Delaware Valley
Regional Planning
Commission

2007

Creating a

REGIONAL TRANSIT SCORE PROTOCOL

Full Report

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Created in 1965, the Delaware Valley Regional Planning Commission (DVRPC) is an interstate, intercounty, and intercity agency that provides continuing, comprehensive, and coordinated planning to shape a vision for the future growth of the Delaware Valley region. The region includes Bucks, Chester, Delaware, and Montgomery counties, as well as the City of Philadelphia in Pennsylvania; and Burlington, Camden, Gloucester, and Mercer counties in New Jersey. DVRPC provides technical assistance and services; conducts high priority studies that respond to the requests and demands of member state and local governments; fosters cooperation among various constituents to forge a consensus on diverse regional issues; determines and meets the needs of the private sector; and practices public outreach efforts to promote two-way communication and public awareness of regional issues and the Commission.

The DVRPC logo is adapted from the official seal of the Commission and is designed as a stylized image of the Delaware Valley. The outer ring symbolizes the region as a whole while the diagonal bar signifies the Delaware River flowing through it. The two adjoining crescents represent the Commonwealth of Pennsylvania and the State of New Jersey. The logo combines these elements to depict the areas served by DVRPC.

DVRPC is funded by a variety of funding sources including federal grants from the U.S. Department of Transportation's Federal Highway Administration (FHWA) and Federal Transit Administration (FTA) The Pennsylvania and New Jersey departments of transportation, as well as by DVRPC's state and local member governments. The authors, however, are solely responsible for this report's findings and conclusions, which may not represent the official views of policies of the funding agencies.

DVRPC fully complies with Title VI of the Civil Rights Act of 1964 and related statutes and regulations in all programs and activities. DVRPC's website may be translated into Spanish, Russian, and Traditional Chinese online by visiting www.dvrpc.org. Publications and other public documents can be made available in alternative languages or formats, if requested. For more information, please call (215) 238-2871.

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EXECUTIVE SUMMARY

This two-phase project defines a method to assess the appropriateness of various modes and intensities of transit service throughout the DVRPC region. Phase I consisted of a statistical evaluation and refinement of New Jersey Transit's existing transit score method. This included a regression analysis to test the relationships between existing variables, additional variables, and transit mode share for the region, the State of New Jersey, and the combined area of the two. Based on the results of this evaluation, a refined transit score equation was derived for congruent use in both New Jersey and Pennsylvania. This DVRPC Transit Score Tool is as follows (all densities gross):

Transit score = [0.41*(Population per acre)] + [0.09*(Jobs per acre)] + [0.74*(Zero car households per acre)]

The DVRPC Transit Score Tool was then classified into five score category ranges (from 'low' to 'high'):

Low: < 0.6
Marginal: 0.6 – 1.0
Medium: 1.01 – 2.5
Medium-High: 2.51 – 7.5
High: > 7.5

Each score category was then associated with particular transit service investments that would be broadly appropriate, depending on other planning considerations:

Appropriateness of transit service intensity/investment by transit score category

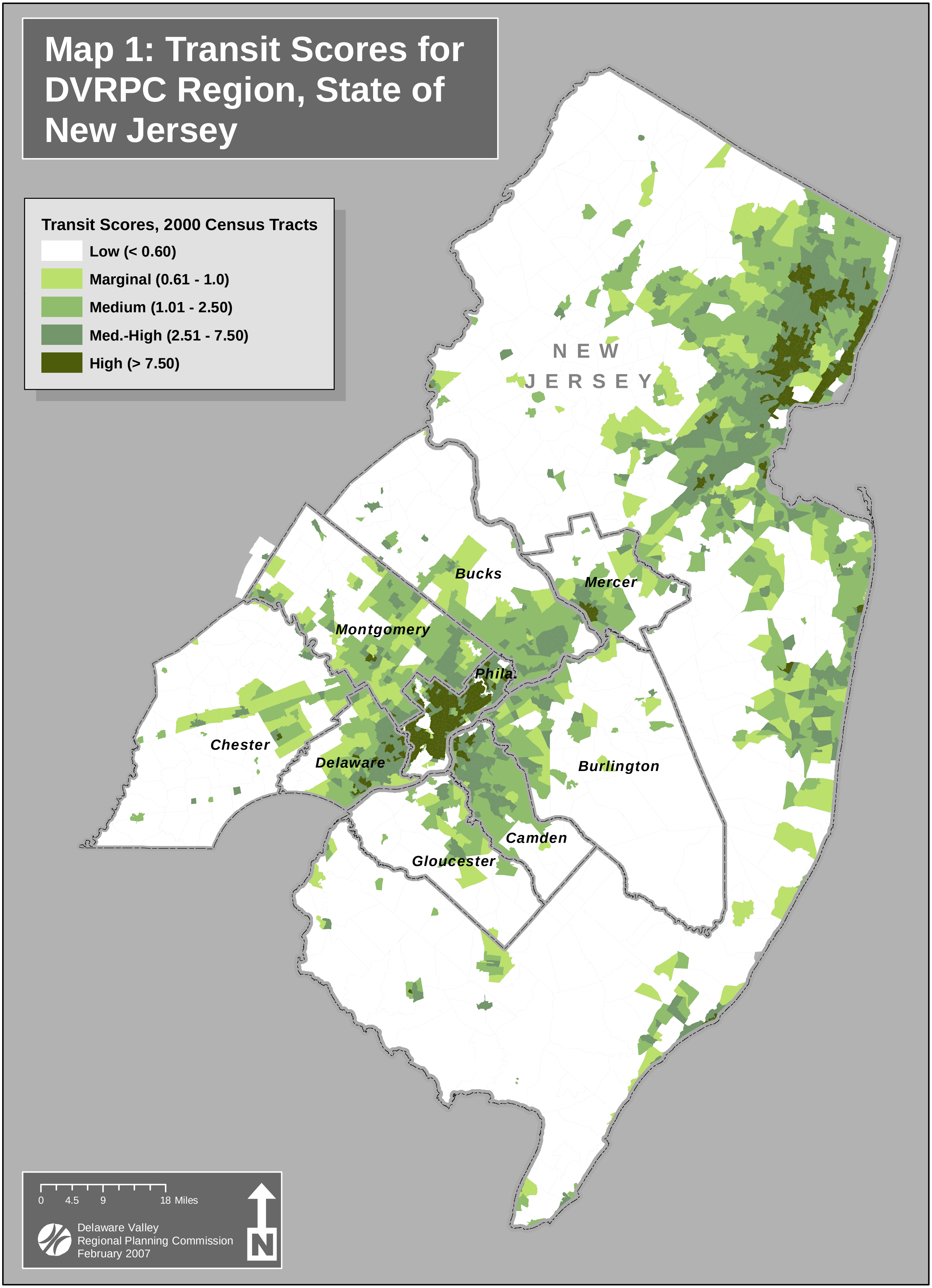
	Transit score category				
Transit modal investment	**High**	**Med.-High**	**Medium**	**Marginal**	**Low**
Heavy Urban Rail	A	N	N	N	N
Light Rail Transit (LRT)	A	A	C	N	N
Commuter Rail	A	A	C	C	N
Bus Rapid Transit (BRT)	A	A	C	N	N
Bus Lanes	A	A	N	N	N
Bus Priority Treatment	A	A	C	N	N
Fixed Route/Line Haul Bus Service	A	A	A	C	N
Express Bus	A	A	C	C	C
Local Circulator Bus/Shuttle/Paratransit	A	A	A	A	A

A = Appropriate
C = May be appropriate depending on conditions
N = Not appropriate

Source: DVRPC 2007

The Transit Score Tool is technical in nature but transparent and accessible in application, and informs a better understanding of the relationship between land use configuration and public transportation. This will enable a more productive discussion among all regional stakeholders of proposed projects at the conceptual level. Map 1 illustrates transit scores for the DVRPC region and State of New Jersey.

Map 1: Transit Scores for DVRPC Region, State of New Jersey



INTRODUCTION

The central purpose of this two-phase project is to define technical criteria to assess the appropriateness of various modes and levels of transit service throughout the DVRPC region. The project has two basic components: the first consists of a thorough evaluation of New Jersey Transit's existing transit score method, including the testing of additional variables for their relevance in the region, the State of New Jersey, and the combined area of the two. Second, based on the results of this evaluation, a refined method is created for congruent use in both New Jersey and Pennsylvania and tested under multiple land use scenarios.

PROJECT HISTORY

The present analysis has its roots in the July 1989 DVRPC report *Transit Potential in Suburban Growth Corridors: SEPTA Service Area Analysis* (Publication No. 89019). This project identified zones as being viable for transit service based on three sequential factors: total work destinations, density of work destinations, and total work origins (considered only for employment centers of a certain threshold). This method recognized that both residential and employment density impact transit viability, but that employment centers and mixed centers of both residence and employment are more likely to sustain transit service than exclusively residential areas.

Two later DVRPC studies refined this method of estimating transit viability. *Transit Potential in the Pennsylvania Counties* (Oct. 1992; Publication No. 92020) and *Transit Potential in the New Jersey Counties* (Oct. 1993; Publication No. 93026) expanded the method to consider a series of demographic variables which were believed to have positive impacts on transit ridership. According to these reports, variables were selected based on data availability, clarity to decision makers, and directness to transit use.

The variables considered to influence transit trip generation on the residential side were the densities of population, households, 0-car households, 1-car households, senior population, and youth population. The density of destination jobs was used to estimate transit viability for an area as an attractor.

Each of these variables was assigned threshold densities beyond which transit was presumed to be supported, and a given geography was 'scored' on each variable by calculating a proportion of its local value to the standard threshold. For example, the threshold for population density was 3.0 persons per acre. If a given zone had a density of 6.0 persons per acre, its 'score' for the population variable was 2.0. A zone's values (or scores) for each of the origin (residential trip-end) factors were averaged and then added to its 'score' for employment density to arrive at its composite transit potential score. A composite score of 1.0 was assigned as being the minimum threshold for transit service viability. A summary equation is as follows (all densities gross):

$$\text{Transit potential} = \Big[\ (\text{Population per acre} / 3.0) + (\text{Households per acre}) + [(\text{0-car households p. acre} / 0.5) + (\text{1-car households p. acre})] + [(\text{Seniors } [\mathit{65+}] \text{ per acre}) + (\text{Youth } [\mathit{12\text{-}18}] \text{ per acre} / 2.0)]\ \Big] / 4 + \Big[\ (\text{Jobs per acre} / 2.5)\ \Big]$$

While each of the thresholds (for each input variable as well as for the composite score) was estimated logically, the actual relative significance of each input in affecting transit ridership was not assessed in any scientific way.

New Jersey Transit (NJT)'s current transit score method was described in the October 2000 publication *The 2020 Transit Score Report: Possibilities for the Future*. This report describes the above-referenced DVRPC 'Transit Potential' studies (specifically the October 1993 New Jersey Counties report) as being the primary influence on the transit score method. Similar to the method employed in these prior studies, the transit score represents a composite value derived from a series of local demographic densities.

Specifically, the factors which combined to impact the NJT transit score are: a) population density, b) household density, c) 0-car household density, d) 1-car household density, and e) destination trip-end employment (i.e. job) density. The transit score method considers each of these items additively, with the transit score being comprised of four trip origin-end (residential) inputs [a-d] and one destination (job) input [e]. This is in contrast to the prior DVRPC studies, which averaged the origin-end factors into a single factor which would be equally weighted with the destination-end factor (job density). The precise transit score equation is as follows:

Current NJT transit score = [(Population per land acre) / 3.0] +
[Households per land acre] +
[(0-car households per land acre) / 0.5] +
[(1-car households per land acre) / 3.0] +
[(Jobs per land acre) / 2.5]

It is worth noting in the context of the current report that this equation has the same format as a regression equation with the transit score being the dependent variable. In this regard, the denominator of each fraction can also be expressed as a coefficient ("*2.0" rather than "/ 0.5" for the density of 0-car households, for example).

Similar to the prior DVRPC studies, the transit score method assigns a score of 1.0 as being the minimum threshold for transit service. Interestingly, the New Jersey Transit report notes that the division of population density by 3.0 (or, alternately written, the assignment of a 0.333 coefficient) is intended to represent the average size of households (at the time estimated to be 3.0). By converting population density to household density in this way, however, the first two factors in the equation are effectively duplicates.

The NJT transit score method moves beyond the prior DVRPC studies in associating transit score categories with particular levels of transit service and transit infrastructure investment. Calculated transit scores are grouped into ranked categories (five categories ranging from 'low' to 'high'). Individual infrastructure and service investments are then listed as being applicable, conditionally applicable, or not applicable for each transit score category. In this way, the transit score serves as a preliminary screening method for specific service recommendations in particular geographies.

The existing transit score method has been employed in conjunction with multiple planning initiatives in the DVRPC region. Several of these are:

- The Delaware River Joint Toll Bridge Commission's Southerly Crossings Corridor Study (August 2002), which evaluated strategies to reduce bridge congestion between Bucks and Mercer Counties, used the transit score method to screen transit service investments that might be appropriate as part of a no-build / systems management scenario.

- New Jersey DOT's Route 70 Concept Development Report (October 2004) used the transit score method to screen various levels of transit investment for their potential appropriateness within the corridor.

- Initial phases of the New Jersey Transit Route 1 Bus Rapid Transit (BRT) study used the transit score method to assess the viability of a Light Rail Transit (LRT) option in the corridor.

- DVRPC's Congestion Management Process (CMP) factors a high transit score as contributing to congested corridors' Intermodal Importance.

SUMMARY OF METHODS

One of the most significant aspects of this project is an assessment of the transit score method for increased application across the DVRPC region. This was originally to include updating the transit score equation inputs to reflect new Census data (refining the division of population density by 3.0 to a division by actual average household size, for example). However, working with the project's steering committee, including representatives from New Jersey Transit and SEPTA, it was determined that a more scientific assessment of the existing transit score method would be appropriate. This assessment would result in a refined scoring equation, with coefficients that more accurately reflect the real-world relative impacts of each demographic characteristic on transit ridership and viability. Such a refined transit score equation could then be adopted as a 'scoring' method by both New Jersey Transit and SEPTA. Use of a refined method by both agencies (as well as DVRPC and any other interested parties) would promote policy congruence across state and other jurisdictional boundaries.

As a means of performing this analysis, a series of linear regression calculations were performed based on the use of the transit score input factors as independent variables and transit work trip mode share (a proxy for transit score) as the dependent variable. These analyses permit a quantitative assessment of the input variables which are statistically significant predictors for Census Tract transit mode share within a given geographic area. Transit mode share is an appropriate proxy for transit score because it reflects transit viability: where transit mode share is high, transit service is both provided and utilized (i.e. it is viable).

Prior to performing regression analyses, a correlation analysis was performed among all of the independent variables to assess the extent to which input variables were correlated with one another. If two variables are highly correlated and do not clearly capture different factors, they are effectively measuring the same phenomena and should not both be used in a regression analysis.

In order to assess the similarities and differences among the various portions of the study area, regression analyses were separately performed for three data sets (geographic areas): a) the DVRPC region, b) the State of New Jersey (including the NJ portion of the DVRPC region), and c) the merged ‘universe’ of New Jersey plus the Pennsylvania portion of the DVRPC region. In addition to the inputs from the existing transit score method, new independent variables relating to transit proximity and travel time were employed to test the significance of these factors. Testing additional inputs in this way refines the understanding of factors which affect transit mode share.

This project will result in a Transit Score Tool that balances statistical viability and soundness with transparency and usability by all manner of groups and agencies.

DESCRIPTION OF DATA

Much of the data for the State of New Jersey was provided by New Jersey Transit staff from the existing transit score dataset. Demographic data for Pennsylvania tracts as well as other journey to work data were extracted from the 2000 Census Transportation Planning Package (CTPP). Spatial data (land acres) was provided by New Jersey Transit staff for the State of New Jersey and extracted from DVRPC’s 2000 regional Land Use dataset for Pennsylvania.

The level of analysis for this project is the 2000 Census Tract. New Jersey Transit data was more readily available at the Census Tract level, and the use of tracts (as opposed to Traffic Analysis Zones) permitted the convenient use of CTPP journey to work data. In order to permit the greatest possible degree of cross-boundary congruence, employment data is extracted directly from the CTPP and is not DVRPC-adjusted.

Analysis variables

The base set of input variables are those used in the existing transit score method:

- Population density (POPpACRE)
- Household (housing unit) density (HUNITpACRE)
- Zero-car household density (0CARpACRE)
- One-car household density (1CARpACRE)
- Destination-based job density (JOBSpACRE)

Each of the analysis densities was calculated based on the gross land area (area not covered by bodies of water, rather than total area) of each Census Tract.

While the existing transit score method references households rather than housing units, data received from New Jersey Transit – extracted from the agency’s transit score database – included the number of housing units rather than households. Whereas households represent a purely demographic characteristic, housing units provide something of a land use measure. Because households are very closely related to other demographic measures such as population (and in fact represented a pure duplicate in the NJ Transit method, as noted above), the present study initially employed the housing unit data provided. To the extent that referencing a land use characteristic rather than a demographic one might capture additional intervariate relationships, it was hoped that the use of housing unit data might contribute to the analysis.

In addition to the inputs employed in the existing transit score equation, other variables were also included in the present analysis. As previously noted, the regression analysis was performed with transit (bus and rail) mode share – extracted from CTPP 2000 – as the dependent variable.

Several iterations of the analysis were tested with origin mode share or destination mode share as the dependent variable. Given that inputs (independent variables) relating to both trip origins (i.e. population density, 0-car household density) and destinations (job density) were employed in the analysis, it was determined that the most appropriate dependent variable might be a weighted combination of origin and destination-based transit mode share in each tract. This was derived by calculating the proportion of transit origins and destinations (combined) to total (all mode) origins and destinations. The specific values used in the analysis represent decimal transit mode shares multiplied by 100 (or expressed as a percentage of total work trips). It is worth noting that when calculated independently, origin-based and destination-based transit mode share had a fairly high correlation for the UNIVERSE dataset of 0.68.

New independent variables
At the request of New Jersey Transit staff, a binary variable was assigned to each Census Tract based on whether any portion of the tract was located within one-half mile of a rail station or fixed rail stop (subway, commuter rail, or light rail). This variable (HALFMI_RAIL) permits an assessment of the role close proximity plays in transit viability. Given that the dependent variable (transit journey-to-work mode share) includes both bus and rail mode share, a similar variable relating to bus service proximity was also employed. The density of bus service (BUSSTOPSpACRE) was calculated for each tract based on the total number of designated bus stops for fixed-route service occurring within the tract. If a given stop location is shared by 5 separate routes, that stop is counted 5 times in the density calculation. The values for each of these transit proximity variables (HALFMI_RAIL and BUSSTOPSpACRE) were calculated using GIS software based on the most recent rail and bus layers provided by New Jersey Transit and SEPTA.

In addition, it was appropriate to consider some factor relating to the nature of the typical work trip and its impact on transit viability for that trip. To this end, values for two additional independent variables were extracted from CTPP 2000: the median travel time from (OrigMedianTravTime) and to (DestMedianTravTime) each Census Tract.

Finally, to supplement destination-based job density (JOBSpACRE), values for origin-based worker density in a tract (WORKERSpACRE) were extracted.[1]

In summary, the additional independent variables tested in this analysis were as follows:

- Residence-based worker density (WORKERSpACRE)
- Median travel time for commutes originating in a tract (OrigMedianTravTime)

[1] Both of these Census-derived factors reflect only the primary job for persons with multiple jobs, and origin-based employment (WORKERSpACRE) excludes military employment whereas JOBSpACRE does not.

- Median travel time for commutes terminating in a tract (DestMedianTravTime)
- Is the tract located within one-half mile of a rail station? (HALFMI_RAIL)
- Bus stop density (BUSSTOPSpACRE)

Correlation analysis and matrix

Prior to performing a regression analysis, a correlation analysis was performed among the full set of independent variables using the UNIVERSE dataset to assess the extent to which certain independent variables were highly correlated with others. Where a given variable is highly correlated with another (or multiple others) and does not appear to capture unique attributes in terms of an anticipated relationship with the dependent variable, such independent variables may be eliminated to simplify the regression analysis.

TABLE 1: Independent Variable Correlation Matrix (UNIVERSE/Merged Dataset)

	POPp ACRE	WORKER SpACRE	JOBSp ACRE	HUNIT pACRE	0CARp ACRE	1CARp ACRE	OrigMedia nTravTime	DestMedia nTravTime	HALFM I_RAIL	BUSSTO PSpACRE
POP pACRE	1.00									
WORKERS pACRE	**0.93**	1.00								
JOBS pACRE	0.22	0.23	1.00							
HUNIT pACRE	**0.95**	**0.95**	0.27	1.00						
0CAR pACRE	0.88	0.85	0.32	**0.94**	1.00					
1CAR pACRE	**0.90**	**0.96**	0.20	**0.92**	0.79	1.00				
OrigMedian TravTime	0.18	0.17	-0.08	0.19	0.18	0.17	1.00			
DestMedia nTravTime	0.18	0.16	0.23	0.20	0.25	0.12	0.12	1.00		
HALFMI_ RAIL	0.11	0.10	0.13	0.13	0.11	0.05	-0.05	0.18	1.00	
BUSSTOP SpACRE	0.53	0.47	0.48	0.53	0.54	0.44	0.06	0.22	0.15	1.00

Source: CTPP 2000, DVRPC 2007

The matrix in Table 1 reveals the correlations among each pair of independent variables. Values are highlighted where a correlation of greater than 0.9 was calculated. There are a number of variable sets which are relatively highly correlated. The majority of these highly correlated pairs (such as HUNITpACRE with 0CARpACRE and WORKERSpACRE with 1CARpACRE) capture unique factors with regard to the transit score method. These factors should therefore be retained as unique independent variables for the purposes of the regression despite their correlation.

However, the variable set of POPpACRE, HUNITpACRE, and WORKERSpACRE are extremely highly correlated (with correlation coefficients of 0.93 and 0.95) and can be expected to relate to one another in a fairly consistent way. In other words, the relationship between employed persons and total population or total population and housing units can be expected to be fairly consistent across Census Tracts. For this reason, each of these factors effectively serves as a proxy for the other two. To this end, one independent variable among these three was selected for use in the regression analysis. With simplicity in mind, population density (POPpACRE) was selected.

Therefore, the variables employed in the regression analysis were as follows:

Dependent Variable:	AvgTRANSIT_SHAREx100
Independent Variables:	POPpACRE JOBSpACRE 0CARpACRE 1CARpACRE OrigMedianTravTime DestMedianTravTime HALFMI_RAIL BUSSTOPSpACRE

SUMMARY AND ANALYSIS OF RESULTS

Tables 2, 3, and 4 summarize the results of the regressions for the DVRPC region dataset, the State of New Jersey dataset, and the merged UNIVERSE dataset, respectively. Charts 1, 2, and 3 are standard residual plots for each respective dataset. Statistical terms key to understanding these tables and charts include:

Adjusted R Square – The proportion of variation in the dependent variable which is explained in sum by the independent variables.

Coefficients – The calculated coefficients for each independent variable in a regression equation. As the regression equation resulting from this analysis is adopted as a revised transit score equation, these would be the coefficients for each input variable in the transit score equation.

Intercept – This value corresponds with the point at which the 'best fit' regression line is calculated to cross the y-axis, and can be viewed as a constant in the resulting transit score equation. Discussions with the project steering committee included the possibility of forcing the calculated regression lines to intercept at zero, eliminating the need for a constant. However, it was determined that there was no compelling reason to proceed in this way, and that the resulting coefficients and equation would be more accurate as presently designed.

Mean Value of the Dependent Variable – The average value of the dependent variable (AvgTRANSIT_SHAREx100) for the dataset.

P-value – The probability that the relationship between the independent variable and dependent variable is due merely to chance. A P-value of < 0.05 is considered statistically significant.

Standard Error – This value refers to the standard error of the estimate, or the standard difference between predicted values and actual values for each independent variable.

Standard Residual – The standardized difference between an observed value for the dependent variable (in this case the actual average transit mode share in a given tract) and the value (or mode share) predicted by the 'best fit' regression equation for the corresponding combination of independent variables. If a plot of standard residuals depicts a vertical clustering around zero with no apparent linear pattern, then the original linear regression can be considered valid.

T Stat – As a general rule, t-statistics of +/-(>1.98) indicate that the independent variable has a statistically significant predictive role for the dependent variable at a greater than 95% confidence level.

In each table, statistically significant and positive relationships between independent variables and transit journey to work (JTW) mode share are highlighted in green. Significant and negative (or inverse) relationships are highlighted in red. Relationships found not to be significant are not highlighted.

TABLE 2: Regression Summary - DVRPC Region

	Coefficients	Standard Error	t Stat	P-value	Significance
Intercept	-13.11	0.91	-14.44	0.0000	
POPpACRE	0.24	0.03	8.51	0.0000	Significant (+)
JOBSpACRE	-0.01	0.01	-1.10	0.2708	Not Significant
0CARpACRE	1.13	0.12	9.80	0.0000	Significant (+)
1CARpACRE	-0.34	0.14	-2.53	0.0116	Significant (-)
OrigMedianTravTime	0.41	0.03	14.15	0.0000	Significant (+)
DestMedianTravTime	0.35	0.03	10.66	0.0000	Significant (+)
HALFMI_RAIL	2.61	0.36	7.28	0.0000	Significant (+)
BUSSTOPSpACRE	20.41	1.91	10.68	0.0000	Significant (+)
Analysis of Variance (ANOVA)					
	df	**SS**	**MS**	**F**	**Significance F**
Regression	8	119030.1	14878.8	411.0	0.0
Residual	1372	49673.6	36.2		
Total	1380	168703.7			
SUMMARY					
Multiple R	0.840		Standard Error		6.017
R Square	0.706		Observations		1381
Adjusted R Square	0.704		Mean Value of the Dependent Variable		9.38

Source: DVRPC 2007

As summarized in Table 2, nearly every independent variable was calculated to have a significant relationship with the dependent variable for Census Tracts within the DVRPC region. Job density was the exception to this pattern, as this variable was determined to not have a significant relationship with the dependent variable for this dataset. While most of the significant relationships were found to be positive, the density of one-car households was calculated to have an inverse relationship with transit mode share.

CHART 1: Plot of Residuals , DVRPC Region Dataset

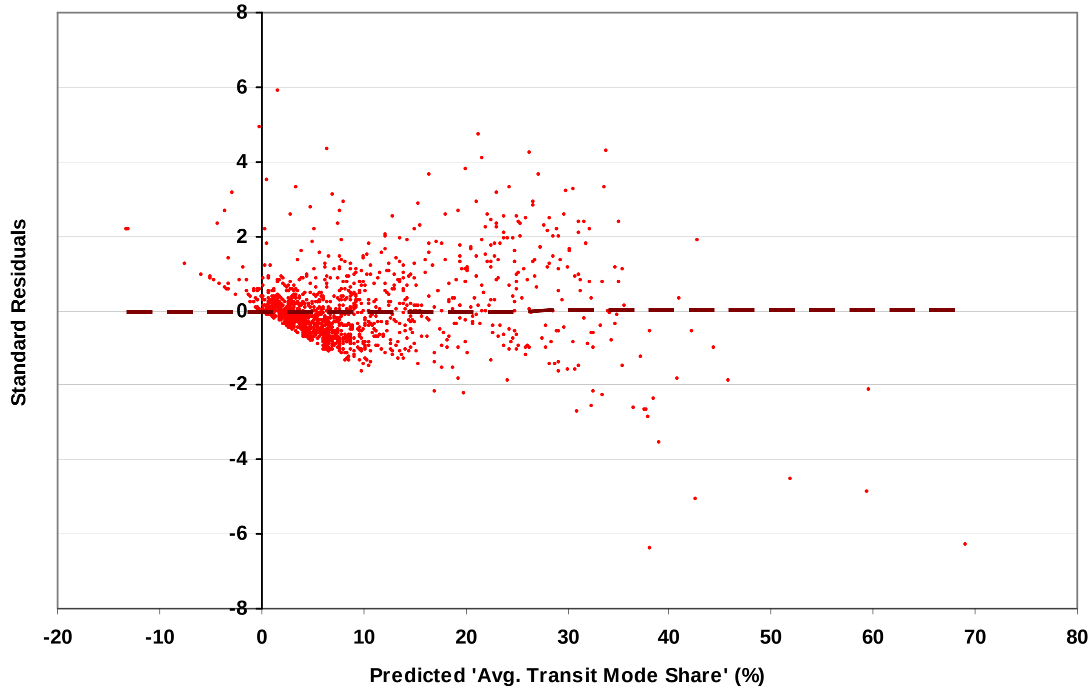


Chart 1 depicts a vertical clustering of standard residuals around 0, and the hashed maroon trend line reinforces the lack of any linear pattern to the residuals. These characteristics indicate that the linear regression is valid for this dataset.

TABLE 3: Regression Summary – State of New Jersey

	Coefficients	Standard Error	t Stat	P-value	Significance
Intercept	-7.46	0.64	-11.70	0.0000	
POPpACRE	0.03	0.02	1.26	0.2086	Not Significant
JOBSpACRE	0.04	0.01	2.69	0.0072	Significant (+)
0CARpACRE	1.44	0.10	14.77	0.0000	Significant (+)
1CARpACRE	0.29	0.07	3.83	0.0001	Significant (+)
OrigMedianTravTime	0.26	0.02	12.91	0.0000	Significant (+)
DestMedianTravTime	0.26	0.02	11.16	0.0000	Significant (+)
HALFMI_RAIL	1.09	0.27	4.05	0.0001	Significant (+)
BUSSTOPSpACRE	9.86	1.22	8.06	0.0000	Significant (+)
Analysis of Variance (ANOVA)					
	df	**SS**	**MS**	**F**	**Significance F**
Regression	8	110456.6	13807.1	510.8	0
Residual	1935	52304.5	27.0		
Total	1943	162761.0			
SUMMARY					
Multiple R	0.824		Standard Error		5.199
R Square	0.679		Observations		1944
Adjusted R Square	0.677		Mean Value of the Dependent Variable		8.13

Source: DVRPC 2007

As summarized in Table 3, the majority of the independent variables were calculated to have a significant and positive relationship with transit mode share for Census Tracts within the State of New Jersey. Population density was the only exception to this pattern; this variable was determined to not have a significant relationship with the dependent variable for this dataset.

CHART 2: Plot of Residuals , State of New Jersey Dataset

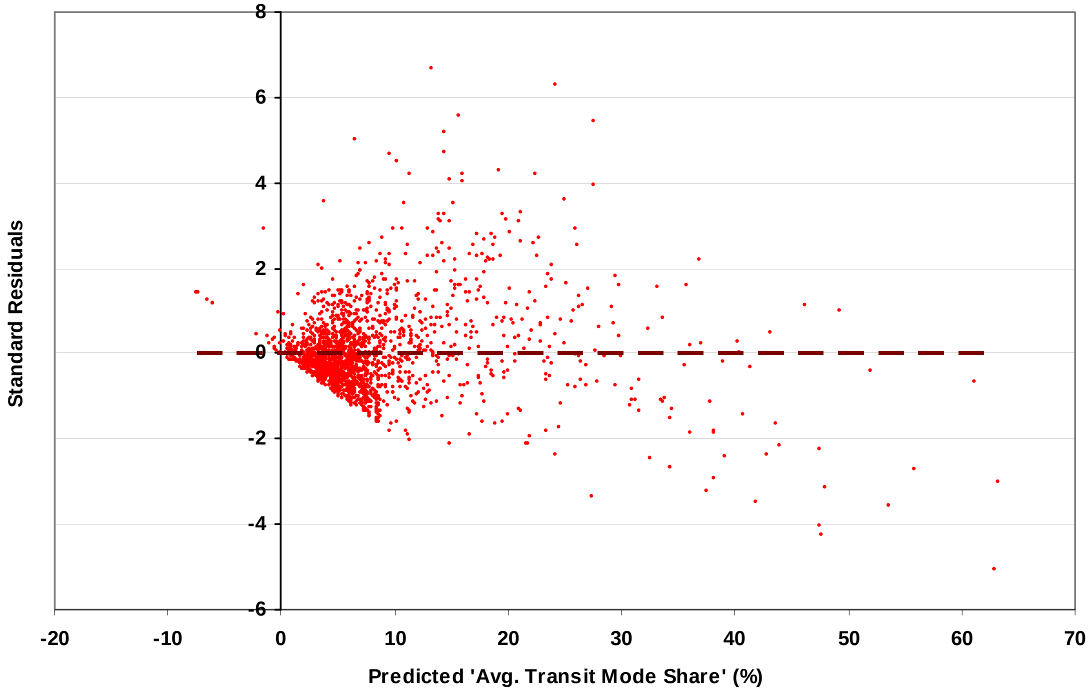


Chart 2 depicts a vertical clustering of standard residuals around 0, and the hashed maroon trend line reinforces the lack of any linear pattern to the residuals. These characteristics indicate that the linear regression is valid for this dataset.

TABLE 4: Regression Summary – UNIVERSE/Merged

	Coefficients	Standard Error	t Stat	P-value	Significance
Intercept	-11.44	0.59	-19.39	0.0000	
POPpACRE	0.19	0.02	9.30	0.0000	Significant (+)
JOBSpACRE	0.01	0.01	1.37	0.1703	Not Significant
0CARpACRE	1.18	0.08	14.55	0.0000	Significant (+)
1CARpACRE	-0.25	0.07	-3.63	0.0003	Significant (-)
OrigMedianTravTime	0.37	0.02	19.58	0.0000	Significant (+)
DestMedianTravTime	0.34	0.02	15.79	0.0000	Significant (+)
HALFMI_RAIL	2.39	0.23	10.34	0.0000	Significant (+)
BUSSTOPSpACRE	14.07	1.15	12.25	0.0000	Significant (+)
Analysis of Variance (ANOVA)					
	df	**SS**	**MS**	**F**	**Significance F**
Regression	8	217941.5	27242.7	793.2	0
Residual	2925	100459.3	34.3		
Total	2933	318400.9			
SUMMARY					
Multiple R	0.827		Standard Error		5.860
R Square	0.684		Observations		2934
Adjusted R Square	0.684		Mean Value of the Dependent Variable		9.21

Source: DVRPC 2007

As summarized in Table 4, the majority of the independent variables were calculated to have a significant and positive relationship with the dependent variable for Census Tracts within the combined UNIVERSE of New Jersey and the Pennsylvania portion of the DVRPC region. Job density and one-car household density were exceptions to this pattern. Job density was determined to not have a significant relationship with transit mode share for the combined UNIVERSE dataset, and one-car household density was calculated to have a significant but inverse relationship.

CHART 3: Plot of Residuals , UNIVERSE/Merged Dataset

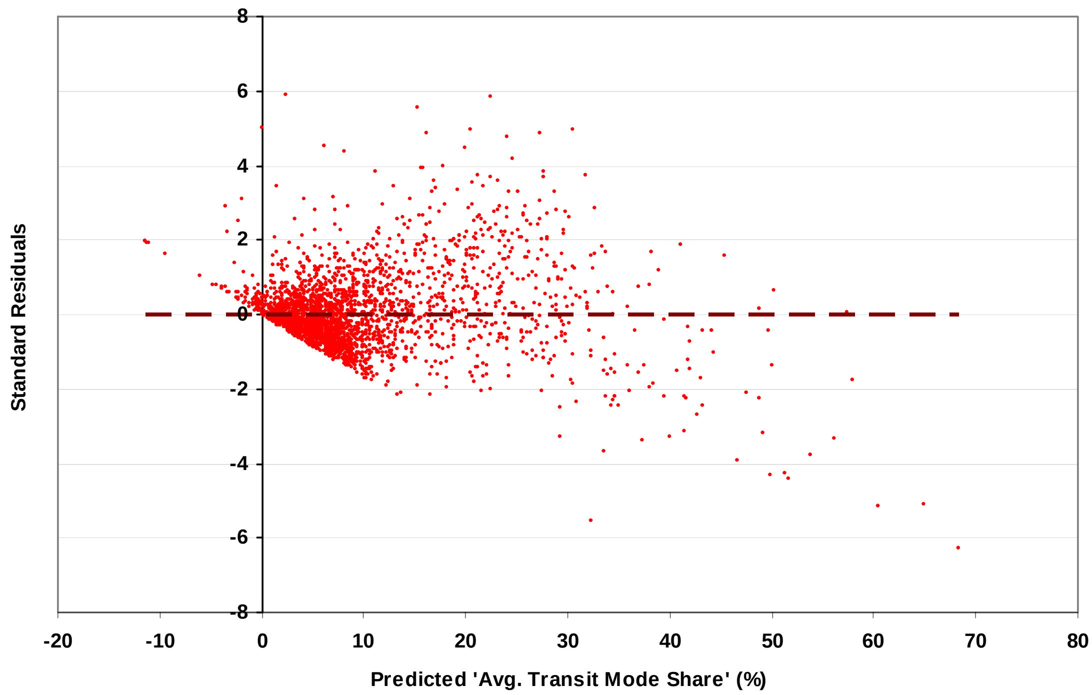


Chart 3 depicts a vertical clustering of standard residuals around 0, and the hashed maroon trend line reinforces the lack of any linear pattern to the residuals. These characteristics indicate that the linear regression is valid for this dataset.

Summary and highlights of regression analyses

Table 5 summarizes the results of the regression analysis for the significance of each independent variable among the three datasets. Independent variables are bold where they were observed to have a consistent relationship across all three datasets. For purposes of visual clarity, relationships found to be significant and positive are shown in green, and those found to be significant and negative are shown in red.

TABLE 5: Summary of Result Consistency

Independent Variable	DVRPC Region	State of NJ	Merged UNIVERSE
POPpACRE	Significant, Positive	Not Significant	Significant, Positive
JOBSpACRE	Not Significant	Significant, Positive	Not Significant
0CARpACRE	**Significant, Positive**	**Significant, Positive**	**Significant, Positive**
1CARpACRE	Significant, Negative	Significant, Positive	Significant, Negative
OrigMedianTravTime	**Significant, Positive**	**Significant, Positive**	**Significant, Positive**
DestMedianTravTime	**Significant, Positive**	**Significant, Positive**	**Significant, Positive**
HALFMI_RAIL	**Significant, Positive**	**Significant, Positive**	**Significant, Positive**
BUSSTOPSpACRE	**Significant, Positive**	**Significant, Positive**	**Significant, Positive**

Source: DVRPC 2007

Several of these initial results bear some discussion. For the New Jersey dataset, population density was not found to have a significant relationship with transit mode share. This is generally understandable in that there are many relatively dense residential or mixed use areas with limited or no transit service and disparate (and consequently less transit-accessible) commuting patterns.

Similar conclusions can be drawn from the marginal results for the significance of job density among the three datasets. Many suburban employment centers with comparatively high job densities simply are not transit accessible. In other words, the results for both population density and job density, while surprising on the surface, may simply be reflective of contemporary commuting patterns that largely lack high volume origin-destination pairs serviceable by transit. Population and employment density do not make transit service viable if the opposite end of the work trip is unique for every commuter (in an extreme example).

The density of one-car households was observed to have a negative relationship with transit mode share in two of the three datasets, in contrast to the assumptions of previous DVRPC and New Jersey Transit studies. Whereas previous studies had presumed that the availability of only one car would mean that a significant portion of trips might be made by transit, it appears that even a single car has a significantly negative association with transit use. This is demonstrated by the greatly contrasting results for zero-car household density, which was calculated to have a significant and positive relationship with transit mode share for all three datasets.

The relationship between both origin and destination-based median travel time and transit mode share was consistently significant and positive. In other words, as trips become longer and median travel time increases, transit mode share also increases. This may be interpreted in two ways: a) Transit work trips are simply more time consumptive on average than auto trips of the same distance; or b) As the typical commute becomes longer the relative comfort of transit makes it a more competitive option.

Full transit score equation

The full transit score equation reflects the coefficients derived through the analysis of the UNIVERSE dataset, which benefits from the largest sample size and encourages cross-boundary congruence. Based on the coefficients calculated during the regression analysis, a revised transit score equation would be as follows:

[0.19*(Population per acre)] +
[1.18*(Zero car households per acre)] –
[0.25*(One car households per acre)] +
[0.37*(Median travel time for Journey to Work (JTW) trips originating in the geography)] +
[0.34*(Median travel time for JTW trips terminating in the geography)] +
2.39 [*If a rail station is located within one-half mile*] +
[14.07*(Bus stops per acre)] -
11.44 [*constant*]

In order to arrive at a final consolidated equation, the model was recalibrated with job density removed because it was found to not be significant. In addition, in order that the model only reflect factors that contribute to transit mode share (having a positive effect on the transit score), the density of one car households was also removed in the recalibration. Each of the remaining factors was found to be positive and significant following the revised regression.[2] The final full transit score model (with the transit score substituting for transit mode share) is as follows (all densities reflect gross land areas):

Transit score = **[0.13*(Population per acre)] +**
[1.21*(Zero car households per acre)] +
[0.36*(Median travel time for Journey to Work (JTW) trips originating in the geography)] +
[0.34*(Median travel time for JTW trips terminating in the Geography)] +
2.47 [*If a rail station is located within one-half mile*] +
[14.99*(Bus stops per acre)] -
11.58 [*constant*]

The coefficients for this equation were calibrated based on data at the Census Tract level, but the equation can generally be applied to any geography (although journey to work data is most readily available at the tract or MCD level).

[2] **Recalibration summary:** *Adjusted R square* = 0.682; *t Stats:* POPpACRE = 9.55, 0CARpACRE = 15.30, OrigMedianTravTime = 19.47, DestMedianTravTime = 16.35, HALFMI_RAIL = 10.70, BUSSTOPSpACRE = 14.24.

PORTABLE TRANSIT SCORE METHOD

The full transit score equation is a useful and effective method to assess the degree of transit mode share predicted for a location based on existing demographic and transit characteristics. Another aspect of the transit score is the estimation of transit supportiveness under specific development or growth scenarios. While the validity of the full transit score equation is enhanced by the inclusion of factors such as median travel time and bus stop density, such factors are difficult to estimate in other than Census years and for specific development scenarios.

For this reason, it was determined that a second, simpler transit score equation should be validated using the same regression method, but with a subset of the original independent variables. The resulting equation would consider fewer input factors than the full transit score equation, but would include only those independent variables which could be readily estimated for a given plan/scenario and which do not depend on existing transit service.

Specifically, the variables tested in the regression analysis for the 'portable' transit score method were as follows:

Dependent Variable:	AvgTRANSIT_SHAREx100
Independent Variables:	POPpACRE JOBSpACRE 0CARpACRE

The density of zero car households was considered, but the density of one car households was not. This is because the significance of one car households in the full transit score regressions was mixed, and it was calculated to have a significant and negative effect for the UNIVERSE dataset. In contrast, the density of zero car households was consistently significant and positive. Zero car households are largely transit dependent, and therefore will logically contribute to the transit score.

In consultation with the project steering committee, it was determined that the portable transit score equation should have no constant (i.e. the regression should be conducted with the constant suppressed). In this way, the resulting model will be more intuitive – no unexplained 'extra factor' will be seen to be affecting scores (and causing certain places to have negative scores), and the minimum possible score will be 0.00. Additionally, this alternative makes sense conceptually given the nature of the dependent variable. If population and job densities are zero (there are no residents or workers in a tract), then transit mode share should also be zero.

Consistent with the overall aim of cross-boundary congruence (and with the aim also of maximizing the geographic sample size), the UNIVERSE dataset was used for the portable transit score regression analysis. Table 6 summarizes the results of the regression. As detailed previously for the full regression, statistically significant and positive relationships between independent variables and transit JTW mode share are highlighted in green.

TABLE 6: Regression Summary – Portable Transit Score, UNIVERSE/Merged Dataset

	Coefficients	Standard Error	t Stat	P-value	Significance
POPpACRE	0.41	0.01	27.44	0.0000	Significant (+)
JOBSpACRE	0.09	0.01	10.52	0.0000	Significant (+)
0CARpACRE	0.74	0.10	7.74	0.0000	Significant (+)
Analysis of Variance (ANOVA)					
	df	**SS**	**MS**	**F**	**Significance F**
Regression	3	397150.3	132383.4	2278.922	0
Residual	2931	170262.9	58.09038		
Total	2934	567413.2			
SUMMARY					
Multiple R	0.837		Standard Error		7.622
R Square	0.700		Observations		2934
Adjusted R Square	0.700		Mean Value of the Dependent Variable		9.21

Source: DVRPC 2007

As summarized in Table 6, each of the independent variables was calculated to have a significant and positive relationship with transit mode share for the UNIVERSE dataset when only the portable subset of variables was included. The significant and positive result for job density is notable, as this variable was not found to be significant in the full regression for the same dataset. This means that the relationship between job density and transit mode share was previously obscured by one or more of the other independent variables. When these variables were not included in the analysis, job density captured some of their impact.

CHART 4: Plot of Residuals , Portable Transit Score Equation, UNIVERSE/Merged Dataset

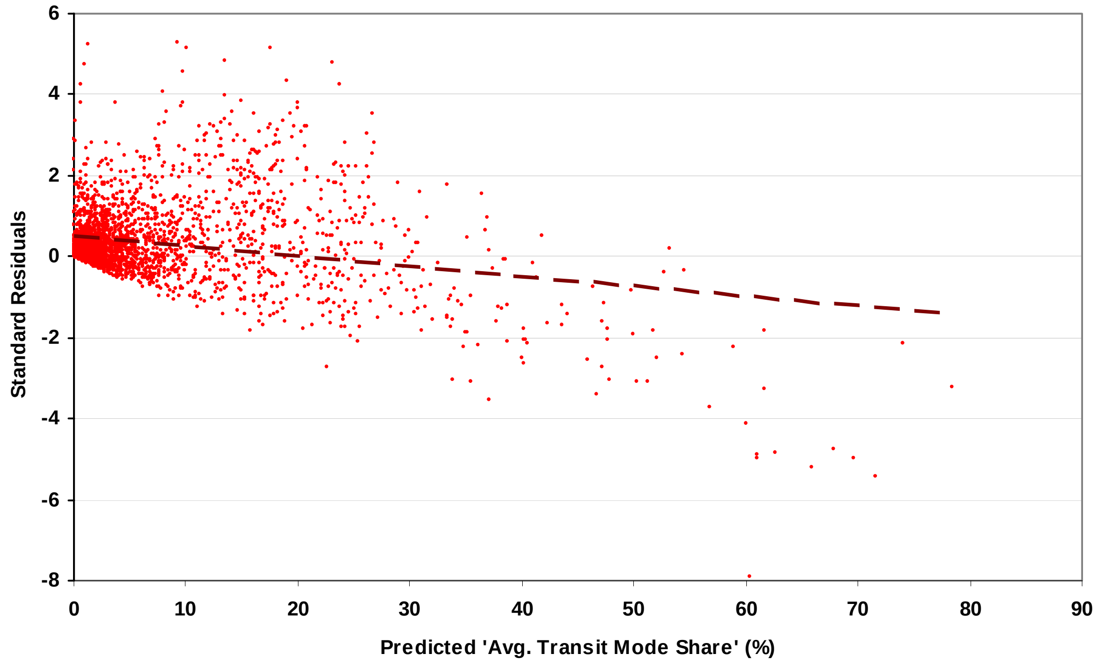


Chart 4 depicts a vertical clustering of standard residuals around 0, and the hashed maroon trend line reinforces the lack of any significant linear pattern to the residuals. These characteristics indicate that the linear regression is valid for this dataset.

Portable transit score equation

Based on the coefficients calculated during the regression analysis, the portable transit score equation (with the transit score simply substituting for transit mode share) is as follows (all densities reflect gross land acres):

Transit score = **[0.41*(Population per acre)] +**
[0.09*(Jobs per acre)] +
[0.74*(Zero car households per acre)]

As noted for the full transit score equation, whereas the coefficients for this equation were calibrated based on data at the Census Tract level, the equation itself can be applied to any geography.

SCORE CLASSIFICATION

Each of the two transit score equations enables the calculation of a numerical transit score. However, this numerical score becomes more meaningful when classified into a set of score ranges that correspond with varying levels of transit supportiveness. A simple comparison of numerical scores will indicate which geographies in a group can be expected to be more transit supportive than others. It will not indicate, however, the extent to which these numerical variations correspond with actual differences in the viability of various intensities of transit service (the ability to support fixed route bus service versus rail service, for example).

This can be achieved by grouping comparable scores into a range of 'transit viability' classifications. However, in order for the classification of scores to be meaningful, it is necessary to ensure that the number and distribution of classification groups is appropriate.

Score calibration method

The first step in classifying the scores is to observe their distribution as a basis for grouping them. Charts 5 and 6 depict the distribution of the numerical scores for the UNIVERSE dataset which result from the full and portable transit score calculations, respectively.

CHART 5: Full Transit Score Distribution, UNIVERSE/Merged Dataset

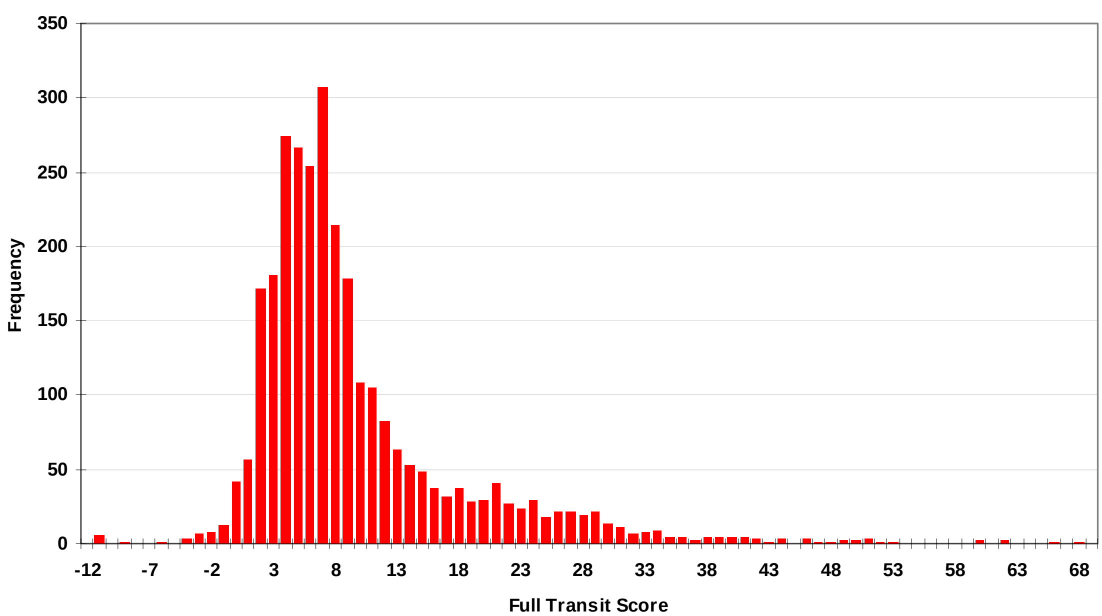
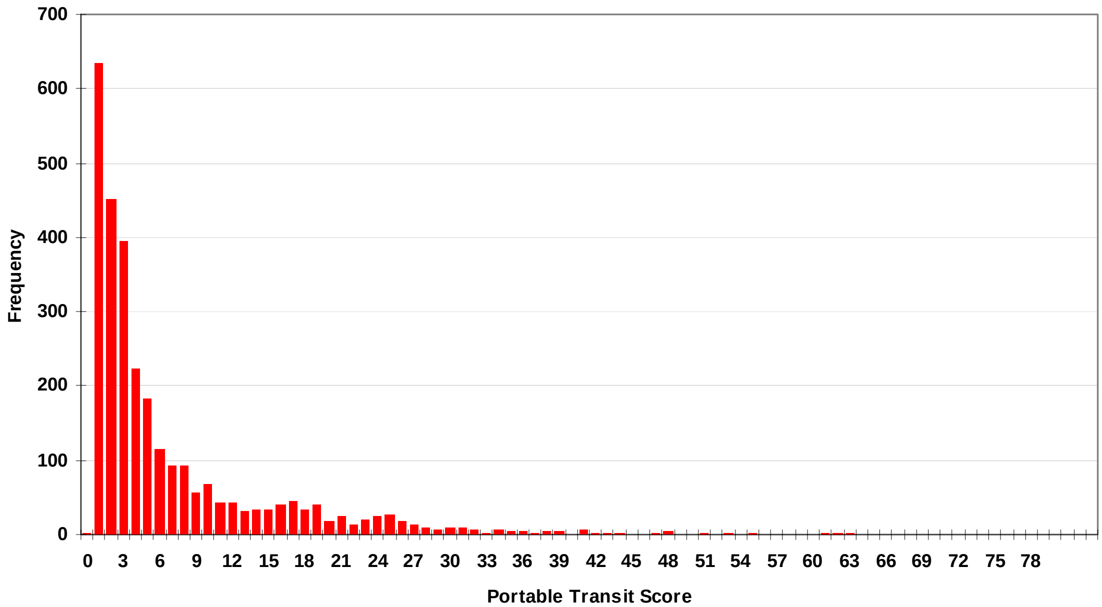


CHART 6: Portable Transit Score Distribution, UNIVERSE/Merged Dataset



The score distributions for the two equations are similar in that both reflect a sharp peaking of scores in the lower ranges (representing tracts with very low predicted transit mode shares). Table 7 summarizes the characteristics of the two distributions.

TABLE 7: Summary statistics for full and portable transit score distributions, UNIVERSE/Merged Dataset

	Full Transit Score	Portable Transit Score
Mean	9.07	6.81
Median	6.54	2.95
Standard Deviation	8.55	9.52
Minimum	-11.58	0
Maximum	67.01	79.24
Range	78.59	79.24

Source: DVRPC 2007

The summary data in Table 7 reinforce the similarity of the distributions under the two equations. The mean and median values are both lower under the portable transit score framework than the full transit score framework. Despite this, the similar standard deviations and ranges for the two frameworks indicate an overall similarity between the two distributions.

Portable transit score equation as the Transit Score Tool

At this point, it is appropriate to differentiate the two transit score equations in terms of their usefulness as scoring tools. In this regard, the full transit score equation has two limitations (which the portable score was created to address). First, as noted previously, factors such as median travel time and bus stop density are difficult to estimate for specific development scenarios and in non-Census years. Second, the inclusion of a wider array of factors introduces peculiar outliers when the full scores are mapped for the DVRPC region and State of New Jersey. A number of rural and exurban tracts, for example, are associated with high full transit scores based exclusively on unusually long median travel times.

The full transit score equation reflects the results of an analysis of several factors that have positive predictive associations with actual transit mode share in the DVRPC region and State of New Jersey. Its usefulness as a self-contained analysis tool, however, is limited for the reasons noted above. The portable transit score method addresses these limitations and fills this role. Consequently, the portable transit score equation will be used as the Transit Score Tool. The following analysis to classify scores into meaningful ranges was therefore conducted based on the portable transit score equation.

Classification method and score category ranges

One of the central roles of the Transit Score Tool is as a screening method to assess, at a gross level, the suitability of a geographic area for transit investments of varying magnitudes. It is possible to calculate a transit score value for each geographical subdivision in a region using a continuous numerical scale, based on specific values for the three input factors. To associate numerical scores with specific transit investments, however, it is helpful to group scores into categories so that they may be differentiated from one another. This also enables a clear delineation between scores on a thematic map. It was therefore decided to create several intervals, or transit score ranges, that would correspond with several possible types of transit investments.

The appropriate number of score categories is determined by the degree of specificity required. Too few categories would result in an inability to differentiate between levels of transit viability, while too many would render the differences between the score categories less meaningful. In this case, it was determined that the five existing categories already provide an effective classification system, eliminating the need to "reinvent the wheel" in this regard. The specific numerical category divisions between the five categories were determined in cooperation with New Jersey Transit staff based on the observed distribution of scores across the UNIVERSE/Merged area. Factors specifically considered included the following:

- Experience with the prior tool's category system;
- The proportion of total land area and population within each category; and
- The correspondence of each category with the Planning Area Designations for New Jersey's State Development and Redevelopment Plan.

This exercise resulted in the following score ranges:

Low:	< 0.6
Marginal:	0.60 – 1.0
Medium:	1.01 – 2.50
Medium-High:	2.51 – 7.50
High:	> 7.50

Evaluation of the scoring system's correlation with actual transit service

In order to assess the degree to which the score classification ranges corresponded to various levels of actual transit service, scores were mapped and evaluated on their correspondence with real world indicators. Specifically, they were compared with the locations of actual rail and bus service, as reflected by the two service measures employed in the full transit score analysis – proximity to rail stations (within one-half mile) and bus stop density.

A basic principle of the transit score concept is that a higher score indicates that a place could support a higher intensity of transit service. Rail service may be supported for only the highest score classes, whereas bus service may be appropriate for all but the lowest score category. As a preliminary means of associating the specific score categories to general transit mode intensities, a GIS analysis was performed to assess the degree of correspondence with half-mile rail station buffers between the top two classes of five (medium-high and above) and top one class of five (high). This same comparison was made between the top four classes of five (marginal and above) and top three of five (medium and above) with the 'primary bus service area.' Concerning the latter, tracts in the UNIVERSE/Merged dataset which had bus stop densities in the upper 80% of all tracts were mapped as an approximation of the 'primary bus service area.' The results of this analysis are shown in Table 8.

TABLE 8: Degrees of correspondence between score classes and transit service indicators, UNIVERSE/Merged Dataset

	Area (square miles)	Comparison area	Area of overlap (square miles)	Overlap % (area of overlap / original area)
All half-mile rail station buffers	293.3	Combined area, tracts with HIGH transit scores	69.3	23.6 %
All half-mile rail station buffers	293.3	Combined area, tracts with MED.-HIGH or higher transit scores	176.1	60.0 %
Primary bus service area	1,821.8	Combined area, tracts with MEDIUM or higher transit scores	1,385.3	76.0 %
Primary bus service area	1,821.8	Combined area, tracts with MARGINAL or higher transit scores	1,641.9	90.1 %

Source: DVRPC 2007

As shown in Table 8, tracts scoring medium-high or higher and marginal or higher have a greater degree of correspondence with actual rail and bus service provision than tracts scoring high and medium or higher, respectively. Further, the degree of correspondence between these particular class ranges and actual bus and rail service indicates that these ranges are generally appropriate as indicators of the viability of these modes. In other words, with a five class scoring system, fixed route bus service may conditionally be appropriate for all but the lowest score category, and passenger rail service (of some form) generally appropriate for the top two categories. While the sixty percent degree of correspondence between the area of the top two categories and half-mile rail station buffers may seem low, it becomes reasonable when one considers the peculiarities of suburban rail service (with many stations, and particularly park-and-ride stations, having a station shed much larger than a half mile).

Applicability of transit mode investments by score category

One of the principal roles of the Transit Score Tool is to permit an estimation of which intensities or modes of transit service will be appropriate in an area or corridor of given land use character (as indicated by densities, etc). Accordingly, it is necessary that each of the five transit score classes correspond with general indications of appropriateness for specific transit investments or intensities of service. It bears noting again that the Transit Score Tool is simply a means of estimation, and that there are many factors involved in actual service planning, as well as the potential viability of routes/modes, which this tool does not address.

For this reason, an indication by the Transit Score Tool that a given mode would be appropriate along a particular corridor should not be taken as strong evidence that it would be a worthwhile investment (and that service would succeed). Rather, the role of the tool is to provide ‘back of the envelope’ comparisons of the intensities of service that could be supported in a given geography. If members of the public or government agencies have interest in transit investment at a given location, the Transit Score Tool can be used to roughly indicate the modes that would be appropriate at that location. The results of the transit score analysis should not be viewed as ‘the final word’ in any case. There may be good reasons for an investment to proceed despite a low transit score indication, and equally good reasons to not proceed despite a high indication. Thus, the Transit Score Tool provides a simple and transparent means to inform discussions between members of the public and policymakers at the conceptual level.

Table 9 summarizes the modes of transit service along with a sampling of service-enhancing infrastructure investments that would be appropriate under each of the five transit score categories. This list, based on Table 1-1 in New Jersey Transit’s October 2000 publication *The 2020 Transit Score Report: Possibilities for the Future*, is not intended to be exhaustive. The modes and investments indicated should serve as a guide for the appropriateness of other modes or investments of similar intensity.

TABLE 9: Appropriateness of transit service intensity/investment by transit score category

	Transit score category				
Transit modal investment	**High**	**Med.-High**	**Medium**	**Marginal**	**Low**
Heavy Urban Rail	A	N	N	N	N
Light Rail Transit (LRT)	A	A	C	N	N
Commuter Rail	A	A	C	C	N
Bus Rapid Transit (BRT)	A	A	C	N	N
Bus Lanes	A	A	N	N	N
Bus Priority Treatment	A	A	C	N	N
Fixed Route/Line Haul Bus Service	A	A	A	C	N
Express Bus	A	A	C	C	C
Local Circulator Bus/Shuttle/Paratransit	A	A	A	A	A

A = Appropriate
C = May be appropriate depending on conditions
N = Not appropriate

Source: DVRPC 2007

Where investments are indicated to be conditionally appropriate, their situational appropriateness will depend on case-specific conditions such as journey to work trip patterns that would support the investment. Generally speaking, rail investments would be inappropriate if they are not anchored by one or more locations with transit scores meeting the ‘high’ threshold.

In addition, many proposed bus routes or guideway investments will pass through or abut geographies of varying transit score levels. Typically, a given route or alignment may be considered appropriate in the transit score context if it abuts or connects multiple places with transit scores for which it is listed as being appropriate. The specific number and distribution of such places required to support an investment should be assessed reasonably on a case by case basis – again, the transit score is a tool, not an answer in itself.

Comparison of score/mode thresholds with established industry guidelines

Boris Pushkarev and Jeffrey Zupan’s *Public Transportation & Land Use Policy* (Indiana University Press, 1977) established ‘rule of thumb’ densities which support various intensities of transit service. These estimated density thresholds remain often-cited today despite the age of this publication. Table 10 below provides a comparison between several of the modal thresholds established in Pushkarev/Zupan’s publication, which are summarized in its Exhibit 6.4, and the comparable densities which result from the Transit Score Tool. Pushkarev and Zupan account for nonresidential density by factoring downtown floorspace, whereas the Transit Score Tool employs localized job density for this purpose. Therefore, in order to permit an ‘apples to apples’ comparison, the table below compares only the residential density thresholds for both methods. For this reason, no values for job or zero car household density are here factored in the Transit Score Tool.

TABLE 10: Comparison of Pushkarev/Zupan and transit score density thresholds

Mode	Pushkarev/Zupan min. residential density (d.u. / gross acre)*	Transit score category	Transit score min. residential density (d.u. / gross acre)**
Fixed route / Line haul bus service	2.67 (minimum – 20 buses per day)	Medium (>1.0)	1.09
Light rail transit (LRT)	6	Medium-High (>2.5)	2.75
Heavy urban rail / rapid transit	8	High (>7.5)	8.24

Source: Pushkarev and Zupan 1977, DVRPC 2007.

* Pushkarev/Zupan’s net density thresholds (4, 9, 12) are converted to gross densities through multiplication by 2/3 (0.6667).

** The calculated persons/acre is converted to households/acre using DVRPC region average household size of 2.22 (from Table H-2 of *Transportation for the 21st Century Household Travel Survey: Travel Survey Results for the DVRPC Region* [May 2001]).

As Table 10 indicates, the residential density thresholds calculated under the transit score method are of the same order of magnitude as those arrived at by Pushkarev and

Zupan, although differing to varying extents. For both fixed route bus and light rail service, the minimum densities resulting from the transit score method are lower than the Pushkarev/Zupan densities (the density thresholds for heavy urban rail, however, are closely comparable). It bears noting that the Pushkarev/Zupan threshold for light rail is indicated to support a relatively high intensity of light rail service, with 5-minute peak hour headways, whereas the minimum transit score threshold (although not referring to specific service levels) would be associated with a more basic level of light rail service (the New Jersey Transit RiverLINE, for example, presently has 15-minute peak hour headways). To this end, the light rail density thresholds are more comparable than they initially appear.

Nevertheless, these types of discrepancies reinforce the importance of viewing the Transit Score Tool as just one of a range of factors to consider when assessing the potential viability of various types of transit service in an area. A gross residential density of 3 units per acre would be insufficient to support light rail service, for example, without higher densities concentrated in the immediate station area as well as trip patterns that would support the rail alignment.

TOOL APPLICATIONS

Two aspects of the Transit Score Tool will enhance its usefulness for a wide range of stakeholders. First, the tool was derived from an analysis of data from all of New Jersey as well as southeastern Pennsylvania. Because of this, it may be applied without modification by all stakeholders in any part of this area (ensuring ‘apples to apples’ comparisons of results). Second, while being technically sound, the tool is accessible and its application transparent. Calculating scores requires only data or estimates for three factors (population density, job density, and the density of zero-car households), and by mapping the calculated scores across a geographic area, planners or other stakeholders can readily observe and numerically compare the degrees of transit supportiveness among various places. Transit score calculations also enable quick and easy comparisons and illustrations of the relative transit-supportiveness of alternative development scenarios (development under prevailing zoning vs. development under a ‘smart growth’ zoning proposal, for example). This type of comparison would be useful as part of the land use evaluation for an FTA New Starts/Small Starts Alternatives Analysis project.

In short, the Transit Score Tool informs a better and more numerically-based understanding of the relationship between land use configuration and public transportation, enabling a more productive discussion of a proposed transportation, planning, or development project at the conceptual level.

The following sections summarize two examples of applications for the Transit Score Tool at the local (corridor) and regional scales.

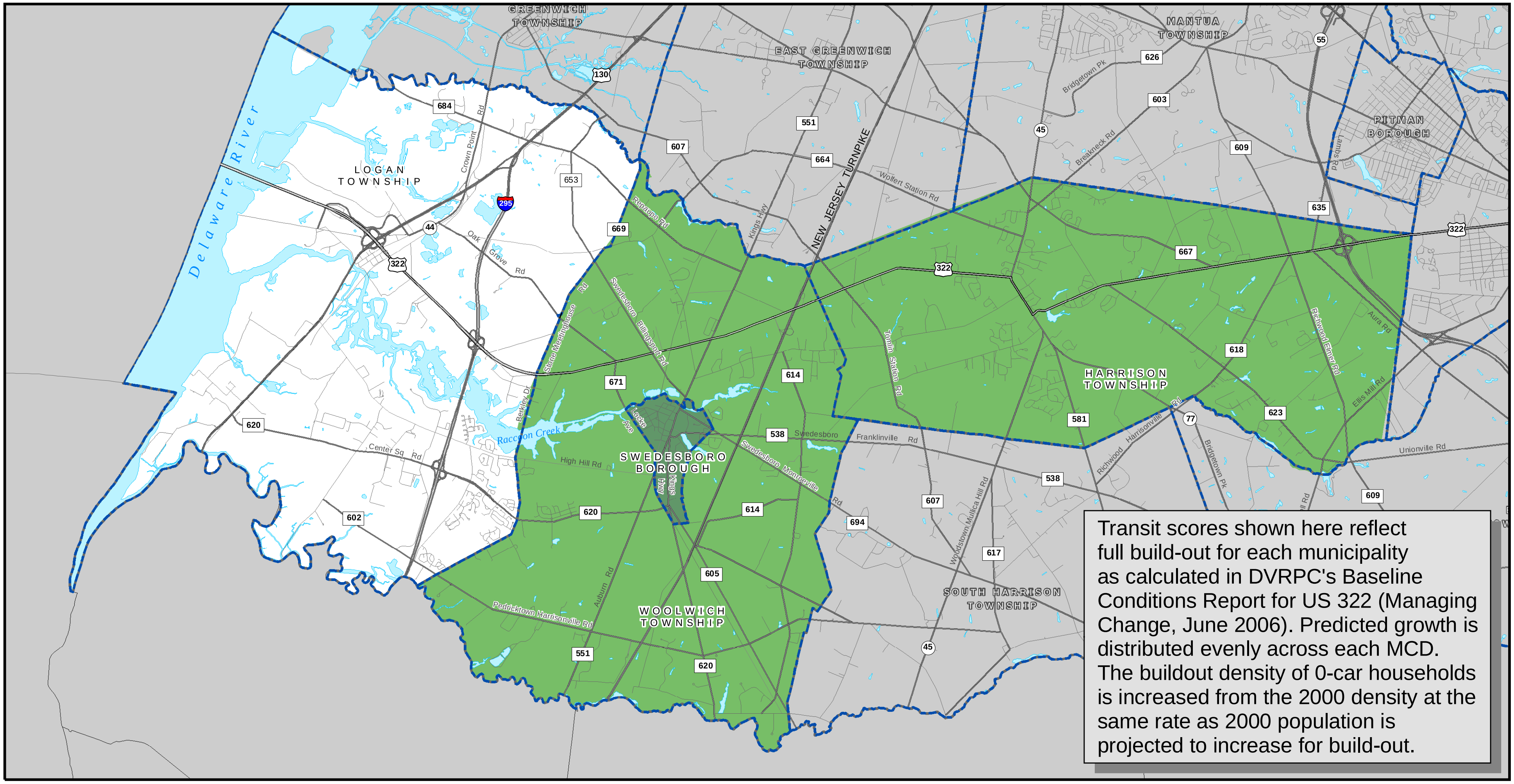
Build-out comparison for the US 322 corridor in New Jersey

DVRPC is currently engaged in a multi-year planning project for the US 322 corridor in Gloucester County, New Jersey. Phase I of this effort, which was published in June 2006 (DVRPC Publication No. 06023), included build-out analyses for each of four study area municipalities (Logan Township, Harrison Township, Swedesboro Borough, and Woolwich Township). These analyses resulted in calculations of the population and job growth that would result from full build-out under prevailing zoning, including any zoning adjustments resulting from active redevelopment plans.

As part of the project's current phase, the Transit Score Tool is being used to illustrate the variation in transit supportiveness that would result from an even distribution of this build-out growth across each municipality (the 'sprawl' scenario – Map 2) in comparison to the concentration of all build-out growth in a series of conceptual 'centers,' each two miles in diameter (the 'smart growth' scenario – Map 3). The specific method for each exercise is summarized on the two maps.

A comparison of these maps highlights in a readily apparent way the notion that by concentrating the same level of growth in transit supportive centers rather than in an even distribution, additional transportation options become viable. In this case, an east-west Bus Rapid Transit line along the corridor could be supported, for example. This expansion of mobility options makes a per-capita reduction in auto trips – and consequently traffic – possible. Additional details concerning the transit score analysis for the US 322 corridor can be found in the forthcoming final report for that project.

Map 2
Transit Scores for 322 Corridor: Prevailing Zoning Build-Out Scenario



DVRPC Transit Scores

- Low (< 0.60)
- Marginal (0.60 - 1.0)
- Medium (1.01 - 2.50)
- Med.-High (2.51 - 7.50)
- High (> 7.50)

1 0.5 0 1 Miles

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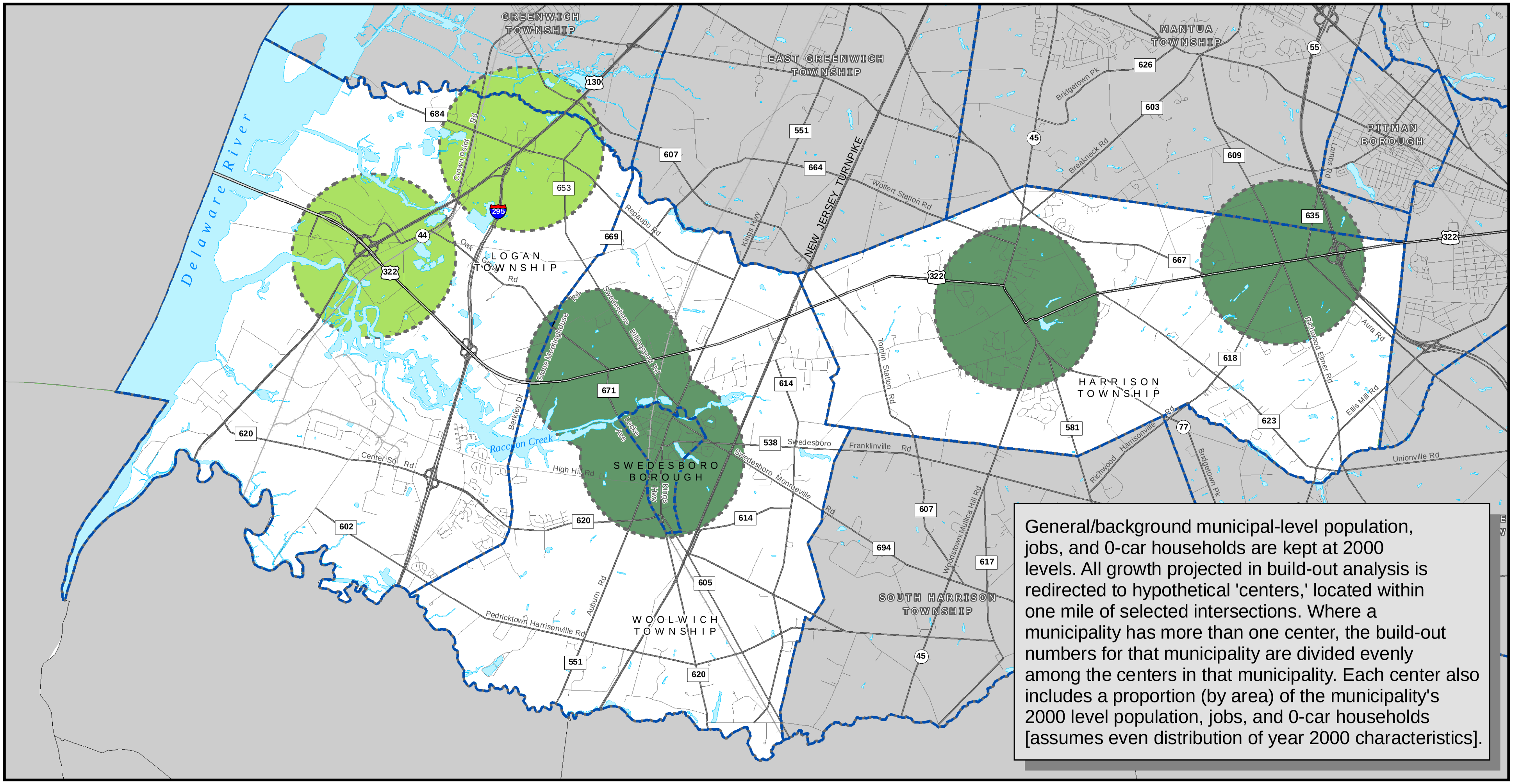
Map 3
Transit Scores for 322 Corridor: Smart Growth Build-Out Scenario



General/background municipal-level population, jobs, and 0-car households are kept at 2000 levels. All growth projected in build-out analysis is redirected to hypothetical 'centers,' located within one mile of selected intersections. Where a municipality has more than one center, the build-out numbers for that municipality are divided evenly among the centers in that municipality. Each center also includes a proportion (by area) of the municipality's 2000 level population, jobs, and 0-car households [assumes even distribution of year 2000 characteristics].

DVRPC Transit Scores

- Low (< 0.60)
- Marginal (0.60 - 1.0)
- Medium (1.01 - 2.50)
- Med.-High (2.51 - 7.50)
- High (> 7.50)

1 0.5 0 1 Miles

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Transit score comparison for the DVRPC Region, 2000 to 2030

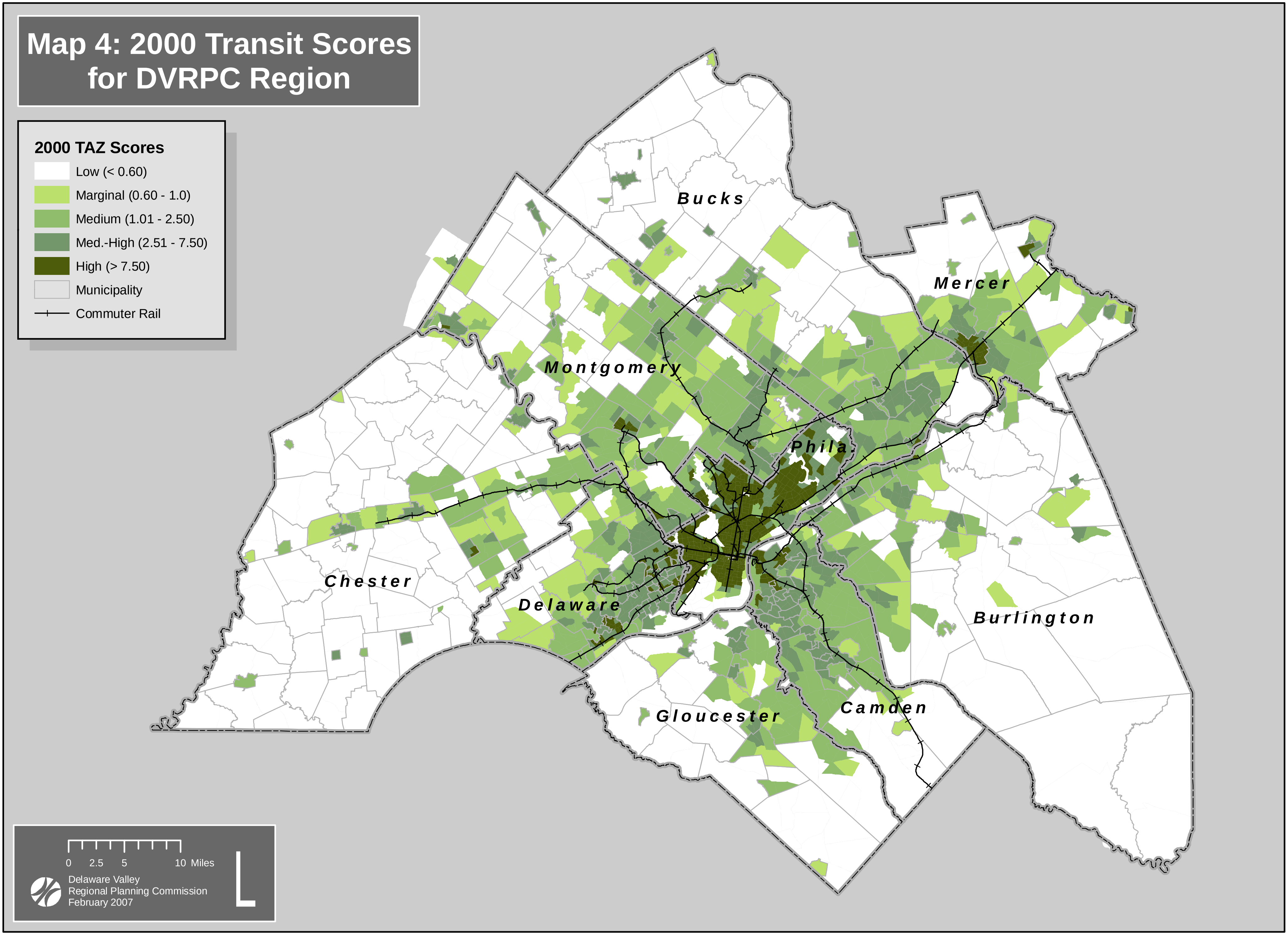
The Transit Score Tool will have broad applications from a regional planning standpoint, including a refined use in DVRPC's Congestion Management Process (CMP) and applications in forthcoming Long Range Plans. The most straightforward application is a simple comparison between present day transit scores across the region (reflecting 2000 Census data) and transit scores reflecting DVRPC's 2030 regional growth projections.

Maps 4 and 5 present this comparison, depicting transit scores at the TAZ-level. One conclusion that may be drawn from both maps is that the transit-supportive areas in the region are generally concentrated among Philadelphia and its inner-ring suburbs, and that existing transit infrastructure is generally co-located with these supportive areas. The differences between 2000 (Map 4) and the 2030 projections (Map 5) are illustrated in Map 6, which summarizes the numerical difference between scores calculated for these two years. TAZs which are forecast to shift from one score category to another are also highlighted on Map 5.

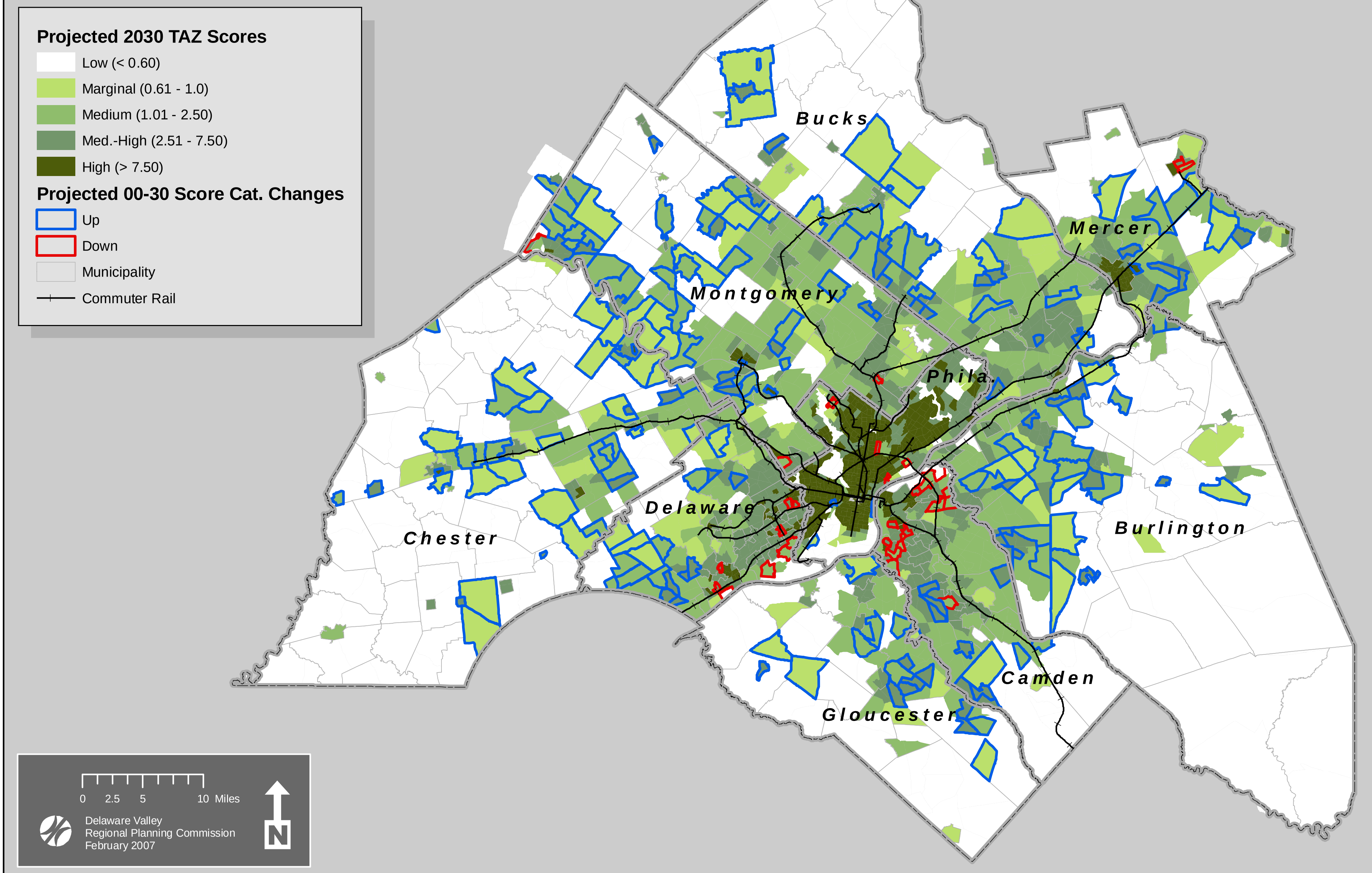
Generally speaking, areas that are forecast to add population and employment to the extent that they would reach a higher transit score classification occur adjacent to other areas that are already transit supportive. This can be seen along SEPTA's R5 Thorndale line, for example, where areas that presently have a 'low' classification (white on the map) are forecast to shift to the higher 'marginal' classification, matching other areas already served along the line. Should this growth proceed as forecasted, this adjacency to existing transit-supportive areas should make serving this new development more viable.

The score changes depicted in Map 6 reflect the broader trends forecasted as part of the 2030 Long Range Plan. The anticipated decline of scores for much of Philadelphia and its immediate environs reflect the continued outward shift of jobs and population (both through actual migration and an ongoing reduction in household size) that is projected. As depicted on Map 5, however, these calculated score reductions do not result in a large scale shift to lower score categories. Also notable is a calculated increase in transit scores for central Philadelphia – 49 of the top 50 regional TAZs in terms of positive numerical score change occur in Center City. These calculations reflect the anticipated continued viability of the region's traditional 'hub and spoke' transit network (centered in the Philadelphia CBD). An examination of suburban areas for which notable positive score changes are projected will prove useful in conceptually evaluating future investments.

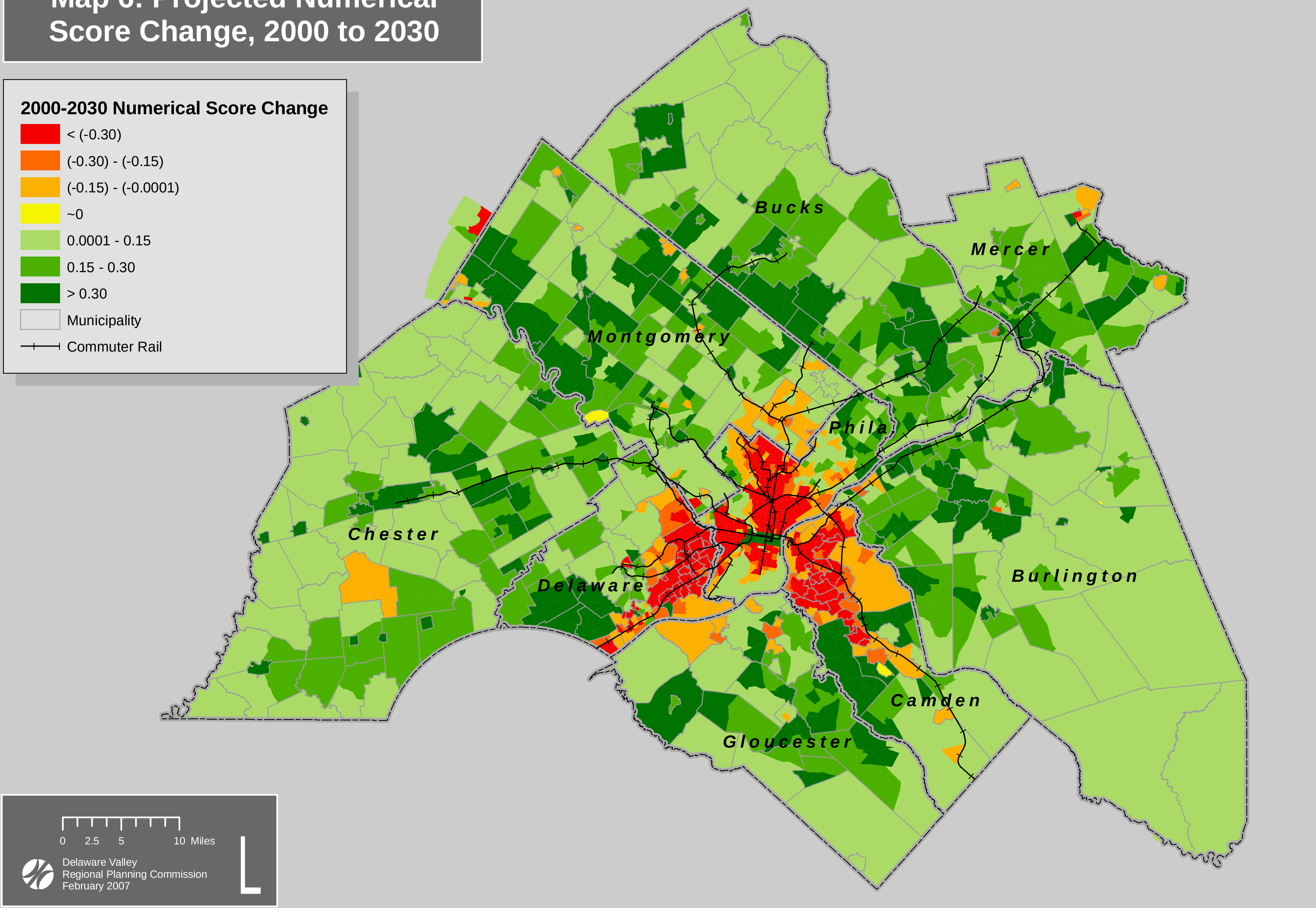
Map 4: 2000 Transit Scores for DVRPC Region



Map 5: 2030 Projected Transit Scores, Projected Category Changes 2000-2030



Map 6: Projected Numerical Score Change, 2000 to 2030



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SUMMARY POINTS/CONCLUSIONS

This two-phase project defines a tool and method to assess the appropriateness of various modes and intensities of transit service throughout the DVRPC region. Phase I consisted of a statistical evaluation and refinement of New Jersey Transit's existing 'transit score' method. This included a regression analysis to test the relationships between existing variables, additional variables, and transit mode share for the region, the State of New Jersey, and the combined area of the two. Based on the results of this evaluation, a refined transit score equation was derived for congruent use in both New Jersey and Pennsylvania. This Transit Score Tool is as follows (all densities gross):

Transit score = **[0.41*(Population per acre)] +**
[0.09*(Jobs per acre)] +
[0.74*(Zero car households per acre)]

The DVRPC Transit Score Tool was then classified into five score category ranges (from 'low' to 'high') and tested for the categories' correspondence with existing bus and rail service characteristics. Each score category was then associated with particular transit service investments that would be broadly appropriate, depending on other planning considerations (see Table 9).

Future work

- As described in this report, the Transit Score Tool is derived from 2000 US Census data, as distributed in the CTPP 2000 package. While it is likely that the calculated relationships between each of the input factors and average transit mode share (the transit score) will not change substantially, the tool itself may nonetheless be recalibrated following each publication of new population and employment data at the Census Tract level for the UNIVERSE area (the DVRPC region and State of New Jersey).

- A central impetus for DVRPC's development of the Transit Score Tool is the desire for its congruent use across the DVRPC region by agencies and planning stakeholders including New Jersey Transit, SEPTA, DRPA / PATCO, DVRPC's member governments, and others. In addition to seeking creative uses for the Tool within DVRPC, staff will continue to work with these and other agencies as needed to encourage and refine Tool applications.

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TITLE: CREATING A REGIONAL TRANSIT SCORE PROTOCOL: FULL REPORT

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Geographic Area Covered: DVRPC Region and State of New Jersey

Key Words: Transit Score, Transit Compatibility, Transit Supportiveness, Transit Viability, Transit Potential, Smart Growth

ABSTRACT: This two-phase project defines a tool and method to assess the appropriateness of various modes and intensities of transit service throughout the DVRPC region. Phase I consisted of a statistical evaluation and refinement of New Jersey Transit's existing transit score method. This included a regression analysis to test the relationships between existing variables, additional variables, and transit mode share for the region, the State of New Jersey, and the combined area of the two. Based on the results of this evaluation, a refined transit score equation was derived for congruent use in both New Jersey and Pennsylvania. This revised equation, the DVRPC Transit Score Tool, was classified into five score category ranges (from 'low' to 'high'), with each score category associated with particular transit service investments that would be broadly appropriate, depending on other planning considerations. The Transit Score Tool is technical in nature but transparent and accessible in application, and informs a better understanding of the relationship between land use configuration and public transportation. This will enable a more productive discussion of proposed transportation, planning, or transit-related development project at the conceptual level.

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