1977

The conversion of agricultural land to urban use: an examination of the land use process in Urbandale, Iowa 1950-1974

Linda Kay Lee
Iowa State University

77-16,964

LEE, Linda Kay, 1950-

THE CONVERSION OF AGRICULTURAL LAND TO URBAN USE: AN EXAMINATION OF THE LAND USE PROCESS IN URBANDALE, IOWA 1950-1974.

Iowa State University, Ph.D., 1977
Economics, general

The conversion of agricultural land to urban use:

An examination of the land use process in

Urbandale, Iowa 1950-1974

by

Linda Kay Lee

A Dissertation Submitted to the

Graduate Faculty in Partial Fulfillment of

The Requirements for the Degree of

DOCTOR OF PHILOSOPHY

Major: Economics

Approved:

Signature was redacted for privacy.

In Charge of Major Work

Signature was redacted for privacy.

For the Major Department

Signature was redacted for privacy.

For the Graduate College

Iowa State University
Ames, Iowa

1977

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

CHAPTER I. INTRODUCTION

Few public policies have played a more important role in the growth and development of the United States than have policies affecting land. As our nation developed, these policies were primarily directed at encouraging growth and expansion. Currently, the emphasis of U.S. land policy has shifted to the problems of directing growth and expansion. Public policies designed to guide the land use changes created by urbanization are becoming increasingly common. If such policies are to be effective, a clearer understanding of the conversion of agricultural land to urban use is needed. This study is an effort to respond to the need for such information. It is hoped that by analyzing the conversion of land from one use to another, methods to alter the land use process to fit public goals can be suggested.

Current Status of U.S. Land Use Planning

Land use planning as defined by Timmons (96, p. 13)

> . . . means developing strategies and means for using land .esources and environment) to provide people with wanted goods and services including consideration of undesirable effects on resources and environment incident to the use of land.

Within this context, land use policy refers to the strategies developed in the planning process which guide the distribution of land among uses and users. Not since the 1930's have land use planning and land use policy received so much attention, locally and nationally, as during the current decade. In the 1930's the focus was on agricultural adjustment, poor living conditions, and high costs for public services (109, p. 1). Currently, urban growth, and its related environmental effects are at issue. Senator Henry Jackson, Chairman of the Senate Committee on Interior and Insular Affairs, explains public concern for land use in the following manner:

> The rapid and continued growth of the nation's population, expanding urban development, proliferating transportation systems, large-scale industrial and economic growth, conflicts in patterns of land use, fragmentation of governmental entities exercising land use planning powers, and the increased size, scale and impact of private actions, have today created what many Americans perceive to be a national land use crisis (99, p. 1).

In response to these problems, cities, counties, states, and the federal government are proposing and implementing land use controls in what has been called "the quiet revolution in land use" (13). Nationally, land use legislation was first proposed in the U.S. Congress in 1971.[1] Eight states have enacted state land use legislation (75, p. 11), while thirty-six states have preferential tax policies to preserve agricultural land (91, p. 9). On the local level, interest in traditional controls such as zoning is strong, but some cities are experimenting with other approaches. A U.S. Appeals Court recently ruled that a Petaluma, California proposal to limit construction was an acceptable means of land use planning (76, p. 9).

Despite the recent increase in land use controls, there is little evidence that they are based on insights into the land use change process. A ten year study of Maryland's preferential tax law could produce little evidence that lower taxes had any effect on the

[1] S. 632, Land and Water Resources Planning Act, 1971, as cited in (37, p. 1).

preservation of agricultural land in that state (51). The California Land Conservation Act of 1965, an attempt to control agricultural land use change through voluntary contracts, found its effectiveness curtailed by lack of farmer cooperation (27, p. 1). Efforts to control land use change have concentrated on modifying individual economic behavior. The mixed results suggest little understanding of the sequence of events behind individual decisions to convert land from one use to another.

Land use change may be viewed as a process of events, each action triggering another action in sequence. Thus, each individual land conversion decision has been preceded by many interrelated public and private actions. Land use planning which concentrates on any one aspect of this process may not realize the desired results. Clawson in discussing the suburban land conversion process emphasizes this point:

> Decision-making in the suburban land conversion process is highly diffused; there are many actors and many processes, complexly interrelated, with numerous feedbacks. . . . No single person, group, or public is responsible for the kinds of suburbs that are built; as one result, there is no single point at which major change in the suburban land conversion process could be implemented (21, p. 5).

If effective land use planning is to occur, it should be based on a clearer understanding of the relationships and processes involved in land use change.

Needs for Land Use Planning

There are important reasons for developing the necessary information on which to base land use planning. The conflicts within our society as to the publicly preferred use of our land resources are intense and should not be expected to resolve themselves.

A major dimension of this conflict is reflected in the urban-rural division in our society. Studies have shown that urban and rural dwellers do not seem to share the same values and orientations toward resource use (33, 49). The results of these studies indicate that for rural dwellers, nature is a utilitarian object to be altered and used for everyday existence, while urban dwellers view nature from a more aesthetic viewpoint. As the dichotomy between the urban and rural aspects of our society widens, these conflicts over attitudes toward land use may well intensify.

A related dimension of this conflict is the issue of property rights in land. The United States has a strong tradition of private ownership of land. This attitude is a natural outgrowth of our history. The colonization of North America was organized in part by English companies who speculated in land. These companies operated in a period when feudal tenure systems were disappearing from Europe and individual ownership of land was an ideal readily accepted by the colonists. Economic growth throughout our history has depended on an individual's ability to develop and on occasion exploit his landed resources for farming, lumbering, and mining. These private rights in land have always been subject to public controls through the police power, taxation, and eminent domain. However, there is a growing feeling that the public has even more rights in land than have previously been exercised. The Task Force on Land Use and Urban Growth of the Rockefeller Brothers Fund finds that:

> There is a new mood in America. Increasingly, citizens are asking what urban growth will add to the quality of their lives. They are questioning the way relatively unconstrained, piecemeal urbanization is changing their communities and are rebelling against the traditional processes of government and the marketplace which they believe, have inadequately guided development in the past (91, p. 33).

If this new attitude prevails, then long established views of individual property rights and autonomy may be revised.

Ultimately, it is public decision makers who will have to decide among alternative land uses, but research on the land use process could provide them with better information to formulate land use alternatives and to evaluate the consequences of those alternatives.

Problem Delimited in this Study

In an effort to provide land use information for planners and decision makers in the state of Iowa, three studies were undertaken. This study is one segment of the larger research project aimed at analyzing land use problems within the state of Iowa. One segment of the project focuses on gathering basic data on current land uses in Iowa and projecting future uses based upon trends (37). A second segment identifies land use planning goals of residents of Region V within Iowa (64). This third segment focuses on the conversion of land from agricultural to urban use and the processes that are involved.

Information obtained from Segment I of this project reveals urbanization to be the dominant force behind future land use changes in the state of Iowa. The land use preferences of Iowans surveyed in Segment II indicate citizen concern about the conversion of agricultural land to urban use exists within the state. Given the background information of these initial two segments, this third segment analyzes the conversion of agricultural land to urban use in an attempt to provide information that could be helpful to public entities and citizens groups who are interested in altering the land use process to meet public goals.

Objectives of Study

The objectives of this study are:

1. To identify the conflicts between urban and rural uses of land.
2. To explore the causes of these conflicts by developing a methodology to identify and explain changes in the land use process.
3. To apply this model to a rural-urban fringe area.
4. To suggest possible methods of altering the land use process through alternative land use policy tools.
5. To suggest further research needs.

Procedures

A microanalytic approach is employed using time series data to try to capture the dynamics of the land use change process. Aerial photographs of one community for a period of twenty-four years are analyzed and coded for land use changes. In addition, land use data for the study period are obtained from the records of city offices, city and county maps, regional planning bodies, and personal interviews. This information is combined to develop a land use change model. Three linear regression models are developed and used along with personal interviews and historical records to obtain an overview of the land use change process.

Area of Study

Since land use change is a complex process, it was felt that by closely observing one area, the interactions and sequences in its experiences could be better identified and analyzed. Urbandale, Iowa, a suburb north and west of Des Moines was selected for analysis. Two reasons were behind this choice. First, this suburb had one of the more rapid rates of population growth within the state of Iowa during the period studied, and thus has experienced considerable land use change. Second, several regional planning studies for the area were available through the Central Iowa Regional Association of Local Governments. Information from these studies provided land use information not readily available from other sources.

Organization of Report

Chapter I provides introductory background on land use planning, introduces the problem, and states the objectives and methodology of the study. A review of the factors which influence the land use change process is contained in Chapter II. Chapter III develops a model to investigate the nature of land use change while the empirical results for Urbandale, Iowa, are presented in Chapter IV. Chapter V includes the summary and conclusions as well as further research recommendations.

CHAPTER II. THE RURAL-URBAN LAND CONVERSION PROCESS: CONFLICTS AND CAUSES

Land Use Change in Iowa

During the past twenty-five years, two major land use changes have occurred in Iowa. One is a decline in the total amount of land in farms while the other is a redistribution of land in farms from woodland and pasture to cropland. These changes are illustrated in Table 2.1. While the decline in wooded area may be viewed as a problem in a state where forests constitute only 4 percent of the total land area, it is not a problem peculiar to the entire state as the bulk of the wooded area in Iowa is concentrated in the eastern one-half of the state (104). Rather, it is the decline in land in farms that has attracted considerable state-wide attention (85). Although the conversion of agricultural land to other uses has not been as pronounced in Iowa as in other more urbanized states, there has been considerable public concern over the implications involved. It is this land use change that is the major subject of this study.

The past shift of agricultural land to other uses has been due to a number of forces, including urbanization, industrial growth, highway and airport construction, and increased recreational facilities (97). In future agricultural land use shifts, urbanization is viewed as a dominant force behind land use changes. Projections made by James Gibson for Iowa nonagricultural land use until 2020 indicate that urban land area could increase from 1.6 percent of total land area in 1970,

Table 2.1. Land use change in Iowa 1950-1969[a]

Land use category	1950	1954	1959	1964	1969	Net change 1950-1969
Land in farms (acres)	34,264,639	34,044,533	33,830,450	33,758,321	33,569,629	-695,010
Total cropland (acres)	26,049,319	25,981,414	26,402,004	26,356,116	27,738,852	+1,689,533
Woodland (acres)	2,320,501	2,133,633	1,968,185	1,980,028	1,630,369	-690,132
All other land (acres)[b]	5,894,819	5,929,486	NA[c]	5,422,177	4,200,408	-1,649,411

[a]Source: U.S. Department of Commerce Agricultural Census, 1969 (105, p. 2).

[b]Includes pastureland other than cropland and woodland pasture, rangeland, and land in house lots, barn lots, ponds, roads, wasteland.

[c]NA = Not available.

to some 3 percent by the year 2020 (37, p. 246). Urban land area in Iowa by this estimate will double in the next 40 years, and will constitute the largest claim on agricultural land in Iowa.

While the urban demand for land is expected to consume some one-half million acres by 2020, there currently exists within Iowa incorporated places approximately 400,000 acres of agricultural land that, if utilized, could fulfill projected urban needs until 2020 in some areas, and at least minimize the rural-urban land conversion process in other areas (37, p. 96). This assumes that this land is of sufficient quality to support development. On a statewide basis, 43 percent of all land within incorporated places in Iowa is agricultural (37, p. 102). Yet, records based on annexation data indicate that rural-urban land conversion is a continuing process. On a statewide basis, between 1960 and 1970, 16.8 percent of the land area in Iowa incorporated places in 1960 was annexed, a process that will presumably continue if projected urbanization trends materialize (37, p. 116).

Land Use Change as a Process

The implication throughout the land use literature is that the rural-urban land conversion process is an aimless and haphazard one, without direction or purpose.[1] This should not be interpreted to mean

[1]For example, The Final Report: The President's Task Force on Suburban Problems describes urbanization as spreading ". . . outward in a haphazard pattern, consuming more land than is necessary, and creating excessive public costs for municipal facilities and services" (41, p. 34).

that there is no explanation for particular patterns of land use. Land use change does not occur in a vacuum, rather it is a response to the actions and needs of many individuals and entities. These actions do not occur at one point in time, but are part of an ongoing process, where certain actions trigger other actions until agricultural land becomes converted to urban use.

Institutions play a key role in this land use change process. An institution as defined by John R. Commons (24, p. 651) is ". . . collective action in control, liberation, and expansion of individual action." Although some types of collective action are designed to control land uses, such as taxation and zoning, many other forms of collective action may have a powerful impact on land uses. Public investments in highways, roads, sewers, and water systems, for example, may significantly influence private decisions in land development. Although collective actions influence individual decisions, the relationship is not without feedback. It is clear that individuals can modify collective action. Thus, special interest groups can influence land use decisions involving reservoir (57) and nuclear power plant construction (111). In more extreme cases, politically powerful individuals may obtain zoning variances and conditional uses, as well as sewer and water extensions to aid development.

There have been many proposals to control the suburbanization process through land use policy.[1] A basic premise of this investigation

[1]See, for example, the policy and program recommendations in The Final Report: The President's Task Force on Suburban Problems (41).

is that before institutions can be devised to control the land conversion process, it must first be realized that institutions have played a vital role in generating the land use pattern that presently exists. An examination of the forces, both private and public, behind the land use change process is essential before effective policies to alter that process can be devised. It is the purpose of this chapter, first, to identify the conflicts between agricultural and urban land uses inherent in the land use change process. Second, in an effort to understand how such conflicts arise, factors influencing rural-urban land conversion are analyzed.

Conflicts Between Agricultural and Urban Land Uses

The first step in any urbanization process seems to be an interspersion of agricultural and urban land uses, commonly referred to as "sprawl." Sprawl, as defined by Harvey and Clark (47, p. 2), is composed of ". . . areas of essentially urban character located at the urban fringe but which are scattered or strung out, or surrounded by, or adjacent to undeveloped sites or agricultural uses." A sprawled area has a heterogeneous pattern with an overall density less than that found in mature, compact areas of the city.

Harvey and Clark distinguish further between three types of sprawl. Low density continuous development is defined as the lowest order of sprawl. Ribbon development, segments compact within themselves, but which extend axially and leave the interstices undeveloped, is a second form of sprawl. A third type of sprawl, leapfrog development, Harvey and Clark define as the settlement of discontinuous although possibly compact patches of development. It is this third type of development that is most commonly associated with sprawl and is focused on in this chapter.

The interspersion of agricultural and urban land uses can create conflicts. Water pollution from septic tanks in new subdivisions may impair the use of water for irrigation and consumption purposes. Soil erosion and flooding from rapid run-off due to construction of streets, sewers, water mains and buildings have been particular problems in some areas. Because suburban growth tends to jump over land, farms may be segmented by the new highways and roads that result. Operations of dairy and poultry farms and livestock feedyards can cause conflicts in nearby residential areas.

Some authors have argued that sprawl has generated problems that extend beyond the daily conflicts of urban-rural fringe dwellers.[1] Sprawl is viewed as imposing substantial costs on both urban and agricultural segments of society. Typically, the objection is not the conversion of the agricultural land to urban use, but the timing and nature of the land conversion process itself. The concern over the land conversion process comes from two different perspectives--agricultural and urban. Although each side views the problem differently, both are concerned about the consequences of sprawl.

[1] See for example, (86, pp. 23-34).

Urban perspective on costs of sprawl

One of the major conflicts thought to be created by the current land conversion process is an increase in the cost of public services. The extension of sewer and water lines, and roads through undeveloped areas to reach fringe settlements is hypothesized to be more costly than provision of such services to a compact development. Ideally, this hypothesis would be tested by studies measuring the effect of various alternative settlement patterns upon public and private costs and benefits. No studies have been made which conform to this ideal, although the results of studies that have been made suggest that sprawl may create substantial public service costs.

The clustering of houses within a subdivision has been proposed as an alternative to sprawl (112). Cluster development concentrates residences in high density zones to reserve open space in a subdivision development. A comparison of the public service costs under cluster development as compared to a conventional development plan of a 300 acre suburb in Ville Du Parc, Wisconsin, estimated a 33 1/3 percent saving under cluster development (74, p. 76). The savings was a direct result of lower improvement costs (sewer, water, and streets) under cluster development.

A similar study of development costs of the new town of Columbia in Howard County, Maryland, under three alternative patterns of development estimated substantial savings in the provision of public services under a more clustered development pattern (52). The study projected population growth for twenty years and then established three alternative patterns of settlement to achieve this growth. Model I assumed a continuation of the existing scattered development and was designated a "trend" model. Model II assumed a partly clustered, partly sprawled growth pattern. Under this alternative, one-half of the county development would be clustered in a new town of Columbia, but all other development in the county would be dispersed. Model III assumed all additional county settlement in the next twenty years to be of the clustered variety. Table 2.2 shows substantially reduced public service costs for the more closely settled development patterns.

With respect to individual public services, Downing (30) has analyzed sewer costs for suburban areas of differing density and location to treatment plants. His results seem to indicate that both density and distance have a significant impact on sewage collection and treatment costs. The economies of higher density are appreciable at all distances from the treatment plant while the economies of distance are equally appreciable at the lowest densities and gradually decline for higher densities. But as Table 2.3 indicates, even in the more densely populated areas, sewer costs for adjacent suburbs could be one-third to one-fourth as much as costs for more distant suburbs. This study covers only one public service, although an important one. The results, however, are suggestive of what might be found for other services.

The question arises: If compact development is so much more efficient in terms of public service provision, why do property owners tolerate inefficient dispersed settlement patterns? Part of the answer lies in how public services are financed.

Table 2.2. Land and public service costs for estimated development by 1985, Howard County, Maryland[a]

Items	Model I[b] - sprawl	Model II[c] - partly sprawl, partly clustered	Model III[d] - closely clustered
Area of land: (acres)			
Residential	49,000	33,900	22,400
Commercial	3,150	2,750	2,450
Industrial	9,000	6,575	4,750
Total	61,160	43,225	29,600
Cost of land: ($1,000)			
Residential	59,710	44,610	33,110
Commercial	3,850	3,450	3,150
Industrial	11,000	8,575	6,750
Parks and open space	2,922	4,006	4,888
Road right-of-way	5,338	3,570	2,265
Subtotal	82,820	64,211	50,163
Water utilities installations	65,011	47,110	32,068
Sewer utilities installations	83,941	62,777	38,693
Road installations	54,745	38,072	25,746
Road maintenance, 1965-1985	20,548	14,773	10,509
County acquisition of parks and open space	534	1,689	2,384
County acquisition of school sites	3,412	2,250	800
School bus operation, 1965-1985	23,965	15,254	9,031
Subtotal, services	254,245	181,925	119,381
Total	337,065	246,136	169,544

[a]Source: Howard County 1958, technical report prepared by Comprehensive Planning Section of the Howard County Planning Commission, April, 1967 (52, pp. 38a-99a). All estimates based on 68,276 dwelling units in 1985, compared with 13,600 in 1965, or an increase of 54,676 in the 20-year period.

[b]Model I assumes that 88 percent of the housing added in Howard County over the 20 years will be in the same dispersed pattern (sprawl) which existed up to 1965; this in effect assumes that the "new town" of Columbia will not be completed.

[c]Model II assumes Columbia will be completed as planned, but that all other new housing in the county will be on a sprawl basis.

[d]Model III assumes that 88 percent of additional housing in Howard County in this period will be built on the same density as planned for Columbia.

Table 2.3. Marginal annual cost per capita of sewage collection and treatment with distance and density--high estimate[a]

Density (people per acre)	Distance from subdivision to treatment plant (miles)					
	5	10	15	20	25	30
	($/per capita/year)					
0.4	$158	$282	$494	$531	$649	$772
1	66	115	164	213	262	301
4	23	38	52	67	81	96
16	12	16	21	26	31	36
64	5	7	9	11	13	15
128	4	5	7	8	10	11
256	3	5	6	7	8	9
512	3	4	5	6	7	8

[a]Source: Paul B. Downing (30, p. 108).

Financing public services

There are two basic methods of public service financing in most U.S. communities. The first method is designed to provide services for an additional population, regardless of location. Typically, bond issues are floated to provide the capital, and taxes are imposed to meet annual operation costs and bond charges. School expansions, main sewer lines and sewage treatment plants, main water lines and supply systems, and municipal parks are usually financed in this manner, and thus paid for equally by old and new community residents.

A second method of public service financing occurs in new subdivisions when the builder or developer is required to bear the costs of public services within the development area. These costs are usually added to lot and home costs so that ultimately the new home buyer bears the burden of financing public services within the subdivision. It is doubtful that either method of public service financing discourages sprawled settlement patterns.

Public services required by new suburban residents may not be located within the subdivision. Schools, trunk sewer and water lines, and sewage treatment plants are examples of public services that may be some distance away from a developing area. Yet, the prices charged for these services rarely reflect the distance involved. An example is the Washington Suburban Sanitary Commission serving the Maryland suburbs of Washington, D.C., where the charges for water and sewage service are unrelated to distance and no charges are made on intervening idle land which is serviceable from the extended lines (90). While a new settler may bear most of the costs for public services within the subdivision, he probably does not bear the increased costs of public services generated by scattered subdivision developments. Under this arrangement, a new settler will have little incentive to reduce public service costs by locating in a subdivision closer to the center of the community.

Even if a developer is required to pay some of the costs outside the subdivision, such as trunk sewer and water line extensions, these costs are usually added to the lot and home costs. Those costs not assessed to the developer are borne by the community as a whole. As Marion Clawson (21, p. 161) concludes, "Although the pricing of public services might not in itself lead to sprawl, pricing policies surely reinforce the trend toward sprawl."

Thompson (94, p. 322) suggests that urban sprawl may be the result of a serious information and communication problem as well as a pricing problem. Even if all public service costs were assessed to a new home owner, it is doubtful that he would be aware of these costs at the time or purchase. A consumer purchasing a home in a rural subdivision is usually not aware of the future public service costs involved in converting dirt roads to paved and lighted streets or the costs of converting individual septic tanks and water wells to centrally supplied sewers and water. If this information is not available, a consumer choosing sprawled development may do so because the costs and alternatives are not clearly outlined.

Costs of sprawl--agricultural perspective

Perhaps the most publicized aspect of the urbanization process is the loss of agricultural land that inevitably accompanies urban growth. Public concern over agricultural land conversion has manifested itself nationally in the report of the Citizen's Advisory Committee on Environmental Quality (20) and locally in the Iowa 2000 reports (28). Nationally, the U.S. Department of Agriculture estimates that 1.3 million acres are added to the nation's cropland base each year, but that 2.7 million acres of cropland are removed from production annually by urbanization, parks, highways, and reservoirs (103). This results in a 1.4 million acre net cropland loss each year, compared to a 382 million acre national cropland base. The USDA predicts that the U.S. will have no trouble meeting anticipated domestic food levels and moderately high export demands, given rising productivity, but that some local areas may be more severely affected by this cropland loss.[1] An examination of the interrelationships of Iowa agricultural and non-agricultural land uses by Gibson (37) found that anticipated urbanization trends will have a minimal impact on agricultural productive capacity within the state as long as productivity trends continue.

There is some evidence that these figures may understate the amount of agricultural land lost to urbanization. Harris and Allee (45) in a study of the impact of urbanization on agriculture in Sacramento, California, found twice as much land withdrawn for urban use than actually developed. One explanation offered by Allee (2) is that more land is valued over capitalized future returns to farming than is likely to be used for urban purposes in time to justify the market prices. However, based on the market prices, owners may be unwilling to reduce their liquidity by signing long-term leases with farmers for agricultural use. The rent from a lease may reduce overall holding costs too little to justify any significant effort to find a renter. In addition, a farmer may find it unwise to rent the land unless the lease is long enough to allow him to recoup his investments in soil fertility, for example.

---

[1]In California, for example, 70 percent of the 1961-1970 urban development occurred on cropland, despite the fact that in 1961, only 16.3 percent of the state was in cropland (102, p. 15).

Thus, land is held idle, waiting for development. If urban pressures for agricultural land continue, idle suburban land may be appreciating in value as rapidly as land converted to urban use. Although holding land is not costless, since taxes and opportunity costs must be considered, an owner's expectations and reservation sale price may make idle land a rational investment policy for some individuals.

If land is not actually idled in anticipation of future development, there is the possibility that it will be underutilized. Conklin and Dymza (26) found that urban expansion in Syracuse and Rochester counties, New York caused a decline in farm productivity over an area of land much larger than physically occupied. Allee (2) hypothesizes that farmers in an area of urban expansion may decide against long-term investments in equipment and real estate improvements due to the uncertainty created by the urbanization process. A 1965 survey of fifty-four farmers in Ontario who were incorporated into a municipal area found that all farmers felt uncertainty as to the future of their farm operation within the next few years (115). Thirty-five out of the fifty-four farmers stated that they expected to be going out of farming if not by retirement then by displacement as urban boundaries expanded. Uncertainty translated back into the production function means a different reaction from that of the farmer not influenced by urban expansion.

In Iowa, large amounts of agricultural land could be affected by this uncertainty. The study by Gibson found that the proportion of land within the incorporated limits of Iowa municipalities, officially classified as agricultural ranged from around 20 percent to 60 percent, depending on the region and size class of the city (37, p. 102). On the average, forty-three percent of all land within the incorporated limits of Iowa municipalities was found to be officially classified as agricultural. If idle or underutilized land is a result of urbanization, there is a considerable amount of land in Iowa in a position to be affected.

Another criticism of the urbanization process is that it forces farmers out of farming against their will.[1] Sprawl leaves agricultural land fragmented by suburban development. Local taxes must rise to provide additional schools and other public services, increasing property tax burdens for farmers. Tax assessors note the rising land values associated with the sale of miscellaneous building sites and gradually associate these higher values with all the land within the area, although an effective demand may exist for the urbanized use of only a fraction of the area. As property taxes rise, the argument continues, farming costs become prohibitive and farmers are forced to sell. This reasoning has led to enactment of preferential tax policies for agriculture in thirty-six states (91, p. 9). The results have been mixed, indicating that ". . . people own farmland for a variety of reasons. Some reasons make owners sensitive to changes in tax costs; others do not" (42, p. 10). Apparently, property taxes alone cannot be held responsible for the ownership and land use changes that occur on the urban-rural fringe.

---

[1]This argument is summarized by Frederick D. Stocker in (89).

Benefits of sprawl

There are those who argue that the present process of land conversion is a beneficial one. Sprawl, argue Harvey and Clark (47), is a natural part of the growth process. Infilling occurs more slowly and follows the expansion process, but the end result is usually compact development. Lessinger (62) suggests that scattered development is a beneficial development pattern as it will simplify the replacement pattern of old houses. Thompson (94, p. 327) believes that sprawl may provide flexibility under conditions of change and uncertainty. With an unknown future and optimum land use patterns shifting, open land may provide options that could be obtained under compact development only by leveling existing structures. Clawson (21, p. 159), for one, expresses serious doubts about such claims. Infilling, he believes, is a matter of decades not years, and diverse ages of housing may be a handicap in housing replacements as renewal is often limited to large tracts.

Evaluation of costs and benefits

Evaluating the benefits and costs of the present land use change process and the resultant settlement patterns generated is a difficult empirical matter. Data on both the agricultural and urban dimensions of the problem are sketchy and difficult to measure in monetary terms. Compounding the problem is the fact that conventional benefit-cost analyses do not include an assumption of irreversibility. Conventional benefit-cost analysis assumes that different projects are independent of each other, but this assumption can break down, especially when projects use or destroy scarce natural environments. Fisher and Peterson argue that the loss of a unique environment where restoration is not practical can be termed an irreversible process (35, p. 6). In such cases, they argue, the site can be developed only once, so the timing and sequence of projects should be optimized.

The Fisher and Krutilla analysis (34) of a proposed molybdenum mining operation in Idaho is a case in point. The project has a positive net present value when completed immediately, even taking into account associated recreational and agricultural losses, but it has an even higher value when delayed a few decades. Not only will the mineral be more valuable then, but recreation benefit could be enjoyed in the interim. An analysis that ignores the project timing dimension would develop the mine immediately on the basis of the positive present value. A more efficient use of the wilderness area, according to the Fisher-Krutilla analysis requires deferred development. Applying this analysis to agricultural land conversion could indicate that ignoring the irreversible aspects of the process could lead to miscalculations in costs and benefits.

Although difficult to quantify for a benefit-cost analysis, the issues of aesthetics and social values may be at least as important as any other issue discussed. Aesthetically, many view the growth patterns of our cities as unattractive and ugly. Sprawl, from this perspective, is a pattern that would not have been chosen if alternatives were available.[1]

In more rural areas, the urbanization process is viewed as an infringement on a scarce natural resource that is essential to continued agricultural growth and prosperity. It may be that loss of agricultural land is regretted as much for the way of life it represents as for cropland foregone, nevertheless the issue is a real one. The Natural Resources Task Force of the Iowa 2000 Conference (28, p. 4) specified ". . . the preservation of Iowa's best agricultural land for agricultural purposes" as a goal for the state. Results of a survey of residents of a 6 county area of Iowa reinforce this goal (64). When asked to react to a land use plan restricting construction around urban areas in order to preserve agricultural land, the citizens surveyed generally agreed to the proposal. On a scale of 0 (strongly disagree) to 16 (strongly agree), the mean response was 10.23. In this survey, proposals to preserve agricultural land from encroaching land uses were received favorably. Whether or not it is economically desirable or necessary to preserve agricultural land in Iowa is a subject of debate, as total cropland has actually increased over the years (see Table 2.1). However, if the preferences of Iowans are considered, there appear to be a considerable number who would prefer to avoid the land use situation projected for the future.

Despite the uncertainty over the nature and severity of the conflicts between agricultural and urban uses of land, one fact is clear.

[1]A principal exponent of this view is Ian L. McHarg. See, for example, (66, pp. 10-52).

The land use change process that generated these conflicts is not a process consciously chosen by society. Rather it is a process that has evolved out of our past and present institutions. Public goals and attitudes indicate that process is becoming increasingly unacceptable. At issue is not whether or not agricultural land should be converted to urban uses. An expanding population and redistribution of that population to urban areas make urban growth necessary. At issue is how and when this land conversion should occur. In altering the process to conform with public goals and norms, a greater understanding is needed about the land conversion process and the development patterns that have evolved from it.

Factors Influencing the Conversion of Agricultural Land to Urban Use

Despite the seemingly haphazard nature of land conversion, there are reasons behind the development of one parcel of land and the continued idling of an adjacent parcel. Both Clawson, and Harvey and Clark have hypothesized causes of sprawl. These hypotheses can be divided into two categories: 1) macro factors which greatly influence the pace and character of private land development decisions, and 2) micro factors which determine why particular parcels of land develop and others do not. Included within the first category are the determinants of an urban demand for land. Within the second category are: 1) physical characteristics of the pacel, 2) regulatory measures, 3) personal characteristics of the landowner, 4) availability of public services, and 5) site accessibility. These factors are discussed in more detail in the following sections.

Urban demand for land

The urban demand for land is determined in part by population growth. The increased number of households resulting from a growth in population need housing and one would expect demand for housing to vary proportionally with population. In the decade beginning with 1948 more than ten million new households were formed in the United States partly due to a backlog of demand for single family homes that had built up during the Depression and World War II, and partly due to an increased number of marriages after the war (21, p. 39). As the urban centers had relatively little vacant land for development, the suburbs became the answer to new housing construction.

More than sheer growth in numbers, however, land use change has been affected by a redistribution of population from rural to urban areas. This is not a recent phenomenon. Americans have been leaving the farm since 1780 when 90 percent of our population was rural (19, p. 2). In recent years, however, this redistribution has intensified until more than one-half of all counties in the U.S. lost population during the 1950's (21, p. 33). The rate of migration seems to have slowed in the later 1960's, but not enough to reverse the trend. This shift in U.S. population from rural to urban areas has increased the demand for urban land.

The forces behind this population shift are explained by Chinitz

(19, p. 5) as a push and pull phenomenon. The demand for the products of primary industries has not kept pace with the growth of income and consumption in the U.S. As food is income inelastic, increased per capita wealth in this county has not affected the demand for agricultural products. In addition, increased productivity in the agricultural sector has sharply reduced the number of man-hours needed to produce any given quantity (101, p. 439). The declining labor needs of agriculture have provided the push toward metropolitan areas.

The pull has come from the growing importance of service industries located in urban centers. The fastest growing segment of the economy in recent years has been the service sector, which includes such diverse activities as trade, finance, advertising, research, education, and entertainment (114, p. 33). The reasons for the rise in these activities parallel those given for the decline in agriculture, more income is spent on the services provided by these industries. At the same time, these industries have been the least affected by technological progress. Labor productivity has risen far less rapidly in these industries than in agriculture or manufacturing, so that employment opportunities have been favorable (114, p. 34).

In addition to the population shift from rural to urban, there have been shifts within the metropolis itself. Dividing a metropolitan area into two distinct parts reveals an urban core or central city and a surrounding suburban ring. In the larger metropolitan areas, at least, the proportion of population living within the central city has been falling since the beginning of the century (19, p. 23). Since 1929, the central cities share of important employment (manufacturing, wholesaling, retailing) has been falling also. It is difficult to say what the timing and sequence of these two trends are, but together they have affected the urban demand for land.

Whatever the standard of measurement - the proportion of metropolitan area manufacturing jobs accounted for by the central city, the rate of manufacturing employment growth in the city and in the suburbs, or the share of total employment accounted for by manufacturing in the city and surrounding areas--during the past fifty years the statistics show that manufacturing has grown more rapidly in the suburban rings than in the urban core (19, p. 24). Lack of space is probably the most important factor underlying the move to the suburbs. In urban areas it is difficult and expensive for a firm to expand. It may be cheaper for a firm to build on open land than to modernize existing urban structures. Improved transportation networks make a peripheral location less of a disadvantage than in earlier years.

Although certain types of jobs have been moving out of the central cities for decades, people have been moving out even longer. The history of most cities reveals a continuous outmigration of residents (19). Rising per capita income may be one explanation for this trend. Housing demand is in part a function of income. Although housing demand has been regarded as a necessity and therefore income inelastic, studies by Reid (79) and Muth (72) suggest that the income elasticity of housing demand is at least 1.0 and perhaps as large as 2.0. At higher income levels households demand more and better housing. Rising per capita incomes have induced first the well-off and later the middle class to move away from the central city in search of space, fresh air, and privacy. The development of urban transportation systems has made this outmigration easier.

Another stimulus to the urban demand for land has been Federal policies. National financial policy, for example, by influencing mortgage interest rates, helps determine the profitability of housing construction and hence the pace and character of residential development. High interest rates have slowed housing demand considerably since the late 1960's (98). The availability of FHA and Veterans Administration loans to finance suburban home construction has provided additional funds for home construction and stimulated housing demand. Mills (71, p. 183) believes however, that the effects of such programs have been exaggerated by some writers. Mills estimates that mortgage interest costs are usually less than one-half of the cost of home ownership, and insured loans are not more than one-half to one percent cheaper than conventional loans. Thus, he estimates federal programs reduce housing costs by no more than 10 percent and probably by less. With a price elasticity of demand of 1.0, housing demand would be increased by 10 percent if all housing, rental and owner-occupied, were under the federal programs. Since only a part of all housing is under federal programs, federal mortgage guarantees can explain only a small part of postwar urban growth.

Federal income tax laws are also thought to encourage home purchases. To support this contention, Clawson (21, p. 42) cites three income tax policies he feels have favored home ownership. These include:

1. The imputed rent does not have to be included as a part of income for federal tax purposes.
2. Payments for real estate taxes may be deducted from gross income.
3. Interest on home mortgages may also be deducted.

Mills (71, p. 181) estimates that the tax break from the first policy alone may reduce the housing cost of an owner-occupied home by nearly 20%. Clawson (21, p. 43) estimates that under typical income and housing conditions, the federal income tax, under 1970 tax rates, is reduced by from 18 to 29 percent by these tax policies. This would provide a substantial incentive for home purchase, resulting in increased urban demand for land.

Population growth and redistribution, rising per capita income, as well as certain Federal policies have probably all helped to stimulate the urban demand for land. Given this demand, urban growth could have occurred in a solid, compact expansion pattern. Instead, discontinuity and dispersion have been its trademarks. While the macro factors of population and income influence the rate and general character of urban growth, it appears that other more micro factors influence the pattern of urban development. It is this pattern of development with its non-contiguous or "leapfrog" design that is the subject of concern to many observers of the land conversion process.

Micro factors

The conversion of agricultural land to urban use can be analyzed from many levels of inquiry. In order to explain the development of one parcel of land while an adjacent parcel remains idle, an analysis from a micro perspective seems appropriate. From this viewpoint, an analysis of the land conversion process suggests five possible explanations for scattered and dispersed development: 1) physical characteristics of the parcel, 2) regulatory measures, 3) personal characteristics of the landowners, 4) availability of public services, and 5) site accessibility.

These factors can be classified in terms of positive and negative effects. On the negative side are those factors which act to reduce the supply of developable land. The physical characteristics of the parcel, regulatory measures, and personal characteristics of the landowner are representative of this category. On the positive side are those factors which increase the demand for certain land parcels for development. Availability of public services and site accessibility are included in this second category. These factors are analyzed in the following sections.

Site qualities One factor that must be considered in analyzing why an idle parcel of land did not develop is the physical characteristics of the site itself. The size of the parcel can influence its development potential. An irregular or small tract of land can limit the construction activities suitable for it. Land located in flood plains or in steeply sloped and rocky areas may not be physically suitable for construction. The costs of modifying the site to make construction feasible may prohibit development until no alternative sites remain in the developing area. In areas of severe physical limitation, sprawl may simply be an attempt to utilize land more suitable for development. Natural geographic features have determined the San Francisco Bay Area's growth pattern. Mountains and ridges interspersed with fertile valleys have concentrated development in areas adjacent to the Bay and in the valleys. What appears on a map to be sprawl, may simply be an accommodation to natural geographic features. A 1962 study by Chapin and Weiss (18) of five cities in North Carolina tentatively confirmed that poor drainage characteristics tend to discourage land development in vacant areas. Although slope and other physiographic information was not specifically tested, the findings seem to support the hypothesis that physical characteristics of a site can limit development.

Regulatory measures Another factor with the potential to prohibit development is existing regulatory measures. Zoning, building and subdivision regulations, and property taxes can all influence the land development process. Of these instruments, zoning is potentially the most comprehensive. It is designed to prevent the harm that one landowner's use of his land can have on the community and on the value of his neighbor's property. Zoning achieves this purpose by designating permissible uses for all parcels of land in terms of allowable activities, characteristics of buildings, and placement of buildings on lots.

Strict enforcement of zoning regulations can prohibit or restrict development in some areas. Land zoned agricultural for example, can be excluded from urban developments entirely. A single family dwelling category can also restrict the type of development that occurs in an area.

Zoning may be the most widespread of all local land use control devices at work in the U.S. (61). Recently however, it has been subjected to heavy scrutiny. Much criticism has centered around the laxness of zoning administration at the local level including: 1) the lack of clear criteria for decisions, 2) the inadequacy of record keeping, and 3) the tendency of local zoning boards to exceed their formal authority in granting "variances" and "exceptions" to the zoning code.[1] From a substantive viewpoint, zoning stands accused as a tool of racial and economic discrimination used by middle and upper-class white neighborhoods to keep out the poor and the black (10).

The passive character of zoning as a means of prevention rather than a tool for change has also been attacked. Zoning is thought to work effectively to prohibit land use change which would have adverse effects on other land uses in areas where land use is well-established. Countervailing political power inhibits change in these areas; the proposer of change is opposed by those who stand to suffer losses. Reps (80), for one, argues that zoning has no role in developing areas where land uses are not firmly established. The political vacuum in such areas means large landowners, developers, and others who stand to gain are relatively unopposed by countervailing groups.

---

[1] See for examples, (32, 82, 110).

Still others argue that zoning is unnecessary. Bernard Siegan (84) in a study of Houston, Texas, a city which relies on private deed covenants instead of zoning to regulate land uses, found no massive intrusion of nonconforming uses even where deed covenants had expired. Siegan also found the lack of zoning regulations to have little adverse impact on property values. Instead, he argues, the absence of zoning has facilitated apartment construction, giving Houstonians a wider variety of housing options. The implication is clearly that zoning is at best unnecessary and at worst harmful.

A study of zoning and urban development in Nashville, Tennessee, was not so pessimistic in its findings. Salamon and Wamsley (83) concluded that the impact of zoning on urban development in Nashville was mixed, but within a limited range of discretion zoning did have a tangible effect. They cite the retardation and geographical concentration of apartment development and the retardation of strip commercial development as examples of that effect. Despite the lack of agreement over the effectiveness or necessity of zoning, it remains an instrument with potential to guide land use change.

Like zoning, subdivision regulations can be used to control land use change. Lot layout, traffic flow, public facilities, densities, and even recreation space can be ensured through subdivision regulations. Salamon and Wamsley (83) question their effectiveness as a comprehensive land use tool as they usually operate in a piece-meal fashion in response to specific subdivision proposals.

Property taxation is a more indirect method of controlling land use. Differential property tax rates, by affecting the cost of holding developable land in nonurban uses, can influence the rapidity and direction of urban growth. Preferential property taxation for agriculture is currently being tried in thirty-six states in an attempt to forestall the land conversion process (91, p. 9). Property tax differentials between school districts or taxing units may encourage development in one area as opposed to another. These differentials, however, usually reflect the quality of public services provided, and individuals who prefer more public services may choose a district with a higher property tax rate in order to obtain them.[1] The record of property taxation in altering growth patterns is largely undocumented. Those studies that have been done (46), mainly in countries outside the United States, have concentrated on the effectiveness of the land tax in controlling land use change.

The land tax is based on the single tax reasoning of Henry George and calls for differential assessments of land based on the value of the land only and not on the collective value of the land and improvements (77, p. 248). Thus, land is taxed on its value in its best alternative use or its opportunity cost. Value becomes independent of present use or ownership and changes year by year as demands change or public improvements are completed. The argument is that taxes on the entire value of improved urban real estate tend to prevent improvement in land uses

[1]A theoretical treatment of this location decision is provided by Charles M. Tiebout (95).

because property taxes increase with the improvements. If only the land were taxed, owners would not hesitate to improve urban land because the improvements would not be penalized. Furthermore, a tax imposed upon the "true" value of unused land would compel its use and, thus, be an instrument to thwart speculation and idle urban land. Accordingly, the tax implies an increased rate of investment in structure. less speculative withholding of land from development, and reduced urban sprawl.

The record of the land tax in controlling sprawl is unimpressive. In New Zealand, the opportunity for the land tax was first established in 1896. In both Sydney and Melbourne, Australia, the land tax has been in effect for many years. Yet, Harvey and Clark (46) document the fact that sprawl is an urban pattern common to both areas. Several explanations are offered by the authors. Administrative problems in determining which of many idle tracts of land on the urban-rural fringe is ready for development and therefore an increased land tax is cited as one factor. In addition, the authors hypothesize that rising land taxes may actually induce sprawl because as the taxes become a part of the cost of development, subdividers are inclined to choose other competing areas with a lower land tax. Despite its theoretical potential the record for the land tax shows no significant results in controlling land uses.

<u>Characteristics of landowners</u> The preferences, personal desires, and expectations of landowners could be a major factor for some tracts developing while others around them do not. The desire of one individual

to retain his potentially developable acreage may significantly influence urban expansion patterns. If landowners directly in the path of urbanization choose to withhold their land from the market, then land developers and other involved in the land conversion process will have to skip to make contact with landowners who are interested in developing their land. Certainly different landowners could be expected to have different expectations about the future and thus different reservation prices. If the market for potentially developable agricultural land is a fairly thin one, then it may take some time for buyers and sellers to reach a mutually satisfactory agreement.

In addition to differences in expectations about the future, different landowners will have a varying need for capital. Some owners may need to raise money immediately through sale of their land, others may have no capital difficulties. Age may be a factor as well. Older landowners, especially farmers, may try to retain their land until retirement. Younger owners may wish to sell and locate elsewhere. A 1968 study of predevelopment landowners in a developing area (59) found that those most likely to sell their land for development were absentee owners, those who were retired, those who owned the land jointly, and those who had owned the land for a very short or very long time. Least likely to sell were those living on the land, those who were not retired, those who owned the land by themselves, and those who at the start of the study period had held the land longer than ten years but less than forty years. Reasons for an individual not to develop his land may be as many and varied as the owners themselves.

Speculative land holding by farmers and developers alike is one explanation for scattered development patterns. Institutional factors, such as estate holdings, trusts, and covenants, may also affect the marketability of certain tracts.

These explanations for dispersed and scattered development have at least one point in common--they all operate to restrict the availability of certain parcels of land for development. The physical suitability of a parcel, the institutional restrictions imposed upon it, and the preferences and motives of the sellers or developer all have an impact on the supply of agricultural land for urban development. Similarly, there are factors which may positively influence the development potential of land parcels and thus the demand for them. The availability of basic public services as well as certain accessibility factors can enhance the development potential of one tract of land as opposed to another which lacks these features.

Public services   The availability of basic public services could have a significant impact on the land development process. Eacy access to sewer and water lines, and school facilities are important assets to a development project. Any long-term difficulty in obtaining these services would have to have some impact on land conversion. Empirical data on public services and land development are limited and inconclusive. A study of land prices in a rapidly urbanizing section of Philadelphia over an eighteen year period by Milgram and Mansfield (70) observed that sewer and water lines had generally preceded development. Those areas, however, where sewers were not available remained relatively undeveloped at the end of the study period. Schools, fire and police stations, playground and parks were found to generally follow development rather than precede it, and no evidence was obtained to show that their absence in any way deterred development.

Chapin and Weiss (18) in a cross-sectional analysis of the spatial structure of a regional cluster of five cities tentatively concluded that the availability of community services and facilities (fire protection, sewer services, water services, and schools) tends to intensify land development. Because the analysis was based on a cross-section, no conclusions were drawn about the role and timing of public services in the land use change process, however. It is generally agreed that it is rare that communities consciously include the provision of public services as an integral part of land use planning policy.[1] Yet, the existence of basic public services or the expectation that these services will soon exist, can considerably increase the development potential of vacant land.

Accessibility factors Closely related to public servives in creating demand for individual land parcels are certain accessibility factors. Accessibility as defined by Wingo (113, p. 26) is a quality of location with respect to the array of economic activities. In a technical sense, Wingo refers to accessibility as a relative quality

[1]Lincoln, Nebraska may be an exception to this policy. For further information, see (63).

accruing to a parcel of land by virtue of its relationship to a transportation system operating at some specified level of service. Access to employment opportunities, shopping, and cultural and recreational facilities can enhance the development possibilities of a land parcel.

Proximity to a job has been found to be a major influence in determining where individuals live (113, p. 33). If all employment opportunities are in the central city, then residential development is likely to be distributed in all directions from the city, provided that time and ease of commuting is equal from all directions. If a large firm or industry is located outside the central city in one direction, then residential development will tend to be concentrated in that direction. Similarly, shopping areas can have an influence over land use patterns as do movements to cultural and recreational facilities.

It is commuting time rather than distance that is important in determining the accessibility of a site to work and shopping. Easy access to expressways and main artery roads has been recognized as a major force in determining land use patterns. Since the 1950's interstate bypasses through and around large cities as well as construction of high speed thoroughfares have greatly reduced commuting time from outlying areas to downtown districts. Officials in the Kansas City area attribute the rapid growth of certain suburban areas to the development of the interstate system (65). Chapin and Weiss (18) in their study of development patterns conclude that the location of major routes of transportation tends to intensify land development. Close proximity to key transportation routes appears to enhance the accessability and thus the demand for certain sites for development.

Summary Most efforts to control the pattern of land conversion have sought to control the supply of land for development. For example, zoning in the form of protective agricultural preserves in California (40) and New York (25) combined with preferential property taxes for agricultural have sought to remove incentives for landowners to sell agricultural land for other uses. However, recent efforts to put more teeth into these policy instruments have run into heavy opposition from groups who fear a reduction in the property rights of the individual would result. Indeed, the safeguards in American law provided private property rights present a considerable barrier to further governmental intervention on the supply side of the land conversion process. The "taking" issue raises the question of when police power regulations create such a reduction in property value that they constitute a "taking" and hence require public compensation of the property owner (14).[1]

What remains to be determined is the importance of public policies in creating demand for spatially noncontiguous development. Municipal sewer and water decisions as well as city, state, and Federal transportation policy may well have just as much impact on land conversion as regulatory measures designed to control the process. Some assessment of the factors influencing the land conversion process is necessary before

[1]The issue arises from the Fifth Amendment to the U.S. Constitution which provides, ". . . nor shall private property be taken for public use without just compensation" (100).

effective land use planning can occur. The hypotheses concerning sprawl reviewed in this section, are used in the development of a methodology to analyze land conversion in Chapter III.

CHAPTER III. DEVELOPMENT OF A METHODOLOGY TO ANALYZE THE CONVERSION OF AGRICULTURAL LAND TO URBAN USE

Residential Location Models

A limited amount of work exploring land conversion as a process exists. This work has dealt primarily with location of residences. Quantitatively, the market for residential land and housing is the most important market in the agricultural land conversion process. Bartholomew estimates that one-half of privately developed land around urban areas is devoted to residential use (9, p. 87). Individual preferences in the housing market, therefore, play an important role in the urbanization process.

Much of the work in the economics of residential location has developed since 1960. Before that time, this was considered a field of study for sociologists and geographers as the location of the household was thought by economists to result from noneconomic social factors. Thus, the regional economist, Isard (56, p. 144), in 1956, stated that ". . . if consumers are households, we are not able thus far to account for the transport inputs for which they are actively responsible;" adding in a footnote that

> . . . to do so would take us into the realm of sociology and social psychology. For, to explain the spatial distribution of household consumers around focal points--for example, the population spread around any given metropolitan core--requires knowledge of the process by which tastes are molded, and in particular, understanding of the space preferences of consumers.

Despite this attitude on the part of economists, the theory used by sociologists and city planners to explain patterns of location had economic implications. The assumption behind much of the early work was that as the population of a city grew and the housing stock increased, the newest dwellings would always be occupied by the highest income groups and that as the buildings aged, they would filter down through the population, becoming cheaper and cheaper, and consequently occupied by households of lower and lower incomes. Since the pattern of location of households with differing incomes would be determined by the growth of the city in the past, this type of theory has been called an historical theory (4, p. 227).

One example of the historical theory is Burgess' (16) concentric zone theory of 1925. In the Burgess theory, the city is represented by a series of concentric zones, radiating outward from the central business district. Burgess argued that as a city expanded in population, each inner zone extended its area by invading the next outer zone. Thus, each site served a succession of users. The implication is that the oldest residential property is near the center, inhabited by the poor, and the newest property is beyond the city limits, inhabited by the highest-income groups.

A second version of the historical theory is the sector theory of Homer Hoyt (53), published in 1939. He, too, argued that as residential structures deteriorate they are occupied by successive groups of people with lower incomes and lower social standing. Hoyt argued, however, that this pattern of residential location could be explained in terms of sectors instead of concentric zones. These sectors were formed along transport routes, towards existing built-up areas, toward high ground, or along lake fronts.

As economists became more interested in residential location analysis around 1960, the approach became different. Trade-off theories of residential location were developed by first Hoover and Vernon (50), and more rigorously by Alonso (3) and Wingo (113). In a trade-off theory the household chooses its optimal location from the center of the city by trading off travel costs, which increase with distance from the center, against housing costs, which decrease with distance from the center, locating at the point at which total costs are minimized.

Few empirical studies have been undertaken to directly confirm the trade-off theory, leading to some skepticism among empirically minded economists, planners, and geographers as to its applicability (44, 81). One recent attempt to explain and predict patterns of urban change adopted a behavioral approach to the problem, by first gathering facts about the people involved in the land development process and then suggesting theories to explain those facts (11). One conclusion of this study was that people are choosing to live in a neighborhood more because of its physical and social properties than because of its accessibility to work and the central city.

All of the aforementioned theories have dealt in some way with the location of households in relation to the center of the city, an important locational problem. None of these theories, however, attempt to explain another important locational problem--the dispersed and noncontiguous development pattern of suburban areas. Those who have attempted to deal with the problem have generally not chosen to discuss it in theoretical terms. The causes of sprawl hypothesized by Clawson (22), and Harvey and Clark (47), as discussed in Chapter II, were formulated in largely institutional and behavioristic terms.

One attempt at a theoretical analysis has been made by Neutze (73, p. 105) who suggests a theory of land speculation to explain sprawl. Neutze argues that the decision to change land uses can be explained in investment terms and is comparable to making a decision to sell maturing wine or maturing forest trees for timber, especially if there is no income derived from land held vacant. Development, then, will take place when

$$(PV_{t+1}-PV_t) - T = iPV_t$$

where

PV = the discounted value of the flow of future net returns to a parcel of land

T = holding costs, including property taxes and maintenance charges

i = discount rate.

The returns to an owner from postponing development from time t to t+1 are $(PV_{t+1}-PV_t) - T$. The cost of postponing development is the interest that could be earned if the land were sold for development, iPV_t. As long as the expected increase in the value of the land, less taxes, exceeds the opportunity cost of holding it vacant, it will pay to postpone development. Development, under this theory, will occur when the returns from postponing development are equal to the costs.

In most instances, there will be some current revenue from the use of underdeveloped land for agriculture. Neutze takes account of this by introducing R_T as the net revenue from current development on the land and reformulating the decision equation so that $R_T + (PV_{t+1} - PV_t) - T = iPV_t$. Neutze argues that R_T will tend to fall over time as capital investments in farm equipment and buildings must increase. Under a land speculation theory, sprawl occurs because different landowners will have different expectations about the future and will put varying rates of discount on uncertainty. Dispersed and scattered developments are the results.

Neutze admits that this theory of land speculation is untested and unconfirmed by empirical evidence. If noneconomic reasons for holding land are very important or if frictions in the market due to lack of knowledge are significant, then he suggests a behavioristic model of land development might be more reasonable. More information on the land development process, concludes Neutze, is necessary to verify the validity of the theory he proposes.

Analyses of the land development process that would provide the information Neutze seeks are limited. Milgram and Mansfield (70) undertook a study of the transformation of a semi-rural area in northeast Philadelphia over an eighteen year period in an attempt to explain the increase in land prices associated with development. The results of this study indicated that improvements in land instigated by the individual owner and by public entities in the form of sewer and water extensions had a significant positive impact on land prices. Locational factors were also found to influence land values. The relationship between land values and land use change, however, was not investigated. Hale (43) hypothesizes that land uses do not necessarily follow land values as a change in land values is a short-run response and land use change is a long-run phenomenon, dependent on changes in institutional forms.

Chapin and Weiss (18) have examined the development patterns of five North Carolina cities. Public servies, locational factors, and physical suitability were all found to influence land use intensity. Cross sectional data were heavily relied upon in this work, however, much of which was developed for forecasting purposes. Implications about the timing and dynamics of the process are necessarily limited. While other developing areas have been studied on a broader scale (31, 39), these two studies constitute virtually all the microempiric work available on the land conversion process.

Land Conversion Model

One important purpose of this study is to investigate the forces behind sprawled development patterns in an effort to provide more information and understanding about the land use change process. Accordingly, the research focuses on individual decision making entities and the causes for their actions. While many aspects of the land conversion problem are of interest on an aggregated basis (total amount of land converted to urban use, total number of acres idle within metropolitan areas), it is also true that individuals and groups of individuals make a large number of the decisions which help to determine the levels of these aggregate variables. To better understand the land conversion process and the patterns of land use that have evolved from it, this study is conducted at a disaggregated level, examining in some detail land use change in one Iowa community.

Land conversion deals with change and development trends. Consequently, an analysis of the process must be dynamic. Some analysis of land use change over time is necessary before any conclusions about the process as a whole can be drawn. Data from 1950-1974 are used in this analysis in an effort to gain insight into the sequence and timing of key forces in the process.

Ideally, a holistic model of land development should be formulated. Such a model would consider the total environment in which land use change occurs. In practice, partial analysis is much more likely, as the total environment in which land use changes are made may be so complex and fraught with interactions as to be impossible to model without dealing with total human social development. Nevertheless, this study attempts to deal with the land use change process in as comprehensive a fashion as possible. To do this, multiple regression analysis is used to assess the importance over time of many of the factors influencing land development discussed in Chapter II. This analysis is combined with observations of those individuals interviewed in the area who are involved in the process and who have an understanding of the sequence of events. Since not all aspects of the process are quantifiable or readily includable in a regression equation, it is hoped that this approach will clarify and integrate the quantitative results into an analysis of land conversion as a process.

Quantitative analysis

To analyze land use change quantitatively, sequential aerial photography is interpreted and evaluated using a grid coordinate system to provide location-specific analysis. Aerial photography has been recognized as a valuable methodology for analyzing land uses in several disciplines. Foresters use aerial photographs as aids in preparing cover-type maps, measuring areas, and identifying and inventorying tree types (1). Geologic applications include structural mapping and fuel and mineral exploration (29). Few engineering projects are planned or constructed without the basic information derived through aerial surveys (12). Urban planners have recently become interested in sequential aerial photography as a means of analyzing the growth patterns of cities. Wagner (108), for one, has developed a procedure for measuring land use changes adjacent to interchanges on limited access highways. Although economic applications of aerial photography have been limited, the methodology for analyzing land use change via aerial photography is available.[1]

In this study, a grid coordinate system is used to divide the area

---

[1]Interpretation of sequential aerial photography as a methodology to evaluate land use change is described in more detail by T. Eugene Avery (8).

of study into cells or grids. Grid analysis was a technique used by Chapin and Weiss (18) in a cross-sectional analysis of land development, although the technique was not specifically applied to aerial photography. The grid system is used as an overlay on the aerial photographs, dividing the area of study into cells or grids. Using sequential aerial photographs, each cell can then be analyzed at various points in time. By observing the set of land use conditions found at each cell at each time period studied, factors influential in the land use change process can then be identified. Each cell is observed at discrete intervals, much like observing consecutive frames in a motion picture. Using the grid cells as units of observation, multiple regression analysis can be performed at varying time periods to provide an analysis of land use change over time and space.

Variables and regression models

In Chapter II, five micro factors were hypothesized to influence the conversion of a parcel of agricultural land to urban use and the resulting land use pattern. These five factors were: 1) physical suitability for development, 2) regulatory measures, 3) personal characteristics of landowners, 4) public service provision, and 5) accessibility. Of these five factors, all but the personal characteristics of landowners are included as explanatory variables in a multiple regression analysis. The personal characteristics of landowners are excluded from formal analysis because of the difficulty in gathering data about the actions and motivations of individuals over a twenty-four year time span.

A variable not discussed in Chapter II is also included in this analysis. The development activity in adjacent tracts of land is hypothesized to influence land use change in a given land parcel. Urban land value studies commonly include a "neighborhood" variable measuring the amenities surrounding an individual land parcel (15). The hypothesis is that land values are affected by neighborhood effects. Similarly, land parcels do not develop in isolation, but are influenced, to some degree, by contiguous development activity.

The purpose of an analysis of the influence of these factors on land conversion is to accept or reject tentatively the original hypotheses of their impact on the conversion of agricultural land to urban use. It is hoped that these hypotheses, along with other relevant information, can be woven into a larger model of the land conversion process.

To test the significance of the factors hypothesized to influence the land conversion process, three separate regression models were formulated. The first model is an attempt to determine which factors, if any, instigate the conversion of agricultural land to urban use. The second model analyzes changes in intensity of urban land uses. The third model examines the significance of factors hypothesized to influence land conversion at various points in time.[1]

---

[1] A fourth model pooling cross-sectional and time-series data (60, pp. 508-517) was not formulated because it would not allow an analysis of changes in the behavior of variables over time.

Model I

Model I is a regression equation formulated to explain changes in land use from agricultural to urban and is of the following general form:

$$\Delta AG_{(T+1)-T} = f(SQ, \Delta RM_{(T+1)-T}, \Delta RM_{T-(T-1)}, \Delta PS_{(T+1)-T},$$

$$\Delta PS_{T-(T-1)}, \Delta Access_{(T+1)-T}, \Delta Access_{T-(T-1)},$$

$$\Delta CD_{(T+1)-T}, \Delta CD_{T-(T-1)}$$

where

$\Delta AG_{(T+1)-T}$ = change in development of a cell between times T+1 and T that was 100 percent agricultural at time T

SQ = site qualities of a cell including soil type, drainage characteristics, and slope

ΔRM = change in regulatory measures (taxes, zoning) during time periods (T+1)-T and T-(T-1)

ΔPS = change in public services (sewer, water, schools) available to a cell during time periods (T+1)-T and T-(T-1)

ΔAccess = change in accessibility characteristics of a cell (time to work, shopping) during time periods (T+1)-T and T-(T-1).

ΔCD = percentage change in development in the cells contiguous to a given cell between time periods (T+1)-T and T-(T-1).

The regression equation is hypothesized to be linear in form. The relationship between SQ and ΔAG is hypothesized to be a positive one, as the more suitable a site is for development, the more likely it will be converted to urban use. ΔRM, in both the preceding period and the period under investigation, is thought to influence agricultural land conversion also. If regulatory measures are relaxed or redefined so as to be more favorable to development, then agricultural land use change should increase. An increase in public services, ΔPS, in the preceding or present period is hypothesized to make a cell more suitable for urban use and thus should increase land use change. Similarly, any change in accessibility of a cell to work or shopping should, by decreasing commuting time, be reflected in increased agricultural land use change. Changes in contiguous development are hypothesized to increase agricultural land use change as the development potential of the given cell is enhanced.

Independent variables lagged one time period are included in this and all of the regression forms because it is hypothesized that there may be time lags in the cause and effect relationships between variables. It may be some time before individuals making land use decisions are able to respond to a zoning change, or a change in public investment policy. Lagged variables are an attempt to gain some insight into the timing of decisions.

Model II

A similar formulation is an attempt to explain land use change in a cell that is partially urbanized at time T.

In general form:

$$\frac{\Delta Urb_{(T+1)-T}}{Urb_T} = f(SQ, \Delta RM_{(T+1)-T}, \Delta RM_{T-(T-1)}, \Delta PS_{(T+1)-T}, \Delta PS_{T-(T-1)}, \Delta Access_{(T+1)-T}, \Delta Access_{T-(T-1)}, \Delta CD_{(T+1)-T}, \Delta CD_{T-(T-1)})$$

where

$\frac{\Delta Urb_{(T+1)-T}}{Urb_T}$ = percentage rate of change in development of a cell between times T+1 and T that was less than 100 percent agricultural at time T.

All other variables were previously defined. The independent variables have the same hypothesized relationships with the dependent variable as in Model I.

Model III

Equation III is an attempt to determine the significance of land use factors hypothesized to influence land conversion, by analyzing their impact on land use patterns at various points in time.

In general form:

$$Y_T = f(SQ, RM_T, RM_{T-1}, PS_T, PS_{T-1}, Access_T, Access_{T-1}, CD_T, CD_{T-1})$$

where

Y_T = percent of a cell urbanized at time T

SQ = site qualities of a cell including soil type, drainage characteristics, and slope

RM = Regulatory measures in effect for a cell at times T and T-1

PS = public service available for a cell at times T and T-1

Access = accessibility characteristics of a cell at times T and T-1

CD = percent of development in the cells contiguous to the given cell at times T and T-1

SQ is hypothesized to be directly related to Y_T; the more suitable a cell is for development, the greater the percentage of the cell will be developed. The regulatory measures in effect for a cell at times T and T-1 are also hypothesized to influence cell development. If zoning and other regulatory measures in effect for a cell are restrictive, then the cell is hypothesized to be less developed. Public services availability is thought to be directly related to percentage of a cell developed as the availability of basic public services at times T and T-1 is hypothesized to increase the percentage of a cell developed at time T. If a cell is accessible to work and shopping at times T and T-1, then it is hypothesized to be more unchanged. Similarly, the greater the percentage of land developed in contiguous cells, the more urbanized the given cell is thought to be.

Land conversion as a process

Using the hypotheses confirmed or rejected by the regression analyses, a model of the agricultural land conversion process may be developed. The conversion of agricultural land to urban use involves people in decision making activities at every step in the process. Although regression analysis can indicate the significance of the results of some of those decisions, it can in no way reveal the rationale or reasoning behind the decision, nor can it indicate which individual or group made the decision. While the regression analysis may give some indication of the timing of certain actions, it probably cannot fully indicate the interactions between individuals and the influence on land use decisions this may have. Therefore, with the regression results as a base on which to build, individuals familiar with the land conversion process within the community are interviewed in an effort to provide a more comprehensive explanation of the process.

Three general classes of individuals are regarded to be influential in the change process and deserving of further analysis. These are owners of agricultural or undeveloped land, developers, and city planning officials. The role of landowners in the conversion of agricultural land to urban use has been discussed in Chapter II where it was hypothesized that key landowners could have a significant impact on land conversion decisions by withholding land from development for personal reasons. The role of the developer in the land conversion process is another issue unanswered through quantitative analysis. Is the developer merely an intermediary who converts land into housing in direct response to market demand, or do the practices of developers have a substantive and direct impact on the nature of the land conversion process? Finally, municipal public policy makers are hypothesized to influence land conversion through public investment decisions. Are these decisions a response to public needs and demands or are they extended consciously in an effort to influence patterns of urban growth and land use change? Although it may not be possible to obtain complete answers to all of these questions, it is hoped that whatever information is obtained will allow the quantitative results to be viewed from the perspective of the process which they reflect.

CHAPTER IV. APPLICATION OF METHODOLOGY TO URBANDALE, IOWA

Urbandale, Iowa, is a suburb of Des Moines, Iowa (in Polk County), located north and west of the central city (Figure 4.1). The city is bordered on the north and west by Interstate Highways 35 and 80, on the south by the suburbs of Clive and Windsor Heights, and on the east by the city of Des Moines. In 1976, the total area of the suburb was approximately 10 square miles.

Urbandale was chosen for analysis because of its rapid rate of growth and corresponding land use changes, the availability of data through a regional planning association (The Central Iowa Regional Association of Local Governments), and its lack of complicating features in that the suburb 1) has no major physical limitations to development and, 2) is primarily residential with little industry or commerce. In this chapter, the methodology developed in Chapter III is applied to Urbandale, Iowa. The history of the city and its economy is reviewed, the data explained, the regression results interpreted, and the land conversion process in Urbandale, Iowa summarized.

History of the Area[1]

Urbandale in the late 19th century was a tiny farming community separated from Des Moines by a considerable amount of farmland. In 1905 the area received its first link to Des Moines as the Des Moines

[1]Information on the history of Urbandale was compiled from unpublished materials in the vertical files of the Urbandale Public Library.

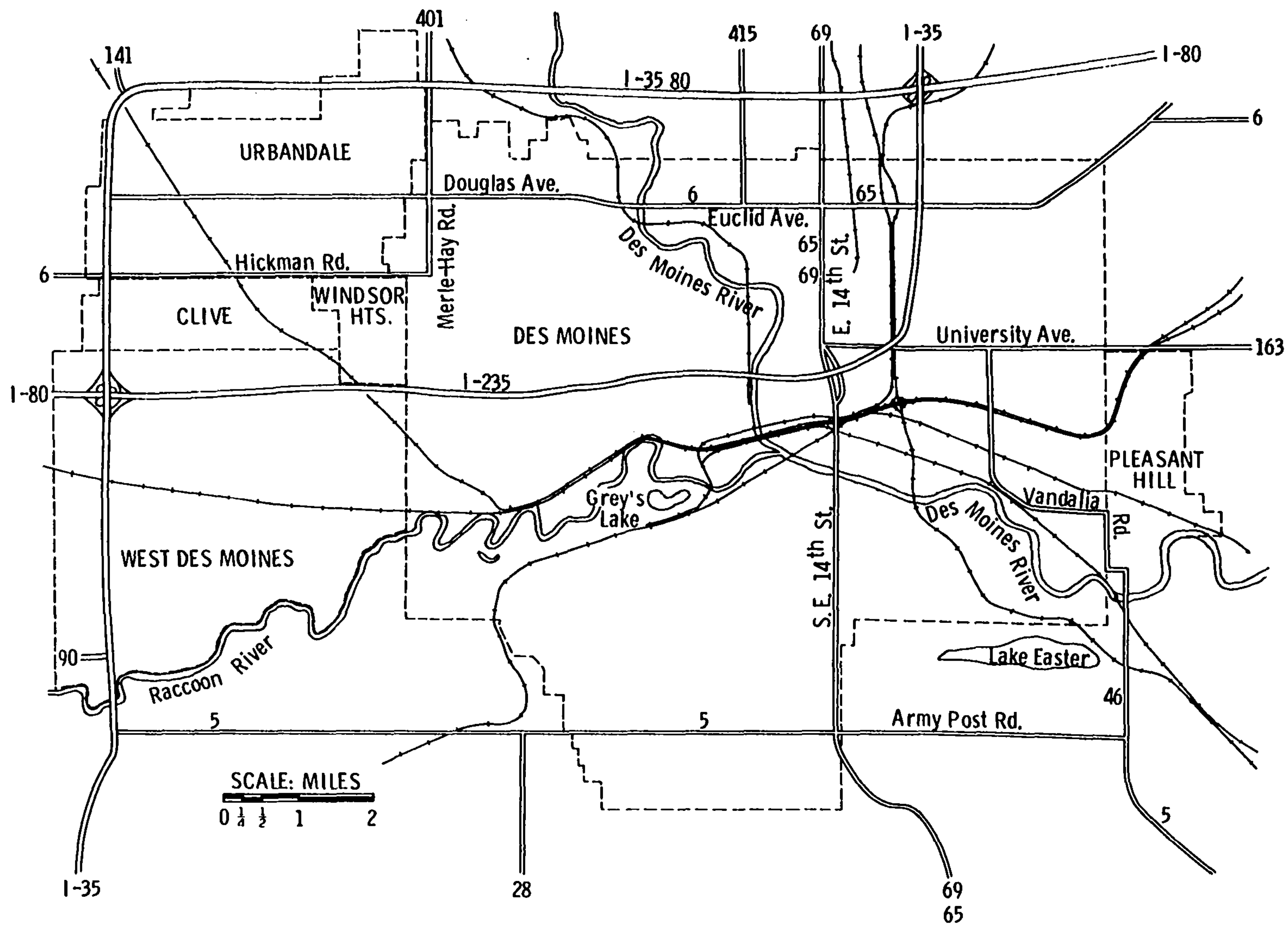


Figure 4.1. Des Moines metropolitan area

Railway Streetcar Co. extended its Urbandale Line to the east edge of the area. As Urbandale trolley stop was a turn around, a stable was built where people could leave their horses as they came from the farms to ride the streetcar to Des Moines. The trolley became a stimulus for growth in the area and in the early 1900's the area was becoming a home for those Des Moines residents who preferred to live in the rural area and commute to work in Des Moines on the trolley. When a school board member from nearby Johnston decided to turn the migration from Des Moines north to his community by requiring the children of Urbandale to be bussed to Johnston, the residents of the area retaliated by deciding to incorporate. On April 5, 1917, by a vote of 49 to 9, the residents voted in favor of incorporation so that they might have their own school. The new town was named Urbandale after the trolley line.

Although Polk County had been a coal mining area since the late 1870's, Urbandale remained a farming community until the 1920's. At that time, four coal mines were established within the present city limits. Even then, the community maintained its farming orientation. Many miners working in Urbandale did not live in the community but commuted to work on the trolley. As the coal became increasingly difficult to mine, the Urbandale mines closed one by one, until by 1940 there were no coal mines remaining in the community.

From 1917 to 1950, Urbandale remained a rural community. By 1930, the town had electricity but there was no water or sewer system. For many years the only paved street in Urbandale was Douglas Avenue--a two lane state highway paved by the state in 1926. But in 1951, the trolley car stopped running, and by 1956 the Interstate Highway around the town had been constructed, as well as the first large subdivision of new homes. In the 1950's Urbandale experienced remarkable growth and became a part of a nationwide phenomenon termed suburbanization.

Population growth

Shortly after Urbandale was incorporated in 1917, it had a total of 298 residents. For the next 30 years the population grew at a fairly steady rate, attaining a total population of 1,777 in 1950. Since 1950, however, Urbandale has had one of the highest rates of growth in the state of Iowa. The population increased 227.6 percent between 1950 and 1960 and 148 percent between 1960 and 1970, reaching a population of 14,434 in 1970. Since 1970 the population has continued to increase but at a slower rate with an estimated population of 16,480 in 1975 (Table 4.1).

This population growth can be explained in three basic ways. First is the natural increase in population due to the excess of births over deaths. Urbandale, like other suburbs around the country, has attracted many families with young children. This is apparent from Table 4.2 which shows that in 1975 only 15.1 percent of the population was over 50, while 45.7 percent of the population was under 20. This age distribution is reflected in a 1973 city live birth rate of 10.5 per thousand and a death rate of 2.3 per thousand (55, p. 26). This compares to a 1973 state live birth rate of 13.4 per thousand and a death rate of 10.1 per thousand (55, p. 26). Naturally the population is increasing at a rate of 3.3 percent in the state of

Table 4.1. Urbandale population, 1900-1975[a]

Year	Population	% Change in population
1900	-	-
1910	-	-
1920	298	-
1930	596	100.0
1940	1,083	31.7
1950	1,777	64.1
1960	5,821	227.6
1970	14,434	148.0
1975[b]	16,410	13.7

[a]Source: Population, Part of a Comprehensive Plan for Urbandale, Iowa (69, p. 12).

[b]1975 Special Census data provided by the Urbandale Department of Community Development.

of Iowa, but at a rate of 8.2 percent in the city of Urbandale.

The second explanation for the population increase is annexation. 1,378 people were residents of areas annexed into Urbandale between 1960 and 1970 (54, p. 48). Any analysis of population growth should take account of the fact that the incorporated boundaries of Urbandale were not constant, but expanded along with population.

In-migration, however, has boosted Urbandale's growth more than any other factor. When people migrate into an area, new housing must be

Table 4.2. Population distribution by age and sex, city of Urbandale, Iowa, 1975[a]

Age	Male	Percent	Female	Percent	Total	Percent
0-5	603	7.5	566	6.7	1,169	7.1
5-9	847	10.5	805	9.6	1,652	10.1
10-14	946	11.7	931	11.1	1,877	11.5
15-19	786	9.8	767	8.9	1,553	9.5
20-24	622	7.7	766	8.9	1,388	8.5
25-29	688	8.5	788	9.2	1,476	9.0
30-34	682	8.4	749	8.7	1,431	8.7
35-39	590	7.3	622	7.2	1,212	7.4
40-44	550	6.8	556	6.5	1,106	6.8
45-49	529	6.5	503	5.9	1,032	6.3
50-54	411	5.1	413	4.8	824	5.0
55-59	307	3.8	288	3.3	595	3.6
60-64	219	2.7	231	2.7	450	2.7
65-69	110	1.3	164	1.9	274	1.7
70-74	65	.81	64	.74	129	.8
75 and over	70	.87	143	.76	213	1.3
Total	8,025	100.0	8,356	100.0	16,381	100.0

[a]Source: 1975 Special Census of Urbandale, Iowa (available through the Urbandale Department of Community Development).

built to accommodate them. City building permit records from 1960 to 1970 indicate 1,505 new housing units were built to accommodate this in-migration (Table 4.3). Urbandale's migratory population increases are

Table 4.3. New housing units, Urbandale, Iowa, 1960-1970[a]

	Single-Family units	Two-Family units	Multi-Family units	Total
Number of units constructed	697	112	696	1,505

[a]Source: Urbandale Building Permits, Office of the City Engineer.

probably attributable to: 1) a state-wide migration of population from rural to urban areas, as well as 2) a migration of population from Des Moines to outlying suburbs.

The younger families attracted to Urbandale appear better educated than the average Iowan in terms of years of school completed. The median school years completed by Urbandale residents over age 25 is 12.6 compared to 11.3 for the state as a whole (69, p. 12). This educational attainment may be reflected in a median family income of $13,230 which is substantially above the state average of $9,018 (106, Table 41, Table 44). In terms of these characteristics, Urbandale is a relatively homogeneous suburb of well-educated, fairly affluent, young families.

Economy

Until recently, the economy of Urbandale has been almost completely dependent on Des Moines for employment and consumer goods. In 1962, a Comprehensive Plan for the city (5) reported virtually no manufacturing and few retail trade outlets with the exception of service stations. Businesses were dominated by services including four physicians, three dentists, a veterinary hospital, and seven barber and beauty shops. Since 1962 the number of firms offering employment has increased steadily, as illustrated in Table 4.4, although most of the firms do not employ over nineteen employees (68, p. 5). The firms are diversified including manufacturing, wholesaling, and warehousing operations. Most of their

Table 4.4. Number of firms attracted to Urbandale, 1962-1970[a]

Year	Number of firms	Employees hired
1962	3	171
1963	4	65
1964	1	8
1965	5	36
1966	3	475
1967	4	60
1968	1	3
1969	1	35
1970	2	345

[a]Source: Industry, Part of a Comprehensive Plan for Urbandale, Iowa (68, p. 4).

employees do not live in Urbandale but commute from Des Moines and the surrounding area. As few as 15 percent of the manufacturing and wholesaling workers in Urbandale commute less than 4 miles to work each day compared to 46 percent of Chicago workers found to commute less than 4 miles (68, p. 7).

Commercial as well as industrial activity has been limited in Urbandale. In 1963, Urbandale had only 23 retail establishments and although the number jumped to 42 by 1967, the lack of a centralized "downtown" district greatly hampered retail trade (67, p. 3). A 1960 study found that shoppers in downtown Des Moines were primarily from the northwest segment of the city and that a majority of the major purchases of the Des Moines area were probably made in downtown Des Moines (5). In addition, construction of a large indoor shopping mall (Merle Hay Mall) just east of the Urbandale city limits was found to be a major retail attraction.

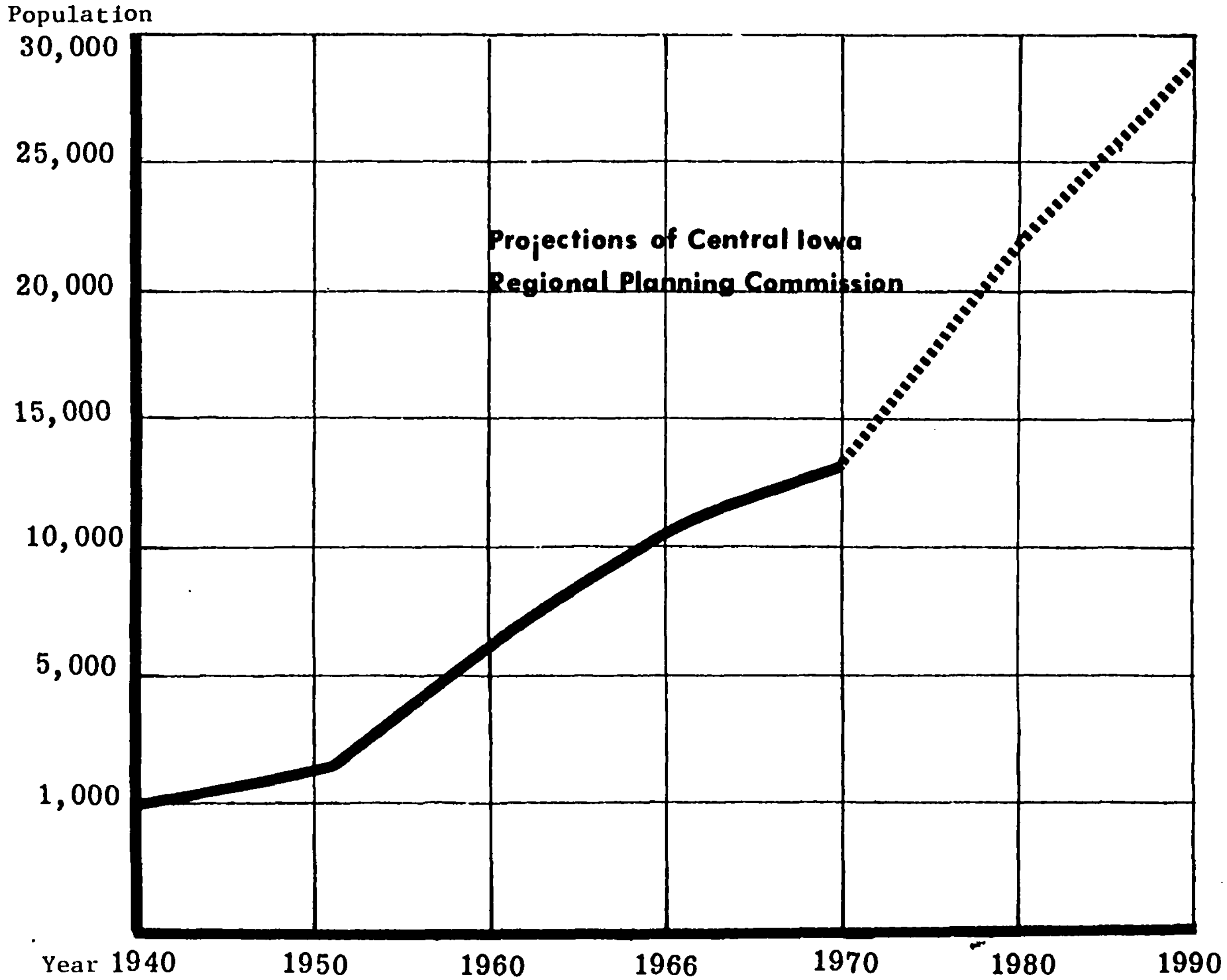
The city of Urbandale has clearly been dependent on Des Moines for shopping and employment in the past. Today, Urbandale is still primarily a "bedroom" community, its economy integrated into that of the Des Moines metropolitan area as a whole, but the number of new firms attracted to Urbandale in recent years indicates it is developing a growing industrial base.

Future

Population projections made by the Central Iowa Regional Association of Local Governments, as illustrated in Figure 4.2, project a slower rate

Figure 4.2. Population trends, Urbandale, Iowa 1940-1990 (Source: Population, Part of a Comprehensive Plan for Urbandale, Iowa, 1970 (69, p. 23)

POPULATION TRENDS AND PROJECTIONS
URBANDALE IOWA, 1940 - 1990



of growth over the next twenty years, but an increase nonetheless. While no one expects the city of Urbandale to become an autonomous part of the metro Des Moines area, estimates for continued industrial and commercial growth are relatively optimistic (67).

Data

Despite the fact that the Des Moines Metro Area has been the subject of several studies, including most recently a 208 Federal Water Quality Study,[1] little of the data was applicable to this study. The information that was available did not extend back earlier than 1970. Therefore, the bulk of the land use information needed for this study was obtained from aerial photographs, files of city officials and regional planners, and interviews with individuals involved in the land conversion process. Lack of adequate data is probably the chief reason so few empirical analyses of the land conversion process have been completed. This project, like others, was hampered by incomplete historical records, a lack of coordination in record keeping between city offices, and few older city officials with a personal knowledge of the details of the files and records at their disposal. Nevertheless, the data gathered provide as complete a picture of the land conversion process as could be obtained from the available information.

---

[1] This study is currently in progress and is being coordinated by the Central Iowa Regional Association of Local Governments, Des Moines, Iowa.

Data was sought in five basic categories, four of which correspond to the factors influencing land conversion outlined in Chapter II: 1) physical characteristics of the site, 2) regulatory measures, 3) availability of public services, and 4) site accessibility. The fifth category of data is the land use change which the four previous factors seek to explain. Data in all five categories were not available for the same time periods or in the same detail so some compromises were made in an effort to make the data more uniform. These compromises are discussed in the following sections.

Land use change

Since the variable under investigation is land use change, the data limitations in this category became the basis by which data in all other categories were gathered. After reviewing the alternatives, it was decided that aerial photography would provide the most complete and accurate record of land use change in the area. Agricultural Stabilization and Conservation Service (ASCS) photography was available for the years 1939, 1950, 1955, 1961, 1967, and 1974. Because Urbandale's population increased by only about 700 residents between 1939 and 1950, the 11 year lag between 1939 and 1950 did not match the other time periods, and little other information was available past 1950, 1939 was not included in the years studied.

The scale of the 1950, 1955, 1961, and 1967 photographs is 1:20,000 (or 1 inch on map = 20,000 inches on ground) while that of the 1974 photographic flight is 1:40,000. Enlargements of a scale 1" = 660' (or 8" = 1 mile) were obtained for the 10 square mile area for all years to facilitate the coding process. In order to code the land use changes occurring over the 24 year period, the 5 sets of photographs were each divided into 302 20-acre cells. Section line boundaries provided the reference points and each section of land (640 acres) was divided into 32 20-acre rectangular cells. Each cell could then be evaluated for land use at each of the five time periods.

Coding procedures were adapted from Interpretation of Aerial Photographs[1] (7, p. 80). A dot grid technique was used for coding. A transparent grid overlay was prepared with 50 dots representing 20 acres or each dot representing .4 acre. Each cell was then coded for urban and agricultural land uses by the number of dots falling in each category. Agricultural land uses were defined as agricultural land and buildings, including farmsteads. Urban land uses were defined as nonagricultural land uses including residential, commercial, industrial, and institutional areas. City parks were excluded from the analysis wherever possible because of the difficulty in distinguishing between recreational open space and agricultural pasture land. Some difficult categorization decisions were necessary in the interpretation and coding of the aerial photographs. Open idle land, for example, did not fit well into either category, but since it was undistinguishable from pasture land, it was coded agricultural. Consistency was the chief guideline by which such decisions were made. The final result of the photo interpretative process was a

[1]This reference was suggested by Dr. Rolland Lee Hardy, Department of Civil Engineering, Iowa State University.

record of the conversion of agricultural land to urban use for 302 20-acre cells from 1950 to 1974.[1]

Physical characteristics of the site

Information on the quality of the 20-acre cells was obtained through the Soil Conservation Service. A soil survey map was available for Polk County and the Urbandale area giving detailed information on soil types. This map was divided into 302 cells corresponding to the grid cells on the aerial photographs. Each cell was then coded for the number of acres suitable for development, using the same dot grid technique applied to the aerial photographs. Soil types suitable for development were obtained from the Soil Conservation Service manual, Soil Survey Information and Interpretations (87).

Regulatory measures

Complete records of the Urbandale Zoning Office were available for the years since 1973. Information prior to that was incomplete or non-existent. Copies of old zoning maps were available only to 1962. Information on zoning changes prior to that was available only through the city minutes. Because zoning classifications had not been uniform throughout the twenty-four year study period and because so little information was available, quantifiable data on zoning was not obtained. Instead, information on the zoning process in Urbandale was obtained through

---

[1]For an example of land use change from 1950 through 1974 in one section of land in the study area, see Appendix A.

interviews with the zoning administration staff.

Information on property taxation was also difficult to obtain. Tax assessment is based on ownership and data on individual land parcels rarely coincides with 20-acre cells. Property tax records were not available for the entire study period. Since most of Urbandale is in the same school district and subject to the same basic mill levy, this variable was considered to be a constant and not investigated further.

Annexation maps were available through the City Engineer's Office and used as an indicator of municipal control over land use.

Public services

Data on sewer and water lines, and schools were obtained from the City Engineer's Office, the Urbandale City Water Board, and the Superintendent of Schools' Office respectively. Information on the development of trunk sewer and water lines was pieced together from old maps, planning reports, and the recollections of staff members in the City Engineer and Water Board Offices. School construction information was obtained from the files of the Urbandale Superintendent of Schools' Office.

Accessibility

A 1973 travel time survey prepared by the Central Iowa Regional Association of Local Governments showing travel time in minutes from downtown Des Moines to outlying areas was available indicating the accessibility of Urbandale to shopping and employment opportunities in Des Moines (17, p. 26). Since local industry plays such a small role in Urbandale's economy, and there is no "downtown" Urbandale, travel times to work and shopping within Urbandale were not considered. Distances were calculated however, from maps to the nearest major shopping area (Merle Hay Mall). The distance of each cell from one of the three interstate access roads in the city was also calculated from maps.

Regression Results

Three general types of regression equations were formulated in Chapter III. Model I was an attempt to explain changes in land use from agricultural to urban. Model II was a similar equation which sought to explain changes in the intensity of urban land uses. Model III analyzed land use patterns at various points in time in terms of hypothesized causal factors. In applying these models to the Urbandale area, modifications were made due to the nature and availability of the data involved.

A major modification, discussed in the previous section, was the use of an annexation variable as a proxy for the regulatory measures of zoning and taxation. This modification was necessary because of the unavailability of data. Still other modifications were necessary because of the characteristics of the data.

Multicollinearity between variables was a major estimation problem in this analysis. The presence of a close linear relationship between variables was indicated by the behavior of the value of the coefficient of determination, R^2, after deletion of suspect variables from the regression (60, p. 390). If the value of R^2 was unaffected by the deletion of a variable thought to be closely related to another independent variable in the regression on the basis of simple correlations, the variables were considered highly correlated.

To minimize the problem, lagged independent variables were not included as formulated in Chapter III because of the close relationship between most variables and their lagged counterparts. Instead, in Models I and II first difference independent variables for the time period (T+1)-T were retained, but the lagged first difference independent variables were replaced by independent variables for time T. In Model III, first difference variables were substituted for lagged independent variables to circumvent the problem. In addition, a variable measuring the distance to the nearest shopping area (a shopping plaza on the east edge of Urbandale) was tested, but dropped from the analysis because of its close linear relationship to another variable, travel minutes to downtown Des Moines.

The problem of multicollinearity was found to be most serious in the latter periods of Model I when the sample size was smaller. In such cases, some variables were deleted from the analysis so that the influence of the remaining variables might be determined. Since the exclusion of such variables from the regression equation does not decrease the explanation of the dependent variable or damage the estimates of the coefficients of other variables (78, p. 51), this was considered an acceptable solution.

Model I

For the Urbandale data, the following regression equation was estimated:

$$\Delta AG_{(T+1)-T} = f(WT_T, \Delta WT_{(T+1)-T}, S_T, \Delta S_{(T+1)-T}, A_T, SCH_T,$$

$$\Delta SCH_{(T+1)-T}, CD_T, \Delta CD_{(T+1)-T}, \text{MINCBD, ST, DISTRDMI})$$

where

$\Delta AG_{(T+1)-T}$ = percentage change in urbanization between times T and T+1 of a cell that was 100 percent agricultural at time T

WT_T = distance of a cell from a trunk water line in miles at time T

$\Delta WT_{(T+1)-T}$ = change in distance of a cell from a trunk water line in miles between times T and T+1

S_T = 1 if a cell is within a sewer service area at time T

= 0 if a cell is outside a sewer service area at time T

$\Delta S_{(T+1)-T}$ = 1 if there is a change in access to sewer service between times T and T+1

= 0 if there is no change in access to sewer service between times T and T+1

A_T = 1 if a cell is inside the city limits at time T

= 0 if a cell is outside the city limits at time T

SCH_T = 1 if a cell is within 1/2 mile of an elementary school at time T

= 0 if a cell is farther than 1/2 mile from an elementary school at time T

$\Delta SCH_{(T+1)-T}$ = 1 if the distance from a cell to an elementary school decreases between times T and T+1

= 0 if there is no change in distance to an elementary school between times T and T+1

CD_T = percentage of land developed in the four cells directly north, south, east, and west of the given cell at time T

$\Delta CD_{(T+1)-T}$ = change in the percentage of land developed in the four cells directly north, south, east and west of the given cell between times T and T+1

MINCBD = travel time in minutes from a cell to downtown Des Moines

ST = percentage of a cell physically unsuitable for development by soil type

DISTRDMI = distance in miles from a cell to the nearest interstate access road

The results of this regression for the four time periods investigated are presented in Table 4.5.

Since no elementary schools were constructed in Urbandale between 1950 and 1961, the variable $\Delta SCH_{(T+1)-T}$ was excluded from the analysis in early time periods. As the sample size decreased, the problems with multicollinearity intensified. Variables labeled D were deleted from the analysis because of their close relationship with other variables. In the third period, MINCBD was highly correlated with DISTRDMI and to a lesser extent it was related to the sewer and water variables. MINCBD was deleted. In the fourth period, there appeared to be a strong relationship between most of the independent variables. In particular, the public services variables were all highly correlated with each other. The school variables were deleted to help separate the influence of the remaining public service variables. A and ST were also deleted because

Table 4.5. Regression results for Model I with $\Delta AG_{(T+1)-T}$ as the dependent variable

Dependent Variables / Independent Variables	ΔAG_{55-50}	ΔAG_{61-55}	ΔAG_{67-61}	ΔAG_{74-67}
Intercept	.0306	.1977	-.1238	-.3376
	(.0726)[a]	(.1312)	(.0505)	(.1420)
WT_T	-.0046	.0210	.0260	-.0064
	(.0079)	(.0187)	(.0454)	(.0429)
$\Delta WT_{(T+1)-T}$	-.0045	.0093	-.0312	-.1985
	(.0055)	(.0208)	(.0585)	(.1242)
S_T	-.0420**	-.1064**	-.0173	-.0158
	(.0186)	(.0371)	(.0313)	(.0259)
$\Delta S_{(T+1)-T}$	-.0153	-.0270	.0621*	-.0214
	(.0455)	(.0182)	(.0340)	(.0353)
A_T	-.0075	.0068	-.0082	D[b]
	(.0075)	(.0158)	(.0354)	

[a]Numbers in parentheses are standard errors of coefficients.

[b]D = deleted from analysis.

*Significant at the .10 level.

**Significant at the .05 level.

Table 4.5 (Continued)

Dependent Variables / Independent Variables	ΔAG_{55-50}	ΔAG_{61-55}	ΔAG_{67-61}	ΔAG_{74-67}
SCH_T	-.0092 (.0119)	-.0387 (.0246)	.0836* (.0435)	D
$\Delta SCH_{(T+1)-T}$	NA[c]	NA	.0851** (.0378)	D
CD_T	.0472 (.0838)	.2124 (.1410)	.1914 (.1873)	.1162 (.1011)
$\Delta CD_{(T+1)-T}$	.5574** (.0970)	1.217** (.0647)	1.283** (.0971)	1.301** (.0708)
MINCBD	-.0006 (.0042)	-.0114* (.0066)	D	.0152** (.0065)
DISTRDMI	-.0069 (.0107)	.0025 (.0216)	.0687 (.0420)	.0534 (.0350)
ST	-.0106 (.0171)	-.0537 (.0343)	.0767 (.0514)	D
	R^2=.201	R^2=.70	R^2=.57	R^2=.727
	F=5.48	F=47.15	F=21.24	F=50.43
	DF=238	DF=213	DF=176	DF=151

[c]NA = not applicable.

of their impact on the model.

As Table 4.5 indicates, the coefficient of WT_T, the distance from a trunk water line, was not significant in any time period studied. To be consistent with the hypothesis that the availability of public services influences land use change, the sign should be negative, implying that the closer an area is to a trunk water line, the more land use change occurs. In two out of the four periods this was the case, however, the fact that the coefficient is not statistically different from zero in any period probably means no significance should be attached to this fact. The coefficient of $\Delta WT_{(T+1)-T}$ was likewise insignificant in all periods studied, but the negative coefficient obtained in three out of the four periods would seem to indicate that as the distance to a trunk water line decreased during the period studied, agricultural land use change increased.

The coefficient of S_T, the availability of sewer service, had a negative sign in all periods studied and was significant in the first two. This would not confirm the hypothesis that public services precede land use change, as a negative coefficient implies that sewer service was lacking at the beginning of the time period studied. Furthermore, with the exception of the period 1961-1967, the data did not reveal a significant change in sewer service during the time periods studied. The implication is that neither the existence of sewers at the beginning of a time period nor the provision of sewer service during the time period had a significant impact on agricultural land use change. Instead, agricultural land generally converted to urban use in areas with a decided lack of access to sewer services.

The coefficient of the last public service variable investigated, the availability of an elementary school within walking distance, SCH_T was insignificant and negative in sign, in the first two periods studied. During the third period, however, the coefficient of SCH_T was positive and significant, indicating that the presence of an elementary school within one-half mile at the beginning of the period caused an increase in agricultural land use change. The coefficient of $\Delta SCH_{(T+1)-T}$ was also positive and significant during the third time period. The period 1961-1967 was a time of school construction and expansion in Urbandale, perhaps accounting for the importance of school variables in this time period. SCH_T and $\Delta SCH_{(T+1)-T}$ were both deleted from the last analysis because of multicollinearity problems.

In summary, the impact of public services on the variable $\Delta AG_{(T+1)-T}$ in Urbandale between 1950 and 1974 would appear to be slight. The variables tested were generally insignificant. Of the four variables which proved to have significant coefficients in at least one time period one variable, sewer service, S_T, did not have the hypothesized sign. No strong case could be made from these results for the importance of public services in instigating the conversion of agricultural land to urban use in Urbandale.

One possible interpretation of these results is that public services in Urbandale did not precede development. The Milgram-Mansfield, Philadelphia study reported in Chapters II and III found that public services had preceded development in that study area. The

Urbandale City Engineer, however, confirmed that this has not been the policy in Urbandale. Services in Urbandale are provided only in response to development activity.

The coefficient of the regulatory variable, annexation, was insignificant in all periods tested, indicating that city boundaries had little impact on the initial conversion of agricultural land to urban use. Likewise insignificant in all periods was the coefficient of the physical suitability variable, ST. The negative sign, however, in the first two periods implies that as more of a cell is unsuitable for development, less agricultural land use change occurs. The change in sign from negative to positive in period three might indicate that land bypassed in earlier time periods because it was less suitable for development is developed in later time periods when land is scarcer.

Of the accessibility variables, MINCBD was the most significant. There was some change in sign over the time periods investigated. For the time period 1955 to 1961, the coefficient of MINCBD was significant and negative in sign, implying that the closer to downtown Des Moines a cell was located, the more agricultural land use change would occur. For the time period 1967-1974, the coefficient of MINCBD was also significant but positive in sign, indicating perhaps that less agricultural land was available for urban use close in and therefore, land conversion was occurring on the outer edges of the area. The coefficient of DISTRDMI, the distance to an interstate access road, was not significant in any time period. The change in sign from negative to positive over the time

[1]Interview with Mr. Ed Teghtmeyer, Urbandale City Engineer, November 8, 1976.

period tested could indicate, similarly to MINCBD, that agricultural land conversion in the early time periods centered around major roads and that as that land became urbanized first, land conversion in later time periods was concentrated in areas further away from main roads.

The most important variable in explaining the conversion of agricultural land to urban use in every time period was $\Delta CD_{(T+1)-T}$, the change in development of the four cells contiguous to the one under investigation. The greater the changes in development in the surrounding cells, the more development occurred in the agricultural cell under investigation. CD_T, the contiguous development present at the start of the period, did not prove to be significant. The importance of $\Delta CD_{(T+1)-T}$ in the regression equations may be an indication of the importance of the developer in the land conversion process. The fact that the conversion of agricultural land to urban use appears to be so dependent on surrounding development activity may mean that the developer plays a crucial role in determining how and when agricultural land changes uses.

Model II

The second model described in Chapter III was an attempt to analyze changes in the intensity of urban land uses. For the Urbandale area, the following regression equation was formulated:

$$\frac{\Delta Urb_{(T+1)-T}}{Urb_T} = f(WT_T, \Delta WT_{(T+1)-T}, \Delta S_T, S_{T-(T-1)}, A_T, \Delta A_{(T+1)-T}, \Delta CD_{(T+1)-T}, \Delta CD_{T-(T-1)}, SCH_T, \Delta SCH_{(T+1)-T}, MINCBD, DISTRDMI, ST)$$

where

$\frac{\Delta Urb_{(T+1)-T}}{Urb_T}$ = percentages rate of change in development between times T+1 and T of a cell that was less than 10C percent agricultural at time T

$\Delta A_{(T+1)-T}$ = 1 if a change in annexation occurred between times T+1 and T

= 0 if no change occurred

$\Delta CD_{T-(T-1)}$ = change in the percentage of land developed in the four cells surrounding a given cell between times T and T-1

The results of these regressions are presented in Table 4.6. A lagged first difference form of CD was used because CD_T proved to be highly related to the other independent variables at time T, making analysis of the separate contributions of individual variables difficult.

The record of public service variables in the urban land use change regression was mixed. The coefficient of the variable WT_T was significant in three out of the four periods studied, the positive sign indicating that the greater the distance from a trunk water line, the more urban land use change occurred. The positive sign appeared to be contrary to the hypothesis that public services influence land use

Table 4.6. Regression results for Model II with $\frac{\Delta Urb_{(T+1)-T}}{Urb_T}$ as a dependent variable

Dependent Variable / Independent Variables	$\frac{\Delta Urb_{55-50}}{Urb_{50}}$	$\frac{\Delta Urb_{61-55}}{Urb_{55}}$	$\frac{\Delta Urb_{67-61}}{Urb_{61}}$	$\frac{\Delta Urb_{74-67}}{Urb_{67}}$
Intercept	1.0277 (1.1029)[a]	.1293 (.7062)	.2241 (.4904)	.6138 (.4156)
WT_T	.2956* (.1666)	.2319 (.1609)	.3189** (.1511)	.2921** (.1433)
$\Delta WT_{(T+1)-T}$	.2512* (.1351)	.1290 (.1405)	.1775 (.1805)	.8499** (.3164)
S_T	.1646 (.1167)	.2071 (.1369)	.0956 (.1084)	.2871** (.1020)
$\Delta S_{(T+1)-T}$	-.1664 (.3389)	.0690 (.1065)	-.1661 (.1459)	.1420 (.1176)
A_T	.1593 (.1427)	.0040 (.1485)	.2043 (.2932)	.0254 (.3337)
$\Delta A_{(T+1)-T}$	NA[b]	.0716 (.1838)	.0987 (.2591)	-.1562 (.3658)

[a]Numbers in parentheses are standard errors of coefficients.

[b]NA = not applicable.

*Significant at the .10 level.

**Significant at the .05 level.

Table 4.6 (Continued)

Dependent Variables / Independent Variables	$\frac{\Delta Urb_{55-50}}{Urb_{50}}$	$\frac{\Delta Urb_{61-55}}{Urb_{55}}$	$\frac{\Delta Urb_{67-61}}{Urb_{61}}$	$\frac{\Delta Urb_{74-67}}{Urb_{67}}$
$\Delta CD_{(T+1)-T}$	.2210 (.5939)	.7235** (.2592)	.4953** (.2032)	.6075** (.1156)
$\Delta CD_{T-(T-1)}$	NA	.6318 (.4566)	.7263** (.1736)	.6573** (.1548)
SCH_T	.1554 (.1052)	.1536** (.0781)	.1260* (.0741)	-.0143 (.0596)
$\Delta SCH_{(T+1)-T}$	NA	NA	-.0302 (.0678)	-.1044 (.0879)
MINCBD	-.1085 (.0703)	-.0563 (.0377)	-.0641** (.0222)	-.0743** (.0173)
DISTRDMI	-.6188** (.1949)	-.2754** (.1355)	-.2634** (.1143)	-.2848** (.1021)
ST	.1248 (.2813)	-.3438 (.2116)	-.3310* (.1794)	-.1122 (.0596)
	R^2=.538	R^2=.5657	R^2=.5929	R^2=.5873
	F=4.79	F=6.95	F=11.2	F=14.02
	DF=41	DF=64	DF=100	DF=128

change. The coefficient of $\Delta WT_{(T+1)-T}$ was positive and significant in two time periods indicating that more urban land use change occurred when the change in distance from a trunk water line was less, a result contrary to the original hypothesis. This may indicate that the extension of trunk water lines lagged development activity in Urbandale.

The remaining public service variables tended to support the hypothesis that public services influence land use change. The coefficient of the variable S_T, was significant in the final time period studied, although insignificant in previous time periods. The positive sign indicated the availability of sewer service was directly related to urban land use change. $\Delta S_{(T+1)-T}$, the change in sewer service, did not have a significant coefficient in any time period. The school variable, SCH_T, was positive in sign and the coefficient significant in the second and third time periods. Urban land use change in those periods directly related to the availability of elementary schools at the beginning of the time period. The coefficient of $\Delta SCH_{T-(T-1)}$ was not significant in any period.

Both of the annexation variables and the variable ST had little impact on urban land use change. The access variables, however, were significant. The coefficients for both MINCBD and DISTRDMI generally indicated that the more accessible a cell was, the more urban land use change could be expected. The coefficient of DISTRDMI was significant in all periods and the negative sign implied that as the distance to an interstate access road decreased, more urban land use change occurred. The coefficient of MINCBD was negative and significant in the last two periods, indicating more urban land use change occurred in areas closer to downtown Des Moines. Finally, contiguous development in both the period under investigation and the preceding period were important variables indicating, once again, that a 20-acre cell does not develop in isolation but is dependent on development activity, past and present, in adjacent tracts.

Model III

The cross-sectional model for Urbandale was formulated as follows:

$$YT = f(WT_T, \Delta WT_{T-(T-1)}, S_T, \Delta S_{T-(t-1)}, A_T, \Delta A_{T-(T-1)}, SCH_T,$$
$$\Delta SCH_{T-(T-1)}, MINCBD, ST, DISTRDMI)$$

where

Y_T = the percentage of a cell urbanized at time T.

The results of this regression are presented in Table 4.7. In this model, contiguous development variables proved to be so dominant that they had to be omitted from the analysis, despite their hypothesized importance. The importance of contiguous development variables in all three models tested may indicate that some spatial dependence of disturbances is present. This is not surprising considering the small area being analyzed. There is a well-established body of literature dealing with the problem of autocorrelation of disturbances in time-series models (58, pp. 243-265; 60, pp. 269-296). The interrelationship of

Table 4.7. Regression results for Model III with Y_T as the dependent variable

Independent Variables \ Dependent Variables	Y_{50}	Y_{55}	Y_{61}	Y_{67}	Y_{74}
Intercept	.2822 (.1809)[a]	.5677 (.2181)	.5415 (.2665)	.5353 (.2990)	1.3010 (.3112)
WT_T	.0261 (.0202)	.0508** (.0252)	.0708 (.0467)	.0910 (.0742)	-.2041** (.0938)
$\Delta WT_{T-(T-1)}$	NA[b]	-.0056 (.0241)	0.0213 (.0275)	0.0045 (.0761)	.2962 (.2358)
S_T	.2635** (.0324)	.3137** (.0370)	.3223** (.0603)	.2079** (.0524)	.1051* (.0630)
$\Delta S_{T-(T-1)}$	NA	-.3256** (.1176)	-.2167** (.0481)	-.1826** (.0663)	-.2888** (.0683)
A_T	.0470** (.0210)	.0512** (.0241)	.0544 (.0433)	.0250 (.0839)	.0638 (.0887)
$\Delta A_{T-(T-1)}$	NA	NA	-.1064** (.0401)	-.0293 (.0587)	-.0266 (.1869)
SCH_T	.0358 (.0275)	.0543* (.0310)	.0624 (.0418)	.2657** (.0557)	.1972** (.0513)

[a]Numbers in parentheses are standard errors of coefficients.

[b]NA = not applicable.

*Significant at the .10 level.

**Significant at the .05 level.

Table 4.7 (Continued)

Dependent Variables / Independent Variables	Y_{50}	Y_{55}	Y_{61}	Y_{67}	Y_{74}
$\Delta SCH_{T-(T-1)}$	NA	NA	NA	-.1846** (.0576)	-.0877 (.0904)
MINCBD	-.0159 (.0109)	-.0290** (.0130)	-.0228* (.0137)	-.0212 (.0148)	-.0513** (.0143)
ST	-.0685 (.0454)	-.1259** (.0526)	-.2524** (.0725)	-.2142** (.0922)	-.2825** (.1048)
DISTRDMI	-.0424* (.0244)	-.1179** (.0333)	-.1396** (.0452)	-.1749** (.0628)	-.0963 (.0775)
	R^2=.34	R^2=.424	R^2=.407	R^2=.423	R^2=.437
	F=21.7	F=23.98	F=19.99	F=19.29	F=20.49
	DF=294	DF=292	DF=291	DF=290	DF=290

disturbances across space, however, has attracted little formal econometric analysis.[1] Therefore, even though autocorrelation of disturbances across space may be a problem in this model, there will be no attempt to correct for it.

Public service variables had a stronger impact in the cross-sectional regressions than in either of the two previous models. The sewer service variables, S_T and $\Delta S_{T-(T-1)}$, were both significant in every time period, the signs indicating that the existence of sewer service at time T is directly related to intensity of development in a cell, and that no significant change in sewer service occurred in the preceding time period. The coefficient of the variable, SCH_T, was significant in three out of five time periods, the positive sign indicating school availability does have an impact on land use. $\Delta SCH_{T-(T-1)}$, the first difference variable, was negative in sign in all periods and the coefficient was significant in one, indicating no significant change in school availability occurred in the previous time period. The water variable, WT_T, is more difficult to interpret. In 1955, the variable was significant with a positive coefficient while in 1974, WT_T was significant again, but this time the coefficient was negative. One explanation might be that the extension of water lines did not keep pace with development in the early years, resulting in development activity some distance from trunk water lines. The negative

---

[1]For one approach to the problem see Walter D. Fisher, "Econometric Estimation with Spatial Dependence," Regional and Urban Economics, Vol. I, 1971, pp. 19-40 (36).

coefficient in 1974 could be an indication that by that time trunk water lines had caught up with development.

The coefficient of the annexation variable, A_T, was significant and positive in the two early time periods, but insignificant thereafter. This might be explained by the fact that in the early time periods little agricultural land was located inside the city limits, hence development could be expected to be more intense inside the city boundaries. In later years, large amounts of agricultural land were annexed into the city, perhaps reducing the relationship between development and city boundaries. The coefficient of $\Delta A_{T-(T-1)}$ was negative in sign and significant for 1961, indicating that annexation into a city at time T-1 does not necessarily result in increased development at time T.

ST, the physical suitability of development, was significant for four periods with the hypothesized sign. The coefficient of the variable MINCBD was significant in three periods while DISTRDMI was important in all five time periods. The negative coefficients of both variables imply that development tends to concentrate in areas close to downtown Des Moines and around interstate access roads.

The results of this model are generally consistent with the results of the cross sectional Chapin and Weiss study discussed in Chapters II and III. In that study water service was found to be an important variable, but only one time period was analyzed, so a comparison of results is difficult.

Interpretation of Regression Results

Some care should be taken in interpreting the results of these three sets of regressions. First, no one time period should be analyzed in isolation. Instead, the importance of variables over time should be evaluated as the danger of misinterpreting the impact of a variable by examining it at one point in time is too great. Variables important over time may be insignificant in a single period. An example is MINCBD in Model III.

Second, the results of these regressions should not necessarily be interpreted as having general significance for all cities in Iowa. The data were collected and analyzed for Urbandale, which may not be representative of other cities throughout the state. Within these guidelines, some conclusions about the land use change process in Urbandale can be drawn from the three sets of regression results.

It would appear that the initial impetus to convert agricultural land to urban use stems in large part from the adjacent development activity. During the first half of the period studied, $\Delta CD_{(T+1)-T}$ explained almost all of the variation in $\Delta AG_{(T+1)-T}$. Public service and access variables had limited influence in some periods, but changes in contiguous development were clearly a dominant explanatory factor. This may be an indication that the developer is a central agent in the land conversion process. Developers often assemble large tracts of land for subdivision purposes. Typically, construction, once begun, progresses rapidly. The fact that urbanization in an undeveloped tract of land depends so much on surrounding development activity may mean that the role of the developer in the land use change process is a critical one.[1]

After the initial land conversion had begun, other variables were important in explaining further land use changes. Urban land use change appeared to intensify around major interstate access roads, areas close to downtown Des Moines, and in some periods around schools. Urban land use change was greatest in areas where development activity was occurring in the given period and had occurred in the preceding period.

The results of the cross section models indicated that development is concentrated in areas accessible to roads and shopping, where public services are available, and the site is suitable for development. The implication is that although the role of some of these variables in initiating land use changes may be limited, once the land use change process is begun, these variables become important in solidifying land use patterns. Public services, it would appear, follow the development process, reinforcing development patterns determined by other forces. Sewer lines and schools are more important than water lines in reinforcing development patterns, judging from the regression statistics. Access variables play a more active role in

[1]Recent research has focused on the role of the developer. See Goldberg and Ulinder (38) and the references therein.

the process, influencing land use change after the initial conversion process has begun, and reinforcing development patterns thereafter. The role of regulatory devices, as measured by annexation, would appear to have a minimal impact on the land use change process.

The timing of the land use change process could not be determined from this analysis. The general failure of the lagged first difference variables to explain much variation in the dependent variables could indicate that the lags were of a different length than hypothesized, or that the forces that precede development were not included in the analysis.

The square of the multiple correlation coefficient (R^2) for the estimated equations ranged from .201 to .727, explaining on the average less than 50 percent of the variation in the dependent variables. One implication might be that important variables were omitted from the analysis. One hypothesized factor, the personal characteristics of landowners, was not included as a variable. On the other hand, the R^2 coefficients may simply reflect the disaggregated type of analysis undertaken. Theil (93, p. 181) argues that an R^2 of .5 or less may be expected for cross-section data on the household level. Researchers attaining higher R^2's may be dealing with data aggregated over individuals, commodities, regions, or time which tends to reduce the relative importance of neglected variables.

Land Use Process in Urbandale

To verify the sequence of land use change compiled through the regression results and to add information on variables not included in the analysis, individuals involved in the land conversion process in Urbandale were interviewed. (See Appendix B for a complete listing of individuals interviewed.)

All municipal officials interviewed agreed that public services were provided in response to demand. The role of the developer in the land use change process was also emphasized. Beyond this, however, the interview data provided further insight into the role of key variables in the land use change process.

The land use process in Urbandale during the study period can be divided into two distinct time periods, 1950-1964 and 1964-1974. Although statistically, public service variables behaved similarly throughout the study period, these variables, sewer and water service in particular, were not controlled by the same groups throughout the twenty-four years studied. In the early period, a small group of landowners influenced the growth of the community through a private sewer corporation and private water lines.[1,2]

---

[1] Data on the development of sewerage service in Urbandale were provided by Mr. Robert Drey, lawyer for the Urbandale Sanitary Sewer District, Bradshaw Law Firm, Des Moines, Iowa.

[2] Historical data on water service in Urbandale were obtained through the Urbandale Water Board Minutes by Mr. Richard Foust, Manager, Urbandale Water Board.

In the later period, public entities assumed responsibility for the provision of public services to the entire community.

In 1950, the city of Urbandale was a small community of 1,777 people situated near a soon-to-be constructed interstate highway. Several developers who owned large tracts of land between the incorporated boundaries of the community and the proposed interstate wished to begin development but found they could not become a part of the Urbandale-Windsor Heights Sewer District serving the established part of Urbandale. The city of Urbandale, although it was in favor of development, could not provide additional sewerage facilities because it lacked the bonding capacity. The developers responded by forming in 1955 the Urban Sanitary Corporation, which constructed at a cost of $500,000, a sewage treatment plant, sewer lines and lift stations to serve the area. In return, the city signed an agreement that required the purchase of a permit from the Urban Sanitary Corporation before any individual or the city of Urbandale itself could gain access to the sewerage system. With the exception of one private development with its own treatment plant, the Urban Sanitary Corporation was the source of sewerage service for the developing part of Urbandale until 1964.

Like sewerage service, the city of Urbandale, which purchases its water from Des Moines, was unable to provide water lines to the new developments. In 1955, one developer, through a private agreement with the city of Des Moines, constructed a private water main to his development along the southern edge of the city. Until 1961, this private water main served the westernmost edge of the city.

During the period 1950-1960, the city experienced the fastest rate of growth in its history (see Table 4.1). Although the city annexed the developing areas, control of basic public services remained in private hands. In 1961, for $21,000 the city purchased the private water main. As the city Water Board Minutes recorded the resolution, ". . . for the protection of the city and to enable proper expansion of the city, private mains must be eliminated" (107). At the same time, the Urbandale Sanitary Sewer District was formed. This is an autonomous body, closely allied with the city of Urbandale, governed by an elected board of officials. The formation of this sewer district increased the bonding capacity of Urbandale. In June 1964, the Urbandale Sanitary Sewer District in an agreement with the Urban Sanitary Corporation, purchased the 1955 contract with the city of Urbandale and 500 unused permits. The sewage treatment plant, sewer lines, and lift stations became the property of the Urbandale Sanitary Sewer District.

Although the city did not control public services in the developing areas during the 1950-1964 period, it did have regulatory power in these areas in the form of annexation and zoning.[1] The first zoning ordinance in Urbandale was established in 1921 and was essentially height and area restrictions. In 1939, a comprehensive zoning

[1] Information on the regulatory process in Urbandale provided by Mr. Rex Parsons, Urbandale Zoning Administrator.

ordinance was passed. That ordinance, as amended in 1940, remained in effect in Urbandale until 1963, when a new ordinance was passed. Land annexed into the city was zoned agricultural as a holding category, but rezoning to a residential category appeared to be a simple procedure. The Urbandale zoning administrator was not aware of any rezoning requests officially denied during the period studied. Regulatory measures during the period studied would appear to be relatively weak instruments of land use control. This may stem from the fact that the zoning ordinance, in particular, was formulated in an earlier decade and was not designed to control the rapid land use change Urbandale faced after 1950.

During the early period of Urbandale's development in 1955-1956, the Interstate Highway 35 and 80 around the city was constructed. Three interchanges were located in what is now the city of Urbandale. The roads designated as access roads then, have continued to influence land use patterns in the years since. At the time of construction, the interstate was outside of the city boundaries of Urbandale. Iowa Department of Transportation authorities contacted doubted that in such a case the city would have had much input into the planning of interchanges beyond informational hearings.[1] Although no individual could be located who was involved in the planning of the interstate around Urbandale and Des Moines, the general planning process outlined by Department of Transportation officials would

---

[1]Mr. Bob Humphrey, Highway Division, and Mr. Ken McLaughlin, Design Department, Iowa Department of Transportation, Ames, Iowa, provided all highway information.

indicate that the location of interstate interchanges was proposed by the state based on traffic data and approved by Federal authorities. Cities were involved in the planning process when an interstate entered their jurisdiction. As the Urbandale city boundaries did not extend to the interstate in 1955, it is likely that one of the key variables in the land use process was determined in the early period of development by state highway planners, with only minimal input from the city of Urbandale.

Since 1964 major changes have taken place in the land use process in Urbandale. The initial impetus for development still comes from the developer according to city officials. However, a proposed development is now subject to the review and approval of city authorities. The City Engineer outlined the steps that must be taken before development can begin as follows:

1. The developer submits a preliminary plat which is reviewed by the City Engineer's Office, the Office of Community Development, and the Urbandale Water Board for zoning, utility extensions, basic street layouts, major arterial street requirements, and drainage requirements. The groups involved meet with the developer once or twice to discuss the project.

2. The developer incorporates the city's comments into his plan and files an official plat.

3. The plat goes to the Planning and Zoning Commission and the City Council for approval.

4. Once the final plat approved is given, the developers must pay for all major sewer and water line extensions and street construction in the area, including trunk sewer and water line extensions outside the development.

Regulatory measures in recent years, if not stricter, have at least changed to meet the situation in the opinion of the Urbandale zoning administrator. The evidence would seem to confirm this. A new zoning ordinance was passed in 1974, with one rezoning case currently in court. Sewer moritoriums have been imposed periodically to relieve the overloaded sewage treatment plant, and a 10 percent mandatory park dedication requirement has been imposed on developers since 1972. The impact of these regulations remains to be determined.

Despite the changes, some aspects of the land use process have remained constant in Urbandale throughout the study period. Farmers have not been a part of the Urbandale area during the entire study period. Although land has been farmed while "ripening" for development, developers have controlled much of the area throughout the study period. In both time periods, large tracts of land were owned by a few individuals. Some tracts of land, idle in the early time period, remained idle throughout the second period, even though they were suitable for development in both periods. Various explanations offered by city officials include estate settlement and transfer difficulties, internal management problems, and owners who simply refuse to sell. These explanations lend credence to the hypothesis that the personal characteristics of land owners can influence land use change.

In summary, many of the key factors in the land conversion process have not been under the control of the city of Urbandale. The development of interstate access roads was basically a decision of a state agency. The extension of sewer and water services in a crucial period of development was a decision made by a few landowners. Of the twenty-four years studied, it is only during the last ten years that Urbandale attained control over traditional municipal decisions. The importance of controlling such variables as sewer service and major roads is reflected in the regression statistics. Omitted from the regression analysis, however, is the fact that for many years the city of Urbandale had little control over these major variables.

CHAPTER V. SUMMARY AND CONCLUSIONS

This study is an analysis of the process by which agricultural land is converted to urban use. Five objectives of the study were stated in Chapter I. The first objective was to identify the conflicts between urban and rural use of land inherent in the land use change process. In Chapter II, conflicts were analyzed from both rural and urban perspectives. The interspersion of agricultural land urban land uses was found to be a major consequence of the land use change process. On the rural side, this interspersion of land uses, or sprawl, was found to affect agricultural land in terms of efficiency. The uncertainty created by urbanization, it was suggested, idled far more land than necessary, and reduced capital investments and thus productivity in other affected areas. From the urban viewpoint, sprawl created conflicts by increasing the cost of public services. From both urban and rural perspectives, sprawl was found to be objectionable with urban dwellers viewing the process as unaesthetic and rural residents concerned over a possible loss of prime agricultural land. Some advocates of sprawl argue the process provides needed flexibility, but this viewpoint does not appear to be reflected in public opinion.

The second objective of this study was to explore the causes of these conflicts by developing a methodology to identify and explain changes in the land use process. In Chapter II, possible explanations for dispersed and scattered settlement patterns were offered.

An urban demand for land was hypothesized to influence the general pace and character of the land conversion process. Population growth and redistribution, income, and federal housing policies were suggested as factors creating an urban demand for land. In terms of explaining the actual pattern of land development, five micro factors were hypothesized to be important. Two of these factors, the availability of public services and the accessibility of a site to work and shopping, affected development by creating a demand for particular parcels of land for development. The remaining three factors influenced land development by restricting the supply of land for development. The personal characteristics of the landowner, the physical suitability of a site for development, and regulatory measures such as zoning were hypothesized to be factors affecting the supply of land for development.

In Chapter III, a methodology to test these hypotheses and explain the land use change process was developed. The model was formulated at a disaggregated level, examining in some detail land use change in one Iowa community through time-series aerial photography. Three multiple regression equations were formulated to explain land use change, the results of those regressions to be combined with information obtained from interviews to provide an analysis of land use change as a process.

The third objective, the application of this model to a rural-urban fringe area was achieved, in Chapter IV. Urbandale, a suburb of Des Moines, Iowa, was selected for analysis. Data on land use were collected for the years 1950-1974 through analysis of ASCS aerial photographs, soil maps, and maps and records available through municipal offices. The results of the regression analysis applied to Urbandale indicated that the variables hypothesized to influence the demand for a site for development generally had more impact on the land use process than did the supply oriented variables. Sewer service, school availability, and the access variables, distance to a major road and travel minutes to downtown Des Moines, were particularly important. The role of the developer in instigating the conversion of agricultural land to urban use appeared from the regression results and interviews to be crucial. Most public services, although influential in the land conversion process, appeared to follow the initial conversion of land. Subsequent interviews revealed that Urbandale had little control over the key variables in the land use process, including public services, until the final years of the study. These interviews emphasized the role of private actions in the land use process.

The fourth and fifth objectives, to suggest possible methods of altering the land development process through the use of alternative land use policy tools and to suggest further research needs, are met in the Conclusions and Future Research Needs sections of this chapter.

Conclusions

The analysis of the land use change process in Urbandale indicated that variables influencing demand for development had more influence on land use change than variables affecting the supply of developable land. The influence of sewer service, neighborhood schools, and interstate access roads was especially significant. Although the data indicated that such public services as sewerage service and schools lag development, nevertheless development was found to be concentrated in areas where these services were present. There is some evidence that developers do not begin a project unless it is certain that sewerage service can be provided, if those services do not currently exist (38). It is the opinion of the Urbandale City Engineer that public services in that community are provided in response to planned development by the private sector.[1]

The importance of neighborhood elementary schools in the development process was indicated in the regression results. Even though schools follow initial development activity, urban land use change was found to increase in areas closer to elementary schools. This may reflect the fact that quality of education may be a major factor in the redistribution of population from central cities to suburbs. Public investment decisions in education may influence the location decisions of households and land use patterns.

---

[1]This information was obtained from Mr. Ed Teghtmeyer, Urbandale City Engineer during a private interview, November 8, 1976.

Major interstate access roads were also found to influence land use change in Urbandale over the period studied. This variable was in existence throughout the majority of the period studied and appeared to be a major determinant of land use change. These results indicate that by planning and coordinating decisions about these three variables, land use change could be guided toward specified objectives. At no point during the specified period, however, were these three variables under the control of the same entity. Interstate access decisions were made largely by state highway planners, sewerage service was provided first by a private corporation and later by a special sewer district, while school decisions were made by yet another special district. Coordination of public investment decisions in accordance with clear objectives for land use change could have a significant impact on the land use process.

Depending on the importance of such factors as the physical suitability of land for development and the personal characteristics of landowners, sprawl might exist in some form even if all public investment decisions were planned and coordinated. The analysis of Urbandale indicated that physical qualities of an area can influence development patterns. Depending on the severity of the physical limitations to development, sprawl could exist as a response to an environment unfavorable to development. The personal characteristics of landowners were also hypothesized to be important in land conversion. Although no formal analysis of this variable was undertaken in this study, internal management disputes and outright refusal to sell were hypothesized by city officials to be reasons why key parcels of land remained idle throughout the study period.

Contrary to the Neutze land speculation theory outlined in Chapter III, behavioral variables may be important in land use decisions. If this is the case, even occasionally, then land use patterns may be dependent at times on certain individuals. Two communities, identical in every respect, but with differing landowners, could still emerge with different land use patterns if behavioral variables are important. A random element, beyond the control of public investments, would be introduced into the land use change process. If such a variable were to play an important role in land use change it would be difficult to control without modifying traditional concepts of the individual's rights in land.

The analysis of land conversion in Urbandale indicated that regulatory variables affecting the supply of land for development were generally weak. The analysis appeared to substantiate the opinion that small suburbs such as Urbandale do not have the financial capacity or administrative expertise to cope with rapid land use change (88). If local control over land use is preferred, then financial and expert assistance may be called for. If land use change is a metropolitan problem, as in the case of Urbandale, then regional planning could be an answer for sharing technical expertise at least. Healy in his book, Land Use and the States (48), concludes that on balance, local government should make the majority of land use decisions. The state should provide financial support, sharing technical expertise and publishing long-range plans for state investment.

Many of the more recent land use policy proposals would appear to require some administrative sophistication to implement. Transferable development rights, for example, is a system that identifies the right to develop and creates a market for the rights by requiring that owners of developable land purchase the development rights in open space prefers as a prerequisite to development (6, p. 41). It would appear that state and regional assistance would be necessary for communities like Urbandale to implement such a policy.

Limitations of Research

Since only one community was studied, no general conclusions about the land conversion process can be drawn for the state of Iowa from this study. Because care was taken to select a community with a rapid rate of growth, this may mean that some aspects of the land conversion process in Urbandale are atypical and not representative of the process state-wide. Nevertheless, for those communities with growth patterns similar to Urbandale, the results of this study may be applicable. It may also be reasonable to assume that some similarities may exist between land conversion in Urbandale and land conversion in other types of communities, making the implications of this study of general interest.

Data were not available for all variables hypothesized to be important. Data in the regulatory measures category were especially difficult to acquire. The proxy variable, annexation, may be a weak substitute that does not accurately reflect the impact of municipal regulatory devices. The personal characteristics of landowners were hypothesized to influence land use change, but this variable was not investigated in this study. The difficulties in locating and interviewing landowners of the 1950's and 1960's made formal analysis of this variable impossible.

Multicollinearity was a problem in the estimation of the regression equations, especially in Model I. It is possible that those variables omitted from the analysis because of multicollinearity were important ones. However, the close relationships between variables in the last two time periods of Model I made isolation of the separate influences of these variables impossible. It is possible that some variables found to be insignificant in explaining variations in the dependent variable were affected by multicollinearity also.

Recommendations for Future Research

In the course of this study, questions arose which were not fully answered in the analysis of land use change in Urbandale. This study was not designed to provide definitive answers to all aspects of the issue. As such, further research in the following areas is recommended:

1. Land use information systems on the national and state level are currently in the research and proposal state (37). Few resources have been allocated, however, to develop land use information systems on the municipal level. Retrieving land use data from municipalities is at the present a time-consuming and often frustrating experience. Basic

research on land use information systems feasible for municipalities with limited resources is necessary if ongoing research on the land use process is to be possible.

2. The type of analysis undertaken in this study needs to be expanded to a wider variety of communities so that conclusions about the land use process in general can be drawn. Of particular interest would be a comparison and contrast of the land use change process in cities with differing growth rates. It is possible that older, established communities with slower and steadier population increases may be better able to cope with land use change. Municipal finances and regulatory controls might not be subjected to the pressures of a rapidly expanding community and thus the city might be able to adapt and keep pace with land use change. More planning and community control might exist in such a situation.

3. Another unanswered issue is the role of the developer in land use change. What are the criteria by which development decisions are made? Does the developer create demand for a certain housing pattern or does he merely respond to the dictates of the market?

4. Another aspect of the process where more information is needed is the transition stage between farmer and developer. There is some evidence that farmers do not sell directly to the actual developer. If this is the case, when and why does a farmer sell his land? Who are the intermediaries between farmers and developers? How long is land in a holding stage? What are the effects on agriculture in the area?

5. The possible importance of behavioral variables in land use change was discussed in an earlier section of this chapter. More research is needed on this topic. How important are the personal characteristics of landowners on land use patterns? Can all landowner behavior be explained through a profit motive in an investment model?

6. Finally, more research is needed on the nature of the conflicts between urban and rural land uses. The problems of implementing effective land use policy are difficult but not insoluble. The real issue is political--what sacrifices is a community willing to make in order to achieve a land use plan? It is doubtful that land use change can be directed effectively without some modification of the traditional property rights of the individual. If such a modification is required, then the community needs to know precisely what the costs involved in different patterns of land use are. Phrases such as "ugly" and "prime agricultural land" do not provide the community with information on which it can evaluate the trade-offs between the costs of the present land use change process and an individual's rights in land. If the consequences of our land use process were clearly formulated, then such an evaluation might be possible.

BIBLIOGRAPHY

1. Aldrich, R. C. Identification of Tree Species on Large Scale Panchromatic and Color Aerial Photographs. U.S. Department of Agriculture Handbook 261. Washington, D.C.: Government Printing Office, 1964.

2. Allee, David. "Changing Use of Rural Resources." Journal of Farm Economics, 48 (December 1966): 1297-1304.

3. Alonso, William. Location and Land Use: Toward a General Theory of Land Rent. Cambridge, Mass.: Harvard University Press, 1964.

4. Alonso, William. "The Historical and the Structural Theories of Urban Form: Their Implications for Urban Renewal." Land Economics, 40 (May 1964): 227-230.

5. Anderson Engineering Co. A Comprehensive Plan, Urbandale Iowa. Des Moines: Author, 1962.

6. Anderson, William D.; Gustafson, Gregory C.; and Boxley, Robert F. "Perspectives on Agricultural Land Policy." Journal of Soil and Water Conservation, 30 (Jan.-Feb. 1975): 36-43.

7. Avery, T. Eugene. Interpretation of Aerial Photographs. Minneapolis: Burgess Publishing Company, 1968.

8. Avery, T. Eugene. "Measuring Land Use Changes on USDA Photographs." Photogrammetric Engineering, 31 (1965): 620-624.

9. Bartholomew, Harland. Land Uses in American Cities. Cambridge, Mass.: Harvard University Press, 1955.

10. Bigham, Harold W., and Bostick, Dent C. "Exclusionary Zoning Practices: An Examination of the Current Controversy." Vanderbilt Law Review, 25 (November 1972): 1111-1150.

11. Birch, David; Atkinson, Reilly; Sandstrom, Sven; and Stack, Linda. Patterns of Urban Change. Lexington, Mass.: D.C. Heath and Co., 1974.

12. Blesch, Robert R., and Liang, Ta. "Application of Photo Interpretation in Route Location." Proceedings of International Symposium on Photo Interpretation, Delft, The Netherlands, 1966, 477-486.

13. Bosselman, Fred, and Collies, David. The Quiet Revolution in Land Use Control. Washington, D.C.: Council on Environmental Quality, 1972.

14. Bosselman, Fred; Callies, David; and Banta, John. The Taking Issue: Analysis of the Constitutional Limits of Land Use Control. Washington, D.C.: Government Printing Office, 1973.

15. Brigham, Eugene F. "The Determinants of Residential Land Values." Land Economics, 41 (November 1965): 325-334.

16. Burgess, Ernest W. "The Growth of the City: An Introduction to a Research Project." The City. Edited by R. E. Park, E. W. Burgess, and R. A. McKenzie. Chicago: University of Chicago Press, 1925.

17. Central Iowa Association of Local Governments. Annual Report: January 1, 1973 - July 1, 1974. Des Moines: Author, 1974.

18. Chapin, F. Stuart, Jr., and Weiss, Shirley F., eds. Urban Growth Dynamics in a Regional Cluster of Cities. New York: John Wiley and Sons, Inc., 1962.

19. Chinitz, Benjamin, ed. City and Suburb. Englewood Cliffs, N.J.: Prentice-Hall, Inc., 1964.

20. Citizens' Advisory Committee on Environmental Quality. Report to the President to the Council on Environmental Quality, Washington, D.C.: Government Printing Office, 1974.

21. Clawson, Marion. Suburban Land Conversion in the United States. Baltimore: The Johns Hopkins Press, 1971.

22. Clawson, Marion. "Urban Sprawl and Speculation in Urban Land." Land Economics, 38 (May 1962): 99-112.

23. Clawson, Marion, and Hall, Peter. Planning and Urban Growth. Baltimore: The Johns Hopkins Press, 1973.

24. Commons, John R. "Institutional Economics." American Economic Review, 21 (December 1931): 648-657.

25. Conklin, H. E., and Bryant, W. R. "Agricultural Districts: A Compromise Approach to Agricultural Preservation." American Journal of Agricultural Economics, 56 (August 1974): 607-613.

26. Conklin, H. E., and Dymza, R. Maintaining Viable Agriculture in Areas of Urban Expansion. New York: New York State Office of Planning Services, June 1972.

27. Conte, John V. "A Quiet Revolution." Wall Street Journal. June, 28, 1971, p. 1.

28. Cooperative Extension Service, Iowa State University. Final Report to the Governor's Conference on Iowa in the Year 2000. Ames, Iowa: Iowa State University, 1973.

29. Dort, Wakefield. Laboratory Studies in Physical Geology. Minneapolis: Burgess Publishing Co., 1964.

30. Downing, Paul B. "Extension of Sewer Service at the Urban-Rural Fringe." Land Economics, 45 (February 1969): 103-110.

31. Doxiadis, C. A. Emergence and Growth of an Urban Region, The Developing Detroit Area, Volume I: Analysis. Detroit: The Detroit Edison Co., 1966.

32. Dukeminear, Jesse, Jr., and Stapleton, Clyde L. "The Zoning Board of Adjustment: A Case of Misrule." Kentucky Law Journal, 50 (Winter 1962): 273-350.

33. Duvall, William B. "Conservation: An Upper-Middle Class Social Movement: A Replication." Journal of Leisure Research, 2 (Spring): 123-126.

34. Fisher, A. C., and Krutilla, J. V. The Economics of Natural Environments: Studies in the Valuation of Commodity and Amenity Resources. Baltimore: The Johns Hopkins Press, 1975.

35. Fisher, Anthony C., and Peterson, Frederick M. "The Environment in Economics: A Survey." Journal of Economic Literature. 14 (March 1976): 1-33.

36. Fisher, Walter D. "Econometric Estimation with Spatial Dependence." Regional and Urban Economics, 1 (1971): 19-40.

37. Gibson, James A. "Land Use Processes and Projections: Interrelationships of Iowa Nonagricultural and Agricultural Land Uses." Unpublished Ph.D. dissertation, Iowa State University, 1976.

38. Goldberg, Michael A., and Ulinder, Daniel D. "Residential Developer Behavior 1975: Additional Empirical Findings." Land Economics, 52 (August 1975): 363-370.

39. Gottmann, Jean. Megalopolis--The Urbanized Northeastern Seaboard of the United States. New York: Twentieth Century Fund, 1961.

40. Gustafson, Gregory C. "The California Land Conservation Act of 1965: Economic Analysis of a New Tool of Land Use Policy." Unpublished Ph.D. dissertation, University of California, Berkeley, 1973.

41. Haar, Charles M., ed. Final Report: The President's Task Force on Suburban Problems. Washington, D.C.: Government Printing Office, 1974.

42. Hady, Thomas E., and Sibold, Ann Gordon. State Programs for the Differential Assessment of Farm and Open Space Land. U.S. Department of Agriculture Economic Research Service Report No. 256, 1974.

43. Hale, Carl W. "Impact of Technological Change on Urban Market Areas, Land Values, and Land Uses." Land Economics, 49 (August 1973): 351-356.

44. Harris, Britton. "Quantitative Models of Urban Development." Issues in Urban Economics. Edited by Harvey Perloff and Lowdon Wingo, Jr. Baltimore: The Johns Hopkins Press for Resources for the Future, 1968.

45. Harris, Curtis, and Allee, David. Urbanization and its Effects on Agriculture in Sacramento County, California. Berkeley, Cal.: University of California Agriculture Experiment Station Report, Giannine Foundation Research Report No. 28, December 1963.

46. Harvey, Robert O., and Clark, W. A. V. "Controlling Urban Growth: The New Zealand and Australian Experiment." Urban Land Use Policy. Edited by Richard B. Andrews. New York: The Free Press, 1972.

47. Harvey, Robert O., and Clark, W. A. V. "The Nature and Economics of Urban Sprawl." Land Economics, 41 (February 1965): 1-10.

48. Healy, Robert G. Land Use and the States. Baltimore: The Johns Hopkins Press, 1975.

49. Henry, Joseph; Gale, Richard; and Hendee, John. "Conservation: An Upper-Middle Class Social Movement." Journal of Leisure Research, 1 (Summer, 1969): 123-126.

50. Hoover, Edgar M., and Vernon, Raymond. Anatomy of a Metropolis. Cambridge, Mass.: Harvard University Press, 1959.

51. House, Peter W. Differential Assessment of Farm Land Near Cities, Experience in Maryland through 1965. Washington, D.C.: U.S. Department of Agriculture, 1976.

52. Howard County Planning Commission. Howard County 1985. Howard County, Maryland: Author, 1967.

53. Hoyt, Homer. The Structure and Growth of Residential Neighborhoods in American Cities. Washington, D.C.: Government Printing Office, 1939; repr. Homer Hoyt Associates, 1968.

54. Iowa Development Commission. Statistical Profile of Iowa, 1974-75. Des Moines: Author, 1974.

55. Iowa State Department of Health. 1973 Iowa Summary of Vital Statistics. Des Moines: Author, 1975.

56. Isard, Walter. Location and Space Economy. Cambridge, Mass.: M.I.T. Press, 1956.

57. James, Richard D. "Wilderness Struggle: Long Battle over Dams on the Snake River." Wall Street Journal, July 29, 1975, p. 38.

58. Johnston, J. Econometric Methods. New York: McGraw-Hill, 1972. p. 243-265.

59. Kaiser, Edward J.; Massie, Ronald W.; Weiss, Shirley F.; and Smith, John E. "Predicting the Behavior of Predevelopment Landowners on the Urban Fringe." Journal of the American Institute of Planners, 34 (September 1968): 328-333.

60. Kmenta, Jan. Elements of Econometrics. New York: The Macmillan Company, 1971.

61. "Land Use Controls: Zoning and Subdivision Regulations." Building the American City: Report of the National Commission on Urban Problems to the Congress and the President of the United States. Washington, D.C.: Government Printing Office, 1968.

62. Lessinger, Jack. "The Case for Scatteration--Some Reflections on the National Capitol Region Plan for the Year 2000." Journal of the American Institute of Planners, 28 (August 1962): 159-169.

63. Lovelace, Eldridge H. "Control of Urban Expansion: The Lincoln, Nebraska Experience." Journal of the American Institute of Planners, 31(Nov. 1965): 348-351.

64. Lundeen, Ardelle A. "Identifying Land Use Planning Goals of Residents of Region V in Iowa." Unpublished Ph.D. dissertation, Iowa State University, 1976.

65. Lynn, Bob. "Improved Access Extends Suburban Boundaries." The Kansas City Times, Sept. 6, 1976, p. 5A.

66. McHarg, Ian L. "Open Space from Natural Processes." Metropolitan Open Space and Natural Process. Edited by David A. Wallace. Philadelphia: University of Pennsylvania Press, 1970.

67. Max Anderson Associates. Economy, Part of a Comprehensive Plan for Urbandale, Iowa. Des Moines: Author, 1970.

68. Max Anderson Associates. Industry, Part of a Comprehensive Plan for Urbandale Iowa. Des Moines: Author, 1970.

69. Max Anderson Associates. Population, Part of a Comprehensive Plan for Urbandale, Iowa. Des Moines: Author, 1970.

70. Milgram, Grace, and Mansfield, Christine. The City Expands. Washington, D.C.: Government Printing Office, 1967.

71. Mills, Edwin S. Urban Economics. Glenview, Ill.: Scott, Foresman, and Co., 1972.

72. Muth, Richard F. "The Demand for Non-Farm Housing." The Demand for Durable Goods. Edited by Arnold C. Harberger. Chicago: University of Chicago Press, 1960.

73. Neutze, Max. The Suburban Apartment Boom. Baltimore: The Johns Hopkins Press for Resources for the Future, 1968.

74. "New Ideas in Land Planning--Cluster Plan Cuts His Building Costs by One-Third." Journal of Home Building, 20 (May 1962): 76.

75. "Pipelines." Land Use Planning Reports. Washington, D.C.: Plus Publications, January 6, 1976.

76. "Pipelines." Land Use Planning Reports. Washington, D.C.: Plus Publications, September 29, 1975.

77. Plunkett, Thomas J. "Taxation and Development." Urban Land Use Policy. Edited by Richard B. Andrews. New York: The Free Press, 1972.

78. Rao, Potluri, and Miller, Roger Leroy. Applied Econometrics. Belmont, California: Wadsworth Publishing Co., 1971.

79. Reid, Margaret G. Housing and Income. Chicago: University of Chicago Press, 1962.

80. Reps, John W. "Pomeroy Memorial Lecture: Requiem for Zoning." Urban Land Use Policy. Edited by Richard B. Andrews. New York: The Free Press, 1972.

81. Richardson, Harry. Urban Economics. London: Penguin Education, 1971.

82. Ross, John M. "Land Use Control in Metropolitan Areas: The Failure of Zoning and a Proposed Alternative." Southern California Law Review, 45 (Fall 1972): 335-368.

83. Salamon, Lester M., and Wamsley, Gary L. "The Politics of Urban Land Policy: Zoning and Urban Development in Nashville." Growing Metropolis. Edited by James F. Blumstein and Benjamin Walter. Nashville, Tenn.: Vanderbilt University Press, 1975.

84. Siegan, Bernard. "Non-Zoning in Houston." Journal of Law and Economics, 13 (April 1970): 91-143.

85. "Slight Drop in Number of Iowa Farms." Des Moines Register, January 11, 1976, 2F.

86. Smith, Edward Ellis, and Riggs, Durward S., eds. Land Use, Open Space, and the Government Process. New York: Praeger Publisher, 1974.

87. Soil Conservation Service. Soil Survey Information and Interpretations. Washington, D.C.: Government Printing Office, 1967.

88. Soth, Lauren. "Timely Lessons for Iowa in Land Use Planning." Des Moines Register, July 20, 1976, p. 6A.

89. Stocker, Frederick D. "Assessment of Land in Urban-Rural Fringe Areas." The Property Tax and Its Administration. Edited by Arthur Lynn. Madison, Wisc.: The University of Wisconsin Press, 1969.

90. Tanian, Francis Xavier. "Water and Sewer Supply Decisions: A Case Study of the Washington Suburban Sanitary Commission." Unpublished Ph.D. dissertation, University of Virginia, 1965.

91. The Council of State Governments. Land, State Alternatives for Planning and Management. Lexington, Kentucky: The Council of State Governments, 1975.

92. The Task Force on Land Use and Urban Growth. The Use of Land: A Citizens' Policy Guide to Urban Growth. Edited by William K. Reilly. New York: Thomas Y. Crowell Company, 1973.

93. Theil, Henri. Principles of Econometrics. New York: John Wiley and Sons, Inc., 1971.

94. Thompson, Wilbur R. A Preface to Urban Economics. Baltimore: The Johns Hopkins Press, 1965.

95. Tiebout, Charles M. "A Pure Theory of Local Expenditures." Journal of Political Economy, 64 (October 1956): 416-424.

96. Timmons, John F. "Issues in Land Use Planning and Control." Focus on Iowa: Land Use Planning Seminar. Edited by Larry R. Whiting. Ames, Iowa: Center for Agricultural and Rural Development, 1973.

97. Timmons, John; Saupe, William; and Joslin, Kenneth. "Iowa's Disappearing Acres--How Much? How Soon?" Iowa Farm Science, 18 (May 1964), 3-5.

98. U.S. Congress. Committee on Banking and Currency. The Residential Mortgage Financing Problem, by Henry Schecter. 92nd Congress, 1st Session, 1968.

99. U.S. Congress. Senate. Committee on Interior and Insular Affairs, National Land Use Policy. 92nd Congress, 1972.

100. U.S. Constitution, Amendment V.

101. U.S. Department of Agriculture. Agricultural Statistics, 1975. Washington, D.C.: Government Printing Office, 1975.

102. U.S. Department of Agriculture. Dynamics of Land Use in Fast Growth Areas. Washington, D.C.: Author, Agricultural Economic Report No. 325, April 1976.

103. U.S. Department of Agriculture. Land Use Policy and Agriculture: A National Perspective. Washington, D.C.: Government Printing Office, 1976.

104. U.S. Department of Agriculture Forest Service. Forest Area in Iowa Counties, 1974. St. Paul, Minnesota: North Central Forest Experiment Station, 1975.

105. U.S. Department of Commerce, Bureau of the Census. U.S. Census of Agriculture 1969. Washington, D.C.: Government Printing Office, 1971.

106. U.S. Department of Commerce, Bureau of the Census. U.S. Census of Population, 1970: General Social and Economic Characteristics. Washington, D.C.: Government Printing Office 1971.

107. Urbandale City Water Board, Minutes of Meeting, July 31, 1961. (Typewritten)

108. Wagner, Robert R. "Using Airphotos to Measure Changes in Land Use Around Highway Interchanges." Photogrammetric Engineering, 29 (1963): 645-649.

109. Webster, Henry N. "Preface." Focus on Iowa: Land Use Planning Seminar. Edited by Larry R. Whiting. AMes, Iowa: Center for Agricultural and Rural Development, 1973.

110. Wexler, Richard L. "A Zoning Ordinance Is No Better Than Its Administration--Platitude Proved." John Marshall Journal of Practice and Procedure, 1 (Spring 1967): 74-91.

111. "Why Atomic Power Dims Today." Business Week, November 17, 1975, 98-101.

112. Whyte, William H., Jr. Cluster Development. New York: American Conservation Association, 1964.

113. Wingo, Lowdon., Jr. Transportation and Urban Land. Washington, D.C.: Resources for the Future, 1961.

114. Wolfbein, Seymour. Work in American Society. Glenview, Illinois: Scott, Foresman and Co., 1971.

115. Wright, Phillip. "Discussion: Agriculture and Urban Development." Journal of Farm Economics, 48 (December 1966): 1316-1318.

ACKNOWLEDGMENTS

I would like to acknowledge the contribution of those persons who made this project possible. I would like to thank the chairman of my committee, Dr. John F. Timmons, for his suggestions and comments throughout the project. I am also indebted to those individuals in Urbandale and Des Moines who spent a considerable amount of time providing me with the data and information necessary for this project. I am grateful for the friendliness and courtesy I encountered, despite the nature of my requests. Finally, I would like to thank my parents for their support and encouragement throughout my career as a student.

APPENDIX A: LAND USE CHANGE IN SECTION 27, URBANDALE, IOWA, 1950-1974

Figure A.1. Section 27, 1950

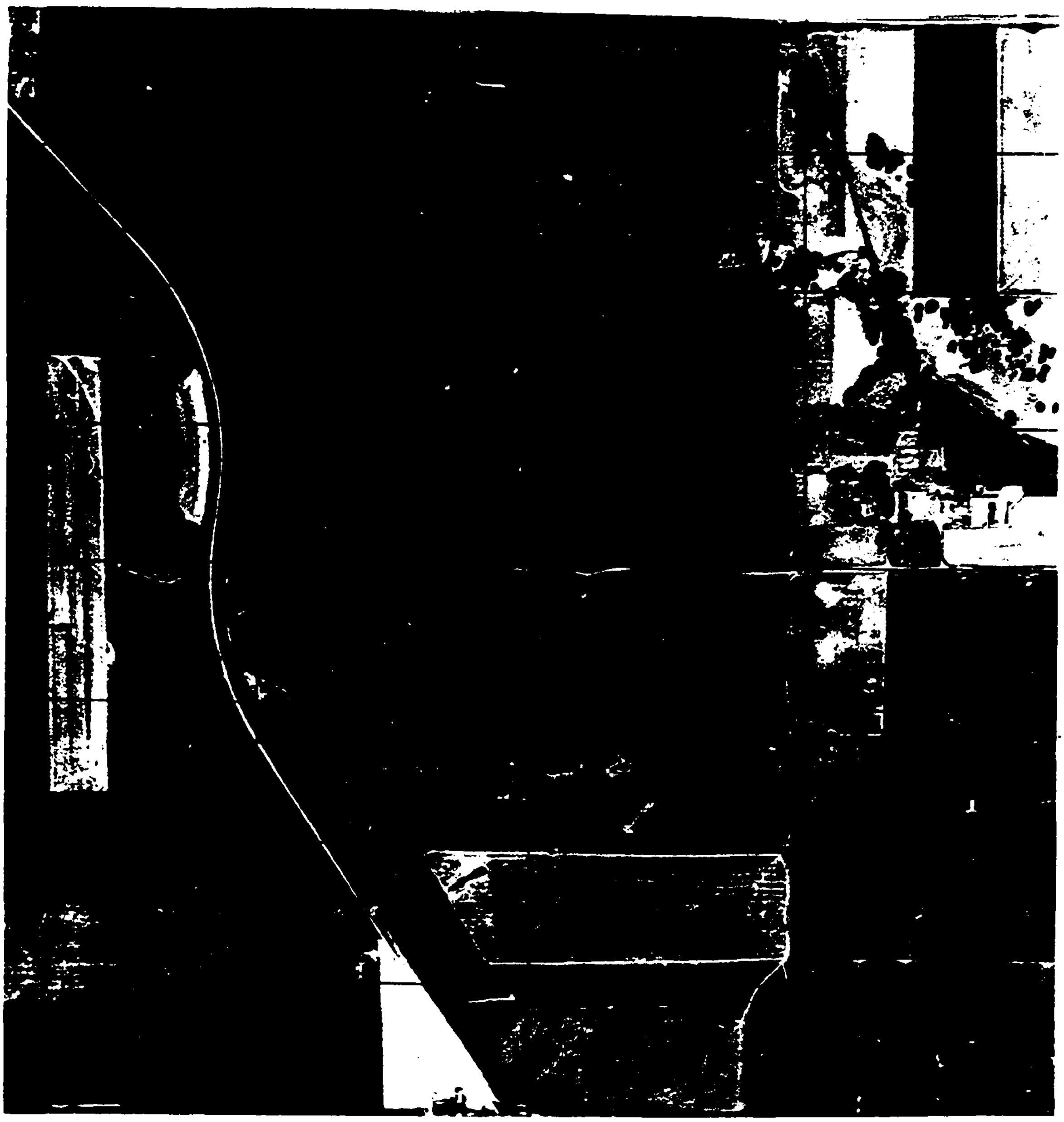


Figure A2. Section 27, 1950

Figure A3. Section 27, 1961

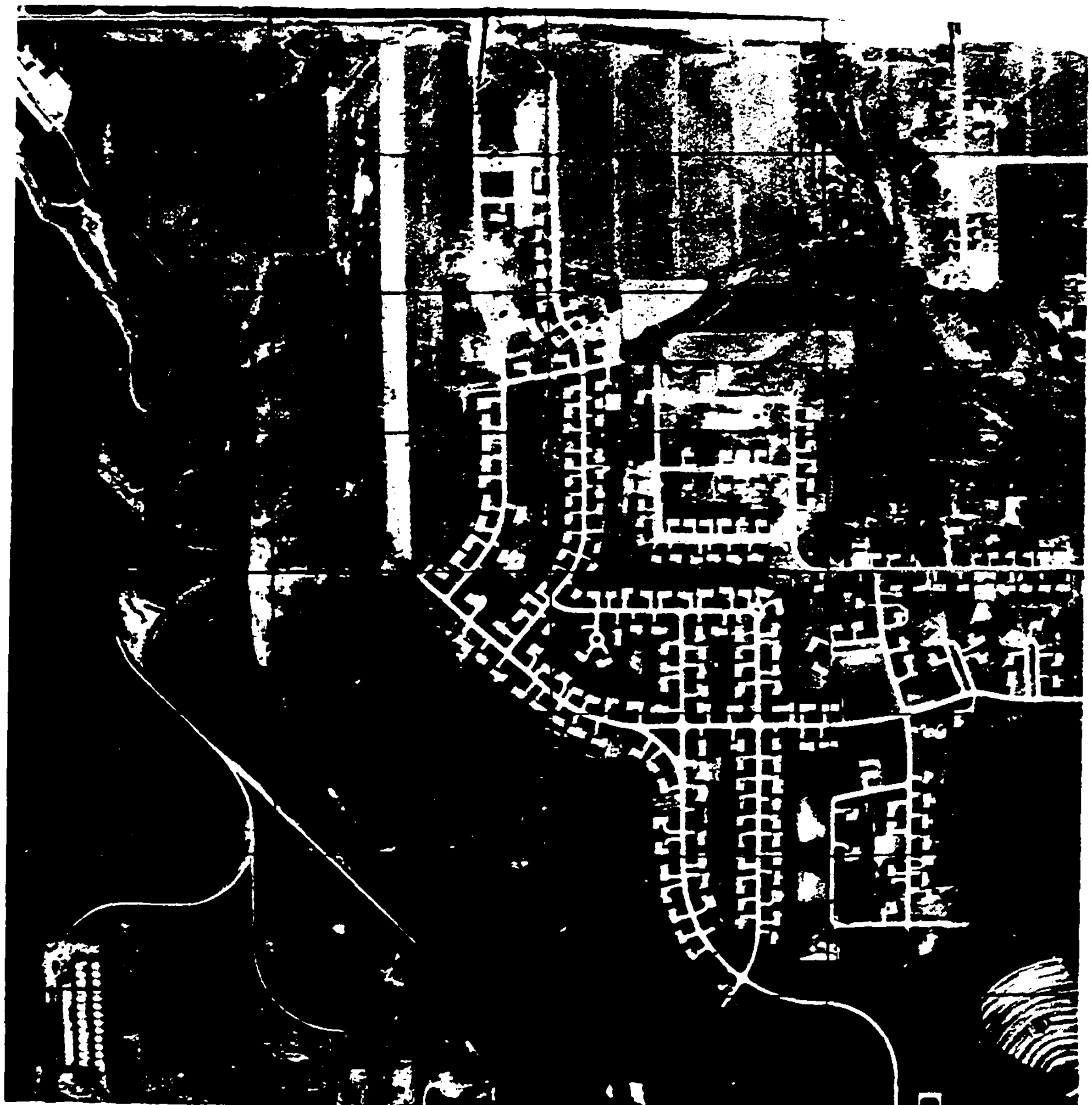


Figure A4. Section 27, 1967

A 4

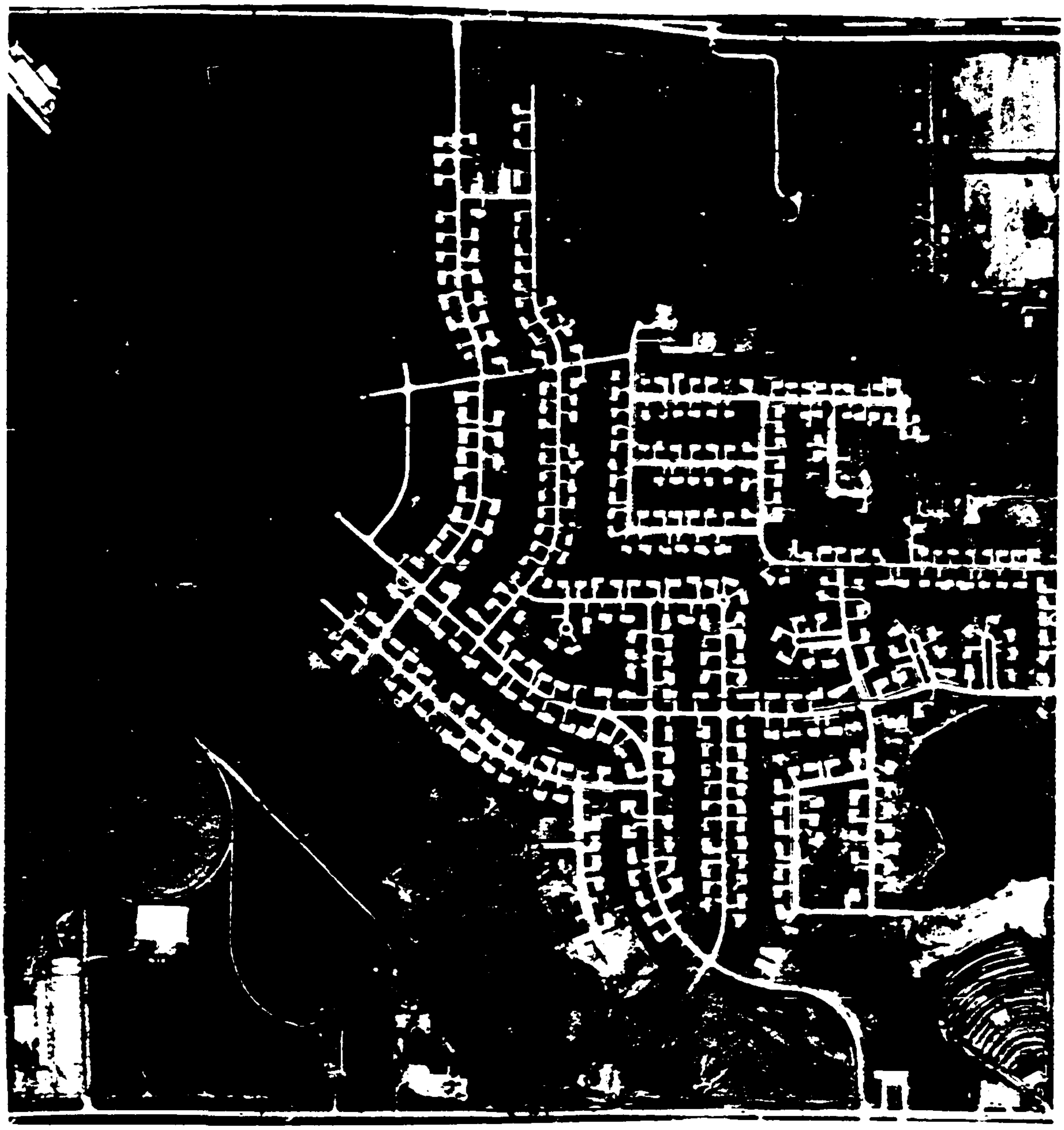


Figure A5. Section 27, 1974

APPENDIX B: INDIVIDUALS INTERVIEWED DURING URBANDALE LAND USE STUDY

A. Urbandale Interviews

1. Ed Teghtmeyer, City Engineer
   Department of Public Services
   9401 Hickman Rd.
   Urbandale, Iowa 50322

2. Rex Parsons, Zoning Administrator
   Department of Community Development
   City Hall
   Urbandale, Iowa 50322

3. Bill Keating, Urban Planner
   Department of Community Development
   City Hall
   Urbandale, Iowa 50322

4. Richard Foust, Manager
   Urbandale Water Board
   7004 Madison
   Urbandale, Iowa 50322

5. Barney Aveaux, Superintendent
   Urbandale Water Board
   7004 Madison
   Urbandale, Iowa 50322

B. Des Moines Interviews

1. Robert Drey, Lawyer
   Urbandale Sanitary Sewer District
   Bradshaw Law Firm
   Des Moines Building
   Des Moines, Iowa 50309

2. Irv Samec, Planner
   Central Iowa Regional Regional Association of Local Government
   104-1/2 E. Locust St.
   Des Moines, Iowa 50309

3. Kelley Lint, Developer
   United Federal Equity and Investment Corporation
   4th and Locust
   Des Moines, Iowa 50309

C. Other Interviews

1. Bob Humphrey
   Highway Division
   Iowa Department of Transportation
   Ames, Iowa 50010

2. Ken McLaughlin
   Road Design Department
   Bureau of Development
   Ames, Iowa 50010