Using Age Structure to Create Projections of Vehicle Miles of Travel in Rhode Island

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Abstract

This study investigated the relationship between demographic variables, specifically age and gender, and travel demand in Rhode Island. The data sources were the Census Bureau and the Nationwide Personal Transportation Survey (NPTS). Annual vehicle miles of travel (VMT) per driver was used as a measure of travel demand. The goal of the study was to assess the importance of incorporating age and gender into projections of greenhouse gases resulting from future personal vehicle use. I created projections of future VMT in Rhode Island through 2025, varying assumptions about population growth and change in VMT per driver, and either incorporating age structure or using only aggregate population. Values of VMT/driver in 1995, as well as the direction and magnitude of historical trends of VMT/driver, differed by age and gender. The range of travel demand projected for Rhode Island for 2025 was 8 to 12 billion vehicle miles of travel (compared to 7.9 billion in 2000). In projections where VMT/driver was held constant at 1995 levels, including age structure did not affect the outcome; however, when VMT/driver was assumed to grow according to past trends, age structure affected results substantially. The effect of including age structure was to increase projected VMT for Rhode Island as a whole by as much as 400 million VMT annually in 2025. There was also a marked difference between the projections I created and ones constructed by Tellus for the Rhode Island Greenhouse Gas Process. This study highlighted the importance of making well-founded assumptions in travel demand modeling, particularly about how VMT/driver will change over time. It also indicated that, if VMT/driver follows different trajectories of change for different age groups, including age structure may improve the accuracy of baseline travel demand projections for Rhode Island.

Question

How might changes in Rhode Island's age structure over the next 20 to 30 years affect greenhouse gas (GHG) emissions from the transportation sector? To answer this question I will first need to address several other questions:

- How can personal transportation information on a national level from the Nationwide Personal Transportation Survey be made applicable to Rhode Island? This involves identifying and standardizing for variables such as urban/rural location and household income that may affect age specific VMT and differ between RI and the US.
- Which consequences of age structure change are likely to matter the most to travel demand: changes in numbers of people of different ages, or changes in household type (defined by size of household and age of household head) driven by aging? In other words, what specific variable should be used to represent demographic change?
- Is the travel behavior (VMT/driver) different for different age and gender groups? Have these groups undergone different trends over time?
- Have cohort effects influenced travel demand in the past 30 years, are they likely to be important in the future, and if so how should projections account for them?
- How can future travel demand be modeled as a function of demographic structure? There are many degrees to which demographic data can be incorporated into projections of future VMT and I will have to determine which projections make the most sense.
- Finally, do projections of future VMT and GHG emissions made incorporating demographic data differ significantly from those made by Tellus Inc., which are

based on data from NEMS, the EIA, and REMI? If so, does this difference have any policy applications?

Background

In order to understand the context for my thesis question, it is helpful to have a bit of background knowledge in the following areas: travel demand modeling, the potential influence of demographic variables on travel demand, the greenhouse gas/climate change issue, both in general and as it relates specifically to Rhode Island; and an overview of the main sources of greenhouse gas (GHG) emissions in Rhode Island, including the role of transportation and currently available projections.

Travel Demand Modeling

Travel demand is the demand (in the economic sense) for movement of people and goods between different points. It is usually measured in trips, vehicle miles of travel (VMT) or person miles of travel (PMT). VMT is the number of miles a vehicle travels in a given period of time, whereas PMT is the number of miles a person travels in a given period of time. So, if you and two friends took a 100-mile long trip, this would add up to 300 person miles of travel but only 100 vehicle miles of travel.

Travel-demand modeling means creating projections of future VMT, PMT, or trips based on currently available data. People make all sorts of decisions that affect their travel behavior. These include short-term travel decisions (purpose, frequency, timing, destination, and mode of trips), long-term decisions about home and work location and car ownership, and decisions about travel-related activities such as work, shopping and recreation (Domenich and McFadden 1975). In recent years, the negative consequences of high levels of automobile use, such as highway congestion, criteria air pollution and carbon dioxide emissions, have become more apparent. The goal of travel demand modeling is to understand what factors affect travel demand in order to define trends, predict future demand, and reduce demand or channel it into less harmful paths (such as increasing travel at off-peak times, carpooling, walking, biking and using mass transit).

Travel demand studies usually attempt to develop a mathematical model for predicting travel demand based on other factors. These models have different goals, ranging from an academic understanding of the factors affecting travel demand to developing an economically efficient tool that can be used in local transportation planning. Myriad travel demand models exist, many of them much more complicated than the one I developed in my thesis. However, in order to put this work in its proper context, it is helpful to have some background knowledge of travel demand modeling.

Models of travel demand range from very simple to highly complex. The most basic travel demand model, which still requires a great deal of data collection and analysis, is to predict future travel demand based on a linear trend in past travel demand (Dyer 1999). A step up from this is to predict it based on one or several variables with which it has been strongly correlated in the past. Examples of such variables are total population, number of households, or GDP. These variables can be very aggregated (for example, total population of the United States), or disaggregated into smaller groups.

Other models focus not on aggregate VMT but on individual trips. The simplest of these more complicated travel demand models is the four-stage model. It is called the four-stage model because it uses trip generation, trip distribution, modal split, and assignment to predict travel demand. In other words, the questions asked by this model are: How many travel movements will be made? Where will they go? By what mode will the travel be carried out? And, what route will be taken? The four-stage model is the most widely used travel demand model for regional transportation planning (Hensher and Button 2000), and it can be modified to fit the needs and data availability of the modeler.

Other approaches to travel demand modeling are the activity-based approach, approaches based on the multinomial logit statistical method, discrete choice analysis, duration modeling, and dynamic traffic assignment models. The activity approach recognizes the fact that people travel in order to participate in activities at various locations, rather than because of a direct demand for travel. Because of this, it models activities and how they create travel demand. Multinomial logit is a statistical model used for situations with different possible outcomes. In the case of transportation, outcomes would be different combinations of where, when and how to travel. Duration modeling is similar to the hazard-based models used in biometrics and industrial engineering. Finally, dynamic traffic assignment models focus on flows in the traffic network rather than individual transportation choices (Hensher and Button 2000).

Rhode Island Statewide Planning currently uses a forecasting program called Transcat, which relies upon the four-stage method to project travel demand. Transcat takes into account population density, location of jobs, and local income levels, but no other demographic variables (George Johnson, personal communication, 12/18/01). For the Greenhouse Gas Process, VMT (and the resultant GHG emissions) for light-duty passenger vehicles are being projected using regional data on PMT/person from NEMS, fuel use data for Rhode Island from the EIA, and population projections from REMI (Charlie Heaps, personal communication).

Greenhouse Gases and Global Climate Change

The greenhouse effect refers to the warming of the earth as a result of the presence of certain gases (mainly carbon dioxide, methane, and water vapor) in the atmosphere. These gases act in much the same way a greenhouse would, allowing sunlight to enter, but trapping the heat that the earth emits after it absorbs solar radiation. Without greenhouse gases in the atmosphere, the earth would be too cold to support life. However, human activities, such as fossil fuel combustion and deforestation, are raising the concentrations of greenhouse gases quickly, and these rising concentrations are correlated with an increase in global temperatures. Although much uncertainty surrounds the issue, many people see the reduction of greenhouse gas emissions as an important environmental goal.

Global warming has been addressed at many governmental levels. In 1992, 165 nations signed the Framework Convention on Climate Change (FCCC), which called for the "stabilization of GHG concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system." This convention has now been signed by 175 countries, and it legally entered into force in 1994. The Kyoto Protocol was signed by representatives of over 150 governments in 1997. It provides specific goals for emission reduction for each industrialized country and envisions a system which allocates tradable emissions permits to different nations (http://www.epa.gov/globalwarming/publications/emissions/us2001/index.html). The Kyoto Protocol has been ratified by many developing countries, but not by any industrialized countries except for Romania (http://unfccc.int/resource/kpstats.pdf).

The United States has national goals for energy efficiency and GHG reduction. In addition, many state and local governments in the US have taken the initiative to formulate and implement GHG reduction policies on a smaller scale. In Rhode Island, the Rhode Island Greenhouse Gas process, spearheaded by the Department of Environmental Management (DEM), is addressing GHG emissions. This process began with the Greenhouse Gas Inventory, which was completed by Brown University in 2001. It now includes a stakeholder committee and three working groups: transportation and land use, buildings and facilities, and energy supply/solid waste (www.raabassociates.org). Each of these groups met over the course of the year to decide on a prioritized portfolio of greenhouse gas reduction strategies. The stakeholder process is structured to represent all major stakeholders with a vested interested in implementing these strategies.

The overarching goal of the Greenhouse Gas Process is to create a Greenhouse Gas Action Plan for the state of Rhode Island. Specific strategies in the plan may go to the state legislature for approval, or the plan may become an element of the State Guide Plan in the future. State legislators and/or the governor may also endorse the plan once it is completed, although it does not necessarily follow that they will implement the strategies in it (Ana Baptista, personal communication, 4/24/02).

The DEM hired Jonathan Raab of Raab Associates as the primary consultant and facilitator for the Greenhouse Gas Process. Raab subcontracted Tellus, Inc., a Boston-based environmental consulting firm, to conduct modeling and technical analysis of strategies (Ana Baptista, personal communication). Tellus constructed a baseline scenario depicting how Rhode Island's GHG emissions would change in the absence of any specific policy changes; compiled a list of possible mitigation policies; and estimated the effects of the different policies relative to the baseline scenario. To do this, Tellus used the Long-Range Energy Alternatives Planning (LEAP). In the LEAP model, Rhode Island's population growth was modeled using the Regional Economic Models, Inc. (REMI) model suggested by stakeholder Gary L. Ciminero. Travel demand was estimated by multiplying the population projection for a given year by an estimate of PMT/person for that year. The estimate of PMT/person came from the NEMS, and the numbers in the baseline scenario reflect trends in NEMS. The data from NEMS is on the regional level, so Rhode Island is included with the Northeast Region. In order to account for differences between Rhode Island and the Northeast Region as a whole, the figures for PMT/person were calibrated to the known fuel use for Rhode Island from the EIA (Charlie Heaps, personal communication, 4/29/02).

The transportation sector is a major source of greenhouse gas emissions in Rhode Island (Rhode Island Greenhouse Gas Inventory http://www.brown.edu/Research/EnvStudies_Theses/GHG/index.shtml). The largest source of GHG emissions in Rhode Island is electric utilities, comprising 37% of total emissions in 1996. Transportation, the second largest contributor, accounted for 28% of all fossil fuel emissions. Almost all of these emissions were CO_2 . Motor vehicles also emit two other greenhouse gases, nitrous oxide and methane, in smaller amounts than CO_2. In addition, the high and increasing level of automobile use in RI has other social costs such as highway congestion and criteria air pollutants.

Demographic Analysis

Demographic variables describe different characteristics of people, including, but not limited to, age, race, gender, and marital status. Three basic types of demographic effects related to age are age effects, period effects, and cohort effects. Age effects, for example, a child's grade level in school, are specifically correlated with a person's age. Period effects are things that affect people who are alive during a given period of time, for example, all people who lived through World War Two. Finally, cohort effects are age and period effects combined. A cohort is a group of people born during a given period of time and sharing certain characteristics. To continue with the World War Two example, a cohort would be the group of all soldiers who served in World War Two. All these people would have been roughly the same age at the same time. Something that affected this cohort of World War Two soldiers was the Baby Boom. After returning from the war, the soldiers and their wives had children more quickly than they would have otherwise, in order to make up for lost time (Fienberg and Mason 1985).

Behavior that varies with age can be explained as being determined either by age directly, or by cohort. These two types of explanations of age related behavior would have different implications for future behavior trends. Age structure is the distribution of a population among different age groups. Because people are constantly moving from one age group to the next, the overall age structure can change over time. The effects of demographic changes are often delayed in time; for example, increases in housing demand occur 30-40 years after an increase in the birth rate because usually people in their 30s are the ones buying houses.

People of different age groups have different patterns of behavior in a variety of areas. This seemingly obvious fact can have important implications for predicting the environmental impacts of behaviors like driving. For example, it would make a difference whether the age group that has the highest impact is expected to increase or decrease relative to other age groups.

In some cases, the cohort effect can explain changes in age- and gender-specific transportation demand. For example, older women today drive much less than males of the same age, perhaps because of the conditions under which they grew up. As baby boom women age, their travel behavior is expected to be more like their fathers' than their mothers' (Spain 1997). This observation, combined with women's relatively long life expectancy, means that the contribution to overall VMT from older women will probably be higher in the future than it is now. Although the "greying" of the population will surely impact aggregate consumption patterns and energy use, it is difficult to tell what exactly this impact will be, and, in particular, how important of a role the cohort effect will play.

Age structure may impact energy consumption more in the future than it does now for two reasons: first, decreasing fertility and increasing life expectancy have led to a general aging of the population; and second, residential, service, leisure activities and personal consumption are making up an increasing percentage of energy use (Buttner and Grubler 1995). These activities and consumption patterns vary with age. Car ownership and usage rates, which both vary considerably with age, have made a particularly strong contribution to energy use. For example, between 1969 and 1995, car ownership increased by 143%, to 670 cars per 1000 people, which is the highest car ownership rate of any nation. This is especially significant since car ownership is the strongest indicator of subsequent modal choice (Pucher et al. 1998).

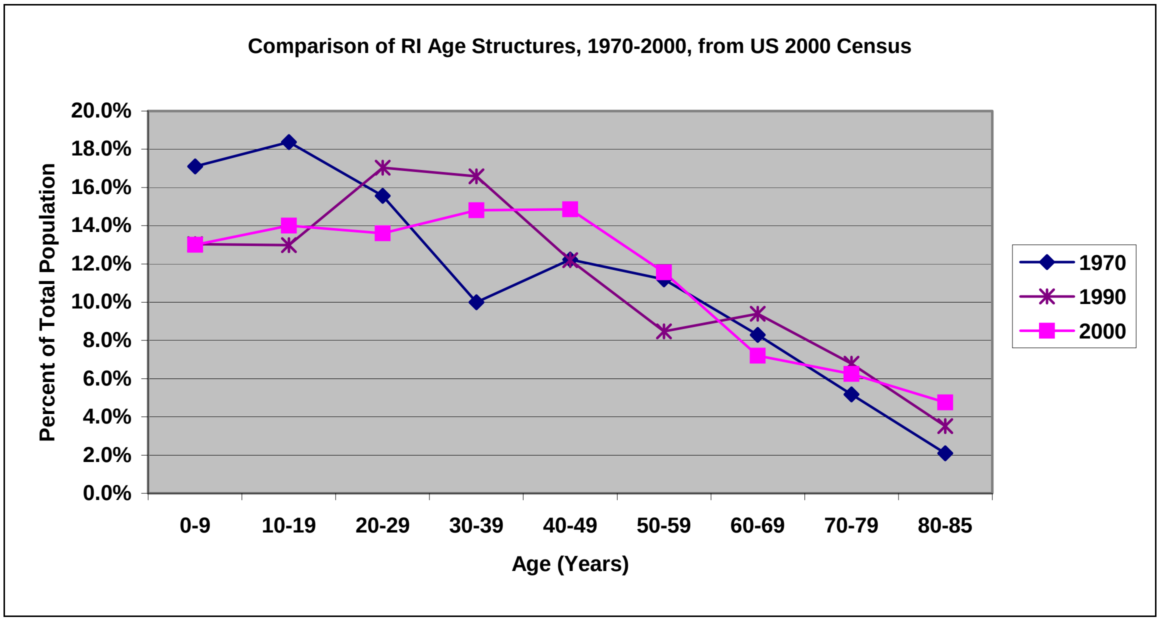
A pertinent example of using age structure to understand environmentally harmful behavior is Thomas Bolioli's thesis, The Population Dynamics Behind Sprawl. Bolioli determined that, in some decades, urban-rural migration in RI has been more a result of changes in age structure than in changes in age-specific housing preference. Urban to rural migration, like vehicle miles of travel, is an indicator of sprawl. Travel behavior has been found to vary significantly with gender and age (Pucher et al. 1998). In addition, family life cycle (married or single, presence and age of children in the home) influenced gasoline consumption (Greening et al. 1995), and per-capita gasoline consumption was related to the degree of centralization of the urban area in which people lived.

In past years, both the value of per capita VMT and the direction an magnitude of changes over time have varied by age group. For example, between 1990 and 1995, older men and women between 20 and 64 have experienced the greatest increase in per capita VMT, while the per capita VMT of teenage drivers of both genders decreased (Pickrell and Schimek 1999).

Rhode Island's age structure is generally similar to that of the United States except that a larger proportion of its population is elderly. If an age structure is stable, this means that the distribution of people among different age groups will remain the same as long as current age-specific birth and death rates continue. However, the age structures of Rhode Island and the United States are not stable, so the proportions of people in different age groups will change over time. As Bolioli showed in his thesis, this can lead to changes in overall behavior that stem not from changes in the way people of a given age behave, but from changes in how many people there are in the various age groups.

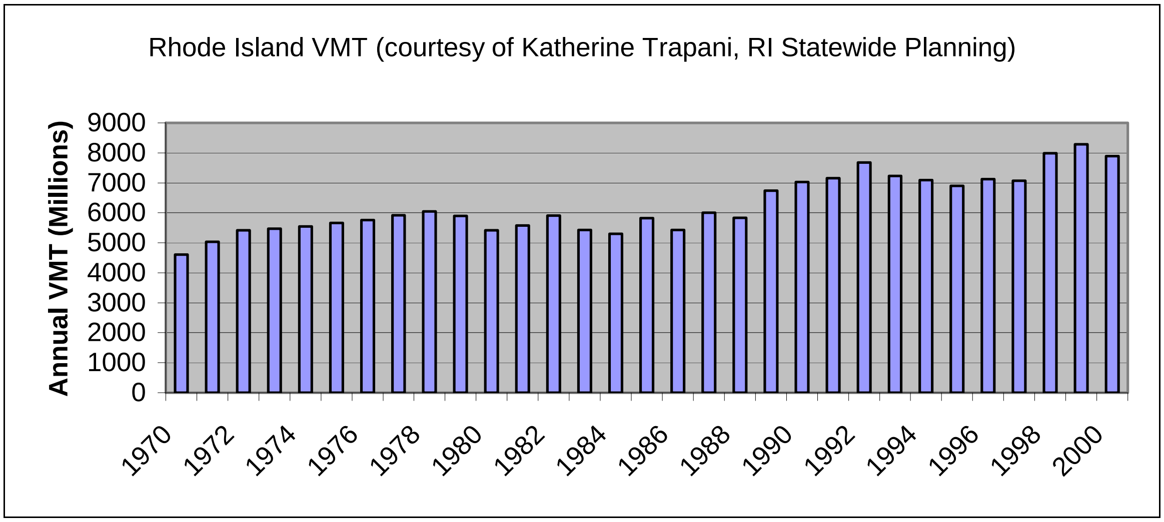
The age structure of RI has changed significantly in the past 30 years, and it is projected to continue changing in the future. The biggest change is the aging of the population. As time progresses, a higher percentage of the population is in higher age classes. In particular, the large cohort of baby boomers is aging. In general, older people drive less than younger ones. However, older people today drive more than they did in the past, which makes it hard to say what exactly the impact of an aging population on VMT would be (Pickrell and Schimek 1999).

FIGURE 1



Travel demand in Rhode Island has increased dramatically, if not always steadily, in the past 30 years. In particular, VMT have increased at a much faster rate than has the population. According to the Federal Highway Administration's Highway Statistics, Table VM-2 (2000), the estimated yearly vehicle miles of travel (VMT) has increased from 4602 million in 1970 to 8283 million in 1999. This is an average increase of 6.2% per year. Over the same period of time, the population of RI increased from 949,723 in 1970 to 1,048,319 in 2000, which amounts to an increase of .33% per year (http://www.planning.state.ri.us/Census/PDF%20Files/county/State.PDF). Clearly, there is more to the increase in travel demand than population growth alone.

FIGURE 2: GROWTH IN TOTAL RI VMT, 1970-2000



Methods

Before discussing my methods, I would like to present three topics related to methodology. These are the Nationwide Personal Transportation Survey, the choice of demographic variable, and the Long-Range Energy Alternatives Planning (LEAP) model. I will first explain what these three things are and why they are important, and then briefly discuss the methods I will use to address my thesis question.

The Nationwide Personal Transportation Survey (NPTS)

The Nationwide Personal Transportation Survey (NPTS) (http://www-cta.ornl.gov/npts/1995/courseware/ug.html#contents) is a database containing information on the personal transportation patterns of Americans. It was administered in 1969, 1977, 1983, 1990 and 1995. The methodology of the NPTS has changed somewhat over time; however, others have used past years of the NPTS to discern long-term travel trends (Pickrell and Schimek 1999). The NPTS collects data on trip purpose, means of transportation used, travel time, time of day the trip took place, number of people in the vehicle, driver characteristics, and vehicle attributes for all trips, all modes, all purposes, all trip lengths, and all areas of the country, urban and rural. The NPTS can be used to quantify travel behavior, analyze changes in travel trends over time, relate travel behavior to the demographics of the traveler, look at the relationship between demographics and travel over time, and look at the relationship of travel and land use. NPTS data can be accessed online by writing queries, which are then answered as tables or charts.

The NPTS surveys only civilian, non-institutionalized residents of the United States. It does not include military personnel living on base overseas or residents of group quarters such as nursing homes, assisted-living facilities, college dormitories, long-term medical institutions, and prisons.

The 1995 NPTS relies on three main data collection methods: a household interview, person interviews for as many household members as possible, and odometer readings collected from each vehicle in a household at two points in time. Households were selected based on randomly chosen telephone numbers. The household interview consisted of calling each of these randomly selected numbers to ascertain that it was in fact a household, and then finding out the number of household members, the vehicles available to be driven by household members, and the mailing address to which to send the travel diaries. The household interview was conducted once per household.

Person interviews were conducted once with each household member 5 years of age or older, with an adult reporting the travel of those between 5 and 13 years of age. During the person interview, the interviewer collected travel day data, long trip data for the two-week travel period, information about worker status and commuting to work, information about mass transit use, and an assessment of how satisfied each household member was with the transportation system. In order for the household to be suitable for inclusion in the study, at least half of household adults over 18 years of age had to be interviewed.

The third method of data collection was odometer readings taken on each household vehicle. Two readings were taken per vehicle: one around the time of the person interviews and the second two to six months later. These readings allowed the researchers to get a more accurate view of aggregate automobile travel per household vehicle.

The methods of data collection for the NPTS varied over the years. The Census Bureau conducted the 1969, 1977, and 1983 NPTS's. The first NPTS survey was based on a multi-stage probability survey of housing units located in 235 sample areas, which were spread out among all 50 states and the District of Columbia. Census Bureau Personnel conducted interviews in 15,000 households. The 1977 NPTS used essentially the same sampling methodology as its predecessor, except that data was collected from 18,000 households, the questionnaire was expanded to address a greater variety of issues, and the survey included other personal vehicles (vans, trucks, campers, motorcycles and mopeds) in addition to automobiles. The 1983 NPTS had a smaller sample size of nearly 6,500 households. All of the first three NPTS surveys used face-to-face interviews to collect data.

The Research Triangle Institute (RTI) took over the NPTS in 1990. It employed computer-assisted telephone interviewing (CATI) technology, which was a significant change from face-to-face interviews. Other important changes in methodology included the use of random-digit dialing sampling procedures, greater use of proxy respondents, and an increase in the allowable window of time for interviewing participants about their travel from four to six days. The 1990 National sample covered 18,000 households;

in addition, one state and two metropolitan planning organizations purchased additional interviews in their area, which added over 4,000 other households to the survey.

Prior to conducting the actual 1995 NPTS, RTI conducted a pretest to assess the efficacy of different methods. As a result of this pretest, RTI decided to notify selected households by mail before interviewing them; to collect more detailed information about household location; to collect paired odometer readings for sample vehicles, and to use a household roster of trips. The 1995 NPTS, which was my main data source, consisted of data collected during the time period May 1995 through July 1996. Overall, 42,033 households were surveyed. Half of the households were part of the national sample, and the other half were specially commissioned by New York State; the Commonwealth of Massachusetts; Oklahoma City, OK; Tulsa, OK; and Seattle, WA. The national sample does not have a large enough sample size to provide accurate data on the state level because the data for each state is likely to be clustered and not representative (1995 NPTS User's Guide).

Although the methods employed by the NPTS have evolved over the years, the measurement of VMT per driver has been consistent. Therefore, it seemed reasonable to use past data on VMT per driver to identify trends and create projections.

Choice of Demographic Variable

In planning this study, I faced a major choice about which demographic variable I should try to correlate with transportation demand. The two types of demographic variables I considered were age group and household type. Age group is a relatively straightforward variable. Much information is available about the age structure of

Rhode Island from the Bureau of the Census, and it is also possible to get person-level data on age and transportation behavior from the NPTS. The drawback of using age structure is that people live in households, and the type of household they live in influences their transportation behavior separate from age. For example, the presence of more than one adult in a household decreases the VMT of each adult by 10 to 18% (Pickrell and Schimek 1999).

However, I found that the NPTS and the Census Bureau grouped households differently. The Census grouped households either by size, age of household head, or "type". The different types of households identified by the NPTS and the Census are listed in Table 1.

TABLE 1: HOUSEHOLD CLASSIFICATIONS OF THE NPTS AND THE CENSUS

US Bureau of the Census	NPTS
Family Households	Single adult, no children
With own children under 18 years	Two or more adults, no children
Married-couple families	Single adult, youngest child age 0-5
With own children under 18 years	Two or more adults, youngest child age 0-5
Female householder, no husband present	Single adult, youngest child age 6-15
With own children under 18 years	Two or more adults, youngest child age 6-15
Nonfamily Households	Single adult, youngest child 16-21
Householder living alone	Two or more adults, youngest child age 16-21
Householder 65 years and over	Single adult, retired, no children
Households with individuals under 18 years old	Two or more adults, retired, no children
Households with individuals 65 years and over	

It might have been possible to match the two classification systems up using the Public Use Micro-Sample (PUMS). However, the PUMS data were not available yet for 2000, and there are no household-level population projections on the Rhode Island level. It is also possible to construct household projections based on person-level population projections; however, following this method would have made my analysis much more complicated and probably no more useful. I decided to do my analysis on the person, not household, level because the data were more readily available, and because projections of number of people are likely to be more accurate than projections of numbers and types of households.

The Long-Range Energy Alternatives Planning (LEAP) Model

In my study, I am using the LEAP model to convert VMT projections from various scenarios into greenhouse gas emissions. The LEAP model was developed by Tellus, Inc. It is a hierarchical model that disaggregates energy use and projects environmental effects. Its structure has several main branches: driver variables, demand, transmission and distribution, electricity generation and resources. Each main branch breaks down into smaller branches, allowing the user to disaggregate energy use. Driver variables include things such as population, GDP, or personal income, which "drive" demand. Demand can be written as a function of driver variables (for example, VMT for personal automobiles could grow at twice the rate of population growth), or directly projected on its own. In turn, demand drives electricity generation and the transmission and distribution of energy, and this energy demand drives modeling of resource use. The user specifies how to deal with resources not being able to meet demand (either demand goes unmet, or resources are imported).

LEAP also includes the energy use of different technologies, allowing you to calculate the energy (fuel) used by gasoline powered personal vehicles, the entire transportation sector, or the whole state of Rhode Island. It includes a Technology and Environmental Database (TED), which can be used to calculate environmental impacts such as greenhouse gas emissions and criteria air pollutantion. LEAP does not allow technologies to become less polluting (while using the same amount of fuel) over time.

Methods and Descriptive Statistics: Census Data

I obtained data on Rhode Island's age structure for the years 1970-2000 and projections of its age structure for the years 2005-2025 from the Census Bureau (The estimates were given to me by Thomas Bolioli, and I obtained the projections from the Census Bureau website). I organized the data into one-year age groups, differentiating between males and females. I obtained the same data for the United States. I used data from the 1970, 1980, 1990 and 2000 Censuses, relying on the 2000 Census for current data.

The Census Bureau created projections using the cohort component method, which uses the four components of population change (births, deaths, internal and international migration). The base year for the projections was 1994. (http://www.census.gov/population/www/projections/ppl47.html). It used separate assumptions about each of these components, by race and Hispanic origin. State differentials in fertility were based on 1989 to 1993 births, 1994 estimated distributions of women of childbearing age among states, and 1994 national fertility data. State differentials in mortality were based on 1989 to 1993 deaths, 1994 estimated population for states, and 1994 national life tables. International migration estimates were taken from the 1990 Census. They were broken down by age, sex and Hispanic origin, used the foreign-born population immigrating between 1985-1990.

The Census produced two population projection series. They had identical assumptions about fertility, mortality, and international migration, and differed only in their assumptions about internal migration. Series A, the Preferred Series, is a time-series model based on interstate migration observed from 1975 to 1994. Series B, the

Economic Series, uses employment projections from the Bureau of Economic Analysis (BEA). I used both these projections because I wanted to see the range of demographic effects that could occur under different population growth scenarios. The projection used by Tellus, which was produced by Regional Economic Models, Inc., is also included for comparison.

As can be seen in Figures 3, 4, and 5, the main difference between the two series is that the Preferred Series gives a higher total population. The age structure in 2025 is projected, in both series, to be different than in 2000. This may mean that population-related changes in state VMT cannot be fully captured by simply looking at changes in total population. However, the age structures of the two projection series do not differ from each other markedly. In fact, the main differences between the two projections are in the Under 15 and 65 and Over age groups, neither of which are major contributors to total state VMT.

FIGURE 3

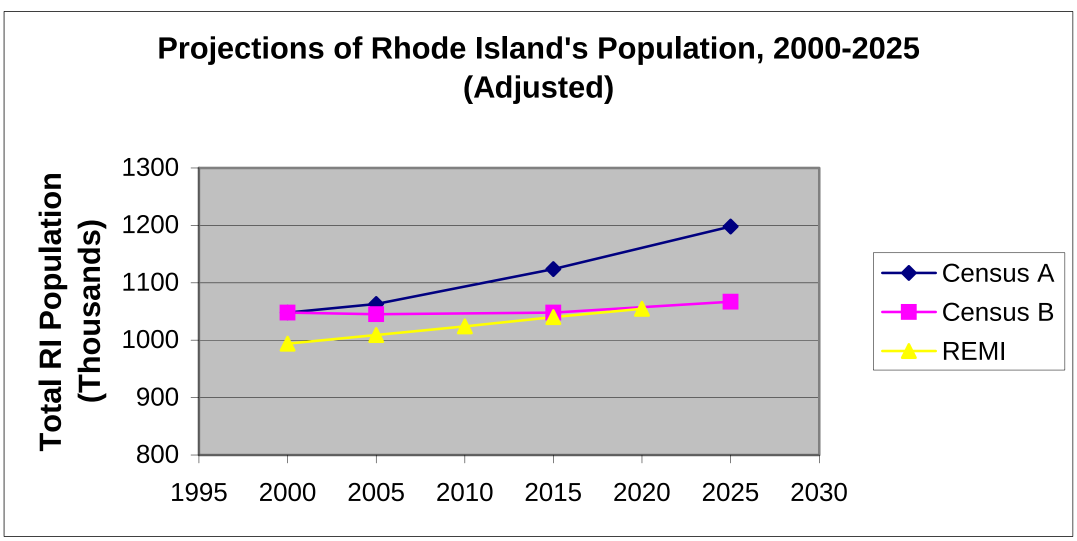


FIGURE 4

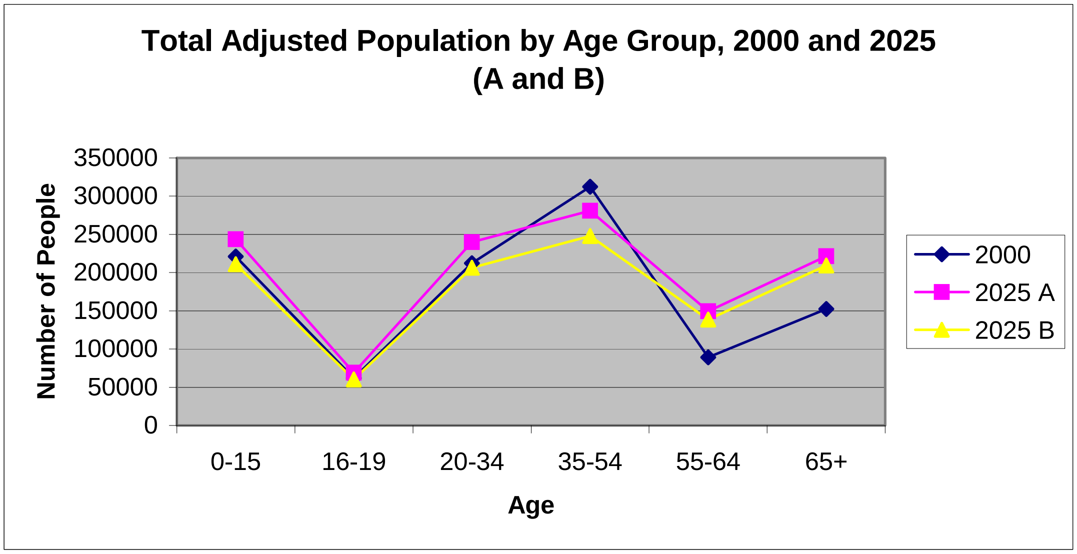
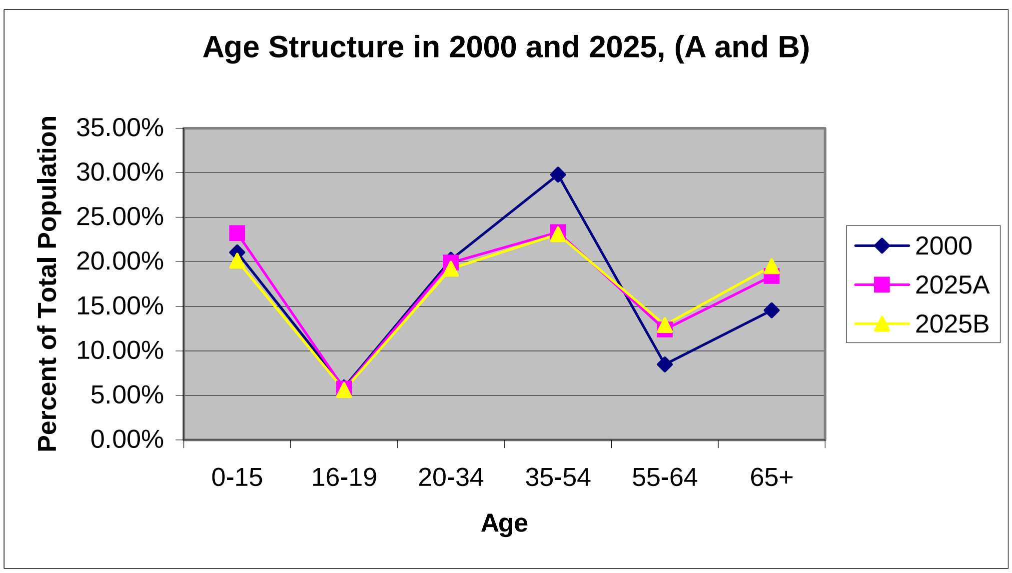


FIGURE 5



You may have noticed that the figures above refer to "adjusted population." I had to adjust the Census population projections because the projections for RI's population in 2000 were seriously in error. The projected value was 998,000 people, whereas the actual value from the 2000 census was 1,048,319. The projections did not predict Rhode Island reaching that population until 2015. In order to address this problem, I scaled up the projections in all years such that the projected population in 2000 matched the actual value from the 2000 Census. Scaling was done on an age- and gender-specific basis. The projected population in each age/gender group in each year was scaled by the ratio of actual to projected population in that group in the year 2000.

One thing to keep in mind with these projections is that, as mentioned before, they were seriously off for 2000. In applying them, I assumed that the predicted rate of increase would be the same, although each projection would be scaled up. However, there is no reason to believe that this assumption is correct, and it may not be beneficial to include age in projections if the source of demographic data is unreliable.

Methods and Descriptive Statistics: Travel Data

I obtained travel data from the Nationwide Personal Transportation Survey (NPTS). The indicator of travel demand I used was annual VMT per driver in personal vehicles. VMT/driver in the 1969, 1977, and 1983 NPTS's was aggregated by gender and into the age groups 16-19, 20-34, 35-54, 55-64, and 65 and over.

Changes in Age-Specific Driving Behavior over Time

My first step was to see whether VMT/driver varied by age, and whether the amount that people of different age groups drove had changed over time. As can be seen in Figures 1 and 2, driving behavior varied with age and gender for all the NPTS years. In addition, the ways in which VMT per driver changed over time depended on age and gender.

FIGURE 6

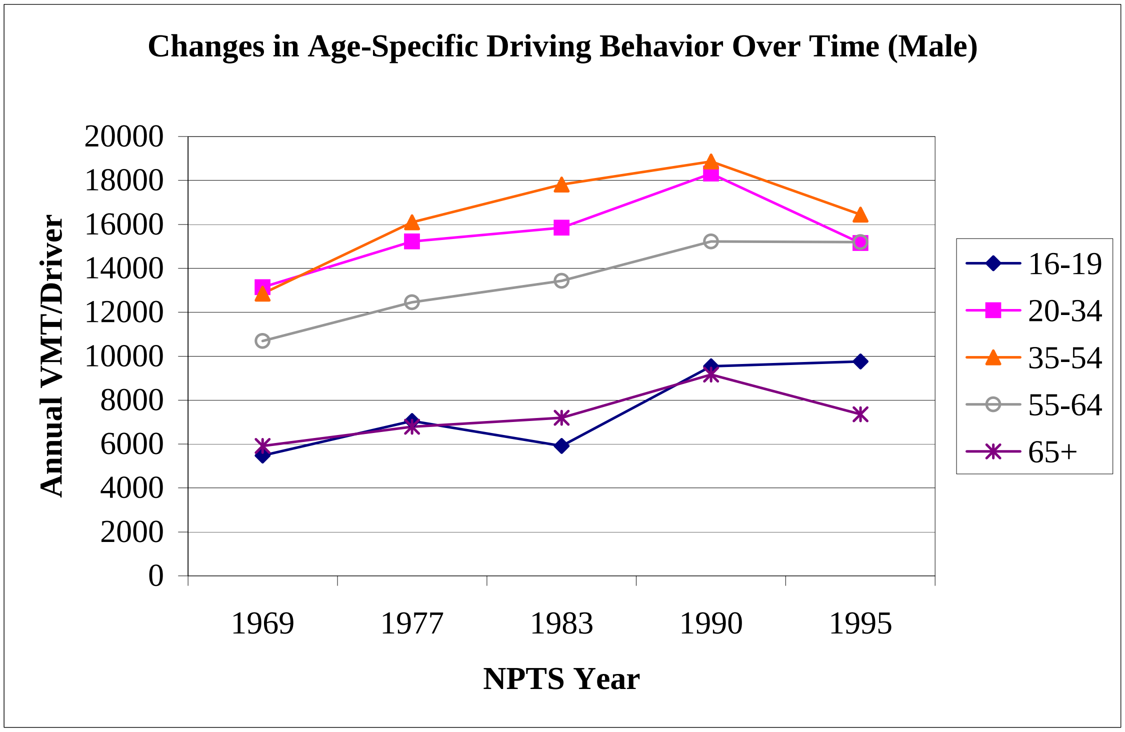
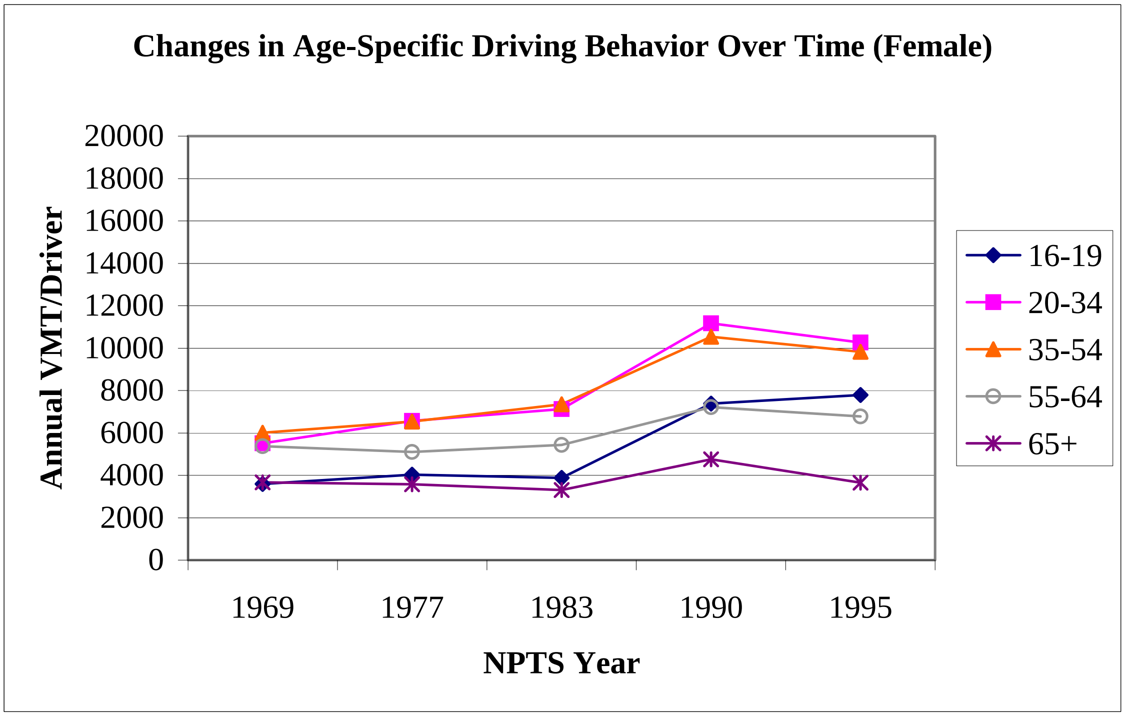


FIGURE 7



Gender differentials were apparent in patterns of VMT/driver. Males consistently accrued more vehicle miles of travel per driver than did females. This was true for all age groups and NPTS years. In both males and females, those between 20 and 54 drove the most, and those under 20 and 65 and up drove least. There was a general increase in annual VMT per driver from 1969 to 1995 for all ages and genders, although the magnitude of this increase varied. In females, younger drivers experienced a great increase in VMT per driver between 1969 and 1995, while the annual VMT of drivers 55 and over changed relatively little. In males, all age groups experienced an increase in VMT per driver over the course of the study period.

In general, VMT per driver seemed to peak in 1990 and then either decrease or remain at a plateau. This effect was reported in the 1995 NPTS Summary of Transportation Trends. It affected male and female teenage drivers, as well as male drivers over age 65, the least. All other groups experienced a marked decrease in VMT per driver between 1990 and 1995. Because the NPTS did not change its method of measuring VMT per driver between 1990 and 1995, and the sample size was large enough to protect against sampling error. Therefore, this appears to be a real effect. Since the GDP of the United States rose between 1990 and 1995 (Bureau of Transportation Statistics, Social and Economic Summary) and the price of gasoline did not increase (http://www.eia.doe.gov/emeu/25opec/sld004.htm), neither of these factors can be called upon as an explanation. However, the period 1990-1995 was a time of recession where GDP grew slower than during other periods, median family income actually dropped over this five-year period, and, according to the Bureau of Transportation Statistics, the number of families living below the poverty line increased (http://www.bts.gov/transtu/indicators/Social_Economic_Summary.pdf). Since income affects travel behavior most at low income levels, the increase in low-income households, and the recession in general, may offer some explanation for this observation.

Standardization

My next task was to make the NPTS data, which was accurate on a national but not a state level, applicable to Rhode Island. The simplest way to do this would have been to scale down national data based on the ratio of Rhode Island's population to the United States' population. However, it seemed possible that some variables that affected travel behavior might differ between the same age group in Rhode Island and the US. If such variables did differ between Rhode Island and the US, standardizing for them rather than just scaling down based on population would make projections more realistic.

The two variables I chose to look at were income and urbanization. I chose these variables because it seemed reasonable that they might differ between Rhode Island and the US, because previous studies have shown that they affect travel demand, and because the Census and the NPTS both collected data on these variables, and this data could be matched up.

I found that, in the NPTS, urbanization affected annual VMT per driver. Americans living in urbanized areas tended to drive less than those living outside of urbanized areas (see Figure 8). For the 1995 NPTS and the 2000 Census, an urbanized area was defined as an area with a population density of at least 1000 people per square mile, although since then "urbanized area" has been redefined as a place with at least 500 people per square mile or 50,000 people total. The actual procedure for deciding whether a given area is urbanized or not is quite complicated, and the numbers given above are only general guidelines (US Census, *Census 2000 Urban and Rural Classification*). The effect of urbanization on VMT/driver was minimal in the oldest and youngest age groups but fairly constant across the rest of the ages and gender groups. In addition, Rhode Island was more urban than the United States as a whole. This difference was greater in some age groups than in others (see Figure 9).

FIGURE 8

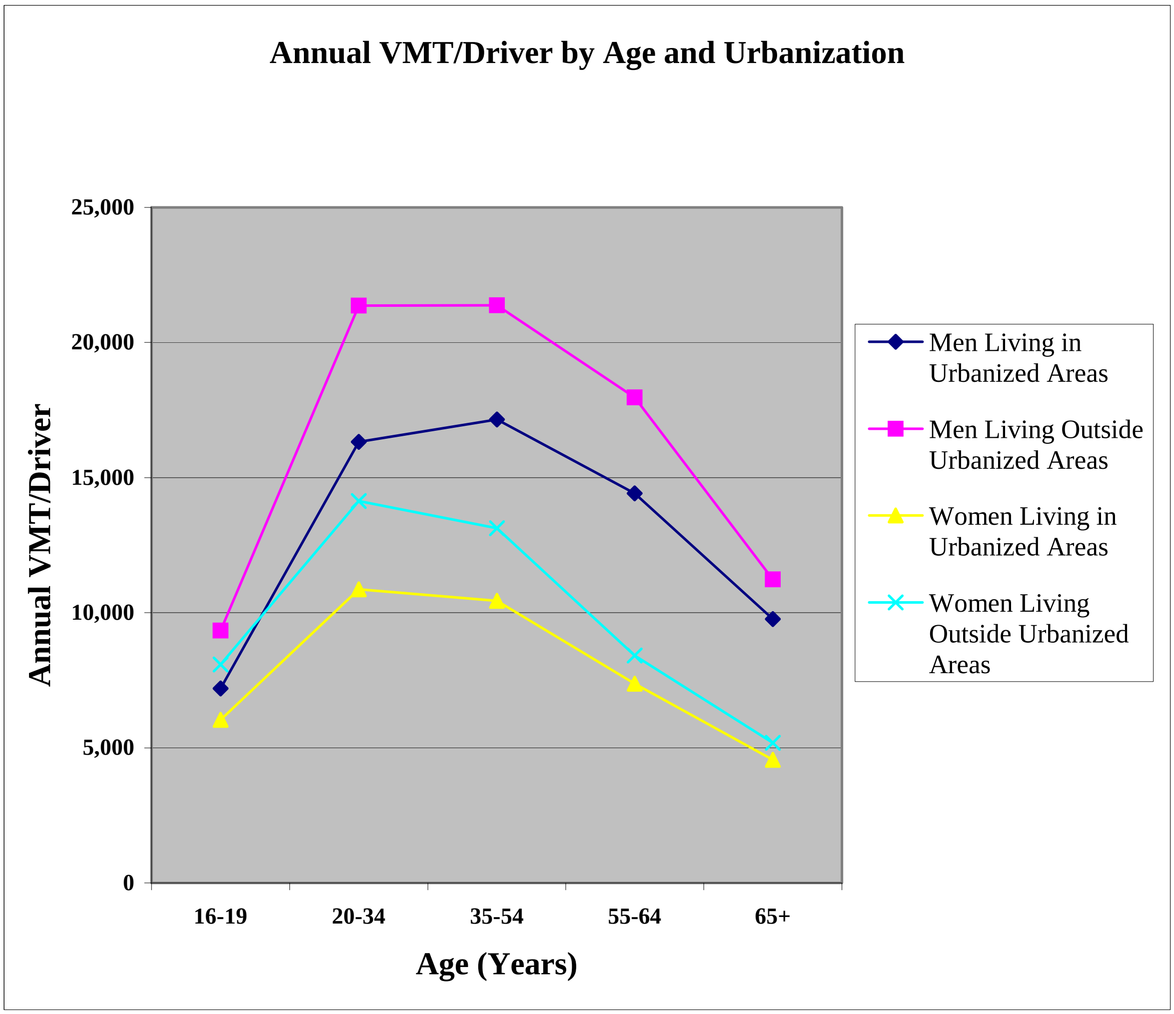
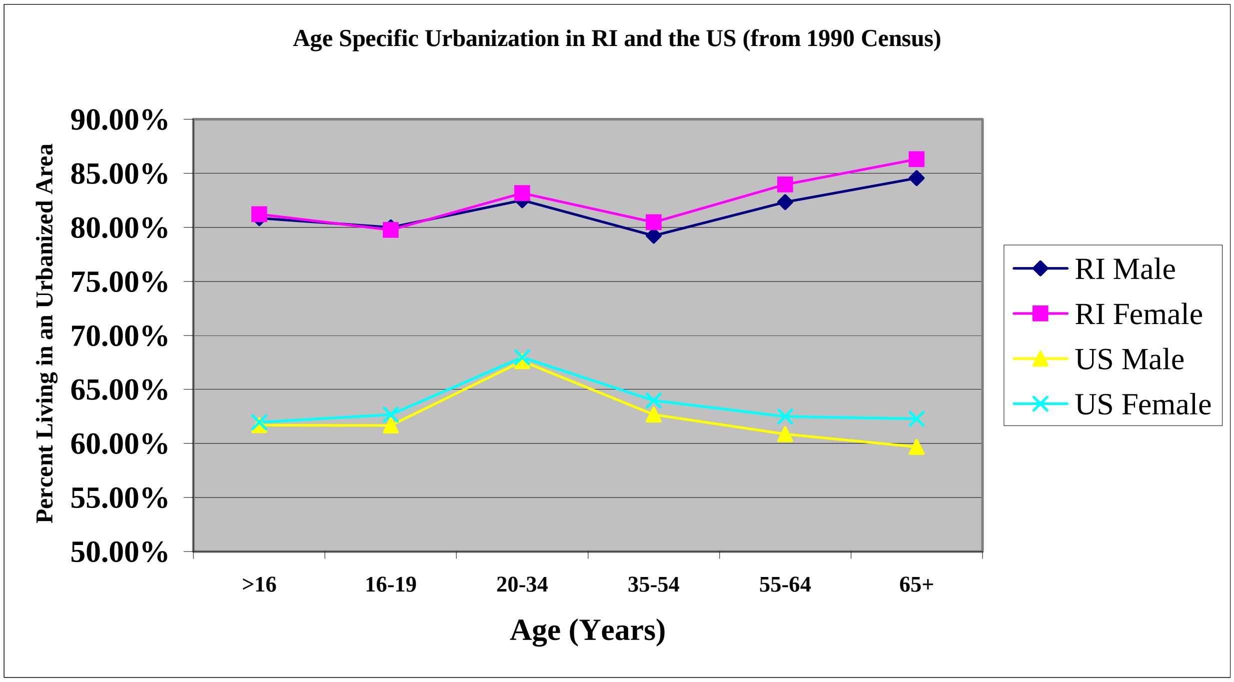


FIGURE 9



Another variable that affected VMT/driver was household income. This effect was different in men than in women, and was apparent mainly at relatively low household income levels. As can be seen in Figures 10 and 11, male drivers with household incomes of less than $25,000 and female drivers with household incomes of less than $15,000 tended to drive less than those with higher household incomes; however, above these cutoffs increasing household income has little effect on VMT per driver. The distribution of households among different income classes is virtually identical in Rhode Island as in the United States as a whole (Figure 12). Therefore, there was no need to standardize for income.

FIGURE 10

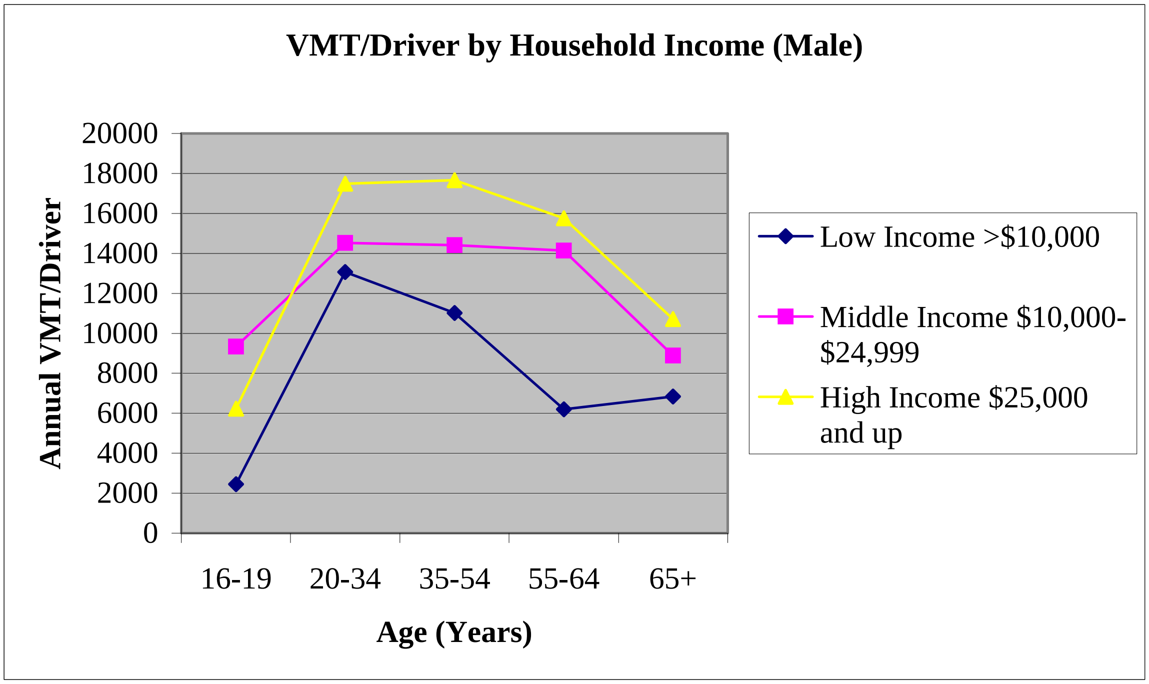


FIGURE 11

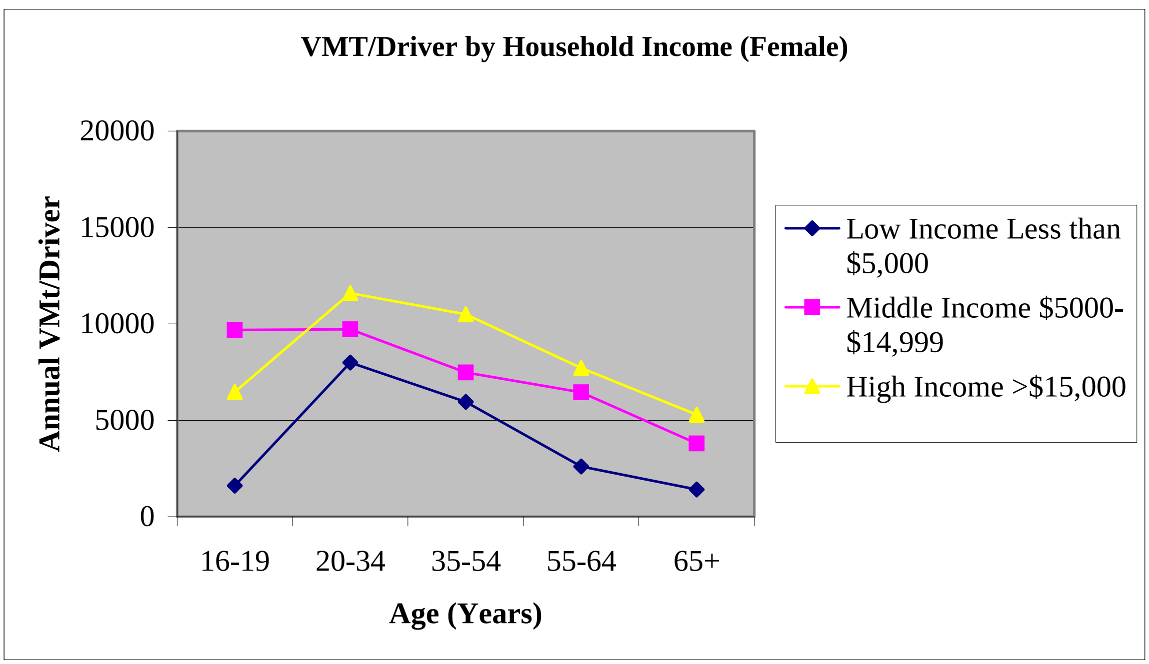
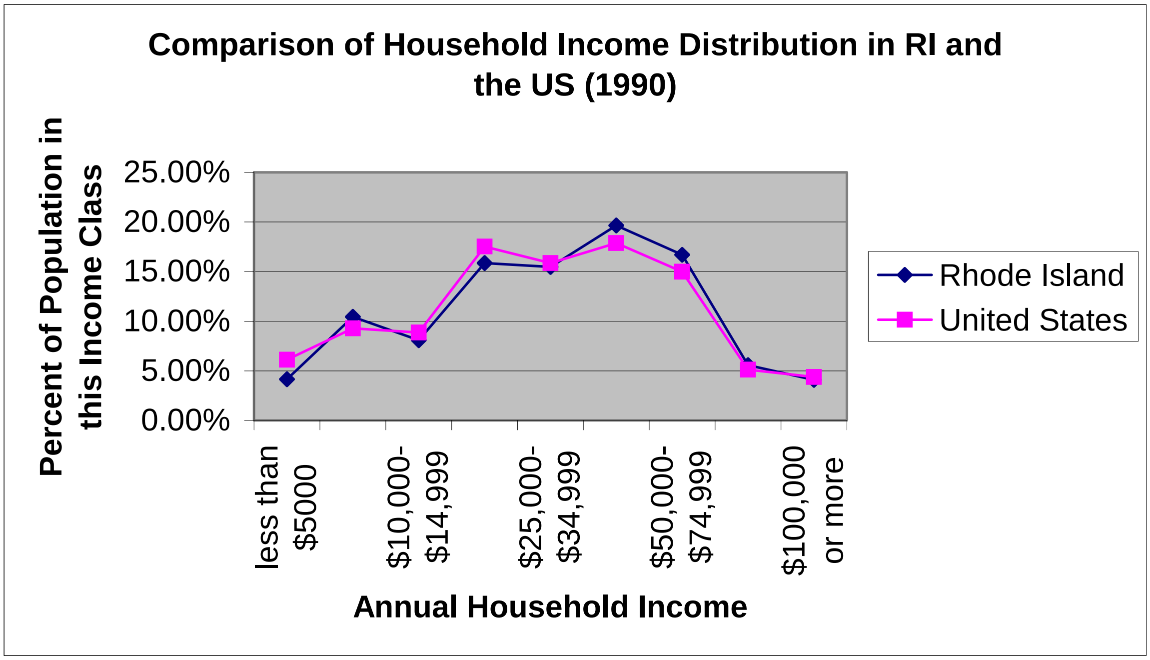


FIGURE 12



Now that I realized that I needed to standardize for urbanization (but not for income), I could calculate what the total VMT for Rhode Island should have been in 2000 based on national NPTS data, assuming that all the differences between Rhode Island and the US were reflected in age structure and urbanization differences. Using the equations below, I calculated the VMT attributable to each of the 20 age, gender, and urbanization groups and then added them together to get total Rhode Island VMT. Population data was Rhode Island-specific and came from the Census, while data on the percent of each group who were licensed to drive and annual VMT/driver for each group was on a national level and came from the 1995 NPTS.

$VMT_{a,,g,u}$=population$_{a,,g,u}$ (RI) * % drivers$_{a,,g,u}$ (US) * VMT/driver$_{a,,g,u}$ (US)

Where a=age, g=gender and u=urbanized area code.

VMT_{total}= Sum of ($VMT_{a,,g,u}$) for all age, gender and urbanization groups

The total calculated in this manner was 9,498,000 VMT, whereas the value I obtained from Rhode Island Statewide Planning for total 2000 VMT was 7,894,000, or only 83% or the projected total. I chose to interpret this as meaning that Rhode Islanders differed from Americans in general in some other way that was affecting their driving behavior. I created a Rhode Island Correction Factor to account for this difference. It simply scaled down VMT in each age, gender and urbanization group by the ratio of the actual Rhode Island VMT in 2000 to the value for Rhode Island VMT in 2000 estimated using the NPTS. Dealing with the problem in this way assumes that the difference between Rhode Island and the US is constant across all age, gender and urbanization groups. If this assumption is not correct, this method may introduce error. In addition it is possible that the discrepancy should be investigated further because it may indicate that one of the sources of data is erroneous; for example, the data from Statewide Planning might not actually be representative of total VMT in Rhode Island.

Cohort Effects

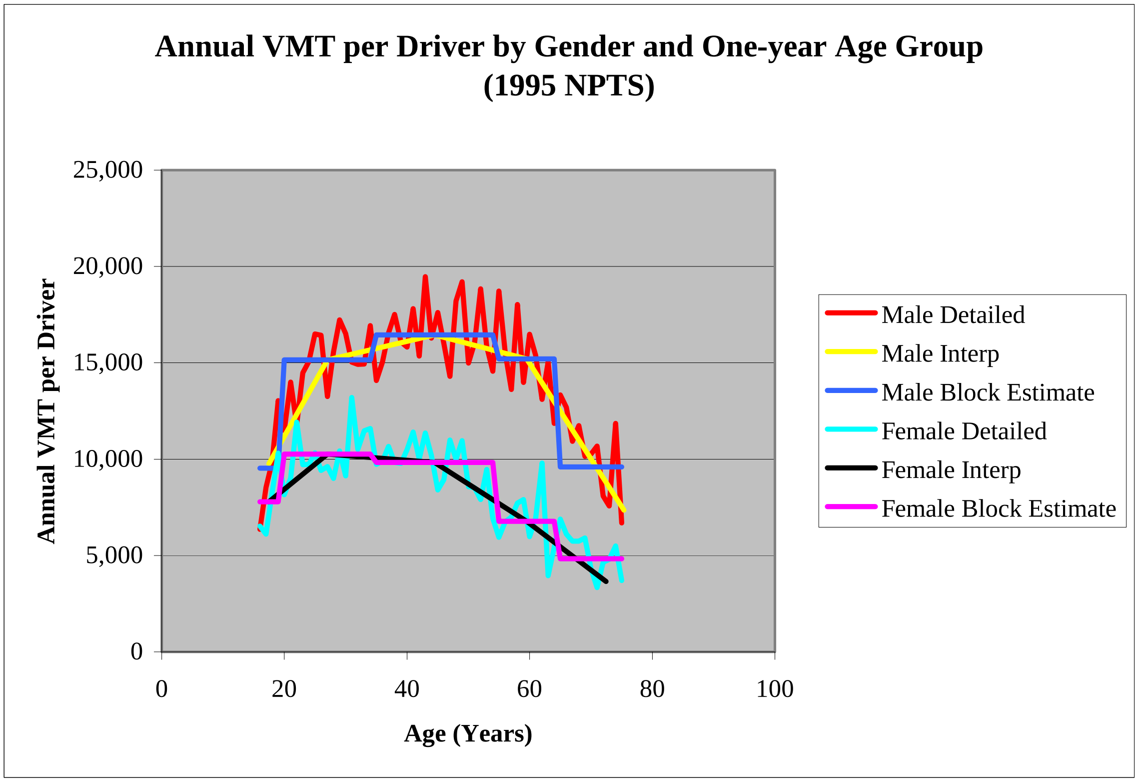
We have already seen that people of different age and gender groups have different driving behavior, and that they have experienced different trends over time. Understanding whether or not cohort effects exist can help us predict whether VMT/driver will change differently for different age groups in the future.

To investigate whether it was age effects or cohort effects that were behind age differences in VMT/driver, I needed to be able to follow cohorts through time. The age groups from one NPTS did not match up with those in other NPTS's, so I needed to have an estimate of driving behavior by one-year age group in order to create new age groups that represented aging cohorts. For the 1995 NPTS, data on VMT/driver by one-year age group was available, enabling me to see how well the broad age groups used in earlier NPTS's captured the age-specific variation of VMT per driver.

I aggregated the one-year age groups into the same groups used by earlier NPTS's and then estimated the VMT per driver for each one-year age group using two different methods. The two approximations I considered were a block method, where I assumed that the VMT/driver for all people within an age group equaled the average value for the group, and a linear interpolation method, where I assumed that the VMT/driver at the midpoint of each age group equaled the average for the group and other values fell along the lines connecting the midpoints. I then calculated both types of approximations for the 1995 NPTS data, for which I had actual VMT/driver by single year of age.

The results of these two estimations are shown below. It is immediately apparent that there is a lot of random variation between age groups in the 1995 data that would be hard to account for with any type of estimation. I calculated the r^2 of each estimation compared to the actual data and found that it was higher for the interpolation (0.77 in men and 0.75 in women for linear interpolation, compared to 0.64 for men and 0.70 for women with the block method). Therefore, I used the interpolation method when I needed estimates of VMT by one-year age group in my investigation of the cohort effect.

FIGURE 13



Figures 14 and 15 show how the driving patterns of various cohorts change as they age. If VMT/driver depended exclusively on age, the curves for all the cohorts would be identical and would lie on top of each other. If a period effect caused VMT/driver to change in the same way for all age groups, then the curves for different cohorts would have the same shape but might be shifted up or down. If the *shape* of the curve is different for different cohorts, this indicates a cohort effect.

There is little evidence of a cohort effect in VMT/driver in men (Figure 14). However, a cohort effect is more apparent in women (Figure 15), which makes sense considering how women's role in society has changed since 1969. In younger cohorts of women, VMT/driver rises more sharply between young adulthood and middle age than in order cohorts. There is no data on the driving behavior of older cohorts at younger ages, or of younger cohorts at older ages. For example, what will happen to women born between 1968 and 1974 as they reach their 50s? However, the patterns in available data indicate that younger women's driving behavior will likely be quite different than that of their mothers.

FIGURE 14

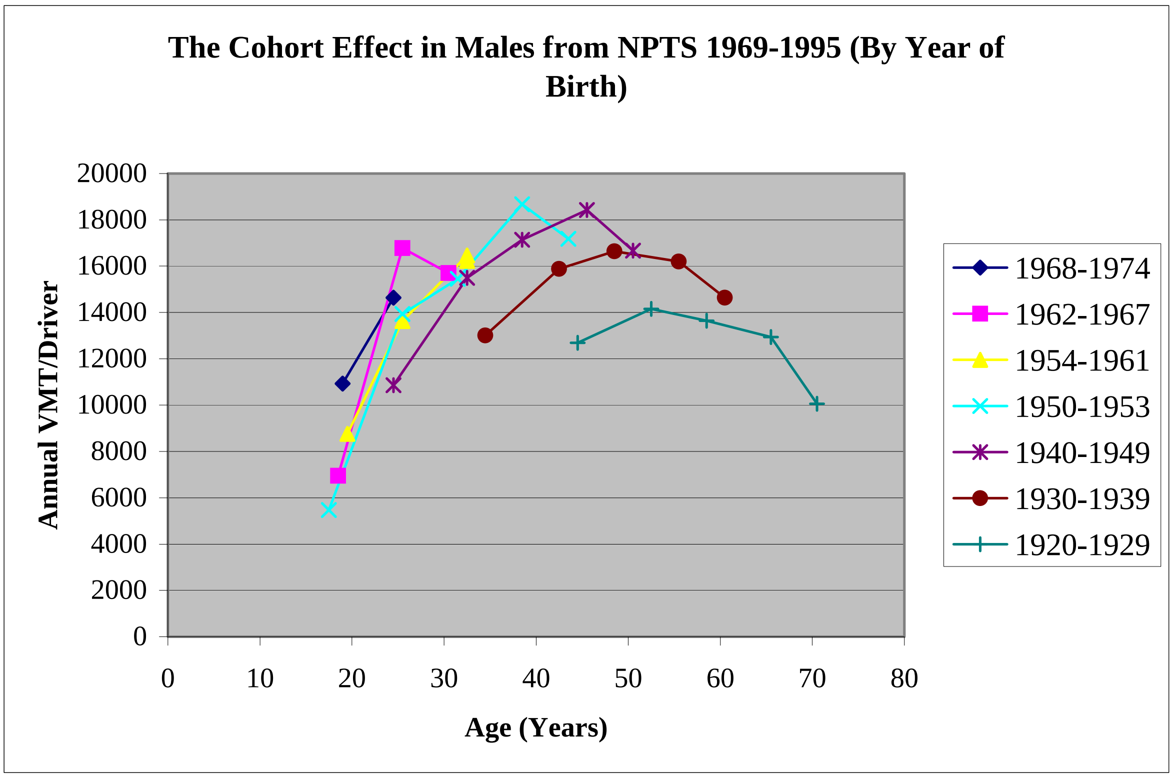
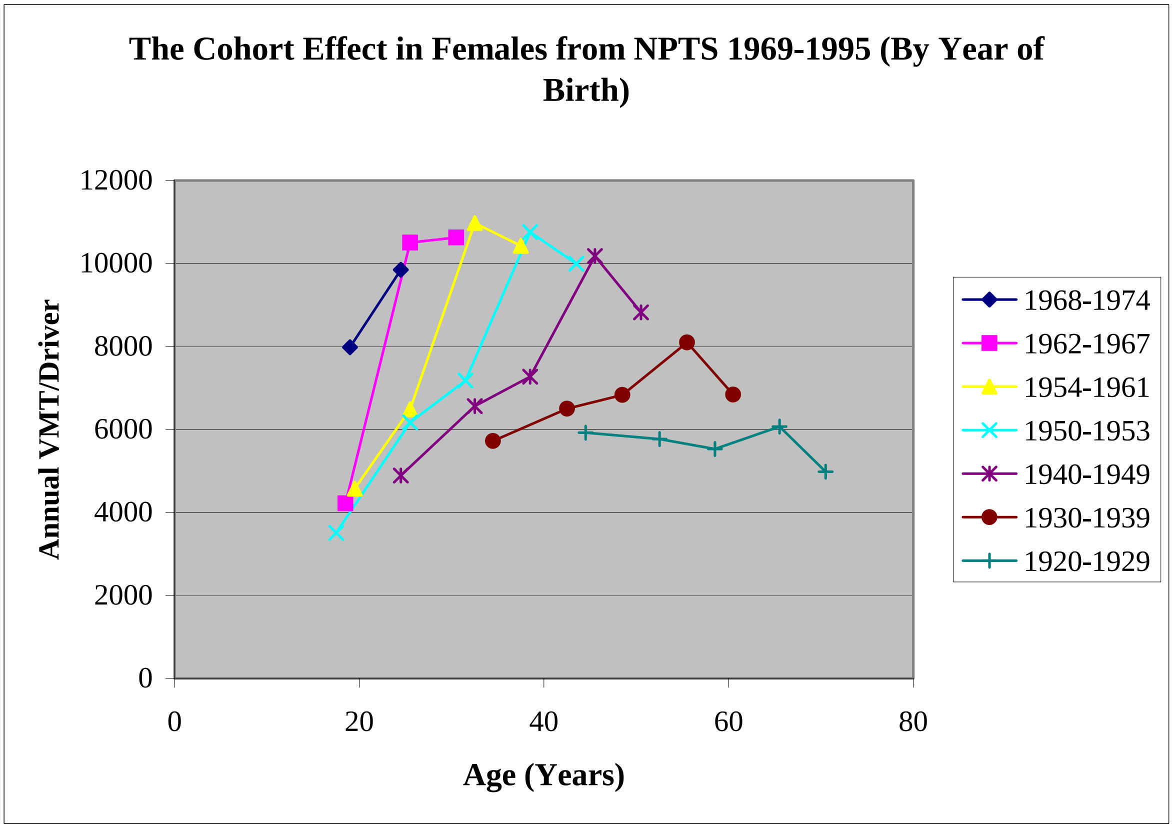


FIGURE 15



Rhode Island VMT Projections

My goal in making VMT projections was to see how accounting for changes in age structure and VMT/driver influenced the projected total VMT for Rhode Island. To make projections, I used the following equation:

VMT=number of people$_{RI}$(from Census)* % who are drivers$_{US}$(from NPTS) * VMT/driver$_{RI}$

Rhode Island VMT/driver was calculated from national-level NPTS data and scaled down using the ratio of actual Rhode Island VMT in 2000 (from Statewide Planning) to estimated Rhode Island VMT in 2000 (from national-level NPTS data). In the projections based on aggregate population growth, I did this calculation once, using the total population and the average value of each variable for the entire population. In the projections that used age structure, I did the calculation 20 times: once for each age, gender and urbanization group. I then added all the values together to get total VMT.

The population numbers came from adjusted Census projections, and varied according to which population projection series was used. The numbers for percent who are drivers came from the 1995 NPTS. It was specific to each age, gender and urbanization group, and it was assumed to remain at 1995 levels in all projections.

The projections I made were:

- Two projections based on aggregate population and assuming VMT per driver remained at 1995 levels. There were two of them because the Census produced two population projection series and I wanted to see how the choice of population projection series affected the outcome of the projection, all other things being equal. These two projections served as references because they incorporated neither age structure nor changes in VMT/driver.
- Two projections with age structure and gender, with age- and gender-specific VMT/driver remaining at 1995 levels. The population projection series were broken down by age and gender. These projections were like the first two except that VMT was calculated separately for each age and gender group, and total VMT was calculated by adding together all the age- and gender-specific VMTs. These projections showed the effect of age structure changes on future VMT.
- Two projections without age structure (in other words, incorporating only aggregate population growth), where VMT/driver grew according to past trends. To estimate the effect of VMT/driver growing according to past trends, I performed linear

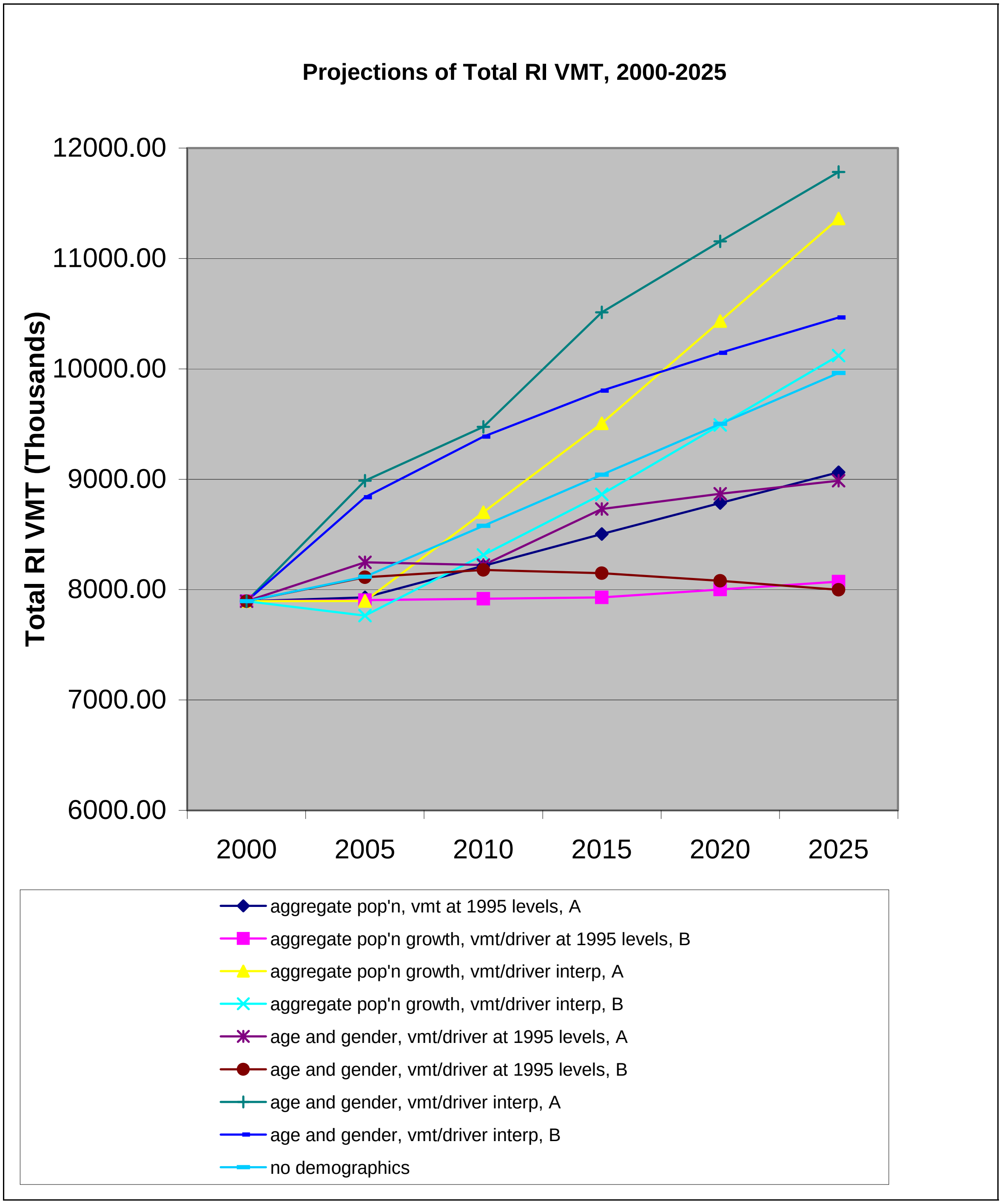
regression on VMT per driver by year and assumed that points in the future would lie on that line.

- Two projections with age structure and assuming that age- and gender-specific VMT/driver continue to increase according to past trends. These projections showed the effect of age structure when accounting for age-specific trends in VMT/driver.
- I also made one reference projection by using linear regression on the past relationship between VMT and time in RI and assuming that that relationship would continue in the future. I made this projection because it took virtually no effort and I wanted to see how it differed from the other, more complicated projections I was making.

Results: Rhode Island VMT Projections

The eight projections I made, and the one reference projection, are presented in Figure 16. Incorporating age structure made virtually no difference when VMT/driver was assumed to stay at 1995 levels. However, when VMT/driver grew according to linear trends, incorporating age structure increased the projected VMT by as much as 16% over 25 years. This means that what is important about age groups in terms of VMT is not what their VMT per driver is now, but what trajectory it will follow in the future.

FIGURE 16



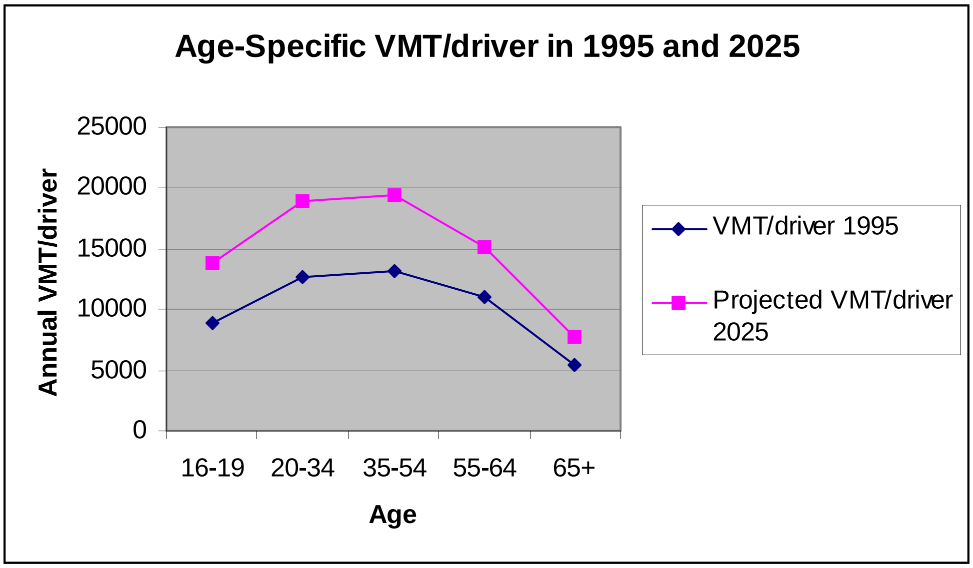
Why did including age structure make a difference only when VMT/driver was changing? One way to think about age structure effects is to consider the way they impact average VMT/driver in the general population. The VMT/driver in the general population is the weighted average of the VMT/driver of each age group:

$$VMT/driver_{general}=Sum(Population_{group} * VMT/driver_{group})$$ for all groups.

If the age structure changes so that a greater share of the population is in the age groups that drive the most, then VMT will grow faster than predicted by population growth alone. However, age structure could also change in ways that do not alter the overall VMT/driver. For example, if the proportion of elderly people increased and the proportion of teenagers decreased, the net effect would be to shift the population between two groups with similar VMT/driver. In the two population projection series, the change in age structure between 2000 and 2025 did not result in a different average VMT/driver in 2025 than in 2000. So, if VMT/driver can be expected to stay at 1995 levels for age groups, there is no reason to include age structure in VMT projections.

When VMT/driver grew according to past trends, however, age structure did make a difference. This is because if VMT/driver changed according to past trends, then the differences in VMT/driver between different age groups would be more pronounced in 2025 than in 2000 (Figure 17). This is a result of the fact that, from 1969-2025, age groups had different trajectories in VMT/driver. For example, people aged 55-64 are projected to make up 5% more of the population in 2025 than they do now; however, their VMT/driver is increasing more slowly than that of other groups such as those 16-19.

FIGURE 17



Finally, I looked at how my projections compared to Tellus's, which were made using different methodology. Tellus's projected VMT was lower than three of the four projections that assumed that VMT/driver would grow according to past trends and higher than all the projections that assumed that it would remain at 1995 levels. It was about equal to two other projections: the one with no demographic information and the one with the Economic Series Population Projection, no age structure, and VMT/driver growing according to past trends. However, since the underlying assumptions of these three projections were quite different, and the fact that their values in 2020 were the same was likely coincidental.

My research showed that the difference in projected state VMT for 2025 was affected much less by the inclusion of age and gender than by the other assumptions. Moreover, including age structure only made a difference if VMT/driver was growing according to past trends. It is unclear how VMT/driver will change in the future, because it was growing for most age and gender groups until 1990 but then underwent a downturn between 1990 and 1995. More research should be done about whether the period 1990-1995 was a temporary decline in the midst of general increase or representative of an actual change in the trend. Also, if the downturn can be explained by another variable, for example GDP, this variable should be included in projections. If possible, this analysis should be done on the Rhode Island level because there is reason to believe that trends in VMT/driver differ markedly by state.

Assumptions of the Projections

I made several assumptions when constructing my projections. It is important that the reader understand these assumptions because in many cases they were rough approximations, and if they turn out to be unreliable, then my findings should be reassessed.

First, I assumed that changes in Rhode Island's VMT in the future would be determined by demographic variables rather than by other factors such as highway capacity, land use, economics, or number of vehicles. If these other variables affect travel demand independently of population and follow their own trends into the future, then a model based on demographic variables alone may be oversimplified and inaccurate. However, my goal is not to predict Rhode Island's VMT using all possibly relevant data; rather, it is to assess the importance of incorporating age structure into VMT projections. As discussed in the introduction, travel demand models often incorporate a much wider range of variables than did mine or Tellus's, and simplifying may either clarify relationships between variables or obscure them.

Whenever I estimated a trend based on past data, I assumed that it was linear. What this means is that if trends are actually non-linear, for example logarithmic or exponential, the approximations may be off, and the projections would diverge from reality more and more as time went on. The linear approximations also do not take into account the possibility that there might be a threshold effect: for example, women's VMT per driver might keep increasing until it was equivalent to that of men, and then stop. Nor do my projections account for any type of feedback: for example, as Rhode Island VMT increases, it may cause more traffic congestion unless additional road capacity is added. This congestion would slow growth in VMT.

I assumed that the percent of people who are licensed to drive within each age and gender group would remain at 1995 levels. I did this because data on licensing rates by age, gender and urbanization were not readily available from past NPTS's, and because most licensing rates were high and probably approaching a threshold (1995 NPTS Summary of Travel Trends).

I also assumed that the relative numbers of Rhode Islanders living in urbanized areas would remain at 1995 levels in the future. This assumption is supported by the fact that most population growth in Rhode Island is taking place in suburban areas, which would be distributed between urbanized and not urbanized classifications (Roger Avery, personal communication). In addition, I assumed that the effect of living in an urbanized area relative to not living in an urbanized area on travel demand would remain at 1995 levels in the future. Given that most growth in Rhode Island is taking place in suburban areas, this assumption is somewhat more suspect. An increase in suburbanization would mean that people in areas classified as urbanized and areas classified as not urbanized would behave more similarly. Since low-density suburban development typically does not allow walking or mass transit as a feasible transportation option, people classified as "urban" may end up driving more than expected.

Finally, in creating the Rhode Island Correction Factor, I assumed that the residual difference between Rhode Island and the US in general could be summed up in one number that would neither vary by age and gender nor change over time. The fact that the residual difference was so significant probably means that more work needs to be done to identify how and why Rhode Islanders' travel behavior differs from that of the US in general, or to examine the quality of the Rhode Island VMT data.

By adopting the Census population projection series, I also took on all the assumptions made by the Census Bureau. Since the projections were so seriously off for 2000, they may not have captured actual population trends and my modification of them may prove inadequate. However, the REMI projections used in Tellus's model were also off. The issue of Rhode Island's population is one that must be dealt with, but one which probably does not affect the broader conclusions of this study. Also, by using the LEAP model I used all the assumptions that Tellus made about changes in the transportation sector, such as the car/light truck split average fuel efficiency of different types of vehicles. This was done to facilitate comparison between my projections and Tellus's; however, if those assumptions prove incorrect it would make the results less valid.

The projections made by Tellus and presented in the Rhode Island Baseline scenario differ from mine in several important ways. First, the specific population projections used were different: I based my projections on the Census Preferred and Economic Series, whereas Tellus’s projections came from Regional Economic Models, Inc. (REMI). Tellus chose to use these population projections because those for the Census were clearly inaccurate and because Gary Ciminero, a stakeholder, already had the REMI projections and offered to let Tellus use them (Chella Rajan, personal communication, 4/25/02). However, looking at the Rhode Island Revised Baseline Scenario, the REMI value for 2000 is even more erroneous than that given by the Census projections (994,000 people compared to 998,000).

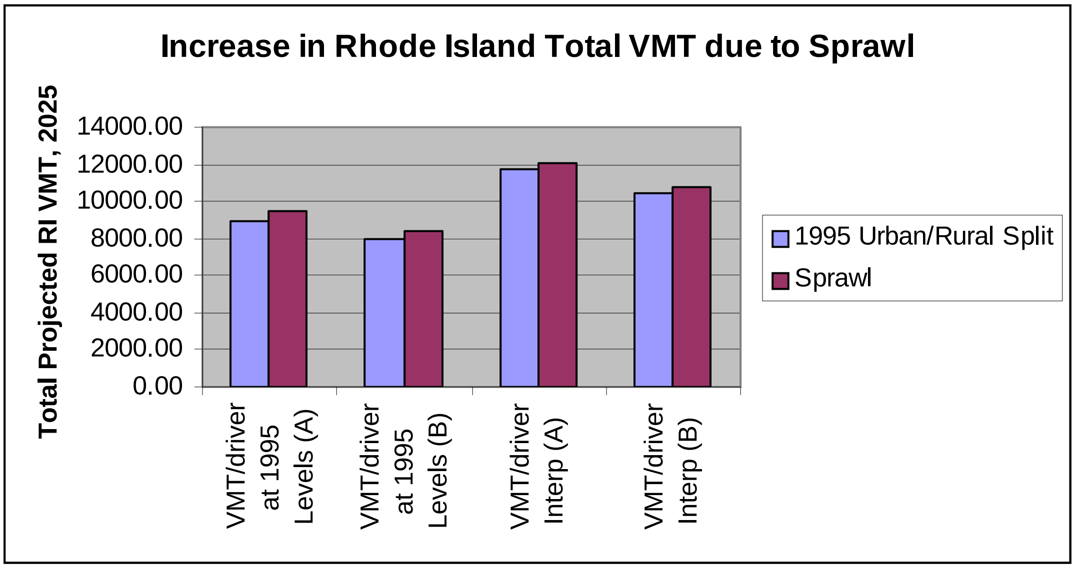
Tellus calculated VMT by starting with population, then multiplying by PMT/person and by 1.6, which is what they assumed average vehicle occupancy would be at all years in the future. The PMT/person data came from the National Energy Modeling System (NEMS) projections for the entire Northeast region. Tellus compared this scaled-down estimate to the Energy Information Administration (EIA)'s data on fuel consumption due to personal vehicle travel, which was specific to Rhode Island. They found that that two numbers were different, and used a correction factor to account for this difference in their projections. In making their projections, Tellus adopted all the assumptions made by NEMS about the Northeast region. Charlie Heaps explained this choice to me by saying that, for making policy scenarios, it was not that important to have an accurate baseline, but it is very important that stakeholders agree, and they could agree on using the NEMS data (Personal communication, 5/1/02).

The different data sources for population and travel information were a major difference in the projections. However, the REMI population projection was quite similar to the Economic Series, so this is not the source of all the difference. Since I did not have the full REMI projection, I was unable to see whether it resulted in a different age structure than the census projections. The REMI population projection in the Revised Baseline Scenario produced by Tellus did not seem to have been updated in light of the 2000 Census, because it gave 994,000 as the value for RI's population in 2000. This was much lower than the figure from the 2000 Census (1,048,000). It would be interesting to see whether the choice of population projection made a difference after it had been updated and disaggregated by age and gender; however, I think that the results dealing with age structure and changes in VMT/driver are more important.

Since age structure only made a difference when VMT/driver was increasing, you would need to have a better idea of what trends in VMT/driver were. As we saw in Figure, there has been a general increase in VMT/driver for all age groups from 1969-1995; however, VMT growth slowed down, stopped, or reversed between 1990 and 1995. The 2000 NPTS data, which will be available soon, should help clarify where VMT/driver trends are actually going. Further analysis, relating VMT/driver to other variables rather than simply looking at changes over time, could also be helpful. If it turns out that VMT/driver is expected to grow in the future, then it might be worthwhile to incorporate age structure into projections of travel demand.

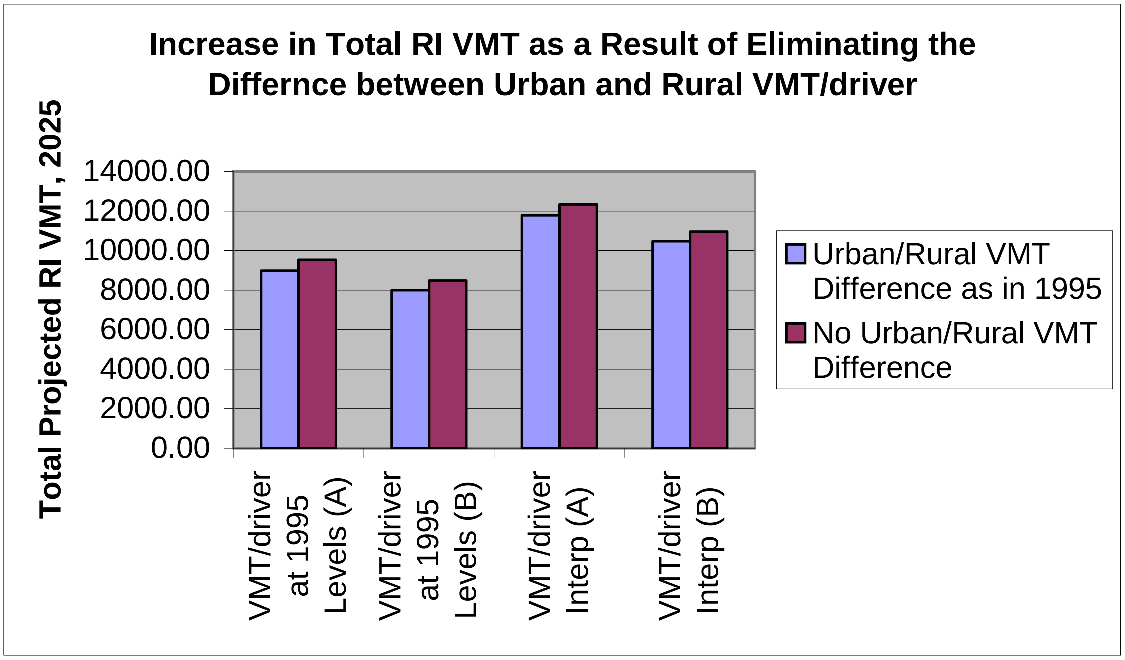
It was not the intention of this thesis to deal with the effects of suburban sprawl on Rhode Island VMT; however, all the projections made the assumption that Rhode Island's urban/rural split would remain at 1995 levels. They also assumed that the effect of living in an urbanized area relative to living outside of an urbanized area would remain the same as it was in 1995. I made a few preliminary projections varying these assumptions to see how they affected the projections' outcome. In one projection, I increased the share of Rhode Island's population in each age and gender group that lived outside of an urbanized area by 10%, holding all other variables constant. This resulted in an increase of 2-5% in projected state VMT for 2025.

FIGURE 18



Another potential effect of sprawl would be to decrease or eliminate the difference in behavior between people living inside and outside urbanized areas. This would occur because people would move out of urban cores and into the surrounding rural and suburban areas, which would make the state's population density distribution more homogeneous. I modeled this effect in its most extreme form by eliminating the difference in VMT/driver between urbanized and non-urbanized areas. Doing this resulted in an increase of 5-6% in total projected state VMT in 2025.

FIGURE 19

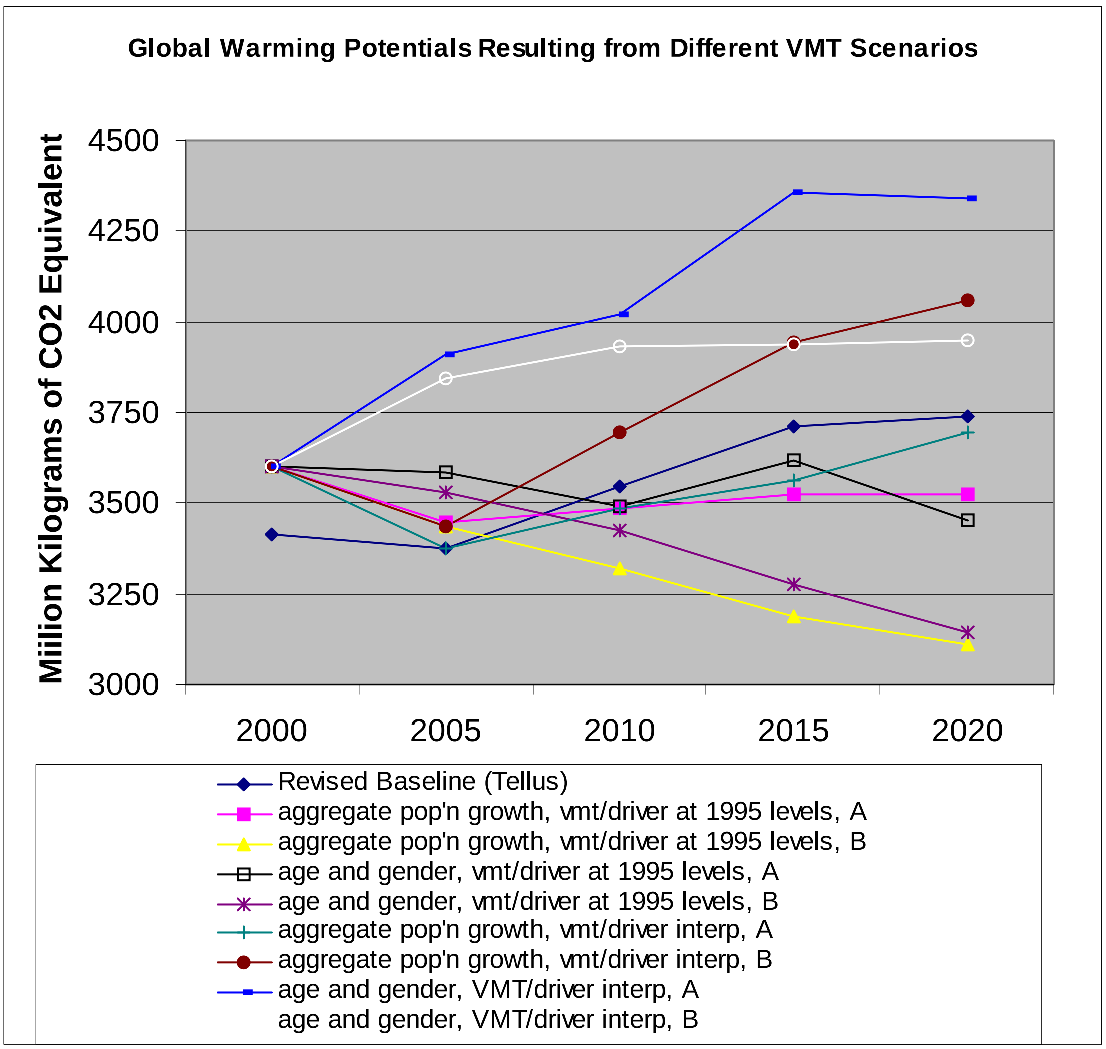


Both these figures show that if suburban sprawl continues in Rhode Island, it will cause VMT to increase independent of other demographic effects. It would be interesting and useful to look at how sprawl interacts with other variables that influence transportation demand and to create more detailed projections using various sprawl scenarios.

Analyzing the Environmental Impact

Finally, I used the LEAP model to see how the different values for total Rhode Island VMT translated into GHG emissions. I obtained the LEAP model for Rhode Island that Tellus, Inc. had developed. I converted my VMT projections into PMT/person by multiplying them by 1.6 (which Tellus was assuming would be the vehicle occupancy) and dividing by the total RI population in that scenario. I then created eight different scenarios, one for each of my VMT projection series. I left everything except VMT constant to facilitate comparison between my projections and Tellus's. The global warming potentials of the eight scenarios range from 3,100 to 4,300 million kilograms of CO_2 equivalent. Since GHG emissions from private vehicles are a direct function of VMT, the GHG projections are in the exact same order as the VMT projections were. Rather than showing anything strikingly new, the point of this step was simply to show the range of GHG emissions that were associated with different VMT scenarios.

FIGURE 20



Conclusions/Recommendations

The original motivation behind this project was to see whether more credible projections about GHG emissions from the transportation sector could be made. If more accurate projections were possible, they could have been used in the Rhode Island Greenhouse Gas Process to formulate more effective policy alternatives. Thus, it seems fitting to conclude this thesis with some recommendations to the DEM about how to use the findings in this thesis to improve attempts at GHG mitigation in Rhode Island.

The first recommendation I would like to make is that Rhode Island obtain more detailed data about travel behavior on a state level. One of the things I discovered in this thesis is that Rhode Island differs from the United States in ways that go beyond age structure and urbanization. Approximating all these differences in one unchanging Rhode Island Adjustment Factor is obviously not the best way to deal with them. I would suggest that Rhode Island either collect its own data on a state level or purchase an add-on sample the next time the NPTS data is collected. Purchasing an add-on sample would have the additional benefit of ensuring the comparability with data from other states and on a national level.

Secondly, I would suggest that Rhode Island investigate projected population growth for the state further. The fact that both the Census projections and the REMI projection were far off for 2000 may indicate a fundamental lack of understanding about Rhode Island's population, and this will affect other sectors such as residential and commercial as well. The population projection chosen affected the projected VMT greatly. If the uncertainty surrounding Rhode Island's population trajectory cannot be resolved, it would be prudent to use a range of possible future populations, rather than a single projection, as Tellus is doing.

The third recommendation is that more study be given to how VMT per driver has changed over time. In particular, the spike in 1990 and the subsequent decrease in many age and gender groups requires some type of explanation. In my projections, assumptions about whether or not VMT per driver grew over time changed the outcome considerably. Instead of approximating clearly non-linear change with a line, I would recommend delving into the other variables that have caused the patterns seen in VMT per driver. One way to do this would be to wait until the 2000 NPTS data is released, because the data point from 2000 might help clarify the trend.

During my conversations with Tellus consultants, they remarked that it was quite possible that the baseline scenarios would turn out to be way off, and that this was not a major problem because the important thing was to be able to evaluate the benefits of different policy options relative to a baseline, not necessarily to make the baseline as accurate as possible. This makes sense at this stage in the Greenhouse Gas Process; an accurate baseline is probably not necessary to choose good GHG reduction policies for RI. However, the credibility of the baseline may become more important when the stakeholders begin trying to set reduction targets and determine whether or not they are being met. If state VMT are growing faster than predicted in the baseline, then policies may not achieve the desired reductions and be deemed failures even if they are actually reducing GHG emissions relative to what they would be otherwise. In addition, the overarching goal of the Greenhouse Gas Process is to reduce Rhode Island's GHG emissions to 1990 levels by 2020. The baseline scenario affects perception of how hard or costly it will be to achieve this concrete goal, as well as how urgent people perceive the situation to be. It may not be necessary to deal with the problem of error in the baseline scenario now but it should be kept in mind during later stages of the GHG Process.

In terms of policy, the variations in travel demand projections may not make a great deal of difference. The chief GHG mitigation strategies suggested by the Transportation and Land Use working group were:

- Improving fuel efficiency by imposing national or regional CAFE standards, instituting a higher gasoline tax, improving the fuel efficiency of government vehicles, enforcing speed limits, using a fee/rebate system to encourage the purchase of more efficient vehicles, and creating VMT-based insurance premium structures
- Enacting land use policies that reduce VMT, for example transit-oriented development, development of bicycle and pedestrian paths, increasing commuting efficiency and decreasing commuting trips

It was not the intent of this thesis to assess the way that people's responses to actions such as those mentioned above might differ by age and gender. However, some policies might affect people of certain age and gender groups more than others. For example, policies encouraging the purchase of smaller cars might affect young people more than middle-aged people because they are just buying their first cars, tend to be more urban, and might be more receptive to financial incentives because of their generally lower income. In order to assess the potential importance of this effect, it would be necessary to look at each policy and determine, either through literature review or some type of survey, how it would affect people of different age groups. For example, use of bike paths or transit would probably vary widely by age. If some age groups were affected more than others, it would be important to determine whether the population of these age groups was increasing or decreasing, as well as what trends their driving behavior had previously exhibited.

Finally, I would like to add a note about what you, the reader, should do with this thesis. If you are a person involved in the RI GHG Process, I hope that this research will re-emphasize to you the importance of the assumptions made about change in VMT/driver when making travel demand projections. Not only do these assumptions affect the projected values of state VMT, they also affect whether or not age structure is important to take into consideration. If more accurate, or state-specific, data become available, it should be incorporated into the baseline and into policy scenarios. If VMT/driver turns out to be growing, making it more important to include age structure in the projections, most of the work has already been done for you. All my data tables and spreadsheets are posted on the Brown Center for Environmental Studies Server, and if you have any questions about them I can be reached by email at Karen_Knee@alumni.brown.edu.

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Appendix of Tables

Table 2: RI Population Structure in 2000 and 2025

Table 2: RI Population Structure in 2000 and 2025

	Male A						**Female A**			
	Under 16	**16-19**	**20-34**	**35-54**	**55-64**	**65+**	**Under 16**	**16-19**	**20-34**	**35-54**
2000	113314	31163	104208	152626	42322	60002	107531	30608	107931	15954
2000%	22.50%	6.19%	20.69%	30.30%	8.40%	11.91%	19.74%	5.62%	19.82%	29.29
2025	124757.1	35120.25	118968.2	138453.9	72943.83	99261.95	118769.3	34084.21	121008.6	142531
2025%	24.77%	5.96%	20.18%	23.49%	12.37%	16.84%	21.81%	5.54%	19.68%	23.18

	Male B						**Female B**			
	Under 16	**16-19**	**20-34**	**35-54**	**55-64**	**65+**	**Under 16**	**16-19**	**20-34**	**35-54**
2000	113314	31163	104208	152626	42322	60002	107531	30608	107931	15954
2000%	22.50%	6.19%	20.69%	30.30%	8.40%	11.91%	19.74%	5.62%	19.82%	29.29
2025	108045.6	30517.23	102392.3	122252.6	67662.54	93705.16	102870.8	29577.66	103831.1	125455
2025%	21.45%	5.82%	19.52%	23.31%	12.90%	17.86%	18.89%	5.40%	18.94%	22.89

Table 3: Standardizing for Urbanization

Table 3: Standardizing for Urbanization

Age	Gender	Urbanized Area	# of people in RI	% who are drivers (US)	Annual VMT per driver (US)	VMT Attributable to this Group	% of RI VMT attributable to this group
16-19	M	Yes	20738.5	0.660505	7202.08	98653242.72	1.04%
20-34	M	Yes	149495.5	0.926493	16325.11	2261133369	23.81%
35-54	M	Yes	95162	0.95376	17148.22	1556401529	16.39%
55-64	M	Yes	34101	0.937588	14412.91	460819555.1	4.85%
65+	M	Yes	49014	0.875357	9765.23	418974525.1	4.41%
							0.00%
16-19	F	Yes	21345	0.617502	6038.66	79593011.99	0.84%
20-34	F	Yes	107565	0.869225	10861.26	1015508185	10.69%
35-54	F	Yes	100124	0.906446	10440.43	947542169.2	9.98%
55-64	F	Yes	40078	0.832221	7370.46	245832466.8	2.59%
65+	F	Yes	80281	0.65858	4562.16	241207966.3	2.54%
							0.00%
16-19	M	No	5184	0.820594	9344.08	39749359.22	0.42%
20-34	M	No	31675.5	0.955541	21361.19	646544259.8	6.81%
35-54	M	No	24968	0.973985	21383.3	520008822.9	5.47%
55-64	M	No	7323	0.96695	17966.64	127221382	1.34%
65+	M	No	8962	0.93391	11230.42	93995244.19	0.99%
							0.00%
16-19	F	No	5414.5	0.760677	8080.93	33282804.62	0.35%
20-34	F	No	21765	0.957343	14131.35	294449013.5	3.10%
35-54	F	No	24323	0.972232	13121.48	310291615	3.27%
55-64	F	No	7654	0.901631	8417	58086428.8	0.61%
65+	F	No	12743	0.743926	5184.13	49144758.54	0.52%

Table 4: Summary of VMT, PMT, and PMT/Person Projections

		Projection Based on Past VMT Growth	Tellus	Projection Based on Aggregate Population Growth, Assuming VMT/driver at 1995 Levels (A)	Projection Based on Aggregate Population Growth, Assuming VMT/driver at 1995 Levels (B)	Projection Based on Aggregate Population Growth, with Interp vmt/driver (A)	Projection Based on Aggregate Population Growth, with Interp vmt/driver (B)	Projection Based on Age and Gender, Assuming VMT/Driver at 1995 Levels (A)	Projection Based on Age and Gender, Assuming VMT/Driver at 1995 Levels (B)	Projection Based on Age and Gender, Assuming VMT/Driver Grows Linearly According to Past Trends (A)	Projection Based on Age and Gender, Assuming VMT/Driver Grows Linearly According to Past Trends (B)
VMT	2000	7894.00	7894.00	7894.00	7894.00	7894.00	7894.00	7894.00	7894.00	7894.00	7894.00
	2005	8117.39	7693.63	7928.65	7905.95	7898.06	7764.32	8247.78	8111.18	8985.95	8834.93
	2010	8578.41	8448.00	8216.14	7917.30	8701.77	8313.54	8221.88	8178.03	9474.00	9386.82
	2015	9039.44	9165.00	8503.63	7928.65	9505.49	8862.77	8731.08	8149.33	10511.24	9801.19
	2020	9500.47	9560.94	8783.55	8000.52	10433.48	9490.94	8869.27	8079.17	11154.93	10145.74
	2025	9961.49		9063.47	8072.39	11361.48	10119.12	8986.37	7998.70	11782.37	10463.83
PMT	2000	12630.40	11975.78	12630.40	12630.40	12630.40	12630.40	12630.40	12630.40	12630.40	12630.40
	2005	12987.82	12309.80	12685.84	12649.52	12636.89	12422.91	13196.44	12977.89	14377.53	14135.89
	2010	13725.46	13516.80	13145.82	12667.68	13922.83	13301.67	13155.01	13084.85	15158.40	15018.91
	2015	14463.10	14664.00	13605.80	12685.84	15208.78	14180.43	13969.72	13038.93	16817.98	15681.90
	2020	15200.75	15297.50	14053.68	12800.83	16693.58	15185.51	14190.83	12926.67	17847.88	16233.19
	2025	15938.39		14501.56	12915.83	18178.37	16190.59	14378.19	12797.92	18851.80	16742.13
PMT per person	2000		12048.1	12048.07	12048.07	12048.07	12048.07	12048.07	12048.07	12048.07	12048.07
	2005		12200.0	11854.80	12022.05	11809.06	11806.67	12331.96	12334.12	13435.67	13434.68
	2010		13200.0	12161.76	12092.92	12880.61	12698.14	12170.26	12491.16	14023.69	14337.46
	2015		14100.0	12377.21	11998.03	13835.43	13411.58	12708.26	12331.97	15299.32	14831.65
	2020		14500.0	12024.72	12029.33	14283.48	14270.28	12142.06	12147.59	15271.14	15254.82
	2025			12039.88	12040.71	15092.55	15093.59	11937.46	11930.79	15651.66	15607.75

*VMT and PMT in millions

Table 5: Female Cohorts, 1969-1995

Table 5: Female Cohorts, 1969-1995

		VMT/Driver							
	age 1969	1969	age 1977	1977	age 1983	1983	age 1990	1990	age 1995
Year of Birth									
1979									16
1978									17
1977									18
1976									19
1975									20
1974							16	6789.02	21
1973							17	7187.65	22
1972							18	7586.28	23
1971							19	7984.91	24
1970							20	8383.54	25
1969							21	8782.17	26
1968							22	9180.8	27
1967					16	3361.312	23	9579.43	28
1966					17	3703.102	24	9978.06	29
1965					18	4044.891	25	10376.69	30
1964					19	4386.681	26	10775.32	31
1963					20	4728.47	27	11173.95	32

1962					21	5070.26	28	11137.59	33
1961			16	3635.7	22	5412.049	29	11101.3	34
1960			17	3902.54	23	5753.839	30	11065.01	35
1959			18	4169.38	24	6095.628	31	11028.72	36
1958			19	4436.22	25	6437.418	32	10992.43	37
1957			20	4703.06	26	6779.207	33	10956.14	38
1956			21	4969.9	27	7120.997	34	10919.85	39
1955			22	5236.74	28	7133.914	35	10883.56	40
1954			23	5503.58	29	7146.828	36	10847.27	41
1953	16	3205.684	24	5770.42	30	7159.743	37	10810.98	42
1952	17	3408.421	25	6037.26	31	7172.657	38	10774.69	43
1951	18	3611.157	26	6304.1	32	7185.571	39	10738.4	44
1950	19	3813.894	27	6570.94	33	7198.486	40	10702.11	45
1949	20	4016.631	28	6568.898	34	7211.4	41	10665.82	46
1948	21	4219.368	29	6566.784	35	7224.314	42	10629.53	47
1947	22	4422.105	30	6564.67	36	7237.228	43	10593.24	48
1946	23	4624.841	31	6562.556	37	7250.143	44	10556.95	49
1945	24	4827.578	32	6560.442	38	7263.057	45	10520.66	50
1944	25	5030.315	33	6558.328	39	7275.971	46	10206.05	51
1943	26	5233.052	34	6556.214	40	7288.886	47	9984.18	52
1942	27	5435.789	35	6554.1	41	7301.8	48	9762.31	53
1941	28	5540.053	36	6551.986	42	7314.714	49	9540.44	54
1940	29	5568.11	37	6549.872	43	7327.628	50	9318.57	55
1939	30	5596.167	38	6547.758	44	7340.543	51	9096.7	56
1938	31	5624.224	39	6545.644	45	7353.457	52	8874.83	57
1937	32	5652.281	40	6543.53	46	7155.488	53	8652.96	58
1936	33	5680.338	41	6541.416	47	7027.821	54	8431.09	59
1935	34	5708.395	42	6539.302	48	6900.154	55	8209.22	60
1934	35	5736.452	43	6537.188	49	6772.487	56	7987.35	61
1933	36	5764.509	44	6535.074	50	6644.82	57	7765.48	62
1932	37	5792.566	45	6532.96	51	6517.153	58	7543.61	63
1931	38	5820.623	46	6390.3	52	6389.486	59	7321.74	64
1930	39	5848.68	47	6294.5	53	6261.819	60	7099.87	65
1929	40	5876.737	48	6198.7	54	6134.152	61	6925.64	66
1928	41	5904.794	49	6102.9	55	6006.485	62	6735.57	67
1927	42	5932.851	50	6007.1	56	5878.818	63	6545.5	68
1926	43	5960.908	51	5911.3	57	5751.151	64	6355.43	69
1925	44	5988.965	52	5815.5	58	5623.484	65	6165.36	70
1924	45	6017.022	53	5719.7	59	5495.817	66	5975.29	71
1923	46	5940.185	54	5623.9	60	5368.15	67	5785.22	72
1922	47	5898.318	55	5528.1	61	5185.931	68	5595.15	73
1921	48	5856.451	56	5432.3	62	5021.892	69	5405.08	74
1920	49	5814.584	57	5336.5	63	4857.853	70	5215.01	75
1919	50	5772.717	58	5240.7	64	4693.814	71	5024.94	
1918	51	5730.85	59	5144.9	65	4529.775	72	4834.87	
1917	52	5688.983	60	5049.1	66	4365.736	73	4644.8	
1916	53	5647.116	61	4920.17	67	4201.697	74	4454.73	
1915	54	5605.249	62	4802.39	68	4037.658	75	4264.66	
1914	55	5563.382	63	4684.61	69	3873.619			
1913	56	5521.515	64	4566.83	70	3709.58			

1912	57	5479.648	65	4449.05	71	3545.541
1911	58	5437.781	66	4331.27	72	3381.502
1910	59	5395.914	67	4213.49	73	3217.463
1909	60	5354.047	68	4095.71	74	3053.424
1908	61	5176.808	69	3977.93	75	2889.385
1907	62	5044.666	70	3860.15		
1906	63	4912.524	71	3742.37		
1905	64	4780.382	72	3624.59		
1904	65	4648.24	73	3506.81		
1903	66	4516.098	74	3389.03		
1902	67	4383.956	75	3271.25		
1901	68	4251.814				
1900	69	4119.672				
1899	70	3987.53				
1898	71	3855.388				
1897	72	3723.246				
1896	73	3591.104				
1895	74	3458.962				
1894	75	3326.82				

Table 6: Male Cohorts, 1969-1995

Table 6: Male Cohorts, 1969-1995

Year of Birth	Age in 1969	VMT/Driver 1969	Age in 1977	1977		1983	Age in 1990	1990	Age
1979									
1978									
1977									
1976									
1975									
1974							16	8158.7	
1973							17	9081.54	
1972							18	10004.38	
1971							19	10927.22	
1970							20	11850.06	
1969							21	12772.9	
1968							22	13695.74	
1967					16	4339.12	23	14618.58	
1966					17	5385.015	24	15541.42	
1965					18	6430.91	25	16464.26	
1964					19	7476.805	26	17387.1	
1963					20	8522.7	27	18309.94	
1962					21	9568.595	28	18342.06	
1961			16	5753.8973	22	10614.49	29	18374.11	
1960			17	6614.6343	23	11660.39	30	18406.17	
1959			18	7475.3713	24	12706.28	31	18438.23	
1958			19	8336.1083	25	13752.18	32	18470.28	
1957			20	9196.8453	26	14798.07	33	18502.34	

1956			21	10057.582	27	15843.97	34	18534.4
1955			22	10918.319	28	15956.23	35	18566.46
1954			23	11779.056	29	16068.46	36	18598.51
1953	16	4261.27	24	12639.793	30	16180.69	37	18630.57
1952	17	5067.8	25	13500.53	31	16292.92	38	18662.63
1951	18	5874.33	26	14361.267	32	16405.15	39	18694.68
1950	19	6680.86	27	15222.004	33	16517.37	40	18726.74
1949	20	7487.39	28	15272	34	16629.6	41	18758.8
1948	21	8293.92	29	15322	35	16741.83	42	18790.85
1947	22	9100.45	30	15372	36	16854.06	43	18822.91
1946	23	9906.98	31	15422	37	16966.29	44	18854.97
1945	24	10713.51	32	15472	38	17078.52	45	18887.03
1944	25	11520.04	33	15522	39	17190.75	46	18506.45
1943	26	12326.57	34	15572	40	17302.97	47	18263.32
1942	27	13133.1	35	15622	41	17415.2	48	18020.19
1941	28	13116.19	36	15672	42	17527.43	49	17777.06
1940	29	13099.5	37	15722	43	17639.66	50	17533.93
1939	30	13082.81	38	15772	44	17751.89	51	17290.8
1938	31	13066.12	39	15822	45	17864.12	52	17047.67
1937	32	13049.43	40	15872	46	17370.3	53	16804.54
1936	33	13032.74	41	15922	47	17078.5	54	16561.41
1935	34	13016.05	42	15972	48	16786.7	55	16318.28
1934	35	12999.36	43	16022	49	16494.9	56	16075.15
1933	36	12982.67	44	16072	50	16203.1	57	15832.02
1932	37	12965.98	45	16122	51	15911.3	58	15588.89
1931	38	12949.29	46	15732.8	52	15619.5	59	15345.76
1930	39	12932.6	47	15490	53	15327.7	60	15102.63
1929	40	12915.91	48	15247.2	54	15035.9	61	14651.3
1928	41	12899.22	49	15004.4	55	14744.1	62	14269.57
1927	42	12882.53	50	14761.6	56	14452.3	63	13887.84
1926	43	12865.84	51	14518.8	57	14160.5	64	13506.11
1925	44	12849.15	52	14276	58	13868.7	65	13124.38
1924	45	12832.46	53	14033.2	59	13576.9	66	12742.65
1923	46	12626.5	54	13790.4	60	13285.1	67	12360.92
1922	47	12483.5	55	13547.6	61	12842.26	68	11979.19
1921	48	12340.5	56	13304.8	62	12449.77	69	11597.46
1920	49	12197.5	57	13062	63	12057.27	70	11215.73
1919	50	12054.5	58	12819.2	64	11664.78	71	10834
1918	51	11911.5	59	12576.4	65	11272.28	72	10452.27
1917	52	11768.5	60	12333.6	66	10879.78	73	10070.54
1916	53	11625.5	61	11920.622	67	10487.29	74	9688.81
1915	54	11482.5	62	11564.212	68	10094.79	75	9307.08
1914	55	11339.5	63	11207.802	69	9702.296		
1913	56	11196.5	64	10851.392	70	9309.8		
1912	57	11053.5	65	10494.982	71	8917.304		
1911	58	10910.5	66	10138.572	72	8524.808		
1910	59	10767.5	67	9782.162	73	8132.312		
1909	60	10624.5	68	9425.752	74	7739.816		
1908	61	10244.78	69	9069.342	75	7347.32		
1907	62	9943.968	70	8712.932				

1906	63	9643.157	71	8356.522
1905	64	9342.346	72	8000.112
1904	65	9041.535	73	7643.702
1903	66	8740.724	74	7287.292
1902	67	8439.913	75	6930.882
1901	68	8139.102		
1900	69	7838.291		
1899	70	7537.48		
1898	71	7236.669		
1897	72	6935.858		
1896	73	6635.047		
1895	74	6334.236		
1894	75	6033.425		

Table 7: Age-Specific Population and VMT/driver, 2000 and 2025

	% of population in 2000	% of population in 2025 (A)	% of population in 2025 (B)	VMT/driver 1995	Projected VMT/driver 2025	% Increase VMT/driver
16-19	6.21%	7.20%	6.97%	8851	13829	56%
20-34	36.62%	24.97%	23.93%	12734	18945	49%
35-54	28.84%	29.24%	28.74%	13143	19489	48%
55-64	10.51%	15.54%	16.08%	11006	15137	38%
65+	17.81%	23.04%	24.27%	5421	7729	43%

Table 8: Preliminary Sprawl Calculations

	1995/2000						
Age		Urbanized Area	# of people in RI	% who are drivers (US)	#Drivers	Annual VMT per driver (US)	VMT/Driver*Number Drivers
16-19	M	Yes	20738.5	0.660504959	13697.8821	7202.08	98653242.72
20-34	M	Yes	149495.5	0.926492575	138506.4707	16325.11	2261133369
35-54	M	Yes	95162	0.953759861	90761.69593	17148.22	1556401529
55-64	M	Yes	34101	0.937588152	31972.69358	14412.91	460819555.1
65+	M	Yes	49014	0.875356567	42904.72678	9765.23	418974525.1
16-19	F	Yes	21345	0.617501764	13180.57516	6038.66	79593011.99
20-34	F	Yes	107565	0.869225056	93498.19312	10861.26	1015508185
35-54	F	Yes	100124	0.906446068	90757.0061	10440.43	947542169.2
55-64	F	Yes	40078	0.832220874	33353.74818	7370.46	245832466.8
65+	F	Yes	80281	0.658579732	52871.43947	4562.16	241207966.3
16-19	M	No	5184	0.82059448	4253.961783	9344.08	39749359.22
20-34	M	No	31675.5	0.955541026	30267.23978	21361.19	646544259.8
35-54	M	No	24968	0.973984908	24318.45519	21383.3	520008822.9
55-64	M	No	7323	0.966950426	7080.977967	17966.64	127221382
65+	M	No	8962	0.933909821	8369.699815	11230.42	93995244.19
16-19	F	No	5414.5	0.760676873	4118.684932	8080.93	33282804.62

20-34	F	No	21765	0.95734347	20836.58061	14131.35	294449013.5
35-54	F	No	24323	0.972232371	23647.60796	13121.48	310291615
55-64	F	No	7654	0.901631117	6901.084567	8417	58086428.8
65+	F	No	12743	0.743925831	9479.846867	5184.13	49144758.54

VMT Attributable to this Group	% VMT attributable to this group		Age	Gender	Urbanized Area	Urban/NonUrban %	sprawl
98653242.72	1.04%		16-19	M	Yes	80.00%	70.00%
2261133369	23.81%		20-34	M	Yes	82.52%	72.52%
1556401529	16.39%		35-54	M	Yes	79.22%	69.22%
460819555.1	4.85%		55-64	M	Yes	82.32%	72.32%
418974525.1	4.41%		65+	M	Yes	84.54%	74.54%
79593011.99	0.84%		16-19	F	Yes	79.77%	69.77%
1015508185	10.69%		20-34	F	Yes	83.17%	73.17%
947542169.2	9.98%		35-54	F	Yes	80.46%	70.46%
245832466.8	2.59%		55-64	F	Yes	83.96%	73.96%
241207966.3	2.54%		65+	F	Yes	86.30%	76.30%
39749359.22	0.42%		16-19	M	No	20.00%	30.00%
646544259.8	6.81%		20-34	M	No	17.48%	27.48%
520008822.9	5.47%		35-54	M	No	20.78%	30.78%
127221382	1.34%		55-64	M	No	17.68%	27.68%
93995244.19	0.99%		65+	M	No	15.46%	25.46%
33282804.62	0.35%		16-19	F	No	20.23%	30.23%
294449013.5	3.10%		20-34	F	No	16.83%	26.83%
310291615	3.27%		35-54	F	No	19.54%	29.54%
58086428.8	0.61%		55-64	F	No	16.04%	26.04%
49144758.54	0.52%		65+	F	No	13.70%	23.70%

RI Popn Projection A	Sprawl Population	# Urban/ Rural	RI Popn Projection B	Sprawl Population	# Urban/ Rural
35120	24584	28096	30517	21361.9	24413.6
118968	86275.5936	98172.3936	102392	74254.6784	84493.8784
138454	95837.8588	109683.2588	122253	84623.5266	96848.8266
72944	52753.1008	60047.5008	67663	48933.8816	55700.1816
99262	73989.8948	83916.0948	93705	69847.707	79218.207
34084	23780.4068	27188.8068	29578	20636.5706	23594.3706
121009	88542.2853	100643.1853	103831	75973.1427	86356.2427
142531	100427.3426	114680.4426	125456	88396.2976	100941.8976
76403	56507.6588	64147.9588	70907	52442.8172	59533.5172
122158	93206.554	105422.354	115463	88098.269	99644.569
35120	10536	7024	30517	9155.1	6103.4
118968	32692.4064	20795.6064	102392	28137.3216	17898.1216

138454	42616.1412	28770.7412	122253	37629.4734	25404.1734
72944	20190.8992	12896.4992	67663	18729.1184	11962.8184
99262	25272.1052	15345.9052	93705	23857.293	14486.793
34084	10303.5932	6895.1932	29578	8941.4294	5983.6294
121009	32466.7147	20365.8147	103831	27857.8573	17474.7573
142531	42103.6574	27850.5574	125456	37059.7024	24514.1024
76403	19895.3412	12255.0412	70907	18464.1828	11373.4828
122158	28951.446	16735.646	115463	27364.731	15818.431

				Table 8: Preliminary Sprawl Projections	
VMT US 1995	VMT US Interp Raw	Rural/Urban Adjustment	RI Adjustment Factor	Projection if VMT/driver= 1995 level (A) (millions)	Projection if VMT/driver= 199 levels (B) (millio
7202.08	14761.12456	0.88	0.83	147.60	
16325.11	20522.55614	0.91	0.83	1209.37	
17148.22	23321.72442	0.91	0.83	1421.38	
14412.91	21131.48571	0.91	0.83	653.70	
9765.23	10866.09297	0.95	0.83	644.40	
6038.66	12897.40999	0.88	0.83	119.89	
10861.26	17367.02584	0.90	0.83	821.97	
10440.43	15655.8632	0.91	0.83	906.10	
7370.46	9142.302309	0.95	0.83	372.24	
4562.16	4592.772664	0.95	0.83	380.84	
9344.08	14761.12456	1.14	0.83	62.11	
21361.19	20522.55614	1.19	0.83	438.61	
21383.3	23321.72442	1.13	0.83	579.74	
17966.64	21131.48571	1.13	0.83	218.17	
11230.42	10866.09297	1.09	0.83	155.86	
8080.93	12897.40999	1.18	0.83	54.45	
14131.35	17367.02584	1.18	0.83	281.57	
13121.48	15655.8632	1.14	0.83	347.58	
8417	9142.302309	1.08	0.83	92.74	
5184.13	4592.772664	1.08	0.83	78.07	

Projection if VMT/driver = interp (A) (millions)	Projection if VMT/driver = interp (B) (millions)	Sprawl Projection VMT/driver 1995, A	Sprawl Projection VMT/driver 1995, B	Sprawl Projection, VMT/driver Interp, A	Sprawl Projection, VMT/driver Interp B
302.5216007	262.8716312	129.15	112.23	264.7064006	230.0126773
1520.320009	1308.491413	1062.82	914.73	1336.083459	1149.924833
1933.083517	1706.886469	1241.95	1096.63	1689.068935	1491.42491
958.4259572	889.037831	574.29	532.72	841.9990916	781.0400381
717.0438124	676.901437	568.17	536.37	632.2267066	596.8326605
256.0544758	222.2033589	104.86	91.00	223.9553814	194.3478545
1314.324939	1127.748124	723.14	620.49	1156.29621	992.1525817
1358.739617	1195.964649	793.49	698.43	1189.868176	1047.323753
461.7218267	428.5081681	327.90	304.31	406.7287554	377.4709875

383.3907849	362.3786424	336.71	318.25	338.9654333	320.3880697
98.12394609	85.26333892	93.17	80.96	147.1859191	127.8950084
421.3922528	362.6790024	689.53	593.46	662.4633357	570.1612692
632.2910074	558.3043649	858.73	758.24	936.5696443	826.9782652
256.5964581	238.0193867	341.56	316.83	401.7302014	372.6457366
150.8017774	142.3594181	256.67	242.30	248.3449711	234.4418359
86.89792962	75.40978061	81.36	70.60	129.8529121	112.6859945
346.0378507	296.9155689	448.87	385.15	551.6456052	473.3359901
414.7106671	365.0289513	525.46	462.51	626.9474466	551.840083
100.7337665	93.48754868	150.56	139.73	163.5353666	151.7715566
69.16029112	65.36988731	135.05	127.65	119.6422554	113.0851335

No U/R Difference, VMT/driver 1995, A	No U/R Difference, VMT.driver 1995, B	No U/R differnce, VMT/driver interp, A	No U/R difference, VMT/driver interp, B
147.15	127.86	301.5899352	262.0620744
1170.55	1007.45	1471.513531	1266.485219
1365.84	1206.02	1857.558984	1640.199333
631.89	586.15	926.4519	859.3786317
600.48	566.86	668.1757013	630.769117
119.35	103.57	254.8981226	221.1998788
799.24	685.78	1277.971089	1096.554935
871.40	767.00	1306.69383	1150.153869
346.14	321.24	429.346319	398.4615714
353.40	334.03	355.7674838	336.2692659
81.82	71.10	129.2528294	112.3123176
580.39	499.52	557.6005494	479.9091811
757.34	668.73	825.9992131	729.3460774
301.49	279.66	354.5933157	328.9214675
235.88	222.67	228.2231467	215.4464947
69.20	60.05	110.4424573	95.84165597
381.30	327.17	468.6068652	402.0851294
459.14	404.14	547.8248047	482.1962149
139.17	129.16	151.1651994	140.2912293
124.74	117.90	110.507069	104.4506108