THE RELATIONSHIP BETWEEN URBAN DENSITY AND ROADWAY MAINTENANCE COSTS

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ABSTRACT

Urban land-use planning in the U.S. has traditionally been based on the Euclidean zoning model, the separation of land uses. The long-term impacts of this development pattern, often termed “urban sprawl”, have been a continued source of controversy (1). This research determines if expert opinion regarding sprawl’s negative effects, specifically, that regarding the public/ private capital and operating costs of communities, is applicable to the state of Iowa. These costs are defined as expenditures related to the construction of physical facilities in addition to their annual maintenance. This analysis investigates the relationship between transportation maintenance costs and population density; specifically, are the operating costs (the maintenance costs of streets) of local governments lower, if population density is higher? The study also employs a new measure of density, based on area proximate to streets and highways, developed using a geographic information system. The research indicates population density is not strongly linked to the costs of street maintenance; however, there is relatively little variation in density among Iowa communities. The statistical analyses demonstrate the street maintenance costs do not vary inversely with population density in Central Iowa, as one might expect.

INTRODUCTION

Although urban planning existed prior to the 1920's, the Standard Zoning Enabling Act (1922), the Standard City Planning Enabling Act (1928) and the legalization of zoning resulting from the 1926 *Euclid v. Amber Realty* Supreme Court decision facilitated its acceptance as American public policy. Consequently, the Euclidean zoning model of segregated land uses became the basis for land-use planning. In this model, residential land uses are considered the most sensitive to externalities; therefore, other land uses are excluded. Thus, the first suburbs were created to separate residential development from industrial and commercial sites to promote the public health, safety and welfare.

Urban Sprawl

During the post World War II era, rapid suburbanization occurred with the aid of federal policies. Post WW II suburban growth was a response to a number of social, economic, demographic, and technological factors. These factors are the postwar population boom, the increased availability of suburban housing, buyer preference for suburban sites, technological advancements, and the greater use of passenger cars. Federal housing policies contributed to suburban growth as the availability of federally insured low-cost mortgages facilitated suburban homeownership. Federal highway spending, particularly the 1956 Interstate Highway Act, financed the expansion of highways that gave consumers access to these suburban locations (2). Relatively few questioned this new configuration of settlement on the city edge or noticed its impact on urban centers (1). In this manner, low-density suburban residential development became part of the American urban landscape, subsequently becoming the most common form of "urban sprawl."

Other examples include any single use development excluding an attractive and functional mix of land uses i.e., industrial and commercial ribbon or strip, scattered, or leapfrog development (3).

Response to Sprawl

During the expanding economy era commencing in the 1960's, virtually all growth was considered inherently good. Concerns for the efficiency and costs of service allocation received less attention than their importance deserved. The rising costs of services, shortages of financing for capital improvements, and escalated costs of basic energy supplies have reversed these trends. Currently, the causes and effects of urban sprawl are being discussed, far more extensively than in the past.

Growth management is a range of policies designed to control, guide, or mitigate the effects of growth. These policies have become increasingly popular as a response to the ineffectiveness of local land use controls, one of the alleged causes of sprawl (3). Motivations for growth management are based on the principles of sustainability, energy and resource conservation, environmentalism, intergovernmental cooperation, coordination of planning with infrastructure provision, and to control the fiscal, functional, and aesthetic impacts of sprawl (3). Similarly, compact mixed-use developments have been proposed as alternative suburban designs to alleviate the problems of automobile dependence, growing vehicle miles traveled (VMT), and regional traffic congestion. These designs are referred to as neo-traditional communities, urban villages, pedestrian pockets, and transit-oriented developments.

They share the characteristics of increased housing density, alternative travel modes, and a mix of commercial and residential uses (4). Their goal, as well as that of growth management, is a more compact and efficient urban form.

Iowa Context

As a follow-up to a 1976 study, the Institute for Design Research and Outreach (IDRO) at Iowa State University completed a survey (March 3, 2000) of local land use planning by Iowa's county and municipal governments (5, 6). The major findings of the census of land-use planning report, as stated by its authors in the executive summary, are as follows:

- The 1977 report noted the legal issues concerning the 100 cities having zoning ordinances without comprehensive plans, since these communities do not comply with the Iowa Code. This code requires zoning to be based on land-use plans. By 1999, this number had increased to 239.
- Among the cities with comprehensive plans, planning as an essential component to land-use management has decreased. Forty percent of the cities indicated they had revised their zoning ordinances without regard to their long-range plans.
- Within the last decade, More than 120 cities that lacked comprehensive plans annexed adjacent land.
- In general, the more urban (highly populated) the area, the more likely a city or county will adopt land-use planning and regulation; however, over 40 percent of the cities within metropolitan counties still lack long-range plans.
- County governments have increased planning and land-use management; twenty-five additional counties adopted comprehensive plans between 1976 and 1999. However, like cities, counties also have discrepancies between land-use plans and zoning ordinances i.e., only 44 percent of counties base revisions of their zoning statutes upon guidance provided by the comprehensive plan.
- Adoption of sign regulations, flood-plain regulations, and zoning ordinances increased significantly among counties between 1976 and 1999. The number of counties regulating the subdivision of land also increased during this period.

In summary, the condition of planning among Iowa's municipalities has deteriorated in the 23-year interim between studies; conversely, the level of planning activity at the county level has improved dramatically. Iowa Counties employ professional planning staffs more often than cities, primarily in the form of Councils of Government (5).

THE PROBLEM

A problem with unplanned growth is its impact on infrastructure costs and provision. Often, growth occurs in areas where the extension of physical utilities is less suitable (other sites may be less costly due to proximity) than other potential locations. The results are increased user fees in an average cost pricing system since the costs of extension are distributed on a per capita basis. This is claimed to be a negative fiscal impact of sprawl development.

In The Costs of Sprawl-Revisited, Robert Burchell et. al. define the public capital and operating costs of sprawl as those costs related to the construction of roads, water and sewer infrastructure, and public buildings, in addition to the annual costs of maintenance for these physical facilities (1). Higher infrastructure costs is alleged to be a negative impact of sprawl. The reasoning is that at lower urban densities or with inefficient urban form linear infrastructure serves a smaller portion of development than it could at higher densities or more efficient urban configurations (1, 7). The objective of this study is to discover if the maintenance costs of streets is lower, if population density is higher. In brief, are the two inversely related?

THE APPROACH

The objective of this Study is to discover, through case studies, if the literature regarding sprawl's negative effects accurately reflects conditions in the state of Iowa. The research investigates the relationship between population density, urban form, and transportation maintenance costs. The outcome is intended to aid the evaluation of urban growth in the state and its fiscal effect(s) on local governments. A prominent inverse relationship between maintenance costs and population density was expected. This would have been reflected by a declining 45-degree angle trend line; however, what we discovered in Central Iowa is illustrated below in figure 1.

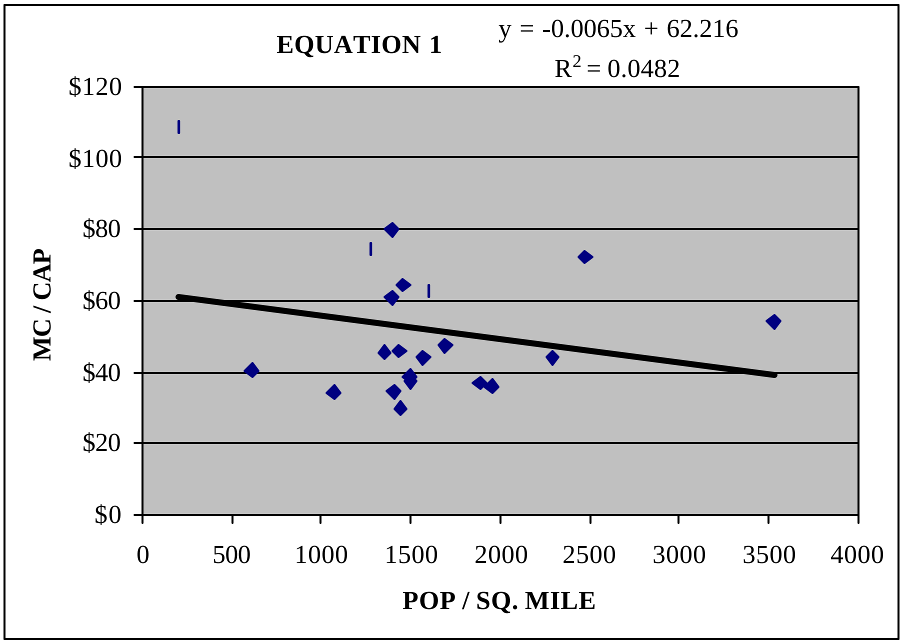

FIGURE 1: Maintenance cost and population density relationship in Central Iowa

The transportation maintenance expenditures of twenty-one selected cities within a nine-county region in central Iowa were studied (see figure 2 for the study area map). The study period is 1988-1998. Most of the selected cities were urban places (>5000 population) in 1998; however, in three cases, places under 5000 population were included. In Dallas and Madison Counties, the largest city is the county seat; therefore, Adel and Winterset have been included. The other exception is Pleasant Hill, which is included as part of the Contiguous Polk County metropolitan area. The selected cities and their respective 1998 populations are as follows:

Adel	3988
Altoona	9567
Ames	48415
Ankeny	25086
Boone	12754
Clive	11125
Des Moines	191293

Indianola	13023
Johnston	6906
Knoxville	8164
Marshalltown	25201
Nevada	6126
Newton	15371
Norwalk	6678

Pella	9525
Perry	7301
Pleasant Hill	4868
Urbandale	27907
West Des Moines	42333
Windsor Heights	4977
Winterset	4685

A longitudinal study of the twenty-one-selected cities was conducted to study the relationship between street maintenance costs, population density, and urban form over time. A categorical analysis of the twenty-one cities for a one-year period (1998) was performed to discover their individual compactness vs. cost relationships for maintenance costs per capita. This examination provides a context for evaluating the growth of Iowa cities and is intended to aid future research on Iowa land use planning.

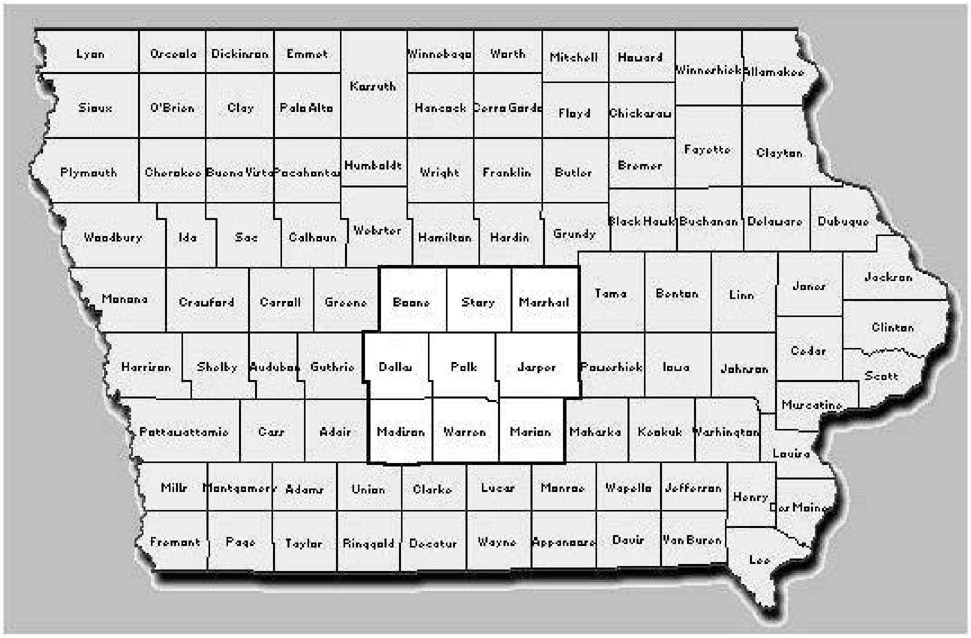

FIGURE 2: Nine-county study area in Central Iowa

Data

Data were collected on the population of cities, transportation maintenance expenditures for cities, and the number of lane miles for cities, from 1988-1998 (even years). The limitation to this decade reflects the availability of the cost data, Iowa DOT Street Finance Report RUT-2A:

Maintenance Costs for Street Purposes. These records are not available prior to 1988 or following 1998. The Iowa DOT also furnished the number of lane miles per city for the study period. Population estimates were obtained from the U.S. Census Bureau.

Standards of Measure

Data were analyzed to determine the rank of each city in maintenance costs per capita, and lane miles per capita, typically inversely related to population density. Low-density development typically requires a larger investment in transportation infrastructure. According to Burchell, the result should be higher maintenance costs. (1). The lane miles per capita measure is employed in this study. Other measures of population density utilized are the traditional population per square mile and a proposed measure, "Buffered Area Density". The new measure is insensitive to open space variability among cities and better reflects the actual housing density (lot sizes) in the study region. The shape index, a measure of city form efficiency, compares the city perimeter to its area. The most efficient form, that is, the one with the lowest ratio of area to perimeter, is the circle. For comparison, the circle has a shape index of 1; a square has a shape index of 1.13. For a given area, the more efficient the form, the less distance urban infrastructure is required to traverse, resulting in decreased costs. Differently stated, the shape index is a comparison of the measured perimeter to the minimum possible perimeter for the same area.

New Density Measure-Buffered Area Density

Street buffers were created in GIS Arc View version 3.2 based on the street networks obtained from the Iowa Department of Transportation. Four buffer sizes, 100 feet, 125 feet, 150 feet and 175 feet were applied to the street networks of nine sample cities and used as inputs to regression analysis. The 100-foot buffer produced the best results (R Square) and was subsequently applied to the remaining street networks. The goal of the buffering process was to capture all development adjacent to streets. According to the Ames City Assessor's Office, pre-1945 lots are approximately 1/8 acre or roughly 75-foot square in size. Most contemporary lots are between ¼ and ½ acre depending on land value, neighborhood, and city in Iowa. This equates to lot lines offset roughly 100-foot from the streets. Once the 100-foot buffers were constructed, the total buffer area for each city was calculated. The street area quantities were divided by the appropriate city population to determine population per buffered street area or buffered area density, the new density measure.

Data Manipulation

The Iowa DOT Street Finance Report RUT-2A contains municipal street maintenance cost data. These financial reports consist of five expenditure categories: Roadway Maintenance (the largest expense), Snow and Ice Removal, Storm Sewers, Traffic Services, and Street Cleaning. For this study, these expenses were combined to determine aggregate street maintenance costs per city on an annual basis for combination with lane mile and population figures. With these data, it was a simple matter to determine lane miles per capita (LMC) and maintenance costs per capita (MCC). For the study period 1988-1998, even years were analyzed to establish six data points for trend evaluation. Since RUT-2A cost data were unavailable for 1990, 1989 and 1991 were averaged on a categorical basis, and then totaled to determine aggregate 1990 costs. Population estimates for the off-census years were obtained from the Census Bureau. As the 2000 census data has yet to be released, the late 1990's estimates may be inaccurate.

1998 CATEGORICAL ANALYSIS RESULTS

Results are presented in two stages. First, the outcome of the 1998 categorical analysis is discussed. This discussion evaluates the utility of the three density measures, population per square mile, buffered area density, and lane miles per capita as well as the urban form efficiency measure (shape index) for the twenty-one selected cities. These results are then compared with maintenance costs per capita rankings for the same year (1998). Secondly, the longitudinal study of the selected cities compares maintenance costs with the city density and growth for the same period. The primary tool employed in this time series analysis is percent change for the study duration 1988-1998.

Population Per Square Mile

The categorical analysis did not reflect a strong relationship between maintenance costs and density; however, in individual examples, a link was observed using the population per square mile measure. The City of Johnston ranks as the least dense of the twenty-one-selected cities. It also has the highest expenditures in maintenance costs per capita. In this case, the results support the hypothesis that low-density development equates to higher maintenance costs. Refer to figure 3 for the results of the population per square mile density measure in comparison with other urban measures and figure 4 for maintenance costs per capita (MCC).

CITY	POP/SQ. MI	POP/BUFAREA	LN MI / CAP	SHAPE INDEX
Adel	1276	7229	92.87	11.1619
Altoona	1394	5949	102.73	17.7423
Ames	2290	7957	124.54	34.5795
Ankeny	1497	5636	99.27	29.0736
Boone	1435	3739	63.70	22.9875
Clive	1689	5660	83.93	21.4416
Des Moines	2472	7925	97.68	71.6022
Indianola	1441	6134	100.92	20.4255
Johnston	202	6782	73.99	21.5133
Knoxville	1885	4278	77.89	15.7823
Marshalltown	1394	7501	74.68	30.8719
Nevada	1457	5717	72.43	14.8584
Newton	1498	5701	71.57	24.5267
Norwalk	1071	8784	107.69	14.3327
Pella	1403	6912	83.12	18.1862
Perry	1952	7408	72.81	15.4455
Pleasant Hill	611	7204	60.59	16.9495
Urbandale	1569	7978	91.50	30.2033
West Des Moines	1600	6308	99.50	36.0256
Windsor Heights	3529	5313	98.93	12.1312
Winterset	1353	4604	68.15	12.3625

FIGURE 3: Urban measure summary for selected cities

However, the most compact city (population per square mile), Windsor Heights, has higher per capita costs than half of all cities. If the hypothesis were correct, the order of cities in MCC would correspond inversely with that of the population per square mile density measure. In other words, the cities would appear in reverse order, the least dense being the most expensive. While this is true for the City of Johnston, the remaining cities do not follow this pattern. In general, the regression and plots indicate practically no relationship between population density and road maintenance cost.

Buffered Area Density

The buffered area density measure reflects the predominant lot sizes of the city, including commercial, industrial and residential areas. For this study, these are treated in aggregate; moreover, no distinction is made between these three land-use types. The results indicate the City of Norwalk has the greatest concentration of population within the 100-foot buffered area. In the costs rankings, Norwalk has the second lowest maintenance costs per capita, which supports the hypothesis. The least dense city, Boone, is average in costs per capita. With the exception of Norwalk, the cities do not illustrate a logical pattern in their cost/ density relationship. Clearly population density, as measured by buffered area, has only a very weak relationship with maintenance costs.

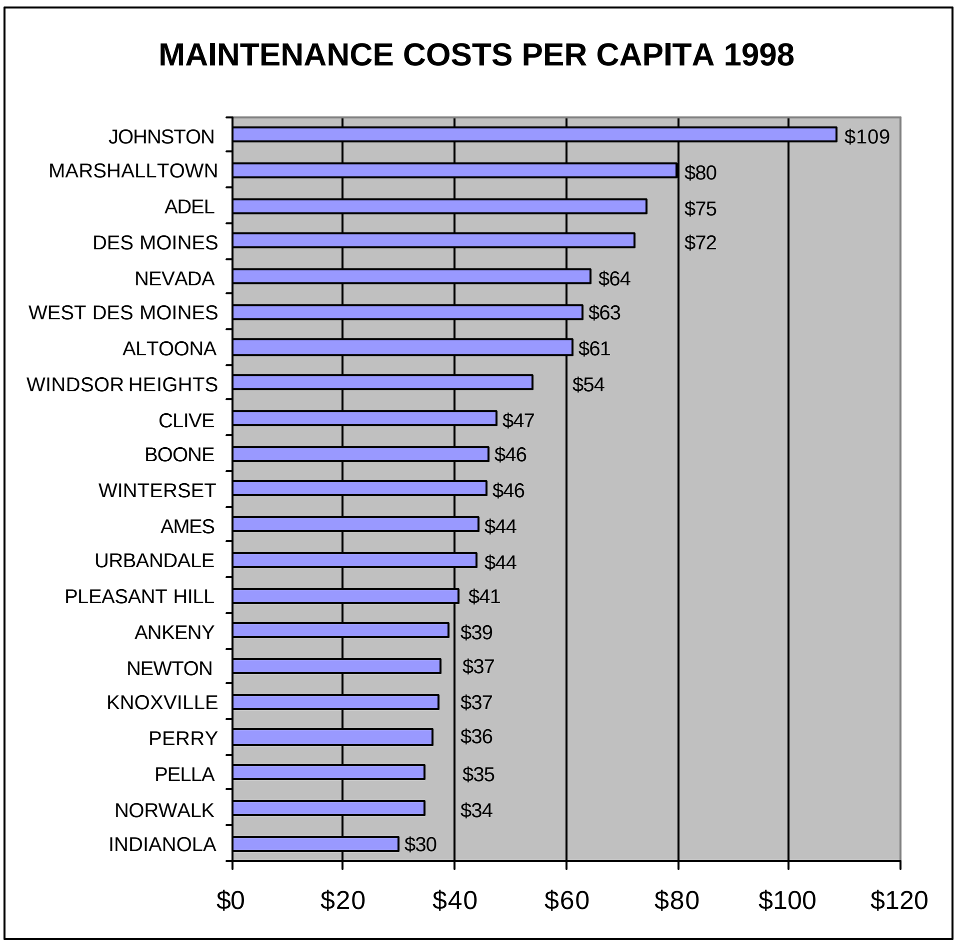

FIGURE 4: 1998 Maintenance costs per capita for selected cities

Lane Miles Per Capita

Burchell contends that population density and lane miles are inversely related; as density decreases, lane miles increase, resulting in higher capital and maintenance costs for linear infrastructure. According to his thesis, cities with the lowest lane miles per capita values (higher densities) would have the lowest maintenance costs. This density measure does not support this conclusion. However, the city of Pleasant Hill has the least lane miles per capita yet roughly average maintenance costs per capita. Pleasant Hill should rank very near the bottom, assuming the Burchell hypothesis is correct. While the City of Johnston has the most expensive maintenance costs, it is above average in the lane miles per capita density measure. In other words, while it is more dense than average by this measure, it has the highest maintenance costs.

Similarly, Ames has the most lane miles per capita, equating to the least density; however, maintenance costs are average. Therefore, this density measure supplies little evidence supporting the hypothesis. Clearly, if there is a strong relationship between density and maintenance cost, other variables account for the cost fluctuation observed in the Iowa cities.

Shape Index

The measure of urban form efficiency, the shape index, is a calculation based on the measured perimeter to the minimum possible perimeter for the same area. It is independent of population. Ames is the least efficient by this measure, West Des Moines, the most. Des Moines is fourth most efficient. The City of Adel ranks third overall; Windsor Heights ranks second. In terms of urban efficiency, the Cities of West Des Moines, Windsor Heights, Adel and Des Moines should have the least expensive maintenance costs with Ames having the most. By referring to the maintenance costs chart, we see this is not the case. In MCC, Adel is third; Des Moines is fourth, West Des Moines is sixth and Ames is twelfth most expensive of the twenty-one total, all contrary to their urban configurations. The measure does not support the hypothesis. In fact, there appears to be a weak positive relationship between the shape index and street maintenance costs.

Regression Analysis

Initially, univariate regression was employed to determine the correlation (R square) between three dependent variables: maintenance cost per lane mile per capita, maintenance cost per lane mile, and maintenance cost per capita, with forty-eight independent variables in various combinations. Plots were created from the output of each of the forty-eight equations to view the relationships. Regression was then performed on nine sample cities:

Adel, Ames, Ankeny, Boone, Johnston, Marshalltown, Newton, Norwalk, and Winterset. The goal-to determine which buffer size (100’, 125’, 150’, and 175’) was the most appropriate measure. Plots from the first regression were utilized to assist this selection. The first analysis is titled “regression,” the second analysis, “regression 1”. Regression 2 consisted of the remaining eleven cities omitted in the original sample. Regression 3 began the multivariate analyses and buffer size was restricted to buffer 100 as per results of the first three analyses. Regression 4 was multivariate, including the three dependent Y variables individually with all possible combinations of the independent X variables. Regression 5, a univariate, consisted of one Y variable, maintenance costs per capita, with four explanatory variables, the density and shape index calculations. Scatter plots were constructed for this final regression to determine the correlation of the density measures and form factor (shape index) with maintenance cost data. Hence, only maintenance cost per capita figures were used. At this point, a stepwise regression was conducted in statistical analysis software (SAS) to determine the optimum combination of the explanatory (X) variables with the response (Y) variables. The SAS procedure was labeled regression 6. The stepwise regression analysis, regression 7.xls, is a test of the stepwise regression completed in SAS. In regression 7, as well as regression 5, the model equation was utilized to estimate the dependent variable Y. In both cases, these estimates of response variables were compared with the actual maintenance costs on the “plots” pages. None of these seven regression analyses resulted in a model of predictive value. In this exercise, no evidence was discovered for the inverse relationship between maintenance costs and the urban measures employed. Although regressions 1, 3, 5, and 7 yield R squared results over 0.5, this phenomenon was caused by collinearity among the explanatory variables rather than a strong relationship per se. None of the density measures were strongly linked to maintenance costs in this study.

1988-1998 LONGITUDINAL STUDY RESULTS

A longitudinal study was conducted to compare the maintenance costs changes (adjusted for inflation) with those in two density measures, population per square mile and lane miles per capita. Physical growth during the period is expressed as changes in urban population and city area in square miles. Categorical shifts are presented as percent change for the study period 1988-1998. Since 1988 population is a census bureau estimate, the city area growth and percent change in population per square mile utilize 1990 census totals as a starting point to improve accuracy.

1990-1998 Population Per Square Mile

For the study period, the majority of cities decreased in population density. Only five of the twenty-one selected cities increased density by a substantial amount (see figure 5 for percent change in population per square mile). These cities, in descending order of percent change, are as follows: Adel, Clive, Indianola, Ankeny, and Boone. Adel, which did not annex land during the study period, increased its population density by 21%. Clive, Indianola, Ankeny, and Boone increased by 8%, 6%, 6%, and 2% respectively. The remaining 15 cities decreased in population density; Johnston had the greatest decline at 40 percent linked with the greatest expansion, 20.3 square miles area increase (refer to figure 6 for area growth during study period. Depending on the accuracy of the 1998 estimates, the trend is toward decreased density resulting in more land area consumed per capita.

1988-1998 Lane Miles Per Capita

The results of this density measure are contrary to the previous. The most notable difference is that of the City of Adel; while it increased in density according to the population per square mile measure (21%), it decreased a similar amount (20%) according to this density measure. As earlier noted, the lower the lane miles per capita, the more dense the city in comparison with others. Obviously, both measures cannot be true in their representation of population density. Second in percent increase (decreased density) for the period is Johnston (18%), which is plausible since it has substantially increased its city area for the duration. It is possible that Adel had a significant area of unimproved land contained within its urban area, and therefore, is now developing it to accommodate a 24% population increase for the decade. However, this does not explain the contradiction in density measures. In similar contrast, most selected cities decreased lane miles per capita for the study duration, the City of Norwalk having the greatest change (-33%). The trend, according to this density measure, is toward increased density. The contradiction in density measures is obvious.

1988-1998 Population Change

The majority of cities gained population during the period; only three cities lost residents, Windsor Heights -3.04% (-156 people), Des Moines -.76% (-1457 people), and Knoxville -.61% (-50 people). Johnston has the greatest percentage gain of new residents, 61% or 2621 people. Clive was the location of the second highest proportional growth, 55% or 3943 people. The percent change is expressed in relation to the 1988 city population; this can be misleading in terms of the actual numerical change, as the previous example indicates. The greatest numerical increase occurred in West Des Moines with 12593 new citizens. Ankeny and Urbandale follow with

7215 and 5533 new community members. Clive, Altoona and Johnston complete the top six in numerical growth. The top seven in percentage growth, in decreasing order of change, is as follows: Johnston, Clive, West Des Moines, Ankeny, Altoona, and Pleasant Hill. Population growth in the study area occurs most rapidly in the Des Moines metropolitan area. West Des Moines had the greatest numerical gain, as opposed to the greatest percentage gain of Johnston.

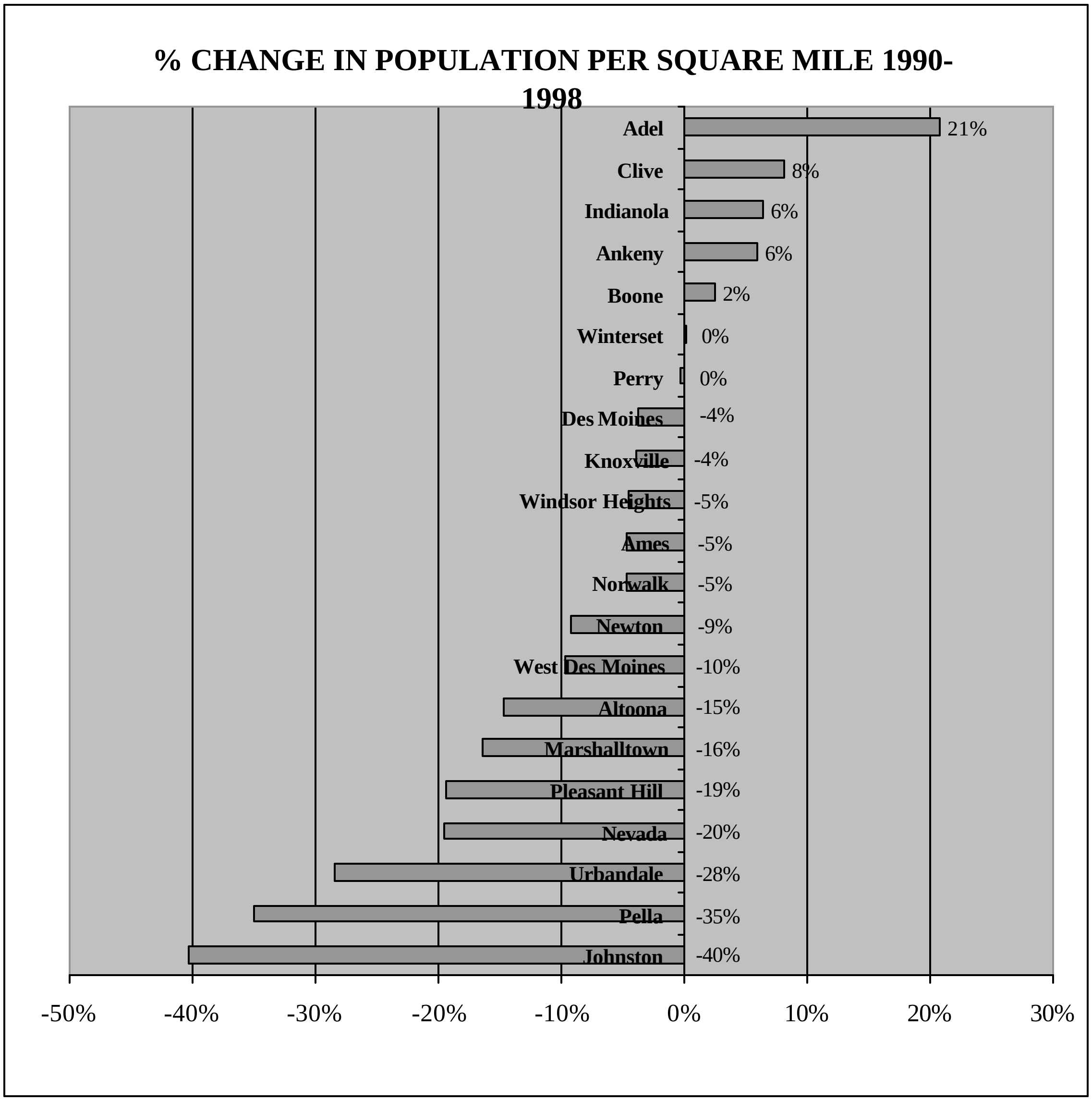

FIGURE 5: 1990-1998 percent change in population per square mile

1990-1998 City Area Growth

The cities with the greatest population increase are also the locations of the most active annexation. Johnston greatly exceeds the remaining selected cities in area growth with over 20 square miles. West Des Moines, Urbandale, Ankeny, and Pleasant Hill follow with 8.55, 7.06, 3.6, and 3.11 square miles respectively. It appears these cities are growing and decreasing in density. The top five cities in growth were again in the Des Moines Metropolitan area. Adel did not grow spatially; Knoxville, Boone, and Windsor Heights had nominal gains. The majority of cities grew; the average growth was 2.9 square miles with Johnston included in the calculation. Without Johnston, the average growth was 2.03 square miles. Most cities are growing at a moderate rate.

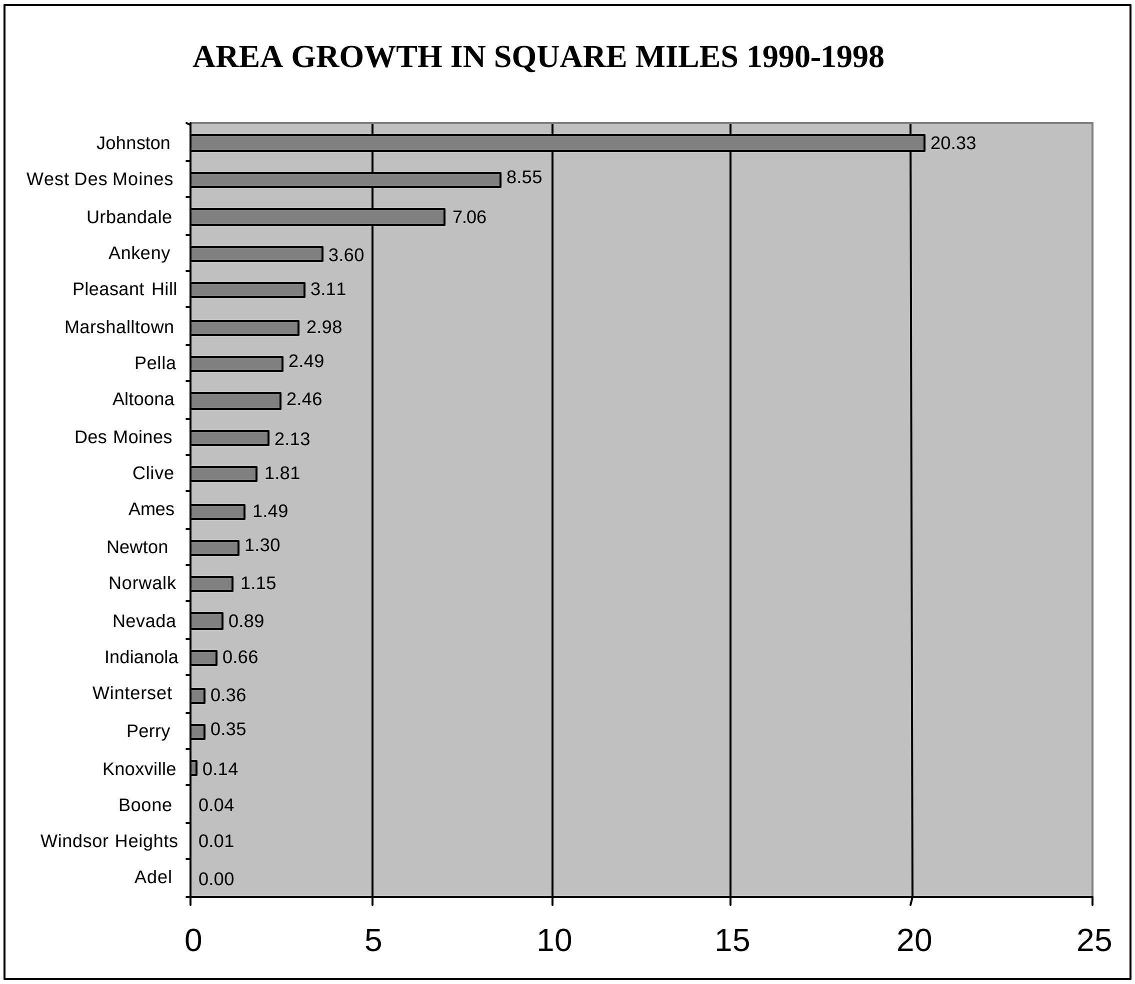

FIGURE 6: 1990-1998 city area growth in square miles

Lane Miles

The changes in total lane miles for the for the study period also provide evidence for the Des Moines Metropolitan area's high growth. The greatest numerical increase in lane miles occurred in West Des Moines (142) with Des Moines (115), Urbandale (102), Ankeny (94), and Clive (72) completing the top five. Expressed as percent change, the order converts to Clive, Norwalk, Pleasant Hill, Altoona and Ankeny. The City of Johnston is anomalous with only a 37% or 25-mile increase, despite its exceptional area growth. It is clear that most of Johnson's annexed area remains undeveloped. The largest growth in lane miles occurred in Des Moines and its suburbs although the City of Des Moines lost 1457 residents for the period. West Des Moines, Urbandale, Ankeny, Clive and Altoona had the greatest gains in population, which corresponds to lane mile increases. Collectively, cities gained lane miles and population simultaneously with the exception of Des Moines, the urban core.

1988-1998 Maintenance Costs

Percent change in aggregate maintenance costs for the period is led by the City of Pleasant Hill (89%) with West Des Moines (81%), Johnston (70%), Norwalk (53%), and Altoona (52%) in the top five. Windsor Heights, Clive, and Pella closely follow with 50%, 49%, and 47%. Adel (-46%), Knoxville (-21%), and Ames (-12%) had the only decreased costs for the period. These three cities also had the greatest decrease in per capita costs expressed as percent change in figure 7. This pattern of the decrease in maintenance costs for three cities also applies to the three of greatest increase. Pleasant Hill, Johnston, and West Des Moines had the greatest increases in terms of total maintenance costs and maintenance costs per capita.

DISCUSSION

It is plausible to connect the greatest gains in lane miles, as infrastructure investment, with area growth, and population increases. In other words, these municipalities have the most rapid growth. Johnston, West Des Moines, Urbandale, Ankeny, Clive, and Pleasant Hill are examples of cities with high growth for the period. The City of Windsor Heights, however, is unique in this respect. Although it had large increases in maintenance costs for the period, its increase in lane miles was disproportionately low and the city actually lost population for the period. Environmental factors may account for some of this anomaly although this increased maintenance cost due to snow and ice removal would likely appear across the board.

There are many other plausible explanations. While winter maintenance and roadway repair standards exist at the state level regarding primary highways; a similar municipal counterpart is lacking. Therefore, it is possible that Windsor Heights has a more aggressive winter maintenance policy; for example, it starts plowing before much snow accumulates as compared to other cities. Windsor Heights also may have a more aggressive level of roadway maintenance; i.e., it repairs the streets more quickly before they become as distressed (as other cities). Another explanation is the age of the streets; older streets obviously require more maintenance. Therefore, older cities or cities with a higher level of deferred maintenance could have higher costs during the study period. This statement implies that fluctuations in city budgets are a factor in the variability of costs. The less money allocated annually for maintenance, the fewer repairs are completed. While collectively the study cities are decreasing population density, this can be partly attributed to consumer preference for large suburban lots.

With this view, increasing income or prosperity coupled with individual choices has an effect on street maintenance costs. The majority of selected cities are increasing in size or experiencing population growth, some just more rapidly. This growth affects maintenance costs by increasing traffic flows on municipal streets. Higher levels of traffic, and more importantly, the traffic composition (i.e. the number of trucks hauling material to support new infrastructure construction) have a large impact on street degradation. Maintenance costs are composed of five categories: roadway maintenance, snow and ice removal, storm sewers, traffic services, and street cleaning. New construction costs should not appear in these categories. Gains in lane miles, as new construction, would not have high road maintenance (the largest expense), storm sewer, or traffic services costs. Accounting practices can also explain some variability in maintenance costs. It is possible that costs are being misallocated to stretch the budget priorities. Street cleaning appears to be done as the funding allows; some cities had no entries in this budget category. Any one or combination of, the above possibilities can explain the variability in maintenance costs for the period.

Density Measures

As the results indicate, the lane miles per capita measure contrasts with the population per square mile criterion. The selected cities cannot be increasing and decreasing aggregate density during the same period. Of the two measures, the results of the population per square mile standard are favored. The lane miles per capita density measure appears flawed. The proposed density measure, buffered area density, has results somewhat similar to the population per square mile measure. In fact, it should be different since it excludes open space in the calculation. However, since density has been found to have little correlation with maintenance costs in Iowa, it is difficult to predict the accuracy of this new measure. In summary, none are a good predictor of maintenance costs in central Iowa cities.

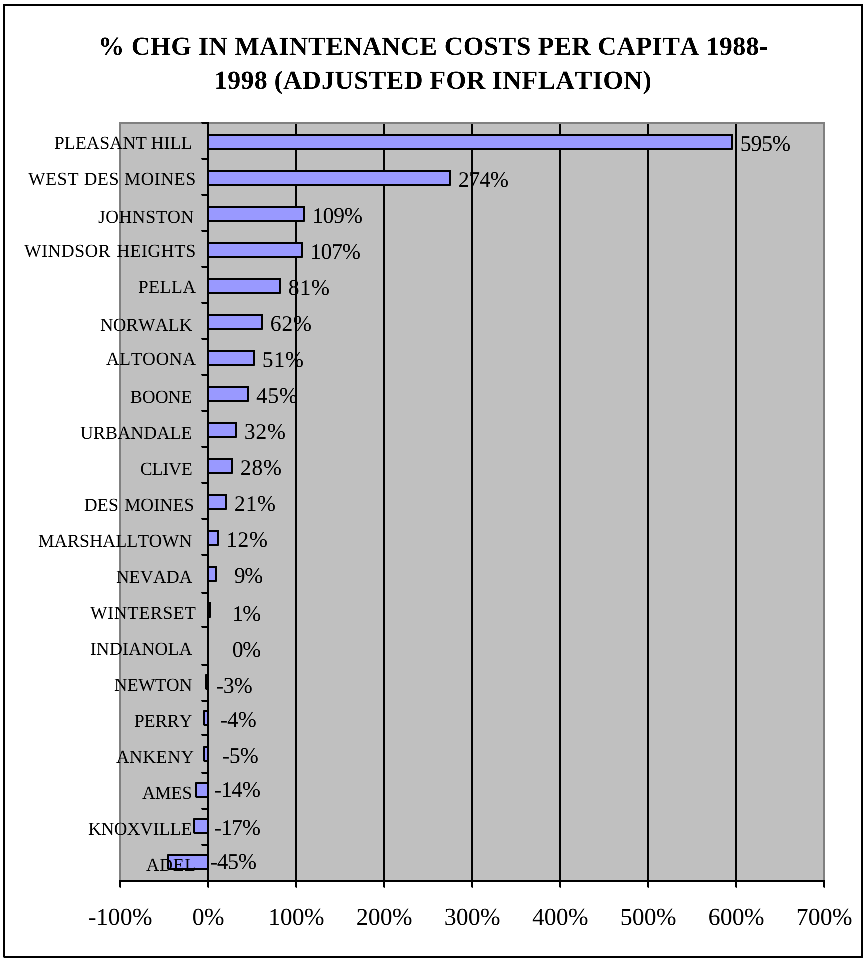

FIGURE 7: 1988-1998 Percent Change In Maintenance Costs Per Capita

Density And Maintenance Costs

The range of development densities in Iowa is not great. When compared with other national and international cities, Des Moines, the Iowa capital, is less dense than all others. A comparison of 1980 populations per square mile between national and international cites (8) follows:

Boston	3127	Melbourne	4269
Chicago	4526	New York	5559
Copenhagen	7881	Phoenix	2199
Des Moines	2190	San Francisco	4011
Detroit	3650	Sydney	4547
Houston	2300	Toronto	10257
Los Angeles	5188	Washington	3425

For longitudinal comparison, Des Moines' population density increased from 2190 to 2567 in 1990, and was estimated at 2472 population per square mile in 1998. Furthermore, all cities analyzed in Central Iowa have a rather similar density profile and layout (shape index). Therefore, there is little variation in density to help explain cost fluctuation.

In Iowa, the operating costs of local governments, as expressed in street maintenance costs, are NOT lower when population density is higher. An inverse relationship between the two does not exist. After review, numerous factors other than density and urban form play a major role in the variation of maintenance costs among cities. These factors include local winter and roadway maintenance policies, annual fluctuations in city budgets, individual accounting practices, consumer affluence and preferences, and traffic levels/ composition.

Much of the variation in simple population density among Iowa communities was eliminated with the buffer approach. This indicates that some of the cities in Iowa have large extents of low-density land uses such as parks, golf courses, cemeteries, soccer/ baseball/ football fields and green belts. These land uses are amenities that contribute little to the costs of maintaining a road network; however, they do significantly add to community quality of life.

Policy Implications

Operating costs vary for a variety of reasons, including local preferences and municipal policies. Such variation is not captured in this analysis. In the sort of city configurations common to Central Iowa, density does NOT appear to influence costs in a significant manner. Community leaders, land use planners, and transportation planners in Iowa should not be overly focused on population and development density as levers for influencing transportation costs. Much higher densities of development (as in older US major metro areas or European “walking cities”) would be needed to realize the economies of density that authors such as Burchell have previously found. Such high densities would be very difficult to develop in the majority of Iowa cities given their current configurations, and transportation systems, which are heavily auto-oriented.

Recommendations For Future Study

Whereas this study explored the connection between urban density and operational cost efficiency, capital expenditures (construction costs) could reveal a better density link. An approach of this nature, including better cost data, is recommended. If possible, population estimates should be avoided. However, since such few new road miles are being constructed (as compared to total lane miles) this may also reveal a weak relationship.

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