REPRINTED FROM

JOURNAL
OF
THE
AMERICAN
INSTITUTE
OF
PLANNERS
NOVEMBER
1963 VOLUME XXIX
NUMBER 4

by William L. C. Wheaton

OPERATIONS RESEARCH FOR METROPOLITAN PLANNING

OPERATIONS RESEARCH FOR METROPOLITAN PLANNING

by William L. C. Wheaton

The recent metropolitan plans for Denver and Washington revive old issues concerning the optimum form of the metropolitan area, and present challenging alternatives. Despite innovations in form and in the staging of growth, these plans fail to provide criteria for choice between the alternatives presented. They depend instead upon traditional intuitions regarding the desirable form of the city. Current developments in operations research should make it possible to establish some measurable criteria and to provide governments and citizens with at least limited indications of the costs and benefits of alternatives and the means necessary for their implementation.

The dominant feature of American society today is the steady and rapid concentration of our population in urban areas. Virtually 100 per cent of our future national population growth will occur in these areas, as a result of both natural increase and migration. Our national productivity and standard of living will depend in considerable degree upon our ability to plan for this future development and for the necessary redevelopment of existing cities in ways which will overcome the congestion, the problems of health and welfare, and the high costs occasioned by deficiencies in our present cities.

Two recent metropolitan master plans, the plans for Denver and Washington, D. C., illustrate the problems of planning for this growth. In different ways they are among the best of recent metropolitan plans and have received some acclaim in the city planning profession. They reflect adequately the state of practice in this field and the philosophical and scientific foundations of that practice.

Both plans are relatively brief—about 100 pages in length—and consist largely of maps and charts. They are addressed to government officials and informed civic leaders. The underlying studies, to the extent that they exist, are not presented, summarized, or referenced. Thus, in both cases, there is no published basis for judging the adequacy of the analysis behind the plans. One aspect of these plans appears to reveal underlying issues most clearly: the distribution of population, activities, and land uses within the metropolitan area.

THE WASHINGTON PLAN

The Washington metropolitan area plan[1] was prepared by the National Capital Planning Commission in 1961. The population of the metropolitan area is projected to grow from a present level of 2,000,000 to an estimated 5,000,000 by the year 2000. Since federal employment bulks large in the metropolitan total, a separate projection has been made for it. In the past, this employment has been concentrated largely in the center of the metropolitan area. The plan assumes that it will become federal policy to create sub-centers of federal employment on the fringes of the metropolitan area, as has been done in recent years with several major agencies. This decentralization of federal employment will presumably be accompanied by a comparable and contiguous growth of other employment on a decentralized basis. The plan further assumes that any scattered pattern of development is uneconomic and socially and aesthetically bad. Finally, it assumes that the reservation of large amounts of open space in the form of greenbelts is a desirable goal and can be achieved through a combination of planned transportation systems and public controls.

Upon these assumptions, the plan briefly examines the following alternatives:

First, the restriction of metropolitan growth by a combination of federal policy,

William L. C. Wheaton is Director of the Institute of Urban and Regional Development, University of California (Berkeley). Formerly Professor of City Planning at the University of Pennsylvania and of Regional Planning at Harvard University, and Assistant to the Administrator of the Housing and Home Finance Agency, Wheaton has been a member of the Board of Governors of AIP, President of the National Housing Conference, and an active figure in the development of national housing and renewal programs.

Editor's Note:
An earlier version of this paper was presented at the meeting of the Operations Research Society of America in Philadelphia, November 9, 1962.

affluent society is shifting the public concern from such measurable goals to less tangible ones, such as equality of opportunity. Here the need is to develop measures of change in social and economic status, and a clearer understanding of the effects of public actions. At present, we are only on the threshold of the analysis of social policy and its consequences.

NOTES

1 *A Policies Plan for the Year 2000: The Nation's Capital,* National Capital Planning Commission, 1961.

2 *Metro Growth Plan 1970–2000,* Master Plan Report No. 16, Inter-County Regional Planning Commission, Denver, (undated) 1961.

3 For a contrary view, however, see Jack Lessinger, "The Case for Scatteration: Some Reflections on the National Capital Region *Plan for the Year 2000," Journal of the American Institute of Planners,* XXVIII (August, 1962), 159–170.

munity or its component parts. This is beginning to be recognized as a serious subject. Some parts of every metropolitan area are tax-deprived and others are tax-rich. Some parts have excessively low levels of municipal service and others have perfectly adequate ones. Thus, in the Philadelphia metropolitan area, certain school districts spend as little as $300 per child per year and others spend as much as $1,000 per child per year. With some comparable efficiency in dollar expenditures for education, it is apparent that some children are being deprived of educational opportunity, opportunity for self-advancement, or even opportunity for future employment, in contrast to others. Thus, planning for the equalization and raising of standards of municipal services may become a vital link to broader social objectives. Here is a limited goal but one which the public could understand and might regard as sufficiently important to affect public policy. With attainable analytical tools, it should be possible to devise plans which would provide a relatively balanced package of public services at a reasonable tax cost to the affected public under present or revised tax systems, grants-in-aid from higher levels of government, and public service patterns. Here the effect of alternative physical patterns of urban growth, the mix of housing, industry, stores, and public facilities, the tax revenue consequence of each alternative mix, and the municipal cost consequences of alternative mixes should be readily measurable. True, local public services do not affect as much as 10 per cent of consumer expenditures, and the variation between alternatives on the service output side might not exceed 30 or 40 per cent of the average. But this is a sensitive area in public policy and one which often motivates people to action.

A system of analysis which would estimate the alternative transportation costs of different patterns of urban growth might exercise a similar influence on public thinking. At the present time, most people spend from 10 to 20 per cent of their income for various forms of transportation. Expenditures for goods shipment are considerably lower in aggregate national income accounts but vary widely with industry and location. If people's time were measured as a cost, aggregate expenditures for transportation would be substantially higher.

It is apparent, however, that most consumers spend about 9/10 of their transportation dollar on equipment—the automobile—and less than 1/10 on the facilities on which they drive the car—roads and highways. Out of this proportional distribution of transportation expenditures they get poor transportation services involving incredible delays, excessive operating, maintenance, and repair costs, and the most tedious, if not psychologically unhealthy, experiences. Presumably, a shift in the distribution of transportation expenditures to increase outlays for facilities through a few cents increase in gas tax for highways, and a corresponding reduction in outlays for new cars, could produce fairly efficient, pleasant, and rapid transportation systems in most cities, with no increase in aggregate expenditures at all. Combining the greater efficiencies possible through reallocation of resources with those which might be realized with different patterns of urban growth, we might point to measurable costs and measurable benefits for alternative systems. The influence of alternative patterns upon aggregate and sub-area transportation expenditures should be readily calculable.

This kind of analysis is under way at the Penn-Jersey Transportation Study in the Philadelphia area and has recently been completed in a fairly well-rounded way for one growth pattern in the Chicago region. Many facets of the analysis remain for further development, but this is a manageable subject.

In combination, these two types of analysis, the costs of municipal services and the costs of transportation, cover nearly a third of consumer expenditures. This order of magnitude is surely sufficient to provide the American people with a basis for choice between alternative patterns of metropolitan growth. It is probably sufficient, if certain patterns appear clearly preferable in these terms, to motivate Americans to create the means for their achievement.

These are two avenues of exploration in which operations research might provide early help for city planning. Beyond this level there are problems of the efficiency of the city as a system of production and distribution of goods and services. It is entirely possible that we can develop measures with which to test these aspects of metropolitan plans, but in the more distant future. Perhaps the emergence of the

vestments in highways, utilities, housing, and factories typically have a physical life of 30 to 50 years. Their economic life may be considerably shorter. Depending upon the type of investment involved, the accuracy of projections of future population growth, for instance, may seriously affect willingness to invest or the types of investment made. Yet, our ability to forecast future conditions in society is notoriously poor. The record of population forecasts is a dismal one. The record of land use forecasting is far worse and no one correctly foresaw such a major innovation as the automobile or its consequences for urban growth. Since investments continue to be made and must be made, it is obvious that all investors discount the future very heavily and therefore make investments only under the most favorable circumstances or where large losses are tolerable. Presumably, if more reliable forecasts could be made, many new types of decisions would follow. Until some radical change in the quality of forecasts becomes possible, only a system of continuously revising projections and of continuously calculating the consequences of current investments can provide the best possible degree of knowledge for current or future decisions.

Despite these difficulties, there are reasons for expecting real progress toward a systematic and scientifically based approach to metropolitan planning.

AREA DATA SYSTEMS

The current vast expansion of urban populations, the proliferation of public services to them, recent rapid advances in computer technology, and the economies involved in handling all kinds of records and accounts electronically, all combine to make possible data systems which will yield knowledge never before available. Recently, the City of Los Angeles proposed the establishment of a central data library extracted from the operating records of over a hundred government agencies. While even a superficial analysis suggested that no single system could serve the multitudinous needs of city agencies, it became obvious that the city was perfectly capable of establishing a persons file and a properties file which would produce dramatically useful current data and make possible a real breakthrough in planning.

A persons file could show the demographic composition of all areas at any time, and, through school-transfer and other records, could show the movement of people and families from district to district, together with the economic, social, and educational characteristics of the movers. It would thus be possible to know annually whether the average income of an area was increasing or decreasing, by knowing the characteristics of those moving into or out of the area. Such trends projected over time could give advance information to private realtors, individual property owners, and municipal officials, of the prospective qualitative improvement or decline of residential areas. It could warn school administrators of changes in prospect for the child population, and enable them to anticipate required adjustments in curriculum. It could forecast major changes in consumer buying patterns for retailers.

The properties file in this same system would contain information on activities concerning each parcel of property, including employment, traffic generation, net profits derived from gross receipts, tax payments, and net investment or dis-investment derived from current property assessments. Thus, the properties file could be used to appraise current conditions in an area and forecast future ones from trend data. It could be used to estimate changing transportation requirements, the changing location of employment, and even the changing character of employment or other economic activity in different parts of the community.

Such a data system could be established at reasonable cost, for it would be based largely on accounting and record-keeping machinery now required for departmental operating purposes. With minor adjustments, such a system could extract vital information for planning purposes.

To benefit from area data systems, planners must know for what purposes they will use the data other than for a description of current trends. We presently lack definitions of goals, measures of efficiency, measures of correlation, theories of urban growth, and the other analytical insights needed to use potentially available data.

SOME ATTAINABLE GOALS FOR OPERATIONS RESEARCH ANALYSIS

In the absence of means for linking broad societal goals to metropolitan plans, planners might well fall back on such simple objectives as the provision of a balanced package of municipal services within the tax resources of the metropolitan com-

or a place to live deeply affect the structure of growth of the metropolitan area. Manifestly no one can directly command or influence more than a fraction of the decisions involved in metropolitan growth. Even the largest and most powerful agents of government are unlikely to have direct influence over more than one or two per cent of investment decision-making. The most important single agent in most metropolitan areas is likely to be the central city municipal government, and after that, the major electric utility.

Second, the values and motivations of these agents have an equally wide range of variation. A small group of a few hundred people directly affected by the location of a major expressway serving millions of other people can halt a major highway location decision for a whole generation. Yet the millions whose desire for an adequate transportation system is but dimly felt, and in conflict with their desire to hold taxes to a minimum, may not be influential in securing a reasonably efficient package of transportation services in any form. The whole structure of government and our political traditions, plus the fact that 75 per cent of the gross national product is spent privately, tend to permit the intensely felt desires of interests of small fractions of the population to dominate the less intensely felt desires of the majority. Any realistic analysis of the operative meaning of welfare under these circumstances must take cognizance of a wide range in the marginal utility of income, and of an equally wide range in the marginal utility of other forms of benefits offered by our society. It must weigh the interests of hundreds of different groups and the effort which they are prepared to expend on behalf of segmental goals, and it must take note of the often conflicting goals of all individuals and most institutions.

Beyond economic considerations, the metropolitan area is a system for conferring status or prestige, a system for producing and receiving communications, a system for the distribution and use of power. Values in any one of these systems often substitute for values in one of the overlying systems. The analytical system required to reproduce the most important of these effects will be complex indeed.

Third, our understanding of the forces which are operative in the growth, development, and change of the metropolitan area is comparatively primitive. The housing market is among the most influential forces at work, but there are still only fragments of a theory of housing market behavior, only fragments of a systematic analysis of the migration of people within a metropolitan area, and there is little knowledge of the reasons for their behavior. Similarly, we have only a partial understanding of the factors affecting industrial and other employment location, and only fragments of theories regarding transportation and movement patterns. Our knowledge of the influence of major public decisions is even more limited. We know comparatively little about the influence of transportation systems on the development of land uses. We know little about the influence of changing land uses on transportation systems. We know little about the actual influence of zoning, subdivision regulations, and building codes upon the pattern or character of urban growth.

Fourth, any attempt to plan for urban growth involves the development and implementation of policies affecting the rates and direction of change in the urban system. It is, therefore, essential to develop measures of these rates of change as they exist under present market conditions and public policies. This is a comparatively new concept among city planners; yet until we know what the existing rates of change are and what the character of these changes is, we can scarcely influence the system in any rational, projectable, or effective way. It is possible now, for instance, to estimate crudely the net rate of investment occurring in newly developing suburban areas. It is obvious that our worst slum areas are the result of net dis-investment over long periods of time. We can infer that between these extremes sub-areas will have varying net rates of investment or dis-investment which will ultimately lead to the improvement or decline of these parts of the city. In some situations, net dis-investment proceeds for some years and then is reversed, as when a former slum area becomes a prestige area for rehabilitation. Yet even so elementary a measure as the net rate of investment is not presently available to city planners. Other rates of change in the urban system have scarcely been conceived.

Fifth, planning requires relatively long-range projections of future conditions. In-

A third traditional bias of the planner favors the maintenance of a strong central business district and the preservation of the density pattern of past cities. Here it is assumed that the city must have a high-density core, containing a high proportion of the area's shopping, banking, commercial, managerial, civic, public, educational, and cultural functions. Because central districts have in the past provided for a large proportion of the cities' tax revenue, it is argued that they must do so in the future. Again, there is much evidence that the central city functions survive as well or better when located elsewhere, that new and vigorous cities are developing without such high-density central business districts, and that the present trend in the location of many if not all of these functions is toward other than central locations.

The fourth planners' bias is that the journey to work should be reduced by shortening the distance between places of residence and places of employment. It is assumed that this reduction of work distance for primary wage earners will not be accompanied by any corresponding increase in work distance or reduction in job choice for secondary wage earners. It is further assumed that people desire to economize in travel time, distance, and cost. Again there is some evidence to the contrary.

Finally, planners usually assume that the American people desire a wider range of choice in the types and locations of dwellings. Most planners will express a greater preference for row houses, garden apartments, and elevator apartments than for single-family houses, and most will express a greater preference for central or urban locations as opposed to suburban locations. It is assumed that the American public has similar preferences but is deprived by the operation of the housing market of opportunities to express them in the purchase or rental of homes. Again there is much evidence to the contrary.

PROBLEMS IN METROPOLITAN ANALYSIS

Other equally important objectives might guide metropolitan plans, but rarely emerge in primary roles. The provision of full employment would probably be chosen by many of the American people as a first objective of any public policy. Perhaps today so few are directly affected by the spectre of unemployment that this has become an objective of overwhelming importance for only a minority. Maximizing opportunity for individual growth and productivity is a classic liberal goal and certainly continues to deserve consideration. Our society may operate fairly smoothly to maximize such opportunities for the majority, but certain minority and underprivileged groups continue to suffer relative deprivation in these fields. Unfortunately we have no means for measuring the effect of any metropolitan growth patterns upon full employment or individual opportunity.

Could a system of planning analysis and projection indicate which plans would maximize gross regional product? In the case of the Washington, D. C. and Denver plans, which of these would accomplish that goal? This generation of planners has no answer to such a question. Few would know how to approach it. Even more difficult might be the analysis of plans in terms of their effect upon individual consumer income, presumably involving some objective of maximizing aggregate consumer income under the constraint of providing some minimum income for each individual and a relatively free market distribution of income above the subsistence level. Again the difficulties are formidable. Both these objectives would have wide public appeal, and might reduce particularist local pressures as the public, business leaders, and government officials gain confidence in the accuracy of the analysis systems being used. However, both objectives also show the fundamental lack of both data and analytic concepts for linking such broad social or economic goals to the physical plans of metropolitan areas.

The problem of establishing feasible goals for metropolitan planning is not merely one of matching objectives to the level of present analytical competence. It also requires coming to grips with the nature of the systems which comprise metropolitan areas.

First, the agents of metropolitan decision-making are widely varied in size, influence, intelligence, and location. In many respects, each of them is autonomous. They include in the typical metropolitan area from 300 to 900 units of local government, plus super-imposed layers of county, state, and federal agencies. Other major decision agents are thousands of business firms, large and small, often acting autonomously and sometimes irrationally. Furthermore, the individual decisions of hundreds of thousands of people in their choice of a place of employment, a journey to work,

no effective means exist for such containment, since our present zoning powers, as they are operated by local governments, have proven incapable of long withstanding normal market forces. It is possible, of course, to hold development within limits by ultra-low-density zoning which raises the cost of houses and thus reduces the size of the market. Such a policy would probably be illegal, however, and would in any case have very serious adverse effects upon metropolitan growth if pursued as a major means of containing development.

The type, quantity, and timing of community facilities—particularly highways, and water and sewer lines—affect the rate and location of urban development (Figure 3), but means do not presently exist for programming such facilities on a metropolitan basis to guide development in conformity with the master plan. Some of the better governed central cities do engage in capital programming. But even within such single-government jurisdictions, systematic consideration of the effect of programmed actions upon development rates and patterns is rare. One of the most common assumptions in modern planning is that the location and character of highway and transit facilities will affect the rate and character of development in the areas served by such transportation facilities. Nevertheless, comparatively little is known about the actual effects involved, and this subject is only beginning to be explored in a systematic way.

In short, the Denver plan proposes to organize the region's future expansion in stages and on a contiguous basis. It assumes that the forces affecting the rate of aggregate expansion are autonomous. It proposes a distribution of population and industry into separated communities, but no very effective means of implementation are presently available to achieve this distribution. Its major contribution is the presentation of the idea of an evolving process of growth, and preliminary notions of the factors that might affect rates of growth in different areas.

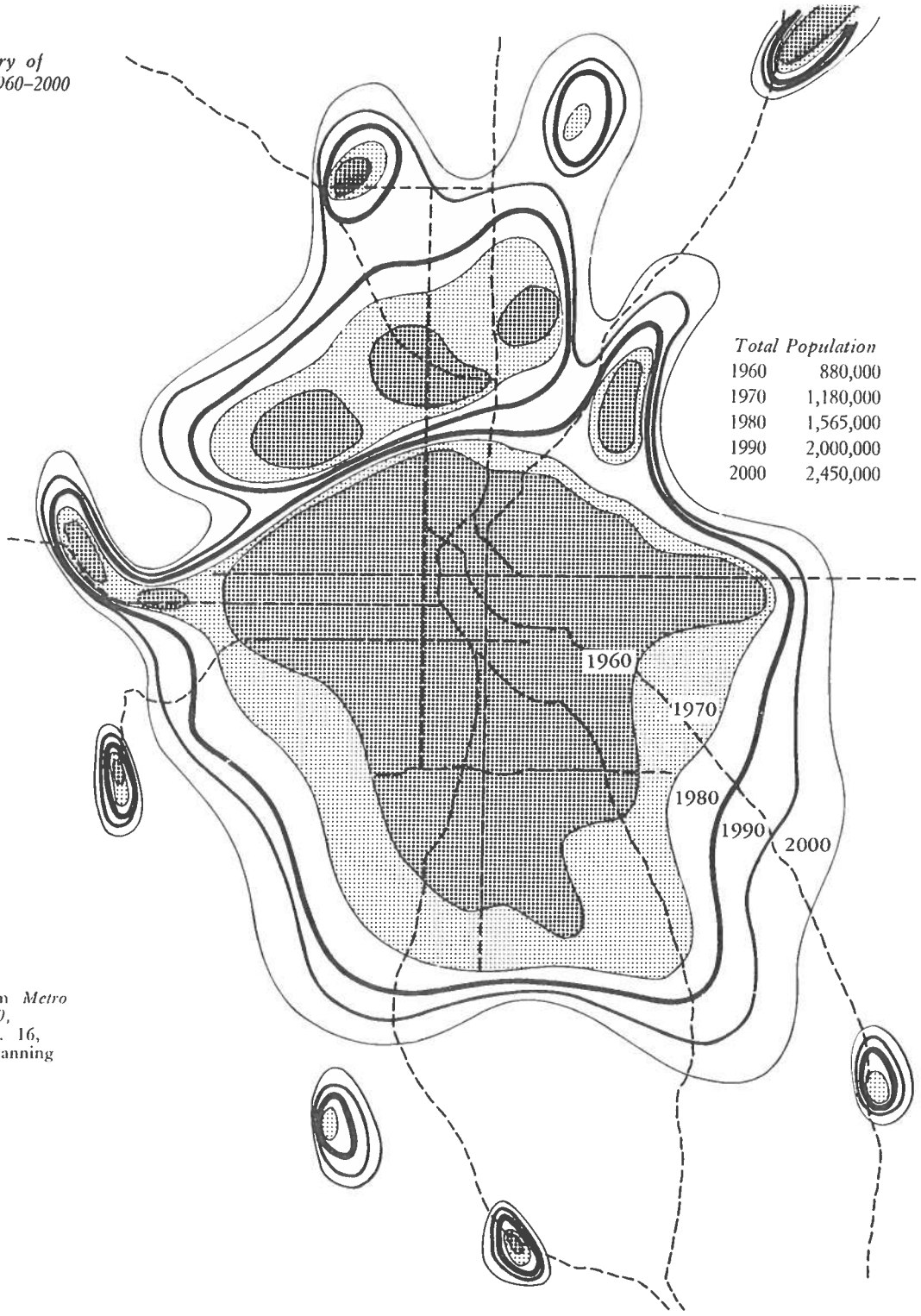
The Washington and Denver plans provoke these questions: What grounds are there for the choice of any of these patterns of development, as opposed to whatever pattern will evolve from normal market forces as they are influenced by normal regulations and the usual imperfections in the market? Is any of these patterns more efficient than any other, more economic? Does any one of these patterns really offer a higher level of "amenity," however defined? How many would support such judgments? Which of these plans most nearly conforms to the preferences of the American public regarding housing, employment, the journey to work, recreation, and community facilities?

PLANNERS' BIASES

The planners' biases are quite clear. They regard the present pattern of scattered development as inherently evil. Often in planning literature this needs no demonstration: like natural law, it is obvious to all right-thinking people. Elsewhere it is claimed that scatteration reduces open space; leads to longer journeys to work; minimizes the efficiency of providing community facilities; reduces choice in housing types and residential location, shopping, and access to community facilities; uses far more land than is necessary for urban growth; usurps land that should be retained in agricultural use; destroys the countryside; is "undemocratic." In extreme cases, such as Spectorsky's *The Exurbanites* and Gordon's *The Split-Level Trap,* the suburban pattern is blamed for excessive drinking, loose moral behavior, and neurotic or psychotic disorders. The case against scatteration, in short, is a popular one with very weak underpinnings.[3]

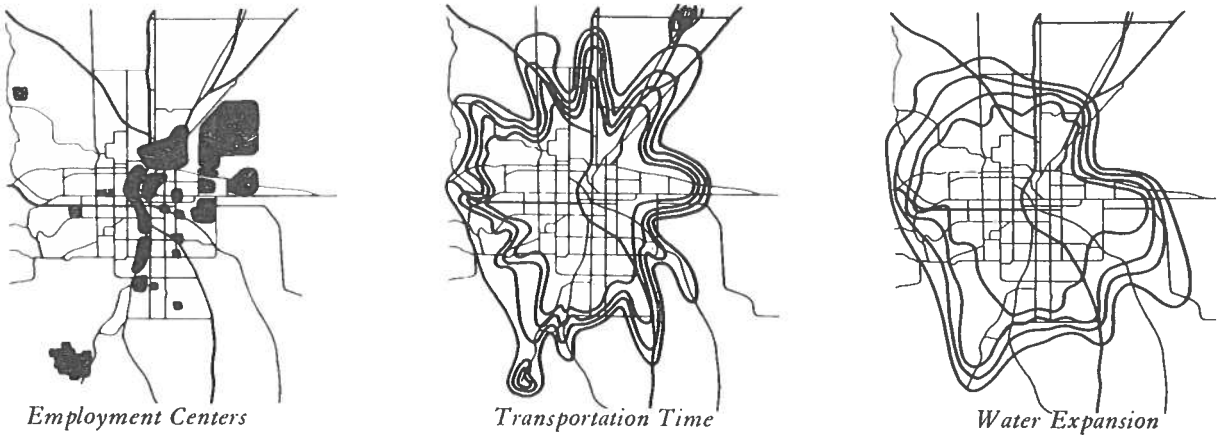
A second universal planners' bias is one in favor of the preservation of open space. This view is derived directly from the middle-class suburban background of many planners and the traditional American and British view which associates the country and the rural life with virtue and rectitude, and the city with sin and evil. Somehow, if open space can be preserved and if people will but go to see it, their lives will be elevated and mankind will be the better. In this line of reason, of course, it is rare that we find any calculations of how many people want how much open space or are willing to pay how much to have it. Nor do we often find calculations of what the price of preserving such open space might be to the community, to the social, geographic, and economic patterns of urban growth, or to our productive capacity.

FIGURE 2 *The Outer Boundary of Urban Expansion in Denver, 1960–2000*



SOURCE: Denver illustrations from *Metro Growth Plan, 1970–2000*, Master Plan Report No. 16, Inter-County Regional Planning Commission, Denver.

FIGURE 3 *Graphic Representation of Three Factors Influencing the Denver Development Plan*



THE DENVER PLAN

The Denver Metropolitan Plan,[2] produced in 1961 after several years of effort, projects the growth of that metropolitan area to the year 2000. It estimates that the population will grow from 880,000 in 1960 to 2,450,000 by the year 2000. The growth rate is assumed to be largely autonomous, the result of regional and national market forces, and therefore, beyond the control of the metropolitan planning agencies. It is rare for any metropolitan plan to examine or even consider whether metropolitan population growth is controllable, or should be the subject of public policy.

Metropolitan employment is derived from estimated population in the Denver plan. From these estimates of population and of employment—broken down at least into industrial, commercial, and other categories—requirements for different land uses are estimated. Such estimates are derived empirically from existing average land use ratios as they appear to be modified by current trends. Marginal rates are rarely used in forecasting land requirements.

Since residential land uses comprise about half of all land uses, and since the housing market is one of the most autonomous of the forces shaping the metropolitan area, the residential land use plan becomes a major element in any metropolitan plan. The usual approach is to estimate the future holding capacity of land based upon existing or prospective zoned densities, and to assume that development will be more or less contiguous to existing development despite the evident fact that current residential development is widely scattered and follows no evident systematic pattern. This procedure leads to an estimated distribution of resident population and residential land uses.

In a similar way, industrial land uses are estimated from the projected industrial employment multiplied by prospective employment density. Sites not clearly usurped for residential use are identified for industrial purposes. Estimates are prepared of the amount and type of land required for commercial and community facility uses, and located by ordinary market area delineation in each community or sub-region.

Given these estimates and locations of residential, industrial, commercial, and institutional or public land uses, transportation requirements are estimated for the major patterns of movement, notably the journey to work, and a transportation system is derived from such estimated requirements. In the Denver case, it is a highway system placing little reliance upon public transit facilities.

In addition, the Denver plan shows space requirements for schools, parks, police and fire stations, libraries, health and welfare facilities, and the other public facilities occupying space. Finally, the plan takes account of such sub-surface facilities as sewer and water systems.

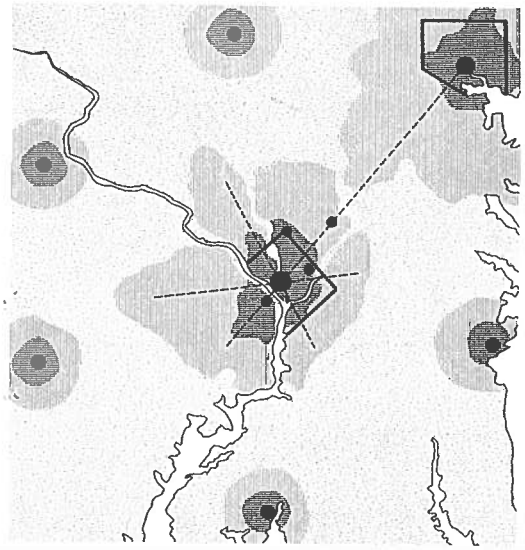
The Denver plan assumes that growth will follow a contiguous pattern, with the edge of the developed area pushing steadily outward during the next forty years (Figure 2). A 50 per cent residential land vacancy rate is assumed from 1960 to 1980 and 30 per cent thereafter. In the last two decades of the forecast period, an almost inconceivable shift to apartment house living is assumed. In combination, these assumptions serve to restrict the area of growth, and to take some account of scatteration. The Denver Plan is unique among American plans in this attempt to project the rate and location of growth through time, and the plan has an interesting although relatively fragmentary basis for analyzing the forces at work which will produce such a pattern and rate of expansion.

The Denver plan also divides the metropolitan area into communities and neighborhoods. Each of these is assumed to contain a resident population, local public and private facilities—such as schools and shops—required to service that population, and some employment opportunities.

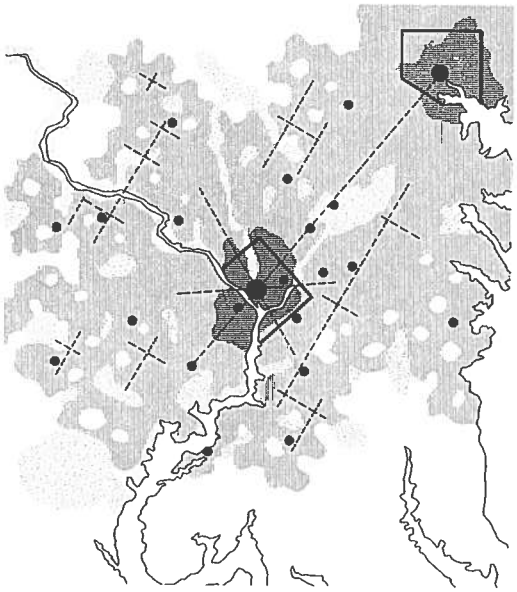
In the plan, these communities are separated from each other by a system of parks, parkways, and expressways. No means presently exist for the reservation of these separations as public open spaces or as reserved sites for future expressways. In fact, the aerial photographs upon which these community plans are superimposed reveal that many of the planned open spaces or separation strips are fully developed for housing or other land uses today.

Finally, the plan assumes that a large proportion, if not all, of the growth of the Denver area can be contained within delineated metropolitan boundaries. Again,

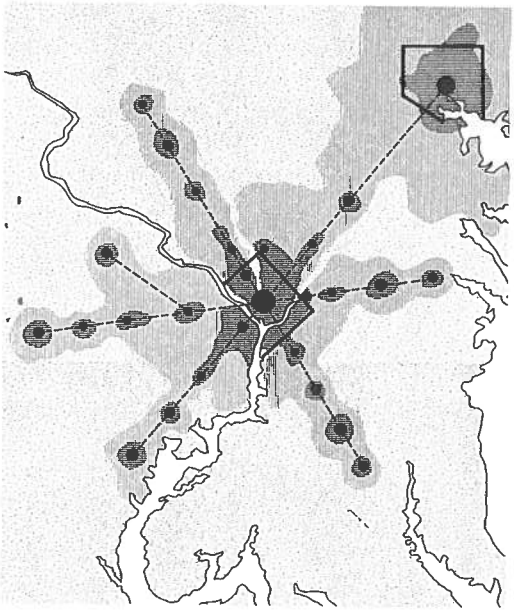
FIGURE 1 *Three Alternatives Considered in the Washington Plan*



New Independent Cities



Planned Sprawl



Radial Corridor Plan

SOURCE: *A Policies Plan for the Year 2000: The Nation's Capital,* National Capital Planning Commission, 1961.

which would move future federal employment centers to other cities, and local policy, which would restrict areas available for urban growth. The effect of these policies would be to increase the density of the remaining areas and deter the movement of people and enterprises to metropolitan Washington. This alternative is rejected as neither feasible nor desirable. In all the other alternatives presented, the rate of population growth is assumed to be exogenous, beyond the control of the public policy.

Second, a pattern which would accommodate present growth in new independent cities. This alternative is described as attractive but difficult to attain, particularly in view of its dependence upon the co-operation of the areas affected and the difficulties of channeling growth into such cities.

Third, a pattern called "planned sprawl." This alternative assumes that the present pattern of residential expansion will proceed, but that sub-centers for community services, commercial services, and federal employment will emerge, linked by highways; and that these will form a sprawling but partially nucleated suburban pattern. This alternative is rejected on the grounds that it would be undesirable, would increase journeys to work, would reserve no open space, and would limit housing and employment choices to those now available in the suburban areas.

Fourth, the emergence of a number of dispersed cities. This alternative differs from the second only in that several more proposed cities of smaller size are suggested.

Fifth, a ring of cities. This pattern would have certain communication and transportation advantages over the dispersed city pattern, but, like it, would tend to generate pressures for development in the greenbelt and would tend to de-emphasize the importance of the metropolitan center.

Sixth, peripheral communities. This alternative is not essentially different from the preceding two, but it poses another possible pattern of growth with narrower open spaces and slightly more concentrated radial transportation routes. Again it assumes less control over the pattern of development than would be the case in preceding alternatives.

Finally, the radial corridor plan, based upon the establishment of major radial transit and expressway systems. This plan assumes that such transit axes can be built, usually in advance of population growth, that employment and community service centers will be generated along them and lead to the development of a fairly high-density core along each corridor and surrounding the stops in the transit system. It is claimed that this pattern would provide a wider choice of housing types, including single family detached homes, garden apartments, and elevator apartments along each corridor. This pattern would supposedly facilitate employment choices by providing employment centers along each linear axis and in the center. The report argues that this plan would lead to the growth and renewal of the metropolitan center as a major business and employment district. Growth could thus be restricted in the interstitial green spaces, preserving access to the countryside at convenient distances from most of the population. A radial transit system and a radial and ring highway system are conceived as the most important development forces to effect the plan.

Needless to say, the radial corridor plan is the pattern of development which is recommended for adoption by the National Capital Planning Commission and the adjoining states, counties, and municipalities.

The plan itself shows a static future state for the year 2000. In this respect it is similar to almost all past master plans, which usually show a condition forecast or proposed for 25 years hence. There is no indication of the intervening states, even little discussion of the processes necessary for their achievement, although one of the alternatives presented is, in effect, a forecast of the results of continued "normal" growth under the normal planning, regulatory, and market forces now operative.

The Washington plan is one of the first to try to present alternatives for public choice. It does so, however, in a totally sketchy fashion, without any analysis of the economic, social, or other implications of the choices offered, or any calculation of the costs or benefits of any alternative. Nevertheless it is an important advance in posing the issues.

OPERATIONS RESEARCH FOR METROPOLITAN PLANNING

by William L. C. Wheaton

The recent metropolitan plans for Denver and Washington revive old issues concerning the optimum form of the metropolitan area, and present challenging alternatives. Despite innovations in form and in the staging of growth, these plans fail to provide criteria for choice between the alternatives presented. They depend instead upon traditional intuitions regarding the desirable form of the city. Current developments in operations research should make it possible to establish some measurable criteria and to provide governments and citizens with at least limited indications of the costs and benefits of alternatives and the means necessary for their implementation.

The dominant feature of American society today is the steady and rapid concentration of our population in urban areas. Virtually 100 per cent of our future national population growth will occur in these areas, as a result of both natural increase and migration. Our national productivity and standard of living will depend in considerable degree upon our ability to plan for this future development and for the necessary redevelopment of existing cities in ways which will overcome the congestion, the problems of health and welfare, and the high costs occasioned by deficiencies in our present cities.

Two recent metropolitan master plans, the plans for Denver and Washington, D. C., illustrate the problems of planning for this growth. In different ways they are among the best of recent metropolitan plans and have received some acclaim in the city planning profession. They reflect adequately the state of practice in this field and the philosophical and scientific foundations of that practice.

Both plans are relatively brief—about 100 pages in length—and consist largely of maps and charts. They are addressed to government officials and informed civic leaders. The underlying studies, to the extent that they exist, are not presented, summarized, or referenced. Thus, in both cases, there is no published basis for judging the adequacy of the analysis behind the plans. One aspect of these plans appears to reveal underlying issues most clearly: the distribution of population, activities, and land uses within the metropolitan area.

THE WASHINGTON PLAN

The Washington metropolitan area plan [1] was prepared by the National Capital Planning Commission in 1961. The population of the metropolitan area is projected to grow from a present level of 2,000,000 to an estimated 5,000,000 by the year 2000. Since federal employment bulks large in the metropolitan total, a separate projection has been made for it. In the past, this employment has been concentrated largely in the center of the metropolitan area. The plan assumes that it will become federal policy to create sub-centers of federal employment on the fringes of the metropolitan area, as has been done in recent years with several major agencies. This decentralization of federal employment will presumably be accompanied by a comparable and contiguous growth of other employment on a decentralized basis. The plan further assumes that any scattered pattern of development is uneconomic and socially and aesthetically bad. Finally, it assumes that the reservation of large amounts of open space in the form of greenbelts is a desirable goal and can be achieved through a combination of planned transportation systems and public controls.

Upon these assumptions, the plan briefly examines the following alternatives:

First, the restriction of metropolitan growth by a combination of federal policy,

William L. C. Wheaton is Director of the Institute of Urban and Regional Development, University of California (Berkeley). Formerly Professor of City Planning at the University of Pennsylvania and of Regional Planning at Harvard University, and Assistant to the Administrator of the Housing and Home Finance Agency, Wheaton has been a member of the Board of Governors of AIP, President of the National Housing Conference, and an active figure in the development of national housing and renewal programs.

Editor's Note:
An earlier version of this paper was presented at the meeting of the Operations Research Society of America in Philadelphia, November 9, 1962.

affluent society is shifting the public concern from such measurable goals to less tangible ones, such as equality of opportunity. Here the need is to develop measures of change in social and economic status, and a clearer understanding of the effects of public actions. At present, we are only on the threshold of the analysis of social policy and its consequences.

NOTES

1 *A Policies Plan for the Year 2000: The Nation's Capital,* National Capital Planning Commission, 1961.

2 *Metro Growth Plan 1970–2000,* Master Plan Report No. 16, Inter-County Regional Planning Commission, Denver, (undated) 1961.

3 For a contrary view, however, see Jack Lessinger, "The Case for Scatteration: Some Reflections on the National Capital Region *Plan for the Year 2000*," *Journal of the American Institute of Planners,* XXVIII (August, 1962), 159–170.