EFFECTS OF LAND USE POLICY ON URBAN GROWTH RATES IN THE WILLAMETTE VALLEY, OREGON

By
Ellen H. Davis

A Research Paper

Submitted to

THE COLLEGE OF EARTH, OCEAN, AND ATMOSPHERIC SCIENCES

In partial fulfillment of the
requirements for the
degree of

MASTER OF SCIENCE

GEOGRAPHY PROGRAM

June, 2013

Directed by
Dr. Laurence Becker

Table of Contents

List of Figures

List of Tables

Acknowledgements

I would like to thank my major advisor, Dr. Laurence Becker, for his help throughout the creation of this paper. I would also like to thank my committee, Dr. James Graham and Kuuipo Walsh, for all their input and support.

Effects of Land Use Policy on Urban Growth Rates in the Willamette Valley, Oregon

Abstract

This study seeks to determine the correlation between changes in statewide land use planning policies and the resulting periods of high or low urban growth in the Willamette Valley, Oregon using automated classification methods and freely available satellite imagery. To protect its farms, forests and open spaces, Oregon became the first state to implement a comprehensive land use planning policy in 1973. Ballot measures and legal rulings that have passed in the intervening decades have in some cases expanded and in other cases reduced the state's power to enforce its land use goals. This study aims to discover whether changes in urban growth rates on the ground, as identified by Landsat satellite imagery, correspond with legislative changes. The shifting landscape weakly reflects the effects of ballot measures and local zoning decisions as they have bolstered or weakened Oregon's urban growth management system. Though no statistically significant correlation appeared in this study, periods of unusually high or low urban area did generally follow the implementation of a corresponding new policy.

Introduction

The Willamette Valley supports some of the best farm land in Oregon and the bulk of the state's population. The growing demand for residential, commercial and industrial development in the mid-twentieth century led to a rapid loss of farm and forest land throughout the valley, prompting state legislators to pass Senate Bill 100 in 1973 (Kline and Alig, 1999). Senate Bill 100 created new state agencies to study and direct land use change, required all incorporated places to establish Urban Growth Boundaries (UGBs), and established a set of statewide planning goals (Oregon Senate Bill 100, 1973). Since 1973, population and economic growth have led to the outward expansion of UGBs for towns and cities of all sizes. Previous research has shown that many factors facilitate urban growth

(Befort et al., 1988; Jordan and Ross, 1998; McGrath, 2005; Burchfield et al., 2006). Research has also demonstrated that land use policy can be used as a restraint to rein in urban development in order to protect farm and forest land (Furuseth, 1983; Weitz and Moore, 1998; Kline, 2005; Gosnell et al., 2011). The purpose of this study is to search for correlation between the new land use policies and corresponding periods of rapid or slow urban growth in the Willamette Valley, Oregon.

For the purpose of this study, "urban" refers to developed land uses such as residential housing, commercial or industrial complexes, roadways, or other human-altered impervious surfaces. This definition comes from the classification used by the National Land Cover Database:

> Urban or Built-up Land is comprised of areas of intensive use with much of the land covered by structures. Included in this category are cities, towns, villages, strip developments along highways, transportation, power, and communications facilities, and areas such as those occupied by mills, shopping centers, industrial and commercial complexes, and institutions that may, in some instances, be isolated from urban areas (Anderson et al., 1976, Definitions Section, 1. Urban or Built-Up Land).

"Rural" is used in this study to describe all other land uses, which generally include agricultural fields, forest land, rangeland, and water features.

The term "urban growth" is used in this paper to refer to the conversion of rural land into urban uses. On the ground and from the air this process is visible as the built landscape of roads, houses, stores, factories, etc. replace farms and forests outside the city (Yuan et al., 2005). The underlying assumption of this study, and of many studies and policies, is that many North American cities will continue to grow, based on current projections, unless stopped by some external force such as a physical or legislative barrier (Sinclair, 1967). Urban growth results as an increasing population becomes spatially concentrated due to modern economic and political systems (Clark, 1998). Cities expand to meet the increasing demands for housing, employment and infrastructure for a growing number of residents. Economic values and pressures at the city's periphery drive land use change from rural to urban uses. As Fitchen (1991, p. 258) states, "this is a version of the 'tragedy of the commons' (Hardin, 1968), in which the individual benefits from the sale of land, but the cumulative effect of land sales by a number of individuals is damaging to the interests of the commonwealth - and hence damaging to each individual." Cities can grow at rates disproportionate to their populations due to a number of enabling factors such as permissive physical geography, low land prices, low transportation costs, proximity to transportation networks, and laissez faire regulations (Befort et al., 1988; Jordan and Ross, 1998; McGrath, 2005; Burchfield et al., 2006). Urban growth beyond the needs of the population is problematic for municipalities as costs per capita for utilities and other services increase with sprawling development (Kline and Alig, 1999). Unchecked urban growth can also endanger the economic and environmental utility of the surrounding countryside (Kline, 2005). Urban growth fragments ecosystems, taking a great toll on ecosystem services. Development on and near farmlands can drive out agricultural uses through higher land values and conflicting uses (Platt, 2004). Loss of recreational areas and draws for tourism can be another cost of urban development. On the other hand, not only can forward thinking land use planning create more livable cities and preserve the economic and recreational uses of rural land, it can also increase carbon storage and mitigate climate change (Cathcart et al., 2007).

Many Oregon cities, particularly in the Willamette Valley are not constrained by physical geographic boundaries such as steep slopes, water bodies, or other geographies that constrain development. To prevent the patterns of sprawl seen in other similarly physically unconstrained cities, the state of Oregon has chosen top-down land use regulation to protect its farming and forestry economic base. Gosnell et al. (2011), using the methods established by Kline (2005), estimate the land area protected by Oregon's most famous land use planning policy, Senate Bill 100, to be about 285,826 acres of farm, forest, and resource land. The research of both Furuseth (1980; 1983) and Nelson (1992), support the assumption that changes in Oregon's statewide land use policy affect the local rates of urban growth in individual cities.

Because of its visible footprint, urban growth can also be determined using remotely sensed data such as satellite imagery (Yuan et al., 2005; Burchfield et al., 2006). This study classifies Landsat Thematic Mapper satellite imagery into urban and rural pixels for the years 1984-2011 and searches for correlation between new policies and periods of either increased or decreased urban growth. The data derived from satellite imagery is compared and correlated with the building permits for new structures in Marion County, home of the state's capital and about a quarter of the study area.

Conceptual Framework

The conceptual framework underlying modern studies of urban growth first took solid form in the nineteenth century through the work of von Thünen. His theories have been adapted and refined over time in response to the changing landscape wrought by new technology and land uses. Urban growth and urban growth management have taken many forms since von Thünen's era internationally, in Africa (Braimoh and Onishi (2007); Todes, 2012), Asia (Portnov et al., 2007; Soo, 2007), Europe (Coleman, 1976; Pérez, 2007) and Latin America (Romero et al., 1999; Torres-Vera et al., 2009). Though certain universals exist for the process of urbanization throughout the world, cultural and economic patterns at the national scale and local factors also shape individual cities (Clark, 1998). For this reason, this study focuses on the efficacy of modern governmental land use policies in controlling urban growth within the state of Oregon. The assumption that changes in statewide land use policy affect the local rates of urban growth in individual cities is supported by the research of Furuseth (1980; 1983), Nelson (1992), Kline and Alig (1999), Kline (2005), and Gosnell et al. (2011) who have all used Oregon as the basis of their studies. However, there is also a large body of literature indicating that a great many factors other than policy influence rates of urban growth (McGrath, 2005; Woudsma et al., 2008; Paulsen, 2012). These studies generally have not focused on Oregon, which has the longest history of statewide planning in the United States, but have instead looked at regions in which government has played a smaller role in regulating urban growth (Mieszkowski and Smith, 1991; Lepczyk et al., 2007) or have studied the United States as a whole (Jordan and Ross, 1998). Though policy is not always found to be a significant factor for urban growth rates in the United States at a national scale, in the case of Oregon, policy plays a greater role in urban growth management due to the state's longstanding history of comprehensive land use planning.

In 1826 von Thünen published *Isolated State with Respect to Agriculture and National Economy*, one of the earliest and most influential works to model the economic behavior of farmers, for whom the spatially fixed commodity of land provides a unique challenge (Lucas and Chhajed, 2004). Von Thünen's model establishes a theoretical isolated state with no neighboring states, topography, transportation networks, or variations in soil or climate. Von Thünen first demonstrated in his intensity theory that farms near a town or market that increased the intensity of their agricultural production, even with greater human labor inputs, gained back higher profits because of the low transportation costs (Grigg, 1984).

In his well-known crop theory von Thünen modeled land use rings based on crop and therefore labor input at increasing distances from the central town market (Grigg, 1984). These theories provided the basis upon which later geographers could model urban growth (Kellerman, 1989a; Kellerman, 1989b). The most pertinent modern adaptation of von Thünen's work for Oregon's land use policies is "impermanence syndrome." Sinclair (1967) argues that the pressures of growth at the urban fringe outweigh the benefits of proximity to a market in modern society. Central to his reasoning is "impermanence syndrome" wherein anticipation of urban development leads farmers to forgo investing in new equipment, crops or techniques because the price of the land as developable real estate is believed to yield higher profits than even the most intensive farming (Hart, 1991; Daniels, 1997). Anticipation of urbanization can be a self-fulfilling prophecy at the city's edge. Sinclair takes von Thünen's theory as the basis for modern studies of sprawl and argues that improvements in transportation, food storage and processing have released agricultural production from its ties to the city market. In this way, Sinclair makes the leap from the distance-locational theory of von Thünen to his modern study of urban sprawl in the industrialized United States.

Although von Thünen's original model focused on agriculture and its intensification near central markets, modern urban growth is also an expression of the intensification of land use for economic profit with residential and commercial real estate now replacing von Thünen's agricultural rings. Despite nearly two hundred years of criticism, Von Thünen's earlier notions of location and profit provide a firm base for subsequent studies of the increasingly complex nature of urban growth (Peet et al., 1967; Chisholm, 1969; Kellerman, 1989a; Kellerman 1989b; Block and DuPuis, 2001; Lucas and Chhajed, 2004).

Modern Studies of Urban Growth

Current thought on the nature of cities' spatial expansion largely assumes that development will continue to spread outward from a single (Park and Burgess, 1925; Sinclair, 1967) or many nodes (Davis, 1990) as residential, commercial and industrial needs grow. According to Sinclair (1967, p. 77), "in most modern industrialized nations the theme is urban expansion, with population growth and constantly expanding areas of urban land use." He goes on to describe the patterns of urban growth along transportation arteries and development around nodes such as factories or shopping districts in a seemingly chaotic fashion (Sinclair, 1967). For many years, scholars have debated the efficacy of policy in regulating urban growth. The body of international research on the efficacy of policy and other factors in shaping urban growth has grown in the past decade (Braimoh and Onishi, 2007; Pérez, 2007; Portnov, 2007; Todes, 2012). Internationally and nationally, some researchers find that policy can be an effective deterrent to sprawl, while others find that other factors are more significant. In the case of Oregon, in particular, the literature appears to lean towards the belief that policy can and does promote development within the UGB and prevents most development in the state's farm and forest lands (Knapp and Nelson, 1992; Kline and Alig, 1999; Nelson, 1999; Harvey and Works, 2002; Howell-Moroney, 2007; Gosnell et al., 2011).

Nelson (1999) finds that states with growth management programs like that of Oregon yield higher urban densities, higher quantities of productive farmland, and lower commute times than comparable states without such a policy. Kline and Alig (1999) discover that, under the policies enacted by Oregon's Senate Bill 100, land within an Urban Growth Boundary (UGB) is most likely to be developed although they do not find statistically significant evidence of long term resource land protection in this study. Kline (2005) concludes that Oregon's laws have significantly decreased development in protected areas compared to an alternate model without regulation. Howell-Moroney (2007) determines through a comparison of state growth management programs, that strong regulatory measures, like that in Oregon, yield highly significant reductions in sprawl. Nelson (1999) argues that UGBs are one of the most effective growth management techniques available to a state. Weitz and Moore (1998) find that Oregon's statewide policies have successfully encouraged compact city growth; Knapp and Nelson (1992) find increased densities within Oregon cities due to statewide land use planning regulations. Harvey and Works (2002, p. 384) go so far as to contend that, "at the national level, most studies of urban sprawl in the US accept a priori the success of the Portland [Oregon] model."

There are, however, critics of Oregon's land use planning policies. One weakness of the system is that it is not always enforced uniformly throughout the state. As Harvey and Works (2002, p. 383-384) point out in their study of the Portland metropolitan area UGB, "this landscape reflects differences in how the counties of the Portland metropolitan area have interpreted state laws, variances granted to developers and individuals, and the tension inherent in enacting strict land-use laws." Because each city and county can implement the statewide laws differently, within reason, certain jurisdictions may differ in their approach to development and their approaches may change over time.

Another major argument against the Oregon land use planning system is that UGBs inflate land values by "artificially constraining the supply of buildable land" and raising the cost of real estate (Abbott and Margheim, 2008, p. 198). Critics of the Oregon system cite evidence of skyrocketing land and housing prices; supporters state that housing prices are driven by demand and rise just as quickly in cities without UGBs (Abbott and Margheim, 2008). Gosnell et al. (2011) remark on further complaints about Oregon's planning system including arguments that it is antiquated after nearly four decades and does not change quickly enough to reflect Oregon's modern social and economic needs. Some authors find that UGBs can lead to spillover of development into areas with less restrictive growth policies, such as Clark County, Washington (Lewis, 1996; Porter, 1997). Another argument is that, through review processes, the UGB may continue to grow without limit as a city's needs for land grow, thereby defeating the purpose of the UGB to a certain degree (Duany, 1999). Abbott and Margheim (2008, p. 199) generalize that detractors from the Oregon system "find its planning regulations to be excessively bureaucratic, to ignore market realities, and to give the cold shoulder to business."

Some critics of statewide planning programs argue that they are ineffective from the start. Nelson (1983) proposes that, at least in its first few years, Oregon's land use planning laws did not yield a dramatic improvement. He argues in his rebuttal to an article by Furuseth that Oregon's land use planning laws did not appear to significantly prevent rural sprawl or subdivision of farms in comparison to national figures in the period 1974-1978 (Nelson, 1983). Nelson (1983, p. 5) argues that "Oregon's agricultural land use trends appear to follow national and regional trends and cannot be attributed to its agricultural policies." However, later studies suggest that the policy has changed land use conversion rates in the long run (Knapp and Nelson, 1992; Kline and Alig, 1999; Nelson, 1999; Harvey and Works, 2002; Howell-Moroney, 2007; Gosnell et al., 2011).

There is also a body of literature indicating that a great many factors influence urban growth rates and that policy may not be the most significant cause at all (Coleman, 1976;

Mieszkowski and Smith, 1991; Jordan and Ross, 1998; Lepczyk et al., 2007; Woudsma et al., 2008; Paulsen, 2012). These studies generally have not focused on Oregon, which has the longest history of statewide planning in the United States, but have looked at regions in which government has played a smaller role in regulating urban growth (Mieszkowski and Smith, 1991; Lepczyk et al., 2007), have studied the United States as a whole (Jordan and Ross, 1998), or have examined regions outside the United States (Coleman, 1976; Woudsma et al., 2008). For instance, Woudsma et al. (2008) find that land use tends to vary significantly in relation to transportation access and congestion in Calgary, Canada. Paulsen (2012) uses U.S. Census and National Land Cover Database (NLCD) data for all metropolitan areas in the United States to show that a three variable monocentric city model, which ignores the influence of policy, generally does predict urban growth nationwide. Coleman (1976) finds that land use planning policies implemented in mid-twentieth century England did not prevent urban sprawl or loss of farmland. Note that the examples provided, and most other research that does not find policy to play a significant role in urban growth, do not focus on Oregon. Although internationally and even nationally the efficacy of policy for controlling urban growth remains contested, for the state of Oregon specifically most studies agree that its statewide planning policies are more effective than no regulation.

Though the assumption that policy plays an insignificant or no role in urban growth has been studied thoroughly internationally, nationwide and in many regions and cities, it is not generally accepted in the case of Oregon due to the state's longstanding and comprehensive approach to planning. Anthony (2004), for example, finds through modeling that growth management alone yields an insignificant change in land use outcome, but finds that protective agricultural zoning yields significant results. The Oregon system makes use of both growth management techniques. The UGB encourages efficient urban land use while protective zoning measures such as exclusive farm use zones preserve prime resource lands.

A Brief History of Oregon's Land Use Policies

Researchers have found that Oregon's land use planning policies have generally been effective in protecting farm and forest land from urban expansion (Furuseth, 1983; Furuseth, 1990; Nelson, 1992; Kline 2005; Gosnell et al. 2011). Oregon's legislators first adopted statewide land use policies to address the issue of loss of farm and forest land to urban growth with a law passed in 1955 to regulate the subdivision of private land (DLCD, No Date). Oregon's legislature established Exclusive Farm Use (EFU) zones in 1963 as another step toward the protection of rural land from encroaching urbanization (DLCD, No Date). In 1966, the Columbia Region Association of Governments, worked toward a regional plan for the Portland metropolitan area, making national history (Harvey and Works, 2002). Oregon Senate Bill 10, proposed in 1969 and fully implemented by 1971, required local jurisdictions to zone their land and required the governor to zone all land in the state not already subject to zoning regulations (Oregon Senate Bill 10, 1969). The bill also necessitated that private land owners notify the governor's office prior to building new dwellings. The nine expressed goals of this bill, which included preservation of water and air quality, conservation of open space and natural resources, and protection of prime farm lands, set the groundwork for later land use planning legislation. Senate Bill 10 was the first bill of its kind passed in the United States.

The greatest legislative impact on Oregon's landscape, however, was achieved through the passage of Senate Bill 100 in 1973 with the help of Governor Tom McCall, Senator Hector MacPherson and Senator Ted Hallock. Legislators, citizens, and other organizations worked together to create and pass Senate Bill 100, also known as the Land Conservation and Development Act, with the expressed purpose to protect and preserve farm and forest land in the face of urban expansion (Furuseth, 1980; Harvey and Works, 2002; Howell-Moroney, 2007). Senate Bill 100 established fourteen, later to become nineteen, statewide planning goals, created the Land Conservation and Development Commission (LCDC), and required that all cities, counties, and regional areas establish a comprehensive plan outlining their projected development and establishing an Urban Growth Boundary (UGB) (Oregon Senate Bill 100, 1973). The UGB and accompanying comprehensive plan were designed “to identify and separate urban and urbanizable land from rural land (Oregon Administrative Rules, 2013, Section 660 [Goal 14: Urbanization]).” The UGB contains all necessary land for residential, commercial, industrial and other growth intended for the next twenty years. Farms, forests, and protected ecosystems are generally outside the boundary, where intensive development is discouraged by strict regulation (Abbott and Margheim, 2008). Each comprehensive plan and UGB is reviewed regularly as well as when necessitated by a major change such as a large annexation. The underlying foundation for all changes to the UGB is:

> (1) demonstrated need to accommodate long-term population growth; (2) needs for housing, employment, and livability; (3) orderly and efficient provision of public services; (4) environmental, economic, and social consequences; and (5) compatibility of urban uses with agricultural uses (Abbott, C. and J. Margheim, 2008, p. 197).

During periodic reviews, which became mandatory for all planning bodies in 1983, or when a specific need is identified, UGBs can and do expand (DLCD, No Date). Nevertheless, Oregon’s land use system generally encourages thoughtful use of land within existing urban areas and protects rural areas for farm, forestry, environmental and recreational uses.

The right of the state to determine the uses acceptable on private land in order to control urban growth was first upheld by the Oregon Supreme Court in 1975 in the case of Baker v. City of Milwaukie (DLCD, No Date). The following year a ballot measure to repeal Senate Bill 100 lost 57% to 43% (DLCD, No Date). Demonstrative of the growing support for Oregon's land use planning laws in the late 1970s, the next attempt to repeal Senate Bill 100 was defeated 61% to 39% in 1978 (DLCD, No Date). Again, in 1982, despite attempts to link economic depression to statewide planning laws, a measure to repeal Senate Bill 100 was out voted 55% to 45% (DLCD, No Date). In the 1970s and 1980s citizens of Oregon consistently voted in support of UGBs and other land use regulations, demonstrating their preference for distinctly urban and rural landscapes over the suburban/ex urban milieu.

Oregon's commitment to maintaining the separation of rural and urban areas is part of a broader sentiment in the United States. Studies from other states indicate that support for land use planning laws that protect rural and agricultural land uses is widespread. For instance, in a study that took place in North Carolina, Furuseth found that 70.9% of responders favored farmland protection policies such as restrictive zoning and 88.3% agreed or strongly agreed with publicly funding transfer of development rights to preserve farmland (1987). These results indicate that support for land use planning may be common not only in the state of Oregon, but nationally.

However, Oregon's land use policies have not remained static since 1973. Over the past four decades there have been fluctuations in policy regarding the implementation of Oregon's land use laws. Measures regarding the state's right to impose restrictions on private land and the private owners' rights have made their way onto the ballot, into the state supreme court, and into law in the intervening years (Abbott and Margheim, 2008). In 1983, Oregon’s legislature passed changes to the state’s land use laws by facilitating the “exceptions process,” revising the Exclusive Farm Use zones, and designating marginal lands (Oregon Revised Statutes 197 and 215). The Marginal Lands Act of 1983 was enacted to loosen development restrictions on less productive farm and forest lands while attempting to improve the protection of higher quality rural lands. The Land Conservation and Development Commission (LCDC) continued its work through the 1980s to differentiate low value or small-scale resource lands from high-value farmland (Grishkin, 2004). Permits for lot-of-record dwellings on farm and forest lands previously protected from development began in 1993. In the same year, the state legislature directed the LCDC to dismantle its system for designating small-scale, lower quality resource lands in favor of permitting higher levels of development on lower quality farm and forest lands on a case-by-case basis (Grishkin, 2004). The Oregon Supreme Court upheld the right of the LCDC to designate and protect high-value farmland as stated in a provision of HB 3661 in the case of Lane County v. LCDC in 2005 (DLCD, No Date).

The first major milestone of waning general support for Oregon’s statewide planning policies was the 2000 election, in which 54% of Oregon residents voted in favor of Ballot Measure 7, which required compensation to property owners for loss of value due to land use regulations. Although Ballot Measure 7 won in the polls, it was overturned by the Oregon Supreme Court for the changes it would have necessitated in the state constitution (DLCD, No Date). An argument used to sway voters in this period stated that the UGB unfairly divided land owners into “winners and losers” with an arbitrary line separating economic prosperity from state oppression (Abbott and Margheim, 2008). This reasoning gained ground against the earlier support for statewide land use planning that had been popular throughout the 1970s and 1980s. The next major election proved that Oregon's earlier enthusiasm for top-down land use regulation had cooled.

In November 2004, a 61% majority voted in favor of Ballot Measure 37, which, similar to Ballot Measure 7, required just compensation for any devaluation of real property caused by land use restrictions. According to Abbott and Margheim (2008, p. 198), Measure 37 "exempted a subset of property owners from UGB restriction by allowing them to claim the right to develop according to the regulations in effect at the time they acquired title, or else to be compensated for lost value." This measure also stated that the government may "remove, modify or not apply" that regulation if it cannot or chooses not to reimburse the property owner (DLCD, No Date; Oregon Revised Statutes 195.305). In 2005, Marion County Circuit Court Judge Mary Mertens James found Measure 37 to be unconstitutional in the case of Macpherson, et al. vs. Department of Administrative Services et al. in 2005 (DLCD, No Date). Yet this ruling was in turn rejected in early 2006 by the Oregon Supreme Court who reinstated the measure (DLCD, No Date). The passage of Measure 37 reveals a shift in paradigm from the policies popular in the 1970s and 1980s that sought to protect rural lands from urban development. Oregon citizens in the early 2000 expressed at the polls a preference for property owners' individual rights. Ultimately Measure 37 led to a marked increase in development outside the UGB (Abbott, C. and J. Margheim, 2008). According to Gosnell et al. (2011), 518,058 acres, about 5% of Oregon's private land, was developed as a direct result of Measure 37.

In response to the changing rural landscape, quantified by Gosnell at al. (2011), a 62% majority of Oregon voters passed Ballot Measure 49 in 2007 to modify Measure 37 (Oregon Revised Statute, 2013, 195.300-336). Measure 49 specifically defined the qualifiers for government compensation or development allowances for loss of value of private property. By including more specific language than Measure 37, Measure 49 curtailed the wave of development begun by the earlier legislation (Gosnell et al., 2011). The campaigning of private citizens and groups, such as 1000 Friends of Oregon, revealed that public sentiment had not entirely turned against the idea of statewide land use planning. In the campaign for Measure 49, letters such as that provided in Appendix A encouraged the state's residents to vote in favor of the measure. The passage of Measure 49 in 2007 showed the change in public sentiment from individual property rights back towards the support of statewide planning that was so widespread in the years leading up to and following the creation of Senate Bill 100 in 1973.

In summary, Oregon has led the nation in progressive land use policies for over half a century. In response to housing boom following World War II and resulting loss of farmland, the state passed its first law regulating the subdivision of private lands in 1955. 1963 saw the creation of the Exclusive Farm Use zone in order to further protect Oregon's agricultural lands. Senate Bill 10, fully implemented by 1971, demanded that all land within the state be zoned for a specific use, required all private land owners to give notice prior to building new structures, and established nine statewide goals to protect and preserve Oregon's natural resources. Senate Bill 100 built on the goals and policies of Senate Bill 10, creating Urban Growth Boundaries, requiring comprehensive plans, and establishing two new state agencies for the protection of Oregon's agricultural lands. Statewide land use planning remained fairly popular for nearly thirty years. In the early 2000s public sentiment shifted to value private property rights more highly. A majority of voters supported Ballot Measure 7 in 2000 and an even greater majority voted for Measure 37 in 2004. Both measures required either compensation for loss of property value due to land use regulations or allowances for increased development. Implementation of this policy led to increased development on farm and forest lands, especially within the Willamette Valley. In 2007, 62% of Oregon's citizens voted for Measure 49, greatly restricting the compensation and development allowed under Measure 37 and slowing urban growth on agricultural lands. As captured by satellite imagery, the shifting urban landscape reflects the changes in land use planning policies over time. This study seeks to assess the efficacy of the Oregon system by using the novel method of automatically classifying satellite imagery to identify urban areas and then searching for correlation to events in statewide land use policy.

Methods

To study rates of urban growth in response to policy change, I selected a representative study area in the mid-Willamette Valley (Figure 1). The study area included a range of city sizes, local approaches to growth, and economic drivers. For example, the study area contains Oregon's capital and third largest city, Salem (population in 2010 approx. 155,000), the college town of Corvallis (approx. 54,000), smaller but more rapidly growing cities such as Lebanon (approx. 16,000), small communities like Adair Village (approx. 840), and the rural areas in between (U. S. Census Bureau, 2010). The study area is representative of the broader Willamette Valley and showcases the development pressure of a growing population against the backdrop of highly productive agricultural land. Oregon's total population grew from 2,633,105 in the 1980 census to 3,831,073 in 2010, an increase of approximately 45% (U.S. Census Bureau, 2010). Most of this population increase occurred in the Willamette Valley, specifically (Gosnell, et.al, 2011).

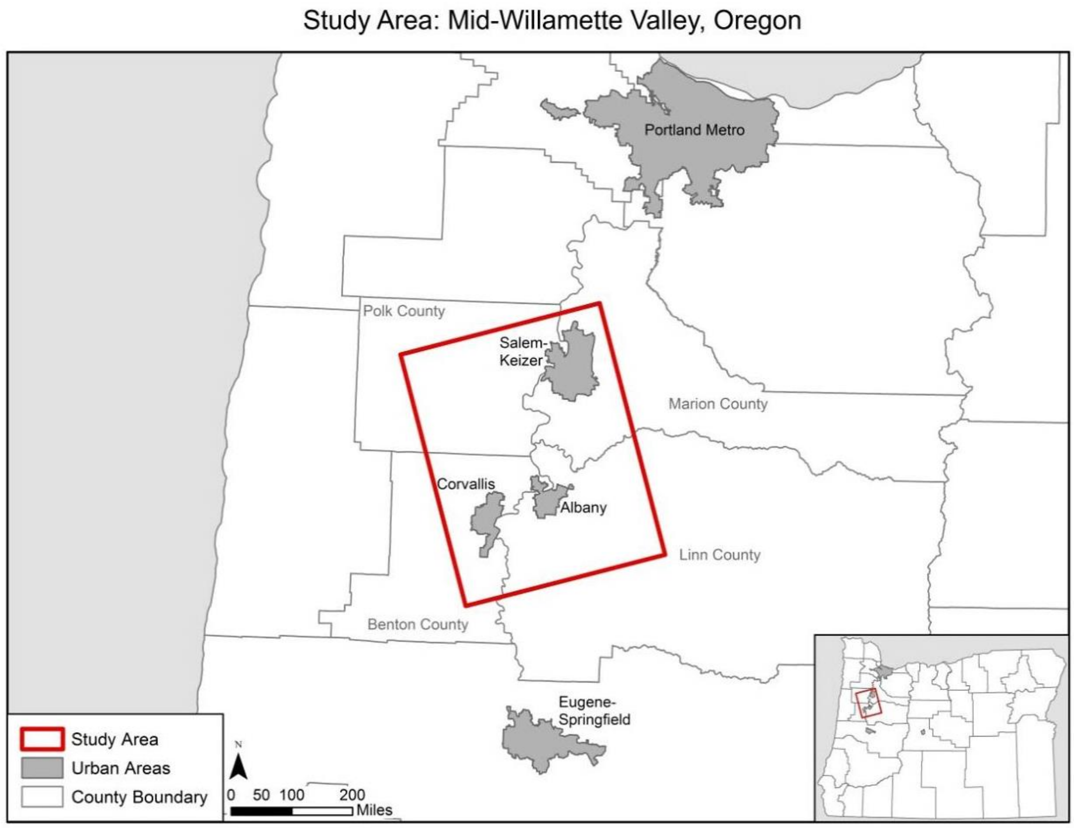


Figure 1: Study area within Oregon.

To establish the effects of land use policy on urban growth rates, the extent of change in urban land was measured by classifying satellite imagery into urban/non-urban space. This research used publicly available Landsat Thematic Mapper imagery for 1984 to 2011. Images for years without high quality data and/or completely cloud-free images between July 25 and September 7 were excluded. This period was selected for the sake of consistency in crop cover year to year and also for the high average number of cloudless days. The remaining Landsat images available through the United States Geological Survey (USGS) showed no visible cloud cover over the study area and were the highest available quality. The Landsat Thematic Mapper sensor collects data in seven separate bands of the electromagnetic spectrum (U. S. Geological Survey, 2013). The pixel resolution of the bands used in this study was thirty meters (U. S. Geological Survey, 2013). To calibrate the data and correct for any atmospheric distortion, the data was preprocessed in ENVI 4.8 using both the Landsat Calibration function and the Dark Subtract (minimum band value).

The Decision Tree Classifier in ENVI was used to classify the imagery into urban and non-urban land use categories. Decision Tree classification is a threshold-based and completely user-defined process that categorizes each pixel in the study area based on its spectral information. A graphic representation of this decision process is shown in Figure 2. This classification system aims to distinguish urban pixels based on the definition underlying the Anderson classification system used in the National Land Cover Database. For the purposes of this study, "urban" land is defined by its development into structures, roads, sidewalks, or any other man-made impervious surfaces as outlined by Anderson et al. (1976).

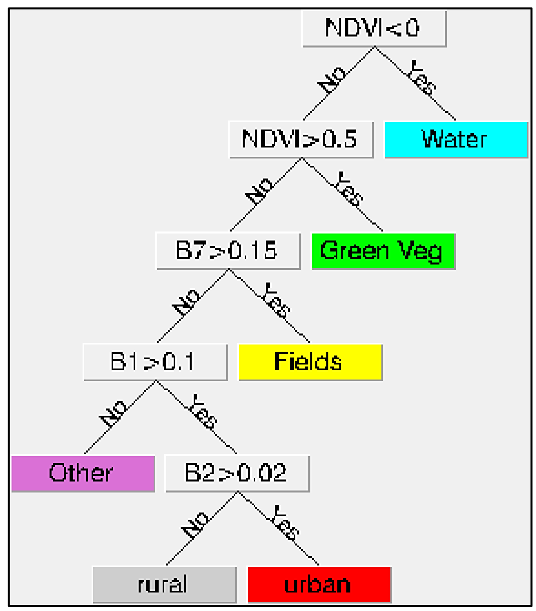


Figure 2: Decision Tree Classification Scheme.

This Decision Tree classifier works by a process of elimination, identifying the non-urban pixels in the image until only urban areas remain. The first step in the classifier identifies water features using the Normalized Difference Vegetation Index (NDVI), which is composed of the red and near-infrared spectral bands. For the purposes of this study, pixels with negative NDVI values were classified as water due to its low reflectance values in these bands. NDVI was also used to identify areas of heavy, high density foliage which were ineligible for classification as “urban”. NDVI is commonly used to identify vegetation and vegetation health (Goward and Dye, 1987; Goward et al., 1991, Ryznar and Wagner, 2001). Band 7 of the Landsat data (2.08-2.35μm) collects information from the shortwave infrared portion of the electromagnetic spectrum. In this classifier, Band 7 was used to identify vegetation with lower moisture content (Jensen, 2007), common throughout the Willamette Valley in the dry summer months. Having already categorized the pixels most easily identified as water or vegetation, the next band threshold I used was Band 1 (0.45-0.52μm). Band 1 captures the blue visible light portion of the electromagnetic spectrum. Values in this band can be used to distinguish human-manufactured surfaces from certain natural features (Jensen, 2007). Finally, to remove commonly misclassified materials such as bare ground from the urban category, I created a texture filter in ENVI for each year and selected only pixels with a relatively high texture value to classify as urban. The texture filters were created as occurrence texture filters of Band 2 (0.52-0.60μm), visible green light, as data range layers. The texture filter provides the benefit of identifying flat, smooth areas that are unlikely to represent the jagged skyline of the city and removing those areas from the urban category. This acts as an extra failsafe against misclassification of non-urban pixels with reflectance values similar to urban materials. The finished product of the decision tree classifier divided the study area into the six categories: water, green vegetation, dry vegetation (fields), other (non-urban), rural (non-urban), and urban. I combined the water, green vegetation, dry vegetation, other and rural categories into a single rural (non-urban) classification in ENVI. After this combination, the resulting imagery is made up of urban and rural (non-urban) pixels.

The resulting images were then imported into ArcGIS 10 and re-projected into the projection of the National Land Cover Database project (Appendix B). This projection facilitated comparison with the NLCD classification results. Once all data was projected into the same coordinate system, I clipped each image to ensure that the study area and number of pixels were the same for each year. The earlier use of a texture filter in the classification resulted in isolated "urban" pixels at edge of fields, roads, streams, and other landscape features that created higher texture rankings. To remove as many of these likely misclassified pixels from the study as possible without removing indicators of on-the-ground development, I created a 200 meter buffer of the 2010 U. S. Census roads layer. By selecting only urban pixels within 200 meters of a road, I increased the likelihood of finding true development while excluding pixels more likely to be an artifact of the classification system (Figure 3). A basic assumption of this practice is that human development is more likely to take place near existing roads networks. This assumption is supported in the urban context by the work of Woudsma et al. (2008). I then calculated and compared the number of urban pixels in each year in ArcGIS.

To establish the success of my classification system (Figure 2), I found the percent error for my data in the three years for which NLCD imagery was available, by using the urban pixels in the NLCD imagery as my expected outcome. I also calculated the correlation between my data and the total number of building permits for new structures issued from 1990 to 2011 in Marion County, the home of Salem, the largest city in my study area (Depicted in Figure 5).

Pixels Classified as Urban from 2008 Satellite Imagery

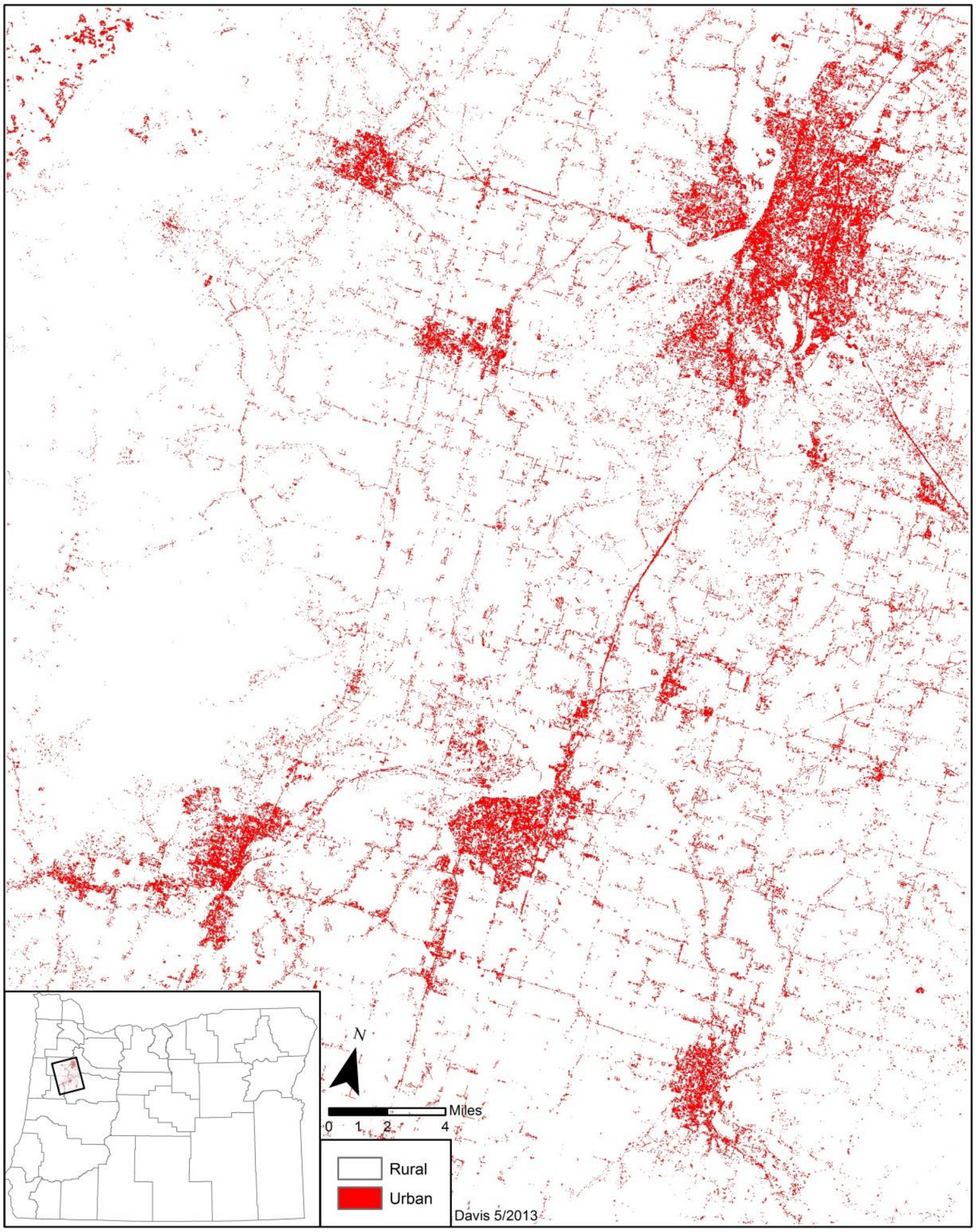


Figure 3: Example of Map Output, 2008 Satellite Imagery

Results

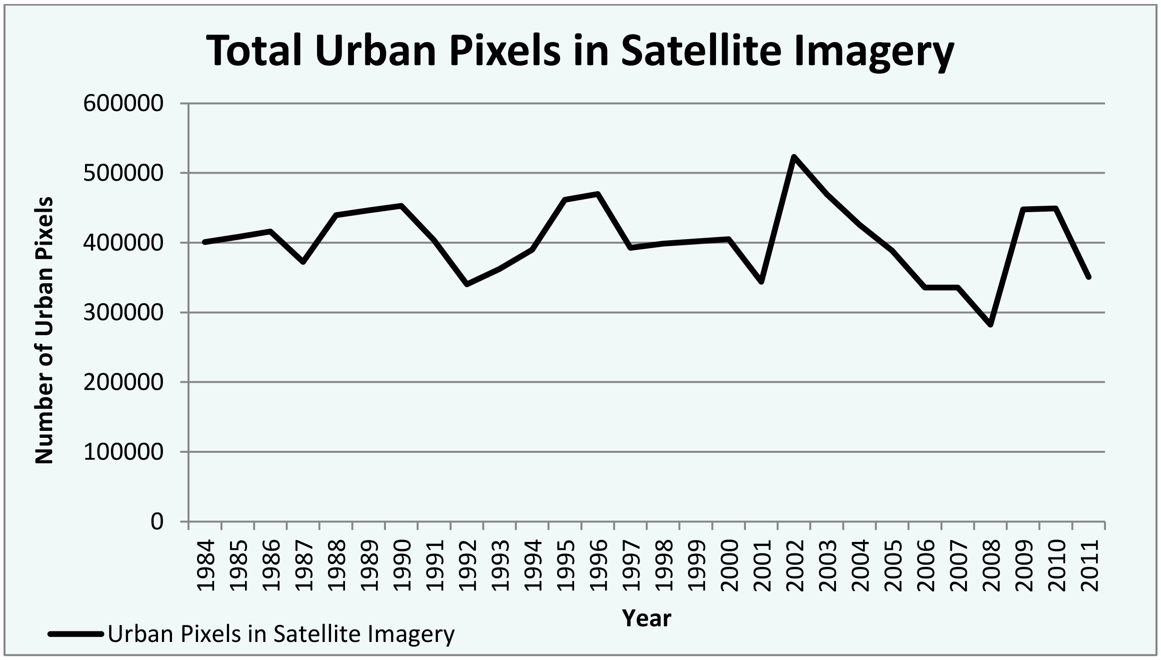


Figure 4: Total number of urban pixels found in the study area, calculated from Decision Tree classified satellite imagery.

The average number of urban pixels in the study area each year was 401,458. The standard deviation for the dataset was 56,315.08. The total number of urban pixels identified each year from the satellite imagery is displayed in Figure 4, with the excluded years interpolated from the surrounding values. In certain years the satellite imagery revealed urban development more than one standard deviation (77044.3 pixels) from the mean (504848.1 pixels). The first of these years was 1992, in which the imagery revealed the number of urban pixels to be more than one standard deviation below the mean. The low urban area found in 1992 followed the implementation of the Transportation Planning Rule in 1991, shown in Table 1. In 1995 and 1996 more urban pixels were identified than expected from the mean and standard deviation of the dataset. This increase in urban areas may have been related to a policy enacted in 1993 that permitted lot-of-record dwellings on farm and forest lands, shown in Table 1. In 2001 the number of urban pixels dipped below the standard deviation, followed immediately by the highest urban classification in the study period in 2002, far exceeding one standard deviation from the mean. As can be seen in Table 1, in 2000, Oregon's Land Conservation and Development Commission had passed a 20 acre minimum parcel size for rural residential lands within one mile of a UGB (Harvey and Works, 2002). The number of urban pixels detected in 2003 remained higher than expected as well. From 2006 to 2009 the number of pixels classified as urban dropped below one standard deviation of average, with the lowest point in the dataset occurring in 2008. In 2007 Ballot Measure 49 had passed, greatly reducing the number of claims allowed under Measure 37, which had passed in 2004 (DLCD, No Date). Overall, the trend line for the entire dataset had a slightly negative slope of -1085.9 pixels per year.

Table 1: Major Oregon Land Use Policy Changes 1984-2011

Year	**Event Description** (DLCD, No Date)
1987	HB 3396 passed: Oregon Board of Forestry gained exclusive jurisdiction over forest lands
1991	LCDC adopted Transportation Planning Rule, which created a planning partnership between DLCD and ODOT
1993	Oregon began permitting lot-of-record dwellings on protected farm and forest lands; LCDC was forced to repeal its designation of small-scale resource lands
1994	LCDC adopted rules for additional protection to high-value farmland
1997	Oregon Supreme Court upheld protections of high-value farmland
2000	LCDC created 20 acre minimum parcel size for lots in rural residential zones within 1 mile of a UGB (Harvey and Works, 2002)
2004	Ballot Measure 37 passed, local governments were forced to pay for loss of value or allow greater levels of development outside the UGB
2005	Marion County Circuit Court Judge Mary Mertens James found Measure 37 unconstitutional (MacPherson, et al. vs. Department of Administrative Services et al.)
2006	Oregon Supreme Court overturned Judge James' decision and reinstated Measure 37
2007	Ballot Measure 49 passed, greatly limiting Measure 37

The correlation between the Decision Tree classified data for the whole dataset and all new structures permitted in Marion County each year was R = 0.23. The correlation coefficient for the satellite imagery when clipped to the Marion County boundary and the Marion County building permit data for the entire study time was 0.19. In the period 1992-2008, however, the correlation coefficient for the Marion County rose to 0.27. The 1990s yielded the highest number of Marion County building permits in the study period. As evidenced by the two decades of permits shown in Figure 5, the number of new structures built in Marion County generally declined over the period 1990-2011. The late 2000s saw the greatest overall decline in new structures.

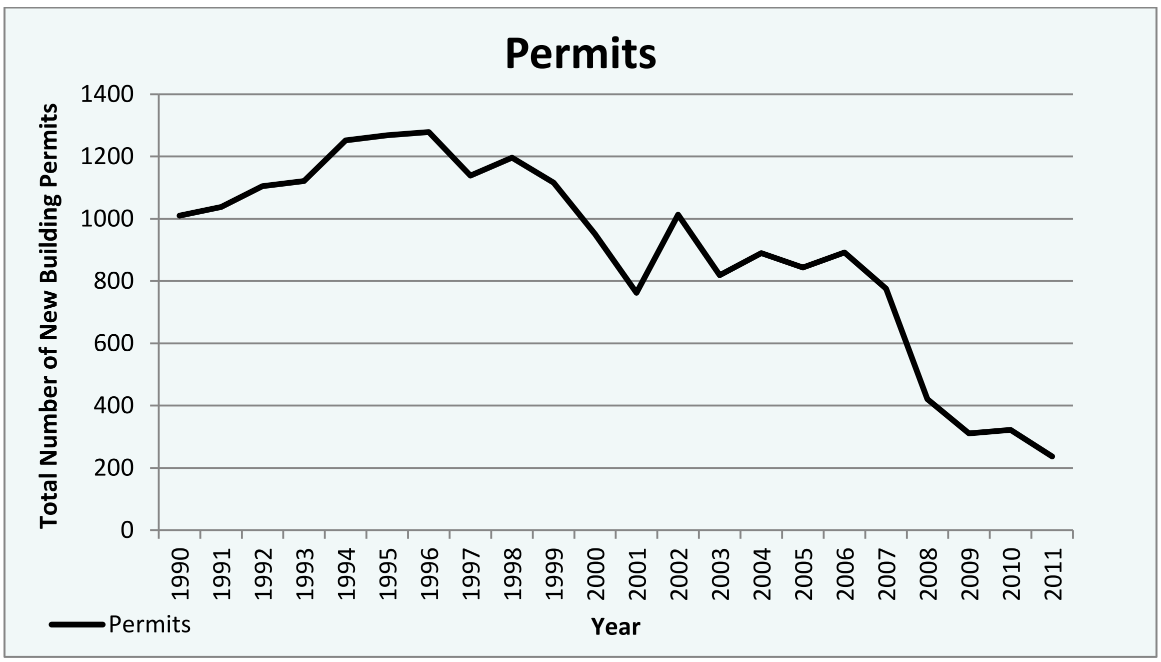


Figure 5: Yearly count of new structure building permits in Marion County.

Discussion

One of the most interesting and unexpected results of this study was the trend line for the urban area calculated from the satellite imagery. While one might expect the total urban area to increase between 1984 and 2011, this study found that the slope of the trend line was slightly negative. Much of this loss of urban pixels may be attributed to maturation of vegetation within cities, causing larger and larger portions of the urban areas to give off the reflectance values of vegetation rather than rooftops and asphalt. However, it would be interesting in later studies to compare the lack of overall urban growth as found by satellite imagery in Oregon with similar studies in areas with more permissive growth policies. The negative slope of the trend line for the Oregon study may indicate that the statewide planning policies are generally effective in curbing sprawl despite regressive policy changes.

The positive correlation between the classified Landsat data and the building permit records suggests that changes in urban development may be detectable through the methodology implemented in this study, though further research is necessary. The higher correlation coefficient between the classified satellite imagery and Marion County's building permits for all new structures in the period 1992-2008 may indicate the role of policy in shaping urban growth rates as revealed both in the classified satellite imagery and in the building permit data. For instance, a large number of residential dwellings were built in the 1990s due to the pressure of the growing population and economy despite prohibitive legislation (Harvey and Works, 2002). The late 2000s saw the greatest overall decline in new structures. This decrease in urban growth may in part be attributed to Measure 49, passed in 2007, curtailing the development that had been allowed under Measure 37. However, economic decline, especially in the real estate market, is also a likely factor behind the drop in new buildings.

Sources of Error

The percent error as found through comparison to the NLCD imagery for the three years available was -59.5% in 1992, 34.1% in 2001 and 41.9% in 2006, which averages to 5.5% error. These high error rates may result not only from my classification system, but also from error in the NLCD data, which has estimated Anderson I accuracy levels of 80.4 in 1992 and 85.3% in 2001 (Homer et al., 2012). The percent error, and the relatively high standard deviation, may reveal that other factors at the local, state, or national level can outweigh the effects of statewide policy changes. However, the study's uncertainty may also result from a number of sources of error in the satellite imagery and classification system.

There are many different sources of uncertainty in studies of urban growth, regardless of their methodologies. Automatic classification of satellite imagery addresses many traditional sources of error. For instance, Woudsma et al. (2008), manually digitized paper flow maps of average weekday traffic volumes in the City of Calgary for 1964-2000. Human error in recording and digitizing their data are a concern when using this method. Another source of uncertainty in Woudsma et al.'s research results from gathering data at the municipal level. The boundaries of the study do not always match the boundaries of the city or of the broader urban area. Satellite imagery, on the other hand, captures the designated study area without the limitations of political boundaries. The greatest limitation of Woudsma et al.'s methodology for many applications is the high labor input and cost. Human labor and overall cost are generally low for automated classification systems. All studies of urban growth, like that performed by Woudsma et al. (2008), add to the growing body of knowledge on urban patterns and processes although every method for exploring urban growth has strengths and weaknesses.

The specific sources of error that may have interfered most with finding statistically significant results in this study include the mixed pixel problem and classification error. As Fisher (1997, p. 680) defines it, the mixed pixel problem results from the imposition of a grid over natural features that do not adhere to this imagined system, are not on the same scale as the grid, and are not usually homogenous: "the pixel is imposed as a division of the space which is imaged, and is very unlikely to match the contents of that space." The problem of mixed pixels leads to misclassification, especially at boundaries between two land cover classes, in ecotones or other inherently transitional areas, and for sub-pixel sized objects such as structures and roads (Fisher, 1997). Examples of these problematic pixel configurations are shown in Figure 6. Spatial autocorrelation of pixels even indicates that the reflectance value of neighboring cells may influence the target (Fisher, 1997). The accuracy of the data used in this study is limited by not only the grain of the image scanner, but also by the suitability of raster representation in general.

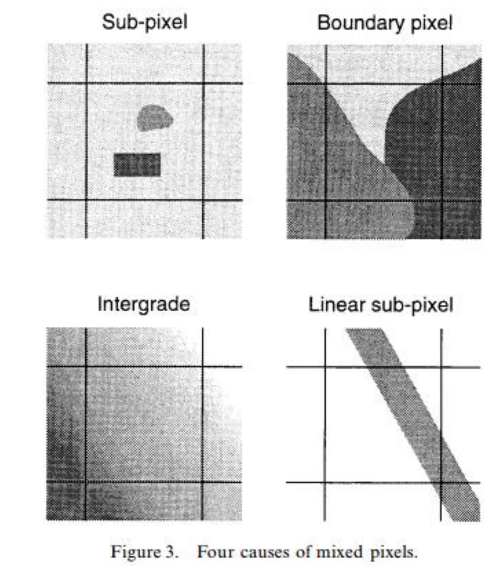


Figure 6: Illustration of the mixed pixel problem (Fisher, 1997, p. 683)

There may also be variable rates of classification error year to year as the growing season shifts. I chose to use images only from July 25th to September 7th each year because certain periods in the growing season for different crops are more likely to lead to misclassification of rural land uses as urban. When crops are first planted or harvested, for instance, the greater amount of bare ground can lead to reflectance signatures similar to urban materials (Jensen, 2007). Despite the use of a texture filter and a roads buffer to eliminate erroneous urban pixels, misclassification does occur. The rate at which rural pixels are misclassified as urban may vary, although only summer images are used, because of shifts in the annual growing season due to fluctuations in the weather pattern.

Another source of uncertainty, particularly in the analysis of this research, arises from the constraint of data collection. Building permit data, for instance, is collected by administrative units rather than comprehensive urban areas. The Marion County building permits used in this study account for the majority of Salem's urban area, but they do not cover the portion of Salem that extends into Polk County ,which is functionally a part of the same urban system.

Conclusion

Land use planning in the Willamette Valley has helped to shape the evolving landscape of growing cities and vibrant agricultural lands. The urban area identified in each year did reveal periods of high and low growth, many of which followed the implementation of a new policy. The findings from the satellite imagery were positively correlated with the building permit data for Marion County. This correlation between the findings indicates that automated classification methods may be a viable alternative to other expensive, time-consuming techniques. The methods used in this study are much faster and cheaper than other classification systems that require extensive ground-truthing, fine-resolution aerial imagery, or other expensive and/or time consuming inputs. As the resolution, availability and affordability of satellite imagery improve, automatic classification may become an increasingly valuable approach to assessing urban growth.

This study has added to the existing body of knowledge of urban growth, particularly to the study of Oregon's unique land use planning system. Its findings indicate that changes in statewide policy may lead to resulting changes in urban development on the ground. However, the statistical results were not conclusive. Future research on the use of a decision tree classifier to identify urban areas should continue as higher resolution satellite imagery becomes more readily available. Another area of future research should be comparative studies between Oregon and states that do not have the same land use planning history. The ease and affordability of the methods established in this study can facilitate comparisons in the future that may reveal once and for all the efficacy of the Oregon land use planning program.

References:

Abbott, C. and J. Margheim. (2008). Imagining Portland's Urban Growth Boundary: planning regulation as cultural icon. *Journal of the American Planning Association*, 74, 196-208.

Anderson, J. R., E. E. Hardy, J. T. Roach, and R. E. Witmer. (1976). A land use and land cover classification system for use with remote sensor data. *Geological Survey Professional Paper 964*. Retrieved February 22, 2013, from http://landcover.usgs.gov/pdf/anderson.pdf.

Anthony, J. (2004). Do state growth management regulations reduce sprawl? *Urban Affairs Review*, 39(3), 376-397.

Befort, W. A., A. E. Luloff, and M. Morrone. (1988). Rural land use and demographic change in a rapidly urbanizing environment. *Landscape and Urban Planning*, 16, 345-356.

Block, D. and E. M. DuPuis. (2001). Making the country work for the city: von Thünen's ideas in geography, agricultural economy and the sociology of agriculture. *American Journal of Economics and Sociology*, 60, 79-98.

Braimoh, A. K. and T. Onishi. (2007). Spatial determinants of urban land use change in Lagos, Nigeria. *Land Use Policy*, 24(2), 502-515.

Burchfield, M., H. G. Overman, D. Puga, and M. A. Turner. (2006). Causes of sprawl: a portrait from space. *Quarterly Journal of Economics*, 121, 587-633.

Cathcart, J. F., J. D. Kline, M. Delaney, and M. Tilton. (2007). Carbon storage and Oregon's land-use planning program. *Journal of Forestry,* 105(4), 167-172.

Chisholm, M. (1969). The relevance of von Thünen. *Annals of the Association of American Geographers,* 59, 401.

Clark, D. (1998). Interdependent urbanization in an urban world: an historical overview. *The Geographical Journal,* 164(1), 85-95.

Coleman, A. (1976). Is planning really necessary? *The Geographical Journal,* 142(3), 411-430.

Daniels, T. L. (1997) Where does Cluster Zoning Fit in Farmland Protection? *Journal of the American Planning Association*, 63(1), 129-142.

Davis, M. (1990). *City of Quartz: Excavating the Future in Los Angeles*. Verso Books: New York, NY.

Department of Land Conservation and Development (DLCD). (No Date). History of Oregon's land use planning. Retrieved January 10, 2013, from http://www.oregon.gov/LCD/Pages/history.aspx#.

Department of Land Conservation and Development (DLCD). (2012). Revising Oregon's urban growth management program: overview of initial concepts. Retrieved February 28, 2013, from http://www.oregon.gov/LCD/docs/meetings/lcdc/012413/Item_7_ Attachment_A_UGB_Design_Team_Overview.pdf.

Duany, A. (1999). Punching holes in Portland. *The Oregonian*, 19 December, E1-E2.

Fisher, P. (1997). The pixel: a snare and a delusion. *International Journal of Remote Sensing*, 18(3), 679-685.

Fitchen, J. (1991). *Endangered Spaces, Enduring Places: Change, Identity, and Survival in Rural America.* Westview Press: Boulder, CO.

Furuseth, O. J. (1980). The Oregon agricultural protection program: a review and assessment. *Natural Resources Journal*, 20(3), 603-615.

Furuseth, O. J. (1983). The impact of local infrastructural and development policies on agricultural land alienation. *Landscape Planning*, 9, 209-226.

Furuseth, O.J. (1987). Public attitudes toward local farmland protection programs. *Growth and Change*, 18(3), 49-61.

Gosnell, H., J.D. Kline, G. Chrostek, and J. Duncan. (2011). Is Oregon's land use planning program conserving forest and farm land? A review of the evidence. *Land Use Policy*, 28, 185-192.

Goward, S.N. and D.G. Dye. (1987). Evaluating North American net primary productivity with satellite observations. *Advances in Space Research*, 7(11), 165-174.

Goward, S.N., B. Markham, D.G. Dye, W. Dulaney and J. Yang. (1991). Normalized difference vegetation index measurements from the advances vary high resolution radiometer. *Remote Sensing of Environment*, 35(2-3), 257-277.

Grigg, D. (1984). *An Introduction to Agricultural Geography.* New York, NY: Routledge Press.

Grishkin, J. (2004). Oregon's land use planning program farm and forest lands. *American Planning Association Oregon Chapter (OAPA) White Paper*. Retrieved March 26, 2013, from http://centralpt.com/upload/342/2410_WP_farm_forestlands.pdf.

Hart, J.F. (1991). The perimetropolitan bow wave. *Geographical Review*, 81, 35-51.

Harvey, T. and M. Works. (2002). Urban sprawl and rural landscapes: perceptions of landscape as amenity in Portland, Oregon. *Local Environment*, 7(4), 381–396.

Homer, C. H., J. A. Fry, and C. A. Barnes. (2012). The National Land Cover Database. *U.S. Geological Survey*, Fact Sheet 2012-3020, 1-5. Retrieved April 17, 2013, from http://pubs.usgs.gov/fs/2012/3020/fs2012-3020.pdf.

Howell-Moroney, M. (2007). Studying the effects of the intensity of US state growth management approaches on land development outcomes. *Urban Studies*, 44(11), 2163-2178.

Jensen, J.R. (2007). *Remote Sensing of the Environment: An Earth Resource Perspective*. Upper Saddle River, New Jersey: Prentice Hall.

Jordan, S. and J. P. Ross. (1998). U.S. suburbanization in the 1980s. *Regional Science and Urban Economics*, 28, 611-627.

Kellerman, A. (1989a). Agricultural location theory 1: basic models. *Environment and Planning A*, 21, 1381-1396.

Kellerman, A. (1989b). Agricultural location theory 2: relaxation of assumptions and applications. *Environment and Planning A*, 21, 1427-1446.

Kline, J. D. and R. J. Alig. (1999). Does land use planning slow the conversion of forest and farm lands? *Growth and Change*, 30, 3-22.

Kline, J. D. (2005). Forest and farmland conservation effects of Oregon's (USA) land-use planning program. *Environmental Management*, 35(4), 368-380.

Knapp, G. and A. Nelson. (1992). *The Regulated Landscape: Lessons on State land Use Planning from Oregon.* Cambridge, MA: Lincoln Institute of Land Policy.

Lepczyk, C. A., R. B. Hammer, S. I. Stewart, and V. C. Radeloff. (2007). Spatiotemporal dynamics of housing growth hotspots in the North Central U.S. from 1940 to 2000. *Landscape Ecology*, 22, 939-952.

Lewis, P. (1996) *Shaping Suburbia: how political institutions organize urban development*. Pittsburgh, PA: University of Pittsburgh Press.

Lucas, M. T. and D. Chhajed. (2004). Applications of location analysis in agriculture: a survey. *Journal of the Operational Research Society*, 55, 561-578.

McGrath, D. (2005). More evidence on the spatial scale of cities. *Journal of Urban Economics*, 58, 1-10.

Mieszkowski, P. and B. Smith. (1991) Analyzing urban decentralization: the case of Houston. *Regional Science and Urban Economics*, 21, 183-199.

Nelson, A. C. (1983). Reader response. *Natural Resources Journal*, 23, 1-5.

Nelson, A. C. (1999) Comparing states with and without growth management: analysis based on indicators with policy implications. *Land Use Policy*, 16, 121-127.

Oregon Administrative Rules. (2013). Retrieved February 12, 2013 from http://arcweb.sos.state.or.us/pages/rules/access/numerically.html.

Oregon Revised Statues. (2013). Retrieved February 14, 2013 from http://www.leg.state.or.us/ors/.

Oregon Senate Bill 10. (1969). Retrieved February 13, 2013 from http://www.oregon.gov/LCD/docs/bills/sb10.pdf.

Oregon Senate Bill 100. (1973). Retrieved February 13, 2013 from http://www.oregon.gov/LCD/docs/bills/sb100.pdf.

Park, R. and E. Burgess. (1925). *The City*. Chicago, IL: The University of Chicago Press.

Paulsen, K. (2012). Yet even more evidence on the spatial size of cities: urban spatial expansion in the US, 1980-2000. *Regional Science and Urban Economics,* 42, 561-568.

Peet, J. R., R. J. Horvath, and R. Sinclair. (1967). The present pertinence of von Thünen theory. *Annals of the Association of American Geographers,* 57, 810-815.

Pérez, J. M. G. (2007). Urban planning system in contemporary Spain. *European Planning Studies*, 15(1), 29-50.

Platt, R. H. (2004). *Land Use and Society: Geography, Law, and Public Policy*. Washington, DC: Island Press.

Portnov, B. A., M. Adhikari, and M. Schwartz. (2007). Urban growth in Nepal: does location matter? *Urban Studies*, 44(5/6), 915-937.

Porter, D. (1997). *Managing Growth in America's Communities*. Washington, DC: Island Press.

Romero, H., M. Ihl, A. Rivera, P. Zalazar, and P. Azocar. (1999). Rapid urban growth, land-use changes and air pollution in Santiago, Chile. *Atmospheric Environment*, 33(24-25), 4039-4047.

Ryznar, R. M. and T. W. Wagner. (2001). Using remotely sensed imagery to detect urban change: viewing Detroit from space. *Journal of the American Planning Association*, 67(3), 327-336.

Sinclair, R. (1967). Von Thünen and urban sprawl. *Annals of the Association of American Geographers*, 57, 72-87.

Soo, Kwok Tong. (2007). Zipf's Law and Urban Growth in Malaysia. *Urban Studies,* 44(1), 1-14.

Todes, A. (2012). Urban growth and strategic spatial planning in Johannesburg, South Africa. *Cities*, 29(3), 158-165.

Torres-Vera, M. A., R. M. Prol-Ledesma, and D. Garcia-Lopez. (2009). Three decades of land use variations in Mexico City. *International Journal of Remote Sensing*, 30(1), 117-138.

U. S. Census Bureau. (2010). American FactFinder. Retrieved April 18, 2013, from http://factfinder2.census.gov.

U. S. Geological Survey. (2013). Landsat Missions. Retrieved March 7, 2013, from http://landsat.usgs.gov/about_mission_history.php.

Weitz, J. and T. Moore. (1998). Development inside urban growth boundaries: Oregon's empirical evidence of contiguous urban form. *Journal of the American Planning Association*, 64(4), 424-440.

Woudsma, C., J. F. Jensen, P. Kanaroglou and H. Maoh. (2008). Logistics land use and the city: a spatial-temporal modeling approach. *Transportation Research Part E: Logistics and Transportation Review*, 44, 277-297.

Yuan, F., K. E. Sawaya, B.C. Loeffelholz and M. E. Bauer. (2005). Land cover classification and change analysis of the twin cities (Minnesota) Metropolitan Area by multitemporal Landsat remote sensing. *Remote Sensing of Environment*, 98, 317-328.

Appendix A

Kathy Freeborn
Rickreall, Oregon 97371

Dear Fellow Oregonian –

In the 1960's, my grandparents purchased the property that we still farm today in the Willamette Valley, near Rickreall. On our almost 1000 acres we grow grain, grass seed and hay, and we raise cattle. Our products are consumed here in Oregon, nationally and even internationally.

I'm a third generation farmer and I've been farming my whole life. Now I am in my mid-20's, with a Masters Degree in Agriculture from Oregon State University, and I help run our entire operation. My past, and more importantly, my future, is in Oregon agriculture.

Unfortunately, massive developments from Measure 37 claims surrounding us seriously threaten our farm. That's why I'm taking a stand and supporting **Measure 49** this November.

Measure 37 was advertised as a way for long-time property owners to build a few houses on their land – for their kids or their retirement – if they could have done so when they bought the land. It sounded pretty fair, and a lot of voters around here supported it.

But what Measure 37 is actually doing is a lot different than what we were told it would do.

The enclosed maps of your area show nearly 2,200 Measure 37 development claims filed in the Willamette Valley alone. These include claims for development of massive subdivisions, strip malls, and even gravel pits. Over 7,500 Measure 37 claims have been filed all across Oregon's precious, productive farmland and timberland.

As farmers, we know that housing subdivisions and commercial development don't mesh well with agriculture. People like to see farms as they drive by, but living or working next door to them is a different story. When we grow your food and products, we also create dust, smoke, noise, etc. – sometimes 18 hours or more a day. Once, my grandfather had the police called on him because he was picking vegetables on his Eugene-area farm in the middle of the night so that he could fill immediate cannery orders.

Farmers often live on slim profit margins. If Measure 37 goes forward unchanged, complaints and the possibility of lawsuits against us will dramatically increase. Most of us can't afford to fight a lawsuit, much less lose one.

It's ironic to propose large developments that disrupt farming at a time when families care more than ever where their food comes from. The small, independent producers of local food will be some of the first to go out of business if farmland turns into subdivisions.

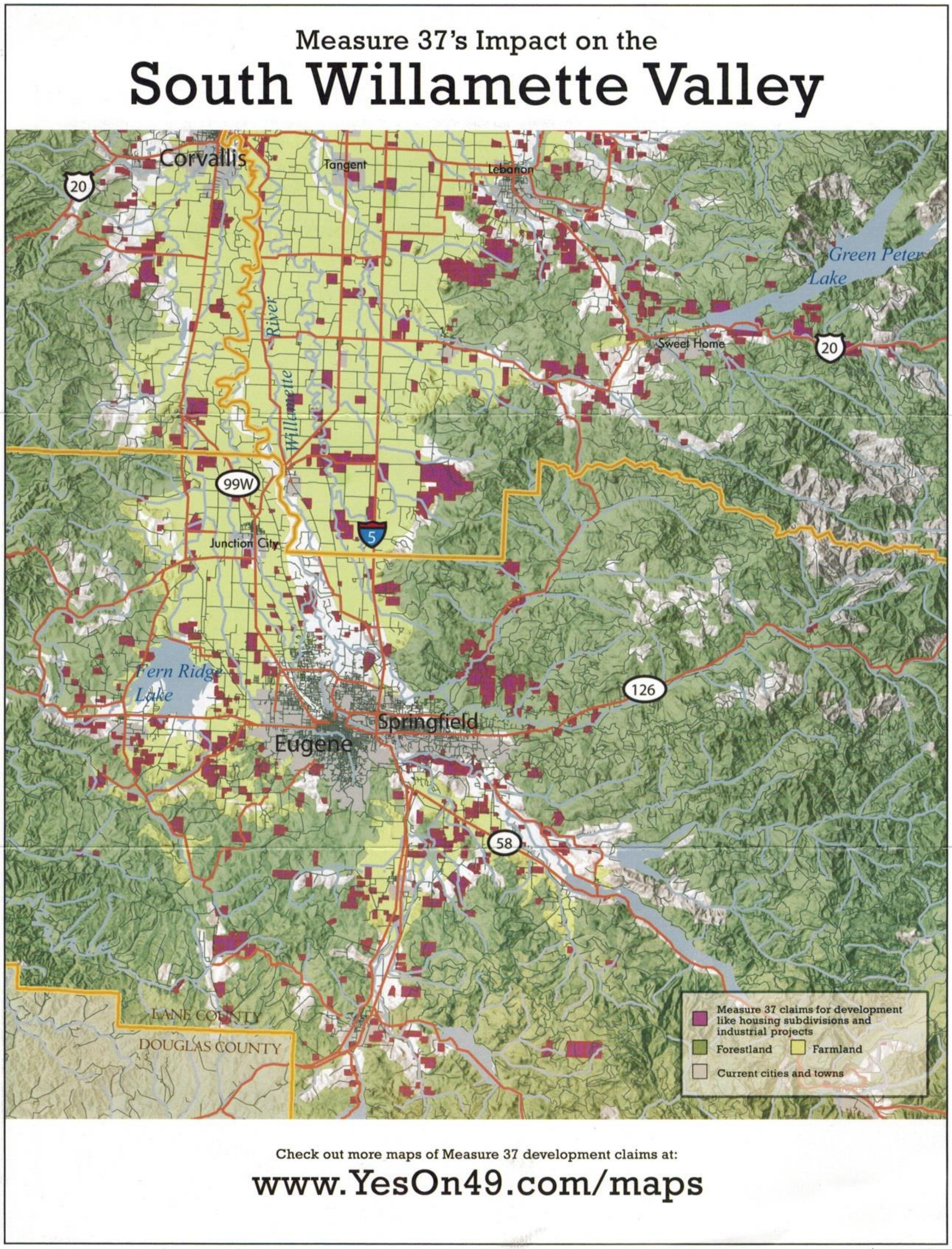
We have a chance to fix the situation this fall by voting Yes on Measure 49. It's a fair compromise: It preserves Oregon's farms, forests and water, and it also protects the rights of families to build a few homes on their land if they could do so when they bought it.

I'm not usually political, but this election is so important to our livelihood and to the future of agriculture in Oregon – that's why I'm taking a stand and supporting Measure 49.

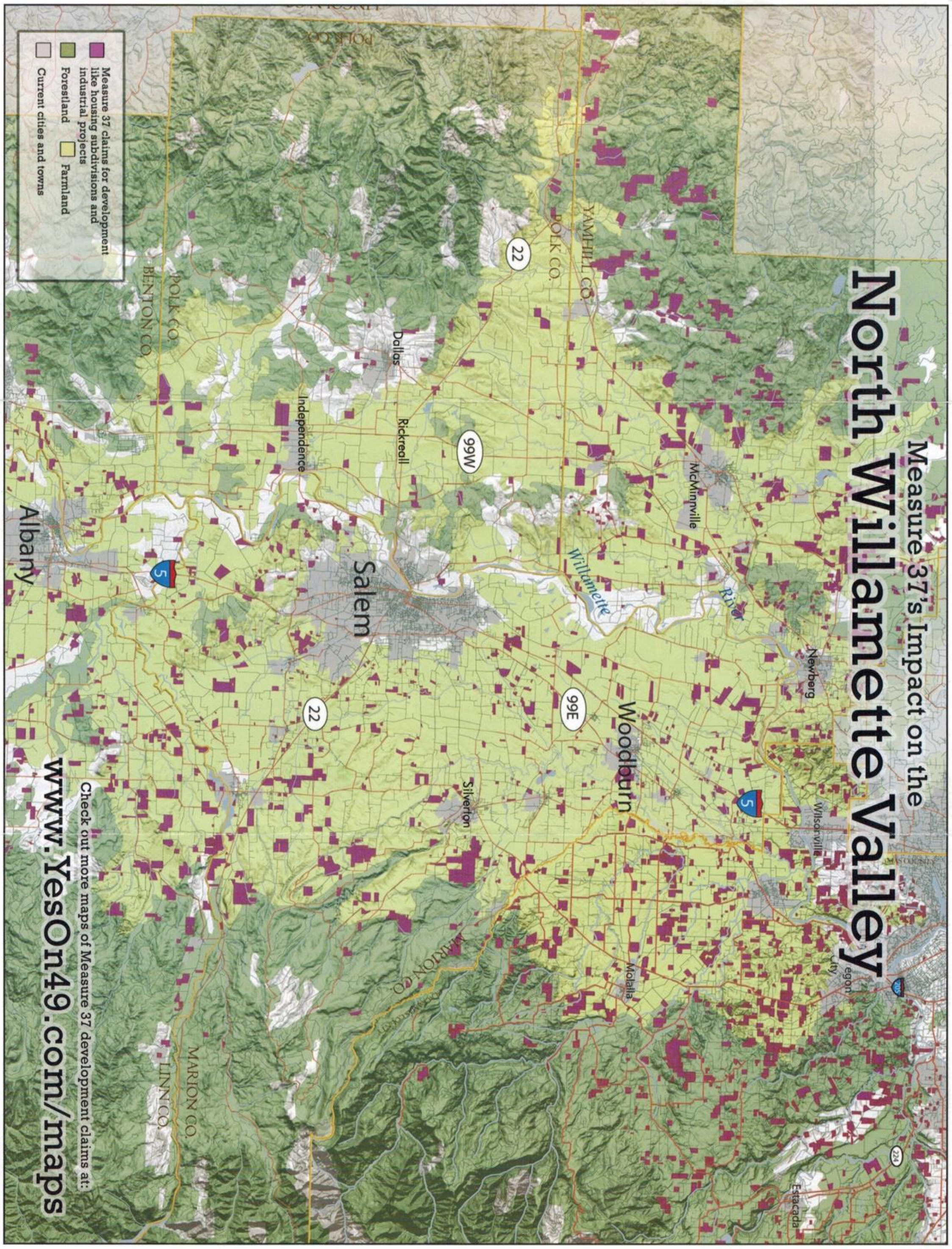
My family and I love Oregon – most farmers do. While other states are losing farmland and forests to development, we are proud to produce local food and products, and serve as an important part of the economy. **Getting pushed out of farming would be devastating for us, and it would also be very bad for all of Oregon.** Please think about us when it comes time to vote in November – Vote YES on 49!

Kathy

Kathy Freeborn letter. This letter was sent to Oregon residents in support of Measure 49, p.1



Kathy Freeborn letter, p.2



Kathy Freeborn letter, p.3

Appendix B

Projection: Albers Conical Equal Area, North American Datum 1983, with standard parallels 29.5° north and 45.5° north, central meridian 96° west, origin of the projection 23° north, false easting and northing 0 meters.