The Elusive Connection between Density and Transit Use

Abstract:

The connection between density and transportation is heralded by planners, yet results are often elusive. This paper analyzes two regions, San Diego and Portland, in order to further understand how density affects travel. San Diego and Portland were chosen for their many similarities. Density is analyzed in several ways over several scales. Transportation statistics are evaluated in order to see the extent to which alternatives to single occupancy vehicles are used and additional aspects of the transportation system that could affect these results. The results are almost as complicated as the question; the San Diego region is denser than the Portland region, yet more people ride transit in the Portland region. When the densities are analyzed in the city level, we see a shift and the City of Portland has more people per square mile. The concluding explanation is that the central city's physical features may be the determining factor in transit use over the entire region.

Purpose:

As traffic continues to worsen in regions throughout the United States, planners have tried to find solutions to the trend. Congestion is increasing in cities of all sizes, and as congestion worsens, the cost of congestion increases. Between 1982 and 2005, the

average auto user saw an increase in yearly delay from 14 hours to 38 hours[1]. The total cost attributed to this delay has increased from $16.2 billion to $78.2 billion increasing more than twice as quickly as delay itself. The authors of the study that found these results have suggested several options to decrease this growing cost one being an increase in Public Transit use. The authors detail these suggestions in Figure 1. Public transit in the United States currently saves Americans over 10 billion dollars every year in reduced congestion by removing vehicles from the road. An increase in Public Transit use, would then suggest a decrease in delay and the total cost to society attributed to congestion.

Exhibit 3. National Congestion Measures, 1982 to 2005

						Hours Saved (million hours)		Gallons Saved (million gallons)		Dollars Saved (billions of 2005$)	
Year	TTI	Delay per Traveler (hours)	Total Delay (billion hours)	Total Fuel Wasted (billion gallons)	Total Cost ($2005 billion)	Operational Treatments & High-Occupancy Vehicle Lanes	Public Transp	Operational Treatments & High-Occupancy Vehicle Lanes	Public Transp	Operational Treatments & High-Occupancy Vehicle Lanes	Public Transp
1982	1.09	14	0.8	0.5	16.2		255		151		4.9
1983	1.09	15	0.9	0.5	16.2		259		154		5.0
1984	1.10	16	1.0	0.6	17.7		266		160		5.0
1985	1.11	18	1.1	0.7	20.5		280		169		5.3
1986	1.13	21	1.3	0.8	23.1		268		167		5.0
1987	1.14	22	1.4	0.9	25.8		277		173		5.1
1988	1.16	25	1.7	1.1	29.7		342		212		6.3
1989	1.17	27	1.8	1.2	32.9		363		227		6.7
1990	1.18	27	1.9	1.3	35.5		367		232		6.9
1991	1.18	28	2.0	1.3	35.8		366		233		6.8
1992	1.18	29	2.1	1.4	38.0		367		233		6.8
1993	1.18	30	2.2	1.5	40.1		367		232		6.8
1994	1.18	30	2.3	1.5	41.9		381		240		7.0
1995	1.19	31	2.5	1.7	45.4		396		251		7.4
1996	1.20	33	2.7	1.8	48.5		403		258		7.5
1997	1.21	34	2.8	1.9	51.3		421		269		7.8
1998	1.22	34	3.0	2.0	53.2		447		285		8.2
1999	1.23	35	3.2	2.1	57.2		471		304		8.7
2000	1.22	34	3.2	2.2	57.6	175	497	92	311	3.2	9.1
2001	1.23	35	3.3	2.3	60.4	197	517	104	325	3.6	9.5
2002	1.24	35	3.5	2.4	63.9	220	520	116	326	4.0	9.5
2003	1.24	36	3.7	2.5	67.2	247	508	130	319	4.5	9.3
2004	1.25	37	4.0	2.7	73.1	270	543	140	340	5.0	10.1
2005	1.26	38	4.2	2.9	78.2	292	541	147	340	5.4	10.2

Note: For more congestion information see Table 1 to 8 and http://mobility.tamu.edu/ums

Figure 1

Increasing public transit use is more complex than simply increasing transit service or funding. Many researchers believe that the current design of our physical environment precludes citizens from using transit or other alternatives to the automobile. Authors increasingly discuss how density is needed to reduce automobile dependence. An

[1] Lomax, Tim and David Schrank. "The 2007 Urban Mobility Report." Texas Transportation Institute, The Texas A&M University System. http://mobility.tamu.edu September 2007, p. 3

article written by several academics at the University of Waterloo details several researchers' work and results used to link increased density to increased transit use[2]. They find that an increase in transit use because of density is rarely seen, unless density is situated properly adjacent to high quality transit routes. In Figure 2 we can see that the authors found many areas with high density and low levels of walking, and other areas where transit service was good, but little density was present.

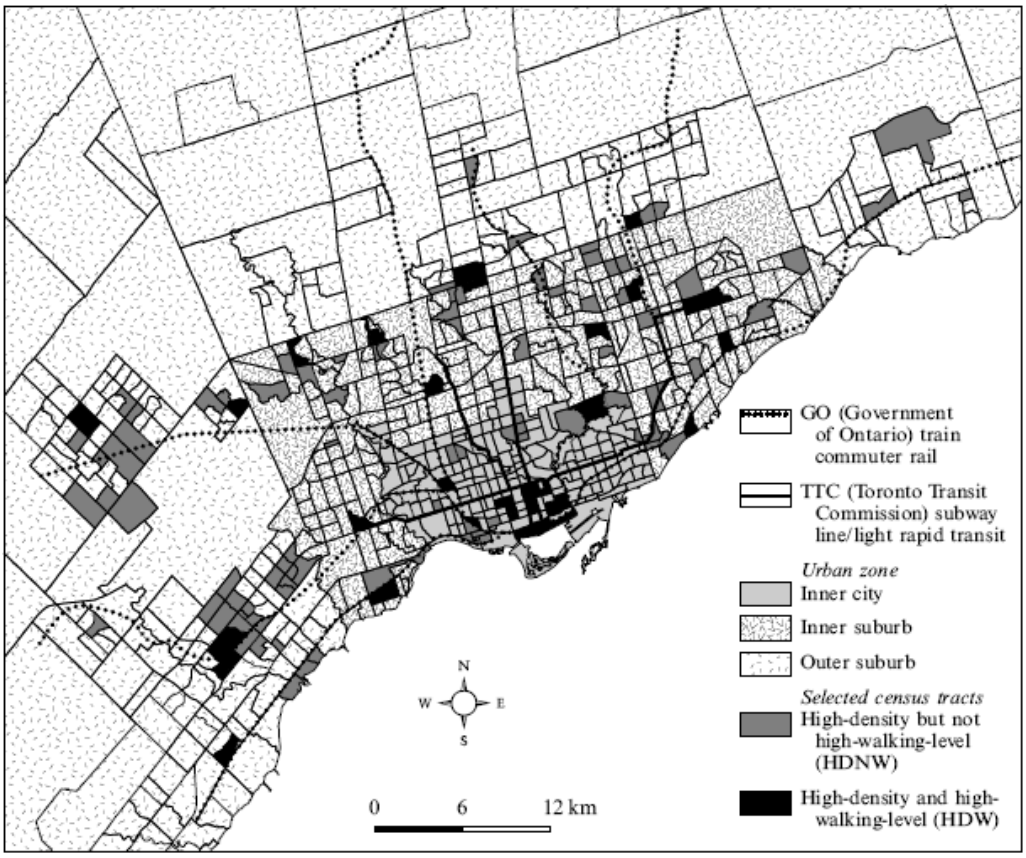

Figure 2 Distribution of high-density but not high-walking-level census tracts (HDNW) and high-density and high-walking-level tracts (HDW), Toronto Metropolitan region.

In response to the mismatch between density and transit use, many cities and regions have embarked on combining transportation and land-use planning. San Diego and Portland both have embarked on ambitious transit oriented development growth

[2] Appleby, Brad; Pierre Filion and Kathleen McSpurren. "Wasted density? The impact of Toronoto's residential density distribution polices on public-transit use and walking." *Environment and Planning A* 2006, Volume 38, pages 1367-1392.

pattern based plans. In Portland, the region wide plan is called the "2040 Growth Concept" and it details areas for growth and the transportation that will serve them. This plan was adopted in 1995 by Metro, a locally elected regional government[3]. San Diego has adopted a similar map in 2006 called the "Smart Growth Concepts."[4] Both of these maps identify areas in which higher intensity development should occur. They also identify existing and future transit routes to show that these areas will have transit access. The resulting multi-centric region will have a hierarchy of centers, allowing for many activities to take place in each center, while also providing for adequate transportation between locations. One of the reasons for such an elaborate plan is to encourage transit use by increasing density in appropriate areas. This in and of itself shows a higher understanding of how density and transportation interact.

The main purpose of this paper is to take a look at these two regions as a whole to understand whether density today has had an affect on alternative transportation use. By determining whether density has been successful in reducing auto use and subsequently congestion, we will have a better understanding of whether density as it is currently conceived has a positive affect on travel patterns. We must keep in mind throughout this analysis that density is more complex than will be represented here. Density can affect travel in several different ways, by reducing trip length and increasing congestion, both of which make alternatives more attractive.[5]

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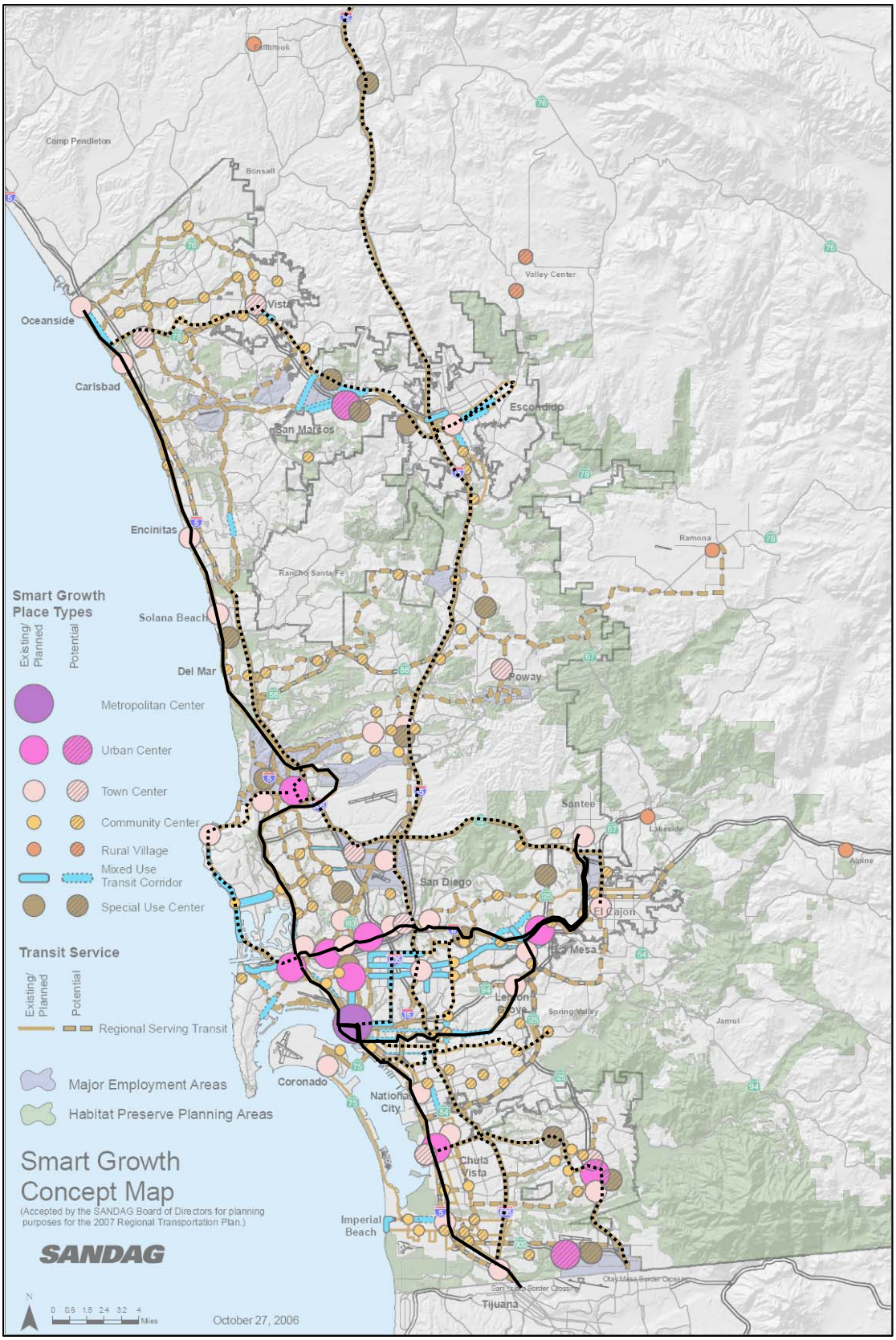
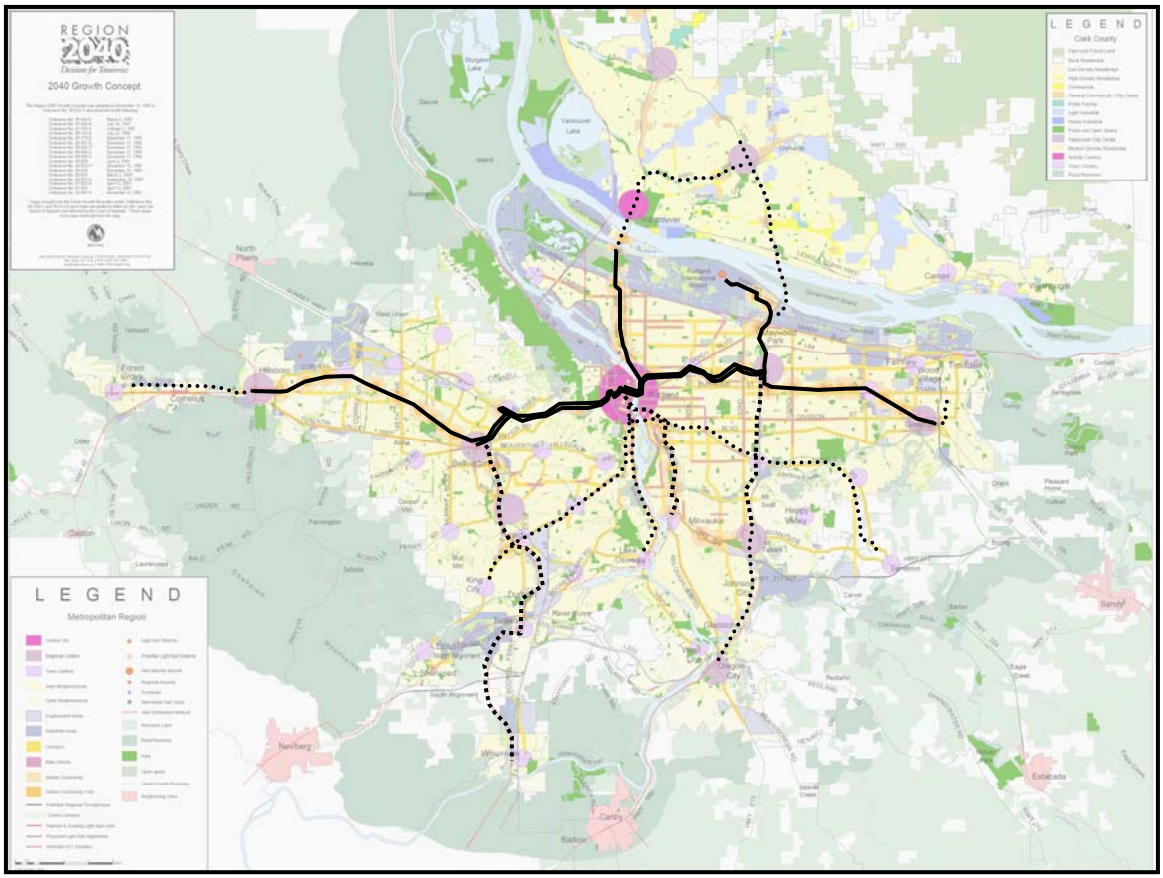
[3] The Region 2040 Growth Concept was adopted on December 14, 1995 in Ordinance No. 95-625-A www.metro-region.org

[4] http://www.sandag.org/index.asp?projectid=296&fuseaction=projects.detail

[5] Boarnet, Marlon and Randall Crane. Travel by Design: The influence of urban form on travel. Oxford University Press, New York. 2001 p. 68



San Diego's Smart Growth Concept with existing and proposed Transit overlaid



Portland's 2040 Concept with existing and proposed Transit overlaid

Analysis:

San Diego and Portland were chosen as they both are west coast cities, first adopters of light rail, constrained by terrain, and they both have almost identical high capacity transit in terms of miles. Portland operates a light rail system of 94.1 miles while San Diego has a light rail system of 96.6[6]. Both are currently expanding. We can see the comparison of these two systems in Figure 3 and Figure 4. These similar transit systems allow us to feel comfortable comparing the two regions without worrying that the difference in results is attributed to the disparity between transit services.

Figure 3 San Diego Light Rail System

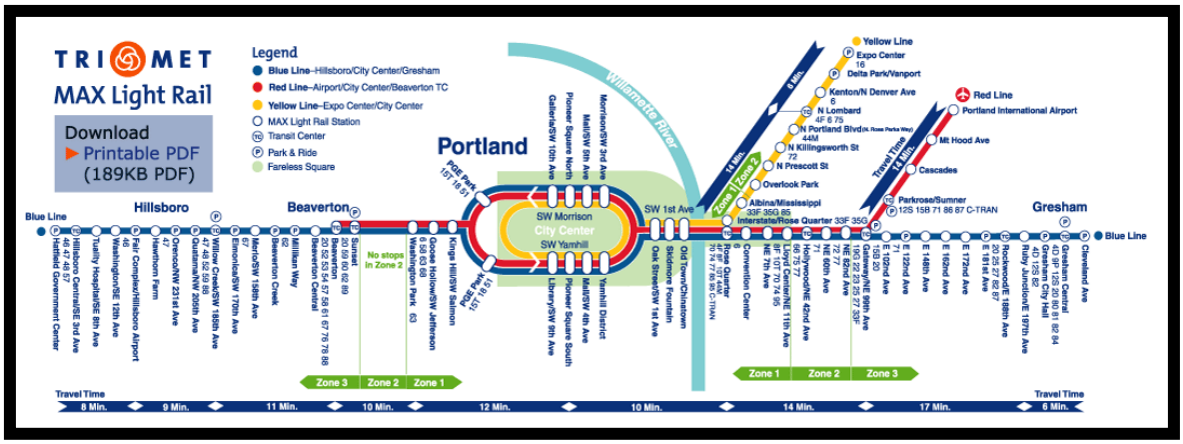


Figure 4 Portland Light Rail System

[6] National Transit Database. www.ntdprogram.com/

In this paper density will be analyzed in two ways, population per square mile and by building type. These values are analyzed at the regional and city level in order to understand the density of the region. To start we will look at the densities of the entire regions. The values are based on the total number of people living in the "Urbanized Area" of the metropolitan regions divided by the number of square miles in those urbanized areas. By using the "Urbanized Area" density we are able to control for different jurisdictional sizes in the regions, giving us a higher quality density rating. In Figure 5 we can see that the densities for these regions are very comparable, with metropolitan San Diego having around 80 more people per square mile than metropolitan Portland. From this we would assume that more people in the San Diego region will ride transit.

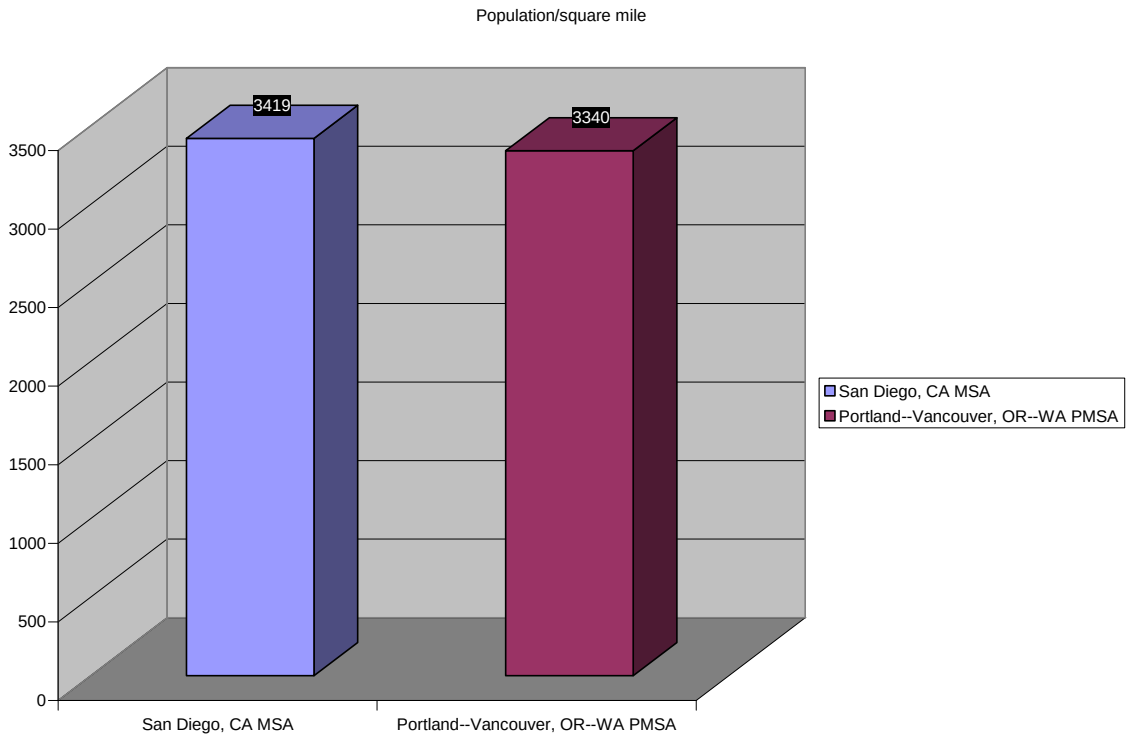


Figure 5 Metropolitan Density Comparison (2000 Census Urbanized area density)

Beyond simply population/square mile, I wanted to look at the housing types found in these Regions. The idea is that multi-unit buildings provide for more concentrated density that may be more appropriate for Transit Oriented Development. We can see the analysis of the housing stock in 2000 in Figure 6. The important figure in this chart is the percentage of housing units in single family detached structures, as these housing types are often disregarded when planning Transit Oriented Development. Again, we see that metropolitan San Diego has a higher percentage of units in multi-unit buildings, while Portland has over 60% of their units in single family detached structures.

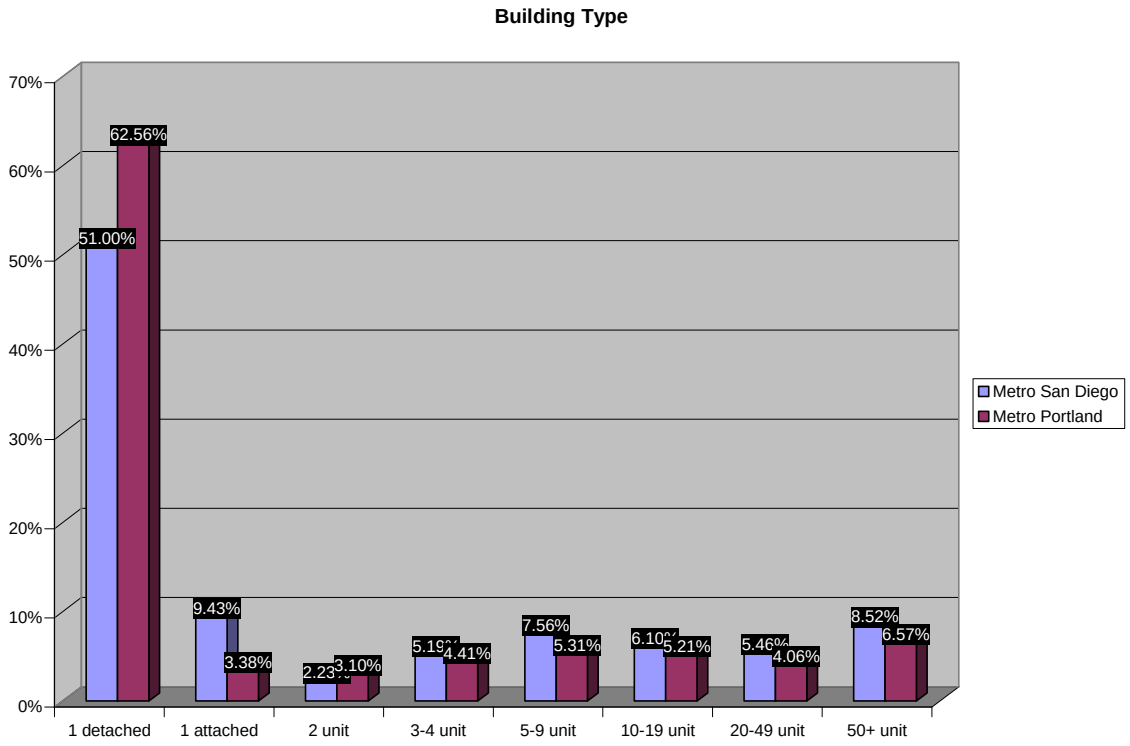


Figure 6 Metropolitan Housing Type Comparison (2000 Census)

We can see that over fifty percent of the housing units in both regions are detached single family units. San Diego again has slightly more multi-unit structures, leading us to

assume that we will see a lower percentage of commuters driving in single occupancy vehicles.

Now that we understand the cumulative density information for these regions, we can analyze travel patterns and see if they match the expected results of San Diego having a higher percentage of workers traveling by alternatives to single occupancy vehicles. In Figure 7 we look at region wide commuting habits for both metropolitan San Diego and Portland.

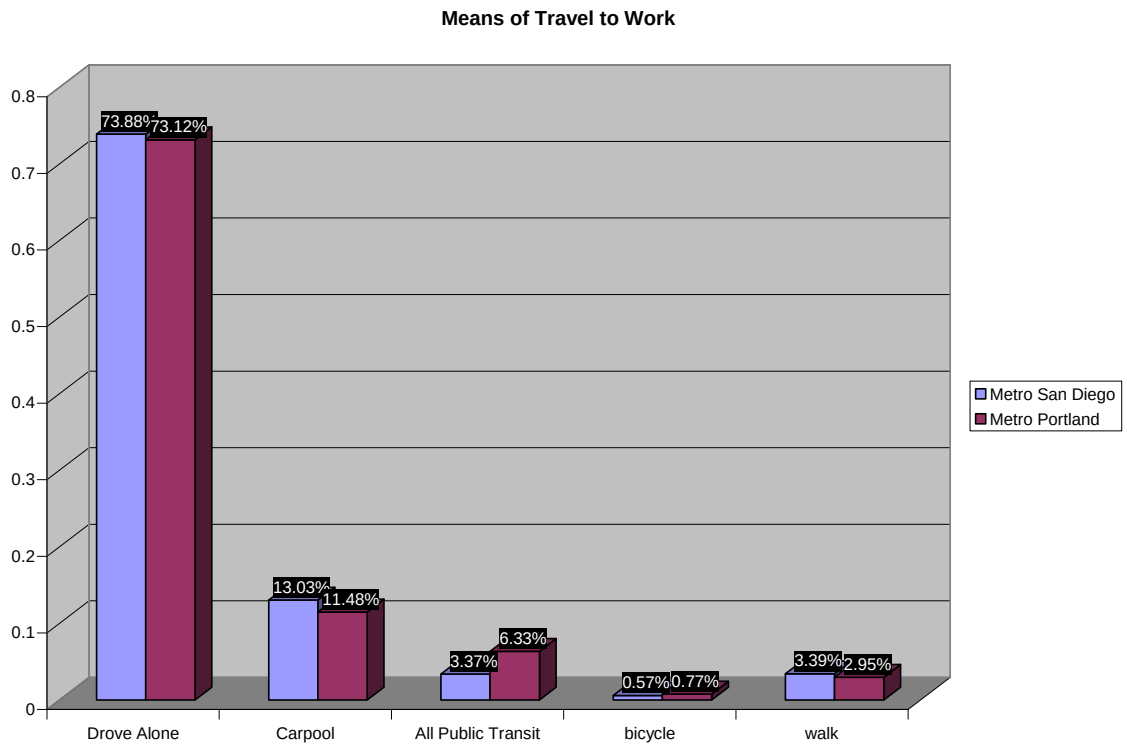


Figure 7 Means of Travel to Work (2000 Census)

The results found in this graph are unexpected. We see that travel patterns are almost identical, with Portland actually having fewer people traveling by single occupant vehicle. Transit in metropolitan Portland carries almost twice the percentage of people as in San Diego, even though San Diego has had a light rail system longer, is denser, and

has a higher percentage of units in multi-unit structures that Portland. From this we can see that density is not the only important factor in determining transit use.

In the next section I wanted to determine if the policies put in place by Metropolitan Portland in 1995 through the 2040 Concept map have made a difference. To understand if Portland has grown more transit friendly over the years, I will analyze new building types over the years and transit use in 2006. We will again compare these values to metropolitan San Diego to see if this approach toward land use planning has increased transit use in Portland while showing no changes in San Diego.

In Figure 8 and 9 we can see that new housing construction types in Portland and San Diego differ immensely from 1995-2006. In Portland, fewer than 50% of new housing units constructed were single family units in seven of the eleven years detailed. In San Diego the majority of new housing units constructed every year were single family units. The trend, however, in San Diego is downward sloping, perhaps indicating the shift in land use priorities in the region over the last 10 years. In the Portland region, an emphasis has been placed on high density residential for a longer period of time, perhaps explaining the higher percentage of attached units being constructed.

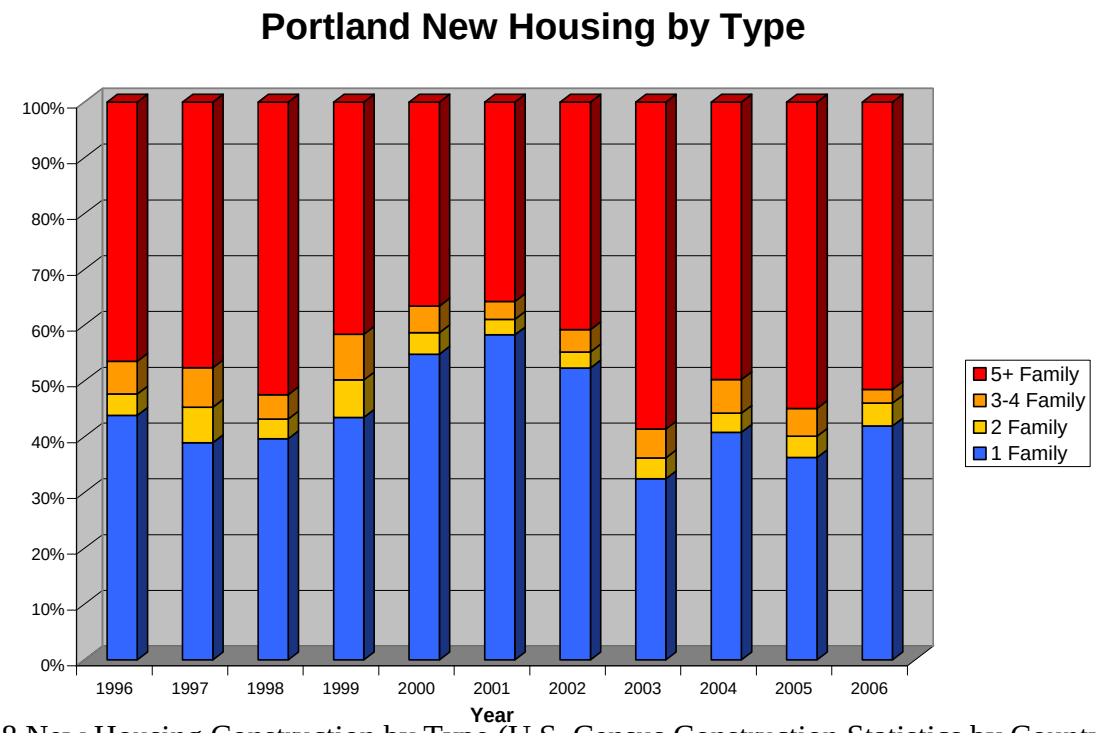


Figure 8 New Housing Construction by Type (U.S. Census Construction Statistics by County)

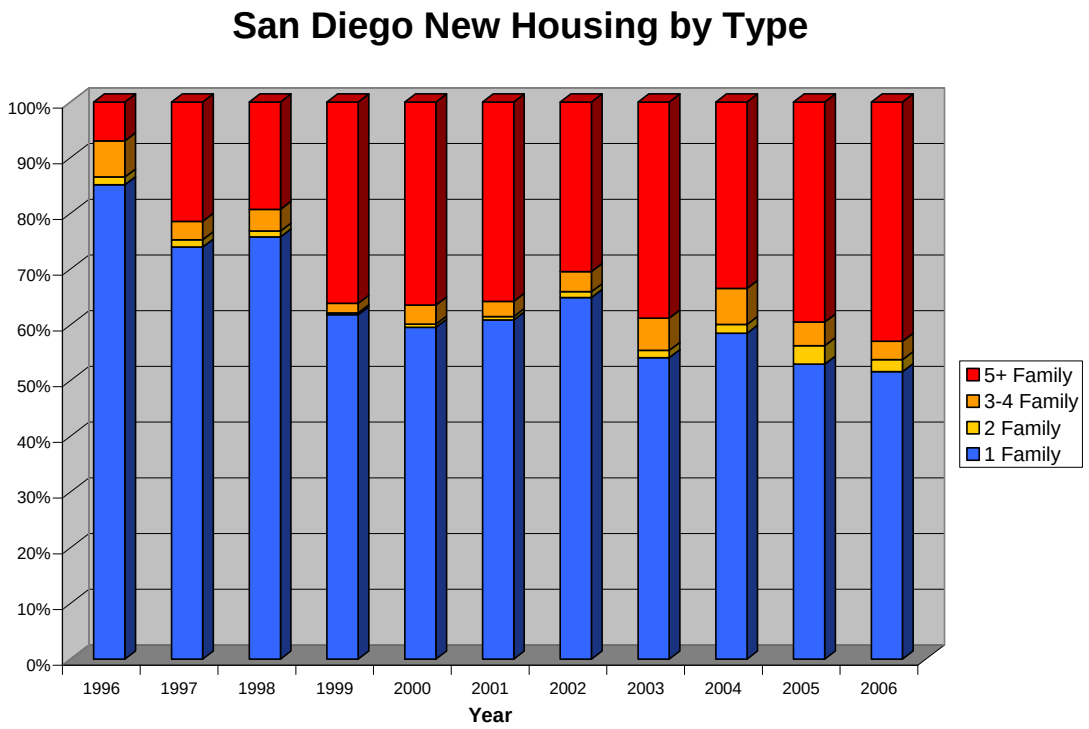


Figure 9 New Housing Construction by Type (U.S. Census Construction Statistics by County)

The second area of interest is transportation use. In order to understand whether the 2040 Concept has led to greater transportation use, it is important to see an increase in the use of alternatives to get to work in the Portland region, while seeing no increase for metropolitan San Diego's use of alternative transportation options. In Figure 10 we see a similar result to Figure 7; however, there is an increase in the percentage of workers in Portland traveling by alternative means. While the decrease in driving alone is only around 2% for Portland, San Diego actually saw an increase in the percentage of commuters driving alone. While the percentage of workers commuting by transit has not increased substantially, there were significant gains in workers bicycling to work in 2006 in Portland.

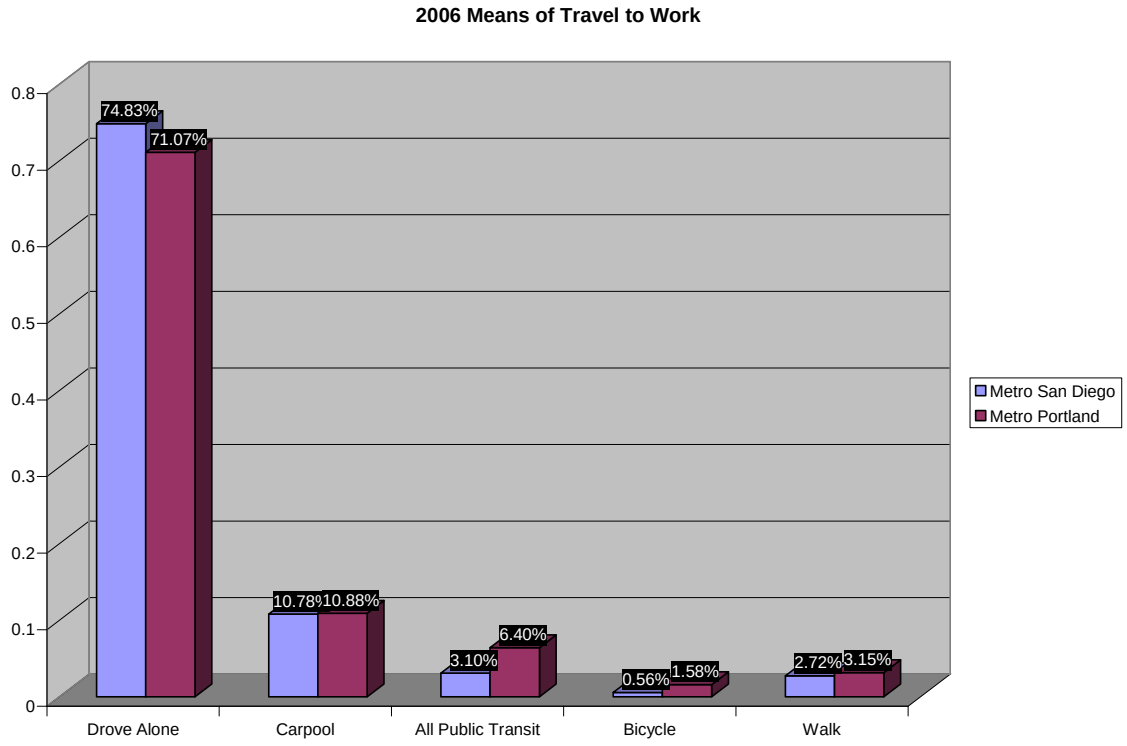


Figure 10 Means of Travel to Work (2006 Census Estimate)

This graph shows that over the course of 6 years, the Portland region has increased its use of sustainable transportation options, while the San Diego region has seen a decrease in alternative transportation use.

Now that we understand that density alone may not determine transit use, and that results at the regional level are either inverse of what we would expect or inconclusive, I would like to analyze two potential explanations for our inability to see a relationship between density and transit use in these regions. The first explanation I would like to explore is that while the transit networks are similar, travel patterns differ to the point where transit is amore attractive option in the Portland region, compared to the San Diego region. The second possible explanation is that the region's transit use follows characteristics of its central city. As most transit systems are based on a central business district and branch like a tree, perhaps the understanding of the physical attributes of the central city better explain transit use than the attributes of the region.

To determine whether travel patterns explain the disparity in results from the first section, I will analyze trip length to work. Time is one of life's most valuable resources, and if it takes a long time to travel to work on transit, people are less likely to use it. In Figures 11 and 12 we will be able to compare the percentage of people traveling to work in a reasonable amount of time by the mode they are using. We can see that in both charts, a higher percentage of workers in the Portland region travel to work in a more reasonable amount of time than in San Diego. The distinction is most striking in Figure 12, where we can see that only 22% of commuters riding transit in Portland have to travel more than 60 minutes, while over 37% in San Diego have this lengthy of a commute.

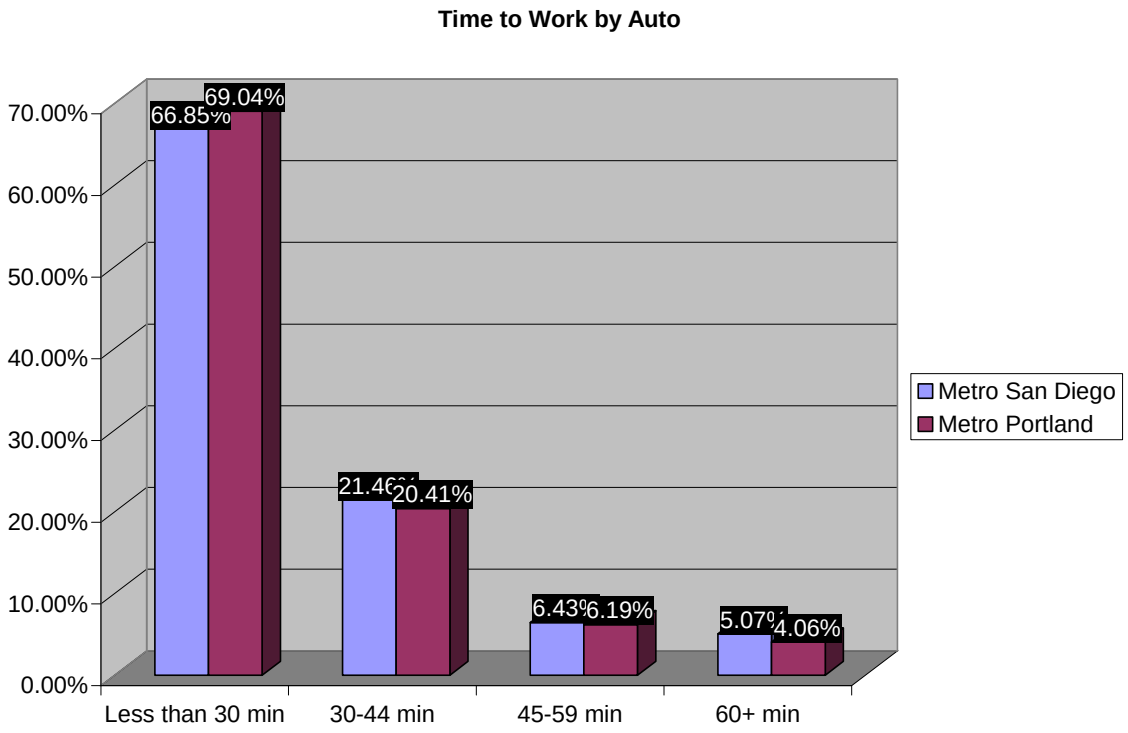


Figure 11 Travel time to Work by Auto (2000 Census)

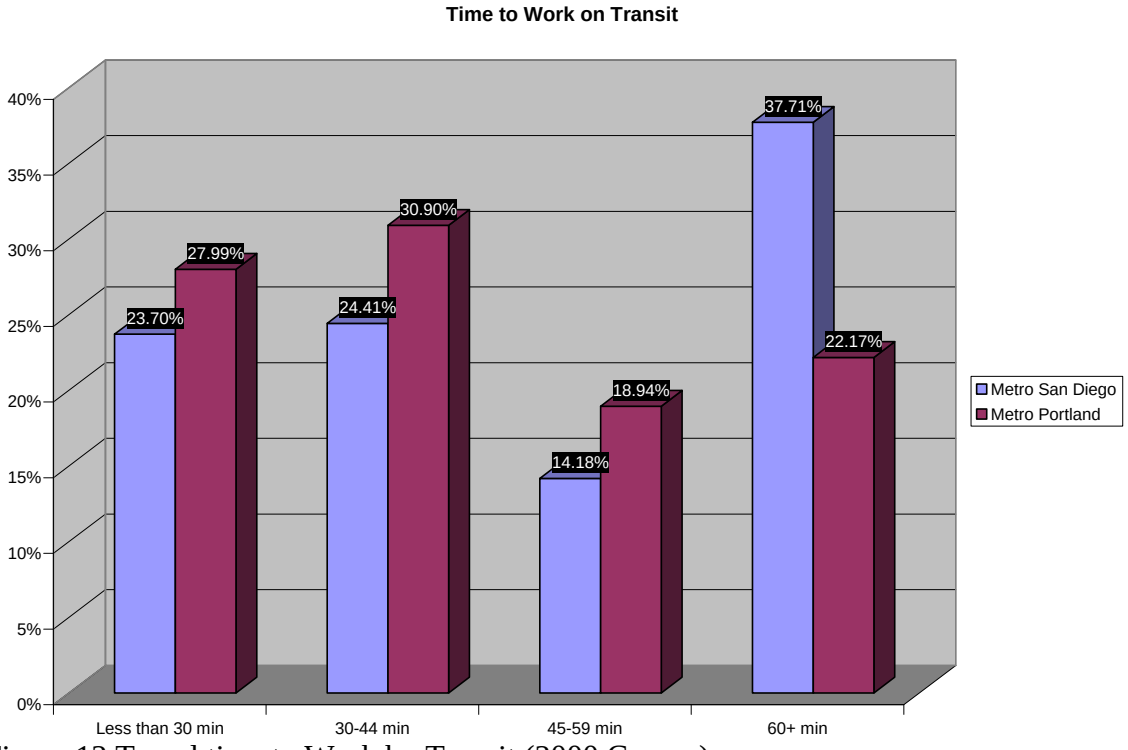


Figure 12 Travel time to Work by Transit (2000 Census)

From this analysis we can see that transit is much more attractive to Portlanders because it tends to take less time to travel to work than it does in San Diego. It is also important to notice that even with much better travel times in Portland compared to San Diego, transit still has little ability to compete with the speed of the automobile. These results help explain the lack of correlation between density and transit use in my first analysis, as transit is more convenient in Portland than San Diego. It appears that San Diego might be experiencing "wasted density" similar to that found in Toronto and described by Appleby and company.

The second possible explanation is that the central city of a region is the most important piece in terms of transit use. By analyzing the density of the central city, perhaps we will see a better correlation between transit use and density. To see if this concept is sound, let us first take a look at whether we see a difference in correlation between regions and central cities for the 25 largest regions in America. In Figures 13 and 14 we can see the correlation between density and the percent of commuters who drove to work alone. We expect to see a downward sloping curve. My assumption that central cities are the true determinate in transit use appears correct. The points on the graph representing regions appear to be scattered and the linier relationship between Single Occupancy commuting and density has an R^2 value of .196, meaning there appears to be no relationship. When we look at the central cities data, however we see a strong downward sloping linear correlation with an R^2 value of .788 (R^2 value over .5 tend to be considered significant.) This means that we are likely to see a positive relationship between density and transit use at the city scale.

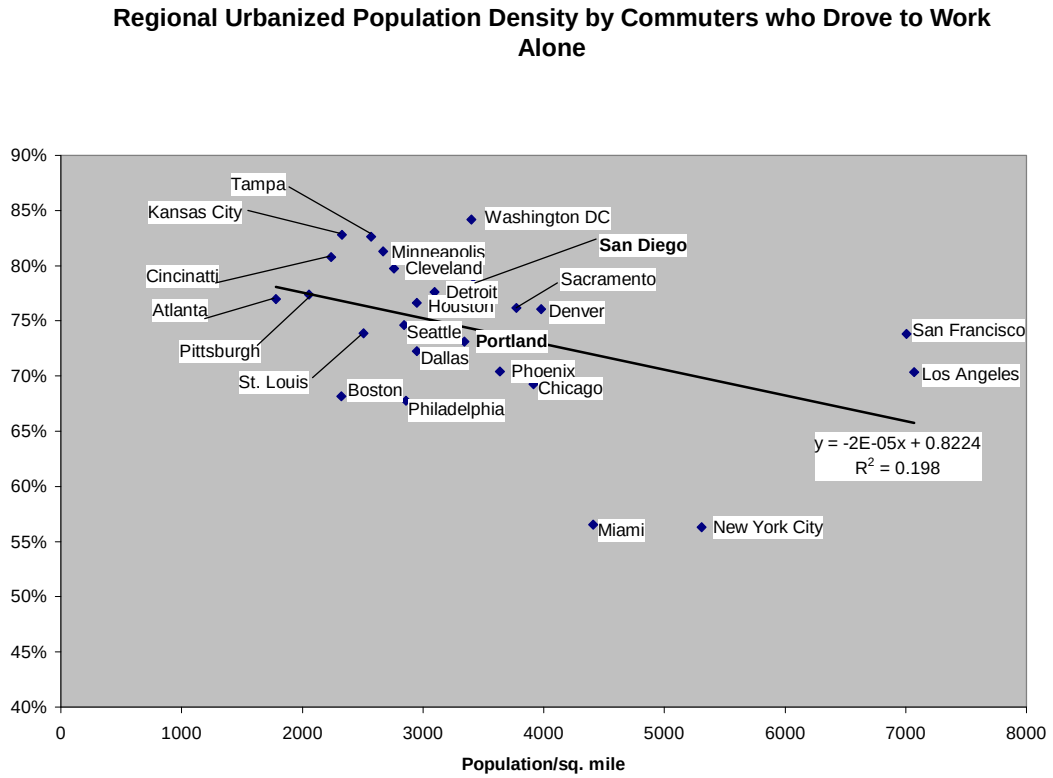


Figure 13 Correlation between density and S.O.V. commuting: REGION (2000 Census)

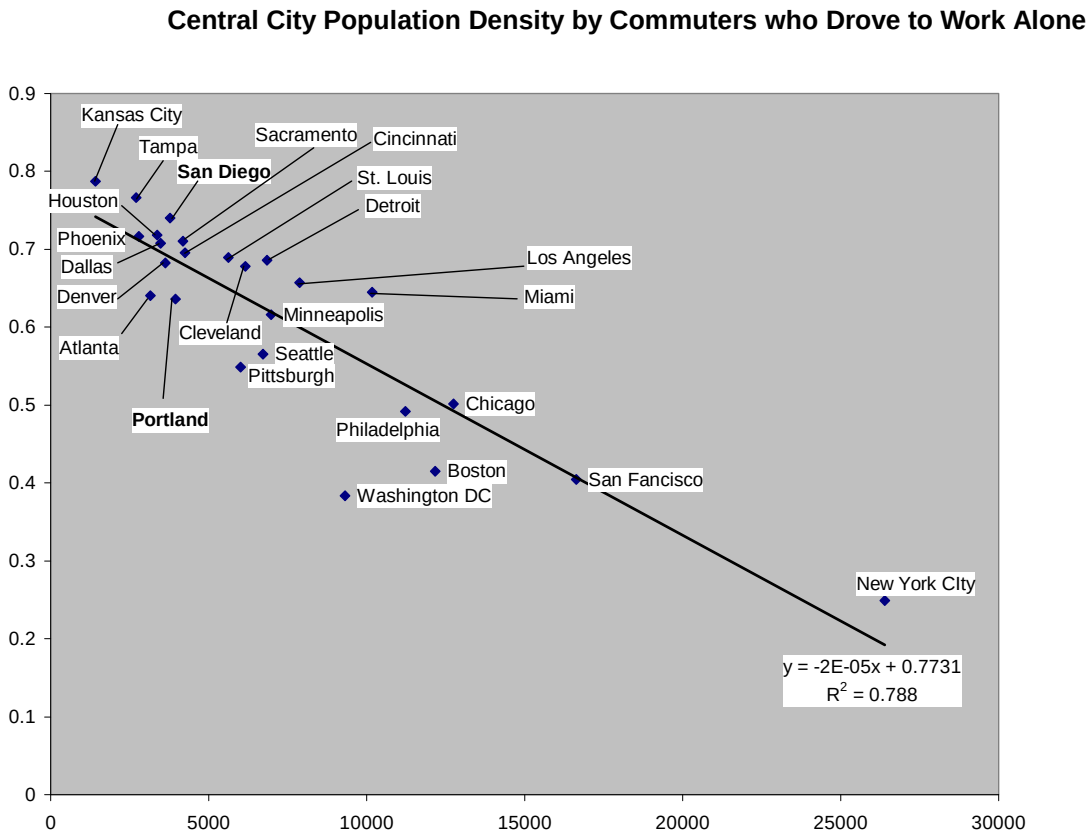


Figure 14 Correlation between density and S.O.V. commuting: Central City (2000 Census)

In Figure 15 We will analyze the density of the central cities for both the Portland and San Diego regions. We can see through this graph that the City of Portland has a higher population density that the City of San Diego. This means that Portland may be a more transit friendly city than San Diego.

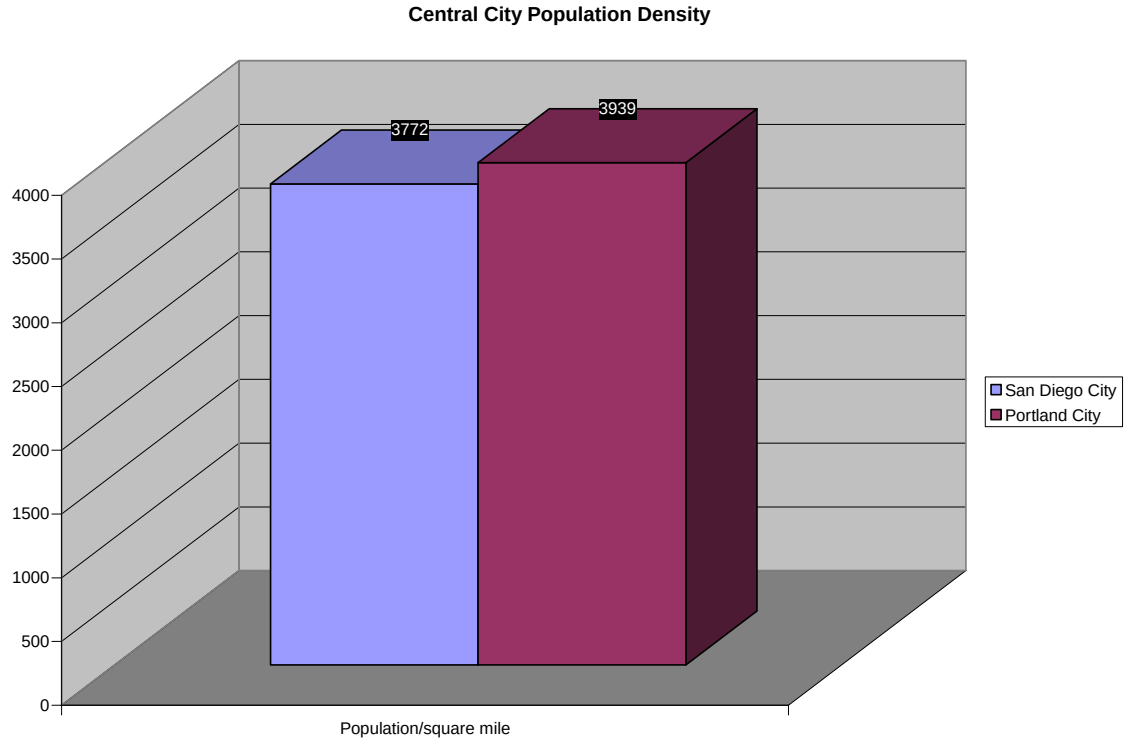


Figure 15 Central Cities population density (2000 Census)

From what we saw in Figures 13-14, we would expect to see a more definitive connection between density and transit use when looking at the mode splits for these central cities. In Figure 16 we see that the City of Portland has a much higher percentage of commuters traveling by transit than the City of San Diego does.

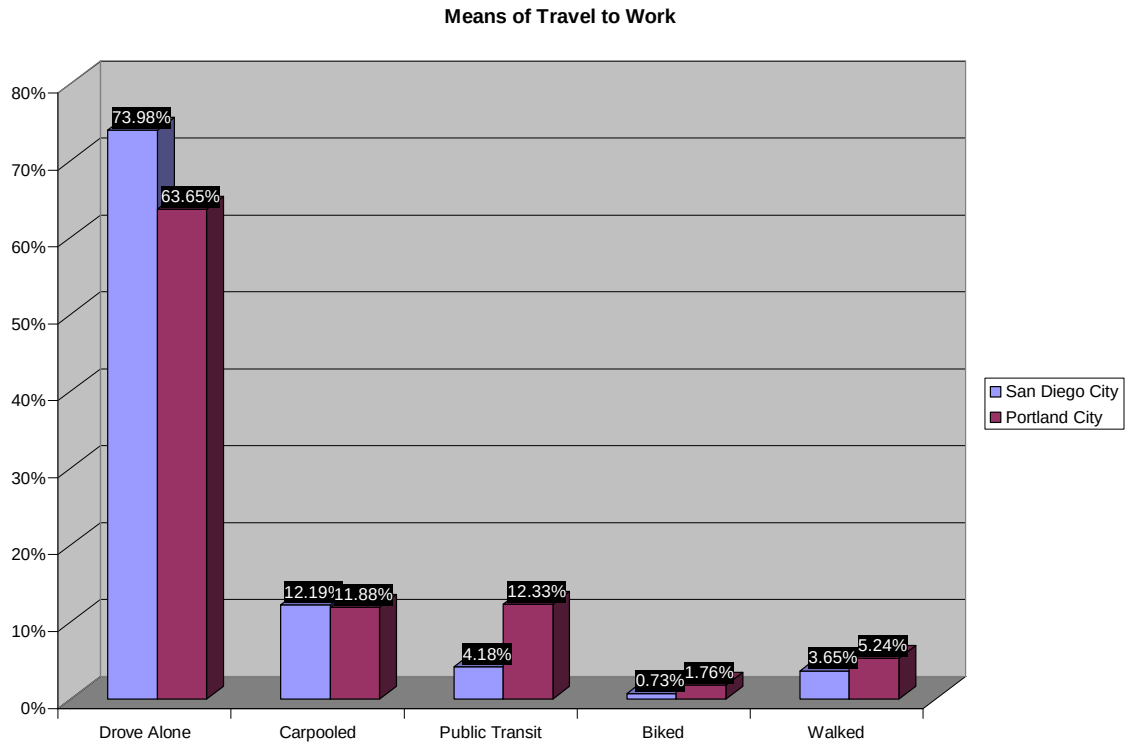


Figure 16 Central city means of transportation to work (2000 Census)

The results are much more striking in the analysis between the central cities, as the percentage of commuters using transit in Portland is almost three times that of San Diego.

Findings:

Through this analysis we have been able to better grasp the interaction between density and transit use. It appears that there may indeed be a connection between density and transit use; however, the connection is only apparent at certain scales. This makes logical sense in that transit operates best at a certain scale, namely the city scale. A region tends to be too large and unwieldy to operate a successful transit system. There are rarely large gaps between population and employment centers in cities, however, gaps are inherent in the shape of a region. Density, land use, urban design and other policies tend to be standardized throughout a city, whereas there are often large disparities in these

policies between different jurisdictions throughout a region. On the other end of things areas smaller than a city tend to be inappropriate for operating transit systems as there is not a critical mass of jobs and people to make it viable. This means analyzing the connection between transit use and density is less valuable in areas the size of a neighborhood, as there are rarely enough jobs or people in a single neighborhood to make a transit system viable, and so the results are reliant on many areas outside of that neighborhood.

These results are not conclusive; they simply represent an additional reason for suggesting caution in any analysis of density and transit use. It is obvious from these results and the findings of countless other researches that density is not necessarily a determining factor in travel patterns. Density can, however, play an important role when used correctly. Both the Portland and San Diego regions are embarking on ambitious campaigns to use density correctly to influence travel. By combining transportation and land use planning, and encouraging mixed use, walkable, transit friendly urban centers throughout the region, the density in these urban centers will have a more positive affect on travel patterns. If successful, these plans will make their respective regions operate more like a city, thus remedying the disparities between jurisdictions and using density to its full potential.

Conclusion:

The correlation between density and transit is still as muddy as before; however, much knowledge has been gained through these analyses. We know that comparing densities and transit use at the regional scale is problematic, as gaps in area and policy

can greatly impact the results. The correlation at the city level, however, is much more valuable. What should take the idea that regions need to be planned more holistically like cities from these findings. The success of density being able to alter travel patterns hinges on its placement in the region and its connection to a transit network. In a city it is likely to have a uniform web of transit service as well as more consistent density. This is why density at the city scale has a better ability to determine transit use than density at a regional scale. Until regions develop more like cities, the regional scale's physical features will have little ability to tell us about the travel patterns in that region.