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A Review of Urban Density Models: Toward a Resolution of the Conflict Between Populace and Planner

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The belief that high density is stressful and unhealthy has contributed to a decline in urban density in many countries, particularly North America and Australia. Yet many physical planners are calling for an increase in urban density. Many human or individual-oriented studies (which involve ethological models, sociological models, and psychological models) have been used to suggest negative effects of urban density. This article raises questions about these conclusions and presents evidence from recent studies which suggests more positive human aspects of urban density. The physical or systems-oriented studies (which involve economic, ecological, historical, and engineering models) suggest advantages in costs, energy, environment, and transport from increasing urban density. The resolution of the conflict between populace and planner is suggested to include greater awareness of mutual benefits from increased density, better planning and design, and encouragement of the more positive human aspects of higher urban density.

KEY WORDS: urban planning; population density; social behavior models; systems models.

INTRODUCTION

Urban density historically has been mostly in the range of 100 to 200 people per hectare (ha) (Chandler and Fox, 1974). Few cities were less dense though some were more so; for example, Babylon was thought to be around 300/ha in 430 B.C., Rome was estimated as 500/ha in 100 A.D., Genoa appears to have been the most crowded with 600/ha in the late Middle Ages, and Edinburgh was nearly as dense by 1750 (Chandler and Fox, 1974).

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Today most Third-World cities and many European urban centers have densities in the 100 to 200/ha range, with a few higher, namely Calcutta (303/ha), Hong Kong (347/ha), and Dublin (210/ha) (United Nations, 1976). However, the most striking change from historical patterns has been the development during this century of low-density cities, particularly in North America and Australia.[2]

These low-density cities have an amazingly uniform range, from about 10 to 30/ha. All major Australian cities have densities of less than 20/ha (Harrison, 1977) with the newer cities closer to 10/ha; the average for U.S. cities is 15 (Pickard, 1967) and even New York, with its high-density center, has a density of only 26/ha. These cities usually have declined in density from around 100/ha at the turn of the century. While European cities have also declined in density, they have not done so nearly as extensively as in Australia and North America. These trends in urban density continue to show still further declines in North America and Australia, a slow decline in Europe, and some increases in the Third World (Newman and Hogan, 1979).

The trend to lower urban density is fueled by the belief that high-density living is unhealthy and stressful. Surveys show that the majority wish to live in a detached house in a low-density suburb (Michelson, 1977; Osborn, 1967; Halkett, 1976; Maddocks, 1978). More recently there has been a trend to shift even further out to completely rural surroundings in a so-called exurb (Berry, 1976). Yet this desire for space, now a powerful social force, is coming more and more into conflict with the conclusions of many urban planners, who are beginning to call for an increase in urban density (Hall and Smith, 1978; Jackson, 1978; Real Estate Research Corporation, 1974; World Bank, 1976; Schneider, 1979). This call has arisen from physical constraints associated with the low-density city, but is gaining momentum through newly recognized human and social constraints as well. This article examines the various models used to interpret the question of urban density in an attempt to resolve the apparent conflict between populace and planner in cities of the late 20th century.

The first section assesses models directed at the human or individual aspects of urban density originating from the disciplines of ethology, sociology, and psychology. The second section considers the more physical or systems-oriented approaches to urban density derived from ecology, history, economics, geography, and transportation engineering.[3] The

[2]Urban density is the population divided by the total built-up area of a city, excluding all non-urban land uses. In this study "low density" is used to describe cities (like those in North America and Australia) with an urban density less than 25/ha and "high density" to describe cities (as found in most of the Third World and in certain parts of Europe) with an urban density greater than 100/ha.

[3]In any interdisciplinary review the categories chosen will be somewhat arbitrary. It is difficult to separate "human" and "physical," as almost everything physical in cities is human made

Table I. Models of Urban Density

Human or individual-oriented models	Physical or systems-oriented models
Ethology—Physiological pathology models Increasing urban density causes greater physiological stress. —Territoriality models Increasing urban density causes aggression through increased violation of territories.	Ecology—Ecological systems models Increasing urban density will lower resource and environmental impacts.
Sociology—Social disorder models Increasing urban density leads to social disorder such as crime, suicide, and drug taking. —Public health models Increasing urban density causes ill health due to greater opportunity for infection, less air, and less light. —Loss of rural innocence models Increasing urban density removes the beneficial value of rural lifestyles available in the garden suburb.	History—Descriptive historical models Increasing urban density will favor the public transport city and walking city rather than the automobile city. Economics/Geography—Density-gradient models Increasing urban density will provide cheaper access as transport costs, particularly of energy, rise. Transportation engineering —Prescriptive empirical and simulation models Increasing urban density will promote public transport, shorten car trips, encourage bicycling and walking, save energy, lower infrastructure costs, and improve environmental quality.
Psychology—Personal space models Increasing urban density produces psychological stress through more frequent violation of personal space. —Crowding models Increasing urban density leads to crowding which causes behavioral effects, although at different densities in different cultures.	

models have been summarized for simplicity in Table I. A third section proposes some overall conclusions.

HUMAN- OR INDIVIDUAL-ORIENTED MODELS OF URBAN DENSITY

The fact that the majority of human-oriented studies on the effects of urban density have reached negative conclusions has suggested to the general public that they should live farther and farther apart. This review seeks to question the conclusions and the consequence.

and everything human is physically expressed in some respect. However, the human or individual models described here are all trying to see the effects of urban density on people directly, whereas the physical or systems models look at the effects on the total city, its form and functions as an entity or an organism, rather than the people who make it up. The categories should be seen not as watertight compartments but as aids in the presentation of a vast array of literature.

ETHOLOGICAL MODELS

As ethology is the study of animal behavior, the ethological model is the means by which the theoretical constructs embodied in animal research are applied to human society. The two main concepts used by ethologists to examine urban density are physiological pathology and territoriality.

Urban Density and Physiological Pathology

Studies on animals in crowded situations have revealed physiological overstimulation, including enlargement of the adrenal gland, decreased male gonadal activity, waning in disease resistance, increased proportions of abortions, average physical size decline, and a number of associated behavioral effects such as rape and homosexuality (Calhoun, 1962; Leyhausen, 1965; Southwick, 1967; Christian *et al.*, 1960). These results have been attributed, at least in part, to the lack of space, leading biologists to suggest a biological necessity for low-density living (Morris, 1968; Lorenz, 1966).

However, there is evidence to suggest that the biological model is oversimplified: the adrenal gland does enlarge under crowded conditions, but this phenomenon is related more to the number of animals than the amount of space per animal. No evidence has been found to consistently correlate density with disease susceptibility, decline in sexual activity, nervousness, and emotionality in general, indicating that other factors may be more important (Freedman, 1974, 1975). Moreover, there is reason to question the relevance of findings about the behavior of animals to that of humans. As Freedman (1975) points out:

> It is both difficult and risky to generalize directly from the behavior of one animal to that of another. It would be a mistake to conclude that dogs act a particular way just because cats do or that monkeys act the same way as lions, and it is of course much more difficult to conclude anything about humans from other animals. Humans are more intelligent, have language, and have extremely complex social structure, are much more flexible and innovative than other animals, have a history which they can remember, and so on. This is not to say that there is a discontinuity between humans and other animals... but there is enough difference between humans and the rest of the animal world to make it difficult to conclude anything about humans from what other animals do. (p. 41; cf. Baldassare, 1979)

Urban Density and Territoriality

Numerous studies of animal behavior show territoriality to be a basic part of animal social organization. When territories are disrupted there is an increase in aggression and a breakdown of social order (Lorenz, 1966). Social biologists or ethologists such as Wynne-Edwards (1965), Ardrey (1966), and Morris (1968) have used this finding to suggest that humans also

possess an innate territoriality which is violated by high-density situations, resulting in heightened levels of aggression. Architects and town planners have tended to adopt this terminology when justifying the need for private space around dwellings.

A critique of this theory must look both at its accuracy regarding animal behavior and the appropriateness of its application to human society. First, it is not certain that territoriality is necessarily an instinctive characteristic of animal behavior. In some animals such behavior is exhibited only in circumstances in which the animal's own survival is threatened (e.g., during breeding season or shortage of food). Montagu and others, in assessing the evidence in this area, conclude that territoriality is a learned behavior and not a "phylogenetically programmed factor of nature" (1973: 16).

Furthermore, there is little evidence that the so-called territorial imperative (Ardrey, 1966) is a universal characteristic in the animal kingdom. Bourliere (1954) and Collier *et al.* (1973), for example, state that territorial behavior is more easily identifiable among birds and fish than in mammals. Montagu also notes a large number of exceptions to the territorial imperative:

> There are many animals that do not exhibit such behavior: The California ground squirrel, adult male long-tailed field mice, she-wolves, the red fox, the Iowan prairie spotted skunk, the northern plains red fox, and in the superfamily to which man belongs, the Hominoidea, the orang-utan, the chimpanzee, and the gorilla, as well as many other animals. (1973: 18)

Field studies by Van Lawick-Goodall (1963, 1971) on chimpanzees, Harrisson (1963) on orangutans, and Schaller (1964) on gorillas indicate that *Homo sapiens'* nearest primate relatives show few, if any, signs of a territorial instinct.

As for directly applying animal behavior theories to human society, Alland (1972) and Fischer (1975) argue that the human genetic inheritance has limited importance in influencing human behavior. Alland points to the role of culture in freeing human populations from biological constraints over the development and maintenance of behavior systems. Fischer argues that if instincts develop and persist because they provide an evolutionary advantage to a species, then territoriality cannot apply to humans, who survive best by living and working together and not by spreading themselves thinly across the landscape.

In summary, while territorial theories have validity within their own framework and may have some relevance for an understanding of human behavior, their past application to human spatial requirements and more specifically to high urban-density settings is certainly questionable. Architects and planners who assume that the human desire for large private space (and hence low density) is a biologically innate territorial instinct do an

injustice to ethological research as well as town planning. The misuse of the theory of evolution by social Darwinism in the late 19th century is perhaps a useful historical analogy here.

More recently, studies by Edney (1976) and Edney and Buda (1976) have used the territoriality model not to suggest simply that such an innate tendency exists in human society, but rather as an analogy that provides useful insights into the psychology of urban life. Edney states

> Ardrey believes that aggression and animosity are natural and pervasive behavioural states among vertebrates, including man, and therefore one of the important functions of territoriality is to separate individuals and thereby reduce the incidence of aggression.
>
> Territoriality is actually a complex set of behaviours in humans, and whereas it is easily identified in lower animals because it is stereotyped, involving aggressive defense of a personal space claim, the corresponding human expression is usually more passive, and often managed on a symbolic level with culturally modified behaviours. (1976: 813)

Edney accepts Ardrey's idea that ownership of a private piece of the environment is a significant factor in determining human behavior, but emphasizes a difference in its expression. Human territoriality is seen as an "association of person-with-place phenomenon rather than as a defense phenomenon" (p. 814). Since territory is conventionally marked by predominant usership, it need not be spatially defined but can be a piece of real estate or a cognitive preserve, for example. Edney suggests that human territoriality is important to individuals, small groups, and communities alike, and that it is "intimately connected with a personal sense of necessity, control, self-determination, freedom and identity" (p. 820). Thus it is possible to maintain the concept of territoriality without having to link it to high-density living in a negative way. Architects, for example, are now designing buildings at high physical-density levels but with in-built environmental mechanisms catering to individual human territoriality (see, for example, Safdie, 1970, 1974; Heideman, 1976; Doxiadis, 1974).

SOCIOLOGICAL MODELS

Sociology attempts to identify trends in society and either to find causal explanations or to link them in terms of cultural beliefs. Both aspects of sociology have been used to analyze urban density. The first suggests there are causal links between high density and social disorder and between high density and ill health; the second suggests there is a link between urban factors like density and the loss of rural innocence.

Urban Density and Social Disorder

Following the social biologist's belief that there must be an association between urban density and social disorder due to genetic and hormonal

factors, sociologists have attempted to establish formally such a causal link. The major index that has been used to relate urban density and social disorder has been crime rates, although such factors as delinquency, educational performance, suicide, and drug taking have also been adduced (Schmitt, 1966; Galle *et al.,* 1972; Levy and Herzog, 1974, 1978). The association of high-density living with social disorder has long been accepted by sociologists (e.g., Schroeder, 1942; Simmel, 1957), though Durkheim and Wirth were both much more circumspect in their assessment of density.

This association has two major shortcomings. First, a correlation based on aggregate data does not imply a causal relationship (Schmitt *et al.,* 1978) and when other variables such as ethnicity, poverty, education, etc. have been controlled, the correlation is less obvious (Galle *et al.,* 1972; Ward, 1975; Kirmeyer, 1978; Choldin *et al.,* 1975). More detailed studies have since confirmed that density bears little consistent relationship to social pathology (Wilner and Baer, 1970; Booth and Johnson, 1975; Choldin and Roneck, 1975; Freedman, 1975; Schmitt *et al.,* 1978).

A study for the Australian Institute of Urban Studies plotted the relationship between varying density levels and mental health, physical health, delinquency, crime, alcohol and drug abuse, truancy, and school-leaving age levels, and concluded that "housing characteristics examined do not 'cause' any of the social behaviour patterns considered" (Pak-Poy and Associates, 1973: 61). Booth *et al.* showed that there are no significant relationships (whether objective or subjective scales are used) between household and neighborhood crowding and patterns of family relationships including spousal relations, reproductive behavior, and child development. They concluded:

> The fact that parental health which is largely unaffected by crowding and family income are much more momentous in their effects on child development would lead us to urge the development of progress directed toward income maintenance and preventive medicine rather than progress designed to alleviate congested housing. (1979: 85)

Second, any long-term or global view of density renders a causal link between density and social disorder even more doubtful; urban densities have been high until very recently in human history, as indicated in the introduction. Even today only a small proportion of the world's people live in low-density cities and these, in comparison to many high-density cities like Tokyo and Hong Kong, have a higher incidence of social disorder (Schmitt, 1963). A recent survey in Hong Kong (Pun, 1979) indicated that despite their comparatively low crime rates and high density the populace consider crime the most important problem and density one of the least important problems in their city. In contrast, while urban densities have been declining in U.S. and Australian cities in recent decades, crime rates have soared.

It is important to make the distinction here between high density and high rise. A number of studies have attempted to link negative social effects with high-rise dwellings (e.g., White, 1950; Newman, 1973; Rosenberg, 1960; Taylor, 1973). The rejection of high-rise housing has been a key element in the move to build only low-density housing. However, the two do not always go together; for example, Tokyo has very few high-rise buildings as it is in an earthquake zone, yet its density is 163/ha, and Taylor (1973) gives numerous examples of housing developments in England where densities of over 100/ha have been achieved yet each family has ground-level space. Certainly throughout history cities have been low in building heights but high in density. Thus the correlations between high-rise dwellings and social pathology would suggest that design factors other than density *per se* were responsible.

A number of more recent studies have begun to show that such external physical factors as density must be seen as secondary to the potential for human responses that can alleviate any social disorder. Baum *et al.* (1975) demonstrated that the formation of groups among crowded dormitory residents served to mitigate any expected adverse social impact of high-density living. Stokols (1972) also showed how such human factors as the social atmosphere of an area mediate the impact of crowding experiences. Even studies on the negative effects of high-rise living have been criticized as inadequate, since for each apartment building with high rates of social disturbance there are others that do not show this because of better management (Conway and Adams, 1977) or social cohesiveness due to the action of individual or collective residents (Biderman *et al.*, 1963; Mercer, 1975; Baum *et al.*, 1975; Stokols *et al.*, 1978).

The present evidence thus suggests that a link between high density and social disorder is very tenuous. This assessment is probably best summarized by Fischer in *The Urban Experience* (1976), which concludes that the density factor is largely irrelevant in shaping social life. Some studies even have begun to suggest that the fragmentation of society may be attributed at least in part to the consequences of low-density urban living (e.g., Schneider, 1979; Schaeffer and Sclar, 1975).

Urban Density and Public Health

The response of public health authorities to urban density has been to stipulate negative effects of high density (e.g., Farr, 1873; American Public Health Association, 1946, 1960, 1974). The basis for this appears to lie in a belief that infection spreads much more quickly in high-density areas, where people come into closer and more frequent contact, and that reductions in available air and sunlight lead to ill health. Historically, there is some basis for this belief. The high density–infection link is thought to be a partial

explanation of such events as the Black Death plague in Europe during the 14th century (Langer, 1964). Studies on children living in inner city slums at the time of the industrial revolution in Europe suggest a causal relationship between poorly lit high-density housing and the frequency of rickets (Loomis, 1970). Certainly, the high-density industrial city without any sewerage system, solid waste collection, or water treatment was an unhealthy environment.

However, recent empirical studies have failed to demonstrate a consistent relationship between high urban density and ill health (e.g., Galle *et al.*, 1972; Schorr, 1966). Two studies even found an inverse relationship between hospital admissions and household density (Levy and Herzog, 1974; Winsborough, 1965). In general, the statisticians have concluded that the relationship is far too complex to permit isolation of something as simple as density (Levy and Herzog, 1978) as being causal.

Yet the belief persists. A major factor in its persistence is the erroneous idea that infection spreads mainly through the air. One urban analyst wrote in 1909:

> In large cities the home spaces are often too small to allow the inhabitants a wholesome supply of good air. A result is an increased mortality in some proportion as the city is larger and its population density greater. Cities are plainly unfavourable to long life and the greater the city the greater the danger. (Jefferson, 1909: 544)

More recently, Condran and Crimmins-Gardner (1978), for example, do not question the validity of this hypothesis when studying mortality rates and causes of death in the U.S. cities of the 19th century. Town planners have contributed to the acceptance of this relationship. Ebenezer Howard (1898) used it as part of a rationale for his alternative "garden city" urban form; King points out that "despite more sophisticated medical knowledge common from 1900, belief in the remedy of a profusion of 'air, light and sunshine' (which pervades Garden City literature between 1910 and 1930) became widespread" (1980: 458).[4] Modern town planning can still be found to rationalize zoning and building by-laws, which guarantee low-density physical separation, on the basis of a concern for public health (Carr, 1977).

The critics of such a relationship suggest that the factual basis of these beliefs has completely altered. As far as light is concerned, diseases such as rickets, considered to be due to light deficiency, have almost disappeared wherever diets have improved. Together with a healthy diet the control of infection in water supplies through sanitary engineering has proved by far the most significant step in improving public health. Solid waste collection also removed a potential source of disease. The few diseases which do spread through the air are far more ubiquitous than the mere spacing of

[4]It should be emphasized that in Howard's conception cities ought to be small but dense (see Mumford, 1961; Freestone, 1980); it was later followers who converted his ideas into the low-density garden suburb.

houses could hope to alter. Dramatic improvements in health found in high-density Third World cities where purified water, waste collection, and good diets are available (such as in Hong Kong and Singapore), show that the low-density criterion for health is baseless. Indeed, wherever water and food have been purified and waste collected, the next most important environmentally controllable source of infection in cities is through the soil, where infections are passed (to children in particular) by fouling from domestic animals and pets (Edington and Edington, 1977). It is interesting to note that the value once assigned to the "profusion of air" is now being replaced in homes by the need to seal off all air leaks in the name of energy conservation; that so little objection on a health basis by the public and health planners has been voiced shows what little foundation there is for providing home spaces with a "wholesome supply of good air."[5]

While the availability of air, light, and sunshine may be valued for esthetic reasons, this is a question of architecture rather than density (see Paterson *et al.*, 1976; Mitchell, 1976). Yet building by-laws and residential codes still specify high standards of space generally on the basis of health (despite the lack of empirical or scientific foundation) and rarely do they specify anything in the way of esthetic or architectural standards. As Mitchell (1976) argues, the high spatial requirements that have set the pattern for 20th century low-density suburbia have been rationalized on the basis of health but are motivated more by cultural norms and expectations.

Urban Density and the Loss of Rural Innocence

Urban sociologists have contributed to a long tradition highlighting the differences between urban and rural lifestyles in which the city is seen as an unnatural environment while the country is seen as both natural and idyllic (Park, 1916; Wirth, 1938; Brett-Crowther, 1977). A number of studies have documented this thinking among the intellectual and political leaders of the 18th and 19th centuries [White and White, 1962; Rourke, 1964; Grabow, 1977 (for the U.S.); Schedvin and McCarty, 1974 (for Australia); King, 1980 (for England)].[6] This belief fostered the desire to find rural values via the garden suburb. The rural values of town planners in the Garden City movement spread rapidly to other parts of the English-speak-

[5]This is not to suggest that "clean air" is an unimportant planning criteria for cities; air pollution is in fact becoming more and more important. The second section shows that lowering density leads to a deterioration in air quality due to so much more automobile use.

[6]While not all social science has provided a legacy of anti-urbanism (the founders of urban sociology had mixed feelings regarding density and noted some positive features) it has been a key tradition (see Grabow, 1977; Hadden and Barton, 1973). Due to the manner in which it has captured the popular imagination, anti-urbanism has been a potent social force in the 20th century and in turn has affected the attitudes of many architects, planners, and politicians.

ing world (King, 1976, 1978), influencing Frank Lloyd Wright's low-density "Broadacre City" [which had its local philosophical roots in a number of anti-urban American writers (Grabow, 1977)]. In Australia the garden city movement influenced all the main cities, and Wilson (1976) notes that the almost universal Australian dream of a "patch of nature" in the suburban backyard can be traced logically at least to the desire for agrarian symbols of kinship and spiritual roots with the land. This is particularly poignant in a country which throughout the 20th century has been the most urbanized in the world.

The tenacity of the arcadian image in low-density cities is indicated by the continuation of this tradition despite the obvious loss of any semblance of rural life as one outer suburb after the other is engulfed in urban sprawl. This dichotomy has led King (1980) to suggest that suburbanites are not rejecting the city but are pursuing an ideology: an urban perception of something called "rural life." However, surveys of urban Australians show that a very high percentage would prefer to live in the country if they had a choice (Maddocks, 1978) and the exurban trend suggests a rather strong anti-urban motive (Fuguitt and Zuickes, 1973, present evidence that disillusioned suburban Americans tend to prefer the small agrarian community). Definitions of a city (e.g., Sherbenou and Flango, 1976) invariably emphasize a concentration or density of human activity and it appears that it is this image of density that is being rejected.

A powerful sociological tradition with its basis in a philosophy of anti-urbanism has thus been essentially negative in its assessment of high density. "In a sense, crowding became the non-social explanation of the society's social problems; no solution short of a mass urban exodus seemed likely to alleviate the problem" (Baldassare, 1979: 6-7). As the roots of these popular images are being reexamined, the anti-urban tradition is beginning to be seen as essentially confined to the English-speaking world, as the tradition in continental Europe seems to be one of urbanity (and acceptance of higher densities) (Merlin, 1976). Empirical studies (e.g., Korte, 1976) have shown that many negative characteristics of the American urban scene (such as callousness and indifference when help is required in the street) are not necessarily urban characteristics as Wirth (1938) suggested, because they are not nearly so obvious in Dutch cities. Social scientists like Harvey (1973), Castells (1975), Wilson (1976), and Moorhouse (1980), suggest that the city, and in particular the high-density city, can be a positive force on culture and human experience, just as rural life can be a source of deprivation, and that the rural-urban dichotomy has directed attention away from more fundamental sources of social disorder and loss of innocence (see especially Ellul, 1970, on the latter point). Thus there has arisen an opposing tradition that stresses the positive aspects of dense cities and tends to have an anti-suburban rather than anti-urban thrust.

The anti-suburban movement is represented by such authors as Mumford (1961), who describes low-density urban development as "anti-city," and more recently Schaeffer and Sclar (1975) and Schneider (1979). Schaeffer and Sclar argue that low-density cities are so strongly committed to automobile use that the nondriving population (usually at least half) are severely affected, resulting in alienation and social fragmentation with inevitable social disorder. They also suggest that individuals in these cities in their search for privacy have lost any genuine community concept. Schneider traces a whole range of sociological problems to the dispersal and decentralization of urban activity in low-density cities, connecting decentralization to a self-reinforcing decline in commitment of the urban populace to the whole process of civilization (see also Perkin, 1976).

While pro-urban authors have had few supporters (e.g., Jane Jacobs, 1961) over a 20-year period of rapid suburbanization, more recent studies have given empirical support to this tradition.[7] Allen (1980) suggests that the "back-to-the-city" movement represents a strong commitment to the positive aspects of dense neighborhoods, though demographically it is still a small movement compared to the large-scale deconcentration of cities that is occurring. Allen points to such attractions as the "proximity of variety," which he says is "an amenity of density" (1980: 416), but suggests that the philosophical roots of pro-urbanism are just as important to the movement and are based on a small tradition linked to the activist movements of the 1960s and early 1970s and to such pro-urban authors as Cox (1966) and Berger (1977). The extent of this movement and thus of possible future patterns in density appears to depend considerably on the dominant intellectual views concerning the nature and relative attractions of city or rural life (see Bookchin, 1974).

PSYCHOLOGICAL MODELS

Psychologists concentrate on the individual; thus urban psychologists have examined the individual's perception of the urban environment and

[7]Two detailed studies of high-density neighborhoods, one in South Beach Florida (density 120/ha) by Millas (1980) and the other in Athens (average density 71/ha but ranging to 380/ha) by the Athens Center of Ekistics (1980) show strong social cohesion due to the proximity of friends and facilities. The latter study showed that "density acts as the determining variable that generates all other ones in the community" (p. 256) so that a neighborhood unit grows in density and facilities until it reaches an optimum level of interaction at around 75/ha (and population of 9,000) and then splits into two distinct smaller neighborhoods. This size of unit allows walking to all facilities within about 10 minutes. Most of this urban development has occurred in Athens without Town Planning so that a highly mixed and dense urban configuration has occurred continuously up to at least the late 1960s when most of the survey data were taken. Resident satisfaction with their neighborhoods was very high and the question of density did not rate a mention in their list of complaints.

the associated effects on the individual. Two levels of perception related to urban density have been examined, one at the micro level of personal space and the other at a macro level examining crowding and its relation to culture. It should be stated that research using these models has little relation to urban density as defined here, since it rarely examines psychological phenomena at the urban agglomeration level (Dean *et al.*, 1978). However, because density studies within rooms or buildings can have relevance to urban density and have certainly been interpreted in this way, they will be examined.

Urban Density and the Violation of Personal Space

Personal space is defined by Sommer (1969: 26) as "an area with invisible boundaries surrounding a person's body into which intruders may not come." This would seem to be a cultural adaptation of the territoriality theory but on a micro scale. The studies conducted in this area of proxemics have shown that personal space clearly exists and that some negative effects can occur if this personal space is violated; thus it has been postulated that high-density living produces these negative effects due to the more frequent violation of personal space.

This interpretation of personal space studies is far too simplistic and does not do justice to the subtleties of interpersonal relationships which have been elucidated. Sundstrom and Altman (1976: 60) present a complex model of personal space and interpersonal relationships based on three key assumptions which they argue have been validated by a long tradition of previous studies. First, people seek an optimal range of interpersonal distances for each situation (Sommer, 1969; Dabbs, 1972; McDowell, 1972; Baxter and Rozelle, 1975). Second, when interpersonal distance is outside the optimal range (either too close or too far), discomfort results, with compensatory reactions designed to achieve an appropriate degree of closeness (e.g., Argyle and Dean, 1965; Patterson, 1973). Finally, the comfortable distance zone and reactions to its violation depend on the age, status, sex, similarity, and body orientation of the persons involved, as well as the setting itself (e.g., Willis, 1966; Dabbs, 1972; Barash, 1973; Fisher and Byrne, 1975).

Hence, the link between personal space and urban density is culturally dependent and is not necessarily a negative one. Apart from the obvious possible architectural adaptions (whatever the density), the violation of personal space could also be seen as a stimulus for developing relationships. This has been confirmed by studies in which people in highly crowded groups performed better at tasks than did the control (Freedman *et al.*, 1971). Such studies emphasize the tremendous adaptability of humans to their environment.

In conclusion, models based on personal space provide a useful way to see human spatial requirements as a learned behavior defined by cultural norms and expectations. However, because of this cultural variation and because most of the studies have been on individuals or small groups within rooms, the main conclusions relate to the need to provide an adequate number of rooms for a family rather than to determine acceptable urban areal density levels. As U.S. and Australian low-density cities have equivalent or higher numbers of rooms per household than anywhere else (Amandon, 1973), personal space violation should not be considered a serious motivating force in the trend toward even lower urban densities in these cities.

Urban Density and Crowding

Urban environmental psychologists have also looked at crowding in order to understand the relationship between density and behavior. Their studies are usually on a smaller scale than a city or even sections of a city (as in sociological studies) but on a larger scale than the personal space studies: primarily localized housing developments, university dormitories, and so on. Crowding is viewed as that level of density where some form of abnormal human behavior can be observed and measured (e.g., Glassman *et al.,* 1978). However, no uniform density at which this occurs has been found.

Two approaches to the relationship between crowding and density have been attempted by environmental psychologists as a way out of this impasse. The first suggests that while density is physical and spatial, crowding is a perceived phenomenon (see Choi *et al.,* 1976). Thus crowding varies with cultures (Mitchell, 1976; Rapoport, 1975), the number of interacting individuals (Loo, 1973; Freedman *et al.,* 1972), their tasks and roles (Desor, 1972; Wicker, 1974; Barker, 1968), their relationships to each other (Zlutnick and Altman, 1972; Mitchell, 1971), and their psychological states (Stokols, 1972). It is therefore improbable that there is a uniform density level at which abnormal behavior can be observed.

A second approach, represented by Rapoport (1975), goes further in regarding crowding as perceptual and subjective, since it depends on the information processed by the individual. Crowding is defined as information overload: i.e., a density level at which there is an excessive quantity of information needing to be processed in a particular situation. This will depend on such factors as cultural beliefs, social laws, architecture, type of activity, and so on.

Environmental psychologists stress the fact that cultural and microenvironmental variations make simple statements about the negative human effects of high density impossible: cultural factors are far more important

than physical density levels.[8] However, there are also dangers in taking the observed variations in urban density found in different cultures and assuming that they are causally linked. Rapoport (1975: 148) suggests there is a minimum housing size in the United States of 340 square feet, in Europe of 170 square feet and in Hong Kong of 43 square feet. Cultural factors apparently determine such "needs" and the environment must be shaped accordingly. Many discussions of low-density residential satisfaction fall into the same environmental and cultural determinism (e.g., Halkett, 1976; Michelson, 1977). Thus low-density cities are seen as a cultural necessity in North America and Australia if breakdowns in human behavior are to be avoided.

Such a model is both amoral and ahistorical. The morality of the U.S. and Hong Kong cultural "requirements" is not questioned, nor is the inevitable growth in consumerism and resource use that seems to follow low-density privatization (Pawley, 1975; Brittan, 1977). Furthermore, the model fails to recognize the relativity of cultural norms over time. In the light of history, the implicit cultural "necessity" for low residential density in North America and Australia would appear to be a very recent phenomenon. The adaptability of humans to potential changes in the near future is also not considered.

Such omissions are frequently criticized by urban political economists, who regard urban sociological and psychological analyses of density and crowding as cultural artifacts of the predominant social ideology (Rieser, 1973; Castells, 1972). While they ignore much that is valuable in urban psychology as it relates to density, their conclusion that there is no necessary link between high urban density and negative psychological effects is a valid one. Several recent psychological studies have begun to reveal some of the more positive aspects of density. Freedman (1971, 1975) has proposed a crowding model that builds on the conclusions of empirical studies while recognizing the great potential for adaptability in humans. His density-intensity theory has two main thrusts, which can be summarized in one sentence: "Crowding is not generally negative and it does intensify reactions to other people" (p. 105). He argues that high-density living brings people

[8]Attitudes to high density and high rise vary both within and across national cultures. For example, Yeung (1977) and Desai (1980) have shown considerable acceptance of the high-rise flat in Asia and India; Rent and Rent (1978) examined U.S. low-income groups housed at high and medium densities and found considerable satisfaction (especially if they were happy with their neighbors) and the question of crowding was quite irrelevant to their satisfaction; Britten (1977) has shown that in England, where high-rise buildings are very unpopular and virtually none are being built, the majority of people who actually live in them (council tenants) are not nearly so negative; and Goldfield (1976) suggests that high-rise apartments are preferred by young singles and childless couples in the U.S. However the stultifying affect of high-rise living on children finds almost universal support.

together in closer interaction and thereby makes other people a more important stimulus (see also Cassel, 1971).

The evidence for this hypothesis, which is based on considerable laboratory research, needs further verification. It does, however, provide a positive conceptual model for the work of environmental psychologists such as Lee (1971), whose neighborhood interaction studies have many urban density implications when seen in this light. For example:

> The warmth of active friendships is inversely related to their distance (or time) from a person's home, since the "crossing of space incurs costs in time and energy for the individual that have to be set against the rewards of the goal on arrival," and "distant friendships lapse unless they are rewarding enough to compensate for the high spatial costs of maintaining them." (Lee, 1971; 309)

In the same way Schaeffer and Sclar (1975) criticize the low density car-based city in which people can too easily retreat from human problems by withdrawing to a private life in the suburbs. They suggest that increased densities with greater interaction between people will force confrontation of many of these problems and could lead to greater human fulfillment.

Amick and Kviz (1975) examined potential interaction patterns and levels of alienation through a survey of residents in different housing types in Chicago. They found no difference in the level of social alienation (defined as a sense of powerlessness and isolation) between residents at various heights in high-rise housing; however they found the alienation significantly worse in residents of high-rise buildings where the site coverage is low compared to those in low-rise buildings where site coverage is high, i.e., where densities were almost the same. They concluded that "high population density had been overemphasized and oversold as the root evil of urban America" (p. 120) and that increased interaction at ground level through more efficient site coverage is a key design parameter for improving social integration. This would suggest that much of the criticism of high-rise living and its socially alienating affects is not due to its high density but to its low density at ground level: i.e., social interaction between families occurs at ground level and no matter how high (or low) the building, if its occupants are faced on the ground with acres of uniform open space mostly taken up by car park or straight lawn, then little interaction will occur. Studies by Conway and Adams (1977) support this by showing that high-rise dissatisfaction often centers not on the building height but on its surroundings.

Architectural psychologists Gehl and Lynch also provide a more positive view of high density. Gehl *et al.* (1977, 1978) examined activity and community interaction patterns at the interface between public and private areas on streets in residential areas with different densities. He found that the highest residential density streets invariably had the highest degree of public community interaction, though it also depended on a number of other design and cultural factors. Lynch (1977) examined the way children

interact with their surroundings in a cross-national study of six cities. In the low-density Australian city he found that although the children were the most mobile they "seem to be exposed to a more restricted variety of people, activity and place" (p. 23). He concluded that such low density urban environments may do little to spark a child's imagination. This was confirmed in the U.S. by Berg and Medrich (1980) in a study of four neighborhoods; the worst area for children was the low-density suburb in Monterey and the best a higher density area in Yuba.

The international elements of this question are seen in a critique by Dewar and Yutenbogaardt (1979) of a new low density housing area in Cape Town. They emphasize the need for a more fully integrated urban community that old higher density areas tend to offer:

> In the newer "construct-planned" communities, sterile and wasteful use of land makes it dificult for the small trader to penetrate and identify, let alone provide, services of needs: too often these townships lack a sense of scale, continuity, enclosure and protection (leading to an identifiable pattern of "muggings") that contrasts sharply with the easy constructive interaction in older areas where children play and neither car nor pedestrian has right of way, suggesting that the planned urban housing environments of the type being built today are among the most expensive environmental mistakes South Africa has ever made.[9]

In summary, the rejection of high density common to human or individual-oriented studies of urban density is increasingly being criticized: one critic calls their findings "half truths based on ethnocentric perspectives" (Yeung, 1977: 594) and another suggests that the "rhetoric about the effects of highrise living must rank as one of the major hoaxes imposed by social scientists on an unsuspecting public" (Wilson, 1976: 45-46). At the same time a number of significant studies have emerged which suggest that high density can have many positive human elements.

PHYSICAL OR SYSTEMS MODELS OF URBAN DENSITY

Cities can also be studied as physical systems rather than as a collection of individuals. Such studies examine cities as physical structures interacting with an environment, as a series of resource inputs and waste outputs, and as patterns of land use formed by various economic and technological factors. As shown in Table I, the disciplinary bases from which systems-oriented models of urban density have come are ecology, history,

[9]It should be noted that the same sterility can be found in new high-density housing developments which have replaced old high-density mixed-use areas. For example, many of the British council house schemes for urban renewal have been criticized for removing the street level interaction, corner shops, and small businesses which are so central to community life (Ravetz, 1980; Taylor, 1973).

economics/geography, and engineering, each of which will be examined in turn. In contrast to the major traditions within the previous models these systems-oriented models tend to suggest that benefits accrue as density is increased.

Ecology: Ecological Systems Models

A total systems approach to cities, called living systems or ecological systems models (Stearns and Montag, 1974) views ecosystem variables such as energy and material flows, waste production and recycling, in the context of urban systems (cf. Holling and Orians, 1971; Newman, 1975; Boyden, 1977; Kalma *et al.*, 1972; Newcombe *et al.*, 1978). Ecological theories are used to help understand the complex patterns of physical change in a city. For example, Holling and Orians point to the "spatial interlocking" properties (1971: 2) of both cities and ecosystems, and Newman (1975) uses succession theory[10] to show how urban systems can become more mature in the ecological sense through reducing their flow of energy and materials by greater integration and increased efficiency; this is achieved ecologically through increased density of development as well as greater diversity and interconnection.

One of the major purposes of this approach is to focus attention on the natural ecosystem into which the urban ecosystem fits and to delineate the capacities that the air, water, and land have for supporting the urban system (Bourne, 1976; McHarg, 1971).

Some empirical studies using this model have shown that density is a key variable in the urban ecosystem and its effect on the natural ecosystem. *The Costs of Sprawl Study* (Real Estate Research Corporation, 1974) examined three different urban forms, ranging from low to high density, to see their variations in energy and material use, waste production, and other factors. The conclusions favor the high-density city in terms of total energy use, water use, air and water pollution, and solid waste production. The more compact high-density city also had far less environmental impact in terms of rural land area alienated for urban use and had a higher amount of land for public open space. Thus these data support the theoretical conten-

[10]This model is comparatively new and should not be confused with the human ecology models of the Chicago school (Berry and Kasarda, 1977). The latter are analogies based primarily on population ecology (population succession and dynamics) and are essentially sociological, while this new approach is an analogy based on synecology or systems ecology which directly links resource and environmental questions. The entropy theory developed by Wilson (1970) is an ecosystem model in which the concept that a system draws on all energy sources and gradually winds down to a state of minimum energy and maximum disorder has been applied to cities; the model is more usually examined in the mathematical spatial models by economists and geographers.

tion that the high-density city is more ecologically mature (Newman, 1975). Although there may be higher levels of pollution due to the intense use of resources in the high-density city, the sprawling city is characterized by much higher per capita resource consumption and waste production, so that the total system effect is much greater. This was confirmed by Berry *et al.* (1974) in a survey of American cities in which air and water quality were found to be inferior in dispersed, low-density urban agglomerations. A detailed ecological comparison between Hong Kong and Sydney showed the low-density city to have much higher resource inputs and waste outputs per capita, though the areal concentrations were higher in Hong Kong (Kalma and Newcombe, 1976).

The ecological systems model requires considerably more data collection and analysis before too much significance can be given to it. However, its contribution so far suggests the need to increase urban densities if the twin problems of resource conservation and environmental impact are to be seriously tackled. The role of the automobile in both these problems has been recognized in ecological systems models but the central role of transportation is more clearly presented in the next three physical models.

History: Descriptive Historical Models

Technology, in particular transportation technology, is what primarily distinguishes the urban ecosystem from a natural ecosystem. History provides the basis for a descriptive understanding of urban form and its relationship to transport technology.

Overview studies such as those by Mumford (1961) and Toynbee (1970) have shown that increased mobility in the 19th century unleashed old constraints on urban growth; Toynbee traces how commuting has transformed the "traditional tiny walled city" to a "boundless city" as a "stationary" population became a "highly mobile" population (1970: 38). Other general studies by Guest (1972), Dutt and Costa (1977), and Schaeffer and Sclar (1975) have examined different urban eras as city transport changed from walking to public transport and then the automobile. Doxiadis (1968) attempted to put some numbers on these trends through increasing distances available to commuters. At each stage of urban transport development urban density fell (Newman and Hogan, 1979).

Historical studies on specific cities have examined the transport technology and urban growth trends in much more detail (Table II) and while some recognize that such allied social factors as privatism and the desire for more space are involved, all stress the role of increased mobility in spreading out the city. O'Connor (1980) has criticized many of these studies for simplistic emphasis on the suburbanization of housing, but even includ-

Table II. Historical Studies on Specific Cities which Examine the Way in which Transport Technology has Changed the Shape of the City

City	Studies
London	Jackson (1973), Young and Willmott (1973)
Brussels and Manchester	McKay (1976)
Leeds	Dickinson (1967)
Paris	Bastie (1964)
Choissy le roi (Paris)	Coornaert and Haumont (1967)
Boston and Philadelphia	Warner (1962, 1968)
Natick (Boston)	Vance (1960)
Los Angeles	Fogelson (1967)
Minneapolis and St. Paul	Borchert (1961)
Buenos Aires	Sargent (1974)
Wellington	Evans (1972)
Melbourne	Cannon (1966)

ing the suburbanization of work, as he suggests, does not alter the fundamental role of transport in dispersing the city as the truck has been central to work dispersal.

Historical studies tend to highlight social aspects of these urban changes, particularly how people interact as the transport technology is altered. Prescriptions for the future are sometimes made on the basis of these historical trends. Webber (1963, 1973) and others emphasize the irrelevance of proximity for community interaction because of the development of electronic communication and the automobile; hence they encourage the low-density trend. Others emphasize the inherent social advantages in higher-density public transport cities, such as in Europe, which derive from greater access rather than mobility alone. Perhaps the best is by Schaeffer and Sclar (1975), who emphasize the inequity of low-density automobile cities that place severe restrictions on children, the elderly, the handicapped, the very poor, many housewives, and others of the more than 50% non-drivers in the population in even the high car-owning societies. Such inequity was not part of the walking and public transport cities. The quality of interaction also is suggested to be significantly enhanced through accidental contact and at times enforced contact in higher-density walking and public transport cities compared to the low-density automobile city. Thus they suggest transport and urban-density patterns should reflect the need for personal contact and better access and that a continuation of trends toward urban systems based on further privatized communication will lead to stilted and fragmented communities. Although heavily based on value judgment, such models cannot be rejected, as they raise questions about the extent to which life in modern cities should be so totally dependent on technology, and on automobile technology in particular (see Ellul, 1964). Some of the economic, energy, and environmental aspects of this dependence are pursued in the other models.

Economics/Geography: Density Gradient Models

The major way that urban density has been linked to economics and geography is through density-gradient models. Urban economists and urban geographers such as Clark (1951, 1967), Rees (1968), Berry *et al.* (1963), Berry and Horton (1970), Newling (1966), Muth (1969), Amson (1972), and Edmonston (1975) have developed and tested mathematical models of urban spatial structure in which urban density is the fundamental physical parameter. Urban density is found to decline with distance from the city center and this negative density gradient appears to be declining with time—at least in Western industrial cities (see also Brine, 1976; Marsden, 1970; Clark, 1951; Mills and Tan, 1980).

These mathematical models (reviewed by Zielinski, 1980) share the theoretical assumption that the distribution of people can be reduced to a "distribution of the relevant cost of location" (Amson, 1972: 165). The models of Clark and those who followed him consider transportation costs the fundamental factor while Amson's and Muth's models emphasize housing costs.[11] Clawson (1971) showed that present housing values are really a consensus of informed expectations about future values, as the purchase is also an investment. And as these future values are no doubt altered by assumptions which include transportation factors (for example, recent trends in many cities suggest that outer-area land values are dropping in anticipation of future transportation cost trends [Thompson, 1973; Badcock and Cloher, 1981]) then this link between housing costs and transportation costs implies that the two approaches to interpreting density gradients may in fact be very similar.

Criticism of these models has come from political economists (Harvey, 1969; Castells, 1977b) who see urban structure as expressing dominant social relationships and from behavioral analysts (reviewed by O'Connor, 1980) who see many more attitudinal factors associated with location than costs. Criteria used in selecting a house were examined by Hempel and Tucker (1979) in America and England and they found that a transport factor (distance to work) was indeed the primary attribute in choosing a place to live though other social factors such as appearance of neighbor's homes and size of house were more important than the cost of the house.

The importance of transporation in density-gradient models has led some recent authors to examine the implications for urban form if transpor-

[11]Mills and Tan (1980) have recently suggested that a model could be developed associating density gradients with the cost of agricultural land, as they find that high urban densities are mostly associated with high national population densities. These costs would obviously influence housing costs. Watt (1979) also develops this idea.

tation costs (relative to income) continue to rise due to oil price increases and the world recession's impact on economic growth. Romanos (1978) suggests that densities will increase, though in several centers rather than one, both through the need to travel shorter distances and the need to live closer to public transport which focuses on centers. After a detailed study of density gradients in U.S. cities Edmonston (1975) addressed the question of how American cities could lower their dependence on automobiles and hence oil; he concludes that it would require simultaneous expansion of rapid transit with the concentration of employment,[12] both of which are dependent on the concentration of population. Borger's (1979) study of urban population density functions of several Belgian cities concluded that the suburbanization process occurring in these cities was likely to slow down in the foreseeable future due to changes in income and transport costs. The implication is that by planning for such changes and encouraging higher densities, the effects of the cost increases will be minimized.

Transportation Engineering: Prescriptive Models

Since the complexities of cities tend to make predictions about the impact of such factors as energy and pollution on density gradients a little suspect (see Ostro and Naroff, 1979-1980), transportation engineers have developed models that attempt to specify more precisely the relationship between transportation and urban density and its possible implications for physical planning (energy, pollution, infrastructure, etc). Both computer simulation and empirical models stress normative policy measures, for which reason they have been classified "prescriptive models" (after Folie *et al.*, 1972).

As noted by Black (1967), the emphasis in early prescriptive transportation studies was to ascertain the optimal transportation network for an assumed or given land-use pattern. More recently, however, planners have come to recognize that both the spatial form (land-use pattern) and the transportation facilities of a given city can be considered as planning variables subject to control.

Computer simulation studies have examined a range of linkages between urban form and transport (Schlager, 1965); Hemmens, 1967; Jamieson *et al.*, 1967; Schneider and Beck, 1974). While Gilbert and Dajani (1974) have criticized simulation models as being both vague and contra-

[12]Economists and geographers examining transport and urban form have usually looked at population density gradients though a lot of research has also examined the suburbanization of work. Alexander (1980) has shown that the dispersal of office space, for example, increases the consumption of energy.

dictory this was probably due to the modelers' inevitable need to simplify the extreme complexity of cities as well as the failure to incorporate temporal variation (Folie *et al.*, 1972). More powerful computers and greater awareness of the complexity of cities have led to more sophisticated models: Edwards and Schofer (1976) provide a comprehensive simulation model with 37 different structures and their transport implications; individual cities have been simulated to examine the probable impact of various planning strategies on the city over time; Sharpe (1980), Sharpe and Brotchie (1975), and Sharpe *et al.* (1978) used computer modeling techniques to observe the effects of possible future development patterns in the city of Melbourne, including their energy conservation potential.

The implications of all these models for urban density are consistent: nucleated high-density centers require significantly less automobile use and encourage more public transport use and therefore less energy use than in low-density cities. Harwood (1977) summarized simulation studies on a range of U.S. cities in which energy savings from 50 to 15% were found to be feasible through land-use changes of this kind. Associated with this, many studies also indicate considerable savings in infrastructure and environmental quality-control costs. For example, *The Costs of Sprawl* (Real Estate Research Corporation, 1974) showed that the high-density city had less car and truck use, less energy use (both in transport and in home heating due to greater insulation in attached houses especially high-rise houses), less air pollution, less water pollution from urban stormwater (due to the smaller area of urbanized catchment), and less infrastructure costs (physical infrastructure such as roads, power lines, and water and sewage pipes are shorter, and social infrastructure such as provision of public transport, solid waste collection, police, and fire services are cheaper to provide over shorter distances).

The second major type of prescriptive model is essentially empirical, relying predominantly on the collation and manipulation of real urban data rather than simulating hypothetical cities and/or projecting future trends on the computer. Many of these studies were done in response to the world energy crisis, which has had significant impact on American cities throughout the 1970s. Two studies in New York showed dramatic declines in per capita energy use as density increased toward the center (Darmstadter, 1977; Regional Plan Association, 1974). Fels and Munson (1974) also showed how energy use decreased for residents in the central city and inner city compared to the outer suburbs in Trenton and Mercer County (a medium-sized east coast U.S. city) due to shorter distances and much more use of public transport and walking. Watt and Ayers (1974) compared gasoline consumption per capita in a large sample of U.S. cities and examined six possible causative factors which are subject to change using feasible urban policies. They concluded that public transport use was the key

positive factor and the length of freeway a secondary negative factor in reducing gasoline consumption; elsewhere Watt (1979) suggests that density is the central factor in the level of public transport use and will become increasingly important in determining national economic trends.

The role of density in public transport utilization, the amount of walking, and the length of car trips have been the subject of numerous empirical studies. Surveys of cities throughout the United States by Dyckman (1965), Pushkarev and Zupan (1977), Cheslow (1978), Fels and Munson (1974), and the Bay Area Transportation Study Commission (1969) all showed that as densities increased, public transport use, bicycling, and walking increased and car trips were shorter. An international survey of 50 cities by Newman and Hogan (1979) and a detailed study of six Australian cities by Newman and Kenworthy (1980) reveals the same pattern. Berry *et al.* (1974), Pushkarev and Zupan (1977), and the Council on Environmental Quality (1977) showed that these relationships were still true after allowing for such social factors as income.[13]

Not only are these transport patterns due to shorter distances in higher-density areas but lower car ownership is also found to be associated with higher density. For example, Lansing *et al.* (1970) examined 10 residential communities of various densities in the eastern half of the United States and found that in the two highly planned medium-density communities, car ownership was about 20% less than in the other low- or medium-density areas. Hillman and Whalley (1979) analyzed the United Kingdom national travel survey data and showed that as densities increased there was less car ownership (of first and second cars) among all income and socioeconomic groups, the number of pensioners and women with a driving license decreased, access to shops increased, the proportion of walking trips increased from 27 to 45% (with a higher percentage of short trips in the high-density areas), and children's journeys on foot increased from 40 to 70% of all journeys. Button *et al.* (1980) showed that car ownership varies with income but also is dependent on accessibility to public transport; improving access to public transport appears therefore to be as important as the cost of services and there is little doubt that density increases, especially around public transport lines, will improve access. One factor behind the lower car ownership in these areas has been suggested by Zahavi (1976), who found in an international survey of cities that as incomes rise the only satisfactory transport technology that can compete with the car is segregated rapid

[13]The range of factors which affect the level of transit use is of course very large, e.g., cost, reliability, frequency of service, safety (especially from crime), comfort and convenience, etc. There is little doubt that increasing density will not guarantee better transit but it is safe to say that to make transit a truly viable option in a low-density city will be impossible without increased densities.

transit, but minimum urban densities of at least 40/ha are usual before rapid transit becomes viable.

Coping with the automobile is a major task faced by urban planners. Added to this the need to reduce energy consumption, air pollution, and infrastructure costs has meant even greater pressure to reduce the use of automobiles and increase public transport, bicycling, and walking. What the above models show is how difficult this will be unless there is a reversal in urban density trends.

CONCLUSION

Urban density has been examined through a series of human or individual-oriented and physical or systems-oriented models. Despite a long tradition within the human-based studies stressing the negative effects of density on the urban populace, more recent studies and a more holistic approach have cast doubts on the validity of such conclusions. These studies suggest that the effects of high urban density on human beings and human society are at best uncertain; they may even support a minority tradition that suggests it can be beneficial. Thus the aversion to high density in the cities of North America and Australia may change as these studies filter through into the perceptions of the general populace. The importance of this is stressed by systems-based studies which show that the low-density city cannot continue its sprawl without great financial, energy, and environmental costs. These models suggest that declining urban density can be linked with greater energy use, greater automobile use, lowered air and water quality, greater loss of rural land, and higher infrastructure costs.

For the populace, conflicts over density may ease as awareness grows of the benefits that may flow from a reversal in density trends. Studies that examine a range of social, physical, and economic factors behind housing preference give much more hope of resolving the density issue than studies which just list housing preferences in vague locations like city, suburb, or rural area. Hempel and Tucker (1979) found that housing preferences emphasized the distance to work, shops, and schools as well as such social factors as neighborhood appearance and age of neighbors before the size of the lot. In one American town this attribute of private space was only the 10th highest attribute sought, in another it was 15th, and in the English town it was 18th out of 21 possibilities. In an English study by Britten (1977) of the qualities in housing seen as necessary, the spatial characteristics came very low (back garden 20th, front garden 32nd, and all-on-one-level 41st out of 42 potential attributes); after internal fittings a number of environmental factors such as clean air were considered more important than the spatial factors. These studies indicate that density increases may be con-

sidered beneficial in a future where energy and environmental factors have to be traded off against the desire for private space. However, this suggests that people essentially will be constrained to live in high-density situations, whereas if all else were possible they would choose lower density. The theme of this article is that this need not be so. As Allen (1980) has indicated, there is at least one small but growing section of the populace who have voluntarily made the move back to the higher-density city with a strong ideological commitment and many perceived benefits.

For the planner, the density factor implies a number of responsibilities: discouraging the further dispersal of housing, shopping, and work; freeing by-laws from unnecessary space requirements; facilitating the growth and renewal of attractive inner and central-city housing at medium and high density; integrating transport facilities so that public transport, walking, and cycling are preferred in time, cost, and comfort in the densifying areas; and upgrading environmental quality in the city, for example, by ensuring that industrial pollution will not drive people away and by improving civic amenity to provide considerable attractions in the city. While none of these is easy, once the central issue of density is perceived at least the direction of planning policy becomes clarified.

A recent study by Schmidt *et al.* (1979) of the factors related to perceptions of crowding gives some further direction for the future. Schmidt *et al.* found that enormous variations in the perceived level of crowding were unrelated to either physical population density or to income or race. At a residential level the number of people per room was important as was the psychological factor of attaining privacy, thus supporting the need for architectural sensitivity in creating sufficient private spaces in homes. However, at a wider level, physical factors were insignificant compared to psychological perceptions of the city and neighborhood.

The conclusions of such physical studies that there are compelling reasons for increasing urban density (especially in the cities of North America and Australia) suggest that human-oriented studies should cease looking for psychological or social reasons why people should not be concentrated together in cities.[14] The task now is to begin isolating the factors which lead some people to find the city attractive rather than repulsive. This must involve physical and social planners (e.g., Smith, 1976; Jacobs, 1961; Lenz-Romeiss, 1973), but probably of more importance are those who examine the complex motivations of the human soul as it relates to cities (e.g., Ellul, 1970; Illich, 1973; Boyer, 1978). A key question is whether a coherent and popular pro-urban philosopy can be articulated which, although realistic

[14]It is interesting that a 1966 paper by Schmitt which found a correlation between density and ill health is widely quoted, but his 1978 paper which repeated the study and no longer found the correlation is almost never quoted.

about the darker side of cities, also celebrates the high-density habitat of human beings.

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