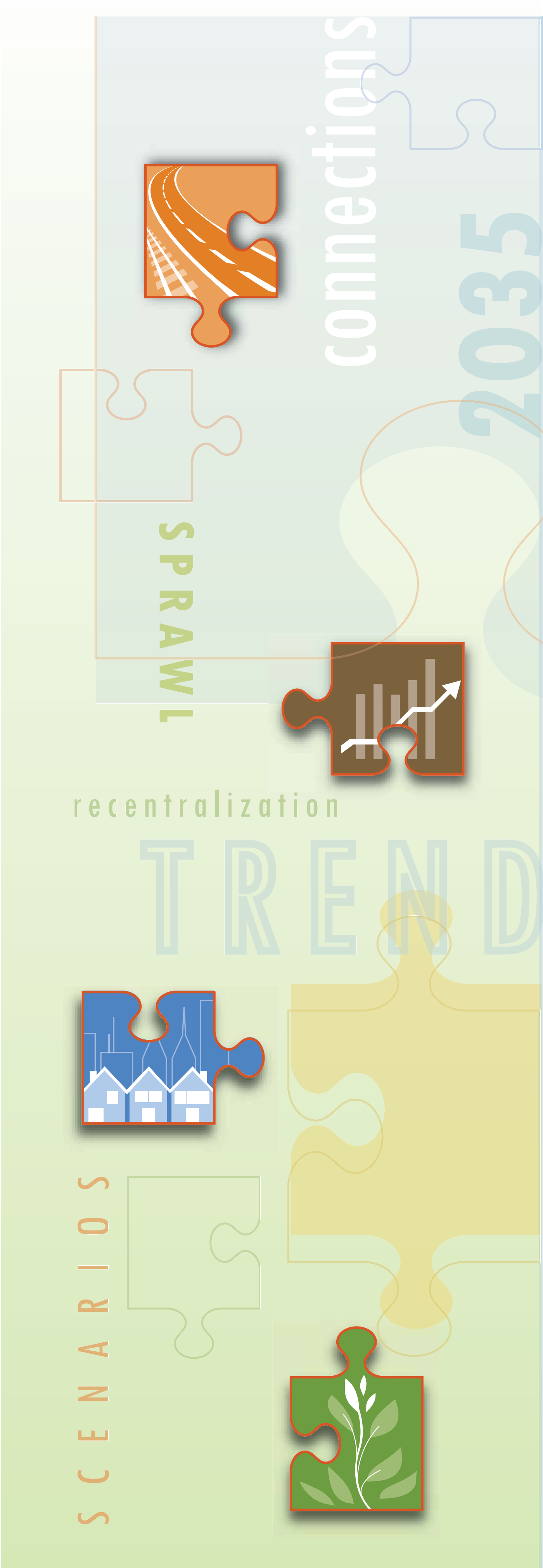

CONNECTIONS

THE REGIONAL PLAN FOR
A SUSTAINABLE FUTURE

Making the Land Use CONNECTION

Regional What-If Scenario Analysis

Delaware Valley
Regional Planning
Commission

connections 2035

SPRAWL

recentralization

TREND

SCENARIOS

CONNECTIONS

THE REGIONAL PLAN FOR A SUSTAINABLE FUTURE

Making the Land Use CONNECTION

Regional What-If Scenario Analysis

Delaware Valley
Regional Planning
Commission

SEPTEMBER 2008

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Created in 1965, the Delaware Valley Regional Planning Commission [DVRPC] is an interstate, intercounty, and intermunicipal 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. The two adjoining crescents represent the Commonwealth of Pennsylvania and the State of New Jersey.

DVRPC is funded by a variety of funding sources including federal grants from the United States 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 author(s), however, are solely responsible for its findings and conclusions, which may not represent the official views or policies of the funding agencies.

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Executive Summary

The Delaware Valley Regional Planning Commission (DVRPC) is conducting a scenario planning exercise that will compare the magnitude of impacts for two extreme settlement patterns – a **Recentralization** of population and jobs back into the region's centers, and an acceleration of **Sprawl** into the region's outlying areas – with the current development **Trend**. The goal of the scenario analysis is to better understand how different development patterns affect land use, transportation, the environment and economic development. These findings will inform the *Connections* update to the region's long-range plan.

Each scenario is developed by estimating future municipal population and employment levels, with differing rates of infill and new footprint development. DVRPC's UPlan land use model allocates the new footprint development by simulating the economic and policy forces that shape where households and commercial interests locate in the region. Using the scenario population and employment levels forecasted for 2035 in DVRPC's Travel Demand Model simulates future travel conditions. Additional indicators are computed using outputs from these two models.

All municipalities in the DVRPC region are associated with a planning area in DVRPC's current long-range plan, *Destination 2030*. The planning areas are core city, developed community, growing suburb, or rural area. The quantifiable differences between these communities are used as a basis for further analysis. On average, housing units in core cities and developed communities tend to be denser and smaller, with better transit access and higher rates of biking and walking trips. Growing suburb and rural area housing units tend to be larger and decentralized, with a much greater reliance on private vehicles for transportation. The main differentiation between the scenarios is the location of future population and employment by planning area. All other assumptions between the scenarios are identical. The following summarizes the key findings for each component of the plan.

Land Use

The Recentralization scenario locates most population and employment growth in the region's core cities and developed communities. The Trend scenario moves some of the region's residents and jobs away from these existing developed communities and relocates them along with future population and employment growth in growing suburbs and rural areas. The Sprawl scenario greatly accelerates the Trend scenario, with deep population and job losses in the developed areas and more gains in outlying suburbs and rural areas. Table ES-1 presents land use indicators for each scenario.

TABLE ES-1. 2035 LAND USE INDICATORS

Indicator	Recentralization	Trend	Sprawl
Core Cities Population	1,880,000	1,690,000	1,100,000
Developed Communities Population	2,200,000	2,000,000	1,610,000
Growing Suburbs Population	1,750,000	2,030,000	2,590,000
Rural Areas Population	320,000	440,000	850,000
Core Cities Employment	948,000	844,000	595,000
Developed Communities Employment	1,180,000	1,080,000	910,000
Growing Suburbs Employment	936,000	1,104,000	1,355,000
Rural Areas Employment	84,900	116,000	288,000
Core City Households	721,000	652,000	433,000
Developed Community Households	855,000	777,000	632,000
Growing Suburb Households	642,000	746,000	961,000
Rural Area Households	112,000	155,000	305,000
Vehicles	3,530,000	3,600,000	3,910,000
Average Number of Vehicles per Household	1.5	1.5	1.7
Percent of Households within Core Cities and Developed Communities	67.6%	61.3%	45.7%
Percent of Jobs within Core Cities	30.1%	26.8%	18.9%
New Acres of Development from 2005 to 2035	5,800	169,000	478,000
Agricultural Acres Lost to Development	2,740	74,500	242,000
Wooded Acres Lost to Development	1,970	39,600	167,000
Percent of Region Developed	39.4%	46.1%	58.8%
Average Acres per Household	0.28	0.34	0.45
Count of High and Medium-High Transit Score Locations (by TAZ)	1,044	1,027	931
Change in the Number Households with Transit Access	190,000	92,400	(159,000)
Change in the Number of Jobs with Transit Access	257,000	192,000	(83,500)

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Key land use findings include:

- The Recentralization scenario saves 163,000 acres from development compared to the Trend scenario, this is an area roughly the size of Camden County.
- Under the Sprawl scenario, an additional 309,000 acres will be developed in the region compared to the Trend scenario, this is an area roughly the size of Montgomery County.
- The more compact nature of the Recentralization scenario allows the region's residents to be less car dependent. This scenario forecasts 70,000 fewer vehicles than in the Trend scenario and 380,000 fewer vehicles than in the Sprawl scenario.

- The Recentralization scenario saves 71,800 agricultural acres from development compared to the Trend scenario, and an additional 167,500 agricultural acres compared to the Sprawl scenario. Reserving more land for agricultural uses may help the region better respond to changes in global trading, specifically those related to shifts in food and energy prices. This allows for more locally grown food, providing economic and nutritional benefits for the region's residents.
- The number of transit-supportive areas as defined by DVRPC's Transit Score Tool increases under the Recentralization scenario and decreases under the Sprawl scenario. More transit supportive area improves the region's ability to expand the system, which can reduce congestion and improve air quality.
- Compared to the Trend scenario, the Recentralization scenario adds more than 98,000 new households and 65,000 new jobs in areas with existing transit access; in the Sprawl scenario, over 250,000 new households and 275,000 new jobs will not be located near transit. Housing units and jobs located near transit encourages more ridership.

Transportation

The Recentralization scenario locates more population and jobs in areas that are already served by transit. The more compact nature and mixed use development pattern of this scenario encourages alternative transportation options, such as biking and walking, which in turn helps to lower vehicle miles traveled (VMT). Population and employment is highly decentralized in the Sprawl scenario, increasing the region's auto dependency. Table ES-2 presents transportation indicators for each scenario, key findings include:

- The Recentralization scenario could reduce annual VMT in 2035 by 1.7 billion compared to the Trend scenario and by 3 billion compared to the Sprawl scenario. Over the 25-year life of the *Connections* plan, the Recentralization scenario could reduce VMT by 39 billion miles compared to the Trend scenario and by 67 billion miles compared to the Sprawl scenario.
- Compared to the Trend scenario, the Recentralization scenario could save 1.25 working days of time spent driving in 2035 per capita; while the Sprawl scenario would mean each resident will spend the equivalent of one extra working day per year spent behind the wheel of an automobile.
- In 2035, the Recentralization scenario could mean an additional 50 million transit trips compared to the Trend scenario and 161 million more transit trips compared to the Sprawl scenario. Transit is a more sustainable form of transportation, as it uses considerably less energy and emits far fewer greenhouse gases per passenger mile than vehicles.
- In 2035, the Recentralization scenario could reduce person hours of delay due to congestion by 24 million hours regionwide, or four hours per capita, compared to the Trend scenario; and by 56 million person hours of delay, or nine hours per capita, compared to the Sprawl scenario.
- Excess time and fuel wasted in congestion in the Sprawl scenario could cost the region an extra $909 million, or $148 per capita, more than the

Trend scenario in 2035; and $1.57 billion, or $255 per capita, in additional congestion costs compared to the Recentralization scenario. Reduced congestion benefits the reliability of freight shipping, which lowers goods movement costs for residents and businesses and enhances the region's economic competitiveness.

- Less driving in the Recentralization scenario translates into an average of 4,200 fewer vehicle crashes in 2035 compared to the Sprawl scenario and 2,200 fewer crashes than in the Trend scenario.
- The Recentralization scenario is estimated to encourage 590 million pedestrian trips in 2035, the Trend scenario projects 554 million, and the Sprawl scenario anticipates 465 million.
- The Recentralization scenario is estimated to encourage 56.8 million bicycle trips in 2035, the Trend scenario projects 54.3 million, and the Sprawl scenario anticipates 48.9 million.

TABLE ES-2. 2035 TRANSPORTATION INDICATORS

Indicator	Recentralization	Trend	Sprawl
Annual Vehicle Miles Traveled (billions of VMT)	47.0	48.7	50.0
Annual Vehicle Hours Traveled (billions of VHT)	1.53	1.59	1.64
Annual VMT per Capita	7,650	7,920	8,120
Annual VHT per Capita	248	258	266
Annual Vehicle Trips (billions)	7.60	7.80	8.29
Annual Crashes	62,400	64,600	66,600
Average Daily Roadway Speed (mph)	30.8	30.7	30.5
Average Peak Period Roadway Speed (mph)	30.2	29.7	28.6
Annual Vehicle Hours of Delay (millions)	124	144	171
Annual Wasted Time (millions of person hours)	146	170	202
Annual Hours of Delay per Capita	23.8	27.7	32.9
Annual Wasted Fuel (millions of gallons)	38.6	47.6	62.5
Annual Congestion Cost (billions of 2008 $s)	$ 3.72	$ 4.33	$ 5.12
Annual Transit Trips (millions of unlinked trips)	418.7	367.9	256.7
Annual Pedestrian Trips (millions)	590.4	554.3	465.0
Annual Bicycle Trips (millions)	56.8	54.3	48.9

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All scenarios will need to make investments in new transportation capacity. The more compact nature of the Recentralization scenario means that transit and alternative transportation can play a major role in fulfilling future travel needs. The more decentralized Sprawl scenario will likely mean that new or widened roads will be the primary solution to meeting future demand.

The Environment

By concentrating on compact, infill development, the Recentralization scenario saves existing open space. The wetlands and forests that remain intact will continue to filter out pollutants, mitigate flooding, and reduce erosion and stormwater runoff. The Sprawl scenario, on the other hand, would develop a considerable portion of the region's existing open space. This scenario creates more pollution, while at the same time reducing the ability of the ecosystem to mitigate the negative impacts of pollutants. Table ES-3 presents environmental indicators for each scenario.

TABLE ES-3. 2035 ENVIRONMENTAL INDICATORS

Indicator	Recentralization	Trend	Sprawl
NO_x Emissions from Vehicles (tons/day)	21.1	21.8	22.2
VOC Emissions from Vehicles (tons/day)	29.6	30.7	31.5
$PM_{2.5}$ Emissions from Vehicles (tons/day)	1.74	1.80	1.85
CO_2 Emissions from Vehicles (tons/day)	73,000	75,600	77,600
Average Annual Residential and Transportation Energy Use Per Household (millions of BTUs)	331	339	349
Total Annual Residential and Transportation CO_2 Emissions (millions of tons)	49.9	51.0	52.5
Total Annual Residential and Transportation CO_2 Emissions per Capita (tons)	8.1	8.3	8.5
CO_2 Equivalent for Additional Energy Used Over Recentralization in Barrels of Oil (millions)	-	2.48	5.62
Additional Trees Needed to Offset Additional CO_2 over Recentralization Scenario (millions)	-	27.3	62.0
Residential Water Use (millions of gallons / day)	523	546	606
Per Household Water Use (gallons / day)	225	234	260

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Key environmental findings include:

- The Recentralization scenario could lead to a reduction of 22 tons of Fine Particulate Matter ($PM_{2.5}$), more than 400 tons of Volatile Organic Compounds (VOCs), and 256 tons of Oxides of Nitrogen (NO_x) compared to the Trend scenario in 2035; and by 40 tons of $PM_{2.5}$, 692 tons of VOCs, and 402 tons of NO_x released into the atmosphere in 2035 compared to the Sprawl scenario. More emissions worsen the region's air quality, which negatively affects health for individuals who suffer from asthma, bronchitis, other respiratory illnesses, and heart disease. Pollutants also damage crops, lower water quality, and contribute to global climate change.
- The average household in the Recentralization scenario will require 2.3 percent less energy to power, heat, cool, and transport than an average household under the Trend scenario. Conversely, the average household in the Sprawl scenario will need 2.5 percent more energy per household than in the Trend scenario.
- Under the Recentralization scenario, the sum of CO_2 emissions from residential and vehicle energy use can be decreased by nearly 3.7 million tons in 2035 and by 25.5 million tons over the life of the *Connections* plan compared to the Trend scenario.

- The Sprawl scenario will likely emit 1.6 million additional tons of CO_2 from transportation and residential energy consumption in 2035. Over the life of the *Connections* plan, this scenario would add 27.8 million tons of CO_2 emissions compared to the Trend scenario and 45 million tons more than the Recentralization scenario.
- The Recentralization scenario has the same effect of reducing CO_2 emissions as planting more than 25 million trees in the region compared to the Trend scenario. It is also the equivalent of burning nearly 2.5 million fewer barrels of oil in the year 2035.
- The Sprawl scenario contributes the CO_2 emissions equivalent of burning 3.1 million barrels of oil compared to the Trend scenario. This would require planting more than 34 million trees in the region to offset these additional emissions.
- The Recentralization scenario is estimated to save 24 million gallons of water per day in the region compared to the Trend scenario in 2035, and 83 million per day compared to the Sprawl scenario. Water use savings could reduce the need to build expensive new water treatment facilities.

Economic Development

The region can receive economic benefits by utilizing and maintaining existing infrastructure rather than duplicating it with new facilities. This can reduce the tax burden on residents and businesses and increase the region's economic competitiveness. By using land more efficiently through higher density and mixed uses, energy consumption can be reduced. This lessens costs for businesses and residents, better prepares the region for energy price volatility by increasing regional self-sufficiency, and lowers greenhouse gas emissions. Table ES-4 presents economic development indicators for each scenario, some of the key findings include:

- The Recentralization scenario is estimated to save the average household $300 in annual auto and utility expenses compared to the Trend scenario and nearly $1,300 compared to the Sprawl scenario.
- Total supporting infrastructure cost for schools, local roads, sewers, and water is $25 billion more under the Sprawl scenario than under the Trend scenario. This is due to the more than twice as many new housing units and $15,900 higher per unit costs under the Sprawl scenario. More greenfield development means more lane miles of road, extension of sewer lines, and new schools, all of which duplicate infrastructure already built in the region's developed communities and core cities. By more fully utilizing existing infrastructure, the Recentralization scenario could save nearly $3 billion total dollars, or more than $6,600 per new housing unit.
- The Trend scenario anticipates increasing jobs in disadvantaged Environmental Justice communities by approximately three percent over the 30-year planning period. The Recentralization scenario would increase the current total by 12 percent, while the Sprawl scenario is forecast to result in the loss of 24 percent of the existing job base in these communities.

TABLE ES-4. 2035 ECONOMIC DEVELOPMENT INDICATORS

Indicator	Recentralization	Trend	Sprawl
Average Annual Household Automobile and Utility Expenses (2008 $s)	$ 14,770	$ 15,070	$ 16,060
Total Supportive Infrastructure Costs (billions of 2008 $s)	$ 7.38	$ 10.8	$ 35.6
Supportive Infrastructure Costs per New Housing Unit (2008 $s)	$ 28,600	$ 37,400	$ 53,300
Jobs Added to Environmental Justice Communities	79,400	17,300	(151,000)

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The scenarios were reviewed for their likely impacts on fiscal health and regional economic competitiveness. The Pennsylvania Economy League (PEL) found a pattern of municipal fiscal decline affecting all forms of local government in developed or developing areas of the Commonwealth of Pennsylvania. As population grows in previously undeveloped areas, new infrastructure and increased revenue from real estate taxes generate healthy fiscal conditions. Population growth, though, brings the need for additional services, and as infrastructure ages, it becomes expensive to maintain and replace, straining municipal budgets. As a result, over time, taxes need to be raised, fees increased, services reduced, or additional debt incurred. Tax increases and service cuts eventually lead to lower property values and/or outmigration, and the municipality begins losing its tax base and risks falling into distress. The Trend scenario continues this pattern of municipal population loss and revenue decline, while the Sprawl scenario would likely intensify it. The Recentralization scenario relocates population and jobs back into many of the communities with fiscal problems related to population decline and job loss. This scenario offers the opportunity to improve municipal fiscal health in these municipalities.

For the lesser developed areas in the region, the American Farmland Trust's 'Cost of Community Services' (COCS) studies, have found that open space and farmland require only 37 cents of expenditure for every dollar of revenue they generate. This is comparable to commercial and industrial uses, which average 29 cents of expenditure for every dollar of revenue generated. The Recentralization scenario preserves open space and farmlands, helping to improve fiscal health in rural and suburban communities.

DVRPC's *A "Post-Global" Economic Development Strategy* recognized that future energy and resource constraints could reverse some aspects of globalization. It predicted that more self-sufficient communities and regions will have greater economic competitiveness in the future. Self-sufficiency essentially means meeting most basic needs locally. This may mean a return to more local and regional manufacturing of basic goods, energy independence, and local food production. As a result, energy availability may greatly impact future location decisions. Locations near rail and port facilities are likely to become preferable, as will compact communities with transit and pedestrian infrastructure. These areas more efficiently use land in terms of energy needs, in contrast to more decentralized automobile-oriented communities. The Recentralization scenario best fulfills these future needs and enhances the region's economic competitiveness.

Conclusion

Based on this analysis of impacts to land use, transportation, the environment, and economic development, Recentralization offers the best solutions for a sustainable future. This scenario best prepares the region for combating global climate change and energy volatility. It offers a superior quality of life for the region's residents by offering more mobility choices, while preserving open space, and reducing household expenses. Energy use and CO_2 emissions can be reduced through smart land use and transportation policies. Mixed land use and higher densities can shorten distances between origins and destinations, which encourages alternative forms of transportation. More compact neighborhoods and housing units can reduce residential energy needs. By spending less on replicating existing infrastructure more money can be invested into green and energy efficient technologies or alternative fuels. This in turn will help ensure the region remains economically competitive in a fast changing world.

Next Steps

Making the Land Use Connection is intended to spur discussion of the long-range planning process and the region's vision for the future by analyzing the impacts of two extreme land use scenarios. The scenarios are intended to help explain the impact of different land-use patterns. One of the scenarios, or more likely, elements of each of the scenarios will be defined, as the preferred scenario for the Plan. This will be determined with public and stakeholder input, at a series of focus groups and workshops in the fall of 2008. At these meetings, goals and strategies to achieve the desired vision will also be identified. These goals and strategies will address any number of issues, such as improving the quality of life, regional competitiveness, combating global climate change and mobility challenges. As seen in the scenario exercise, the goals and strategies are all interconnected.

Background

The Delaware Valley Regional Planning Commission (DVRPC) is conducting a scenario planning exercise to help inform the *Connections* update to the region's long-range plan through the year 2035. DVRPC is a nine-county, bistate Metropolitan Planning Organization (MPO) covering Bucks, Chester, Delaware, Montgomery and Philadelphia counties in Pennsylvania and Burlington, Camden, Gloucester, and Mercer counties in New Jersey. Figure 1 places the region in context.

FIGURE 1. DVRPC REGION

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Scenario planning is used to assess the different impacts of long-term development strategies. The benefits of such an exercise include:

- creating a foundation for analysis and understanding of complex issues in order to better respond to change;
- building consensus by giving communities the ability to participate actively in planning;
- developing tools and techniques to assess the impact of land use, transportation and other public policy choices on a community;
- recognizing tradeoffs among competing goals;
- enhancing decision making; and,
- improving the management of increasingly limited resources.[1]

[1] FHWA 2005.

DVRPC conducted a similar exercise in 2003, which resulted in *Regional Analysis of What If Transportation Scenarios*. These scenarios informed the development of the *Destination 2030* long-range plan (2030 Plan). This analysis contains four separate scenarios plus a baseline. Two of the scenarios—Sprawl and Recentralization—from the previous analysis will be considered again in the current exercise. The previous exercise also reviewed Regional Population Growth and Regional Population Decline scenarios. For simplicity in analysis, presentation, and comprehension, DVRPC will focus on three scenarios for the *Connections* update. This enables each scenario to have more depth and allows the analysis to concentrate on their differences.

Where possible, DVRPC has built off of the previous scenario effort. Many of the indicators in *Making the Land Use Connection* were included in the previous effort. In many cases the analysis has become more sophisticated. For example, research in the intervening years has added complexity to the residential energy use indicator. The previous effort was based on the national average residential energy consumption. In the current effort, residential energy use varies by planning area location using a similar set of planning areas (city, town, suburban, and rural) from the Energy Information Administration (EIA) as used by DVRPC. In other cases, new indicators are added based on current key issues, such as residential energy and vehicle-based CO_2 emissions, or utilization of new DVRPC planning tools, such as the transit score. The main body of this document analyzes the findings of the scenario exercise, organized by the four components of the *Connections* Plan: land use, transportation, the environment and economic development. Appendices A to D contain information related to scenario development, assumptions, and modeling.

The findings in this report should not be seen as absolutes; instead, the relative differences should guide future decision making. The characteristics attributed to each of the four planning area communities are based on long-term trends. Recent price increases for gasoline, rising transit ridership, and the crisis in the housing market have little effect on DVRPC's modeling and scenario analysis. Over the long term, market conditions, government policies, or any number of other factors can have major impacts on future land use and transportation patterns. A model is not able to predict precisely what these changes will be. Rising gas prices have already led to significant changes in nonautomobile transportation usage. Increasing energy costs, coupled with a recentralization of population and employment, will likely lead to even larger gains for alternatives to single-car use. The intent is to showcase an order of magnitude impact from drastically different land use patterns in order to understand and better prepare for the future, and to spur thought and discussion of what we collectively would like the future to hold.

Introduction

Making the Land Use Connection: Regional What-If Scenario Analysis will compare a pair of disparate future scenarios with current development trends. The first scenario explores what will likely occur if **Sprawl** accelerates in the region's growing suburbs and rural areas. The second considers the effects of a **Recentralization** to core cities and developed communities. The Recentralization scenario essentially brings the vision, goals, and strategies of the *Destination 2030* long-range plan (2030 Plan) to fruition. The core planning principles from this plan include:

- linking land use and transportation;
- creating and maintaining centers;
- promoting growth areas;
- implementing smart growth and smart transportation; and
- maintaining and preserving rural conservation lands and creating a greenspace network.

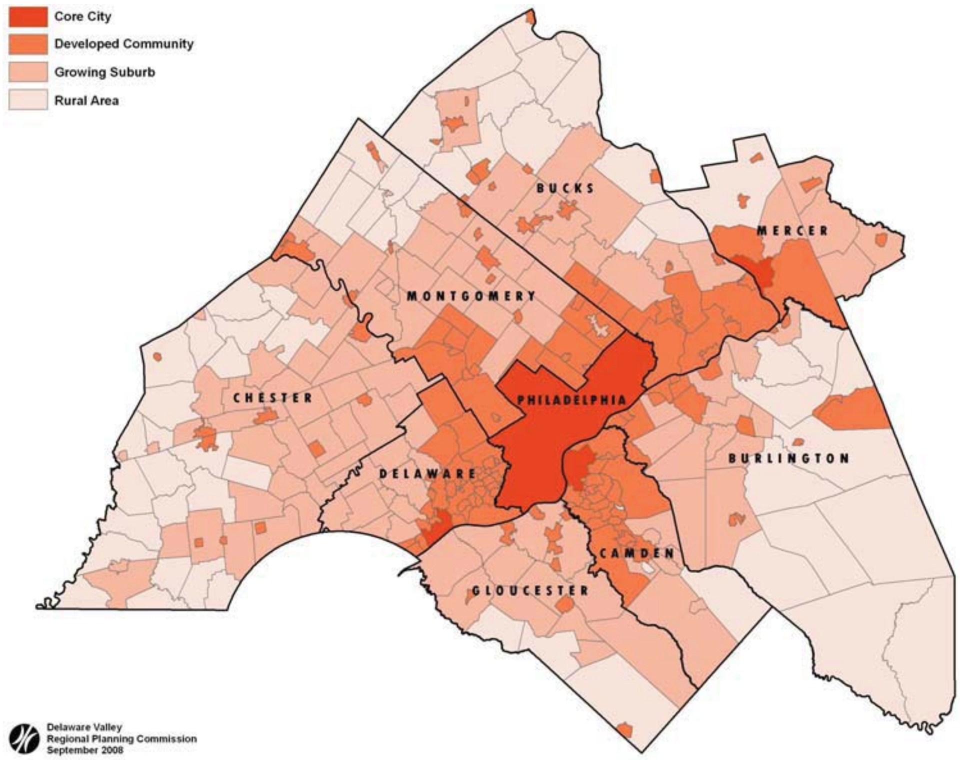
The Trend scenario is developed using DVRPC Board-adopted population and employment forecasts for 2035 and extrapolating historical settlement patterns. The goal of this analysis is to understand the magnitude of impacts for two extreme settlement patterns compared with current land use trends on regional transportation, the environment, energy use, household expenditures, municipal fiscal health, regional economic competitiveness, and other key issues.

Each municipality in the DVRPC region is defined in *Destination 2030* as one of the following planning areas: core city, developed community, growing suburb, or rural area. Figure 2 presents the planning areas for each municipality in the DVRPC region. Planning areas will be used throughout this document to refer to these four different area types from the 2030 Plan. Much of the scenario analysis is based on the quantifiably different characteristics between the typical household in these types of communities.

Housing units in core cities and developed communities are generally denser and smaller, requiring less energy to maintain. Households tend to be more transit oriented, leading to lower rates of vehicle ownership and usage. The more compact nature of these communities also allows for more trips by alternative modes such as walking and biking.

Housing units in growing suburbs and rural areas tend to be large and diffuse. Residents are less likely to have nearby access to transit, leading to higher household rates of vehicle ownership and more vehicle miles traveled. Walking and biking in these communities tend to be more recreational.

FIGURE 2. DVRPC PLANNING AREAS



Policies Guiding Scenario Development

In all scenarios, regional population and employment levels will remain at the Board-adopted projections of 6.15 million and 3.15 million, respectively. The Recentralization scenario will be based primarily on infill development; where new footprint development does occur, it will be at a higher density; and the amount of land available for future development is restricted to the future growth areas identified in the 2030 Land Use Plan. Infill, in this case, is using previously built-on vacant parcels, or the teardown of existing buildings, to redevelop at higher density. All scenarios recognize a second type of infill, which occurs on previously undeveloped land surrounded by development.

The Sprawl scenario restricts infill to the filling in of greenfield sites left vacant by leapfrog development. All development is essentially new footprint and is based on current densities. This scenario will have the least amount of land restricted to development because it only prohibits development on the protected lands inventory (as identified in the 2030 Plan). The Sprawl scenario also accounts for 'intracounty movement,' wherein existing population and jobs will relocate from core cities and developed communities to growing suburbs and rural areas within the same county.

The Trend scenario is essentially based on Board-adopted municipal forecasts for 2035, with a level of infill to suit those forecasts. New footprint development is built at current density levels and the protected lands inventory and regional greenspace network from the 2030 Plan will limit development. Table 1 summarizes the policies used to develop the scenarios.

TABLE 1. KEY POLICIES GUIDING THE SCENARIO ANALYSIS

Policy Area	Recentralization	Trend	Sprawl
2035 Population (millions)	6.15	6.15	6.15
2035 Employment (millions)	3.15	3.15	3.15
Core Cities	Gain Population and Employment Through Regional Growth	As Forecast	Lose Population and Employment to Intracounty Movement
Developed Communities	Gain Population and Employment Through Regional Growth	As Forecast	Lose Population and Employment to Intracounty Movement
Growing Suburbs	Maintain Population and Employment	As Forecast	Gain Population and Employment Through Regional Growth and Intracounty Movement
Rural Areas	Maintain Population and Employment	As Forecast	Gain Population and Employment Through Regional Growth and Intracounty Movement
Development Allocation Area	Restricted to Existing Development and Future Growth Areas in *Destination 2030* Land Use Plan	Restricted by Protected Lands Inventory and Regional Greenspace Network in *Destination 2030* Land Use Plan	Restricted by Protected Lands Inventory in *Destination 2030* Land Use Plan
Infill Development	80 to 90%	As Needed to Meet Forecast	None
New Footprint Density	Increased from UPlan Calibration (see Appendix B)	UPlan Calibrated Development Density	UPlan Calibrated Development Density

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Scenario Performance Measures

The scenarios are primarily analyzed using two simulation models–UPlan, a land use model that spatially distributes new population and employment, and the DVRPC Travel Demand Model (TDM)—to determine the resulting transportation needs for the different development patterns. A number of the indicators are calculated directly using these two models. Additional indicators are computed from data derived by these models. More than 100 indicators were analyzed to quantify the consequences of the different development patterns, including:

- population and employment levels by planning area;
- number of vehicles;
- driving characteristics (such as average speed, vehicle miles traveled (VMT), vehicle hours traveled (VHT), and delay);
- transit ridership;
- percent of households and jobs with transit access;
- transit score at the Traffic Analysis Zone (TAZ) level;
- bicycle and pedestrian trips;
- amount of land developed;
- household density;
- residential and vehicle energy use;
- transportation-related emissions;
- CO_2 emissions from residential energy use and transportation; and
- average annual household energy and automobile expenses.

Method

The scenario development process consists of four steps. The documentation of the process and assumptions used to develop the scenarios can be found in appendices A to D. The first step creates alternate municipal- and county-level population control figures from the Board-adopted 2035 forecasts and estimates how much future development is new footprint and how much is infill (see Appendix A). These are input into UPlan, which locates the new footprint development in step two (see Appendix B). Step three allocates new population and employment figures to the Traffic Analysis Zones (TAZs) that the DVRPC TDM uses to perform an analysis of the transportation network under the different land use scenarios (information related to the DVRPC TDM can be found in Appendix C). Step four computes additional performance indicators using outputs from both models (see Appendix D).

Land Use

The main difference between the scenarios is where new population and employment growth locates over the next 25 years. The Recentralization scenario incorporates most new population growth through infill development located in the region's existing centers. At the other extreme, the Sprawl scenario envisions impacts that will likely happen if the long-term trend of outward movement from the centers accelerates. Table 2 presents the population and employment estimates by planning area as determined by DVRPC's county control and infill estimates (in Appendix A) and new footprint development allocated by UPlan (see Appendix B).

TABLE 2. POPULATION, EMPLOYMENT, HOUSEHOLDS, AND VEHICLES BY SCENARIO AND PLANNING AREA

Indicator	Recentralization	Trend	Sprawl
Core Cities Population	1,878,000	1,685,000	1,104,000
Developed Communities Population	2,202,000	1,998,000	1,606,000
Growing Suburbs Population	1,752,000	2,029,000	2,594,000
Rural Areas Population	318,000	437,000	846,000
Total Population	6,150,000	6,150,000	6,150,000
Core Cities Employment	948,000	844,000	595,000
Developed Communities Employment	1,177,000	1,083,000	910,000
Growing Suburbs Employment	936,000	1,104,000	1,355,000
Rural Areas Employment	85,000	116,000	288,000
Total Employment	3,150,000	3,150,000	3,150,000
Core City Households	721,000	652,000	433,000
Developed Community Households	855,000	777,000	632,000
Growing Suburb Households	642,000	746,000	961,000
Rural Area Households	112,000	155,000	305,000
Total Households	2,330,000	2,330,000	2,330,000
Vehicles	3,526,000	3,596,000	3,907,000
Vehicles per Household	1.5	1.5	1.7
Zero-Vehicle Households	361,000	327,000	257,000
One-Vehicle Households	826,000	824,000	749,000
Two-Vehicle Households	846,000	873,000	957,000
Three+ Vehicle Households	298,000	305,000	368,000

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Core city population in the Recentralization scenario is 11 percent greater than in the Trend scenario. While in the Sprawl scenario, these communities have 35 percent less population than in Trend. Core city employment is just as dramatic, with the Recentralization scenario increasing by 12 percent over the Trend scenario and the Sprawl scenario declining by 29 percent under the Trend scenario. This is further illustrated in Figures 3 and 4.

The more compact nature of Recentralization allows the region's residents to be less car dependent. This scenario forecasts 70,000 fewer vehicles than in the Trend scenario and 380,000 fewer vehicles than in the Sprawl scenario.

FIGURE 3. PLANNING AREA POPULATION BY SCENARIO

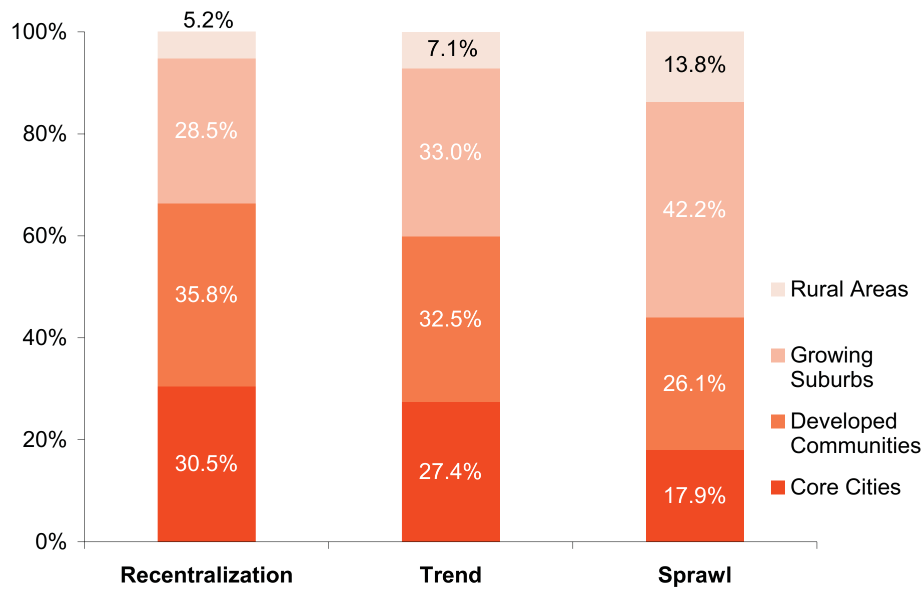

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FIGURE 4. PLANNING AREA EMPLOYMENT BY SCENARIO

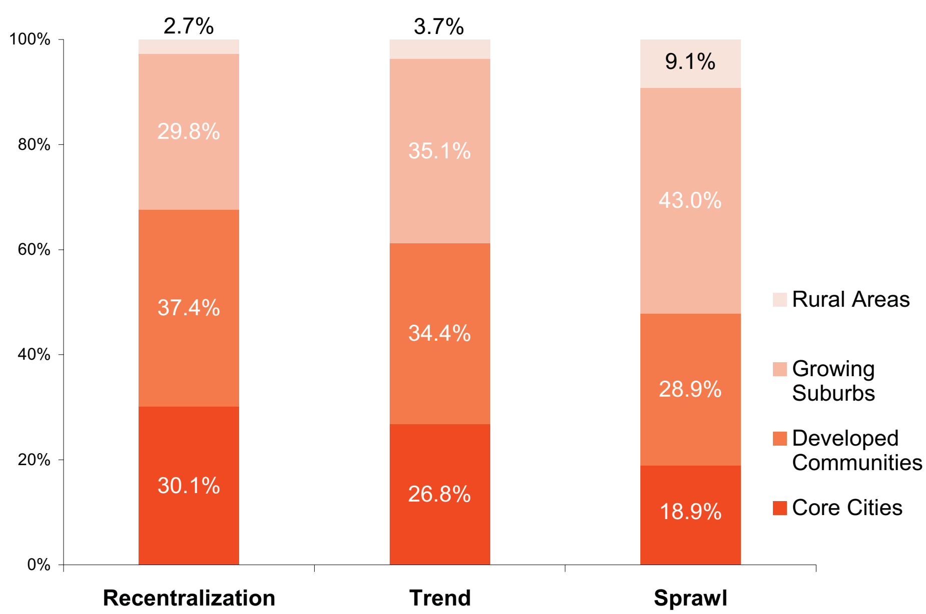

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FIGURE 5. PERCENT CHANGE IN NUMBER OF HOUSEHOLDS FROM 2005 TO 2035

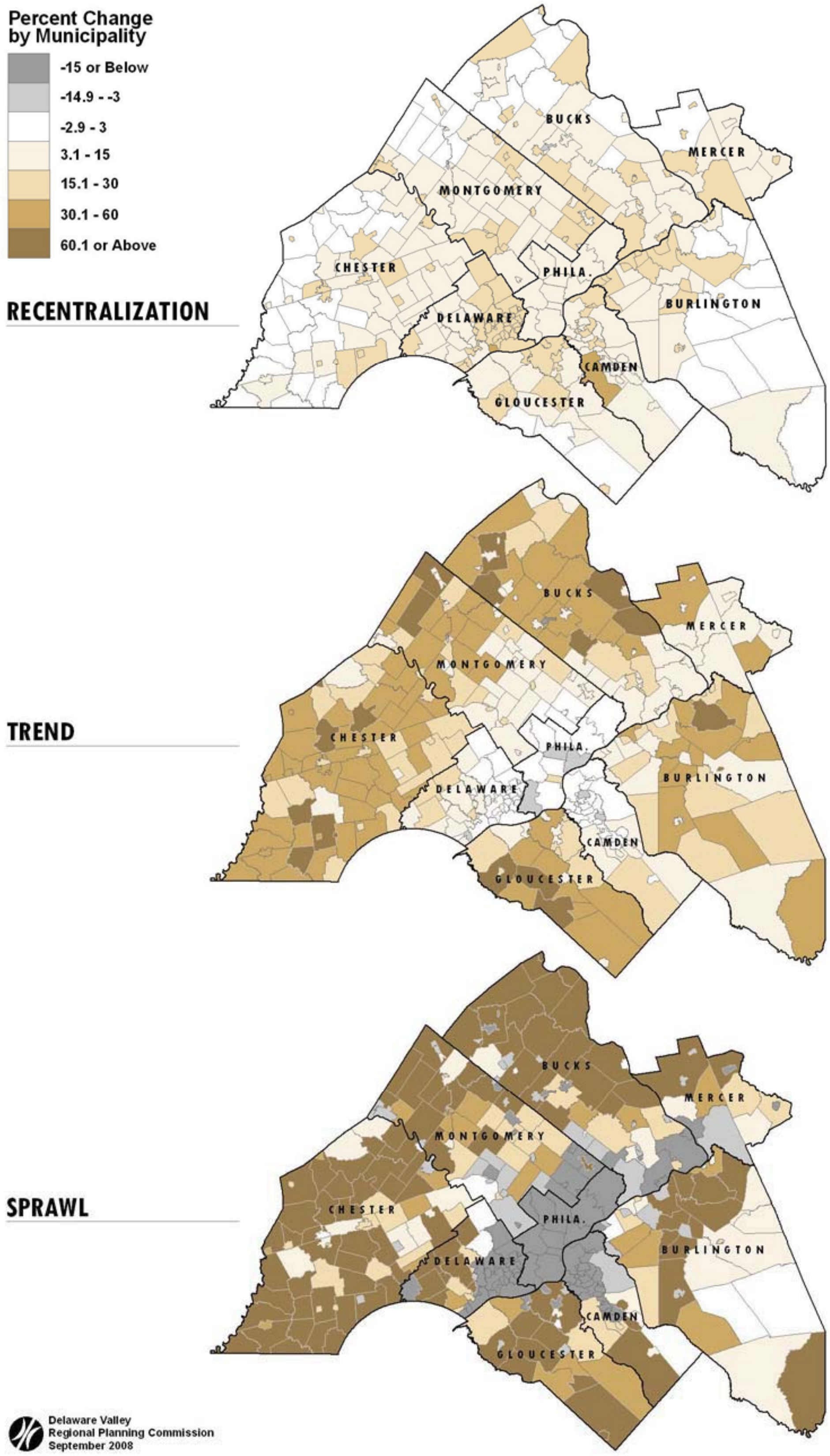

FIGURE 6. PERCENT CHANGE IN EMPLOYMENT FROM 2005 TO 2035

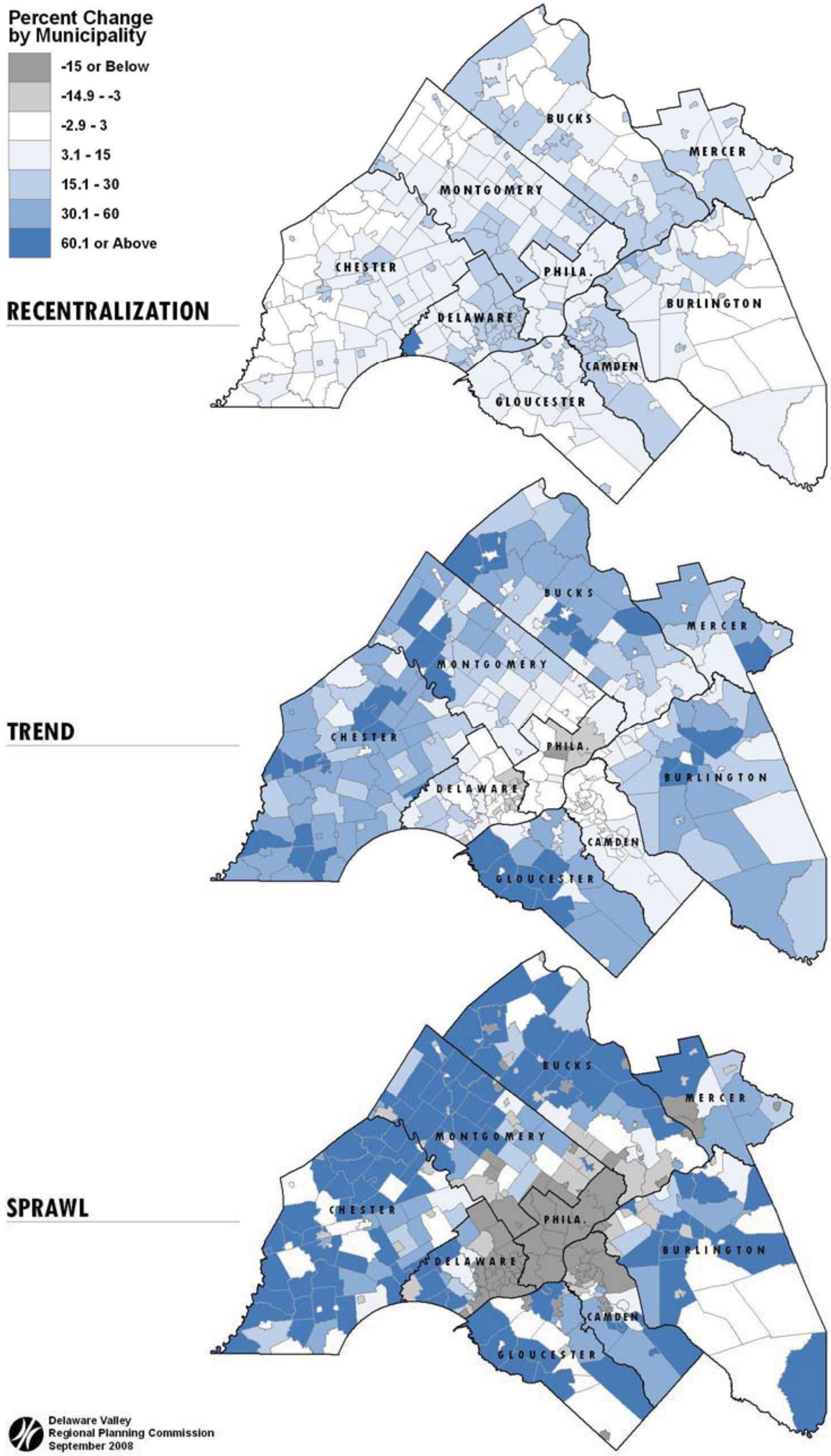

Figure 5 shows the percentage change in households for each municipality by scenario. Figure 6 presents the percentage change in employment for each municipality by scenario. These two figures illustrate that the Recentralization scenario concentrates households and employment in the region's existing developed areas. The Trend scenario shows losses in most of the region's existing developed areas and gains in the growing suburbs and rural areas. The Sprawl scenario greatly accelerates the Trend scenario, with deep losses in the developed areas and large gains in the growing suburbs and rural areas.

Significant population and job growth in the rural areas under the Sprawl scenario and, to a lesser extent, under the Trend scenario will likely fundamentally alter the character of these communities to a much more suburban nature.

UPlan identifies the acreage needed to meet residential and commercial new footprint development for each scenario. Starting with base year 2005 land use data, new total acres of development can be determined along with resulting residential densities for each scenario. These measures are presented in Table 3. Figure 7 shows UPlan-allocated new footprint development under each of the three scenarios.

TABLE 3. LAND USE INDICATORS BY SCENARIO

Indicator	Recentralization	Trend	Sprawl
New Footprint Acres of Development 2005 to 2035	5,800	169,000	478,000
Total Acres Developed in 2035	970,000	1,120,000	1,440,000
Percent of Region Developed in 2035	39.4%	46.1%	58.8%
Total Residential Acres Developed in Region in 2035	660,000	800,000	1,040,000
Agricultural Acres Lost to Development 2005 to 2035	(2,700)	(74,500)	(242,100)
Wooded Acres Lost to Development 2005 to 2035	(1,969)	(69,600)	(166,600)
Percent of Households within Core Cities and Developed Communities	68%	61%	46%
Percent of Jobs within Core Cities	30%	27%	19%
Core City Households per Acre	19.4	15.5	11.6
Developed Community Households per Acre	5.0	4.2	2.5
Growing Suburb Households per Acre	2.2	1.8	2.1
Rural Area Households per Acre	1.0	0.9	1.2
Average Regional Residential Lot Size (in acres)	0.28	0.34	0.45

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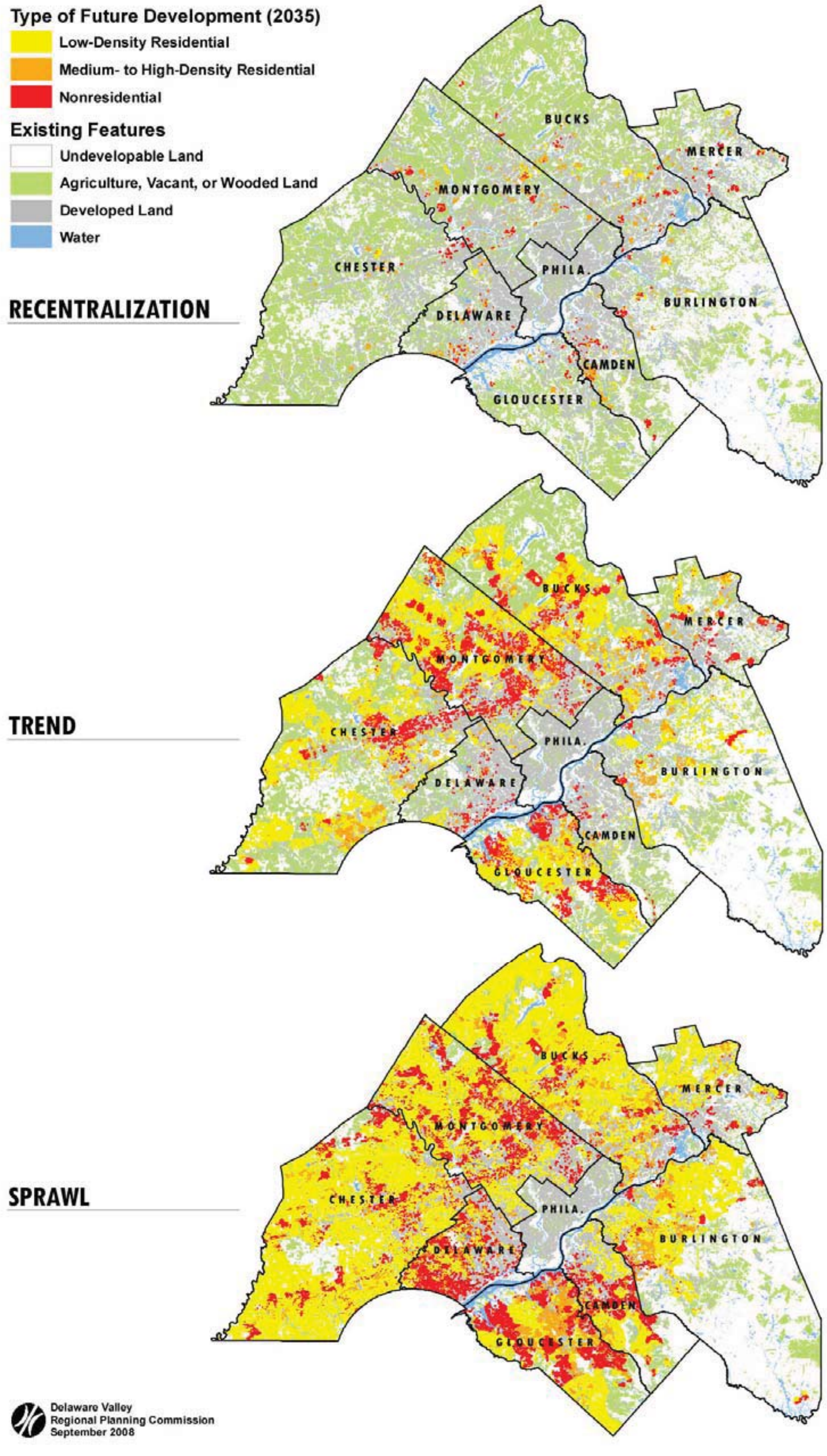
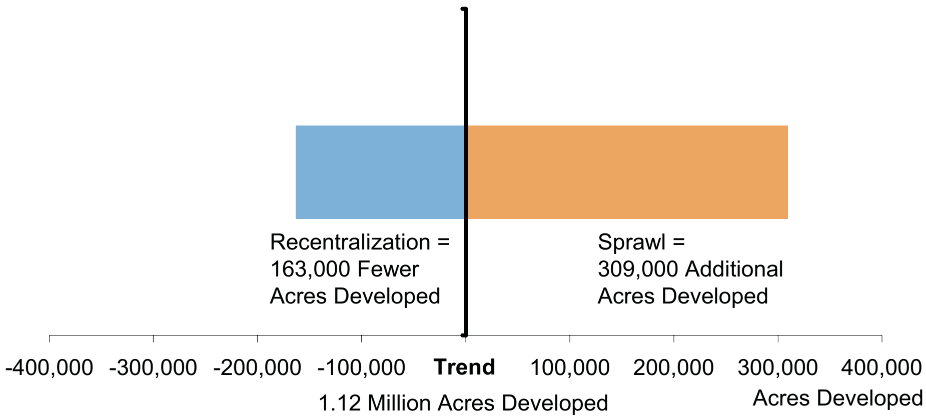
FIGURE 7. NEW FOOTPRINT DEVELOPMENT AS ALLOCATED BY UPLAN



The Recentralization scenario relies heavily on infill development on reclaimed sites, resulting in very few new acres of development. This scenario could save more than 163,000 acres from development in the nine-county region compared to the Trend scenario. This is an area larger than all of Camden County. The Sprawl scenario assumes a considerable increase in land consumption, consuming an additional 309,000 acres by 2035. This scenario would lead to the paving over of nearly one-fifth of the region's total land area with new development, or an area roughly the size of Montgomery County (see Figure 8).

FIGURE 8. NEW ACRES DEVELOPED FROM 2005 TO 2035



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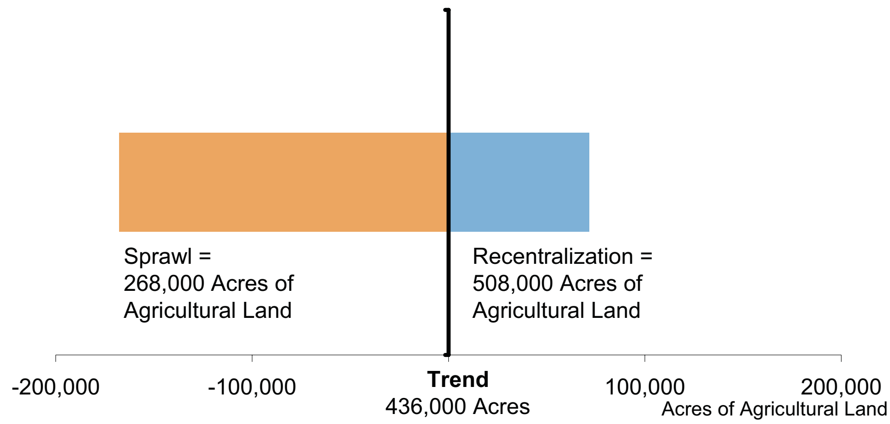
The Recentralization scenario reduces the average regional residential lot size by 25 percent compared to the Trend scenario. In 2005, the regional average is 0.31 residential acres per household. A 2035 residential lot size of 0.28 acres per housing unit requires only a 12.5 percent increase from current average density, which is an achievable increase.

The land designated for new footprint development in each scenario is open space today, much of it in the form of farmlands and forests. Forests are critical in reducing greenhouse gas emissions, as they are carbon sinks. Trees remove CO_2 and other pollutants from the atmosphere and store it. They also help to cool the air, reduce erosion, and provide aesthetic beauty. Cutting down forests not only takes away carbon sinks, but likely replaces the land with a use that emits carbon, doubly expanding the region's carbon footprint. Open space contains wetlands, which absorb and filter storm water runoff, mitigate flooding, and recharge groundwater aquifers. Maintaining open space benefits both air and water quality, which limits economic and ecological risks to the region such as flooding, impacts to human health, and loss of biodiversity. It also provides wildlife habitat and opportunities for recreation.

Figure 9 indicates the acres of existing agricultural land remaining undeveloped in each scenario. This assumes that no land is shifted from another use to an agricultural one. The Recentralization scenario projects 508,000 acres of agricultural land, the Trend scenario 436,000, and the Sprawl scenario 268,000.

FIGURE 9. ACRES OF AGRICULTURAL LAND IN 2035



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In the future, maintaining the availability of land for agriculture will enable the region to produce more food locally. This will capture more of the region's household and institutional local share spending on food and curb CO_2 emissions generated by shipping it long distances. Saving farmland can allow rural and suburban communities to concentrate on agricultural economic development. It can also improve their fiscal health, as the revenue-to-expenditure ratio for both farmland and open space is comparable to commercial and industrial uses.[2]

Transit Score

DVRPC's Transit Score Tool provides a quick and easy way to test the transit appropriateness of a community or area by its residential, employment, and zero-car household densities. The resulting numerical score is categorized into low, marginal, medium, medium-high, and high levels of transit supportiveness. The top two levels, high and medium-high, are generally of the most interest because they indicate rail appropriateness. Table 4 indicates the count of high and medium-high transit scores for each scenario. Figure 10 maps these transit scores by TAZ for the region by scenario.[3]

[2] American Farmland Trust 2007.
[3] More information on computing Transit Score can be found in Appendix D.

FIGURE 10. TRANSIT SCORE IN 2035

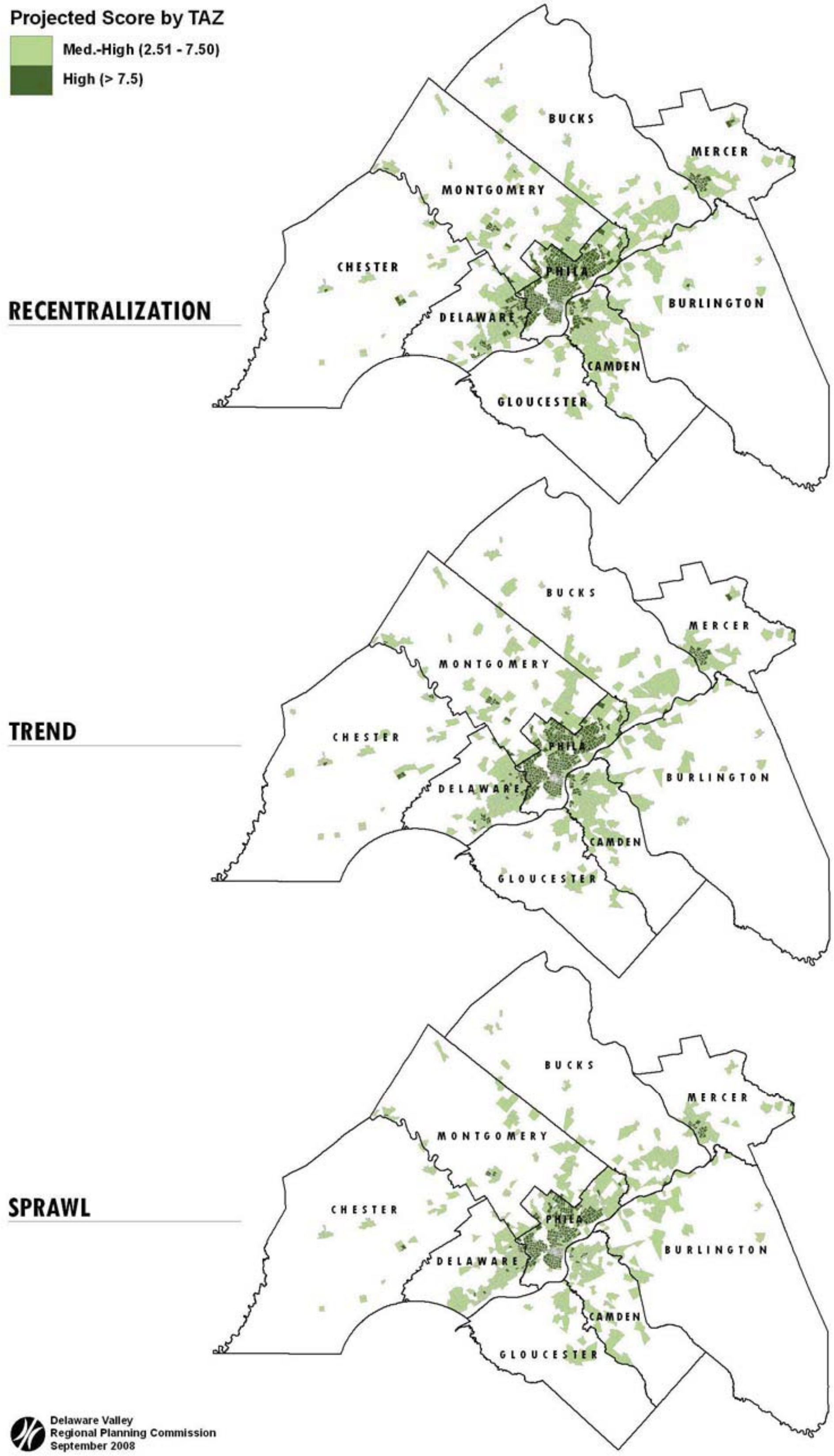

TABLE 4. COUNT OF HIGH AND MEDIUM-HIGH TRANSIT SCORE TAZS BY SCENARIO

Count	Recentralization	Trend	Sprawl
Count of Medium-High TAZs	517	542	561
Count of High TAZs	527	485	370
Total High + Medium-High TAZs	1,044	1,027	931
High + Medium High TAZ Residents (millions)	3.8	3.4	2.4
High + Medium High TAZ Jobs (millions)	1.7	1.6	1.1

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The Recentralization scenario increases the number of transit-supportive areas in the region, while the Sprawl scenario decreases them. More transit-supportive area increases the possibility of expanding the region's transit infrastructure.

Transit Access

Transit access in the scenarios is defined by TAZs. Each TAZ with a rail station or bus route with three or more peak hourly service runs is defined as an area with transit access. All households and jobs located in these TAZs are considered transit accessible.[4]

Table 5 indicates the change in the number of households with access to existing transit services. A negative number (in parenthesis) implies a decline in the number of households or jobs, while a positive value implies an increase. The Recentralization scenario locates many more new households and jobs in core cities and developed communities where there is transit access already. The Sprawl scenario would result in significant growth in the number of households and jobs without easy transit access. This is because it moves existing households and jobs out of core cities and developed communities and locates them along with population and employment growth in the growing suburbs and rural areas. Farther out suburban and rural communities tend not to have existing transit service, and lack the requisite density needed to support it in the future.

TABLE 5. CHANGE IN THE NUMBER OF HOUSEHOLDS AND JOBS WITH TRANSIT ACCESS FROM 2005 TO 2035

Indicator	Recentralization	Trend	Sprawl
Change in the Number of Households with Transit Access	190,000	92,000	(159,000)
Change in the Number of Jobs with Transit Access	257,000	192,000	(83,000)

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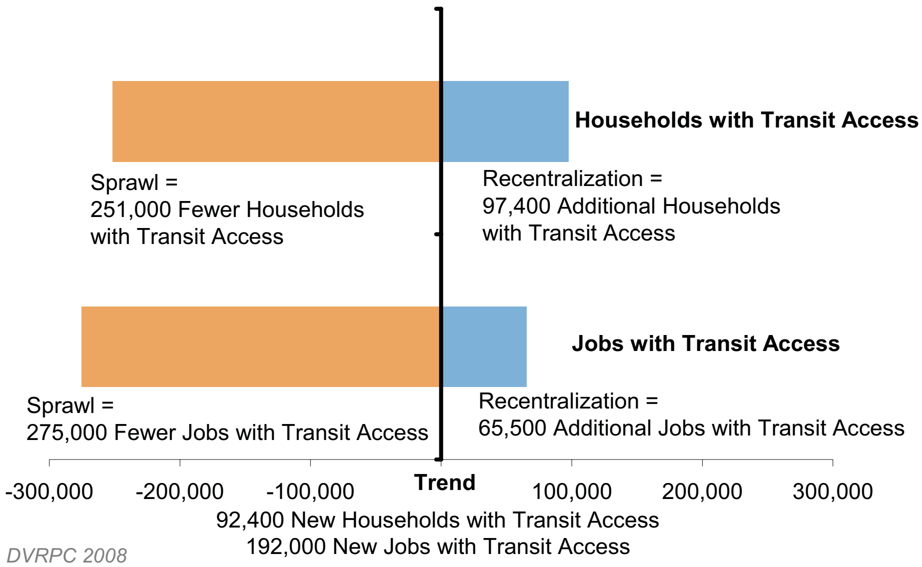
[4] More information on computing transit access can be found in Appendix D.

Compared to the Trend scenario, the Recentralization scenario adds more than 98,000 new households and 65,000 new jobs in areas with transit access. In the Sprawl scenario, over 250,000 new households and 275,000 new jobs will not be located near transit (see Figure 11).

FIGURE 11. DIFFERENCE IN NUMBER OF HOUSEHOLDS AND JOBS WITH TRANSIT ACCESS BY SCENARIO FROM 2005 TO 2035



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By increasing the number of households and jobs with access to transit, residents will have improved mobility options and not be restricted to private vehicles as the only means of transportation. Transit is particularly critical for providing transportation to work for zero-car and low-income households, and especially for lower-wage service-sector jobs. For these reasons transit is a key component of meeting Environmental Justice goals. Transit access is also valuable for lowering driving rates, which would decrease greenhouse gas emissions and reduce oil dependence. The Recentralization scenario preserves land through increased density and has more housing units near transit. This combination can reduce driving demand by shortening trip lengths and increasing transportation options.

Transportation

The DVRPC Travel Demand Model (TDM) simulates future travel conditions for each of the three scenarios based on their population, employment, vehicle ownership levels, and other factors. The sum of all regional travel demand is based on these factors aggregated for nearly 2,000 Traffic Analysis Zones (TAZs). These are roughly equivalent to U.S. Census tracts, with some TAZs further disaggregated into block groups. Table 6 presents the annual roadway conditions for each scenario in 2035 as determined by the TDM.

TABLE 6. ANNUAL ROADWAY CONDITIONS IN 2035

Indicator	Recentralization	Trend	Sprawl
Annual Vehicle Miles Traveled (billions)	47.0	48.7	50.0
Annual Vehicle Hours Traveled (billions)	1.53	1.59	1.64
Annual VMT per capita	7,647	7,915	8,123
Annual VHT per capita	248	258	266
Annual Vehicle Trips (billions)	7.86	8.06	8.41
Freight VMT (billions)	4.19	4.24	4.34

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The TDM projects higher VMT in the Sprawl scenario than in the Recentralization scenario. This is expected since residences, employment, and commercial uses are more spread out in the Sprawl scenario. This scenario leads to more vehicle trips as transit, walking, and biking tend to be less accessible. Many vehicle trips are longer as well due to the greater distances between origins and destinations. The Recentralization scenario saves the average resident in the region the equivalent of 1.25 working days in less driving time per year. The Sprawl scenario adds the driving equivalent of one extra working day per year. The differences are apparent in freight vehicle VMT as well.

Table 7 presents a similar set of figures as Table 6, but for an average day. Roadway speeds by functional class are also included in this table. Average speeds for all functional classes were calculated at roughly the same level in all scenarios, at just under 31 miles per hour. A lack of variation in speed is expected since this is an average of over 129 to 137 million daily VMT. The Recentralization scenario has slightly faster speeds for all functional classes. The Recentralization scenario also increases alternative transportation options, lowers total daily vehicle trips, and lowers daily VMT per capita, saving 0.7 miles per day compared to the Trend scenario and 1.3 miles per day compared to the Sprawl scenario.

TABLE 7. DAILY ROADWAY CONDITIONS IN 2035

Indicator	Recentralization	Trend	Sprawl
Daily VMT (millions)	128.8	133.4	136.9
Daily VHT (millions)	4.20	4.34	4.46
Daily VMT per Capita	21.0	21.7	22.3
Daily VHT per Capita	0.68	0.71	0.72
Average Daily Speed (mph)	30.8	30.7	30.5
Daily Vehicle Trips (millions)	20.8	21.4	22.7
Daily Freeway VMT (millions)	36.9	37.7	36.8
Average Daily Freeway Speed (mph)	54.3	54.2	53.9
Daily Arterial VMT (millions)	62.1	64.2	66.1
Average Daily Arterial Speed (mph)	27.6	27.7	27.4
Daily Local Road VMT (millions)	26.6	28.2	30.7
Average Daily Local Speed (mph)	22.5	22.6	22.4

DVRPC 2008

Table 8 presents average peak period roadway conditions. The peak period is 7 A.M. to 9 A.M. and 4 P.M. to 7 P.M. during the work week. Peak period roadway speeds are highest in the Recentralization scenario, likely as a result of the alternative transportation options available.

TABLE 8. PEAK ROADWAY CONDITIONS IN 2035

Indicator	Recentralization	Trend	Sprawl
Daily Peak VMT (millions)	48.3	52.0	55.0
Daily Peak Vehicle Trips (millions)	8.2	8.3	9.0
Average Peak Speed (mph)	30.2	29.7	28.6
Daily Peak Freeway VMT (millions)	14.2	15.0	14.9
Daily Peak Freeway Speed (mph)	53.3	52.4	50.8
Daily Peak Arterial VMT (millions)	22.6	24.4	26.1
Average Peak Arterial Speed (mph)	27.0	26.6	26.0
Daily Peak Local Road VMT (millions)	10.4	11.4	12.8
Average Peak Local Speed (mph)	22.2	22.0	21.7

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The differences in daily VMT between scenarios is most pronounced during the peak period. Daily off-peak VMT ranges from 80.5 million miles in the Recentralization scenario to 81.3 million miles in the Trend scenario to 81.8 million miles in the Sprawl scenario. Comparatively, daily peak period VMT is 6.7 million higher in the Sprawl scenario than in the Recentralization scenario.

FIGURE 12. DAILY VEHICLE MILES TRAVELED IN 2035 BY COUNTY PLANNING AREA

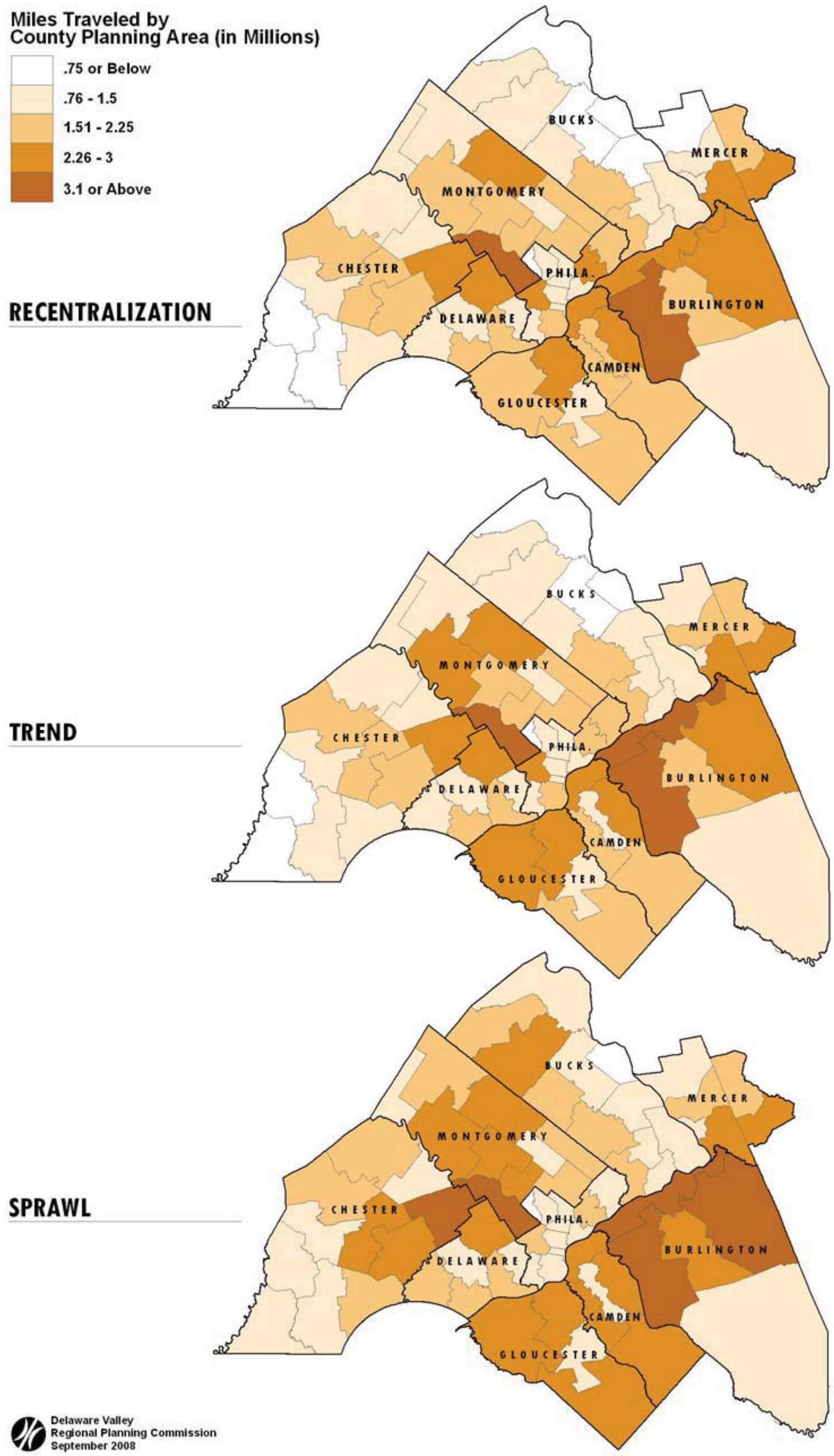

Figure 12 presents daily VMT for each scenario by county planning area, which consists of several municipalities grouped together. Compared to the Trend scenario, a greater percentage of the region's VMT occurs in the developed communities around the core cities in the Recentralization scenario. In the Sprawl scenario, more VMT occurs in the growing suburbs and rural areas, with less VMT in the core cities compared to the Trend scenario.

Figure 13 (for the year 2035) and Figure 14 (cumulative for years 2010 to 2035) highlight the difference in VMT between the scenarios. The Recentralization scenario could reduce annual VMT by 1.7 billion compared to the Trend scenario in 2035 and by 39 billion over the 25-year span of the *Connections* plan. The Sprawl scenario would mean an additional 1.3 million VMT in the year 2035 and an extra 28 billion miles over the life of the plan. Assuming the region's current average fuel efficiency of 17.7 miles per gallon, the Recentralization scenario could reduce regional CO_2 emissions by more than 21.4 million tons of over the life of the plan, just from driving less.

FIGURE 13. DIFFERENCE IN VMT BETWEEN SCENARIOS IN 2035

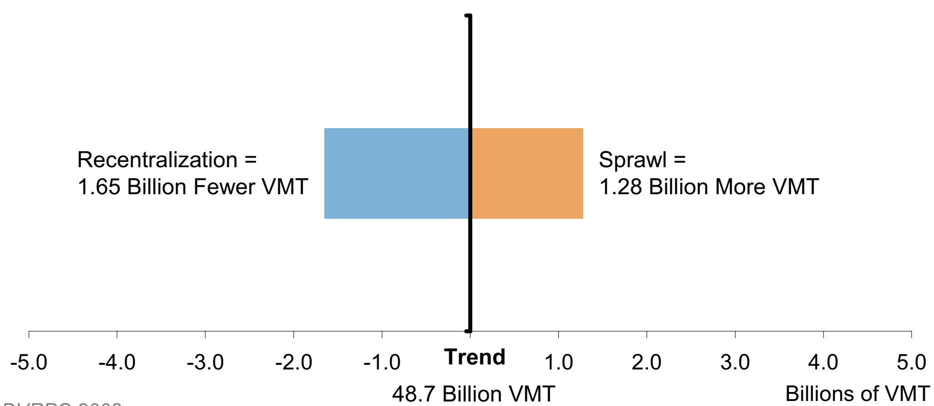

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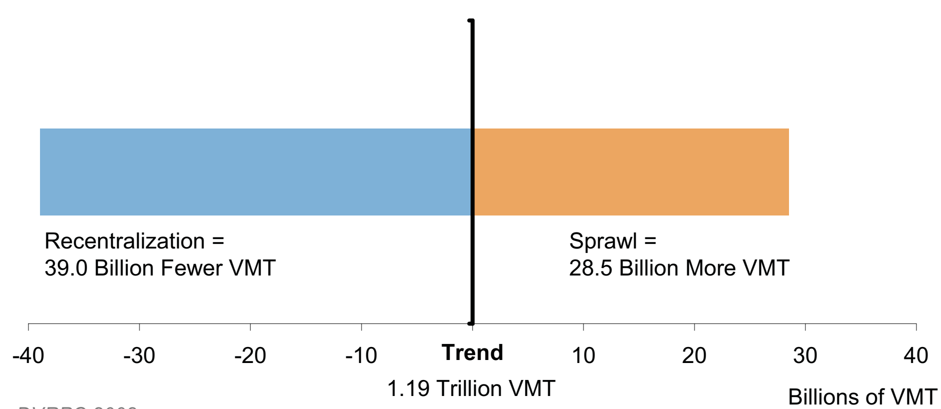
FIGURE 14. CUMULATIVE VMT DIFFERENCE FROM 2010 TO 2035



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Alternative VMT Estimate

A second model was used to estimate VMT for the region based on the International Council on Local Environmental Issues' (ICLEI) density-VMT calculator.[5] This sketch model estimates VMT based on per acre residential density. Table 9 presents the results for each scenario using this model as the sum of each municipality's average household residential density-VMT estimate multiplied by the number of households.

TABLE 9. ALTERNATE VMT ESTIMATES USING ICLEI HOUSEHOLD DENSITY MODEL

Indicator	Recentralization	Trend	Sprawl
Annual VMT (billions)	45.9	48.8	55.1
Annual VMT per Capita	7,460	7,930	8,960
Daily VMT (millions)	126	134	151
Daily VMT per Capita	20.4	22.0	24.5

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The ICLEI model projects 45.9 billion miles of VMT in the region for 2035 in the Recentralization scenario, approximately 1.1 billion VMT less than the DVRPC TDM. In the Trend scenario, ICLEI forecasts 75 million VMT, or 0.2 percent, more than the TDM. In the Sprawl scenario, the calculator estimates that there will be an additional 5 billion VMT over the DVRPC TDM estimate.

The ICLEI density-VMT calculator is a simple, single variable model. It is not constrained by congestion, nor does it consider transit access or any number of other variables that the DVRPC TDM contains. Rather it can be viewed as a proxy of household travel demand. Seen in this light, these findings suggest that lower congestion levels in the Recentralization scenario may indicate excess capacity in the transportation network. Since congestion tends to self regulate, this excess capacity may be manifested through extra driving that may otherwise be unnecessary.[6] In the Sprawl scenario, extreme congestion leads to a reduction in driving, where trips are put off, combined, or otherwise shortened in order to avoid additional traffic time costs.[7] The result may indicate a latent demand for driving in this scenario, kept somewhat in check by a lack of roadway capacity.

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[5] The ICLEI Density-VMT calculator can be downloaded from: http://www.iclei-usa.org/library/documents/8-Density-VMT%20Calculator%20%282%29.xls.

[6] VTPI 2006.

[7] IBID.

Congestion

Figure 15 shows peak-hour roadway congestion for each scenario. For this report, congestion is defined by a generalized Level of Service (LOS) rating of 'E' where the volume to capacity ratio (V/C ratio) is greater than or equal to 0.85. LOS is a rating used by transportation engineers to quantify a roadway's performance, or ability to handle its traffic volume. LOS designations range from the best, 'A,' representing the most ideal, free flowing conditions, to the worst, 'F.' At LOS 'F' traffic operates under breakdown conditions, where demand exceeds capacity. At LOS 'E' capacity is reached at its lower boundary, and traffic operations are volatile, as passing is virtually impossible and speed becomes greatly reduced. The roads shown in red in the congestion maps will likely experience congested conditions of LOS 'E' or 'F' in the peak period. Congestion is shown for individual road facilities for all functional classes. In addition, Figure 15 has clouds of congestion (shaded in light orange), where the average for all the local roads and arterials in a two-kilometer-by-two-kilometers grid is determined to have a V/C ratio greater than or equal to 0.85.

Comparing the Sprawl and Recentralization congestion scenarios in Figure 15 finds congestion occurring frequently in both scenarios. However, the centralized, compact nature of congestion in the Recentralization scenario suggests that it can be more easily mitigated by enhancing transit services. Transit is most efficient in dense, compact communities. It is less efficient in the low-density areas that occur more frequently in the Sprawl scenario. The spread out nature of the Sprawl scenario likely means more roadway capacity will be necessary to reduce congestion.

A person hour of delay is a measure of how much time is lost by commuters due to peak period congestion on the roadways. Congested conditions cause vehicles to move slower than they would in free-flow speed, causing trips to take more time to complete. Not only is this a problem for the drivers who lose time stuck in traffic, the slower speeds and stop-and-go driving conditions mean more air pollution and wasted fuel. Table 10 summarizes vehicle and person hours of delay, wasted fuel, and congestion costs by scenario.[8]

[8] More information on computing congestion indicators can be found in Appendix D.

FIGURE 15. PEAK-HOUR CONGESTION IN 2035

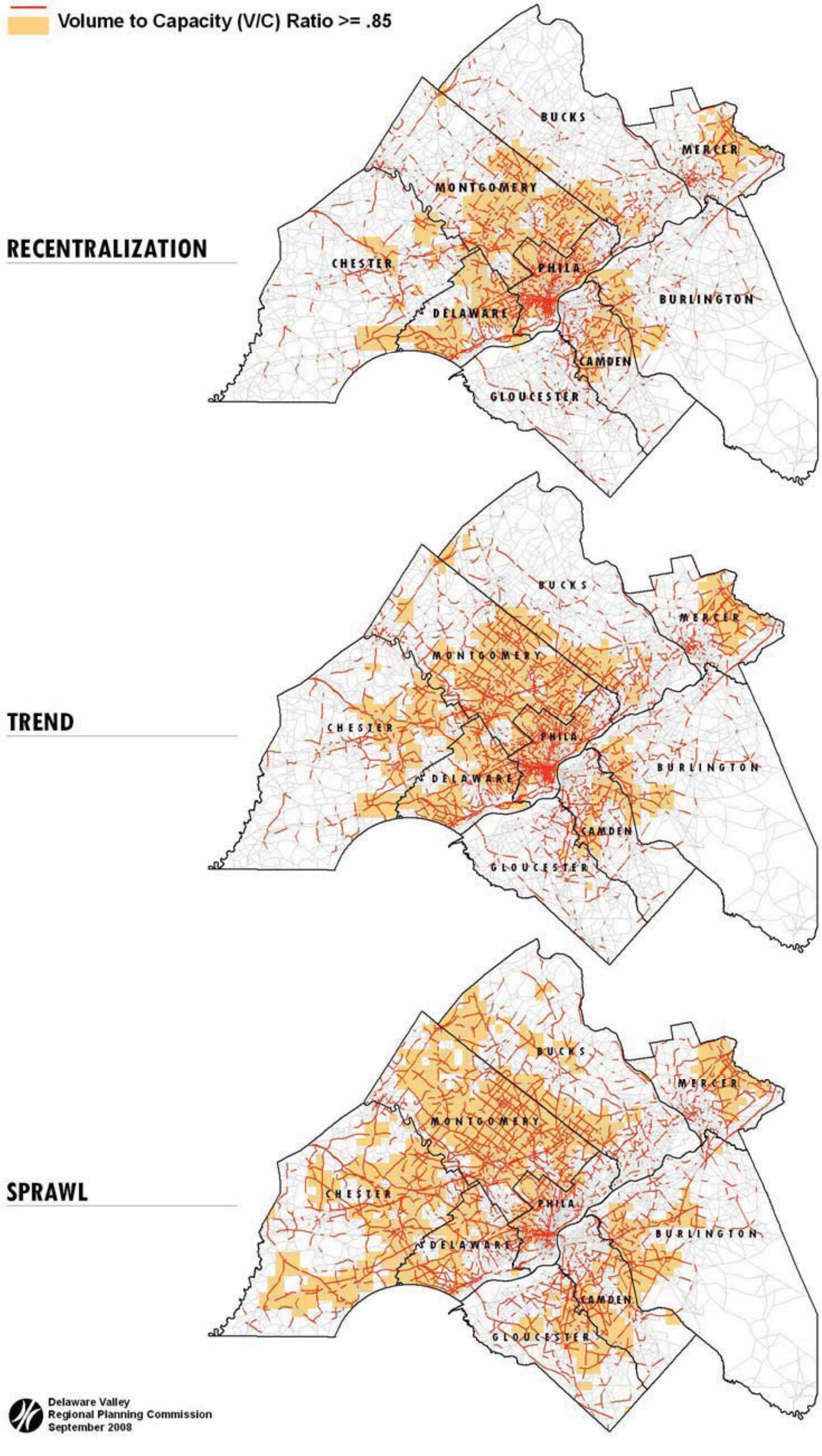


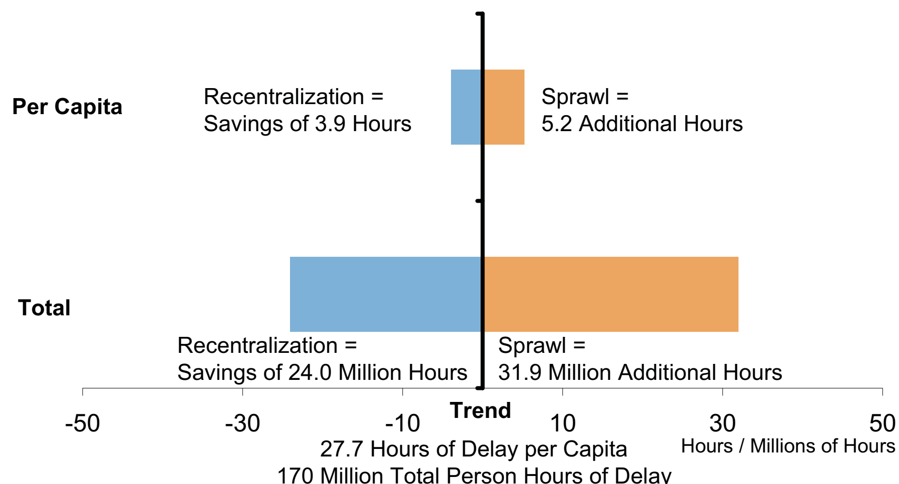
TABLE 10. VEHICLE HOURS OF DELAY IN 2035

Indicator	Recentralization	Trend	Sprawl
Annual Vehicle Hours of Delay (millions)	124.0	144.4	171.4
Annual Wasted Time (millions of person hours)	146.3	170.3	202.3
Annual Person Hours of Delay per Capita	23.8	27.7	32.9
Annual Wasted Fuel (millions of gallons)	21.3	27.1	35.5
Annual Congestion Cost (billions of 2008 $s)	$ 3.12	$ 3.64	$ 4.33
Annual Congestion Cost per Household (2008 $s)	$ 1,338	$ 1,560	$ 1,857

DVRPC 2008

The Recentralization scenario reduces annual person hours of delay in 2035 by more than 24 million hours for the region, or about 4 hours less per capita, compared to the Trend scenario. The Sprawl scenario adds nearly 32 million person hours of delay in 2035, or more than 5 hours per capita, over the Trend scenario (see Figure 16).

FIGURE 16. DIFFERENCE IN 2035 PERSON HOURS OF DELAY BY SCENARIO



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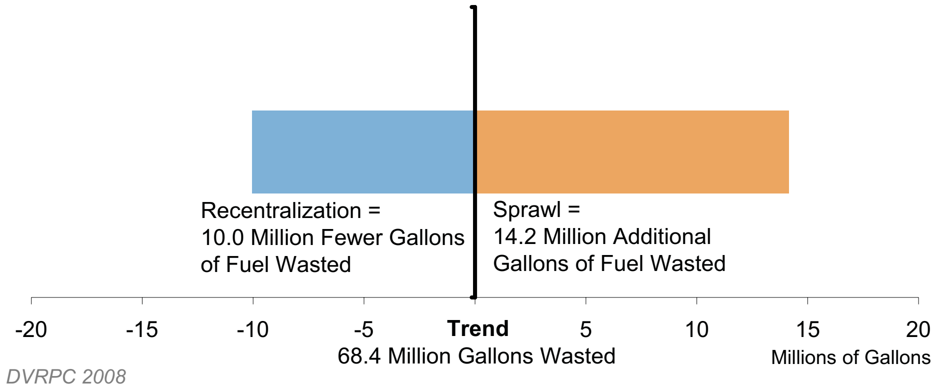
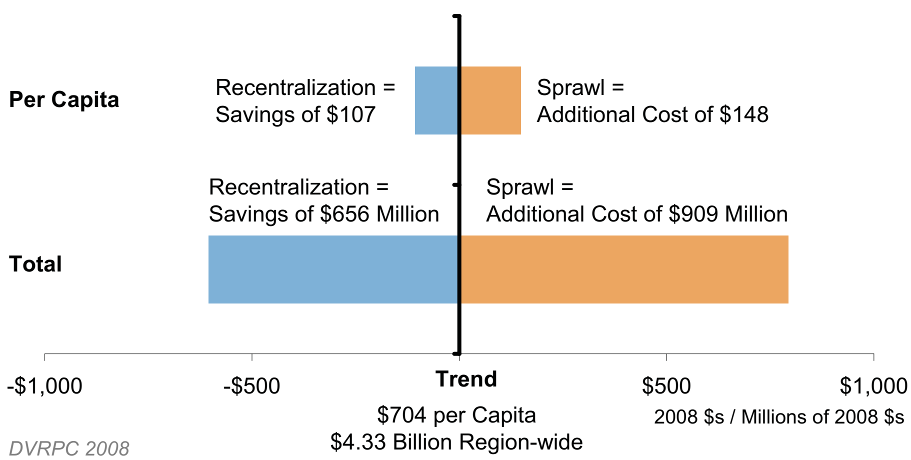
With less time wasted in congested conditions, the Recentralization scenario could save 10 million gallons of fuel in 2035 compared to the Trend scenario. The Sprawl scenario would waste an additional 14 million gallons (see Figure 17). Fuel wasted in congestion costs drivers time and money, contributes to global climate change, and worsens air quality through additional, unnecessary emissions.

FIGURE 17. DIFFERENCE IN GALLONS OF WASTED FUEL BY SCENARIO IN 2035



Wasted time and fuel have societal costs. Individual time is valuable, and excess fuel burned means more pollution. Figure 18 summarizes the annual 'hidden' cost of congestion in dollar terms for personal and commercial time lost and excess fuel burned. The Recentralization scenario can save the region $656 million in congestion costs in 2035, or $107 per capita, compared to the Trend scenario. The Sprawl scenario would cost the region an additional $909 million in 2035, which is an additional expense of $148 per capita, compared to the Trend scenario. Freight shipping is directly impacted, as extra shipping time means additional labor and fuel costs. These costs do not reflect the additional climate costs due to additional CO_2 and other greenhouse gas emissions. They use very conservative estimates for fuel cost, starting at $2.90 per gallon in 2008 and increasing only three percent annually after that.[9]

FIGURE 18. DIFFERENCE IN CONGESTION COST BY SCENARIO IN 2035



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[9] AAA 2008.

Reducing congestion improves the reliability of freight shipments. This is a key element of the global economy, and the logistics supply chain. More reliable shipments benefits area businesses and residents through lower costs, and enhances the region's economic competitiveness.

Vehicle Crashes

Table 11 presents estimates for annual vehicular crashes based on current crash rates per million vehicle miles traveled by functional class.[10]

TABLE 11. VEHICLE CRASHES IN 2035

Indicator	Recentralization	Trend	Sprawl
Annual Crashes*	62,400	64,600	66,600

* Annual crash estimates for DVRPC roadway network only, and do not include estimates for crashes occurring off-network.

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With less VMT in the Recentralization scenario, fewer crashes are expected. More driving in the Sprawl scenario will more than likely lead to more crashes. The Sprawl scenario would likely mean an average of 11 crashes more per day than recentralization. This increases the likelihood for injuries and fatalities resulting from crashes. It also leads to additional costs due to loss of life, injury, and property damage.

Transit Ridership

Table 12 presents the TDM estimated transit ridership for 2035 under each scenario.

TABLE 12. TRANSIT RIDERSHIP IN 2035

Indicator	Recentralization	Trend	Sprawl
Annual Transit Boardings (millions of unlinked trips)	418.7	367.9	256.7
Daily Transit Trips (linked trips)	850,000	747,000	521,000
Annual Transit Passenger Miles (billions)	1.83	1.62	1.20
Annual Transit Passenger Hours (millions)	100.7	88.6	63.8
Average Transit Speed (mph)	18.2	18.3	18.8
Average Transit Trip Length (miles)	5.9	6.0	6.3

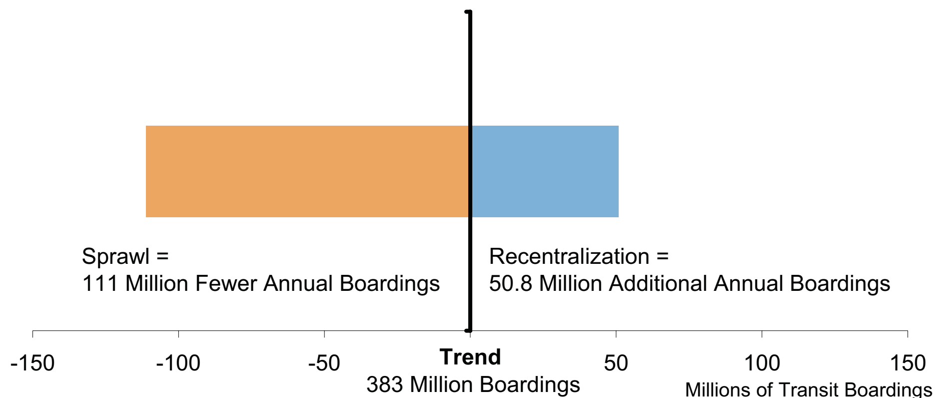
DVRPC 2008

The Trend scenario represents a slight, half-percent drop from 2005 transit ridership. The Recentralization scenario forecasts a 13 percent increase in

[10] More information on estimating vehicle crashes can be found in Appendix D.

ridership from current levels. The Sprawl scenario forecasts a 30 percent drop in ridership from 2005 (see Figure 19). The Commonwealth of Pennsylvania allocates public transportation funding on the basis of transit service ridership. Increases in ridership will likely lead to more funding, while decreases will probably mean less. Both cases lead to a cycle in which either more funding can yield service improvements, generating additional ridership, or less funding, leading to service cuts, which are likely to further reduce ridership. Transit provides key services for segments of the region's population. It is a means to work for low-income workers and provides transportation to zero-car households. Increased transit use, coupled with reduced driving, reduces the region's energy demand and CO_2 emissions and helps the region fulfill its Environmental Justice goals.

FIGURE 19. DIFFERENCE IN TRANSIT RIDERSHIP BETWEEN SCENARIOS IN 2035



DVRPC 2008

Alternative Transportation

Table 13 presents biking and walking trips in each scenario as estimated by the bike-walk component of the TDM.

TABLE 13. ALTERNATIVE TRANSPORTATION TRIPS IN 2035

Indicator	Recentralization	Trend	Sprawl
Daily Pedestrian Trips (millions)	1.62	1.52	1.27
Daily Bicycle Trips	156,000	149,000	134,000

DVRPC 2008

As with transit ridership, the Recentralization scenario's more compact urban form increases biking and walking (see Figures 20 and 21). This scenario forecasts more than 2.4 million additional annual biking trips and 36 million additional annual walking trips over the trend scenario. The Sprawl scenario anticipates nearly 5.4 million fewer biking trips and 89 million fewer annual walking trips compared to the trend scenario.

The additional walking and biking trips in the Recentralization scenario would otherwise be completed using a motorized form of transportation, or foregone altogether. The opposite is true in the Sprawl scenario, where more trips are taken by motorized transport, and these trips are far more likely to use an automobile. Reductions in motorized trips also mean lower emission levels and energy consumption. Walking and biking on a regular basis can incur health and physical fitness benefits, as well as reduce obesity, heart disease, diabetes, and other diseases.[11]

FIGURE 20. DIFFERENCE IN PEDESTRIAN TRIPS BY SCENARIO IN 2035

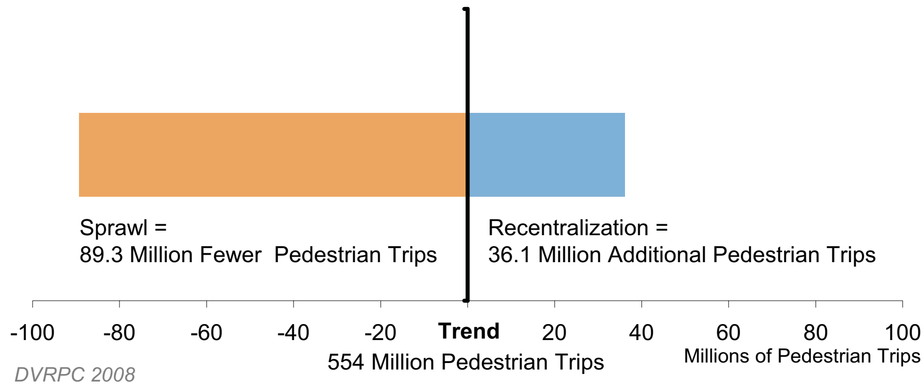


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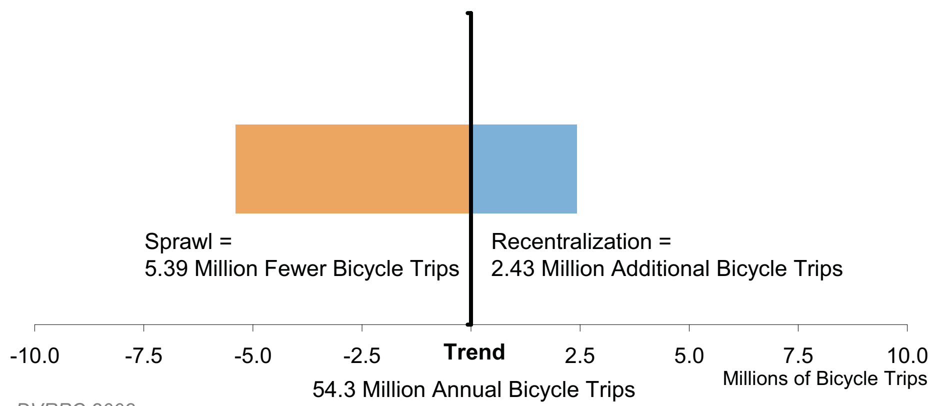
FIGURE 21. DIFFERENCE IN BICYCLE TRIPS BY SCENARIO IN 2035



DVRPC 2008

Figure 22 summarizes daily trip modeshare by scenario. While the differences may seem minor in percentage terms, the absolute differences are significant when considering approximately 24 million total daily trips. Each tenth of a percent represents approximately 24,000 trips. Table 14 presents the total number of trips by mode. Daily auto person trips is the sum of all drivers and passengers who travel by automobile in the region. The

[11] Dr. Ted Emmett, e-mail dated 8/25/08.

average vehicle occupancy for these trips is 1.35 passengers, including the driver. Table 8 splits auto person trips into auto driver trips, which also represent the total number of vehicle trips, and auto passenger trips which represent the nondriving riders in each vehicle trip.

FIGURE 22. 2035 DAILY PERSON TRIP MODESHARE

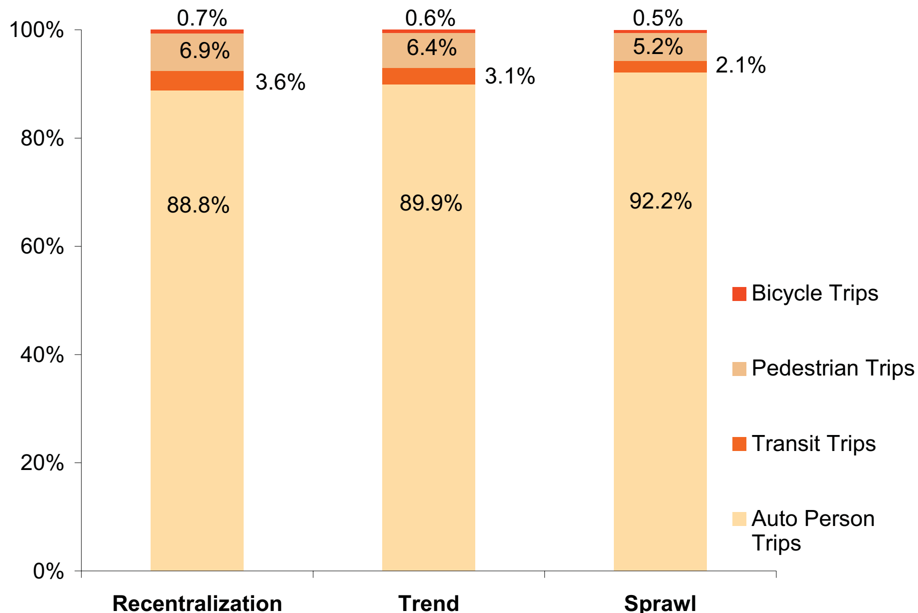


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TABLE 14. 2035 DAILY PERSON TRIPS BY MODE

Type of Trip	Recentralization	Trend	Sprawl
Daily Auto Driver Trips (millions)	15.3	15.7	16.7
Daily Auto Passenger Trips (millions)	5.51	5.66	6.01
Daily Auto Person Trips	20.8	21.4	22.7
Daily Transit Trips (millions)	0.85	0.75	0.52
Daily Pedestrian Trips (millions)	1.62	1.52	1.27
Daily Bicycle Trips (millions)	0.16	0.15	0.13
Total Regional Trips (millions)	23.4	23.8	24.6

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The Environment

Decentralized development patterns reduce open space and increase travel distance between locations. More driving means more emissions, which pollutes the air we breathe and contributes to the region's nonattainment of air-quality standards for ground-level ozone and fine particulate matter. This impacts health for children, the elderly, outdoor workers, and all at-risk groups for heart and lung disease. On extremely poor air-quality days, generally in the summer, everyone's health is at risk. Loss of open space means that there are less carbon sinks to absorb pollution. Meanwhile, our ecosystems are imperiled by massive challenges related to global climate change and peak oil. Combating these twin global crises will require cooperation on the local, regional, national, and international levels. Solutions need to decrease energy use, find alternative sources (not part of this study), and drastically reduce CO_2 emissions.

Emissions Estimates

Table 15 presents the daily transportation emissions from automobiles, light- and heavy-duty trucks, and transit vehicles in each scenario as estimated by the Mobile 6 emissions model developed by the Environmental Protection Agency (EPA), which functions by using output from the TDM.

TABLE 15. DAILY TRANSPORTATION EMISSIONS BY SCENARIO IN 2035

Indicator	Recentralization	Trend	Sprawl
NO_x (tons/day)	21.1	21.8	22.2
VOC (tons/day)	29.6	30.7	31.5
$PM_{2.5}$ (tons/day)	1.7	1.8	1.8

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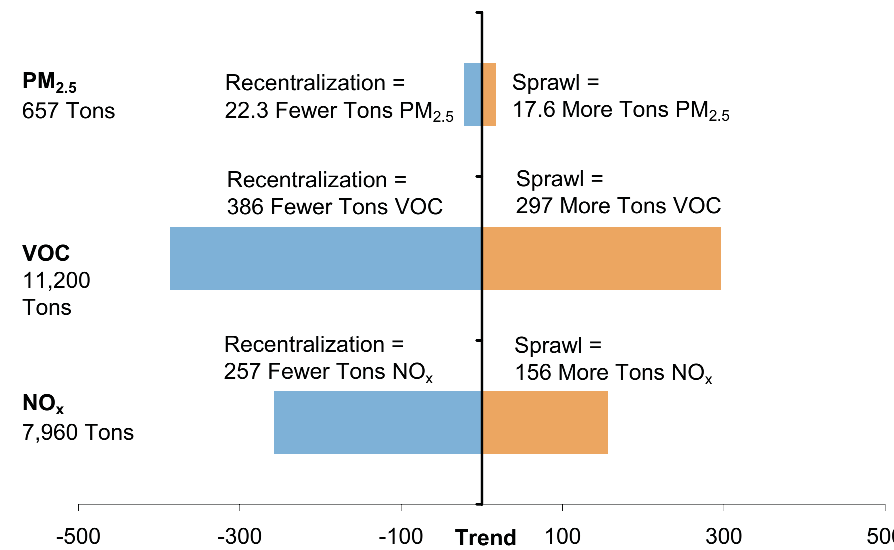
Ground level ozone (O_3), also known as smog, is formed when oxides of nitrogen (NO_x) and volatile organic compounds (VOCs) combine and bake in the sun. Ozone is a strong oxidizer and has similar impacts to lung tissue as sunburn does to skin. Short-term exposure to elevated levels of ground-level ozone can irritate lung passages and cause inflammation. Exposure to elevated levels of ozone can cause coughing, wheezing, chest pains, and headaches. Ozone can aggravate chronic respiratory diseases, such as asthma and bronchitis, and lead to increased emergency room visits and hospital admissions. Exposure to long-term, low levels of ozone may cause asthma in children and can permanently damage lungs.

Fine particulate matter ($PM_{2.5}$) is composed of small particles of dust, metals, toxins, and liquids. When breathed deep into the lungs, it can cause wheezing, coughing, difficulty breathing, or aggravate asthma or bronchitis. Fine particle pollution also poses a health risk for individuals with heart conditions. The smallest particles may actually enter the blood stream, changing blood chemistry. This can make the heart work harder to get oxygen to the body. Long-term exposure to particle pollution has been linked to decreased lung function and even shortened life expectancy. Increased fine particle pollution emissions into the atmosphere raise the likelihood that at-risk groups will develop problems or have them worsened.[12]

Figure 23 presents the estimated vehicular $PM_{2.5}$, VOC, and NO_x emissions in 2035 by scenario. The Recentralization scenario could lead to a reduction of 22 tons of $PM_{2.5}$ particles, over 400 less tons of VOCs, and 256 fewer tons of NO_x in 2035. Alternatively, the Sprawl scenario requires more driving, which could mean an extra 18 tons of $PM_{2.5}$, 292 additional tons of VOCs, and 146 more tons of NO_x released into the atmosphere in 2035, compared to the Trend scenario.

FIGURE 23. DIFFERENCE IN VEHICLE EMISSIONS BY SCENARIO IN 2035



DVRPC 2008

Poor air quality worsens conditions for those who suffer from asthma, bronchitis, heart disease, and other respiratory illnesses. Higher emission rates increase the number of pollutants in the atmosphere, which results in poorer air quality. In addition to harming human health, pollutants damage

[12] More information on air quality and health impacts in the DVRPC region is available at the Air Quality Partnership website: www.airqualitypartnership.org.

crops, and lower water quality. Emissions are highest in the Sprawl scenario and are lowest in the Recentralization scenario.

Energy Use and Peak Oil

Table 16 presents average household energy consumption by all sources and average annual household auto fuel use, by scenario. Auto fuel use is determined by dividing all nonfreight VMT by the average fuel efficiency for the region's personal vehicle fleet. Fuel average for the vehicle fleet is estimated by Mobile 6. The model presumes an improvement in vehicle fuel efficiency on an annual basis up until 2015, and it assumes no additional improvement in the regional vehicle fleet's fuel efficiency after 2015. Since the scenarios contain basically the same set up assumptions, except for residential and employment locations, this will not significantly impact the ability to compare them. It will, however, yield fuel consumption levels larger than are likely to occur in actual future conditions. For ease of comparison, all fuel types have been converted to British Thermal Units (Btu's).[13]

TABLE 16. 2035 AVERAGE HOUSEHOLD RESIDENTIAL ENERGY USE AND AUTOMOTIVE FUEL CONSUMPTION BY SCENARIO (IN MILLIONS OF BTU'S)*

Indicator	Recentralization	Trend	Sprawl
Average Annual Household Auto Fuel Use	141.3	146.3	150.3
Average Annual Household Energy Use	109.7	110.5	112.9
Average Annual Energy Use Per Household	251.0	256.8	263.2

* These are preliminary estimates developed using national figures only for the purpose of this scenario exercise. DVRPC is currently working with a consultant to carefully determine all energy consumption in the region. Once complete, those findings will supercede this estimate.

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The lowest overall rate of average household energy use is in the Recentralization scenario. The average household in this scenario requires 2.3 percent less energy than an average household in the Trend scenario. Conversely, the average household in the Sprawl scenario will need 2.5 percent more energy per household compared to the Trend scenario. While seemingly insignificant per household, this is a major difference when considering the region is projected to have more than 2.3 million households in 2035. Energy conservation is one of the best ways that the region can prepare for increasingly volatile energy prices due largely to peak oil.

Peak oil is expected to occur when worldwide demand for oil exceeds the ability to produce more oil, resulting in annual decreases in supply. Global demand for oil is growing from developing economies, such as China and

[13] Appendix D contains information on computing energy use by scenario, and conversion factors from various fuel types to Btu's.

India. Recent increases in oil prices suggest that the world may already be reaching a supply deficit. The global, national, and regional economy is highly energy dependent and assumes that energy will continue to be affordable and accessible.[14] However, it is likely that neither of these conditions will continue, even in the near future.[15] Meeting energy needs under the volatile pricing conditions of peak oil is critical to the region's future economic development. The Post Carbon Institute and others suggest that localities and regions that are most able to meet their own energy needs will have a competitive advantage in the future over those that cannot.

Carbon Dioxide and Climate Change

Transportation currently is the source of nearly one-third of all CO_2 emissions.[16] Personal vehicles are responsible for 60 percent of these emissions.[17] Residential energy use currently accounts for 20 percent of all CO_2 emissions.[18] Residential and auto energy use jointly account for just over half of all CO_2 emissions. Energy needs for these two sources are used to estimate regional CO_2 emissions for each scenario, presented in Table 17.[19] DVRPC is currently undertaking a detailed regional greenhouse gas inventory, which will update these figures.

TABLE 17. 2035 CO_2 EMISSIONS BY SCENARIO

Indicator	Recentralization	Trend	Sprawl
Total Annual Vehicle CO_2 Emissions (millions of tons)	25.8	26.7	27.4
Total Annual Residential Energy CO_2 Emissions (millions of tons) [a]	24.1	24.3	25.1
Total Annual Residential Energy and Transportation CO_2 Emissions (millions of tons)	49.8	51.0	52.5
Total Annual Residential Energy and Transportation CO_2 Emissions per Capita (tons)	8.1	8.3	8.5
Difference in CO_2 Emissions From Recentralization Scenario (millions of tons)	-	(1.2)	(2.7)
CO_2 Equivalent Additional Energy Use in Millions of Barrels of Oil [b]	-	2.48	5.62
Millions of Trees Needed to Offset Additional CO_2 in Scenario [b]	-	27.3	62.0

[a] Annual household CO_2 emissions for electricity is based on primary (or generated) use. This includes electricity delivered to the housing unit and the energy used to create and deliver it.
[b] From: http://www.epa.gov/cleanenergy/energy-resources/refs.html

DVRPC 2008.

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[14] Post Carbon Institute 2007.
[15] Ibid.
[16] USEPA 2008.
[17] Ibid.
[18] Ibid.
[19] See Appendix D for more information on how CO2 emissions are estimated for each scenario, and the rates at which CO_2 is emitted per unit of fuel.

The sum of 2035 residential energy and vehicle CO_2 emissions can be decreased by more than 1.2 million tons in the Recentralization scenario compared to the Trend scenario (see Figure 24). Over the life of the *Connections* plan, the Recentralization scenario amounts to 25.4 million fewer tons of CO_2 emissions (see Figure 25). This is due, in part, to smaller housing units located in denser neighborhoods. Housing units that are attached have fewer walls exposed to the outside from which heat can escape, meaning less energy is needed to heat the home in the winter, reducing heating bills as well. The higher density, along with a mixture of uses, encourages alternative modes of transportation. This means less driving, which also decreases CO_2 emissions.

In the Sprawl scenario, more housing units are detached, which is a less energy efficient form of housing. Sprawl-based neighborhoods are more spread out, leading to more driving and less use of alternative transportation. This scenario will likely increase CO_2 emissions from transportation and residential energy by nearly 1.5 million tons in 2035. Over the life of the *Connections* plan, the Sprawl scenario would add 27.7 million tons of CO_2 emissions compared to the Trend scenario and an increase of more than 53 million tons compared to the Recentralization scenario.

FIGURE 24. 2035 RESIDENTIAL ENERGY AND AUTOMOTIVE CO_2 EMISSIONS BY SCENARIO

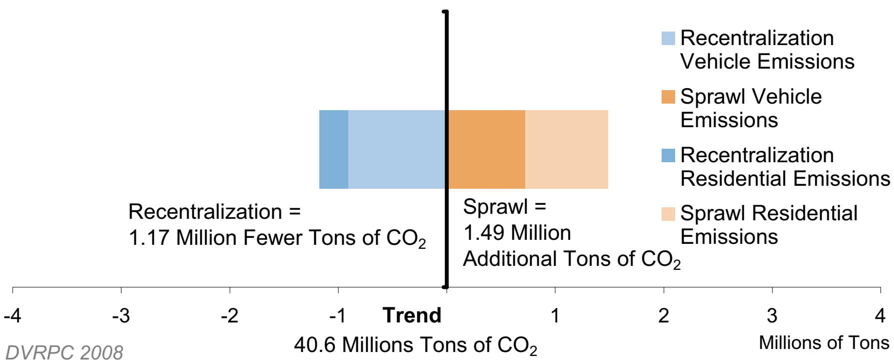

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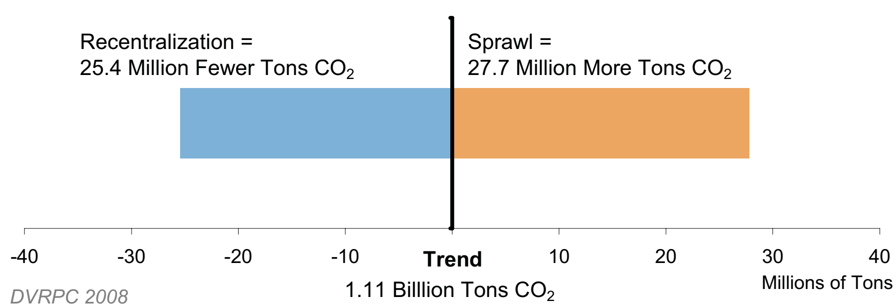
FIGURE 25. CUMULATIVE HOUSEHOLD AND AUTOMOBILE ENERGY CO_2 EMISSIONS BY SCENARIO FROM 2010 TO 2035



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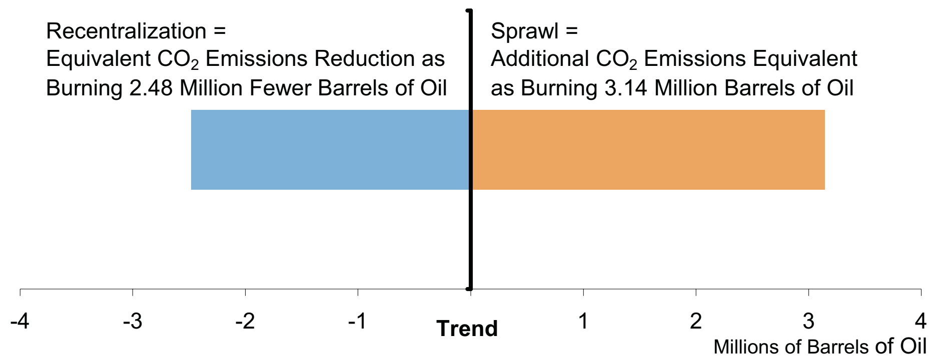
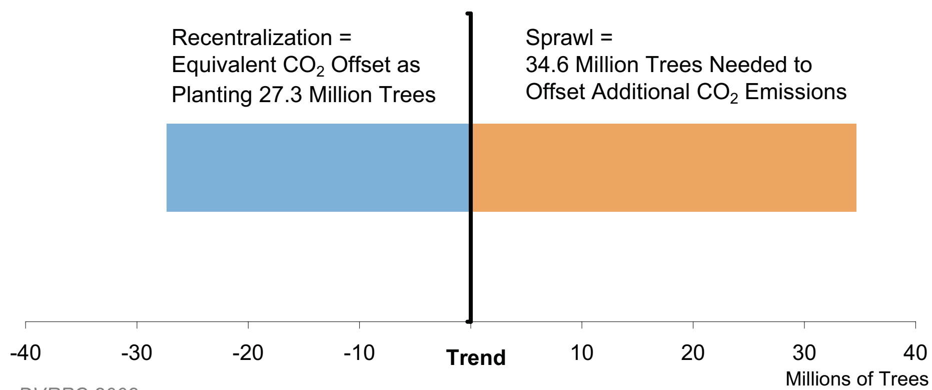
Figures 26 and 27 illustrate the additional CO_2 equivalents and offsets for 2035. The Recentralization scenario has the same effect of reducing CO_2 emissions as planting more than 25 million trees in the region, compared to the Trend scenario. It is also the equivalent of burning nearly 2.5 million fewer barrels of oil in the year 2035. The Sprawl scenario is the CO_2 emissions equivalent of burning 3.1 million additional barrels of oil, compared to the Trend scenario. This would require the region to plant more than 34 million trees to offset the increase in pollution.

FIGURE 26. CO_2 EQUIVALENCIES BY SCENARIO IN 2035



DVRPC 2008

FIGURE 27. CO_2 OFFSETS BY SCENARIO IN 2035



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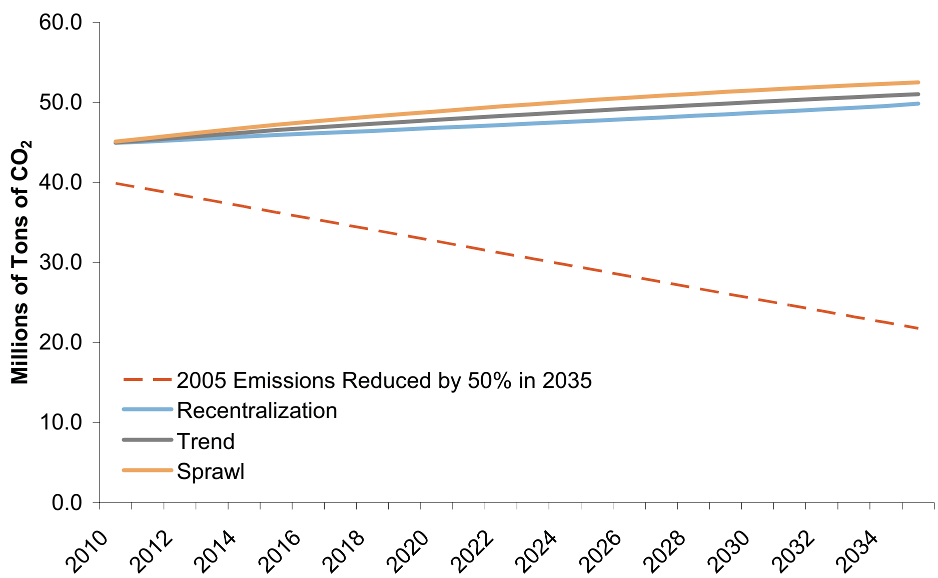
A common goal with respect to combating global climate change is to reduce CO_2 emissions by 50 to 80 percent by the year 2050. Different base years have been suggested for this reduction goal.[20] Carbon dioxide emissions come from a variety of industrial-, transportation-, and household-based sources. Each of these sources will need to be reduced in order to achieve

[20] The Urban Land Institute (2007) recommends a 60 to 80 percent reduction in 1990 CO_2 emissions by 2050. During the July 2008 conference in Toyako, Japan, the G-8 signed an agreement to halve greenhouse gas emissions by the year 2050, but did not specify a base year. DVRPC is currently undertaking an inventory of all greenhouse gas emissions for the year 2005.

such a goal. This analysis has focused on emissions sources from vehicles and residential energy use. Using a base year of 2005, automobile and residential energy emissions in the DVRPC region are estimated to be 43.5 million tons of CO_2. To attain the goal of a 50 percent reduction by 2035 from a base year of 2005, 2035 automobile and residential energy emissions for the region need to be reduced to 21.7 million tons of CO_2.[21] This estimate assumes no improvements in vehicle fuel economy, alternative energy sources, or any other variety of means by which CO_2 could be reduced. Nor does it account for the 130,000 acres of open space saved by the Recentralization scenario compared to the Trend scenario, and 309,000 acres compared to the Sprawl scenario. Leaving this land undeveloped maintains existing carbon sink benefits that the other two scenarios do not. Instead, this analysis focuses on the benefits that each scenario offers in CO_2 reductions based on residential and vehicle energy demand. The Recentralization scenario comes closest to achieving the goal at 49.8 million tons of CO_2 in 2035. The Sprawl scenario is the furthest from this goal, with 52.5 million tons of CO_2 emissions (see Figure 28 and Table 18).

FIGURE 28. COMPARISON OF ANNUAL CO_2 EMISSIONS FROM RESIDENTIAL ENERGY AND VEHICLES WITH REDUCTION GOAL BY SCENARIO



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[21] This goal is used for illustrative purposes only and is not an official policy recommendation of DVRPC.

TABLE 18. COMPARISON OF SCENARIO CO_2 EMISSIONS FROM RESIDENTIAL ENERGY AND VEHICLES WITH REDUCTION GOAL (IN MILLIONS OF TONS)

CO2 Emissions from Residential Energy and Vehicles	Estimate	Difference From Goal
2005 Regional Residential Energy and Vehicle CO_2 Emissions	43.5	-
2035 CO_2 Emissions Goal (50% reduction from 2005)	21.7	-
2035 Recentralization Scenario CO_2 Emissions	49.8	(28.1)
2035 Trend Scenario CO_2 Emissions	51.0	(29.2)
2035 Sprawl Scenario CO_2 Emissions	52.5	(30.7)
Cumulative CO_2 Emissions Goal from 2010 to 2035	800.9	-
Cumulative Recentralization CO_2 Emissions from 2010 to 2035	1,229.0	(428.1)
Cumulative Trend CO_2 Emissions from 2010 to 2035	1,254.4	(453.6)
Cumulative Sprawl CO_2 Emissions from 2010 to 2035	1,282.2	(481.3)

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Princeton University's Carbon Mitigation Initiative has identified some 15 different 'wedge' strategies to reduce carbon emissions.[22] A wedge is a partial solution to the global climate problem. Since no single solution will be capable of solving this issue on its own, a combination of strategies that work together to reduce CO_2 emissions to sustainable levels needs to be implemented together in order to avoid a global climate crisis. A number of wedge strategies relate to household and automotive energy use, such as: improved vehicle fuel efficiency; reduced driving; more efficient buildings; more efficient energy plants; substitution of coal electricity production with nuclear, solar, wind, or biomass; on-site CO_2 sequestration; reforestation; and land preservation. Overall, the Recentralization scenario, without considering other technological possibilities, offers the most CO_2 reduction benefits, with 2.4 percent fewer emissions than the Trend scenario and 5.4 percent fewer emissions than the Sprawl scenario. All of the above strategies, in addition to a 'Recentralization wedge,' will need to be considered and as many as possible implemented in order to achieve the CO_2 reduction goal. [23]

Water Use

Table 19 presents the estimated household water usage for each scenario.[24]

TABLE 19. DAILY REGIONAL WATER USE IN 2035

Indicator	Recentralization	Trend	Sprawl
Water Use (millions of gallons/day)	523	547	606
Water Use per Household (gallons/day)	225	235	260

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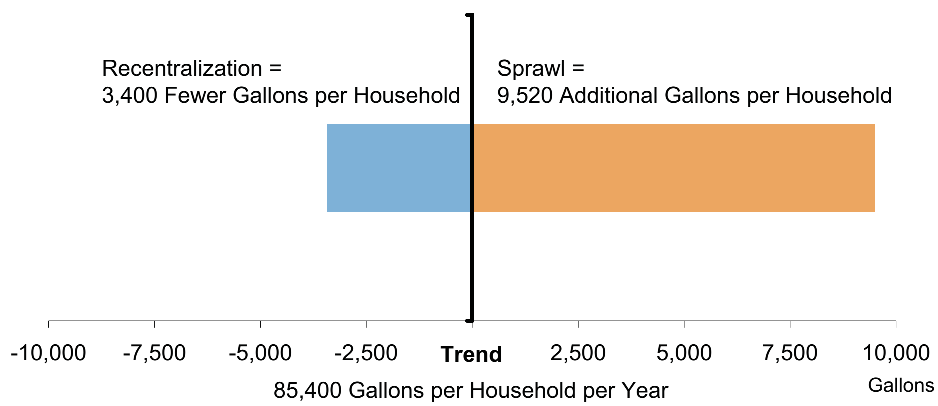
[22] Socolow 2005.
[23] ULI 2007.
[24] See Appendix D for more information on computing water use by scenario.

The Sprawl scenario's housing units tend to be on larger lots, which lead to more lawn watering and other additional water use. There is estimated to be a savings of 24 million gallons of water per day under the Recentralization scenario and an excess use of 59 million gallons of water per day in the Sprawl scenario. Recentralization households use an average of 3,400 fewer gallons of water annually, which can be attributed to smaller yards, fewer pools, and fewer cars to wash (see Figure 29). The average household in the Sprawl scenario will need an additional 9,500 gallons in 2035 over the Trend scenario forecast. Considering there will be more than 2.3 million households in the region by 2035, this is an opportunity for substantial water savings. This could reduce the need to build expensive new water treatment facilities.

FIGURE 29. DIFFERENCE IN ANNUAL HOUSEHOLD WATER CONSUMPTION BY SCENARIO IN 2035



DVRPC 2008

A recent study by 10,000 Friends of Pennsylvania found the City of Philadelphia, and its surrounding, older developed communities have significant excess capacity in their existing water treatment facilities.[25] Considerably more population and jobs could be supported before there is any need to expand treatment capacity. Increased City and developed community population and employment in the Recentralization scenario will more efficiently utilize this infrastructure.

[25] 10,000 Friends of Pennsylvania 2007.

Economic Development

There are economic impacts to each scenario. By building in previously undeveloped areas, the Sprawl scenario requires considerable new infrastructure, such as roads and sewers. This often leads to a duplication of existing infrastructure, as regional populations shift from older developed areas to newer ones. When this occurs, existing infrastructure, such as schools, is underutilized but still needs to be maintained. By more fully utilizing existing infrastructure, the Recentralization scenario requires fewer new facilities to be built. Additionally, the average Sprawl household is more energy intensive, leading to higher costs. The sum of infrastructure and energy needs can have a great impact on local taxation and regional economic competitiveness.

Household Expenses

Table 20 presents the annual driving and energy costs in 2035 by scenario in 2008 dollars based on average household use.[26]

TABLE 20. 2035 AVERAGE ANNUAL HOUSEHOLD RESIDENTIAL ENERGY AND AUTOMOTIVE EXPENSES BY SCENARIO (2008 $S)

Indicator	Recentralization	Trend	Sprawl
Average Annual Household Automobile Expenses [a]	$ 12,040	$ 12,320	$ 13,190
Average Annual Household Electricity Expenses [b]	$ 1,240	$ 1,250	$ 1,340
Average Annual Household Natural Gas Expenses [c]	$ 940	$ 940	$ 900
Average Annual Household Heating Oil Expenses [d]	$ 220	$ 220	$ 230
Average Annual Household Propane (LPG) Expenses [e]	$ 90	$ 90	$ 120
Average Annual Household Water Expenses [f]	$ 240	$ 250	$ 280
Average Annual Household Automobile and Utility Expenses	$ 14,770	$ 15,070	$ 16,060

[a] Assumes a per mile driving cost of $0.5965 in the Recentralization scenario, $0.5897 in Trend scenario, and $0.6153 in the Sprawl scenario. Per mile figures developed using 2008 Edition of AAA's *Your Driving Costs* per vehicle mile, based on miles driven per vehicle.
[b] Assumes average cost per KWh electricity of $0.1078 in Pennsylvania and $0.1416 in New Jersey.
[c] Assumes average natural gas cost per 1,000 cubic feet of $15.94 in Pennsylvania and $21.28 in New Jersey.
[d] Assumes average heating oil cost per gallon of $4.28 in New Jersey and $4.17 in Pennsylvania.
[e] Assumes average propane cost per gallon of $3.40 in New Jersey and $3.00 in Pennsylvania.
[f] Assumes average water expense of $0.002369 per gallon.

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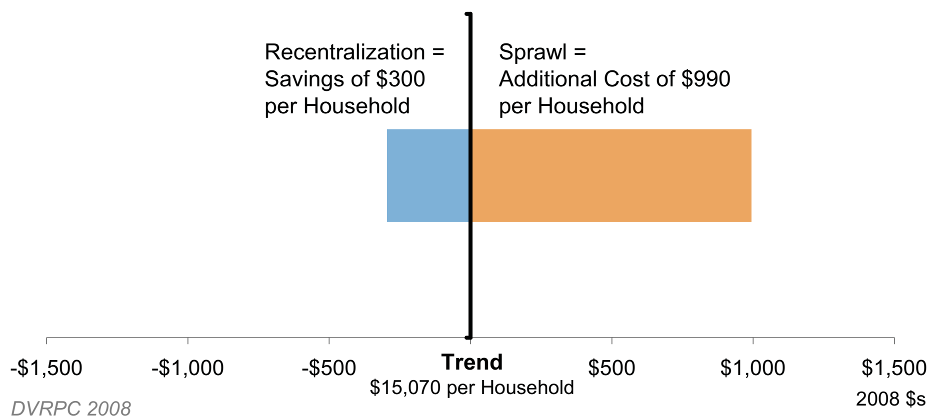
[26] See Appendix D for more information on how household energy expenses are computed for each scenario.

The sum of all residential utility expenses includes electricity, natural gas, propane, heating oil, and water. The average household in the Recentralization scenario uses less fuel for heating, cooling, and electrical power compared to the Sprawl scenario. Likewise, the more alternative transport-friendly nature of the Recentralization scenario means that the average household drives less and owns fewer automobiles compared to the Sprawl scenario. Overall, the Recentralization scenario is estimated to save the average household $300 in annual auto and utility expenses compared to the Trend scenario. Sprawl is expected to cost the average household an additional $990 in these expenses compared to the Trend scenario. The difference between the Recentralization and Sprawl scenarios is nearly $1,300 (see Figure 30).

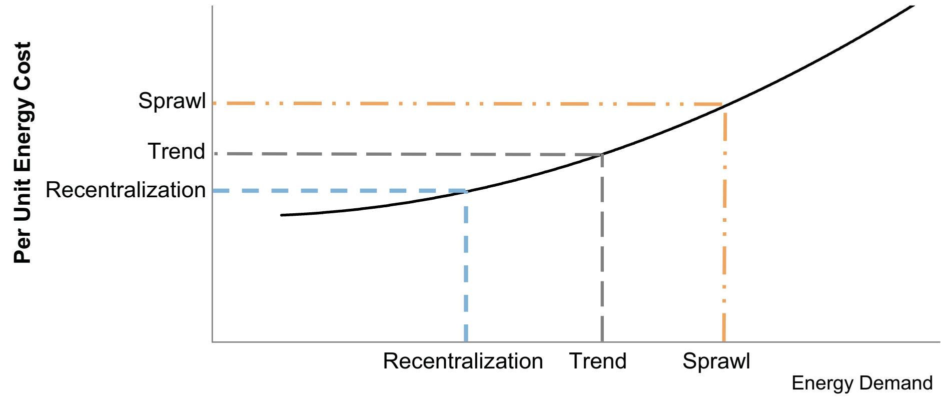
FIGURE 30. DIFFERENCE IN HOUSEHOLD AUTO AND UTILITY EXPENDITURES IN 2035 BY SCENARIO



DVRPC 2008

The scenarios assume that per unit energy costs in 2035 are the same, regardless of demand. However, this is unlikely to be the case. After 25 years of higher consumption in the Sprawl scenario, and to a lesser extent the Trend scenario, per unit energy prices are likely to be higher in these scenarios. The nature of supply and demand is that prices increase as demand rises. This could be due to the need to build additional power plants or import more fossil fuels. Costs are likely to further increase due to the diminishing supply and growing demand for fossil fuels (see Figure 31).

FIGURE 31. PER UNIT ENERGY SUPPLY-DEMAND COST CURVE



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The best way to keep energy prices down is to reduce demand. Conservation, through Recentralization and other policies, is one way to achieve this. Others include: increasing the region's supply of renewable energy sources such as wind and solar power, and greening buildings.

Supportive Infrastructure Costs

The capital expense portion of supportive infrastructure costs, such as new local roads, sewers, utilities, and in some cases schools, is generally paid by developers as part of the cost of development. These costs are passed on to the purchasers of the final product. Though they primarily represent private costs, they can vary dramatically. The new housing units built in each scenario have supporting infrastructure costs that vary based on location and density. Initial infrastructure costs are paid by the housing unit purchasers, but system maintenance costs for the expanded system are spread out over all users.

In general, extending sewer service to presently unserved areas is much more expensive than tapping into existing systems. For example, a multifamily building will be able to serve the water and sewer needs of many units with a single connection, while development in rural areas may require the construction of entirely new systems.

The Sprawl scenario envisions building 670,209 new housing units. This is considerably more than either the Trend scenario, with 293,052 new units, or the Recentralization scenario, with 257,678 new units. All the new housing units in the Sprawl scenario are new footprint, or greenfield development. An estimated 38,532 new lane miles of local roads will be needed to service the new housing units. By contrast, the Trend scenario will need an additional 3,156 new local road lane miles, and the much denser Recentralization scenario will require only 420 new local road lane miles, as much of its development is infill. The addition of new roads will likely have implications on storm water runoff and water quality. The more new roads built, the greater the increase in runoff and decrease in water quality.

School costs are determined by estimating the cost of new school facilities on a per-student basis multiplied by the number of new students in a municipality compared to the number of school-aged children in 2005. This assumes that all existing schools are at capacity and each new student requires additional facilities. Table 21 shows the resulting supportive infrastructure costs by scenario.[27]

TABLE 21. SUPPORTIVE INFRASTRUCTURE COSTS FOR NEW HOUSING UNITS BY SCENARIO

Infrastructure	Recentralization	Trend	Sprawl
Sewer and Water (billions of 2008 $s)	$ 1.37	$ 2.24	$ 6.27
Roads (billions of 2008 $s)	$ 3.35	$ 5.29	$ 23.1
Schools (billions of 2008 $s)	$ 2.65	$ 2.80	$ 6.29
Total Cost (billions of 2008 $s)	$ 7.38	$ 10.3	$ 35.6
Per New Household (2008 $s)	$ 28,600	$ 35,300	$ 53,300

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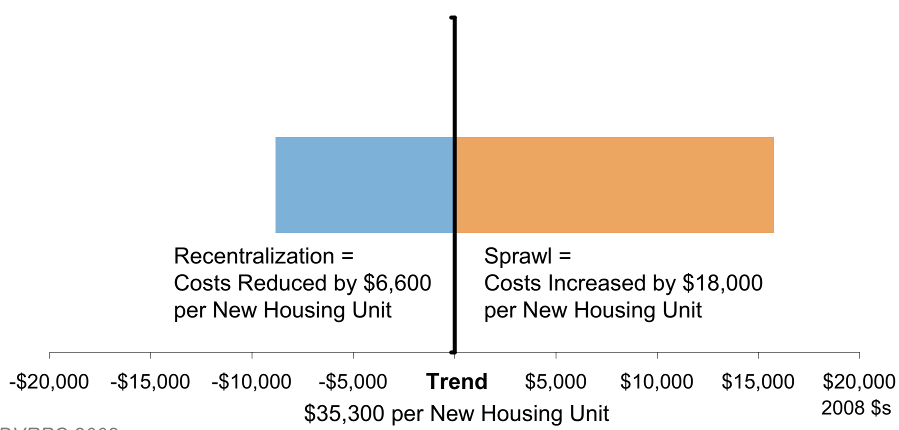
The Sprawl scenario's total supporting infrastructure cost is $25 billion higher than in the Trend scenario. This is because it would build more than twice as many new housing units and per-unit costs are considerably higher. More greenfield development means more lane miles of road, more extensions of sewer lines, and more new schools, all of which duplicate infrastructure that already exists in the region's developed communities and core cities. Meanwhile, the Recentralization scenario could save nearly $3 billion, or more than $6,600 per new unit from the Trend Scenario (see Figure 32).

FIGURE 32. SUPPORTING INFRASTRUCTURE COSTS PER NEW HOUSEHOLD



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[27] More information on computing supportive infrastructure costs can be found in Appendix D.

Cost savings could come from other sectors as well. For instance, in health care, more new hospitals and patient treatment centers will need to be built in the Sprawl scenario, which will likewise result in underutilizing existing facilities in core cities and developed communities.[28] Saving these unnecessary capital costs for health infrastructure reduces healthcare costs and allows institutions to concentrate on patient care.

Both the Recentralization and Sprawl scenarios will require additional transportation capacity. In the Sprawl scenario, this will likely be new roads and highways. In the Recentralization scenario, transit, which is a more sustainable form of transportation, may be able to solve most new capacity needs.

Jobs Added to Environmental Justice Communities

Environment justice (EJ) is an assessment used to mitigate potential direct and disparate impacts of the planning process and development projects on defined minority groups, persons with disabilities, and lower-income populations in the Delaware Valley region. DVRPC recognizes eight degrees of disadvantage, which is defined as exceeding the regional average for each of the following population groups:

- non-Hispanic minorities;
- Hispanic minority;
- elderly;
- physically disabled;
- female-headed households with child;
- carless households;
- low-income households; and
- limited English proficiency.

Each census tract with five or more of these degrees of disadvantage is considered an EJ community. One of the goals of EJ is to promote development in distressed communities. Jobs added to EJ communities are determined by subtracting the groups' forecasted employment levels in each scenario from their existing employment levels in 2005.[29] The findings are presented in Table 22.

[28] Dr. Ted Emmett, e-mail dated 8/25/08.
[29] More information on computing jobs added to Environmental Justice communities can be found in Appendix D.

TABLE 22. JOBS ADDED TO ENVIRONMENTAL JUSTICE COMMUNITIES FROM 2005 TO 2035

Indicator	Recentralization	Trend	Sprawl
Jobs Added to Environmental Justice Communities	79,401	17,313	(151,494)

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In 2005, there were 641,316 total jobs located in EJ communities. The Trend scenario anticipates increasing this amount by approximately three percent over the 30-year planning period. The Recentralization scenario would increase the current total by 12 percent in 2035, while the Sprawl scenario is forecast to result in the loss of 24 percent of the existing job base in these communities.

Municipal Fiscal Health

Municipal fiscal health is a determination of how each scenario potentially impacts revenues, expenditures, and debt levels for the region's local governments. Growth in rural and suburban areas may have short-term revenue benefits. But this growth can lead to long-term negative impacts, as noted by the Pennsylvania Economy League (PEL) in their *Structuring Healthy Communities* study. Population growth brings the need for additional services and, as infrastructure ages, it becomes expensive to maintain and replace. These both put strains on municipal budgets. As a result, taxes need to be raised, fees increased, services reduced, or debt must be incurred. This last option places additional pressure on future budgets. Eventually, tax increases and service cuts lead to outmigration and the municipality begins losing its tax base and risks falling into distress. The PEL found that all forms of local government are susceptible to these patterns, from the largest cities to the smallest townships and boroughs.

The land use impacts of new development must be carefully balanced within a community. The American Farmland Trust has pioneered 'Cost of Community Services' (COCS) studies to gauge the fiscal impact of different land uses on municipal fiscal health. These studies consider only existing fiscal impacts, which are not suited to project forward as a way to impact growth. Generally, they compare the existing revenues generated by land use with the expenditures associated with it. Studies in hundreds of communities over a 20-year period have all found that farmlands are net contributors to fiscal budgets. The median fiscal impact is that for every dollar of revenue, farmland requires 37 cents of expenditures. By median comparison, industrial and commercial lands have a $1-to-$.29 revenue-to-expenditure ratio, whereas for residential it is $1-to-$1.19. Two of their COCS studies focused on communities in Bucks County. Table 23 presents the findings.

TABLE 23. REVENUE-TO-EXPENDITURE RATIOS BY LAND USE FOR SELECT DVRPC COMMUNITIES

Municipality	Residential Land (Including Farmhouses)	Commercial and Industrial	Working and Open Land	Source
Bedminster Township, Bucks County	1:1.12	1:0.05	1:0.04	Kelsey, 1997
Buckingham Township, Bucks County	1:1.04	1:0.15	1:0.08	Kelsey, 1996
Median for All Studies	1:1.19	1:0.29	1:0.37	American Farmland Trust, 2007

Source: American Farmland Trust 2007.

The Sprawl scenario would develop 408,742 acres of farmland and open space, converting them to various commercial, industrial, and residential uses. By comparison, the Trend scenario would develop 114,143 acres and the Recentralization scenario would develop 4,705 acres.

Density also impacts revenues and expenditures. Dense communities tend to have more services, which are reflected by higher spending per capita. On the revenue side, low-density residential units have higher per-unit property tax assessments. But on a per-acre basis, medium- and high-density residential developments generate considerably more revenue, even with lower per-unit assessments.[30] This is another example of how dense development is a more efficient use of land.

Fiscal distress is compounded by the region's tax structure. As population leaves a municipality, property values are reduced. Since many of the region's communities are highly dependent on property taxes, revenues begin to decline. In the New Jersey subregion, these problems may be even more of a concern, as its local governments generate 94 percent of their income with the property tax.[31] To combat revenue declines, taxes need to be raised, core services must be cut, or greater debt is incurred. Regardless, the municipality will likely find itself starting into a downward spiral that is difficult to reverse.

By returning population and employment to older, currently struggling, core city and developed community municipalities, the Recentralization scenario can improve their fiscal health. Preserving open space can help rural and suburban municipalities maintain fiscal health, though purchasing agricultural easements may lead to some higher expenditures in the short term. By slowing development in rural and growing suburbs, these areas can develop gradually without being overwhelmed. This allows more time to plan better

[30] Hosack 2001.
[31] 2002 Census of Governments.

and carefully consider land use changes. Additional benefits accrue by strengthening the region's agriculture sector, which creates more options for local food and reduces greenhouse gases emitted by shipping produce long distances. Denser communities help preserve land in other parts of the region, while increasing revenues per acre with lower per-unit taxes. Both increase land use efficiency.

Globalization and the Future Economy

Trade between societies has existed since the earliest days of civilization. With the opening of markets around the world, global trade and investment has greatly intensified over the past few decades. There is now a highly interconnected international economy, which is the driving force for growth and development. This has greatly impacted the region's economy, with the loss of manufacturing jobs giving rise to services as the largest employment sector. The history of trade, inexpensive communication, economies of scale, and the fact that no community in the world can supply all of its resource needs ensure that globalization will continue to expand.

DVRPC's *A "Post-Global" Economic Development Strategy* recognizes that future energy and resource constraints could reverse some aspects of globalization.[32] It predicts that more self-sufficient communities and regions will have greater economic competitiveness in the future. Self-sufficiency essentially means meeting most basic needs locally. This may mean a return to more local and regional manufacturing of basic goods, especially as shipping costs rise; energy independence; and more local food production. Few areas of the world are self-sufficient in fossil fuels. Those that are not currently import fuels at a considerable burden. The United States' Gross Domestic Product (GDP) in 2007 was approximately $13.8 trillion. It imported 3.65 billion barrels of oil that same year. If the price of a barrel of oil reaches $200, this is a cost $730 billion, or 5.3 percent of GDP, representing a significant drain on the economy.

Energy constraints and availability may greatly impact future location decisions. Locations near rail and port facilities are likely to become preferable, as rail and marine shipping are considerably more fuel efficient then trucking, aviation and other forms of goods movement. Likewise, compact communities with transit and pedestrian infrastructure, which uses land efficiently and lowers energy needs, will be in higher demand than more decentralized, automobile-oriented communities.

[32] DVRPC 2006. Report #06004.

To the extent that a region can efficiently use land to reduce motorized transportation needs, it becomes that much closer to energy self-sufficiency. Saving agricultural land instead of disparate and uncoordinated development uses may help the region better respond to shifts in global trading, specifically changes to food and energy prices.

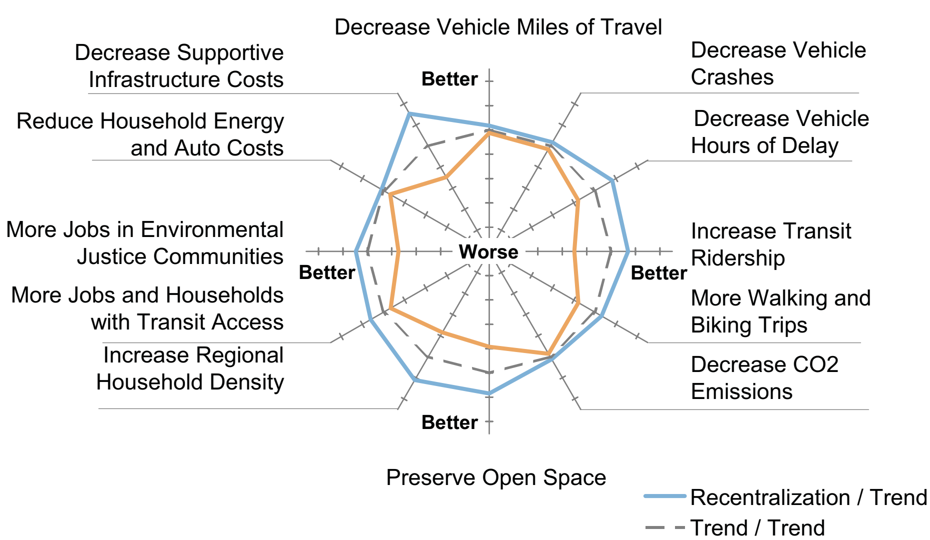
The Recentralization scenario can enhance regional self-sufficiency and economic competitiveness by reducing motorized travel demand (VMT), saving agricultural land from development, and focusing growth on existing regional centers. This scenario can better ensure future quality of life for the region's residents and make it more attractive for location decisions. The Sprawl scenario results in a less competitive region by relying more on motorized transportation and the energy needed to fuel it, develops agricultural land and reduces regional food supply, and decentralizes population and employment away from important future development locations.

Conclusion

M*aking the Land Use Connection: Regional What-If Scenario Analysis* is intended to spur discussion of the long-range planning process and the region's vision for the future. The Recentralization scenario is fundamentally based on the vision and goals set in the *Destination 2030* plan: linking land use and transportation; creating and maintaining centers; promoting growth areas; implementing smart growth and smart transportation; and maintaining and preserving rural conservation lands and creating a greenspace network. The Trend scenario extrapolates recent development patterns. With some notable exceptions, detached housing units on large lots located in the region's periphery away from transit has been the norm for new development over the past several decades. The Sprawl scenario accelerates the recent trend.

Figure 33 compares a key set of summary indicators by indexing the Trend scenario estimates at a value of one and taking a ratio of the other two scenarios compared to the Trend scenario. This indicates the magnitude of impact of each of the scenarios on various regional goals. Each indicator is arranged so that a larger number is considered to be a better outcome for the region. For the goal to reduce energy and auto costs, the Recentralization scenario has the lowest household costs, so the Recentralization value is furthest out on the corresponding axis.

FIGURE 33. SCENARIO COMPARISON INDEX



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The indicators in Figure 33 show that the Recentralization scenario decreases vehicle miles traveled, vehicle hours of delay, vehicle crashes, acres of development, CO_2 emissions, and average household energy and automotive cost; while it increases transit ridership, residential density, households and jobs with access to transit, jobs in environmental justice communities, biking, and walking trips. The Sprawl scenario generally results in less efficiency than the Trend scenario. The Sprawl scenario will likely result in considerably more acres developed and increased VMT, vehicle hours of delay, CO_2 emissions, residential energy and automotive costs; while decreasing transit ridership, walking, and biking trips.

In addition to offering goals and strategies that progress towards the region's vision, the *Connections* long-range plan will address peak oil and global climate change. Strategies to address these issues should be based on conservation and encouragement of less energy-intensive alternatives. CO_2 emissions can be reduced through smart land use and transportation policies, which increase alternative transportation options and lower residential energy use. Mixed land uses and higher densities can shorten distances between origins and destinations. Shorter trip lengths mean that travel can more easily be completed using transit, on foot, or by bicycle. More compact neighborhoods can reduce household energy needs. These are partial solutions that will need to be combined with technological improvements to fully achieve CO_2 reduction goals.

The Recentralization scenario offers the best solutions for a sustainable future that combats global climate change, better prepares for peak oil, and offers the best quality of life for the region's residents by offering more mobility choices, preserving open space, and reducing household expenses. With less spending on replicating existing infrastructure, more money can be invested into green and energy efficient technologies or alternative fuels. This in turn will help ensure that the region remains economically competitive in a fast-changing world.

Next Steps

The first task in developing a plan for the future is to collectively envision what the future, ideally, should be. Public and stakeholder input will guide the vision set in the *Connections* Plan. More than 5,000 people responded to an online visioning survey, with overwhelming support for continuing the goals set in *Destination 2030*. Specifically, the survey respondents showed strong regional support for smart growth policies and reinvestment in and improvements to existing transportation infrastructure, particularly transit.

The vision for the region's future and the goals and strategies for attaining it will continue to be determined through public and stakeholder input. The scenarios are intended to help these groups understand the impact of different land use patterns. These groups will continue to help develop the future vision through a series of focus groups and workshops held in the fall of 2008. During these meetings, one of the scenarios or more likely elements of each of the scenarios will be indentified as the preferred scenario for the plan, which will become the basis for the vision. Also as part of these meetings, the goals and strategies to achieve the desired vision will be identified. Goals and strategies can address any number of issues, such as improving the quality of life, regional competitiveness, combating global climate change, or mobility challenges, and, as seen in the scenario exercise, will likely be interconnected.

Appendices

A. Develop Forecasts for County Controls, Infill, and Intracounty Movement

The first step in the scenario development process is to create alternate county population forecasts for both the Sprawl and Recentralization scenarios. New population and jobs will be defined as either infill or new footprint, which will vary by scenario. This is necessary because UPlan allocates new footprint development to each county based on projected future demand from additional population; however, UPlan does not forecast regional or county population and employment levels. Instead, a systematic approach is developed using planning areas and simple equations to forecast 2035 municipal population based on multipliers to forecast county and municipal population and employment for the Sprawl and Recentralization scenarios. The Trend scenario is based on the Board-adopted 2035 forecast.

Population

Alternate population and employment forecasts for the Recentralization and Sprawl scenarios are developed from the bottom-up using a series of municipal growth multipliers. The first multiplier is based on planning area from the 2030 Plan. The values in Table A-1 are assigned to fit the expected trends for each scenario. In the Recentralization scenario, the majority of new population and employment locates in the region's core cities and developed communities. In the Sprawl scenario, existing population and employment relocates from core cities and developed communities to growing suburbs and rural areas (referred to as intracounty movement). Regional population and job growth occurs primarily as new footprint development in the growing suburbs and rural areas.

TABLE A-1. PLANNING AREA POPULATION MULTIPLIERS

Destination 2030 **Planning Area**	**Planning Area Multiplier (PAM)**	
	Recentralization	**Sprawl**
Core City	2.0	1.0
Developed Community	3.0	1.1
Growing Suburb	1.0	2.0
Rural Area	0.0	2.0

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The second multiplier is the DVRPC Board-adopted growth rate for each municipality between 2005 and 2035. This multiplier captures elements such as taxation, location, availability of open space, and other development factors that impact a community's attractiveness to growth, especially relative to other communities in the same planning area. The value of the multiplier is determined by calculating one plus the Board-adopted population growth rate. For example, if a community is forecast to grow 20 percent by 2035, the multiplier is 1.2. A negative growth rate has a multiplier of less than one.

The Recentralization scenario utilizes a third multiplier based on DVRPC's Transit Score Tool.

Employment

UPlan requires county employment totals for each scenario. Board-adopted county employment forecasts are readily available for the Trend scenario. For the Recentralization and Sprawl scenarios, county employment totals are based on a preliminary allocation to municipalities. The preliminary municipal forecasts are summed to county totals for reallocation of the new footprint portion for each scenario by UPlan. In the Trend scenario, infill is allocated separately from new footprint.

In the Recentralization scenario, communities with infill population are assumed to infill employment at the 2005 population-to-employment ratio. For example, consider a community with 1,000 residents and 500 jobs, and it is expecting 100 new infill residents. This community's 2005 population-to-jobs ratio is 0.5; and multiplying by 100 new infill residents, the infill employment is 50 new jobs.

In the Sprawl scenario, intracounty job movement is also expected to occur proportionally with intracounty population movement. The ratio of population to jobs in 2005 for each municipality is used to predict job losses in those areas losing population. A community with 1,000 residents and 500 jobs in this scenario expects to lose 100 residents to intracounty movement. With 0.5 jobs per resident, the community would also lose 50 employees. Municipalities with preliminary population growth proportionally increase employment by the same rate. New county population and employment figures are totaled after applying this method to each of the 353 municipalities in the region.

Infill

Prior to the start of this analysis, DVRPC developed a methodology using UPlan to estimate infill development for the Board-adopted forecast. This estimate is used in the scenario analysis as the Trend scenario. Since UPlan is used to allocate municipal population and employment, there is some variation with the Board-adopted forecasts. A few outliers aside, most municipalities in the Trend scenario are within five percent of the Board-adopted forecast.

The Sprawl scenario assumes that all development is new footprint, with no infill. In the Recentralization scenario, new footprint is assumed to be 10 percent of population growth in Delaware County, Pennsylvania, and Mercer County, New Jersey, and 20 percent in all other counties in the region except Philadelphia. The region's principle city is a special case, as it has essentially been built out for decades. As a result, all growth in the region's major urban area is considered to be infill. Delaware and Mercer counties are also essentially built out and, therefore, do not have appropriate land available for new footprint development, hence the higher rate of infill.

Sprawl

The population multiplier equation for the Sprawl scenario is:

$$\text{Municipal Sprawl Population}_{2035} = MP_{2005} * PAM * (1 + MG)$$

Where,
MP = Municipal Population (Board-adopted)
PAM = Planning Area Multiplier (see Table A-1)
MG = Forecast Municipal Growth Rate

The calculation based on the 2035 Sprawl scenario equation yields regional population levels well above the Board-adopted forecast. The intent is to hold regional growth steady at 6.15 million in 2035, while varying the distribution of regional population. After applying the multipliers, each municipality's population is reduced proportionally to maintain the regional control levels.

Table A-2 presents the population growth in the Sprawl scenario divided between new footprint and intracounty movement. This scenario projects many core cities and developed communities will lose population. The difference between core city and developed community population levels from 2005 to 2035 is the intracounty population movement. This is also converted into corresponding household and employment intracounty movement. The 'Revised Base Population' column in is determined for each municipality by subtracting the intracounty population movement from the 2005 population. The 'UPlan Input' column in Table A-2 represents the base population in 2005 as identified in UPlan plus the new footprint development that will happen over the course of the 30-year analysis period. UPlan allocates both the intracounty movement and projected growth as new footprint development.

Delaware and Camden counties are projected to lose population in the 30-year Sprawl scenario analysis period. The population loss is reflected in the revised base population.

TABLE A-2. SPRAWL SCENARIO GROWTH AND INTRACOUNTY MOVEMENT

County	2005 Population	Intracounty Population Movement	Revised Base Population*	Projected Growth	2035 Sprawl Population	UPlan New Footprint	UPlan Input
Bucks	624,351	(57,770)	566,578	217,500	841,851	275,270	899,621
Chester	473,880	(6,860)	467,021	336,561	810,441	343,421	817,301
Delaware	555,206	(109,670)	419,147	(26,391)	528,815	109,670	664,876
Montgomery	780,544	(83,757)	696,723	185,789	966,333	269,546	1,050,090
PA Subtotal	2,433,981	(258,057)	2,149,469	713,459	3,147,440	997,907	3,431,888
Burlington	446,866	(17,746)	429,121	208,028	654,894	225,774	672,640
Camden	515,027	(101,900)	389,619	(24,437)	490,590	101,900	616,927
Gloucester	274,229	(7,698)	266,532	210,098	484,327	217,796	492,025
Mercer	365,097	(48,554)	316,532	31,267	396,364	79,821	444,918
NJ Subtotal	1,601,219	(175,898)	1,401,804	424,956	2,026,175	625,291	2,226,510
Total	4,035,200	(433,955)	3,551,273	1,138,415	5,173,615	1,623,198	5,658,398
Philadelphia	1,483,851	-	-	(507,839)	976,012	-	-
Grand Total	5,519,051	(433,955)	3,551,273	630,576	6,149,627	1,623,198	5,658,398

* Revised base population is 2005 population minus intracounty population movement, and minus projected growth if less than zero. This occurs in both Camden and Delaware counties.

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In step two, UPlan allocates each county's new footprint population, with corresponding employment and household growth. UPlan determines the location for new footprint development in the municipalities best suited for growth. The new footprint population, employment, and households allocated by UPlan are added to the revised base population, employment, and households to determine the final Sprawl scenario demographics.

Recentralization

The Recentralization scenario uses a third multiplication factor based on the DVRPC transit score.[33] This additional multiplier is used to reflect the desirability of transit access in a dense, centralized, transit-oriented future

[33] DVRPC 2007. Report #07005.

scenario. Since transit scores tend to be higher in core cities and developed communities, this multiplier will also help to counter the Board-adopted municipal growth rate multiplier. Board-adopted forecasts locate most growth over the next 30 years in growing suburbs and rural areas. Excluding Philadelphia, 2005 transit scores range from 0 to 11.2 for the region's other municipalities and townships. This multiplier is computed by adding one to the transit score and dividing by 100.

The equation for the Recentralization scenario allocates only regional population growth. For the DVRPC region, new population is forecast to be approximately 630,000 residents by the year 2035. Municipalities not forecast to add population in this scenario maintain their existing 2005 population levels.

The population multiplier equation for the Recentralization scenario is:

$$\text{Municipal Recentralization Growth}_{2035} = MP_{2005} + (PGF * PAM * (1 + MG) * (1 + TS/100))$$

Where,
MP = Municipal Population (Board-adopted)
PGF = Regional Population Growth Forecast from 2005 to 2035
PAM = Planning Area Multiplier (see Table 1)
MG = Forecast Municipal Growth Rate
TS = Municipality's Transit Score

The Recentralization population growth equation also yields forecasts well over the Board-adopted regional growth forecasts. Each municipality's forecast population growth is reduced proportionally, so that the Recentralization scenario matches the region's Board-adopted 2035 forecast of 630,000 new residents. The growth in each municipality is added to the 2005 population to determine the 2035 forecast for this scenario.

Rural areas have a planning area multiplier set to zero; thus, no growth is initially forecast for these communities in the Recentralization scenario. In step two of the analysis, UPlan reallocates the new footprint portion of the county control totals. At this time, new population can be allocated to rural areas within designated growth areas.

Table A-3 presents the population growth in the Recentralization scenario divided between new footprint and infill development. DVRPC estimates the infill population in the Recentralization scenario to be 80 to 90 percent, depending on the county. The 'UPlan Input' column in Table A-2 represents the population in 2005 as identified in UPlan plus the new footprint development that occurs over the 30-year analysis period.

TABLE A-3. RECENTRALIZATION SCENARIO GROWTH AND INFILL

County	2005 Population	2035 Projected Growth	2035 Recentralization Population	Infill Percent	Infill Population	UPlan New Footprint	UPlan Input
Bucks	624,351	71,185	695,536	80%	56,948	14,237	638,588
Chester	473,880	37,707	511,587	80%	30,166	7,541	481,421
Delaware	555,206	78,173	633,379	90%	70,356	7,817	563,023
Montgomery	780,544	93,867	874,411	80%	75,094	18,773	799,317
PA Subtotal	2,433,981	280,932	2,714,913		232,563	48,369	2,482,350
Burlington	446,866	40,367	487,233	80%	32,294	8,073	454,939
Camden	515,027	69,357	584,384	80%	55,486	13,871	528,898
Gloucester	274,229	23,108	297,337	80%	18,486	4,622	278,851
Mercer	365,097	43,996	409,093	90%	39,596	4,400	369,497
NJ Subtotal	1,601,219	176,828	1,778,047		145,862	30,966	1,632,185
Total	4,035,200	457,760	4,492,960	-	378,425	79,335	4,114,535
Philadelphia	1,483,851	172,822	1,656,673	100%	172,822	-	1,483,851
Grand Total	5,519,051	630,582	6,149,633	-	551,247	79,335	5,598,386

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In step two, UPlan allocates each county's new footprint population, along with corresponding employment and households. The new footprint population and employment is located by UPlan in the municipalities that the model determines are best suited to attract growth. The new footprint population, employment, and households identified in step two were added to 2005 and infill totals, as determined in step one, to determine the final demographic numbers.

Trend

Table A-4 presents the population growth in the Trend scenario divided between new footprint and intracounty movement. UPlan is used to allocate Board-adopted county forecasts to infill and new footprint development. The first step to compute these numbers is to allocate all population growth in UPlan. Population growth for each municipality was then tabulated and compared with the Board-adopted forecasts. The following rules were then applied:

- If UPlan > Forecast; Then Infill = 0 (this condition assumes that population growth is completely accommodated by new footprint development);
- If UPlan ≈ Forecast; Then Infill = 0 (this condition assumes the same as above); or
- If UPlan < Forecast; Then Infill = (Forecast – UPlan) (this condition assumes that population growth is not accommodated by new footprint development and is accommodated as infill).

The result of the above step determines where and how much infill is located in the Trend scenario. The remaining development is new footprint. A second run in UPlan allocates only the new footprint portion of growth between 2005 and 2035.

TABLE A-4. TREND SCENARIO GROWTH AND INFILL

County	2005 Population	2035 Projected Growth	2035 Board-adopted Population	UPlan Infill Estimate	Percent Infill	UPlan New Footprint	UPlan Input
Bucks	624,351	129,433	753,784	58,637	45%	70,796	695,147
Chester	473,880	148,618	622,498	89,235	60%	59,383	533,263
Delaware	555,206	4,750	559,956	4,750	100%	-	555,206
Montgomery	780,544	113,592	894,136	38,353	34%	75,239	855,783
PA Subtotal	2,433,981	396,393	2,830,374	190,974	48%	205,419	2,639,400
Burlington	446,866	94,337	541,203	54,177	57%	40,160	487,026
Camden	515,027	9,657	524,684	6,729	70%	2,928	517,955
Gloucester	274,229	95,145	369,374	37,433	39%	57,712	331,941
Mercer	365,097	38,879	403,976	21,881	56%	16,998	382,095
NJ Subtotal	1,601,219	238,018	1,839,237	120,220	51%	117,798	1,719,017
Total	4,035,200	634,411	4,669,611	311,195	49%	323,216	4,358,416
Philadelphia	1,483,851	(3,828)	1,480,023	172,822	100%	-	1,483,851
Grand Total	5,519,051	630,583	6,149,634	484,017	60%	323,216	5,842,267

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Initial Scenario Forecasts

Table A-5 compares the first iteration of 2035 population levels by scenario and planning area. For comparison, this table also presents the 2035 Board-adopted forecast as the Trend scenario. Slight variation in regional totals is due to rounding.

TABLE A-5. FIRST ITERATION POPULATION FORECASTS BY PLANNING AREA AND SCENARIO

	2035 Recentralization Scenario		2035 Board-adopted Forecast (Trend Scenario)		2035 Sprawl Scenario	
Planning Area	Population	Percent	Population	Percent	Population	Percent
Core Cities	1,881,434	31%	1,685,400	27%	1,169,086	19%
Dev. Communities	2,181,413	35%	1,946,862	32%	1,486,421	24%
Growing Suburbs	1,761,274	29%	2,063,168	34%	2,864,061	47%
Rural Areas	325,512	5%	454,204	7%	630,059	10%
Region	6,149,628	100%	6,149,634	100%	6,149,627	100%

DVRPC 2008

Core cities and developed communities experience strong population growth in the Recentralization scenario. In the Sprawl scenario, these communities experience dramatic population losses, while growing suburbs and rural areas experience considerable population increases. Table A-6 compares the initial county population forecasts by scenario.

TABLE A-6. FIRST ITERATION COUNTY POPULATION FORECASTS BY SCENARIO

County	2035 Scenario		2035 DVRPC Board-adopted Forecast (Trend Scenario)
	Recentralization	Sprawl	
Bucks	695,536	841,851	753,784
Chester	511,587	810,441	622,498
Delaware	633,379	528,815	559,956
Montgomery	874,411	966,333	894,136
Philadelphia	1,656,673	976,012	1,480,023
Burlington	487,233	654,894	541,203
Camden	584,384	490,590	524,684
Gloucester	297,337	484,327	369,374
Mercer	409,093	396,364	403,976

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It is easy to grasp the population differences between the scenarios by contrasting Philadelphia's population with the population of Bucks County. The Board-adopted forecast predicts that Philadelphia's population loss will continue, albeit at a slower pace than in the past, to a 2035 population of 1.48 million. In the Recentralization scenario, Philadelphia adds 170,000 residents for a total of 1.65 million. In the Sprawl scenario, Philadelphia experiences considerable population losses, falling to under one million people. Bucks County's Board-adopted forecast is 754,000, as opposed to 857,000 in the Sprawl scenario and 695,000 in the Recentralization scenario.

Average population densities are computed for each municipality and planning area by scenario to ensure that the future estimates are feasible. Densities are highest in the Recentralization scenario. Core cities average approximately 18 persons per acre, developed communities six persons per acre, growing suburbs two persons per acre, and rural areas 0.3 persons per acre. In the Sprawl scenario, population density averages 11 persons per acre in core cities, four persons per acre in developed communities, three persons per acre in the growing suburbs, and 0.7 persons per acre in rural areas.

This completes step one of this analysis. Next, the alternate county populations are input into UPlan, which allocates new footprint development within each county among competing municipalities. This will allocate new population and employment at the TAZ level (step two) for use with the DVRPC TDM (step three).

B. Allocate New Footprint Development in UPlan

The second step in the scenario exercise allocates the new footprint development of population and job growth from the county controls developed in step one using UPlan. The future county control numbers for each scenario are found in Appendix A.

UPlan is calibrated to accurately model land use changes in the DVRPC region using U.S. Census data between 1990 and 2000. Forecasting future regional development with UPlan assumes a continuation of development patterns set during this period. In the calibration phase, various model inputs are estimated to simulate the economic and policy forces that combine to shape new footprint development based on whether a site developed over this period.

Attractors, detractors, and policy coefficients are inputs that influence where development will occur. Parameters such as lot size and percentage of density determine how much development will transpire.[34]

Masks are another input and are used to emulate policy decisions or land development realities. They are used to restrict development in certain locations, such as the regional protected lands network, water bodies, flood plains, wetlands, and existing development. The regional greenspace mask restricts the occurrence of new development in designated greenspace areas (as defined in the 2030 Plan) in all scenarios.

New footprint development is guided by an allocation area that determines where the combination of attractors, detractors, and masks can locate new footprint development. In the Recentralization scenario, new footprint development is located entirely within future growth areas as described in the 2030 Plan. The Trend and Sprawl scenarios use the areas designated wooded, vacant, and agricultural in the 2005 DVRPC land use inventory.

Successfully running the scenarios using this model requires DVRPC to work around a couple of issues. The first is that each county runs separately in UPlan. To locate new jobs and households requires new county population and employment control forecasts. These are created in step one (see Appendix A).

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[34] For more information on the DVRPC UPlan calibration process, see *Development and Calibration of the UPlan Land Use Planning Model* (DVRPC 2005. Report number 05017) and *Testing and Implementation of the UPlan Land Use Planning Model* (DVRPC 2006. Report number 06041).

The second issue is that UPlan does not densify (or add population to) existing developed locations. UPlan operates with the assumption that once a specific place is developed, it tends to remain at a static density over time. In the Recentralization scenario, most new population and employment growth is assumed to locate into core cities and developed areas, which are, to a certain degree, completely built out. Accommodation of additional residents in these areas is expected to occur in large part through the densification process. UPlan, in its current form, does not identify areas that are suited for densification through this process. Infill estimates for population and employment by municipality and TAZ are developed in step one (see Appendix A).

The Recentralization scenario is run using a set of attractors, detractors, and density values that differ from the calibration parameters. The future development that occurs in this scenario is denser and more transit oriented. The Sprawl and Trend scenarios use the calibrated DVRPC regional attractors and detractors. Table B-1 shows the Recentralization attractors that change and the related policy implications.

TABLE B-1. POLICY BASIS FOR RECENTRALIZATION UPLAN ATTRACTOR CHANGES

Attractor	Policy Basis
Increase Residential New Footprint Density	Promote Transit-Oriented Development
Increase Residential and Commercial Attractors to Transit	Promote Transit-Oriented Development
Increase Residential Attractor to Commercial	Encourage Mixed-Use Development
Increase Commercial Attractor to Residential	Encourage Mixed-Use Development

DVRPC 2008

Table B-2 indicates the alternate densities used for residential and commercial space. No change was made to industrial in this scenario. These values are to be used in place of the calibrated values listed in Table 1 of DVRPC's *Testing and Implementation of the UPlan Land Use Planning Model*. In the calibrated DVRPC UPlan model, high-density residential ranges between five and 28 percent of all households, while high-density commercial ranges between seven and 61 percent of all employment. Philadelphia County is considered built out for the purposes of UPlan and is not modeled.

The alternate values presented here are considered appropriate in meeting the goals set forth in DVRPC's *Destination 2030* Long-Range Plan for creating a denser, more transit-oriented region.

TABLE B-2. RECENTRALIZATION DENSITY PARAMETERS BY COUNTY

	Growing				Stabilized			
Residential	Bucks	Chester	Burlington	Gloucester	Montgomery	Delaware	Camden	Mercer
High-Density	50.0%	45.0%	50.0%	45.0%	60.0%	70.0%	80.0%	60.0%
Medium-Density	35.0%	40.0%	35.0%	40.0%	30.0%	20.0%	15.0%	30.0%
Low-Density	15.0%	15.0%	15.0%	15.0%	10.0%	10.0%	5.0%	10.0%
Very Low-Density	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Total	100%	100%	100%	100%	100%	100%	100%	100%

	Growing				Stabilized			
Employment	Bucks	Chester	Burlington	Gloucester	Montgomery	Delaware	Camden	Mercer
Industrial	4.3%	0.1%	0.1%	5.0%	1.0%	8.2%	0.1%	11.7%
High-Density Commercial	70.7%	75.0%	77.6%	71.0%	80.0%	78.5%	77.6%	80.8%
Low-Density Commercial	25.0%	24.9%	22.3%	24.0%	19.0%	13.3%	22.3%	7.5%
Total	100%	100%	100%	100%	100%	100%	100%	100%

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Table B-3 lists attractor and discouragement parameters related to transportation and land use. The values in this table will supplement the ones found in Appendix A of DVRPC's *Testing and Implementation of the UPlan Land Use Planning Model*. These alternate values are considered appropriate to meet the goals set forth in DVRPC's *Destination 2030* Long-Range Plan for creating a mixed-use, transit-oriented region. The buffer size shown in Table B-2 determines how far the attractor or detractor reaches from its origin point, whether it is a transit stop, a commercial building, a residential development, or a highway interchange. The weight gives the overall strength of the attractor or detractor, with a higher number giving it more strength. For bus and rail lines two different intervals vary their attractor strength. Interval 1, closer to the station or stop has a greater attractor than Interval 2, which is for areas further away. All parameters not listed in Table B-3 maintain their calibrated value.

TABLE B-3. RECENTRALIZATION ATTRACTOR AND DISCOURAGEMENT PARAMETERS FOR ALL COUNTIES

Industrial Attractor/Detractor Parameters	Buffer Size (ft.)	Weight
Bus Lines (Interval 1)	400	10
Bus Lines (Interval 2)	800	6
Rail Stations (Interval 1)	1,320	10
Rail Stations (Interval 2)	2,640	6

Commercial High Attractor/Detractor Parameters	Buffer Size (ft.)	Weight
Bus Lines (Interval 1)	400	20
Bus Lines (Interval 2)	800	12
Rail Stations (Interval 1)	1320	40
Rail Stations (Interval 2)	2,640	24
1990 High-Density Residential	3,000	25

Commercial Low Attractor/Detractor Parameters	Buffer Size (ft.)	Weight
Bus Lines (Interval 1)	400	15
Bus Lines (Interval 2)	800	9
Rail Stations (Interval 1)	1320	20
Rail Stations (Interval 2)	2,640	12
1990 High-Density Residential	5,000	10

Residential High Attractor/Detractor Parameters	Buffer Size (ft.)	Weight
Bus Lines (Interval 1)	400	25
Bus Lines (Interval 2)	800	15
Rail Stations (Interval 1)	1320	50
Rail Stations (Interval 2)	2,640	30
1990 Commercial	3,000	25

Residential Medium Attractor/Detractor Parameters	Buffer Size (ft.)	Weight
Bus Lines (Interval 1)	400	15
Bus Lines (Interval 2)	800	9
Rail Stations (Interval 1)	1320	20
Rail Stations (Interval 2)	2,640	12
1990 Commercial	5,000	10

Residential Low Attractor/Detractor Parameters	Buffer Size (ft.)	Weight
Bus Lines (Interval 1)	400	5
Bus Lines (Interval 2)	800	3
Rail Stations (Interval 1)	1,320	10
Rail Stations (Interval 2)	2,640	6

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Setting up the attractor and detractor values for the scenario and county is the first step in running the UPlan model. The UPlan input values for each scenario in Appendix A is used to identify new footprint population. Table B-4 presents the new footprint population forecasts for each scenario. UPlan will proportionally estimate the number of jobs and households formed along with the population growth.

TABLE B-4. UPLAN NEW FOOTPRINT POPULATION ALLOCATION BY SCENARIO

Scenario	New Footprint Population
Sprawl	1,623,198
Trend (Board-adopted)	323,216
Recentralization	79,335

DVRPC 2008

As the model runs, it uses the following order for land use location priority based on market bidding power:

- Industrial
- High-Density Commercial
- High-Density Residential
- Low-Density Commercial
- Medium-Density Residential
- Low-Density Residential

Industrial land uses get the first selection in where to locate, while low-density residential uses get the last choice. Table 4 presents the new population totals that UPlan will allocate for each scenario. The scenarios will vary with regard to the density of the new footprint households. The Recentralization scenario will build at a higher density (see Table B-2); while the Sprawl and Trend scenarios will use UPlan calibrated densities. Residential lot sizes for high-, medium-, and low-density development vary by county in UPlan. Their calibrated values are maintained in each scenario. High-density lot sizes range between 0.09 and 0.15 acres per unit. Medium-density lot sizes range between 0.14 and 0.5 acres per unit. Low-density lot sizes range between 0.5 and 1.1 acres per unit.

Table B-5 shows the resulting population and employment for each county in DVRPC's region as computed by UPlan. These are the figures that are used throughout the scenario analysis. There is some variation in regional totals between scenarios due to rounding.

TABLE B-5. FINAL COUNTY POPULATION AND EMPLOYMENT FORECASTS BY SCENARIO

	Recentralization		Trend		Sprawl	
	Pop.	Emp.	Pop.	Emp.	Pop.	Emp.
Bucks	695,401	319,098	753,784	342,236	857,132	350,940
Chester	511,579	280,015	622,498	337,093	831,847	432,323
Delaware	633,166	278,161	559,956	243,547	523,366	226,035
Montgomery	874,288	565,090	894,136	585,430	956,594	617,436
Philadelphia	1,656,351	830,434	1,480,023	736,268	966,121	518,910
PA Subtotal	4,370,785	2,272,798	4,310,39	2,244,574	4,135,060	2,145,644
Burlington	488,363	236,242	541,203	260,529	648,282	321,600
Camden	584,270	256,140	524,684	226,682	495,111	223,726
Gloucester	297,217	119,940	369,374	145,895	478,757	195,745
Mercer	409,026	261,112	403,976	269,446	392,422	260,416
NJ Subtotal	1,778,876	873,434	1,839,237	902,552	2,014,572	1,001,48
Regional Total	6,149,661	3,146,232	6,149,634	3,147,126	6,149,632	3,147,131

DVRPC 2008

Tables B-6 to B-14 present the final county level population, employment, household, and new footprint development estimates as determined by UPlan. Since modeling is not an exact science, there are some differences in the final county totals shown here and those determined in step one. There is variation between scenario population and employment totals due to rounding.

TABLE B-6. RECENTRALIZATION POPULATION GROWTH, INFILL, AND NEW FOOTPRINT

County	2005 Population	Infill	New Footprint	2035 Population
Bucks	624,351	56,917	14,268	695,536
Chester	473,880	30,129	7,578	511,587
Delaware	555,206	70,347	7,826	633,379
Montgomery	780,544	75,092	18,775	874,411
Philadelphia	1,483,851	172,822	-	1,656,673
PA Subtotal	3,917,832	405,307	48,447	4,371,586
Burlington	446,866	31,042	9325.11	487,233
Camden	515,027	55,455	13901.9	584,384
Gloucester	274,229	18,460	4648.5	297,337
Mercer	365,097	39,560	4436.1	409,093
NJ Subtotal	1,601,219	144,516	32311.61	1,778,047
Total	5,519,051	549,823	80,759	6,149,633

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TABLE B-7. TREND POPULATION GROWTH, INFILL, AND NEW FOOTPRINT

County	2005 Population	Infill	New Footprint	2035 Population
Bucks	624,350	37,015	92,419	753,784
Chester	473,881	81,951	66,666	622,498
Delaware	555,204	2,106	2,646	559,956
Montgomery	780,541	45,679	67,916	894,136
Philadelphia	1,483,848	(3,825)	-	1,480,023
PA Subtotal	3,917,824	162,926	229,647	4,310,397
Burlington	446,864	53,864	40,475	541,203
Camden	515,007	7,282	2,395	524,684
Gloucester	274,230	31,050	64,094	369,374
Mercer	365,093	21,799	17,084	403,976
NJ Subtotal	1,601,194	113,995	124,048	1,839,237
Total	5,519,018	276,921	353,695	6,149,634

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TABLE B-8. SPRAWL POPULATION GROWTH, INTRACOUNTY MOVEMENT, AND NEW FOOTPRINT

County	2005 Population	Intracounty Movement	New Footprint	2035 Population
Bucks	624,351	(81,725)	299,225	841,851
Chester	473,880	(36,525)	373,086	810,441
Delaware	555,206	(135,877)	109,486	528,815
Montgomery	780,544	(83,403)	269,192	966,333
Philadelphia	1,483,851	(507,839)	-	976,012
PA Subtotal	3,917,824	(845,368)	1,050,988	4,123,452
Burlington	446,866	(17,523)	225,551	654,894
Camden	515,027	(135,031)	110,596	490,592
Gloucester	274,229	(7,572)	217,670	484,327
Mercer	365,097	(48,538)	79,805	396,364
NJ Subtotal	1,601,219	(208,663)	633,621	2,026,177
Total	5,519,051	(1,054,032)	1,684,610	6,149,629

DVRPC 2008

TABLE B-9. RECENTRALIZATION HOUSEHOLD GROWTH, INFILL, AND NEW FOOTPRINT

County	2005 Households	Infill	New Footprint	New Footprint Density High	Medium	Low	2035 Households
Bucks	229,839	22,849	5,945	2,978	2,074	893	258,188
Chester	171,987	11,935	2,786	1,264	1,107	415	190,359
Delaware	207,606	28,403	3,261	2,269	668	324	241,533
Montgomery	299,455	31,625	7,166	4,307	2,148	711	338,873
Philadelphia	584,004	73,000	-	-	-	-	646,790
PA Subtotal	1,492,891	167,812	19,158	10,818	5,997	2,343	1,675,743
Burlington	163,204	12,940	3,441	1,727	1,200	514	180,452
Camden	187,978	21,940	6,466	5,163	979	324	216,651
Gloucester	98,147	7,144	2,066	938	820	308	108,585
Mercer	130,394	15,121	1,590	952	480	158	148,864
NJ Subtotal	579,723	57,145	13,563	8,780	3,479	1,304	654,552
Total	2,072,614	224,957	32,721	19,598	9,476	3,647	2,330,295

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TABLE B-10. TREND HOUSEHOLD GROWTH, INFILL, AND NEW FOOTPRINT

County	2005 Households	Infill	Intracounty Movement	New Footprint	New Footprint Density High	Medium	Low	2035 Households
Bucks	229,839	28,956	(4,318)	27,726	5,545	6,098	16,082	282,203
Chester	171,987	40,928	(11,437)	24,509	3,742	5,529	15,239	225,987
Delaware	207,606	5,493	(2,829)	1,103	314	340	449	211,373
Montgomery	299,455	23,736	(4,996)	25,922	4,462	5,868	15,593	344,117
Philadelphia	584,004	8,441	-	-	-	-	-	592,445
PA Subtotal	1,492,891	108,254	(23,581)	79,260	14,063	17,836	47,362	1,656,125
Burlington	163,204	24,604	(3,940)	14,935	3,023	3,374	8,538	198,803
Camden	187,978	6,621	(2,874)	1,114	225	419	470	192,839
Gloucester	98,147	12,755	(2,104)	28,486	4,897	6,447	17,142	137,284
Mercer	130,394	12,142	(3,407)	6,123	1,489	2,296	2,339	145,252
NJ Subtotal	579,723	56,122	(12,325)	50,659	9,633	12,536	28,490	674,179
Total	2,072,614	163,676	(35,906)	129,919	23,696	30,372	75,851	2,330,304

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TABLE B-11. SPRAWL HOUSEHOLD GROWTH, INTRACOUNTY MOVEMENT, AND NEW FOOTPRINT

County	2005 Households	Intracounty Movement	New Footprint	New Footprint Density			2035 Households
				High	Medium	Low	
Bucks	229,839	(74,432)	124,677	12,454	18,706	93,517	280,084
Chester	171,987	(78,654)	137,164	13,722	20,589	102,853	230,497
Delaware	207,606	(39,310)	45,619	13,670	20,536	11,413	213,915
Montgomery	299,455	(56,766)	102,754	10,270	20,559	71,925	345,443
Philadelphia	584,004	(1,228)	-	-	-	-	582,776
PA Subtotal	1,492,891	(250,390)	410,214	50,116	80,390	279,708	1,652,715
Burlington	163,204	(46,034)	83,229	16,826	18,817	47,586	200,399
Camden	187,978	(44,444)	51,440	5,144	10,306	35,990	194,974
Gloucester	98,147	(60,251)	96,742	18,130	48,394	30,218	134,638
Mercer	130,394	(11,420)	28,604	2,856	4,294	21,454	147,578
NJ Subtotal	579,723	(162,149)	260,015	42,956	81,811	135,248	677,589
Total	2,072,614	(412,539)	670,229	93,072	162,201	414,956	2,330,304

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TABLE B-12. RECENTRALIZATION EMPLOYMENT GROWTH, INFILL, AND NEW FOOTPRINT

County	2005 Employment	Infill	New Footprint	2035 Employment
Bucks	277,886	65,507	7,547	350,940
Chester	253,628	174,213	4,482	432,323
Delaware	237,582	(18,375)	6,828	226,035
Montgomery	505,952	99,037	12,447	617,436
Philadelphia	728,054	102,380	-	830,434
PA Subtotal	2,003,102	422,762	31,304	2,457,218
Burlington	214,621	104,214	2,765	321,600
Camden	222,721	(4,639)	5,644	223,726
Gloucester	108,229	85,622	1,894	195,745
Mercer	228,502	27,572	4,342	260,416
NJ Subtotal	774,073	212,769	14,645	1,001,487
Total	2,777,175	635,531	45,949	3,458,655

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TABLE B-13. TREND SCENARIO EMPLOYMENT GROWTH, INFILL, AND NEW FOOTPRINT

County	2005 Employment	Infill	New Footprint	2035 Employment
Bucks	277,886	34,341	30,009	342,236
Chester	253,628	33,376	50,089	337,093
Delaware	237,582	5,670	295	243,547
Montgomery	505,952	34,320	45,158	585,430
Philadelphia	728,054	8,214	-	736,268
PA Subtotal	2,003,102	115,921	125,551	2,244,574
Burlington	214,621	35,128	10,780	260,529
Camden	222,721	1,326	2,635	226,682
Gloucester	108,229	20,691	16,975	145,895
Mercer	228,502	19,641	21,303	269,446
NJ Subtotal	774,073	76,786	51,693	902,552
Total	2,777,175	192,707	177,244	3,147,126

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TABLE B-14. SPRAWL SCENARIO EMPLOYMENT GROWTH, INTRACOUNTY MOVEMENT, AND NEW FOOTPRINT

County	2005 Employment	Intracounty Movement	New Footprint	2035 Employment
Bucks	277,886	(6,684)	79,738	350,940
Chester	253,628	(6,613)	185,308	432,323
Delaware	237,582	(62,525)	50,978	226,035
Montgomery	505,952	(6,683)	118,167	617,436
Philadelphia	728,054	(209,144)	-	518,910
PA Subtotal	2,003,102	(291,558)	434,100	2,145,644
Burlington	214,621	(7,893)	114,872	321,600
Camden	222,721	(53,516)	54,521	223,726
Gloucester	108,229	13,031	74,485	195,745
Mercer	228,502	5,191	26,723	260,416
NJ Subtotal	774,073	(43,187)	270,601	1,001,487
Total	2,777,175	(334,836)	704,792	3,147,131

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C. Analyze Transportation Impacts in DVRPC's Travel Demand Model

Step three of the scenario development process is to analyze the transportation impacts of the different scenarios using DVRPC's Travel Demand Model (TDM). The DVRPC TDM cycles through a four-step model process consisting of trip generation, trip distribution, mode choice, and trip assignment, using the Evan's Algorithm to equilibrate travel patterns and congested highway times.

Travel Demand Model Inputs

TAZ-level socioeconomic inputs for the Sprawl and Recentralization scenarios are estimated by factoring the detailed Board-adopted (Trend) forecasts by the ratio of scenario-to-Trend population for households by auto ownership and employed residents. Scenario employment by Standard Industrial Classification (SIC) code is estimated by factoring the 2035 Trend number by the ratio of TAZ scenario to the Trend scenario total employment. Though not in the DVRPC Board-adopted forecast, all three scenarios assume the currently operating Philadelphia Park and Chester Harrah's Casinos as well as the proposed casinos are built in Philadelphia along the Delaware River.

All three scenarios assume the 2009 transportation network as the basis of the TDM. This network contains the existing highway and transit network, as well as the projects in the Pennsylvania and New Jersey Transportation Improvement Program (TIP) that are expected to be open for operation by the end of 2009. By running the model with the base year network, no assumptions have been made as to which transportation projects will be included in the plan. As a result, the plan can identify where the need for improvements is greatest depending on which scenario is envisioned as being the most desirable and reflective of the region's future. Plan projects can then be chosen to help guide the development towards the desired future scenario.

Travel Demand Model Outputs

The TDM provides estimates for many outputs, including vehicle miles traveled, vehicle trips, speed by functional class, average vehicle occupancy, transit trips, transit passenger miles, transit passenger hours, pedestrian and bike trips, fuel consumption, and emissions. Raw output from the TDM is further refined with a postprocessor. The TDM contains a road network of approximately 18,000 miles in the region. This postprocessor fills in the gap to calculate the final VMT and average roadway speeds, including all roads not in the TDM network.

Other Model Components

DVRPC uses the Mobile 6 model from the Environmental Protection Agency (EPA) to estimate emissions output for each scenario. This model utilizes emissions factors based on the vehicular emissions controls stipulated in the Pennsylvania and New Jersey State Implementation Plans (SIPS).

The bike-walk model component estimates pedestrian and bicycle trips in the trip generation phase of the TDM.

D. Additional Indicator Calculations

In this final step of the scenario analysis, additional indicators are computed using outputs from the from the UPlan and DVRPC TDM models. These indicators include:

- Transit Score by TAZ
- Change in the Number of Households with Transit Access
- Change in the Number of Jobs with Transit Access
- Alternative VMT Estimate
- Annual Vehicle Hours of Delay, Gallons of Wasted Fuel, and Congestion Costs
- Automobile Crashes
- Annual Residential Energy Use
- Annual Household Water Use
- Average Household Carbon Dioxide Emissions
- Average Annual Household Utility and Automobile Expenses
- Jobs Created in Environmental Justice Communities
- Supportive Infrastructure Costs
- Municipal Fiscal Health

Each of the following sections presents the methodology used to compute these additional performance indicators.

Transit Score

DVRPC's Transit Score Tool is a method to assess the appropriateness of various modes and intensities of transit service throughout the DVRPC region. Transit Score calculations also enable quick and easy comparisons and illustrations of the relative transit supportiveness of alternative development scenarios (for example, development under prevailing zoning versus development under a 'smart growth' zoning proposal). The transit score was developed using regression methods. Its equation is:

$$\text{Transit Score}_{TAZ} = 0.41 * PD + 0.09 * ED + 0.74 * ZC$$

Where,
PD = Population Density (per acre)
ED = Job Density (per acre)
ZC = Zero-car Household Density (per acre)

Each score category is associated with particular transit service investments that would be broadly appropriate, depending on other planning considerations (such as trip patterns). Transit modes include heavy-urban rail, light-rail transit, commuter rail, bus rapid transit, bus lanes, bus priority treatment, fixed-route/line haul bus service, express bus, and local circulator bus/shuttle/paratransit. The most densely populated areas, with a transit score of "high," may support heavy urban rail, while nearly all areas, including those with a transit score of "low," may support paratransit and/or a local circulator bus route. The type of transit each score range can theoretically support is shown in Table D-1.

TABLE D-1. TRANSIT SCORE CATEGORIZATION AND SERVICE APPROPRIATENESS

Transit Score	Category	Generally Appropriate Transit Service	Conditionally Appropriate Transit Service
> 7.5	High	Heavy Rail, Light Rail, Commuter Rail, Bus Rapid Transit, Bus Lanes, Bus Priority, Fixed-Route Bus, Express Bus, Local Circulator/Shuttle/Paratransit	-
2.51 – 7.5	Medium-High	Light Rail, Commuter Rail, Bus Rapid Transit, Bus Lanes, Bus Priority, Fixed-Route Bus, Express Bus, Local Circulator/Shuttle/Paratransit	-
1.01 – 2.5	Medium	Fixed-Route Bus, Local Circulator/Shuttle/Paratransit	Light Rail, Commuter Rail, Bus Rapid Transit, Bus Priority, Express Bus
0.6 0 1.0	Marginal	Local Circulator/Shuttle/Paratransit	Commuter Rail, Fixed-Route Bus, Express Bus
> 0.6	Low	Local Circulator/Shuttle/Paratransit	Express Bus

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The top two transit score categories, high and medium-high, are generally considered the most important for transit service, as they indicate rail appropriateness. The scenario indicator for the transit score will focus on these two categories. The transit score for each TAZ is calculated using the projected population, employment, and zero-car household densities.

Transit Access

A TAZ-level analysis is utilized to determine the change in the number of households and jobs with transit access in the region. Only the TAZs with either bus (at three times peak hourly service) or rail are included. This is approximately 1,225 out of 1,914 TAZs. To determine the change in the number of jobs and households with transit access, the 2035 scenario value for each TAZ with transit access was subtracted from its 2005 TAZ value.

Alternate VMT Estimate

The equation the ICLEI model uses to calculate VMT by household is:

$$\text{Annual Household VMT}_{\text{Municipality}} = 32{,}237 * HD^{-0.3135}$$

Where,
HD = Household Density (housing units per acre)

Annual Vehicle Hours of Delay

The Texas Transportation Institute (TTI) determines annual vehicle hours of delay to track congestion in the major urban areas of the United States. Using this indicator as a proxy, it ranks the different urban areas according to which suffer the least impacts due to congestion and which endure the most. The cost of congestion is calculated by associating losses with a dollar amount. Not all costs are directly paid; rather, the cost of congestion can be seen as a hidden tax on drivers. A similar methodology as employed by TTI was used to determine vehicle hours of delay by scenario.[35]

The equation estimates daily vehicle hours of delay using highway and arterial links during the peak period. Recurring delay is considered the difference in peak period VMT divided by peak period speed compared to peak period VMT divided by free-flow speed for the functional class. The equation used to calculate daily recurring hours of delay for freeways is:

$$\text{Daily Freeway Recurring Hours of Delay}_{\text{Scenario}} = FM_P / FS_P - FM_P / 60$$

Where,
FM_P = Peak Period Freeway Miles (daily)
FS_P = Peak Period Freeway Speed

A similar equation is used for arterials:

$$\text{Daily Arterial Recurring Hours of Delay}_{\text{Scenario}} = AM_P / AS_P - AM_P / 35$$

Where,
AM_P = Peak Period Arterial Miles (daily)
AS_P = Peak Period Arterial Speed

Nonrecurring delay is time lost due to crashes and other irregular occurrences that slow traffic on roadways. This is computed as 2.2 hours for each hour of recurring freeway delay and 1.1 hours for each hour of recurring arterial delay.

[35] See Appendix A on methodology from *The 2007 Urban Mobility Report* by the Texas Transportation Institute.

$$\text{Daily Nonrecurring Hours of Delay}_{\text{Scenario}} = \text{FRHD} * 2.2 + \text{ARHD} * 1.1$$

Where,
FRHD = Freeway Recurring Hours of Delay (daily)
ARHD = Arterial Recurring Hours of Delay (daily)

The total daily vehicle hours of delay is found by adding freeway and arterial recurring delay and nonrecurring hours of delay. The result is multiplied by 250 working days to get an annual estimate. Thus:

$$\text{Annual Vehicle Hours of Delay}_{\text{Scenario}} = [\text{FRHD} + \text{ARHD} + \text{NRHD}] * 250$$

Where,
FRHD = Freeway Recurring Hours of Delay (daily)
ARHD = Arterial Recurring Hours of Delay (daily)
NRHD = Nonrecurring Hours of Delay (daily)

To determine annual person hours of delay, average vehicle occupancy in the peak period is multiplied by annual vehicle hours of delay. In the DVRPC region, peak-period vehicle occupancy was determined by the TDM to be 1.18 passengers per vehicle. Annual hours of delay per capita is determined by dividing annual person hours of delay by the region's forecasted 2035 population.

TTI also calculates gallons of wasted fuel due to congestion. To determine this indicator, fuel use under free-flow conditions is estimated and subtracted from fuel use in congestion. Gallons of fuel consumed in free-flow conditions are determined by dividing peak period VMT by average fleet fuel efficiency. The equation for fuel used in congested conditions is:

$$\text{Gallons of Fuel Used in Congestion}_{\text{Scenario}} = \text{VMT}_P / (8.8 + \text{AS}_P/4)$$

Where,
VMT_P = Peak Period Vehicle Miles Traveled in Congestion
AS_P = Peak Period Average Speed for all Functional Classes of Road

Fuel use in free-flow conditions is determined by dividing the total VMT in congested conditions by the regional vehicle fleet's average fuel efficiency. Wasted fuel is found by subtracting the fuel used in congested conditions from the fuel that would have been used in free-flow conditions.

Total congestion costs can be calculated by converting wasted time and fuel into dollar costs. The time and fuel costs for freight are considered separately and at different values from those for individuals. Freight costs are estimated at $84.22 per hour for both time and fuel.[36] Individual time is valued at $15.59 per hour, while fuel wasted is valued at $2.90 per gallon.[37] The resulting equation is:

[36] In the DVRPC region, freight accounts for approximately 9.5 percent of all VMT.
[37] AAA 2008.

$$\text{Annual Congestion Cost}_{Scenario} = (FVMT_P * 84.22) + ((AVMT_P - FVMT_P) * 15.59) + ((WF_A – WF_F) * 2.90)$$

Where,
$FVMT_P$ = Freight Peak Period Vehicle Miles Traveled in Congestion
$AVMT_P$ = All Peak Period Vehicle Miles Traveled in Congestion
WF_A = Wasted Fuel (in gallons) for All Vehicles
WF_F = Wasted Fuel (in gallons) for Freight Vehicles

Automobile Crashes

Future crashes are estimated using 2005 crash rates by functional class. Crash rates are the number of incidents per million vehicle miles traveled. For highways and freeways, the 2005 DVRPC crash rate is 0.73 per million VMT. For arterials, the crash rate is 1.89 per million VMT. And for local roads, the crash rate is 1.00 per million VMT. Multiplying these rates times the number of VMT for each functional class by scenario yields future year crash estimates.

Energy Use and CO_2 Emissions

National figures from the Energy Information Administration (EIA) were used to develop average residential energy consumption. Table D-2 presents the average United States residential energy consumption by urban area type. Electricity is measured either as ‘primary,’ which includes both what is used by a household and the energy needed to create and deliver it; or ‘site,’ which contains only the energy used in a household. The average household energy use analysis is based on site electricity use.

TABLE D-2. AVERAGE ANNUAL U.S. HOUSEHOLD ENERGY BY URBAN/RURAL LOCATION

Type of Energy	City	Town	Suburbs	Rural
Electricity (kWh)[a]	8,858	10,444	12,028	14,190
Natural Gas (cf)	48,858	47,111	52,877	16,872
Fuel Oil (gallons)	25.6	75.1	41.4	89.3
Kerosene (gallons)	0.6	3.1	-	13.2
LPG (gallons)	5.2	40.3	15.4	157.2
Wood (cords)	0.0	0.2	0.1	0.6
Average U.S. Household Energy Use (mmBTU)	85.6	101.7	104.6	107.4
Average Mid-Atlantic Household Energy Use (mmBTU) [b]	96.0	114.1	117.3	120.4

[a] Electricity estimate is based on site (or distributed) use only, and does not include energy used to generate and distribute electricity.
[b] Average energy use adjusted to reflect 12 percent higher use rates in the Mid-Atlantic region compared to the U.S. average.

Source: Energy Information Administration, 2002. See http://www.eia.doe.gov/emeu/recs/recs2001/ce_pdf/enduse/ce1-8c_urbanrural2001.pdf

Table D-3 presents the conversion rates used to determine total energy-use in each scenario in BTUs, which allows total energy use to be directly compared between the scenarios.

TABLE D-3. CONVERSION RATES BETWEEN BTUS AND VARIOUS ENERGY SOURCES

- one gallon of Gasoline has approximately 124,000 Btu
- one kilowatt hour of Electricity (site) contains 3,412 Btu
- one kilowatt hour of Electricity (primary) has 10,338 Btu
- one cubic foot of Natural Gas has 1,031 Btu
- one gallon of Distillate Fuel Oil No. 2 has 138,690 Btu
- one gallon of LPG (propane) has 91,330 Btu
- one gallon of Kerosene has 135,000 Btu
- one cord of Wood has approximately 20,000,000 Btu

Source: US EPA 2004.

The urban area types in Table D-2 match up with the four planning areas in the *Destination 2030* plan, with values for towns used as a proxy for developed communities. In the survey used to prepare the data, judgment was left to the respondent as to what area type they lived in. Average energy use in the mid-Atlantic by urban area type in Table D-2 was multiplied by the total number of households in each *Destination 2030* planning area. The result was then divided by the number of households in the scenario to determine average household energy use. These are preliminary estimates developed using national averages for the purpose of this scenario exercise only. DVRPC is currently working with a consultant to carefully determine all energy consumption in the region. Once complete, these findings will supersede this estimate. Table D-4 shows the average household energy consumption by source for each scenario.

TABLE D-4. AVERAGE ANNUAL DVRPC REGION RESIDENTIAL ENERGY USE BY SCENARIO*

Annual Average Household Consumption	Recentralization	Trend	Sprawl
Electricity (kWh)	10,571	10,742	11,293
Natural Gas (cf)	47,782	47,629	45,851
Fuel Oil (gallons)	51.2	51.4	53.9
Kerosene (gallons)	2.0	2.0	2.7
LPG (gallons)	28.2	29.6	38.8
Wood (cords)	0.1	0.1	0.2
Average Household Energy Use (mmBtu)	109.7	110.5	112.9

* These are preliminary estimates developed using national figures only for the purpose of this scenario exercise. DVRPC is currently working with a consultant to carefully determine all energy consumption in the region. Once complete these findings will supersede this estimate.

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Residential energy CO_2 emissions estimates can be developed using the energy use estimates from above at emission rates in Table D-5.

TABLE D-5. CO_2 EMISSION RATES FOR VARIOUS ENERGY SOURCES

- one gallon of Gasoline emits 0.00969 tons of CO_2.
- in the Pennsylvania, New Jersey, and Maryland (PMJ) region, one megawatt hour of primary electricity emits 0.636 tons of CO_2 on average.
- one gallon of Distillate Fuel Oil (no. 2) emits 0.01107 tons of CO_2.
- one gallon of LPG (propane) emits 0.00635 tons of CO_2.
- one cubic foot of Natural Gas emits 0.00006 tons of CO_2.

Source: US EPA 2004 and US EPA 2007.

Water Use

The International Council on Local Environmental Issues (ICLEI) has developed a model that estimates VMT and water use based on household density. Results from the water-use equation in this model were deemed to be unrealistic. DVRPC developed a similar equation using water-use estimates in *The Cost of Sprawl*.[38] This report estimated that a single-family house at a density of 1.1 units per acre uses 321 gallons of water per day. An attached house with a density of 6.7 units per acre uses 211 gallons of water per day. A multifamily house uses about 163 gallons of water per day. DVRPC estimates multifamily households to be 18.1 units per acre. Using these points, a similar regression equation to the ICLEI model was developed in Microsoft Excel:

$$\text{Daily Household Water Use}_{\text{Municipality}} = 333.09 * HD^{-1.0138}$$

Where,
HD = Household Density (per acre)

Household Expenditures

Annual automobile expenses are estimated at approximately $0.60 per mile multiplied by the average VMT per household for each scenario. These costs include insurance, fuel, purchase, interest payments, maintenance, and all costs associated with ownership. Electricity cost is estimated at $0.1078 per kilowatt hour in Pennsylvania and $0.1416 in New Jersey.[39] Electricity costs are multiplied by annual kilowatt hours used by the average household in each scenario. Natural gas costs are estimated to be $15.94 per 1,000 cubic

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[38] TCRP 2002.
[39] EIA price is based on average residential price for 2008, see http://www.eia.doe.gov/cneaf/electricity/epm/table5_6_b.html.

feet in Pennsylvania and $21.28 per 1,000 cubic feet in New Jersey.[40] These natural gas costs are divided by 1,000 and multiplied by the average number of cubic feet used per household for each scenario. Distillate Fuel oil number 2 is the most commonly used residential fuel oil in the region. Its costs are estimated to be $4.28 per gallon in New Jersey and 4.17 per gallon in Pennsylvania.[41] Fuel oil costs are multiplied by the average number of gallons used per household for each scenario. Propane costs are estimated to be $3.40 per gallon in New Jersey and 3.00 per gallon in Pennsylvania. Propane costs are multiplied by the average number of yearly gallons used per household by scenario.[42] Water costs are estimated to be $0.0029 per gallon multiplied by the average number of gallons used annually per household for each scenario.[43]

Environmental Justice

A TAZ-level analysis similar to the household and job transit access is used to determine how many jobs were created or lost in Environmental Justice (EJ) communities. The EJ communities match up very well with the TAZs at the census tract level. For EJ communities, the number of jobs added or lost by scenario is determined by subtracting 2035 employment from 2005 employment.

Supportive Infrastructure

Density, building type, and location affect the cost and amount of new local roads, schools, water and sewer required for each scenario. The first step in the supportive infrastructure analysis is to determine the number of new households by type, planning area, and location for each scenario. The UPlan model output indicated the number of new footprint households. In step one of the scenario process, infill housing units are determined.

Destination 2030 identifies future growth areas in its land use plan. These represent areas that are already served by sewer infrastructure. Development located in these areas will be less expensive because there is no need to extend or build new infrastructure. A GIS analysis of the UPlan output is used to determine new footprint households located in future growth

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[40] EIA, based on residential price for June 2008. See http://tonto.eia.doe.gov/dnav/ng/ng_pri_sum_a_EPG0_PRS_DMcf_a.htm.
[41] EIA based on June 2008 retail price, see http://tonto.eia.doe.gov/dnav/pet/pet_pri_dist_a_EPD2_PTC_cpgal_m.htm.
[42] EIA prices based on residential price in March 2008, see www.**eia**.doe.gov/pub/oil_gas/petroleum/data_publications/weekly_petroleum_status_report/current/pdf/tablec3.pdf.
[43] Philadelphia Water Department, price is based on $21.80 for first 2,000 cubic feet of water use per month. Average household use is less than 1,000 cubic feet per month in all three scenarios. see http://www.phila.gov/water/your_H2O_Bill.html.

areas in the Trend and Sprawl scenarios. New footprint housing units were restricted to growth areas in the Recentralization scenario. The cost for sewer development varies as to whether there is existing infrastructure (developed area) or not (undeveloped area). All infill and future growth area housing units for each scenario are considered to be in developed areas, while all new footprint units outside of future growth areas are in undeveloped areas (see Table D-6).

Although each scenario accommodates roughly the same number of new households, the Trend and Sprawl scenarios result in the building of additional housing units. This is because the assumed outward movement of these scenarios will leave a number of vacant units behind.

TABLE D-6. NEW HOUSING UNIT LOCATIONS BY SCENARIO

Infill / New Footprint Location	Recentralization	Trend	Sprawl
New Footprint Nongrowth Area	-	72,059	387,354
New Footprint Growth Area	32,721	57,317	282,855
Infill	224,957	163,676	-
Total	257,678	293,052	670,209
Percent of Housing Units in Developed Areas	100%	75%	42%

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The final distinction is community type. Households in rural areas and growing suburbs are considered rural and suburban, respectively, while households in developed communities or core cities are considered urban. Community type is also used to determine the density type of the original infill households. Infill in rural and suburban municipalities is medium-density and urban infill is high-density. All new footprint households are categorized into high-, medium-, and low-density in UPlan.

Sewer and water costs are calculated by multiplying each new unit by the cost associated with developed or undeveloped area, density, and rural, suburban, or urban location. Table D-7 indicates the estimated sewer cost per household.

TABLE D-7. NEW HOUSING UNIT SEWER COSTS (IN 2008 $S)

	Developed Area			Undeveloped Area		
Density	Urban	Suburban	Rural	Urban	Suburban	Rural
Low-Density	$ 8,285	$ 8,867	$ 10,489	$ 9,754	$ 10,768	$ 12,161
Medium-Density	$ 6,937	$ 6,942	$ 8,373	$ 7,639	$ 8,577	$ 10,599
High-Density	$ 4,890	$ 5,574	$ 6,784	$ 5,963	$ 6,967	$ 8,697

Source: TCRP 2002.

Each municipality's schools are assumed to be at capacity in the scenario analysis. Thus, every new student added to the municipality will require the equivalent expense of constructing new school facilities per student. In 2006, about 17.7 percent of the population in the DVRPC region was between the ages of 5-18.[44] 17.7 percent of the average regional household size of 2.66 yields 0.47 school-aged children per new household. For each household added to a municipality, the cost for new school facilities is estimated to be $9,302 per household in rural and suburban areas and $10,581 per household in urban areas.[45].

The ICLEI density-VMT model calculates new lane miles of local roads needed in each scenario. The equation used by this model is:

$$\text{New Local Road Lane Miles}_{\text{Municipality}} = (0.1 / \text{NFHD}) * \text{NFHU}$$

Where,
NFHD = New Footprint Household Density (units per acre)
NFHU = Number of New Footprint Housing Units

Table D-8 shows the estimated new footprint and infill local road lane miles by scenario.

TABLE D-8. SUPPORTIVE INFRASTRUCTURE COSTS FOR NEW HOUSEHOLDS BY SCENARIO

Scenario	New Footprint Local Road Lane Miles	Infill Local Road Lane Miles
Recentralization	420	4,631
Trend	3,156	8,337
Sprawl	38,852	0

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Costs for new footprint and infill local road lane miles vary by urban, suburban, and rural locations. PennDOT has provided an estimate of $725,000 per lane mile for local roads. This is used as the base estimate for suburban areas, with higher costs for urban locations and lower costs for rural locations. Infill expenses are estimated to be 70 percent of new footprint. This is because infill construction will not always necessitate any improvements, or could include road improvements without widening. The full tally of road costs is calculated as follows:

[44] American Community Survey 2006.
[45] National Clearinghouse for Educational Facilities 2005.

$$\text{New Road Cost}_{\text{Scenario}} = RN * (\$362{,}500) + RI * (\$252{,}000) + SN * (\$725{,}000) + SI * (\$504{,}000) + UN * (\$1{,}087{,}500) + UI * (\$756{,}000)$$

Where,
RN = Rural New Footprint Lane Miles
RI = Rural Infill Lane Miles
SN = Suburban New Footprint Lane Miles
SI = Suburban Infill Lane Miles
UN = Urban New Footprint Lane Miles
UI = Urban Infill Lane Miles

The sum of all new road, school and water costs are added together to determine total supportive infrastructure cost for each scenario.

Municipal Fiscal Health

Estimating future municipal fiscal health is a considerable study on its own. Attempts to estimate future municipal fiscal health were made by examining revenues, expenditures, and debt using data acquired for 240 out of 353 municipalities in the region. Efforts to estimate future municipal revenues and expenditures were done using a multitude of factors, such as acres of development, density, population and employment increases, water use, new local road lane miles, and vehicle ownership. Ultimately, these attempts were deemed unsatisfactory. A multitude of complex factors go into how fiscally healthy a community is, making future estimates difficult to compute in a simple fashion. The PEL study, *Structuring Healthy Communities*, found that only 12 percent of the change in fiscal health can be attributed to population change.

Among the problems with developing municipal fiscal health indicators using the data developed in the scenario exercise were that they could not estimate how increased development in rural areas and growing suburbs would impact expenditures as needs arise for additional services. Also, it was unable to consider how expenditure cuts in developed areas must either be raised per capita or per job as employment and population decreases, or cuts in services must be made to reflect lower revenues. Finally, existing tax rates are higher in the older, urban areas of the region, with higher per-capita spending. These areas are more likely to have existing debt as well. The Recentralization scenario assumes individuals and jobs are returning to these areas for a multitude of reasons, including financial ones. Such a return could be as a result of change in tax structures, or in market conditions, such as increasing energy prices, making core areas more desirable.

E. Glossary

Allocation Area – In UPlan this is the total land area to absorb new footprint development (sum of wooded vacant and agriculture after removing masks).

Attractor – A factor in UPlan that acts as a magnet for development types; may affect development types to a greater or lesser degree.

Connections – The update to the *Destination 2030* Plan for the years from 2010 to 2035, which the What-If Scenarios help to guide.

Destination 2030 **(2030 Plan)** – The current long-range plan for the nine-county DVRPC region. The plan details policies, projects, and implementation agendas related to both land use and transportation planning, and serves as the basis for the transportation improvement program (TIP).

Detractor – A factor in UPlan that acts as a discouragement for development types; similar to attractor.

Environmental Justice - Title VI of the Civil Rights Act of 1964 and the 1994 President's Executive Order on Environmental Justice (#12898) state that no person or group shall be excluded from participation in, or denied the benefits of, any program or activity utilizing federal funds. Each federal agency is required to identify any disproportionately high and adverse health or environmental effects of its programs on minority populations and low-income populations. As a Metropolitan Planning Organizations (MPO), DVRPC must evaluate the agency's plans and programs for environmental justice (EJ) sensitivity and expand any outreach efforts to low-income, minority, and other disadvantaged populations.

Global Climate Change – This is the effect of greenhouse gas emissions into the atmosphere trapping solar radiation in the earth's atmosphere causing variation in global weather patterns and potentially melting polar ice caps resulting in a rise in sea levels.

Globalization - In the economic sense, this is the integration of national economies around the world into a highly interconnected international economy through increased trade and investment.

Infill – In this scenario exercise this is the redevelopment of existing buildings or vacant, previously built-on parcels, at higher density.

Intracounty Movement – This represents individuals who move from core cities or developed communities to growing suburbs or rural areas in either the Trend or Sprawl scenarios.

Mask – Used in UPlan to exclude areas from development allocation (water, preserved open space, etc.).

Municipalities – refers to the 353 units of local government in the DVRPC region, including cities, boroughs, and townships. In the Census and other DVRPC literature these are also known as minor civil divisions (MCDs).

Peak Oil - refers to the point in time when global oil production can no longer be increased to meet growing global demands, resulting in shrinking oil availability each year.

Peak Period – The time during the work week in which demand for roadway access is the greatest, i.e. rush hour. This is the time of day when virtually all congestion occurs. In the DVRPC region this is considered to occur from 7 A.M. and 9 A.M. in the morning and 4 P.M. and 7 P.M. in the evening.

Planning Area – one of four municipality types (core city, developed community, growing suburb, or rural area) defined for each municipality in the DVRPC region in the *Destination 2030* Plan.

Travel Demand Model (TDM) – Estimates transportation demand at the TAZ level using inputs for population, jobs, employed residents, vehicles, and zero-, one-, two-, and three-plus-vehicle households. The model uses a four-step process of trip generation, trip distribution, mode choice, and trip assignment to determine regional forecasts for vehicle miles traveled; vehicle trips; speed by functional class; average vehicle occupancy; transit trips; transit passenger miles; transit passenger hours; etc.

Traffic Analysis Zone (TAZ) – These are roughly the equivalent of census tracts, with some larger areas further disaggregated into census blocks. They are used as the basis for estimating transportation demand in the TDM.

Transportation Improvement Program (TIP) - The TIP is the regionally agreed upon list of priority projects, as required by federal law (ISTEA, TEA-21, SAFETEA LU). The TIP document lists all projects that intend to use federal funds, regionally significant non-federally funded projects, and DVRPC includes all other state-funded capital projects. The projects listed on the TIP are multimodal: bicycle, pedestrian, freight-related, air-quality projects, as well as the more traditional highway and public transit projects.

UPlan – A GIS-based land use planning and forecasting model with an embedded transportation/land use interface.

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Making the Land Use Connection: Regional What-If Scenario Analysis

Publication No.: 08059

Date Published: September 2008

Geographic Area Covered

The nine-county Delaware Valley Regional Planning Commission area which covers the counties of Bucks, Chester, Delaware, Montgomery, and Philadelphia in Pennsylvania and Burlington, Camden, Gloucester, and Mercer in New Jersey.

Key Words

Scenarios; what-if analysis; recentralization; trend; sprawl; land use; transportation; environment; economic development; *Connections*; planning areas; forecasts; 2035.

Abstract

This report examines three disparate future land use scenarios: Recentralization, Trend, and Sprawl. The Recentralization scenario locates future population and employment growth in the region's core cities and developed communities. The Trend scenario is based on the Board-adopted population and employment forecasts. The Sprawl scenario moves existing population and employment from core cities and developed communities and relocates them along with future growth in growing suburbs and rural areas. The scenarios are analyzed for their impacts on land use, transportation, the environment and economic development in the DVRPC region through the year 2035. The document also summarizes the assumptions and methodology employed to develop the scenarios.

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