A GUIDEBOOK FOR EVALUATING THE INDIRECT LAND USE AND GROWTH IMPACTS OF HIGHWAY IMPROVEMENTS

Appendices
SPR 327

A GUIDEBOOK FOR EVALUATING THE INDIRECT LAND USE AND GROWTH IMPACTS OF HIGHWAY IMPROVEMENTS

Appendices

SPR Project 327

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16. Abstract

In 1998, the Oregon Department of Transportation undertook a study of the impacts of highway capacity improvements on land uses and growth, particularly at the urban fringe. The objective was to better understand the "cause and effect" relationships among highway capacity, travel demand and development patterns. A variety of factors to resulting growth were evaluated for their ability to predict growth. Case studies of six communities provided an in-depth understanding of the pressures which drive development decisions and land use change.

This guidebook provides guidance to ODOT staff for completing environmental analysis and documentation on indirect land use impacts of highway improvements, based on findings of the study. One finding was that most highway capacity increases do not cause development to be dramatically different from local land use plan guidance, or from what would have occurred in absence of the highway improvement. In Oregon, local governments hold the tools to determine development patterns, using zoning and public utilities such as water, sewer and roads.

This guidebook is not a directive, but a compilation of recommendations for a systematic look and consistent approach to predicting the indirect land use impacts of highway improvements. Appendices A-F of this report provide background on the study findings, including the literature review, growth trends analysis and six in-depth case studies. Also included in the appendices are a discussion of population and employment forecasting issues and a summary of ODOT processes for project evaluation.

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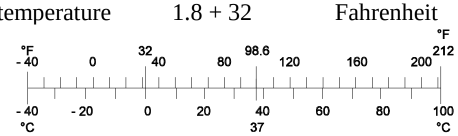
SI* (MODERN METRIC) CONVERSION FACTORS

APPROXIMATE CONVERSIONS TO SI UNITS

Symbol	When You Know	Multiply By	To Find	Symbol
		LENGTH		
In	Inches	25.4	Millimeters	Mm
Ft	Feet	0.305	Meters	M
Yd	Yards	0.914	Meters	M
Mi	Miles	1.61	Kilometers	Km
		AREA		
in^2	Square inches	645.2	millimeters	mm^2
ft^2	Square feet	0.093	meters squared	M^2
yd^2	Square yards	0.836	meters squared	M^2
Ac	Acres	0.405	Hectares	Ha
mi^2	Square miles	2.59	kilometers squared	Km^2
		VOLUME		
fl oz	Fluid ounces	29.57	Milliliters	ML
Gal	Gallons	3.785	Liters	L
ft^3	Cubic feet	0.028	meters cubed	m^3
yd^3	Cubic yards	0.765	meters cubed	m^3
NOTE: Volumes greater than 1000 L shall be shown in m^3.				
		MASS		
Oz	Ounces	28.35	Grams	G
Lb	Pounds	0.454	Kilograms	Kg
T	Short tons (2000 lb)	0.907	Megagrams	Mg
		TEMPERATURE (exact)		
°F	Fahrenheit temperature	5(F-32)/9	Celsius temperature	°C

APPROXIMATE CONVERSIONS FROM SI UNITS

Symbol	When You Know	Multiply By	To Find	Symbol
		LENGTH		
mm	Millimeters	0.039	inches	in
m	Meters	3.28	feet	ft
m	Meters	1.09	yards	yd
km	Kilometers	0.621	miles	mi
		AREA		
mm^2	millimeters squared	0.0016	square inches	in^2
m^2	meters squared	10.764	square feet	ft^2
ha	Hectares	2.47	acres	ac
km^2	kilometers squared	0.386	square miles	mi^2
		VOLUME		
mL	Milliliters	0.034	fluid ounces	fl oz
L	Liters	0.264	gallons	gal
m^3	meters cubed	35.315	cubic feet	ft^3
m^3	meters cubed	1.308	cubic yards	yd^3
		MASS		
g	Grams	0.035	ounces	oz
kg	Kilograms	2.205	pounds	lb
Mg	Megagrams	1.102	short tons (2000 lb)	T
		TEMPERATURE (exact)		
°C	Celsius temperature	1.8 + 32	Fahrenheit	°F



***** SI is the symbol for the International System of Measurement

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A GUIDEBOOK FOR EVALUATING THE INDIRECT LAND USE AND GROWTH IMPACTS OF HIGHWAY IMPROVEMENTS

APPENDICES

APPENDIX A

OVERVIEW OF THE PROJECT RESEARCH

OVERVIEW OF THE PROJECT RESEARCH

The main objective of this project was to develop a basis for identifying the indirect impacts of highway improvement projects on land use. Specifically, any major highway improvement project that ODOT undertakes will require an Environmental Assessment (EA) or an Environmental Impact Statement (EIS), which in turn requires an assessment of the project alternatives' impacts on land use. Figure A.1 shows the primary elements of the research effort. The guidebook and other products of the research have been prepared with the assistance and review of a Technical Advisory Committee. The following is a brief description of the research activities and final deliverables for the project.

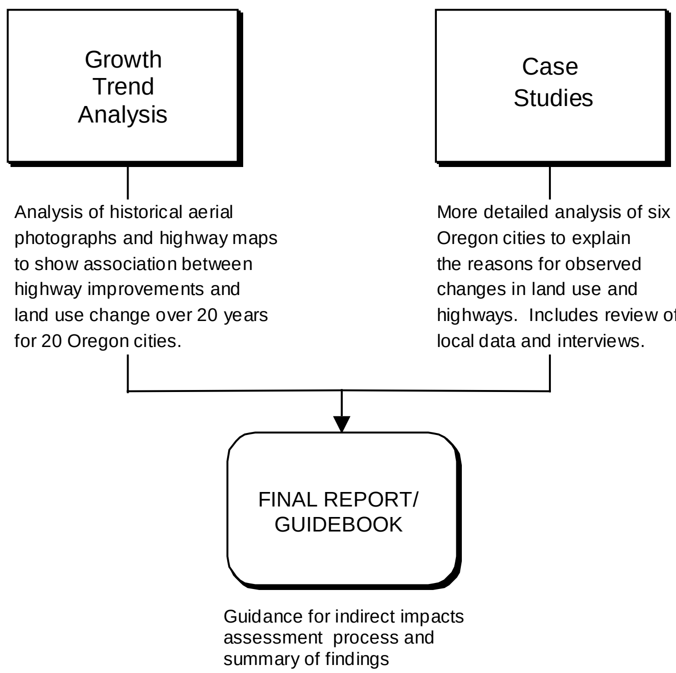

Figure A.1: Structure of the Research

In 1994, ECONorthwest (ECO) produced a working report for the Oregon Department of Transportation (ODOT) addressing the question: to what extent do Oregon's state highway improvements contribute to the premature conversion of rural lands to urban uses? The report, *The Effects of Transportation Improvements on Rural Lands: A Framework for ODOT Policy*, described the forces acting to convert rural lands, and the role that transportation improvements play in the process. Due to a lack of definitive empirical data, ECO did not go beyond theory and develop quantifiable measures for analyzing the transportation and land use interactions. ODOT and ECO agreed that such analysis would not take place as part of that study; instead, ECO would investigate and report on the feasibility and cost of developing quantitative measures of the magnitude of specific roadway improvements on land use development.

At the conclusion of its study, ECO developed a framework to provide reasonable estimates of the direction and magnitude of the effect of various factors on land use. In 1998, following the framework outlined in the 1994 report, the Center for Urban Studies at Portland State University (PSU) and ECO undertook a new research project and developed a methodology by which these effects could be analyzed. The research included a growth trend analysis of urban development patterns with particular emphasis on state highway corridors (see Appendix C). The research also included a set of case studies examining specific land use changes as a function of state highway modifications (see Appendix D).

The growth trend analysis used historical land use information derived from aerial photography to examine the change in urban development for selected cities over time. The detailed case studies analyzed trends in local transportation improvements, land development, public facilities, public policies, and market conditions. This information complements the results of the growth trend analysis for an overall understanding of historic urban development impacts from state highway capacity increasing projects.

GROWTH TREND ANALYSES

The first phase of the project focused on land use changes and urban growth that occurred in 20 selected Oregon cities. A review of pertinent literature was used to set the theoretical context for the analysis (see Appendix B). The literature on the effect of transportation infrastructure on the development of land is large, but reaches few definitive conclusions and provides little empirical guidance. While there is widespread acknowledgment that the provision of roads opens land up to development and that land closer to road access points is more valuable than land further from access points, there is relatively little analysis of whether this is due to increased levels of development or simply the movement of activity that would have occurred in any case. The academic and other literature has analyzed the effect of road improvements on state and regional economic development, with the results helping to provide context for evaluating the effect of specific road improvements.

The Growth Trend Analysis focused on the spatial trends in land use change that have occurred in Oregon over a twenty-year period. Spatial indicators were used to describe the patterns of urban development. While the development of a comprehensive, predictive model was beyond the scope of this project, the methodology and results can be used for impact assessment analyses. Several spatial measures were used to analyze urban development activities resulting from highway accessibility improvements. Logit regression analyses were then used to test the significance of these spatial measures in predicting the location of urban development. A primary objective of this research was to identify the historical relationship between capacity increasing highway improvements and urban land use conversion.

CASE STUDY ANALYSES

The case studies evaluate the impacts of major improvements to state highways (lanes or interchange) at the urban fringe (primarily inside, secondarily outside, UGBs). Six case studies were completed for this project: five for highway widenings (Albany, Bend, Corvallis, La Grande/Island City, and McMinnville) and one primarily for a new alignment and partially for a widening (Grants Pass).

The case study analyses were both quantitative and qualitative. To conduct the baseline analysis, we reviewed environmental documents, land use plans, and capital improvement programs. Those sources are the basis for the description of existing conditions before the case study highway improvements.

As with most policy research, the intent of the case studies was to isolate the impacts (the effects) uniquely attributable to a change in public policy (highway improvement). Figure A.2 illustrates the concept.

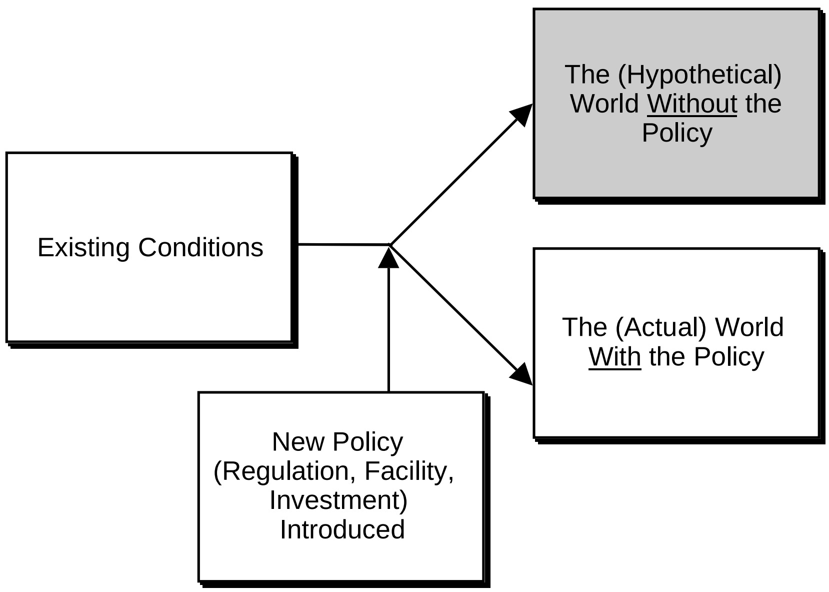

Figure A.2: Conceptual Case Study Method

The shaded box represents a world that does not exist, but one that an analyst must somehow describe. It is a world that would have existed but for the introduction of the new policy. The case study can document, to the extent the data allow, what happened after that improvement (box on bottom right). Describing what would have happened without the improvement (the shaded box) is more speculative, but, in concept, it is required if one were to comment on the differences that a policy makes. As applied to this case study, the method does not formally define a hypothetical world and compare it to an actual one. Rather, it relies on expert opinion about the contribution of the project to the changes observed between "Existing Conditions" and the "Actual World".

INDIRECT IMPACTS GUIDEBOOK

The final product of this research is a framework to guide the indirect land use impact assessment process. With the focus on practice and application, the guidebook is organized in a way that puts supporting information in the background (as appendices), with the main text being the recommended evaluation techniques. The hope is that users of the guidebook will have time to refer to the appendices that provide more detail about the research that leads to the recommended techniques, variations on those techniques, and their limitations. The guidebook is divided into four chapters and six appendices:

- Chapter 1: Introduction.
- Chapter 2: A framework for evaluating the indirect impacts of highway improvements on land use.
- Chapter 3: Steps for evaluating the indirect impacts of highway improvements on land use.
- Chapter 4: Sample analysis and report.
- Appendix A: Overview of the Research Project.
- Appendix B: Literature review.
- Appendix C: Growth Trends Report.
- Appendix D: Case Study Report.
- Appendix E: Population and employment forecasting issues
- Appendix F: ODOT process for project evaluation

APPENDIX B

LITERATURE REVIEW

Indirect Land Use and Growth Impacts

LITERATURE REVIEW

SUMMARY

This literature review summarizes the studies reviewed to provide context for the research on indirect land use impacts. It is part of a larger study sponsored by the Oregon Department of Transportation (ODOT) to help asses the land use impacts of future highway projects. Significant highway improvement projects that ODOT undertakes require environmental analysis[1], which in turn require an assessment of the improvements on land use.[2] The study consists of three research components and a final report. The three research components are:

- *Literature Review.* Review of state and national studies to summarize empirical estimates of the relationship between highway and land use change, especially at the urban fringe (Appendix B).
- *20-Site Analysis.* Analysis of historical aerial photographs and highway maps to show the association between highway improvements and land use changes over 20 years in 20 Oregon cities (Appendix C).
- *Case Study Analysis.* More detailed analysis of highway projects and land use changes in six Oregon cities (Appendix D).

This research led to the development of *A Guidebook for Evaluating the Indirect Land Use and Growth Impacts of Highway Improvements: Final Report*, which is published as a separate document from these appendices.

The literature on land use impacts from transportation improvements focuses primarily on direct impacts. Direct impacts are the physical, social, and economic effects that can be causally linked to the transportation investment. It is important to understand these direct relationships first in order to understand potential indirect relationships. While direct impacts tend to have immediate spatial and temporal effects, indirect impacts tend to be more widely distributed and long-term in nature. These distinctions between direct and indirect impacts provide clues as to why there is a huge literature on direct impacts and very little devoted to indirect impacts.

The literature on land use impacts from transportation improvements is also very theoretical. Because the dynamics of land use change rely in large part on local and regional economic factors, it is difficult to construct a general framework of analysis that applies to a broad range of circumstances. Discussions of land use and transportation interactions are therefore abstract and provide little practical advice on how to predict impacts, especially those occurring at a distance from the transportation improvement and perhaps several years into the future. The studies that

[1] Depending on the scale of the project, ODOT might prepare an Environmental Impact Statement (EIS) or an Environmental Assessment (EA). Larger projects generally require a more detailed EIS.

[2] In addition, of course, to other environmental and socioeconomic impacts.

are most applicable to the current research project are probably the case study style articles in publications such as the Transportation Research Record. These articles generally summarize analyses conducted by researchers, engineering consultants, or transportation agencies and have practical methodological value.

INTRODUCTION

There is an interdependent relationship between land development and the provision of transportation infrastructure. Transportation services must be available to provide access before land can be developed, but the demand for development also creates a demand for access, which in turn increases requests for improvements to the transportation infrastructure. This interdependence complicates efforts to determine the effect of road improvements on land development, because most road modernization improvements are at least partially in response to growing demand.

The following is a review of two important sections of the literature. One examines the effect of infrastructure development (highway construction) on overall levels of economic development or growth, while the other looks at the effect of road construction on the allocation of economic development among geographic areas within a region.

GUIDANCE FROM REGULATORY AGENCIES

The National Environmental Policy Act of 1970 (NEPA) requires an Environmental Impact Statement (EIS) evaluation to distinguish between direct impacts and indirect impacts. The distinction between direct impacts and indirect impacts is important, because this research was focused on the indirect impacts of transportation on land use.

The NEPA, as amended, is the federal statute most relevant to the assessment of indirect impacts. The NEPA, however, does not include any specific references to indirect impacts. The Council on Environmental Quality (CEQ) clarified the meaning when it issued its NEPA regulation in 1978. The CEQ says direct effects "…are caused by the action and occur at the same time and place." Indirect effects "…are caused by the action and are later in time or farther removed in distance, but are still reasonably foreseeable." Moreover, indirect effects "…may include growth-inducing effects and other effects related to induced changes in the pattern of land use, population density or growth rate, and related effects on air and water and other natural systems, including ecosystems." The CEQ differentiates direct and indirect effects from the term cumulative impact. A cumulative impact "…is the impact on the environment which results from the incremental impact of the action when added to other past, present, and reasonably foreseeable future actions…" *(CEQ 1986).*

NEPA is based on a concern about "adverse" environmental impacts, but it is clear that impacts can be either positive or negative, and that both are important for decision making. Also, the definition of indirect impacts refers to impacts that are "reasonably foreseeable." This definition is problematic because reasonably foreseeable is not clearly defined.

The Federal Highway Administration (FHWA) also provides guidance on conducting an environmental review of transportation projects. That guidance refers to the need to discuss "secondary" impacts, induced development and adverse effects. It does not specifically address indirect impacts, and provides little that goes beyond CEQ definitions regarding the evaluation of indirect land use impacts. *(FHWA 2001).*

The California Department of Transportation (CalTrans) produced the "Community Impact Assessment: CalTrans Environmental Handbook Volume 4" to provide guidance in meeting environmental regulations and procedures *(CalTrans 1997)*. This handbook addresses social, economic, and public service impacts as well as land use and growth impacts.

The Wisconsin Department of Transportation published "Indirect and Cumulative Effects Analysis for Project-Induced Land Development" a technical reference guide for evaluating the indirect and cumulative effects of transportation projects *(WisDOT n.d.)*. This document provides a framework for the analysis, discusses background and reference information, and provides details of analysis techniques. Both the Wisconsin and California publications provided useful models for the development of the ODOT guidebook, and offer additional tools for the land use analyst.

OTHER LITERATURE

The literature on the effect of transportation infrastructure on the development of land is large but reaches few definitive conclusions and provides little empirical guidance *(Giuliano 1989; Bourne 1980)*. There is widespread acknowledgment that the provision of roads opens land up to development and that land close to road access points is more valuable than land further away. Relatively little analysis has been done, however, to identify whether the provision of roads is due to increased levels of development or simply due to the movement of economic activity that would have occurred in any case. Academic literature has analyzed the effect of road improvements on state and regional economic development, with the results helping to provide context for analyzing the effect of specific road improvements *(Fisher 1997; Forkenbrock and Foster 1990; Rietveld 1994; Brooks et al. 1993).*

This review focuses largely on the urban impacts, although there are substantial possibilities for road improvements to affect rural economic development as well. In particular, the economic literature concentrates either on state level data *(e.g., Holtz-Eakin and Schwartz 1995; Hulten and Schwab 1991; and Morrison and Schwartz 1996)* or on the effect of urban road investments on the level of economic development *(e.g., Deno 1988 or Duffy-Deno and Eberts 1991)*. The key finding of this literature is that total investments in road infrastructure are sufficiently large in most urban areas that marginal investments for road improvements appear to have little impact on the rate of local economic growth. In *The Effects of State and Local Public Services on Economic Development*, Fisher notes, "Of all the public services examined for an influence on economic development, transportation services, and highway facilities especially, show the most substantial evidence of a relationship. Of the 15 studies reviewed, a positive effect of highway facilities or spending on economic development is reported in 10…[however]…the magnitudes of the estimated effects of highway spending on economic development appear to be quite small." *(Fisher 1997)* Hence, the road system is generally acknowledged as being very important in terms of the local economy, but the amount of infrastructure affected over relatively short periods is sufficiently small that it shows little impact on the overall level of growth. These studies are necessarily rather crude in their attempts to identify the impact of investment, but the results are consistent with expectations.

In 1998, the National Cooperative Highway Research Program (NCHRP) reviewed and summarized the literature on the effect of road development on land use *(NCHRP 1998)*. Three types of induced growth effects are identified with respect to transportation projects: projects planned to serve specific land development, projects that stimulate complementary functions, and projects that influence intraregional land development location decisions. In the first category, development is planned prior to the road improvement and the improvement is integral to the land use development, e.g., road improvements to provide access to a new regional shopping center. Such improvements allow land development to occur; but the development clearly causes the demand for the road, so the development is not directly induced by the road improvements. In the second case, the development directly serves activity associated with the improvement. The examples presented are "gas stations, rest stops, and motels at highway interchanges" *(NCHRP 1998)*. These activities are to some extent induced by the existence of the road. The last category is the one most related to the concerns of this study:

> This category of induced growth occurs when the transportation facility will likely influence decisions about the location of growth and land development among various locations within a region, a phenomenon commonly referred to as intraregional development shifts. This category is associated with highway and transit modes. On a regional basis, the impact of highway and transit projects on economic growth appears to be minimal; however, the localized effect of such projects on land use can be substantial. If the conditions for development are generally favorable in a region – i.e., the region is undergoing urbanization – then highway and transit projects can become one of many factors that influence where development will occur. Extensive research on the topic of the impact of highway on intraregional locational decisions by others, and a lesser amount of related research on transit impacts, has produced certain generalizations about the circumstances of transportation-induced development shifts. These generalizations relate to the potential nature (type and density) and location of such development shifts; the timing of such shifts is very difficult to forecast as it is highly dependent on the national economy and other factors. Where transportation projects do influence land development, the general tendency is toward relatively high density commercial or multifamily residential development near facility nodes: up to 1.6 km (1 mi.) around a freeway interchange; up to 3.2 to 8 km (2 to 5 mi.) along major feeder roadways to the interchange; and up to 0.8 km (0.5 mi.) around a transit station. The exception is the urban fringe where low land prices and high land availability favor single-family residential development *(NCHRP 1998, 79-80)*.

Hence, the effect of road improvements on land development is associated with two important factors: the overall level of growth and related deficiencies in the transportation system. The effect of the road on improving accessibility to specific areas then affects the relative likelihood of development there as opposed to other places.

ISSUES

The development of transportation infrastructure can have several types of effect on land development. The provision of transportation services is one of the key inputs into the overall level of development in a region. On the other hand, each individual transportation improvement contributes to the overall level of development but also facilitates development in specific areas. This is particularly evident in suburban areas that have high levels of radial access to central business districts as well as emerging employment concentrations at the urban fringe *(Greene 1980; Erickson and Gentry 1985)*. A related concern is whether the infrastructure can influence the type of development that is likely to occur, or more relevantly, the density at which development is likely to occur. This study is interested in this latter influence of transportation development, and with separating the effect of infrastructure on the overall level of development from its effect on the location of development that otherwise would have occurred.

There are several distinctions that should be made in evaluating the impact of road improvements. The first is between urban and rural; the second is between average and marginal impacts; and the third is between different types of highway improvements that provide varying amounts of local access, e.g., the through-route function versus the local access function for roads.

The impact of road improvement on the location of economic activity depends, in part, on the level of economic growth. Where access is limited by low mobility (levels of service) on the road system (i.e., from congestion), road improvements are likely to affect the overall level of economic development. Where access is not severely limited, however, people seem to be able to accommodate new traffic demands by altering behavior, e.g., traveling outside of the peak. Thus, this analysis tells the reader that he/she needs to know something about the overall level of economic activity before trying to evaluate the land use impact of road improvements on land use. Where growth is slow to moderate, the impact is largely one of moving the location of activities, with little change in the level of activity. However, the impact of road improvements in rapidly growing areas is more likely to be to accommodate a level of development that otherwise would not have been feasible. In these circumstances, the road improvement is likely to affect the overall level of activity as well as the distribution of activity.

The effect of road improvements on the distribution of land use activity has received much less statistical analysis than the impact on overall levels of economic development. In particular, there is little discussion of the effect that ready availability of accessible land has on the density of development. Anas et al. *(1988)* summarize the discussion, "Highly accessible land is still underpriced and hence is developed at inefficiently low density. So the resulting land use pattern is likely to be inefficiently dispersed (not clustered enough). It is more difficult to say if the pattern is also inefficiently decentralized (too spread out from the center)…" The literature on this topic relies heavily on the impact of land price on the density of development. Making land available for development is an increase in supply that reduces the price of such land. The lower price then induces lower density of development *(Fare and Yoon 1981; McDonald 1981; Jackson et al. 1984)*. Metro, the Portland, Oregon metropolitan regional government district, has been analyzing the effect of land price on the substitution of capital for land in the provision of housing and has been working on generating models of this effect for residential construction *(Condor and Larson 1998)*. However, much less analysis is available on the effect of land price on the density of commercial and industrial development. From an economic perspective the ultimate determinant of the impact of road improvements on density of development is likely to work out through the effect on land prices.

For a given land price gradient, differential access is likely to affect the location of activity rather than the level of activity or the density of development. Where large amounts of land with good access are available, the relatively low price of the land should lead to a lower density of development than in situations where limited availability leads to high prices for land. This points out a key issue in analyzing effects of a single improvement on the density of development: in most cases, no single improvement is likely to affect such a large quantity of land that it will significantly alter the price of land with good access. Hence, it would be difficult to trace the effects of an individual road improvement project on density.

Following Mohring's *(1961)* early work on highway benefits, a wide range of analyses have been performed that measure the influence of transportation accessibility on land values *(De La Barra 1989; Pendleton 1963; and Alcaly 1976)*. Many of these studies focus on the effect of transportation investments on urban form while others use land value analyses for highway impact assessment purposes *(Langley 1976, 1981; Adkins 1957)*. Researchers have also identified land value effects at the urban fringe which typically identify transportation improvements as having a significant relationship with growth pressures *(Shonkwiler and Reynolds 1986; Shi, Phipps, and Golyer 1997)*. In these cases, land values are seen as a proxy indicator for potential land use development, where land prices will influence the type and intensity of development.

Previous efforts to quantify the impact of road improvements on land development have been very limited *(Deakin 1989)*. Some studies have analyzed historical development trends in highway corridors to illustrate the clustering associated with highway improvements *(Baerwald 1982; Hartgen and Li 1994)*. However, detecting and quantifying agglomeration economies for highway corridor improvements requires detailed historical land use information that typically is not easy to assemble or analyze. In many cases, projections of the impact of road development, as required, for example, in a Draft Environmental Impact Statement (DEIS), start with an assumption of a fixed amount of activity and travel, then try to determine the effect of the road improvement on mobility (travel times) and other traffic conditions *(e.g., see ODOT 1995)*. For example, in reviewing the DEIS for the proposed Mt. Hood Corridor project, "With the no build alternative, travel demand is expected to level off because of the limited roadway capacity available" *(ODOT 1994; CH2M Hill 1993)*. Often there are statements that deteriorating travel conditions and rising congestion might prevent the expected level of development if road improvements are not made.

More recent studies try to identify likely land use impacts, but there is seldom any quantitative analysis of the effect that the road improvement is likely to have on the future development of land and subsequent demand for use of the road. *(e.g., David Evans and Associates 1993; ODOT 1996)*. To conduct such an analysis, it would be necessary to determine both the impact of the road improvement on the total amount of economic activity that would occur in a specific area and the allocation of that activity, both with and without the road improvement. Where the effect is largely a reallocation of activity, some method must be generated to evaluate the impact of the reallocation on the total supply of accessible land, and the effect of this supply change on the price of land and hence on density. Estimating these effects is substantially complicated by the other policy factors that are likely to affect the ability to bring land into development, such as the availability of urban infrastructure, land use regulations, suitability of the land for development, and the other amenity characteristics of the land (such as views or access to recreation). To overcome some of these difficulties, analysts have relied on "expert panels" and other forms of public involvement to incorporate factors that are not easily quantified *(CalTrans 1997; Mulligan and Horowitz 1988).*

The literature is more specific about particular aspects of the transportation and land use relationship. There are empirical analyses on the connection between transportation improvements, land values, and economic development. The results of these analyses, along with supporting economic theory, tend to indirectly account for land use changes. Compared to land value and aggregate economic development analyses, there are few empirical studies of land use impacts resulting from transportation investments. One reason is that information on changes in land use over time is very difficult to obtain while land sales transactions and aggregate economic activity (employment, sales, production, etc.) is much more accessible.

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APPENDIX C

GROWTH TRENDS REPORT

Indirect Land Use and Growth Impacts

GROWTH TRENDS REPORT

INTRODUCTION

In 1994, ECONorthwest (ECO) produced a working report for the Oregon Department of Transportation (ODOT) addressing the question: to what extent do Oregon's improvements to its highways contribute to the premature conversion of rural lands to urban uses? The report, *The Effects of Transportation Improvements on Rural Lands: A Framework for ODOT Policy,* described the forces acting to convert rural lands, and the role that transportation improvements theoretically play in the process (*ECONorthwest 1994*). Due to a lack of definitive empirical data, however, ECO did not go beyond theory to develop quantifiable measures for analyzing transportation and land use interactions. ODOT and ECO agreed that such analysis would not take place as part of that study, but that ECO would explore the feasibility and cost of developing such measures.

At the conclusion of its 1994 study, ECO developed a framework to provide estimates of the direction and magnitude of the effect of various factors on land use. Using this framework, ODOT asked the Center for Urban Studies at Portland State University and ECO to develop a methodology by which to assess historical land use changes related to the location of state highway projects. The purpose of this study is to build upon the 1994 ECO report by measuring the impacts of highway improvements on land use, identifying land use and transportation variables, and defining the methodologies and model specifications for impact analysis procedures. This study consisted of two phases:

- Phase I included a trend analysis of urban development patterns with particular emphasis on the location of state highway corridors. In this phase, aerial photographs were analyzed to determine the extent of urban development for cities over time, and a geographic information system (GIS) overlay was used to estimate the rate of urbanization.

- Phase II included a set of detailed case studies examining specific land use changes as a function of state highway modifications.

The combined results of Phase I and II were used to prepare guidelines that ODOT can apply during the highway impact assessment process when considering induced indirect land use changes.

BACKGROUND

Much like many other states, Oregon has experienced significant rates of growth in and around its urbanized areas. The growth has not been limited to metropolitan areas; many non-metropolitan cities in the Willamette Valley have experienced population increases in the range of 4% to 9% annually between 1970 and 1997 *(Center for Population Research and Census*

1998). In an attempt to manage growth impacts, Oregon has instituted a statewide policy of urban growth boundaries (UGBs). These boundaries are used to contain and direct urban development and provide coordination between jurisdictions (*Knaap and Nelson 1992; Weitz and Moore 1998*).

As urban areas increase in size, road and highway construction projects are used to facilitate both work-related and non-work-related travel demand. In the period from 1975 to 1995, per capita vehicle miles traveled increased by more than 50% within the Willamette Valley (*Gregor 1998*). Much of this increase has been attributed to an increase in the number of single-occupancy commuters. The challenge has been to accommodate local and regional travel demand with highway projects while not encouraging dispersed development, especially at the urban fringe. It has been shown that, while new development generates demand for new transportation facilities, increased accessibility from new highway facilities also induces urban development (*Moore and Thorsnes 1994*). In this dynamic relationship between transportation and land use it is not known, however, whether capacity improvements induce development as increased accessibility does.

To address these concerns, ODOT has been in the process of improving its ability to analyze the indirect land use impacts of highway improvements. ODOT has undertaken this study to better understand the relationship between capacity-increasing highway improvements within urban fringe areas, associated rates of development, and land use changes in surrounding areas. This information can then be used to improve the impact assessment procedures used for transportation projects in compliance with the National Environmental Policy Act (NEPA) and other laws and regulations.

The purpose of Phase I (Growth Trends Analysis) was to examine the spatial trends in land use change that have occurred in Oregon over a twenty-year period. For this analysis, spatial indicators were relied upon to describe the patterns of urban development. While the development of a comprehensive, predictive model was beyond the scope of this project, the following methodology and results can contribute to a proposed impact assessment framework. Detailed case studies (Phase II) provided analyses of trends in local transportation improvements, land development, public facilities, public policies, and market conditions. This information will complement the results of the growth trend analysis for an overall understanding of urban development impacts from state highway capacity increasing projects.

METHODOLOGY

A primary objective of this study was to identify the historical relationship between capacity-increasing highway improvements and associated land use impacts. The research assessed the induced land use effects of highway improvements on the conversion of land to urban uses. To do this, historical trends in urban development patterns were examined using aerial photography and spatial analysis within a Geographic Information System (GIC). As part of this, the research employs geographical factors to examine the potential of ODOT roadway improvements to cause conversion of land to urban uses. The methodology is similar to that of Chapin and Weiss *(1962)* who presented one of the first comprehensive, grid-cell based land development pattern analyses. Similar to this study, they did not propose a predictive model; rather, they sought to describe factors influencing development patterns. Their model, however, was not longitudinal, as is the analysis presented here.

This investigation was part of a statewide focus to track development trends over a twenty-year period for twenty selected cities in Oregon. A set of spatial measures was used as predictors of urban development activities associated with highway accessibility improvements. Logit regression analyses were then used to test the significance of these spatial measures in predicting the location of urban development. A primary objective of this research was to identify the historical relationship between capacity-increasing highway improvements and urban land use conversion. The analysis provides quantifiable indicators that can potentially be used in the impact assessment phases of highway project review.

The growth trend analysis was based on aerial photographs from 1970 to 1990. Aerial photography at a 1:20,000 or 1:40,000 scale for these time periods were available from U.S. Department of Agriculture, Agricultural Stabilization and Conservation Service for 25 of the 36 Oregon counties. A GIS was used to overlay the extent of urban development over time (derived from aerial photography) to determine the location of new urban development. Historical highway improvement information was overlaid on the urban growth patterns delineated from the aerial photos to examine the coincidence of changes in land use with changes to the highway system.

SELECTION OF URBAN AREAS

The first step in the process was to identify the twenty urban areas that were most suitable for trend analysis. To do this we used the following four criteria:

1. **Availability of a time series of aerial photographs**.
   Given the selected methodology, it was important that aerial photographs be available at regular time intervals for each of the selected urban areas. The analysis assessed the rates of urban development/growth based upon aerial photos from 1970, 1980, and 1990; so it was preferable that data for estimates of growth rates be comparable for each of the 20 urban areas. This meant that aerial photographs for each of these time periods were needed in order for an urban area to be selected.

2. **Substantial growth**.
   Because this study was about growth at the urban fringe, there was more interest in growing cities than in stagnant ones. In this case urban growth was measured in terms of historic population change. Growth could have been measured in a number of ways, but population was common, adequate, and likely to be correlated with other measures of growth such as employment change or building permit issuance. As cities grow in population size, they generally grow in urbanized area as well. Subsequent research on slowly growing or declining urban areas could provide a broader range of comparisons. Additional research could look at why urban areas with similar levels of highway accessibility experienced different rates and forms of urban development.

3. **Relevant highway improvements.**
   This study focuses on the relationship of major highway improvements to land use development activities. Though documentation of urban development trends, independent of major highway improvements, may be interesting to many people, it was not ODOT's focus. Thus, the preference was that most of the selected urban areas had such improvements. However, fringe areas that experienced significant growth without substantial highway improvements could also serve as important control cases. An initial list of highway projects was provided by ODOT staff.

4. **Variation in city type, size, and geography**.
   To make the study as generalizable and applicable to statewide concerns, it was important to include urban areas that varied in size, composition, and geography. Some small cities have experienced substantial population growth rates over the last twenty-five years (200% or more). However, a 200% change in population for a city of 500 persons has different land use implications than does a 50% change for a city of 50,000. For this reason, the rate of population growth was not in itself an adequate criterion for selection purposes. It was also important that a variety of city types in regard to economic activities and geographic location be considered. For instance, local economies relying on tourism experience different types of land use impacts than do local economies relying on high-technology manufacturing. In addition, metropolitan cities experience different urban development pressures than do non-metropolitan cities.

From a list of thirty candidate urban areas, the project Technical Advisory Committee (TAC) selected the twenty that they felt would be most relevant to this study. Table C.1 shows the twenty Oregon cities selected for the growth trend analysis.

Table C.1: Cities Selected for Growth Trend Analysis

City	County	Population 1970	Population 1990	% Change 1970-1990
Albany	Linn	18,181	29,540	62.5%
Aumsville	Marion	590	1,650	179.7%
Bend	Deschutes	13,710	20,447	49.1%
Canby	Clackamas	3,813	8,990	135.8%
Central Point	Jackson	4,004	7,512	87.6%
Columbia City	Columbia	537	1,003	86.8%
Corvallis	Benton	35,056	44,757	27.7%
Dallas	Polk	6,361	9,422	48.1%
Florence	Lane	2,246	5,171	130.2%
Grants Pass	Josephine	12,455	17,503	40.5%
Hillsboro	Washington	14,675	37,598	156.2%
Klamath Falls	Klamath	15,775	17,737	12.4%
Lincoln City	Lincoln	4,196	5,908	40.8%
Madras	Jefferson	1,689	3,443	103.8%
McMinnville	Yamhill	10,125	17,894	76.7%
North Plains	Washington	690	997	44.5%
Redmond	Deschutes	3,721	7,165	92.6%
Sherwood	Washington	1,396	3,093	121.6%
Troutdale	Multnomah	1,661	7,852	372.7%
Woodburn	Marion	7,495	13,404	78.8%

Source: Center for Population Research and Census, Portland State University

Figure C.1 shows the geographic distribution of the selected locations. The twenty cities represent sixteen different counties, generally from the western portion of the state. In addition, sixteen of the cities had identified highway projects.

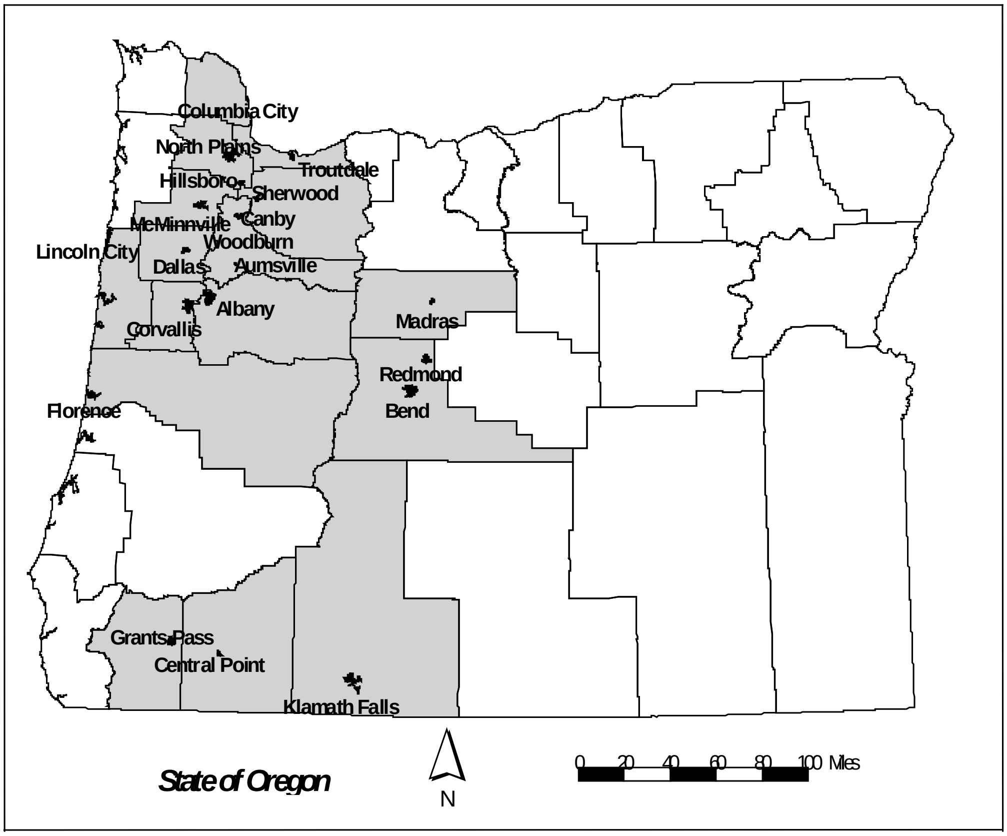


Figure C.1: Cities Selected for Growth Trend Analysis

The selected cities range in population (1990) from 997 (North Plains) to 44,757 (Corvallis). These cities had grown an average of 64.9% from 1970 to 1990. This was significantly higher than the 35.9% increase realized by the state of Oregon over this same time period. Average annual growth rates from 1970 to 1990 range from a low of 0.6% (Klamath Falls) to a high of 8.1% (Troutdale).

URBAN CHANGE DETECTION PROCESS

The process used to convert aerial photography to GIS coverages of urban development for the twenty cities included the following steps. Aerial photos obtained from the U.S. Department of Agriculture, Farm Service Agency, Aerial Photography Field Office (USDA-FSA-APFO) for 1970, 1980, and 1990 were used to estimate the extent of urban development over time. The photography provided the physical coverage for each of the selected urban areas and ranged in fractional scale from 1:20,000 for the 1970 time period to 1:40,000 for 1980 and 1990. All aerial photography was obtained as printed images that needed to be first converted into a digital format so that they could be analyzed within a GIS. Because individual photos do not generally cover entire urban areas, a set of photos had to be assembled to provide a complete geographic view of each urban area. The resulting mosaicked images were then registered to an existing layer of geo-referenced highway features from the United States Geological Survey (USGS). Figures C.2 through C.7 shows each step illustrated with a simplified example of the process used to estimate the change in urban development over time.

Areas were classified as “urban” if development (residential, commercial, or industrial structures) was visible from the aerial photography. Other unvegetated areas that had no structures but were contiguous to developed areas were also classified as urban. Areas located toward the center of urbanized areas that had dense vegetation, with no visible structures or impervious surfaces, were more likely to be considered urban because of their proximity to urban land uses than were similar areas at the urban fringe. For example, recreational open space within cities would generally be considered urban, while a farm at the urban fringe would not (although farmhouses and out-buildings would be considered urban). In addition, areas considered to be at the urban fringe were those at the boundary of areas of contiguous urban development. The urban fringe may or may not have coincided with a city incorporated limits or urban growth boundary (UGB). Because this analysis was concerned with conversion of land to urban uses, physical characteristics dictated how areas were classified, rather than legal or administrative designations.

Figure C.2: Step 1. Aerial Photographs are Scanned to Obtain Digital Graphic Image

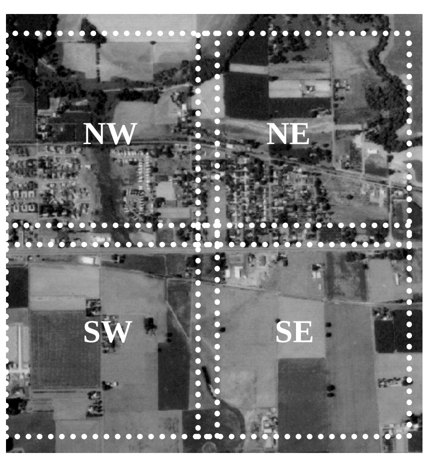


Figure C.3: Step 2. Scanned Photos are Assembled in a Mosaic and Cropped to Desired Map Extents

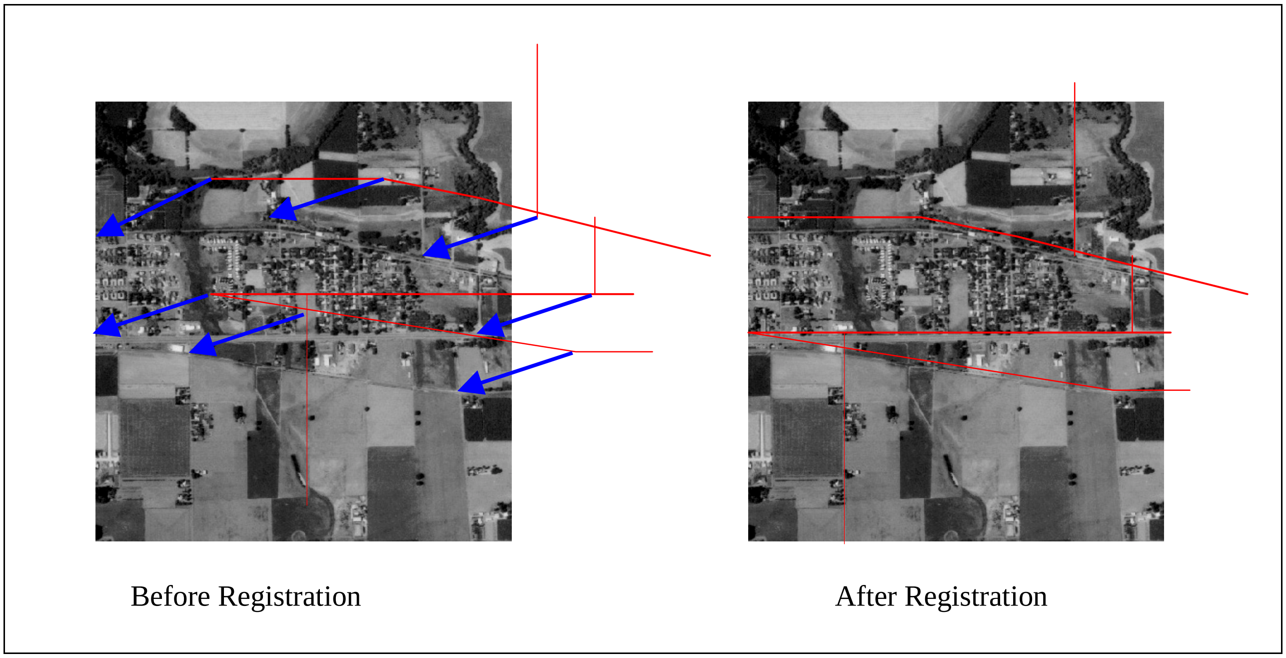


Figure C.4: Step 3. The Image is Registered and Rectified to an Existing Geo-Referenced Coverage

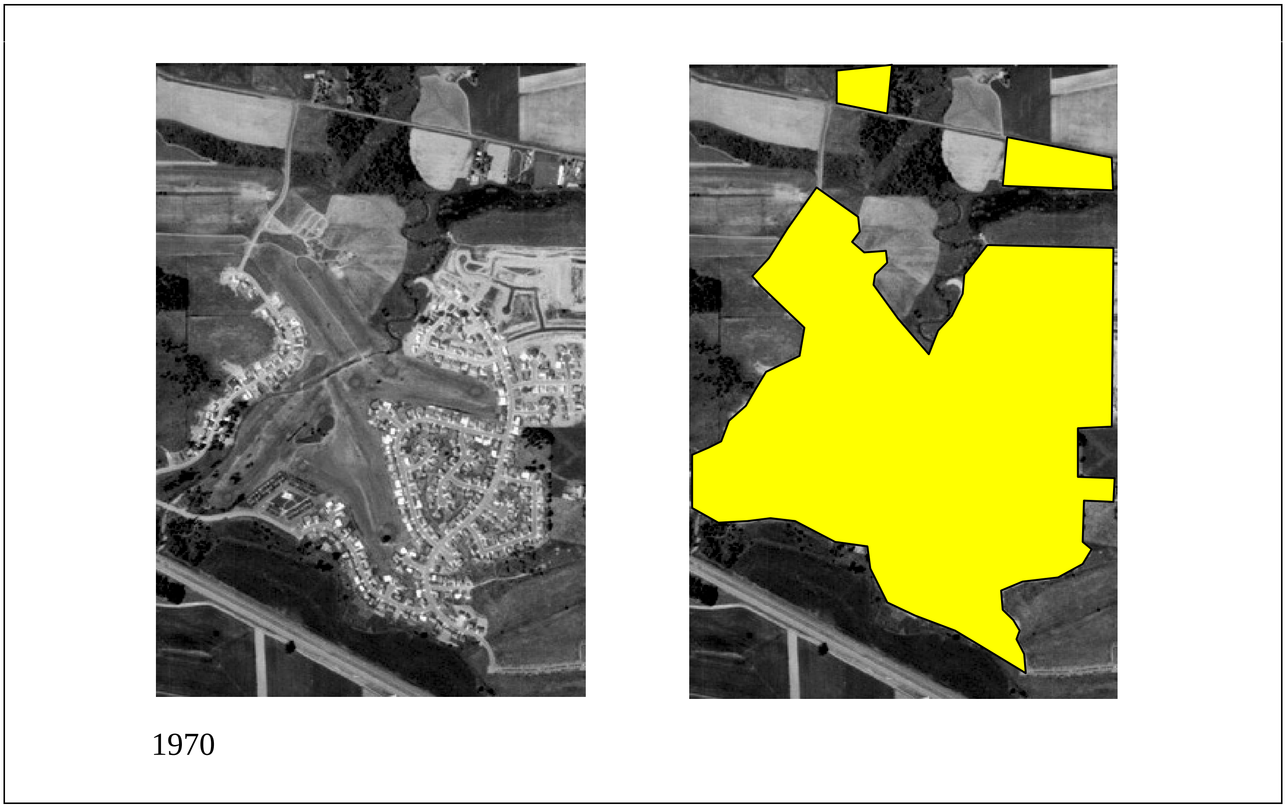


Figure C.5: Step 4. The Boundaries of Urban (Developed) Areas are Digitized from the 1970 Aerial Photos

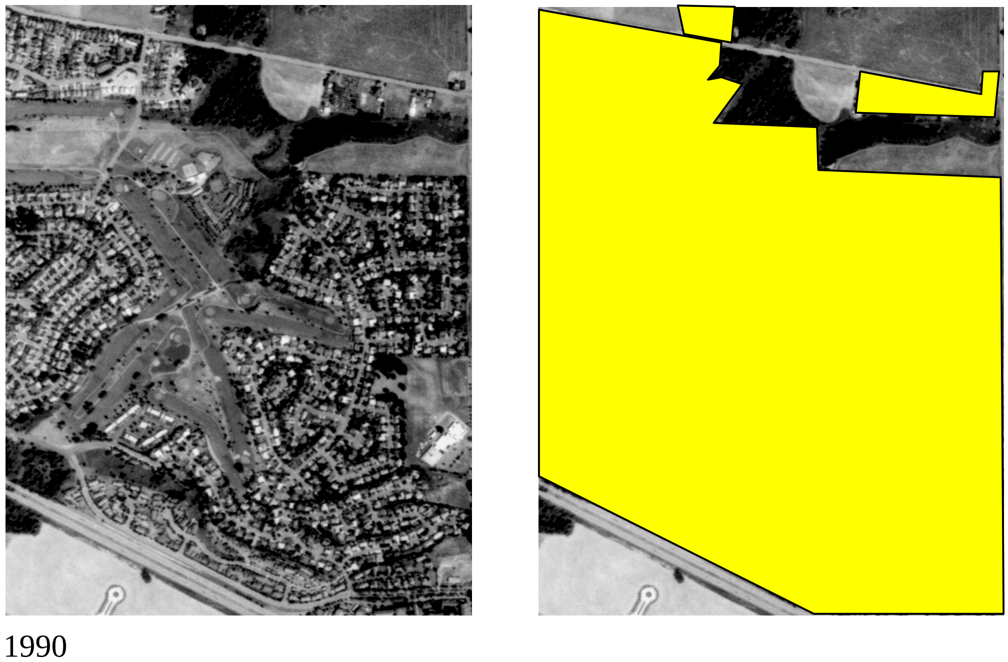
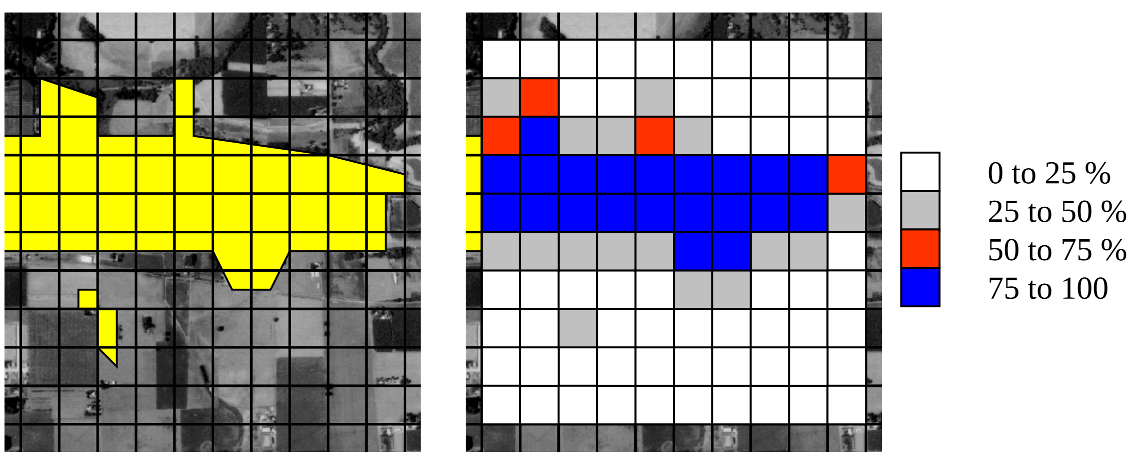


Figure C.6: Step 4. The Boundaries of Developed Areas are Digitized for the 1990 Aerial Photos



Note: For analysis purposes, the degree of change is a binary variable: 0 for 0% change and 1 for > 0% change

Figure C.7: Step 5. A Grid Coverage is Overlaid on the Digitized Coverage of Developed Areas and the Percent of Developed Area within Each Grid Cell is Calculated

URBAN CHANGE DETECTION RESULTS

Based upon the estimates of urbanized area from the aerial photography, it was evident that significant urban development had occurred in nearly all of the twenty selected cities. For each city, the analysis of land use change was limited to areas up to 1.61 km (1 mi) outside of the 1990 incorporated limits. This 1.61 km buffer was used so that growth outside of city limits which was still geographically related to each city would also be included. In this way, discontiguous development was included while excluding areas that may not have been influenced by growth-inducing activities associated with the city.

On average, rates of change were over twice as high during the period from 1970 to 1980 compared to the period from 1980 to 1990 (see Table C.2). For the twenty-year period from 1970 to 1990, these cities expanded at an average rate of 72.2%, or an average annual conversion of approximately 39.1 hectares (96.5 acres) per city. Rapid rates of urbanization were not limited to cities that were initially small in geographic size. Both smaller communities like Aumsville, Sherwood, and Troutdale and larger communities like Albany, Hillsboro, and McMinnville more than doubled in size. City population size and the rate of urban expansion from 1970 to 1990 exhibited a relatively weak, negative correlation (r = -0.232).

Table C.2: Rates of Urban Development for the 20 Selected Cities

City	Acres			% Change		% Change 1970 to 1990
	1970	1980	1990	1970 to 1980	1980 to 1990	
Albany	4,789	9,928	10,573	107.3%	6.5%	120.8%
Aumsville	135	323	414	139.3%	28.2%	206.7%
Bend	2,705	4,745	7,224	75.4%	52.2%	167.1%
Canby	1,018	1,415	1,562	39.0%	10.4%	53.4%
Central Point	3,699	4,211	4,882	13.8%	15.9%	32.0%
Columbia City	280	333	401	18.9%	20.4%	43.2%
Corvallis	5,254	6,710	7,709	27.7%	14.9%	46.7%
Dallas	1,496	1,875	2,024	25.3%	7.9%	35.3%
Florence	na	1,049	1,184	na	12.9%	na
Grants Pass	3,862	4,642	6,074	20.2%	30.8%	57.3%
Hillsboro	6,847	9,166	13,958	33.9%	52.3%	103.9%
Klamath Falls	7,837	9,468	9,850	20.8%	4.0%	25.7%
Lincoln City	na	1,419	1,419	na	0.0%	na
Madras	906	1,067	1,231	17.8%	15.4%	35.9%
McMinnville	2,203	3,679	4,655	67.0%	26.5%	111.3%
North Plains	284	330	383	16.2%	16.1%	34.9%
Redmond	1,914	2,461	2,747	28.6%	11.6%	43.5%
Sherwood	464	978	1,338	110.8%	36.8%	188.4%
Troutdale	532	1,144	1,357	115.0%	18.6%	155.1%
Woodburn	1,491	1,845	2,346	23.7%	27.2%	57.3%
Average				40.7%	21.8%	72.2%

Note: Complete sets of 1970 aerial photography were not available for Florence and Lincoln City

In addition to the total geographic extent of urban development for the cities, the density of development and land usage was also seen as an important indicator of growth trends. Measures of increases in the physical size of a city did not provide an indication of how intensely land was being used. For this reason, the rates of land consumption per person and per housing unit were compared for 1970 and 1990 (see Tables C.3, C.4, and C.5). The totals for developed areas in Table C.2 were different from those shown in Table C.3. Table C.3 shows the change in developed area within the 1990 incorporated limits so that comparable density estimates can be shown at each time interval. Table C.2 includes all urban development associated with each city (in some cases this includes discontiguous development).

Table C.3: Rates of Urban Development for the Selected Cities (Within 1990 City Limits)

City	Acres			% Change		% Change 1970 to 1990
	1970	1980	1990	1970 to 1980	1980 to 1990	
Albany	4,050	6,466	6,794	59.7%	5.1%	67.8%
Aumsville	106	250	311	135.8%	24.4%	193.4%
Bend	2,341	3,285	4,725	40.3%	43.8%	101.8%
Canby	874	1,224	1,286	40.0%	5.1%	47.1%
Central Point	843	923	1,061	9.5%	15.0%	25.9%
Columbia City	187	225	264	20.3%	17.3%	41.2%
Corvallis	4,217	5,116	5,599	21.3%	9.4%	32.8%
Dallas	1,139	1,464	1,571	28.5%	7.3%	37.9%
Florence	na	1,039	1,174	na	13.0%	na
Grants Pass	2,977	3,216	3,749	8.0%	16.6%	25.9%
Hillsboro	4,736	5,282	8,920	11.5%	68.9%	88.3%
Klamath Falls	3,937	4,339	4,453	10.2%	2.6%	13.1%
Lincoln City	na	910	910	na	na	na
Madras	617	678	768	9.9%	13.3%	24.5%
McMinnville	1,897	2,994	3,696	57.8%	23.4%	94.8%
North Plains	226	239	282	5.8%	18.0%	24.8%
Redmond	1,849	2,250	2,446	21.7%	8.7%	32.3%
Sherwood	354	662	774	87.0%	16.9%	118.6%
Troutdale	241	813	998	237.3%	22.8%	314.1%
Woodburn	1,227	1,522	1,783	24.0%	17.1%	45.3%
Average				46.0%	18.4%	73.9%

Note: Complete sets of 1970 aerial photography were not available for Florence and Lincoln City

As Table C.4 shows, nearly two-thirds of the selected cities experienced increases in population density for the twenty-year period from 1970 to 1990. Canby and Central Point had the largest gains in density at over two additional persons per acre of urbanized land. On the other hand, the population density for Bend decreased by slightly more than 1.5 persons per acre, and McMinnville decreased by about 0.5 persons per acre. Population densities increased on average by 0.31 persons per acre.

Along with average population densities for the selected cities, housing unit densities also increased slightly during the same time period (see Table C.5). With the exception of Aumsville, Bend, and Grants Pass, all cities experienced increases. The largest housing density increases occurred in Central Point (two units per acre) and Canby (one unit per acre). Aumsville and Bend experienced the largest decreases in housing densities at 1.6 and 0.25 units per acre respectively. In general, it appeared that the urban development patterns in the selected cities had either increased or maintained 1970 density levels.

Table C.4: Population Density, Change from 1970 to 1990

City	Population 1970	Population 1990	Change 1970-1990	Persons/Acre 1970	Persons/Acre 1990	Change 1970-1990
Albany	18,181	29,540	62.5%	4.489	4.348	-0.141
Aumsville	590	1,650	179.7%	5.566	5.305	-0.261
Bend	13,710	20,447	49.1%	5.856	4.327	-1.529
Canby	3,813	8,990	135.8%	4.363	6.991	2.628
Central Point	4,004	7,512	87.6%	4.750	7.080	2.330
Columbia City	537	1,003	86.8%	2.872	3.799	0.928
Corvallis	35,056	44,757	27.7%	8.313	7.994	-0.319
Dallas	6,361	9,422	48.1%	5.585	5.997	0.413
Florence	2,246	5,171	130.2%	na	4.405	na
Grants Pass	12,455	17,503	40.5%	4.184	4.669	0.485
Hillsboro	14,675	37,598	156.2%	3.099	4.215	1.116
Klamath Falls	15,775	17,737	12.4%	4.007	3.983	-0.024
Lincoln City	4,196	5,908	40.8%	na	6.492	na
Madras	1,689	3,443	103.8%	2.737	4.483	1.746
McMinnville	10,125	17,894	76.7%	5.337	4.841	-0.496
North Plains	690	997	44.5%	3.053	3.535	0.482
Redmond	3,721	7,165	92.6%	2.012	2.929	0.917
Sherwood	1,396	3,093	121.6%	3.944	3.996	0.053
Troutdale	1,661	7,852	372.7%	6.892	7.868	0.976
Woodburn	7,495	13,404	78.8%	6.108	7.518	1.409
Weighted Average				5.185	5.490	0.305

Note: Density based on developed areas – see Table C.3

Table C.5: Housing Unit Density, Change From 1970 to 1990

City	Housing Units 1970	Housing Units 1990	Change 1970-1990	Units/Acre 1970	Units/Acre 1990	Change 1970-1990
Albany	6,402	12,322	92.5%	1.581	1.814	0.233
Aumsville	350	529	51.1%	3.302	1.701	-1.601
Bend	5,039	9,004	78.7%	2.152	1.906	-0.247
Canby	1,360	3,245	138.6%	1.556	2.523	0.967
Central Point	600	2,831	371.8%	0.712	2.668	1.956
Columbia City	123	361	193.5%	0.658	1.367	0.710
Corvallis	10,637	17,307	62.7%	2.522	3.091	0.569
Dallas	2,218	3,672	65.6%	1.947	2.337	0.390
Florence	816	2,741	235.9%	na	2.335	na
Grants Pass	5,984	7,480	25.0%	2.010	1.995	-0.015
Hillsboro	4,962	13,347	169.0%	1.048	1.496	0.449
Klamath Falls	6,304	7,832	24.2%	1.601	1.759	0.158
Lincoln City	2,547	4,023	58.0%	na	4.421	na
Madras	609	1,374	125.6%	0.987	1.789	0.802
McMinnville	3,464	6,778	95.7%	1.826	1.834	0.008
North Plains	164	309	88.4%	0.726	1.096	0.370
Redmond	1,439	2,932	103.8%	0.778	1.199	0.420
Sherwood	492	1,239	151.8%	1.390	1.601	0.211
Troutdale	409	2,509	513.4%	1.697	2.514	0.817
Woodburn	2,960	4,922	66.3%	2.412	2.761	0.348
Weighted Average				1.756	2.217	0.460

Figures C.8 and C.9 show there was a positive correlation between the changes in urbanized area and the rates of population change. With the exception of Troutdale, with a 373% population increase, the observations form a relatively flat cluster around the 100% population change level. With the exceptions of Central Point (372% housing unit change) and Troutdale (513% housing unit change), there was no perceptible trend in percent change in urbanized area and the percent change in housing units from 1970 to 1990 (see Figure C.9).

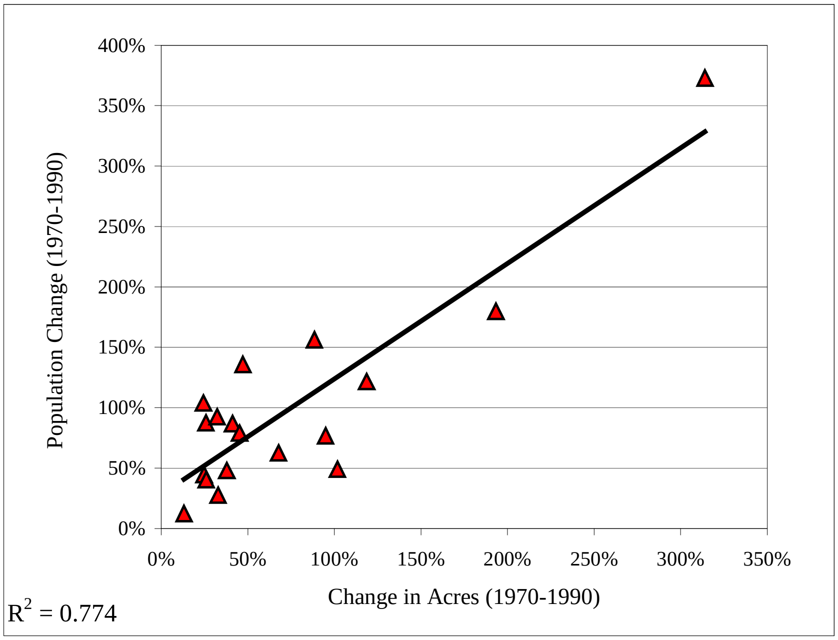


Figure C.8: Percent Change in Urban Acres and Rate of Population Change

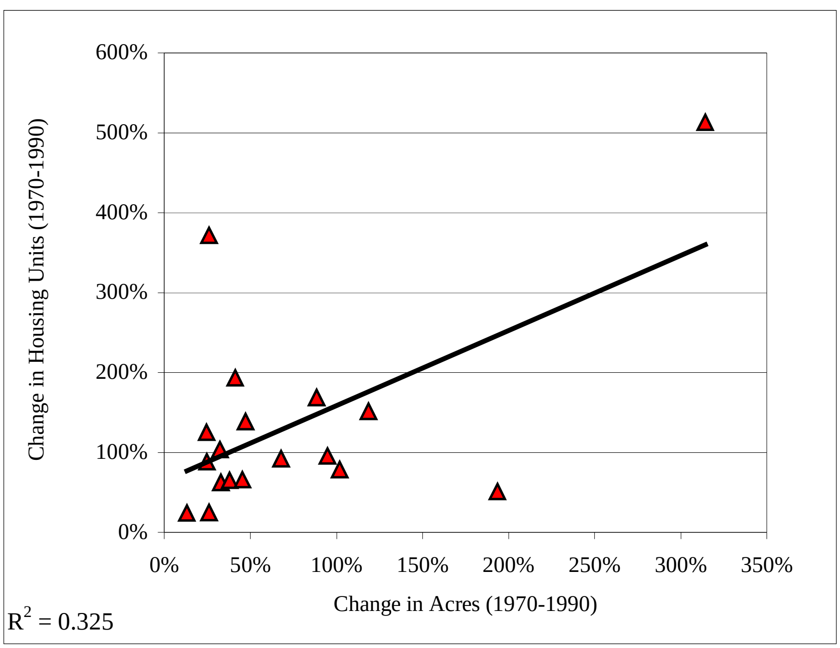


Figure C.9: Percent Change in Urban Acres and Rate of Housing Unit Change

LOGIT REGRESSION ANALYSIS

In addition to the amount of land being converted to urban uses, this analysis was particularly concerned with whether conversions were related to the location of capacity-increasing highway improvements. Typically the relationship between land use impacts and transportation facilities is seen as a function of physical proximity and market demand, so this analysis attempted to isolate the correlation between the location of urban land conversion and the location of highway improvements, and assumed that demand for urban land uses existed. The analysis controlled for other spatial measures that typically indicate the likelihood of land being developed into urban land uses. These measures are summarized in Table C.6. To account for nonlinear distance relationships, squared distances were included for each of the primary spatial measures. For example, along with the variable D_HIGHWAY (linear distance to the nearest highway) was D_H2, which was the linear distance to the nearest highway squared.

Table C.6: Land Use and Spatial Measures (Variable Names)

Measures	Comment
Linear distance to nearest highway (miles) (D_HIGHWAY, D_H2)	Development potential expected to be higher near transportation facilities
Linear distance to UGB (miles) (D_UGB, D_U2)	Rate of development expected to be slower approaching growth limit
Linear distance to city center (miles) (D_CENTER, D_C2)	Decreasing likelihood of development as distance from center increases
Linear distance to nearest highway project (miles) (D_PROJECT, D_P2)	Potential for development should be higher near accessibility enhancements
Within 1990 city limits (0, 1) (IN_CITY)	Less growth should be occurring outside of incorporated limits
Neighborhood urban index (1970) (NEIGH70)	Conversion potential should be higher for land near previously developed areas
Years since nearest highway project completion (YEARS)	Growth impacts expected to occur over time
Land zoned as commercial (0,1) (Z_COM)	Rate of development dependent on local economic conditions
Land zoned as industrial (0, 1) (Z_IND)	Rate of development dependent on local economic conditions
Land zoned as rural/agriculture/open space (0, 1) (Z_RUR)	Limited development should occur in areas zoned for these uses
Land zoned as single-family residential (0, 1) (Z_SFR)	Most urban development should be directed to land zoned for these uses
Land zoned as multi-family residential (omitted) (Z_MFR)	Control variable
Spatial lag (SPATIAL)	Controls for spatial autocorrelation

The 'within city limits' variable was binary (0, 1), where 1 = within city limits and 0 = not within city limits. The 'neighborhood urban index' was the average percent urbanized of surrounding grid cells in 1970. This value was calculated for each cell using a neighborhood function within the GIS. Figure C.10 shows an example of how cell values were calculated.

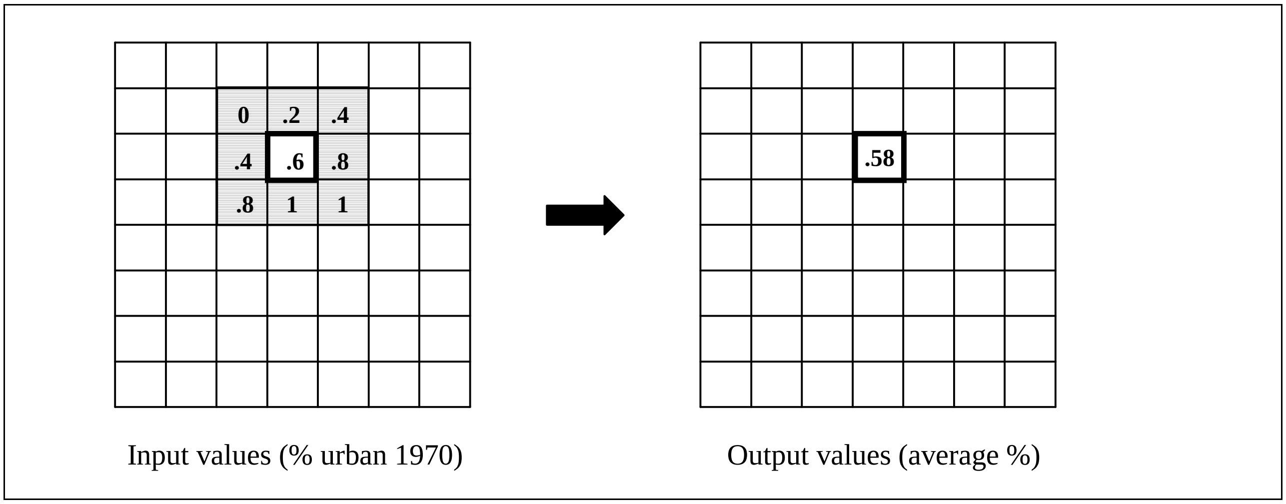


Figure C.10: The Neighborhood Function on an Individual Cell

LOGIT REGRESSION RESULTS

A logit regression model incorporating the land use characteristics and spatial measures shown in Table C.6 tested the significance of proximity to highway projects as a factor in the rate of land use conversions. If the nearness to a highway project significantly affected accessibility and increased development potential close to the improvement, the coefficients for D_PROJECT should be negative. This means that as the distance to a highway project increases, the likelihood of being urbanized should decrease over time. The unit of analysis was the overlay grid cell [approximately 2.3 ha (5.75 acres) – 152.5 m (500 ft) on a side]. A binary dependent variable (CHANGED) indicated whether any new development occurred in a grid cell between 1970 and 1990. While the change in the percentage of urban land area within each grid cell was estimated by the method described earlier, the distribution of values tended to be bimodal with most of the grid cells either showing no change or 100% change. If a grid cell was completely urban in 1970, it was not included in the regression equation. In addition, grid cells also had to be within the 1990 city limits or up to 1.61 km (1 mi) outside of the city limits to be included.

The logit regression equations successfully predicted the location of urban land use conversion between 79% (Aumsville) and 95% (Florence) of the grid cell change for nineteen of the twenty cities. Lincoln City was not included in the logit analysis because the aerial photo analysis did not detect significant land use change for the time period of interest. Overall, the most consistent predictors of urban land use were the variables for being within 1990 city limits (IN_CITY) and the spatial lag variable (SPATIAL). As might be expected, the coefficient for IN_CITY was positive in practically every case that the coefficient was statistically significant at the 0.01 level (see Table C.7). This means that in nearly every case, urban development was more likely to occur inside city limits rather than outside controlling for the other locational factors.

Table C.7: Logit Regression Results with CHANGED as the Dependent Variable

Variable	Albany	Aumsville	Bend	Canby	Central Point	Columbia City	Corvallis
D_CENTER	**-0.649**	-8.486	**2.784**	**-3.039**	1.280	-4.722	**1.886**
D_C2	**0.155**	5.842	**-0.502**	0.443	**-1.642**	1.705	**-0.269**
D_HIGHWAY	0.100	0.232	**1.853**	-1.081	1.534	1113.957	0.179
D_H2	-0.109	-0.657	-0.200	0.230	0.141	3665.396	0.008
D_PROJECT	**-0.415**		0.030			-1114.070	**-2.808**
D_P2	**0.102**		**-0.803**			-3672.090	**0.691**
D_UGB	**-3.485**	0.267	**2.716**	-2.907	**-6.262**	-3.625	**-1.573**
D_U2	**3.870**	-5.211	-0.261	-1.471	**4.835**	6.465	**2.387**
IN_CITY	**1.052**	0.115	**0.441**	**1.164**	**1.292**	0.065	**1.792**
NEIGH70	**6.236**	-5.711	**2.005**	**-4.173**	1.434	2.092	**1.610**
YEARS	0.027		**0.079**				**-0.173**
Z_COM	0.937	0.801	**0.967**	1.751	0.988		**1.136**
Z_IND	-0.394	0.960	**1.809**	-1.325	-0.516	-0.373	**-0.846**
Z_RUR	**-1.187**	-0.472	**-1.023**	-1.960	**-3.276**	-0.546	**-2.038**
Z_SFR	0.195	**1.774**	0.046	0.591	**-1.746**	0.750	0.206
SPATIAL	**6.504**		**3.364**	**12.687**	**9.124**	**5.185**	0.561
(Constant)	0.684	2.088	**-7.219**	**4.257**	**1.805**	1.557	**-2.146**
% Correct	83.9%	78.8%	84.6%	91.7%	87.5%	94.7%	83.1%
N	5,354	354	5,014	1,234	1,454	1,170	3,829

Note: Coefficients shown in bold are significant at < 0.01
% Correct as reported by SPSS statistical output

Table C.7: Logit Regression Results with CHANGED as the Dependent Variable (cont.)

Variable	Dallas	Florence	Grants Pass	Hillsboro	Klamath Falls	Lincoln City	Madras
D_CENTER	**-7.529**	-0.124	1.101	**-4.306**	**2.182**	--	**5.310**
D_C2	**1.681**	0.187	-0.420	**0.728**	**-0.330**	--	**-2.146**
D_HIGHWAY	0.040	5.210	**-1.792**	**-2.593**	**-2.887**	--	**-7.930**
D_H2	-0.871	-2.276	-0.143	**0.813**	**0.902**	--	**4.040**
D_PROJECT	-0.829	-4.219	**2.297**	**2.928**	**1.524**	--	**-10.103**
D_P2	0.428	1.011	**-0.923**	**-1.528**	**-0.517**	--	**3.249**
D_UGB	-1.978	-3.921	0.386	**-1.033**	**2.158**	--	3.413
D_U2	-0.832	3.407	**-3.315**	**0.963**	**-0.843**	--	-6.568
IN_CITY	**1.495**	**0.954**	**0.970**	**-1.287**	-0.331	--	0.599
NEIGH70	**-7.947**	-1.406	-0.273	**4.922**	**1.878**	--	-3.192
YEARS			-0.039	0.025	**0.581**	--	0.628
Z_COM	0.542	-0.527	0.4318	**1.559**	**2.115**	--	0.628
Z_IND	-1.646	-0.494	0.436	**-0.668**	**1.980**	--	**3.815**
Z_RUR	-0.730	**-2.293**	**-3.544**	**-2.083**	0.058	--	1.587
Z_SFR	0.556	-0.313	**-1.431**	**1.535**	**1.938**	--	**2.378**
SPATIAL	**9.525**	**5.472**	**5.560**	**9.059**	**3.712**	--	**13.505**
(Constant)	**6.152**	-0.937	1.435	**6.632**	**-8.139**	--	2.301
% Correct	91.7%	94.9%	84.4%	90.4%	92.4%	--	89.4%
N	1,897	1,663	2,178	4,280	6,231	--	1,115

Note: Coefficients shown in bold are significant at < 0.01
% Correct as reported by SPSS statistical output

Table C.7: Logit Regression Results with CHANGED as the Dependent Variable (cont.)

Variable	McMinnville	North Plains	Redmond	Sherwood	Troutdale	Woodburn
D_CENTER	-0.913	17.710	**4.849**	**-5.953**	**4.702**	-0.970
D_C2	-0.226	-7.838	**-1.950**	**1.365**	**-5.802**	-0.272
D_HIGHWAY	**-2.502**	3.888	**-2.919**	1.349	**3.330**	-1.312
D_H2	**0.713**	-4.429	**1.671**	**-1.860**	**0.900**	1.810
D_PROJECT	0.234	7.613	-0.650	**4.733**	**3.173**	**-4.132**
D_P2	-0.040	**-6.432**	0.144	**-1.351**	-0.380	**0.973**
D_UGB	0.725	-10.226	**6.409**	**-3.695**	**-2.967**	**-5.441**
D_U2	-0.235	8.809	**-2.001**	**5.361**	**1.511**	**5.662**
IN_CITY	**1.419**	**3.539**	**1.263**	**1.960**	0.633	**2.453**
NEIGH70	-0.551	10.852	**-4.847**	-4.928	**6.111**	-0.355
YEARS			**0.500**			
Z_COM	-1.303	3.192	-0.791	0.129	0.201	0.202
Z_IND	-1.042	-0.748	**-3.272**	0.794	0.181	0.475
Z_RUR	**-2.343**	-1.488	-1.318	**1.361**	0.167	-0.867
Z_SFR	-1.006	0.615	0.218	**1.549**	**0.740**	1.012
SPATIAL	**1.762**	**33.992**	**9.907**	**9.525**	**6.726**	**10.918**
(Constant)	**3.678**	**-9.027**	**-5.280**	0.684	**-4.812**	**4.756**
% Correct	88.9%	91.2%	93.7%	86.3%	88.9%	88.7%
N	3,277	339	2,645	1,320	1,714	1,601

Note: Coefficients shown in bold are significant at < 0.01
% Correct as reported by SPSS statistical output

In terms of the spatial index, in all cases the coefficient was positive and reasonably high indicating the strong influence of adjacent land use activities on spatial development trends. Surrounding land that becomes predominantly urban will exert pressure on nearby properties to urbanize as well. Other variables that were reliable predictors of urban status were the distance to the center of the city (D_CENTER and the squared term D_C2) and the distance to the UGB (D_UGB and the squared term D_U2). In just over half of the cases where the distance to the center of the city variable was significant, the probability of urban development increased with increasing distance. In each of the six cases, the squared term was negative indicating that the development potential declined with increasing distance. In most cases where the distance to the UGB variable was significant, development activity was less likely to have occurred with increasing distance to the boundary *(see Kline and Alig 1999, for discussion about UGB effects on conversion of Oregon forest and farmland).*

In nine of sixteen cases (four cities did not have identified highway projects) the coefficients for the distance to the nearest highway project (D_PROJECT) were statistically significant. For five of the cities, the coefficients were positive and for four they were negative. Controlling for other locational factors, the likelihood of development with increasing distance from highway projects was highest for Sherwood and Troutdale. The highest likelihood for development to be concentrated near highway projects occurred for Madras and Woodburn. A negative relationship between distance and urban development was expected if capacity increasing highway improvements were having a significant impacts on development patterns. These mixed results indicate that the impacts of highway projects cannot be generalized across city types. The results also indicate that the location of projects was an inconsistent predictor of urban development. Because many of the selected cities only had one highway project being analyzed, the length of time that a highway project had been completed (the YEARS variable) could not be included in many of the regression equations. In 3 of 4 cases that the coefficient was significant (Bend, Klamath Falls, and Redmond) the sign was positive, with Corvallis being the exception.

The urban status of surrounding properties (the NEIGH70 variable) and the land use zoning classification were also inconsistent predictors of whether a particular location was developed for urban purposes. The NEIGH70 variable controls for the natural "spread effect" of urban development pressure. The coefficient for this variable was positive in 6 of 9 cases for predicting the likelihood of land use change from 1970 to 1990. As also indicated by the spatial lag variable, as would be expected, the neighborhood variable suggests that land was more likely to be developed or become developed if surrounding properties were developed. The land use zoning variables were not consistent predictors of development patterns. In cases where the coefficient was significant, land zoned for single family residential and commercial land uses was more likely to be developed compared to land zoned as industrial or rural. This suggests that in some cases, rural and agricultural designations had generally inhibited development while growth accommodating commercial and residential zones was associated with increases in urban land use activities.

MEASUREMENT ERROR

The manual method of digitizing urbanized areas from aerial photographs involves a degree of error in a few different forms. Image distortion, edgematching errors, and image registration errors potentially contribute to either over- or under-estimation of total urbanized areas *(see Aronoff 1991, Tellez and Servigne 1997)*. Because the analysis was performed at a relatively small geographic scale and because general rates of development were being reported, it is likely that the overall level of error in estimates of urbanized areas does not significantly affect the outcomes of the analysis.

When many spatial measures are included within a single regression equation there was an increasing chance of multicollinearity. Undetected multicollinearity can bias regression results and potentially lead to unreliable regression coefficients *(Neter, Wasserman, and Kutner 1989)*. For this analysis, it is possible that there may be a high degree of correlation between the distance to nearest highway and distance to nearest highway project. In addition, it is possible that the measures of urban proximity; distance to UGB and distance to city center were correlated. If a UGB were a perfect circle, then the distance to the center of the city would have a significant negative correlation with the distance to the boundary. As would be expected, the correlation matrix for the pooled observations suggests that squared terms for spatial measures were collinear with their root measures. However, there does not appear to be an excessive amount of correlation among other distance measures with 1-tailed correlations generally around 0.40 or less. The correlation between distance to the nearest highway and distance to the nearest highway project being -0.048 means that there appears to be little relationship between the two distances measures.

Testing variance inflation factors proved to be problematic due to the inclusion of the squared terms of the spatial indicators *(see SPSS 1993, p.355 for discussion of variance inflation factors)*. As an alternative test, eleven iterations of an ordinary least squares regression predicting the percentage of land area within each grid cell that converted to urban uses were performed removing individual variables in succession. For example, first D_CENTER and D_C2 were excluded from the regression equation and the results were examined. Then, D_CENTER and D_C2 were returned to the equation and D_HIGHWAY and D_H2 were excluded, and so forth. In virtually all cases the sign of the coefficients remained constant, except for D_U2 and YEARS, which tended to be statistically insignificant variables in most models. Chi-square statistics for each of the regressions did not vary significantly. Based on the results of these tests, multicollinearity does not appear to be having a substantial influence on the regression results.

Along with multicollinearity it was suspected that there was a lack of independence in the spatial data. A test for spatial autocorrelation confirmed this suspicion. For this reason an autoregressive procedure using generalized least squares regression was used to fit the data. A spatially lagged variable was generated using a simultaneous spatial autoregression (SAR) model *(see Kaluzny, Vega, Cardoso, and Shelly 1998; Haining 1990)*. A second logit model was then fit that controlled for the spatial trend of residuals from the initial specification. In each case the spatially lagged model (including the variable SPATIAL) provided improved performance.

Measurement errors may also result from the method used to estimate accessibility measures. In this case the straight-line (Euclidean) distances from grid cell centroids to the nearest highway, highway project, and city center were used rather than the road network distance or travel time. In addition, the distances to the nearest highway and highway project were measured from the grid cell centroid to the nearest point along each line segment, rather than to the actual access point such as an on-ramp or interchange. This is significant because the ability to use a highway facility is influenced by the distance to an access point, which means that the variability of distance measures was affected by the type of highway (limited access, controlled access, unlimited access, etc.). It was probable that these measures did not have an adverse effect given the geographic scale of the analysis. More detailed network analysis would probably not add much variation to the relative accessibility measures for each of the grid cells.

CONCLUSIONS

The analytical method used in this study incorporated a set of commonly used data sources and techniques to assess highway impacts on urban development patterns. The results suggest that for 19 selected cities, the spatial measures have mixed performance in predicting the location of urban development from 1970 to 1990. This information provides a baseline for assessing the potential land use impacts of capacity increasing highway improvements.

Of most significance to this analysis, the results of the logit regression model indicated that controlling for other location factors, urban development has not clustered along state high project corridors. One possible explanation is that while growth occurred, these highway facilities provided the requisite accessibility for urban development to occur elsewhere in the area. With the exception of particular outliers (such as Troutdale and Hillsboro), city size and growth rates from 1970 to 1990 explain only a small amount of the variation in development occurring around specific highway improvements (see Table C.8 and Figures C.11 and C.12). It should be noted that the analysis did not account for intra-urban transportation network improvements administered by city or county jurisdictions. Non-highway transportation improvements may certainly improve circulation and congestion conditions, but not have the growth inducing impacts that major highway capacity increases tend to produce. In the case of the cities analyzed in this study, it appears that highway capacity increasing projects, which are typically a response to current or anticipated increases in travel demand, did not lead to direct and immediate land development activities.

Table C.8: Proportion of Grid Cell Changes by Population Size, Growth Rate, and Location

City	% Change < 1.61 km	% Change > 1.61 km	% Change City	1990 Pop.	% Pop. Change 1970-1990	Project Location(s)
Albany	52.3%	30.5%	35.3%	29,540	62.5%	CL/UGB
Aumsville	na	na	na	1,650	179.7%	na
Bend	43.5%	10.0%	24.5%	20,447	49.1%	CL/UGB
Canby	na	na	na	8,990	135.8%	na
Central Point	na	na	na	7,512	87.6%	na
Columbia City	9.6%	0.0%	6.5%	1,003	86.8%	CL/UGB
Corvallis	34.1%	16.6%	21.4%	44,757	27.7%	CL
Dallas	27.6%	9.6%	15.5%	9,422	48.1%	CL/UGB
Florence	11.6%	2.2%	6.9%	5,171	130.2%	CL/UGB
Grants Pass	45.2%	30.1%	35.6%	17,503	40.5%	CL
Hillsboro	50.5%	22.7%	31.5%	37,598	156.2%	CL
Klamath Falls	21.1%	9.3%	11.8%	17,737	12.4%	CL/UGB
Lincoln City	na	na	na	5,908	40.8%	na
Madras	32.6%	10.9%	16.7%	3,443	103.8%	CITY
McMinnville	30.2%	23.1%	24.9%	17,894	76.7%	CL/UGB
North Plains	29.6%	12.1%	24.5%	997	44.5%	CL
Redmond	27.2%	4.4%	14.2%	7,165	92.6%	CL/UGB
Sherwood	32.1%	28.4%	30.2%	3,093	121.6%	CL
Troutdale	42.4%	15.0%	22.9%	7,852	372.7%	CL
Woodburn	35.6%	16.4%	26.0%	13,404	78.8%	CL

Note: CL = near city limit, UGB = near urban growth boundary, CITY = within city limits

Comparing development rates around highway improvements by location of the improvement suggests that projects that were generally at or near city limit boundaries exhibit more land use conversion than do projects at or near UGBs. On average, 41.6% of grid cells within 1.61 km (1 mi) of highway projects converted to urban land uses for projects near city limits compared to 31.4% for projects near UGBs. This can be partly explained by the fact that projects near city limits were closer to previously developed land than were projects near UGBs. This is consistent with the logit regression results that suggest development had a higher likelihood to occur within city limits and contiguous to other land in urban uses.

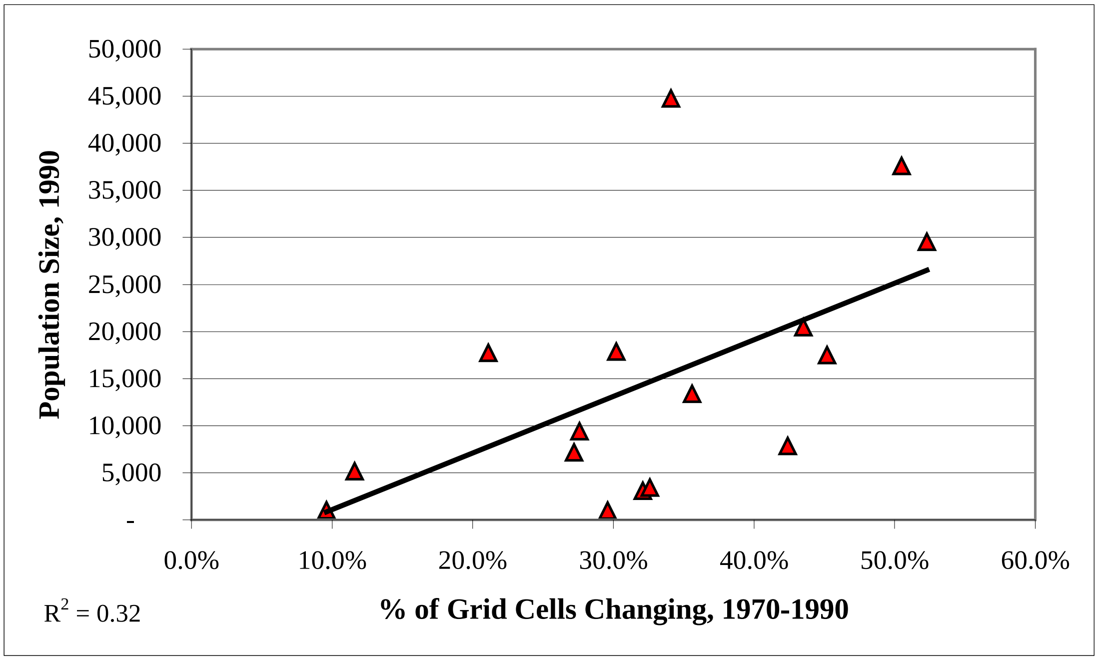


Figure C.11: Comparison of Grid Cell Changes within 1.61 km of Highway Project with City Size

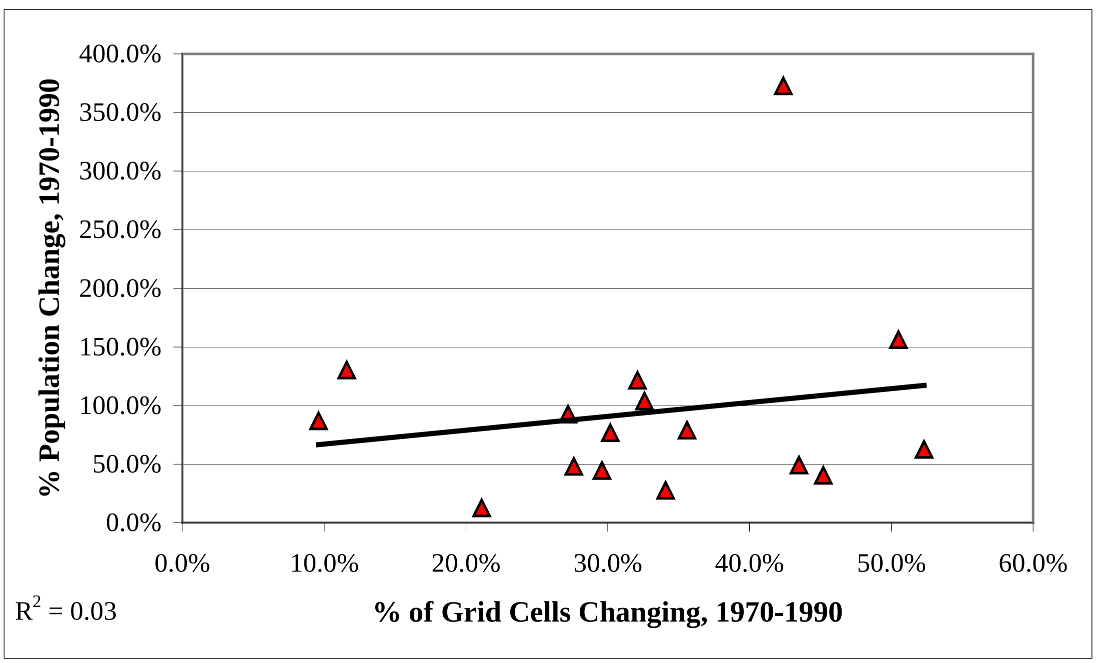


Figure C.12: Comparison of Grid Cell Changes within 1.61 km of Project with Population Change

The distance to the nearest highway project (D_PROJECT) coefficients were also compared, to determine if the pattern of land use impacts was related to city type – either by city size or by the population growth rate from 1970 to 1990. There were four cities with positive coefficients, five with negative coefficients, and seven with statistically insignificant coefficients (see Table C.7). On average, cities with negative coefficients (indicating more localized highway project impacts), cities with positive coefficients (indicating more dispersed project impacts), and cities with statistically insignificant coefficients for this variable did not differ significantly in terms of population size (see Figure C.13).

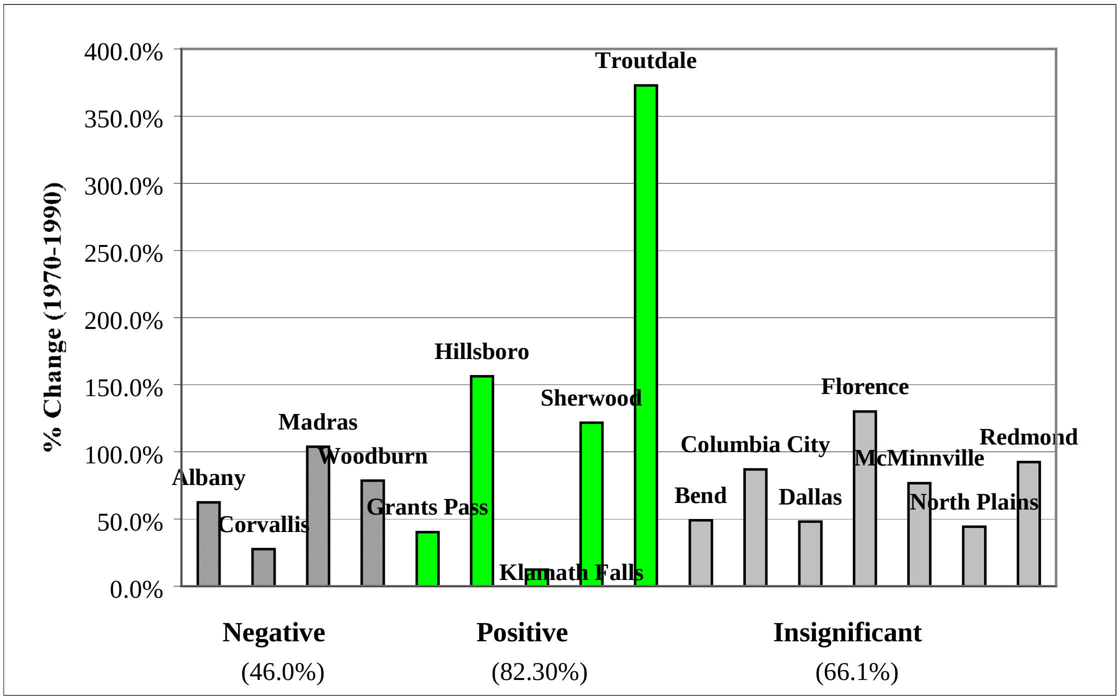


Figure C.13: D_PROJECT Coefficients by Percent Population Change, 1970-1990
(average change in parentheses)

The distance to the nearest highway project coefficients and the percent population change from 1970 to 1990 were also compared for the above groups of cities. Similar to the comparison by population size, the average rate of population change for cities with negative D_PROJECT coefficients, and statistically insignificant coefficients did not exhibit a strong or consistent pattern (see Figure C.14).

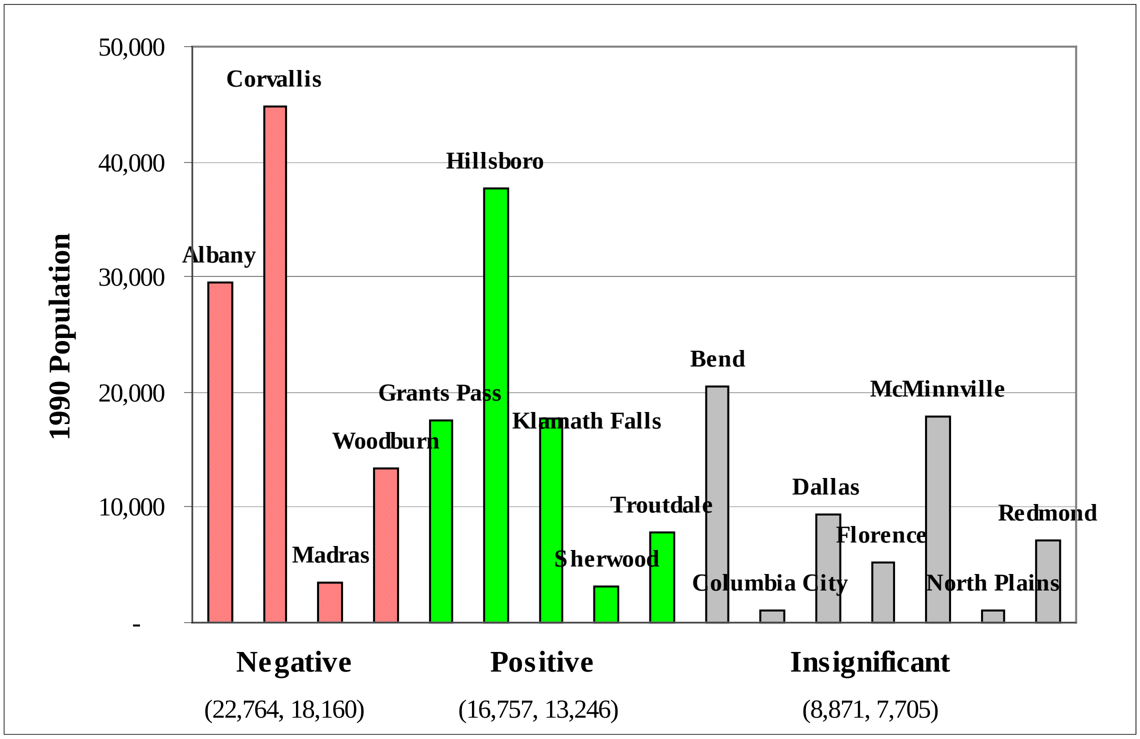


Figure C.14: D_PROJECT Coefficients by Population Size, 1990
(average and standard deviation in parentheses)

The following are the key findings of this research.

- The selected cities had experienced significant rates of urban development from 1970 to 1990. The average increase in urbanized area was approximately 72.2%.
- Urban development appeared to occur more rapidly during the period from 1970 to 1980 compared to the period from 1980 to 1990.
- While these cities grew in population size and geographic extent, most increased both in population density and housing density within their 1990 city limits.
- As would be expected, changes in physical size of cities were generally correlated with changes in population size and number of total housing units.
- Urban proximity measures were reasonable predictors of the extent and rate of urban development.
- The location of existing highways and capacity increasing highway improvements were somewhat correlated with urban development patterns.
- The correlation between land use change and highway project locations was inconsistently related to city size and city population growth trends.

Like other quantitative analyses of urban growth trends, this study could be enhanced with additional information about each of the urban areas. The study was limited by the availability and quality of the aerial photography, the precision of the urban area estimation techniques, the availability and reliability of the highway data, and the resolution and extent of city data. Additional information could also include the historic land use regulations and parcel information for each of the cities. Another important variable that should be included in subsequent analyses is the highway traffic volume. Additional vehicle traffic resulting from highway capacity increases is likely to be correlated with induced urban development demand. The location of other capital investments besides transportation facilities also influence development patterns. Many of these issues are addressed in Phase II and III (case studies) of this research project where specific highway improvement corridors are analyzed at a more localized level.

The analysis presented here provides useful information about trends in land use development. Similar analyses can be utilized for highway impact assessment purposes – especially during the environmental impact assessment phases of project design. However, such a model cannot anticipate changes in political or economic environment of an urban area.

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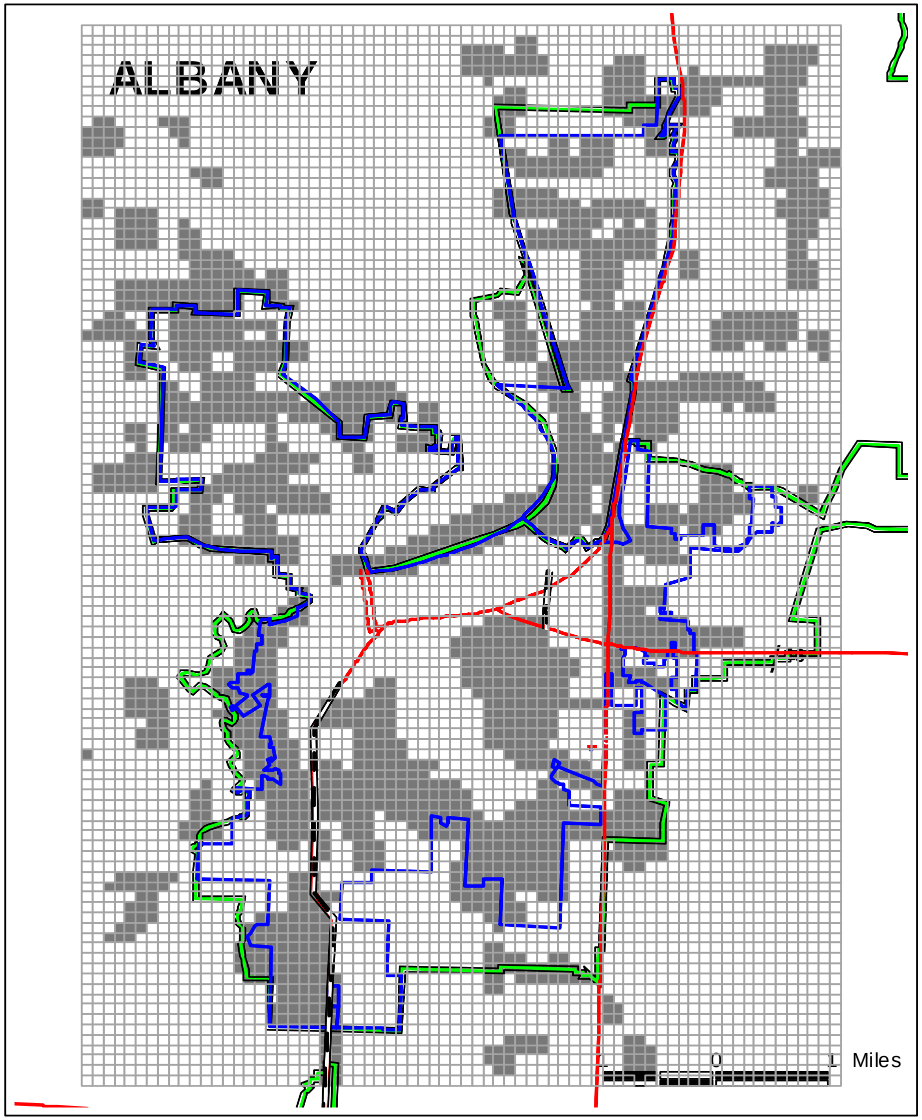
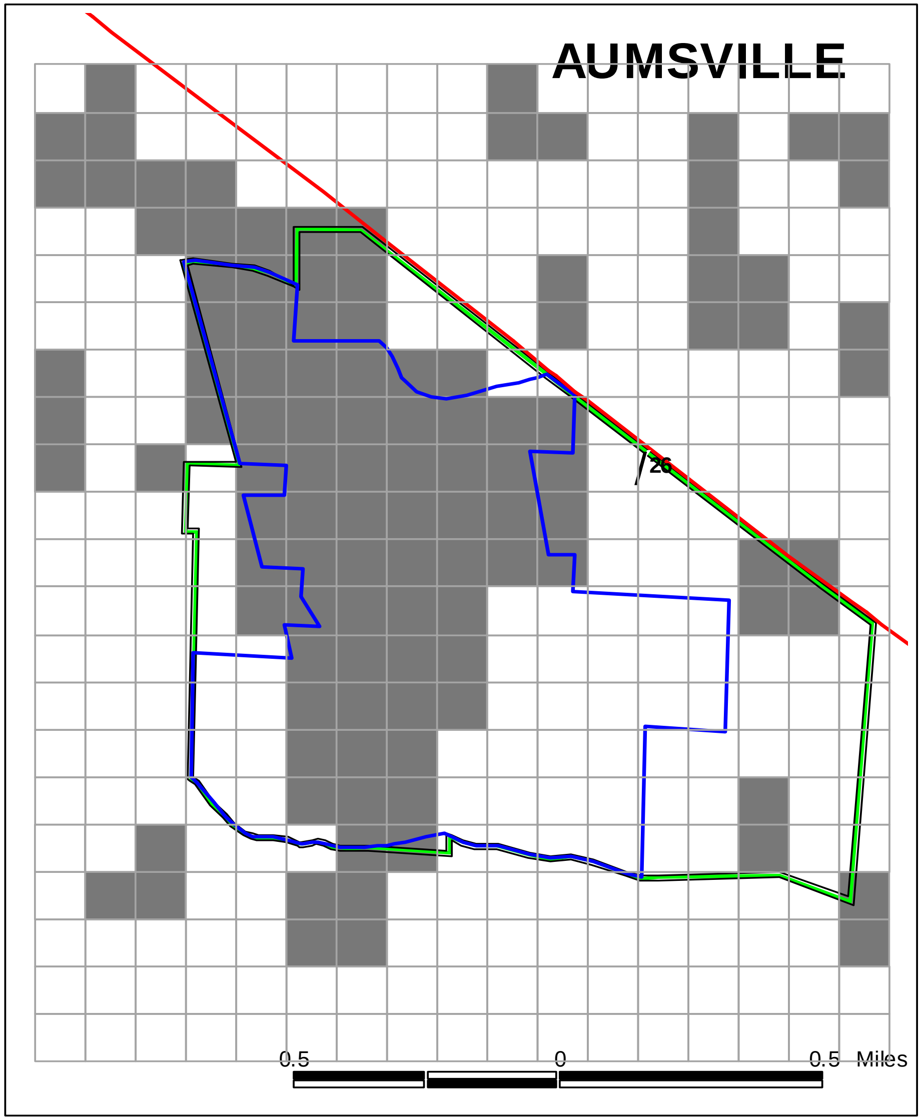
Maps of Growth Trend Analysis Cities





Legend

City Limit	Highways
Urban Growth Boundary	Highway Project

1970-1990 Grid

Unchanged

Changed

N

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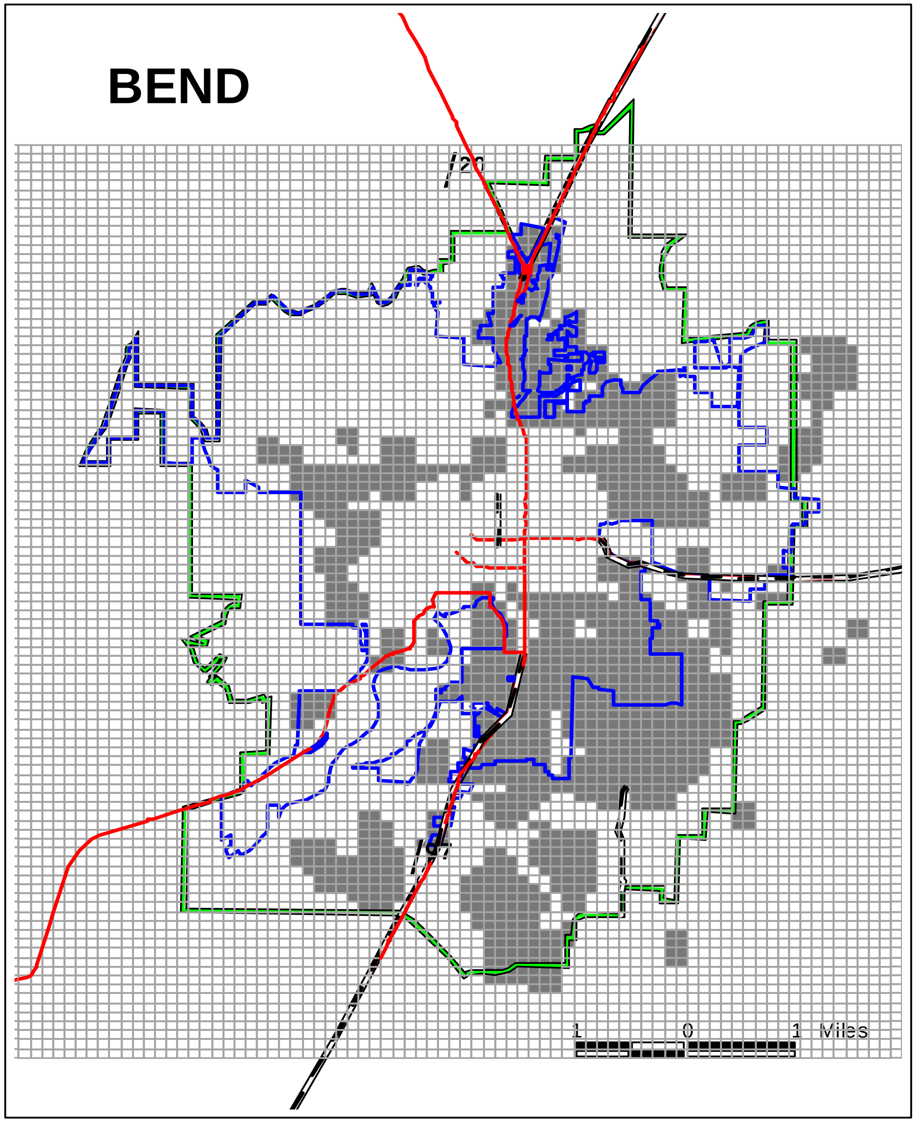
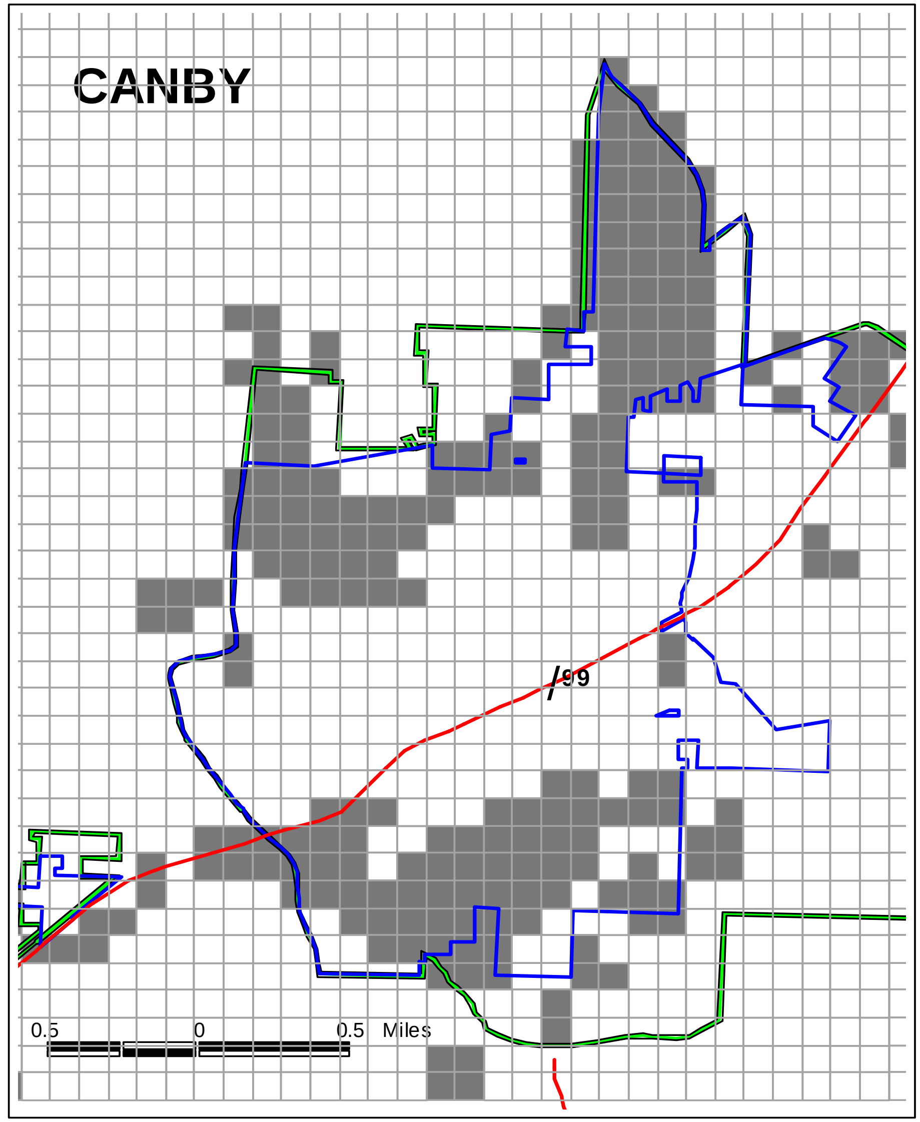
prepared for the Oregon Department of Transportation
July 1999

Maps of Growth Trend Analysis Cities





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City Limit

Urban Growth Boundary

Highways

Highway Project

1970-1990 Grid

Unchanged

Changed

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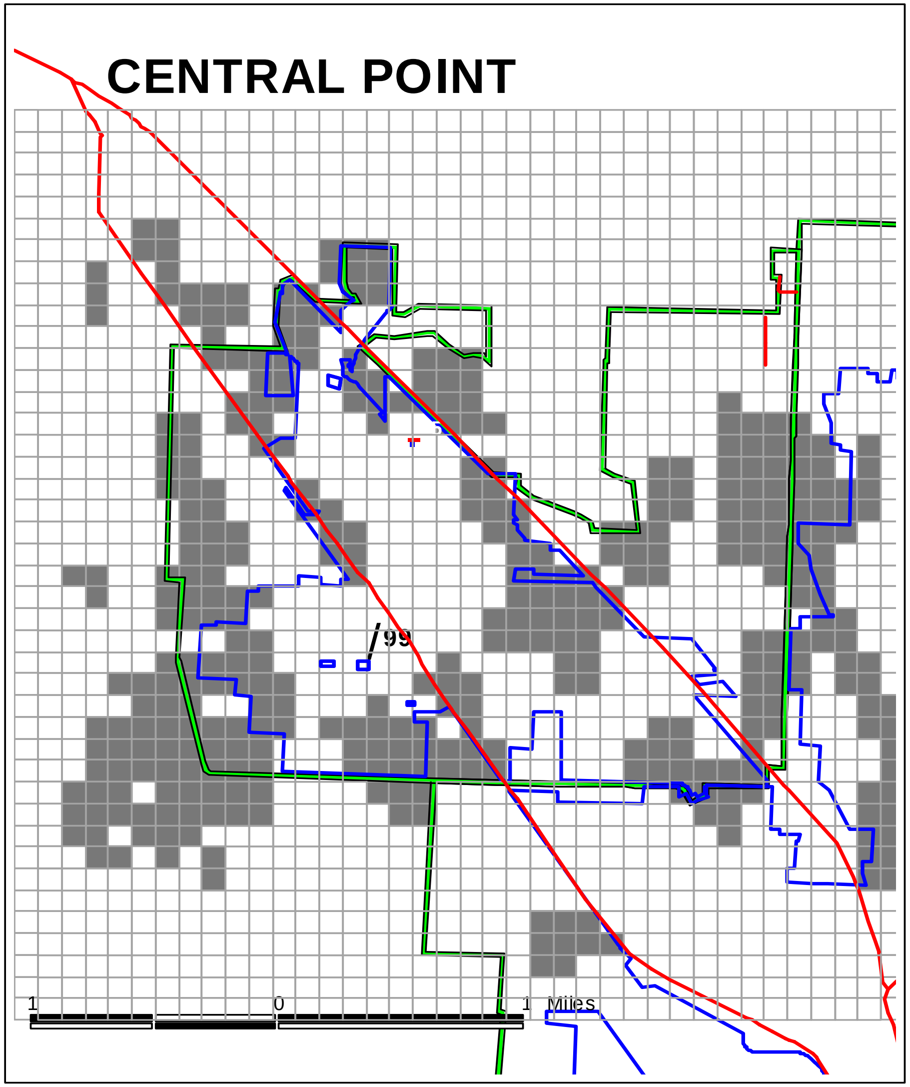
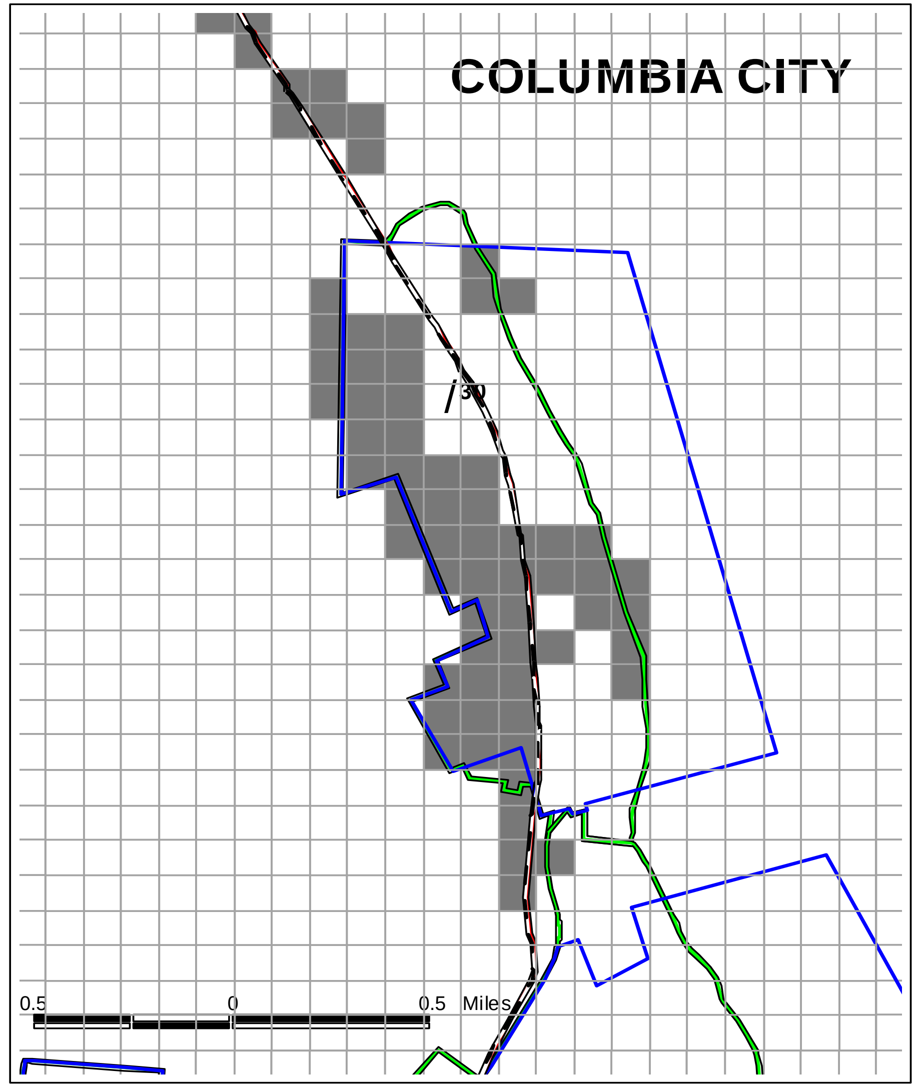
MAPS OF GROWTH TREND ANALYSIS CITIES





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City Limit

Urban Growth Boundary

Highways

Highway Project

1970-1990 Grid

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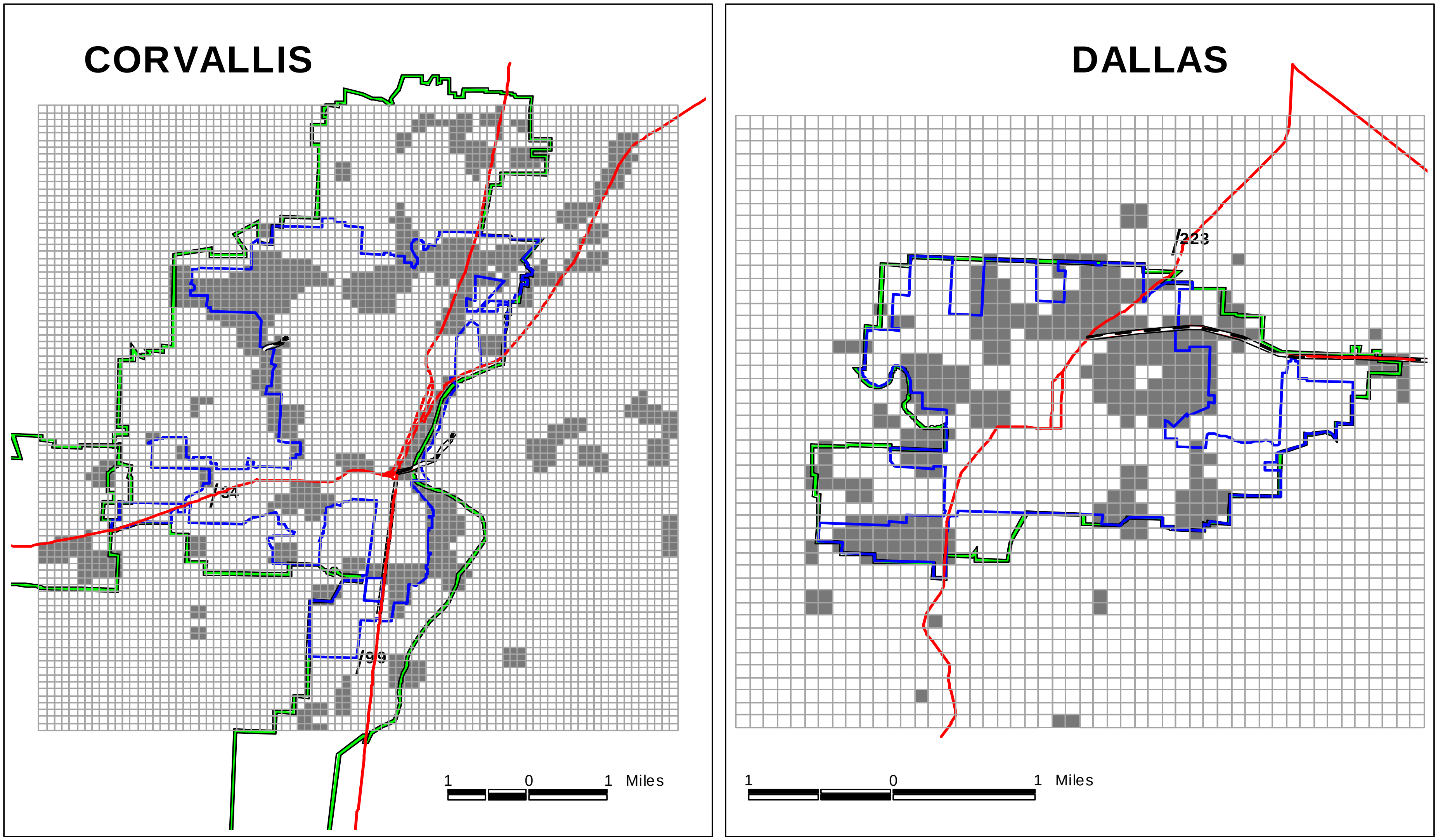

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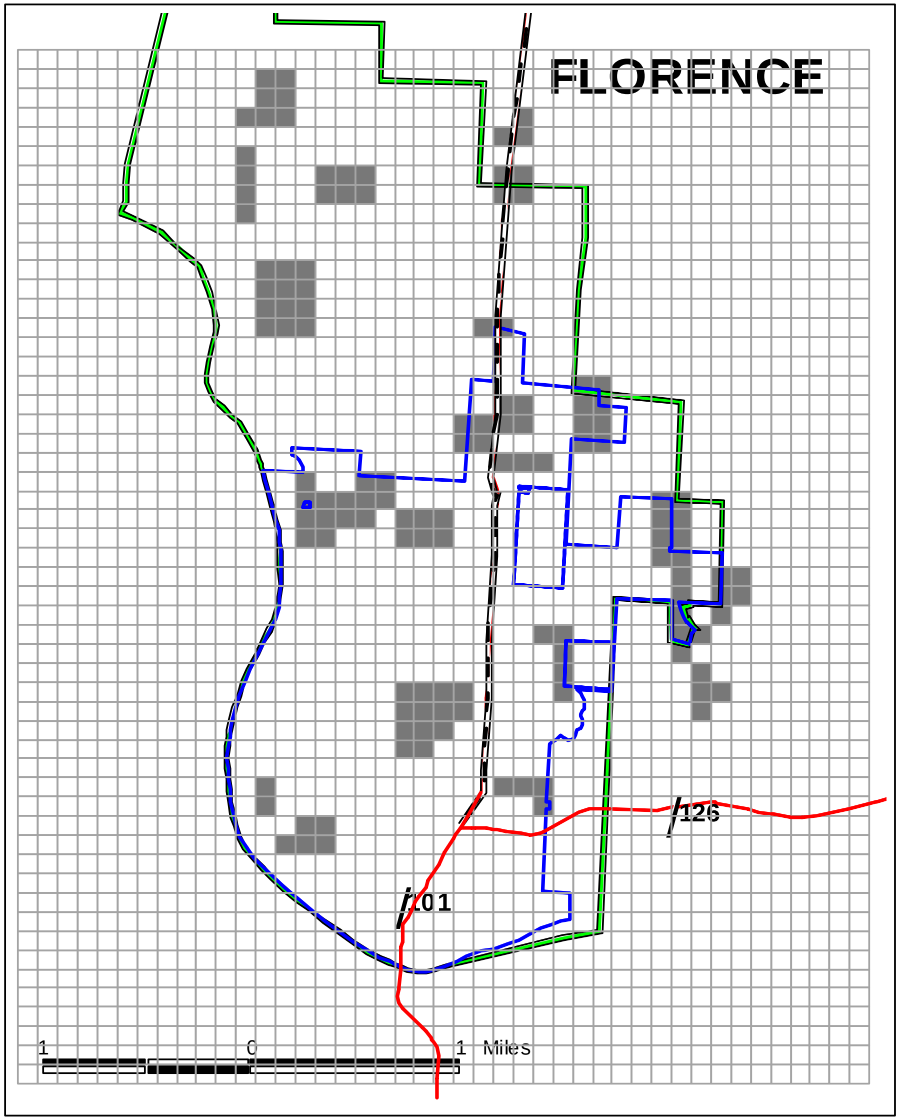

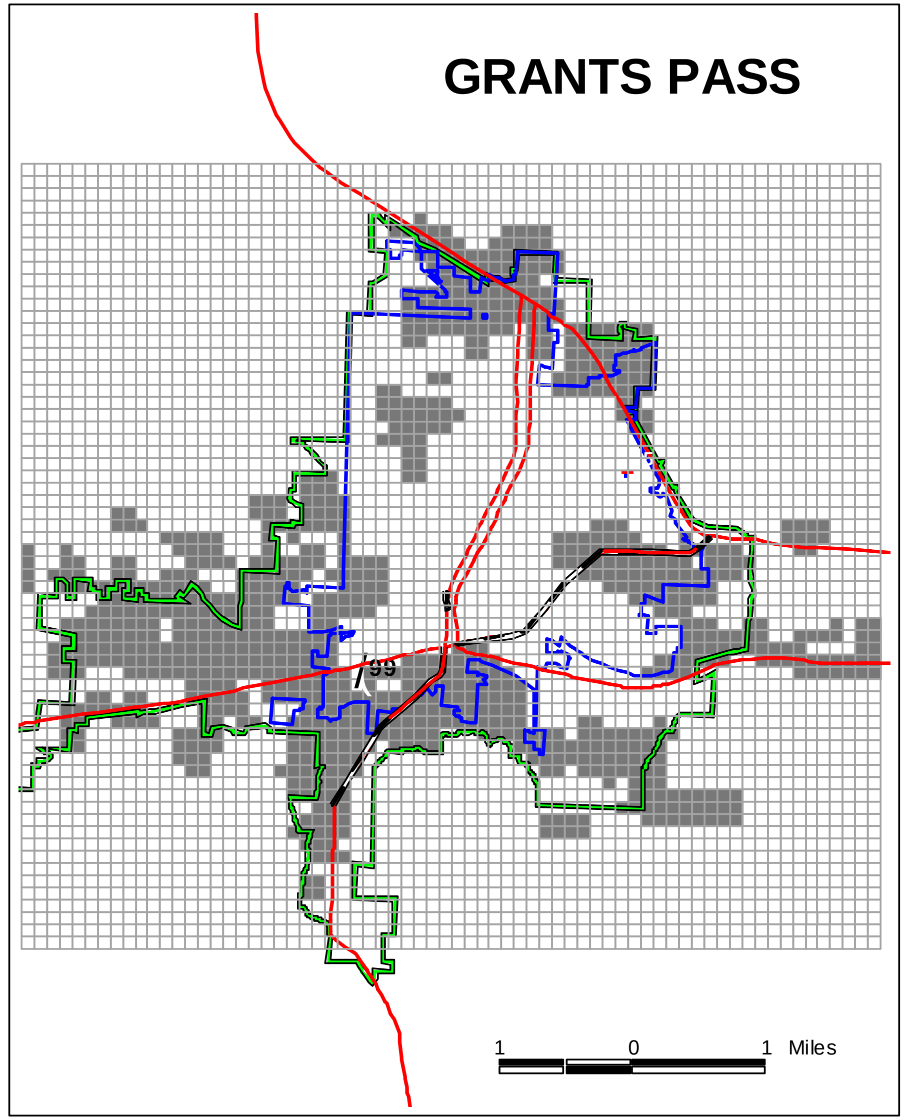

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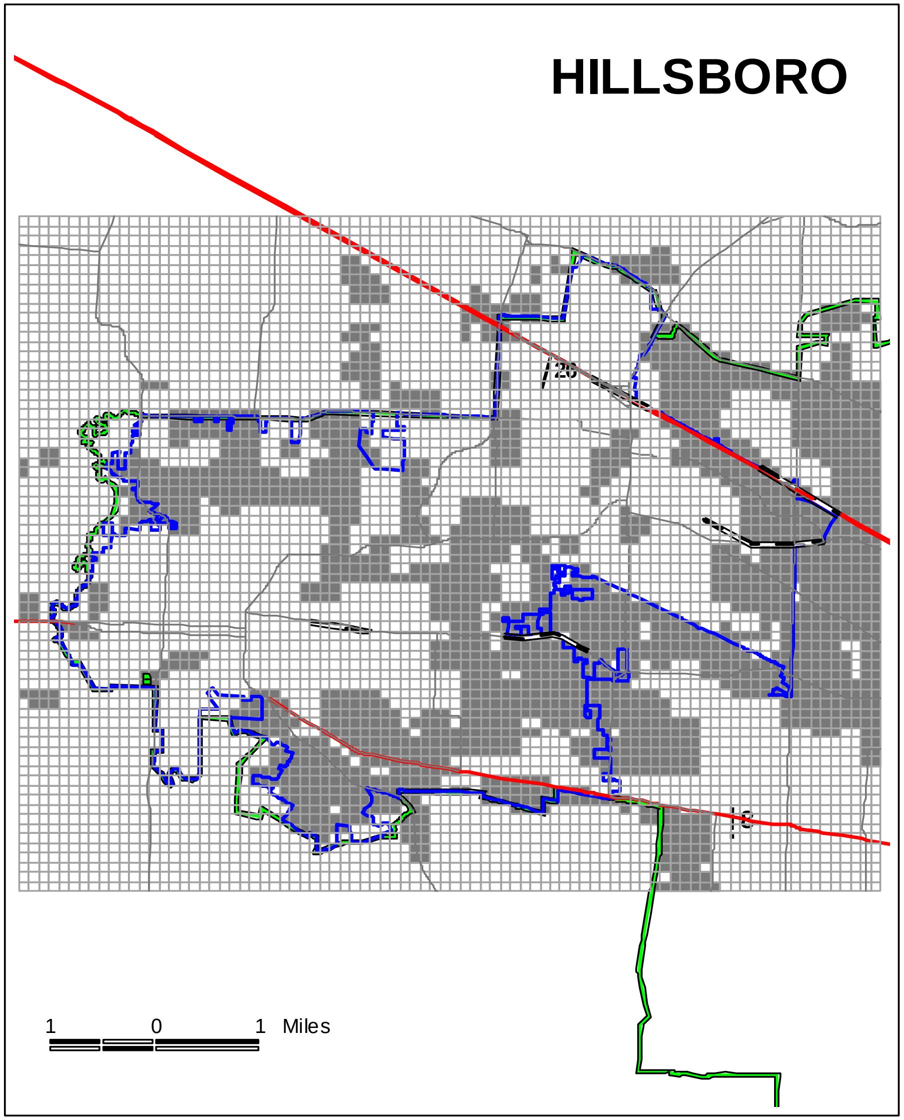

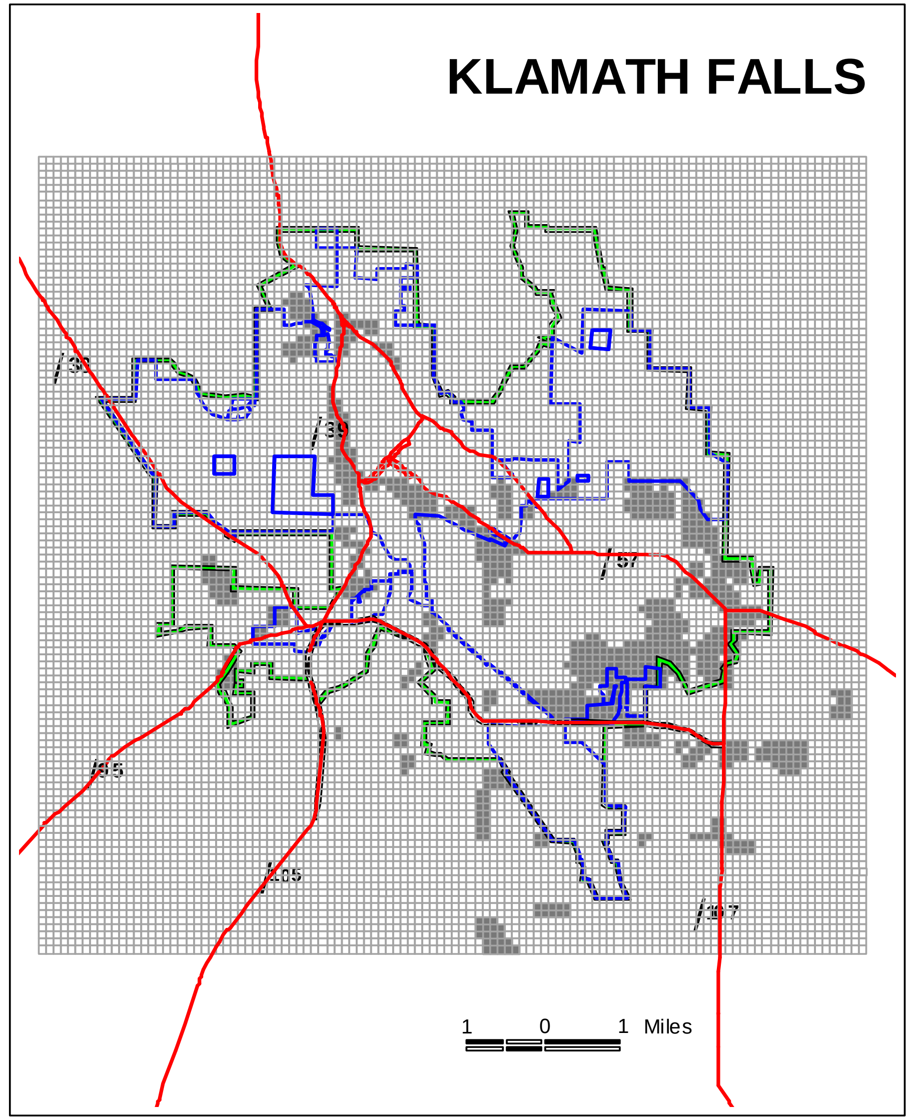

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Highways

Highway Project

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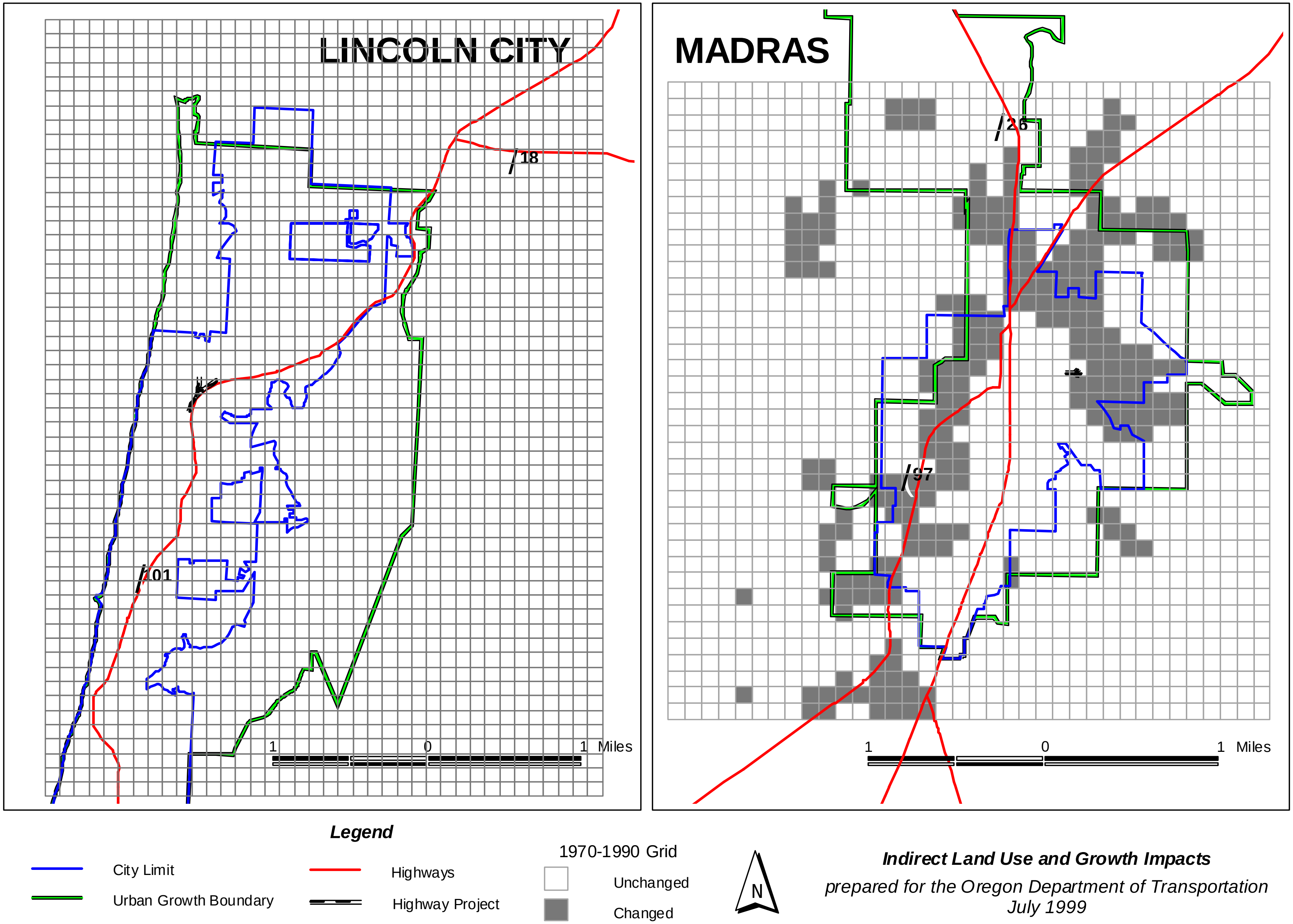

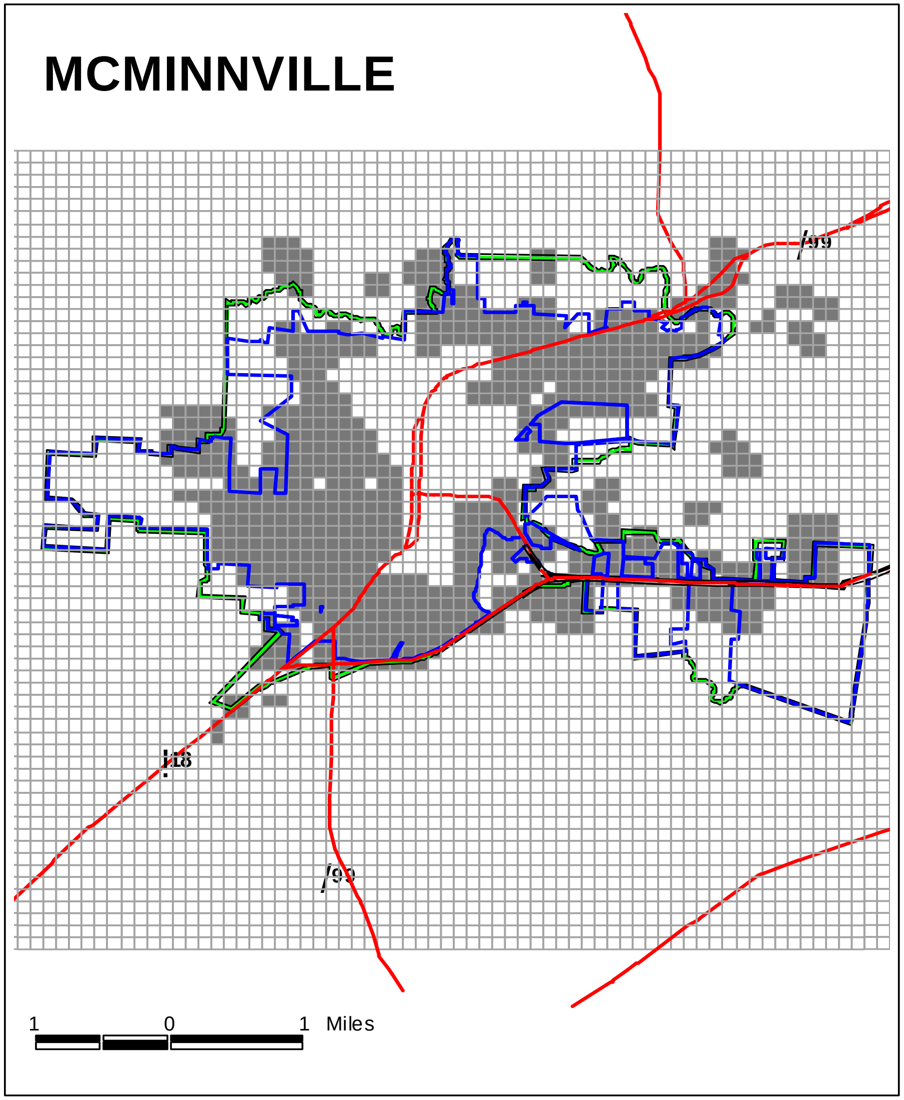

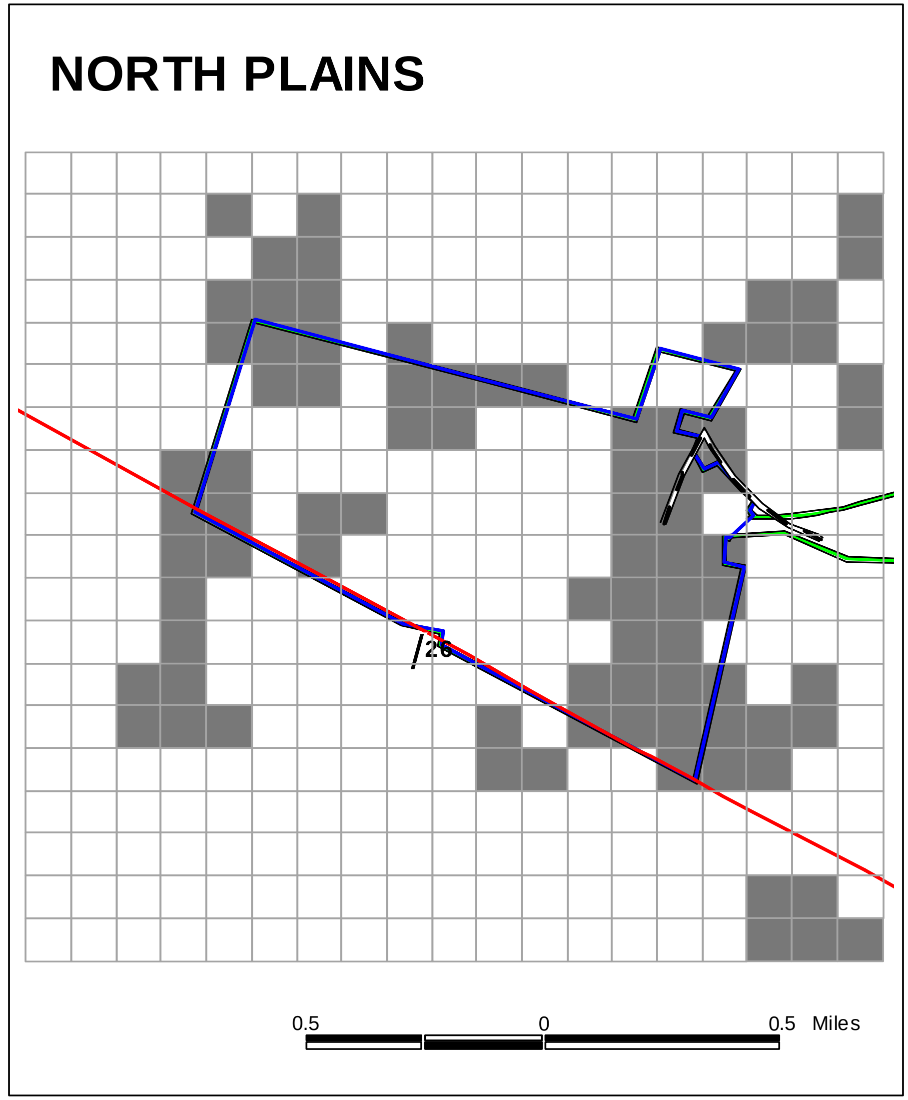

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Highways

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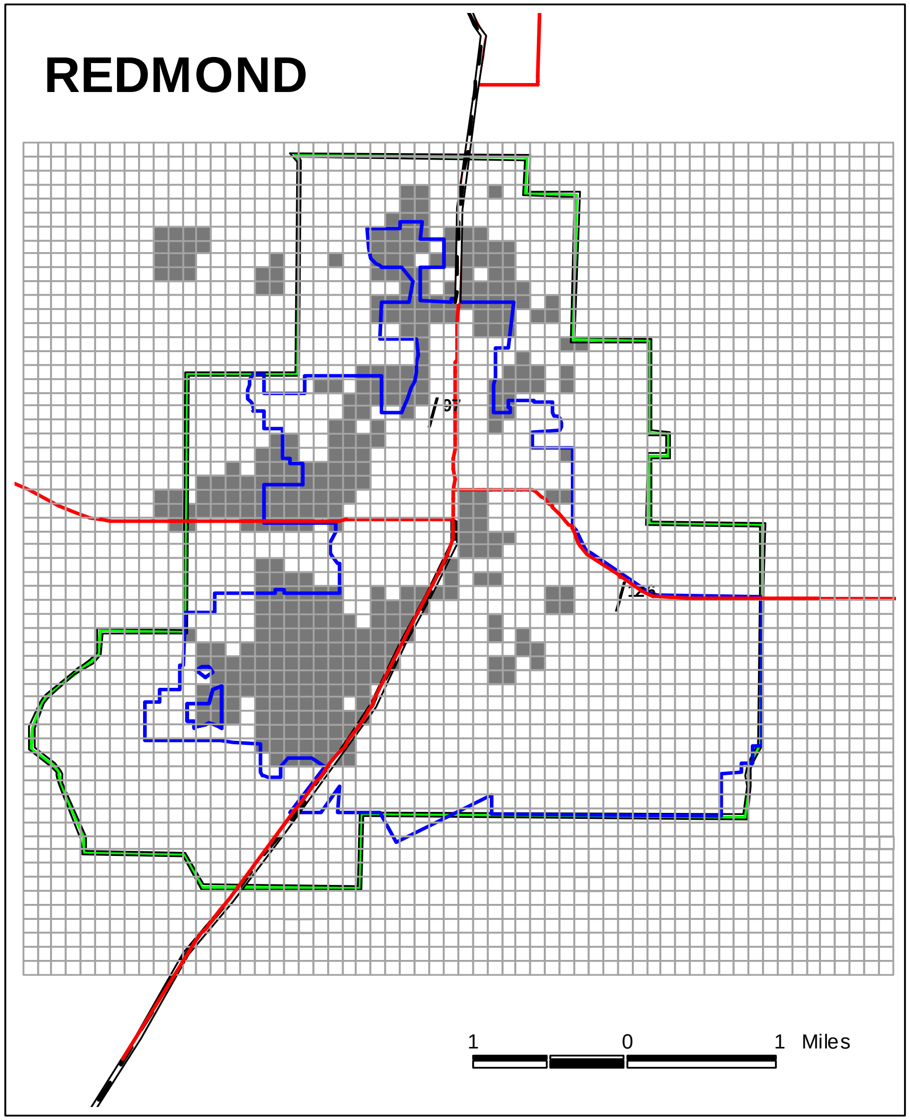

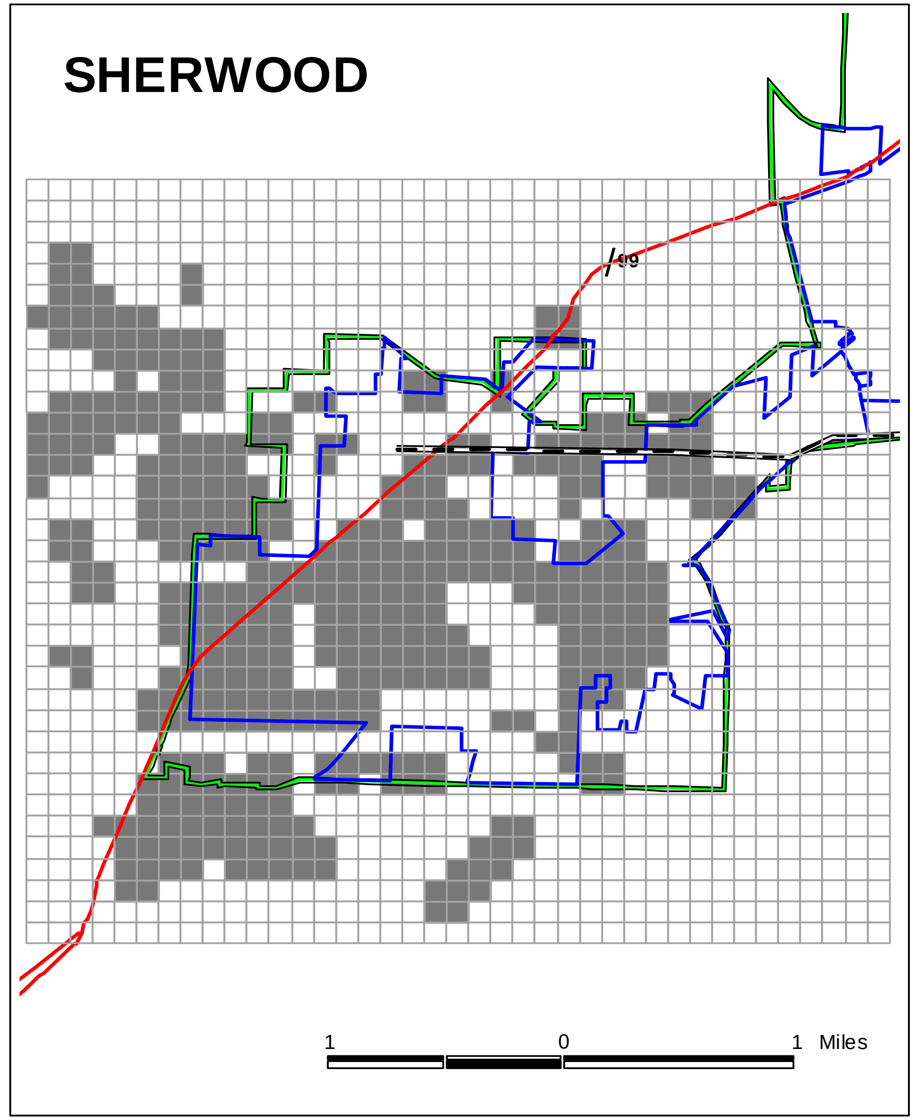

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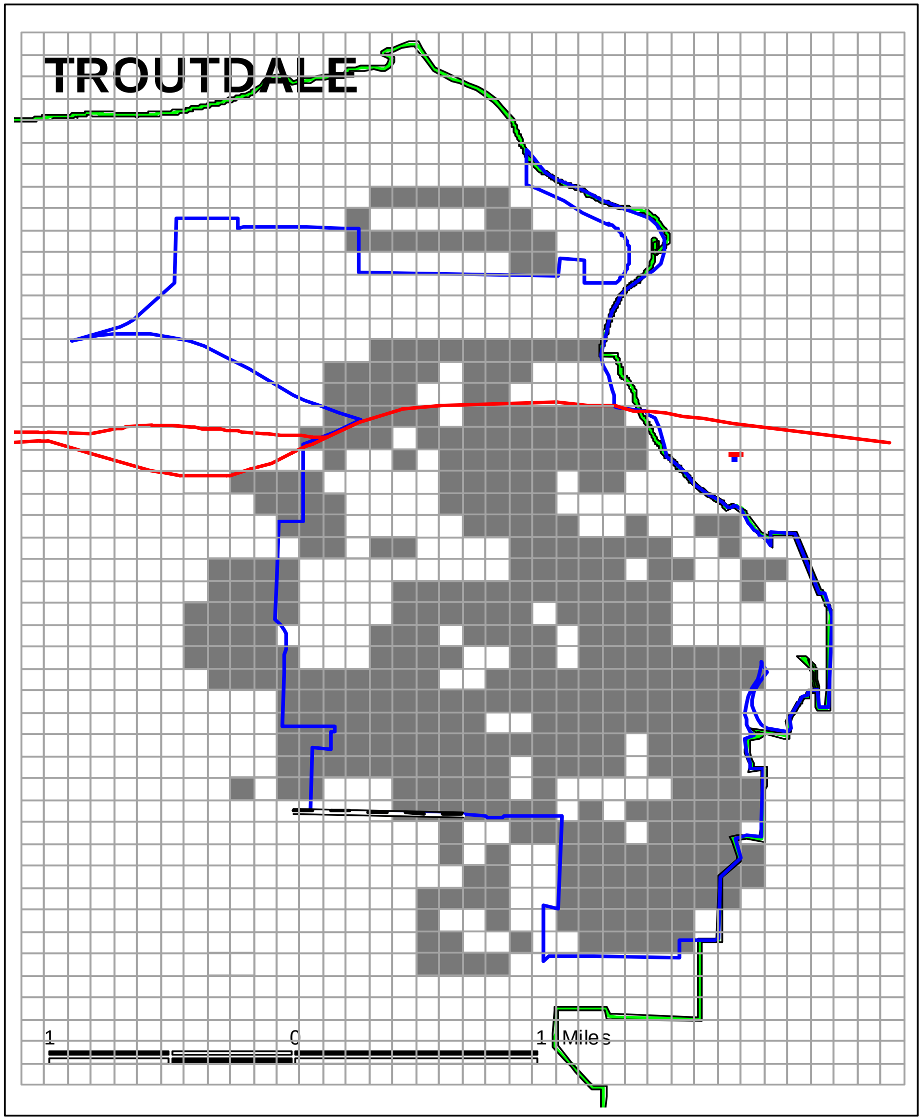

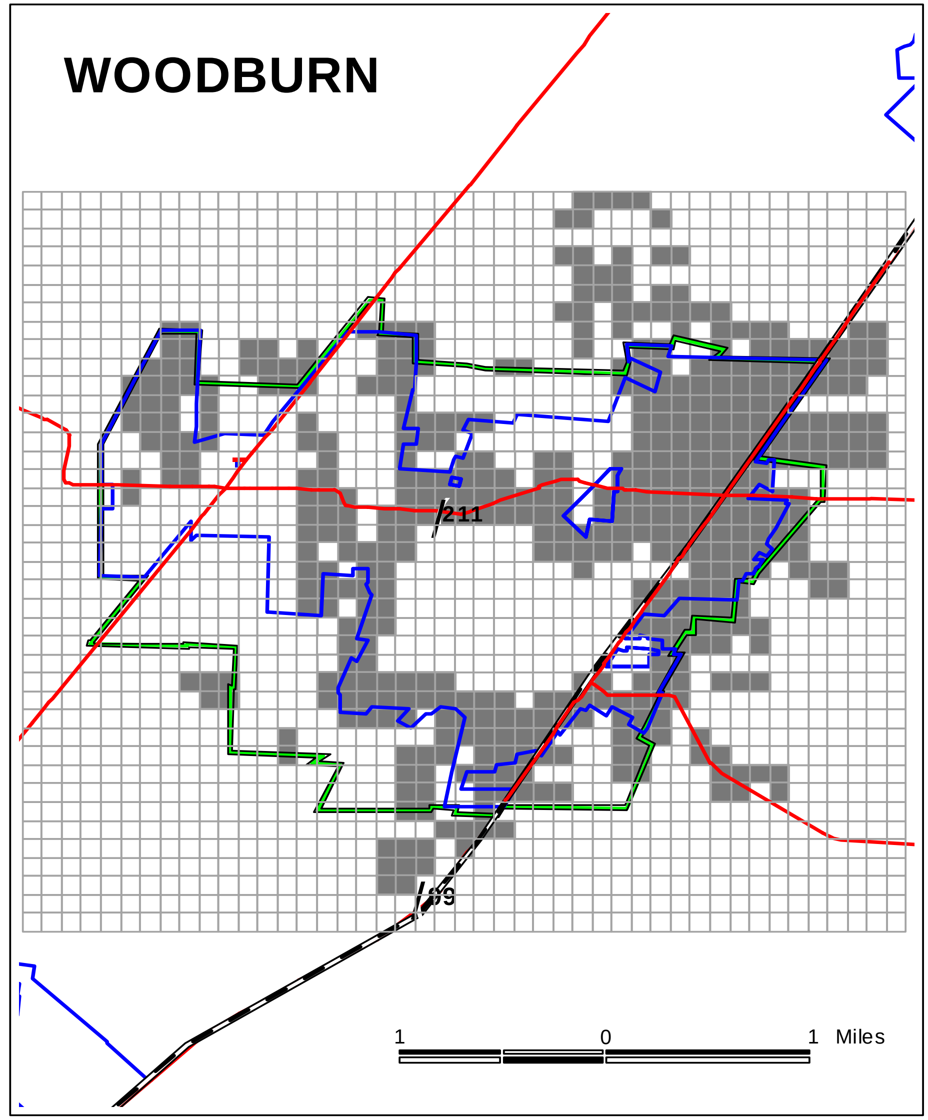

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City Limit	Highways
Urban Growth Boundary	Highway Project

1970-1990 Grid

- Unchanged
- Changed

N

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List of Highway Projects

Albany

Highway 99E (Queen Ave to Tangent Drive). Widen 5.5 miles from 2 lanes to 4 lanes with CLTL between I-5 and Corvallis. Construction completed 1988.

Lake Creek to I-5. Widen Highway 34 from 2 to 4 lanes outside UGB between I-5 and Corvallis. EIS 1984. Construction completed 1990.

Waverly Drive between Route 99E and U.S. 20 Road widening, improvement. EIS 1979. Estimated completion 1985.

Aumsville

None

Bend

Murphy Road to Lava Butte. Widen 9 miles of Highway 97 from 2 to 4 lanes with CLTL south of Bend UGB. EIS 1986. Construction completed 1989.

Highway 97 Bend SCL to Murphy Road 2 to 4 lanes with CLTL. FEIS 1977. Estimated completion 1985.

Highway 97 Bend to Redmond Section 10 miles 2 to 4 lanes with CLTL EIS 1986. Estimated completion 1990.

Greenwood Ave. Reconstruct .13 miles of Greenwood Ave. between Hill St. and First St. Elevation Lowered to provide clearance under railroad structure and Division St. to improve capacity of both Green wood Ave. and Division St. EIS 1981. Construction completed 1984.

Route 46 Oregon Forest Highway, Cascade Lakes Highway, beginning at Bachelor Butte in Deschutes County and extending west and southerly approximately 11.2 miles following the existing Cascade Highway to Elk Lake. Widen existing highway. EIS 1974. Estimated completion 1985.

Division St. improvement from Greenwood north to Deschutes Pl. to relieve congestion on Hwy 97. EIS 1981. Estimated completion 1985.

Rt. 20 Central Oregon Highway. East city limits extending 2.37 miles east. Realignment, increase lane and shoulder width. EIS 1971. Estimated completion 1980.

Canby

None

Central Point

None

Columbia City

U.S. 30 North of Columbia City to Bennett Rd. 6.96 miles, 2 to 5 lanes. EIS 1989. Estimated completion 1990.

Corvallis

Highway 34 (Lake Creek to I-5). Widen Highway 34 from 2 lanes to 4 lanes with CLTL between I-5 and Corvallis. EIS 1984. Construction completed 1990.

Corvallis Bypass. New alignment connecting Highway 34 to 99W on east side of Corvallis. EIS 1978. Construction completed 1989.

N.W. Circle Blvd, from N.W. Lantana Drive to N.W. Witham Hill Drive. New link, arterial, 2 lanes, 0.35 miles. EIS 1980. Estimated completion 1985.

Dallas

Rickreall to Independence Section toward Dallas. Widen Highway 22 5.3 miles to 4 lanes with CLTL. EIS 1971. Estimated completion 1980.

Florence

Highway 101 (Sutton Lake to NCL Florence). Widen 5.44 miles - 5 lanes between 37th and 10th in Florence, 3 lanes for the rest. EIS 1979. Construction completed in 1989.

Grants Pass

Highway 238 (Grants Pass to New Hope Road). Widen 1.5 miles from two lanes to four lanes with CLTL outside the urban area near the Redwood Highway Interchange. Construction completed 1975.

Third river crossing facility through urban area to serve both through traffic bound for I-5 to the north and highway 199 to the south and local traffic in the Grants Pass urban area. DEIS 1978. Estimated completion 1985.

Hillsboro

East Main Street to Hillsboro ECL; Cornell Road. Widen 2.4 miles from 2 lane to a 4 lane with a CLTL. (Connects to a state highway in developing area) FEIS 1982. Construction completed in 1985.

Hillsboro ECL to NW 185th. FEIS 1986. Estimated completion 1990.

Cornell Road from 242nd to Elam Young Parkway (west end). Widened to 4 lanes with continuous left-turn lane. Construction completed 1978.

Cornell from 242nd (Shute) to Cornelius Pass. Widened to 4 lanes with continuous left-turn lane. Construction completed 1988.

Cornell from 188th to 185th. Widened to 4 lanes with continuous left-turn lane. Construction completed 1989.

Cornell from Arrington to 34th. Widened to 4 lanes with continuous left-turn lane. Construction completed 1985.

Cornelius Pass/Highway 26 interchange - Northbound Cornelius Pass to eastbound Hwy. 26 on-ramp, and various signals. Construction completed 1987.

Klamath Falls

Highway 97 (Greensprings to Midland Junction). 2 to 4 lanes. Replace structures over Klamath River and railroad. Construction completed 1990.

Klamath Falls South Side Bypass south of urban area linking Highway 97 with highway 140. Segment 1. Linking Hwy 97 to Washburn Way and Johns Way. Two 12' lanes shoulder, 2.6 miles controlled access. Segment 2. Washburn Way to Highway 39. EIS 1978. Estimated completion 1985.

Lincoln City

Highway 101 and Logan Rd. intersection redesign. Additional travel lanes and signal. EIS 1984. Estimated completion 1990.

Madras

Replacement of "C" Street bridge across Willow Creek. Replace 17 foot wide bridge with 54 foot wide bridge. EIS 1974. Estimated completion 1985.

McMinnville

East McMinnville Interchange to Airport Road. Salmon River Highway Route 18. Widen 2.2 miles from 2 to 4 lanes with CLTL (Extended south of UGB) EIS 1984. Construction completed in 1984.

North Plains

Glencoe Rd and West Union Rd. realignment, replace rail crossing and bridge over McKay Creek. Estimated completion 1990.

Redmond

Highway 97 widen highway from 2 lanes to 4 lanes. Project extends north from one-way couplet to 0.1 miles north of O'Neil Junction where it ties into previously improved section of Hwy. 97 (2.07 miles). EIS 1986. Estimated completion 1990.

Sherwood

Tualatin- Sherwood Road/Eddy Road from I5 to Highway 99. Tualatin-Sherwood Road from Boons Ferry Road to Tenton Avenue, 3 to 5 lanes. Tenton Avenue to Highway 99, 2 to3 lanes. Estimated completion 1990.

Troutdale

SE Stark Street from 242nd Ave to 700' east of 257th Drive. Widen from 3 to 5 lanes. Estimated completion 1990.

Woodburn

Highway 99. Widen and improve highway from north city limits to south city limits (2.19 miles). Estimated completion 1990.