LAND USE TRENDS AFFECTING AUTO DEPENDENCE IN WASHINGTON'S METROPOLITAN AREAS

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16. ABSTRACT

In order to better integrate land use and transportation planning and implement less auto dependent land use patterns, it is useful to know where and to what extent the urban land market is producing less auto-dependent urban growth. Data on the population density, housing density, employment density, jobs-housing balance, and retail-housing balance of metropolitan cities and unincorporated places in Washington state were examined for the 1970-1990 time period. Analyses included the examination and comparison of statistical distributions and thematic maps in each decade. During the twenty year period, there was an increase in the proportion of the population living in jobs- and retail-housing balanced communities and an increase in housing densities. Meanwhile, population and employment densities declined. Density declines were attributable to falling household size, suburbanization, and the growth of very low density urban fringe developments. Distinct geographic patterns were found in density changes but changes in balance measures were less predictable. Relationships between land use variables were found and associations between both density and balance and less auto use were confirmed. It is recommended that efforts be made to promote greater density and balance in certain urban areas and that land use information be used to target communities whose land use patterns are capable of supporting greater transit use and less outcommuting.

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Trends and Patterns of Transit - Oriented Development

LAND USE TRENDS AFFECTING AUTO DEPENDENCE IN WASHINGTON'S METROPOLITAN AREAS

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Implementation Recommendations

Three groups of recommendations were developed from the findings of this report. The first encourages efforts to increase the density and balance of Washington's metropolitan areas in order to reduce auto dependence. The second suggests that transit providers and transportation planners should use land use information to target areas where less auto use might be achieved without changing land use patterns. The third prescribes action steps for implementing the recommendations.

Increasing the density and balance of metropolitan areas

Previous studies and existing public policies support increasing the density[1] and balance[2] of Washington's metropolitan areas. This study gives further support to this goal by confirming that greater density and balance is associated with less auto use[3]. However, more importantly, this report contains specific information on density and balance trends and where efforts to increase them would have the greatest impact on the overall density and balance of Washington's metropolitan areas. While we encourage all communities to continue efforts to increase their density and balance, we urge the state to focus its efforts on three types of jurisdictions: larger jurisdictions that are now low in density (e.g., Pasco or Woodinville) or balance (e.g., Tukwila), larger jurisdictions in the process of losing density (e.g., Yakima) or balance (e.g., Kent), and larger jurisdictions where, due to their location, there probably is a strong market for greater density or balance (e.g., Tukwila). We recommend that the Washington Department of Transportation,

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[1] The term density here means population, employment and housing density.

[2] The term balance here means jobs-housing and retail-housing balance.

[3] Less auto use is achieved by creating shorter trips and reducing the percentage of trips made by single occupant vehicles.

the Department of Community, Trade and Economic Development, metropolitan planning organizations, and affected local agencies work together to adopt growth management plans and implementing measures that promote greater density and balance in these three types of communities. As part of this effort the cooperating agencies should do the following:

- Examine the experience of places that have been significantly transformed over the past 20 years into having less auto-dependent land use patterns (e.g., Kirkland) to see what lessons they can offer other communities. Conduct seminars and consultations designed to transfer these lessons to other jurisdictions.

- Recognize and reward the most compact and complete communities for their contribution to regional mobility. This can include both public recognition, media events and financial rewards that pay the community back for causing less of a burden on the state's transportation facilities.

- Encourage counties (particularly King, Pierce, Clark and Snohomish) to control the creation of new low density, auto dependent places on the urban fringe. Use state and regional authority to review and comment on growth management plans and regulations to ensure that urban growth boundaries, capital improvement programs, urban area zoning, and other local policies discourage the proliferation of the kinds of low density communities that flourished during the 1980s.

- Develop a specific statewide strategy to encourage population growth in the state's largest, densest and most transit-oriented central cities that have lost population density over the past two decades including Seattle, Spokane, Yakima and Vancouver. This will require coordination with agencies

responsible for public safety and education, because these issues affect residential development patterns. We are convinced that the successful revitalization of population growth in urban areas will significantly alter land use and transportation trends in metropolitan areas and directly benefit both urban and suburban communities.

Use land use information to target areas where less auto use might be achieved

An additional benefit of this research is that it gives a picture of the density and balance in every metropolitan community in the state. When this information is compared to relationships that are known to exist between land use and travel behavior it is possible to identify whether any given community is more or less auto dependent than should be expected given its particular land use configuration.

We have found that certain communities in Washington use less transit and generate more outcommuting (which leads to more vehicle miles of travel) than their land use characteristics would predict. We recommend that transportation planners and transit service providers examine these cities and places to determine what could be done to reduce auto use to levels more in line with their land use patterns. Better transit service could increase bus use in higher density places that have lower than expected transit usage (e.g., Yakima). Efforts to increase local employment of local residents could significantly reduce outcommuting and auto miles traveled in places with enough jobs for local residents but high levels of outcommuting (e.g., Kent).

Undertake the following action steps

We recommend that the following specific steps be taken to begin implementing our recommendations.

- The Department of Transportation should meet with each metropolitan planning organization (MPO) to discuss the findings of this report and develop a list of communities and transit service providers in each MPO's jurisdiction that might

become the focus of efforts to either increase density, increase balance or decrease auto use to levels in line with current land use patterns.

- MPOs should work with the focus communities and transit service providers to discuss strategies for achieving greater density, greater balance or less auto use. Local growth management and transit service programs should then be adjusted to incorporate these strategies.
- The Department of Transportation and the Department of Community, Trade and Economic Development should work with the metropolitan planning organizations to provide technical assistance to local governments and transit service providers in identifying and implementing effective strategies for accomplishing these planning objectives. This should include dissemination of lessons learned from communities that have experienced significant increases in density and balance over the past two decades.
- The Governor should create an interagency and public-private task force to design a special conference and statewide strategy for the revitalization and stimulation of population growth in the state's central cities. The task force should develop an appropriate strategy for this purpose. Private foundations should be encouraged to help with this program.[4]

Summary of Findings

Transit Oriented Land Use is Uncommon, Increasing in Some Respects, and Decreasing in Others

Previous research has shown that certain land use densities, jobs-housing balances and retail-housing balances are associated with less use of single occupant vehicles (SOVs). These densities and balances are referred to as "transit-oriented" land use

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[4] We are encouraged by the interest already expressed by the JC Penny Foundation to 1000 Friends of Washington to support work on this problem in Vancouver.

patterns. This study finds that transit-oriented land use patterns decreased in some respects and increased in others between 1970 and 1990. In particular, more people are working in transit-oriented job centers and living in balanced communities. At the same time, however, there has been a decline in the percentage of people living at transit-oriented population and housing densities. The residential density trends have made it more difficult to provide transit service at the home end of work trips even though the job density trends have made it easier to provide transit service at the job end of work trips. Trends toward greater balance have increased the opportunity for people to live and work in the same community.

As shown in Table 1, one out of five persons in Washington's metropolitan areas was living or working in a transit-oriented environment in 1990. Table 1 also shows the changes that occurred between 1970 and 1990.

Table 1. Percentage of Washington's population or workforce living or working in transit-oriented environments

	1970	*1980*	*1990*
Gross population density >2000 per sq. Km	32	22	17
Gross housing density >750 per sq. Km	33	20	18
Gross employment density >6000 per sq. Km & 5000 jobs	3	20	20
Adjusted jobs-housing balance of 0.8-1.2	8	14	13
Adjusted retail-housing balance of 0.8-1.2	8	11	16

Statewide Trends are Toward People Living at Lower Population Densities in More Balanced Communities with Higher Housing Densities and Working at Lower Employment Densities

There is evidence suggesting that *any* increase in densities and balance will reduce auto use (see Figure 21 and 22) even if the high levels of balance and density that characterize transit-oriented land use patterns are not attained. Therefore, it is useful to be aware of the general trends in land use densities and balance irrespective of any particular transit-oriented thresholds. Moreover, a better understanding of general density and balance trends can also be used to determine where transit-oriented land use patterns may be achieved in the future.

Between 1970 and 1990 the weighted median *population* density of cities and unincorporated places *declined* by about 5 percent while the same value for *housing* densities *increased* by about 5 percent (see Table 2). The difference is probably explained by the decline in household size which prevented population densities from keeping pace with housing densities.

Reliable longitudinal employment density data were only available for 1980 and 1990 and only for the Puget Sound region. Weighted net job densities there declined by about 15 percent during the 1980s, reflecting job decentralization and suburbanization.

Jobs- and retail-housing *im*balance declined between 1970 and 1990 as the suburbanization of employment brought more jobs and shopping into suburban bedroom communities.

Counties Compared

No one county was consistently at the top or bottom of the distribution for all five land use factors. However, King, Pierce, Spokane and Yakima counties ranked high while Franklin and Kitsap counties ranked low in several categories (Table 3).

Table 2. Trends in land use factors that influence travel behavior in cities and unincorporated places of Washington's metropolitan areas (densities in units per square kilometer; 0 = perfect balance)

	1970	*1980*	*1990*
Median weighted gross population density	1296	1280	1224
Median weighted gross housing density	489	513	515
Median weighted net employment density	NA	6330	5375
Median weighted adjusted jobs/housing imbalance	.73	.69	.65
Median weighted adjusted retail/housing imbalance	.67	.57	.57

Table 3. Relative Ranking of Counties in 1990 Based on Weighted Mean Scores for Cities and Unincorporated Places

	Population density	*Housing density*	*Job density*	*Jobs/ housing*	*Retail/ housing*	*1970-90 Pop. density change*	*1970-90 Housing density change*
Benton	11	11	11	5	3	6	8
Clark	6	5	7	8	6	9	9
Franklin	12	12	12	6	8	11	11
Island	9	10	10	1	9	1	2
King	1	1	1	9	4	5	1
Kitsap	10	9	6	12	12	12	12
Pierce	4	3	4	7	5	4	3
Snohomish	5	6	3	11	10	10	7
Spokane	3	2	8	2	1	7	6
Thurston	8	8	2	10	7	3	5
Whatcom	7	7	9	4	11	2	4
Yakima	2	4	5	3	2	8	10

Places Compared

A compact and complete community index was computed that incorporated all of the land use factors into a single measure. Figure 1 shows the relative ranking of the 25 most compact and complete communities in Washington.

Correlations

Residential density factors (housing and population) were moderately correlated with job density in 1990. Jobs-housing balance was moderately correlated with retail-housing balance. A weak relationship was observed between the balance and density variables. Thus, greater living density, working density, jobs-housing balance and retail-housing balance tended to be found together in cities and unincorporated places in 1990.

Some relationships were observed between *changes* in the same land use variable from decade to decade. The strongest one was between job density change in the two decades. A more moderate link was found between population change in each of the two decades.

Correlations were not found between changes in different land use variables. The only exception was for population and housing density change. Other changes appear to have been independent of one another within a given community. For example, a place that experienced increased job density did not tend to experience increased population density or jobs-housing balance.

Geographic Patterns

In 1990, densities in the Puget Sound region declined with increasing distance from the metropolitan core. The "inner ring" of suburbs adjacent to central cities received the largest density increases.

There were multiple centers of high employment density in 1990 in the Puget Sound region. Some were located in and around the downtowns of the central cities of Tacoma and Seattle. Most were located in non-downtown central city locations or in and

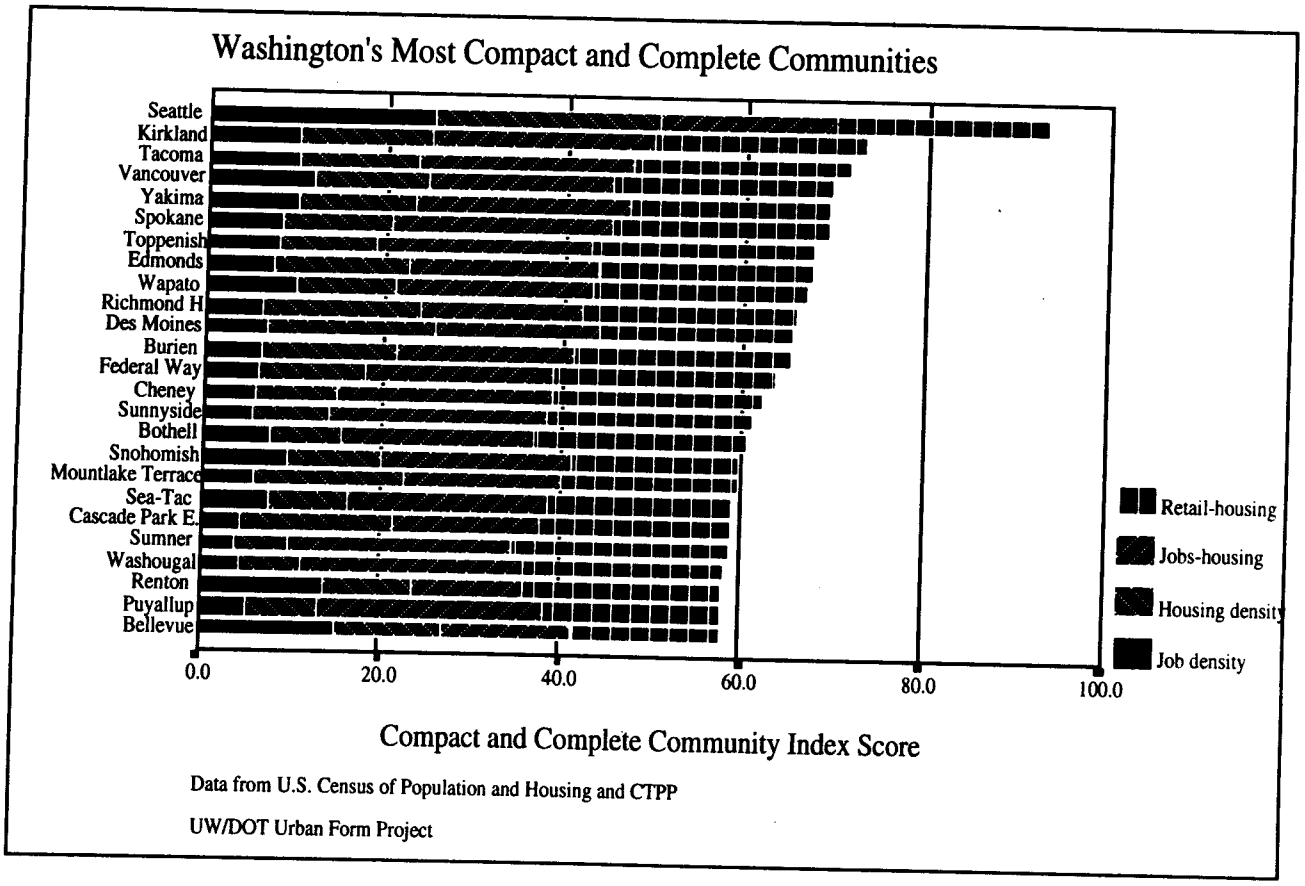

Figure 1. Relative ranking of Washington's most compact and complete communities

around suburban downtown areas. Locations with densities in the second highest category tended to be either adjacent to these high density centers or along freeway corridors. Locations that experienced the greatest increase in net job densities between 1980 and 1990 were even more decentralized. In fact, several of the most centrally located and highest density areas in 1990 lost density during the 1980s.

Three major observations were made from maps of jobs-housing and retail-housing balance. First balance appears to have been unstable. The maps change substantially from decade to decade. Second, forecast analysis zones (FAZs) which had the best jobs-housing balance in 1990 appeared to be located between employment centers and bedroom communities, holding the middle ground along a gradient between the two. Third, FAZs that were retail balanced in 1990 were one of two types. Most of them lay along gradients running from retail-rich zones (along highway corridors) to retail poor ones. Others were in more rural locations surrounded by retail poor territory.

INTRODUCTION

This report examines land use changes between 1970 and 1990 that affect auto dependence in Washington State including changes in employment density, population density, housing density, jobs-housing balance, and retail-housing balance. It focuses on cities and unincorporated places in metropolitan areas as defined by the U.S. Census Bureau and Forecast Analysis Zones of the Puget Sound region as defined by the Puget Sound Regional Council.

The goal of the project is to learn more about where and the extent to which the urban land market is producing less auto dependent land use patterns and whether trends favor their increase or decrease in the future. This will help planners better integrate land use and transportation planning, understand where less auto dependent land use patterns are and are not occurring, and learn more about which areas may have greater and lesser potential to promote these patterns in the future.

Evidence will be presented on changes in the proportion of people who are living or working in transit-oriented environments, overall land use trends in metropolitan areas statewide, how counties compare to one another, and individual cities and unincorporated places at the top and bottom of rankings for various land use characteristics. Thematic maps of land use measures at different times in the Puget Sound region also are presented in order to allow spatial patterns to be observed.

This project is the second study in a series implementing a strategic plan for studying land use and travel behavior in Washington State (Pivo and Moudon 1992). The first part of the plan calls for studies to find out which land use patterns reduce auto use. Relationships Between Land Use and Travel Behavior in the Puget Sound Region (Frank and Pivo 1994) was the first report prepared for that purpose. The second part of the plan calls for research into the market for less auto dependent land use. The study reported here falls under that heading. The third part of the plan recommends investigations into

how public policies can promote land use patterns that reduce auto use. A study currently underway by the author for the Department of Transportation falls into that category and is entitled How Do You Implement Less Auto Dependent Land Use?

REVIEW OF PREVIOUS WORK

WHICH LAND USE FACTORS REDUCE AUTO USE?

Land use does not affect travel behavior on its own. It interacts with economic factors, such as the cost of parking, socioeconomic factors such as household incomes and travel preferences, and government policy factors, such as the frequency of bus service, to produce the travel patterns of our society. Thus while land use has the potential to shape travel behavior, it is not the only factor that can and will make a difference.

A recent review of the literature on how land use affects traffic and travel behavior was written by Ewing (1994). While debates continue about the exact nature of these relationships, the following factors are thought by many researchers to be among the determinants of travel behavior in general and auto-use in particular.

Parking Supply

The availability of parking appears to be one of the most crucial variables affecting the use of single occupant vehicles (SOVs). Cervero (1986) discusses the uphill task of promoting transit usage in suburban office parks given the abundance of free on-site parking at such developments. Feeney (1989) came to the conclusion that parking variables probably influence mode choice more than journey time and cost elements.

Alverson (1991) reports a striking difference in auto use by workers in neighboring suburban office towers with different parking supplies in downtown Bellevue, Washington. She found an SOV split spread of as much as 61 percentage points between the office tower with the lowest SOV mode share (Bell Terrace) and the one with the highest (Skyline). This difference is especially striking because the two office towers were adjacent to each other, had similar employee profiles, and identical levels of transit service. The most important difference between these office buildings was an immense variation in the availability of parking spaces for SOV commuters. The

Bell Terrace building imposed strict limits on SOV parking. SOV parking was abundant in the Skyline tower. Alverson's study found that office towers with lower SOV commuting rates consistently maintained very tight controls on parking for SOV commuters.

Another study by Dunphy and Lin (1990) found that employment centers which maintained parking supply constraints were also characterized by a lower number of vehicle trips per 100 employees. Similar results were reported in a study conducted by K.T. Analytics for the U.S. Department of Transportation (1989).

Cervero (1991) reported vehicle occupancy rates went up by 0.46 occupants per trip if the parking supply in an office development of 1,000,000 square feet was halved from an initial level of 4,000 spaces. This would translate into a reduction of close to 30 percent in vehicle miles of travel (VMT) and vehicle trip-making, other factors being held constant.

Land Use Density

Researchers have consistently found that dense developments exhibit less dependency on SOV commuting. Both residential and employment density have been found to be positively associated with a decrease in solo commuting (Newman and Kenworthy 1991). Warren (1988) found that both employment and residential density were linked to increased transit ridership in two Australian towns. Keyes (1982) came to the conclusion that medium-sized cities with high residential densities were associated with lower-than-average levels of per capita gasoline consumption. A study conducted in the Portland area found that dense in-city locations exhibited lower levels of auto travel than suburban areas (1000 Friends of Oregon 1993). Among the latest local studies is Frank and Pivo (1994), which found a weak but statistically significant positive correlation between employment density and reduced SOV commuting in the Puget Sound region of Washington State.

Mixed Use and Jobs-Housing Balance

Mixing land uses reduces trip lengths and encourages the use of non auto travel options. In fact, Ewing (1994) suggests that many of the benefits of density may be attributable to the mixed land uses with which it often occurs in central city locations. Frank and Pivo (1994) found that greater land use mixing at the census tract scale was associated with more busing and walking to work, less driving to work, shorter work trip distances and faster work trips.

Jobs-housing and retail-housing balance are specific types of land use mix in which either employment or retail uses occur together with residential uses and at an amount that meets but does not exceed the amount needed to serve the residential area.

No scientific studies were found on the subject of retail-housing balance, however research on jobs-housing balance is available. Nowlan and Stewart (1991) found that increasing downtown housing, which improved jobs-housing balance, coincided with a decrease in commuting trips into downtown Toronto. Another study found that commuters living in jobs-housing balanced communities in the San Diego region made work trips that were on average 20 percent shorter than the regional average and 40 percent shorter than those made from bedroom communities (San Diego Association of Governments, 1991a and 1991b). Frank and Pivo (1994) found that jobs-housing balanced census tracts in the Puget Sound region generated work trips that were about 30 percent shorter in time and distance than those generated by imbalanced tracts.

TRENDS IN LAND USE FACTORS THAT REDUCE AUTO USE

Recent studies on density trends in urban areas were not identified in the literature review conducted for this study. However, recent studies on suburbanization shed considerable light on density trends insofar as suburbanization is generally indicative of declining urban densities.

In recent years, there has been a partial halt to suburban flight and a partial residential revival of city areas, significantly due to immigrants moving in and minorities

staying on (Chinitz 1993). However, cities are still losing industry to suburban locations and becoming heavily services-dependent. Increasingly it is the suburbs which are economically diversified. The bulk of new job creation is in the suburbs.

A detailed study of the population growth trends of seven metropolitan areas during the 1980s reached findings highly relevant to this study (Speare 1993).[5] The trend was toward decentralization. In general, outer suburban and rural areas increased their share of metropolitan population. The fastest growing parts of the metropolitan areas were low density rural areas although outer employment centers and outer suburbs also experienced significant population growth. In relative terms, rural areas grew faster than the regions as a whole causing them to increase their share of the total population. The same was true for most outer suburbs and outer centers. On average, outer suburban and rural areas contained 50 percent of the populations in the seven study regions in 1990 compared to 43 percent in 1980.

A recent study of the 35 major metropolitan areas (MMAs) that had more than 1 million population in 1980 presented trends in the employment/residence ratio, a measure that is similar to jobs-housing balance (Forstall 1992). The employment/residence (E/R) ratio is the ratio of workers at their place of work to workers at their place of residence. For a given city, it is the total number of workers who are employed in the city over the total number of workers who reside in the city.

The E/R ratios for cities and suburbs show a continuing contrast between job-rich central cities and job-poor suburbs. Since 1960, central cities have experienced an increase in in-commuting due to a slight growth in population and a moderate growth in jobs. In 1960, cities had an E/R ratio of 1.23[6], indicating a 23 percent surplus of jobs

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[5] The areas studied included Atlanta MSA, Boston CMSA, Detroit CMSA, Houston CMSA, Los Angeles CMSA, Minneapolis MSA, and Phoenix MSA.

[6] This number may be too high because of coding problems, according to Forstall (1992).

over working residents. By 1980 it had grown to 1.36 and then declined to 1.34 in 1990. For the suburbs, the ratio was 0.81 in 1960, showing a 19 percent deficiency of jobs compared to workers. It has risen slowly since then to 0.88 in 1990. Forstall estimates that at current trends, it would take another 35 years to achieve a net balance in the suburbs.[7] Overall, imbalances appear to have begun declining in the 1980s, however they will likely remain for the foreseeable future.

To summarize, previous studies show that density and jobs-housing balance reduce auto reliance in urban areas. Studies of national land use trends also show that suburbanization is reducing densities while slightly improving balance in our urban areas.

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[7] Forstall presents data for the Seattle and Portland areas. Seattle's suburbs showed an increase in their E/R ratio from .80 to .86 between 1960 and 1990. Portland's increased from .67 to .77. During the same time period the City of Seattle's ratio increased from 1.27 to 1.57 and the City of Portand's ratio increased from 1.36 to 1.57.

PROCEDURES

Data on population density, housing density, employment density, jobs-housing balance and retail housing balance were collected from the 1970, 1980 and 1990 U.S. Census of Population and Housing, the 1990 Census Transportation Planning Package, and the Puget Sound Regional Council. Table 4 shows the variables used in the study and related information. No statewide or regional longitudinal secondary data sources were available on parking supplies and land use mix.

Two data sets were prepared from the secondary data sources. One data set covered cities and unincorporated places with populations greater than 2500 in the 12 counties of Washington's metropolitan areas. It contained housing and population density figures for 1970, 1980 and 1990 and gross job density, jobs-housing balance and retail-housing balance figures for 1990. The second data set was on Forecast Analysis Zones in the Puget Sound region and contained both gross and net job densities, jobs-housing balance and retail-housing balance figures. The net employment density data were available only for 1980 and 1990. All other data were available for 1970, 1980, and 1990.

Data analysis was both descriptive and correlational. Measures of ratios, central tendency, and absolute dispersion and thematic maps were used to examine land use variables. Simple correlation coefficients were used to measure the degree of association between land use changes. A curve fitting program was employed to model relationships between land use and travel characteristics.

Table 4. Urban form measures

Measure (Units)	Unit of Analysis	Population	Component Data	Data Sources	Data Points (Years)
Gross dwelling unit density (units per sq km)	Cities and unincorporated places	All incorporated cities and all census designated unincorporated places with populations greater than 2500 in 12 metropolitan counties of Washington State	Land area Number of dwelling units	U.S. Census of Population and Housing	1970 1980 1990
Gross population density (persons per sq km)	Cities and unincorporated places	All incorporated cities and all census designated unincorporated places with populations greater than 2500 in 12 metropolitan counties of Washington State	Land area Population	U.S. Census of Population and Housing	1970 1980 1990
Gross job density (jobs per sq km)	Cities and unincorporated places	All incorporated cities and all census designated unincorporated places with populations greater than 2500 in 12 metropolitan counties of Washington State	Land area Number of jobs	U.S. Census of Population and Housing, Census Trans. Plng Pkg (CTPP)	1990
	Forecast Analysis Zones	King, Pierce, Snohomish and Kitsap Counties (Puget Sound Region)	Employment land area No. of jobs in five economic sectors: Resources/ Construction, Manufacturing, Wholesale Trade/ Transportation/ Communications, Retail Trade, Services, Government/Education)	Puget Sound Regional Council (PSRC)	1970 1980 1990
Net job density (jobs per sq km of employment land)	Forecast Analysis Zones	King, Pierce, Snohomish and Kitsap Counties (Puget Sound Region)	Employment land area No. of jobs in five economic sectors: Resources/ Construction, Manufacturing, Wholesale Trade/ Transportation/ Communications, Retail Trade, Services, Government/Education)	Puget Sound Regional Council (PSRC)	1980 1990
Jobs/housing balance	Cities and unincorporated places	All incorporated cities and all census designated unincorporated places with populations greater than 2500 in 12 metropolitan counties of Washington State	Number of housing units, average number of workers per housing unit, Number of jobs	U.S. Census of Population and Housing (land area, housing), Census Trans. Plng Pkg (CTPP) (Jobs)	1990
	Forecast Analysis Zones	King, Pierce, Snohomish and Kitsap Counties (Puget Sound Region)	Number of housing units, average number of workers per housing unit, Number of jobs	PSRC	1970 1980 1990
Retail/housing balance	Cities and unincorporated places	All incorporated cities and all census designated unincorporated places with populations greater than 2500 in 12 metropolitan counties of Washington State	No. of housing units, average number of retail workers per housing unit, Number of retail jobs	U.S. Census of Population and Housing (land area, housing), Census Trans. Plng Pkg (CTPP) (Jobs)	1990
	Forecast Analysis Zones	King, Pierce, Snohomish and Kitsap Counties (Puget Sound Region)	Number of housing units, Average retail number of workers per housing unit, Number of retail jobs	PSRC	1970 1980 1990

DISCUSSION

POPULATION DENSITY

A State-Level View

How many of us are living in places with transit oriented population densities?

Previous research has shown that a significant decline in the percentage of persons who drive alone occurs after crossing a density threshold of approximately 2000 persons per square km (Frank and Pivo 1994). Figure 2 shows that the percentage of the state's population living in places with population densities at or above this threshold has declined over the past 20 years.

What are the overall trends in population density?

Greater transit use associated with certain density thresholds is not the only way density affects travel behavior. Higher densities can also reduce auto use by shortening distances between trip ends. For this reason we examined general population density trends irrespective of particular thresholds.

The typical census designated place grew denser between 1970 and 1990. The greatest change occurred in the 1980s. Table 5 shows there were 67 places in 1970. Their median density increased by about 8 persons per square km during the 1970s. In 1980 there were 110 places because new Census Designated Places were created during the 1970s. The median density of these 110 places increased by about 52 persons per square km during the 1980s.

When the density increase occurring in existing places is compared to the trend in cumulative density, a paradox emerges. Even though places typically got denser between 1970 and 1990, the cumulative density of all places *declined* during the same time period. The cumulative figures for all places are shown in Table 6.

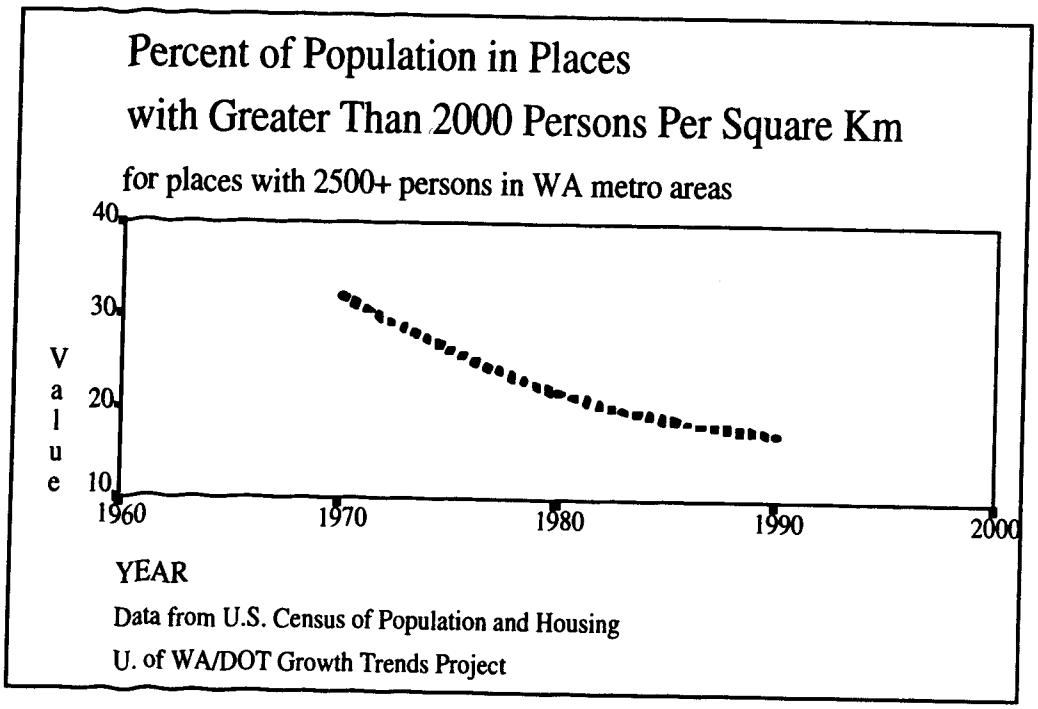

Figure 2. Percent of population in places with greater than 2000 persons per square km for places with 2500+ persons in Washington metropolitan areas

Table 5. Absolute increase in the population density of Census Designated Places with greater than 2500 persons in Washington metropolitan areas (in persons per square km)

Year	*Mean*	*Median*	*Std dev*	*Minimum*	*Maximum*	*Valid Cases*
1970-1980	-45.845	8.217	402.653	-1657.325	819.873	67
1980-1990	53.284	52.234	205.072	-623.946	594.379	110

Data from U.S. Census of Population and Housing

Table 6. Population density of Census designated places with greater than 2500 persons in Washington metropolitan areas (in persons per square km)

Year	*Mean*	*Median*	*Std dev*	*Minimum*	*Maximum*	*Valid Cases*
1970	941.521	821.053	476.352	119.500	2451.604	66
1980	941.175	799.701	457.749	139.508	2275.788	122
1990	871.567	800.140	471.027	9.942	2375.964	179

Data from U.S. Census of Population and Housing

The solution to the paradox lies in the addition of new lower density places in each decade that offset any density increases that occurred in previously existing places. This was particularly evident during the 1980s when 33 places with densities lower than 800 persons per square km were created. As Figure 3 shows, the average density of places established between 1980 and 1990 were much lower than that of previously existing places. Even though older places were becoming denser over time, it was not enough to offset the cumulative effect of creating so many low density places during the 1980s.

Pierce County was the most common location of the new low density places created during the 1980s. It spawned 10 new places that averaged around 400 persons

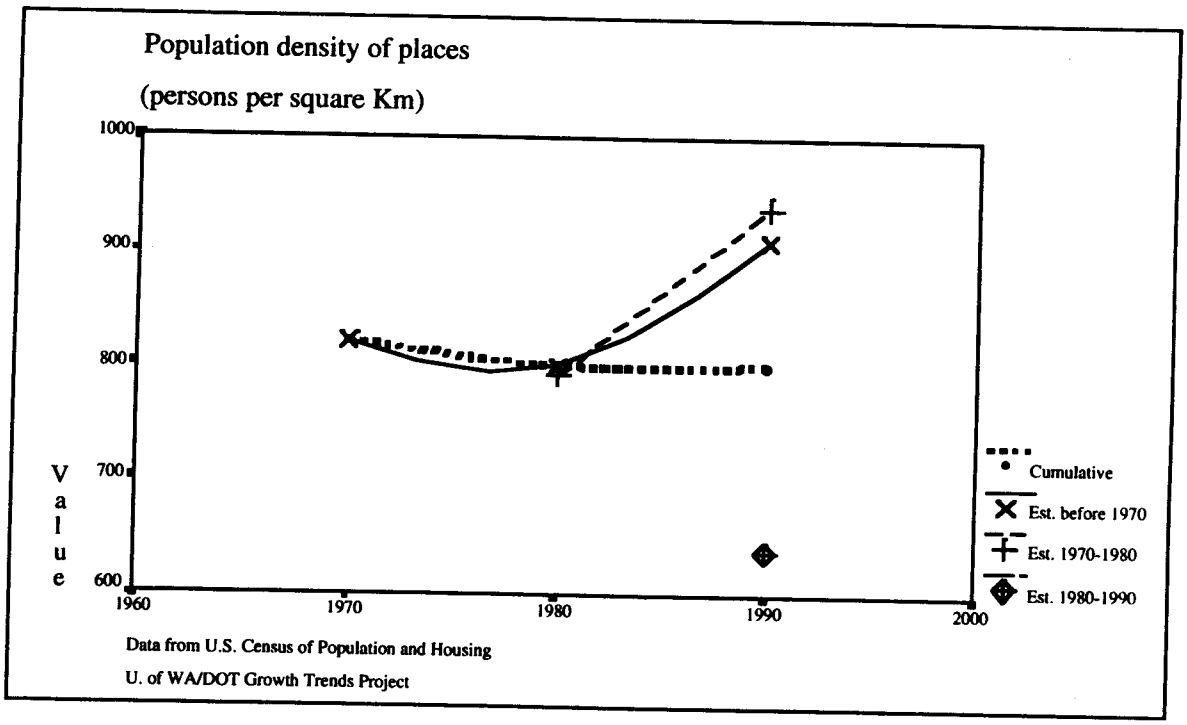

Figure 3. Population density of places (persons per square km)

per square km which was about half the statewide median for all places in 1990. King, Clark and Snohomish counties were the next most common locations for new low density places: King and Clark counties each created five and Snohomish County created four. A complete list of places established during the 1980s and their populations and densities is given in Appendix A.

Three characteristics of the low density places born in the 1980s are evident. One is that nearly all of them are part of the urban growth found around the large cities of Portland and Seattle. Another is that nearly every one is an unincorporated place under the jurisdiction of county government. In addition, they are generally located on the urban fringe and appear to be the result of what has come to be called exurbanization.

Weighted summary statistics show the experience of persons rather than the nature of places. Because higher density places are often the most populated, weighted summary statistics show the typical person living at densities that are higher than those of typical places. As shown in Table 7, the typical person in 1990 lived at a lower population density than the typical person did in 1970. Moreover, the density in 1990 was slightly more than half that necessary to cross the transit oriented threshold of 2,200 persons per square km.

Table 7. Population density of Census designated places with greater than 2500 persons in Washington metropolitan areas weighted by population (in persons per square km)

Year	*Weighted Mean*	*Weighted Median*	*Weighted Std dev*	*Minimum*	*Maximum*
1970	1508.335	1295.990	718.743	119.500	2451.604
1980	1329.397	1280.269	597.202	139.508	2275.788
1990	1258.700	1223.594	619.373	9.942	2375.964

Data from U.S. Census of Population and Housing

Table 8. Population density of Census designated places with greater than 2500 persons in Washington metropolitan areas that had small area changes (i.e., the median plus or minus 0.5 the standard deviation) weighted by population (in persons per square km)

Year	*Weighted Mean*	*Weighted Median*	*Weighted Std dev*	*Minimum*	*Maximum*
1970	1568.010	1295.990	724.954	119.500	2451.604
1980	1465.039	1283.409	627.375	316.746	2275.788
1990	1508.038	1288.807	627.400	288.688	2375.964

Data from U.S. Census of Population and Housing

Even if only cases that had small changes in their geographic areas are examined, a decline in weighted population density is observed (see Table 8).

This presents yet another apparent paradox — people living at lower density even though places are getting denser. The solution in this case lies in a twenty year decline in the density of the state's largest places,[8] an increase in the proportion of the total population living in suburban areas[9] and, to a lesser extent, an increase in the number of persons living in the lowest density places[10].

The general conclusion to be drawn about overall population density trends is that despite density gains by many places, people are living at lower density in 1990 than they were in 1970, far below the densities necessary to support alternatives to driving alone.

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[8] The 10 percent largest places in the state, which had about 40 percent of the state's metropolitan population in 1990, experienced a slight density decline between 1970 and 1990.

[9] In 1970 40.4 percent of the metropolitan population in Washington was living in central cities, compared to 32.5 percent in 1990.

[10] In 1970, 0.4 percent of all persons were living in places in the bottom 10 percent of the population density distribution . In 1990, 7.1 percent of the population was living in places in the bottom 10 percent of the population density distribution.

A County-Level View

When counties are examined separately, the statewide differences become apparent (see Figures 4 and 5). In 1990, people were living at the highest densities in King County and at the lowest densities in Franklin County. People in Island county experienced the greatest density increase between 1970 and 1990 while those in Kitsap County saw the most decline. The decline in Kitsap is mostly explained by the annexation to Bremerton of large amounts of land, not by a loss of population. Most of the growth in land area occurred during the 1970s when it annexed its reservoir and watershed. The watershed represents an anomaly in the data and should be considered when interpreting these results.

A Place-Level View

Table 9 lists the places in the top and bottom deciles of population density in 1990. Seattle was the densest place with about 2,400 person per square km. White Swan, in Yakima County, had the lowest density at just under 10 person per square km. The median density for all places in 1990 was 800 persons per square km, or about one-third of the threshold required to be transit-oriented. In fact, only Seattle exceeded this threshold. In addition to Seattle, eight places came within 15% of the density threshold. All of them were located in the central Puget Sound counties of King, Pierce and Snohomish. Together, these places accounted for just under 20 percent of the total population living in Washington's metropolitan places with more than 2500 residents.

These eight densest places are less auto dependent, as should be expected. On average, for example, 7.4 percent of their employed residents took the bus to work in 1990, compared to 1.5 percent for all of Washington's metropolitan places.

Table 10 gives the places in the top and bottom decile of density *change* from 1970 to 1990. The relative change in population and land area are also given in order to allow their combined effect on density to be considered. For example, the large density

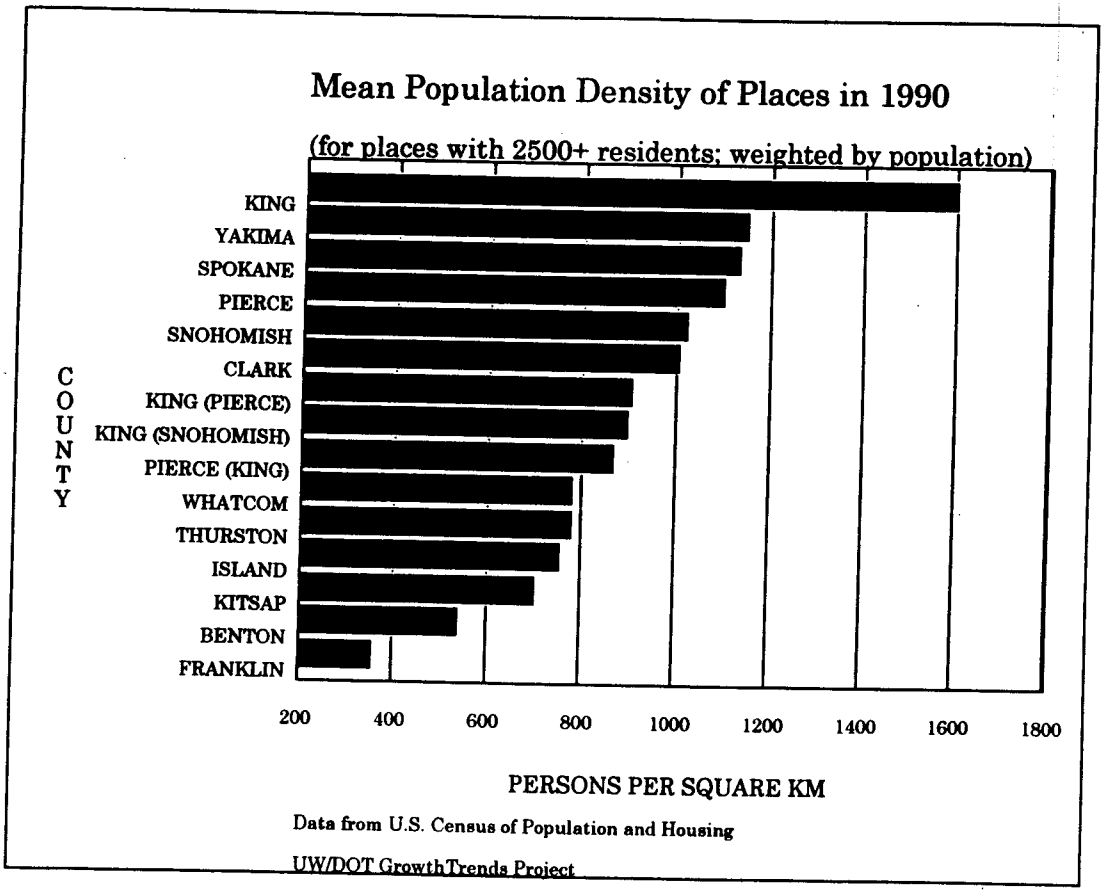

Figure 4. Mean density change of places by county in 1990

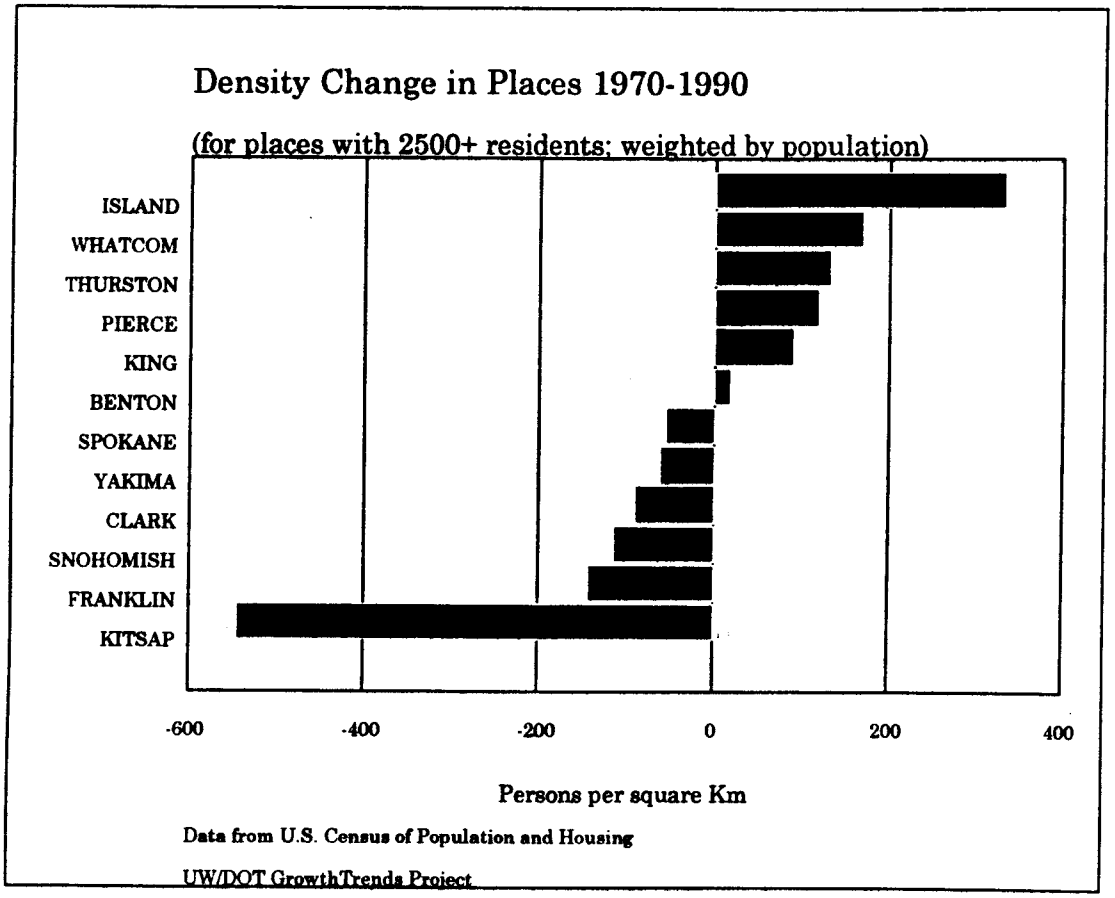

Figure 5. Density change in places 1970-1990

Table 9. Places in the top and bottom decile of population density in 1990
(Places above or approaching TOD threshold are shown with gray background)

	Place	*County*	*Population*	*Density*
TOP DECILE	Seattle city	KING	516259	2375.96
	White Center-Shorewood CDP	KING	20531	2023.36
	Esperance CDP	SNOHOMISH	11236	2012.90
	Richmond Highlands CDP	KING	26037	1973.10
	Des Moines city	KING	17283	1962.42
	North City-Ridgecrest CDP	KING	13832	1939.43
	Fircrest town	PIERCE	5258	1905.07
	Mountlake Terrace city	SNOHOMISH	19320	1889.67
	Cascade Park East CDP	CLARK	6996	1727.41
	Sheridan Beach CDP	KING	6518	1647.62
	Wapato city	YAKIMA	3795	1625.96
	Edmonds city	SNOHOMISH	30744	1625.55
	Kingsgate CDP	KING	14259	1624.96
	West Lake Sammamish CDP	KING	6087	1623.63
	Lake Forest North CDP	KING	8002	1596.89
	Toppenish city	YAKIMA	7419	1595.14
	Lynnwood city	SNOHOMISH	28695	1590.37
BOTTOM DECILE	Union Gap city	YAKIMA	3120	310.42
	McChord AFB CDP	PIERCE	4538	302.09
	Smokey Point CDP	SNOHOMISH	2620	300.87
	Fairchild AFB CDP	SPOKANE	4854	288.69
	Arlington city	SNOHOMISH	4037	282.98
	Artondale CDP	PIERCE	7141	260.81
	Ault Field CDP	ISLAND	3795	213.02
	Marietta-Alderwood CDP	WHATCOM	2766	178.58
	Frederickson CDP	PIERCE	3502	176.25
	Suquamish CDP	KITSAP	3105	175.23
	Finley CDP	BENTON	4897	165.04
	Sudden Valley CDP	WHATCOM	2615	160.55
	Brush Prairie CDP	CLARK	2650	130.82
	West Richland city	BENTON	3962	72.85
	Birch Bay CDP	WHATCOM	2656	64.12
	Highland CDP	BENTON	3656	53.00
	White Swan CDP	YAKIMA	2669	9.94

Table 10. Places in top and bottom decile of density change, 1970-1990
(Places with TOD density in 1990 are shown with gray background)

	PLACE	COUNTY	1970-1990 DENSITY CHANGE	1990 POP.	1970-1990 % POP. GROWTH	% LAND AREA CHANGE	1990 LAND AREA
TOP DECILE	Wapato city	YAKIMA	894.69	3795	33.58	-39.92	2.334
	Redmond city	KING	837.85	35800	1045.23	42.95	37.395
	Des Moines city	KING	788.97	17283	337.43	161.57	8.807
	Tanglewilde-Thompson Place	THURSTON	626.56	6061	77.07	-1.95	4.317
	Spanaway CDP	PIERCE	607.53	15001	160.07	19.68	13.329
	University Place CDP	PIERCE	448.13	27701	109.38	40.40	20.364
BOTTOM DECILE	Town and Country CDP	SPOKANE	-460.71	4921	-24.11	2.23	3.707
	Fort Lewis CDP	PIERCE	-465.93	22224	-41.60	3.85	37.117
	Grandview city	YAKIMA	-484.17	7169	98.86	263.02	12.223
	Cheney city	SPOKANE	-490.71	7723	21.47	73.49	6.740
	Bremerton city	KITSAP	-650.46	38142	8.03	102.92	51.504
	Sumner city	PIERCE	-759.04	6281	45.23	219.50	9.930

increase in the City of Wapato appears to have been caused as much by a decline in land area as an increase in population. Redmond, on the other hand, had a large density gain that was apparently much more the result of changes in population than changes in land area. The average density increase among the top six gainers was 700 persons per square km which nearly equals the median density of all places in 1990.

Maps 1 and 2 spatially depict population density characteristics in the census designated places of the Puget Sound Region.[11] Map 1 gives gross densities in 1990 and Map 2 shows density change between 1970 and 1990. The pattern in 1990 shows how densities still follow the traditional pattern associated with monocentric regions in which densities decline with increasing distance from the region's center (in this case Seattle).

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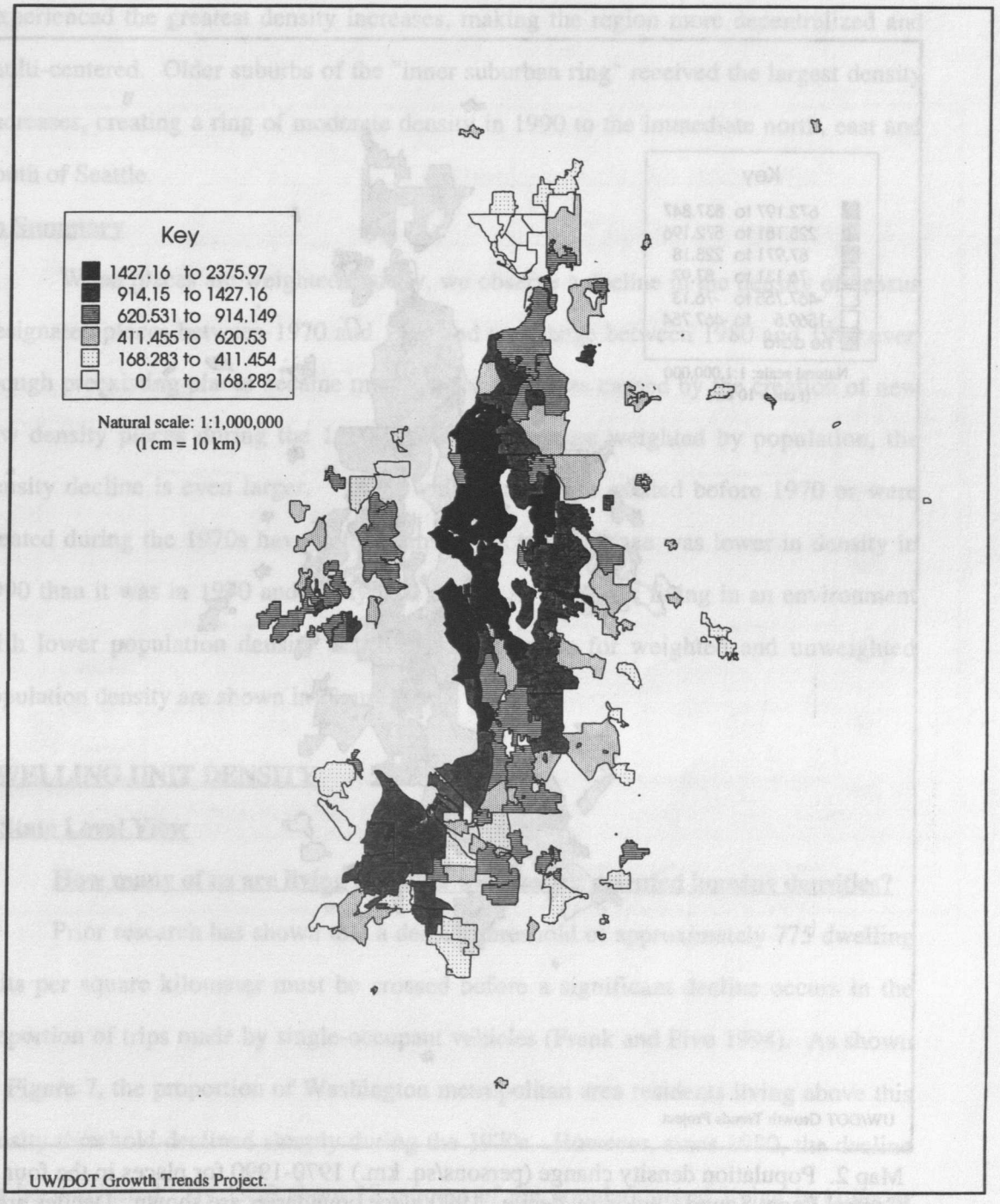
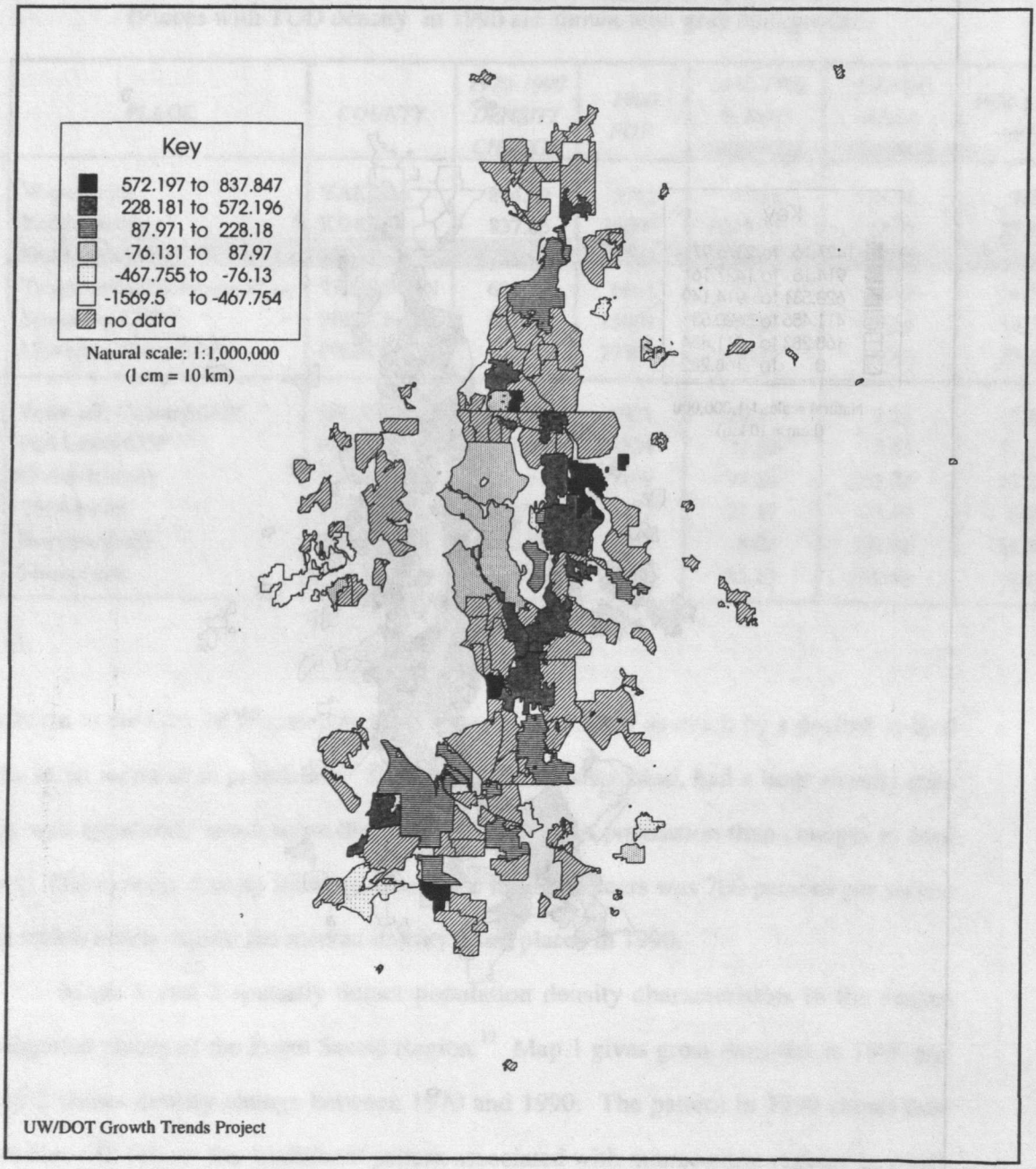
[11] Maps were not prepared for places outside the Puget Sound Region because computerized boundary files could not be obtained within the project budget.



Map 1. Population density (person/sq. km.) 1990 for places in the four county Central Puget Sound Region by decile. Deciles are defined using data for all places in the metropolitan counties of Washington State. Top and bottom deciles are shown; middle deciles are combined. Data source: Census of Population and Housing, 1990, U.S. Census Bureau.



Map 2. Population density change (persons/sq. km.) 1970-1990 for places in the four county Central Puget Sound Region by decile. 1990 place boundaries are shown. Deciles are defined using data for all places in the metropolitan counties of Washington State. Top and bottom deciles are shown; middle deciles are combined. Data source: Census of Population and Housing, U.S. Census Bureau.

However, Map 2 shows the suburbanization that has occurred. Suburban places have experienced the greatest density increases, making the region more decentralized and multi-centered. Older suburbs of the "inner suburban ring" received the largest density increases, creating a ring of moderate density in 1990 to the immediate north, east and south of Seattle.

In Summary

When places are weighted equally, we observe a decline in the density of census designated places between 1970 and 1980 and no change between 1980 and 1990 even though preexisting places became more dense. This was caused by the creation of new low density places during the 1980s. When places are weighted by population, the density decline is even larger. Thus, while places that existed before 1970 or were created during the 1970s have gotten denser, the typical place was lower in density in 1990 than it was in 1970 and the typical person in 1990 was living in an environment with lower population density than in 1970. Trends for weighted and unweighted population density are shown in Figure 6.

DWELLING UNIT DENSITY

A State Level View

How many of us are living in places with transit oriented housing densities?

Prior research has shown that a density threshold of approximately 775 dwelling units per square kilometer must be crossed before a significant decline occurs in the proportion of trips made by single-occupant vehicles (Frank and Pivo 1994). As shown by Figure 7, the proportion of Washington metropolitan area residents living above this density threshold declined sharply during the 1970s. However, since 1980, the decline has been arrested. By 1990 about 18 percent of the population was living in cities or unincorporated places above the transit-oriented housing density threshold.

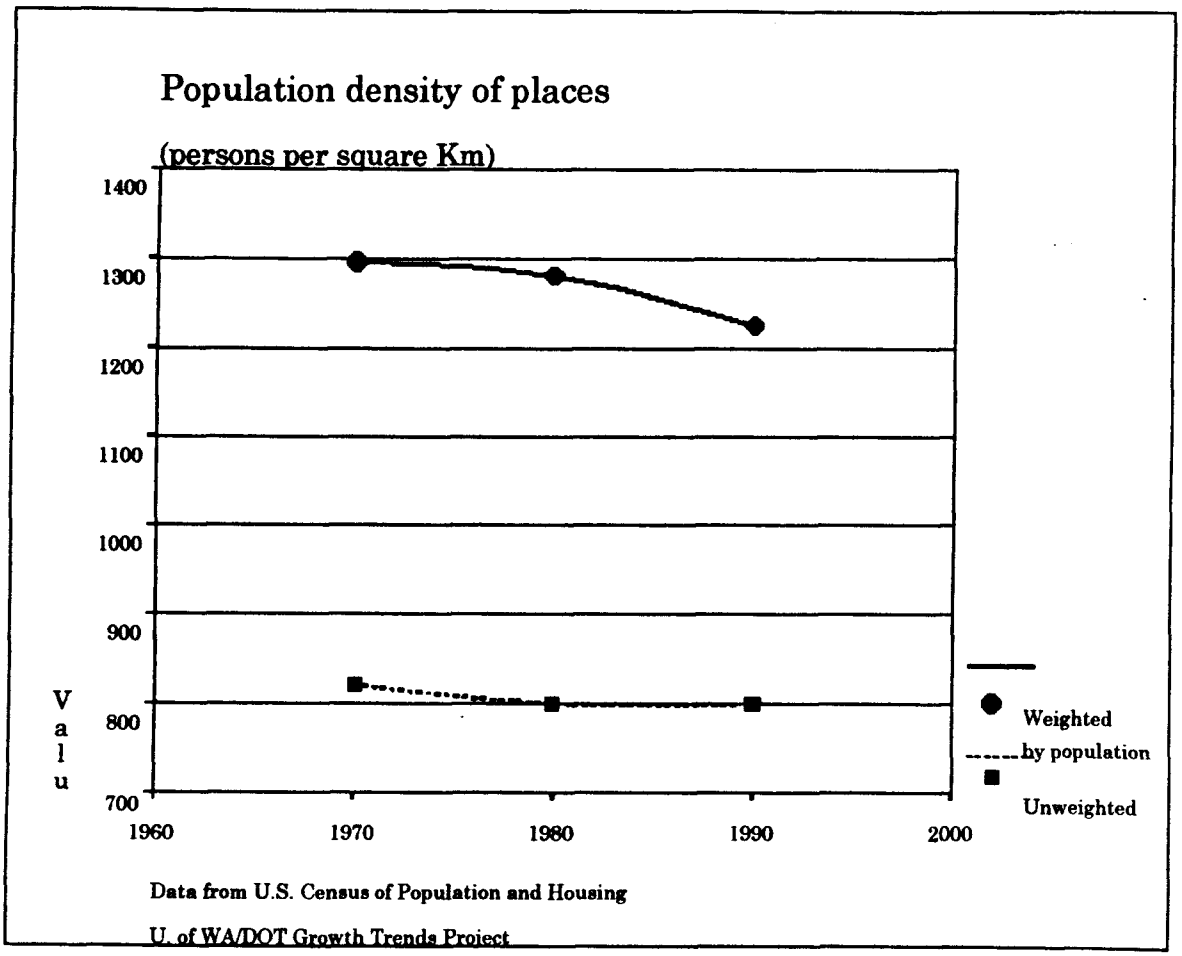


Figure 6. Population density of places (persons per square km)

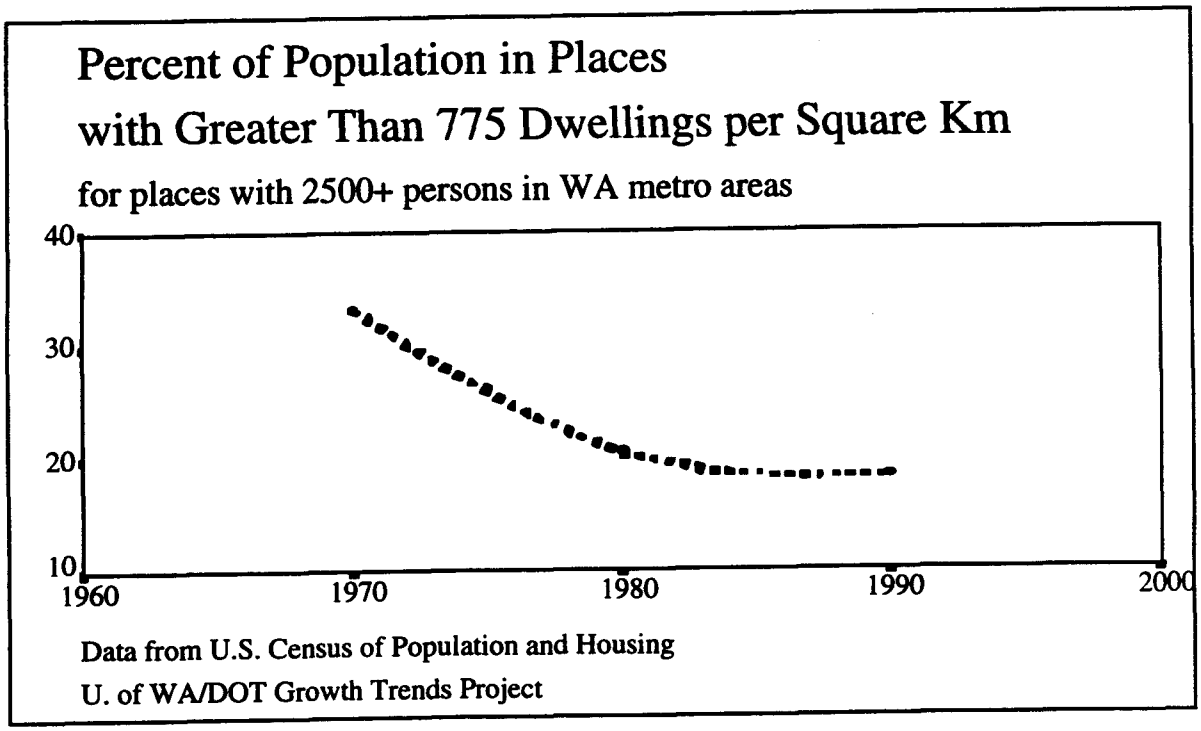


Figure 7. Percent of population in places with greater than 775 dwellings per square km for places with greater than 2500+ persons in Washington metropolitan areas

Table 11. Absolute change in the dwelling unit density of Census designated places with greater than 2500 persons in Washington metropolitan areas (in units per square km)*

	Mean	*Median*	*Std Dev*	*Minimum*	*Maximum*	*Valid N*
1970-1990	84.51	103.41	140.81	-340.31	473.31	67
1970-1980	47.61	52.79	120.10	-429.99	321.52	66
1980-1990	34.92	31.46	86.84	-181.70	271.17	110

Table 12. Dwelling unit density of places with greater than 2500 persons in Washington metropolitan areas (in units per square km)*

	Mean	*Median*	*Std Dev*	*Minimum*	*Maximum*	*Valid N*
1970	317.57	269.50	186.47	69.08	1025.17	67
1970	354.99	312.42	185.54	18.96	1060.09	110
1980	345.11	321.03	199.97	2.85	1146.11	178

*Data from U.S. Census
UW/WSDOT Land use Trends Project

What are the overall trends in housing density?

Communities have typically seen an increase in housing density over the past two decades. The largest changes occurred during the 1970s. Over the twenty years, gross housing densities typically grew by around 100 units per square km (Table 11).

As with population density, the cumulative density increase over the past twenty years was slowed by the creation of new lower density places, particularly during the 1980s. Table 12 shows the cumulative housing density for all places with more than 2500 persons. The median density for all places went up by about 19 percent. This is less than the gain posted by places that existed in 1970. Figure 8 shows the relationship between cumulative housing densities and densities for places created before 1970, during the 1970s and during the 1980s. It clearly shows how density gains, made in the 1970s were offset by the creation of low density places during the 1980s.

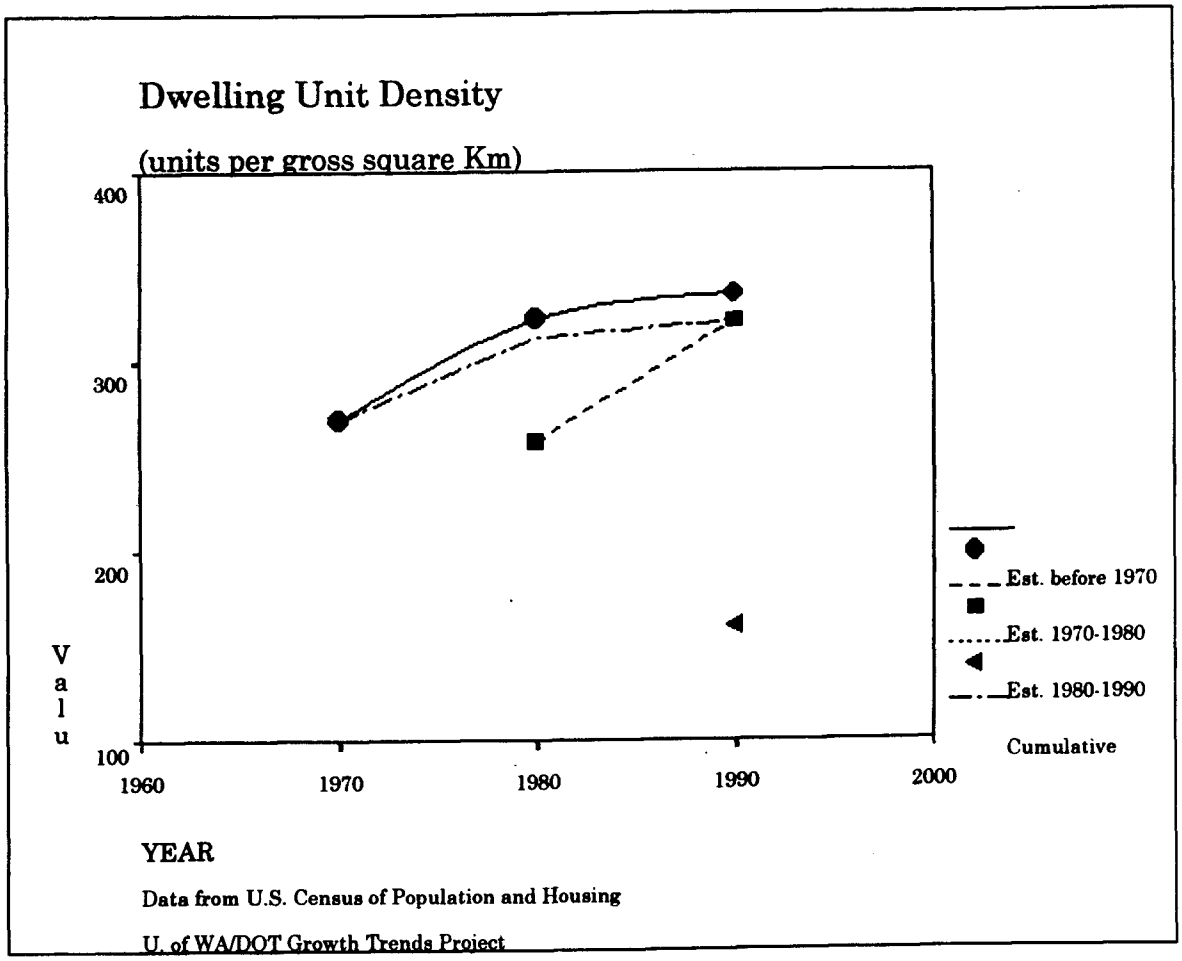


Figure 8. Dwelling unit density (units per gross square km)

Figure 9 shows the overall trend for the housing density of places, both weighted by population and unweighted. In contrast to the weighted *population* trend which has been declining, there was a small increase in weighted housing densities during the two decades. This was the net result of suburbanization and exurbanization, which were reducing the densities experienced by most people, and new single- and multi-family housing developments in preexisting suburban places, which were increasing densities of existing communities.

It is interesting how the net result of these processes was to *increase* weighted *housing* density and to *decrease* weighted *population* density. We suspect the difference can be explained by the decline that occurred in household size during the past twenty years. It was not a factor in housing trends (other than to increase demand for smaller, denser units) but it was a factor in population densities. This one factor may explain why weighted housing density increased while weighted population density declined between 1970 and 1990.

A County-Level View

As with population density, there are significant housing density differences among counties across the state. Also as with population density, King County had the highest and Franklin County had the lowest densities in 1990 (Figure 10). King county residents also saw the greatest increase in housing densities over the past two decades, while residents in Kitsap experienced the greatest decline (Figure 11).[12]

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[12] As with population density, the large decline in Kitsap County was caused by a large decline in the housing density of Bremerton, its largest city. The large decline in Bremerton was the result of having its land area increase by 108 percent between 1970 and 1990 while its housing unit count increased by only 29 percent. Most of its growth in land area occured during the 1970s when it annexed its watershed and reservoir.

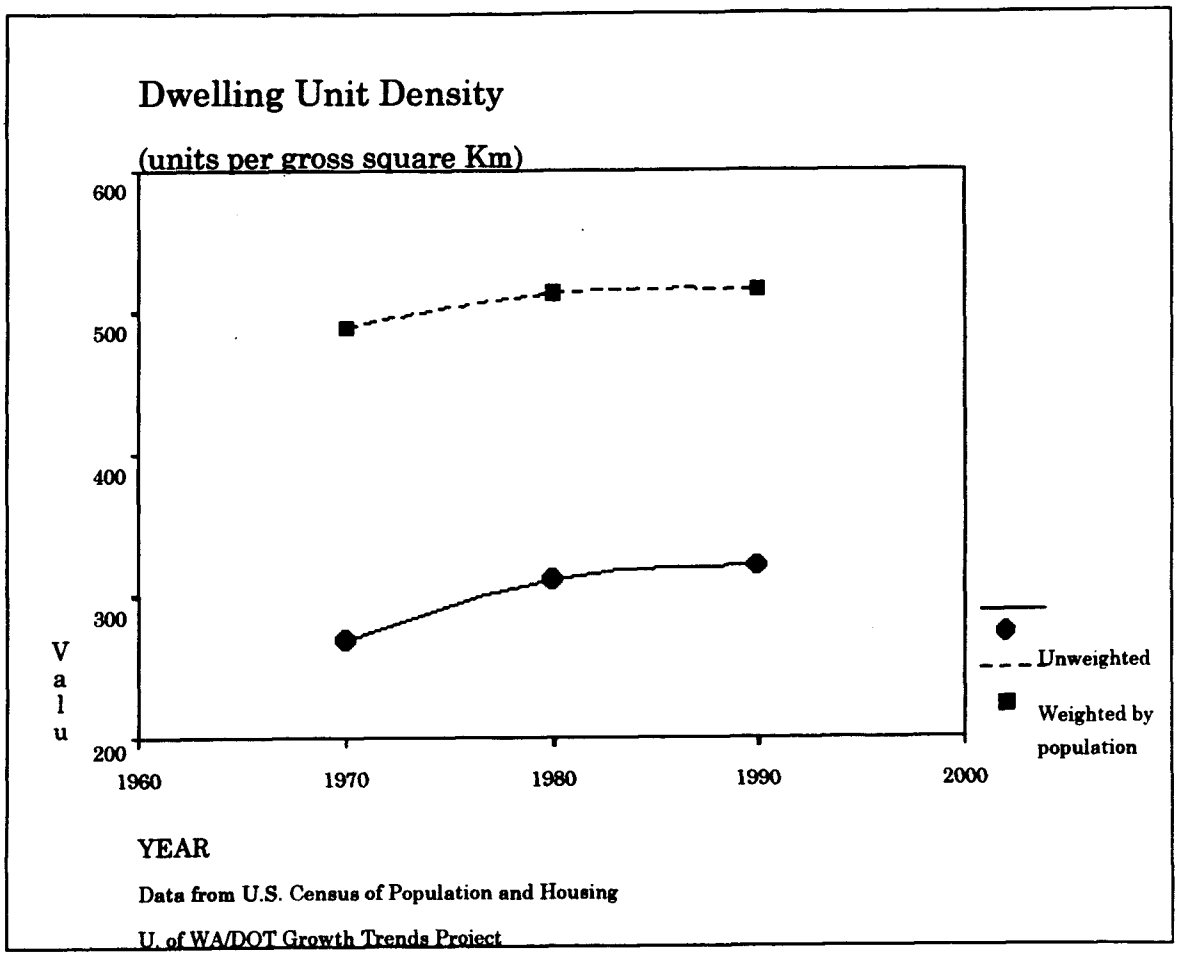


Figure 9. Dwelling unit density (units per gross square km)

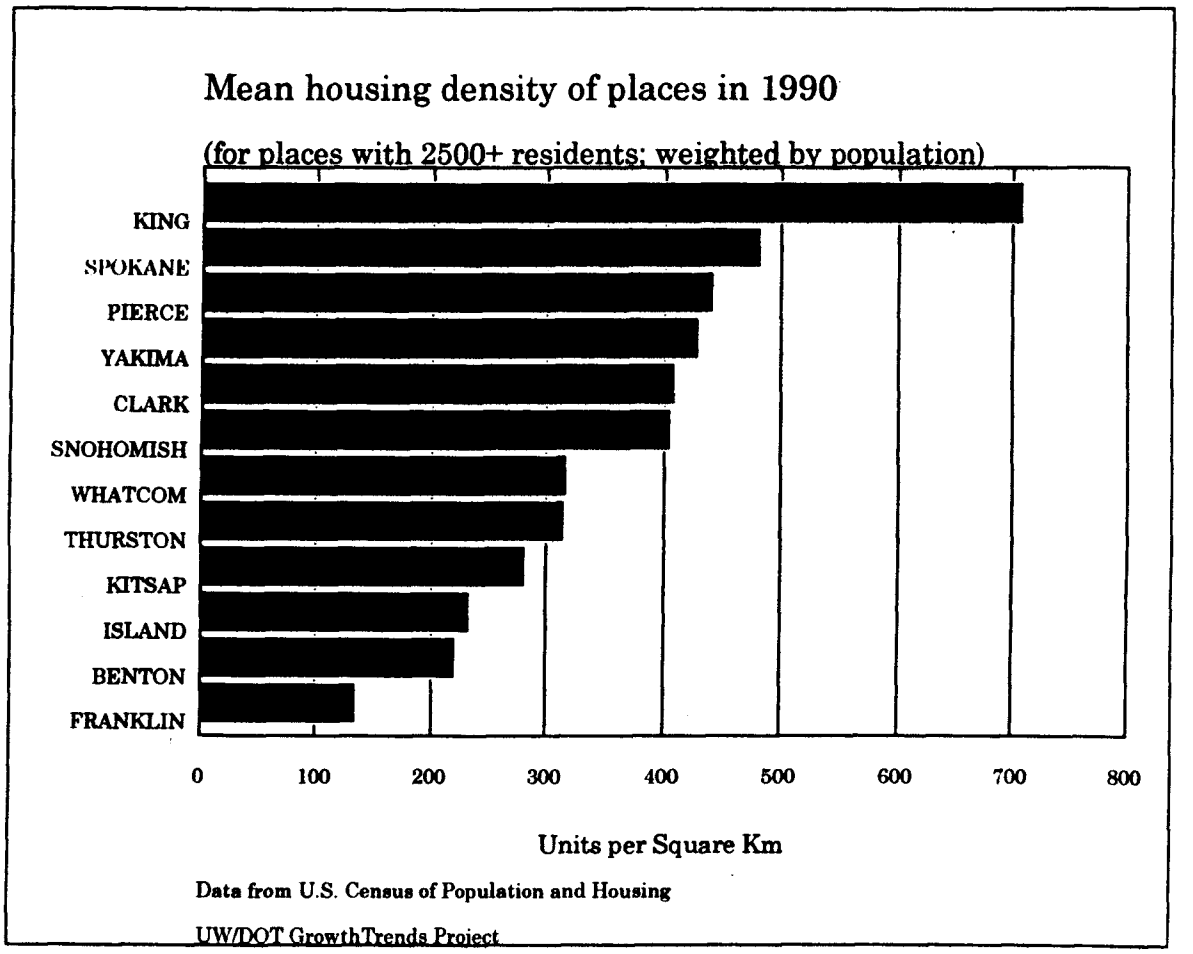


Figure 10. Mean housing density of places in 1990 (for places with 2500+ residents; weighted by population)

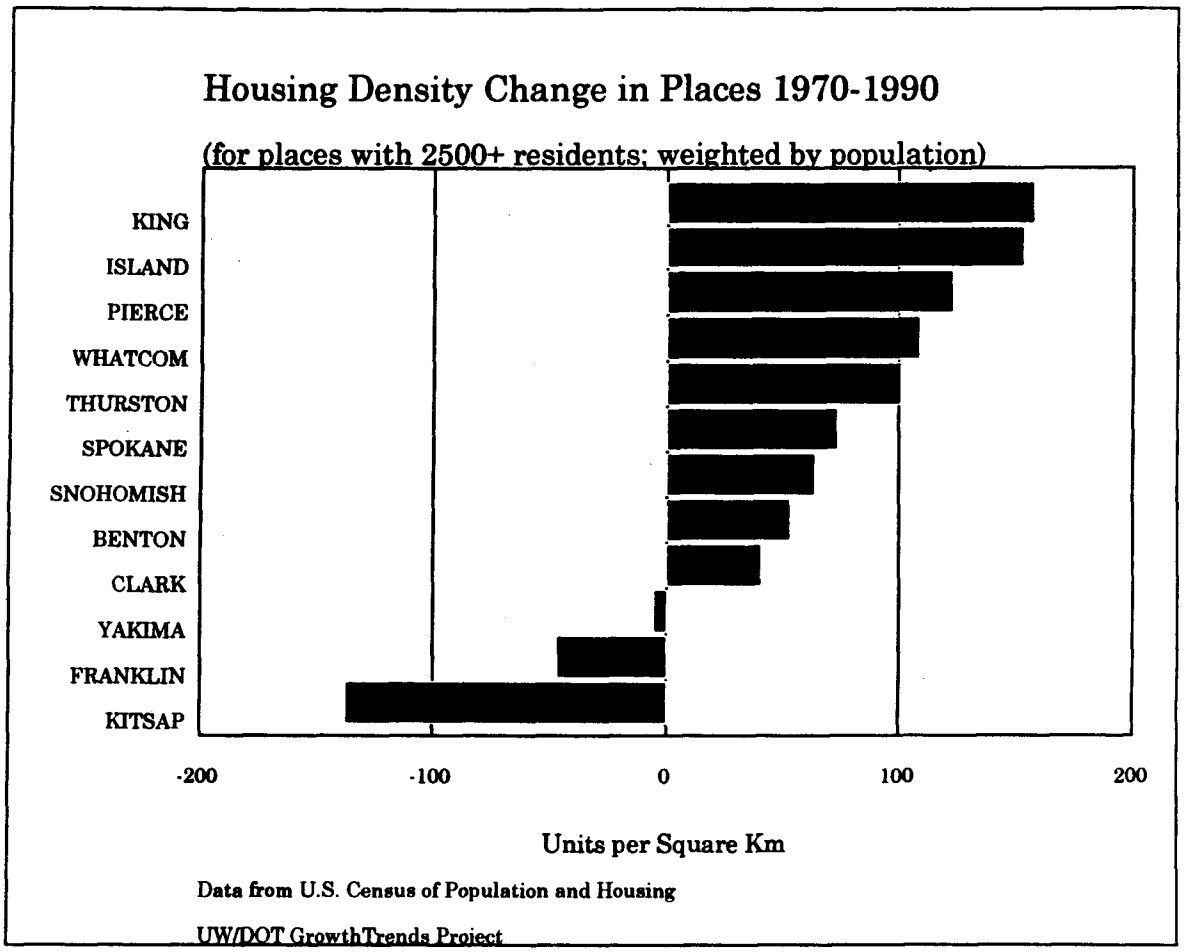


Figure 11. Housing density change in places 1970-1990
(for places with 2500+ residents weighted by population)

A Place-Level View

Table 13 gives the places with the highest and lowest housing densities in Washington's metropolitan areas. Seattle was the most dense and Satus was the least dense place in 1990. Places above or within 15 percent of 775 units per square km, the threshold for a significant decline in SOV mode share, are shown in gray. Fourteen places in King, Pierce, Snohomish and Clark counties met this criteria and in total were home to about 699,000 persons, or 22 percent of the population in places with more than 2500 residents in Washington's metropolitan areas.

Table 14 gives the places in the top and bottom decile of housing density *change* from 1970 to 1990. The percent change in housing unit count and land area are also given in order to allow their combined effect on density to be considered. For example, the large density declines in the bottom decile appear to have been caused by land areas increasing much more rapidly than housing unit counts.

Des Moines and Kirkland, two suburban cities in King County, are notable for being in both the top decile of housing density change and housing density in 1990. Des Moines, in particular, increased its density by nearly 500 percent and in so doing crossed the threshold associated with a significant decrease in the proportion of trips made by single occupant vehicles.

Maps 3 and 4 show housing density patterns and changes in the Puget Sound region. As with population densities, they depict how in 1990 housing densities followed a traditional density gradient with density declining with greater distance from the regional core. The maps also show that housing density increases between 1970 and 1990 were highest in jurisdictions adjacent to the region's central cities of Seattle, Everett, Tacoma and Bellevue.

Table 13. Places in top and bottom decile of dwelling unit density in 1990 (in units per square km; places equal to or approaching TOD threshold are shown with gray background)

	PLACE	COUNTY	DENSITY	POPULATION
TOP DECILE	Seattle city	KING	1146.11	516259
	Des Moines city	KING	844.56	17283
	Esperance CDP	SNOHOMISH	839.84	11236
	White Center-Shorewood CDP	KING	809.89	20531
	Richmond Highlands CDP	KING	806.91	26037
	Fircrest town	PIERCE	805.80	5258
	Cascade Park East CDP	CLARK	774.81	6996
	Mountlake Terrace city	SNOHOMISH	768.19	19320
	North City-Ridgecrest CDP	KING	750.70	13832
	Burien CDP	KING	687.00	25089
	Edmonds city	SNOHOMISH	684.45	30744
	Sheridan Beach CDP	KING	680.23	6518
	Lynnwood city	SNOHOMISH	657.93	28695
	Kirkland city	KING	651.46	40052
	Bryn Mawr-Skyway CDP	KING	636.99	12514
	Cascade Park West CDP	CLARK	620.42	6656
	Riverton-Boulevard Park CDP	KING	612.89	15337
BOTTOM DECILE	Satus CDP	YAKIMA	1.20	1343
	White Swan CDP	YAKIMA	2.85	2669
	John Sam Lake CDP	SNOHOMISH	12.93	432
	Waverly town	SPOKANE	14.75	37
	DuPont city	PIERCE	15.62	592
	Shaker Church CDP	SNOHOMISH	16.21	670
	Highland CDP	BENTON	16.86	3656
	Ault Field CDP	ISLAND	18.02	3795
	Stimson Crossing CDP	SNOHOMISH	22.83	591
	Mesa town	FRANKLIN	23.69	252
	Nisqually Indian Community	THURSTON	24.07	558
	West Richland city	BENTON	28.76	3962
	Cathan CDP	SNOHOMISH	30.57	428
	Meadow Glade CDP	CLARK	40.81	1584
	Brush Prairie CDP	CLARK	45.22	2650
	Freeland CDP	ISLAND	55.45	1278
	Deer Park city	SPOKANE	58.16	2278

Table 14. Places in top and bottom decile of dwelling unit density change, 1970-1990 (places with TOD density in 1990 are shown with gray background)

	PLACE	COUNTY	Absolute Change, 1970-90	Housing Density, 1990	Percent Change	Land Area, 1990	Percent Change
TOP DECILE	Des Moines city	KING	473.31	844.56	495.04	8.81	161.57
	University Place CDP	PIERCE	289.33	566.98	186.71	20.36	40.40
	Tanglewilde-Thompson Place CDP	THURSTON	262.48	507.99	102.87	4.32	-1.95
	Redmond city	KING	260.77	400.37	309.97	37.40	42.95
	Marysville city	SNOHOMISH	259.67	378.96	154.74	12.05	-19.81
	Kirkland city	KING	247.95	651.46	214.21	27.72	94.62
BOTTOM DECILE	Selah city	YAKIMA	-124.39	274.34	69.89	7.04	146.93
	Grandview city	YAKIMA	-175.64	197.99	92.37	12.22	263.02
	Bremerton city	KITSAP	-176.20	304.69	28.57	51.50	102.92
	McChord AFB CDP	PIERCE	-193.44	65.50	-2.19	15.02	286.67
	Sumner city	PIERCE	-260.29	262.24	60.34	9.93	219.50
	Edmonds city	SNOHOMISH	-340.31	684.45	68.18	18.91	151.80

EMPLOYMENT DENSITY

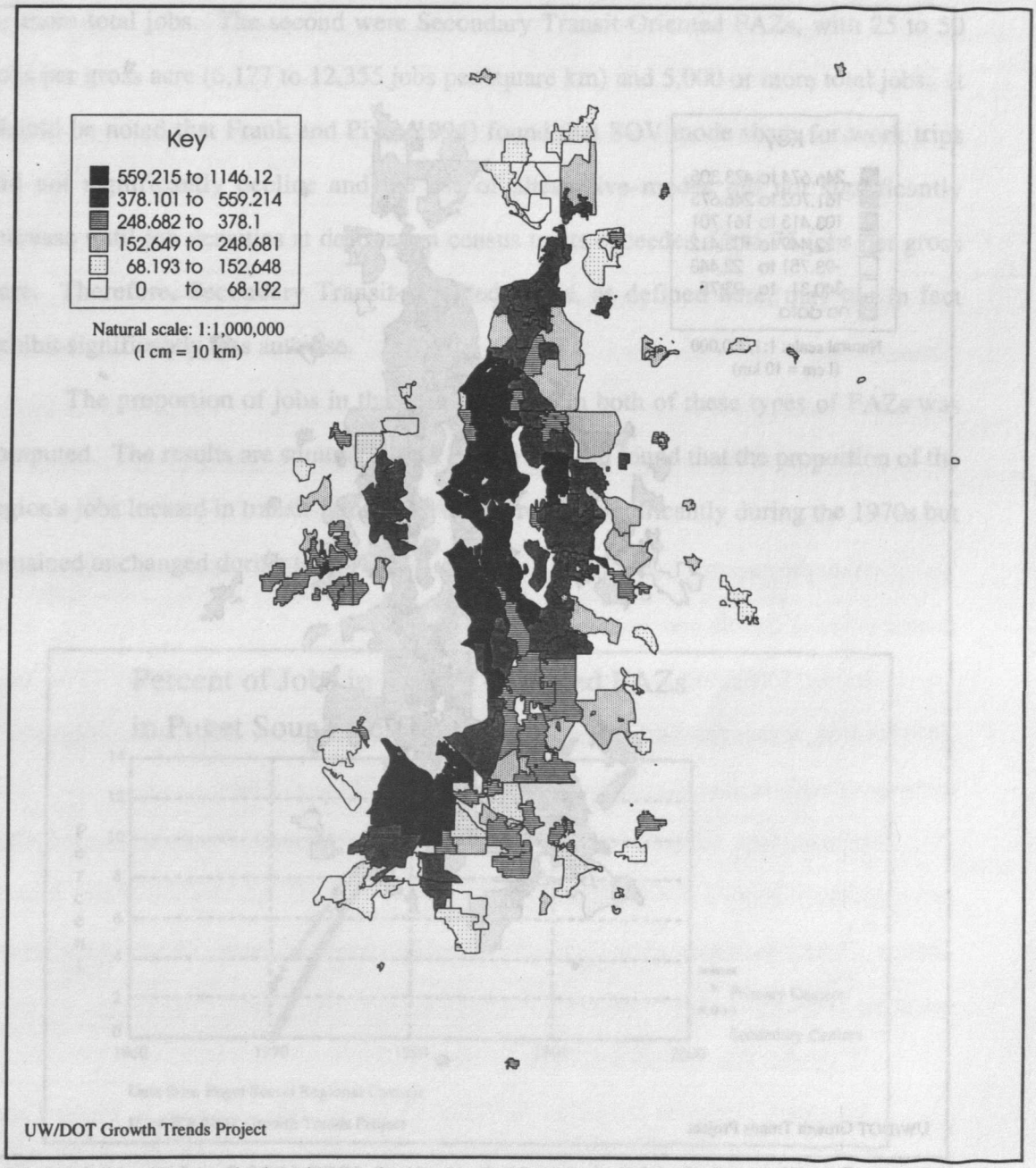
A Puget Sound Regional View

How many of us are working in places with transit oriented job densities?

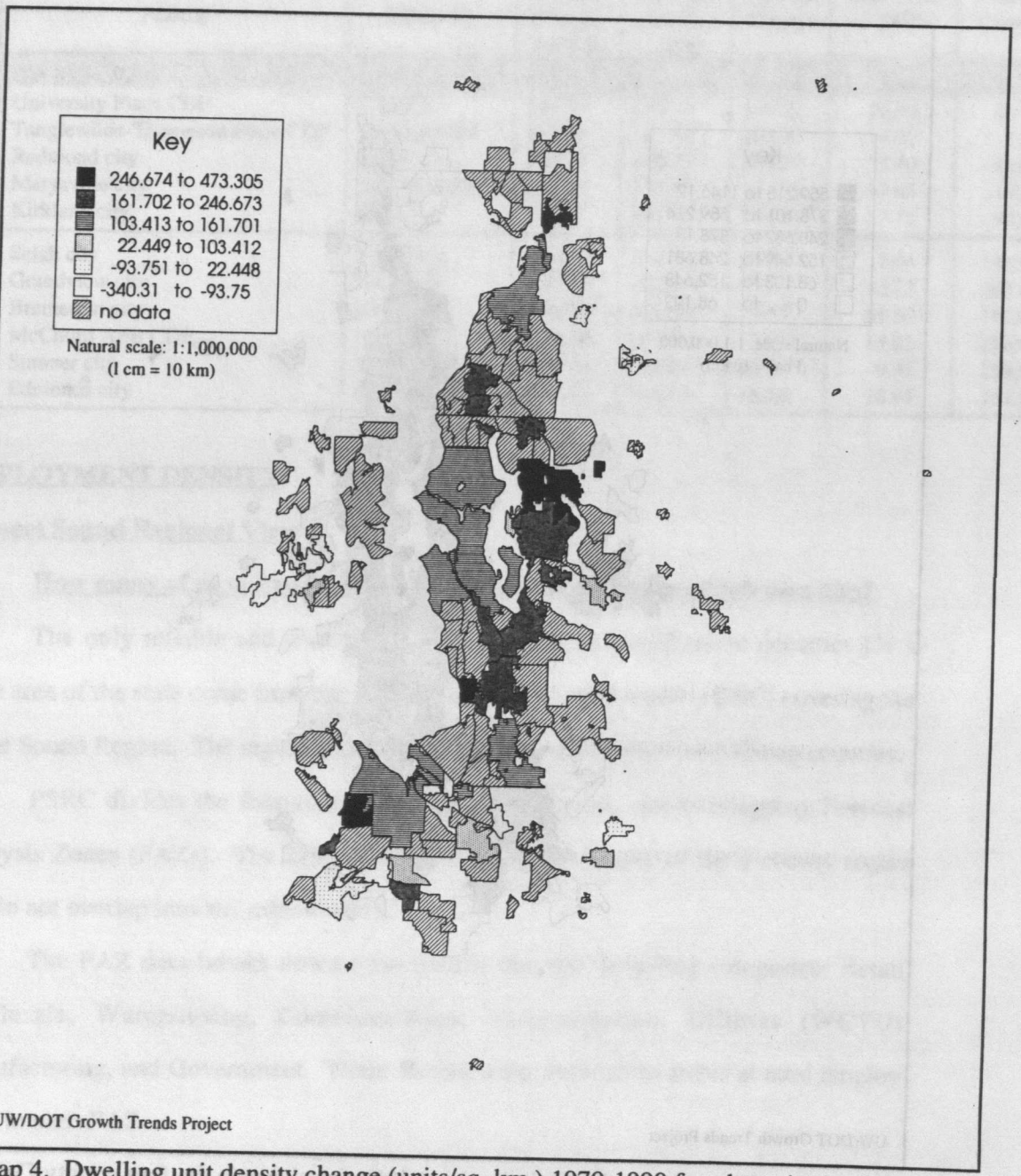
The only reliable and reasonably available data on employment densities for a large area of the state come from the Puget Sound Regional Council (PSRC) covering the Puget Sound Region. The region includes King, Pierce, Snohomish and Kitsap counties.

PSRC divides the four-county area into 219 distinct, non-overlapping Forecast Analysis Zones (FAZs). The 219 FAZs encompass the entirety of the 4-county region and do not overlap into any other county.

The FAZ data breaks down employment into the following categories: Retail, Wholesale, Warehousing, Communication, Transportation, Utilities (WCTU), Manufacturing, and Government. These sectors were summed to arrive at total employment in each FAZ.



Map 3. Dwelling unit density (units/sq. km.) 1990 for places in the four county Central Puget Sound Region by decile. Deciles are defined using data for all places in the metropolitan counties of Washington State. Top and bottom deciles are shown; middle deciles are combined. Data source: Census of Population and Housing, 1990, U.S. Census Bureau.



Map 4. Dwelling unit density change (units/sq. km.) 1970-1990 for places in the four county Central Puget Sound Region by decile. Deciles are defined using data for all places in the metropolitan counties of Washington State. Top and bottom deciles are shown; middle deciles are combined. Data source: Census of Population and Housing, U.S. Census Bureau.

In order to determine the number of workers employed in transit-oriented places we defined two types of transit-oriented FAZs. The first were Primary Transit-Oriented FAZs, with a minimum of 50 jobs per gross acre (12,355 jobs per square km) and 15,000 or more total jobs. The second were Secondary Transit-Oriented FAZs, with 25 to 50 jobs per gross acre (6,177 to 12,355 jobs per square km) and 5,000 or more total jobs. It should be noted that Frank and Pivo (1994) found that SOV mode share for work trips did not significantly decline and the use of alternative modes did not significantly increase until job densities at destination census tracts exceeded 50 to 75 jobs per gross acre. Therefore, Secondary Transit-Oriented FAZs, as defined here, may not in fact exhibit significantly less auto use.

The proportion of jobs in the region located in both of these types of FAZs was computed. The results are summarized in Figure 12. We found that the proportion of the region's jobs located in transit-oriented FAZs increased significantly during the 1970s but remained unchanged during the 1980s.

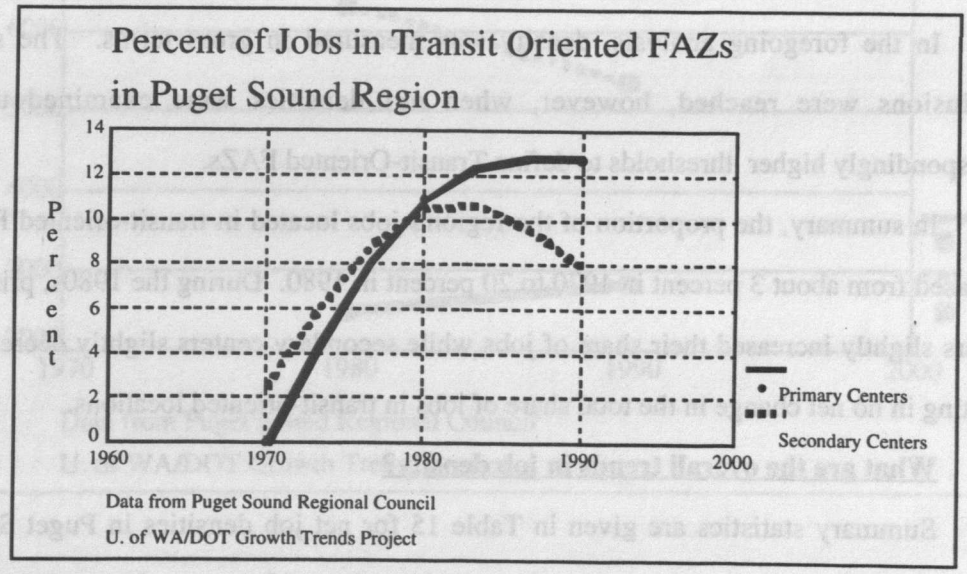


Figure 12. Percent of jobs in Transit Oriented FAZs in Puget Sound Region

No FAZs met the criteria for Primary Transit-Oriented FAZs in 1970. By 1980, the Denny Regrade and Seattle CBD emerged as Primary Transit-Oriented FAZs and together contained about 11 percent of the region's jobs. By 1990, Bellevue CBD was added to the list. Between 1980 and 1990 Primary Transit-Oriented FAZs increased their regional job share only slightly. This happened despite the rapid job growth in Denny Regrade and Seattle CBD because it was offset by the overall suburbanization of employment that was occurring elsewhere in the region.

In 1970, Tacoma CBD/Stadium was the sole Secondary Transit-Oriented FAZ. By 1980, the list had expanded to include the University of Washington, Lake Union/Seattle Center and First Hill/Broadway. No new Secondary Transit-Oriented FAZs were added during the 1980s. Secondary Transit-Oriented FAZs grew from having about 2 percent of the region's jobs in 1970 to 10 percent in 1980. This fell back to 8 percent in 1990.

With the exception of Bellevue CBD, all transit-oriented FAZs were located in the central cities of Seattle and Tacoma.

In the foregoing analysis, density was measured in gross terms. The same conclusions were reached, however, when *net* densities were examined using correspondingly higher thresholds to define Transit-Oriented FAZs.

In summary, the proportion of the region's jobs located in transit-oriented FAZs increased from about 3 percent in 1970 to 20 percent in 1980. During the 1980s, primary centers slightly increased their share of jobs while secondary centers slightly decreased, resulting in no net change in the total share of jobs in transit-oriented locations.

What are the overall trends in job density?

Summary statistics are given in Table 15 for net job densities in Puget Sound FAZs in 1980 and 1990. The median increased by about 15 percent during the 1980s. However, when FAZs were weighted by total employment, we saw an approximately 15 percent *decline* in median net densities (Table 16). Thus, even though jobs in individual

Table 15. Net job density in FAZs of the Puget Sound Region (in jobs per square km)

Year	*Mean*	*Median*	*Std dev*	*Minimum*	*Maximum*	*Valid Cases*
1980	5713.076	2485.409	12865.903	80.645	135828.712	219
1990	6083.903	2828.743	13840.845	55.948	148581.883	219
Change	370.827	166.323	2605.850	-10565.824	21781.041	219

Table 16. Net job density in FAZs of the Puget Sound Region, weighted by total jobs (in jobs per square km)

Year	*Mean*	*Median*	*Std dev*	*Minimum*	*Maximum*	*Valid Cases*
1980	24610.176	6330.267	39104.034	80.645	135828.712	219
1990	25692.009	5374.517	43123.368	55.948	148581.883	219

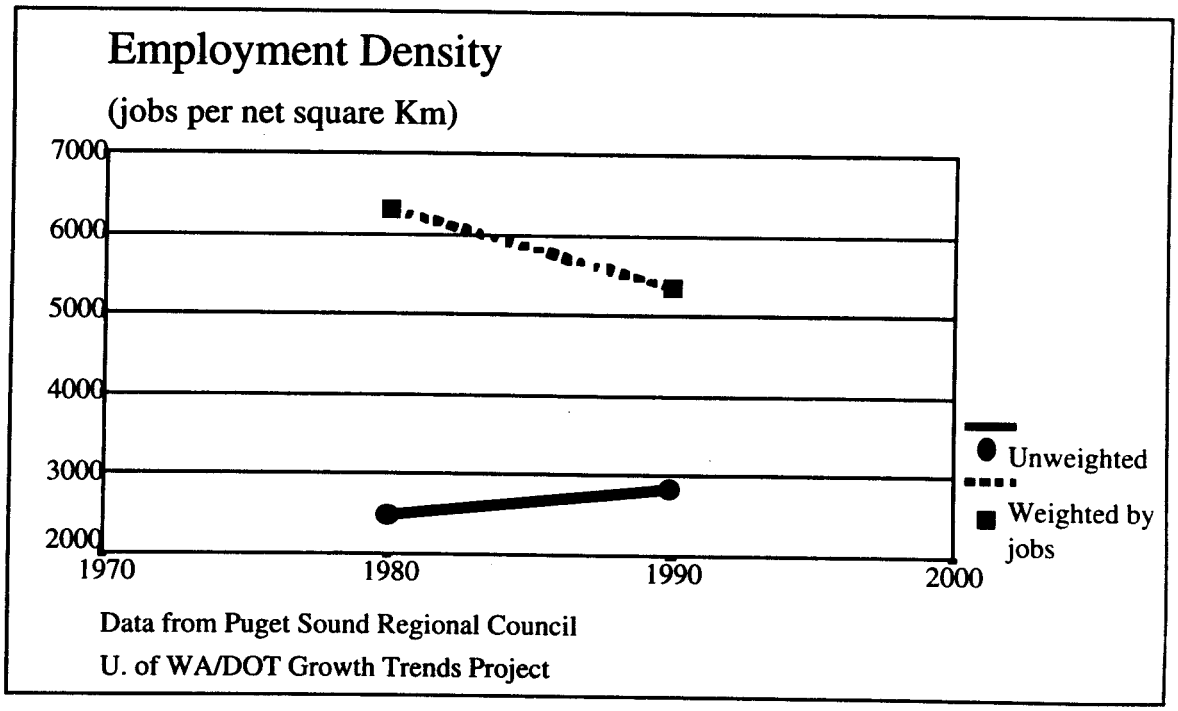


Figure 13. Employment density (jobs per net square km)

FAZs grew denser over the decade, the general movement of jobs to lower density FAZs resulted in the typical worker in 1990 laboring at a lower density than in 1980. Figure 13 graphically displays these results.

A County-Level View

Figures 14 and 15 show the weighted average job densities in the four Puget Sound counties. The places of King County stand out as having had a weighted average net density that was two to three times greater than that of the other counties in the region. When it comes to change during the 1980s, however, Snohomish County stands apart. While the weighted average density increased elsewhere, it declined in Snohomish County.

An FAZ-Level View

As shown by Table 17, nearly all the FAZs with the highest job density in 1990 were centrally located. Except for Downtown Bremerton and Downtown Renton, all of the FAZs in the top decile of the job density distribution were in one of the region's four central cities (Seattle, Tacoma, Everett, or Bellevue). In addition, all but three of the densest FAZs were in King County which is centrally located in the region.

Table 18 lists FAZs in the top and bottom decile of net job density change during the 1980s. FAZs where there was both a large density gain and a large employment base were generally in or next to central business districts. They include the Denny Regrade, next to downtown Seattle, as well as the CBDs of Seattle, Tacoma and Bellevue.

Map 5 shows there are multiple centers of higher density employment. Some are located in and around the downtowns of central cities of Tacoma and Seattle but most are in other central city locations or around suburban downtowns. The two easternmost high density areas are small concentrations of less than 1000 jobs. All other areas have at least 6000 jobs and range up to as many as 117,000 in downtown Seattle. Locations with densities in the second highest category tend to be either adjacent to these high density centers or along freeway corridors.

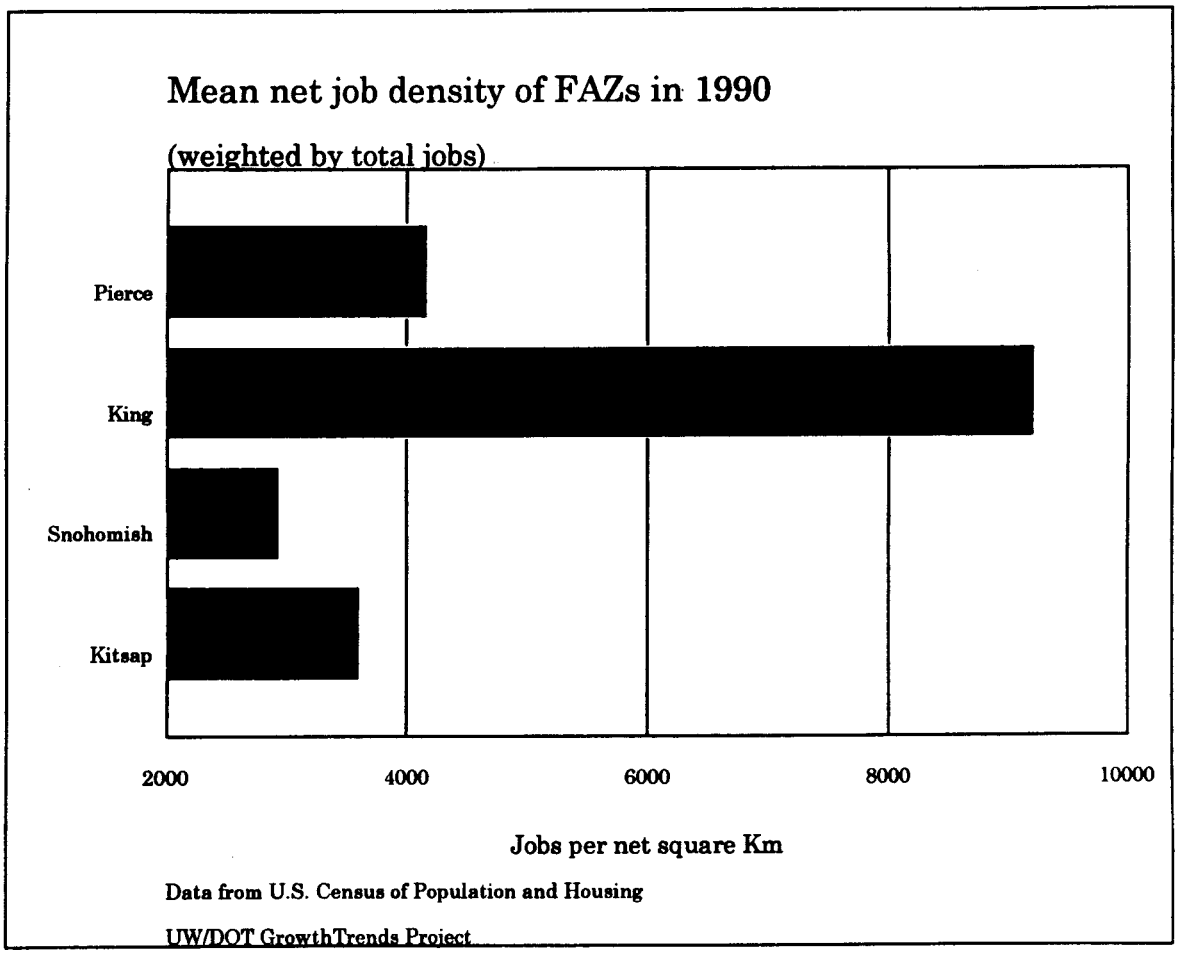


Figure 14. Mean net job density of FAZs in 1990 (weighted by total jobs)

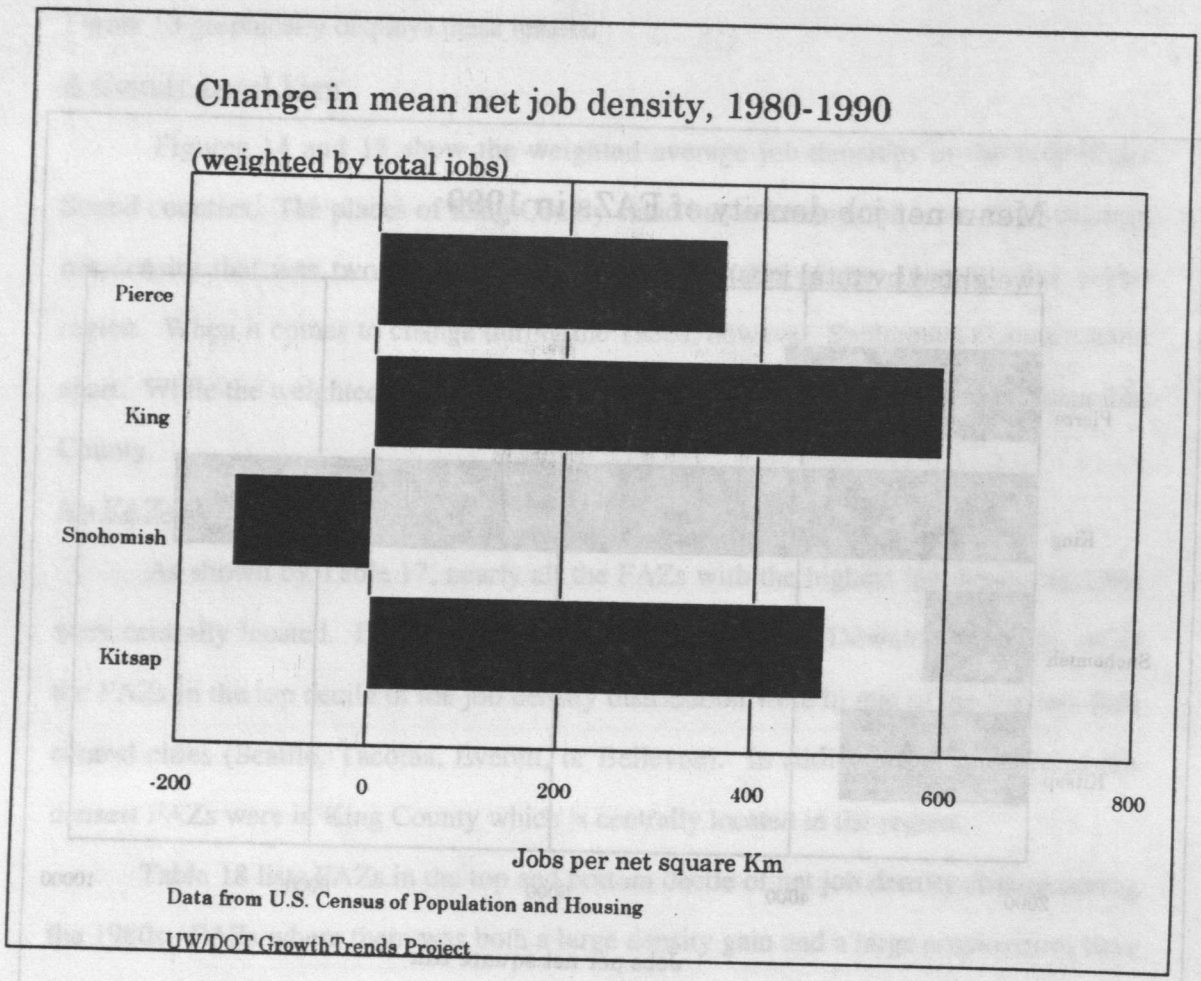


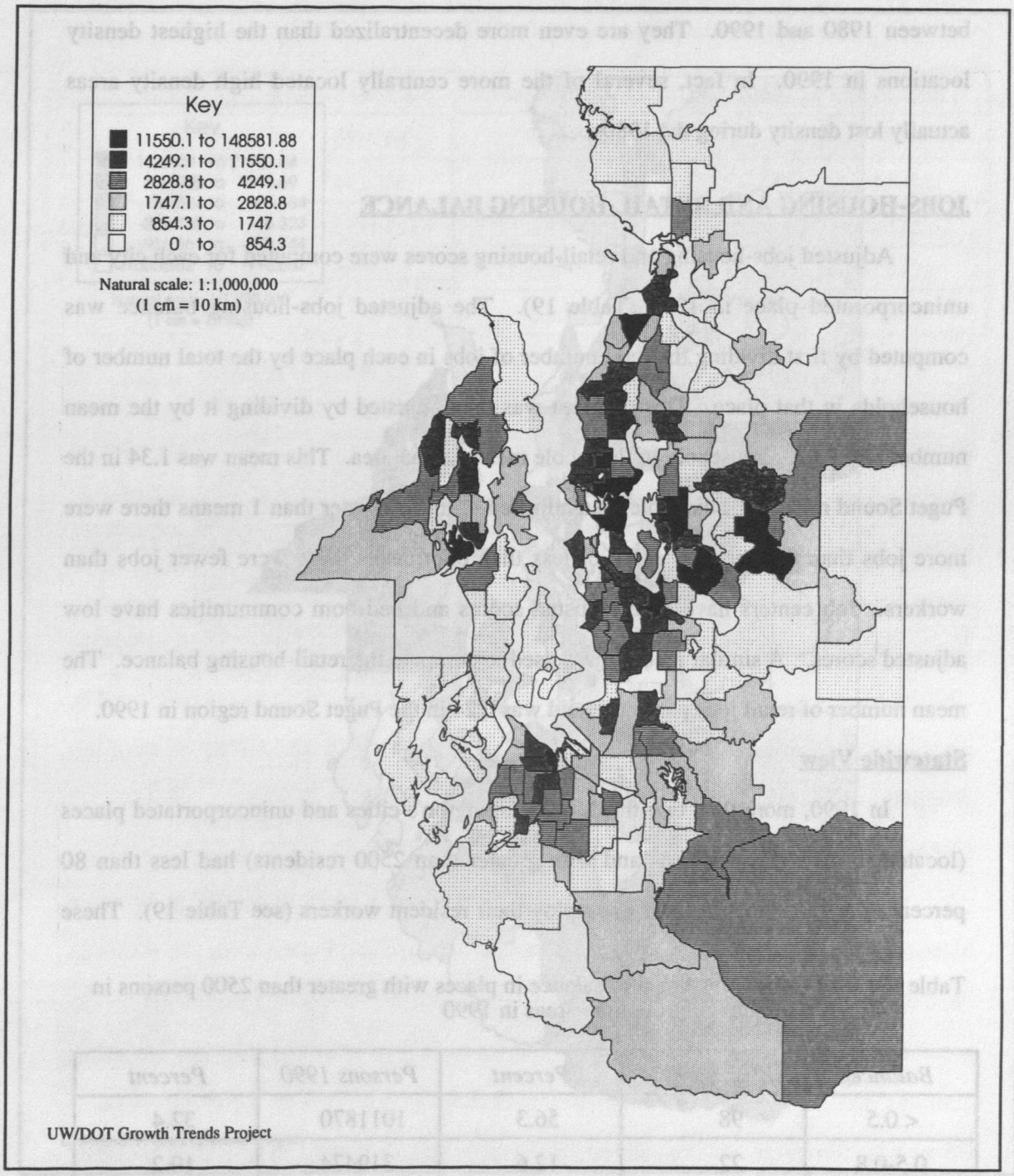
Figure 15. Change in mean net job density, 1980-1990 (weighted by total jobs)

Table 17. Top and bottom decile of jobs per net square km in 1990
(FAZs that exceed primary or secondary center criteria shown in gray)

	FAZ Name	*County*	*Density*	*Total Jobs*
TOP DECILE	SEATTLE CBD	King	148581.90	117252
	DENNY REGRADE	King	73442.68	44582
	TACOMA CBD/STADIUM	Pierce	58703.37	21856
	BELLEVUE CBD	King	57289.58	22257
	FIRST HILL/BROADWAY	King	40947.44	32479
	NORTH BELLEVUE	King	40880.78	21838
	NORTHGATE	King	37598.55	12629
	TACOMA CBD/UNION STATION	Pierce	28680.57	12187
	CENTRAL BELLEVUE	King	26816.89	13240
	PAINE FIELD	Snohomish	25315.58	10040
	EAST CAPITOL HILL/CENTRAL AREA	King	22334.20	15546
	WINDERMERE/LAURELHURST	King	15928.34	6446
	WALLINGFORD/FREMONT	King	15366.11	9763
	RAVENNA/UNIVERSITY DISTRICT	King	14897.21	12178
	NORTH CAPITOL HILL/MADISON PARK	King	14865.51	6437
	BEAVER LAKE	King	14710.94	893
	WEST BREMERTON/CBD	Kitsap	12752.49	30655
	COUGAR MOUNTAIN	King	12750.58	258
	UNIVERSITY OF WASHINGTON	King	12460.23	20170
	RENTON AIRPORT/CBD	King	12023.58	29730
BOTTOM DECILE	GORST/BURLEY/GLENWOOD	Kitsap	845.80	1109
	RENTON PLATEAU	King	805.27	554
	CUMBERLAND/SOUTHEAST KING COUNTY	King	786.36	576
	ROY	Pierce	735.90	408
	THREE LAKES	Snohomish	719.42	460
	GRANITE FALLS	Snohomish	701.53	917
	LAKE MERIDIAN	King	690.85	1328
	THUN FIELD	Pierce	657.49	753
	MALTBY/HIGH BRIDGE	Snohomish	650.42	687
	NORTHEAST TACOMA	Pierce	615.13	936
	CLEARVIEW/SILVER FIRS/SNOHOMISH	Snohomish	552.63	577
	SISCO HEIGHTS	Snohomish	518.92	21
	NORTH SNOHOMISH VALLEY	Snohomish	505.66	309
	OSO/DARRINGTON	Snohomish	504.49	1129
	POINT CITIES	King	478.45	941
	BRYANT	Snohomish	411.84	135
	SKYKOMISH VALLEY	Snohomish	350.00	1262
	TULALIP	Snohomish	270.48	2152
	MEADOW LAKE/WOODS CREEK	Snohomish	184.30	358
	DUPONT	Pierce	55.95	12

Table 18. Top and bottom decile of 1980-1990 change in jobs per net square km

	FAZ	*County*	*Change*	*Total Jobs, 1990*
TOP DECILE	DENNY REGRADE	King	21781.04	44582
	BEAVER LAKE	King	13166.54	893
	SEATTLE CBD	King	12753.17	117252
	BELLEVUE CBD	King	7826.76	22257
	COUGAR MOUNTAIN	King	6325.87	258
	TACOMA CBD/STADIUM	Pierce	5929.41	21856
	NORTHWEST BELLEVUE	King	3442.29	4263
	EAST PIERCE COUNTY	Pierce	2873.47	303
	SEABECK/OLYMPIC VIEW	Kitsap	2746.98	763
	BANGOR	Kitsap	2612.57	9258
	NORTH TACOMA	Pierce	2428.59	4524
	SKYWAY/BRYN MAWR	King	2391.25	1131
	REDMOND/UNION HILL	King	2328.81	5668
	MOUNTLAKE TERRACE	Snohomish	2120.06	4818
	ALGONA/PACIFIC	King	2117.93	1364
	GOLD MOUNTAIN/HOLLY	Kitsap	1915.06	175
	CARNATION	King	1875.59	621
	PANTHER LAKE	King	1844.79	4050
	CANYON PARK	Snohomish	1759.40	3024
	BUCKLEY/SOUTH PRAIRIE/WILKESO	Pierce	1707.16	2434
BOTTOM DECILE	LAKE STEVENS/FRONTIER VILLAGE	Snohomish	-918.72	1872
	MANETTE/VIEW RIDGE	Kitsap	-943.89	5568
	SISCO HEIGHTS	Snohomish	-1013.13	21
	WEST BREMERTON/CBD	Kitsap	-1038.03	30655
	RENTON AIRPORT/CBD	King	-1072.42	29730
	NORTH BEACON HILL/MOUNT BAKER	King	-1182.25	10896
	GREENWOOD/CROWN HILL	King	-1187.94	4114
	LOWER DUWAMISH/BOEING FIELD	King	-1351.81	22038
	EDMONDS SOUTH	Snohomish	-1352.02	5782
	SOUTHWEST SOOS CREEK	King	-1781.23	1227
	GETCHELL HILL	Snohomish	-1942.10	350
	SAHALEE	King	-2113.50	543
	LAKE YOUNGS	King	-2140.44	568
	WINDERMERE/LAURELHURST	King	-2818.64	6446
	RAVENNA/UNIVERSITY DISTRICT	King	-3837.36	12178
	NORTH BELLEVUE	King	-4210.49	21838
	CENTRAL BELLEVUE	King	-4821.13	13240
	WEST BELLEVUE	King	-6152.73	6490
	FIRST HILL/BROADWAY	King	-8121.76	32479
	PAINE FIELD	Snohomish	-10565.8	10040



Map 5. Net employment density, 1990, for forecast analysis zones in the central Puget Sound region by decile. Top and bottom deciles are shown; middle deciles are combined.
Data source: Puget Sound Regional Council.

Map 6 shows locations that experienced the greatest increase in net job densities between 1980 and 1990. They are even more decentralized than the highest density locations in 1990. In fact, several of the more centrally located high density areas actually lost density during the 1980s.

JOBS-HOUSING AND RETAIL-HOUSING BALANCE

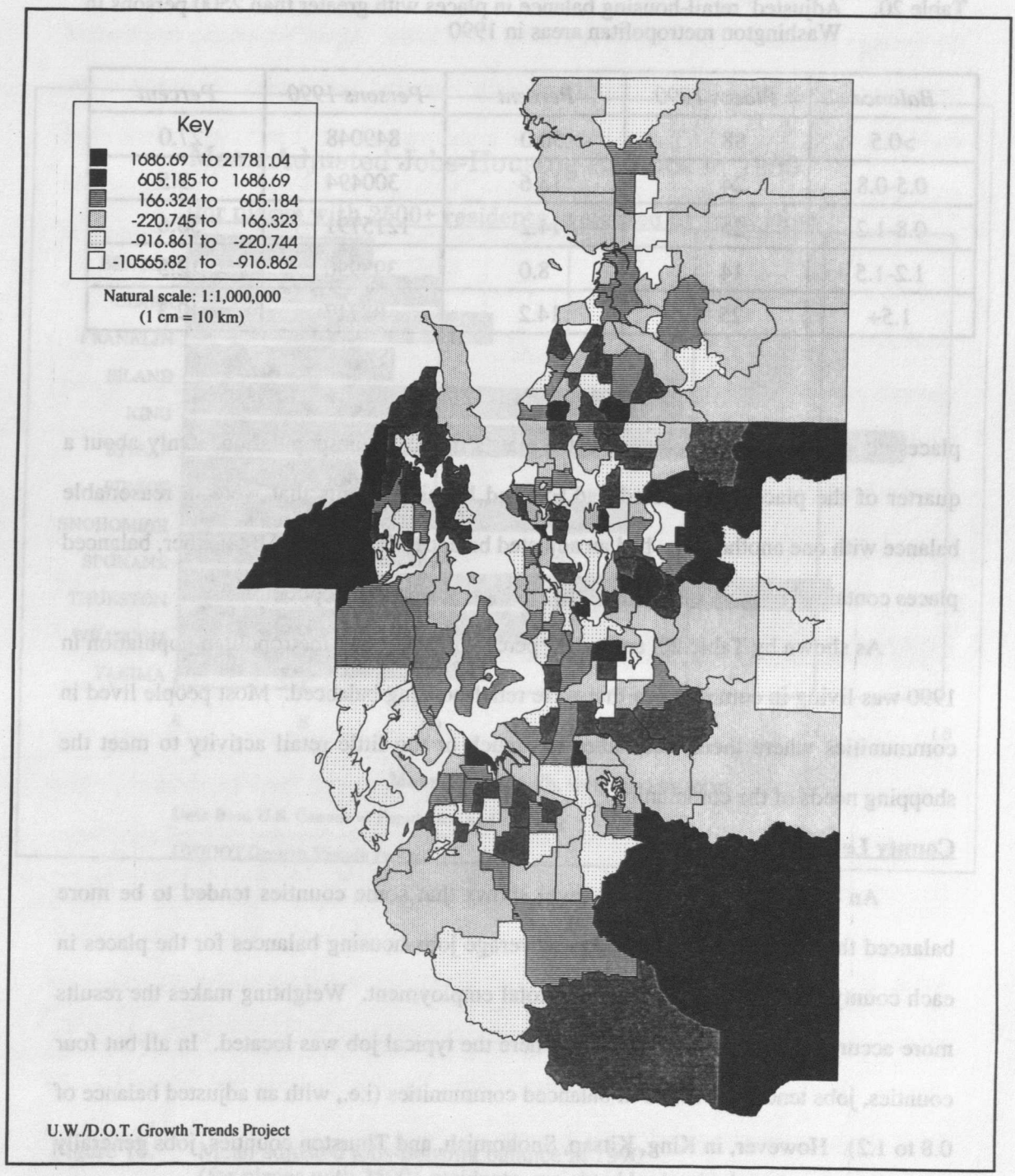
Adjusted jobs-housing and retail-housing scores were computed for each city and unincorporated place in 1990 (Table 19). The adjusted jobs-housing balance was computed by first dividing the total number of jobs in each place by the total number of households in that place. This quotient was then adjusted by dividing it by the mean number of jobs per household in the whole metropolitan area. This mean was 1.34 in the Puget Sound region, for example. An adjusted score of greater than 1 means there were more jobs than workers. A score of less than one means there were fewer jobs than workers. Job centers have high adjusted scores and bedroom communities have low adjusted scores. A similar method was used to compute the retail-housing balance. The mean number of retail jobs per household was 0.24 in the Puget Sound region in 1990.

Statewide View

In 1990, more than two-thirds of Washington's cities and unincorportated places (located in metropolitan areas and with greater than 2500 residents) had less than 80 percent of the jobs they needed to employ their resident workers (see Table 19). These

Table 19. Adjusted jobs-housing balance in places with greater than 2500 persons in Washington metropolitan areas in 1990

Balance	*Places 1990*	*Percent*	*Persons 1990*	*Percent*
< 0.5	98	56.3	1011870	32.4
0.5-0.8	22	12.6	319474	10.2
0.8-1.2	24	13.8	660453	21.2
1.2-1.5	11	6.3	700968	22.5
> 1.5	19	10.9	427931	13.7



Map 6. Net employment density change, 1980-1990, for forecast analysis zones in the central Puget Sound region by decile. Top and bottom deciles shown; middle deciles combined.
Data source: Puget Sound Regional Council.

Table 20. Adjusted retail-housing balance in places with greater than 2500 persons in Washington metropolitan areas in 1990

Balance	*Places 1990*	*Percent*	*Persons 1990*	*Percent*
>0.5	88	50.0	849048	27.0
0.5-0.8	24	13.6	300494	9.5
0.8-1.2	25	14.2	1215791	38.6
1.2-1.5	14	8.0	393990	12.5
1.5+	25	14.2	88717	12.3

places contained about 42 percent of the state's metropolitan population. Only about a quarter of the places we studied had job and housing counts that were in reasonable balance with one another (i.e., had an adjusted balance of 0.8-1.2). All together, balanced places contained roughly one-fifth of the state's metropolitan population.

As shown by Table 20, around 39 percent of the state's metropolitan population in 1990 was living in communities that were retail-housing balanced. Most people lived in communities where there was either too much or too little retail activity to meet the shopping needs of the community.

County Level View

An overview at the county level shows that some counties tended to be more balanced than others. Figure 16 shows average jobs-housing balances for the places in each county in 1990, weighted by their total employment. Weighting makes the results more accurately reflect the conditions where the typical job was located. In all but four counties, jobs tend to be found in balanced communities (i.e., with an adjusted balance of 0.8 to 1.2). However, in King, Kitsap, Snohomish, and Thurston counties, jobs generally occur in places with an excess of jobs relative to housing. In this situation, workers must commute from other communities to their workplace.

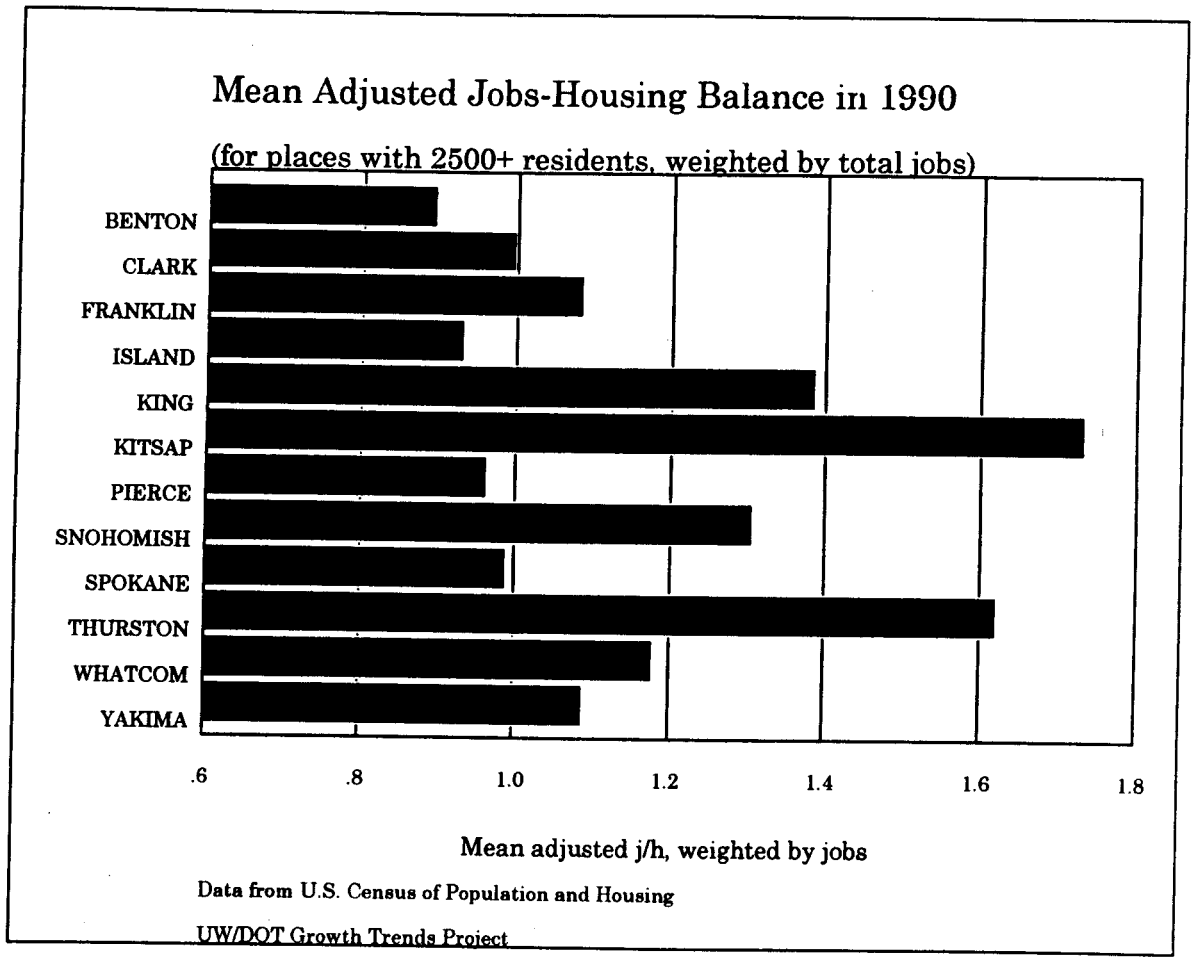


Figure 16. Mean adjusted jobs-housing balance in 1990
(for places with 2500+ residents, weighted by total jobs)

Retail-housing balance in some counties is also far from ideal. Figure 17 shows the average balance in counties, weighted by population. Again, weighting emphasizes the retail-housing balance where people typically live. In Clark County, for example, the typical resident lives in a community with a shortage of retail services. They must commute elsewhere to shop. In Island, Kitsap, Thurston and Whatcom counties, people typically live where there is an over- supply of shopping opportunities. This helps them find adequate shopping near where they live. But it probably also means that shoppers from outside their community are commuting into their area to meet their needs and to generate adequate demand to support the retail businesses that are there. While this may be desirable from the viewpoint of those benefiting from the added sales and sale tax revenues, it nonetheless increases driving for shopping purposes.

Place Level View

The most and least balanced communities are shown in tables 21 and 22. Table 21 concerns adjusted jobs-housing balance. Places with large numbers of jobs are most significant because of the impact they have on their region. Kirkland, Spokane, Tacoma, and Yakima make significantly positive contributions to their regions because they contain large numbers of jobs and are well balanced. Kent and Tukwila, industrial cities in southern King County, have a significant adverse effect because of their significant housing shortages and large job bases.

The most and least retail housing balanced places in Washington are given in Table 22. Similar to the case of jobs-housing balance, the most important places are those with large populations because of their larger effect on their region. Federal Way, Burien, Richmond Highlands, Vancouver, Seattle, Tacoma, Spokane and Edmonds make large positive contributions while Lynnwood, Silverdale, and Marysville contribute significantly to imbalance in their areas.

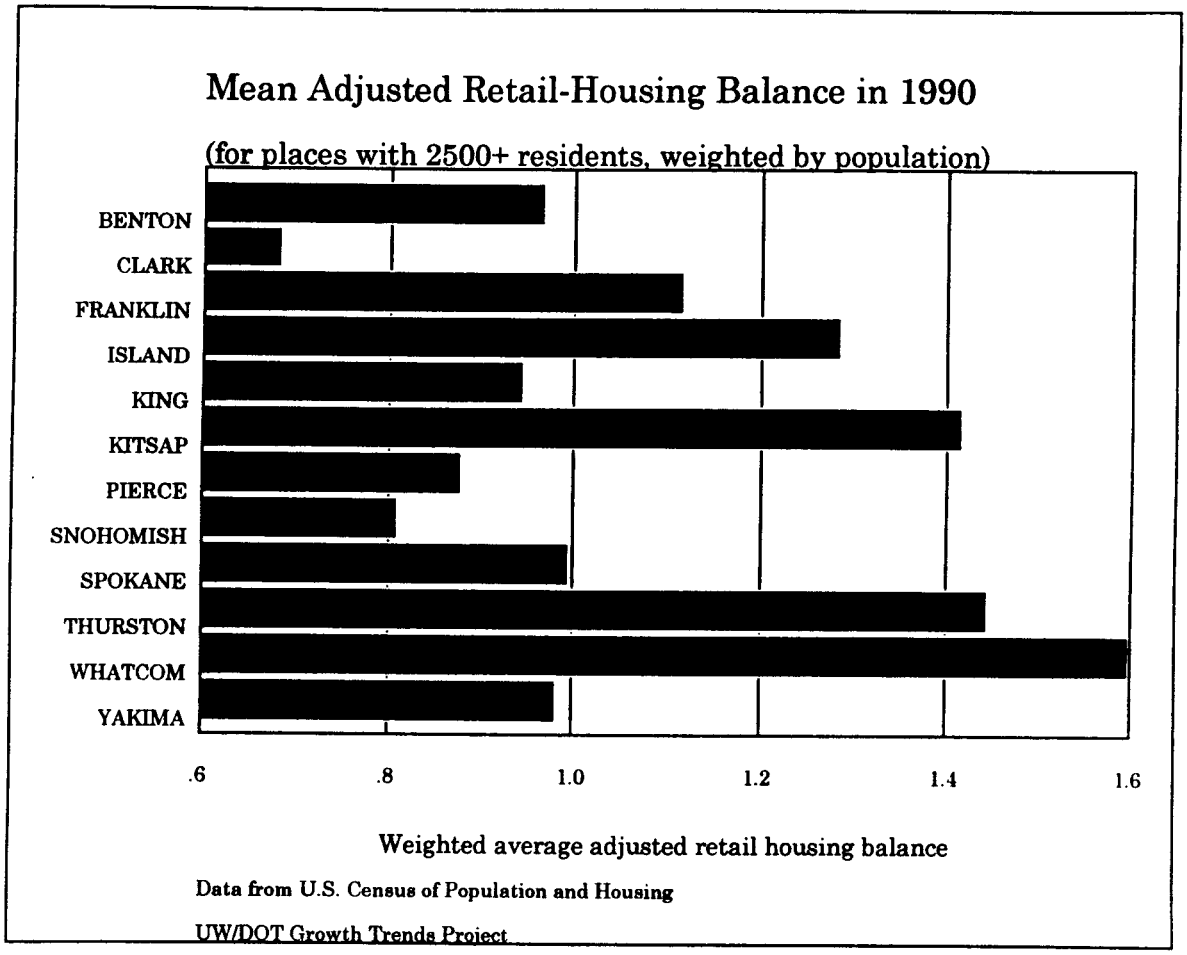


Figure 17. Mean adjusted retail-housing balance in 1990
(for places with 2500+ residents, weighted by population)

Table 21. Top and bottom decile of adjusted jobs housing balance in 1990

	Place	*County*	*Balance*	*Jobs*	*Population*
TOP DECILE	Puyallup city	PIERCE	1.002	11953	23875
	Kirkland city	KING	1.011	23231	40052
	North Bend city	KING	1.016	1418	2578
	Washougal city	CLARK	.982	2510	4764
	Sumner city	PIERCE	.978	3239	6281
	Spokane city	SPOKANE	.973	98907	177196
	Prosser city	BENTON	1.027	2175	4476
	Ferndale city	WHATCOM	.967	2530	5398
	Richland city	BENTON	1.053	18582	32315
	Oak Harbor city	ISLAND	.940	7381	17176
	Sunnyside city	YAKIMA	.939	4271	11238
	Lacey city	THURSTON	.936	9618	19279
	Lynden city	WHATCOM	1.064	2934	5709
	Tacoma city	PIERCE	1.070	102250	176664
	Cheney city	SPOKANE	.918	3190	7723
	Toppenish city	YAKIMA	1.092	3132	7419
	Yakima city	YAKIMA	1.097	32050	54827
BOTTOM DECILE	Lakeland South CDP	KING	.087	373	9027
	East Port Orchard CDP	KITSAP	.078	186	5409
	Highland CDP	BENTON	.073	108	3656
	Parkwood CDP	KITSAP	.070	230	6853
	Elk Plain CDP	PIERCE	.069	375	12197
	Felida CDP	CLARK	.065	86	3109
	Prairie Ridge CDP	PIERCE	.063	236	8278
	Covington-Sawyer-Wilderness	KING	.043	442	24321
	Sudden Valley CDP	WHATCOM	.038	70	2615
	North Marysville CDP	SNOHOMISH	.029	229	18711
	Fife city	PIERCE	2.045	5599	3864
	Kent city	KING	2.047	45517	37960
	Arlington city	SNOHOMISH	2.070	4213	4037
	Union Gap city	YAKIMA	2.124	3640	3120
	Winslow city	KITSAP	2.188	4441	3081
	Fairchild AFB CDP	SPOKANE	2.737	4408	4854
	Tukwila City	KING	5.680	33918	11874

Table 22. Top and bottom decile of retail housing balance in 1990

	Place	*County*	*Balance*	*Population*
TOP DECILE	Milton city	PIERCE	1.002	4995
	Toppenish city	YAKIMA	1.006	7419
	Buckley city	PIERCE	.982	3516
	Federal Way CDP	KING	1.031	67554
	Lake Stevens city	SNOHOMISH	1.036	3380
	Burien CDP	KING	1.053	25089
	Tumwater city	THURSTON	1.066	9976
	Sumner city	PIERCE	.925	6281
	Vancouver city	CLARK	1.079	46380
	Seattle city	KING	1.108	516259
	Tacoma city	PIERCE	1.114	176664
	Richmond Highlands CDP	KING	.882	26037
	Spokane city	SPOKANE	1.121	177196
	Prosser city	BENTON	1.123	4476
	Edmonds city	SNOHOMISH	.875	30744
	Wapato city	YAKIMA	.857	3795
	Ferndale city	WHATCOM	1.143	5398
BOTTOM DECILE	Highland CDP	BENTON	.000	3656
	Ault Field CDP	ISLAND	.000	3795
	Sudden Valley CDP	WHATCOM	.000	2615
	Fife city	PIERCE	2.001	3864
	Arlington city	SNOHOMISH	2.005	4037
	Monroe city	SNOHOMISH	2.015	4278
	Marysville city	SNOHOMISH	2.109	10328
	Poulsbo city	KITSAP	2.215	4848
	Winslow city	KITSAP	2.303	3081
	North Bend city	KING	2.427	2578
	Gig Harbor city	PIERCE	2.456	3236
	Issaquah city	KING	2.638	7786
	Port Orchard city	KITSAP	2.758	4984
	McChord AFB CDP	PIERCE	2.898	4538
	Lynnwood city	SNOHOMISH	3.060	28695
	Bangor Trident Base CDP	KITSAP	3.270	3702
	Silverdale CDP	KITSAP	3.616	7660

JOBS-HOUSING BALANCE CHANGE IN THE PUGET SOUND REGION

Adjusted jobs-housing and retail-housing scores were computed for each FAZ in the Puget Sound Region following the same method used for cities and unincorporated places. This was done in order to take advantage of the longitudinal data available there and to examine changes in balance over the past two decades.

Maps 7 to 9 show the results for jobs-housing balance and maps 10 to 12 give the results for retail-housing balance. Several patterns can be observed. First, jobs- and retail-housing balance patterns appear unstable. The maps change substantially from decade to decade. Second, FAZs which had the best jobs-housing balance in 1990 appear to be located in-between major employment centers and bedroom communities, holding the middle ground along a gradient between the two. Third, FAZs that were retail balanced in 1990 appear to be in one of two situations. Most appear to be lying along gradients that run from retail-rich zones (along highway corridors) to retail-poor ones. Others appear to be in more remote locations surrounded by retail poor territory.

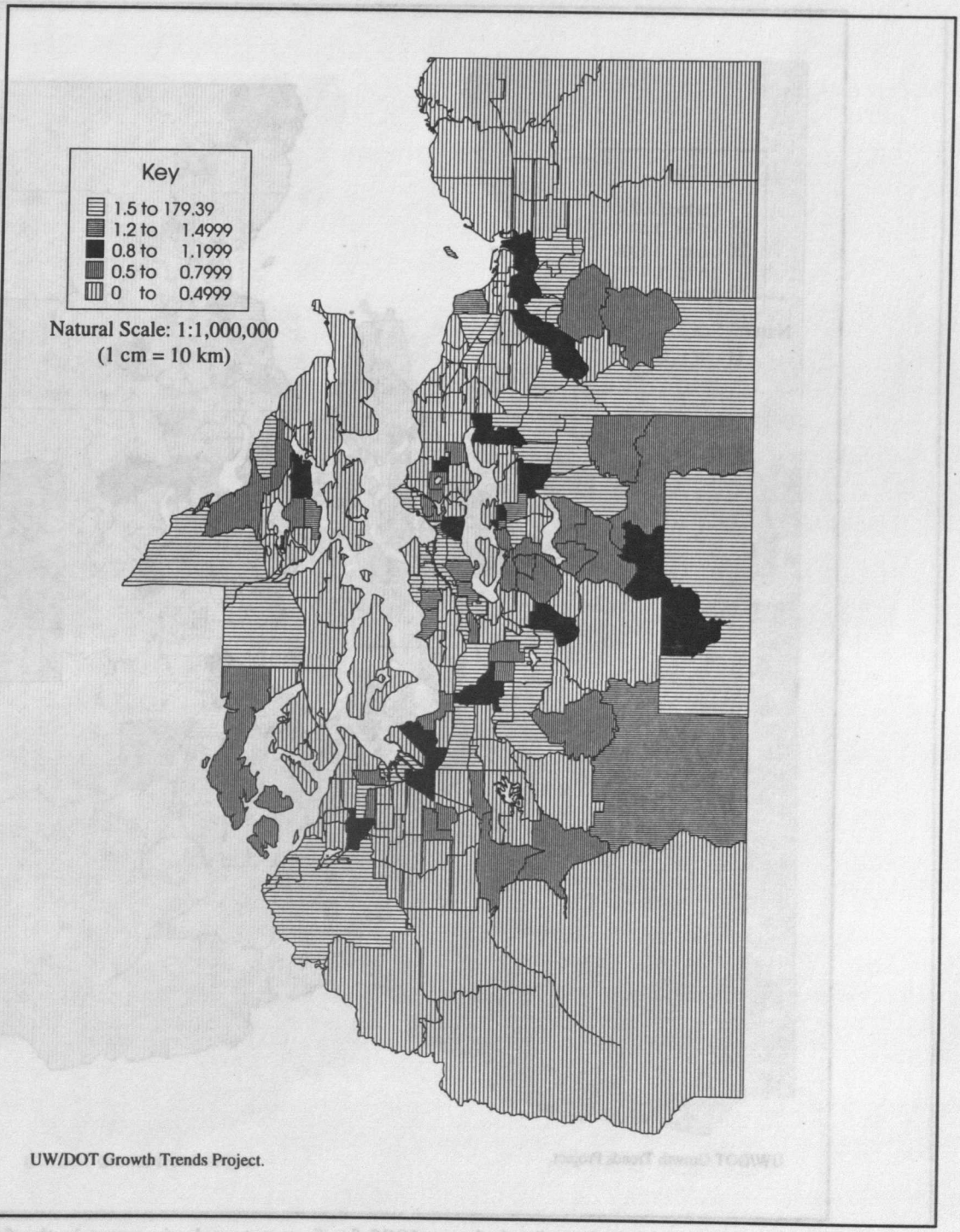
A Regional View

How many of us are living in balanced places?

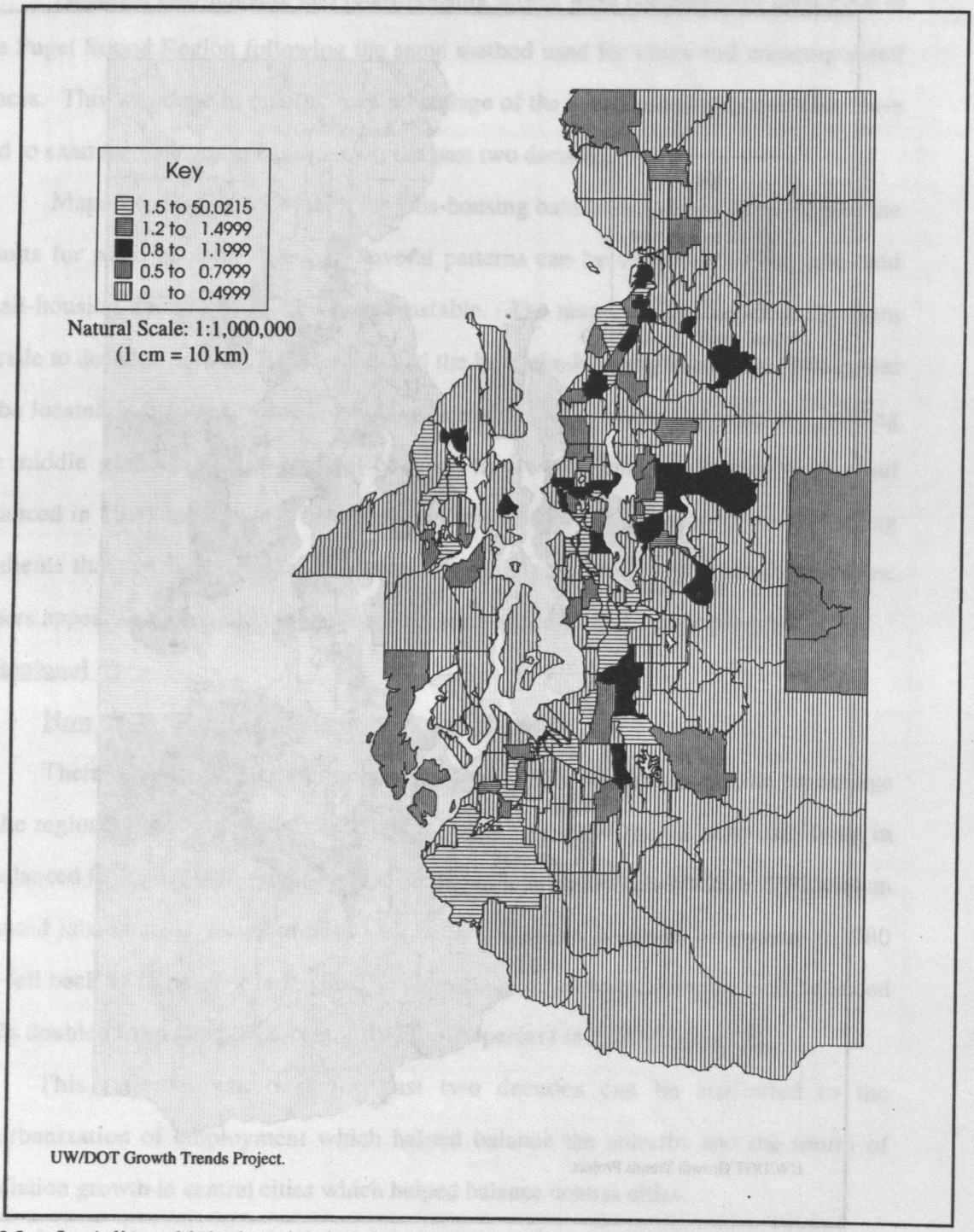
There has been a small improvement over the past twenty years in the percentage of the region's population living in balanced areas, but most people were still living in unbalanced FAZs in 1990. Eight percent of the population lived in FAZs in 1970 with an adjusted jobs-housing scores of 0.8 to 1.2. That increased to about 14 percent in 1980 and fell back to 13 percent in 1990. The percentage of persons living in retail balanced FAZs doubled from about 8 percent in 1970 to 16 percent in 1990 (Figure 18).

This improvement over the past two decades can be attributed to the suburbanization of employment which helped balance the suburbs and the return of population growth in central cities which helped balance central cities.

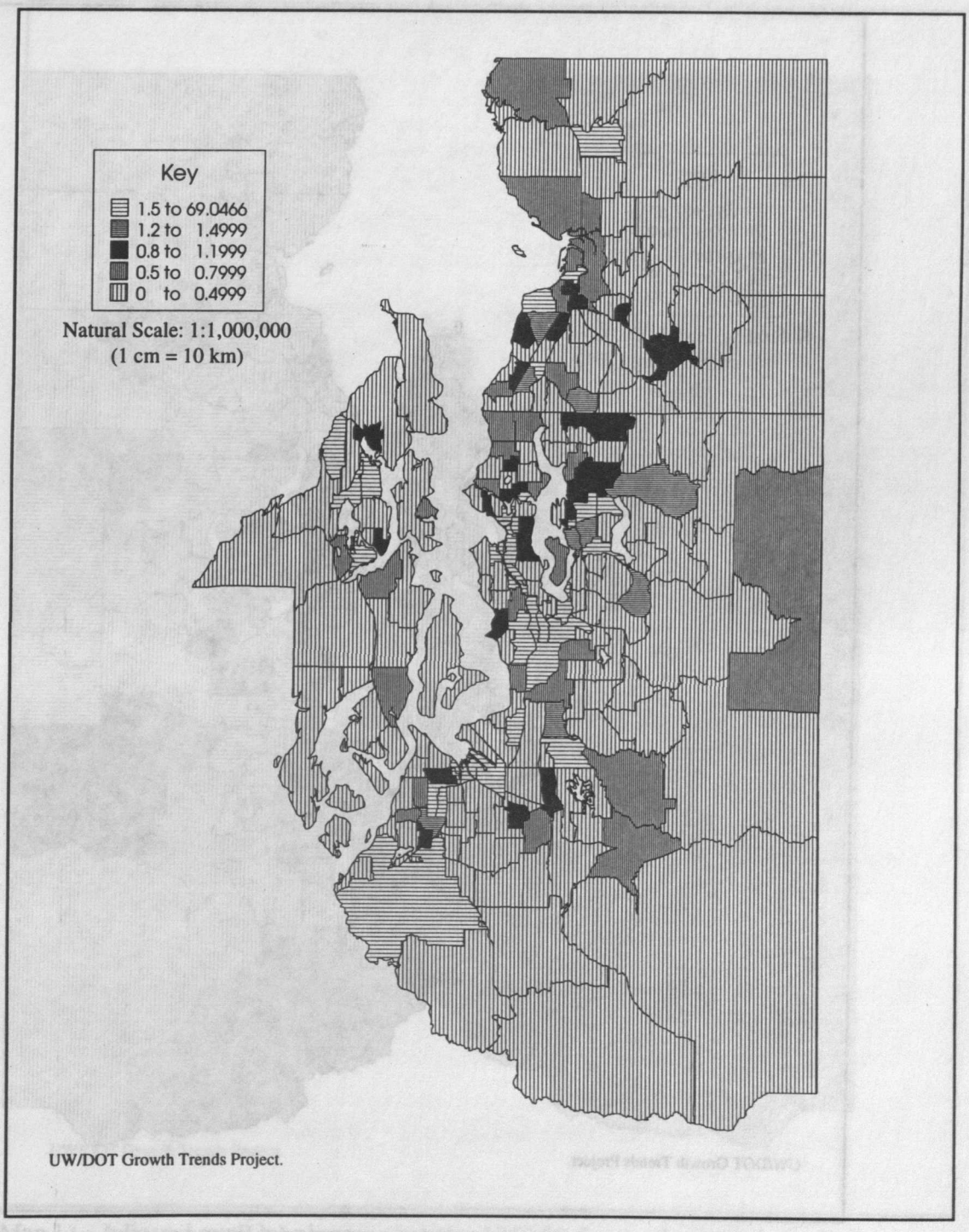
It is worth noting the decline in jobs-housing balance during the 1980s. The large increase in population in exurban bedroom communities explains much of this decline.



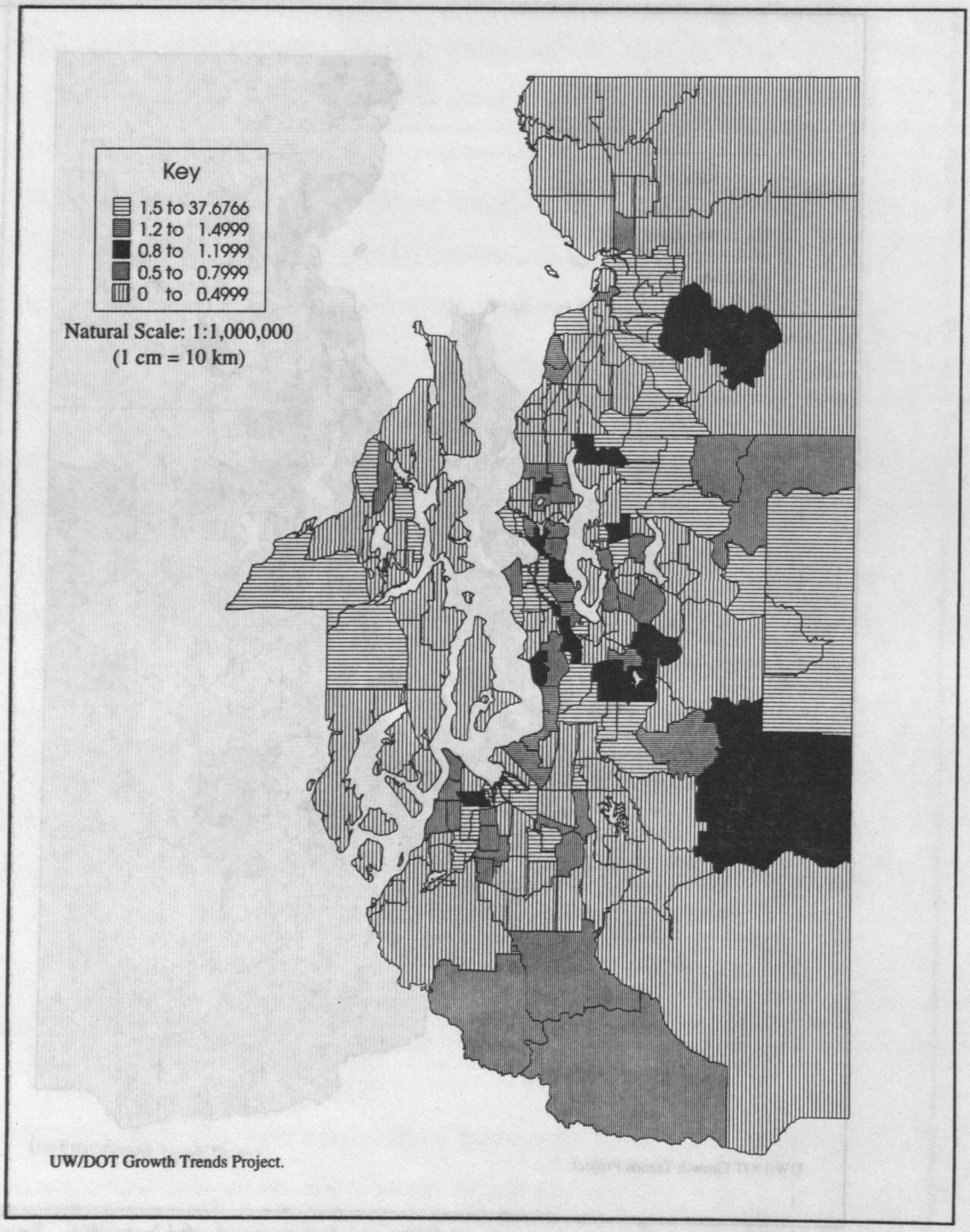
Map 7. Adjusted jobs housing balance 1970 for forecast analysis zones in the four county Central Puget Sound Region. Data source: Puget Sound Regional Council.



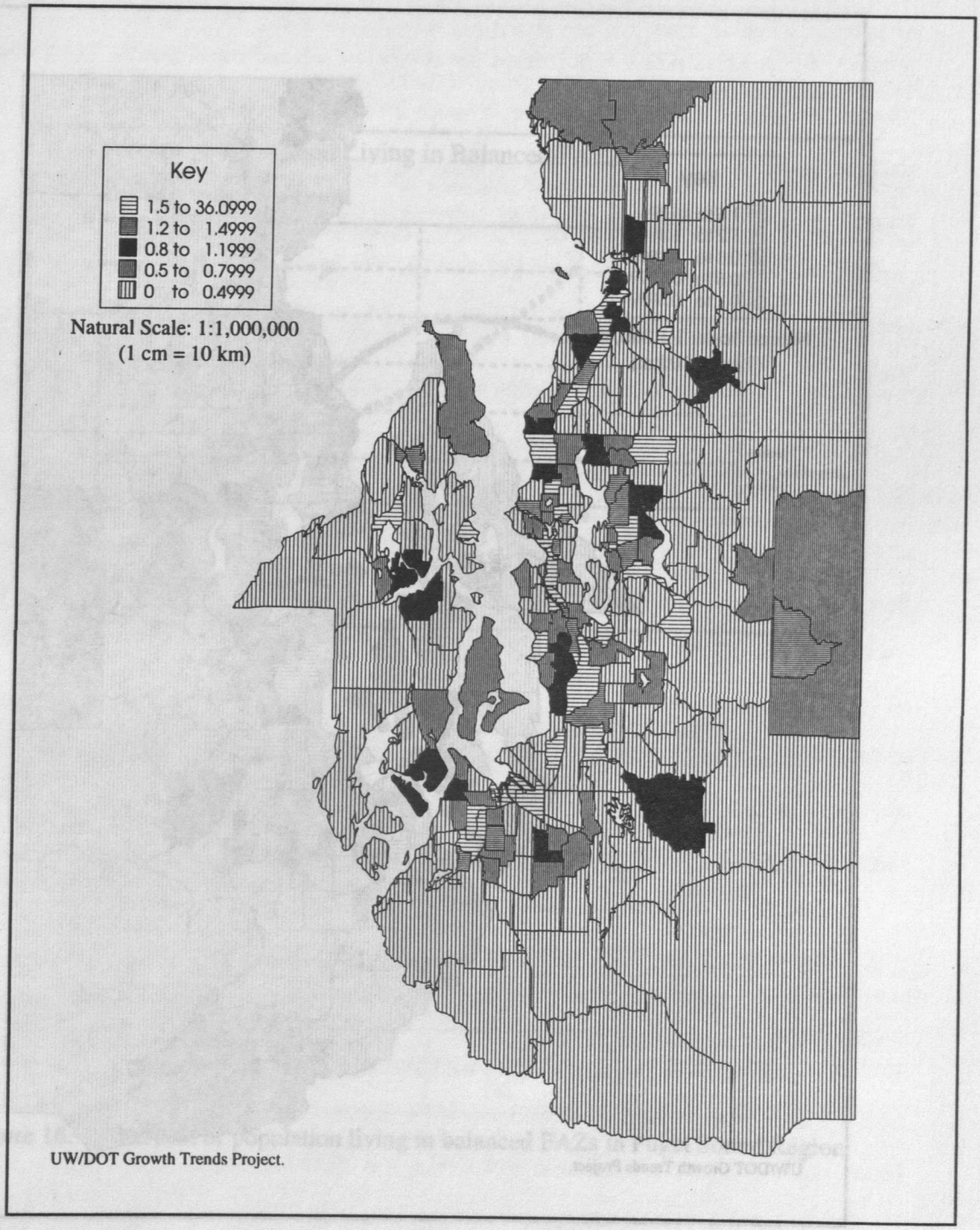
Map 8. Adjusted jobs housing balance 1980 for forecast analysis zones in the four county Central Puget Sound Region. Data source: Puget Sound Regional Council.



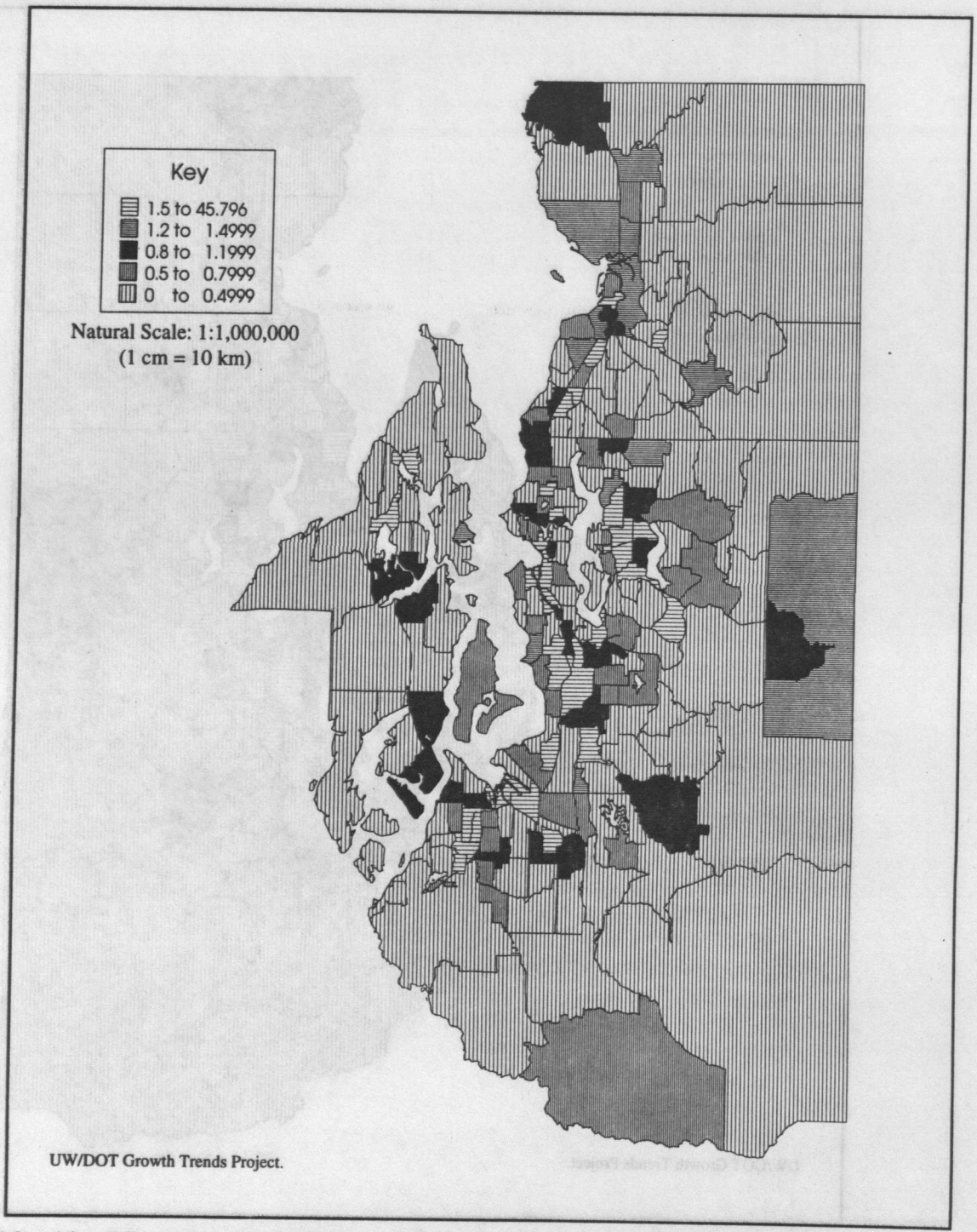
Map 9. Adjusted jobs housing balance 1990 for forecast analysis zones in the four county Central Puget Sound Region. Data source: Puget Sound Regional Council.



Map 10. Adjusted retail jobs housing balance 1970 for forecast analysis zones in the four county Central Puget Sound Region. Data source: Puget Sound Regional Council.



Map 11. Adjusted retail jobs housing balance 1980 for forecast analysis zones in the four county Central Puget Sound Region. Data source: Puget Sound Regional Council.



Map 12. Adjusted retail jobs housing balance 1990 for forecast analysis zones in the four county Central Puget Sound Region. Data source: Puget Sound Regional Council.

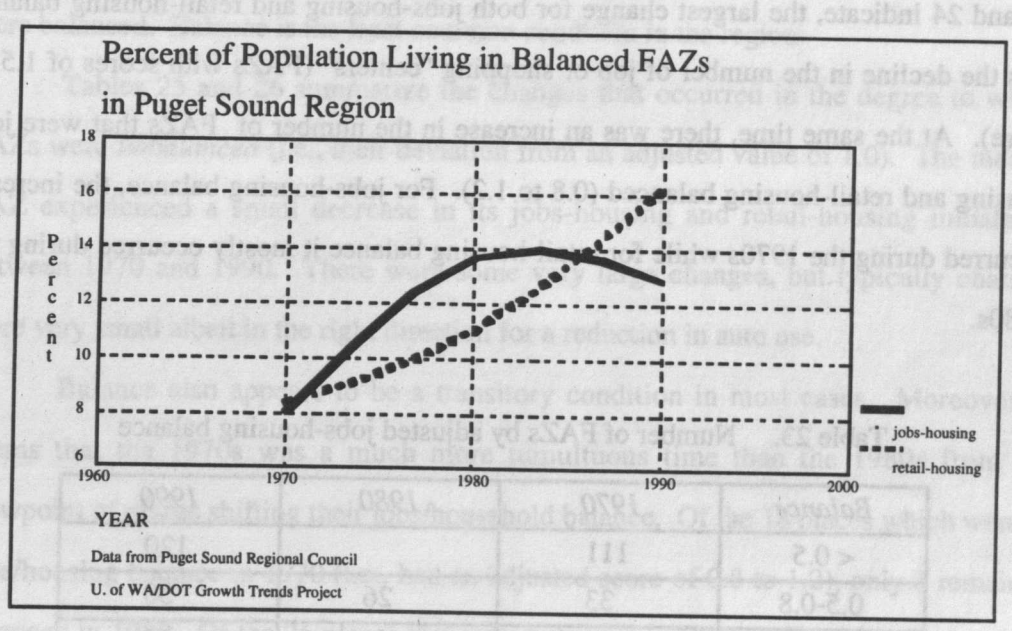


Figure 18. Percent of population living in balanced FAZs in Puget Sound Region

An FAZ-Level View

Economic decentralization over the past two decades marginally increased the number of balanced FAZs and decreased the number of job and retail centers. As Tables 23 and 24 indicate, the largest change for both jobs-housing and retail-housing balance was the decline in the number of job or shopping "centers" (FAZs with scores of 1.5 or more). At the same time, there was an increase in the number of FAZs that were job-housing and retail-housing balanced (0.8 to 1.2). For jobs-housing balance, the increase occurred during the 1970s while for retail-housing balance it mostly occurred during the 1980s.

Table 23. Number of FAZs by adjusted jobs-housing balance

Balance	*1970*	*1980*	*1990*
< 0.5	111		120
0.5-0.8	33	26	30
0.8-1.2	18	26	25
1.2-1.5	9	6	9
> 1.5	48	33	35

Table 24. Number of FAZs by adjusted retail-housing balance

Balance	*1970*	*1980*	*1990*
>0.5	108	109	100
0.5-0.8	31	42	40
0.8-1.2	18	20	29
1.2-1.5	12	14	13
1.5+	50	34	37

Despite the increase in balance that has occurred, imbalance was by far the most common condition in 1990. Less than 15 percent of the region's FAZs fell into the balanced range in 1990. Most were too housing rich and job poor. Overall, roughly 65 percent of the region's FAZs were housing rich, 20 percent were job rich and 15 percent were balanced. Balance is the least common condition in the region.

Tables 25 and 26 summarize the changes that occurred in the degree to which FAZs were *imbalanced* (i.e., their deviation from an adjusted value of 1.0). The median FAZ experienced a small decrease in its jobs-housing and retail-housing imbalance between 1970 and 1990. There were some very large changes, but typically changes were very small albeit in the right direction for a reduction in auto use.

Balance also appears to be a transitory condition in most cases. Moreover, it seems that the 1970s was a much more tumultuous time than the 1980s from the viewpoint of places shifting their jobs/household balance. Of the 18 places which were in jobs/housing balance in 1970 (i.e., had an adjusted score of 0.8 to 1.2), only 3 remained balanced in 1980. Of the 26 places that were balanced in 1980, 13 remained so in 1990. The same is found for retail balance. Two of the 18 FAZs that were balanced in 1970 remained so in 1980 and 11 of the 20 that were balanced in 1980 remained balanced in 1990. A close examination of what happened to places that once were but no longer are balanced shows that there was a roughly equal split between those that became too job rich and those that became too housing rich.

The handful of FAZs that were either retail-housing or jobs-housing balanced in 1970 and remained so in 1990 are listed in Table 27.

Tables 28 and 29 list FAZs that experienced the most and least change in their jobs and retail-housing balance between 1970 and 1990. Bothell, Woodinville, Canyon Park, and East Bellevue/Lake Hills are particularly notable because they experienced significant reductions in imbalance resulting in their being balanced in 1990.

Table 25. Absolute change in adjusted jobs-housing imbalance

Year	*Mean*	*Median*	*Minimum*	*Maximum*	*Std Dev*
1970-80	.17	-.02	-26.44	29.40	3.86l
1980-90	.11	-.05	-14.90	26.87	2.25l
1970-90	.28	-.07	-25.66	31.87	4.32l

Data from Puget Sound Regional Council
UW/WSDOT Land use Project

Table 26. Absolute change in adjusted retail housing imbalance

Years	*Mean*	*Median*	*Minimum*	*Maximum*	*Std Dev*
1970-80	-.22	-.04	-36.02	34.03	4.15
1980-90	-.03	-.04	-19.07	9.70	1.65
1970-90	-.24	-.05	-35.31	43.73	4.74

Data from Puget Sound Regional Council
UW/WSDOT Land use Project

Table 27. FAZs that were balanced in 1970 and 1990

	FAZ NAME	*POPULATION 1970*	*POPULATION 1990*
JOBS-HOUSING BALANCED	Lakewood/Ponders	7560	12725
	Northgate	13340	15920
	E. Capitol Hill	33300	28732
	N. W. Bellevue	6454	6836
	Redmond CBD	8669	27093
RETAIL-HOUSING BALANCED	Kenmore/Inglewood	9778	16551
	Central	20105	19902

Table 28. Top and bottom decile of change in retail housing imbalance
(FAZs that were balanced in 1990 are shown with gray background)

	FAZ NAME	Change, 1970-1990	Adjusted Balance 1970	Adjusted Balance 1990	Total Population, 1990
TOP DECILE	UPPER DUWAMISH/HARBOR ISLAND	-35.31	37.66	2.35	3724
	INDUSTRIAL DISTRICT	-21.35	37.68	16.33	2331
	EAST KING COUNTY	-12.20	13.63	1.43	2682
	GORST/BURLEY/GLENWOOD	-9.74	11.33	.42	10963
	WOODINVILLE	-8.26	9.51	1.26	14805
	FOBES HILL	-7.28	8.88	.39	9528
	GOLD MOUNTAIN/HOLLY	-5.68	7.46	.23	3454
	WEST BELLEVUE	-5.51	6.82	.69	8453
	NORTH BEAR CREEK	-4.85	6.82	.03	7276
	LAKE STEVENS/FRONTIER VILLAGE	-4.15	5.70	.46	9911
	KINGSGATE/HOLLYWOOD HILL	-3.95	5.52	.43	11051
	MACHIAS/CAVALERO CORNER	-3.71	5.70	.02	3468
	BOTHELL	-3.42	4.46	1.04	10552
	EAST BELLEVUE/LAKE HILLS	-2.82	3.84	.99	24165
	CATHCART	-2.54	4.32	.22	4505
	ORCHARD/MANITOU	-2.39	4.00	1.61	10747
	BANGOR	-1.94	3.94	.00	4410
	MUKILTEO/SOUTHWEST EVERETT	-1.68	3.15	.54	7932
	MALTBY/HIGH BRIDGE	-1.57	3.33	.24	5836
	LOWER DUWAMISH/BOEING FIELD	-1.52	3.63	2.11	4047
	TACOMA CBD/STADIUM	-1.42	3.86	2.44	5467
BOTTOM DECILE	MONTE VISTA/FLETT	.65	1.92	2.57	9368
	ISSAQUAH	.65	.25	2.40	8578
	EASTGATE/VASA PARK	.69	.49	2.20	15682
	KIRKLAND/HOUGHTON	.71	1.05	1.76	20322
	FIFE	.72	1.81	2.53	5595
	CUMBERLAND/SE KING COUNTY	.74	.96	.22	5948
	NORTHGATE	.74	.63	2.11	15920
	MEADOW LAKE/WOODS CREEK	.77	.87	.10	5533
	THREE LAKES	.80	.88	.09	6593
	LAKE UNION/SEATTLE CENTER	.80	1.96	2.76	9422
	RENTON PLATEAU	.90	.97	.08	9393
	RENTON AIRPORT/CBD	1.06	.03	3.03	11187
	NORTH BELLEVUE	1.23	.29	2.94	11181
	REDMOND/OVERLAKE	1.41	.01	3.40	11578
	CENTRAL FEDERAL WAY	1.68	.00	3.67	18587
	TACOMA MALL/SOUTH TACOMA	1.71	3.04	4.75	10628
	SILVERDALE	2.60	.42	4.18	8111
	DENNY REGRADE	2.91	1.09	4.00	4758
	ALDERWOOD MALL	13.18	.48	14.70	2183
	SOUTH TUKWILA	15.67	1.19	16.86	4130
	SEATTLE CBD	16.50	.86	17.64	6785
	BELLEVUE CBD	43.73	2.07	45.80	1182

Table 29. Top and bottom decile of change in jobs housing imbalance
(FAZs that were balanced in 1990 are shown with gray background)

	FAZ NAME	Change, 1970-1990	Adjusted Balance 1970	Adjusted Balance 1990	Total Population, 1990
TOP DECILE	UPPER DUWAMISH/HARBOR ISLAND	-25.66	29.13	3.47	3724
	GORST/BURLEY/GLENWOOD	-14.52	16.30	.22	10963
	BOTHELL	-7.22	8.28	1.07	10552
	FOBES HILL	-6.46	8.14	.32	9528
	EAST KING COUNTY	-6.14	7.46	.68	2682
	SWAMP CREEK	-4.07	5.75	.32	10195
	LAKE STEVENS/FRONTIER VILLAGE	-3.74	5.33	.41	9911
	SKYWAY/BRYN MAWR	-2.28	4.07	.21	10333
	WOODINVILLE	-2.09	3.25	.83	14805
	PAINE FIELD	-1.86	3.28	1.42	12696
	GOLD MOUNTAIN/HOLLY	-1.77	3.66	.11	3454
	FAIRWOOD	-1.58	3.37	.21	20036
	ORCHARD/MANITOU	-1.56	3.38	1.82	10747
	LAKE HEIGHTS	-1.23	3.01	.23	11162
	WEST BELLEVUE	-1.23	2.53	1.29	8453
	LAKE MERIDIAN	-1.23	3.01	.22	13220
	CANYON PARK	-1.15	2.39	1.23	5584
	MACHIAS/CAVALERO CORNER	-1.13	2.97	.16	3468
	CATHCART	-1.09	2.76	.33	4505
	DELRIDGE/HIGHLAND PARK	-1.06	2.61	.45	21195
BOTTOM DECILE	EASTGATE/VASA PARK	1.02	.63	2.39	15682
	KEYPORT/BROWNSVILLE	1.37	.94	2.43	3660
	FIFE	1.38	1.15	2.53	5595
	REDMOND/OVERLAKE	1.57	.06	3.51	11578
	EVERETT CBD	1.61	.28	3.33	8262
	NORTH BELLEVUE	1.65	.46	3.20	11181
	ALDERWOOD MALL	2.33	.30	4.03	2183
	TACOMA CBD/UNION STATION	2.36	4.03	6.40	4332
	RENTON AIRPORT/CBD	2.42	.03	4.39	11187
	LAKE UNION/SEATTLE CENTER	2.72	2.41	5.13	9422
	BANGOR	3.21	5.47	8.68	4410
	MUKILTEO/SOUTHWEST EVERETT	3.50	3.00	6.50	7932
	KENT INDUSTRIAL	4.02	1.51	5.53	12337
	NORTH TUKWILA/RIVERTON	4.45	.68	5.77	6895
	LOWER DUWAMISH/BOEING FIELD	4.62	4.91	9.52	4047
	SOUTH TUKWILA	5.97	1.78	7.75	4130
	INDUSTRIAL DISTRICT	5.99	29.13	35.12	2331
	DENNY REGRADE	7.26	1.72	8.98	4758
	SEATTLE CBD	21.67	1.37	23.03	6785
	BELLEVUE CBD	24.33	.94	25.40	1182
	PORT OF TACOMA	25.48	43.56	69.05	545

At the bottom of the lists, indicating the greatest *increase* in imbalance, are found two of the regions densest employment centers—downtown Bellevue and Seattle. This points out the potential conflict that can arise between density and balance, particularly if new housing is not included when dense job centers are being created.

THE COMPACT AND COMPLETE COMMUNITY INDEX

In an effort to develop a summary measure that combined the factors examined in detail above, a Compact and Complete Community Index[13] was developed. The index measures compactness in terms of gross housing and employment densities and completeness in terms of jobs-housing and retail-housing balance. Each component was standardized to a scale of 0 to 25 relative to all other places in the state with the densest and most balanced places receiving the highest scores. The sum of all four factors was the final index score for each city or unincorporated place in the study.

A County Level View

Figure 19 shows the weighted average index score for places in each county. Places in King County scored the highest and Kitsap County scored the lowest. When individual components are examined, the best counties were King for job and housing densities, Island for jobs-housing balance, and Spokane for retail-housing balance. The worst performers were Franklin for job and housing density and Kitsap for jobs- and retail-housing balance.

A Place-Level View

Figure 20 shows the most complete and compact communities in Washington. They vary in population size, ranging from 3,800 (Wapato) to 516,000 (Seattle). They

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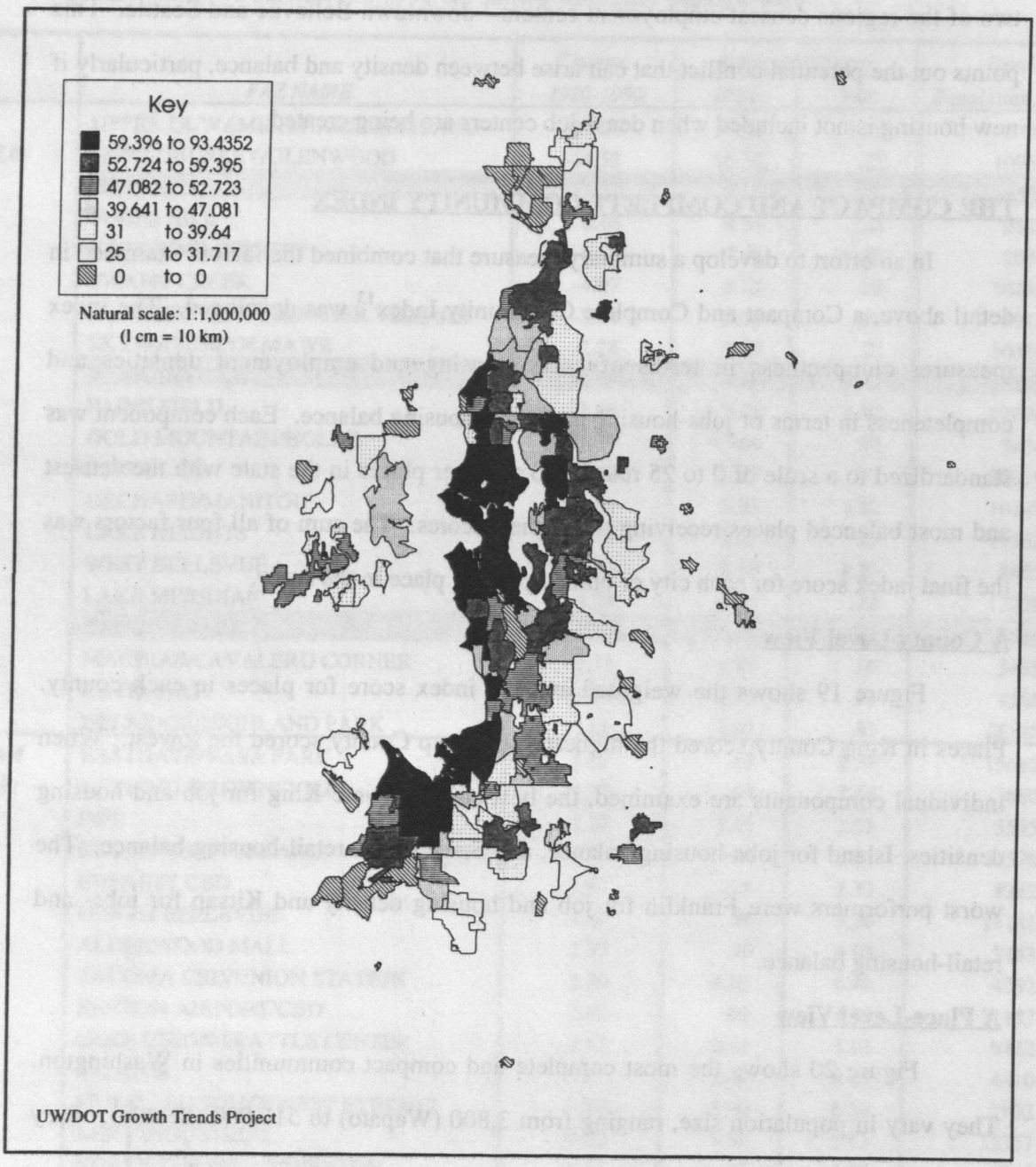
[13] CCI = sum of employment density, dwelling unit density, adjusted retail housing balance and adjusted jobs housing balance all standardized to 1. The formula for densities was 25*(density/density range). The formula for balance was: 25 x (1-((l1-adjusted balancel)/range (absolute value (1 - the adjusted balance))).



Map 13.Compact and Complete Community Index, 1990 for places in the four county Central Puget Sound Region by decile. Decile are defined using data for all places in the metropolitan counties of Washington State. Top and bottom deciles are shown; middle deciles are combined. Data sources: Census of Population and Housing, Census Transportation Planning Package, U.S. Census Bureau.

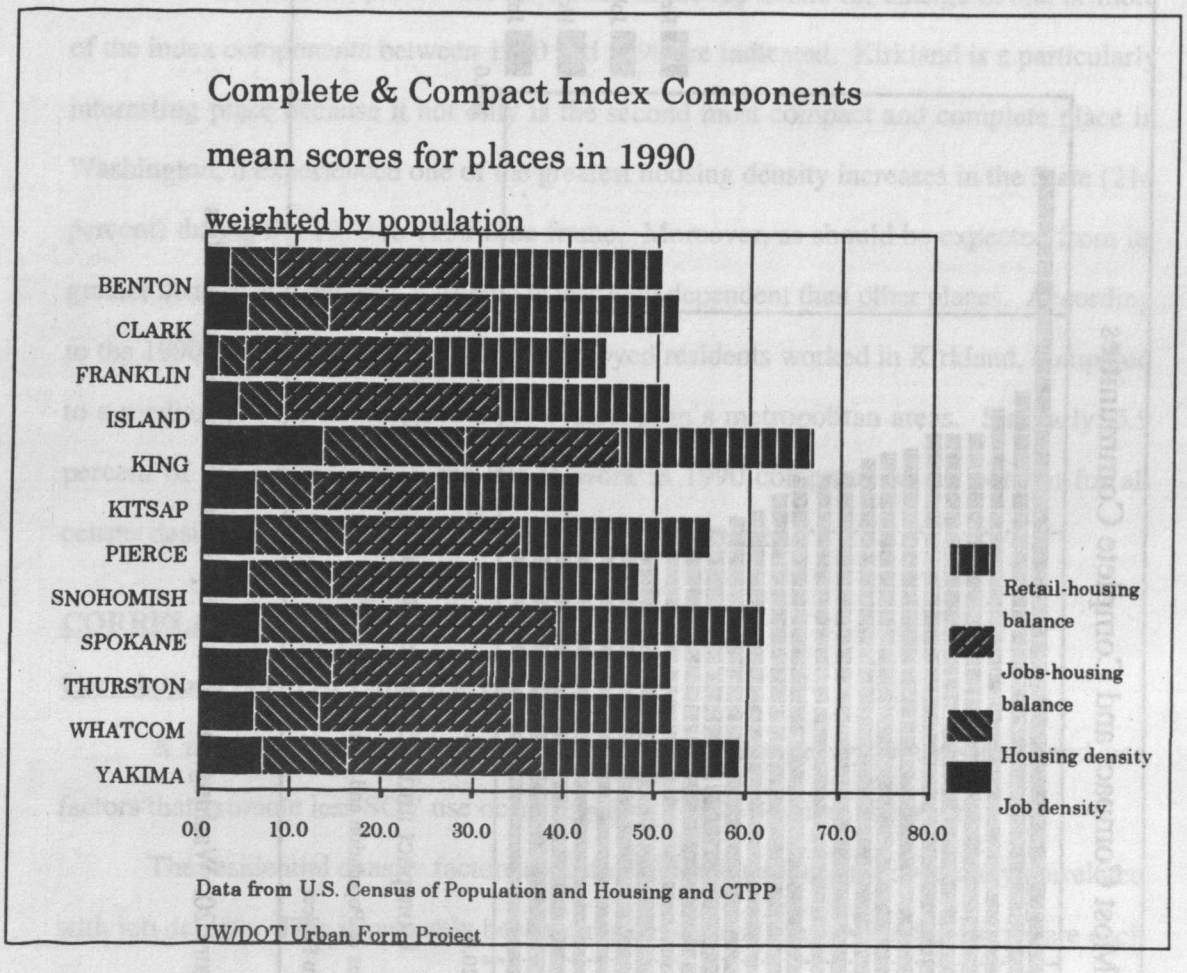


Figure 19. Complete and compact community index components mean scores for places in 1990 weighted by population

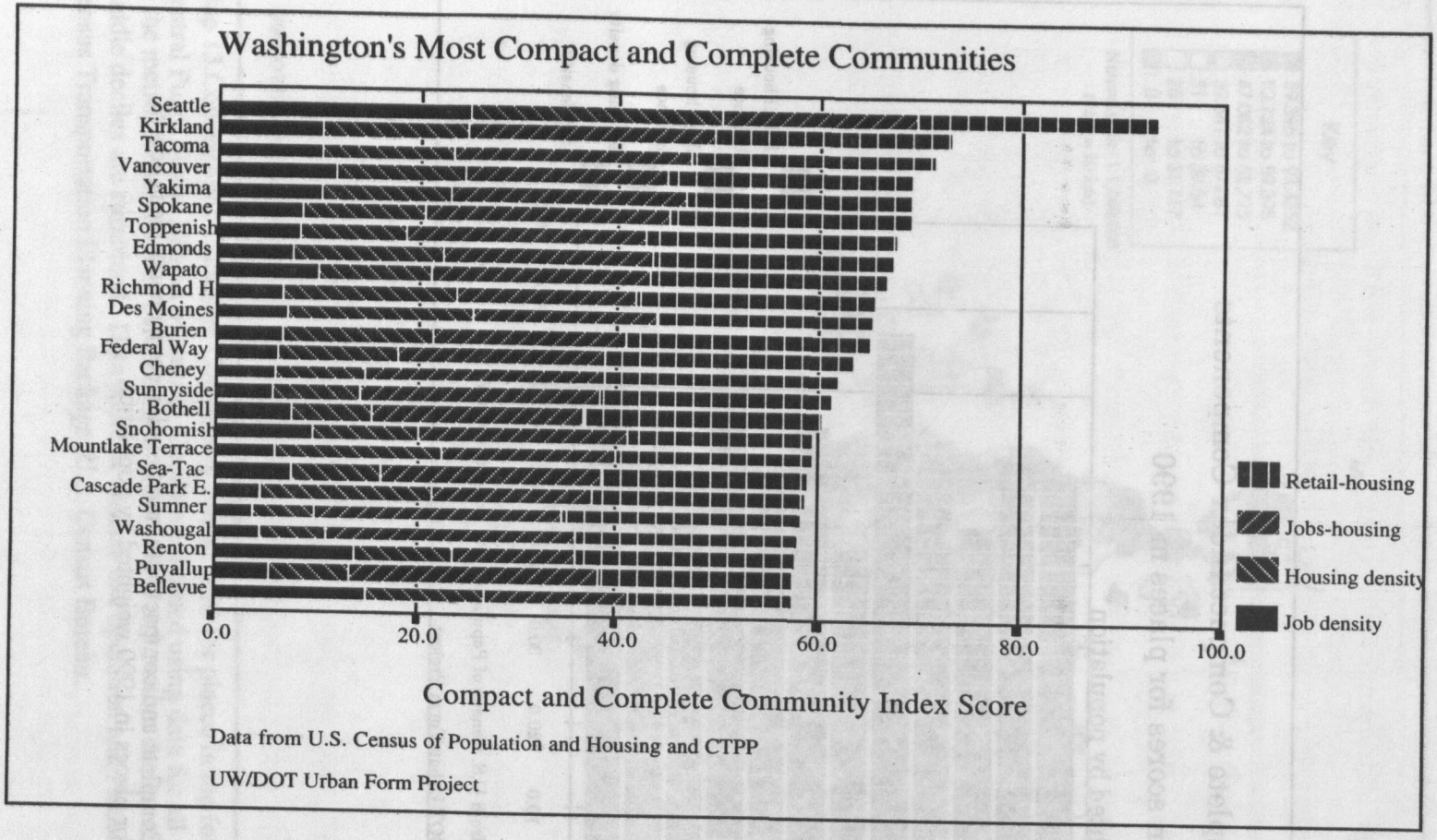


Figure 20. Washington's most compact and complete communities

also vary in location and include central cities, like Tacoma, suburban cities like Kirkland, and rural centers like Cheney. Table 30 gives the actual index scores for each component. This allows the strengths and weaknesses of each community to be examined. In addition, places that have been in the top decile for change in one or more of the index components between 1970 and 1990 are indicated. Kirkland is a particularly interesting place because it not only is the second most compact and complete place in Washington, it experienced one of the greatest housing density increases in the State (214 percent) during the 1970 to 1990 time frame. Moreover, as should be expected from its greater density and balance, Kirkland is less auto dependent than other places. According to the 1990 census, 22.4 percent of its employed residents worked in Kirkland, compared to a median of 11.3 percent for all of Washington's metropolitan areas. Similarly, 5.9 percent of the residents took the bus to work in 1990 compared to 1.5 percent for all census designated places in Washington's metropolitan areas.

CORRELATIONS

Correlations Between Land Use Factors

A number of correlations were computed to test the hypothesis that land use factors that promote less SOV use occur together. Table 31 gives the results.

The residential density factors (housing and population) are moderately correlated with job density. This is probably because residential and employment densities are each positively related to accessibility and the higher land values it causes. The very strong association between housing and population densities is unsurprising given their obvious connection.

Table 30. Most compact and complete communities in Washington in 1990

(Maximum possible score for each component is 25; maximum possible score for c&c index is 100; places in top decile of improvement for one or more factors shown with gray background)

Place	*County*	*Compact & Complete Community Index*	*Housing Density*	*Job Density*	*Jobs-Housing Balance*	*Retail-Housing Balance*
Seattle city	KING	93.44	25.03	25.02	19.428	23.965
Kirkland city	KING	72.90	14.22	10.37	24.839	23.471
Tacoma city	PIERCE	71.26	13.19	10.17	23.996	23.908
Vancouver city	CLARK	69.17	12.54	11.82	20.561	24.241
Yakima city	YAKIMA	68.99	12.95	10.24	23.602	22.203
Spokane city	SPOKANE	68.96	12.04	8.45	24.618	23.846
Toppenish city	YAKIMA	67.52	10.58	8.33	23.669	24.938
Edmonds city	SNOHOMISH	67.29	14.95	7.68	20.861	23.802
Wapato city	YAKIMA	66.64	11.26	9.90	21.843	23.637
Richmond Highlands	KING	65.57	17.62	6.32	17.761	23.869
Des Moines city	KING	65.26	18.44	7.13	18.323	21.359
Burien CDP	KING	65.23	15.00	6.49	19.242	24.491
Federal Way	KING	63.51	12.04	6.08	20.685	24.705
Cheney city	SPOKANE	62.08	8.85	5.86	23.813	23.553
Sunnyside city	YAKIMA	61.21	8.43	5.70	24.120	22.962
Bothell city	KING	60.29	8.16	7.44	21.180	23.507
Snohomish city	SNOHOMISH	59.42	10.44	9.66	20.910	18.402
Mountlake Terrace	SNOHOMISH	59.36	16.77	5.82	17.530	19.236
Sea-Tac	KING	59.08	8.76	7.68	21.872	20.764
Cascade Park East	CLARK	58.88	16.92	4.63	16.063	21.264
Sumner city	PIERCE	58.72	5.73	4.04	24.681	24.278
Washougal city	CLARK	58.06	6.52	4.62	24.737	22.177
Renton city	KING	57.96	9.99	13.59	12.214	22.173
Puyallup city	PIERCE	57.78	7.69	5.55	24.969	19.572
Bellevue city	KING	57.75	11.95	14.87	14.530	16.393

Table 31. Correlations among land use factors

	Standardized Job Density	Standardized Housing Density	Standardized Population Density	Standardized Adjusted Jobs-Housing Balance
Standardized Housing Density	.4593 (178) P= .000			
Standardized Population Density	.3839 (178) P= .000	.9779 (256) P= .000		
Standardized Adjusted Jobs-Housing Balance	.2996 (174) P= .000	.1673 (174) P= .027	.1653 (174) P= .029	
Standardized Adjusted Retail-Housing Balance	.1063 (176) P= .160	.3024 (176) P= .000	.2975 (176) P= .000	.4617 (173) P= .000

(Coefficient / (Cases) / 2-tailed Significance)
" . " is printed if a coefficient cannot be computed

Jobs-housing and retail-housing balance were also moderately correlated with one another. This is also unsurprising given that retail-housing balance is actually a component of jobs-housing balance and the possibility that similar forces are at work in creating improvements in both conditions.

A positive but weak relationship was observed between the balance variables and the density variables. As already noted above, market conditions that promote greater densities may in fact work against balance. Indeed Pivo (1993) found employment activities in the densest job centers tend to squeeze out other uses that are needed to create balance. Nevertheless, the relationship between balance and density was positive, not negative, and apparently some link may exist between the two conditions.

Additional correlations were examined to test the hypothesis that there was a relationship between *changes* in the land use variables. Two types were considered.

The first type of relationship examined were those between changes in the same variable during the two separate decades that were studied. For example, did the fact that a place grew denser in the 70s indicate it also grew denser in the 80s? The strongest such relationship that was found was between job density change in the two decades ($r=.88$, $p<.01$). A more moderate link also was found between population change in each decade ($r=.27$, $p<.01$). A relatively weak correlation existed between change in retail-housing balance in each decade ($r=.18$, $p<.01$) while no significant relationship existed in jobs-housing balance change from one decade to the next.

The second type of relationship were those between different variables over the same time period. For example, did increasing job density coincide with increasing housing density? The only strong correlation that was found was the one that would obviously be expected to occur. That is the relationship between population density change and housing density change ($r=.89$, $p<.01$). Correlations between job density change and other kinds of change were not statistically significant. A relatively weak

correlation was found between increases in population density and reductions in both jobs/housing and retail/housing ratios ($r=-.18$, $p<.01$ and $r=-.17$, $p<.05$, respectively).

If these relationships hold, the record of past job density change in a place can be relied upon to predict future job density change in the same place while just the opposite can be said for population density, housing density and balance. Perhaps this is so because freeway building in the 60s, 70s and 80s put down the roots of future suburban job centers by establishing the basic pattern of accessibility that will shape job patterns for some time to come. Thus predetermined suburban job centers have been growing and maturing decade by decade. Meanwhile the other elements of land use have been undergoing change in different places at different times. This would be consistent with a wave theory of population intensification in which each place awaits its turn to be washed over by a wave of intensification that is moving from the center to the edge of each metropolis. If this is so, then during the next twenty years, job intensification can be expected to continue where it has already been occurring while pressures for greater population and housing densities will occur in new locations farther away from the metropolitan core than the places that intensified over the few decades. New growth management plans and regulations aimed at redirecting residential growth back to existing urban areas could be undermined by these decentralizing tendencies.

Correlations Between Land use and Travel Behavior

Although the main purpose of this study was not to examine relationships between land use and travel behavior, but rather to explore trends in aspects of land use already known to influence travel behavior, the data allowed some such relationships to be examined. Figure 21 shows that in the data used in this report, there existed a rather strong positive nonlinear relationship between the percentage of workers in a community who work in the same community and the jobs-housing balance in the community. The

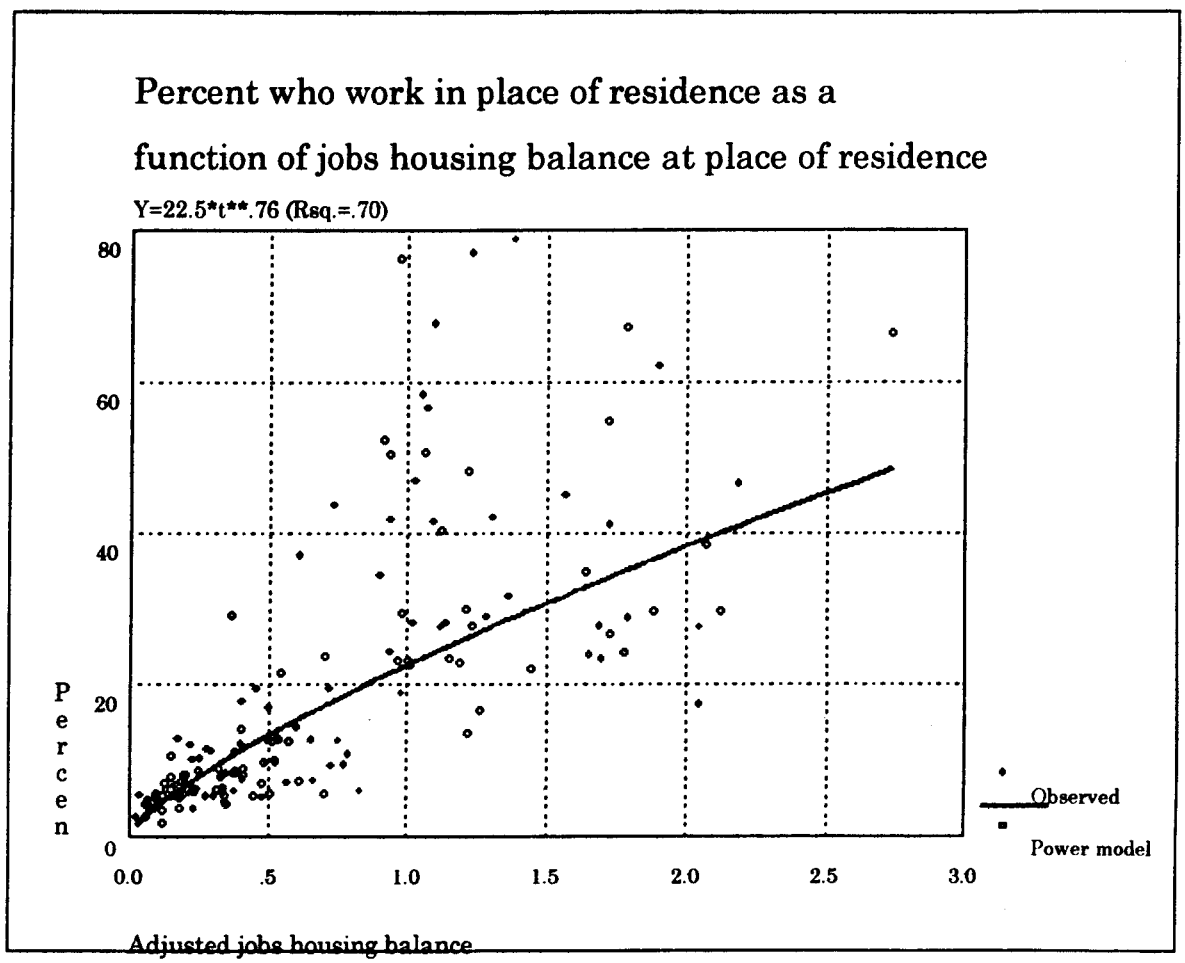


Figure 21. Percent who work in place of residence as a function of jobs housing balance at place of residence

reverse was also found, that is, the percentage who work outside the community was inversely related to jobs-housing balance. It follows that balanced communities minimize commuting to work between communities.

Figure 22 shows that bus use to work increased as a function of housing density. However, unlike previous studies that have emphasized a density threshold below which there was little change in bus use from increased density, this model shows a steady increase in bus use along the full range of density study. The threshold normally cited, around 800 persons per gross square km (Frank and Pivo 1994), was found to correspond with the "elbow" in the model above which the rate of change in bus use from greater density increased, but there was change in bus use from density increases below this level nonetheless.

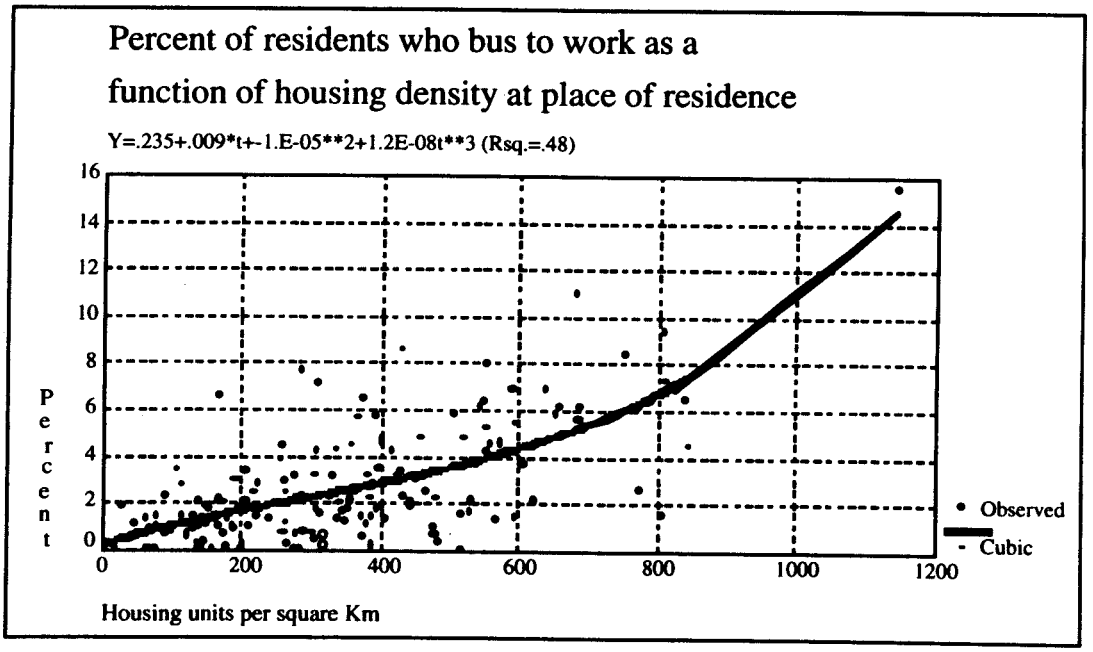


Figure 22. Percent of residents who bus to work as a function of housing density at place of residence

APPLICATION/IMPLEMENTATION

The correlations in this study confirm the findings of the authors and others that density and balance can reduce auto use. Therefore, in order to promote the state's goals of promoting a multimodal transportation system and reducing reliance on driving alone efforts should be made to increase the density and balance of urban areas.

The findings presented here suggest two broad opportunities for reducing auto use. One is to use the information presented here to find increase the density and balance of urban areas which will lead to less auto use. The second is to focus on reducing auto use in communities whose land use characteristics would predict they are fertile grounds for such efforts.

INCREASING DENSITY AND BALANCE

The findings of this report suggest three strategies that could be followed to increase the density and balance of urban areas. One is to increase density and balance in all areas. The second is to emphasize efforts to increase density and balance in those locations where they have been eroding and offsetting gains made elsewhere. The third is to focus on places that should be denser or more balanced given their regional location.

Increase density and balance in all urban areas

Figures 21 and 22 show that small increases in density and balance can contribute to less auto use. Therefore, benefits can be gained from efforts to increase density and balance in all urban areas. Specific measures for doing this have been identified elsewhere (SNO-TRAN 1993, 1994). For the first time, however, this shows that some areas are doing much better than others in moving toward greater balance and density. The experience of these more successful places should be examined more closely to see what lessons they can offer to other communities. Places that have both experienced significant improvement and achieved high levels of density and balance should be examined further, including the suburban cities of Kirkland, Bothell and Des Moines in

King County. In addition, the more compact and complete communities should be rewarded for the contribution they are making to regional mobility, particularly if their long-range planning is consistent with the retention of their more transit-oriented form. Likewise, the less compact and complete communities should be asked to contribute more to solving regional traffic problems because they contribute more to those problems.

Turn around areas that are offsetting gains being made elsewhere

This report shows that if it were not for the density trends of certain places, there would be a significantly greater increase in overall densities. The creation of new low density places, mostly in Pierce, King, Snohomish and Clark counties should be controlled with stable urban growth boundaries designed to discourage new low density places and minimum density standards. Also, the twenty year density decline in some of the state's largest cities (i.e., Seattle, Spokane, Yakima and Vancouver) should be reversed if possible. Fortunately, both Seattle and Vancouver have partially offset the large density losses of the 1970s by gaining density during the past decade. This trend should be encouraged to continue. An examination should be made of regional, county and city plans being adopted under the Growth Management Act to determine whether they are adequately addressing the problem of new low density urban areas and declining large city densities.

The state should take a place-focused approach and carefully examine the jurisdictions whose low density patterns or growing imbalance have offset the gains being made by many other jurisdictions. The largest of these jurisdictions should be given priority because of their relative contribution to overall trends. Tables 32 through 35 indicate places or FAZs that are relatively large and became significantly less dense or balanced between 1970 and 1990. Their plans should be the first to undergo

Table 32. Larger places that lost population density between 1970 and 1990

Place	*1990 Pop.*	*Pop. Density Change, 70-90*
Seattle city	516259	-75.64
Spokane city	177196	-72.40
Yakima city	54827	-128.70
Vancouver city	46380	-79.98
Bremerton city	38142	-650.46
Richland city	32315	-50.09
Edmonds city	30744	-1569.50

Table 33. Larger employment centers that lost job density between 1970 and 1990

FAZ Name	*Jobs, 1990*	*Net Job Density Change, 1970-90*
WEST BREMERTON/CBD	30655	-1038.03
RENTON AIRPORT/CBD	29730	-1072.42

Table 34. Larger FAZs that increased their jobs/housing imbalance between 1970 and 1990

FAZ Name	*Pop. 1990*	*Change in Jobs-Housing Imbalance, 1970-90*
FIRST HILL/BROADWAY	25936	.38
SEA-TAC	27143	.18
KENT CBD/KENT EAST HILL	26863	.19
SOUTH BEACON HILL/COLUMBIA	32304	.20
WEDGEWOOD/VIEW RIDGE	27656	.63
TWIN LAKES	31103	.58

Table 35. Larger FAZs that increased their retail/housing imbalance between 1970 and 1990

FAZ Name	*Jobs, 1990*	*Change in Retail-Housing Imbalance, 1970-90*
SEA-TAC	27143	.21
EAST CAPITOL HILL/CENTRAL AREA	28732	.33
SOUTH BEACON HILL/COLUMBIA	32304	.34
WEDGEWOOD/VIEW RIDGE	27656	.48

examination. In addition to the areas listed in Tables 32 through 35, large low density or imbalanced areas should also be targeted by efforts to change land use patterns. The least compact and complete communities in each county are listed in Appendix 2.

Increase densities and balance where they are significantly lower than would be expected

It is easier to increase density or balance where the market demands it than where the market does not. Therefore, an effective strategy to increase density or balance is to focus such efforts on places that are less dense or balanced than their location would suggest. Chances are that if it were not for locally adopted zoning constraints, these places would be made denser or more balanced by the urban land market. Places of this kind can be identified by preparing and examining maps such as those presented in this report. For example, Map 1 shows population densities and how they decrease with distance from the regional core. It also reveals that some places are much less dense than their location would suggest. These include, for example, parts of southern King County and western Snohomish County. Many of these areas, of course, have reasons for being lower density, which typically is a local desire to maintain a more rural or industrial character. However, somewhat greater densities could be achieved without eliminating these characteristics.

REDUCING AUTO USE WHERE ITS GREATER THAN LAND USE PATTERNS WOULD PREDICT

Consideration should be given to increasing transit use in places that are more auto dependent than their density or balance would suggest. Tables 36 and 37 lists two sets of places falling into this category.

Table 36. Places with over 10,000 population whose bus use to work is significantly less than their housing density would predict

PLACE	*COUNTY*	*1990 Population*	*Residual*
Yakima city	YAKIMA	54827	-3.11240
University Place CDP	PIERCE	27701	-2.98426
Sunnyside city	YAKIMA	11238	-2.74790
Opportunity CDP	SPOKANE	22326	-2.39710
Oak Harbor city	ISLAND	17176	-2.19144
Des Moines city	KING	17283	-1.91313
Lakewood CDP	PIERCE	58412	-1.85905
Marysville city	SNOHOMISH	10328	-1.76689
South Hill CDP	PIERCE	12963	-1.74028
Parkland CDP	PIERCE	20882	-1.44473

Table 37. Places with over 10,000 population where the percentage of residents who work in the city or place where they live is significantly lower than the jobs-housing balance of their community would predict

Place	*County*	*1990 Population*	*Residual*
Kent city	KING	37960	-21.16406
Sea-Tac CDP	KING	22694	-16.87645
Renton city	KING	41688	-15.59499
Redmond city	KING	35800	-15.06286
Bothell city	KING	12345	-14.92750
Lynnwood city	SNOHOMISH	28695	-13.63137

In Table 36, communities are listed whose bus use for work trips is less than their housing density would predict. These are places that fall below the regression line shown in Figure 22. In Table 36, communities are listed with those farthest below the regression line coming first. The "residual" column is a measure of how much less their bus use is than their housing density would predict. Specifically, it is the actual percentage of workers who take the bus to work minus the value predicted by a linear regression equation.[14] For example, the percentage of workers who bus to work in Yakima is 3.1 percent lower than its housing density would predict.

The communities listed in Table 36 may be fertile ground in which to reduce auto use because their densities appear to be consistent with higher transit use than they are currently generating and because they are home to relatively large populations. The key question in each of these cases is what explains their lower than predicted bus use? Perhaps transit levels of service are lower than average for similar types of communities or perhaps the proportion of residents without a drivers license are lower than average. Either of these conditions, as well as others, might explain lower than expected transit use. If transit service levels are lower than normal, then higher use could be expected from better service. If, on the other hand, the lower transit use is due to more people having a drivers license, then greater transit use may be harder to obtain.

Table 37 is similar to Table 36 except it lists communities in which a significantly lower proportion of resident workers are employed where they live than is predicted by their level of jobs-housing balance (see Figure 21). Here again, only places with greater than 10,000 residents are listed and the first ones listed are those that fall farthest below what is expected. The residual column gives the actual difference between the percentage

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[14] The residuals are based on a linear regression equation rather than the non-linear one shown in Figure 22. The linear model had an adjusted R-squared of 0.42 compared to 0.48 for the non-linear model.

REDUCING AUTO USE WHERE ITS GREATER THAN LAND USE PATTERNS WOULD PREDICT

Consideration should be given to increasing transit use in places that are more auto dependent than their density or balance would suggest. Tables 36 and 37 lists two sets of places falling into this category.

Table 36. Places with over 10,000 population whose bus use to work is significantly less than their housing density would predict

PLACE	*COUNTY*	*1990 Population*	*Residual*
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Des Moines city	KING	17283	-1.91313
Lakewood CDP	PIERCE	58412	-1.85905
Marysville city	SNOHOMISH	10328	-1.76689
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Parkland CDP	PIERCE	20882	-1.44473

Table 37. Places with over 10,000 population where the percentage of residents who work in the city or place where they live is significantly lower than the jobs-housing balance of their community would predict

Place	*County*	*1990 Population*	*Residual*
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Sea-Tac CDP	KING	22694	-16.87645
Renton city	KING	41688	-15.59499
Redmond city	KING	35800	-15.06286
Bothell city	KING	12345	-14.92750
Lynnwood city	SNOHOMISH	28695	-13.63137

In Table 36, communities are listed whose bus use for work trips is less than their housing density would predict. These are places that fall below the regression line shown in Figure 22. In Table 36, communities are listed with those farthest below the regression line coming first. The "residual" column is a measure of how much less their bus use is than their housing density would predict. Specifically, it is the actual percentage of workers who take the bus to work minus the value predicted by a linear regression equation.[14] For example, the percentage of workers who bus to work in Yakima is 3.1 percent lower than its housing density would predict.

The communities listed in Table 36 may be fertile ground in which to reduce auto use because their densities appear to be consistent with higher transit use than they are currently generating and because they are home to relatively large populations. The key question in each of these cases is what explains their lower than predicted bus use? Perhaps transit levels of service are lower than average for similar types of communities or perhaps the proportion of residents without a drivers license are lower than average. Either of these conditions, as well as others, might explain lower than expected transit use. If transit service levels are lower than normal, then higher use could be expected from better service. If, on the other hand, the lower transit use is due to more people having a drivers license, then greater transit use may be harder to obtain.

Table 37 is similar to Table 36 except it lists communities in which a significantly lower proportion of resident workers are employed where they live than is predicted by their level of jobs-housing balance (see Figure 21). Here again, only places with greater than 10,000 residents are listed and the first ones listed are those that fall farthest below what is expected. The residual column gives the actual difference between the percentage

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[14] The residuals are based on a linear regression equation rather than the non-linear one shown in Figure 22. The linear model had an adjusted R-squared of 0.42 compared to 0.48 for the non-linear model.

of local workers that hold jobs in the community minus the value predicted by the regression equation.[15]

In these communities, the goal could be to reduce auto use by shortening work trips by increasing the proportion of people employed in the same community. We know less about what motivates people to work where they live than we do about what motivates bus use. This makes it difficult to explain why there is more out-commuting than is predicted. However possible explanations suggested by labor market theory include things such as a lack of information about local job openings and a poor match between the skills required by local jobs and those held by local residents. If these were the causes, less out-commuting might be attained by programs that encourage local firms to hire local workers, give local workers more information about local jobs and incentives to take those jobs, and training programs to match the skills of the local workforce to those demanded by local jobs.

Based on this discussion it is recommended that the following specific steps be taken to implement these strategies:

1. The Department of Transportation should meet with each metropolitan planning organization to discuss the findings in this report and to develop a list of communities and transit service providers in their jurisdiction that might become the focus of efforts to either increase density, increase balance, increase transit use to levels that should be expected given the existing density and balance, or reduce out-commuting to levels that should be expected given existing density and balance.
2. Each metropolitan planning organization should work with the selected communities and transit service providers to discuss their potential for achieving the appropriate objectives. If the objectives are determined to be feasible, then local growth

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[15] As before, the residuals are based on a linear equation rather than the non-linear one used in Figure 21. The R-square value for the linear eqution was 0.51 compared to 0.74 for the non-linear one.

management and transit service programs should be adjusted to incorporate these objectives.

3. The Department of Transportation and the Department of Community, Trade and Economic Development should work with the metropolitan planning organizations to provide technical assistance to local governments and transit service providers in identifying and implementing effective strategies for accomplishing the planning objectives. This should include dissemination of lessons learned from communities that have experienced significant increases in density and balance over the past two decades.

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APPENDIX A

NEW PLACES ESTABLISHED DURING THE 1980s

APPENDIX A

NEW PLACES ESTABLISHED DURING THE 1980s

County	*Place*	*Population*	*Population Density 1990*
Benton	Highland CDP	3656	53.00
	Finley CDP	4897	165.04
Clark	Brush Prairie CDP	2650	130.82
	Felida CDP	3109	429.72
	Walnut Grove CDP	3906	469.13
	Five Corners CDP	6776	729.31
	Salmon Creek CDP	11989	737.10
	Orchards South CDP	12956	844.70
	Ellsworth South CDP	4423	815.75
	Evergreen CDP	11249	955.09
	Vancouver Mall CDP	6938	898.94
	Minnehaha CDP	9661	998.24
	Hazel Dell South CDP	5796	980.88
	Lake Shore CDP	6268	1409.49
	Ellsworth North CDP	5796	1507.02
	Cascade Park West CDP	6656	1506.56
	Cascade Park East CDP	6996	1727.41
King	Covington-Sawyer-Wilderness CDP	24321	462.01
	Lea Hill CDP	6876	469.10
	Woodinville CDP	23654	507.30
	Pine Lake CDP	13940	507.08
	Sahalee CDP	13951	672.21
	East Hill-Meridian CDP	42696	939.82
	Sea-Tac CDP	22694	893.25
	Woodmont Beach CDP	7493	1227.15
	Federal Way CDP	67554	1326.43
	West Lake Sammamish CDP	6087	1623.63

County	*Place*	*Population*	*Population Density 1990*
Kitsap	Bangor Trident Base CDP	3702	488.71
	Manchester CDP	4031	531.58
	Silverdale CDP	7660	550.84
Pierce	Frederickson CDP	3502	176.25
	Artondale CDP	7141	260.81
	Prairie Ridge CDP	8278	377.04
	Waller CDP	6415	392.96
	Elk Plain CDP	12197	411.39
	Edgewood-North Hill CDP	9120	405.55
	Summit CDP	6312	503.67
	North Puyallup CDP	2886	415.43
	South Hill CDP	12963	711.51
	Midland CDP	5587	685.61
	Lakewood CDP	58412	1275.73
Snohomish	Smokey Point CDP	2620	300.87
	West Lake Stevens CDP	12453	416.40
	North Creek-Canyon Park CDP	23236	542.54
	Harbour Pointe CDP	9107	607.25
	Lake Serene-North Lynnwood	14290	948.12
	Mill Creek city	7172	987.88
	Paine Field-Lake Stickney	18670	932.06
Spokane	Trentwood CDP	4060	876.13
	Country Homes CDP	5126	1027.67
Whatcom	Birch Bay CDP	2656	64.12
	Sudden Valley CDP	2615	160.55
Yakima	White Swan CDP	2669	9.94
	West Valley CDP	6594	772.04

APPENDIX B

CCI AND COMPONENT SCORES FOR PLACES BY COUNTY

APPENDIX B

CCI AND COMPONENT SCORES FOR PLACES BY COUNTY

Maximum score for each component is 25; maximum for Index is 100; top 25 have grey background

County	*Place*	*Compact and Complete Index*	*Density*		*Balance*	
			Housing Density	*Employment Density*	*Jobs-Housing*	*Retail-Housing*
BENTON	Prosser city	54.39	3.42	2.53	24.611	23.820
	Kennewick city	53.66	7.21	3.79	21.107	21.548
	Richland city	53.55	3.65	2.77	24.235	22.895
	Finley CDP	30.96	1.32	.21	13.841	15.584
	Wst Richland city	30.74	.63	.08	13.126	16.908
	Highland CDP	27.47	.37	.02	11.643	15.436
	Benton City city	.	3.32		.	.
CLARK	Vancouver city	69.17	12.54	11.82	20.561	24.241
	Cascade Park East CDP	58.88	16.92	4.63	16.063	21.264
	Washougal city	58.06	6.52	4.62	24.737	22.177
	Hazel Dell South CDP	54.90	9.79	5.54	21.902	17.665
	Camas city	51.23	2.85	2.33	23.048	23.007
	Cascade Park West CDP	51.12	13.55	2.29	13.967	21.316
	Vancouver Mall CDP	49.78	8.13	2.25	16.113	23.287
	Hazel Dell North CDP	49.67	9.33	2.53	16.012	21.798
	Ellsworth North CDP	49.31	11.74	4.03	17.447	16.100
	Walnut Grove CDP	48.03	4.04	2.24	21.684	20.059
	Battle Ground city	47.77	4.58	4.00	21.931	17.252
	Orchards South CDP	47.08	6.80	2.56	18.129	19.589
	Minnehaha CDP	46.07	8.45	2.31	16.060	19.257
	Evergreen CDP	42.71	7.56	1.87	15.527	17.761
	Orchards North CDP	42.43	4.93	1.24	15.635	20.612
	Five Corners CDP	41.57	5.22	1.26	15.425	19.666
	Salmon Creek CDP	40.00	6.66	1.16	14.077	18.104
	Lake Shore CDP	39.35	10.38	.93	12.375	15.667
	Ellsworth South CDP	38.08	7.35	.80	12.769	17.159

County	Place	Compact and Complete Index	Density		Balance	
			Housing Density	Employment Density	Jobs-Housing	Retail-Housing
	Brush Prairie CDP	32.45	.99	.14	13.472	17.853
	Felida CDP	30.51	3.15	.15	11.525	15.691
	Ridgefield city	.	4.96		.	.
	Yacolt town	.	3.55		.	.
	La Center town	.	3.22		.	.
	Meadow Glade CDP	.	.89		.	.
FRANKLIN	Pasco city	48.65	2.85	2.30	23.268	20.242
	West Pasco CDP	31.75	3.01	.29	12.501	15.953
	Connell city	.	4.38		.	.
	Kahlotus city	.	1.86		.	.
	Mesa town	.	.52		.	.
ISLAND	Oak Harbor city	55.26	6.89	4.67	24.136	19.573
	Ault Field CDP	37.07	.39	.21	21.037	15.436
	Langley city	.	4.48		.	.
	Coupeville town	.	4.20		.	.
	Clinton CDP	.	1.43		.	.
	Freeland CDP	.	1.21		.	.
KING	Seattle city	93.44	25.03	25.02	19.428	23.965
	Kirkland city	72.90	14.22	10.37	24.839	23.471
	Richmond Highlands CDP	65.57	17.62	6.32	17.761	23.869
	Des Moines city	65.26	18.44	7.13	18.323	21.359
	Burien CDP	65.23	15.00	6.49	19.242	24.491
	Federal Way CDP	63.51	12.04	6.08	20.685	24.705
	Bothell city	60.29	8.16	7.44	21.180	23.507
	Sea-Tac CDP	59.08	8.76	7.68	21.872	20.764
	Renton city	57.96	9.99	13.59	12.214	22.173
	Bellevue city	57.75	11.95	14.87	14.530	16.393
	North City-Ridgecrest CDP	56.23	16.39	4.80	16.443	18.595
	Enumclaw city	55.00	6.78	4.39	23.537	20.292
	White Center-Shorewood CDP	54.64	17.68	3.14	14.135	19.682
	Kenmore CDP	54.64	9.37	3.55	18.153	23.563
	Redmond city	54.50	8.74	10.89	14.500	20.363

County	Place	Compact and Complete Index	Density		Balance	
			Housing Density	Employment Density	Jobs-Housing	Retail-Housing
	Mercer Island city	52.83	10.99	4.33	18.470	19.039
	Kingsgate CDP	52.74	12.07	3.57	16.507	20.583
	Riverton-Boulevard Park CDP	52.67	13.38	3.91	16.424	18.957
	Sheridan Beach CDP	51.60	14.85	3.38	15.146	18.217
	Newport Hills CDP	50.77	8.54	2.52	16.479	23.230
	Lake Forest Park city	50.60	11.82	2.85	15.409	20.519
	Auburn city	50.20	5.98	7.07	15.775	21.370
	Woodmont Beach CDP	49.32	11.29	1.86	13.879	22.297
	Eastgate CDP	48.44	12.14	3.00	15.529	17.773
	Kent city	47.82	7.79	11.49	9.918	18.620
	Duvall city	47.77	5.95	2.29	18.262	21.270
	Lake Forest North CDP	46.88	12.98	2.00	13.667	18.230
	Woodinville CDP	45.62	3.63	1.50	18.845	21.652
	Bryn Mawr-Skyway CDP	45.53	13.91	1.53	12.794	17.293
	West Lake Sammamish CDP	44.83	12.46	1.09	12.343	18.933
	Medina city	43.94	6.90	2.00	16.390	18.647
	Clyde Hill town	43.11	8.69	1.74	14.583	18.098
	Normandy Park city	42.88	9.25	1.37	13.548	18.705
	Cascade-Fairwood CDP	42.22	10.17	1.16	12.861	18.035
	Pacific city	41.77	7.76	1.70	14.966	17.339
	North Bend city	41.61	3.17	2.32	24.766	11.356
	North Hill CDP	41.44	12.67	.95	12.087	15.737
	Lakeland North CDP	41.19	6.10	1.66	16.036	17.390
	Inglewood-Finn Hill CDP	40.97	9.66	1.29	13.264	16.757
	Richmond Beach-Innis Arden	39.55	7.33	1.44	14.522	16.261
	East Hill-Meridian CDP	36.79	7.10	.77	12.760	16.158
	Issaquah city	35.62	5.55	7.17	13.566	9.331
	East Renton Highlands CDP	35.39	3.77	.53	13.407	17.684
	Lea Hill CDP	34.97	3.48	.68	14.522	16.290
	Sahalee CDP	33.82	4.83	.45	12.445	16.092
	Pine Lake CDP	33.77	4.13	.49	12.958	16.194
	Lakeland South CDP	32.84	4.85	.31	11.848	15.831
	Covington-Sawyer-Wildernes	30.39	3.38	.10	11.205	15.702

County	Place	Compact and Complete Index	Density		Balance	
			Housing Density	Employment Density	Jobs-Housing	Retail-Housing
SNOHOMISH	Edmonds city	67.29	14.95	7.68	20.861	23.802
	Snohomish city	59.42	10.44	9.66	20.910	18.402
	Mountlake Terrace city	59.36	16.77	5.82	17.530	19.236
	Everett city	56.73	8.69	10.78	14.615	22.647
	Lake Stevens city	54.61	6.14	3.11	20.703	24.655
	Mill Creek city	54.41	9.42	3.51	18.044	23.440
	Lynnwood city	53.20	14.37	15.02	18.508	5.303
	Marysville city	52.37	8.27	6.86	22.843	14.389
	Esperance CDP	51.33	18.34	2.58	13.399	17.013
	Mukilteo city	48.74	8.68	3.03	17.572	19.460
	Paine Field-Lake Stickney	45.90	9.44	2.46	15.810	18.193
	Harbour Pointe CDP	42.88	4.47	2.12	20.084	16.201
	Martha Lake CDP	41.26	6.64	1.82	16.072	16.731
	Alderwood Manor-Bothell No	41.21	8.59	1.45	13.964	17.207
	Lake Serene-North Lynnwood	40.84	8.56	1.20	13.404	17.677
	North Creek-Canyon Park CD	39.22	4.07	1.23	16.643	17.272
	Monroe city	38.62	3.77	4.61	14.947	15.296
	Brier city	37.57	7.29	.94	13.171	16.165
	Silver Lake-Fircrest CDP	32.95	4.73	.32	11.955	15.948
	West Lake Stevens CDP	32.52	3.22	.42	13.207	15.667
	Smokey Point CDP	31.74	2.60	.23	12.326	16.588
	Arlington city	31.07	2.45	3.65	9.581	15.386
	North Marysville CDP	30.29	3.62	.08	11.006	15.592
	Gold Bar town	.	6.15		.	.
	Granite Falls town	.	5.53		.	.
	Darrington town	.	4.77		.	.
	Stanwood city	.	4.36		.	.
	Tulalip Bay CDP	.	3.54		.	.
	Index town	.	3.40		.	.
	Sultan town	.	2.97		.	.
	Priest Point CDP	.	2.77		.	.
	Weallup Lake CDP	.	2.45		.	.
	Woodway city	.	2.44		.	.

County	Place	Compact and Complete Index	Density		Balance	
			Housing Density	Employment Density	Jobs-Housing	Retail-Housing
	Lake Goodwin CDP	.	2.42		.	.
	Cathan CDP	.	.67		.	.
	Stimson Crossing CDP	.	.50		.	.
	Shaker Church CDP	.	.35		.	.
	John Sam Lake CDP	.	.28		.	.
SP0KANE	Spokane city	68.96	12.04	8.45	24.618	23.846
	Cheney city	62.08	8.85	5.86	23.813	23.553
	Dishman CDP	56.00	10.49	4.93	19.988	20.587
	Town and Country CDP	55.40	11.52	5.06	19.369	19.458
	Opportunity CDP	53.69	11.24	3.26	16.389	22.800
	Trentwood CDP	51.16	6.92	4.14	22.552	17.547
	Country Homes CDP	47.72	8.41	3.02	17.764	18.523
	Veradale CDP	45.99	7.44	1.80	15.415	21.336
	Medical Lake city	43.31	2.97	3.35	16.818	20.179
	Green Acres CDP	39.03	4.51	1.13	15.607	17.781
	Fairwood CDP	34.32	4.48	.57	13.153	16.114
	Otis Orchards-East Farms CDP	31.70	2.20	.24	12.735	16.523
	Fairchild AFB CDP	25.88	1.64	3.24	.000	20.994
	Millwood town	.	9.51		.	.
	Liberty Lake CDP	.	3.31		.	.
	Spangle city	.	3.18		.	.
	Fairfield town	.	2.78		.	.
	Rockford town	.	2.27		.	.
	Latah town	.	1.86		.	.
	Airway Heights city	.	1.62		.	.
	Deer Park city	.	1.27		.	.
	Waverly town	.	.32		.	.
THURSTON	Lacey city	56.71	6.74	4.55	24.073	21.354
	Tumwater city	53.85	3.90	3.35	22.236	24.365
	Tanglewilde-Thompson Place	50.51	11.09	2.91	15.829	20.686
	Olympia city	49.56	8.32	11.41	12.002	17.826
	Tenino town	.	5.48		.	.

County	Place	Compact and Complete Index	Density		Balance	
			Housing Density	Employment Density	Jobs-Housing	Retail-Housing
	Bucoda town	.	4.03		.	.
	Yelm town	.	3.21		.	.
	Rainier town	.	1.99		.	.
	North Yelm CDP	.	1.95		.	.
	Rochester CDP	.	1.66		.	.
	Grand Mound CDP	.	1.44		.	.
	Nisqually Indian Community	.	.53		.	.
WHATCOM	Lynden city	56.99	6.63	5.09	24.072	21.201
	Ferndale city	54.64	3.82	2.66	24.524	23.629
	Bellingham city	54.21	8.47	7.51	21.679	16.548
	Marietta-Alderwood CDP	43.62	1.62	.87	21.365	19.763
	Birch Bay CDP	30.34	1.41	.10	11.977	16.856
	Sudden Valley CDP	28.55	1.92	.05	11.145	15.436
	Everson city	.	4.30		.	.
	Sumas city	.	3.07		.	.
	Blaine city	.	2.85		.	.
	Nooksack city	.	2.50		.	.
YAKIMA	Yakima city	68.99	12.95	10.24	23.602	22.203
	Toppenish city	67.52	10.58	8.33	23.669	24.938
	Wapato city	66.64	11.26	9.90	21.843	23.637
	Sunnyside city	61.21	8.43	5.70	24.120	22.962
	Selah city	56.78	5.99	4.83	23.298	22.663
	South Broadway CDP	50.44	9.06	2.92	17.036	21.418
	Fairview-Sumach CDP	49.86	6.71	2.30	17.438	23.420
	Fruitvale CDP	48.22	7.56	3.08	18.729	18.849
	Grandview city	46.58	4.32	1.89	19.330	21.035
	West Valley CDP	37.50	6.06	1.03	13.975	16.445
	White Swan CDP	34.36	.06	.02	15.892	18.388
	Terrace Heights CDP	33.79	3.80	.54	13.409	16.042
	Union Gap city	.	2.93		8.798	.
	Mabton town	.	8.27		.	.
	Naches town	.	6.06		.	.

County	*Place*	*Compact and Complete Index*	*Density*		*Balance*	
			Housing Density	*Employment Density*	*Jobs-Housing*	*Retail-Housing*
	Zillah city	.	5.38		.	.
	Tieton town	.	4.95		.	.
	Granger town	.	4.70		.	.
	Harrah town	.	4.00		.	.
	Moxee city	.	2.70		.	.
	Satus CDP	.	.03		.	.