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**THE DEFICIENCIES OF CURRENT UA DEFINITION
AND
REMOTE SENSING TECHNIQUES**

by

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A PLAN B PAPER

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ABSTRACT

This paper focuses on the deficiencies of current Urbanized Area (UA) definition. There are four specific objectives. The first one is a discussion of the background and the conceptual context in which this investigation is being carried out. The second one is to identify the problems of 1980 UA definition and the problems caused by the UA definition. The third covers a case study in Lansing/E. Lansing UA in Michigan, and develops a methodology to analyze the UA problem; and identify the possible solutions. The last one examines the feasibility in applying remote sensing-based techniques to the UA delineation. It reveals the insufficient variables used in 1980 UA criteria, and finds that a multivariate approach is more appropriate. Remote sensing-based methods can probably be a surrogate, but the high cost of imagery obstructs its feasibility politically.

TABLE OF CONTENTS

LIST OF FIGURES	iii
LIST OF MAPS	iv
I. INTRODUCTION	1
II. BACKGROUND OF UA DEFINITION AND CONCEPTUAL PERSPECTIVE ..	3
Background of Official UA Definition	3
Historical Conceptual Perspective	6
III. PROBLEMS OF URBAN BOUNDARY DELINEATION	10
Purpose of Defining Urbanized Area(UA) and an Extended City	11
Definition and Current Boundary Criteria of UA	12
Definition of an Extended City	13
Procedures Used in Delineating 1980 UA's	13
Problems of 1980 UA Definition	16
Other General Problems	20
IV. CASE STUDY IN LANSING/E. LANSING UA	22
Samples and Sites Selected	23
Variables Specifications	26
Analysis Methodology	28
Statistics, Results, and Conclusion	29
V. POSSIBLE SOLUTIONS FOR UA DEFINITION PROBLEMS	33
Integrating Other Variables into UA Criteria	33

Government Consolidation	34
Other Methods	36

VI. REMOTE SENSING-BASED TECHNIQUES APPLIED TO US

DELINEATION	38
--------------------------	----

Airphoto-Based	38
----------------------	----

Landsat-Based	42
---------------------	----

SLAR/SAR-Based	48
----------------------	----

The Feasibility of Remote Sensing-Based Techniques	51
--	----

VII. CONCLUSION	54
------------------------------	----

REFERENCE	55
------------------------	----

APPENDICES

I. DATA LISTING OF THE 14 CENSUS VARIABLES FOR THE LANSING/E. LANSING SAMPLE AREA

II. CLUSTER ANALYSIS IN LANSING/E. LANSING UA

III. RANK OF CENSUS TRACTS BY SOCIO-ECONOMIC INDICATORS

IV. 1950 TO 1980 UA CRITERIA

LIST OF FIGURES

Figures	Page
1. The Inner and Outer Lines Established for Existing and P-1 Potential UA's	15
2. Urban Development with Rural Census Block	19
3. Feature-Spacing Algorithm	43
4. Shuttle Imaging Radar-A Image of Baoding Area	52
5. Shuttle Imaging Radar-A Image of Dexhou Area	53

LIST OF MAPS

Maps	Page
1. Study Area	24
2. Current Lansing/E. Lansing UA	25
3. Potential UA 1 : Results through Cluster Analysis	31
4. Potential UA 2 : Results through Ranking Census Tracts by Socio-Economic Indicators	32

I. INTRODUCTION

The main purpose in defining urban boundaries today is to use them in determining the distribution of federal grants-in-aid and federal programs. People who live in a defined urbanized area benefit from government services such as schools, hospitals, parks and libraries, etc. Because the urban boundaries are so important, there always exists an argument about the appropriateness of this Urbanized Area (UA) definition since the first census and first UA criteria.

Every 10 years, the U.S. Bureau of Census conducts a census of population and housing. Before this census is taken, the Geographic Division of the Census Bureau should delineate the potential extent of the UA by a new UA definition. The methodology and definition they adopted is mainly based on 2 statistic figures -population size and population density. Whether or not those two figures present the whole UA has been argued and discussed by researchers and experts for a long time. In the past, the Census Bureau typically used aerial photography to identify the urban fringe to perform this job. However, due to the timely airphotos were not available for each of more than 300 Standard Metropolitan Statistical Areas (SMSA's), other data such as land use maps were used as a replacement. Nevertheless, the potential problems and deficiencies of the UA definition still exist. Because of the rapid changes of social and economic structures in recent decades, it's irrational to define perfect UA boundaries without considering

the socio-economic status. Nowadays, the growth and expansion of population and economic activities around major urban areas, and penetrating into the periphery, make it difficult for the UA definition to distinguish the purely urban and purely rural.

II.BACKGROUND OF UA DEFINITION AND CONCEPTUAL PERSPECTIVE

Background of Official UA Definition

In 1790, Congress provided statutory authorization for taking a census, and population censuses have been conducted every 10 years since then. At that time, the growth in the areas adjacent to the limits of incorporated places had been apparent, but were still relatively limited before the early 19th century. During the latter half of 19th century and the earlier 20th century, the rapid growth adjacent to the industrial city increased the demand for a statistical definition to define an area encompassing the urban centers and their suburbs. Before this time, the city could generally represent the extent of urban development but became less representative after then.

After 1900, some state laws were enacted to increase the ability of municipalities to annex the developing suburban areas. However, because the suburban dwellers preferred services provided by a county or a minor civil division (MCD) government rather than annex to a city or incorporate as places, the Census Bureau increasingly failed to measure accurately the urban territory by using its primary geographic unit to measure the urban population. The first attempt to define a statistical area encompassing the industrial city and its suburban area occurred in the 1905 census. For the 1910 census, the Census Bureau planned a more restrictive criterion for defining large urban cluster based on MCD rather than

counties. These areas were known as "metropolitan districts," this definition concept was continuously used until the 1940 census with minor changes. There are some inadequacies by using the density of MCD as a measure of the urban area around large cities. Many MCD's, the building-blocks of the districts, were too large to serve as a unit for precisely measuring the urban population. Most of the districts include significant amounts of rural population and rural area. The other problem was that the MCD data were not available for most states. Also, some MCD boundaries did not remain stable over time, the was comparability therefore questionable. Moreover, this metropolitan district definition did not improve its definition of urban and rural until the 1950 UA (urbanized area) definition.

To improve the urban-rural classification, for the 1950 census, two new geographic statistical entities were developed - one to identify the metropolitan area, the other one to identify the urban area around the largest cities. This was the first attempt to provide a precise separation between urban and rural population around large metropolitan areas. In this census, the Census Bureau introduced the UA as a statistical area and added population and area of the UA to the definition to better delimit the urban population. Another statistical area, "unincorporated places" (now called "census designed area" or CDP), were also introduced at this census. This definition provided a statistical area for which a wide range of socio-economic data were available, also, boundaries of SMA's followed the county boundaries (except

for New England areas) instead of MCD boundaries which presented a more stable geographic unit over time. One of the problems of 1950 UA criteria is that it used previous census data to delineate the UA boundary and was somewhat out of date. The selection of central cities, also based on the previous census, would result in an inconsistent and incomplete identification of UA's. This 1950 UA criterion excluded adjacent areas of slightly lower density that have suburban population also oriented toward the major urban core.

For the 1960 census, the qualification of UA's was changed to have its basis the current census, rather than the previous census, by using enumeration districts (ED's) as the unit of density measurement. The Census Bureau also enabled the delineation of unincorporated places within the UA fringe. That allowed the population living in the UA to include persons living within unincorporated places as well as incorporated places.

In the delineation of UA's for the 1970 census, there were two major changes: introduction of the concept of extend cities, and the use of blocks instead of ED's as the measure of density. For the 1980 census, the Census Bureau employed a number of modifications to the UA criteria designed to deal with the following problems: the central city requirement, contiguous nonresidential urban land use, and developed areas separated from the main body of the UA by "undevelopable" area that will be discussed latter.¹

¹U.S. Bureau of the Census, Geographic Areas Reference Manual, 1987, CH.15

Historical Conceptual Perspective

Historically, the concepts of "rural" and "urban" used in the census have been based mainly on one criteria - size of population. In some countries, including the United States, political organization has sometimes been used as a secondary criterion. The initial U.S. census report to differentiate between urban and rural population was after the 1880 Decennial census, the criterion used to identify the urban place was the concentration of 8,000 or more population in a community. Even then, it was considered that this 8,000 minimum population was too high to truly represent the urban population and places that were really urban in character. Hence, from the 1880 to the 1900 census report, the population size criterion was lowered to 4,000. In these reports, the "semi-urban" had also been classified for inhabitants living in all incorporated places of less than 4,000.² In 1900, the 2,500 population threshold was first used in identifying the urban population. But there was no explanation or a conceptual basis for proving its adoption at that time. In 1940, Truesdell set forth a conceptual basis for differentiating urban and rural population and place in censuses. He suggested several factors in differentiating urban from rural conditions - population size, population density, land use type, political organization, and the presence of agricultural occupa-

²Truesdell, L.E. "The Development of the Urban-Rural Classification in the United States: 1874 to 1949," Current Population Report Population Characteristics (Series No.1) 1949, pp.4

tion.³ Accordingly, The differentiation between urban places and rural places could become very straightforward when the above criteria reach certain levels.

In the past, it might be appropriate to categorize the people as rural who are living in places below 2,500 threshold upon U.S. Census's urban definition criteria and were mainly employed in agriculture or other primary economic activities. However, the economy and lifestyles of Americans have changed widely in recent year. Not only has the proportion of the labor force in agriculture and other primary activities decreased, but the labor force in manufacturing and the actual number living on farms has decreased also.⁴ These conditions combined with the changing socio-cultural lifestyles of the American population make it more difficult to discriminate the difference between urban and rural. Shevky and Bell used social characteristics - "**societal scale**" in the social area analysis to examine the urban life. It included three constructs by using six variables - economic status (occupation and education), family status (fertility, woman at home, and single family detached dwelling units) and Ethnic status(ethnic groups).⁵ They supposed that (1) with the increasing division of labor, an occupational status system develops, (2) family becomes

³Truesdell, 1949

⁴Freudreis, J.P. "The Information Revolution and Urban Life," Journal of Urban Affairs, Vol.11, pp. 327-337

⁵Shevky, E., and W. Bell, Social Area Analysis (Stanford University Press, Stanford, California, 1955), p.4

less important as an individual economic unit, and a weakening of traditional organization of family after higher urbanization, and (3) the improved transportation results in higher mobility, and that leads the resorting of the population and the segregation of different ethnic and racial groups.⁶

In Western urban theory, the key parameters used in the classification method were population size, population density, and social heterogeneity.⁷ Wirth suggested that the technological development in transportation and communication, and the rapid dispersal and impact of assimilation had tremendously extended the urban mode of living beyond the city's boundary. Even at that time, Wirth had determined that urbanism, as a way of life, crossed the boundaries of the physical city and the landscape to become the dominant way of life among rural dwellers.⁸

From a sociological and economic viewpoint, there is no longer a dividing line between purely urban and purely rural under the expansion of the influence of urban life in American society. Friedmann and Miller introduced a new ecological unit termed "the urban field" replacing the traditional concept of city and metropolis. While urban living extends far beyond existing metropolitan cores and penetrates into the periphery, the older

⁶Cadwallader, M.T. "Urban Social Areas," in Analytical Urban Geography - Spatial Patterns and Theories, (New Jersey: Prentice-Hall, 1985), pp.125

⁷Wirth, L., "Urbanism As a Way of Life," American Journal of Sociology, Vol.44, 1938, pp.1-23

⁸Wirth, L. 1938

urban centers together with the intermetropolitan peripheries will constitute this new ecological unit.⁹ From each point of view, it is becoming nearly impossible to trace a sharp dividing line to distinguish urban and rural, town and countryside.

⁹Friedmann, I., & Miller, J. "The urban field," Journal of the American Institute of Planners, Vol.31, 1965, pp.312-319.

III. PROBLEMS OF URBAN BOUNDARY DELINEATION

Different federal grants-in-aid and federal programs to states and local governments are based on the population size and whether a place is rural or urban. An urbanized area boundary is therefore important because it becomes an influential line to determine who are the beneficiaries for certain kinds of services and grants. Also, various types of economic development programs, community development programs and differing focuses are also applied to different areas, according to whether the place is defined as an urbanized area or rural area. An example is the Urban Development Action Grant (UDAG) program, designed to help alleviate physical and economic deterioration in severely distressed cities and urban counties only. In fiscal year 1987, the funding under UDAG was \$255 million.¹⁰ On the other hand, various developments of economic, agriculture/nature resources, infrastructure and human resources were assigned to rural areas. In fiscal year 1987, about \$6.4 billion in grants and payments, \$1.6 billion of loan, and the expenditures of about \$3.1 billion were provided by infrastructure programs.¹¹ Thus, in order to let the proper dwellers get the appropriate services, a reasonable and acceptable definition of

¹⁰U.S. Federal Accounting Office, Urban Action Grants: an Analysis of Eligibility and Selection Criteria, and Program Results, P.3

¹¹U.S. General Accounting Office, Rural Development: Federal Program that focus on Rural America and Its Economic Development." pp. 39

urbanized area and rural area is needed. In 1980 UA criteria, some potential problems were revealed, such as the 2,500 minimum population requirement, jumping area problem, and the relationship of UA boundaries to the census blocks. The other general problems that are caused by urban definition, such as local government fragmentation, should also be considered prudently. Before getting into the discussion of UA problems, the way UA boundaries were delineated is revealed below.

Purpose of Defining Urbanized Area(UA) and an Extended City

There are two major proposes in defining UA's and extended cities. One is setting up a better separation of urban and rural population and area around the large cities. The other is providing a measure of the urban population, and extent of urban area. Since the first UA definition in the 1950 census, the UA's definition criteria has been slightly adjusted with each subsequent decennial census in order to accurately represent the extent of urban development and delimit the National large urban clusters.¹² Moreover, urban area definition has been used as a basis of distribution of government budgets and resources, redefining of UA will result in the redistribution of budgets and beneficiaries.

The purpose of defining an extended city is to alleviate the classification problem which classifies the rural territory as part of urban land area. While cities extend their boundaries, some

¹²U.S. Bureau of the Census,

territory essentially in rural character was also classified as part of the urban area. Therefore, in the 1970 census, the Census Bureau used the concept of the extended city to define the rural part of those incorporated places within UA's and exclude these areas from the UA.

Definition and Current Boundary Criteria of UA

According to 1980 UA criteria, an urbanized area consists of an incorporated central city or cities and adjacent densely settled surrounding area with a minimum population of 50,000. The densely settled surrounding areas consist of:¹³

1. Contiguous incorporated places or census designated places having:

- a) at least 2,500 population, or
- b) having a population density of 1,000 person per square mile, a closely settled area with a minimum of 50 percent of the population, or a cluster of minimum 100 housing units.

2. Contiguous unincorporated area that is connected by roads and with a population density of no less than 1,000 persons per square mile.

3. Other contiguous unincorporated area having a density of less than 1,000 persons per square mile, but together with some other characteristics as listed in the criteria.

¹³U.S. Bureau of Census, 1980 Census of Population and Housing,

4. Large concentrations of nonresidential urban area (such as major airport, office areas, industrial parks), which is contiguous to an urbanized area with at least 1/4 of its boundary.

Definition of an Extended City

An extended city consists of an urban part and a rural part. This kind of city is an incorporated place that contains one or more areas, with each area being at least 5 square miles in extent with a population density of less than 1,000 persons per square mile. The area or areas must have at least 25 square miles or minimum 25 percent of the land area of the city. All population of these areas will be classified as rural, and these areas are excluded from the UA. Only the urban part is considered to be the central city of an UA.

Procedures Used in Delineating 1980 UA's¹⁴

The delineation of UA reflects some subjective decisions, such as separating one UA into two or more, or combining two or more UA's into one. The procedures used in 1980 were similar to the one used in 1970. It included 5 major steps: 1)determining potential UA's, 2)establishing the outer line, inter line and measurement units(MU), 3)measuring the land area and obtaining the population count for each MU, 4) determining the area of continuous residential development, and 5)determining and adding additional

¹⁴U.S. Bureau of the Census, Geographic Areas Reference Manual, 1987

area to the UA.

Determining Potential UA's

In step 1, the Census Bureau reviewed total UA's including potential new UA's, and classified the potential UA's into P-1 and P-2 groups according to the possibility of qualification. P-1 areas were the most likely to achieve the required minimum 50,000 population. The less likely areas to achieve the above requirement were classified into P-2 areas, which were evaluated from enumeration districts(EDs) by using 1980 census maps. Then, a density evaluation was made based on group block(called measurement units or MUs) for each P-1 potential UA and 1970 existing UA.¹⁵

Establishing the Outer Line, Inner Line and MU's

Step 2, the census Bureau delineated an inner line and outer line for each existing UA and P-1 potential UA as shown in figure 1.¹⁶ The inner line was an approximation of 1970 UA and the outer line represented the estimated maximum extent of the 1980 UA. The Census Bureau determined the location of the outer line by observing the density of the street pattern shown on the current maps, the examination of recent aerial photography, and data from the last census. The area between the inner line and outer line

¹⁵Those block were delineated on the MMS sheet or VMS sheet.

¹⁶Source from Geography Division, Bureau of Census

was subdivided into MUs for population density examination.¹⁷

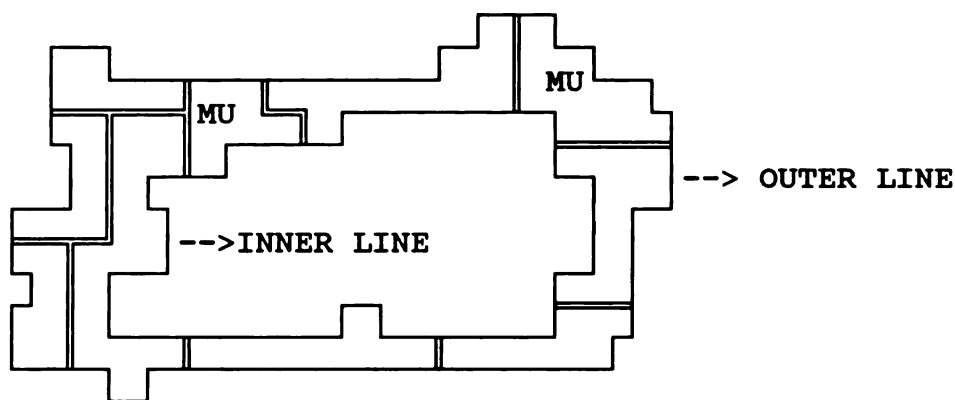


Figure 1: The inner and outer lines established for existing and P-1 potential UA'S

Measuring the Land Area and Obtaining the Population for Each MU, and determining the Area of Continuous Residential Development

After the inner line, outer line, and MU's boundaries were built, the Census Bureau started to obtain the land area and population count for each MU. In land area measurement, the area of water and nonresidential land use had been subtracted from the total MU area. Then, the Bureau went to step 4 to determine whether the area is continuous residential development or not? All qualifying places that added to the UA had followed the two condition as below:

¹⁷Boundaries of the MUs were obtained by using the information about street pattern provided by census map and by reference to the latest U.S.G.S. topographic quadrangles and areal photography.

1. All places should have a population of 2,500 or more, or a density of more than 1,000 persons per square mile.

2. All MUs are contiguous to the inner line or adjacent to qualifying places.

Determining and Adding Additional Area to the UA

Beside above qualifying areas, in step 5, the Census Bureau added other qualifying area on the basis of criteria of the 1980 UA other than minimum population, density and contiguity. Therefore, more qualifying areas might be added to the UA, such as places having a density less than 1,000 persons per square mile or total population of 2,500 but having a cluster of more than 100 housing units adjacent to or not more than 1.5 miles from the previous defined UA core. The result is that such means of qualification might cause some special scenario, such as jumping area.

Problems of 1980 UA Definition

Before every Decennial Census, the Census Bureau had tried to improve the deficiency of urban definition to more accurately classify urban population for the coming census. Therefore, since first revision of UA criteria in 1950 till now, UA criteria has been revised 5 times (1960, 1970, 1974, 1980) based on statistical geographic entity, in an attempt to remove any regional bias and to measure more precisely the changing settlement pattern of the Nation. However, the UA boundaries today still have certain

limitations, and the criteria used today still have exist some deficiencies.

Minimum Population and Population Density

"A contiguous incorporated place having 2,500 minimum population" has been used in UA criteria since 1950, and "a minimum population density of 1,000 persons per square mile" has also been employed by the Census Bureau since 1960. There is a question as to whether those two figures(2,500 and 1,000) can fully represent the different characteristic between urban life and rural life? Doubtlessly, the socio-economic characteristics and the cultural characteristics have been widely changed in the three decades. Hence, a place with less than 2,500 inhabitants might had a rural scenario 30 years ago, but not now. Similarly, a territory with population density less than 1,000 persons per square mile might also present an urban life at present. Accordingly, The requirements of 2,500 minimum population and population density of 1,000 persons no longer provide an appropriate border for the urban and rural division.

Another risk that may also arise when using those two criteria is the undercount or overcount problem of every decennial census. Because the Census Bureau uses the census data as a basis to define the urbanized area, the data are supposed to be very accurate. In fact, this data could never be precise enough. After every census, argument always occurs regarding the overcount or undercount problem which would affect the distribution of federal expenditures

or revenue programs. For example, under the estimation by the Census Bureau, approximately 2.2% of the overall population was missed in 1970 census, roughly 8% of all blacks went uncounted.¹⁸ Therefore, if those two figures will be used as criteria, allowances for this error must be made.

Jumping Areas

Jumping areas were allowed based on the criteria of 1980, which had a population density less than 1,000 persons per square mile in a contiguous unincorporated area. The Census Bureau examined and measured the jumping area by connecting road, and accepted it if the area is connected by a road and 1) no more than 1-1/2 miles from the main body of urbanized area, or 2) separated from the main body of the UA by water or other undevelopable area, but less than 5 miles away from the main body of UA. This criteria will make the same error as above. What is the meaning of 1-1/2 miles and 5 miles? What is the social distance of 1-1/2 miles and 5 miles? How does one define the difference between 1-1/2 miles and 2 miles? What is difference between 5 miles and 4 miles?

Relationship of UA Boundaries to Census Blocks

Each UA structure is based on the geographic unit used by the census - census block. Hence, the census block must be identifiable and correspond to recognizable features. However, a par-

¹⁸Harvard Law Review, Feb. 1981, Vol 94, pp.841-863. "Demography and Distrust: Constitutional Issue of the Federal Census."

ticular census block may include both a sizable urban and a rural population, or population density. Urban development will not always have close boundaries on physical features, and the UA boundary cannot separate the different internal areas according to the census block as shown on figure 2. Therefore, the configuration of census blocks constrains the shape and position of the UA boundary, especially when the census maps are not updated fast enough, and the non-updated maps still hold old urban street patterns in a large block with sizable area. The UA boundaries will be criticized as not accurate enough because they are based on the old street pattern map.

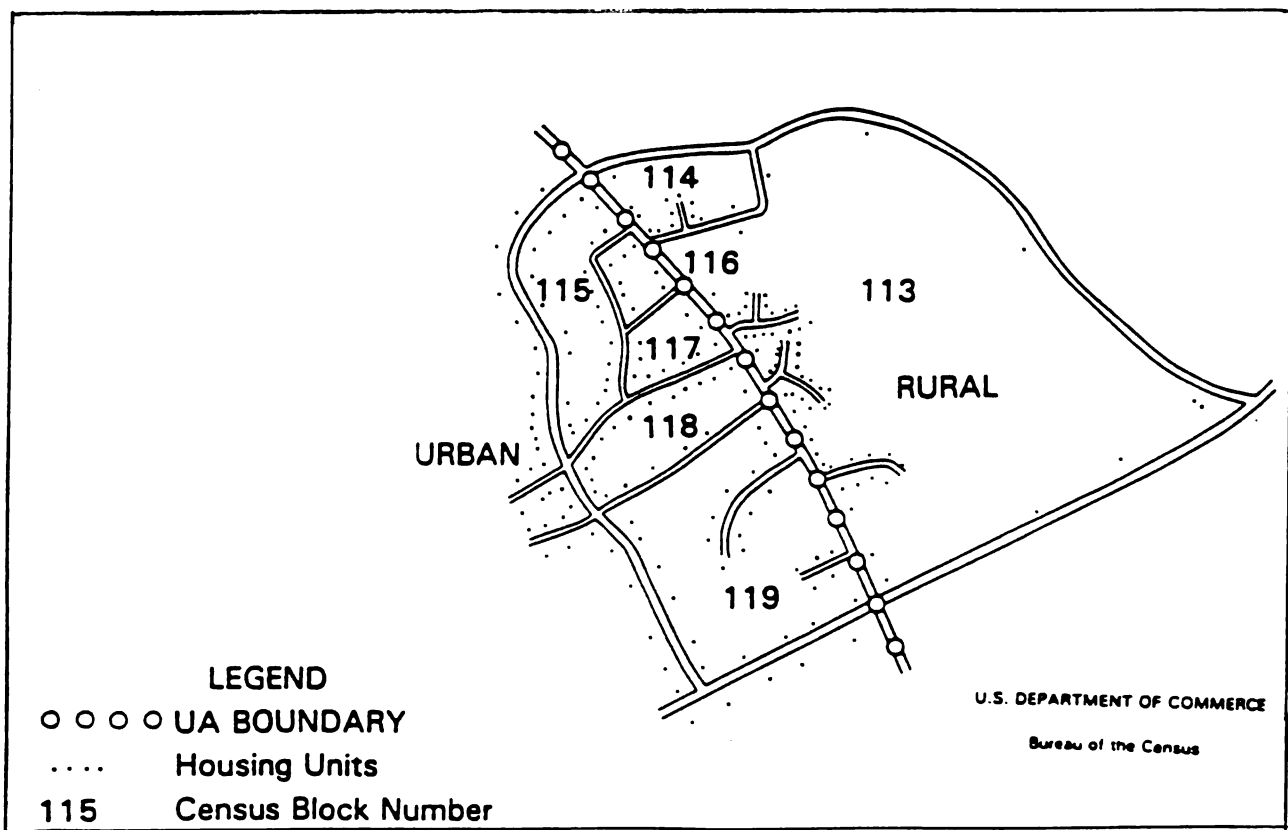


Figure 2: Urban development with rural census block

Other General Problems

While it has been decided which settlements are urban, there might exist one spatial extent problem of those settlements. Because the corporate boundary may not truly represent the real extent of that city, this legal definition will lead to an underbounded city or overbounded city. This underbounded city occurs when the legal city inside the real or physical city is designated.¹⁹ Today, urbanism as a way of life predominates the boundaries of the physical city and the way of life among rural dwellers. Most cities in the United States are underbounded cities, which are usually surrounded by suburbs. Those suburbs use the facilities of the central cities, such as schools and hospitals, that lead to the severe problems of fiscal imbalance in central city and local government fragmentation.

Local Government Fragmentation

As the suburb population grew, and the industrial and commercial activities increased, a whole range of government services were required to serve the settlements. Those services usually came to be supplied by local government rather than by the corporate city. Hence, the local government units increased rapidly and created local government fragmentation. This fragmented pattern of local government makes for a situation in which many districts administer **overlapping programs** of social

¹⁹Cadwallder, 1985, Ch.1

service which are supposed to be unifunctional, but came to function individually. It became difficult to coordinate other individual policies and interests, such as water, sewage, gas, parks, and libraries. Consequently, some large issues in urban areas, such as conservation and land use planning, are ignored because of the incapability of coordinating the policy decisions made at each local level of government.²⁰ Fiscal imbalance is another critical problem in these underbounded cities. While people and industries have been moving out to the suburbs, the tax base in the central city has been eroding. Even the central cities lost the huge tax bases and revenues, but there are still increased expenditures and demand for social service. Because of the old and dilapidated buildings, there needs more fire protection. Because of the higher crime rates, more police protection is needed. Also because the suburbanites work downtown, they use the downtown facilities, such as parking lots, hospitals, and libraries, that create another burden on the central city.²¹ Compared to the high revenue/expenditure ratio characteristic of most suburban municipalities, the above burden causes the central cities to tend to have a giant deviation between revenues and expenditures.

²⁰Cadwallader, 1985, Ch.1

²¹Paul Knox, "Spatial Organization and Locational Conflict," Urban Social Geography, 2nd. ed. (New York: John Wiley & Sons, 1987), pp.266

IV. CASE STUDY IN LANSING/E. LANSING UA

Up-to-date, most cities in the United States are underbounded cities and do not represent the real extent of the city. Not only was the city located inside the real physical city, some sites inside the city had been rejected for incorporation into the UA. The intention of this section is to try to test one urbanized area to see if the UA boundary should be extended or not? Should the sites surrounded by the UA, but excluded from the UA definition, be redefined as being incorporated into the UA? Because of the 1980 UA criteria's deficiencies as mentioned previously, the urbanism can not be presented only by those criteria but together with some other variables. Sjoberg and others²² also have exhibited several prominent characteristics to distinguish the urban places from non-urban places, such as water system for household, non-agricultural labor force, etc. Accordingly, this section is going to use some other census variables (such as socio-economic status, personal characteristics, housing structure characteristics), which can present the urban characteristics more, to reveal the potential problem of current boundary and redefine a possible boundary in the Lansing/ E.Lansing urbanized area.

²²G. Sjoberg, The Preindustrial City (New York: The Free Press, 1960)

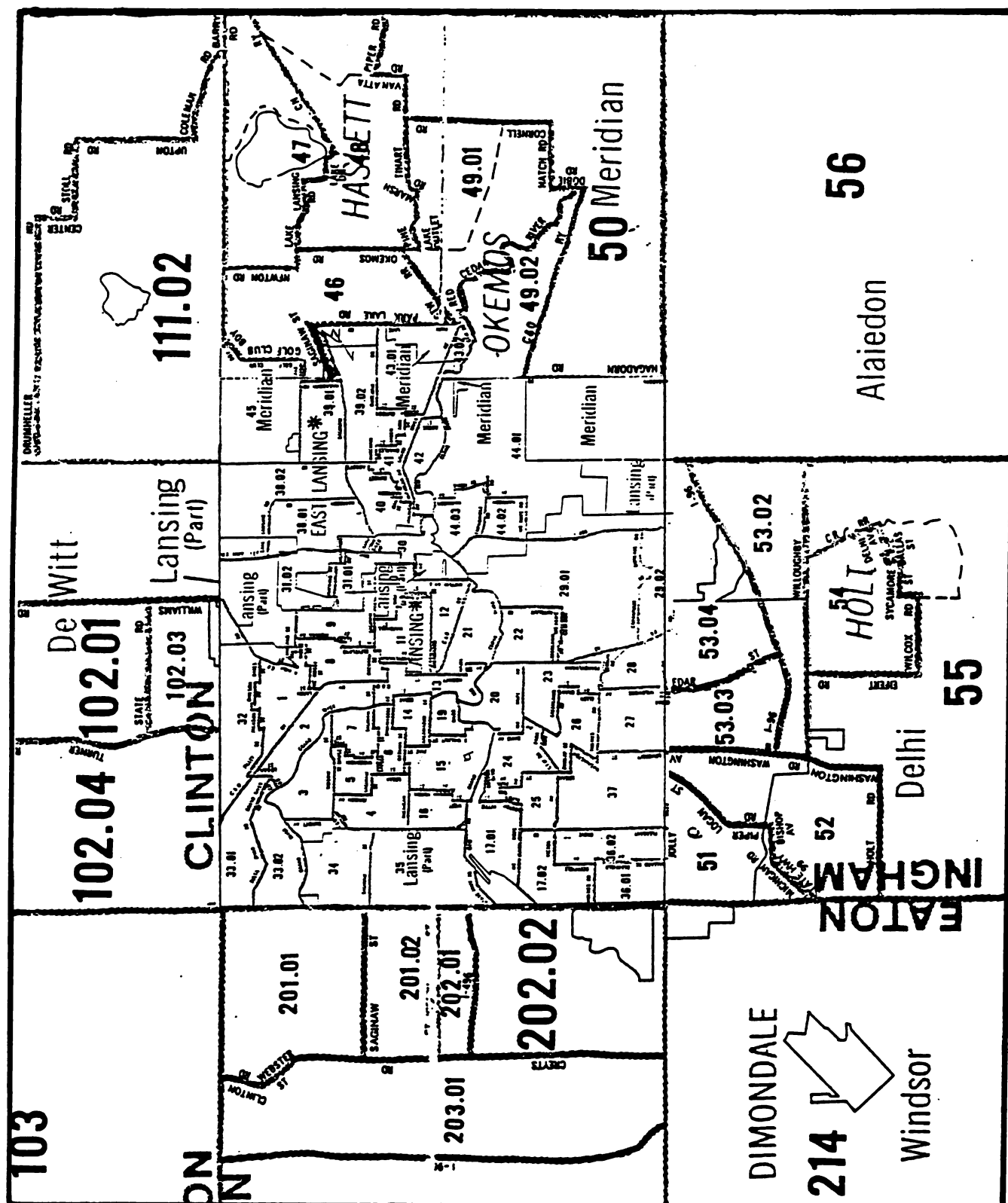
Samples and Sites Selected

Because it is difficult to get census block data, in this study, census tract data are used instead of block data. In total, 102 census tracts were selected in Lansing city, East Lansing city and some adjacent area located in Michigan as shown in map 1. Those target samples consist of all urbanized area (map 2) and some sites within Lansing/E.Lansing city, but not defined as urbanized area (such as census tracts N30, N30.01, N31.02 N34, etc,)²³ and the neighboring sites (including Holt CDP, tracts 54 and 55, etc). Because the SPSSX Cluster analysis excluded the samples with missing values, only 81 samples with complete data sets will be included in the final analysis. The samples with missing values have 3 kinds of circumstances. One is the census tracts with zero population, where the commercial areas are located, such as parts of tract 30 and 31.01 including Frandor Mall, Sears, Kroger, were defined as urbanized area. Another one is the places with low population size. The other one is because the area is on the University campus (census tract 42, 43.01, 43.02, 44.01). Of course, the fertility, rent, mortgage and housing value can hardly present the truth of the variables.

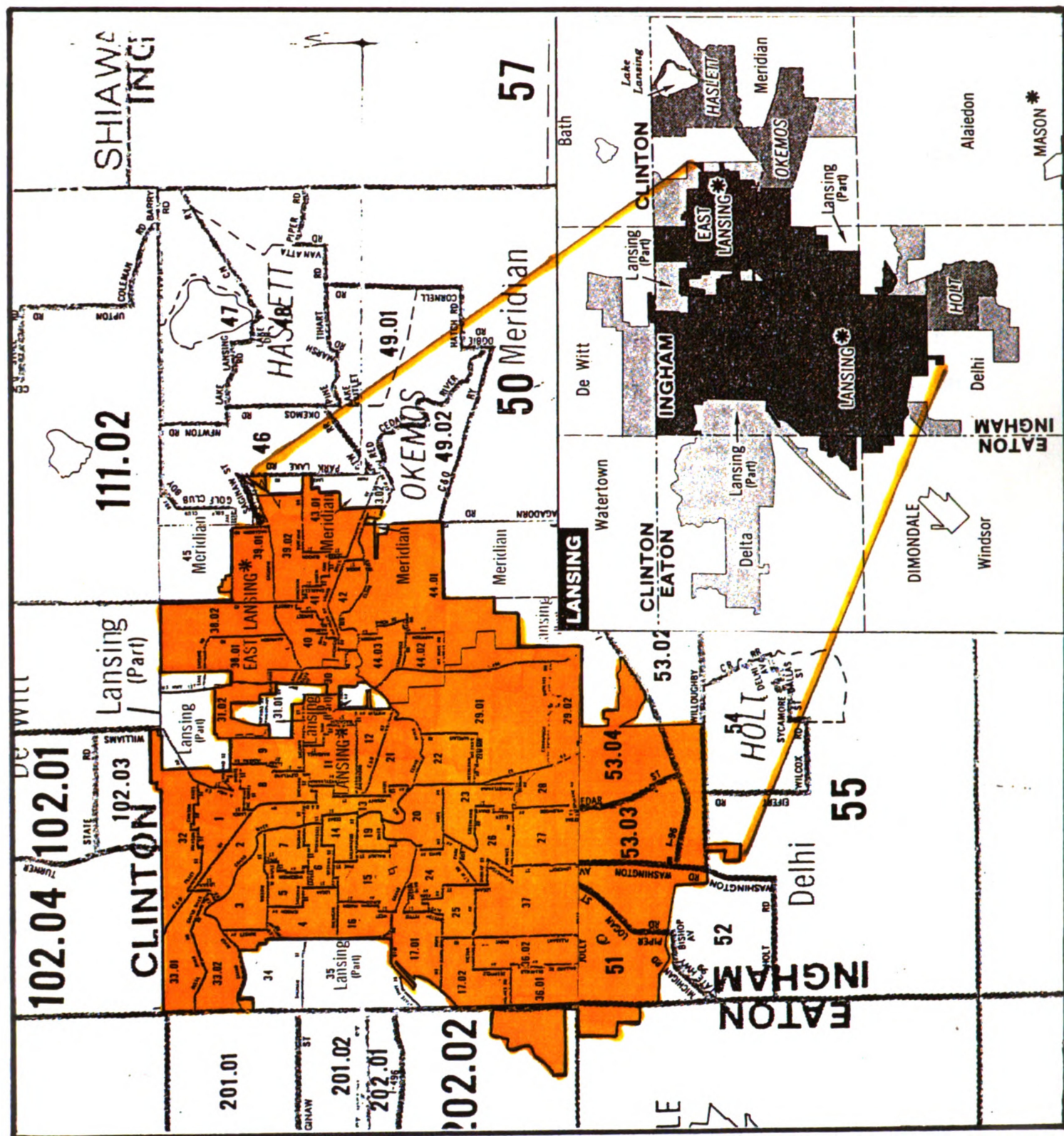
In the analysis, " N " was put in front of the census tract number of the sites not defined as UA in order to distinguish them from the ones defined as being include in the UA.

²³Some area in one census tract is divided into two parts. One part is incorporated in the UA, another is not. In order to easily distinguish of them, the census tract numbers followed after an "N" present the areas not incorporated in the UA.

Map 1 : Study Area



Map 2 : Current Lansing/E. Lansing UA



Variable Specifications

There are 14 variables used in this study. Total population shows the general characteristic. Total Housing units is used to calculate the percentage of housing units connected with public water, sewer and gas utility. The other 12 variables with socio-economic and housing characteristics and assumed hypotheses are listed as below :

Mean Travel Time to Work.

This variable is the average time in minutes spent traveling from home to work. In a more urban place, the higher proportion of work force results in more traffic jams which, in turn, causes increased travel time.

Fertility and Women at Home.

The fertility variable is the number of children born of 1,000 women in the age bracket between 35 and 44. Women at home is the percent of women in the labor force who are unemployed. In a more urban place, the family becomes less important as an individual economic unit; hence, the traditional organization of the family is weakened²⁴. More independent working women, more single parent families lead to fewer women staying at home. Also because of the high-stress urban life style, people tend to have fewer children, leading to a lower fertility rate.

²⁴Martin T. Cadwallader, 1985, pp.125

Percentage of School Completed with High School Graduates.

Usually, experts assume that more urban places have a higher proportion of high school educated population. This assumption will have little problem while applying to compare different countries. However, while applying this assumption to the UA in the United States, it may run into some risk because of the higher proportion of poorly educated minority individuals in most American metropolitan areas. But for the sites in a whole urbanized area, they may have similar results for the education characteristic.

Percentage of Population Employed in Agriculture, and in Craft & Operative.

Doubtlessly, a lower percentage of agricultural labor force exists in more urban places. With the increasing division of the labor force in urban areas, the occupational status system develops and results in a larger percentage of employment involved in the craft and operative sectors.

Percentage of Housing with Public Water, Sewer, Gas Utility.

An urban site becomes has a higher proportion of its housing units connected to a public water supply system, a public sewer system and utility gas system. The gas system may be provided by either a private company or a public utility.

Median Rent, Median Mortgage and Mean Value of Housing Units.

Characteristically, places with higher rent, and a higher mortgage, higher value of housing units are more urban than those with lower ones. Rent and mortgage, here, consist of monthly payment by tenants or houseowner. Housing unit values, here, are presented in thousands of dollars. Because of the greater demand for housing in an urban place, housing costs are greater. Consequently, the rents and the mortgages will be increased to match the higher housing costs.

Analysis Methodology

This analysis include two parts. One is using cluster analysis in SPSSX program on Michigan State University's IBM 3090 mainframe computer. Another one is ranking the census tracts by the urbanism index. Both of these two parts of the analysis are based on Z-score data transformed from the raw data sets to avoid the disadvantage of different scale.

Cluster analysis classifies the census tracts into categories based on distance and similarities. The distance used here is squared Euclidean distance. The less the distance between the census tracts means higher similarities between them, and they will be group together.

In the part II ranking procedure, 3 variables - fertility, percent of women at home, and percent of agricultural employment

use negative values to show lower levels of urbanism,²⁵ because a more urban place will have lesser fertility and a lower percentage of women at home, and a lower percentage of agricultural employment. The summation of the 12 Z-scores for 12 variables (except population and housing units) for each census tract provides combined information for its level of urbanization. Larger positive composite values indicate a more urban place, and larger negative values indicate the less urban.

Statistics, Results, and Conclusion

In cluster analysis, an Hierarchical Icicle Plot provides the case similarity and group information. Based on this information, census tract N201.01 (not incorporated into UA) and 31.02 (part of UA) have the most similarity and are clustered together with dissimilarity coefficient 2.84 (Appendix ii). This means census tract N201.01 owns urban characteristics as well as tract 31.02, but was excluded from UA by current UA definition. On a basis of urban socio-economic characteristics, N201.01 should be incorporated into the urbanized area. Analogously, tract N46.00 groups with 40.00; 41.00 groups with 39.02 and N43.01; N49.02 groups with 38.01; 17.01 groups with 33.02, N201.02 and N201.01; 38.02 groups with N49.01 and N31.02; 21.00 groups with N35.00; 54 groups with 33.01; and 55 groups with 53.03. Thus, based on this cluster analysis, at least

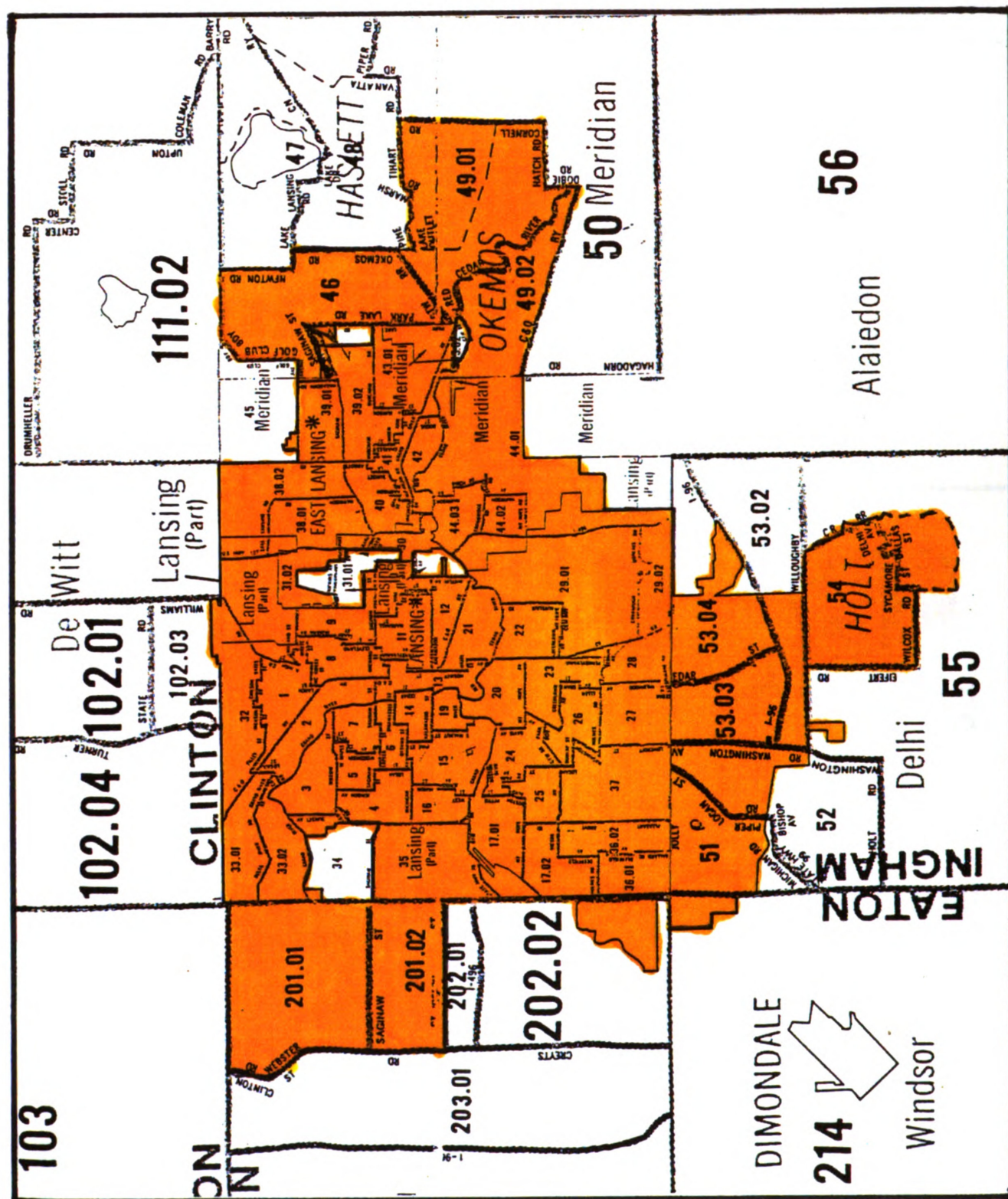
²⁵M.S. Kamiar & J.T.Darden, "Socio-Economic Development of Black Ghetto Tracts in Michigan: The Microcosm Model Reconsidered," The East Lakes Geographer, Vol.23, 1988, pp.71-84

another 10 census tracts (N46.00, N43.01, N49.02, N201.02, N201.01, N49.01, N31.02, N35.00 and 2 tracts of Holt CDP -tracts 54 and 55) should also have been included in the Lansing/E. Lansing urbanized area (see map 3).

Through the ranking procedure, the higher composite values possess the more urban characteristics. As show in appendix iii, the UA census tracts and non-UA census tracts are mixed together. This demonstrates that not all the UA census tracts own more urban characteristics than the non-UA census tracts. From the cluster analysis, it can be seen that another 10 census tracts should be parts of the UA. The lowest composite value of those 10 census tracts is $-.81$ in tract N35.00. Thus, using the census tract N35.00 as a borderline, the rank higher than the tract N35.00 will be considered as more urbanized areas and be qualified to the UA. In totally, 17 census tracts²⁶, including the above 10 census tracts, are qualified to be in the UA, according to their socio-economic indices (see map 4). As a result, the Lansing/E. Lansing urbanized area presents an underbounded city and the boundary of this UA should be extended.

²⁶They are census tracts N202.01, N46, N49.01, N31.02, N31.01, N201.01, N49.02, N45.00, N48.00, N201.02, 55, N34, N53.02, N43.01, N50, 54, AND N35.

Map 3 : Potential UA 1 : Results through Cluster Analysis



V. POSSIBLE SOLUTION FOR UA DEFINITION PROBLEM

The potential problems of the UA definition have been revealed since the first definition. To find a method or another criterion to delineate the urban boundary flawlessly is rarely possible. But it is possible to incorporate some other methods into the current UA definition and make the UA boundary more feasible and more reasonable.

Integrating Other Variables into UA criteria

To use only population size and/or population density as the predominant indices to define UA has some shortcomings in presenting the whole urbanism. In some countries, administrative jurisdiction or local government status are the major criteria for urban classification.²⁷ In some other countries, the urban characteristics, such as the existence of public water and sewage systems and the predominance of non-agricultural employment, are used as prominent secondary urban definition criteria.²⁸ Doubtlessly, no matter how large the population, urban characteristics always present the true urbanism. Places with a high proportion of agricultural employment will never be considered as urban.

²⁷Department of International Economic and Social Affairs, Statistical Office. "Urban and Total Population by Sex: 1977-1986," in 1986 Demographic Yearbook, (New York: United Nations, 1988), pp. 186-189

²⁸Department of International Economic and Social Affairs, Statistical Office, 1988

Public water and sewage systems are usually connected to housing units in urbanized area. Thus, to present the actual extent of UA, integrating such socio-economic variables into the UA definition criteria can better mitigate the UA problems definition. While based on socio-economic variables, in the Lansing/E. Lansing urbanized area, the census tracts N31.01 and N31.02 will positively be part of the urbanized area.

Government Consolidation

As to the fiscal imbalance problem in central cities, revenue sharing can be one of the solutions to this problem. While the central cities receive an increasing amount in grant money from federal, state, and provincial government to balance the fiscal situation, the suburban local governments are also developing additional sources of revenue. In response to the government fragmentation problem, different types of government consolidation are being attempted, such as city-county consolidation, the Atlanta model. In Atlanta, there is a Atlanta Regional Commission, which functions as an umbrella government, governing the operation of local government within the area. This commission can construct something that the individual local government unit lacks the jurisdiction to build, such as a rapid transit system.²⁹ This commission even has its own power regarding zoning. It is responsible for coordinating the region's overall zoning policy.

²⁹Martin T. Cadwallader, 1985, pp.22

Generally, in strengthening the role of government at the metropolitan level, in an effect to remove the fiscal problem and government fragmentation problem, federal government should provide revenue sharing, develop more powerful regional agencies, and institute a national land use planning policy (This situation is not politically likely in U.S. because of the fear of centralized government power). The state government, such as in California and Florida, should then put efforts on making local government participation in regional planning obligatory, providing financial assistance for metropolitan government, and cooperating in the organization of multistate metropolitan areas.³⁰ Consequently, the Urbandale neighborhood (census tract N30) in Lansing/E. Lansing UA will get better treatment and may result in its incorporation into the current UA after the government consolidation. At present, because the Urbandale neighborhood is in a flooding area and excluded from the UA, the housing value is very low and developers are reluctant to redevelop it. This area seems to have been abandoned by local and metropolitan government. If the governments can cooperate together, this area will get more attention and better treatment. The flooding problem in this area will also be solved earlier. Moreover, the place might be incorporated into the

³⁰R.D. Honey, "Metropolitan Governance," in Urban Policy making and Metropolitan Dynamics: A Comparative Geographical Analysis, ed. J.S. Adams, (Mass.: Ballinger, 1976), pp.425-462

UA because of its socio-economic urban characteristics³¹. This may result in increased land value and new development. With the new development will come a better built environment and increased housing value that will bring higher rent tenants or higher income house owners, and accordingly change other socio-economic characteristics (such as education status, fertility, and % of women at home). All those possible changes in Urbandale will make this area became a complete urbanized area. The less fortune after those changes will be the people who can not afford the higher housing costs and must move.

Other Methods

Some other new techniques were recently introduced to define urban boundaries, such as remote sensing techniques and GIS techniques. The remote sensing imagery, such as airphoto and satellite imagery, can present the ground truth and define the urban boundary in physical rather than in conceptual terms. That physical definition can make up for some deficiencies in the conceptual definition. Through this method, the UA boundary can separate the different internal areas according to the census block, and the configuration of census blocks. Non-updated maps will not constrain the shape and position of the UA boundaries. Also, instead of sending people to do site observation or check in

³¹From the Case Study section, census tract N30 has 4.83% agriculture employment, 100% public sewer, 100% public water and 88% utility gas connected

the traditional way, interpreting airphoto or satellite imagery may save more time and labor, with higher accuracy.

Nowadays, Geographic Information Systems (GIS) is very welcome in every field of study. Remote sensing imagery currently can be transformed into GIS raster data and census data, are also put into most of the GIS packages that make GIS more and more desirable to planners. The advantage of this technique is that it can overlay different layers of socio-economic data and land use data, and present data in spatial patterns. With the integration of GIS and remote sensing data, the results can be presented in spatial patterns and can own the ground truth character. The urban boundaries, therefore, will be outlined both conceptually and physically.

VI. REMOTE SENSING-BASED TECHNIQUES APPLIED TO UA DELINEATION

The use of remote sensing in the urban environment is concerned with recording and interpreting an image procedure by radiant flux, which exists from a ground source toward the sensor. The most commonly used approach in remote sensing to aid in understanding and interpreting urban features is spectral reflectance statistics.³² In the last two decades, this powerful technology has been magnificently used in urban analysis, such as land use, population/ housing estimation, transportation system, industry and commerce, and recreation. Since urban activities are so dynamic, aerial photography and other remote sensing imagery can provide useful information quickly and economically to the planner, developer, etc. through correct interpretation and classification. Particularly, in defining urban boundaries, remote sensing techniques can provide more advantages than other solutions.

Airphoto - based

Aerial photography (AP) is the principal remote sensing medium used in urban application. It includes panchromatic AP, multiband AP, color AP and color-infrared AP. Among all AP media, color aerial photography is the most often used in urban/suburban

³²Spectral signature of a feature is a set of values for the reflectance of this feature measured at specific wavelength intervals.

application because of its true color advantage that makes it easier to identify the urban/suburban features than other aerial photography media. Compared to the color AP, the color-infrared aerial photography is less preferred in urban application because of some drawbacks such as loss of shadow information, odd color present familiar urban features, etc.

Criteria

This aerial photography method uses visual and manual identification on Black-and-White panchromatic or color aerial photographys to delineate urban fringe and urban boundary. In order to fulfill the intent of the study, initiating a series of aerial photo samples to determine various land use proportions at periodic intervals is needed. Based on the varying size of study areas and the different scale of aerial photographs, the aerial photographs might need to be arranged in the form of a mosaic to present a whole area, especially with very large scale aerial photographs.

Advantages

Aerial photography carries some useful information such as shadow and texture that provide valuable aid in identifying urban features further enhanced interpretation. Moreover, Interpretation of color aerial photography is more straightforward because the color balances with the real-world experience. Especially in

suburban applications, aerial photography is more effective.³³ The other advantage is its high accuracy through large scale to small scale.

Disadvantages

Even though aerial photography has distinct advantages, some disadvantages cause researchers to look for more effective methods. First, it is manual interpretation. Hence, it needs a professional and skillful interpreter to effectively do this job. Second, it costs more than other remote sensing methods, and it is hard to obtain up-to-date photography on a large scale due to the limitation of time and funding.³⁴ Third, the non-digital nature of photographs will take more time to process than other digital images which can be processed by using a computer.

In the last decade, some researchers have digitized aerial photographs and then performed digital image processing to classify urban features. As stated by Jensen, that was a drawback only because it still required accurate interpretation of every feature before it can be programmed to computer. Not only was more time spent in this double work, all of the features cannot be programmed to the computer in as much detail as required by the interpreter. Thus, manual interpretation is still the main stream in handling

³³John R. Jensen, "Urban/Suburban Land Use Analysis," in Manual of Remote Sensing, 2nd. ed., Ch.30.

³⁴N.C. Gautam, "Aerial Photo-Interpretation Techniques for Classifying Urban Land Use," Photogrammetric Engineering and Remote Sensing, Vol.42, No.6, June 1976, pp.815-822

aerial photography information and data.

Accuracy

High accuracy can be achieved through this manually - interpreted aerial photography, whether it is a low altitude image, high altitude image, or satellite platform image. Even the SKYLAB color photography interpretation was 83 percent correct (1:970,000). The SKYLAB S-190B sensor system can also provide adequate spectral and spatial information to classify Level III categories of urban features.³⁵

Application

Falkner³⁶ used periodic photography in determining short range physical land use changes in the Parkway School District in Missouri. The sampled land use data he used was coupled with the information obtained from the school superintendent, and then compared over time, Falkner concluded that the development of this school district was changed from a rural setting to a typical suburban community. (figure) McCoy and Metivier³⁷ used photos as an effective method for measuring house density in an analysis of urban housing, but the temporal and regional elements of the socio-

³⁵Jensen, 1985, pp.1573-1578

³⁶Edgar Falkner, "Land Use Changes in Parkway School District," Photogrammetric Engineer & Remote Sensing, Vol.34, No.1, 1970, pp.52-57

³⁷Roger M. McCoy, "House Density vs. Socioeconomic Conditions," Photogrammetric Engineering & Remote Sensing, Vol.39, No.1, 1973, pp.43-47

economic correlation need to be understand better. Dennis M. Richter³⁸ also utilized sequential photography to detect the urban change and showed that information useful to urban planning can be obtained from the aerial photographs.

LANDSAT-based

Prior to the advent of satellite data as a tool for remote sensing, interpretation of aerial photography could serve to map urban land use. In 1975, the Geography Program of Survey initiated discussion on a land cover change assessment methodology by including Landsat data.³⁹ In 1977, the Census Bureau had to do a similar experiment to use satellite data to update an urban land use map and monitor urban growth that had to serve as a surrogate for population density or other ground collected information. Since then, Landsat data has been used to examine land use change and urban growth. The principle of the Landsat based method can be condensed into two criteria as below.

Criteria 1

Use visual identification on Landsat image enhancements and classification overlays to define UA.

In outer liner delineation, image enhancement by using

³⁸Dennis M. Richter, "Sequential Urban Change," Photogrammetric Engineering & Remote Sensing, Vol.35, No.8, 1971, pp.764-770

³⁹John R. Jensen, "Urban Change Detection Mapping Using Landsat Digital Data", American Cartographer, Vol 8, No.2, Oct 1981, pp.127-147

stepwise linear contrast stretch is needed because of the insufficient tonal contrast between non-urban and urban features on the Landsat image. Moreover, the computer-aided classification of Landsat multispectral digital data is training on known areas of urban growth to produce thematic maps for urban land cover by a feature-spacing partitioning algorithm.⁴⁰

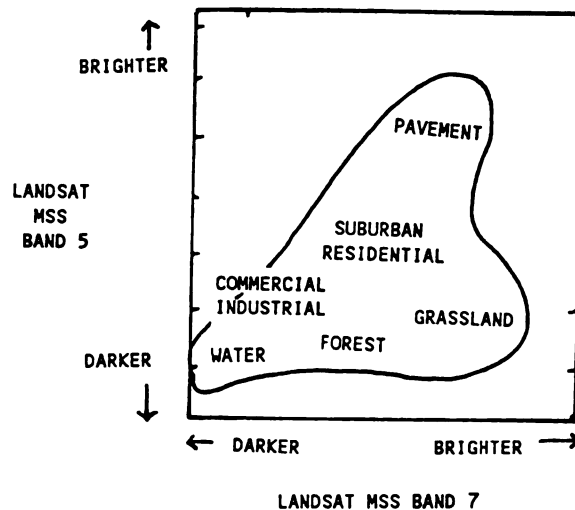


Figure 3: Feature-spacing algorithm

Criteria 2

The other Landsat-based criteria is using digital change detection procedures to delineate UA. It is using spectral signatures on multitemporal Landsat data to detect non-urban to urban cover change on the urban fringe.⁴¹

Some consideration should be addressed in affecting change detection, such as temporal characteristics and environmental characteristics. Usually, the anniversary dates of the image are

⁴⁰Jensen, pp.1611-1612

⁴¹Jensen, Ibid.,

recommended for use because they minimize the difference in reflectance caused by seasonal vegetation change, or sun angle difference, etc. Furthermore, an August date can provide better results. In reducing adverse effects from environmental factors (eg. different atmospheric conditions, sun angles, or surface-cover moisture) which will affect the radiance changes between dates, the data transformation and principal-component transformation are also useful for urban change detection.

Change Detection Algorithms

Three change detection approaches have been used in criteria 2 - image differencing, image regression, and classification comparison. Image differencing technology is based on differencing two Landsat images obtained on two different dates to get information on urban land cover change. It is the simplest one, and an efficient change-detection processing approach. Its accuracy of classification could reach 77 percent.⁴² Some results suggested that this image differencing procedure is too simple to deal with all types of change in a complex residential scene. However, this situation could be improved in conjunction with other change detection methods. Image regression is using a least squares transformation between dates to reduce the effect of environmental and system multiplicative factors. An advantage of using image regression instead of image differencing is that image regression

⁴²Jensen, Ibid.,

can adjust for between-date environmental difference in variance. Recently, this technology was criticized as being a statistically invalid method due to the non-Gaussian, bimodal distribution it is based upon.⁴³

The other change detection technology, classification comparison, evaluates the classification of Landsat data for two or more dates. This technique includes five alternatives -post-classification comparison; spectral/temporal change classification; layered spectral/temporal classification and clustering comparison; but is useful only if accurate land use classification can be obtained.

Generally speaking, digital change detection must be familiar with the environment under study, and the quality of the data set. It must also focus on identifying the optimum algorithm for the specific study area. Image differencing or image regression of spectral data are more practical, but may be too simple to identify the various changes in the urban scene. One possible way to improve the change detection accuracy is using textural data together with Landsat spectral data in identifying urban change.⁴⁴

Advantages

⁴³J.W. Robinson, "Critical Review of the Change Detection and Urban Classification Literature", Technical Memorandum 79/6235, Computer Sciences Corp., Silver Springs, Md., 1979, pp.90

⁴⁴John R. Jensen, and David L. Toll, "Detecting Residential Land-Use Development at the Urban Fringe," Photogrammetric Engineer & Remote Sensing, Vol.48, No.4, April 1982, pp. 629-643

Landsat images can cover a larger area and are less expensive than manual aerial photography. By using visual identification, a Landsat image could develop the boundaries similar to those obtained with aerial photographs. Computer-aided classification can reduce interpretation time by 50 percent.⁴⁵ Furthermore, it uses physical, visual variables rather than two figures (population or density size) to define urbanized areas and give a more unbiased UA boundary.

Disadvantages and Accuracy

Landsat itself is not able to identify all various ground categories by unique spectral signature. Low density suburban housing and small villages may be misclassified as large gardens or high vegetation content.⁴⁶ Rural areas of bare soils, harvested field, dry heath land, sand bank may also be misclassified to the urban area. Because the spectral signature of those areas are close to urban area, single date multispectral classification is not sufficient to distinguish them. Moreover, while analyzing a Landsat image by spectral signature, the researcher not only needs to be familiar with the environment of the study area, but he also needs to spend much more effort to develop and select the optimum algorithms for each type of environment. Even using visual identi-

⁴⁵Jensen, Ibid.,

⁴⁶This type of error is called Omission. The other type of error is called Commission which is the misclassification of rural area as urban area.

fication on a Landsat image could produce a similar boundary to those obtained with aerial photography, with its accuracy still less than manual airphoto interpretation with large scale aerial photographs.

Application

Jensen and Toll⁴⁷ detected residential land-use development at the urban fringe in Denver, Colorado by using band 5 Landsat spectral data and derived texture data, with approximately 81 percent of change detection accuracy. Ellefsen and Peruzzi⁴⁸ proposed a method for delimiting the boundary of an urbanized area by using computer-aided analysis of Landsat digital data. The general rules in determining delimitation they adopted were from the U.S. Census to encompass exclaves and to close embayments.⁴⁹ Haack⁵⁰ also used computer processing and utilized Landsat digital data to differentiate urban and near-urban land covers around Miami, Florida. Moreover, some other researchers (Davis and Friedman, 1974, Ellefsen and Davidson, 1980, Welch and Pannell,

⁴⁷Jensen and Toll, 1982

⁴⁸Richard Ellefsen and Duilio Peruzzi, "A Suggested Method for Delimiting Urbanized Area Using Landsat Data," American Society of Photogrammetry, Proc. Fall Technical Meeting, Albuquerque, NM, Oct 1978, pp.176-183

⁴⁹Enclaves could be brought into the urban mass if they were within a distance of a mile and a half, embayment could be closed into the urban mass too if the mouths were less than a mile wide.

⁵⁰Barry Haack, "An Assessment of Landsat MSS and TM data for Urban and Near-Urban Land-Cover Digital Classification," Remote Sensing of Environment, Vol.21, No.2, 1987, pp.201-213

1975, etc.) used digital imagery and image processing technology for the mapping of urban land expansion.

SLAR/SAR-Based (Radar-Based)

Aerial photography and Landsat imagery have received the most attention and are more widely employed than other techniques in urban analysis. Unfortunately, those data will become useless while the study areas are covered in cloud or bad weather conditions. Under those situations, all-weather radar imagery can be an appropriate medium to be employed. Unlike other sensor systems, radar records' signatures on film are the result of interaction between terrain features (surface roughness) and actively produced microwave energy, rather than spectral natures of urban and suburban feature. It therefore can overcome the limitation of bad weather conditions.

Criteria

One example of this methodology is hiring visual identification on radar imagery. Henderson and Anuta (1980) used images produced by X band or K band radar from different areas, with different scales of the United State for settlement detection. After that, manual interpretation by using a Baush & Lomb 240Z stereoscope in mono-mode was conducted to examine the imagery.⁵¹

⁵¹Floyd M. Henderson and Michael A. Anuta, "Effects of radar system parameters, population, and environmental modulation on settlement visibility," Int. J. Remote Sensing, 1980 Vol. 1, No.2, pp.137-151

Another approach is employing digitally processed SAR L-band images for mapping urban land-cover. Data obtained from digital processing could then be used to delineate urban-rural fringe.⁵²

Advantages

The main advantages of using radar imagery are its all-weather capability and its high accuracy. In urban analysis, all level II and most level III categories of the urban land cover are identifiable with a radar system, such as residential(including older and newer housing), commercial core and large strip developments, and major transportation networks(including smaller residential streets.) Henderson and Anuta detected all settlements over 1,000 population on X - band imagery at a scale of 1:200,000 through manual interpretation. By employing digital enlargement of SAR imagery at Denver, Colorado(Henderson, 1980), the accuracy of urban land-cover classification was from 77% in the inner city zones to 94% in the new residential areas and urban fringe zones at a scale of 1:410,000. The most identifiable land-cover categories were residential, industrial-commercial, open space, and water; those categories could also be obtained with an accuracy of 87.9% at a scale of 1:131,000.⁵³

⁵²Jensen, Ibid.,

⁵³Jensen, Ibid.,

Disadvantages

Radar imagery may not be available for the entire United States. Thus, for analysis of an entire nation, radar imagery might need to include various scales, different wavelengths and different systems. Its accuracy will be decreased with a small scale. Settlement size, radar azimuth or look direction will also influence the settlement detectability and visibility. Using manual interpretation in settlement detection would have the same shortcomings as manual airphoto interpretation: time-consuming and lower efficiency.

Accuracy

Larger scale radar imagery could provide higher accuracy. Detection of settlements with population of 1,000 and more can get 100% accuracy at a scale of 1:200,000. For all the K-band imagery and scales, the type of error was omission not commission. The maximum error of commission was less than 1 percent.⁵⁴

Application

As mentioned above, Henderson and Anuta used radar imagery for population settlement detection with high accuracy. Lo⁵⁵ also employed Shuttle Imaging Radar-A(SIR-A) in detecting Chinese

⁵⁴Henderson and Anuta, Ibid.,

⁵⁵C.P. Lo, "Chinese Settle Pattern Analysis Using Shuttle Imaging Radar-A Data," Int. J. Remote Sensing, Vol.5, No.6, 1984, pp.959-967

settlement patterns and population. These settlements reflect strongly the radar beam and against a dark background. Each individual settlement stands out against the dark background and therefore the sizes of the settlements can be differentiated. (see figure 4 in Baoding area and figure 5 in Dezhou area)

The Feasibility of Remote Sensing-Based Techniques

In general, remote sensing-based methods are very welcome in many fields of study because they can provide relatively high accuracy in testing the ground truth. In a private or an individual research, remote sensing techniques have always been considered perfect solutions in providing accurate physical data, high accuracy and high efficiency. Many researchers, even the Census Bureau, have conducted studies of the UA delineation by using remote sensing technique. Unfortunately, those highly efficient remote-sensing techniques have been rejected by the Census Bureau to use as a methodology in defining UA boundaries for the entire nation because of the budget constraint. For the entire country, the cost of reproducing images will cost the Census Bureau millions of dollar. Even those techniques can save labor and time; compared to the cost of imagery, the cost (from the view of the Census Bureau) is still far above the benefit. Hence, remote sensing-based methods become infeasible because of the imbalance of cost and benefit.

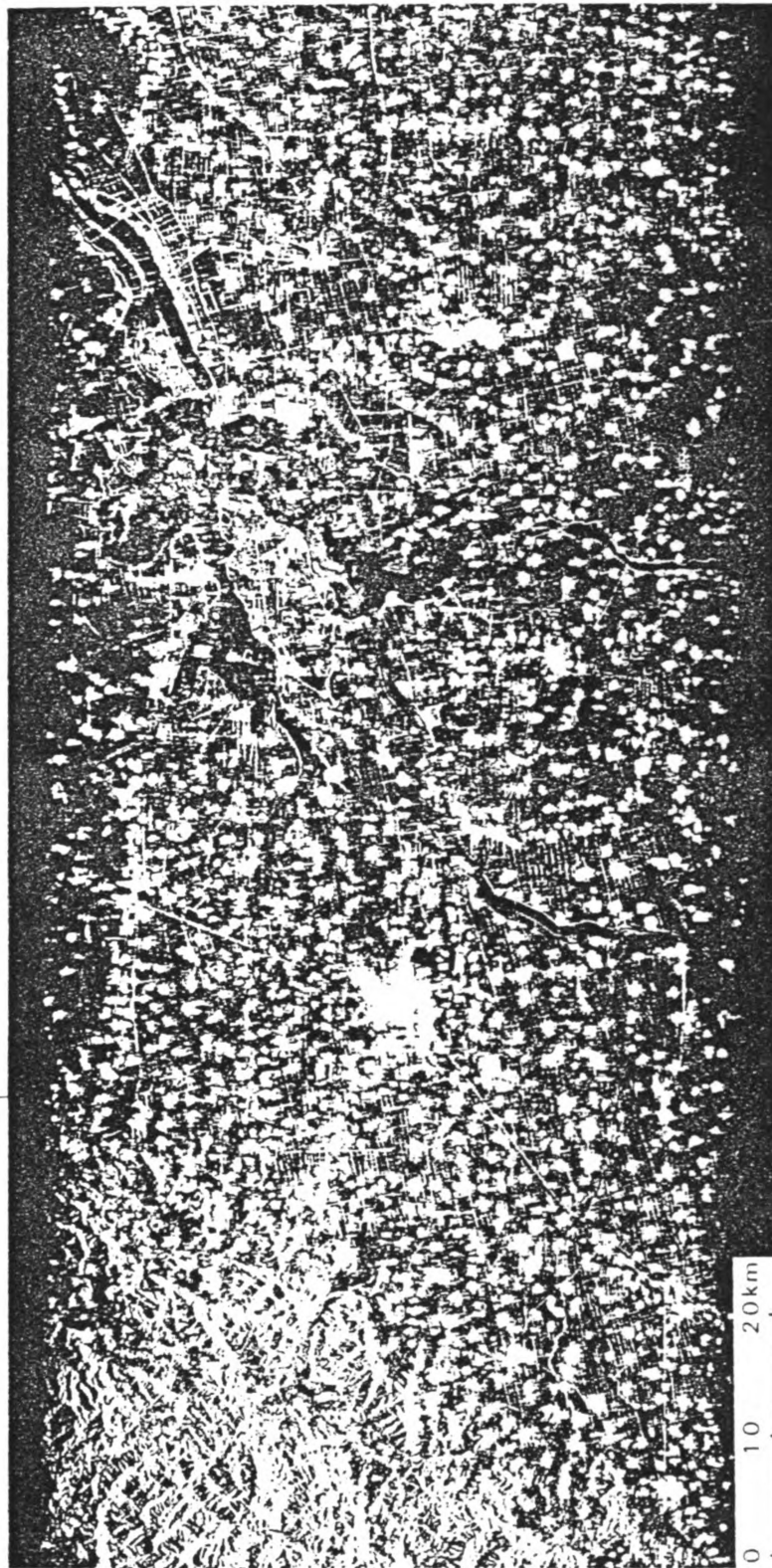


Figure 4: Shuttle Imaging Radar-A Image of Boading Area
(Source: Lo, 1984)

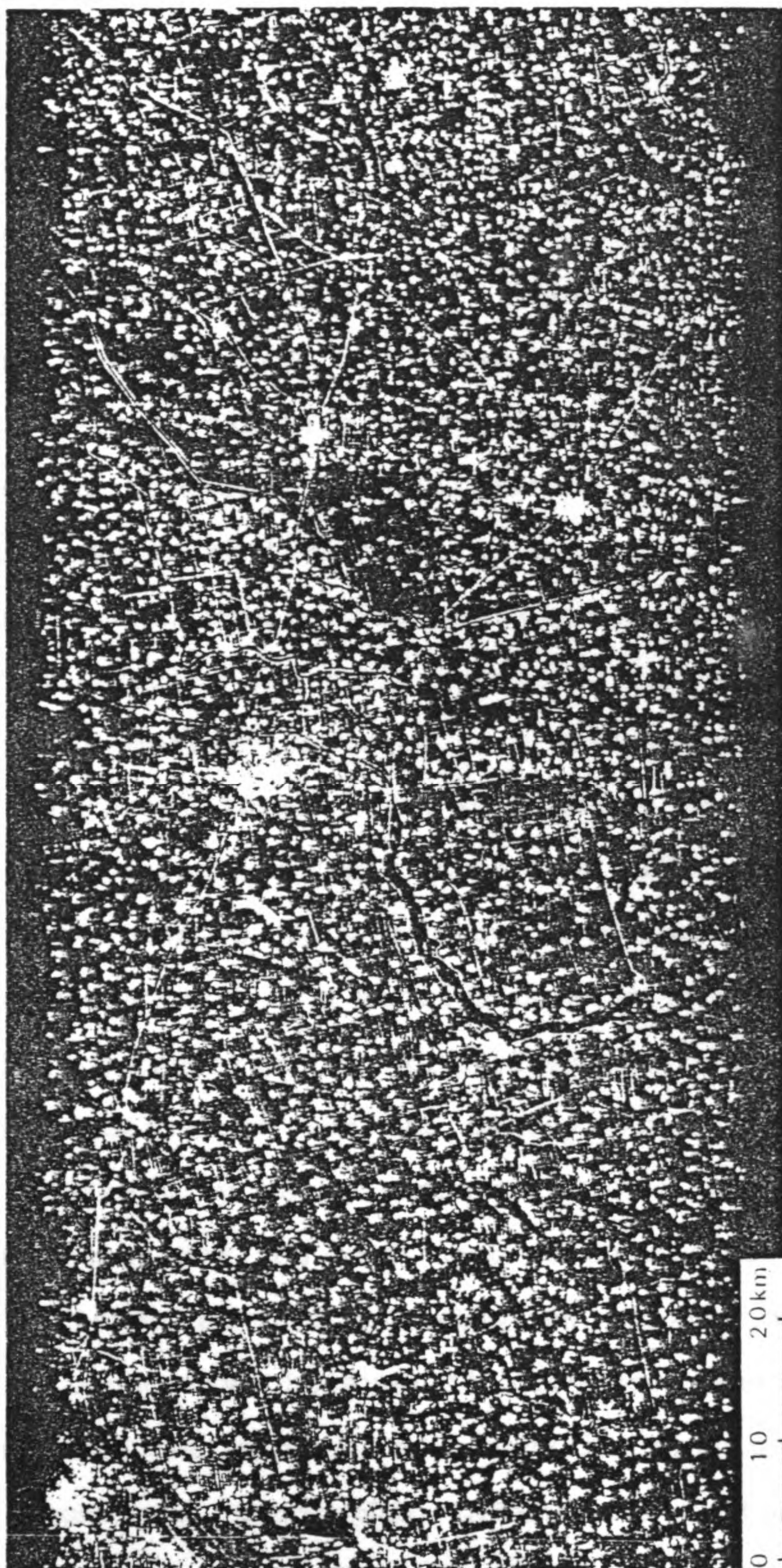


Figure 4: Shuttle Imaging Radar-A Image of Boading Area
(Source: Lo, 1984)

VI. CONCLUSION

Either from the conceptual view, or the potential problem of UA, it is appropriate to consider a multivariate approach for defining urban population and place. Also, using census data is the easiest and cheapest way to improve the UA definition because of the ease of getting existing census data. Some industrialized countries use the presence and utilization of public utilities and/or public services as indicators of urbanism. The employment of non-agricultural activities has been used frequently too. Even government consolidation can relieve some UA definition problems. A more appropriate definition using more variables can reduce the problems to the lowest level. The case study in the Lansing/E. Lansing urbanized area, reveals that the 1980 UA definition produces an underbounded city without considering the socio-economic urban character. Only population size can not present the socio-economic characteristics or lifestyle of inhabitants. Recently, some researchers and the Census Bureau have tried to conduct some projects by using Landsat data to define the UA's. If one does not consider the high cost of satellite imagery, the remote sensing technique can probably be another surrogate in defining urban boundaries because it provides great savings in labor and time involved in defining boundaries physically. If one uses another technique, Geographic Information System (GIS), the urban boundaries can be presented physically, and the socio-economic characteristics can be intergrated into the results.

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APPENDIX I

**DATA LISTING OF THE 14 CENSUS VARIABLES FOR THE
LANSING/E. LANSING SAMPLE AREA**

Census Tract	V01 POP	V02 HS UNIT	V03 TRVL TIME	V04 FRTLTY	V05 SCHL CMPLD	V06 WOMAN HOME	V07 AGRI	V08 CRAFT OPRATN	V09 WATER	V10 SEWAGE	V11 GAS	V12 RENT	V13 MORTG	V14 HS VALUE
102.03	0	0												
202.02	364	1184	17.8	2559	85.1	5.9	0.41	26.60	99.8	100.0	92.6	297	361	42.6
214.00	1076	642	16.8	1607	94.4	4.5	0.90	29.67	99.2	98.4	76.9	218	476	53.6
38.01	4323	1625	16.1	2291	96.1	4.9	0.42	8.05	100.0	100.0	83.8	275	652	73.7
38.02	2002	977	18.5	1633	93.9	3.4	0.00	5.29	98.2	98.1	81.7	302	505	61.5
39.01	1791	719	15.3	2541	93.4	0.0	0.65	7.00	100.0	100.0	82.6	383	868	124.1
39.02	3989	1576	13.2	2307	96.6	2.6	1.28	8.53	99.8	100.0	73.0	272	475	65.2
40.00	3776	1700	13.9	2126	98.1	2.4	0.26	6.01	89.9	89.9	72.9	252	512	68.1
41.00	4882	1379	13.6	2115	94.3	4.6	1.16	8.37	100.0	100.0	73.7	292	447	45.6
42.00	5656	44	8.1		100.0	10.6	2.33	7.82	100.0	100.0	50.0	180		
43.01	4253	1517	15.3	2121	94.8	3.4	0.36	9.59	100.0	99.7	81.2	372	434	51.3
43.02	2877	883	14.5		100.0	3.7	2.77	9.60	100.0	100.0	64.7	386		162.5
44.01	11436	188	7.9	667	100.0	8.7	2.21	7.27	93.6	93.6	16.0	240		
44.02	3852	1537	13.8	1872	98.0	6.6	0.00	7.93	101.3	99.6	38.6	103		
44.03	2993	1312	12.0	2241	97.9	1.9	0.00	6.40	99.5	99.6	29.1	164	389	50.4
45.00	0	0												
46.00	269	126	13.5	909	100.0	4.9	2.30	13.22	100.0	100.0	93.7	343		80.0
54.00	7384	2899	18.3	2689	77.4	7.0	0.84	32.55	90.2	96.3	72.0	268	360	40.2
55.00	2713	895	21.4	2570	81.3	4.0	0.00	29.16	95.3	97.0	94.5	230	387	43.3
1.00	2466	874	15.0	3271	51.3	6.4	0.00	42.42	100.0	100.0	79.2	277	259	22.7
2.00	1561	684	15.2	3009	53.9	17.4	0.96	31.26	100.0	98.7	81.6	183	300	28.5
3.00	2894	1072	14.4	3481	56.5	20.0	0.59	45.69	100.0	99.6	83.1	268	296	22.4
4.00	3684	1403	14.2	3503	75.5	9.3	0.51	24.60	100.0	100.0	16.3	268	326	33.0
5.00	2185	772	12.5	3403	68.0	9.9	0.00	38.24	100.0	100.0	90.3	275	277	24.1
6.00	2547	1343	12.2	1000	83.0	13.8	0.47	21.04	100.0	100.0	76.3	218	365	27.3
7.00	3129	1659	13.9	2889	74.4	8.4	0.90	27.44	100.0	98.9	76.9	206	327	23.6
8.00	3966	1441	16.0	3844	56.1	11.6	0.14	29.42	100.0	99.6	80.8	242	267	21.2
9.00	1803	715	14.1	3653	72.9	8.8	0.00	29.83	100.0	100.0	85.6	291	309	30.6
10.00	2701	1108	17.4	1972	77.9	6.7	2.22	22.96	100.0	99.5	88.1	296	308	29.5
11.00	4167	1934	14.8	2474	77.3	5.8	0.83	25.65	100.0	100.0	81.5	217	291	26.7
12.00	2660	996	15.9	3520	60.2	14.6	2.85	26.93	100.0	99.4	89.0	266	282	21.3
13.00	1629	824	16.6	3650	57.5	5.0	1.64	36.99	100.0	100.0	73.7	189	292	20.3
14.00	229	200	11.3		58.6		0.00	0.00	100.0	100.0	42.0	76		
15.00	2271	1007	13.8	3710	49.4	21.8	1.50	30.07	100.0	99.4	69.5	212	280	24.4
16.00	1567	488	15.5	1761	78.3	2.7	0.00	23.17	100.0	100.0	86.7	306	370	44.2
17.01	1007	460	20.8	2630	89.9	3.1	0.00	5.89	100.0	100.0	96.7	380	580	78.0
17.02	3978	1497	15.4	2125	87.7	1.8	0.24	18.39	99.6	100.0	84.6	265	422	59.8
19.00	743	516	12.0	2438	80.1	1.8	0.00	16.10	100.0	98.8	63.4	211	163	35.0
20.00	4815	2053	15.6	3141	60.3	16.8	0.37	36.86	100.0	99.1	80.5	213	284	21.0
21.00	2609	978	15.4	3103	56.5	9.3	0.28	39.70	100.0	99.4	83.0	273	267	22.1
22.00	1835	776	12.7	2379	82.8	4.6	0.80	20.45	100.0	100.0	88.1	241	334	38.3
23.00	3774	1640	13.9	2558	73.3	6.1	0.98	21.26	100.0	99.6	90.7	256	312	33.1
24.00	3809	1511	14.2	2520	73.3	6.0	0.34	27.60	100.0	100.0	86.5	231	303	30.6
25.00	2518	1120	13.6	2163	81.5	2.4	0.00	22.22	99.7	99.7	84.1	285	341	39.5
26.00	2452	1085	12.3	2982	69.4	4.1	0.32	32.59	100.0	99.8	84.1	232	304	29.0
27.00	3588	1034	17.3	2780	73.2	4.0	0.28	27.49	100.0	100.0	97.8	280	301	32.2
28.00	3110	1271	17.8	2520	75.5	2.9	0.00	27.29	100.0	100.0	80.3	245	284	33.7
29.01	2572	840	14.5	3015	75.8	6.7	0.60	24.57	97.0	92.5	86.9	335	401	45.2
29.02	2090	934	16.0	2435	86.1	4.3	0.46	17.82	100.0	100.0	69.0	308	320	25.7
30.00	0	0												
31.01	0	0												
31.02	2485	742	16.0	2681	84.4	4.7	0.43	14.35	100.0	99.1	95.3	247	458	67.0
32.00	2669	925	13.7	3610	49.4	17.6	0.00	38.54	100.0	96.8	82.5	232	283	23.6
33.01	3398	1375	15.4	3082	73.4	3.0	1.00	28.06	99.5	100.0	81.4	253	343	37.1
33.02	2780	965	16.0	2449	89.0	0.9	0.00	19.01	100.0	100.0	86.0	288	412	54.0
34.00	109	37	8.5	4353	100.0	0.0	0.00	0.00	100.0	100.0	100.0	263	475	80.9
35.00	0	0												
36.01	4695	1368	20.0	2922	81.8	6.5	0.78	33.38	99.2	100.0	96.1	213	330	37.5
36.02	4344	1443	20.7	3133	69.0	6.6	0.17	36.71	100.0	99.4	86.7	223	315	30.2
37.00	6366	2525	15.8	2556	66.0	8.0	0.35	34.01	99.7	100.0	82.4	239	310	34.5
51.00	3138	1003	20.1	3174	60.2	5.2	0.52	41.41	97.8	95.3	87.6	230	356	31.7

	V01	V02	V03	V04	V05	V06	V07	V08	V09	V10	V11	V12	V13	V14
Census	HS	TRVL	SCHL	WOMAN	CRAFT	HS								
Tract	POP	UNIT	TIME	FRTLTY	CMPLD	HOME	AGRI	OPRATN	WATER	SEWAGE	GAS	RENT	MORTG	VALUE
52.00	5387	1921	18.4	2904	75.4	6.9	1.07	30.08	95.5	95.3	89.2	219	310	31.6
53.02	2887	1308	19.1	2463	84.9	7.1	0.36	26.23	91.2	91.2	58.0	352	325	35.1
53.03	4624	2009	20.6	2240	74.3	4.1	0.09	29.56	98.9	96.5	85.1	243	360	41.4
53.04	3452	1451	16.9	2804	74.4	3.4	1.30	30.43	99.6	98.0	75.7	279	355	42.4
N101.02	1953	747	16.9	2406	74.1	5.0	1.06	41.21	40.2	48.9	65.3	216	394	48.5
N102.01	2697	890	16.3	2566	78.2	2.6	0.29	33.45	9.7	92.0	80.3	232	394	48.4
N102.03	1971	809	14.8	2837	58.3	8.6	2.06	43.46	63.8	98.4	88.5	264	288	27.8
N102.04	1308	426	21.6	2551	73.6	6.6	1.05	38.15	15.0	73.9	72.3	218	405	43.0
N103.00	3062	1180	21.4	2873	79.1	2.1	3.08	31.36	3.3	4.2	46.2	219	450	57.9
N111.02	2730	965	23.4	3396	64.2	7.5	1.50	43.44	18.8	59.3	65.1	201	289	31.0
N201.01	6742	2376	16.2	2813	87.4	2.3	0.17	19.43	92.9	94.4	77.7	242	539	71.4
N201.02	6267	2659	13.8	2436	87.6	3.0	0.51	18.55	99.6	100.0	77.1	307	389	49.2
N202.01	2693	922	15.4	2623	91.0	1.6	0.00	20.98	100.0	100.0	87.2	321	474	68.1
N202.02	1158	403	14.1	2857	75.8	1.3	1.09	29.89	11.9	3.0	63.5	262	355	39.8
N214.00	6078	2068	18.0	2217	79.7	5.2	0.92	30.79	62.7	62.7	76.5	231	433	51.0
N17.01	180	72	7.9	1833	68.1	0.0	0.00	23.76	8.3	86.1	84.7		636	80.7
N30.00	410	158	11.5	2000	45.9	18.7	4.83	23.45	100.0	100.0	88.0	316		19.4
N31.01	1559	918	11.5	1160	85.1	1.5	0.00	9.67	100.0	100.0	78.5	248	372	47.1
N31.02	1558	614	16.7	1527	89.2	3.6	0.00	14.67	90.7	93.2	71.3	288	416	51.5
N32.00	0	0												
N34.00	2828	1112	13.3	2508	86.4	5.7	0.00	19.42	100.0	99.4	83.3	252	333	46.6
N35.00	3410	1521	12.6	3016	63.7	8.9	0.00	41.77	100.0	97.0	75.0	275	308	27.7
N38.01	27													
N38.02	68	33	59.0	1200	81.0	60.0	0.00	46.43			66.7		303	43.8
N39.02	292				61.8									
N43.01	1763	701	16.0	1925	96.1	4.6	1.12	9.49	98.6	96.6	66.6	236	436	60.5
N43.02	568	288	11.5		65.5	10.2	4.08	7.82	100.0	100.0	14.6	293		
N44.01	35	4												
N45.00	3321	1512	18.5	2264	85.0	3.9	0.94	14.26	92.8	98.3	87.2	309	499	45.6
N46.00	1477	494	15.4	2505	96.2	1.4	0.00	10.58	72.3	78.7	84.0	272	581	77.0
N47.00	2369	1125	24.9	2407	65.9	7.1	1.33	24.91	58.4	91.1	53.8	209	370	40.0
N48.00	5112	2364	18.8	2407	94.0	1.9	0.16	12.92	85.2	93.1	75.6	312	401	51.5
N49.01	5450	1097	16.4	2052	94.2	4.1	0.48	7.30	82.3	98.2	76.5	301	524	70.8
N49.02	3634	1390	15.8	2392	97.3	4.7	1.56	4.05	78.7	98.1	76.5	305	594	77.6
N50.00	4760	1644	20.1	2397	90.8	2.4	2.16	7.89	57.4	66.4	78.3	303	582	81.0
N51.00	128	45	14.3		63.9		0.00	31.11	0.0	84.4	68.9		375	34.4
N52.00	1159	449	21.5	2963	69.4	5.2	1.39	34.98	46.3	85.1	80.8	259	390	43.3
N53.02	1702	575	20.5	2492	83.1	1.9	0.00	24.74	23.7	84.7	80.0	297	452	56.0
N53.04	50	17	2.0		89.1		0.00	44.19	41.2	0.0	70.6		325	30.0
N55.00	4008	1333	23.4	2535	75.7	4.7	1.68	35.15	33.3	38.9	54.5	304	468	53.0
N56.00	2845	935	18.9	2991	83.8	3.7	4.21	25.74	3.0	5.2	16.6	325	431	53.0

Blank = Missing Vlaue.

APPENDIX II

CLUSTER ANALYSIS IN LANSING/E. LANSING UA

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1 0 FILE HANDLE URBANFAS / NAME = 'LANSING DATA A'
2 0 DATA LIST FILE = URBANFAS RECORDS = 1
3 0 /1 TRACT (A7) V01 9-13 V02 15-19 V03 21-25 V04 27-31 V05 33-37
4 0 V06 39-43 V07 45-49 V08 51-55 V09 57-61 V10 63-67 V11 69-73 V12 75-79
5 0 V13 81-85 V14 87-92
6 0

```

0This command will read 1 records from LANSING DATA A1

Variable	Rec	Start	End	Format
TRACT	1	1	7	A7
V01	1	9	13	F5.0
V02	1	15	19	F5.0
V03	1	21	25	F5.0
V04	1	27	31	F5.0
V05	1	33	37	F5.0
V06	1	39	43	F5.0
V07	1	45	49	F5.0
V08	1	51	55	F5.0
V09	1	57	61	F5.0
V10	1	63	67	F5.0
V11	1	69	73	F5.0
V12	1	75	79	F5.0
V13	1	81	85	F5.0
V14	1	87	92	F6.0

Variable	Rec	Start	End	Format
7	0	VARIABLE LABELS		
8	0	V01 'TOTAL POPULATION IN 1980'		
9	0	V02 'TOTAL HOUSING UNITS IN 1980'		
10	0	V03 'MEAN TRAVEL TIME TO WORK'		
11	0	V04 'FERTILITY'		
12	0	V05 'PCT SCHOOL COMPLETED WITH HIGH SCHOOL GRADUATES'		
13	0	V06 'PCT WOMAN AT HOME'		
14	0	V07 'PCT POP. EMPLOYED IN AGRICULTURE'		
15	0	V08 'PCT POP. EMPLOYED IN CRAFT & OPERATIVE'		
16	0	V09 'PCT HOUSING UNITS WITH PUBLIC WATER'		
17	0	V10 'PCT HOUSING UNITS WITH SEWER'		
18	0	V11 'PCT HOUSING UNITS WITH UTILITY GAS'		
19	0	V12 'MEDIAN RENT IN DOLLARS'		
20	0	V13 'MEDIAN MORTGAGE IN DOLLARS'		
21	0	V14 'MEDIAN VALUE OF HOUSING UNITS'		
22	0			
23	0			
24	0	DESCRIPTIVES V03 TO V14/SAVE		

0Number of valid observations (listwise) = 81.00

Variable	Mean	Std Dev	Minimum	Maximum	Valid N	Label
V03	16.328	3.073	9	25	81	MEAN TRAVEL TIME TO WORK
V04	2644.642	589.958	1000	4353	81	FERTILITY
V05	78.370	13.064	49	100	81	PCT SCHOOL COMPLETED WITH HIGH SCHOOL GR
V06	5.751	4.397	0	22	81	PCT WOMAN AT HOME
V07	.696	.789	0	4	81	PCT POP. EMPLOYED IN AGRICULTURE
V08	24.459	11.381	0	46	81	PCT POP. EMPLOYED IN CRAFT & OPERATIVE
V09	86.299	27.053	3	100	81	PCT HOUSING UNITS WITH PUBLIC WATER
V10	91.301	20.677	3	100	81	PCT HOUSING UNITS WITH SEWER
V11	77.685	15.063	16	100	81	PCT HOUSING UNITS WITH UTILITY GAS
V12	262.753	44.181	164	383	81	MEDIAN RENT IN DOLLARS
V13	385.556	107.287	163	868	81	MEDIAN MORTGAGE IN DOLLARS
V14	44.542	18.732	20	124	81	MEDIAN VALUE OF HOUSING UNITS

-The following Z-Score variables have been saved on your active file:

Variable	Z-Score	Label	Weighted Valid N
-----	-----	-----	-----

V03	ZV03	Zscore: MEAN TRAVEL TIME TO WORK	81ALUE OF
V04	ZV04	Zscore: FERTILITY	81ALUE OF
V05	ZV05	Zscore: PCT SCHOOL COMPLETED WITH HIGH	81ALUE OF
V06	ZV06	Zscore: PCT WOMAN AT HOME	81ALUE OF
V07	ZV07	Zscore: PCT POP. EMPLOYED IN AGRICULTUR	81ALUE OF
V08	ZV08	Zscore: PCT POP. EMPLOYED IN CRAFT & OP	81ALUE OF
V09	ZV09	Zscore: PCT HOUSING UNITS WITH PUBLIC W	81ALUE OF
V10	ZV10	Zscore: PCT HOUSING UNITS WITH SEWER	81ALUE OF
V11	ZV11	Zscore: PCT HOUSING UNITS WITH UTILITY	81ALUE OF
V12	ZV12	Zscore: MEDIAN RENT IN DOLLARS	81ALUE OF
V13	ZV13	Zscore: MEDIAN MORTGAGE IN DOLLARS	81ALUE OF
V14	ZV14	Zscore: MEDIAN VALUE OF HOUSING UNITS	81ALUE OF

```

25 0 CLUSTER ZV03 TO ZV14
26 0 /ID=TRACT
27 0 /PRINT=SCHEDULE
28 0 /METHOD=COMPLETE
29 0 /PLOT=HICICLE
30 0

```

***** H I E R A R C H I C A L C L U S T E R A N A L Y S I S *****

Data Information

81 unweighted cases accepted.

Squared Euclidean measure used.
1 Agglomeration method specified.

***** H I E R A R C H I C A L C L U S T E R A N A L Y S I S *****

Agglomeration Schedule using Complete Linkage

Stage	Clusters		Coefficient	Stage Cluster 1st Appears		Next Stage
	Cluster 1	Cluster 2		Cluster 1	Cluster 2	
1	23	35	.821913	0	0	13
2	29	45	.871551	0	0	16
3	13	32	.953935	0	0	18
4	47	51	1.172177	0	0	34
5	48	50	1.192643	0	0	34
6	33	34	1.211413	0	0	13
7	12	53	1.250440	0	0	29
8	44	54	1.253963	0	0	23
9	27	36	1.310256	0	0	40
10	17	21	1.637828	0	0	35
11	6	8	1.754190	0	0	26
12	14	31	1.776819	0	0	43
13	23	33	1.986008	1	6	31
14	1	38	2.104812	0	0	36
15	4	75	2.141928	0	0	33
16	29	62	2.307381	2	0	24
17	15	43	2.350105	0	0	46
18	13	69	2.404857	3	0	41
19	37	49	2.817415	0	0	21
20	42	61	2.836611	0	0	45
21	19	37	3.000111	0	19	44
22	7	72	3.097726	0	0	45
23	11	44	3.159822	0	8	39
24	29	63	3.159822	0	0	40
25	55	65	3.200413	16	0	57
26	6	70	3.241568	0	0	48
27	71	74	3.246586	11	0	37
28	58	78	3.415353	0	0	47
29	12	39	3.788434	0	0	36
30	3	76	3.905653	7	0	48
31	23	68	3.922592	0	0	44
32	41	52	4.059260	13	0	60
33	4	67	4.061964	0	0	42
34	47	48	4.186225	15	0	50
35	17	20	4.286482	4	5	41
36	1	12	4.455862	10	0	50
37	9	71	4.812362	14	29	42
38	56	79	5.155076	0	27	70
39	11	40	5.784764	0	0	53
40	27	29	6.030714	23	0	52
41	13	17	6.099318	9	24	64
42	4	9	6.106804	18	35	52
43	14	26	6.106817	33	37	46
44	19	23	6.240144	12	0	55
45	7	42	6.250968	21	31	54
			6.417419	22	20	

***** H I E R A R C H I C A L C L U S T E R A N A L Y S I S *****

Agglomeration Schedule using Complete Linkage (CONT.)

Stage	Clusters Combined		Coefficient	Stage Cluster 1st Appears		Next Stage
	Cluster 1	Cluster 2		Cluster 1	Cluster 2	
46	14	15	6.745536	43	17	65
47	58	73	8.003086	28	0	56
48	3	6	8.154741	30	26	54
49	24	57	8.384402	0	0	58
50	1	47	9.825518	36	34	64
51	2	66	10.450663	0	0	59
52	4	27	10.555255	42	40	68
53	11	22	10.648429	39	0	60
54	3	7	10.684379	48	45	63
55	19	30	11.269794	44	0	67
56	58	60	11.675501	47	0	62
57	55	80	12.047439	25	0	62
58	24	25	12.127471	49	0	65
59	2	18	12.456859	51	0	67
60	11	41	12.920809	53	32	68
61	59	81	12.980795	0	0	72
62	55	58	17.174728	57	56	70
63	3	77	17.415680	54	0	74
64	1	13	18.081390	50	41	73
65	14	24	18.468658	46	58	73
66	5	28	18.626984	0	0	74
67	2	19	19.049820	59	55	71
68	4	11	20.349335	52	60	71
69	10	16	21.307907	0	0	76
70	55	56	24.602554	62	38	77
71	2	4	28.816696	67	68	76
72	59	64	31.795898	61	0	79
73	1	14	40.802475	64	65	77
74	3	5	42.652023	63	66	75
75	3	46	43.090881	74	0	80
76	2	10	43.640015	71	69	78
77	1	55	58.524429	73	70	78
78	1	2	65.872192	77	76	79
79	1	59	111.076736	78	72	80
80	1	3	121.532486	79	75	0

Horizontal Icicle Plot Using Complete Linkage	Number of Clusters
	2
	3
	4
	5
	6
	7

[illegible]

	C	A	S	E	Label	Seq
	1234567890	1234567890	1234567890	1234567890	1234567890	1234567890
	1111111111	1222222222	3333333333	4444444444	5555555555	6666666667
						7777777777

[illegible]

[illegible]

[illegible]

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31 0 PROXIMITIES ZV03 TO ZV14/
32 0 VIEW=CASE/
33 0 MEASURE=SEUCLID/
34 0 MATRIX=OUT(*)
35 0
36 0

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Data Information

Squared Euclidean measure used.

Squared Euclidean Dissimilarity Coefficient Matrix

Case	1	2	3	4	5	6	7	8
2	9.5607							
3	14.6324	11.1241						
4	10.4367	10.2323	5.0484					
5	51.4167	49.4785	18.9001					
6	12.0971	8.6286	5.8038					
7	14.0366	8.6149	3.9755					
8	8.7432	8.5505	8.1547					
9	8.4588	17.0472	10.7102					
10	36.1358	21.7529	29.6323	30.7480				
11	3.5312	8.8766	19.5701	7.9949	31.7137			
12	4.3894	9.6828	18.5753	5.2085	30.9141	2.6037		
13	14.2245	30.5523	45.0929	6.8812	39.9110	1.7542	4.7007	
14	22.5811	29.3745	45.6595	5.3807	32.8420	8.1046	9.8160	5.0569
15	23.9672	40.7226	54.8793	29.2333	74.9984	18.6064	15.5188	20.4824
16	31.5749	35.4085	44.2773	16.5668	60.0630	14.2010	17.0009	11.1473
17	10.7379	27.0702	37.5793	14.3066	61.4725	19.7411	18.1270	17.8016
18	18.8391	12.4569	28.0127	40.6562	91.7401	36.6683	40.2069	30.9765
19	9.7700	13.3503	27.1871	46.8095	104.7067	38.8929	42.6811	33.7910
20	16.1106	33.7299	43.6091	55.9641	107.5331	49.0833	54.7491	41.5429
21	7.4260	24.7678	29.3000	43.6400	86.8825	31.1539	34.8258	28.0400
22	7.5377	13.1966	25.6624	36.5258	85.1092	30.0451	33.5378	24.6428
23	6.5894	9.6528	24.4137	22.7075	82.7065	21.5363	21.4646	15.2845
24	22.5435	36.9742	48.8895	27.0596	80.0547	17.7821	21.1303	14.1817
25	20.7245	27.8656	46.5471	42.4909	96.0968	36.8824	40.0840	31.3921
26	35.6163	47.6161	61.4005	28.7155	71.3144	23.3982	26.4881	19.0580
27	3.7608	9.1875	14.9189	19.3550	67.8176	15.4928	23.3347	10.1819
28	16.4311	28.4055	10.2664	20.8467	76.1185	14.6856	17.5263	11.0531
29	4.6002	5.0634	7.1198	50.5988	98.2705	36.6645	48.7185	30.8965
30	16.8623	19.0498	33.6012	47.6653	100.2370	34.3096	41.0552	31.7064
31	18.1570	28.7063	45.0480	65.3421	119.4641	51.4217	58.8549	45.3107
32	10.8702	25.9799	40.3719	7.4869	49.0146	11.3028	11.4284	7.6497
33	5.3141	8.2032	16.7371	8.9032	18.6270	19.2560	18.2484	19.5195
34	4.5144	11.9039	20.8249	4.8445	38.3435	4.5400	4.0316	4.6666
35	5.3069	10.9804	23.5020	26.3727	86.2954	18.2791	18.7612	15.9424
36	3.9010	9.5891	15.9030	44.2304	103.8225	39.0570	41.9403	32.6260
37	8.9115	16.4824	28.9395	36.2813	89.0666	32.6801	36.6174	26.4409
				14.9348	60.1939	8.1182	10.7787	5.9035
				18.0611	65.2548	12.2003	16.2072	8.5751
				20.0460	72.3408	15.8899	17.5601	12.2019
				10.4134	53.7680	9.5682	10.1034	6.4460
				27.8267	76.0879	19.4350	22.0541	16.5307

Squared Euclidean Dissimilarity Coefficient Matrix (Cont.)

Case	1	2	3	4	5	6	7	8
38	2.1048	15.1478	23.3913	17.8578	65.7200	18.5930	20.8338	14.4120
39	4.0768	10.8349	23.1316	16.1773	69.5327	16.9413	17.1999	13.5223
40	3.5638	17.1105	16.3369	15.5624	45.3315	12.3963	16.0670	9.2201
41	4.6014	12.6030	19.0700	11.8286	59.6956	10.6886	13.2906	5.5385
42	5.4514	8.6019	5.9328	8.0144	36.3046	6.3037	6.1271	7.6493
43	25.0682	41.2424	54.1514	55.1340	109.5012	48.5596	51.5180	42.0929
44	4.8682	12.2303	21.0740	20.3493	61.4535	12.7309	16.9950	10.9422
45	3.3050	8.3642	8.6248	5.5986	38.7684	6.4369	6.0153	5.8234
46	33.3826	43.8096	24.5471	36.2962	43.0909	21.9370	22.3063	28.2329
47	5.3755	11.5532	24.6262	22.7208	73.2587	21.3714	23.4594	19.1575
48	7.8447	17.8006	31.8544	28.0517	81.9073	29.0927	30.0589	25.4236
49	5.8137	12.4839	26.4410	22.8680	74.0668	20.2901	22.2552	16.2466
50	9.8255	19.6041	33.8966	31.7101	79.8834	30.9178	33.0750	27.7632
51	5.5927	12.0469	25.8106	23.5238	75.6387	19.3885	22.6594	16.3040
52	7.6662	18.0424	24.3747	15.5294	59.2036	18.4745	20.7749	12.7087
53	3.9816	8.3291	19.6595	13.1812	62.6855	18.4020	17.5360	15.4385
54	4.0767	10.3284	19.5736	17.4625	55.7472	11.5825	16.6734	9.5786
55	21.0323	17.0730	33.9682	32.9702	75.5129	27.2589	26.0277	26.6697
56	15.7299	16.9554	27.2801	25.6156	66.2670	23.2354	20.8639	22.7493
57	15.8289	25.2643	43.5915	42.3991	89.6416	31.8256	40.0792	27.1426
58	20.6192	20.2970	35.8450	33.1689	79.7506	33.1734	31.8531	31.3587
59	62.4037	53.7671	67.9567	69.4935	101.2910	58.0832	59.1848	60.5172
60	33.8528	39.3238	60.8820	57.6452	113.3962	53.3391	54.4990	50.5371
61	9.4303	8.0582	4.6659	8.8259	30.0982	6.2499	4.2977	9.3145
62	4.0280	9.2912	10.5373	7.9256	41.0078	4.3712	6.5833	2.6708
63	5.6824	12.0707	6.6356	6.4897	26.8611	7.0090	6.9590	7.7455
64	41.0836	43.1758	54.2878	51.9916	91.5363	43.2616	40.8673	42.1243
65	10.2508	7.5920	18.3900	16.8561	56.8824	15.2979	14.0341	14.5170
66	15.4851	10.4507	16.8515	10.2994	55.9442	9.8519	8.0192	7.8457
67	7.6802	6.3952	9.9483	2.8694	43.2522	7.5459	5.3749	5.1279
68	4.3652	8.8848	14.0382	11.7109	55.0431	8.1851	8.2479	6.3466
69	11.1700	22.5779	35.5209	33.5699	80.6785	27.5161	30.3696	22.4254
70	11.6815	4.5139	7.8572	6.8214	42.6520	2.5746	3.3205	3.2466
71	4.0923	8.9128	7.1230	4.5850	35.4145	7.1035	8.8859	4.7477
72	14.9573	13.2874	3.7336	7.1240	22.8391	7.3684	3.0977	10.6844
73	22.1772	20.6627	36.2522	30.2177	83.4874	32.1214	32.7719	29.4021
74	5.1656	11.0286	9.8800	4.0671	39.3715	7.8430	7.0517	6.1682
75	10.6337	9.7051	2.7022	2.1419	24.1570	3.6709	2.5673	4.4436
76	17.5022	14.9998	3.9226	8.5777	19.3147	4.1457	6.2764	6.7327
77	23.5491	21.0739	13.3160	15.8861	27.3902	13.9315	15.5218	17.0645
78	11.3327	18.0236	28.9063	26.7517	67.0873	25.4155	27.8905	23.4145
79	12.3243	17.8218	19.2377	14.6236	47.3599	20.7814	17.1866	19.7947
80	29.5726	30.5696	39.6648	35.8705	67.5449	36.9174	37.2050	35.3792
81	84.5665	79.4290	89.2377	89.8486	112.0896	71.7736	79.1957	72.1381

Case	9	10	11	12	13	14	15	16
10	35.9603							
11	15.6639	29.1664						
12	20.3022	36.7749						
13	33.5242	49.0480	5.9346					
14	47.7552	47.1921	10.2151	17.5249	13.7415	6.7455		
15	47.9864	65.8722	15.1334	23.0106	10.7610			
16	37.4465	21.3079	18.1058	30.4105	25.1291	30.2170	31.5518	27.1308
17	27.9267	46.1621	10.3656	38.5868	3.6932	11.9254	7.7330	37.2727
18	26.3814	27.9487	17.9568	17.1227	31.1096	20.5001	30.9818	19.8574
19	25.9440	25.0858	5.6285	24.2497	9.9284	7.4911	14.8244	22.9364
20	37.6120	46.9241	11.6338	11.9719	4.5703	6.9814	7.1165	22.2257
21	20.6107	40.5640	7.7539	18.0814	5.4364	14.8280	11.1659	36.1105
22	15.6134	42.9564	7.6018	14.9302	21.3321	22.7218	28.2576	24.1934
23	20.6333	24.2039	4.6987	8.5718	11.0898	11.8904	20.4876	35.8329
24	42.0524	63.8479	17.0316	30.4944	19.6575	11.2767	12.9375	25.0433
25	45.5062	42.0409	11.5716	19.0706	9.7747	10.9091	18.1971	28.4961
26	60.2509	60.0857	24.8662	40.8025	20.4170	4.3792	6.3225	33.9962
27	6.4939	31.5081	7.9892	9.2894	17.4843	30.1350	33.9962	34.7391
28	9.3822	58.4693	26.5513	22.9714	48.7899	63.0405	63.5758	59.4176
29	7.1851	22.2235	8.2374	7.8475	23.6319	31.2173	39.5577	33.2164
30	25.1913	14.1266	14.6338	20.0226	18.8161	25.4999	36.8176	21.5454
31	42.5278	47.1456	12.1087	19.6266	8.7851	1.7768	3.3769	26.3194
32	30.0650	47.3873	7.4997	14.7741	9.9539	9.1273	6.9564	24.8345
33	13.3993	23.4325	6.9465	10.3751	15.7783	18.4016	26.4344	28.7704
34	15.0397	30.8062	5.3707	9.8270	10.7917	13.5158	19.6510	28.0613
35	19.1697	27.3880	4.9395	7.6894	8.0788	11.7454	18.0252	25.9665
36	7.9022	25.1809	7.2619	9.7175	14.5838	26.3929	30.7177	28.8803
37	23.9388	29.6906	7.4024	12.0504	5.5481	13.3850	17.4746	24.3406
38	15.0348	40.4835	5.0560	4.8124	8.1476	18.9613	21.1925	33.5566
39	17.0460	26.8141	3.7075	3.9057	9.2120	18.6956	24.9738	25.2189
40	8.0463	39.4844	6.0307	12.8875	12.0982	23.0816	20.3341	26.3805
41	7.1109	24.0558	5.2342	11.9194	15.7497	26.5282	29.0993	19.1454
42	11.4913	28.5525	9.5981	7.4255	24.6938	26.1486	35.2347	37.2058
43	50.0626	58.1758	19.0769	28.3071	8.2968	4.6235	2.3501	29.9472
44	17.1880	28.8671	3.1598	7.9501	8.2999	15.9413	20.7920	22.0855
45	5.5543	25.7916	7.9984	7.2432	21.2618	33.5907	38.7024	32.4269
46	31.1722	45.1114	42.4674	41.6400	53.4582	62.3424	68.1332	57.9530
47	25.7365	39.1117	4.9506	2.5834	14.4775	14.9561	21.6699	35.5573
48	30.2026	41.5203	5.0579	3.9616	7.8062	12.8127	16.9597	29.7237
49	22.3376	32.4486	3.3010	7.3690	5.0859	8.4376	12.6569	23.9043
50	32.8514	46.6892	5.7914	6.1956	6.3116	13.2844	16.7088	31.7056
51	24.4593	35.1127	3.2926	4.8579	10.7388	10.5666	17.5953	28.6917
52	9.9171	34.1827	5.9449	15.5647	18.4939	31.8621	28.8537	18.0528
53	18.0718	32.8443	3.7884	1.2504	13.6963	20.3126	27.5858	32.3142
54	14.1627	30.6154	1.6094	8.2358	10.4006	18.9083	22.4700	21.1960
55	36.3199	35.5887	11.9163	19.0042	24.7294	26.7989	34.4017	31.8612
56	28.2137	35.4342	12.1223	14.2288	23.1498	30.6211	37.2449	37.1215
57	35.6384	55.5480	10.0015	21.0613	10.3266	12.6917	13.4824	34.6619
58	39.1573	45.3908	11.9938	15.4321	27.4162	27.5031	35.2080	38.0814
59	74.2998	69.8962	46.3726	58.7752	73.9429	71.4502	84.3200	62.8775
60	60.8603	61.1320	20.1968	26.7498	29.1736	28.8901	35.1487	40.0366
61	13.6065	21.6802	10.3562	9.7766	27.7372	32.8398	41.6119	30.7954

***** PROXIMITIES *****

Squared Euclidean Dissimilarity Coefficient Matrix (Cont.)

Case	9	10	11	12	13	14	15	16
62	3.9188	23.3294	6.8041	12.2569	19.2415	29.9837	33.2252	24.6454
63	4.6220	32.5943	11.6312	12.1247	26.3623	40.7056	42.1991	36.3787
64	49.0668	53.4763	32.8774	43.4039	44.0121	53.7496	59.0372	47.9233
65	21.6622	29.6775	6.1424	9.0384	22.5345	23.4426	32.2765	31.5662
66	13.4227	18.8616	19.4040	20.8367	33.5560	38.7805	51.9796	40.3767
67	6.1068	20.9189	10.0333	11.8824	28.8801	36.2885	44.3930	31.2821
68	10.8414	20.4424	6.7966	9.1214	15.8053	20.4184	26.4708	25.3694
69	26.4816	38.4618	7.7022	17.0350	2.4049	11.8930	8.7423	19.8111
70	11.8574	13.8262	11.2414	15.1052	36.0116	33.0217	46.8394	28.3988
71	5.1551	34.3855	7.6171	8.9247	26.1138	32.6903	38.1499	35.6739
72	11.8563	28.0997	19.4496	17.5417	42.2693	48.8743	57.6837	44.1726
73	39.0979	37.1307	11.1500	15.7685	28.6941	24.9216	37.7869	28.2853
74	4.2806	26.5792	8.5504	9.4453	27.3748	39.3387	44.1464	30.1443
75	5.1335	25.5556	14.5134	16.4840	38.8839	43.3871	51.4675	36.7646
76	10.1324	32.4012	20.3358	25.4825	49.5162	49.5462	58.2932	41.9400
77	20.0028	46.3163	23.6207	27.3151	55.8463	56.8759	67.4067	52.5173
78	28.0696	46.6956	5.7897	9.5882	17.6116	22.3822	26.8379	33.1394
79	17.6176	40.9962	12.2823	11.9130	29.4385	42.2203	46.0691	40.4317
80	37.8551	56.2748	19.9240	29.2949	41.8967	49.1867	52.3894	40.6077
81	83.3867	87.0877	65.6217	92.9608	96.5659	99.0744	104.1956	64.7823
Case	17	18	19	20	21	22	23	24
18	24.5748							
19	6.9772	13.3562						
20	4.4559	31.3004	7.5995					
21	1.6378	26.8620	7.2550	4.3161				
22	19.6718	17.3179	11.7252	23.6530	17.9805			
23	8.8486	11.4280	1.3102	11.2528	8.8183	8.0840		
24	16.8857	34.7437	13.5351	13.3353	16.8871	13.6619	17.1337	
25	13.2444	35.2708	6.6253	8.1897	13.8007	19.8494	9.4811	12.1275
26	17.8771	34.5071	15.9740	10.2540	20.1380	33.1099	23.8444	10.1398
27	16.2081	14.9700	14.0590	24.4921	13.9015	10.2744	8.7629	34.3328
28	44.3771	50.4141	44.2187	49.9877	32.9431	31.2294	38.6973	57.1035
29	20.0388	17.1659	13.1041	26.9707	15.6983	13.0536	8.6523	36.0547
30	17.4965	18.4627	9.2286	20.4284	16.3633	21.5745	6.6047	35.9402
31	6.6858	20.6027	6.7021	3.9084	9.3842	22.3963	10.7199	13.0824
32	2.3429	24.3591	6.8511	3.2537	4.0708	16.0349	8.0815	14.1444
33	10.6963	11.3593	4.2568	16.8117	9.5976	8.3046	1.9860	21.4551
34	7.4641	13.3109	3.2986	11.2772	6.6998	5.8090	1.6971	14.2356
35	5.7920	12.0295	2.1291	9.3950	6.1711	10.1281	.8219	19.0854
36	11.7574	14.2376	9.3592	19.7442	9.7477	11.1078	5.4135	30.9782
37	3.9247	19.0046	2.8503	8.0518	4.8774	15.1503	2.8834	19.8524
38	7.0298	22.1979	7.8891	10.6520	5.3654	9.1653	5.0087	20.0190
39	10.1731	18.2214	6.1606	12.0430	8.3174	11.4318	3.0935	25.7690

Squared Euclidean Dissimilarity Coefficient Matrix (Cont.)

Case	17	18	19	20	21	22	23	24
40	8.4076	23.9382	11.3326	14.1771	4.7423	10.6484	10.4320	19.2185
41	13.8157	16.8181	9.3813	18.0846	9.6083	8.4362	6.4274	25.4755
42	19.0779	21.5578	12.7757	23.0173	14.0017	15.2523	10.2304	30.1669
43	6.6133	30.8085	12.4546	3.6372	9.8973	32.2693	18.1661	16.5961
44	7.6857	22.0024	3.6443	9.7758	5.5282	8.8016	2.8937	15.4493
45	17.8399	21.9158	14.1069	24.8197	12.6855	14.0719	9.7142	36.2146
46	39.7349	61.8200	39.1300	47.4332	30.8269	52.9891	39.1988	60.6575
47	12.3695	23.2953	6.9512	12.6974	10.8122	11.6100	5.4622	18.7573
48	9.6377	27.3240	7.6346	7.2408	8.5194	16.4524	7.2387	20.2132
49	5.1016	13.8844	3.0001	6.9300	5.8815	10.6139	2.4902	16.6898
50	10.1128	31.0236	8.8503	7.9588	9.7342	16.6449	8.9333	18.6335
51	9.4890	19.6257	3.3862	8.9896	8.4298	8.2830	2.6739	12.9134
52	19.0195	25.0357	17.7146	22.1645	13.6479	12.9208	15.1011	29.7431
53	15.5262	19.2527	10.0200	16.5076	13.1480	11.4880	6.3834	28.2563
54	11.1350	22.0820	6.4072	13.5811	8.2390	5.9396	4.8442	15.8095
55	26.6586	29.0724	17.2619	28.4419	26.0926	23.6531	16.9548	34.1032
56	22.7717	29.4947	17.4047	26.7540	21.0258	24.1516	15.4123	38.2238
57	11.0759	27.3830	10.0495	13.4753	13.7419	10.9504	10.9294	8.3844
58	30.3735	34.6456	20.8016	28.1711	28.2199	23.8815	20.0360	33.1415
59	78.9609	79.5215	58.5613	73.8527	72.8030	55.7092	58.8976	64.2679
60	35.4261	53.6057	27.0848	27.1920	33.8478	34.6245	28.8473	31.4614
61	24.1601	26.8759	16.0432	27.8280	17.7803	22.3083	14.3319	39.4667
62	15.1685	17.8815	11.4056	22.7329	10.6634	10.3746	8.2034	29.2487
63	21.6168	28.8167	20.8392	30.5815	15.2780	18.9120	16.8686	40.9823
64	44.8550	54.6802	38.0617	48.0106	42.3117	43.5023	37.7052	53.8848
65	22.1416	20.0110	12.2618	24.5581	19.7311	14.0379	10.3440	29.1107
66	29.5044	10.9342	18.7405	39.0006	27.6290	19.3972	12.7940	49.1764
67	26.6769	13.9593	17.8803	33.1583	21.8035	14.2021	12.4552	42.8842
68	10.2028	12.4584	6.2510	16.1794	7.8191	13.0833	4.0593	27.5680
69	1.8608	20.7671	6.3396	6.1068	3.6726	18.6657	8.0099	19.4911
70	31.3081	15.2699	15.0646	34.9144	25.3582	13.7953	11.5907	36.3283
71	23.2663	21.9543	16.3362	27.5260	17.0178	8.3654	12.4651	28.6886
72	35.8038	32.7240	27.6664	42.7800	27.7088	29.0978	24.2001	53.5058
73	35.9039	33.3908	20.1277	26.5979	31.3057	20.8954	19.0801	30.3030
74	24.8545	25.7189	18.9902	29.3526	17.1771	14.4095	14.0925	38.7346
75	33.5145	23.6614	24.1175	39.6684	25.4881	18.7447	19.8219	44.5198
76	42.2726	32.8328	29.9438	47.7765	32.7225	21.6099	27.0559	43.0905
77	53.0583	46.3709	38.5257	55.1724	42.7023	24.5532	34.6511	46.4499
78	20.6245	34.1940	14.9756	18.6258	17.3354	13.8529	14.0031	20.3391
79	29.9931	36.2412	26.1133	33.1861	23.7563	23.6538	22.0287	45.0425
80	47.5434	52.0379	37.8932	45.6088	41.2085	30.0490	36.3728	44.4392
81	101.5207	101.7976	82.0529	98.0598	92.5460	69.8248	83.4848	77.4407

***** PROXIMITIES*****

Squared Euclidean Dissimilarity Coefficient Matrix (Cont.)

Case	25	26	27	28	29	30	31	32
26	16.6354							
27	28.9028	46.6219						
28	60.7018	78.0977	18.5793					
29	27.9282	48.1486	3.0197	15.7687				
30	20.4578	38.0040	14.0441	49.6597	13.0359			
31	11.2001	6.2401	26.1005	58.3980	29.0745	23.3966		12.5469
32	9.0658	15.5559	15.3814	45.3164	21.0526	18.1706	4.9785	7.6183
33	16.6330	31.3197	5.7041	30.1793	4.3800	7.4100	17.3284	5.7592
34	12.4095	24.2222	6.4081	30.5260	7.1814	9.6635	12.5638	12.9094
35	11.1300	24.1712	6.6803	35.4228	7.6677	7.2401	9.6231	4.9477
36	23.4974	41.1220	1.3103	23.1237	2.7476	8.3138	22.3773	6.3025
37	8.7151	23.8531	10.6551	41.5707	11.4031	8.0147	10.6590	7.9786
38	14.6063	32.0458	5.5497	24.6349	8.0653	14.3020	14.8244	9.8128
39	13.3149	33.2297	5.4379	29.4673	6.5795	7.8657	14.8818	13.2681
40	21.2987	30.5671	6.7435	17.1908	8.2568	19.7352	18.8874	21.1306
41	21.6769	36.6809	4.9572	23.8527	6.9707	9.9414	21.6270	5.9466
42	25.6827	41.0922	8.0466	14.3174	2.5422	18.3559	25.7371	6.9678
43	15.1857	6.0824	33.1410	65.0445	37.3915	30.0396	2.2197	19.4189
44	7.4323	25.7853	8.7230	29.6152	7.6844	10.6282	13.9732	52.3230
45	27.8620	49.5967	2.9536	13.0521	.8716	13.9730	29.5197	10.8240
46	54.3609	72.1792	38.2955	33.9546	25.6214	38.0761	60.4547	6.0862
47	11.0887	28.8586	13.7070	32.5024	11.7368	19.0526	12.7826	2.9443
48	8.5938	24.9525	15.3784	36.9828	16.1491	19.1820	9.1894	5.4557
49	9.3571	19.4383	8.2313	36.3660	10.4827	11.2698	6.1893	7.3238
50	6.6581	24.8118	16.7064	38.8925	18.0989	22.8706	10.4910	16.0023
51	6.8885	21.8773	12.5653	35.2390	11.6993	14.7188	9.3324	11.4247
52	28.5690	39.5967	9.7386	22.9461	13.6042	20.7629	24.9969	8.6148
53	17.1589	37.1076	6.0427	24.5187	6.8035	15.9287	17.2680	22.6855
54	10.3035	28.5017	7.5172	25.6659	7.3694	13.9490	16.7474	21.8326
55	21.5975	39.0680	23.3639	49.4462	21.4127	25.8549	25.9710	7.5885
56	24.8064	45.5520	17.2589	38.1712	15.2322	22.4004	28.0448	24.3548
57	9.3285	18.4687	21.5900	52.6475	25.4326	26.5788	12.3033	70.7822
58	22.8216	40.3029	26.6120	45.7698	25.0186	33.7279	26.3045	27.1459
59	55.1578	79.5013	69.4748	82.5883	61.9255	70.6592	74.3803	25.7275
60	19.6312	36.3316	45.0906	69.1286	44.2020	43.0961	27.7000	16.9406
61	27.8942	47.7776	11.0669	15.6282	3.6457	20.2951	31.4098	24.5461
62	25.6406	41.7601	3.2190	16.9403	2.3074	11.7759	26.4124	43.2892
63	35.7791	55.3483	5.8645	8.4058	2.9907	22.4284	36.0490	19.1815
64	43.2450	63.1381	42.1081	65.7526	40.7379	41.1444	51.6694	30.6344
65	20.6344	37.9526	12.3755	30.5880	9.8711	20.5516	22.7296	25.5425
66	40.2399	58.0826	6.5285	32.6105	5.9991	11.1112	37.9564	13.0093
67	36.4939	53.3277	3.3788	17.6303	3.0531	15.2329	33.1599	1.8561
68	21.0850	33.4080	4.7553	25.1297	3.0657	6.7990	17.5344	31.1277
69	12.3583	18.2964	13.5505	44.6315	17.9505	14.9462	6.9910	
70	31.3895	47.4312	11.0650	23.6467	4.7344	15.4175	33.7551	

Squared Euclidean Dissimilarity Coefficient Matrix (Cont.)

Case	25	26	27	28	29	30	31	32
71	28.9766	45.5020	5.5858	9.7002	4.4449	23.9928	30.4805	22.0697
72	45.5992	65.9306	14.4478	12.4834	6.5557	28.9758	46.9970	39.3738
73	19.7910	35.9630	27.5162	45.3506	25.9052	30.4068	25.6769	25.3945
74	33.2334	53.8663	5.8892	10.6888	4.0449	18.1050	34.6165	24.6836
75	43.0845	58.2679	9.2104	9.4072	4.3028	25.1942	41.8566	34.6910
76	47.1247	61.1182	18.8370	12.5286	10.7735	35.9522	50.3062	44.1665
77	49.3056	69.8283	26.8279	17.4473	18.8992	47.1967	58.6692	50.7151
78	14.3958	32.8664	18.7159	32.3432	18.1173	29.0427	20.7993	15.1297
79	35.7928	58.0547	14.0922	19.2163	12.8258	30.2243	37.6351	27.7022
80	39.3918	58.5244	34.6604	41.6935	33.8677	49.9333	46.8792	39.2132
81	79.9944	96.8723	90.6154	99.9503	85.6227	92.2281	100.6942	93.1491
Case	33	34	35	36	37	38	39	40
34	1.2114							
35	1.9754	1.4063						
36	2.6045	3.9242	3.7488	5.9807				
37	4.0717	3.3158	1.4976	4.5511	5.0905			
38	5.4732	3.2119	3.2251	3.9181	4.7384	2.4495	9.2923	
39	5.2171	4.6060	2.4129	3.9181	4.5111	5.2036	5.0473	6.0907
40	7.4185	5.5068	8.0827	5.7916	8.8999	6.4835	9.4254	8.0810
41	5.8469	5.7867	6.7156	3.4802	9.6785	8.5167	21.7621	21.5150
42	5.8702	7.4511	8.9329	7.1173	12.4797	19.7814	3.5302	5.3893
43	24.3387	18.1612	15.1264	28.5441	13.7031	3.3132	5.8498	6.2475
44	3.6365	2.3975	2.8500	5.6178	2.6822	6.2060	39.9081	27.6123
45	5.5279	7.6634	8.1610	2.4284	11.0519	35.8639	4.9951	12.8356
46	27.9204	32.7070	36.3082	30.4561	33.4733	4.7228	4.2051	13.6509
47	8.6616	7.1111	5.8039	12.1151	8.9175	4.9476	2.9456	8.2208
48	12.8061	9.5186	6.4143	13.8411	8.1146	3.7785	6.2784	13.5001
49	5.3410	3.2326	1.2659	6.5079	2.8174	5.9905	4.0367	10.4235
50	14.4308	10.2951	7.7895	15.5989	8.1372	4.0107	10.3312	8.3948
51	6.1704	3.9497	3.4560	10.2777	5.8258	11.9514	1.9958	11.2191
52	15.9041	14.2690	14.8850	10.6517	18.6608	4.0758	4.4800	4.8113
53	8.7096	7.7076	5.6125	7.0623	9.9772	22.1630	17.7574	22.5209
54	5.5589	4.0008	5.2400	6.2959	6.2720	16.0805	13.7649	18.6637
55	19.9722	19.9905	17.8510	21.9294	19.2418	12.5091	15.8766	14.4177
56	15.7311	16.5971	14.5636	15.5922	15.8926	21.8626	18.5840	25.6991
57	14.6210	9.6097	11.1080	19.6169	10.7037	66.6139	60.9997	61.5997
58	25.0320	23.1816	21.2730	26.8832	24.8142	31.3063	27.9166	37.5694
59	62.8904	62.0459	64.4894	68.4181	66.6255	13.9461	11.7658	11.1606
60	38.7878	33.6979	31.2502	43.1380	32.4031	7.3644	7.2380	3.8557
61	10.2750	13.3742	13.2333	9.8034	15.4218	10.6902	12.1205	6.1069
62	3.9345	5.5530	7.3569	1.9097	9.5666	40.9999	38.4209	36.2435
63	10.3498	12.6684	14.2441	6.0993	16.6183			
64	38.0887	38.0838	38.3649	38.5919	37.4556			

***** PROXIMITIES *****

Squared Euclidean Dissimilarity Coefficient Matrix (Cont.)

Case	33	34	35	36	37	38	39	40
65	11.0840	11.5828	10.9357	12.3444	14.6105	12.9333	10.2017	13.6830
66	7.6537	12.2774	12.2368	5.7792	17.2248	18.0699	13.7584	19.4537
67	9.0413	11.8702	12.0139	4.8770	18.1676	13.0167	9.2631	12.1510
68	1.6226	3.4369	2.8785	1.8263	5.2448	5.7150	4.4729	6.5021
69	10.5477	7.8907	5.3108	10.1138	3.5470	8.3570	8.6253	8.5056
70	8.2619	12.1452	13.8902	10.1849	19.7243	18.1840	13.4119	16.1386
71	8.9482	8.9733	12.3044	7.3518	17.4362	8.7069	10.3576	6.5069
72	16.4251	21.0645	22.5908	14.1987	26.3030	21.8951	20.9432	15.8606
73	26.7447	23.6443	22.3272	28.7433	27.9757	23.4011	16.7795	29.1182
74	10.7191	12.3117	13.7480	6.4758	18.5096	10.1007	8.7350	8.6496
75	13.0504	16.3841	19.3362	10.5553	25.1595	18.6319	17.4484	12.3281
76	18.8501	22.0615	27.9823	19.6276	33.2867	27.2560	27.8833	16.6386
77	28.6692	30.0057	36.5942	29.5327	42.6526	32.5623	33.3487	23.8394
78	17.6442	14.1355	14.6437	19.1135	17.0035	11.5360	11.8684	14.1771
79	20.5282	20.7750	20.5736	15.8419	24.5073	15.9513	14.9717	15.6727
80	39.3981	36.8660	38.2609	37.5049	42.1458	34.8043	32.0355	29.9426
81	85.5650	83.7588	90.7975	89.4477	91.8742	92.5964	87.7001	75.8425
Case	41	42	43	44	45	46	47	48
42	11.7657							
43	29.1408	32.5182						
44	6.1958	7.9012						
45	5.4954	3.4003	19.0515	7.0325				
46	37.4498	19.2500	36.7556	30.5380	23.5038			
47	13.0348	9.5625	21.0378	5.4448	11.5277	42.1370		
48	13.7587	14.7282	14.7724	6.2409	14.7719	49.5208	2.4380	
49	8.6246	11.2718	10.8470	3.5973	10.9530	44.2926	5.3664	4.0299
50	16.5384	16.4936	14.7970	5.9749	16.8975	52.0179	4.2865	1.1926
51	10.0647	10.1481	16.6107	3.0083	11.8351	42.1224	1.1722	2.7078
52	4.0620	19.0196	32.0646	12.6285	11.2320	51.6762	18.0274	16.4567
53	8.6306	8.5739	25.6410	6.5350	6.7928	46.6384	4.0249	3.9560
54	5.2227	8.8830	23.0649	1.2540	6.9289	36.8879	6.5755	7.6062
55	23.1076	23.7082	33.4230	16.4545	23.5257	59.4984	18.5960	19.1539
56	19.2640	17.0571	34.7209	14.0184	15.7855	44.5991	16.1370	17.3804
57	19.8591	24.8486	16.0419	9.3473	26.0244	59.6793	13.4936	13.6594
58	25.4429	25.2359	35.3182	19.1165	26.1739	67.2508	15.7186	15.9347
59	61.6460	62.3447	85.5901	53.6034	64.5179	99.1024	57.2594	60.7123
60	37.5781	42.4304	34.7422	26.5204	43.9661	85.0678	22.6338	19.4768
61	13.6130	2.8366	38.3621	10.0777	4.3431	20.4297	13.8806	17.5497
62	2.8986	5.6638	32.9184	5.9123	1.8183	24.7838	14.2053	17.3930
63	9.8051	4.5589	41.8592	11.2638	1.6687	20.5580	17.1963	21.0195
64	38.2478	43.8765	56.3966	34.5268	40.7619	66.6280	43.9611	44.1703
65	13.8552	11.1301	31.5648	10.1291	11.7553	45.9732	10.4229	13.1154
66	11.8615	12.8075	47.5562	17.7699	9.0415	38.7145	25.6553	30.4156

Squared Euclidean Dissimilarity Coefficient Matrix (Cont.)

Case	41	42	43	44	45	46	47	48
67	6.0715	8.8111	43.3006	13.9449	4.2149	40.0233	18.1815	21.3547
68	5.0174	4.6200	23.6228	5.2487	3.4098	24.2924	9.6255	12.3674
69	11.7585	19.6559	7.6332	7.0618	16.7596	45.5417	13.8321	9.6930
70	9.9054	7.2645	45.8090	13.1747	7.7534	33.4278	17.1448	23.9896
71	6.6797	5.3969	39.3948	9.3895	4.0830	33.7077	12.5569	16.8846
72	19.0133	6.4174	54.7435	19.8467	7.1597	20.2024	24.6906	30.8606
73	22.1803	26.6644	36.7830	19.2459	27.6490	75.5910	16.3551	14.6233
74	4.9040	7.3497	43.6735	11.1920	2.5717	31.0451	14.9800	17.9994
75	11.8008	6.0239	51.2631	17.2944	5.4011	27.7777	22.6298	28.6910
76	19.2422	9.9220	60.1032	22.0746	12.4445	27.1440	29.1195	38.0340
77	27.7020	17.4157	69.7711	27.6248	20.4655	43.0276	31.6996	40.2365
78	16.9559	16.9321	27.8940	9.6471	17.6232	53.6336	8.7169	8.8833
79	16.4419	14.8932	45.3240	17.5103	11.5115	44.4541	18.5788	19.6359
80	30.9539	36.2796	56.0390	30.2683	33.7432	78.7025	32.2413	32.0208
81	74.2468	89.7143	111.0767	74.8913	86.9890	121.5325	89.4581	92.5442

Case	49	50	51	52	53	54	55	56
50	4.5505							
51	3.1053	3.7605						
52	13.2462	18.8417	15.5380					
53	4.6012	5.5304	4.6176	11.3975				
54	4.7437	6.9377	4.1884	8.3032	5.8134	14.7862		
55	15.9300	17.1733	15.2674	22.3288	16.4850	14.6164	8.6653	
56	14.8410	17.2014	14.8010	22.1455	13.9727	9.2135	17.0229	17.5445
57	8.5115	10.4088	8.7244	23.0460	17.8120	16.9305	5.2501	6.3067
58	17.9836	15.1575	14.3088	22.7757	14.8001	16.9305	19.3336	39.4217
59	61.8625	56.3016	51.5877	55.4099	56.8206	47.8762	11.3617	18.7777
60	25.9378	17.8507	19.6064	32.9606	25.9660	25.1155	19.8597	15.1048
61	14.9387	18.6232	14.5880	18.5571	10.6188	10.2411	22.5340	17.1519
62	10.0289	18.9981	12.1715	8.2254	9.9814	5.1809	28.0181	19.6638
63	16.4187	22.3842	18.0996	13.2964	12.1507	10.1303	10.5988	22.5860
64	39.1052	41.1410	37.2905	37.4915	40.6364	33.5934	3.2416	7.7735
65	10.3517	12.7437	8.7983	15.0646	7.6583	8.3812	30.7117	24.4456
66	17.5458	33.3261	22.9302	23.2245	16.5603	18.3800	21.8634	17.7386
67	14.1593	24.4363	17.1051	9.4828	8.6668	11.4584	21.0632	15.3555
68	5.7751	15.4275	8.1720	12.8385	7.8636	7.1200	20.6281	20.1208
69	3.4856	9.2398	10.0765	14.9029	13.2672	8.8536	22.1264	21.0684
70	17.0890	27.1636	15.6006	16.2714	13.2139	11.3983	23.7332	18.4114
71	13.7108	17.8962	12.0030	10.0997	8.1489	6.9451	24.8341	18.2600
72	26.2407	32.4784	25.4794	23.7912	19.0454	19.3135	15.0492	18.9998
73	18.0388	15.3005	14.0393	19.4810	12.7900	15.6885	23.2364	16.7030
74	15.9026	21.2018	14.9022	6.8453	8.6501	8.9764	27.4605	20.4066
75	22.0270	31.1698	22.3229	15.1556	15.5924	14.6249	32.5362	27.0370
76	30.9620	39.1742	28.0879	22.8791	25.4735	18.6968		

***** PROXIMITIES *****

Squared Euclidean Dissimilarity Coefficient Matrix (Cont.)

Case	49	50	51	52	53	54	55	56
77	37.6393	39.2849	30.6514	27.0600	27.6290	22.1162	25.4091	26.5517
78	11.5445	7.3536	7.3657	15.3420	9.1209	7.4994	8.9388	8.4750
79	20.1070	20.3726	18.9017	14.5065	12.0840	15.0567	14.4022	5.7848
80	33.5822	29.3548	29.2948	21.0854	26.4871	23.0897	10.7566	22.2161
81	87.7773	87.3095	79.2337	62.9930	86.8817	65.0269	42.9226	66.8274
Case	57	58	59	60	61	62	63	64
58	17.3141							
59	51.6822	23.8711						
60	20.3187	5.9701						
61	30.2733	22.8649	22.6435	40.3396	6.8958			
62	21.3424	27.3978	53.8469	44.0199	4.4732	3.2004		
63	30.7973	31.2893	68.2495	51.3246	38.9042	37.7400	44.6030	
64	36.0639	21.5863	16.2135	24.4532	9.8741	12.3015	15.5010	17.7019
65	16.3348	6.2748	27.5714	17.1747	15.3049	8.2481	14.1765	48.4481
66	35.7308	38.7544	78.0587	62.3475	8.8234	4.4606	7.1395	39.6656
67	31.0984	24.9081	60.0615	45.6444	7.5644	2.8629	7.0688	39.1291
68	20.0653	25.7889	66.8208	40.6192	21.6874	13.2998	20.5406	39.7083
69	10.3212	26.2215	70.6647	32.1414	7.0784	6.7032	10.9837	42.0131
70	31.1994	25.9893	51.9547	44.4938	7.5212	4.5547	5.2904	41.5188
71	23.2771	22.4893	55.8042	40.1141	3.5221	10.0813	5.6407	36.4362
72	42.1081	28.7317	54.2824	51.3225	24.8023	28.1608	34.9928	38.5134
73	23.3303	8.0000	33.0677	11.6755	7.1780	3.8389	4.2517	37.3241
74	30.3358	23.0368	55.1954	39.7368	5.3947	5.7854	4.6244	44.0643
75	36.6612	28.8681	59.1026	52.0631	9.0511	11.0845	9.7984	47.7218
76	39.7681	33.8927	54.8838	56.6297	15.4591	20.7474	18.4675	34.7499
77	40.7558	25.2879	31.4895	42.8038	17.1716	18.3375	21.2715	26.0501
78	10.0906	3.7884	30.6177	8.6424	12.3044	14.6415	12.7680	26.3619
79	27.3527	9.4792	40.0803	24.6026	30.1883	32.6719	35.0810	17.3343
80	31.5103	10.4022	12.5797	15.2470	79.2082	76.4258	87.5573	31.7959
81	70.4019	50.7378	12.9808	48.4039				
Case	65	66	67	68	69	70	71	72
66	19.0551							
67	10.6319	5.2676						
68	11.6225	7.4636	6.6109					
69	17.9810	25.3732	22.0093	9.8590	27.3953			
70	10.9818	8.6442	4.9225	7.9943	21.9311	7.5976	9.3815	
71	10.6804	14.2969	5.5385	9.0418	33.7840	9.8560	21.4961	35.5194
72	13.4739	16.4177	9.6084	12.8242	29.7437	21.5790	3.4154	7.8874
73	12.1052	38.0623	23.3569	27.4697	22.9201	7.4007	4.3605	3.6462
74	11.6350	13.3799	3.4787	7.6530	30.5199	4.7337		
75	14.0347	11.5775	4.1862	10.3121				

***** P R O X I M I T I E S *****

Squared Euclidean Dissimilarity Coefficient Matrix (Cont.)

Case	65	66	67	68	69	70	71	72
76	18.9620	21.1210	12.6808	18.1091	39.9242	7.5991	7.6484	6.6244
77	15.4428	33.7637	19.7461	29.3657	49.6479	14.9993	11.9721	11.4919
78	6.3623	34.7477	21.0113	19.1814	18.5853	21.8611	13.3808	24.7583
79	8.7523	25.9834	12.2030	17.5468	27.1267	19.0221	10.8290	11.7258
80	12.0474	50.8809	29.5946	39.3562	39.9542	31.7711	25.5981	31.8984
81	52.5794	100.3892	78.8260	89.9475	90.4737	69.7429	73.7067	77.6802
Case	73	74	75	76	77	78	79	80
74	22.2570							
75	28.9959	4.1449						
76	34.3467	10.5045	2.9858					
77	27.8553	15.0031	10.3676	6.2040				
78	8.0031	15.9367	22.9242	26.3465	20.0947			
79	18.0949	7.9600	12.2823	18.8945	15.7134	8.5572		
80	15.3286	25.1288	31.0053	32.6500	17.3477	11.3955	14.9686	
81	55.8606	72.2205	75.4203	66.1604	44.8037	53.8013	63.2153	24.7406

APPENDIX III

RANK OF CENSUS TRACTS BY SOCIO-ECONOMIC INDICATORS

```

1 0 FILE HANDLE URBANFAS / NAME = 'LANSING DATA A'
2 0 DATA LIST FILE = URBANFAS RECORDS = 1
3 0 /1 TRACT (A7) V01 9-13 V02 15-19 V03 21-25 V04 27-31 V05 33-37
4 0 V06 39-43 V07 45-49 V08 51-55 V09 57-61 V10 63-67 V11 69-73 V12 75-79
5 0 V13 81-85 V14 87-92
6 0

```

0This command will read 1 records from LANSING DATA A1

OVariable	Rec	Start	End	Format
TRACT	1	1	7	A7
V01	1	9	13	F5.0
V02	1	15	19	F5.0
V03	1	21	25	F5.0
V04	1	27	31	F5.0
V05	1	33	37	F5.0
V06	1	39	43	F5.0
V07	1	45	49	F5.0
V08	1	51	55	F5.0
V09	1	57	61	F5.0
V10	1	63	67	F5.0
V11	1	69	73	F5.0
V12	1	75	79	F5.0
V13	1	81	85	F5.0
V14	1	87	92	F6.0

7 0 VARIABLE LABELS
8 0 V01 'TOTAL POPULATION IN 1980'
9 0 V02 'TOTAL HOUSING UNITS IN 1980'
10 0 V03 'MEAN TRAVEL TIME TO WORK'
11 0 V04 'FERTILITY'
12 0 V05 'PCT SCHOOL COMPLETED WITH HIGH SCHOOL GRADUATES'
13 0 V06 'PCT WOMAN AT HOME'
14 0 V07 'PCT POP. EMPLOYED IN AGRICULTURE'
15 0 V08 'PCT POP. EMPLOYED IN CRAFT & OPERATIVE'
16 0 V09 'PCT HOUSING UNITS WITH PUBLIC WATER'
17 0 V10 'PCT HOUSING UNITS WITH SEWER'
18 0 V11 'PCT HOUSING UNITS WITH UTILITY GAS'
19 0 V12 'MEDIAN RENT IN DOLLARS'
20 0 V13 'MEDIAN MORTGAGE IN DOLLARS'
21 0 V14 'MEDIAN VALUE OF HOUSING UNITS'
22 0
23 0
24 0 DESCRIPTIVES V03 TO V14/SAVE

Number of valid observations (listwise) = 81.00


```

27 0 COMPUTE TZV04 = ZV04 * -1.0
28 0 COMPUTE TZV06 = ZV06 * -1.0
29 0 COMPUTE TZV07 = ZV07 * -1.0
30 0
31 0
32 0 COMPUTE TZSUM = SUM(TZV04,ZV05,TZV06,TZV07, ZV08, ZV09, ZV10,
33 0 ZV11,ZV12,ZV13,ZV14)
34 0
35 0 DESCRIPTIVES VARIABLES = TZSUM
36 0

```

Number of valid observations (listwise) = 81.00

Variable	Mean	Std Dev	Minimum	Maximum	Valid N	Label
TZSUM	.000	4.878	-13.06	13.88	81	

```

37 0 SORT CASE BY TZSUM(0)
38 0 LIST VARIABLES = TRACT TZSUM
39 0

```

TRACT	TZSUM
-------	-------

39.01	13.88
17.01	9.20
N202.01	7.48
38.01	6.71
38.02	6.58
43.01	6.23
33.02	5.45
N46.00	5.31
16.00	5.30
17.02	5.12
N49.01	5.02
214.00	4.55
N31.02	4.29
N31.01	4.24
N201.01	4.21
40.00	4.02
34.00	3.99
N49.02	3.86
N45.00	3.74
N48.00	3.68
31.02	3.66
25.00	3.65
N201.02	3.56
202.02	3.53
39.02	3.30
55.00	2.98
41.00	2.33
53.03	2.32
29.01	1.97
N34.00	1.95

TRACT	TZSUM
N53.02	1.93
27.00	1.77
N43.01	1.68
N50.00	1.28
28.00	.94
53.02	.90
22.00	.88
29.02	.75
36.01	.40
53.04	.37
6.00	.01
24.00	-.23
54.00	-.25
10.00	-.35
33.01	-.42
37.00	-.58
26.00	-.63
23.00	-.64
N35.00	-.81
36.02	-.82
9.00	-.83
51.00	-.88
N102.01	-.89
5.00	-.99
N214.00	-1.04
11.00	-1.56
1.00	-1.82
44.03	-1.88
52.00	-2.00
21.00	-2.21
19.00	-2.30
N52.00	-2.74
7.00	-3.44
N55.00	-3.97
N101.02	-4.09
N102.03	-4.12
N102.04	-4.39
3.00	-4.96
20.00	-5.49
8.00	-5.63
N47.00	-5.85
32.00	-6.11
13.00	-6.40
4.00	-6.43
2.00	-7.21
12.00	-7.88
N202.02	-8.08
N111.02	-10.01
N103.00	-10.96
15.00	-11.05
N56.00	-13.06

APPENDIX IV

1950 TO 1980 UA CRITERIA

The Urbanized Area Criteria: 1950-1980

I. The 1950 Urbanized Area Criteria

An urbanized area is an area that includes at least one city with 50,000 inhabitants or more in 1940 or later according to a special census taken prior to 1950 and also the surrounding closely settled incorporated places and unincorporated areas that meet the criteria listed below: ...

The urban fringe of an urbanized area is that part that is outside the central city or cities. The following types of areas are embraced if they are contiguous to the central city or cities, or if they are contiguous to any area already included in the urban fringe:

1. Incorporated places with 2,500 inhabitants or more in 1940 or at a subsequent special census conducted prior to 1950.
2. Incorporated places with fewer than 2,500 inhabitants containing an area with a concentration of 100 dwelling units or more with a density in this concentration of 500 units or more per square mile. This density represents approximately 2,000 persons per square mile and normally is the minimum found associated with a closely spaced street pattern.
3. Unincorporated territory with at least 500 dwelling units per square mile.
4. Territory devoted to commercial, industrial, transportation, recreational, and other purposes functionally related to the central city.

Also included are outlying noncontiguous areas with the required dwelling unit density located within 1 1/2 miles of the main contiguous urbanized part, measured along the shortest connecting highway, and other outlying areas within one-half mile of such noncontiguous areas that meet the minimum residential density rule.

Although an urbanized area may contain more than one city of 50,000 or more, not all cities of this size are necessarily central cities. The largest city of an area is always a central city. In addition, the second and third most populous cities in the area may qualify as central cities provided they have a population at least one-third that of the largest city in the area and a minimum of 25,000 inhabitants. The names of the individual urbanized areas indicate the central cities of the areas.¹

¹An exception to the above central city rule was the inclusion of additional central cities in the regional UA's, such as the 1950 New York Northeastern New Jersey UA.

II. The 1960 Urbanized Area Criteria

An urbanized area is an area that includes at least one city with 50,000 inhabitants or more in 1960, as well as the surrounding closely settled incorporated places and unincorporated areas that meet the criteria listed below.¹

In addition to its central city or cities, an urbanized area contains the following types of contiguous areas, which together constitute its urban fringe.

1. Incorporated places with 2,500 inhabitants or more.
2. Incorporated places with less than 2,500 inhabitants, provided each has a closely settled area of 100 housing units or more.
3. Towns in the New England States, townships in New Jersey and Pennsylvania, and counties elsewhere that are classified as urban.
4. Enumeration districts in unincorporated territory with a population density of 1,000 inhabitants or more per square mile. (The areas of large nonresidential tracts devoted to such urban land uses as railroad yards, factories, and cemeteries were excluded in computing the population density of an enumeration district.)
5. Other enumeration districts in unincorporated territory with lower population density provided that they served one of the following purposes:
 - a. To eliminate enclaves.
 - b. To close indentations in the urbanized areas of one mile or less across the open end.
 - c. To link outlying enumeration districts of qualifying density that were no more than 1 1/2 miles from the main body of the urbanized area.

A single urbanized area was established for cities in the same standard metropolitan statistical area (SMSA) if their fringes adjoin. Urbanized areas with areas with central cities in different standard metropolitan statistical areas are not combined, except that a single urbanized area was established in the New York, NY-Northeastern New Jersey Standard Consolidated Area and in the Chicago-Northwestern Indiana Standard Consolidated Area.

¹There are a few urbanized areas composed of twin central cities. These twin central cities must have contiguous boundaries and constitute, for general economic and social purposes, a single community with a combined population of at least 50,000, the smaller of which must have a population of at least 15,000.

With two exceptions, the names of the central cities appear in the titles of urbanized areas. The central cities of the two regional urbanized areas appear in the title of their respective standard metropolitan statistical areas.²

²The central cities of the New York, NY-Northeastern New Jersey urbanized area are the central cities of the New York, Newark, Jersey City, and Paterson-Clifton-Passaic Standard Metropolitan Statistical Areas. Likewise, the central cities of the Chicago, IL-Northwestern Indiana urbanized area are the central cities of the Chicago and Gary-Hammond-East Chicago Standard Metropolitan Statistical Areas.

III. The 1970 Urbanized Area Criteria

The major objective of the Census Bureau in delineating urbanized areas is to provide a better separation of urban and rural population in the vicinity of the larger cities. An urbanized area consists of a central city, or cities, and surrounding closely settled territory. The specific criteria for the delineation of an urbanized area are as follows:

- 1a. A central city of 50,000 inhabitants or more in 1960, in a special census conducted by the Census Bureau since 1960, or in the 1970 census.
- b. Twin cities; i.e., cities with contiguous boundaries and constituting, for general social and economic purposes, a single community with a combined population of at least 50,000, and with the smaller of the twin cities having a population of at least 15,000.
2. Surrounding closely settled territory, including the following (but excluding the rural portions of extended cities, ...):
 - a. Incorporated place of 2,500 inhabitants or more.
 - b. Incorporated places with fewer than 2,500 inhabitants, provided that each has a closely settled area of 100 housing units or more.
 - c. Small parcels of land normally less than 1 square mile in area having a population density of 1,000 inhabitants or more per square mile. The areas of large nonresidential tracts devoted to such urban land uses as railroad yards, airports, factories, parks, golf courses, and cemeteries are excluded in computing the population density.
 - d. Other similar small areas in unincorporated territory with lower population density provided that they serve
 - to eliminate enclaves,
 - to close indentations in the urbanized areas of 1 mile or less across the open end,
 - to link outlying enumeration districts of qualifying density that are not more than 1 1/2 miles from the main body of the urbanized area.

The central city category consists of the population of the cities named in the title of the urbanized area.¹ The title is limited to three names and normally lists the largest city first and the other qualifying cities in size order. This order is, in many cases, based on 1960 population because most names were fixed before the 1970 counts were available. For other cities to be listed in the title, they must have:

1. 250,000 inhabitants or more.
2. At least one-third the population of the largest city and a population of 25,000 or more (except in the case of the small twin cities).

¹The four exceptions are: New York, NY-Northeastern New Jersey, which includes New York, Newark, Jersey City, Paterson, Clifton, and Passaic; Chicago, IL-Northwestern Indiana, which includes Chicago, Gary, Hammond, and East Chicago; Los Angeles-Long Beach, CA, which includes Los Angeles, Long Beach, Anaheim, Santa Ana, and Garden Grove; and San Francisco-Oakland, CA, which includes San Francisco, Oakland, and Vallejo.

IV. The 1974 Urbanized Area Criteria

The major objective of the Bureau of the Census in delineating urbanized areas is to provide a better separation of urban and rural populations in the vicinity of the larger cities. A UA includes a central city or cities that qualify under one of the criteria listed below. All population criteria refer to 1970 census population counts (except as specified in criterion 1a).

- 1a. A city of 50,000 inhabitants or more according to the 1970 census, a special census taken between 1960 and 1970, or the 1960 census, provided that the city is located in an SMSA and is not included in an existing UA,
- b. A city with at least 25,000 inhabitants which, together with those contiguous places (incorporated or unincorporated¹ having population densities of at least 1,000 persons per square mile, has a combined population of 50,000 and constitutes for general economic and social purposes a single community, provided that the city is located within an SMSA and is not included in an existing UA.
2. In addition to a central city or cities, a UA includes contiguous territory meeting the following criteria:
 - a. Incorporated places of 2,500 inhabitants or more but excluding the rural portions of extended cities.
 - b. Incorporated places with fewer than 2,500 inhabitants, provided that each has a closely settled area of 100 housing units or more; and all unincorporated places recognized in the 1970 census.
 - c. Contiguous small parcels of unincorporated land determined to have a 1970 census population density of 1,000 inhabitants or more per square mile. The areas of large nonresidential tracts devoted to such urban land uses as railroad yards, airports, factories, parks, golf courses, and cemeteries are excluded in computing the population density.
 - d. Other similar small areas in unincorporated territory without regard to population density provided that they serve:
 - to eliminate enclaves, or
 - to close indentations of one mile or less in width across the open end of the UA's in order to eliminate narrow fingers of "rural" areas,
 - to link outlying areas of qualifying density provided that these are not more than 1 1/2 miles from the main body of the UA.

¹Unincorporated places as identified and defined for the 1970 census by the Census Bureau.

3. Urbanized Area Title. The title is limited to three names and normally lists the largest cities in descending order of size. For other cities to be listed in the title of a UA with a central city of 50,000 or more, such cities--
 - a. Must have at least one-third the population of the largest city and a population of 25,000.
 - b. Must have 250,000 inhabitants or more.

For those areas in which the largest city has a population of at least 25,000 but less than 50,000 (criterion 1b), any named city or cities must have a population equal to one-third or more of that of the largest city and a minimum population of 15,000.

Area titles that include the names of more than one city start with the largest city and list other cities in descending order of size according to the most recent census, except that cities that qualify the area under criterion 1b are listed prior to the names of any other qualifying city.

V. The 1980 Urbanized Area Criteria

The following criteria are used to determine the eligibility and the definition of 1980 urbanized areas.¹

Urbanized Area Criteria

An urbanized area comprises an incorporated place² and adjacent densely settled surrounding area that together has a minimum population of 50,000.³ The densely settled surrounding area consists of:

1. Contiguous incorporated or census designated places having:
 - a. A population of 2,500 or more.
 - b. A population of less than 2,500, but having either a population density of 1,000 persons per square mile, a closely settled area containing a minimum of 50 percent of the population, or a cluster of at least 100 housing units.
2. Contiguous unincorporated area that is connected by roads and has a population density of at least 1,000 persons per square mile.⁴
3. Other contiguous unincorporated area with a density of less than 1,000 persons per square mile, provided that it:
 - a. Eliminates an enclave of less than 5 square miles that is surrounded by built-up area.
 - b. Closes an indentation in the boundary of the densely settled area that is not more than 1 mile across the open end and encompasses no more than 5 square miles.

¹All reference to population counts and densities relate to data from the 1980 Census of Population and Housing.

²In Hawaii and Puerto Rico, incorporated places do not occur in the sense of functioning local governmental units. In Hawaii, census designated places are used in defining a central place and for applying urbanized area criteria; in Puerto Rico, zonas urbanas and aldeas are used.

³The rural portions of extended cities, as defined in the Census Bureau's extended city criteria, are excluded from the urbanized area. In addition, in order for an urbanized area to be recognized, it must include a population of at least 25,000 that does not reside on a military base.

⁴The area of extensive nonresidential urban land uses, such as railroad yards, airports, factories, parks, golf courses, and cemeteries, is excluded in computing the population density.

c. Links an outlying area of qualifying density, provided that the outlying area is:

- Connected by road to, and is not more than 1 1/2 miles from, the main body of the urbanized area.
- Separated from the main body of the urbanized area by water or other undevelopable area; is connected by road to the main body of the urbanized area; and is not more than 5 miles from the main body of the urbanized area.

4. Large concentrations of nonresidential urban area (such as industrial parks, office areas, and major airports), which have at least one-fourth of their boundary contiguous to an urbanized area, will also be included.

Urbanized Area Title

The title of an urbanized area includes:

1. The name of the incorporated place with the largest population in the urbanized area.
2. The titles of new urbanized areas qualifying as the result of the 1980 census are determined as follows:
 - a. The name of the incorporated place with the largest population in the urbanized area is always listed.
 - b. The names of up to two additional incorporated places may be listed, with eligibility determined as follows:
 - Those with a population of at least 250,000.
 - Those with a population of 15,000 to 250,000, provided that they are at least one-third the population of the largest place in the urbanized area.
3. Area titles that include the names of more than one incorporated place will start with the name of the largest and list the others in descending order of their population.
4. In addition to incorporated place names, the area title contains the name of each State into which the urbanized area extends.
5. Regional titles may be used to identify urbanized areas with populations over 1 million, in which case only the largest city of the urbanized area is included in the title.

Central Cities

Central cities will be those named in the titles except where regional titles are used.⁵ In such cases, the central cities will be those that would have met the title criteria under items 1 and 2 above.

⁵Only Newark and Jersey City, NJ qualify under this provision.

The Extended City Criteria of 1970 (and 1980)

An extended city is an incorporated place that includes essentially rural territory. A separation of the inhabitants into urban and rural is made by an examination of population density under the following criteria:

- 1. The incorporated place, to be designated as an extended city, must contain one or more sparsely settled areas, each of at least 5 square miles in extent with a population density of less than 100 persons per square mile.**
- 2. The sparsely settled area or areas meeting criterion 1 must total at least 25 percent of the land area of the legal city, or be greater than 25 square miles.**
- 3. The delineation of extended cities is limited to incorporated places within urbanized areas.**

**Source : U.S. Bureau of the Census, Geographic Areas Reference Manual, 1987
Ch.15**

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