

**Using a Typological Approach to Compare the Impact of Transit-Oriented  
Development  
On travel Behavior in the United States**

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## ABSTRACT

This project examined the regional characteristics of four American metropolitan regions that recently reintroduced rail transit into their area. It was based on two former NCIT projects that examined the regional characteristics of the Denver metropolitan region and their relationship to the rail transit system that was reintroduced there in 1994. In the original projects, transportation system changes, growth pattern changes, economic changes, planning and policy changes, and environmental changes were all evaluated. In this project, data for Denver from the first project were updated, and a sprawl index and a larger scale growth pattern change analysis added.

Because the former projects focused on the Denver metropolitan region, and the fact that rail transit service in the Denver area is dramatically expanding, Denver was used as the baseline to compare the other three metropolitan regions to in this project. As that baseline for analysis, the presentation of the Denver data is much more detailed than that for the other three. Upon a conclusion of the comparative analysis, a typology of regional characteristics and their relationship to the rail transit in that region was developed.

When comparing the other three regions to Denver, it is found that none are the same. The Denver region has become what is typed as a “rail transit” region, or a region now totally engaged in making rail transit a major component of the overall transportation system. Along with a significant investment in rail transit that is being made in Denver, the region also was found to have other factors that strongly support rail transit including a booming downtown and central city, exurbs that are not expanding as rapidly as they once were, above average congestion, and an air quality problem, but one that is improving.

While the Denver region was typed as a “rail transit” region, the Seattle region was typed as a “rail transit supportive” region. The Seattle region has many similarities to Denver, especially demographically, but is about fifteen years behind in regards to its development of a rail transit system. Though behind, it is in many ways following Denver having opened one line, being in the process of building a second line, and now looking to create an entire rail transit system through a tax financed plan that is to be voted on this fall. Though many of the characteristics of Seattle are similar to Denver, one significant difference that could help increase support for rail transit is the larger amount of congestion found in Seattle area than in Denver.

The Dallas region was typed as a “rail transit commuter” region. It has a slightly longer rail transit system with slightly higher ridership than Denver, but is in a much larger region with a much larger population than Denver. Because of this larger population and especially because of this larger region, rail transit serves more as a commuter supplement rather than an overall transportation alternative. Other factors supporting its typing as a “rail transit commuter” region are a slowly expanding downtown and central city, continually growing exurbs, and congestion slightly above the national average.

The St. Louis region was typed as a “Midwestern light rail transit” region. It reintroduced rail transit near the same time as Denver and quickly expanded from one to two lines, but has not and is not planning for any further expansions at this time. Much of the reason for this is that St. Louis is a classic Midwestern industrial region that has not been rapidly growing like the other three, instead being more an area that has experienced decline since the 1960s, especially in the central city. Recently, it has begun to grow again, but at nowhere near the rate of the other three metropolitan areas. Other factors supporting the “Midwestern light rail transit” region designation are its slightly above average congestion that has been continually worsening and its older population with average education and average income.

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## INTRODUCTION

This project is the continuation of two previous NCIT projects, the first of which examined the location of transit-oriented development (TOD) in Denver using a typological approach, and the second of which developed a profile on how the Denver region has changed since rail transit was reintroduced in 1994. In the second project that have occurred within the Denver region since rail transit was reintroduced were examined.

This project takes the approach and results from both of the former projects and incorporates them into a new project that seeks to analyze similarities and differences between four American metropolitan regions that have all reintroduced rail transit back into their areas and place these regions into a typology. Though many facets of each region are examined, the primary interest is in how the new rail transit is being integrated into the changing regions, and how the regions are reorienting themselves to adjust to the new rail transit. The four urban regions included in this project are Denver, Colorado, Seattle, Washington, Dallas, Texas, and St. Louis, Missouri.

Denver is used in this study as the basis by which the other metro areas are compared to. Dallas and St. Louis are examined because similar to Denver they reintroduced rail transit into their regions in the mid-1990's. However, while Dallas has been growing rapidly since this reintroduction similar to Denver, St. Louis has had fairly stagnant growth. Seattle is also a fast growing region, but didn't reintroduce rail transit in to the region until 2009.

Similar to the second study, in this study transportation system changes, growth pattern changes, economic changes, planning and policy changes, and environmental changes are evaluated. In addition, measures of sprawl, and census tract based population growth are added in this study. The ultimate goal of this project is to examine several metropolitan regions that have reintroduced rail transit, see how their region has changed over the past 50 years, see how rail transit is fits into this picture, and then create a regional typology of cities with new rail transit and regional change.

## **OBJECTIVE**

The first objective of this project is to survey regional changes occurring in four American metropolitan regions that have recently reintroduced rail transit into their transportation system and then examine how this new rail transit is fitting into the changing region. Numerous different regional factors are evaluated including demographics, transit system growth and development, congestion, transit oriented planning and policies and air quality.

The second objective of this project is to compile the information from the completion of the first objective and create a typology based on rail transit development and regional change. This typology will be based on similarities among, and differences between the four regions in the factors previously examined. Once developed, it will be used for a discussion on the most appropriate future planning goals and policy directions to best meet the needs of each typological region in regard to future changes and the integration of new rail transit.

## SCOPE

The scope of this project is the Denver, Colorado; Dallas, Texas; St. Louis, Missouri and Seattle Washington metropolitan areas. Though there were other candidate regions for this study, these four were chosen as a representative cross section of American metropolitan regions that have reintroduced rail transit since 1990 and beyond.

Denver was chosen as it was the case study used in previous analyses that helped establish the parameters of this project. Dallas is a growing community similar to Denver with a similar rail transit reintroduction experience. St. Louis, though it reintroduced rail transit at a similar time to Denver and Dallas, is a more industrial Midwestern region that is not growing as rapidly and also has not seen its rail transit service expand. Seattle is another growing western community, but its rail transit service was reintroduced much more recently. It also has different reasons and patterns of growth than either Denver or Dallas. It is realized that numerous other American metropolitan areas could have been included in this project, but it was decided that the four utilized represent a good cross section of similar and different communities with similar and different strategies and responses to their reintroduction of rail transit.



**Figure 1: Case Study Cities**

## METHODOLOGY

The data and methods from the previous two NCIT projects were the basis for the data and methods for the first part of this project. In those projects, numerous factors oriented to changes in the Denver metropolitan area were examined and related to rail transit and transit-oriented development. This project began by collecting data similar to those assembled for Denver for the other three case study metropolitan areas. Two new types of data were also added to this project, census tract population growth maps and a sprawl index, both of which were also obtained for all three new metro areas as well as for Denver.

The census tract population growth maps examine decennial population growth by census tract for each metropolitan region from 1960 to 2010. To create these maps decennial census tract population data and census tract boundary data were obtained from the U.S. Census Bureau. As census tract boundaries have not remained consistent during this time period, in some instances earlier census boundary designations are carried over to the more recent data.

To analyze the census tract boundary maps, for each ten year period areas of high or low growth are identified, and then compared to the other ten year growth periods to identify consistent or inconsistent trends. The exact definition of what constitutes an “area” varies, but generally it is several census tracts. This scale of analysis is much larger than the county scale used in the previous study for Denver, and allows for a much more precise analysis of which areas in the region are experiencing the growth or decline and how might the growth or decline in these areas be related to new rail transit development.

The sprawl index was developed by Smart Growth America in 2002 and published in a report titled “Measuring Sprawl and Its Impact” (<https://www3.epa.gov/airdata/>). In the report, first sprawl is defined and then an index for it developed. The index is made up of four dimensions and applied to 83 metropolitan areas in the United States including the four being evaluated for this project. The index uses a base of 100 as average and then relates each of the regions to this base. The lower the score the more sprawling. Scores for the four dimensions of sprawl as well as the overall sprawl index are examined in this project.

Upon the conclusion of the data collection for all four Metropolitan Areas, an in depth reexamination and updating of the current situation in Denver was conducted. Updating of the region’s current demographics and reviewing of its county-based historical population growth were the first step in this reexamination. Reviewing the sprawl index and its four dimensions for the Denver region was done next. This was then followed by an evaluation of the decennial census tract population growth maps. Reviewing and updating the reintroduction of rail transit followed along with an examination of all transit-oriented planning and policy changes that have occurred in the region. Finally, the reexamination of changes in the Denver region since the reintroduction of rail concluded with an analysis of changes in regional congestion and air quality. Congestion data came from the Texas Transportation Institute annual Urban Mobility Scorecard. Air quality data came from the Denver Department of Environmental Health and the U.S. Environmental Protection Agency.

With a renewed understanding of regional changes and the reintroduction of rail transit into the Denver region, the next step in the project compared this situation to the other three case study metropolitan areas. Each of the areas of analysis developed for Denver was compared to the same areas for the other three metro regions with a discussion following that presented similarities and differences.

The next step of this project was to take the four different metropolitan regions and their individual characteristics and create a typology that labels each and identifies their similarities and differences. The final step of the project was to examine the typology and discuss and recommend how it can be used for planning and policy decisions in the future.

## **DISCUSSION OF RESULTS**

This discussion of the results begins with an in depth profile of the Denver region since the reintroduction of rail transit. That is then followed by a comparison of the Denver region to the three other case study regions. In the Denver profile, current demographics are examined first. These demographics are then tied in to an analysis of regional growth patterns at several different scales. That is then followed by a discussion of the reintroduction of rail transit into the region and a presentation of the current system characteristics and future system plans. Next is a discussion on the status of transit oriented planning and policy within the Denver region. The profile ends with an examination of changes in regional congestion and air quality since the reintroduction of rail transit.

As mentioned previously, much of the information presented on Denver was collected during the two previous NCIT projects, though it has been updated. The three other case study regions used for comparison were each chosen due to their also having recently reintroduced rail transit into their regions and either their similar or different characteristics to Denver. The Dallas region reintroduced rail transit in 1996, and is similar to Denver being also located in the southwest United States, generally a region of the country that has been experiencing rapid growth since the 1960s like Denver. The St, Louis region reintroduced rail transit in 1993 similar to Denver and Dallas, but is not located in the rapidly growing southwest U.S., being more of a classic Midwestern regional center. Seattle did not reintroduce rail transit into its region in the 1990s, instead it began in 2009. Regardless, it is another U.S. metro region that has experienced significant growth since the 1960s, even though it is not in the southwest U.S.

## The Denver Metropolitan Region

### Demographics

The Denver Metropolitan Statistical Area (MSA) used in this study includes the five counties shown in Figure 2 (Denver, Arapaho, Adams, Douglas and Jefferson). This boundary reflects the Denver MSA prior to the year 2000 when the MSA became the Denver-Aurora-Lakewood MSA. The earlier boundary is used in order to have consistent boundaries throughout the period of time this study covers. These five counties encompass an area of 4,532 square miles.

In 2015, the population of the Denver MSA was estimated at 2,812,732. The median household income was \$69,205 and the per capita personal income was \$54,619. The median age of the population was 37 years old with 90.2 percent having a high school diploma, and 42.5 percent having a Bachelor's degree or higher (US Census).

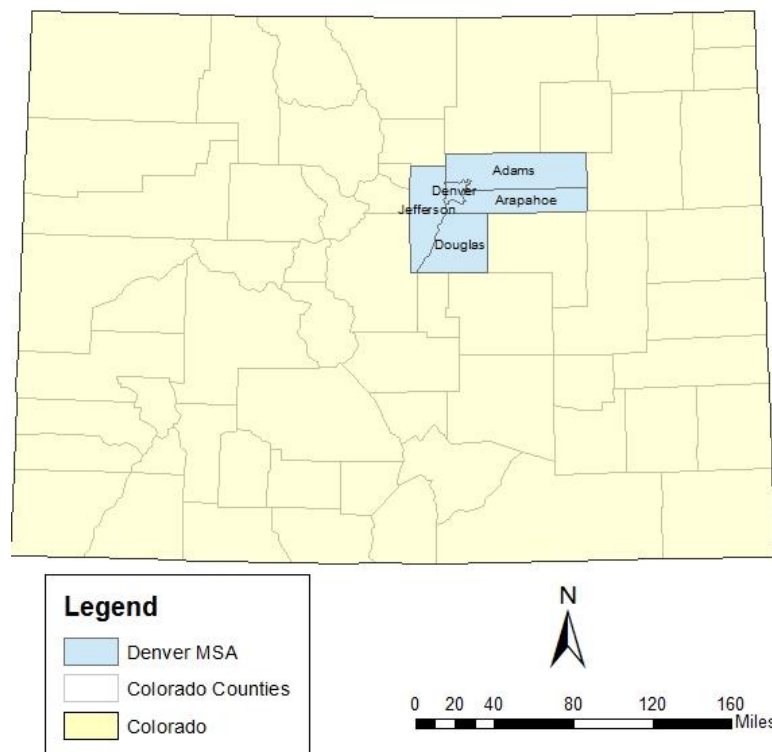


Figure 2: The Denver MSA



## Population Growth

### Historical

Historically, the Denver region has experienced numerous cycles of boom and bust. The first boom was in the 1860s when gold was discovered nearby and quickly a desolate area at the foothills of the Rockies became a booming mining related region with Denver as its center. Like most mining oriented areas, when the mining became less profitable, the booms in the towns nearby slowed or even busted completely. Denver never busted completely, but has certainly showed a pattern of very rapid development followed by stagnation.

This pattern that began in 1860 has gone through several cycles with one of the most recent being a boom in the 1970s related to the gas shortage in the country and the nearby availability of oil shale. The boom brought significant new office development into the downtown and other development throughout the entire region. It also led to a rapidly increasing population, especially in the more sprawling exurban areas. In the 1980s, the energy picture changed, oil shale was no longer profitable, and the City and County of Denver and especially the downtown went into decline. Downtown office vacancy rates were high and Denver began losing population.

In a reaction to the decline, planning for several major projects to be funded by bonds occurred in the 1980s. These projects included a new airport, a new convention center, a light rail line, and a large amount of money for infrastructure and school improvements. In addition, a 0.1 percent sales tax to build a new baseball stadium for the Colorado Rockies in the Lower Downtown (LoDo) was instituted. Partially due to this renewed public investment, by the 1990s the City and County of Denver and especially the downtown were growing again, both in population and economic importance.

In Table 1 the population changes mentioned above are easily identified, especially the decline in the City and County of Denver during the 1970s and 1980s. However, it is also seen that during the 1970s, outlying counties such as Arapaho, Douglas and Jefferson were booming. In the 1980s, Douglas County continued to grow rapidly, but in the rest of the outer counties growth slowed down.

	Adams	Arapaho	Denver	Douglas	Jefferson
<b>1940's</b>	79%	62%	29%	0%	81%
<b>1950's</b>	199%	118%	19%	37%	129%
<b>1960's</b>	54%	43%	4%	75%	85%
<b>1970's</b>	32%	81%	-4%	199%	58%
<b>1980's</b>	8%	33%	-5%	140%	18%
<b>1990's</b>	37%	25%	19%	191%	20%
<b>2000's</b>	21%	17%	8%	62%	1%

**Table 1: Counties in Metro Denver; Population Growth**

In the 1990s, the growth rate for the entire Denver metropolitan region was 30 percent, one of the highest in the country. In the 2000s, this rate slowed to 16.7 percent, which was still very high especially considering the recession during this decade. Currently, the Denver metropolitan region is the sixth fastest growing metropolitan region in the United States with a 2015 annual population growth rate of 1.43 percent (Forbes).

### Sprawl

In 2002, Smart Growth America conducted a project on “Measuring Sprawl and Its Impact” (Ewing, Pendall, Chen. *Smart Growth America*). In this project, they first defined sprawl and then developed an index for it. This index was made up of four separate dimensions related to sprawl. After its development, it was applied to 83 metropolitan areas in the United States including Denver. According to this index, overall Denver is one of least “sprawled” metropolitan areas in the country with a ranking of 73<sup>rd</sup> least sprawled out of 83. Denver ranked above the average in all four dimensions of the index being especially strong in regards to the accessibility of its street network. The dimension where it is closest to the average is residential density factor. In this project, the Denver region is found to be the least sprawled of the four case study metropolitan areas (see Table 2).

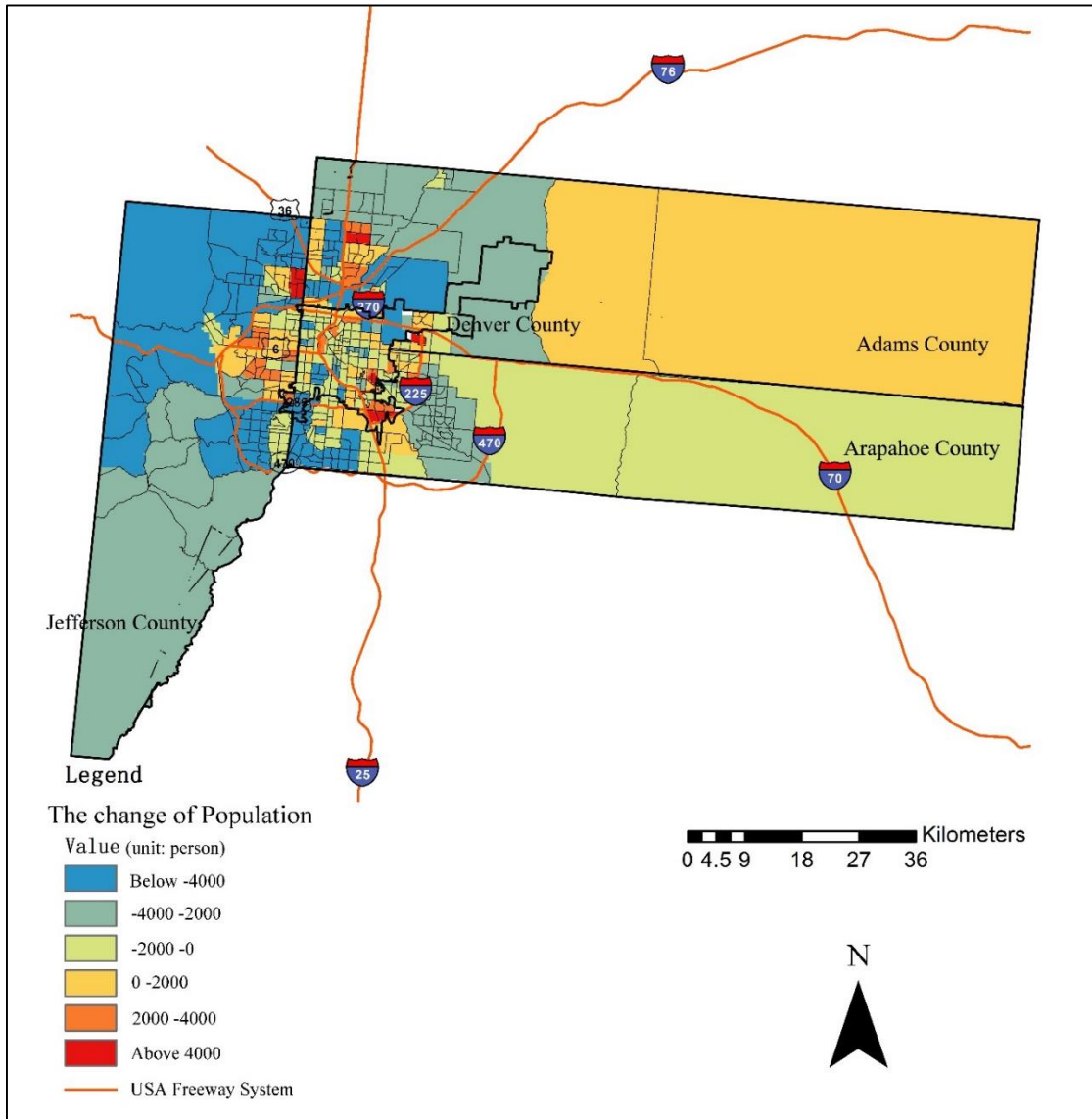
Sprawl Factor	Index (most to least)	
	Score	Ranking (out of 83)
Residential Density Factor		
Dallas	99.5	55
Denver	103.7	62
Seattle	103.62	61
St. Louis	90.29	27
Mix of homes, jobs & services		
Dallas	82.6	22
Denver	115.67	57
Seattle	79.42	16
St. Louis	107.44	51
Strength of town centers/downtowns		
Dallas	81.06	18
Denver	108.87	54
Seattle	98.01	37
St. Louis	76.16	15
Accessibility of street network		
Dallas	90.23	32
Denver	125.72	70
Seattle	117.07	63
St. Louis	105.99	52
Overall Sprawl Index Score		
Dallas	78.26	13
Denver	125.22	73
Seattle	100.91	44
St. Louis	94.51	35

**Table 2: Smart Growth America Sprawl Index**

### **Census Tract Population Change**

As a final method to examine the growth of the Denver metropolitan region, five maps of the decennial change in population by census tract since the 1960s were created. This larger census tract scale and use of numbers rather than percentages allows for a more precise understanding of which specific areas in the Denver region were actually growing and when, instead of just looking at percentage growth by county population data as done in the previous studies.

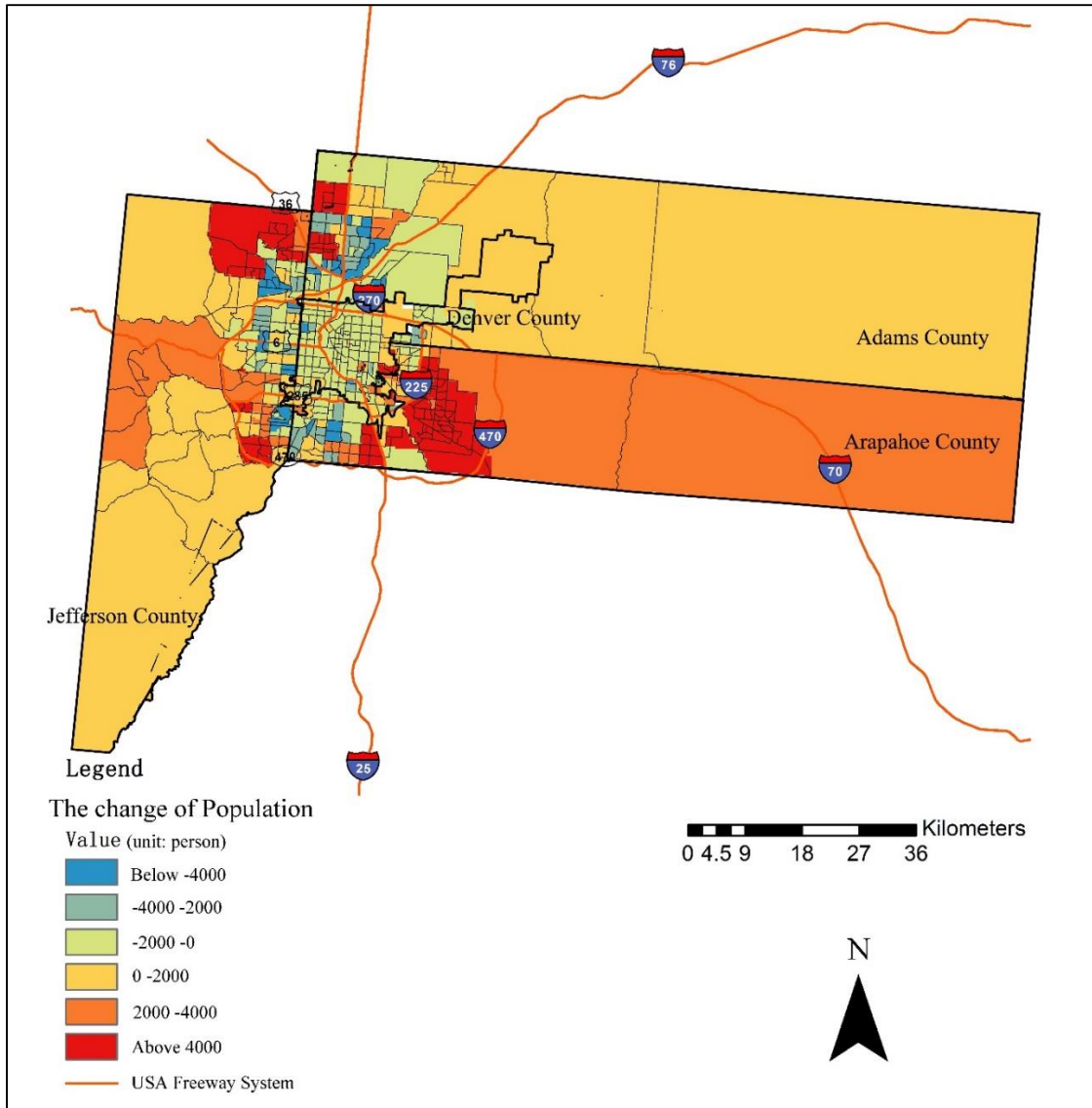
The five maps created are presented below. Under each map are bulleted findings on the patterns and trends ascertained from that map.



**Figure 3: Denver Metro Area Population Change 1960-1970**

## Findings

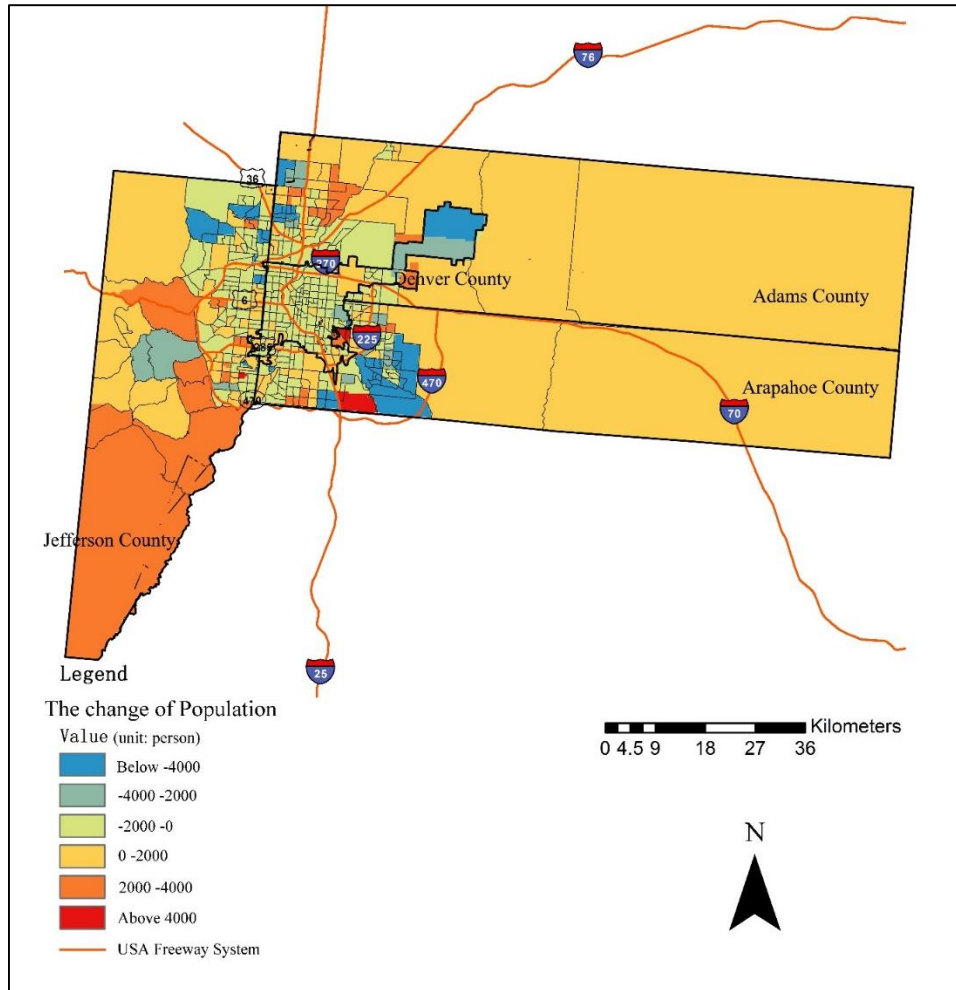
- Population increase along the major arteries and the inner beltway
- Population increase in eastern Adams County
- Population decrease in the downtown and much of Denver County
- Population decrease in Adams and Arapaho counties except in eastern Adams County and along I-25 in Arapaho County
- Large population decrease in the western parts of Jefferson County



**Figure 4: Denver Area Metro Area Population Change 1970-1980**

### Findings

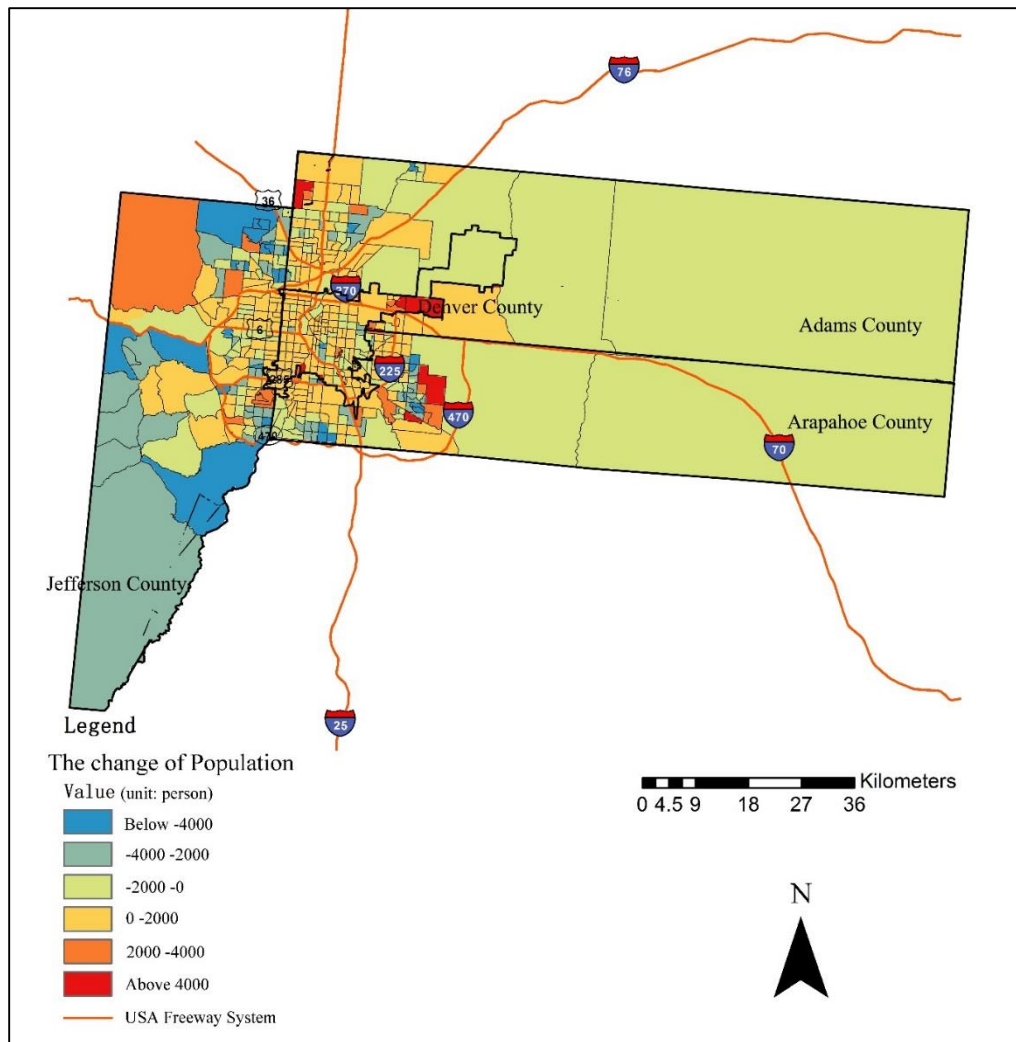
- Major population increase in eastern Arapaho County between the inner and outer beltways
- Major population increase in the northeast corner of Jefferson County
- Population increase now in the western parts of Jefferson County
- Continued Population decrease in the downtown and much of Denver County
- Continued population decrease in the western Adams County



**Figure 5: Denver Metro Area Population Change 1980-1990**

## Findings

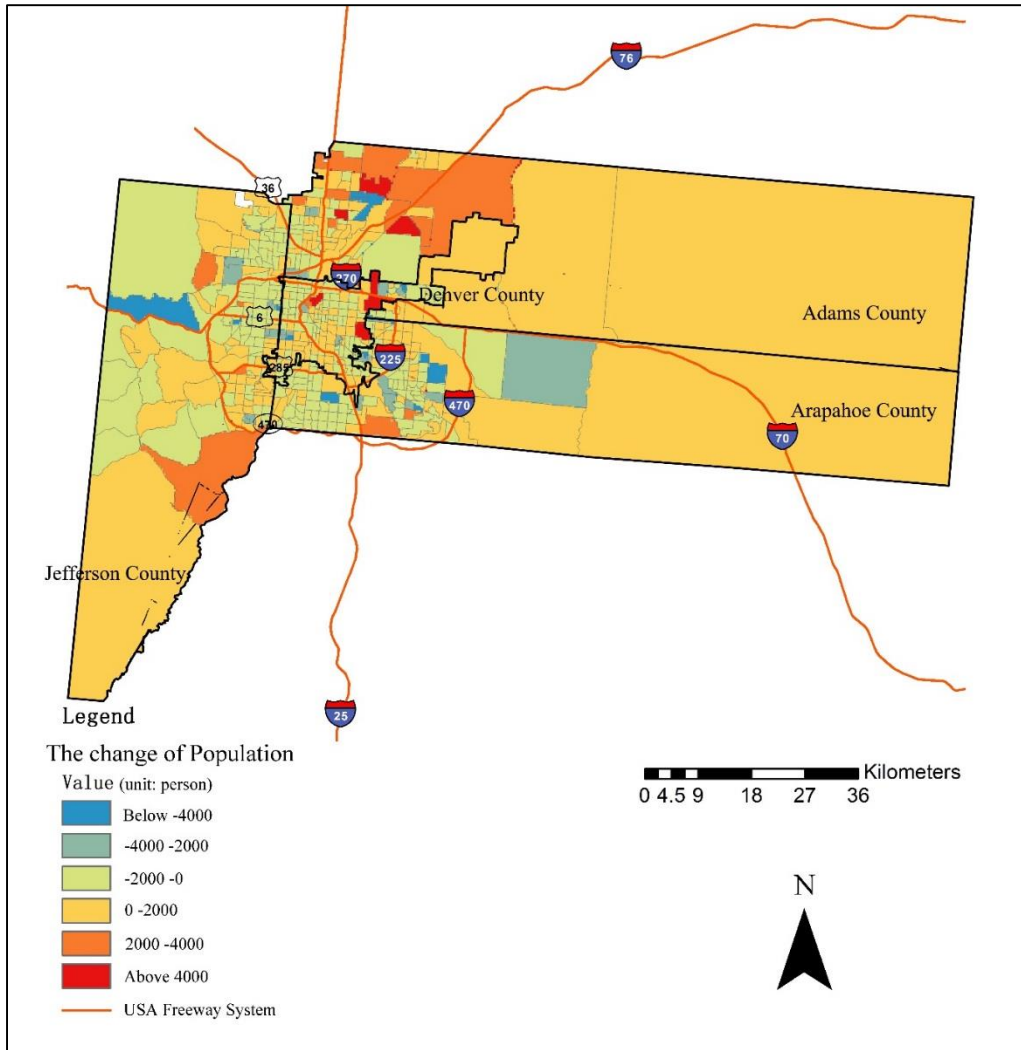
- Few places with major population increase
- Continued population increase in eastern Arapaho and Adams County
- Continued population increase in western Jefferson County
- Change to population decrease in the northeast corner of Jefferson County
- Continued Population decrease in the downtown and much of Denver County
- Continued population decrease in the western Adams County



**Figure 6: Denver Metro Area Population Change 1990-2000**

### Findings

- Still few places with major population increase
- Population increase returns to downtown and Denver County
- Population increase in Eastern Arapaho County
- Population changes to decrease in eastern Arapaho and Adams County
- Population changes to decrease in southwestern Jefferson County
- Change to population increase in the western Adams County



**Figure 7: Denver Metro Area Population Change 2000-2010**

## Findings

- Southern Denver County and Downtown increase population while northern Denver County decreases population
- Southern Jefferson County increases population while northern Jefferson County decreases population
- Population increase in nearly all of Adams County
- Population decrease in southwest Arapaho County
- Places with major population increase in smaller census tracts
- Population increase along inner and outer beltways



Overall, the following conclusions are drawn from the decennial population change maps above:

- While during the 1960s, 1970s and 1980s Denver County and the downtown saw population decreases, in the 1990s and 2000s, this trend reversed now showing predominantly population increases
- Starting in the 1970s, the majority of the area in the eastern counties of Adams and Arapaho exhibit population increases except during the 1990s
- The population changes in the western areas of Adams and Arapaho are more similar to those in Denver County than the rest of their own county
- Population changes are the most varied in Jefferson County changing by decade and by area within the county
- Population increases are seen along major roadways in the 1960s and the 2000s
- Population growth through the entire region slowed in the 1980s and 1990s

## **Reintroduction of Rail Transit**

In 1994, Denver's first light rail line, the 5.3 mile Central Corridor opened. That was followed by the opening of the 8.7 mile Southwest corridor light rail line in 2000. In 2002, the 1.8 mile Central Platte Valley light rail line opened, and in 2006, the 19 mile Southeast corridor light rail line opened for a 24.8 mile total system twelve years after service was first reintroduced.

In 2004, the voters of the Denver region approved a measure to develop the FasTracks program. The FasTracks program is:

A multi-billion dollar plan to build a comprehensive, integrated region-wide transit network that will provide a reliable and safe system, enhance mobility and respond to the growing transportation needs within the eight-county Regional Transportation District. ([www.rtd-denver.com/FF-FasTracks.shtml](http://www.rtd-denver.com/FF-FasTracks.shtml) )

The programs first new line, the 12.1 mile West light rail line opened in 2014. In 2016, two commuter rail lines, one light rail line extension and one bus rapid transit line are all scheduled to open. The first of the rail lines, the 22.8 mile East commuter rail line connecting downtown Denver to the Denver International Airport actually opened in April. The second, the 11.2 mile Gold commuter rail line connecting downtown Denver to the suburb of Wheat Ridge and the historic community of Arvada is scheduled to open near the end of the year. The third, the 10.5 mile I-225 light rail extension which will complete a circumferential loop around the east side of the region and access the community of Aurora is also scheduled to open near the end of the year. The 18 mile bus rapid transit line connecting downtown Denver to Boulder started offering service in January.

All of the lines opening in 2016, along with the other lines still under construction connect at Denver Union Station. Union Station was renovated and reopened as an intermodal passenger station in 2014 with bus, light rail, and Amtrak service, along with a new 22-gate bus concourse. It also has more than 100,000 square feet of space for mixed use development and the Crawford Hotel. The entire area around Union Station has been significantly redeveloped over the past twenty years, especially the area to the west which was previously abandoned rail yards.

The final new rail lines associated with the FasTracks program are the 41 mile Northwest corridor diesel multiple commuter rail line from downtown Denver to Longmont and the 13 mile North Metro commuter line from downtown Denver north through Commerce City, Thornton, and Northglenn (see Figure 8). The Northwest line is presently building its terminus station in Longmont which will be used as a bus station until the rail line arrives. This rail line is still awaiting complete funding. The North Metro line is currently still in design, though the first segment is scheduled to open in 2018.

Thus, over the past 25 years rail transit has received significant public investment and become a viable transportation option in the Denver region. This option is about to become even more pronounced in 2016 with the extension of the I-225 light rail line and the opening of two new commuter rail lines. Overall connectivity of the system has also tremendously increased with the renovated Union Station now having become the intermodal transportation hub for the entire Denver region.



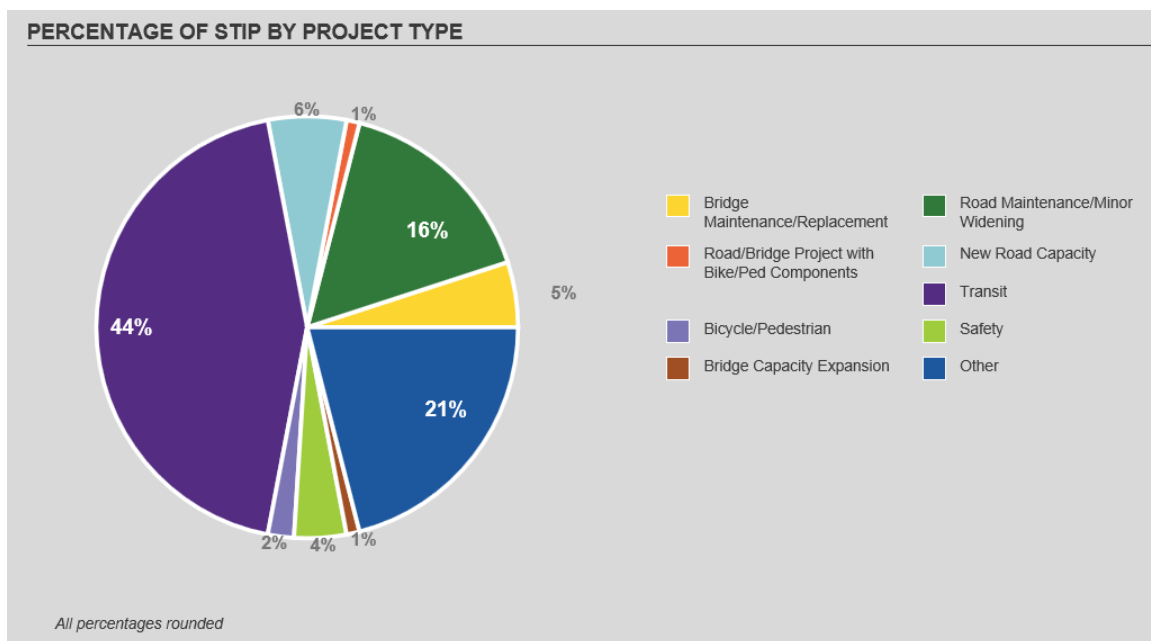
Figure 8: Denver Rail Transit System

## Rail Transit Oriented Planning and Policy Changes

Since rail transit was reintroduced into the Denver region, there have been a number of planning and policy changes oriented to that development or the development of land near that development that have been made. Of these, the most significant is the rewrite of the city of Denver zoning codes. In this rewrite, the primary change was to go from a code based on floor area ratios to a form-based code in order to make development more uniform. However at the same time, the rezoning also changed to better allow for mixed-use development, and created a “transit mixed-use zone” which is now found at numerous rail station locations within the city of Denver.

Another policy change that has occurred since rail transit was reintroduced into the Denver region is the allocation of state transportation funds. This change now allows more flexibility in how the Highway Tax Users Fund is allocated. As such, in an examination of the Colorado statewide Transportation Improvement Program (TIP) by the Tri-State Transportation Campaign in 2012, it was found that a majority of transportation funds are now scheduled to go to transit (see Figure 9).

[http://www.trackstatedollars.org/media/documents/Tracking\\_State\\_Dollars-FINAL.pdf](http://www.trackstatedollars.org/media/documents/Tracking_State_Dollars-FINAL.pdf) )



**Figure 9: Denver Transportation Funding**

In the planning realm, planning specifically oriented to transit-oriented development (TOD) has become quite widespread in the Denver region. This began with a TOD Strategic Plan that was originally drafted in 2006, and has been updated in 2014.

According to the 2014 TOD Strategic Plan:

The Transit Oriented Development (TOD) Strategic plan is intended to guide the critical City-led actions needed for successful TOD in Denver (and) not revise station area plans or alter long-standing TOD policies; rather, (focus) these multiple efforts into a concise work program for the City. (Denver 2014).

TOD planning has continued since the development of the original TOD Strategic Plan with the development of plans specifically oriented to individual rail stations. Currently, most stations on the existing rail lines have approved station area plans in place, and are moving forward to implement these plans. Of those that do not have approved plans, most are in the process of creating them. At many station locations on lines still to open, station area plans have already been completed or are in process.

The Denver Regional Transportation District (RTD) has also changed its focus on planning for TOD since rail transit was first reintroduced. Originally, much of RTD's TOD emphasis was oriented to parking for commuters. However, recently this emphasis changed. The agency now is more oriented to non-parking transit-oriented development, and especially working on cooperative development efforts with land owners, developers and municipal governments. In 2011, RTD even started a pilot program with the goals to: "Proactively work on fostering livable communities by testing an expanded role for RTD in facilitating TOD" ([/newpartners.org/2014/wp-content/plugins/schedule-viewer/data/presentations/Friday/3.30-5.30pm/Rail%20in%20the%20West/Sirois.pdf](http://newpartners.org/2014/wp-content/plugins/schedule-viewer/data/presentations/Friday/3.30-5.30pm/Rail%20in%20the%20West/Sirois.pdf) ).

## Congestion

Two different regional congestion measures available from the Texas Transportation Institute were obtained in order to examine regional congestion levels both before and after rail transit was reintroduced into the Denver region. The first measure examined was the Travel Time Index (TTI) which is an index that calculates the ratio of travel time in the peak period compared to free-flow travel time. The second measure examined was the Annual Delay per Peak Auto Commuter (Delay) measured in person hours.

Figure 10 exhibits the TTI from 1985 to 2013 for all four metropolitan areas included in this study, along with the national average. In the table, it is seen that Denver's TTI was very close to the national average from 1985 until 1993 when it began to increase much more rapidly than the national average. It kept on this trend for twelve years until 2005 when the rate actually began to decrease. This decrease continued until 2012 when a slight increase was seen, though since then it has remained stable.

Figure 11 exhibits the Annual Delay per Peak Auto Commuter from 1985 to 2013 for all four metropolitan areas included in this study, along with the national average. In looking at this table, it is seen that Denver's delay was very close to the national average from 1985 until 1993 when it began to increase much more rapidly than the national average, similar to the TTI statistic. This trend of rapid increase also continued until 2005 before a decrease occurred until 2011, followed by a slight increase for a year before stabilization, similar to the TTI index.

The decrease in both measures in 2005 coincides with the start of the economic recession in the U.S. and around the world. However, even though by 2009 the economic turnaround was starting, both measures remained stable. Since 2009, even with the overall improvement of the economy, both measures have only seen increases in one year. There are numerous reasons for this change in the rate of congestion growth in Denver, but according to Bhattacharjee and Goetz in an article in the *Journal of Transport Geography* entitled "Impact of light rail on traffic congestion in Denver" it is found that:

It is evident that light rail is succeeded in reducing some amount of traffic within the influence zone excluding I-25 and I-225 after opening of the Southwest and Southeast corridors. . . Light rail kept the rate of increase of traffic lower within the influence zone despite the large amount of residential, office and commercial developments taking place around light rail stations. (Bhattacharjee and Goetz (2012) p.269)

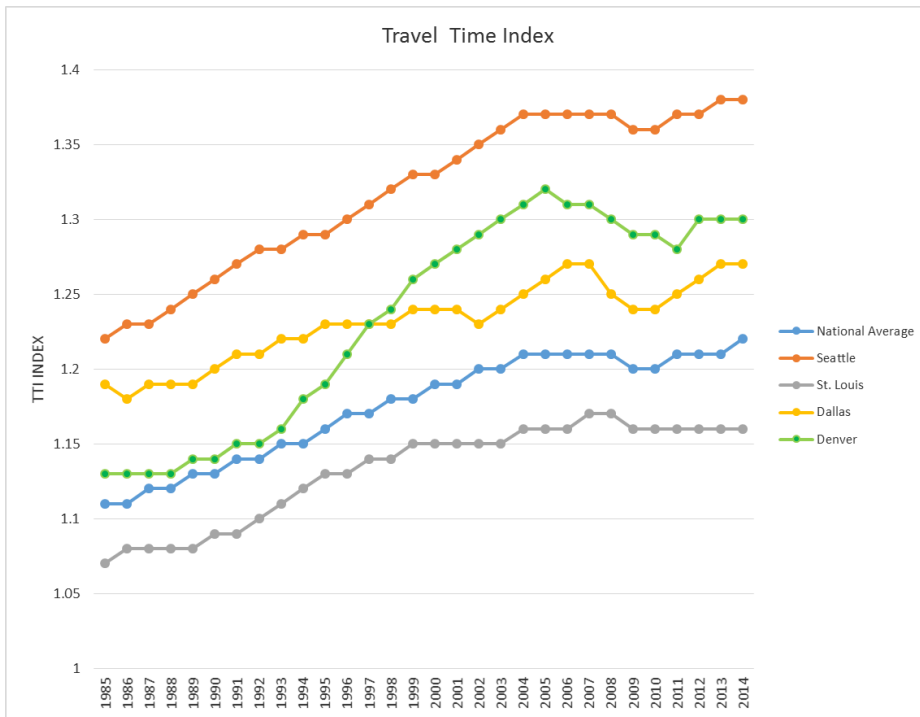


Figure 10: Travel Time Index

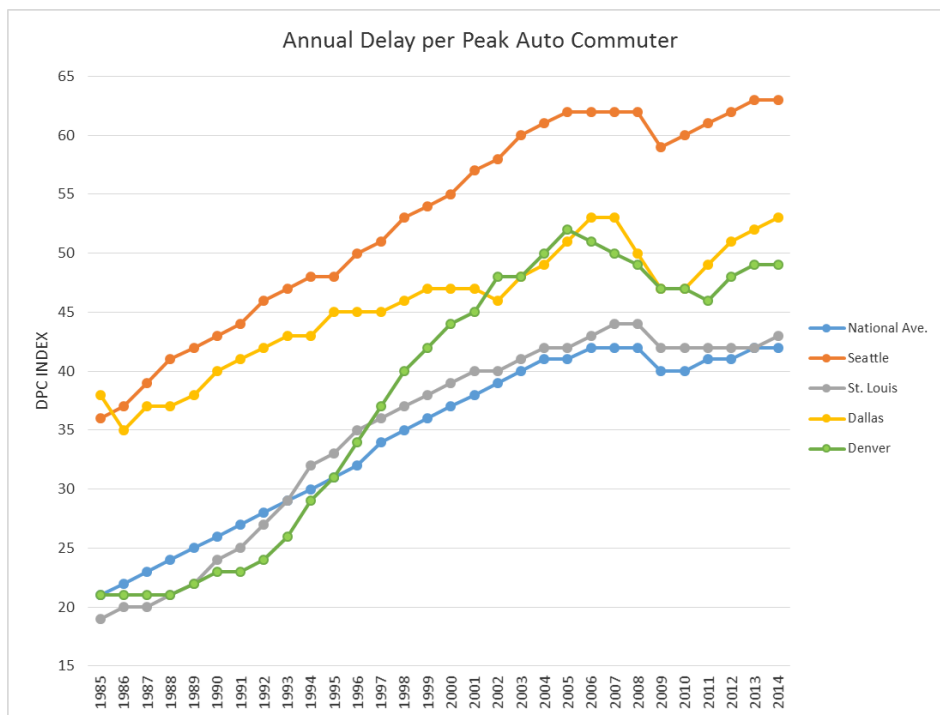


Figure 11: Annual Delay per Peak Auto Commuter

## Air Quality

Since the reintroduction of rail transit, air pollution problems in the Denver region have improved. Figure 12 below from the Denver Department of Environmental Health shows this trend quite clearly in regards to Carbon Monoxide. A similar pattern is also seen in Figure 13 in regards to sulfur dioxide. Overall, according to the Denver Department of Environmental Health:

Since 1995, Denver is in attainment for all pollutants except ozone and the looming brown cloud is visibly reduced.

(<https://www.denvergov.org/environmentalhealth/EnvironmentalHealth/EnvironmentalQuality/AirQuality/tabid/444649/Default.aspx> )

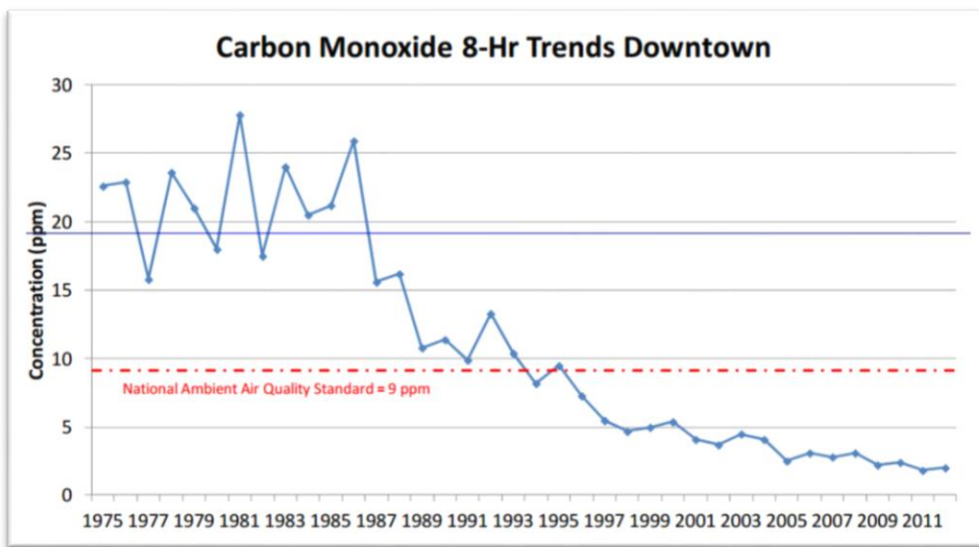


Figure 12

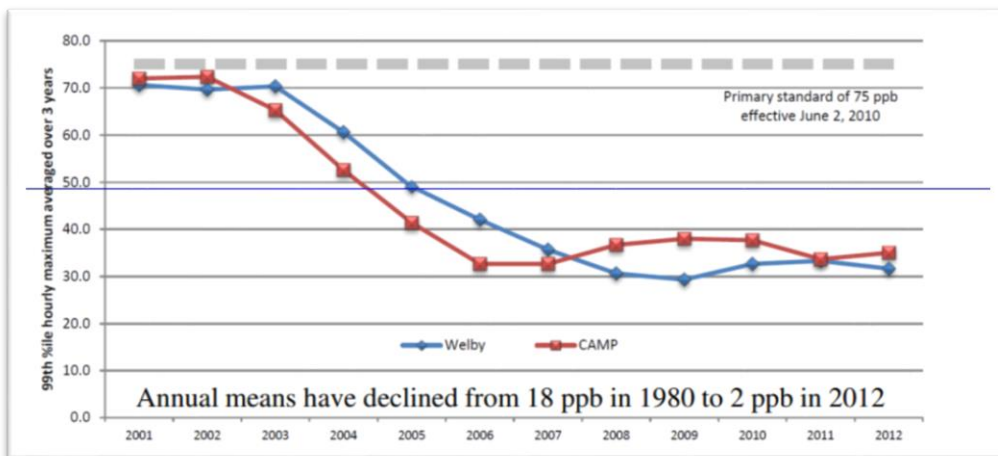


Figure 13



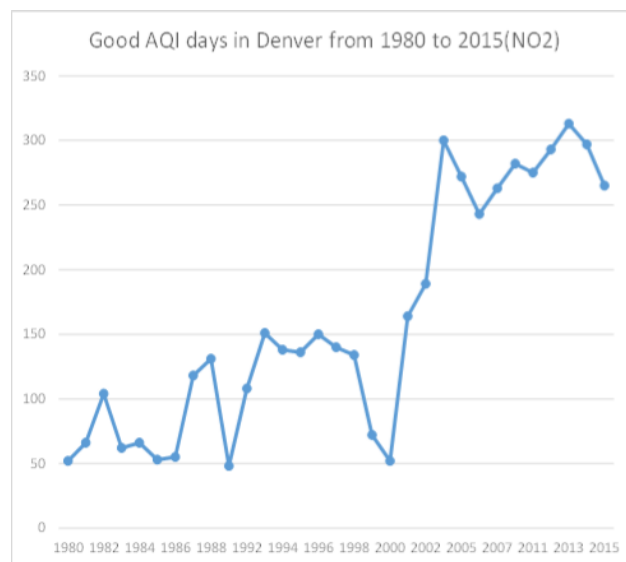
In an NCIT study entitled Transport, Energy and Environmental Benefits of Transit-Oriented Development Strategies, the reduction in CO<sup>2</sup> due to transit-oriented development was calculated for two different rail stations in Denver. For the first station, the following conclusion was reached (Sherry, Van Vleet, Ratner):

Examining the total CO<sub>2</sub> savings for a year of commuting we find that the presence of the Alameda Station TOD results in a savings of 252,374 kg of CO<sub>2</sub> emissions compared to a similar sample of residents not using public transportation. Thus, TOD allows the population in the .5 mile radius zone to reduce CO<sub>2</sub> emissions by almost 5 percent per year (p. 35).

While at the second station, the following conclusion was reached:

Taking into account the entire TOD zone it is estimated that the over a one year time period that the TOD allows the population in the .5 mile radius zone, to reduce CO<sub>2</sub> emissions by 3 percent per year (p. 38).

Figure 14 exhibits the number of days considered having “good” air quality in the Denver region from 1980 to 2015 ([www.epa.gov/airdata/](http://www.epa.gov/airdata/)). Upon examination, the graph shows that since 2000, there has been a very dramatic shift in this measure. From 1980 to 2000 no years had more than 151 “Good” AQI days and 10 years had less than 104 “Good” AQI days. However, since 2000, there are no years with less than 243 “Good” AQI days. This is an improvement of over 60 percent from the previous time period.



**Figure 14: Good AQI Days in Denver**

## Regional Comparison

### Demographics

Demographically, none of the other three case study metropolitan areas are a direct comparison to Denver. Dallas has more than double the population, double the area, and a much younger median age. Dallas's per capita income and median household income are much lower than Denver's, the national average, and the other two case study cities. Dallas's percentage of its population with a Bachelor's degree is slightly below the national average, but more than six percent points below Denver's. Its percentage of its population with a high school diploma is above the national average, but over eleven percentage points behind Denver's.

	2015 est. Pop	Rank	Area	Median Age	Median Hshld Inc	Per Cap Inc	% High School Diploma	% Bachelor's or higher
Denver	2,814,330	19	4,532	37	69,205	35,256	90.2%	42.5%
Dallas	7,102,796	4	9,636	33.6	43,836	20,460	84.0%	31.0%
St. Louis	2,811,588	20	8,458	38.2	55,535	30,293	83.2%	30.4%
Seattle	3,733,580	15	5,872	36.2	71,273	36,894	91.8%	39.4%
U.S. Ave				37.2	51,939	28,889	86.0%	29.0%

**Table 3: Demographic Comparisons**

St. Louis has a very similar size population to Denver, but in a much larger area, more like that found in Dallas. St Louis's median age is just larger than Denver's, and the oldest of the four case study cities. Its per capita income and median household income are both lower than Denver's, being closer to the national average. Its percentage of its population with a Bachelor's degree and percentage of it population with a high school diploma are both very similar to that found in Dallas being significantly lower than that found in Denver.

Seattle's population is about one-third larger than Denver's, as is its area. Its median age is slightly younger than Denver's, but very near the national average. Its per capita income and median household income are both slightly larger than Denver's, are both the highest of all four case study cities, and are both much larger than the national average. Seattle has the highest percentage of it population with a high school diploma with Denver's rate very close. Seattle's percentage of its population with a Bachelor's degree is just behind Denver, but still very far above the national average.

To sum up the difference in demographics between the three case study metropolitan areas and Denver:

- Dallas is much larger in population and area, but with a younger poorer, less educated population
- St. Louis has about the same population, but in a much larger area. It's population is the oldest, with income and education levels similar to the national average, but below those found in Denver
- Seattle has a slightly larger population and area, a slightly lower median age, the highest income of all four case study cities, and a similar high education level to that found in Denver

## Population Growth

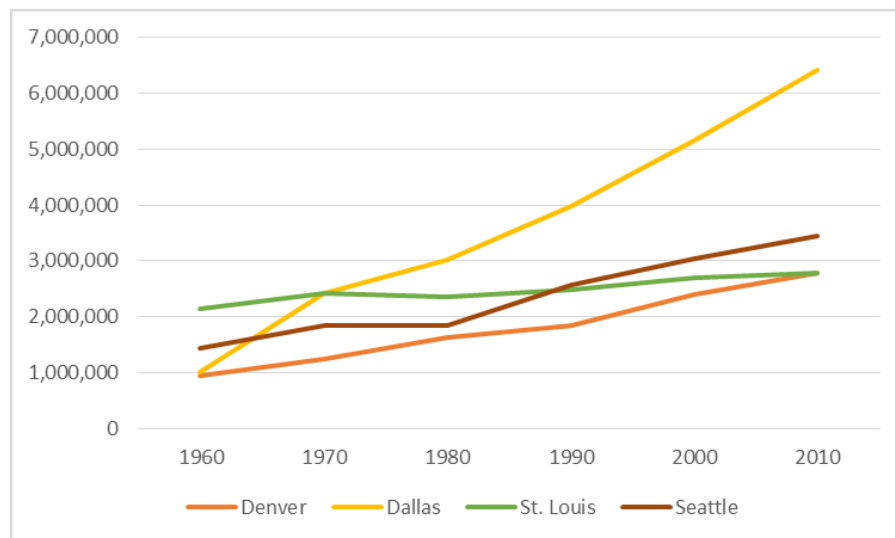
### Historical

In examining the historical population growth of the Denver region, the most predominant characteristics noted were the following:

- Cycles of boom and bust
- The recent resurgence of the central city as a whole and the downtown specifically after a precipitous decline
- The fact that according to the Smart Growth America Sprawl index, Denver is the tenth least sprawled region and better than average on all sprawl factors
- How fluid exurban area growth has been with different areas throughout the region rapidly expanding and then stopping growing at different times

Of the four case study cities, Seattle is the one that also has experienced cycles of boom and bust similar to Denver. The first boom was in the 1880s and was oriented to the city's access to lumber and coal as well as its becoming a major regional center. This boom was then followed by a significant slowdown that reversed again in the 1890s as the region became a supply center for the Yukon Gold Rush. After another slowdown, the economy again rebounded in the 1910s and 20s, before busting during the depression and then booming again during the war years, followed by another slump after the war. Similar to Denver, the regions last downturn was in the 1970s and the 1980s.

Dallas and St. Louis, on the other hand have both experienced much steadier rates of historical population growth, with the Dallas rate much more rapid over the last 50 years than the St. Louis rate. St. Louis, being a more Midwestern industrial city peaked in population in the 1950s. In Figure 15 below, it is seen that in the 1960s St. Louis had the largest population of the four metro regions, but now it is below Dallas and Seattle and about equal to Denver. In the figure, it is also seen that Dallas has undergone the most significant population growth over the past 50 years.



**Figure 15: Metro Area Population Growth**

All four of the case study cities are experiencing a revival of their central cities and downtowns after declines, but to different extents. St. Louis being a more Midwestern industrial city began its decline in the early 1960s, and its recent revival is much less dramatic than the other three cities. Denver and Dallas both experienced declines in the 1980s after 1970s oil oriented growth periods, and now recently are both experiencing major turn arounds within their downtowns. Dallas's revitalization began ten years later than Denver and has not reached the level found in Denver, but both are classic examples of *The Great Inversion and the Future of the American City* as described by Alan Ehenhalt in his book of that title. Unlike the other three cities, Seattle's downturn decline began in the late 1960s and continued throughout the 1970s, before a turnaround began in the 1980s. The decline was primarily oriented to difficulties at Boeing, with the rejuvenation significantly oriented to arrival of Microsoft in 1979 followed by other technology companies not much later.

### **Sprawl**

Upon a comparison of Denver's sprawl index to the other three case study cities sprawl index, none can compare. As mentioned earlier, Denver rates near the top in regards to this index with a score of 125.22 and a ranking of 73 least sprawled out of 83. For the other three, Seattle is the closest with a score of 100.91 (U.S. average 100), and a ranking of 44 least sprawled. Dallas performs the worst on this overall index with a score of on 78.26 and a ranking of 13<sup>th</sup> most sprawled of the 83 metro areas examined. St Louis's score is 94.51, 35<sup>th</sup> most sprawled of the 83 cities examined (see Table 4).

When reviewing the four individual factors used to compile the overall sprawl index, Denver is above the U.S. average for all four factors and ranks the best of the four case study cities in all four categories. Seattle exhibits better than average scores, and close to Denver rates for the Residential Density and Accessibility of the Street Network factors, but ranks very low for the Mix of Homes, Jobs and Services factor (#16) and near the national average for its Strength of Town Centers/Downtowns factor. Both Dallas and St. Louis rank very low on the Strength of Town Centers/Downtowns factor with St. Louis being the fifteenth lowest of Dallas being the eighteenth lowest of the 83 cities ranked. Dallas also ranks quite low for its Mix of Homes, Jobs and Services (22<sup>nd</sup>), while St. Louis also ranks quite low for its Residential Density.

<u>Sprawl Factor</u>	Index	(most to least)
	Score	Ranking (out of 83)
<b>Residential Density Factor</b>		
Dallas	99.5	55
Denver	103.7	62
Seattle	103.62	61
St. Louis	90.29	27
<b>Mix of homes, jobs &amp; services</b>		
Dallas	82.6	22
Denver	115.67	57
Seattle	79.42	16
St. Louis	107.44	51
<b>Strength of town centers/downtowns</b>		
Dallas	81.06	18
Denver	108.87	54
Seattle	98.01	37
St. Louis	76.16	15
<b>Accessibility of street network</b>		
Dallas	90.23	32
Denver	125.72	70
Seattle	117.07	63
St. Louis	105.99	52
<b>Overall Sprawl Index Score</b>		
Dallas	78.26	13
Denver	125.22	73
Seattle	100.91	44
St. Louis	94.51	35

**Table 4: Smart Growth America Sprawl Index**

### **Census Tract Population Change**

All of the case study cities experienced and continue to experience exurban growth, though the patterns of this growth vary significantly.

Each of the major conclusions drawn from the Denver decennial population change maps is listed below and followed by a discussion on the similarities and differences found between Denver and the other three case study metro areas.

- While during the 1960s, 1970s and 1980s Denver County and the downtown saw population decreases, in the 1990s and 2000s, this trend reversed now showing predominantly population increases

All three of the other metro areas follow this pattern to some degree, especially with the population decreases in the central city in the 1960s, 1970s and 1980s. Seattle's central city did not decrease to the extent of the three cities, but did decrease. Dallas's central city population decreased at a rate not seen in any other city or any other time period during the 1980s. None of the other central cities have seen the population increase seen in Denver in the 1990s and 2000s. Dallas's central city population started to fairly rapidly grow again in the 2000s, not the 1990s like in Denver. St Louis's central city population also started to grow again in the 2000s, but to nowhere near the extent seen in Denver and Dallas. Seattle's central city population began to grow again in the 1990s similar to Denver, but not to the same extent as in Denver.

- Starting in the 1970s, the majority of the area in the eastern counties of Adams and Arapaho exhibit population increases except during the 1990s
- The population changes in the western areas of Adams and Arapaho are more similar to those in Denver County than the rest of their own county
- Population changes are the most varied in Jefferson County changing by decade and by area within the county

The exurban development in the three metro areas is not as scattershot as in Denver. Seattle has an especially even population growth pattern in the exurbs, though its more suburban areas saw population declines in the 1970s, 1980s, and 1990s similar to its central cities. St. Louis also has fairly even growth in the suburban and exurban areas, though starting in the 1990s, the furthest exurbs started losing population. Dallas's exurbs were growing rapidly until the 1980s when they nearly all show population decline. This is also when the central city showed major decline and coincides with the decline in the energy industry. In the 1990s in Dallas the exurbs began to have increased population, but not the suburban areas.

- Population increases are seen along major roadways in the 1960s and the 2000s

Growth along the major roadways is seen in Dallas and St. Louis during the 1990s and 2000s while in Seattle more of the growth is in the exurban areas not along the major roadways

- Population growth through the entire region slowed in the 1980s and 1990s

This is very true for Dallas, especially in the 1980s. St. Louis's central city declines the all decades except the 2000s, while the outer region mainly declines in the 2000s. Seattle's decline in the 1980s and 1990s was mainly confined to the Central City, while more exurban decline is found in the 2000s.



## Reintroduction of Rail Transit

	Denver	Seattle	Dallas	St. Louis
Light rail reintroduced	1994	2009	1996	1993
1st Line	5.3 miles	13.9 miles	11.9 miles	13.9 miles
Commuter rail reintroduced	2016	2000	1996	
Total track miles	48 (soon 93)	96	124	46
System expansions	Steady	minimal	Rapid	Steady
Future expansion	4 new lines (2016)	1 new line (2016)	1 extension (2016)	Talk, no plans
Central Hub	Union Station	King Street Station	Union Terminal	Union Station
Rank (annual ridership)	8	16	7	10
		<u>Light Rail</u>		
Number lines	6	1	4	2
Track miles	48	16	90	46
Number of stations	46	13	62	37
Average weekday ridership (2014)	86,300	37,200	101,800	49,900
Annual ridership (2014)	26,362,900	11,915,900	29,884,200	17,182,100
2012 to 2013 light rail ridership growth rate	9.46%	3.76%	4.22%	1.42%
		<u>Commuter Rail</u>		
Current rank		14	15	
Number lines	3	2	1	
Track miles	45	80	34	
Number of stations	15	9	10	
Average weekday ridership (2014)		13,700	8,200	
Annual ridership (2014)		3,362,800	2,293,500	
2012 to 2013 Commuter rail ridership growth rate		-5.38%	-5.38%	

**Figure 16: Rail Transit Facts and Figures**

Up to this point the reintroduction of rail transit into the Dallas metropolitan region is the most similar to what has occurred in Denver. The system which opened two years later than Denver ranks seventh in ridership in the U.S. one position ahead of Denver. The number of lines it offers is less than Denver, but its total miles of track is greater with more of this being light rail. Whereas Denver will soon have three commuter rail lines, Dallas currently only has one with no plans for expansion of this system. In regards to expansion overall, Dallas is expected to open one new line in 2016, while Denver is expected to open four new lines in 2016 (one already opened), and two more in the future. Thus, to conclude while the systems are similar in ridership and length, the Denver system is and will in the future provide service to a much larger part of the region, with numerous lines going different places as opposed to less than that travel greater distances.

The rail transit system in St. Louis was the first to open of the four metro areas, but after several initial expansions is the one with the least potential for further expansion in the future. It currently has 46 miles of track, no commuter service and is ranked tenth in regards to ridership in the U.S. Its ridership growth rate is the lowest of the four metro areas and there are only two lines operating as opposed to nine in Denver and five in Dallas.

Seattle reintroduced rail transit back into its region much later than the other three urban areas with its first line opening in 2009. Currently Seattle has one light rail line and two commuter lines, but there is expected to open a second light rail line in 2016. In regards to ridership Seattle ranks sixteenth in the U.S., but while its light rail ridership has been increasing, its commuter rail ridership has been decreasing. Though there are discussions regarding further expansion, there is nothing planned for at this time.

## **Rail Transit Oriented Planning and Policy Changes**

When examining transit oriented planning and policy changes in the other three metropolitan areas, none has made nearly the changes found in the Denver region. Dallas includes TOD in its transit system Master Plan. The Seattle transit system has a TOD policy. In St. Louis, there are TOD “Best Practices” that have been compiled by their transit system. In none of the regions have there been actual policy changes such as found with Denver’s recodification of its zoning ordinance, change in funding priorities or change in TOD philosophy.

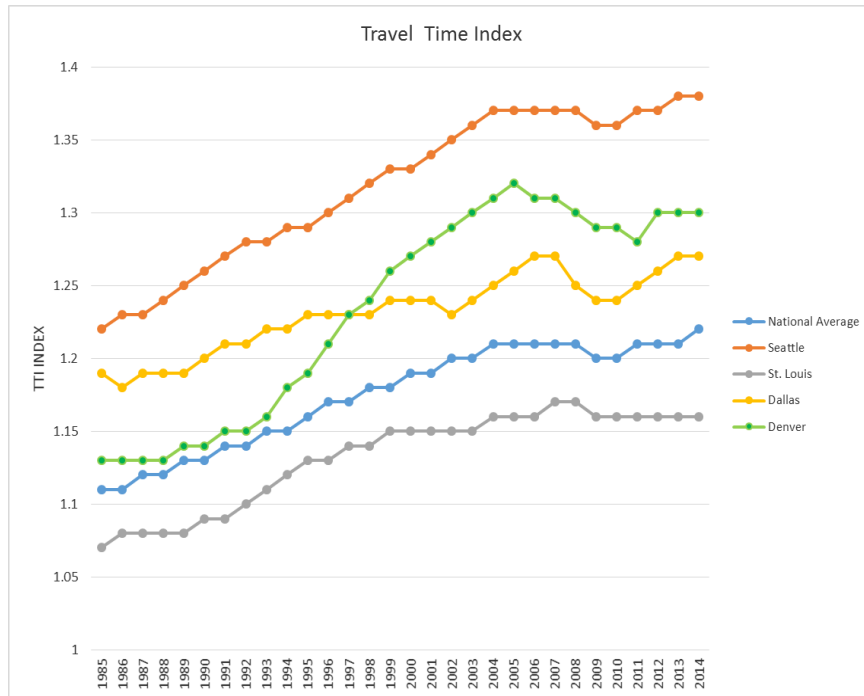
In regards to actual station area planning, Dallas has station area Fact Sheets and St. Louis has station area Profiles, but neither of these are documents that required approval as is found with Denver’s station area plans. However similar to Denver, in both Dallas and Seattle neighborhood pilot projects focusing on TOD and conducted through partnerships with the transit agency are ongoing.

## **Congestion**

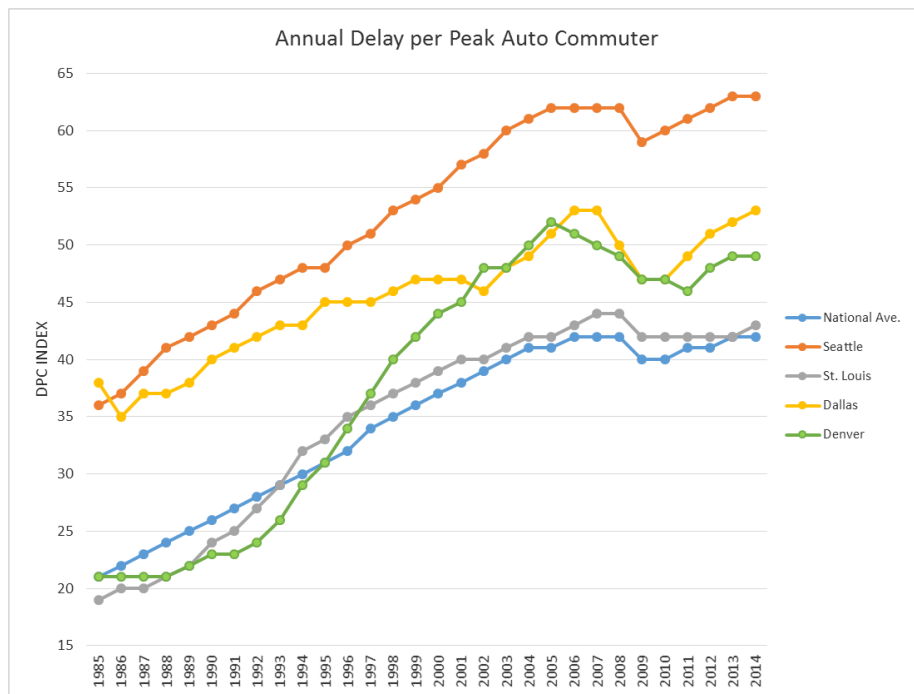
In comparing regional congestion statistics for all four of the metropolitan areas, Seattle is found to be the most congested in regards to both the Travel Time Index and Annual Delay per Peak Auto Commuter (see Figures 17, 18). Their rates are not only the highest of the four metro areas, but are also significantly above the national average. From 1992 to 2004, Denver’s TTI and Delay does grow more rapidly than in Seattle narrowing the gap between the two, but in 2004 Denver’s rate for these statistics begins to drop whereas in Seattle it just stabilizes.

In the earlier years, Dallas’s congestion statistics are worse than those found in Denver. However, in 1997 Denver TTI or ratio of travel time in the peak period compared to free-flow travel time becomes larger than in Dallas, as also occurs 2001 for the Delay statistic. Whereas in Denver and Seattle fairly rapid growth is seen in both statistics beginning in the late 1980s and continuing until the early 200s, in Dallas the growth in the statistics is much slower except from 2000 to 2005 when Dallas’s Delay statistic takes a fairly sizable jump.

In St. Louis, both congestion statistics show slow but steady increases until 2007 when the Travel Time Index stabilizes and the Annual Delay per Peak Auto Commuter drops slightly before stabilizing again. St Louis’s rate on both statistics is always below that of the other three metro areas except at the very beginning of the time period when for Annual Delay per Peak Auto Commuter the rate is slightly above Denver’s rate. St. Louis’s Travel Time Index is consistently below the national average, while it’s Annual Delay per Peak Auto Commuter starts slightly below the national average before in 1994 moving just above the national average and then remaining there.



**Figure 17: Travel Time Index**



**Figure 18: Annual Delay per Peak Auto Commuter**

# Air Quality

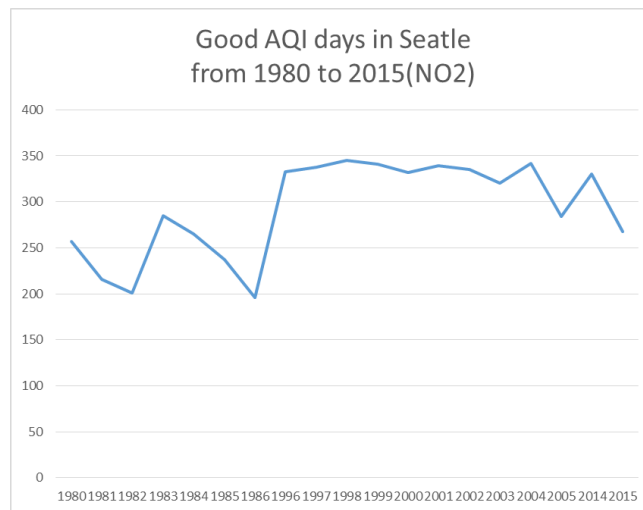
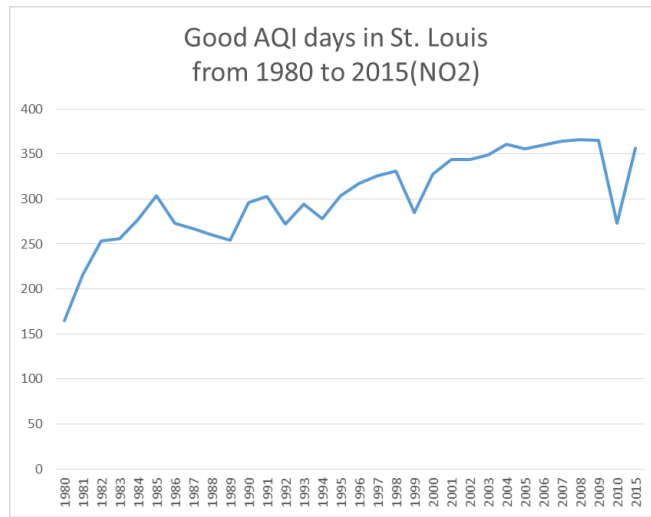
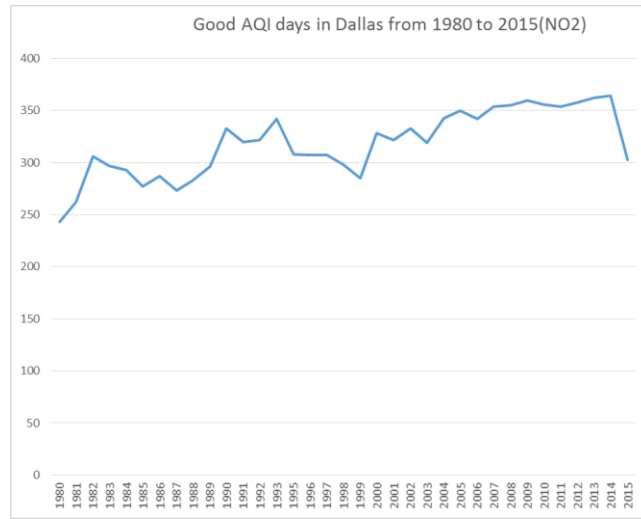


Figure 19: Good Air Quality Index Graphs

Upon a review of the Good Air Quality Index graphs (see Figure 19) to that presented earlier for Denver, none of the other regions exhibit the dramatic jump to significantly more “good” air quality days that was seen in Denver from 2000 to 2004. In St. Louis there is a significant increase in “good” air quality day from 1980 to 1985, but then the rate levels off except for a large drop in 2010, followed by a quick return to the earlier rate. In Dallas there is large increase in the number of “good” air quality days from 1980 to 1982, but then the rate is fairly consistent except for a decrease in 2015. In Seattle, from 1980 to 1996 the number of “good” air quality days fluctuates dramatically before leveling off until 2004 when the rate again starts to fluctuate. Overall, Denver’s number of “good” air quality days is less than found in the other three metro areas. AS the Denver region is known for having more problematic air quality than the other three areas, this is not a surprise.

## CONCLUSION AND TYPOLOGY

To conclude this project, first a review of the reintroduction of rail transit and the changing characteristics of each of the case study metropolitan regions is presented. Denver, being the original metropolitan region of study and the one the others were compared to is presented first. Interestingly, the Denver metropolitan region ended up being totally different in regards to both its reintroduction of rail transit and regional characteristics from any of the other case study regions. Overall, all four of the case study rail transit reintroduction stories and regional change statistics were very different from one another. After the review of each of the case study metropolitan areas, a simple metropolitan region/reintroduction of rail transit typology is presented and discussed.

The reintroduction of rail transit into the Denver metropolitan area and its relationship to changes occurring in the region is very unique and most likely different from any other metropolitan area in the country. To begin with, in Denver an entire interconnected rail transit system is being built from a single public transportation plan (FasTracks), instead of individual lines being built one at a time. The lines will all connect at Union Station, the new intermodal transportation hub, and provide service to most major destinations throughout the region.



Figure 20: Denver Rail Transit System

Coinciding with the development of the rail transit system in Denver has been a strong focus on transit oriented planning and policy. This includes TOD staff working for RTD, the city of Denver and the Denver regional planning commission. It also includes a TOD Strategic Plan, approved individual station area plans, revised transit friendly zoning, and changes in public transportation funding to better support the development of rail transit.

The characteristics of the Denver region both before and after rail transit was reintroduced are also very different from the other three case study regions. To begin with, Denver is the smallest region with the least population. It is also the least sprawling of the four case study metro areas, and is one of the least sprawling metropolitan areas in the country. Denver's average family and per capita income are quite high, as are its percentage of the population with both a high school diploma and a bachelor's degree.

In the time that rail transit has been in existence in the Denver area, its central city has grown and developed very rapidly and rail transit has become a major mode of travel for those living and working in this location. At the same time, its exurban areas have experienced growth, but this growth has been in rather scatter shot pattern, rather than a continuous expansion in the same areas. Though its congestion and air quality problems were rapidly exacerbating in the 1990, both have leveled off since the early 2000s.

Rail transit was reintroduced into the Dallas metropolitan region around the same time as Denver. It has expanded to having even more miles of track than Denver, and also has slightly higher ridership than Denver. The light rail system is the longest in the country having expanded from its initial one line when opening to four lines today (see figure 21). Planning and policy related to transit has not been nearly as pronounced in Dallas as in Denver. TOD is recognized and briefly discussed in the transit agency master plan and station area fact sheets are available. However, no significant transit planning projects or policy changes have been made since rail transit was reintroduced. Several pilot projects utilizing public private partnership for station area development are presently ongoing however.

Dallas is one of the most sprawled metropolitan areas in the U.S. being twice the size of the Denver metro area. Regardless of this sprawl, its measures of congestion are very similar to those in Denver, and similar to Denver they have leveled off since in the early 2000s. Dallas's central city has begun to grow again, but this growth began later than in Denver and has not been nearly to the extent seen in Denver. In fact, for the sprawl index dimension of "Strength of Town Centers/Downtown it rated very poorly.

Dallas's exurban growth has consistently been in the same parts of the region, unlike Denver where it continually moved around. Dallas's population have much lower family and per capita incomes than Denver's and the national average, as well as much lower percentage of the population with either a high school diploma or Bachelor's degree than Denver or the national average. The number of good AQI days in Dallas has also been more stable than in Denver, bouncing around somewhat, but generally being on a trend of improvement.

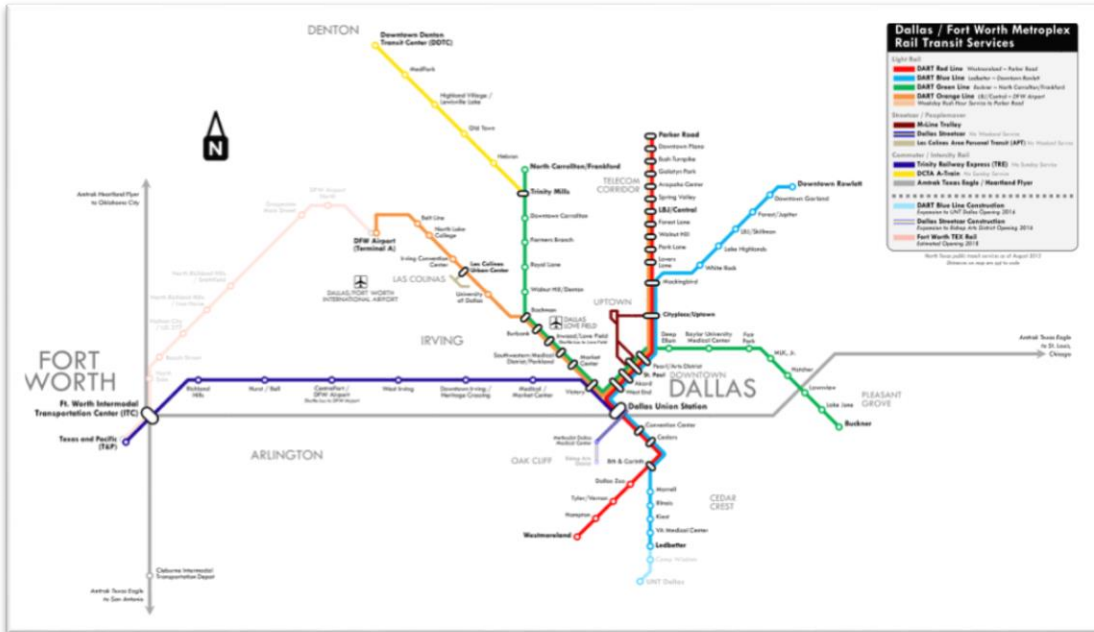


Figure 21: Dallas Rail Transit System

Rail transit was also reintroduced into the St. Louis metropolitan region around the same time as in Denver and Dallas. However, in St. Louis the system has not expanded like in Denver and Dallas. Instead, today there are two lines as there have been since 2000, with several short extensions added, but no serious discussion about adding any new lines at this time. In regards to transit oriented planning and policy, there are TOD “Best Practices” and station area profiles, but little true transit planning has been done and no major transit oriented policy changes have been implemented.

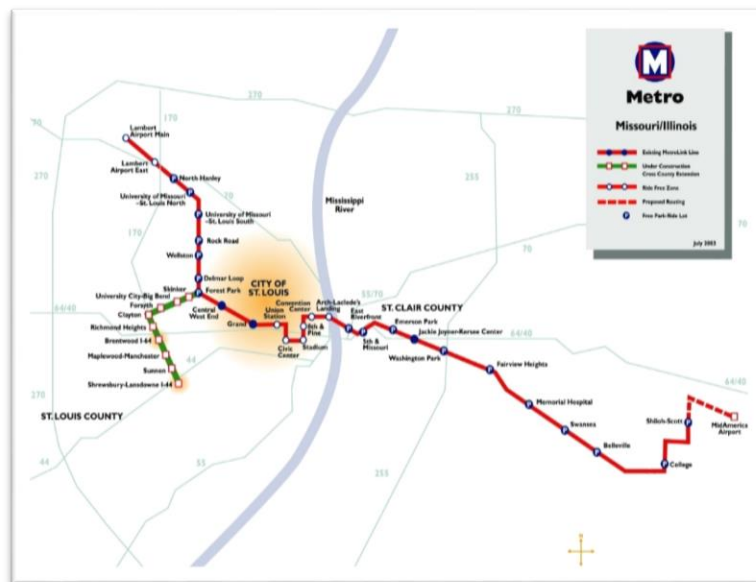
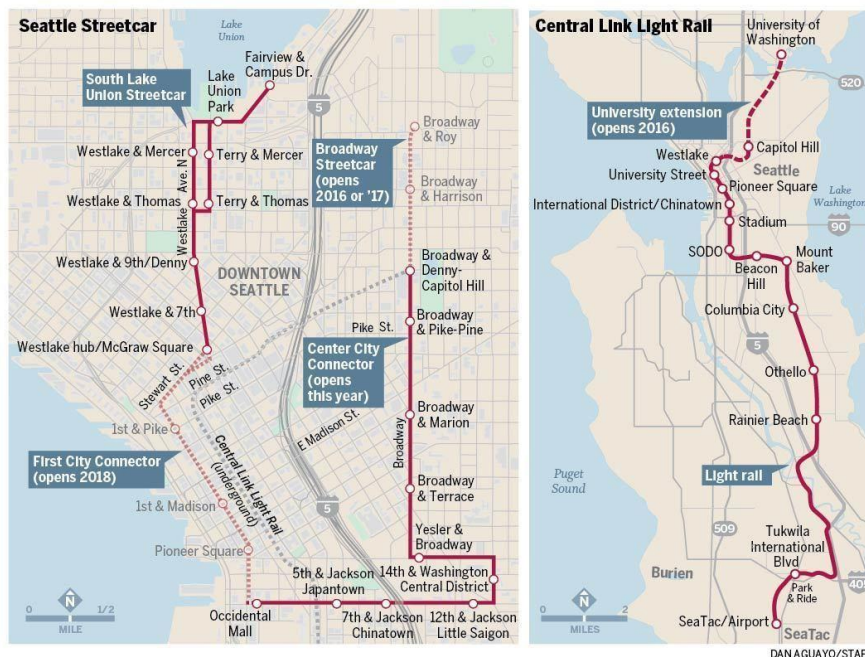


Figure 22: St. Louis Rail Transit System



Upon examination of the St. Louis metropolitan area, it has about the same population as Denver, but in a much larger area. It has the oldest population and income and education levels similar to the national average, but below those found in Denver. St. Louis is the second most sprawling of the four case study metro areas, with an especially low rating in regards to its Strength of Town Centers/Downtowns (similar to Dallas). Recently, its central city has begun to slightly grow again, though at nowhere near the rate seen in Denver, or even Dallas for that matter. Of the four case study regions, St. Louis has the least congestion, being at about the national average in regards to Delay and just over the national average in regards to the TTI. Both of these measures have steadily increased, but at about exactly the same pace as the national average. Good AQI days in St. Louis made a significant improvement in the early 1980s and have remained fairly steady since.

Light rail transit wasn't reintroduced into the Seattle metropolitan region until 2009, though a commuter service to Tacoma did start in 2000. Since 2009, the light rail line has been extended but no new lines have been built. A new light rail line to the northwest is under construction and scheduled to open in 2021. Two short inner city streetcars also operate in the central city (see figure 23).



**Figure 23: Seattle Light Rail and Streetcar Lines**

Transit oriented planning projects and policy changes similar to those found in Denver are also found in Seattle. Sound Transit has an up to date TOD Strategic Plan, a TOD Policy and a TOD staff. There is also currently a proposal (Sound Transit 3) for the voters to pass a tax increase similar to FasTracks in Denver to build out a regional light rail system.

The Seattle metropolitan area is a similar size to Denver and has similar population, but has a much worse problem with congestion. Seattle's sprawl factor is equal to the national average, even though it ranks very low in the Mix of Homes Jobs and Services dimension.

The central city has recently been growing in both housing and jobs since 2000, unlike Denver which started its central city growth in 1990. Seattle's exurban areas have continually grown though its more inner suburbs did decline from the 1970s to the 1990s. Seattle has the highest income of the four case study metro areas and a similar high income to Denver.

From the reviews above it is seen that the four metropolitan regions examined in this project have some similarities but many more differences. Remembering back to the methodology, this is what was expected as the regions were specifically chosen for their differences. All four have reintroduced rail transit into their regions, the how that rail transit has grown and how the region has reacted around it varies greatly. The final step of this project is to collate these differences into a simple typology.

The typology will begin with a discussion about Denver. Denver is now a "rail transit" region. Making it a "rail transit region" are the following characteristics:

- An integrated rail transit system
- Rail transit planning at different scales
- Changing policy to support rail transit operation and development
- Significant public monetary investment
- Well-educated people with above average incomes
- Not an overly large region in area
- Not a region considered sprawling
- Has a booming central city
- Has exurbs that continue to grow in spots, but not over the entire region.
- Air quality was a major issue for many years
- Air Quality dramatically improved from 2000 to 2005
- Congestion above the national average
- Congestion which increased rapidly from 1991 to 2004 but has now stabilized and even decreased.

Seattle is the region most like Denver with similar demographics and now possibly following in Denver's footsteps in building a regional rail transit system, so it is a "rail transit supportive" region. Making it a "rail transit supportive" region are the following characteristics:

- Several rail transit lines in place
- Rail transit planning at different scales
- Changing policy to support rail transit operation and development
- Strong interest in the making a significant public monetary investment
- Well-educated people with above average incomes
- Not an overly large region in area
- A region with an average level of sprawl
- Has a growing central city

- Congestion is a major problem especially with a continually increasing travel time index
- Air quality not a large issue

Dallas is the region with a rail transit system most similar to Denver's. However, its demographics are much different as is its support for rail transit so it is a "rail transit commuter" region. Making it a "rail transit commuter" region are the following characteristics:

- Large region in area and large population
- Very sprawled area
- Has a growing central city
- Several rail transit lines in place
- Strong ridership and support for rail transit service
- Rail transit planning at station level scale
- No long range rail transit plan in place
- Congestion above the national average
- Air quality not a large issue
- Less educated, lower income population

St Louis is the region most different from Denver. It has been a large urban center for longer than any of the other three regions but is not part of the fast growing southwest or northwest so it is a "Midwestern light rail transit" region. Making it a "Midwestern light rail transit" region are the following characteristics:

- Classic Midwestern sprawled growth with central city vacated during 1960s and 1970s
- Recent small growth in central city
- Several light rail transit lines in place
- Minimal growth in the light rail system
- No long range rail transit plan in place
- Minimal interest in large scale public investment rail transit
- Traffic congestion near the national average, but steadily increasing
- Air quality not a large issue
- Older population with average education and average income

## RECOMMENDATIONS

This project has provided a much better and deeper understanding of the ways that rail transit is fitting in to different U.S. metropolitan areas and the changes that are occurring in those metropolitan areas, whether oriented to rail transit or not. As such, this project is very useful to any region looking to see how rail transit development and regional change can best mesh together. The final outcome of this project is a typology that describes the regional characteristics of numerous different categories of information for metropolitan areas that have reintroduced rail transit.

In an area given the typological definition of a “rail transit” region like Denver, many different regional characteristics that support rail transit service and development are found. However, in a region designated a “Midwestern light rail transit” region like St. Louis, many fewer supportive characteristics are seen. Recognizing the difference between the characteristics of a region and assigning it to a rail transit related typological designation will help any region to better understand how to move forward with its future rail transit program.

Often when regions have rail transit and are trying to understand how it fits into their region, and how their region fits the rail transit service, many important issues are not examined. From this project, what some of those important issues might be are now more clearly spelled out. For example, in a “commuter rail transit” region such as Dallas, knowing that the service is more oriented to moving commuters over the large size of the area, rather than providing comprehensive regional transportation would change the design and future development of that service.

The primary recommendation of this project is for planners and policy makers to be sure to recognize that metropolitan areas with different characteristics accommodate rail transit service differently. The characteristics laid out in the topological definitions found in the conclusion will help these individuals do this. In some instances large scale rail transit oriented planning projects and transit supportive policy changes can lead to significant new or improved rail transit service. However, in other instances these types of activities may be expensive exercises in futility.

From this project, the most interesting region to watch will be Seattle. Here is a region with many similarities to Denver, but about fifteen years behind Denver in regards to its rail transit development. Though currently it was designated in this project as a “rail transit supportive” region, it has the potential to move to being a full “rail transit” region in the near future. One characteristic identified that would tremendously support this change is the high level of congestion found in and around Seattle. However, another characteristic that might hinder this change is financial support from the public, which will be voted on later this year.

A final recommendation is to expand the analysis conducted for Denver, Dallas, St. Louis and Seattle to other U.S. metropolitan regions that have reintroduced rail transit over the past 30 to 40 years. Upon collecting information on these areas, it could then be added to the typology already developed to either expand the characteristic for an already created typological designation, or to create an entirely new typological designations if needed.

## **ACRONYMS, ABBREVIATIONS, AND SYMBOLS**

AQI – Air Quality Index  
Delay - Annual Delay per Peak Auto Commuter  
LODO – Denver’s Lower Downtown District  
MSA - Metropolitan Statistical Area  
NCIT – National Center for Intermodal Transportation  
RTD - Denver Regional Transportation District  
TIP - Transportation Improvement Program  
TTI - Travel Time Index  
TOD - transit-oriented development



## REFERENCES

### Written References

Bhattacharjee and Goetz. "Impact of light rail on traffic congestion in Denver". *Journal of Transport Geography*, 22. (2012).

Downtown Denver Partnership. *Downtown Denver Commuter Survey 2013*.

Texas A & M Transportation Institute. *Annual Urban Mobility Report*, 2014.

Denver RTD, *2013 TOD Status Report*.

Denver RTD, *TOD Strategic Plan 2014*.

Alan Ehrenhalt, *The Great Inversion and the Future of the American City*. Knopf Publishing, 2012.

NCIT Report. Transport, Energy and Environmental Benefits of Transit-Oriented Development Strategies (2013).

Reid Ewing, Rolf Pendall, Don Chen, Smart Growth America. "MEASURING SPRAWL AND ITS IMPACT". Smart Growth America (2002)

Texas A & M Transportation Institute. *2014 Annual Urban Mobility Report*

Tri-State Transportation Campaign. "Tracking State Transportation Dollars", July 2012.

## Internet Websites

A Brief History of St. Louis

<https://www.stlouis-mo.gov/visit-play/stlouis-history.cfm>

A Brief History of Seattle

<http://www.seattle.gov/cityarchives/seattle-facts/brief-history-of-seattle>

APTA Public Transit Ridership Report, 4th Quarter 2013

<http://www.apta.com/resources/statistics/Documents/Ridership/2013-q4-ridership-APTA.pdf>

Belmar Redevelopment Project <http://urbanland.uli.org/development-business/belmar-urbanizing-a-suburban-colorado-mall/>

Denver Department of Environmental Health

<https://www.denvergov.org/environmentalhealth/EnvironmentalHealth/EnvironmentalQuality/AirQuality/tabid/444649/Default.aspx>

Denver FasTracks Program [www.rtd-denver.com/FF-FasTracks.shtml](http://www.rtd-denver.com/FF-FasTracks.shtml)

Denver RTD, TOD Pilot Projects [/newpartners.org/2014/wp-content/plugins/schedule-viewer/data/presentations/Friday/3.30-5.30pm/Rail%20in%20the%20West/Sirois.pdf](http://newpartners.org/2014/wp-content/plugins/schedule-viewer/data/presentations/Friday/3.30-5.30pm/Rail%20in%20the%20West/Sirois.pdf)

EPA Air Quality Data

<https://www3.epa.gov/airdata/>

FasTraks Program description

[www.rtd-denver.com/FF-FasTracks.shtml](http://www.rtd-denver.com/FF-FasTracks.shtml)

Forbes Magazine [www.forbes.com/sites/erincarlyle/2014/02/14/americas-20-fastest-growing-cities/](http://www.forbes.com/sites/erincarlyle/2014/02/14/americas-20-fastest-growing-cities/)

RTD Pilot Projects [/newpartners.org/2014/wp-content/plugins/schedule-viewer/data/presentations/Friday/3.30-5.30pm/Rail%20in%20the%20West/Sirois.pdf](http://newpartners.org/2014/wp-content/plugins/schedule-viewer/data/presentations/Friday/3.30-5.30pm/Rail%20in%20the%20West/Sirois.pdf)

“Seattle region’s population growing at historic pace, making biggest annual gain in a century”

<http://www.geekwire.com/2016/seattle-regions-population-growing-historic-pace-making-biggest-annual-gain-century/> -

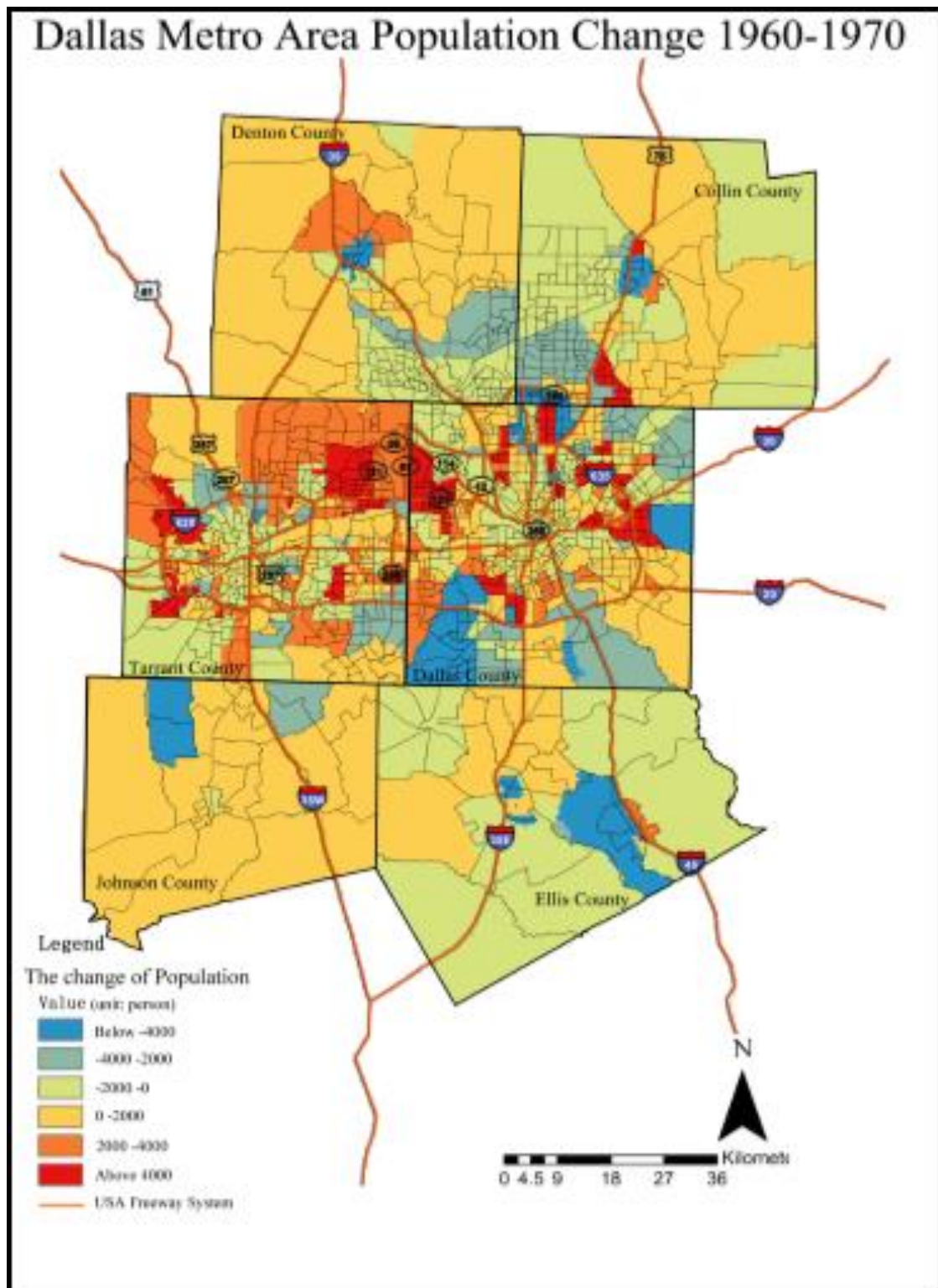
Stapleton Airport Redevelopment Project <http://www.stapletondenver.com/community/>

“The Rebirth of Dallas”

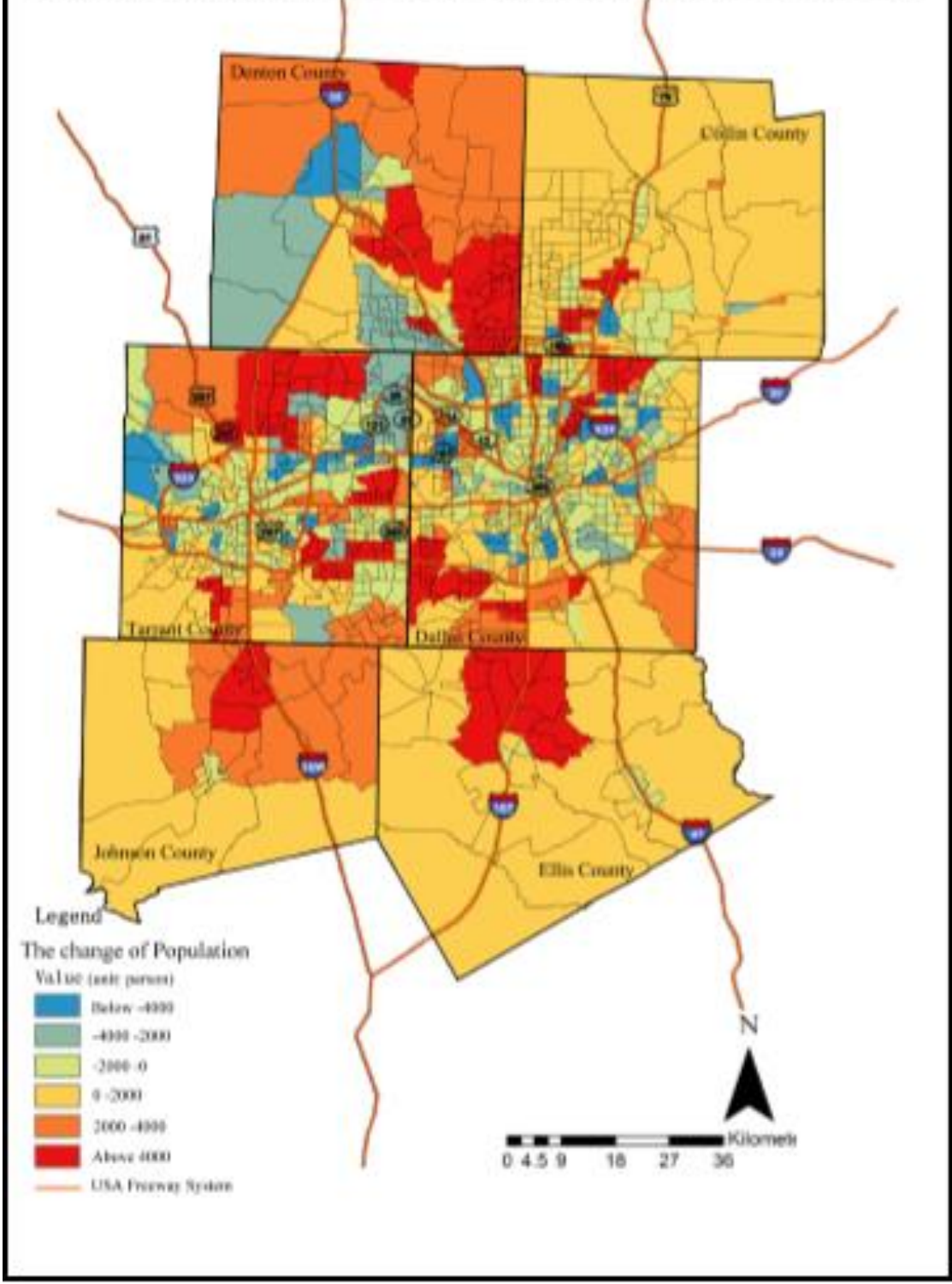
<http://www.dmagazine.com/publications/d-magazine/2014/september/rebirth-of-dallas/> -



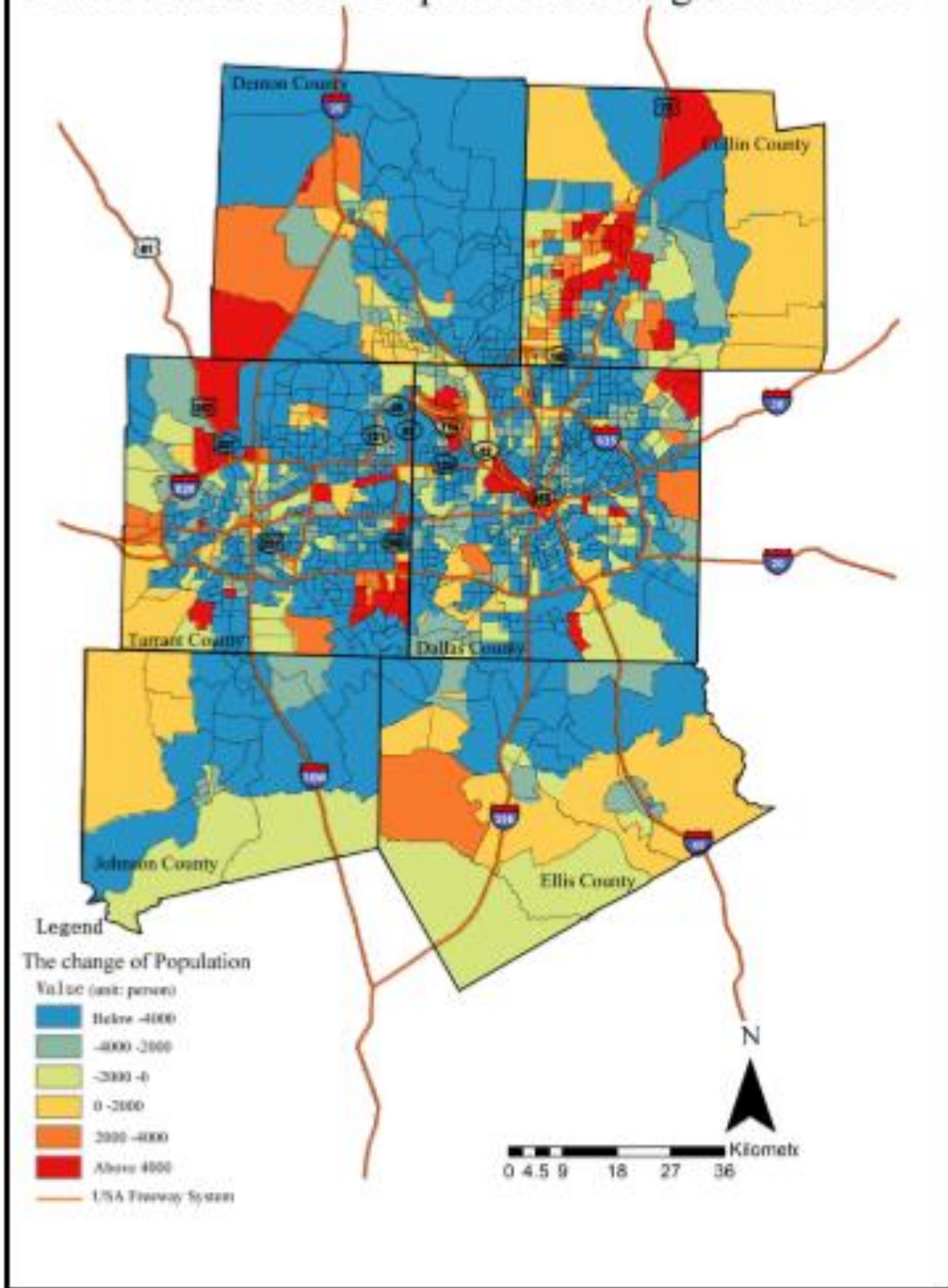
## APPENDIX A: CENSUS TRACT POPULATION CHANGE MAPS



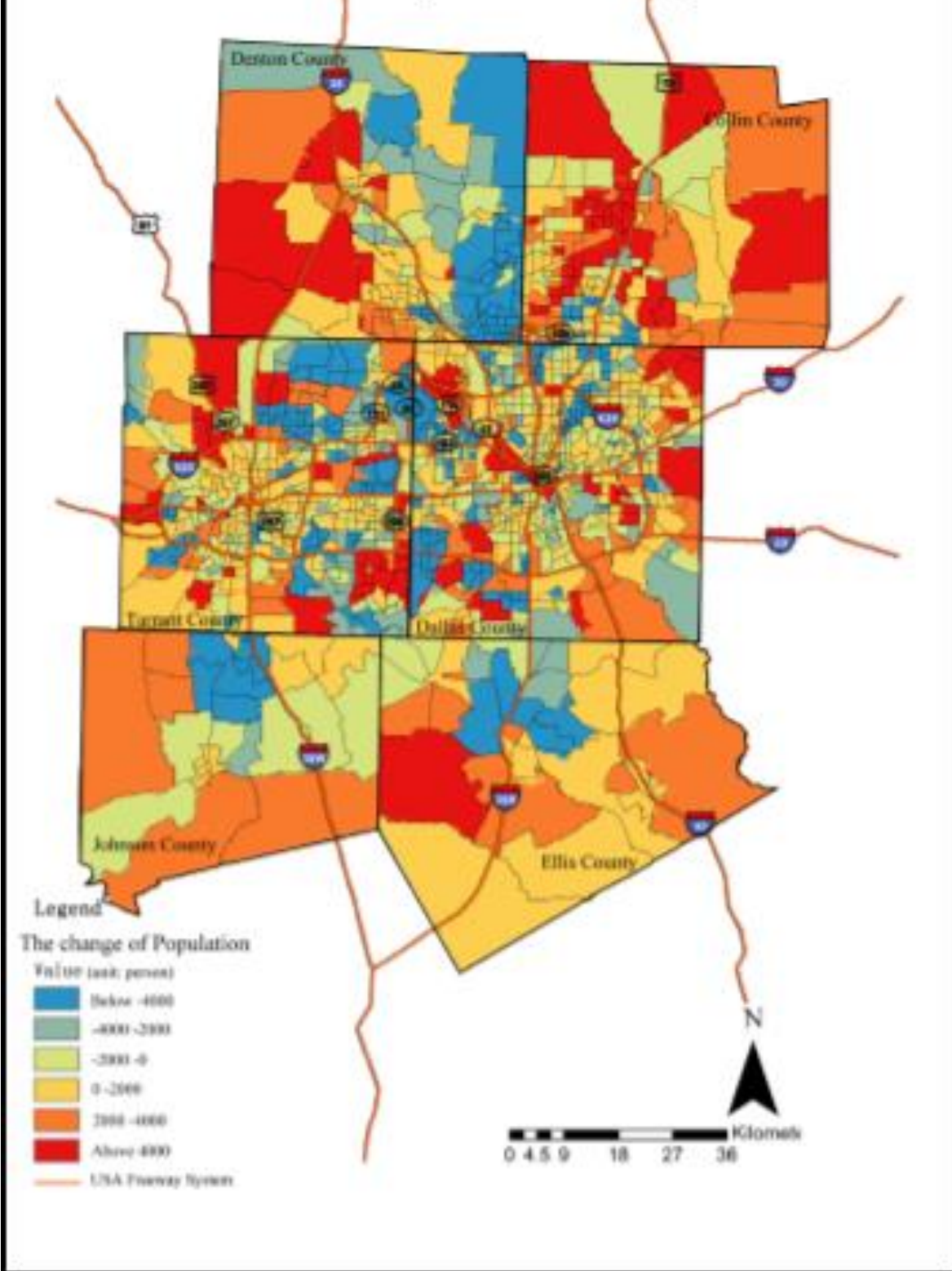
# Dallas Metro Area Population Change 1970-1980



# Dallas Metro Area Population Change 1980-1990



# Dallas Metro Area Population Change 1990-2000



# Dallas Metro Area Population Change 2000-2010

