be the development of weight coefficients for each of the location determinants. This would be achieved through several means, such as correlation analysis, regression analysis, or factor analysis. The research can also be extended to include other environmental determinants and constraints as they emerge.

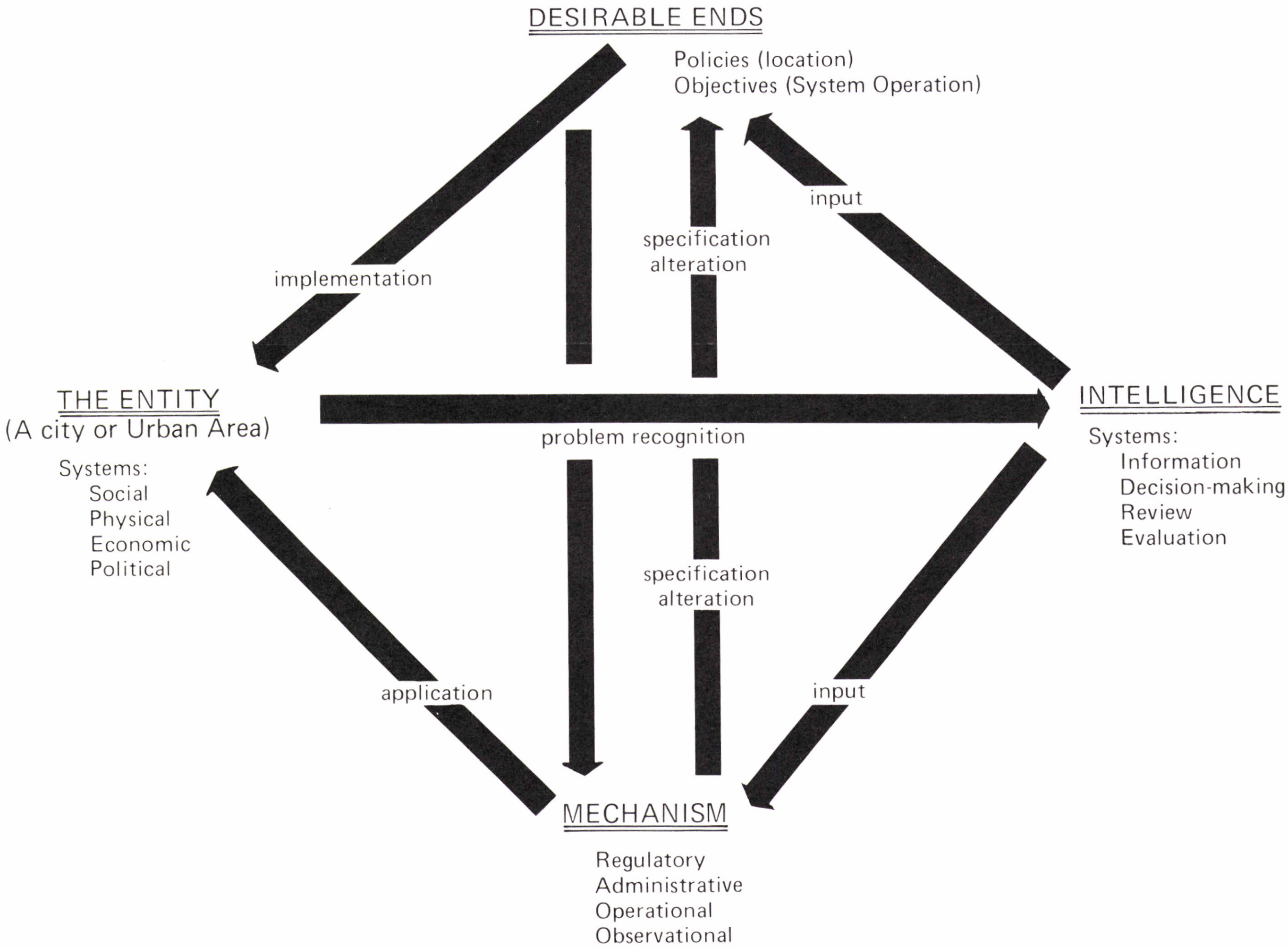
Both models contain potential for conversion to more sophisticated mathematical formulation, but the advantage of the simplistic approach described in this paper is primarily ease of application and utilization. Physical principles, such as mass-balance equations, and conservation of mass are easily applied, given a series of observations for each factor over time.

The most fruitful area for future application of the concept appears to be that of the study of the impact of development on the social, physical and economic systems of which urban areas are constituted. Varying the scale of the analysis of urban areas offers a basis for studying smaller areas (i.e., neighborhoods) or larger areas (i.e., regions) at will. The model appears to work best when used to determine the location and impact of a single function, such as a highway, a low-income housing project, or a shopping center. Its versatility, functionally, is dependent upon the modeler's ability to conceptualize the system being modeled, to define the relevant factors of location (which vary according to the specific land use function), and to establish meaningful and relevant relationships between the factors. Once these parameters are defined, the system should accept any constraints placed on it by the user.

Figure 1a: Organizational Context

Order of Flow:

$$\begin{tikzcd}[column sep=small, row sep=small]
 & b_1 \arrow[r] & c_1 \arrow[r] & d_1 \arrow[dr] & \\
\text{(the entity)}\ \underline{a} \arrow[ur] \arrow[dr] & & & & \underline{e}\ \text{(Change)} \\
 & b_2 \arrow[r] & c_2 \arrow[r] & d_2 \arrow[ur] &
\end{tikzcd}$$



After G. H. Hemmens,
Metropolitan Analysis

Figure 1b: Organizational Flow (Processual)

Identification

Affecting Factors

Policy Specification

Determining of Feasible Locations

Selection of the Appropriate Location

Figure 1c: Information Requirements (Intelligence)

Identify:

Function to be located

Factors Affecting Location

1. Environmental Amenity
   - Appearance and Visual Quality
   - Physical Conditions
2. Activity Systems
   - Intensity
   - Type
3. Physical Constraints
   - Topography
   - Soils
4. Statutory Constraints
   - Protected Lands
   - Historic Areas
   - Regulatory Controls
5. Community Identity
   - Contiguous Social Areas
   - Homogeneous Developed Areas
   - Imageable Areas
6. Communications (Facilities)
   - Railroads System
   - Roads System
7. Accessibility (Time - Distance)
   - Proximity to Shops
   - Proximity to Employment
   - Availability of Communications
   - Proximity to Institutions

Determine:

Factor Locations Policies

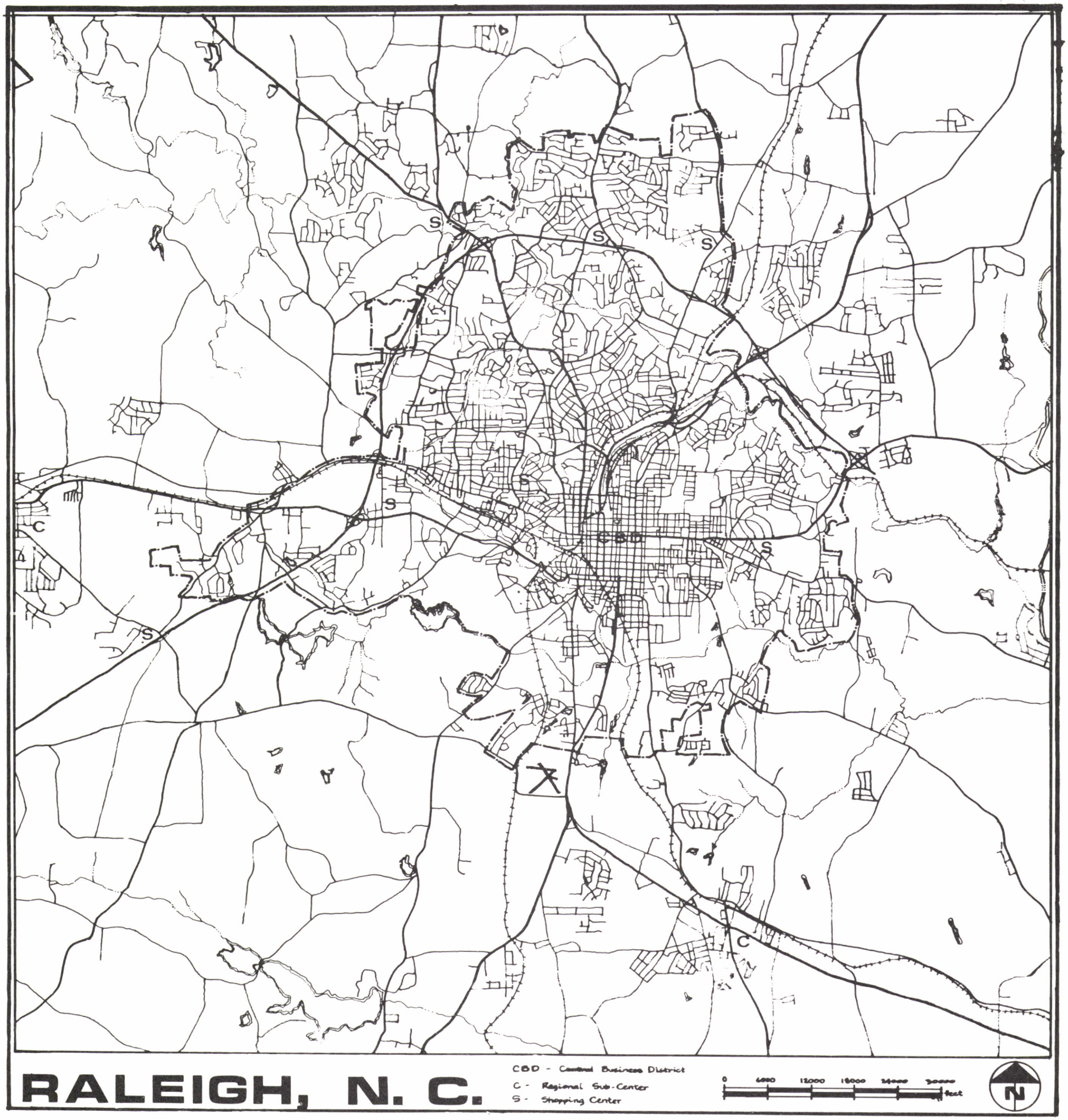

RALEIGH, N. C.
CBD - Central Business District
C - Regional Sub-Center
S - Shopping Center
0 6000 12000 18000 24000 30000 feet
N
CBD
C
S

Figure 2

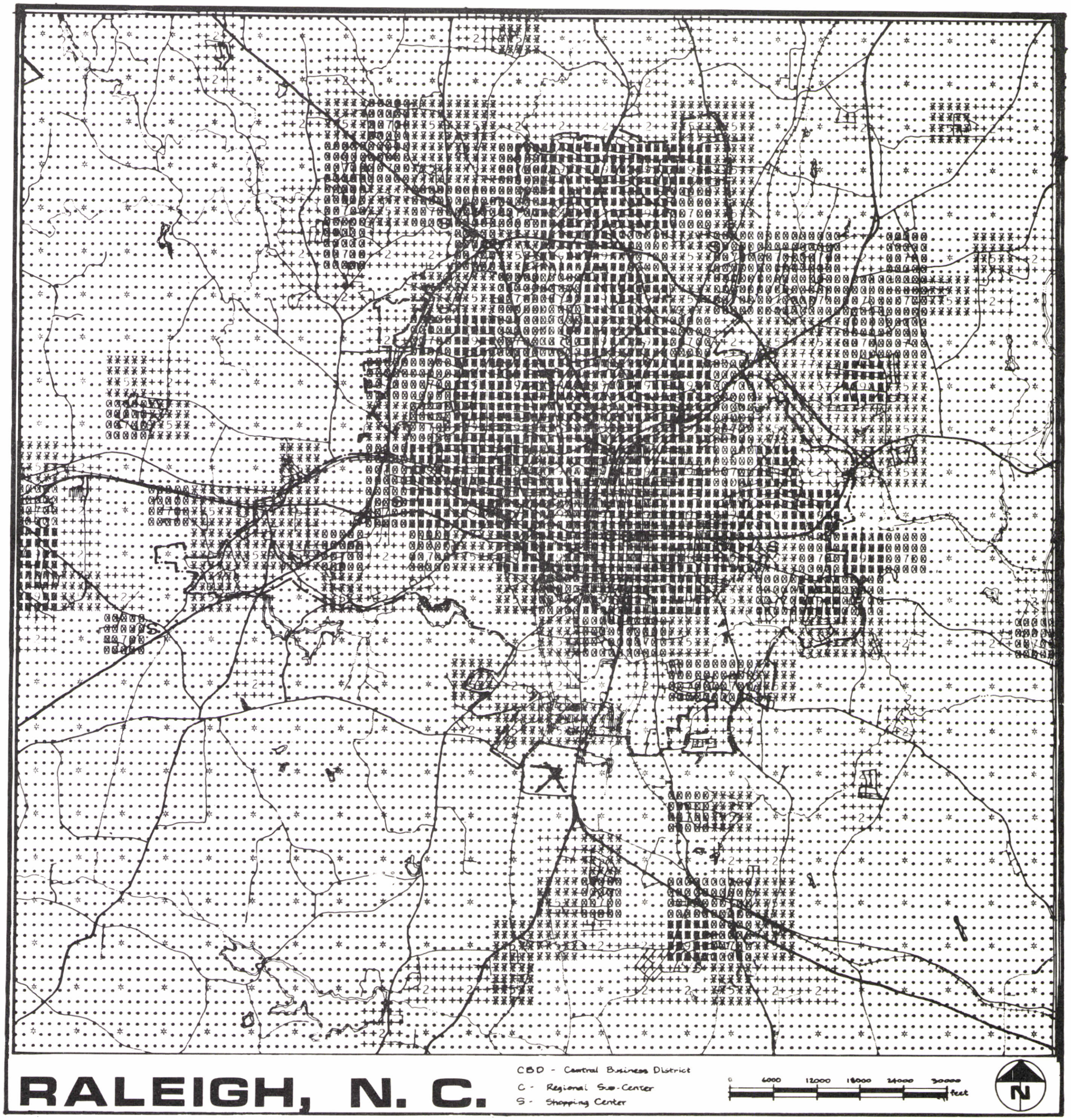
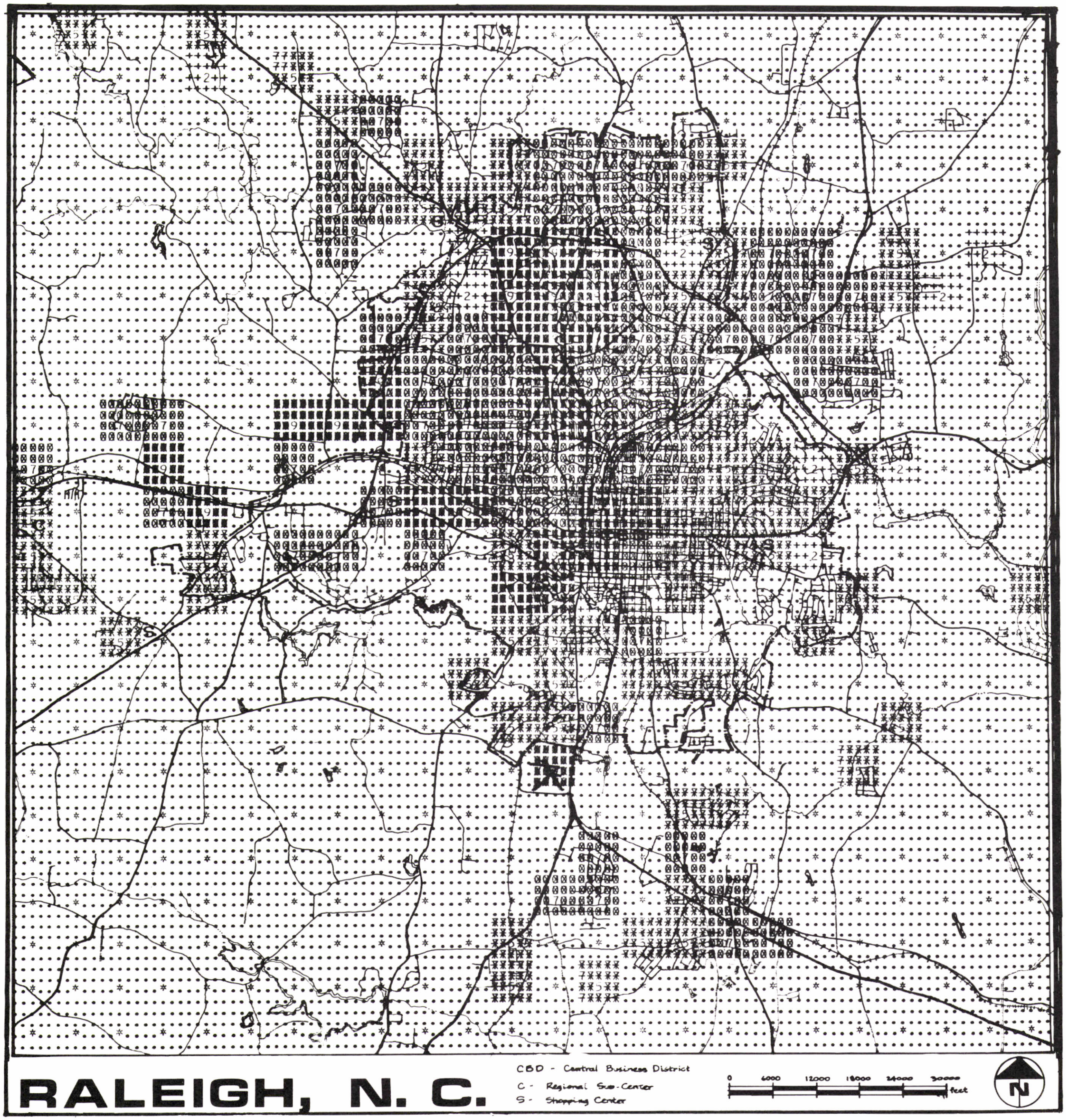

RALEIGH, N. C.
CBD - Central Business District
C - Regional Sub-Center
S - Shopping Center
0 6000 12000 18000 24000 30000 feet
N

Figure 3



RALEIGH, N. C.
CBD - Central Business District
C - Regional Sub-Center
S - Shopping Center
0
6000
12000
18000
24000
30000
feet
N

Figure 4

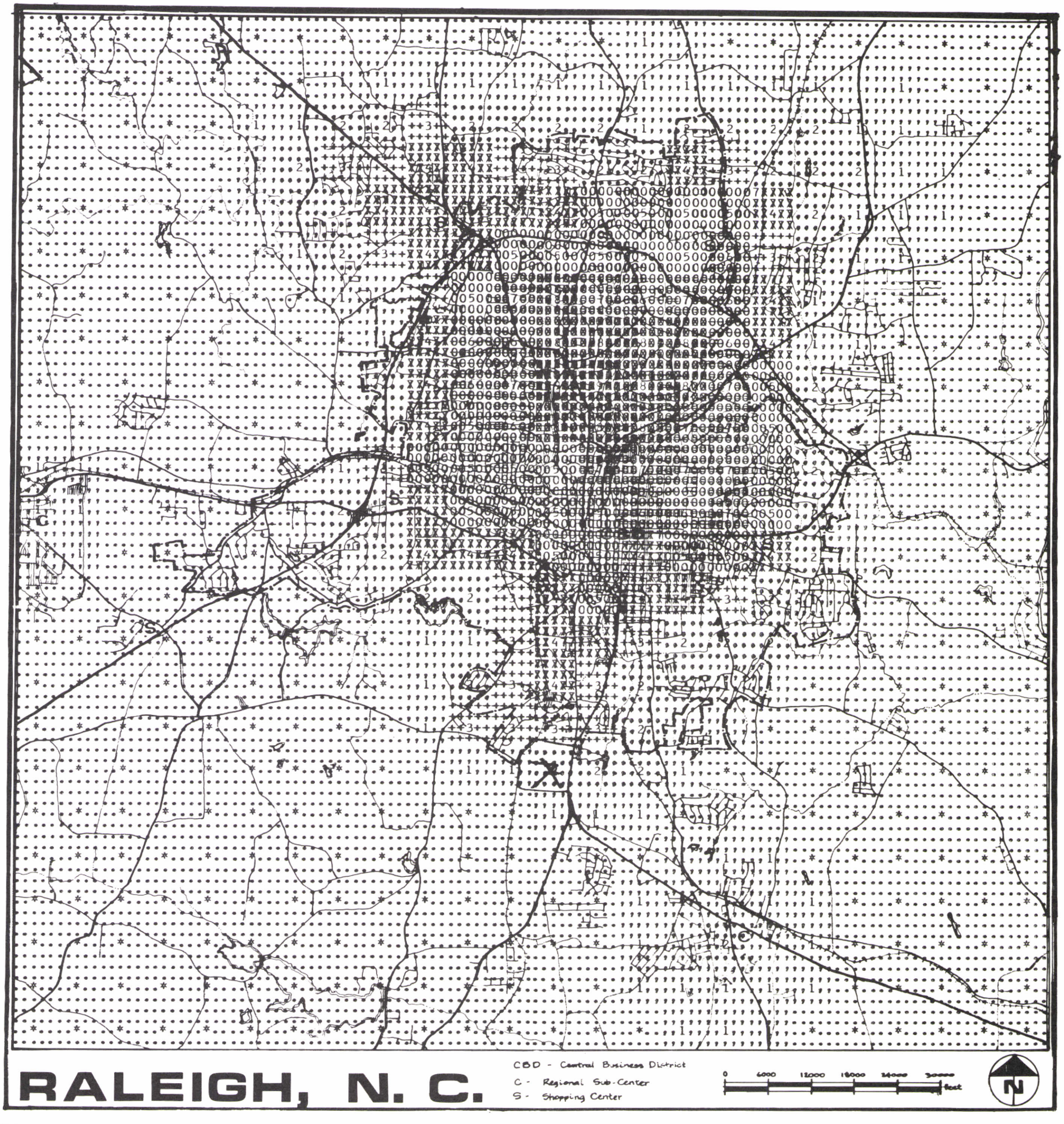

RALEIGH, N. C.
CBD - Central Business District
C - Regional Sub-Center
S - Shopping Center
0 6000 12000 18000 24000 30000 feet
N

Figure 5

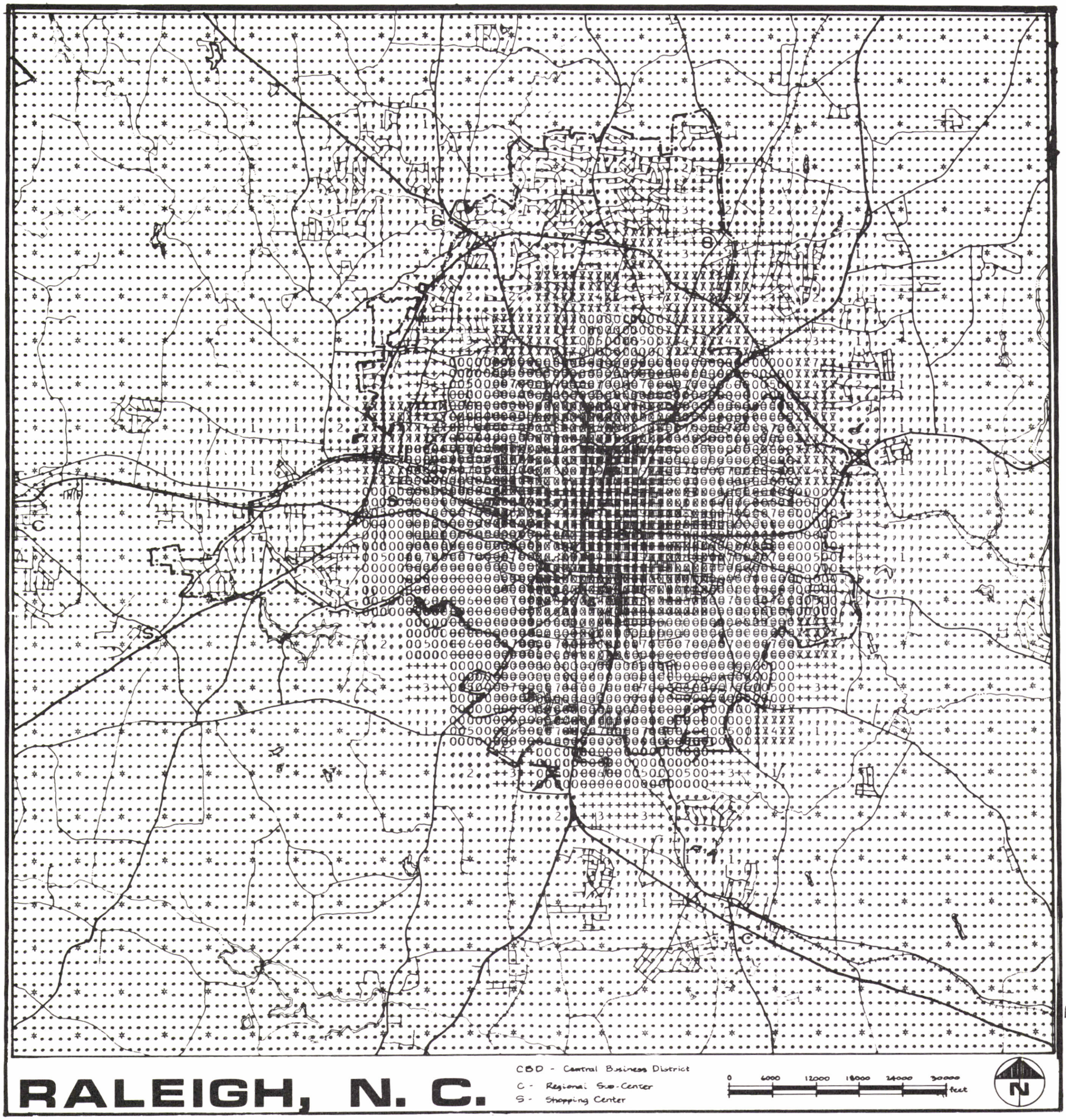

RALEIGH, N. C.
CBD - Central Business District
C - Regional Sub-Center
S - Shopping Center
0 6000 12000 18000 24000 30000 feet
N

Figure 6

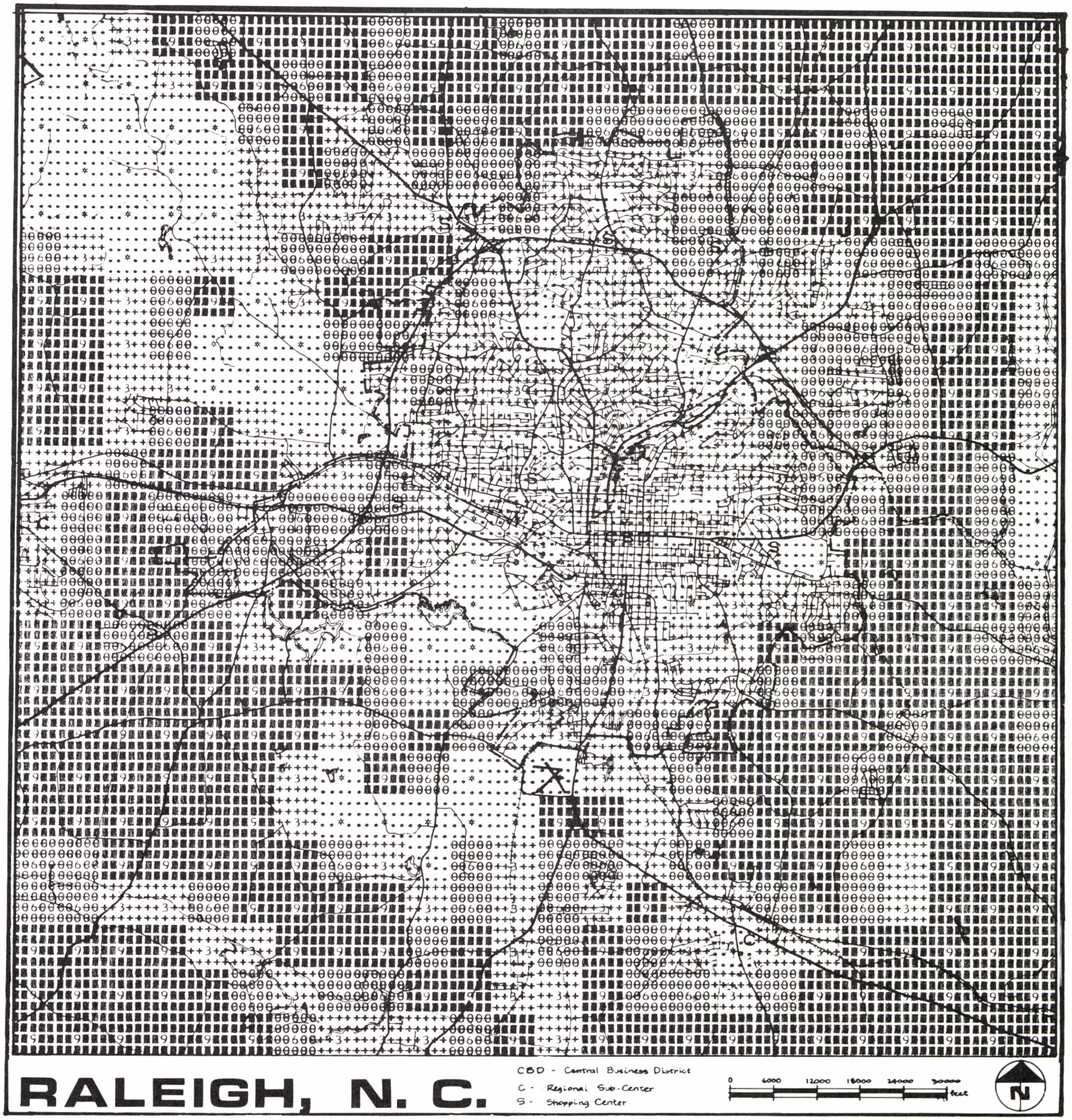
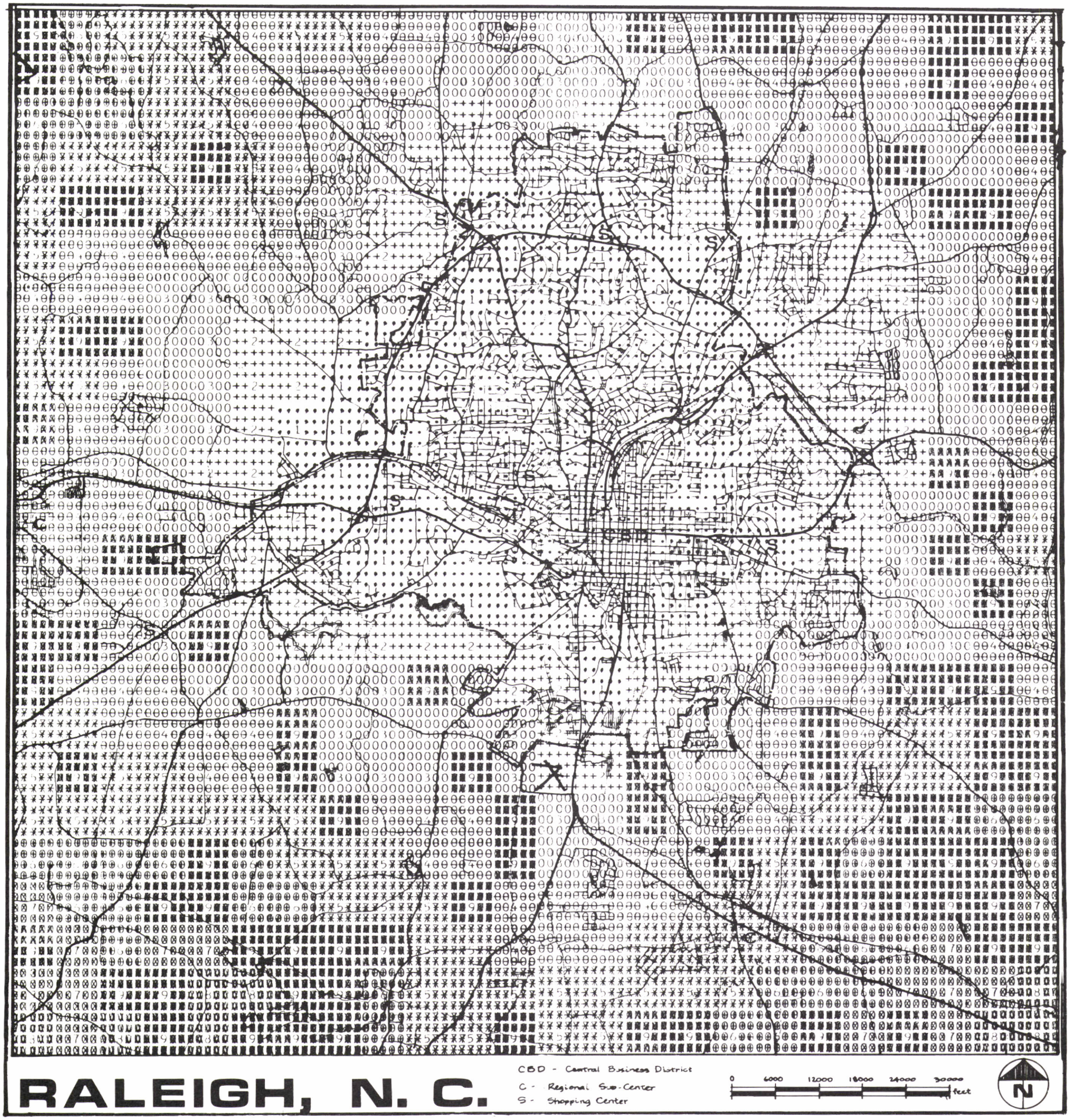

RALEIGH, N. C.
CBD - Central Business District
C - Regional Sub-Center
S - Shopping Center
0 6000 12000 18000 24000 30000 feet
N

Figure 7



CBD
S
C
RALEIGH, N. C.
CBD - Central Business District
C - Regional Sub-Center
S - Shopping Center
0 6000 12000 18000 24000 30000
feet
N

Figure 8

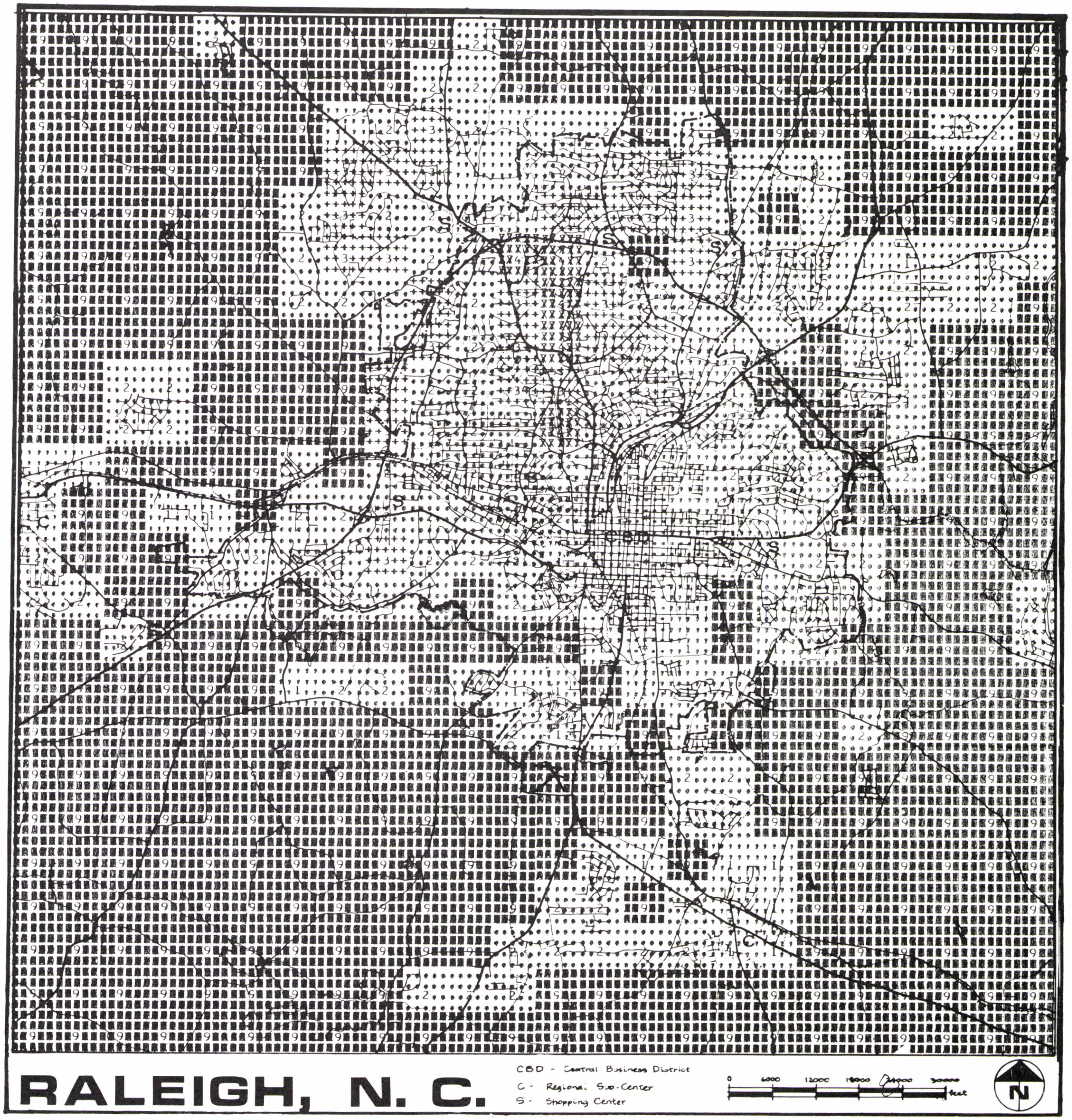

RALEIGH, N. C.
CBD - Central Business District
C - Regional Sub-Center
S - Shopping Center
0 6000 12000 18000 24000 30000
feet
N
CBD

Figure 9

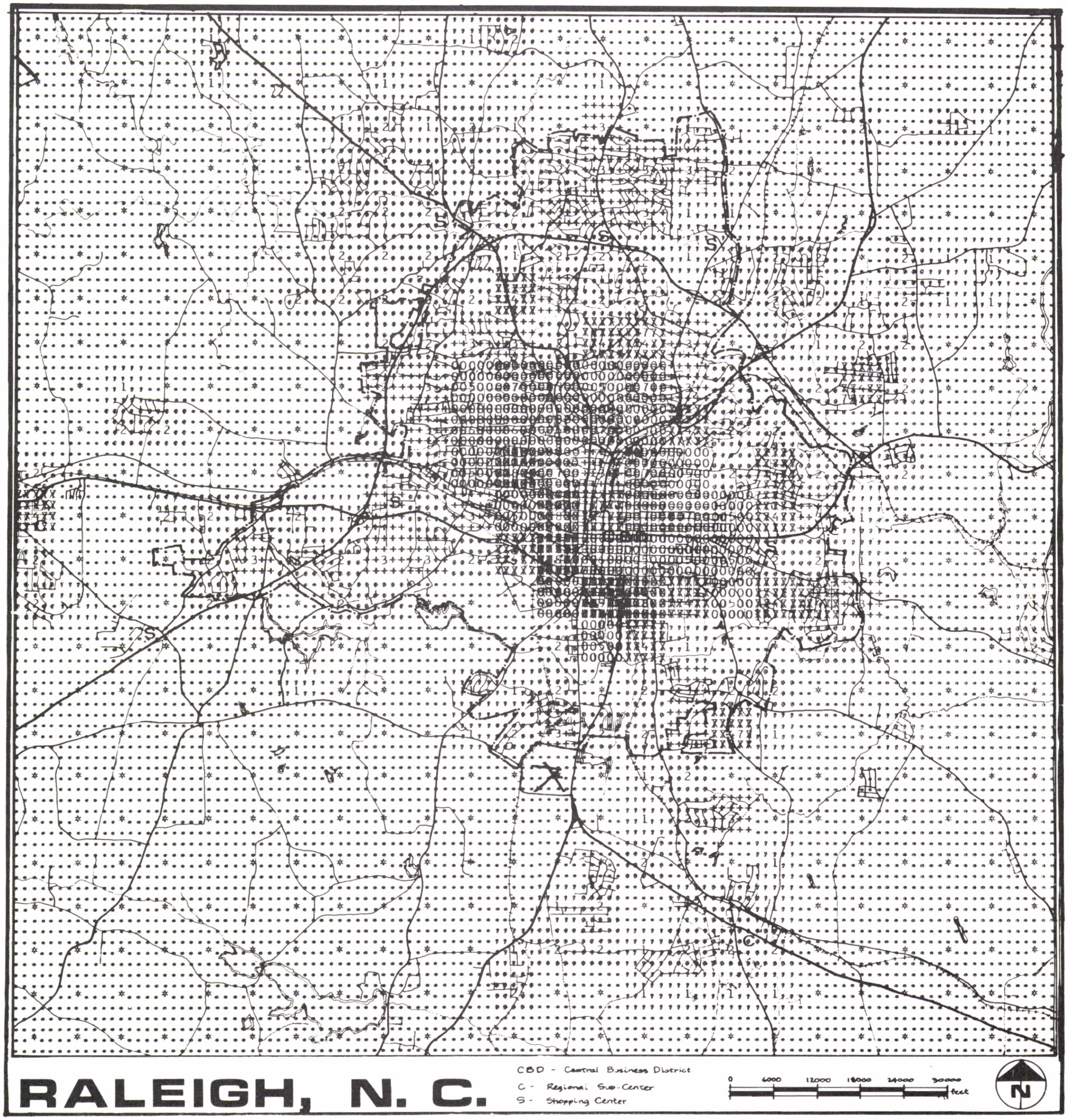

RALEIGH, N. C.
CBD - Central Business District
C - Regional Sub-Center
S - Shopping Center
0 6000 12000 18000 24000 30000 feet
N

Figure 10

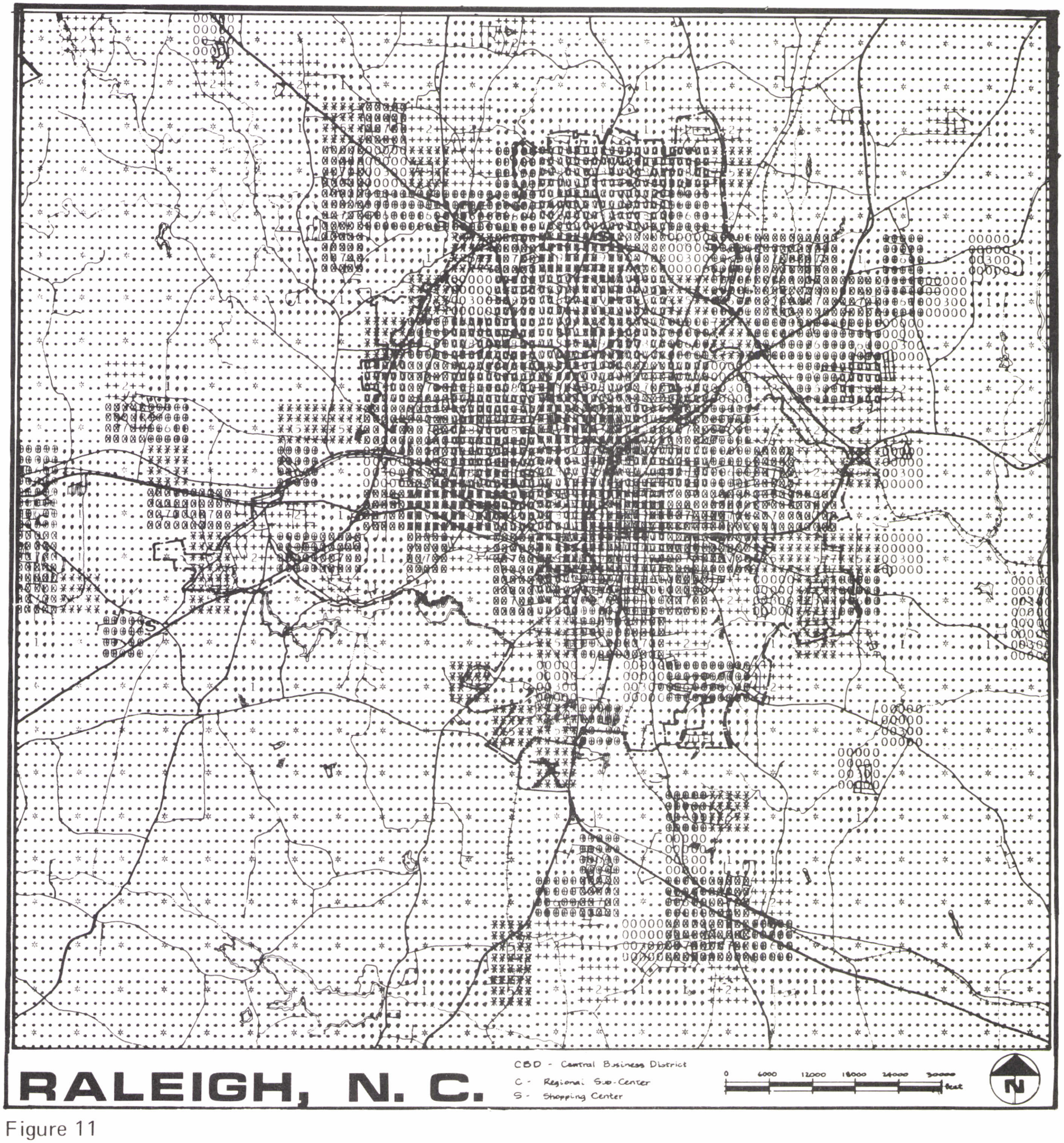

RALEIGH, N. C.
CBD - Central Business District
C - Regional Sub-Center
S - Shopping Center
0 6000 12000 18000 24000 30000 feet
N

Figure 11

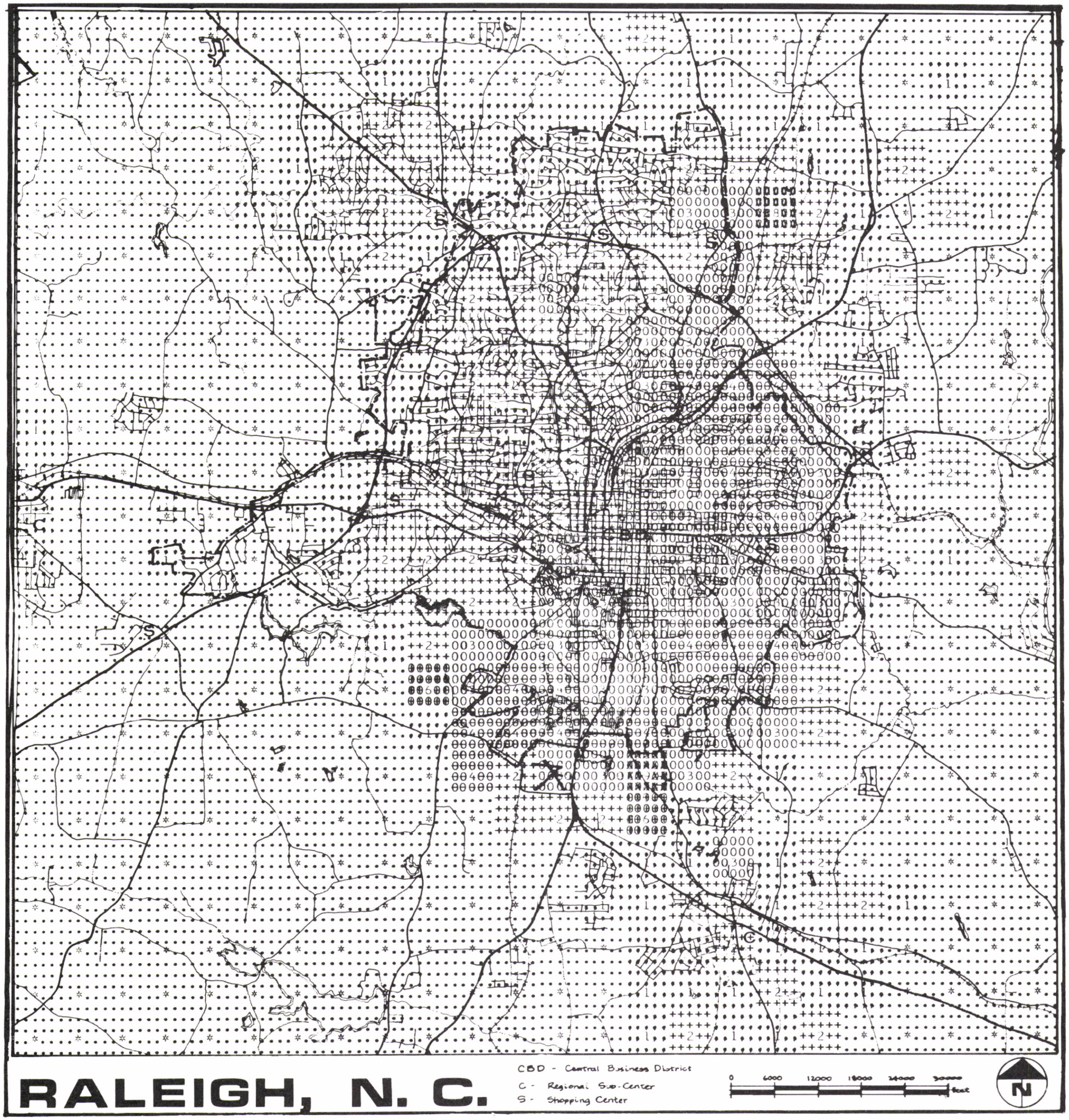

RALEIGH, N. C.
CBD - Central Business District
C - Regional Sub-Center
S - Shopping Center
0
6000
12000
18000
24000
30000
feet
N

Figure 12

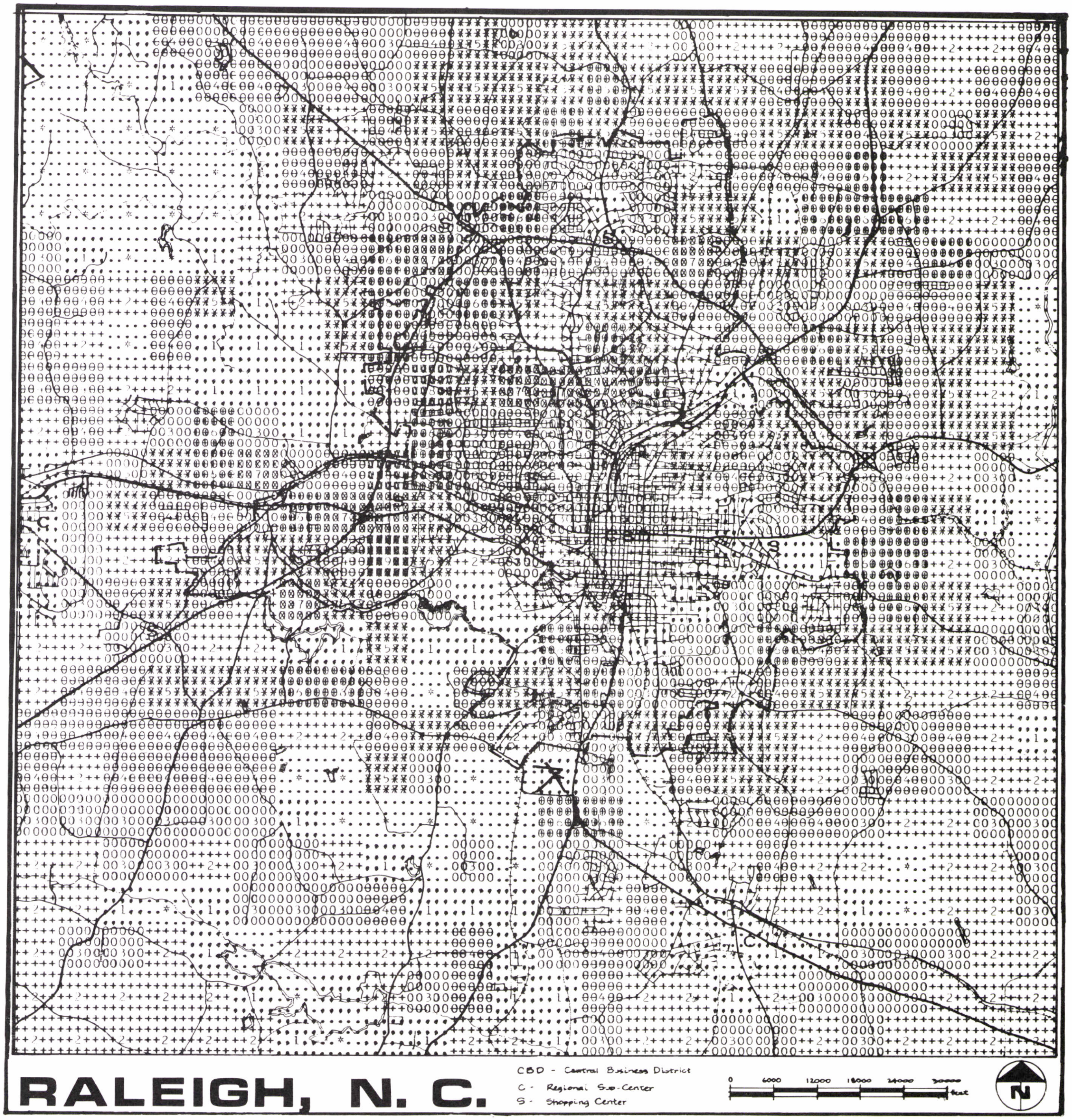

RALEIGH, N. C.
CBD - Central Business District
C - Regional Sub-Center
S - Shopping Center
0
6000
12000
18000
24000
30000
feet
N

Figure 13

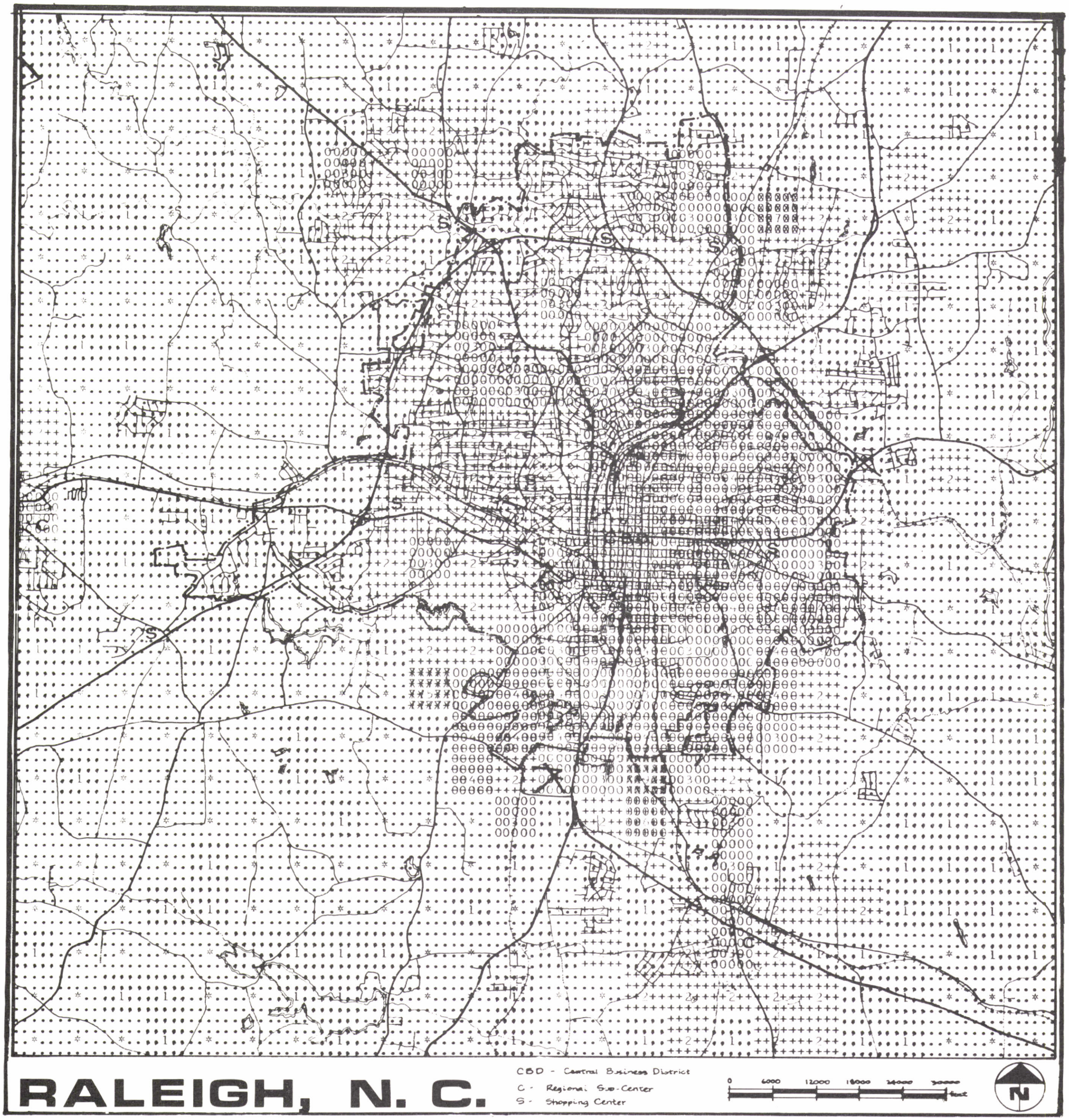
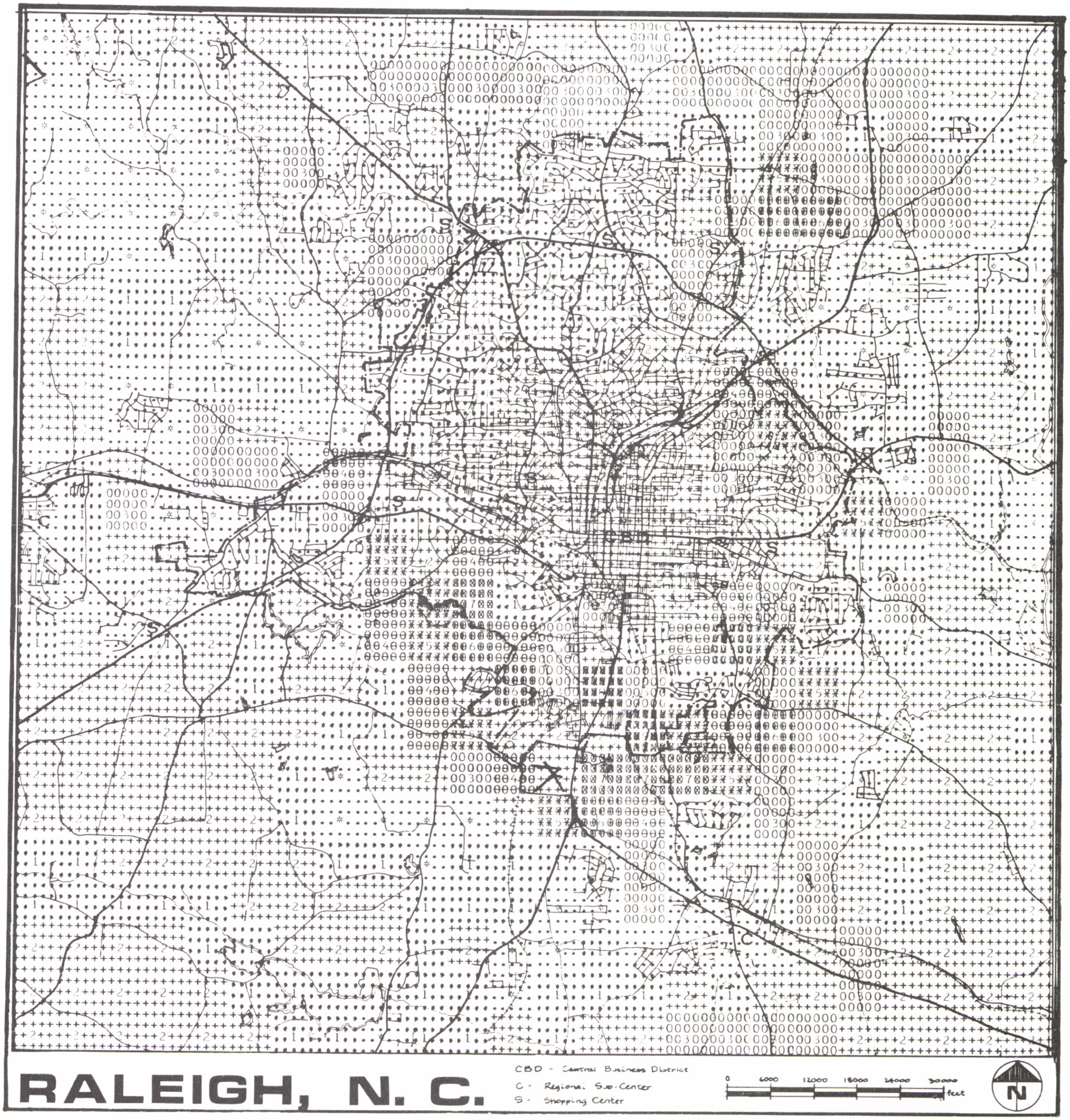
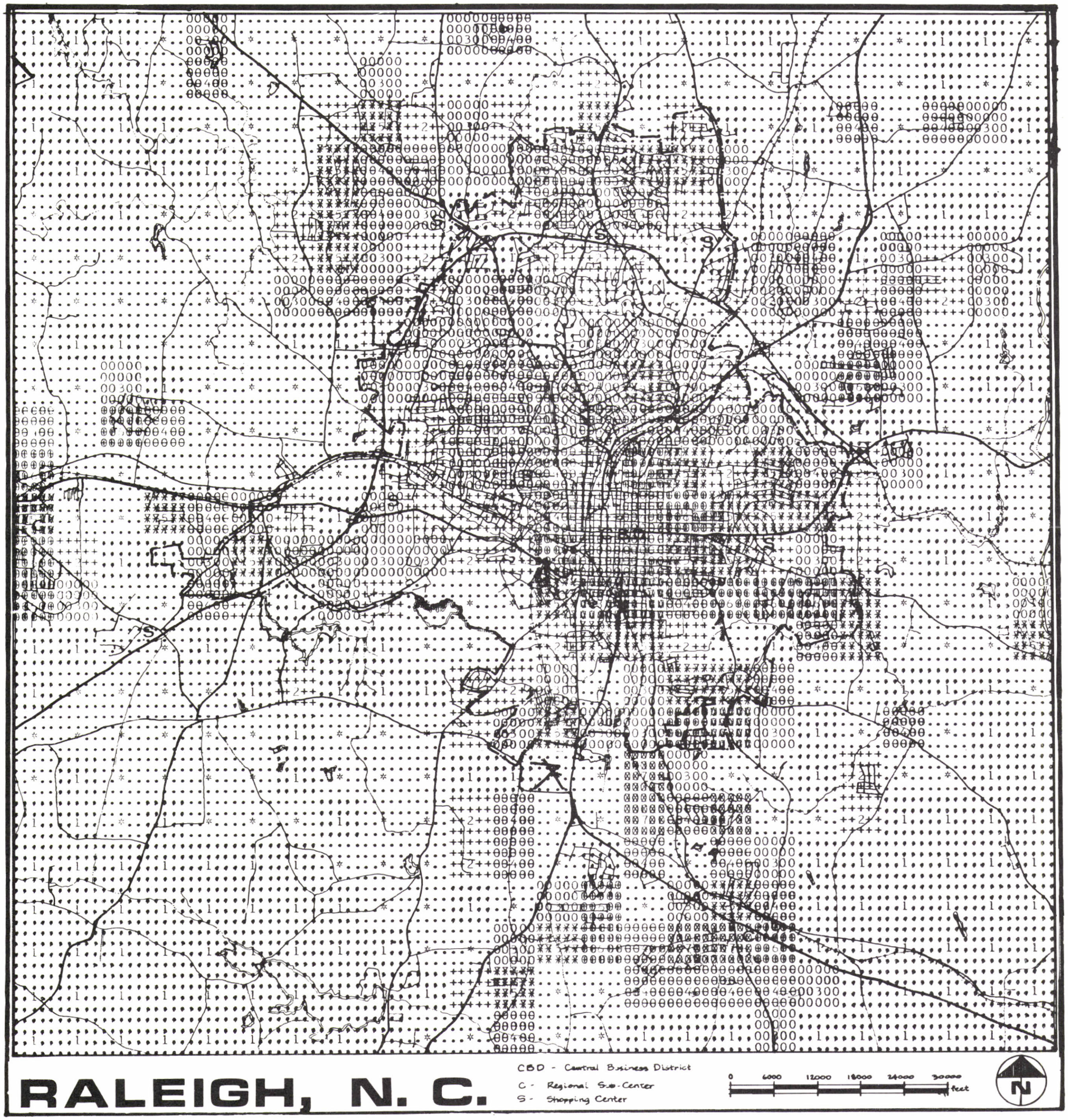

RALEIGH, N. C.
CBD - Central Business District
C - Regional Sub-Center
S - Shopping Center
0 6000 12000 18000 24000 30000
feet
N

Figure 14


RALEIGH, N. C.
CBD - Central Business District
C - Regional Sub-Center
S - Shopping Center
0 6000 12000 18000 24000 30000 feet
N
CBD
S
C
Figure 15


RALEIGH, N. C.
CBD - Central Business District
C - Regional Sub-Center
S - Shopping Center
0 6000 12000 18000 24000 30000 feet
N
Figure 16

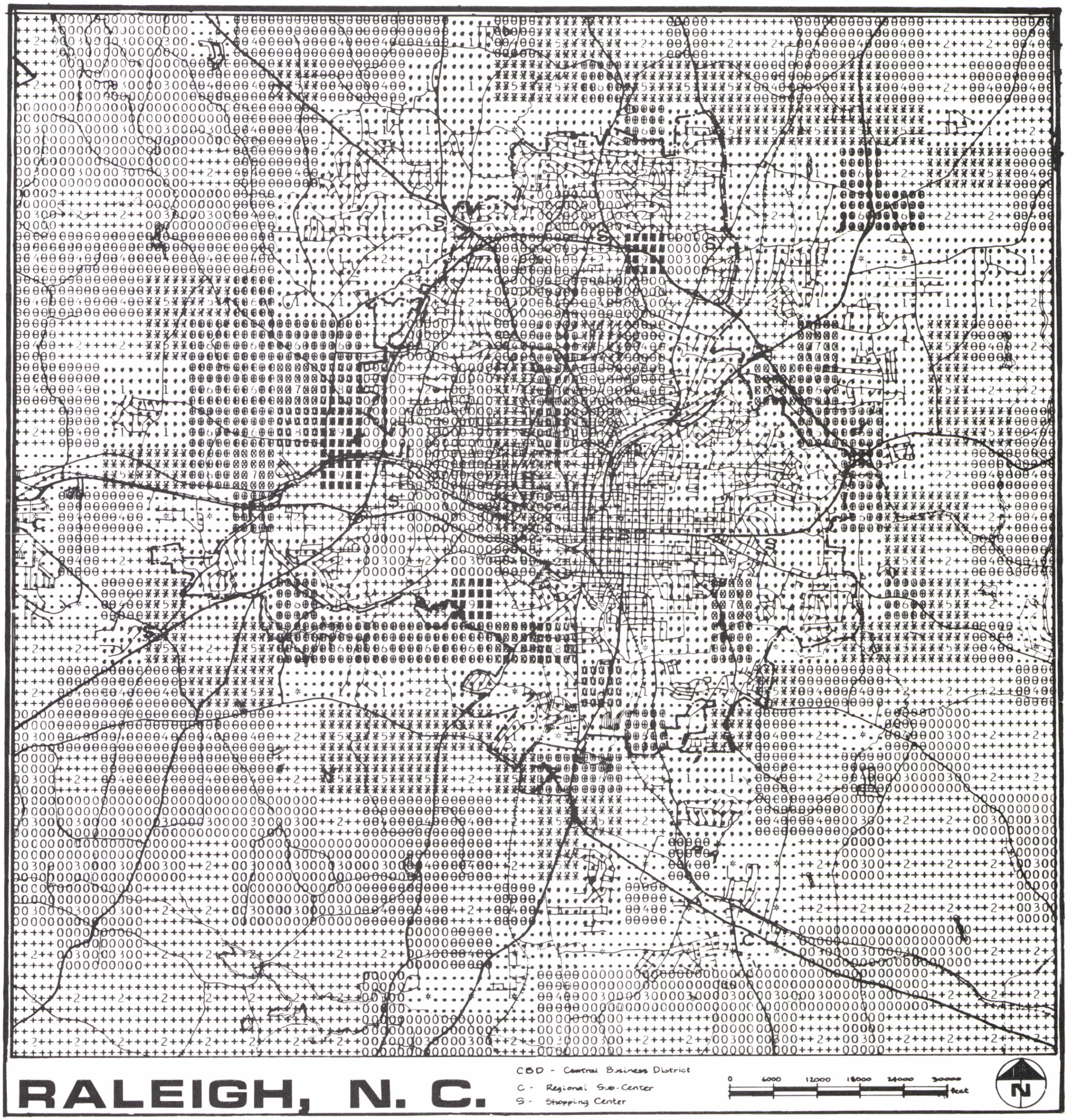

RALEIGH, N. C.
CBD - Central Business District
C - Regional Sub-Center
S - Shopping Center
0 6000 12000 18000 24000 30000 feet
N
CBD
C
S

Figure 17

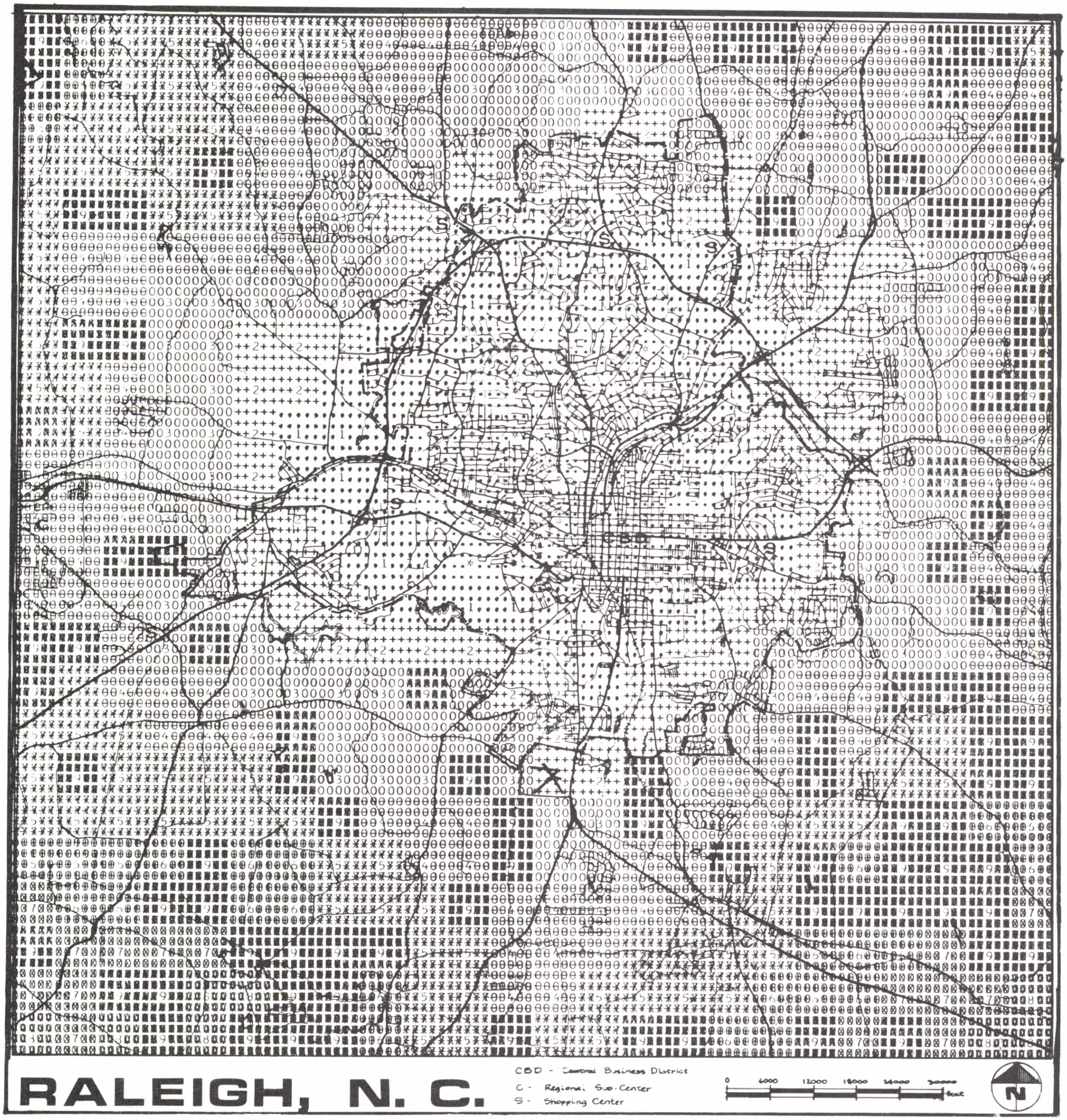

RALEIGH, N. C.
CBD - Central Business District
C - Regional Sub-Center
S - Shopping Center
0
6000
12000
18000
24000
30000
feet
N

Figure 18

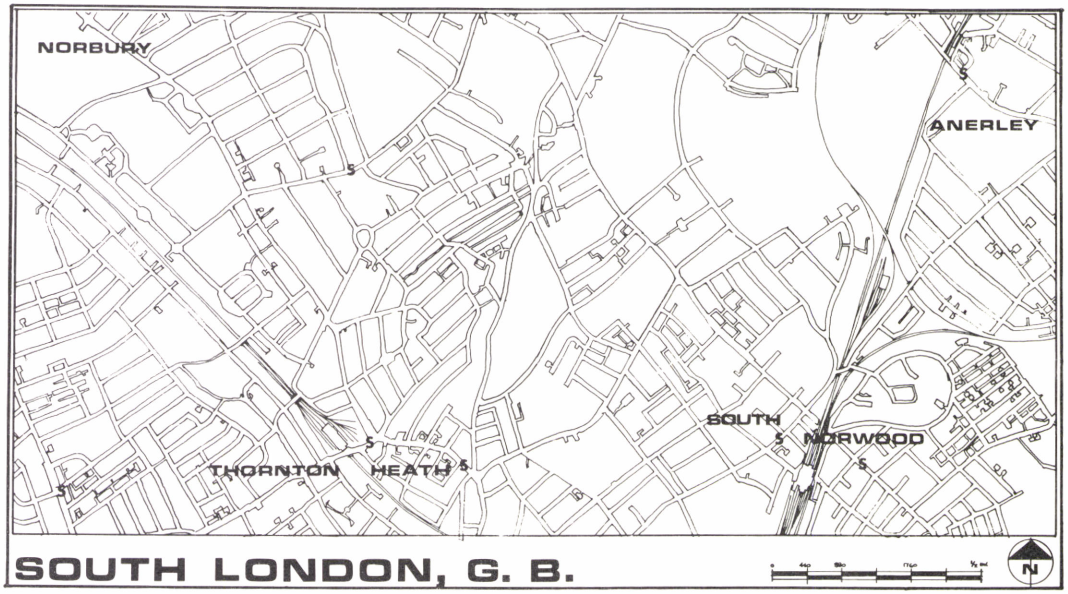

NORBURY
ANERLEY
SOUTH
NORWOOD
THORNTON
HEATH
SOUTH LONDON, G. B.
N

Figure 19

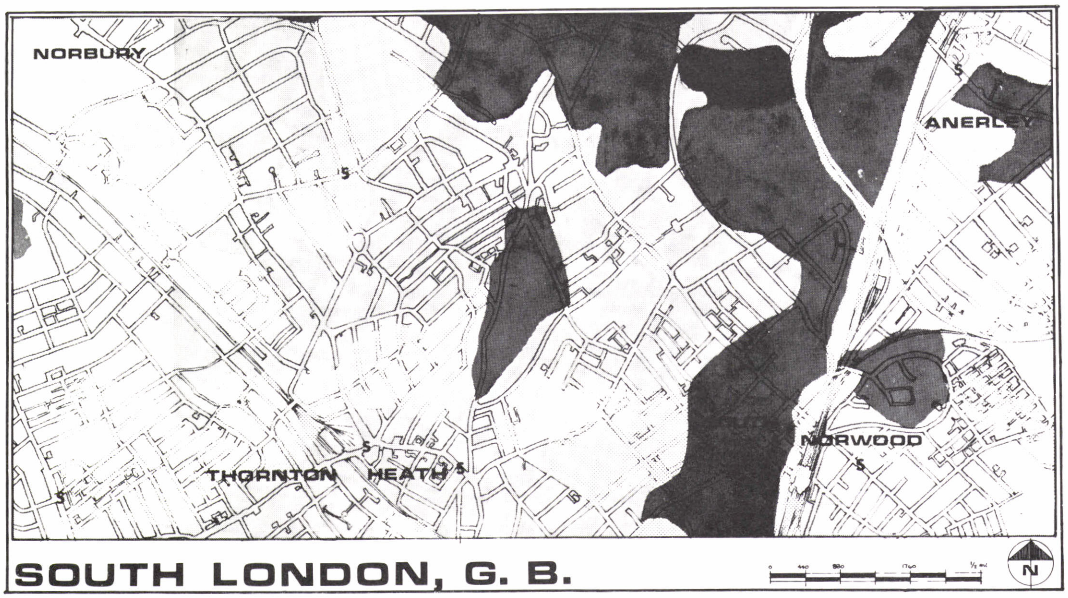


Figure 20

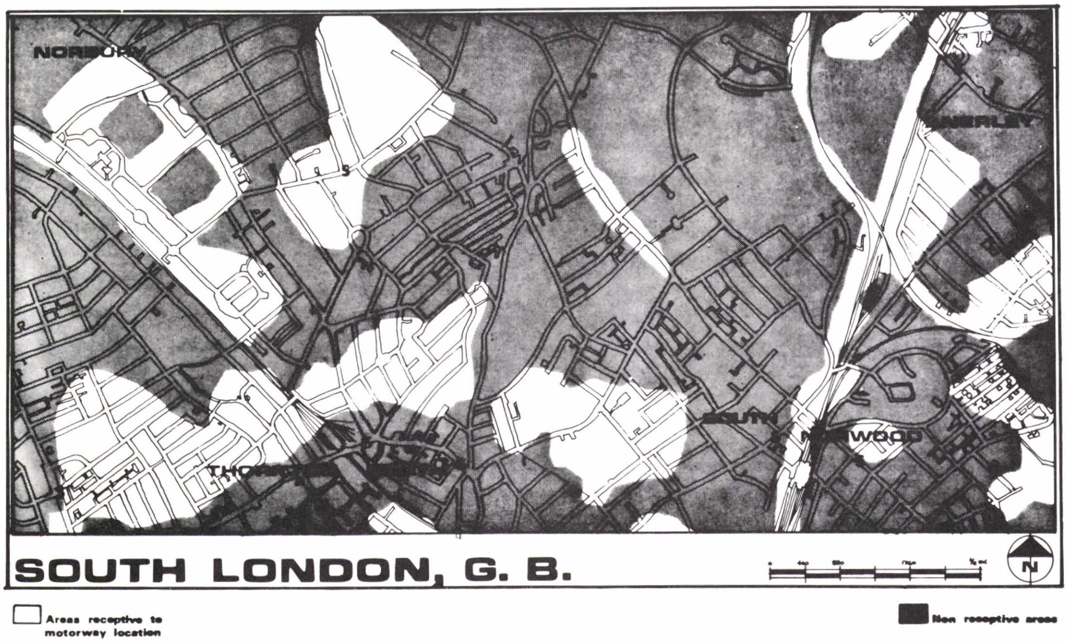
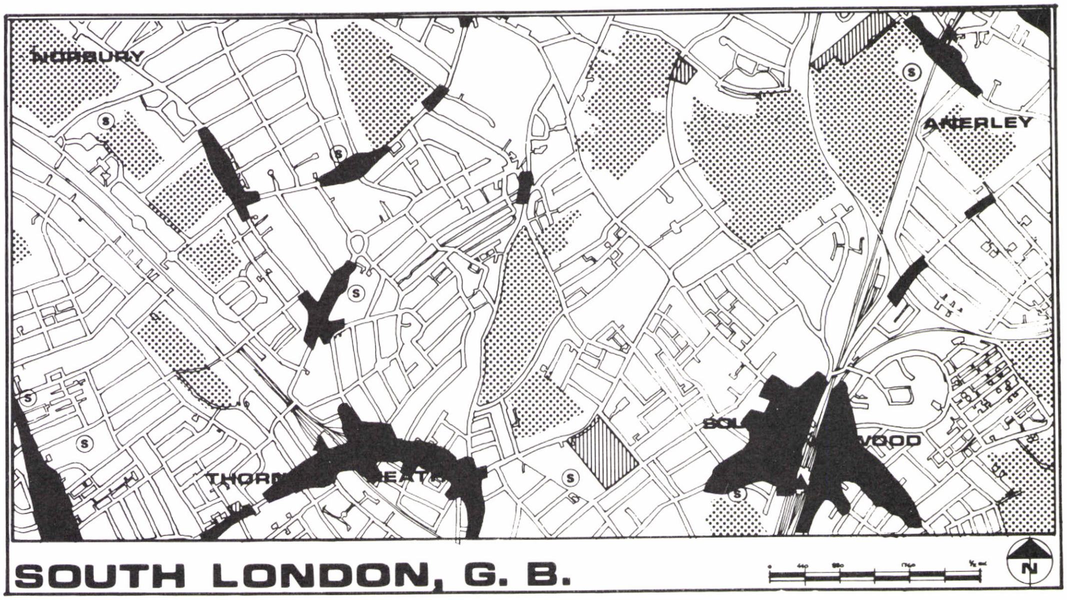


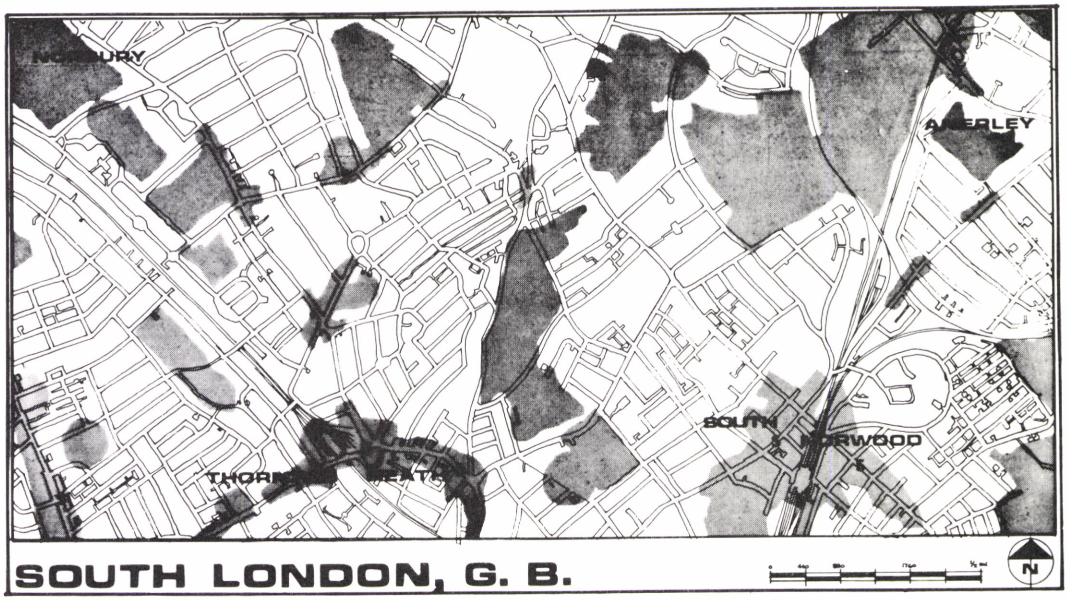
Figure 21



low
medium
high
perceived activity intensity

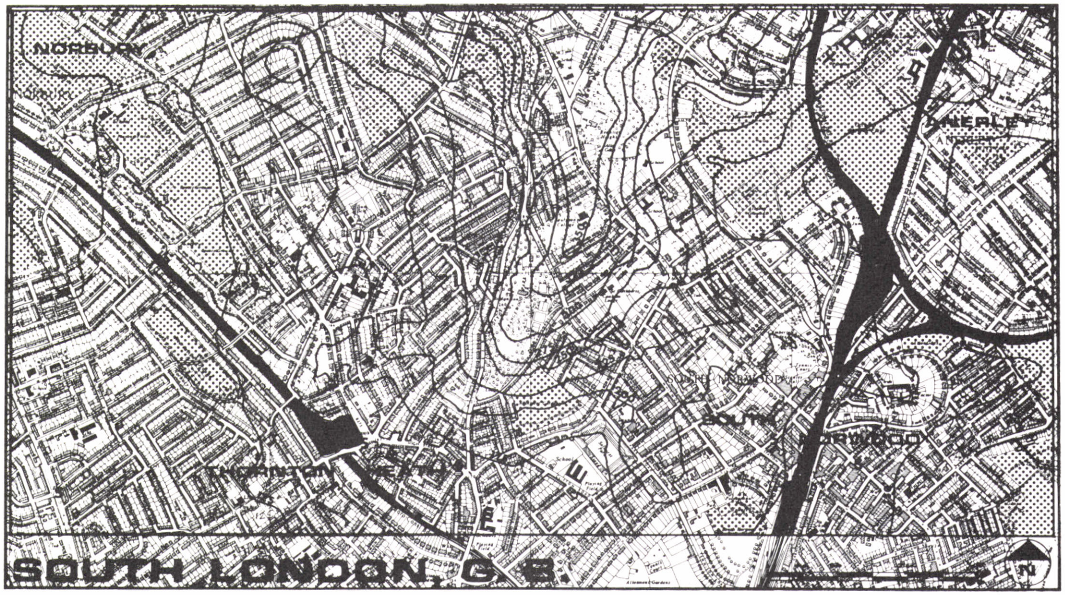
Part time activity generators
recreation and open space
schools
LT stations
public buildings

Figure 22



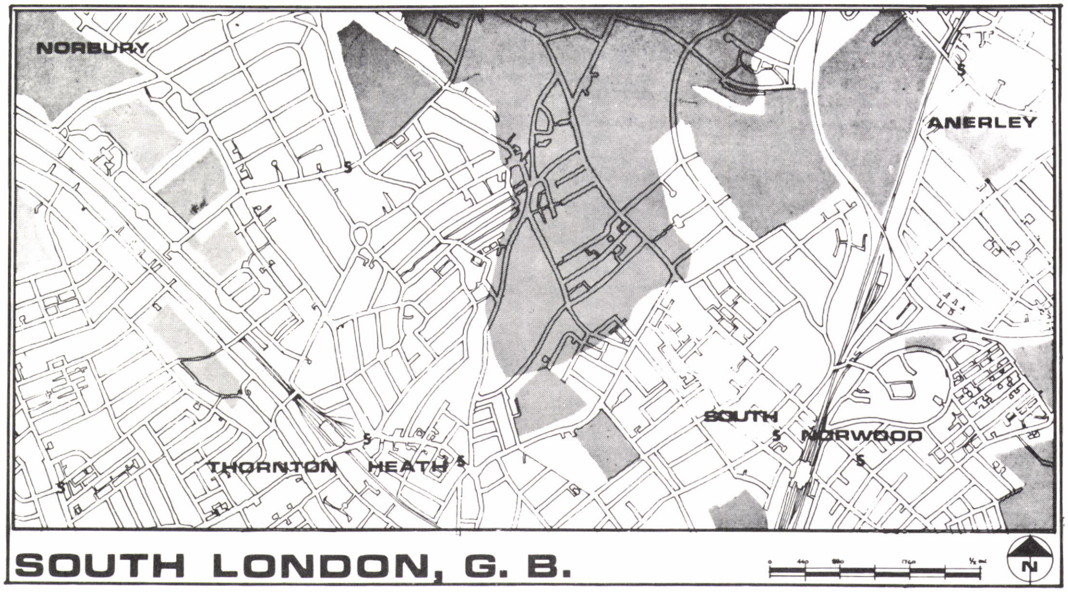
Areas receptive to motorway location
Non receptive areas

Figure 23



Open space
Land form
Railway land

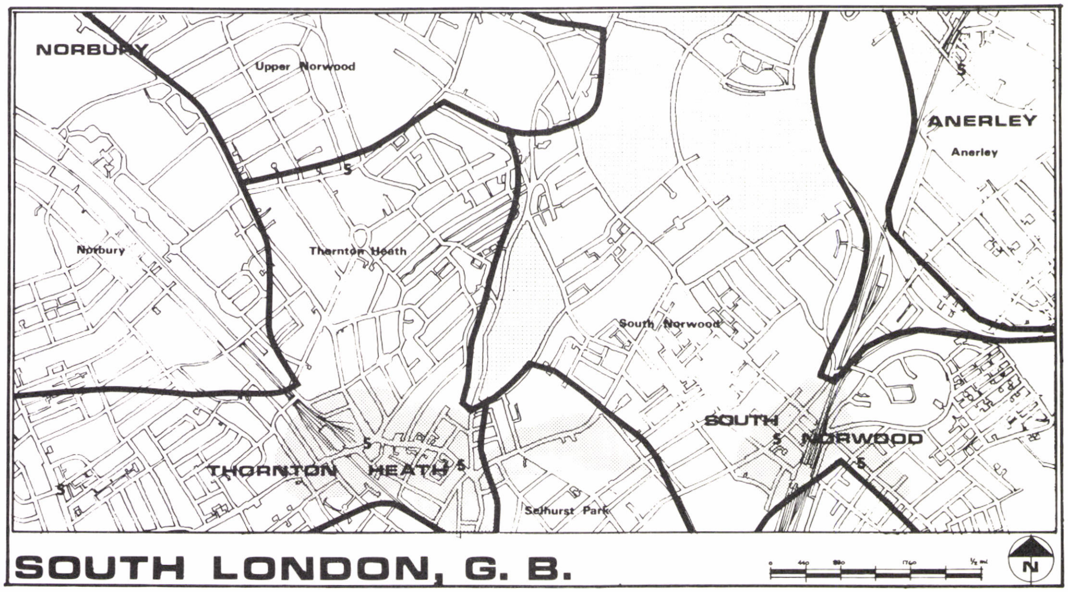
Figure 24



Areas receptive to motorway location

Non receptive areas

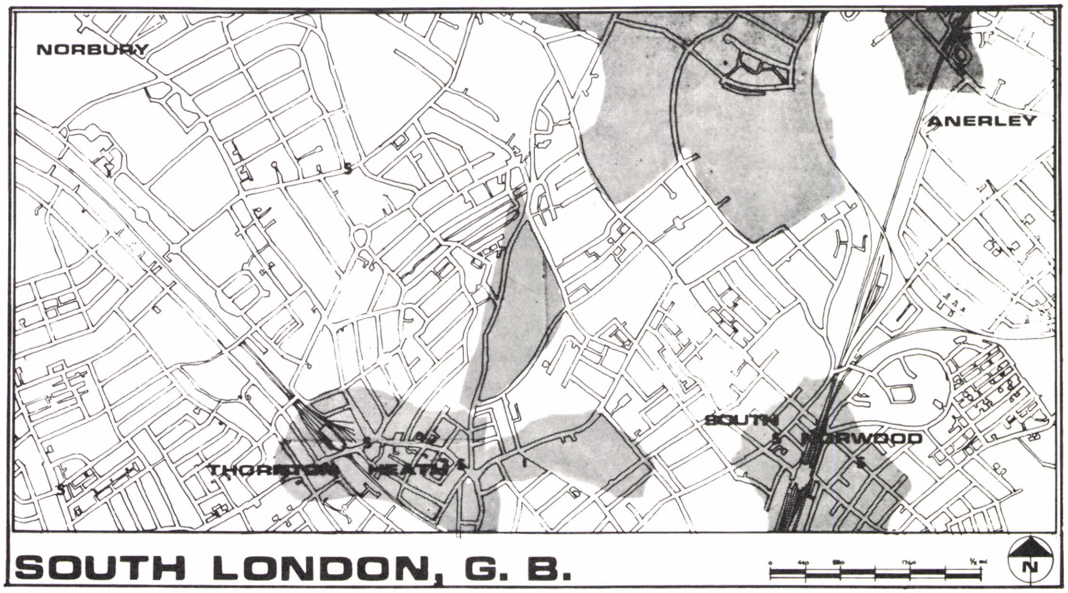
Figure 25



Identity areas - level of identity assessed from number of elements present

Defined urban groupings

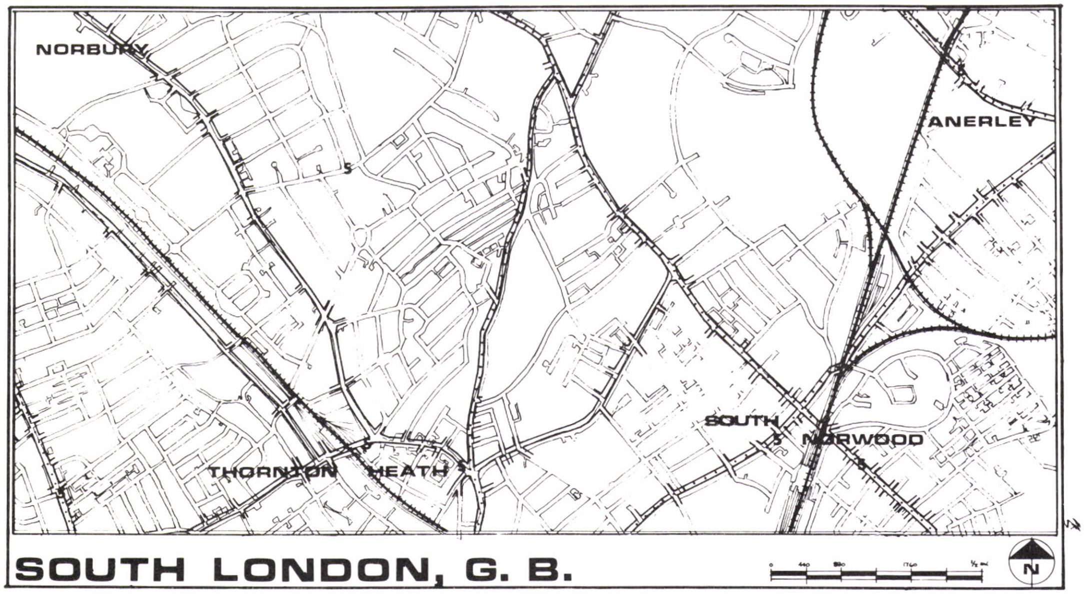
Figure 26



Areas receptive to motorway location

Non receptive areas

Figure 27



British railways
Major roads
Bus routes

Figure 28

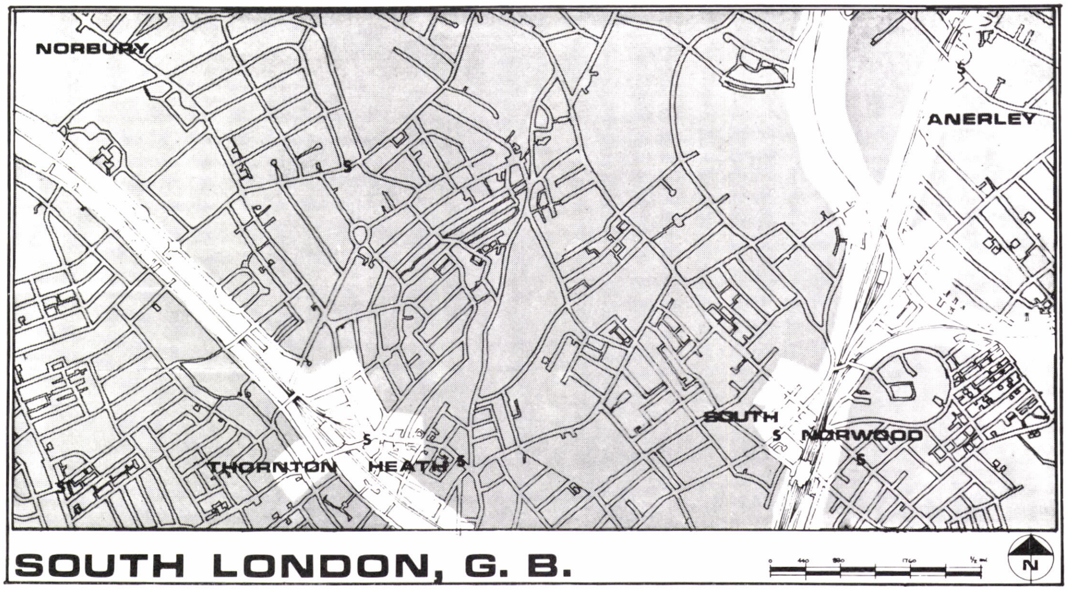
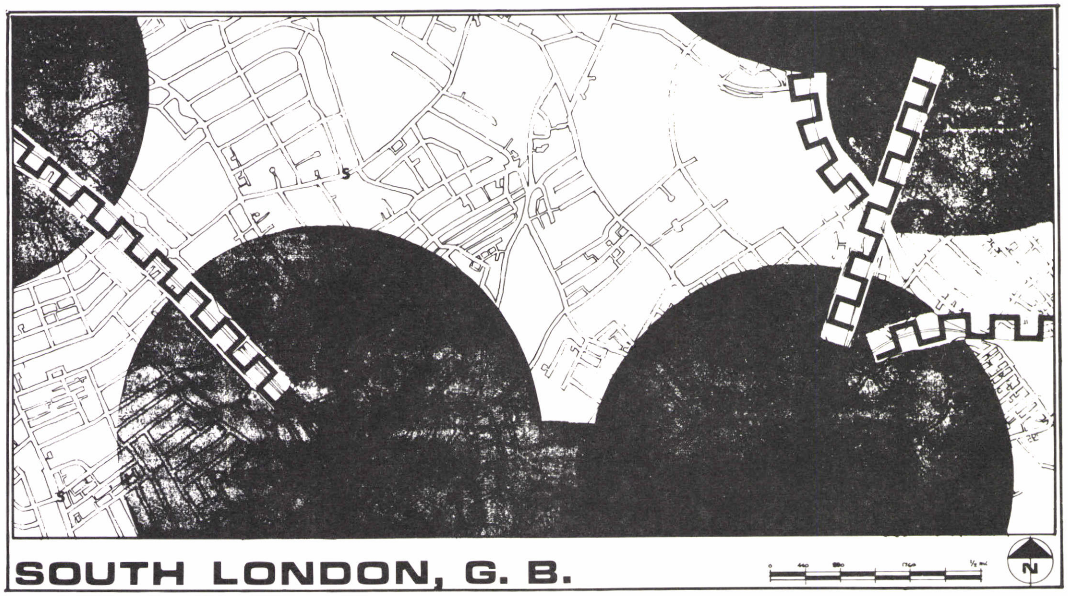


Figure 29



access to one station

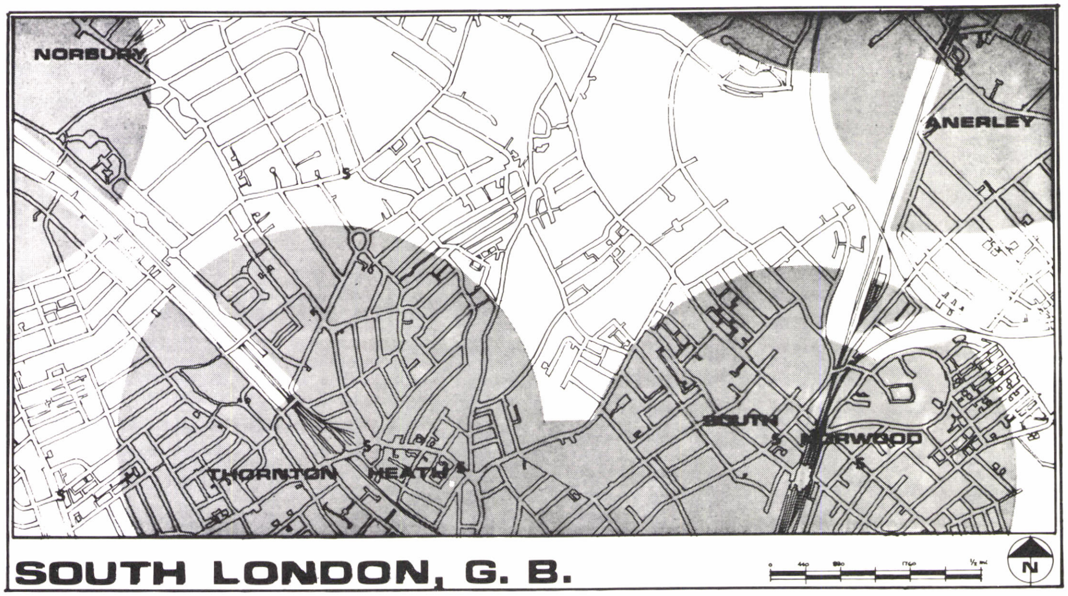
one rail service

physical barrier effect

two stations

pedestrian access to station

Figure 30



Areas receptive to motorway location

Non-receptive areas

Figure 31

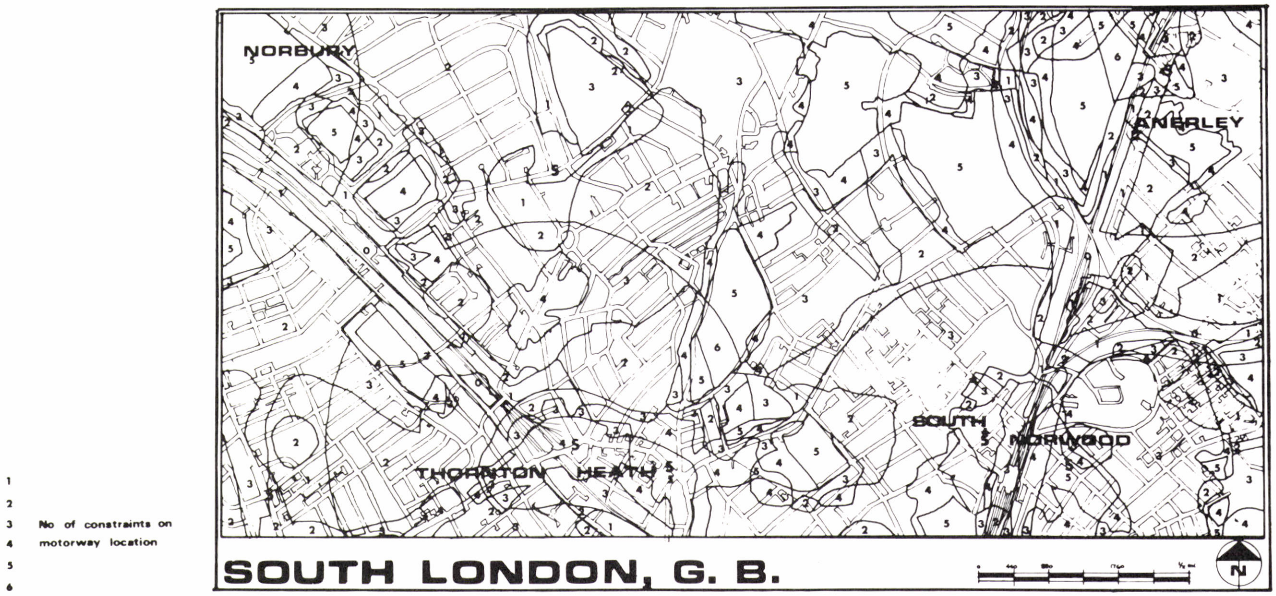


Figure 32

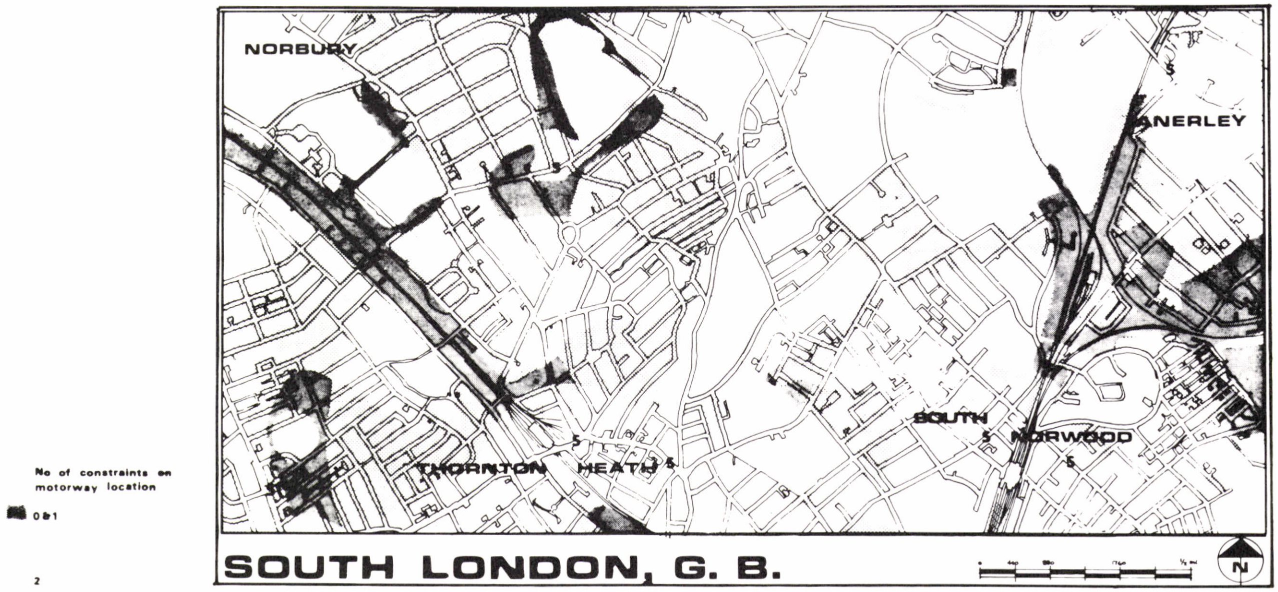
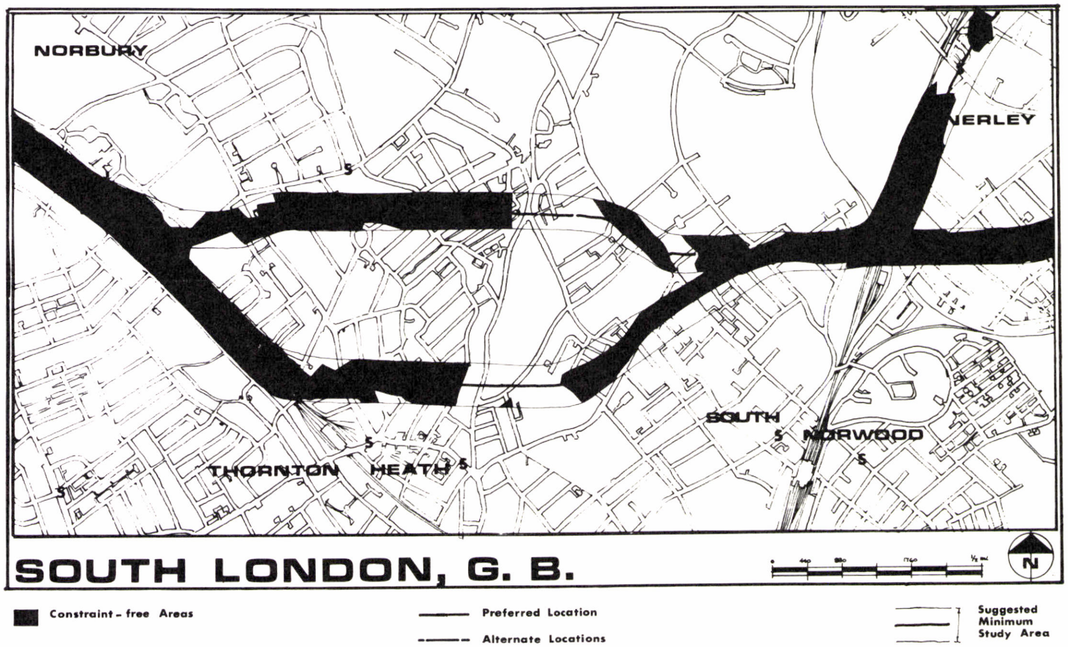


Figure 33



NORBURY
NERLEY
SOUTH
NORWOOD
THORNTON HEATH
SOUTH LONDON, G. B.
N
Constraint - free Areas
Preferred Location
Alternate Locations
Suggested
Minimum
Study Area

Figure 34

Editor: James H. Ross, Jr.
Business Manager: Keller Smith
Circulation Manager: Ashley Spearman
Art Auction Co. Chairmen: Rhinehart Goethert, Raymond Craun

The staff would like to thank Dean Henry Kamphoefner for his vigilant support.

The staff would like to express its appreciation to the following for their generous contributions:

donors:
(50 dollars or more)

Arts and Architecture - Los Angeles, California
Pietro Belluschi - Boston, Massachusetts
Joseph N. Boaz - Raleigh, North Carolina
Leslie N. Boney - Wilmington, North Carolina
James L. Brandt - Raleigh, North Carolina
Alden B. Dow Associates - Midland, Michigan
Rockwell King DuMoulin - Washington, D. C.
Charles M. Goodman - Washington, D. C.
Harwell Hamilton Harris - Raleigh, North Carolina
Henry J. Heinz, II - Pittsburgh, Pennsylvania
Vincent King - Philadelphia, Pennsylvania
E. Archie Mishkin - Philadelphia, Pennsylvania
Walter A. Netsch, Jr. - Chicago, Illinois
A. G. Odell, Jr. - Charlotte, North Carolina
Department of Architecture, Rice University - Houston - Texas
James M. Strutt - Ottawa, Canada
Student Government, N. C. State - Raleigh, North Carolina
Student Supply Stores, N. C. State - Raleigh, North Carolina
Kenzo Tange - Tokyo, Japan

patrons:
(16 dollars or more)

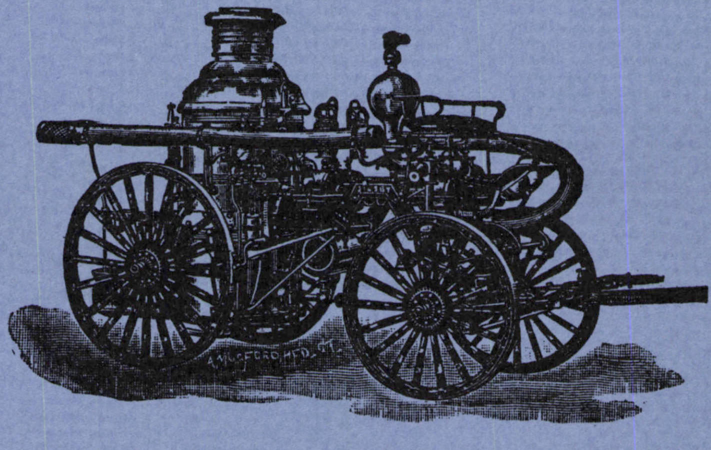
Frei Otto - Berlin, Germany
Henry Robert Kann - New York, New York
G. E. Kidder Smith - New York, New York
Dale M. Wiars - Milwaukee, Wisconsin

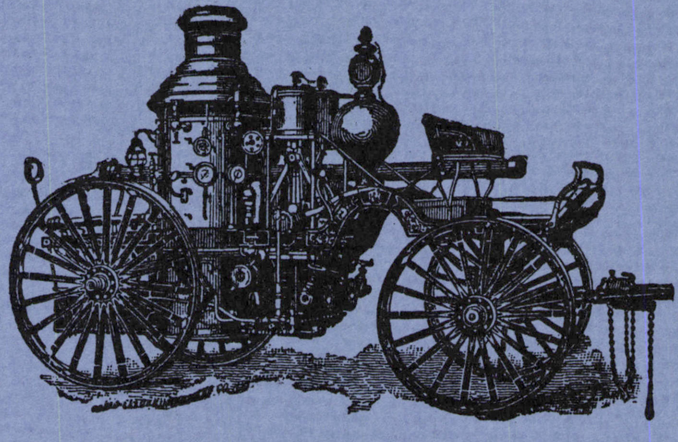
For their past financial support we thank Wallace K. Harrison and Edgar J. Kaufmann, Jr.

Subscription rates:
Donor: $50 or more
Patron: $16 or more

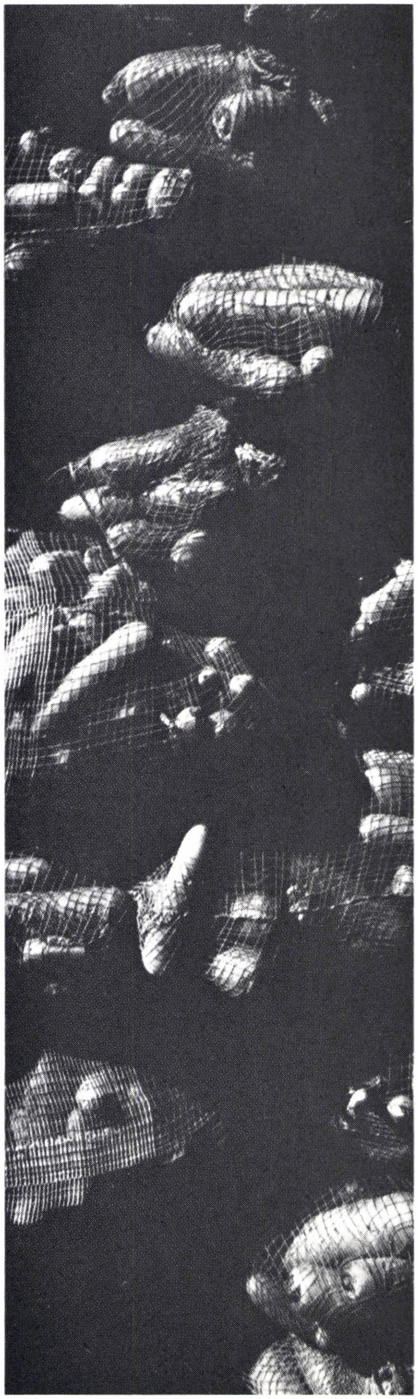
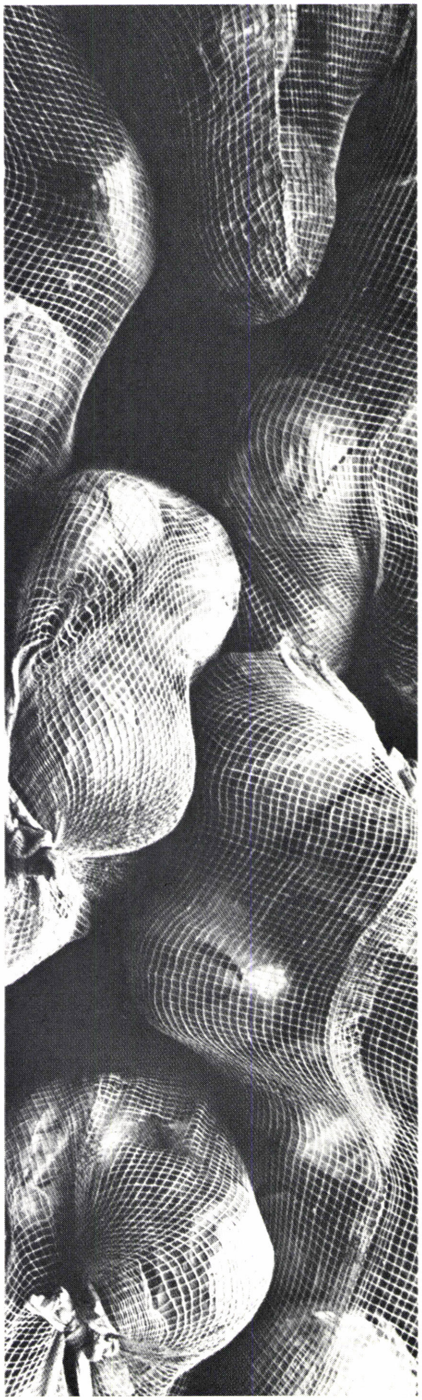
Annual subscription based on number of publications issued per year, $2 per issue.
Address all inquiries to: Student Publications of the School of Design, P. O. Box 5273, Raleigh, N. C.
Distributors: George Wittenborn and Co., 1018 Madison Avenue, New York, 21, N. Y. and Alec Tiranti, Ltd., 73 Charlotte Street, London W. 1, England
Printed by: Associated Printing Company, Charlotte, N. C.

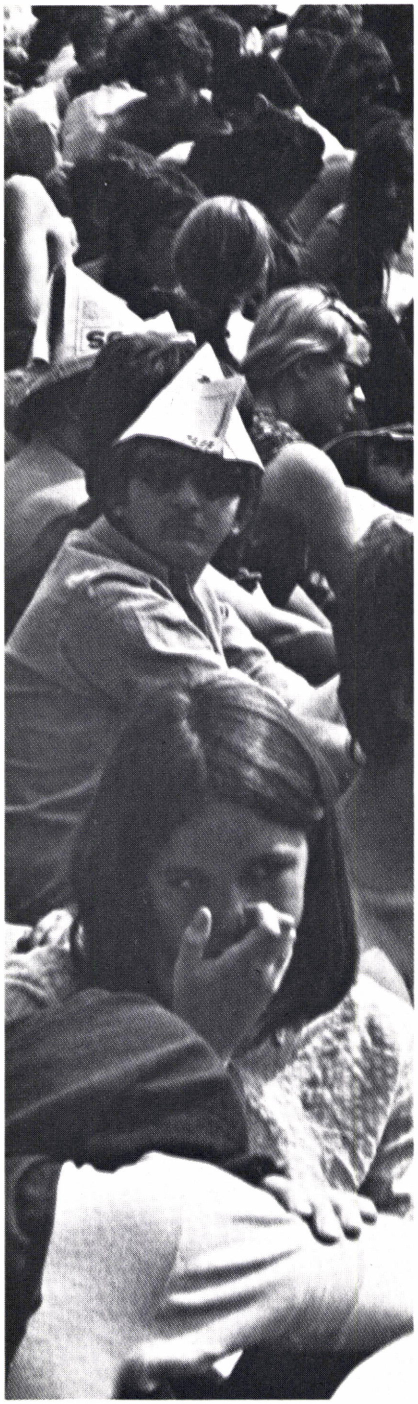
Volume 15 Number 2.

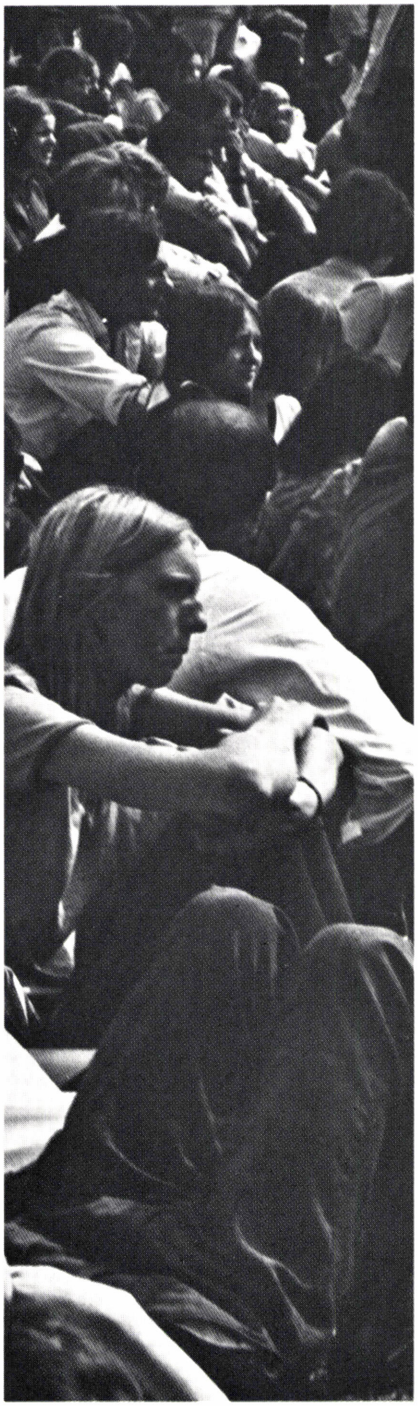




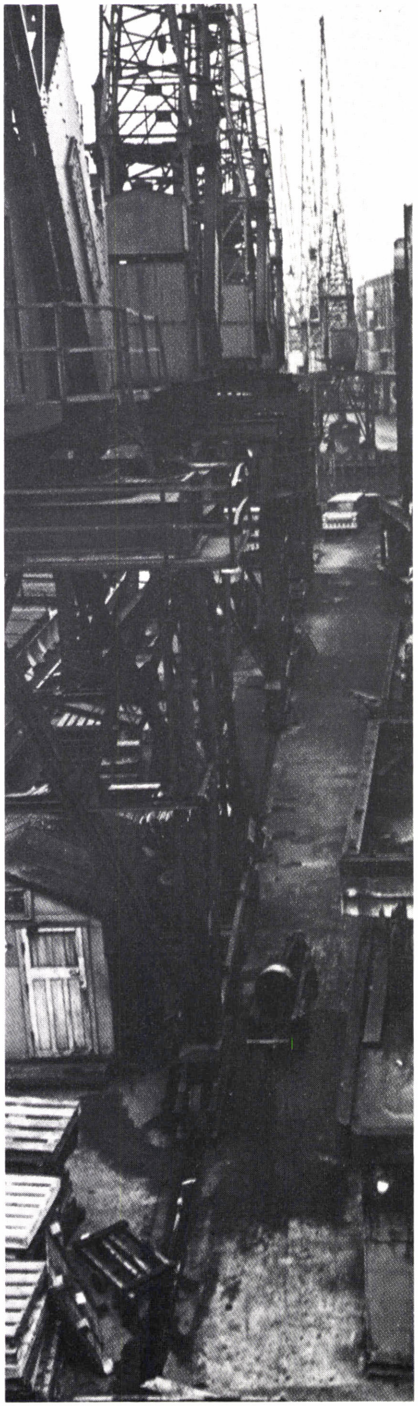
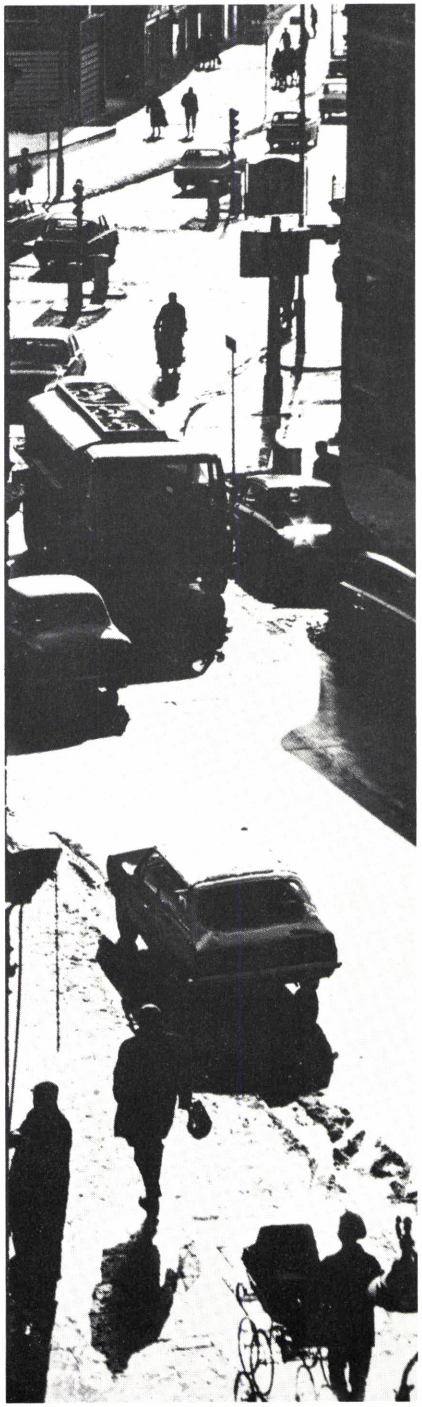
Frank Hough
PHOTOGRAPHS

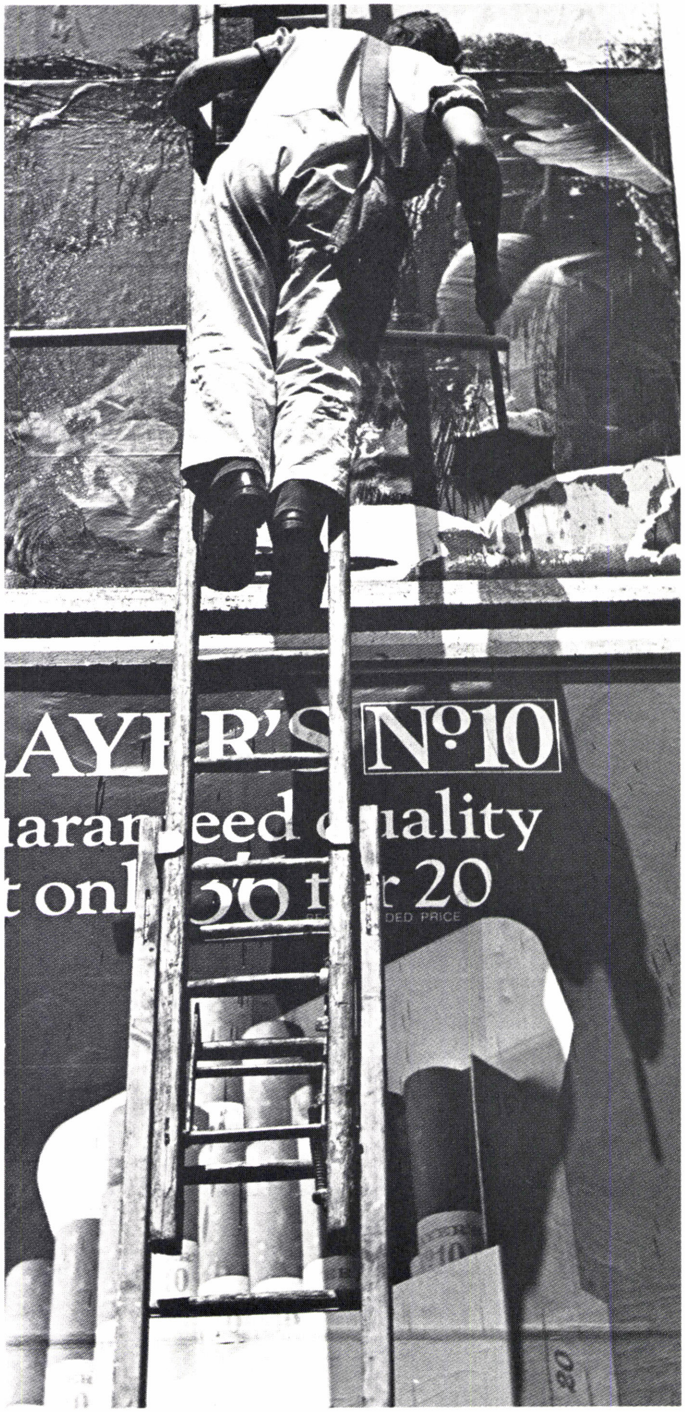





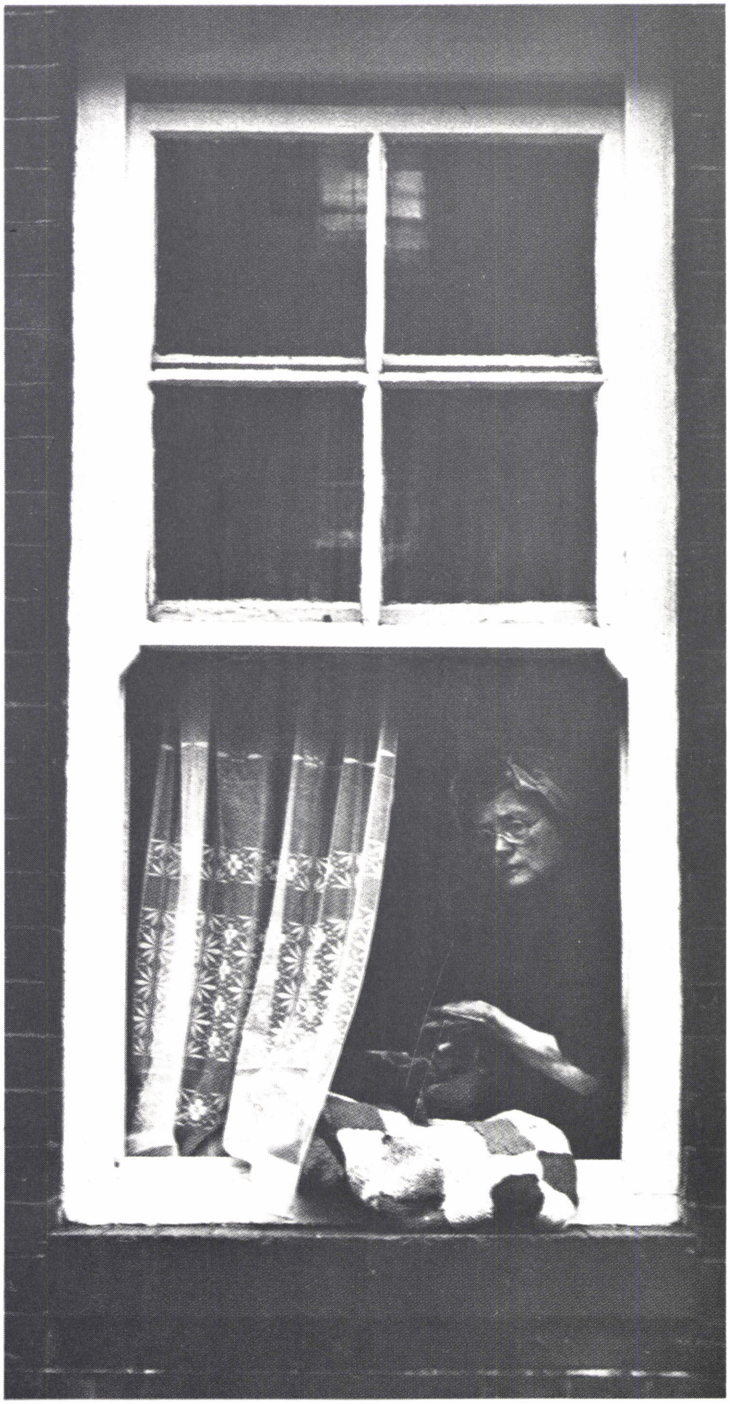



TOILETS



AYER'S
Nº10




WILLIAM SAY & CO LTD