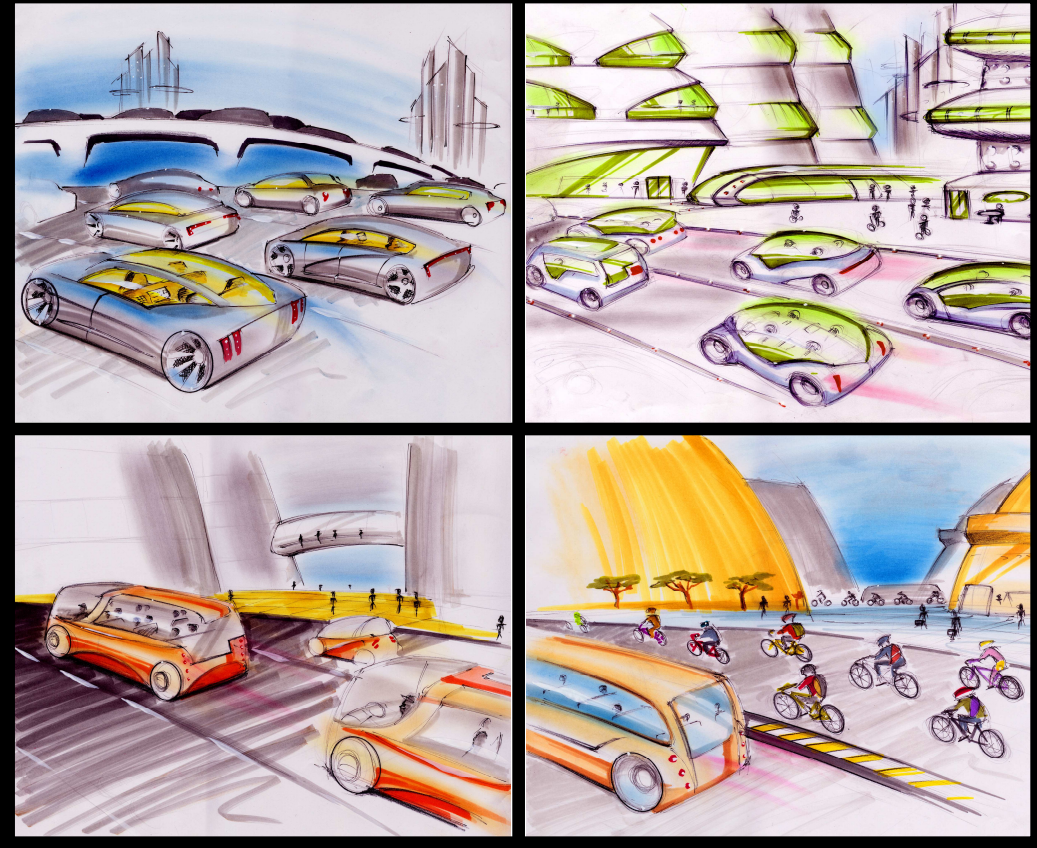


VISUALIZING CALIFORNIA TRANSPORTATION IN 2030 USING SCENARIO PLANNING

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DONALD BREN SCHOOL OF ENVIRONMENTAL SCIENCE AND MANAGEMENT
MASTER'S THESIS

MAY 2007

SIGNATURE PAGE

Visualizing California Transportation in 2030 Using Scenario Planning

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The Group Project is required of all students in the Master's of Environmental Science and Management (MESM) Program. It is a four-quarter activity in which small groups of students conduct focused, interdisciplinary research on the scientific, management, and policy dimensions of a specific environmental issue.

This Final Group Project Report is authored by MESM students and has been reviewed and approved by:

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ABSTRACT

Future scenario planning is a method that explores the boundaries of future possibilities to prepare for the uncertainty of what is to come. By establishing two driving forces of change, environmental priority and economic growth, we create four different scenarios for transportation in California in the year 2030:

- 1.) “GREEN IS GOLDEN”
- 2.) “CONVENIENCE TRUMPS”
- 3.) “HOLDING OUR OWN”
- 4.) “GROWN FROM GRASSROOTS”

We then assess the implications of each of these future scenarios for the transportation system and its various stakeholders. In addition, we describe how to scan for signs that aspects of these future scenarios are unfolding. Finally, we explain how stakeholders, such as businesses and government agencies, can develop robust plans that are effective in multiple scenarios.

EXECUTIVE SUMMARY

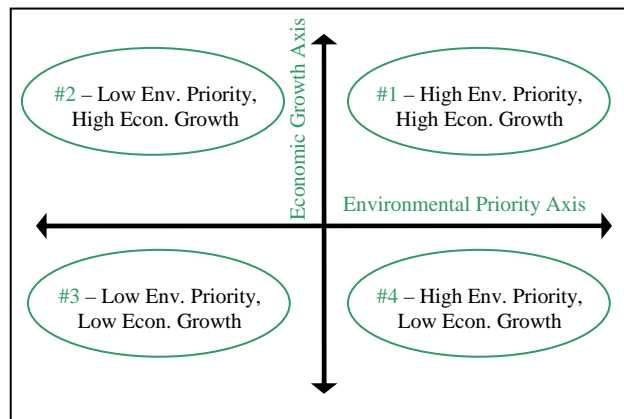
Introduction

The future of transportation in California is uncertain, and the state faces a number of increasing transportation problems including congestion, population growth, and environmental impact. This project provides a framework for addressing these problems in a long-term, strategic manner.

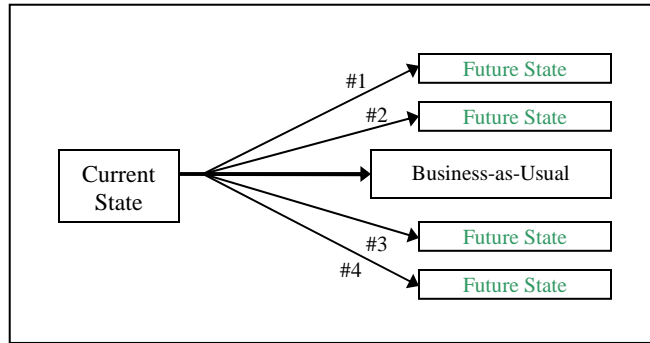
Other methods of predicting the future often fall short because they are narrowly focused and rely only on mean historical trends. This project uses **future scenario planning** as a method for government and business to prepare for uncertainty by considering a wide range of future possibilities.

Methodology

The primary goal of the scenario planning method is to identify and organize future uncertainties, and in doing so, to create a framework for understanding the implications of those uncertainties. Scenario planning typically uses two **drivers** to address uncertainties. Drivers are defined as the main forces that effect change within the studied system. This project uses **economic growth** and **environmental priority** as its two drivers. Drivers can be visualized as a set of axes, as seen in the figure below, where **each quadrant represents a scenario**.

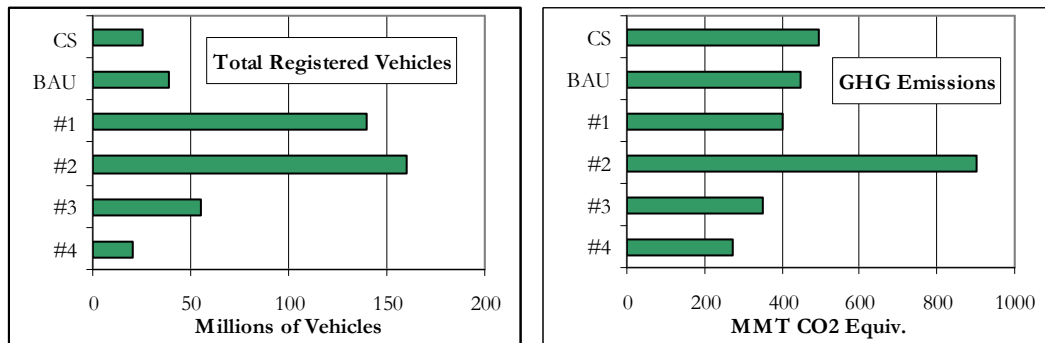


The California transportation system is described through a set of **system variables**. From the **current states** (CS) of these variables and their historic trends, a business-as-usual (BAU) projection is made for the year 2030. For each variable, four **possible future states** are obtained by using the drivers to deviate from the BAU projection, as shown in the figure below. This creates the quantitative skeleton for our four scenarios, which are then fleshed out with narrative descriptions.



Results

For each of the 74 system variables, we determined the current state and calculated values for the BAU projection and the four possible future states (one for each scenario). Here are two examples of the results:



By analyzing and comparing the results, we can begin to uncover the story of each scenario, which is then expanded upon in the qualitative descriptions.

Scenario 1: Green is Golden

- Highly mobile, highly automated society.
- Citizens strive for “green” status.
- Transport activity is subject to a carbon tax.



Joe's commute

Joe wakes up in his suburban condo to the smell of coffee from the café downstairs. He is up just in time to make the 8a.m. commute shift. It is his turn to drive the carpool. He inserts his transport card into the dash console and drives to the usual meeting spot.

On the way to work, they have to pass by old neighborhoods that have not made the change to new efficient technology. He looks at the new light rail system with pride, as his firm has helped build it.

It doesn't take a lot of effort to drive with all the sensors on the road. The office is getting quiet these days because so many people are telecommuting. He misses the old days, when you could chat at the water cooler with co-workers.

Almost every part of life in California is now regulated for eco-efficiency. California's transportation system has been re-structured to meet the high consumption demands of economic success and stringent environmental protection laws. Business in California has flourished by meeting the demand for low emission vehicles and other green technology.

Californians still have a high level of mobility, as long as they travel according to optimized travel times and modes. The distribution of "transport cards" has replaced drivers' licenses as standard issue identification. The transport cards maintain a digital record of each citizen's carbon footprint, for which they are taxed at the end of the year.

Fuel demand has been met by the introduction of an array of energy sources that are domestic, clean, and renewable, while emitting almost zero greenhouse gases. The replacement of old vehicles has become requisite by government mandate.

Cars are still the most popular mode of transportation—for the middle and upper class who can afford the low carbon technology and taxes. Public transit plays a major role in moving people around, but to the chagrin of the state government, is under-utilized.

Scenario 2: Convenience Trumps

- Transportation channels near maximum capacity
- Commute is part of work day; extreme multitasking.
- Luxurious lifestyles, several single purpose vehicles



Joe's commute

Joe grabs his morning coffee at 5:30a.m. He is waiting for the corporate shuttle to pick him up for the nearly 60 mile commute. In order to optimize their time while waiting in traffic, Joe and his colleagues have a meeting every morning en route at 6:30a.m. on the dot.

Each person has a work station on the shuttle which is as fully equipped as their office. Most of the participants for the morning meeting are on the bus, and they videoconference with the rest using state of the art audiovisual equipment. There are personal screens for high definition projection, along with surround sound for each workspace.

As soon as they reach the office, they begin acting on the decisions made en route. The shuttle home leaves the office at 3:30p.m. and they may use this time for small group meetings as needed.

California is very isolated as societal trends focus on personal freedom and prosperity, at the expense of community and environmental concerns. People and businesses continue to migrate to the state thanks to government deregulation and financial security, resulting in high levels of technological advances and reduced unemployment.

The transportation system is stressed and people opt to respond instead of waiting for the ineffectual and inefficient government to intervene. In order to be time-efficient, commuters purchase vehicles with built-in workspaces and hire drivers to enable themselves to multi-task. Businesses also organize shuttle pools to offer alternatives to the crowded and degraded public transportation means. Often, the wealthy hire helicopter taxis to bypass road and rail traffic altogether.

Homes, workplaces and shopping areas are spread out and continue to expand. This trend has opened up a market for travel easements; technologies that address traffic avoidance, telecommuting, audiovisual, comfort, and air filtration needs are of particular importance. Environmental quality has become a low priority due to a lack of immediate urgency.

Scenario 3: Holding Our Own - A Modest Energy Society

- All energy sources are domestic
- High-density urban development emerges
- Limited mobility: work/shop from home
- Widespread use of public transportation



Joe's commute

Joe awakes to the sound of rain. Since he started working from home over ten years ago, Joe is no longer bothered by the weather. Joe and his family do many things in his apartment complex: shop, go to the movies, work out, and dine.

Last week Joe took the bus to his company's main office for an "in-person" meeting. These meetings allow Joe and his coworkers the chance to work with his company's clients directly. Joe's transportation engineering firm is one of the few remaining that still offers personal meetings.

During lunch Joe has to fill out a consent form for his son's upcoming "field trip." As part of the 3rd grade curriculum, each student is required to take a field trip to at least three foreign countries and to write a report on cultural differences. Naturally, each trip only lasts half an hour each so that the rest of the teaching day is not wasted. But each trip is full of highlights necessary for the students to learn about different cultures. This Friday, Joe's son will travel to Japan and learn about the past fifty years of urban planning and transportation evolution. Joe opts to pay a little extra to download an extended trip for himself later.

Californians are now among the most “virtually-mobile” people in the world. The transportation system in California has changed dramatically over the past couple decades. Fewer and fewer cars occupy the roads while buses and hyper-efficient trucks travel freely on the open spaces. It has become too expensive, and is often seen as unnecessary, for many people to purchase their own car. Any individual who needs to travel can take a bus almost anywhere without problems.

Many people have long since moved to high density apartments to be able to afford living in California. New apartment complexes incorporate businesses in the lower floors along with recreational and entertainment facilities. Small businesses have flourished near their close customer base while others have had to rely on virtual shopping and hyper-efficient shipping to transport goods.



Scenario 4: Grown from Grassroots

- Main impetus for change brought on by local, grassroots activism
- Mobility and the transport of goods localized, as the costs of transportation soar
- Lack of funds encourages cooperation between government and businesses

Joe’s commute

Joe gets up for work early on Monday morning. Along with several of his neighbors, Joe walks through his backyard to a dirt path that connects Joe’s neighborhood with the nearby business and commercial district where most local residents work. The path was created through a governmentally-organized Community Pathways Program, funded by donations from area stores, and is maintained through community and employee volunteers.

Joe’s job is located in a small mixed use area, with restaurants and shops so he can run errands easily. His building is LEED Platinum certified, and the entire complex is LEED MU certified (mixed use). A quick glance at the small parking lot reveals a handful of small alternative fuel cars, a large bike rack taking up over one third of the lot, and a corporate carpool bus, fueled by waste oils from local businesses and restaurants.

At the end of the day, Joe walks home knowing that because his day was almost carbon neutral, he can apply to be named Carbon Neutral Person of the Week.

“Grown from Grassroots” illustrates the potential impact of individuals working together to demand changes from the government, businesses, and each other. Mobility is severely limited, both due to choice and economic necessity. Major shifts in public demand for local, organic, and environmentally-friendly goods have led to a significant decline in the need for shipping.

Through the help of urban redevelopment and mixed-use, high density neighborhoods, the need for individuals to drive during a typical day has almost vanished in some parts of California. Many people choose to walk or bike to work and to run errands, and many more cannot afford the high costs of gas. Inexpensive alternative energy sources, particularly ones derived from California sources (such as waste-to-energy and biofuels from agricultural waste), have made significant inroads with people and businesses who still must drive.

Recommendations and Conclusions

In going through the steps of using the scenario planning method, we have learned a great deal about the process of building scenarios. Accordingly, we make a few recommendations to those who wish to duplicate our methodology in the future.

- The first step should be to pick a few drivers and perform quick, non-extensive ‘test’ scenarios.
- Second, scenario planners should discuss their scenarios and write up what the scenarios will look like in qualitative, narrative form, then use supporting data for scientific rigor.
- Lastly, the scenario planning team should be as multidisciplinary and diverse as possible. This will help to avoid bias and to ensure that the scenario narratives are diverse and comprehensive.

Identifying Commonalities

The following elements were determined to be similar across two or more of the scenarios envisioned in this project:

- 1.) *Increasing congestion*
- 2.) *Increasing use of public transportation*
- 3.) *Corporate carpooling*
- 4.) *No clear technology winner*

In addition to these specific commonalities, we observed a number of themes that appeared in multiple scenarios, but arose through very different circumstances. These themes are particularly notable, as they show how positive outcomes can arise through a variety of pathways. The following are the most important themes we have observed:

Common Themes:

- 1.) *Energy Efficiency, arising from either economic or environmental efficiency – Scenarios 1, 3, & 4*
- 2.) *Higher environmental impacts result from high economic growth than from low environmental priority.*

How Others Can Use This Project

The ultimate goal of this project is to facilitate discussion and consensus-building about the future direction of transportation within the state of California, in hopes of promoting sustainability. It is our desire that this project can be used by diverse parties in business, government, and academia to actively plan for their future transportation-related decisions.

Signposts & Affecting the Future

In addition to making decisions based on a scenario analysis, planners often want to know which scenario is ‘coming true’ as time passes and the future becomes the present. Since each scenario is designed to be an extreme case, the future is unlikely to look exactly like any specific scenario and will likely contain elements of all four. However, the stakeholders can still have a substantial influence in shaping the future, based on their knowledge of the possibilities. These facts lead to two additional uses for scenario planning: Scanning for “Signposts” (defined as ‘indicators of which scenario is coming true’) and Affecting the Future.

Examples of Signposts:

- Changing environmental priority: Green party candidate elected governor; Inconvenient Truth wins an Oscar
- Changing economic growth: Shortage of Middle Eastern oil
- Hybrid car sales trends.

In order to affect the future, business, policymakers, academia, and households can look at the scenarios and decide which is best for them and for society as a whole. Making stakeholders aware of the drivers of change and of the possible outcomes of their actions can lead them to make choices with this long-term future in mind.

Conclusion

Future scenario planning provides a useful tool for governments, businesses, non-profit groups, and research institutions facing an ever-changing world. Only time will tell if scenario planning helps inform successful decision making in California’s transportation future. Ultimately, the measure of good scenarios is not whether they get the future right, but whether they lead to better decisions in the present.

In scenario planning, it is important to keep in mind that the greatest insights are gained from the scenario planning process, rather than simply reading scenarios. Thus, we encourage organizations to practice scenario planning in their long-term strategies.

"The only certain thing about the future is that it will surprise even those who have seen the furthest into it." - E J Hobsbaum, historian.

1. INTRODUCTION

1.1. Background

Why do we need Scenario Planning to plan for the future?

“With over fifty foreign cars already on sale here, the Japanese auto industry isn’t likely to carve out a big slice of the U.S. market for itself.”
Business Week, 2 August 1968

“A severe depression like that of 1920-1921 is outside the range of probability.”
The Harvard Economic Society, 16 November 1929

“I think there is a world market for about five computers.”
Thomas J. Watson, chairman of IBM, 1943

“There is no reason for any individual to have a computer in their home.”
Ken Olson, president, Digital Equipment Corporation, 1977

“We don’t like their sound. Groups of guitars are on the way out.”
Decca Recording Co. executive, turning down the Beatles, 1962

(Quotes collected by Paul J.H. Schoemaker, “Scenario Planning: A Tool for Strategic Thinking”, Sloan Management Review, Winter 1995, pp 25-40.)

Throughout history, humans have managed to accomplish feats that were thought improbable, if not impossible, only years earlier. The unpredictability of future events makes planning for the future difficult. Traditionally, companies and academics alike have used projections, based on past trends, to predict the likely direction that different variables, such as population growth or stock performance, will take in the future. Even when taking into account present forces acting on such variables, projections are still based on our historic understanding of underlying trends. However, managers and policy makers who are able to imagine a wider range of potential pathways and possible futures will be better prepared to deal with and profit from unexpected events. To accomplish this, scenario planning was developed as a systematic method for imagining a variety of possible future states.

Scenario planning was pioneered by Royal Dutch/Shell in the early 1970s in order to deal with the uncertainty of the oil market. When other major oil companies were taken by surprise by the energy crisis of the late 1970s, Shell had foreseen the possibility of such a crisis through the use of scenario planning, and was able to respond more quickly and effectively, sustaining fewer losses. They continued to use the methods of scenario planning and were again able to foresee the possibility of a seemingly impossible event – the fall of the U.S.S.R. In realizing the potential for the collapse of the Soviet Union, they were able to avoid costly investments in the North Sea that would have been unprofitable in the face of falling oil prices. Instead, they were able to capitalize on those falling prices, due to the opening of the northern Russian oil fields, by investing in those oil

fields once they were unlocked to multinationals. These two maneuvers, made possible by scenario planning, allowed them to rise from one of many oil companies to one of the top oil-producing corporations in the world.

Scenario planning allowed Shell to foresee these unlikely events because it encourages planners to envision futures that are possible, but not necessarily probable. This kind of thinking is particularly important when there is a “major shift in the business environment that makes whole strategies obsolete” (Zergas 2004). Scenario planning differs from more traditional planning methods, such as contingency planning or sensitivity analysis, because it accounts for a greater number of uncertainties and for interactions between uncertainties. As a result, it allows for multiple variables to change at the same time, creating a number of future states, with each variable taking on a different value in each state. Meanwhile, it also organizes these variables and uncertainties into a format that can be easily interpreted and communicated.

1.2. Methodology

In order to achieve the goals discussed above, the scenario planning method seeks to identify and organize the most important and most uncertain aspects of the system in question, and then creates a framework for understanding the implications of these uncertainties. The following is an outline for accomplishing this process:

1.) Define the system

This step is, in essence, identifying the focus of the exercise. In our case, we are addressing the sustainability of transportation and mobility in California. We limit ourselves to features that are confined to the geographic boundaries of the state of California. In addition, we further define this system by identifying a number of *system variables* that describe the state of the system. System variables are defined as the qualitative and quantitative aspects used to describe the state of the transportation system. The following is an alphabetical list of our system variables:

- Accessibility
- Commercial Aviation
- Cost of Mobility
- Demographics
- Freight
- Greenhouse Gas Emissions
- Public Transportation
- State of the Environment
- Total On-Road Vehicles
- Tourism
- Travel Time
- Vehicle Miles Traveled

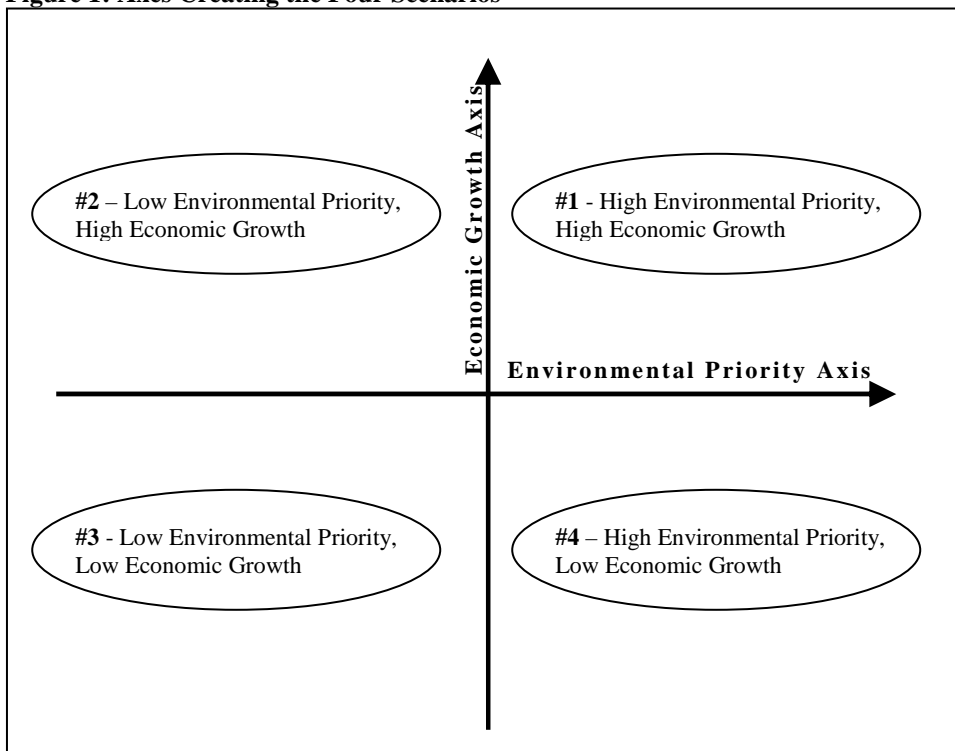
2.) Identify driving forces within the system

This step involves listing all of the forces acting on the system that will affect the outcome of the issue in question. In our case, we were interested in forces within the state of California that will have a substantial effect on shaping mobility in the next twenty-five years. Clearly, there are a seemingly infinite number of potential forces.

3.) *Rank forces by importance and uncertainty and select drivers*

Next, the forces should each be ranked with regards to their importance and their uncertainty, with relation to the issue in question. The two drivers that are ultimately chosen should be among the most important forces acting on the system, and should also be relatively uncertain. For example, population growth would be a poor driver, since level of growth is relatively certain. In our case, we chose economic growth and environmental priority. Although there are projections as to the likely direction these two drivers will take, there is also a significant amount of uncertainty in those predictions. Additionally, we felt that both drivers would have a noteworthy impact on the state of mobility. Once choosing the two primary drivers, each is assigned to an axis, creating a scenario in each quadrant.

Figure 1: Axes Creating the Four Scenarios



‘Environmental priority’ is defined as behaviors and/or attitudes of different societal stakeholders that reflect the importance of the environment in decision-making. That priority is characterized by the support or rejection of environmental issues by the following stakeholder groups:

- Government
- Media

- Business
- Households
- Science/Education

Economic growth is defined as the annual percentage growth in California’s Gross State Product (GSP) per capita. GSP is the state-level equivalent of the U.S. Gross Domestic Product (GDP) and is sometimes referred to as simply California’s GDP. It is generally interpreted as a measure of the size of a state’s economy, and is technically defined as the final value of all goods and services produced annually within an economy. The axis is thus defined by the following values:

“High Economic Growth”	+6% to +7% annual growth in GSP
“Low Economic Growth”	0.5% to +1.5% annual growth in GSP

For the current values and trends of GSP, please see the chapter on California’s Current State.

4.) *Identifying implications of each combination of drivers*

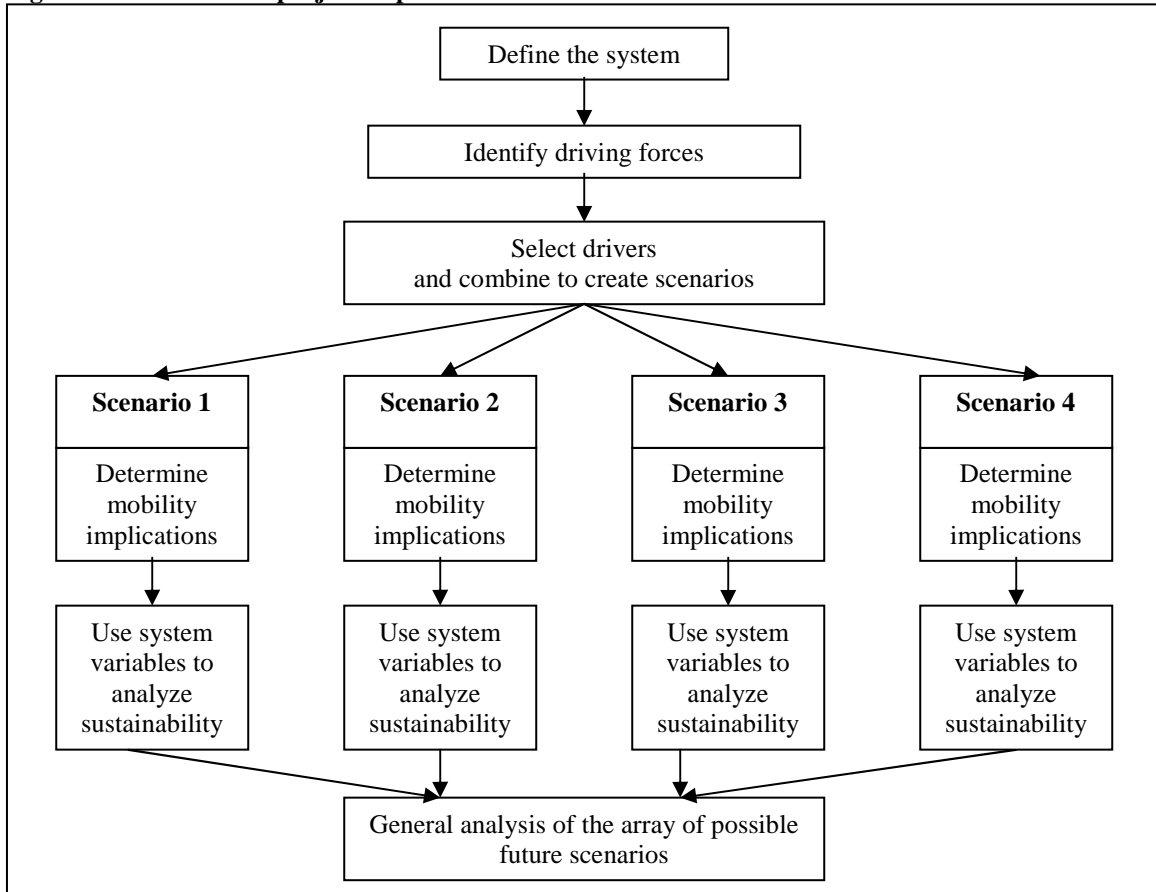
This step involves telling the “story” of each scenario, through imaginative brainstorming. In general and qualitative terms, each scenario is described in a narrative format. This is the stage at which most of the exploratory thinking occurs, where participants are encouraged to consider possible, though not probable outcomes. (It is important to note, however, that certain improbable events, such as the energy crisis of the 1970s or the Great Depression, would be within the range of out-of-the-box thinking, but other events, such as alien attacks or the sudden discovery of zero-cost energy, would not be considered useful.)

5.) *Defining values for system variables in each scenario*

After the initial brainstorming, each scenario is fleshed out, and values are given for all of the system variables that were used to define the initial state. These values are obtained from first deriving a Business-as-Usual (BAU) value for each variable in the year 2030. BAU values are based on the current state value and on historic and current trends. The four future state values (one for each scenario) are then determined by deviating from the BAU value, according to the drivers. In other words, the drivers are the independent variables that then effect changes in the system variables.

This step allows for easy comparison between scenarios, and gives a more rigorous definition to the qualitative narrative.

Figure 2: Flow chart of project steps



(Source: Zegras et al. *Scenario Planning for Strategic Regional Transportation Planning*)

6.) *Checking for internal consistency*

Once an initial description of each scenario has been derived, it is important to check for the internal consistency of each scenario. Problems with consistency arise from the interactions of endogenous forces. These are forces, other than the primary drivers, which can alter the ultimate outcome of the scenarios through their feedback. Although, by definition, endogenous forces can not alter the (exogenous) primary drivers, they can impact the final states of the system variables. For example, the high level of economic growth may lead to congestion in “Convenience Trumps.” However, as congestion worsens, it will motivate efforts to reduce congestion-related delays, which, when coupled again with the high economic growth, may lead to the eventual reduction of congestion to more moderate levels.

This step is not commonly mentioned in the literature by most expert scenario-planners. As such, we developed our own standardized method to ensure consistency within and across our scenarios. We chose three issues that were important within each scenario, and as a group, discussed the possible endogenous variables affecting each issue. We used these three issues as a test: if we found them to be consistent within and across scenarios,

we deemed our scenarios to be consistent. Our three issues were the following: congestion, development patterns, and general environmental quality.

1.3. Applications of Scenario Planning

Although scenario planning is often used by companies in order to create a more robust business strategies for their future growth (such as the Royal Dutch/Shell example above), there is a notable number of academic reports that have used scenario planning as a tool to facilitate discussion and aid in consensus-building. Topics addressed range the future of biotechnology to the availability of clean water in developing countries and many others (WBCSD 2000, WBCSD 2006). Overall, these more academic applications of scenario planning, like our project, seek to enhance understanding of the boundaries of possible future developments and to build consensus on necessary next-steps.

For applications related to transportation, the Federal Highway Administration (FHWA) “is actively encouraging and supporting” the use of scenario planning by regional planners. The FHWA “believe[s] that scenario planning can help citizens, businesses, and government officials understand the impacts of growth, especially the relationship between transportation and the social, environmental, and economic development of regions” (FHWA 2005). While they allow that scenario planning is not a replacement for other forms of traditional planning, they have chosen to support scenario planning as one technique in a toolbox of planning methods. Specifically, they contend that it helps their decision-makers to recognize how various forces interact, rather than seeking a single, specific outcome. Other groups to apply the techniques of scenario planning to transportation include the Transportation Planning Board for Washington, D.C., the University of Utah, and the MIT Center for Transportation & Logistics.

2. CURRENT STATE OF TRANSPORTATION IN CALIFORNIA

The current state of transportation is outlined here in order to create a baseline against which to compare the future state of transportation in the year 2030. In order to create standardized descriptions, we have listed a set of system variables which define the state of California's transportation system in its current form and in the future.

2.1. Defining the System

We have chosen to define the system through a set of attributes, or *system variables*. These system variables were specifically chosen for their direct impact on transportation. Table 1 provides a complete list of these variables, along with their current state values and baseline years. Values are given for the entire state of California on an annual basis, unless otherwise noted. In Section 2.2, the system variables are defined in more detail.

Table 1: System Variables Values and Baseline Years.

Driver / System Variable	Current State Value	Baseline Year
Gross State Product (GSP)	\$1.62 X 10 ¹²	2005
Average Percentage Growth in GSP	4.4%	1997-2004
Accessibility		
Average fare over all local systems of public transportation for all types of riders	\$ 0.93	2003
Percentage of rural population utilizing public transportation	1%	2003
Distance of low income residents to public transportation:		
% of low income <i>urban</i> residents living further than ¼ mile from a transit line	23%	2003
% of low income <i>rural</i> residents living further than ¼ mile from a transit line	96%	2003
Commercial Aviation		
Enplanements per commercial year	86,657,635	2005
Cost of Mobility		
Fuel Price		
Average nationwide gasoline cost per gallon (retail)	\$2.504	2006
Average nationwide diesel cost per gallon (retail)	\$2.963	2006
Total cost per mile (in \$2006)	86 ¢	
Fuel Tax		

State	44.7 ¢ / gallon	2006
Federal	18.4 ¢ / gallon	2006
Vehicle price (domestic)	\$22,727	2001
% of income spent on transportation		
Low income households	39%	2002
Middle-class households	19%	2002
Demographics		
Population	36,038,859	2005
Unemployment Rate	4.6%	November 2006
Employment	17,057,000	November 2006
Median Weekly Earnings	Men, \$722 Women, \$585	2005-2006
Median Household Income p.a.	\$51,312	2004-2005
Consumer Price Index (CPI) – Los Angeles	211.1	11/2006 (1983 = 100)
Freight		
Short Tons		
Rail	1.4 X 10 ⁷	1997
Road	6.3 X 10 ⁸	1997
Air	1.1 X 10 ⁶	1997
Sea	6.5 X 10 ⁷	1997
TOTAL	7.6 X 10 ⁸	1997
Value		
Rail	\$7.1 X 10 ⁹	1997
Road	\$5.4 X 10 ¹¹	1997
Air	\$4.7 X 10 ¹⁰	1997
Sea	\$1.9 X 10 ¹⁰	1997
TOTAL	\$7.9 X 10 ¹¹	1997
GHG Emissions		
CA GHG emissions (million metric tons CO ₂ equivalents)	493	2002
% of CA GHG emissions from transportation	41%	2002
CA GHG emissions from transportation (million metric tons CO ₂ equivalents)	202	2002
Public Transportation		
Number of commuters who rode public transportation to work	734,704 riders	2005
% of commuters riding public transportation	5.1%	2000
Funding	\$75 X 10 ⁶ state	1999

	\$5.298 X 10 ⁹ local	
State of the Environment		
Land Quality		
Extent of developed land (million acres out of 194.5 million acres total in CA & the Great Basin)	6.9 X 10 ⁶	2003
Air Quality		
Total days above state ozone standard (measured within each air basin)	562	2003
Peak 1-hr ozone concentration (statewide – observed in the South Coast Air Basin)	0.178 ppm	2003
NOx emissions from mobile sources (tons/day)	1518	2005
VOC emissions from mobile sources (tons/day)	772	2005
Days with PM10 exceeding state standard (measured within each air basin)	1366	2003
Lifetime asthma prevalence rate (% of adult population)	14%	2004
Water Quality		
# of days of MCL exceedances detected for drinking water	483	2002
Days of beach closings (per year)	102	2000-2001
Resource use / efficiency		
Statewide waste diversion rate	52%	2005
Total energy consumption (BTU)	8.130 X 10 ¹²	2003
Personal energy consumption (BTU per capita)	2.29 X 10 ⁷	2003
Biodiversity		
Total threatened species (federally listed & found in CA – “animals/plants”)	40 / 47	2006
Total endangered species (federally listed & found in CA)	84 / 139	2006
Tourism		
# travelers to CA	3.354 X 10 ⁸	2005
# within-state travelers	2.798 X 10 ⁸	2005
% Hotel beds occupied	70.6%	2005
Transient occupancy tax receipts	\$9.3 X 10 ⁹	2004
Total On Road Vehicles		
Total number of all registered vehicles	25.627 X 10 ⁶	2005

Passenger	18.62 X 10 ⁶	
Truck 1	3.849 X 10 ⁶	
Truck 2	2.228 X 10 ⁶	
Truck 3	0.405 X 10 ⁶	
Truck 4	0.139 X 10 ⁶	
Motorcycles	0.386 X 10 ⁶	
Avg. # of autos per person	0.86	2005
Travel time		
Average commute time (minutes)	27.1	2004
Median commute time (minutes)	20	2004
Vehicle miles traveled		
Vehicle miles traveled	328.6 X 10 ⁹	2004
Passenger Autos	235.804 X 10 ⁹	2004
Trucks	91.481 X 10 ⁹	2004
Average fuel economy for on-road vehicles (mpg)	18.13	2004

2.2. Current State of Drivers & System Variables

2.2.1. Gross State Product

California's GSP accounts for approximately 13% of the U.S. GDP, and is the highest of any state in the nation. In recent years, the percentage growth has outpaced the U.S.'s percentage growth by about 1%, with an average of 4.4% (Bureau of Economic Analysis, 2005).

2.2.2. Accessibility

Accessibility of mobility is not defined by one set of figures. Instead, it is a combination of factors that either promote or create barriers to mobility. Accessibility can most readily be defined through analyzing the combined affects of other system variables, such as public transportation ridership, percent of income spent on transportation, and cost of mobility. The cost of mobility captures how expensive utilizing a vehicle can be, and when compared to average income or public transportation fares demonstrates which method of transportation is most cost effective. Ridership of public transportation in high density low income areas, distance to transit lines for low income populations, and fares for using public transportation all demonstrate the accessibility of transportation to low income segments of the population. (The emphasis on lower income residents is a reflection of existing legislation that requires public transportation to cater first to lower income residents and only second to middle- and high-income residents.)

Other factors of accessibility cannot be captured through actual values. Intangible aspects of accessibility involve perceptions by various stakeholders (such as riders and California planning and transportation agencies), monetary investments not reported through accounting reporting mechanisms, and other information not monitored or reported to any agency regularly. These features might include:

- Reliability of service
- Convenience
- Availability of transportation to specific destinations (Such as transportation between areas where large groups of low income workers live and work. For example, transportation in the Central Valley to farms and agricultural work.)
- Appearance and sanitation of buses
- Need for car during work hours
- Advertising and promotion of public transportation by CalTRANS (Business, Transportation, and Housing Authority 2003)

Measuring and reporting these variables would provide a deeper insight into the public’s opinion regarding accessibility of transportation in California. Several CalTRANS reports have identified these areas for increased monitoring in order to more fully understand the barriers to utilizing public transportation. While future reports might include these variables, they are currently unavailable and therefore are not able to assist in quantitatively describing the current state of the system variable accessibility.

Fares

Fares are one indicator of accessibility that can be captured through actual values. Higher fares create financial barriers to public transportation, decreasing accessibility overall. Fares for public transportation are not static around the state, but range depending on location (Business, Transportation, and Housing Authority 2003).

Table 2: Average Public Transportation Fees in California (for all transit systems, including buses, trains, commuter rails, ferry, etc.)

Rider	Avg. fare
Adult	\$ 1.35
Student	\$ 0.86
Senior/ disabled	\$ 0.55
Child	\$ -
Specialized service	\$ 1.88
Avg. Fare	\$ 0.93

(Source: American Public Transportation Association 2003)

According to the American Public Transportation Association, the national average for fares across all forms of public transportation is \$1.02, and for buses only the average is \$0.75. California fares are less expensive than the national average across all transportation modes, but more expensive for buses alone.

Distance from a Transit Line

The distance a low income resident lives from a transit line can have an affect on the ability of employees to travel to work in a timely, consistent, and easy fashion, as well as their willingness to use public transportation to get to work. The table below illustrates the percentage of people who live 150% below the poverty line or hold low- wage jobs, who must travel more than ¼ mile from home to reach a transit line.

Table 3: Percentage of Low-Income Residents and Low-Wage Jobs Located ¼-mile from a Transit Line, by County Type

County Type	Below 150% of poverty line	Low-wage job holders
Agriculture	83%	18%
Mixed	45%	53%
Rural	96%	9%
Urban	23%	72%

(Source: California Transportation Needs Assessment 2003)

California Programs to Increase Accessibility

Currently, there are several projects in place to increase ridership and accessibility of public transportation. Examples of initiatives are:

- 2003 Business, Transportation and Housing Agency report: *An Analysis of Public Transportation To Attract Non-Traditional Transit Riders In California*
- 2003 California Department of Transportation Division of Transportation Planning report: *Public Participation Report for the Draft California Transportation Plan 2025*
- 2003 California Department of Transportation report: *California Transportation Needs Assessment: The Transportation Barriers and Needs of Welfare Recipients and Low-Wage Workers*
- 2002 study: *Statewide Transit-Oriented Development Study: Factors for Success in California*

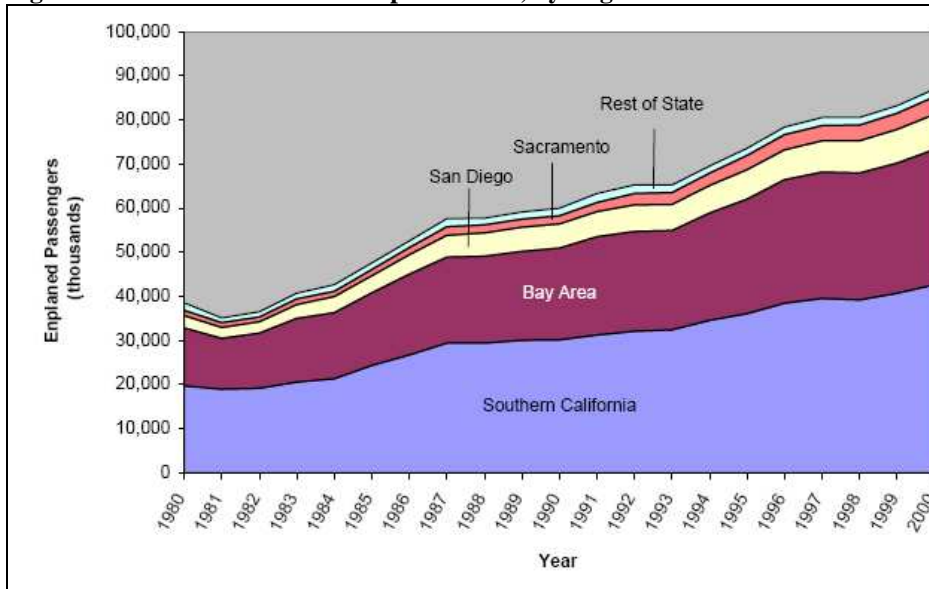
The presence of these programs indicates that accessibility is an issue that CA is attempting to address and increase. These programs also indicate that accessibility is low in much of the state, because significant amounts of funding are being used to study the problems and create long-term solutions.

2.2.3. Commercial Aviation

86,657,635 passengers boarded planes at 26 primary airports within the state of California in the year 2005 (Federal Aviation Administration 2005). An enplanement occurs when a passenger boards an airplane at a primary commercial airport within California. No distinction is made between passengers embarking on new trips and those who board connecting flights. The Federal Aviation Administration (FAA) uses passenger boarding and all-cargo data to determine funding entitlements for the next full fiscal year.

Enplanements increased by 3% in California from 2004 to 2005 and by 7% from 2001 to 2005 (FAA 2005). Enplanement activity has been highly concentrated in metropolitan area airports, namely SFO (San Francisco International Airport) and LAX (Los Angeles International Airport). Together, these two airports account for almost sixty percent of the state’s enplanements. Additionally, California’s population growth is closely correlated to increased enplanement numbers.

Figure 1: Trends in California Enplanements, by Region



(Source: Hansen 2002)

2.2.4. Cost of Mobility

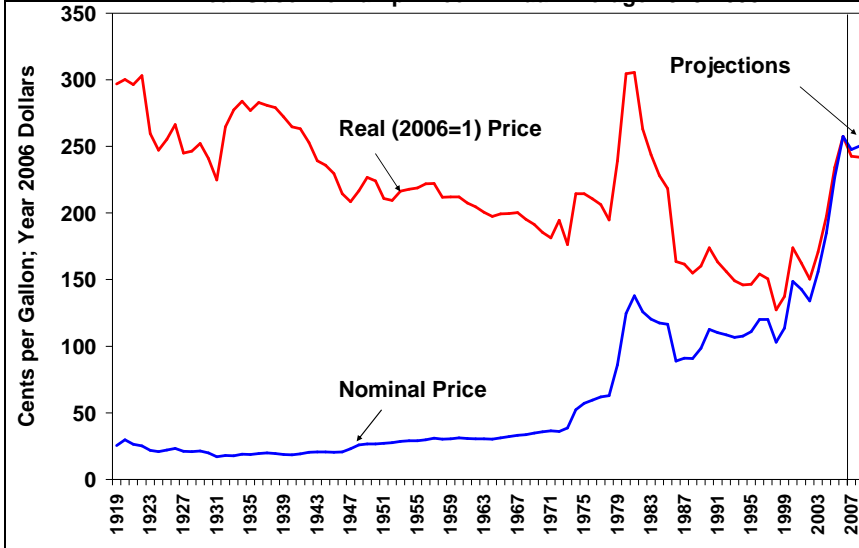
The cost of mobility refers to the total amount spent by the average household on all annual transportation needs. Retail petroleum fuel price, i.e. the price at the pump, is the most obvious component of total cost. However, total cost also includes the purchase price of a vehicle, if one is owned, as well as the maintenance cost of all vehicles owned. These expenses are reflected in the variable “total cost per mile.” If alternative transportation is used, such as buses or biking, then the cost of mobility would be total bus fare, cost of bicycle maintenance, etc.

A broader economic definition might also include the opportunity cost of travel, typically measured as a portion of the individual’s wage rate multiplied by the time spent during travel. While we accept that this is an important component of travel, particularly when facing increased congestion and commute times, it is outside the scope of this project.

Overall, the cost of mobility has steadily increased in recent decades. The average domestic vehicle price has been increasing since the early 1980s, but has begun to level off in the late 1990s. On the other hand, state and federal fuel taxes have been increasing

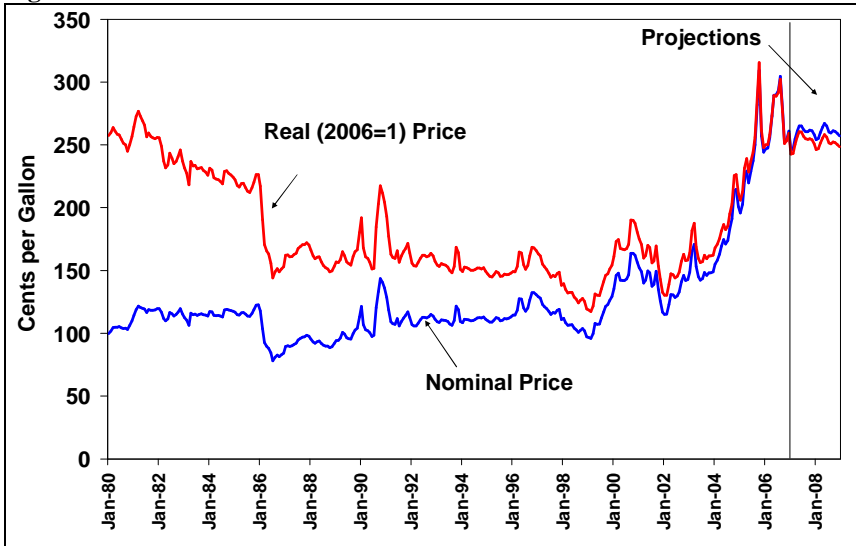
since the early 1900s at an increasing rate, which has a direct effect on the price at the pump. Average fuel price is the most unpredictable component of the total cost of mobility, with prices declining from the mid 1950s until the price spikes of the 1970s. Prices then dropped precipitously during the 1980s, staying low during most of the 1990s, before spiking again in 2005. Furthermore, predictions for future fuel prices range from 1990s-levels to many times that amount. Detailed projections of fuel price are also considered outside the scope of this project.

Figure 3: Real and Nominal Gasoline Pump Price: Annual Average 1919- 2008



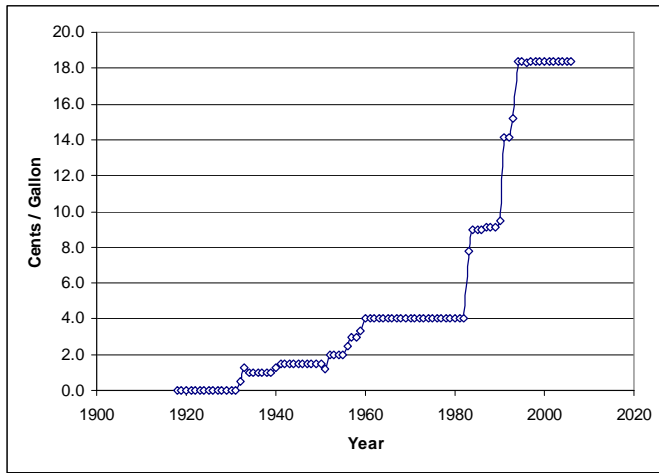
(Source: Energy Information Administration, Department of Energy 2007)

Figure 4: Diesel Fuel Prices: Nominal and Real



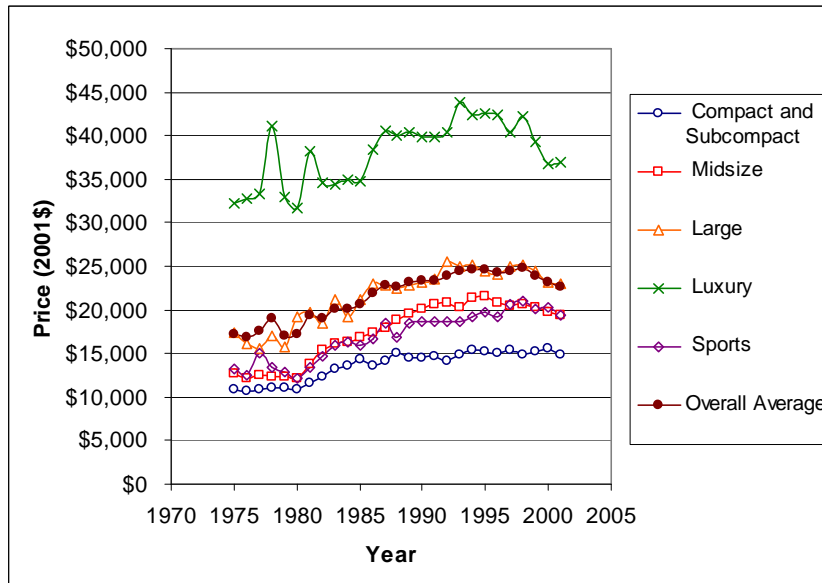
(Source: Energy Information Administration, Department of Energy 2007)

Figure 5: Real Federal Fuel Tax



(Source: American Petroleum Institute 2006)

Figure 6: Average Car Price



(Source: Abeles 2004)

Although aggregate values for the cost of mobility are important, the percentage of income spent on mobility is equally important for its implications on accessibility and equity. Typically, lower income households are forced to spend a significantly higher percentage of their income on basic transportation needs, indicating that they are relatively more affected by rising costs of mobility. They are also relatively less able to afford any new, cleaner transportation technologies that might develop.

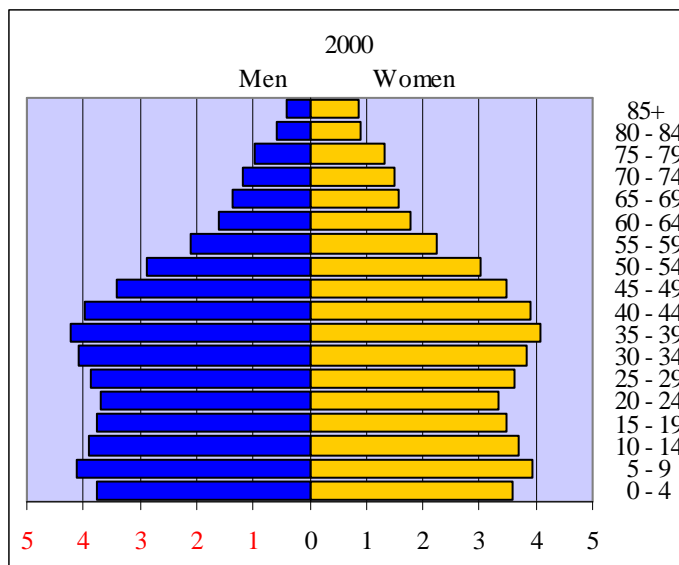
2.2.5. Demographics

The demographics of California represent a fundamental quality that cannot be ignored in scenario analysis. Age, income, and employment status all affect household behavior which ultimately affects markets, politics, demands for education and media consumption. This study focuses on age distribution, median income, consumer price index (CPI), and employment/unemployment rates. Ethnicity was not considered in this study due to social implications that are beyond the scope of this project.

Age Distribution

California's population will continue to age as life expectancies increase and baby boomers begin to reach retirement age in 2011. As shown in Figure 7 below, a large segment of the population is at an age that will heavily use transportation for many years to come. It should also be noted that the number of college-age adults will increase dramatically between 2005 and 2010 and again between 2020 and 2025. These different population segments each will have unique transportation demands as well as maintain differing generational levels of environmental priority.

Figure 7: Pyramid Age Distributions for California Residents, 2000



(Source: California Department of Finance 1993)

Median Income

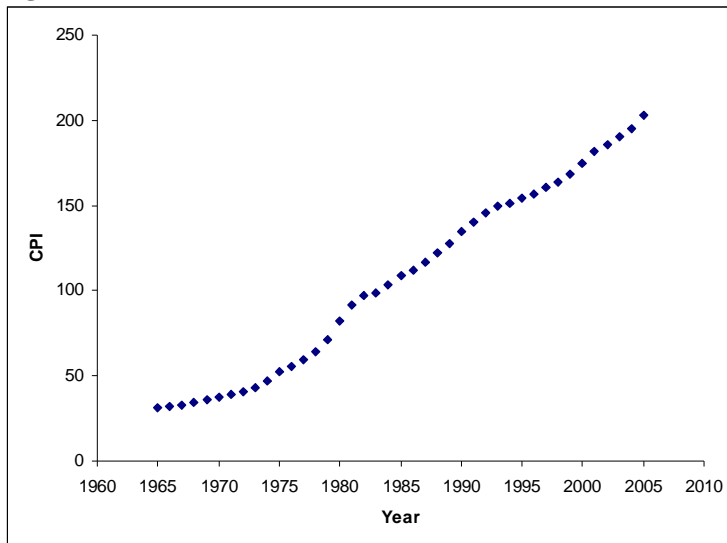
Median income is a general economic measure considered more reliable than mean income (due to the sensitivity of means to extreme high and low values). It reflects the overall economic strength of California. In general, median income is a good metric at state-level analysis. These statistics are compiled and reported regularly. The two-year average median income for California for 2004 – 2005 was \$51,312 (US Census 2006). Income, factored in with many other variables, can help explain or justify certain

household behaviors. Given historical trends, annual increase of median income over the next thirty years is expected to increase at a rate of \$1,200 per year (in current dollars). Median income is important to monitor in part because environmental goods and services can oftentimes be seen as normal goods. As income increases, the demand for normal goods (environmental amenities) will also increase. However, current environmental economic theory admits that the case is not clear cut and some goods can be regarded as inferior (Kahn 1997). Thorough economic analysis in each scenario may help account for this unique property of public environmental goods.

Consumer Price Index

The CPI is a measure of the cost of living by tracking the prices of a basket of goods over time (excluding volatile commodities such as food and energy). It is also a measure of inflation. CPI data for California since 1965 is shown in Figure 8 below.

Figure 8: California CPI 1965 – 2005 (1982-1984=100)



(Source: California Department of Finance 2006)

This rising trend reflects a long-term rise in inflation, yet this is no guarantee in the future inflation will rise as smoothly. In the event of drastic economic changes, such as the recession in the early 1980s, inflation can rapidly increase and have major impacts to the transportation system.

Employment/ Unemployment Rates

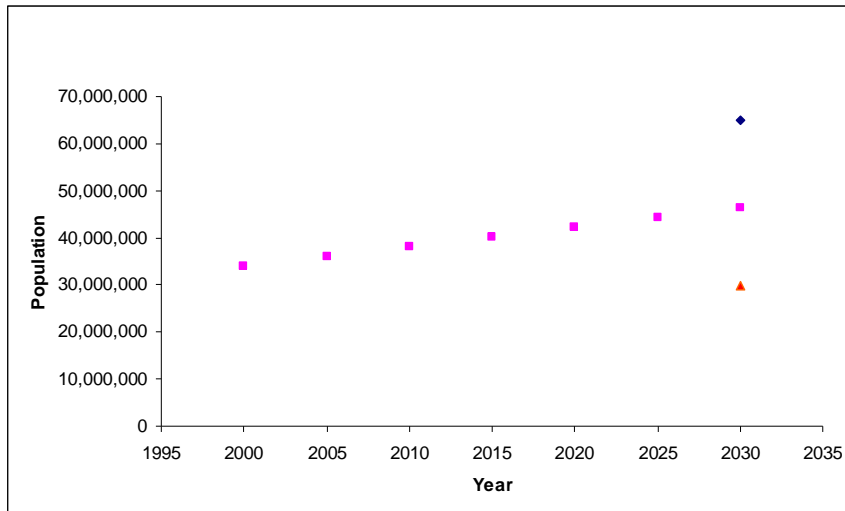
Many people would consider lowering unemployment to have only positive impacts. However, the lower unemployment falls, the higher prices will rise to compensate. As explained by the Phillips Curve (DeLong 2007), unemployment is negatively correlated to inflation (for our project, measured by CPI). This correlation will help our analysis by directly inferring the state of one variable (CPI or unemployment) based on the assumed value of the other for a given scenario.

Measuring this rate is important to reflect personal income as well as overall productivity in the state. Personal income is important in influencing behavior in regards to consumption of normal and inferior goods. It is this behavior that can directly reflect the economic effects on environmental priority. In November 2006 employment in California was 17,057,000 and unemployment was 824,300 (4.6%) (Bureau of Land Statistics 2006).

Total Population

California's total population is projected to reach 45 million by 2030 (US Census 2006). The state population projections were produced by the Population Division as an interim product consistent with the U.S. interim projections released in March 2004 (US Census 2006). The projections for California were organized by age and sex for the years 2001 to 2030, based on Census 2000 results. These projections were calculated under the assumption that recent trends in fertility, mortality, domestic migration, and international migration will continue at the same rates.

Figure 9: CA Projected Population



(Source: US Census Bureau 2006)

2.2.6. Freight

Table 4: Tonnage and Value of California Freight

	Value (\$ millions)			Tons (thousands)		
	2002	1997	1992	2002	1997	1992
State Total	923,689	790,384	638,523	903,954	763,957	706,554
By Mode						
Air	51,996	46,658	1,162	636	1,099	20
Highway	625,530	535,879	521,646	767,680	630,070	523,011
Other	20,129	14,127	17,191	74,898	62,990	100,825

Rail	9,718	7,059	11,019	21,358	14,041	15,225
Water	1,789	19,000		8,673	65,000	
	Ton-Miles (millions)			Average Miles/Shipment		
	2002	1997	1992	2002	1997	1992
State Total	166,862	131,211	136,682	782	682	644
By Mode						
Air	933	1,952		2,826	1,954	
Highway	114,225	81,982	77,456	237	237	237
Other						
Rail	22,836	15,760	19,483	1,730	1,702	1,497
Water				2,383	1,740	37

(Source: US DOT BTS 2002)

Freight statistics for California have been aggregated to represent the four major modes of transportation: air, sea, rail, and road. In 2004, the state of California issued its Commodity Flow Survey (taken in 2002). The survey is conducted in partnership with the Bureau of Transportation Statistics (BTS) and U.S. Department of Transportation (USDOT). The results of the survey provide information regarding the movement, value, and weight of shipments by mode. The survey is traditionally used as a policy tool to analyze future demand for transportation services, resource requirements, risk, and environmental impact. The previous survey for California was conducted in 1997.

As a whole, freight tonnage is experiencing linear growth while the value of goods flowing in and out of California grows exponentially. This growth indicates California's increasing supply and demand for finished goods of higher quality and value.

In addition, certain supply characteristics of freight in California are not captured simply by measuring the tonnage and value. California supplies between 85% – 90% of some of the nation's citrus fruit (i.e. Valencia Oranges, navel oranges, etc.) (Bernstein 2007). The exports of these commodities represent a tiny fraction of the total tonnage and value of freight leaving California, yet these exports represent a significant portion of domestic supply. As such, overall changes in tonnage and value may be interpreted differently and could have significant implications for specific markets in a given scenario.

Each mode of freight transportation offers unique benefits to the user, be it speed, cost effectiveness, range, etc. Often, modes compete with each other (e.g. rail versus road for ground shipping) and the lowest cost, most reliable alternative wins out. These interactions and price sensitivity of the consumer play a vital role in scenario analysis of freight in California. Likewise, outside considerations must also be made. Outside competition to use the same modes, such as passenger rail, directly compete with freight for railway right-of-way (Congressional Budget Office 2006). Any increase in passenger rail will negatively impact rail freight, regardless of the scenario.

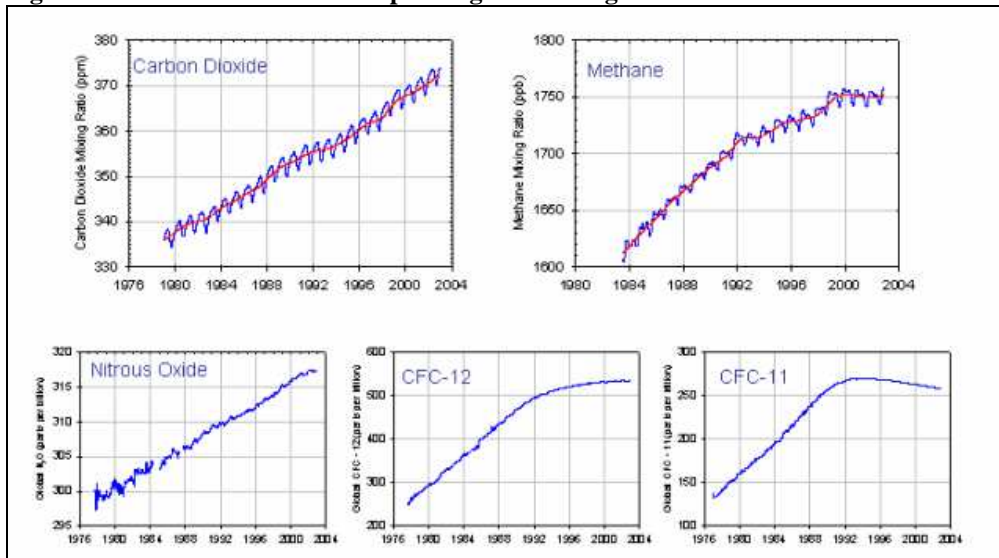
Freight plays a critical role in the California economy. Commodity flow through California affects the size and operation of airports, sea ports, rail, and roadway congestion. The Port of Los Angeles was the nation’s top freight gateway in 2003 (by value, \$122 billion) (USDOT BTS 2006), playing a large role in Pacific Rim container trade. The Port of Long Beach is the nation’s third busiest sea port (by value, \$96 billion) (USDOT BTS 2006), and its role in international Pacific Rim trade is equally important to the California economy. In a future scenario with increased sea cargo, one would expect sea port changes to occur to accommodate these changes. Equally important is the sensitivity of trade to the functionality and reliability of these ports.

By 2035 freight is expected to more than double (USDOT 2006) in California, with a majority of growth expected to take place on the road. In 2002 over one billion tons of freight were shipped within California, compared to 120 million tons exported and 330 million tons imported. That trend towards intra-state commerce dominating freight will have a major impact on roadways in the future. In any future scenario where freight increases further, the demands on transportation infrastructure will be enormous.

2.2.7. Greenhouse Gas Emissions

Greenhouse gases are atmospheric compounds that absorb infrared radiation and thereby trap heat (EIA 2004). They include CO₂ and methane, among others, and evidence shows that these compounds have been accumulating in the global atmosphere, as shown in Figure 10. This has coincided with the commencement of the Industrial era, which has promoted increased anthropogenic fossil fuel emissions, in addition to an increase in the human population. Transportation is a major contributor to fossil fuel emissions via automobile and airplane tailpipes.

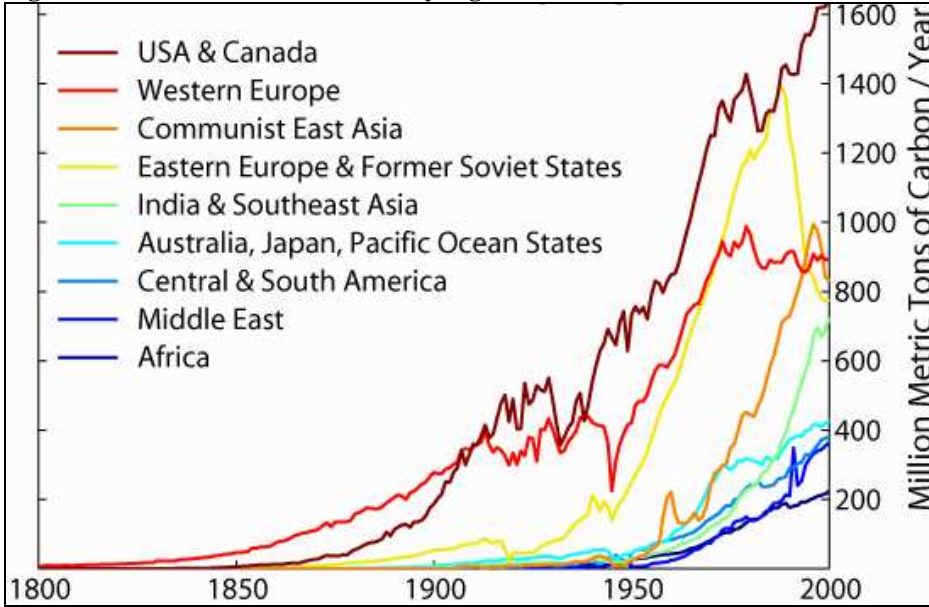
Figure 10: Global trends of atmospheric greenhouse gas concentrations.



(Source: NOAA 2007)

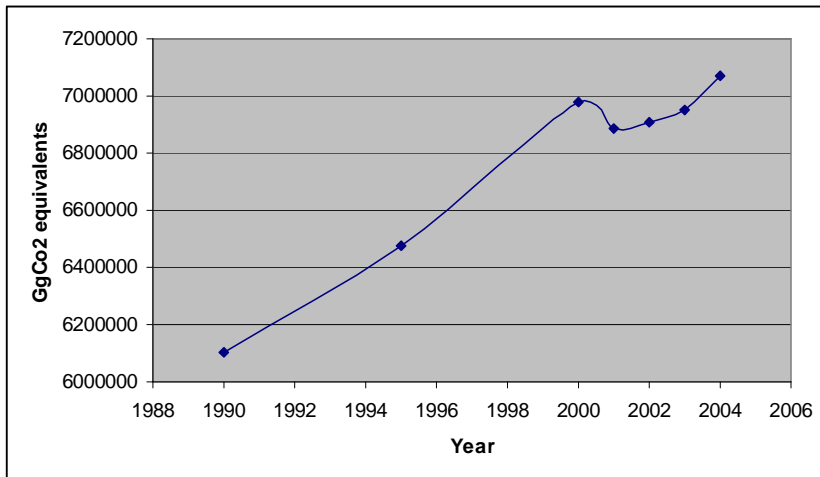
Figure 10 shows the U.S. and Canada as top contributors to carbon dioxide emissions. The Kyoto Protocol, put forth by the United Nations Framework Convention on Climate Change, requires countries that sign it to reduce their greenhouse gas emissions to at least 5% below 1990 levels by 2008-2012 (1998) based on individual targets assigned to them. The United States, of which the individual emissions can be seen in Figure 11, has signed but not ratified this document at this time.

Figure 11: World carbon emissions by region



(Source: CDIAC 2000)

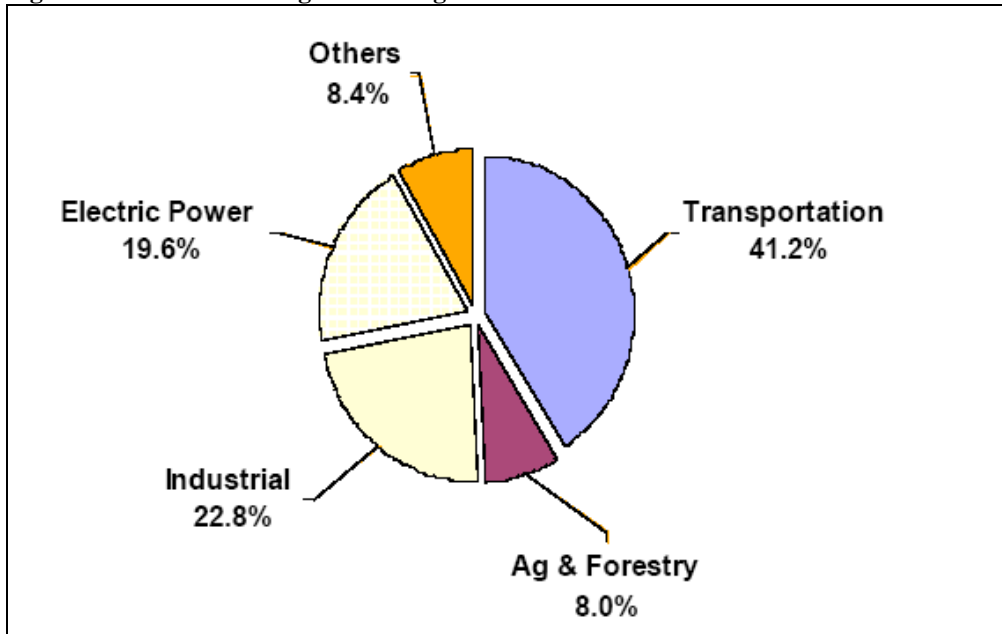
Figure 12: Greenhouse gas emissions in the United States Between 1990-2004.



(Data Source: EIA 2004)

Transportation is the leading source of greenhouse gases in California, as shown in Figure 12. As the 10th largest overall emitter, contrary to the inaction of the United States as a whole, California has demonstrated a greater aligning of its goals with those of the Kyoto Protocol. Assembly Bill 32 requires the California Environmental Protection Agency to set a statewide cap on greenhouse gas emissions as well as reduce these emissions from major stationary sources and develop a mandatory reporting system (Nunez 2006).

Figure 13: Breakdown of greenhouse gas emissions in CA.



(Source: CEC 2007)

2.2.8. Public Transportation

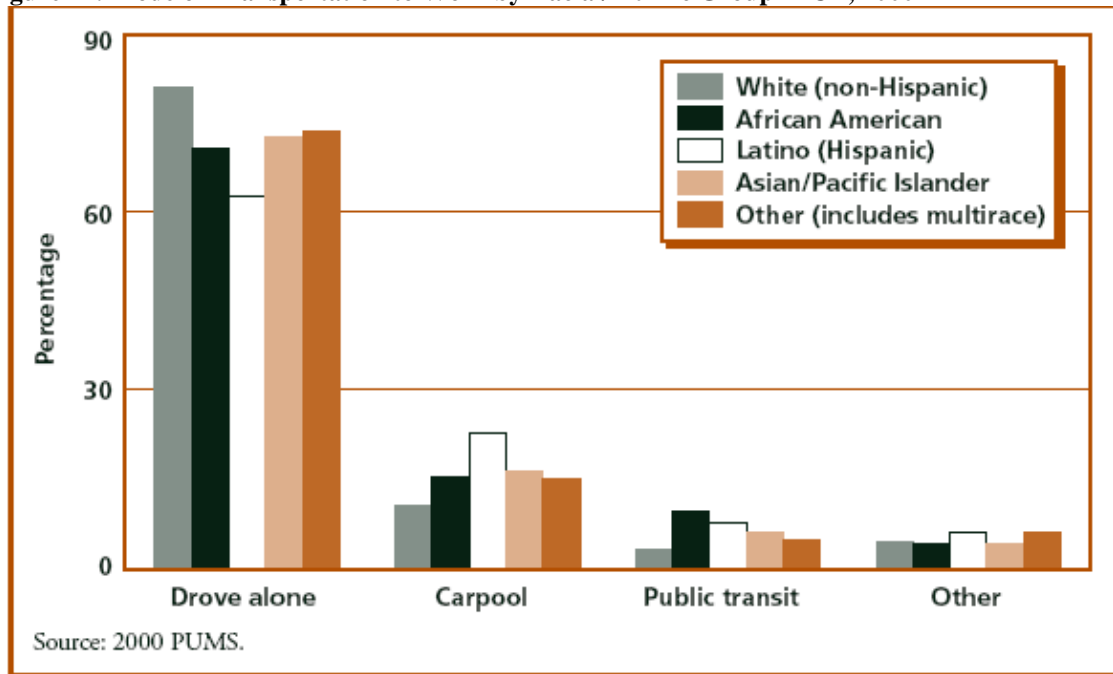
Public transportation includes travel by bus or trolley bus, streetcar or trolley car, subway or elevated rail, railroad, and ferryboat (US Census Transportation Planning Products 2000). The US Census tabulates the number of commuters that take public transportation to account for peak demand. Funding data is based on the U.S. Department of Commerce, U.S Census Bureau, State and Local Government Finance Estimates (2001). Dollars are converted using a chain-type price index.

In 2005, 734,704 commuters rode transit, or 5% of all commuters (US Census 2005). Commuting via public transport, on average, took twice as long as trips taken by drivers in their own cars. Buses represented the most popular transit choice at fewer than 4% of commuters. The highest rate of public transportation use occurred in San Francisco County, with 31% of commuters riding in 2000. The lowest public transit shares

belonged to Kern, Riverside, and San Bernardino Counties—low density areas which had high rates of carpooling.

Among demographic groups, African Americans were most likely to commute via public transportation; they were twice as likely as other workers to ride public transportation to work, resulting in a higher average commute time.

Figure 14: Mode of Transportation to Work by Racial/ Ethnic Group in CA, 2000



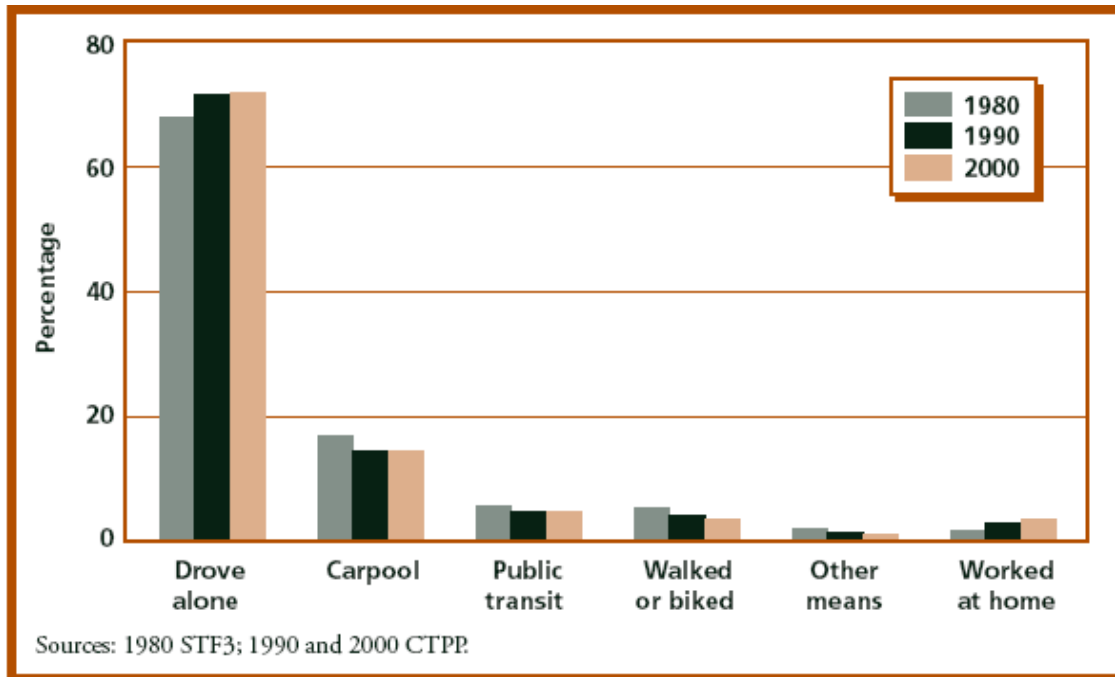
(Source: Barbour 2006)

Since the 1970s, an increasing share of transportation funding in California has gone to public transit:

“Per capita expenditures on California transit projects more than doubled between 1972 and 1997 as four major cities—San Diego, Los Angeles, San Jose, and Sacramento—opened new rail systems during the 1980s and 1990s. In recent years, transit has accounted for 20 to 40 percent of the combined capital outlay for transit, highways, and roads” (Hanak 2005).

Despite the national trend of decreasing public transport ridership, California’s rate of ridership has increased by 0.2 percent from 1990 to 2000. National ridership decreased by 0.5 percent during the same period. California’s increase in public transportation ridership was likely linked to increases in capital funding for new transit projects. Much public debate has centered on whether this 20 to 40 percent allocation of transportation funding can be justified by a slight increase in the number of transit riders in the state. This debate will factor into the future of public transportation in California.

Figure 15: Journey to Work by Mode in CA, 1980- 2000



(Source: Barbour 2006)

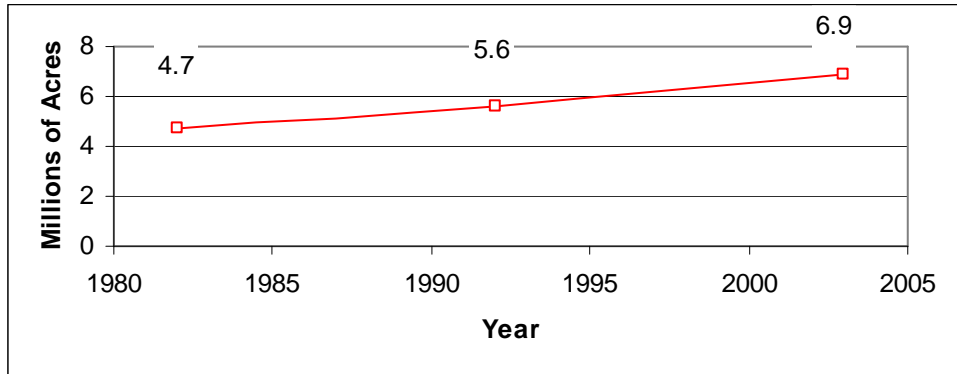
2.2.9. State of the Environment

Land Quality

The extent of developed land measures the total number of acres that have been developed for high-density, urban or suburban uses. The extent of developed land is a strong indicator of land quality, due to the high impact of urban development on the occupied land and its nearby areas. While increasing levels of development indicates growing direct pollution impacts, it also indicates substantially increased resource use and intensity in surrounding areas.

California and the Great Basin (which includes large areas of Nevada, Utah, and Oregon) comprise 194.5 million acres, 114.4 million of which are federally owned. As of 2003, 6.9 million acres were developed. However, this represents a 23% increase since 1992, and a 47% increase since 1982. Most of the developed land is former cropland, with some former rangeland and forest land.

Figure 16: Extent of Developed Lands



(Source: Natural Resources Conservation Service, Department of Agriculture 2007)

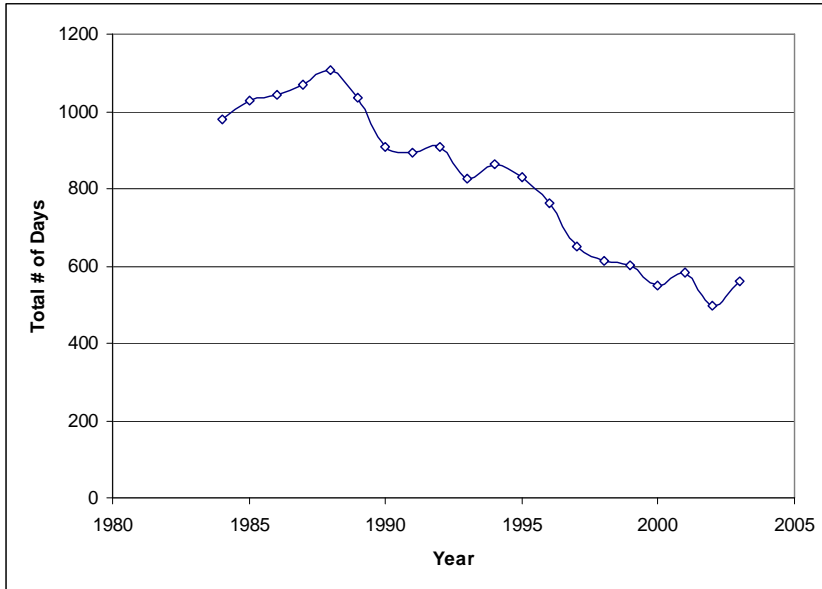
Air Quality

As mandated by the Clean Air Act, the EPA commonly uses six criteria pollutants as indicators of air quality: ozone, carbon monoxide, nitrogen dioxide, sulfur dioxide, particulate matter, and lead. Among these, mobile sources are a primary contributor to nitrogen dioxide, particulate matter, and ozone emissions. (Contributions to ozone are indirect, through the chemical reactions of NO_x and VOC emissions in the air.) The EPA uses two methods to measure these pollutants – total days above state standards and peak levels. This is done in an effort to monitor and minimize both chronic and acute exposure.

California has consistently had poor air quality in its urban area, which often are transferred to the surrounding rural areas. In particular, Los Angeles has been in non-attainment with the Clean Air Act since its passing into law. As such, air quality is closely monitored throughout the state. Although it is significantly worse than much of the country, it has also shown improving trends in recent decades as more stringent regulations have been put into place. However, without significant technological change and innovation, future population growth is expected to reverse this trend.

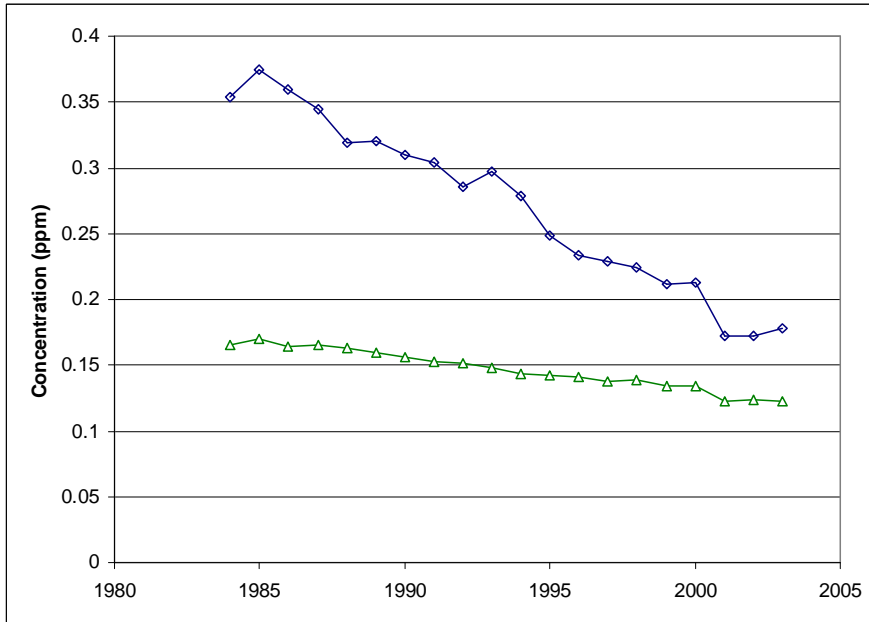
To attempt to summarize a variety of air quality issues related to transportation, we use measurements of ozone, NO_x, VOCs, and PM₁₀ to assess the current state. Additionally, we include asthma cases as a way of translating the physical measurements into human health terms. Greenhouse gas emissions are considered separately.

Figure 17: Total Days Above State Ozone Standard



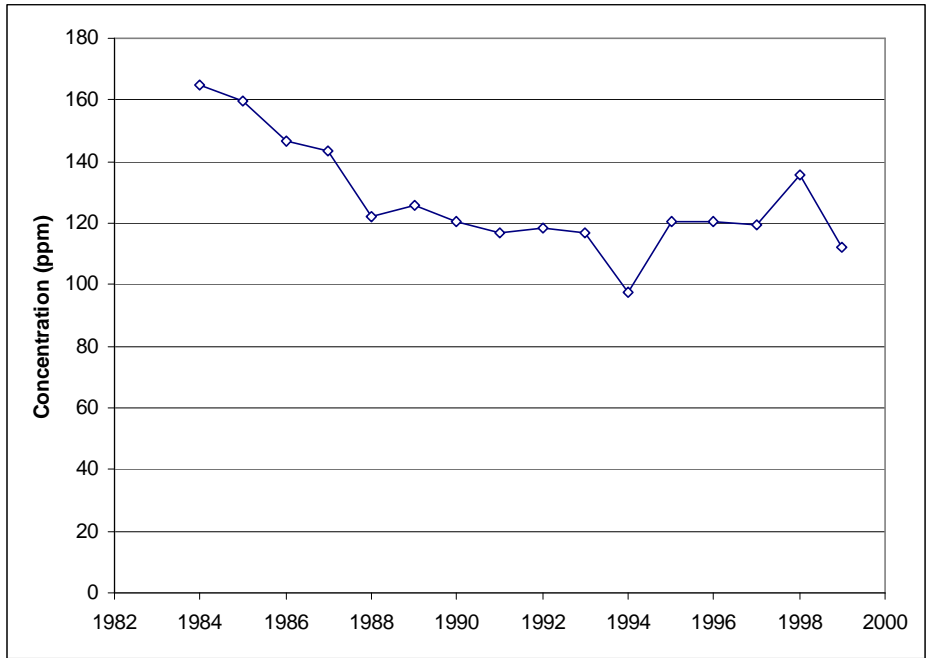
(Source: Source: Air Resources Board, Cal/EPA 2006)

Figure 18: Overall Average Peak 1-Hr Ozone Concentration



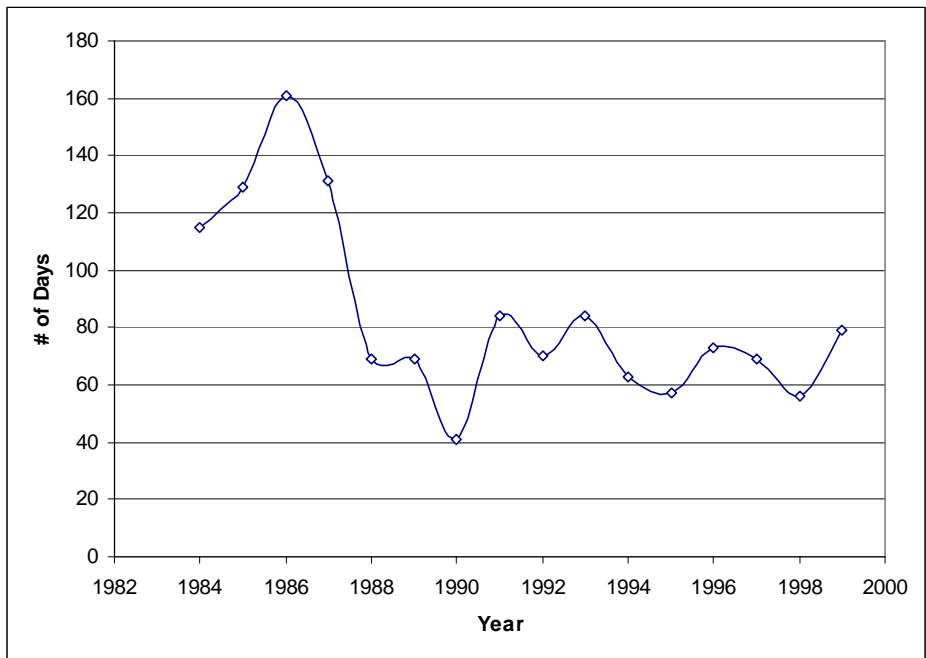
(Source: Air Resources Board, Cal/EPA 2006)

Figure 19: Overall Average Peak 24-Hr PM10 Concentration



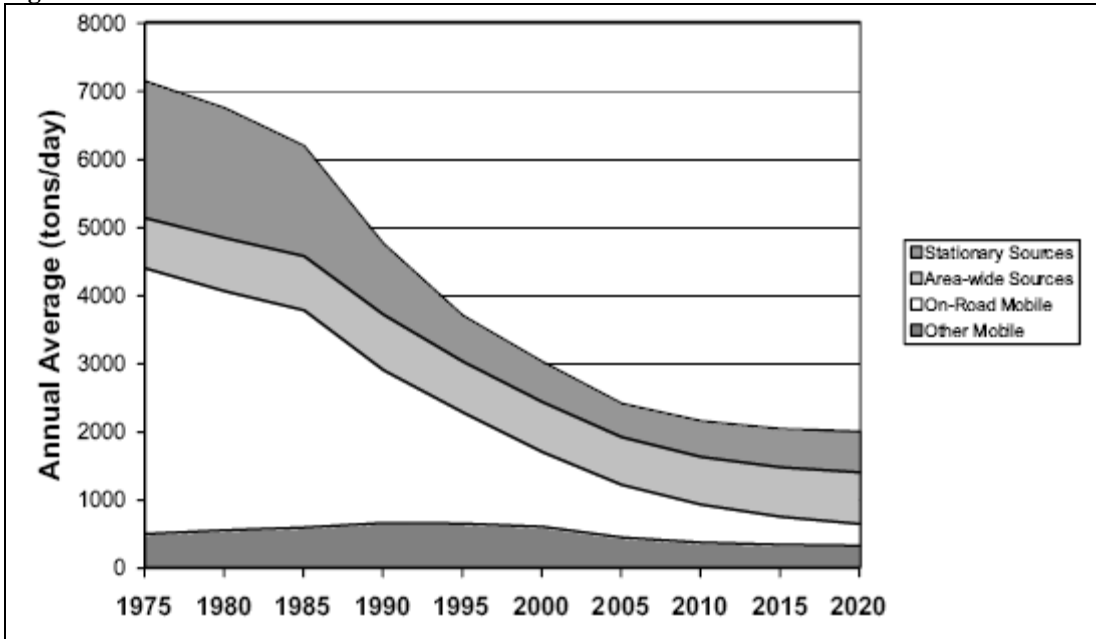
(Source: Air Resources Board, Cal/EPA 2006)

Figure 20: Total Days above PM10 Standard



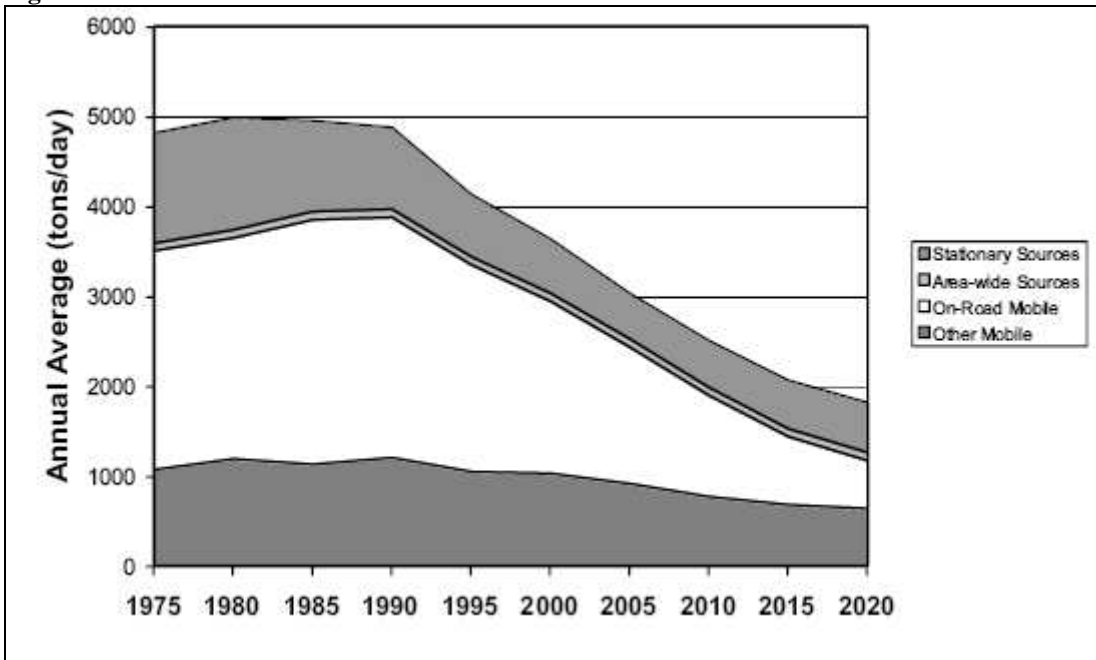
(Source: Air Resources Board, Cal/EPA 2006)

Figure 21: VOC Emissions Trends



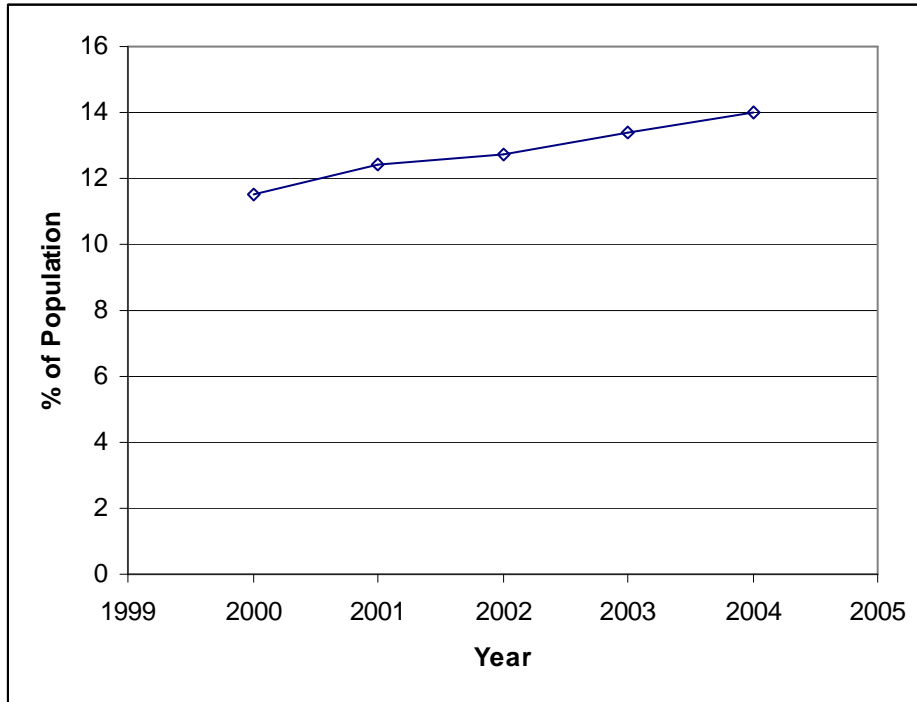
(Source: Air Resources Board, Cal/EPA 2006)

Figure 22: NOx Emission Trends



(Source: Air Resources Board, Cal/EPA 2006)

Figure 23: Adult Self-Reported Lifetime Asthma Prevalence Rate

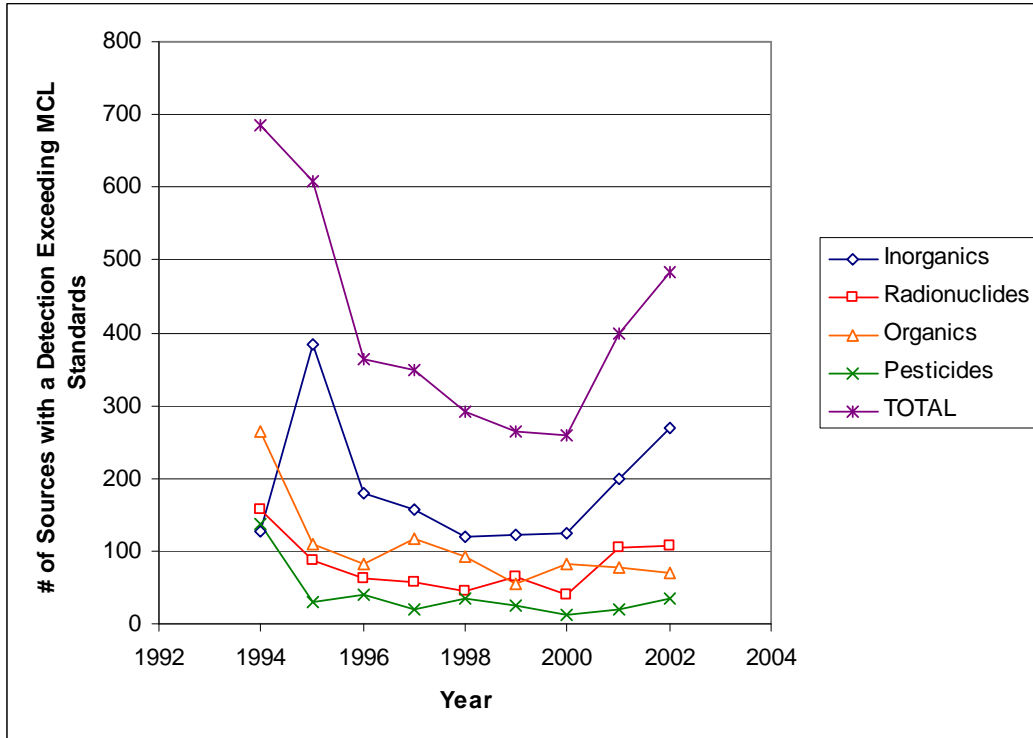


(Sources: Center for Disease Control 2002)

Water Quality

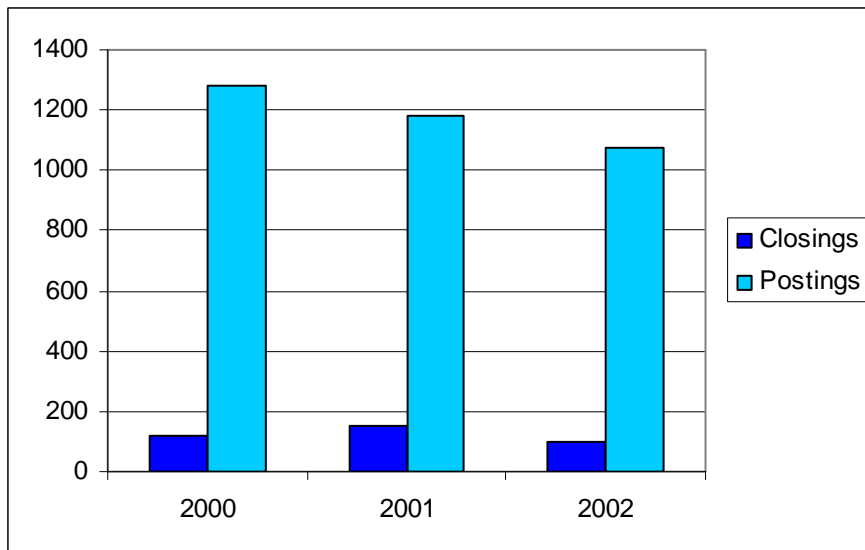
Water quality represents the quality of natural and coastal waters as well as the quality and reliability of drinking water supplies. Drinking water quality is measured through the number of days in which the Maximum Contaminant Levels (MCLs) are exceeded. We have chosen the number of days of beach closings as a proxy for water quality in natural bodies. Beach closings are a particularly interesting indicator, as the source of the contaminant which causes the closing is oftentimes unknown. Thus, the closings represent both pollution problems that we are aware of, and some problems that we are not. In general, both MCL exceedances and beach closings can be caused by chronic failures of our water sanitation systems, as well as sudden, unexpected events. In many cases, runoff of oil and other transportation-related pollution from roadways is a major part of the pollution from “unknown” sources. It is important to note that the recent increase in MCL exceedances observed in the data represents changing reporting standards, and likely does not reflect an actual decrease in water quality.

Figure 24: Exceedances of Maximum Concentration Level (MCL) Water Quality Standards



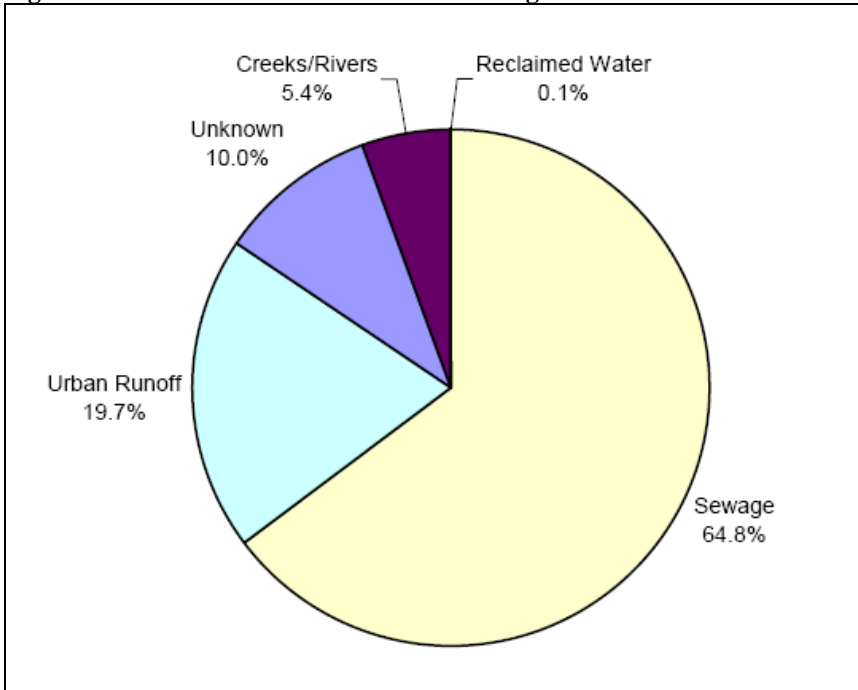
(Source: Department of Health Services 2002)

Figure 25: Beach Postings and Closings



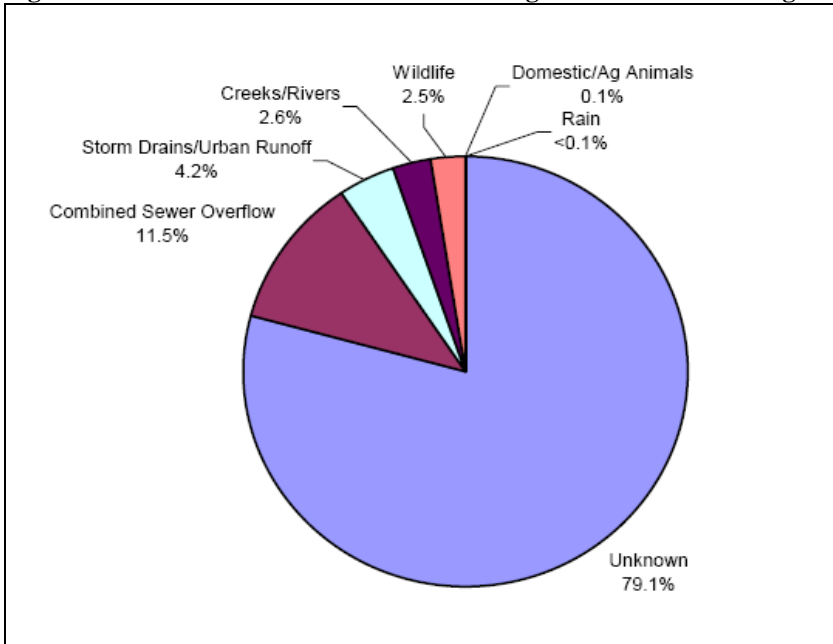
(Source: State Water Resources Control Board 2002)

Figure 26: Sources of Contamination Resulting in 2002 Beach Closures Statewide



(Source: State Water Resources Control Board 2002)

Figure 27: Sources of Contamination Resulting in 2002 Beach Postings Statewide



(Source: State Water Resources Control Board 2002)

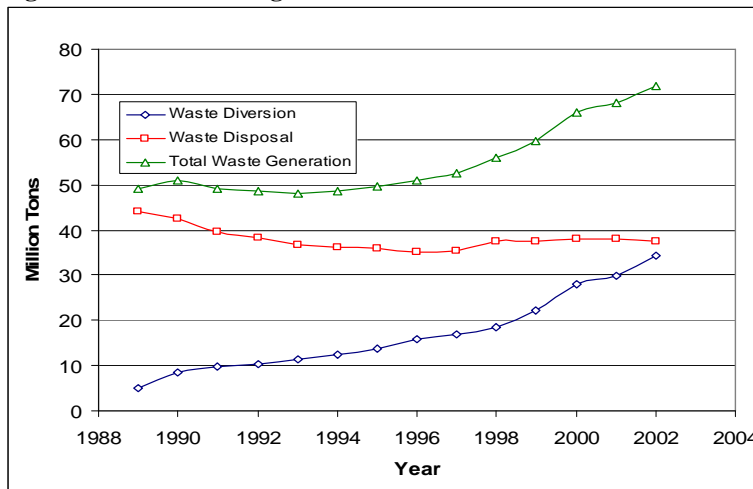
Resource Use & Efficiency

Efficient use of our natural resources will become ever more important as our population and economy continues to expand. Whether or not we are able to support sustainable growth will depend largely on our ability to increase our resource productivity, particularly the productivity of energy and virgin materials. Since transportation accounts for a significant percentage of total energy use, transportation efficiency has major implications for energy efficiency as a whole. Similarly, with the growing number of on-road vehicles, efficient use of resources in automobile production, such as steel and aluminum, will play an important role in overall resource efficiency. Although the idea of ‘resource productivity’ encompasses an almost infinite variety of products, services, and activities, we have chosen waste diversion and energy consumption as a proxy for the overall efficiency of the economy.

The percentage of waste diverted represents the percentage of municipal solid waste (MSW) generated by society that is cycled back into the system, instead of permanently stored in a landfill. It is important because it also represents a reduction in the use of virgin resources, and a move towards a more sustainable system. Recycling efforts in the state of California have generally been initiated on the city level, with some cities achieving diversion rates much higher than the state average of 48%. Additionally, this average represents several decades of steady improvement.

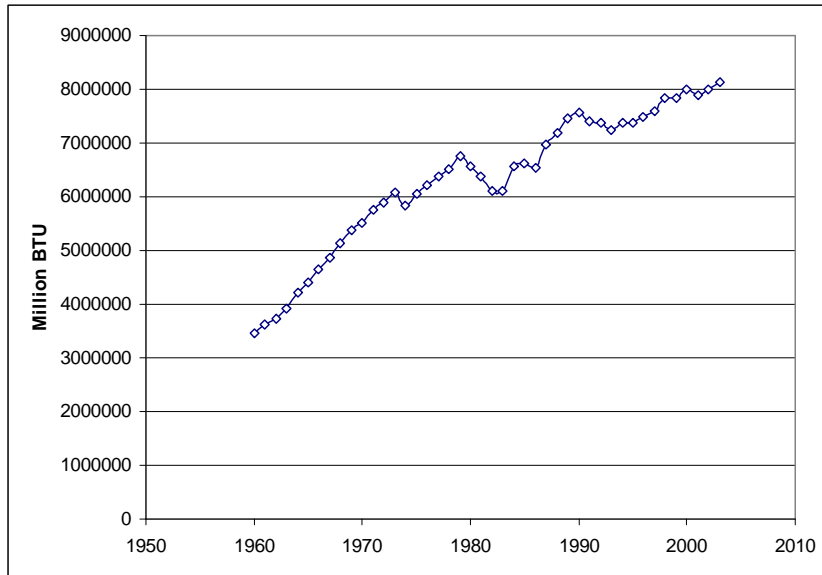
When measuring energy consumption, it is important to describe both total energy consumption and energy consumption per capita. While total energy consumption in California has been climbing steadily for the past several decades, energy consumption per capita peaked in the 1970s and has since slowly but steadily declined. Particularly with the expected growth in population, it will continue to be important to monitor both of these quantities.

Figure 28: Waste Management



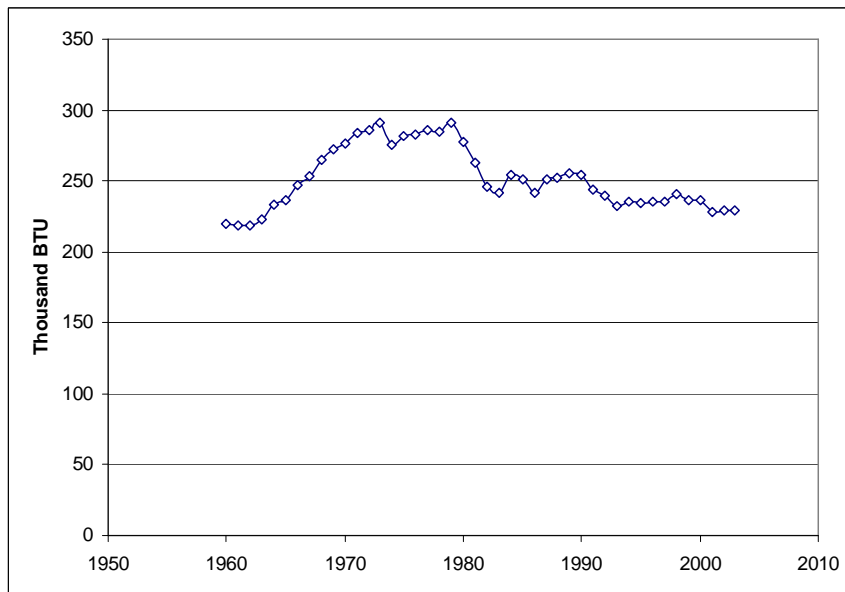
(Source: California Integrated Waste Management Board 2006)

Figure 29: California Energy Consumption



(Source: Energy Information Administration, Department of Energy 2003)

Figure 30: California Energy Consumption per Capita



(Source: Energy Information Administration, Department of Energy 2003)

Biodiversity

Biodiversity is defined as the variety of the different forms of life existing together in different ecosystems on Earth. Commonly, it is expressed as the number of species that

exist in a given place, or on the Earth as a whole. California, in particular, is considered a biodiversity “hotspot,” because it is home to an above average number of different species. However, for various reasons, it is often difficult to catalogue all of the different species that live in a particular location. To circumvent this issue, we have chosen to instead look at the number of species that are listed as ‘endangered’ or ‘threatened’ under the federal Endangered Species Act. This list is constantly growing, as it is rare for a species to be de-listed once it has been labeled as endangered. However, the rate of increase in the number of species listed is also closely tied to budget allocated to the US Fish and Wildlife Service by Congress for listing activities.

Measuring biodiversity is particularly important at this point in time because scientists estimate that the current level of extinctions is far above the average, ‘background’ rate, due to human being’s vast impact on the natural system. Additionally, as we face the possibility of a rapidly changing climate, it is unclear how well many species will be able to adapt, or if they will be able to adapt at all.

2.2.10. Total On-Road Vehicles

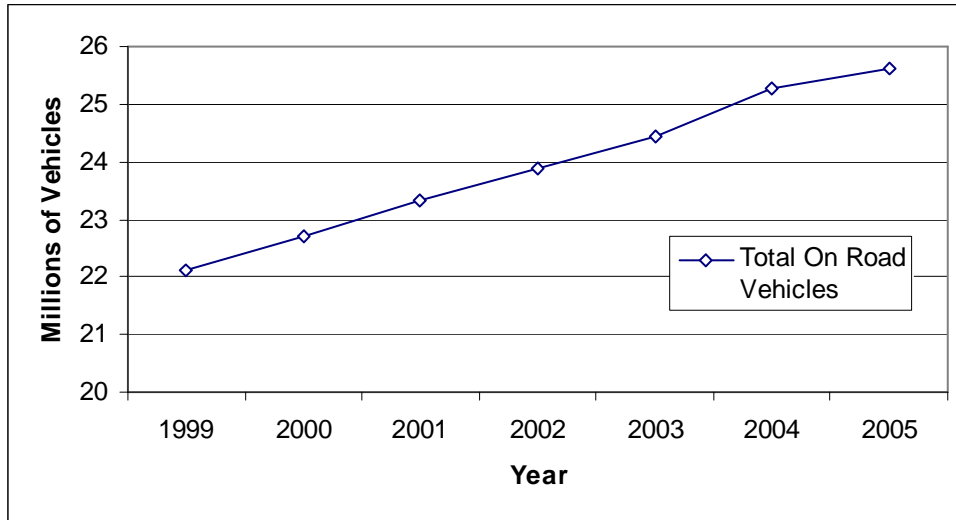
The total number of on-road vehicles in California has increased by over 15% from 1999 to 2005. This includes all body types of trucks, autos, and motorcycles. The figures below represent registered vehicles in California per year, as reported by the California Department of Transportation. The number of on-road vehicles can be combined with data on travel time and population to indicate congestion, number of cars per person or per household, and the effect of total vehicles on the amount of time the average person spends in transit.

Table 5: Total Autos Registered in CA (in millions)

Year	Total Vehicles
1999	22.126
2000	22.713
2001	23.314
2002	23.886
2003	24.432
2004	25.255
2005	25.627

(Source: Transportation System Information Program, California Department of Transportation 2005)

Figure 31: Total On-Road Vehicles



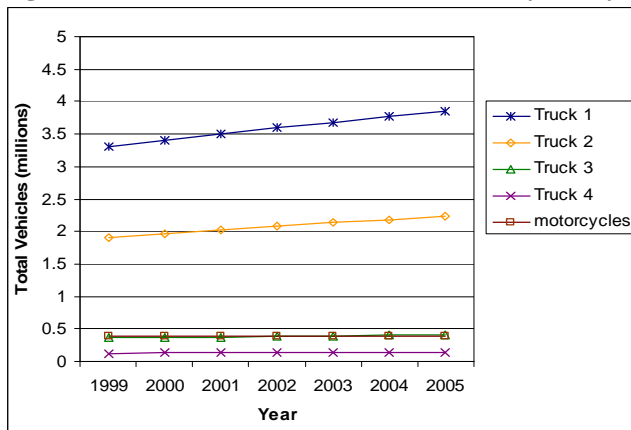
(Source: Transportation System Information Program, California Department of Transportation 2005)

Table 6: Total Vehicles by Body-Type, Excluding Autos

Year	Truck 1	Truck 2	Truck 3	Truck 4	MC
1999	3.299	1.91	0.362	0.125	0.384
2000	3.396	1.966	0.37	0.127	0.394
2001	3.497	2.024	0.377	0.13	0.391
2002	3.592	2.079	0.385	0.132	0.39
2003	3.682	2.131	0.392	0.135	0.389
2004	3.77	2.182	0.399	0.137	0.388
2005	3.849	2.228	0.405	0.139	0.386

(Source: Transportation System Information Program, California Department of Transportation 2005)

Figure 32: Total On-Road Trucks and Motorcycles By Body Type



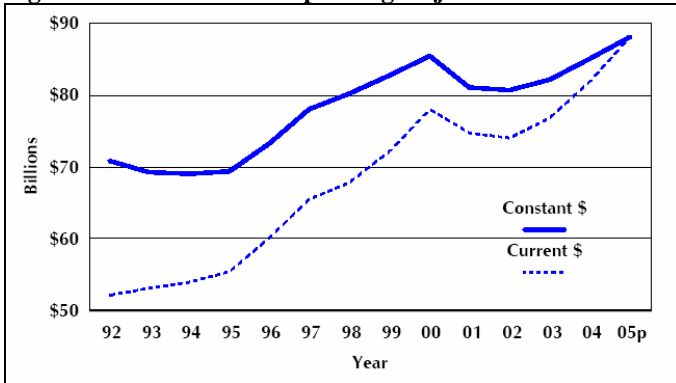
(Source: Transportation System Information Program, California Department of Transportation 2005)

Average number of cars per person can be found by dividing the total registered vehicles of a year by the total number of driving age residents living in California. In 2005, there were 25,627,000 registered vehicles. Excluding residents under 15, who cannot drive, 2005 CA population was 29,916,395.264 (US Census Bureau 2005). Therefore, average number of cars per person in 2005 was 0.86.

2.2.11. Tourism

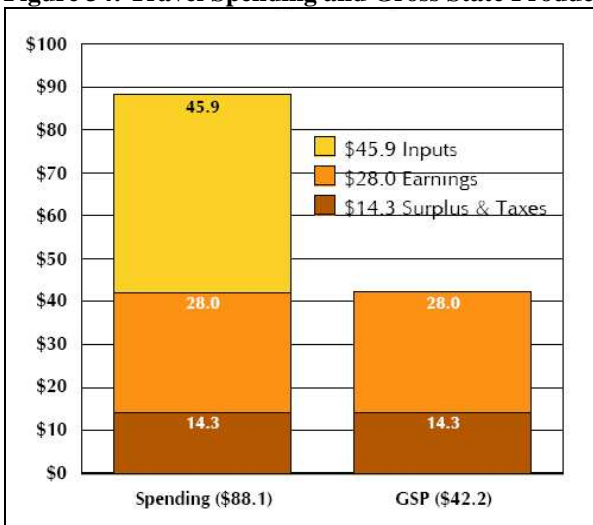
Tourism is a major industry in the U.S., with national travel spending reaching nearly \$600 billion in 2005. Figure 33 shows California’s share of this spending, coming in at nearly \$90 billion in 2005, from over 335 million travelers to the state. This value translates into \$28 billion actual earnings, as seen in Figure 34 (California Transportation Commission 2005).

Figure 33: Direct Travel Spending Adjusted for Inflation



(Source: California Transportation Commission 2005)

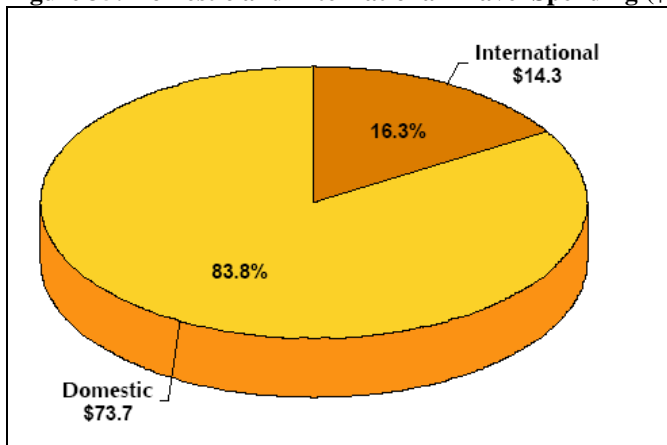
Figure 34: Travel Spending and Gross State Product of CA Travel Industry, 2005 (\$ billions)



(Source: California Transportation Commission 2005)

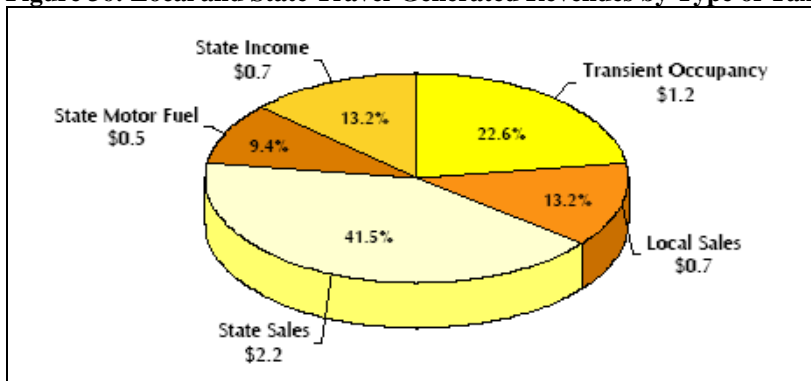
Figure 35 shows that while most Californian visitors are domestic travelers, around 16% come from abroad (California Transportation Commission 2005). These visitors use the state's transportation system as a means to get to California, as well as to travel within the state, be it locally, regionally, or statewide.

Figure 35: Domestic and International Travel Spending (\$ billion)



(Source: California Transportation Commission 2005)

Figure 36: Local and State Travel-Generated Revenues by Type of Tax, 2005 (\$ billion)



(Source: California Transportation Commission 2005)

One of the major sources of earnings from the tourism industry is the taxation that visitors face. Transient occupancy taxes (TOTs), which are paid to hotels or other lodging accommodations, make up over 22% of these tax revenues (Figure 36). \$0.5 billion is generated by state motor fuel taxes, which is indicative of the amount of automobile travel that travelers participate in when they visit (California Transportation Commission 2005).

Indicators of the tourism system variable should measure the magnitude of this factor as it pertains to transportation. The number of visitors to and within the state, hotel bed occupancy rates, and transient occupancy tax receipts are used in this study.

2.2.12. Travel Time

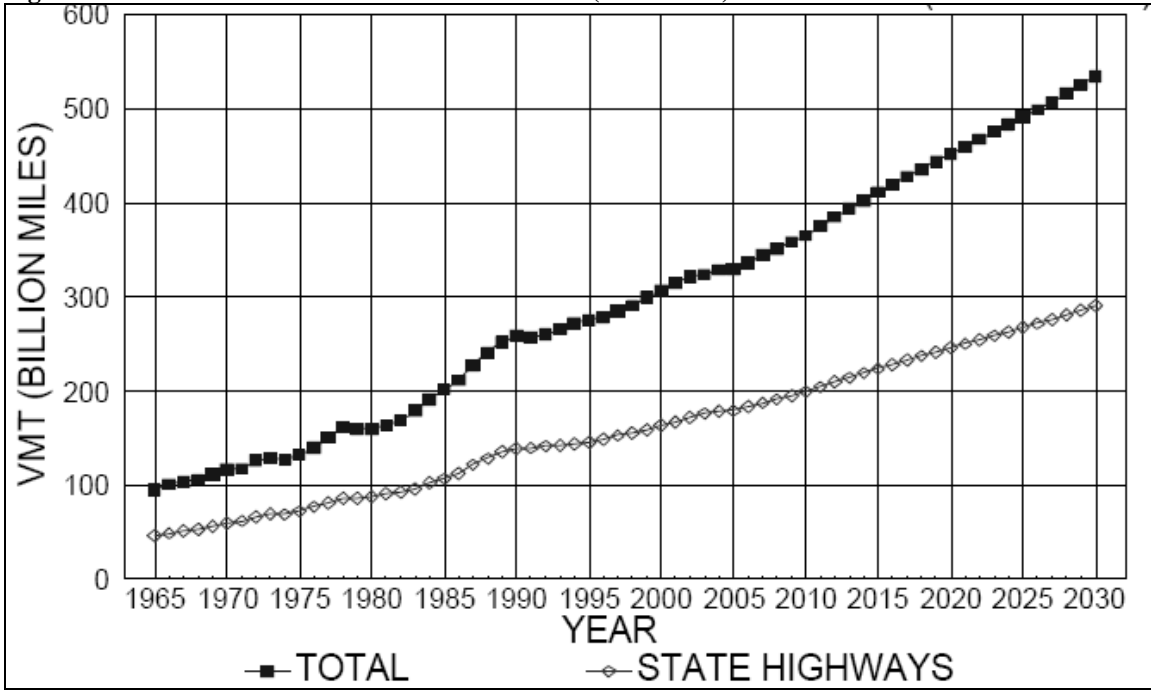
Commute times were derived by responses to the US Census question asking, “How many minutes did it usually take this person to get from home to work last week?” The US Census Bureau uses commute times as an indicator for travel time because they provide insight into the interaction between public and private choices about transportation and land use. Although commuting trips constitute only one-fifth of all trips, they cause the highest impacts on the transportation system because they are highly concentrated at peak times and tend to be the longest regular trips taken (Barbour 2006). As a result, transportation planners determine investment in roads and public transport based on accommodating this peak demand.

Two important trends in Californians’ travel time are decreases in median commute time and increases in average commute time. From 1990 to 2004, workers’ median commute time dropped 9% while their average commute time increased by 10%. This is a departure from the period between 1980 and 1990, when both median and average commutes dropped by 9% and 10% respectively. This dichotomy is partly caused by an increase in the number of workers who make “extreme” commutes, or commutes over 45 minutes. The “suburbanization” of jobs, or relocation of jobs to non-metropolitan areas, has increased commute times through increased distance traveled and increased numbers of single drivers. Increased public transportation ridership, a relatively slow commute mode, has also extended travel time. Furthermore, the reliability of commute times has decreased. The standard deviation in commute time has increased by 20% from 1990 to 2004.

2.2.13. Vehicle Miles Traveled

Total vehicle miles traveled represents the total number of miles traveled by passenger and freight vehicles on California roads. By itself, it is a good indicator of traffic, and when combined with average fuel economy, it represents the source of total fuel consumption and total air emissions from mobile sources. Total vehicle miles traveled has been increasing relatively steadily over the past several decades, except for a slight decline during the energy crisis of the late 1970s. Meanwhile, average fuel economy has been increasing as well, but at a much slower rate, leading to steady increases in total fuel consumption. In the future, total vehicle miles are expected to continue climbing. Additionally, if average fuel economy begins to decline or level off (due to consumer preference for less fuel-efficient vehicles), total fuel consumption will continue to rise, perhaps even at an increasing rate.

Figure 37: California Total Vehicle Miles of Travel (1965- 2030)



(Source: Transportation System Information Program 2005 -- Forecasts are based on a business-as-usual scenario.)

3. FUTURE STATE OF SYSTEM VARIABLES FOR THE FOUR SCENARIOS

3.1. Methodology for Determining Future State

For each of the system variables defined in the Chapter 2, we sought to determine an appropriate value in each of our scenarios. In order to perform this calculation, we first plotted basic trend lines for the historic data for all the system variables, and determined a ‘business-as-usual’ or baseline value for the year 2030. (For some variables, historic trends were not available, in which case we used our knowledge of the variable to make reasonable projections.) Based on these business-as-usual projections, we then determined how these baselines would change within each scenario.

Please note that whenever dollar values are given for the four scenarios, these values are given in 2006 dollars. This was done for ease of comparison between scenarios, as rates of inflation are expected to be different within each scenario. Additionally, each value represents an average, annual value for the state of California.

3.2. Future State of System Variables

Table 7: Predicted Future Values for Drivers & System Variables (Prices in 2006 Dollar Values)

Driver / System Variable	Business-as-Usual	“Green is Golden”	“Convenience Trumps”	“Holding Our Own”	“Grown from Grassroots”
Economic Growth		High	High	Low	Low
Environmental Priority		High	Low	Low	High
Gross State Product (GSP)	\$4.3 X 10 ¹²	\$7.8 X 10 ¹²	\$7.8 X 10 ¹²	\$2.1 X 10 ¹²	\$2.1 X 10 ¹²
Average Percentage growth in GSP	4.4%	6.5%	6.5%	1%	1%
Accessibility					
Average fare over all systems of public transportation for all types of riders	\$1.75	\$5.00	\$12.00	\$4.00	\$2.50
Percentage of rural population that utilizes public transit	5%	25%	10%	40%	50%
Distance of low income residents to public transportation:					
% of low income urban	30%	15%	50%	10%	5%

residents living further than ¼ mile from a transit line					
Commercial Aviation					
Enplanements	120.5 X 10 ⁶	100 X 10 ⁶	160 X 10 ⁶	65 X 10 ⁶	50 X 10 ⁶
Cost of Mobility					
Fuel Price					
Gasoline (retail price per gallon)	3%/yr for 25 yrs = \$5.23	\$12	\$7	\$10	\$10
Diesel (retail price per gallon)	3%/yr for 25 yrs = \$6.20	\$15	\$9	\$12	\$12
Cost per mile	\$1.00	\$3	\$1.50	\$1.75	\$2
Fuel Tax					
State (cost per gallon)	80 ¢	\$3.00	65 ¢	2.00 ¢	\$2.50
Federal (cost per gallon)	60 ¢	\$1.50	45 ¢	30 ¢	\$1.10
Domestic vehicle price	\$34,896	\$50,000	\$50,000	\$30,000	\$25,000
% of Income spent on transit					
Low income households	39%	50%	35%	45%	25%
Middle-class households	19%	10%	15%	25%	10%
Demographics					
Median Income	\$82,000	\$164,000	\$185,000	\$45,000	\$53,000
Population/Age Groups					
Total	46.4 X 10 ⁶	53 X 10 ⁶	66 X 10 ⁶	30 X 10 ⁶	35 X 10 ⁶
5 - 17	11 X 10 ⁶	12.7 X 10 ⁶	13.8 X 10 ⁶	9.4 X 10 ⁶	8.3 X 10 ⁶
18 - 24	4.4 X 10 ⁶	5 X 10 ⁶	5.5 X 10 ⁶	3.7 X 10 ⁶	3.3 X 10 ⁶
25 - 44	12.8 X 10 ⁶	14.7 X 10 ⁶	16 X 10 ⁶	10.9 X 10 ⁶	9.6 X 10 ⁶
45 - 64	9.9 X 10 ⁶	11.4 X 10 ⁶	12.4 X 10 ⁶	8.4 X 10 ⁶	7.4 X 10 ⁶
65 +	8.3 X 10 ⁶	9.5 X 10 ⁶	10.4 X 10 ⁶	7 X 10 ⁶	6.2 X 10 ⁶
85 +	1.2 X 10 ⁶	1.3 X 10 ⁶	1.4 X 10 ⁶	1 X 10 ⁶	9 X 10 ⁵
Unemployment Rates	2.0%	1%	1%	14%	10%
Freight					

Value (\$2006)					
State Total	1.7 X 10 ¹²	3.4 X 10 ¹²	3.9 X 10 ¹²	9 X 10 ¹¹	7 X 10 ¹¹
Air	2 X 10 ¹¹	4 X 10 ¹¹	4 X 10 ¹¹	1 X 10 ¹¹	1 X 10 ¹¹
Highway	1 X 10 ¹²	1.8 X 10 ¹²	2.1 X 10 ¹²	5 X 10 ¹¹	4 X 10 ¹¹
Rail	6 X 10 ⁹	12 X 10 ⁹	14 X 10 ⁹	3 X 10 ⁹	3 X 10 ⁹
Water	2 X 10 ⁹	4 X 10 ⁹	4 X 10 ⁹	1 X 10 ⁹	1 X 10 ⁹
Other	28 X 10 ⁹	57 X 10 ⁹	64 X 10 ⁹	14 X 10 ⁹	12 X 10 ⁹
Short Tons					
State Total	1.6 X 10 ⁹	3.2 X 10 ⁹	3.6 X 10 ⁹	8 X 10 ⁸	7 X 10 ⁸
Air	2 X 10 ⁶	5 X 10 ⁶	5 X 10 ⁶	2 X 10 ⁶	1 X 10 ⁶
Highway	1.3 X 10 ⁹	2.7 X 10 ⁹	3 X 10 ⁹	7 X 10 ⁸	6 X 10 ⁸
Rail	40 X 10 ⁶	77 X 10 ⁶	87 X 10 ⁶	19 X 10 ⁶	16 X 10 ⁶
Water	9 X 10 ⁶	17 X 10 ⁶	20 X 10 ⁶	4 X 10 ⁶	4 X 10 ⁶
Other	2 X 10 ⁶	5 X 10 ⁶	5 X 10 ⁶	1 X 10 ⁶	1 X 10 ⁶
Ton-Miles					
State Total	2.7 X 10 ¹¹	5.4 X 10 ¹¹	6.1 X 10 ¹¹	1.3 X 10 ¹¹	1.1 X 10 ¹¹
Air	15 X 10 ⁶	31 X 10 ⁶	35 X 10 ⁶	8 X 10 ⁶	7 X 10 ⁶
Highway	3.4 X 10 ¹²	6.8 X 10 ¹²	7.7 X 10 ¹²	1.7 X 10 ¹²	1.5 X 10 ¹²
Rail	7 X 10 ¹²	1.4 X 10 ¹²	1.6 X 10 ¹²	3.5 X 10 ¹¹	3 X 10 ¹¹
Water	0	0	0	0	0
Other	0	0	0	0	0
Average Miles/Shipment					
State Total	1.2 X 10 ³	2.3 X 10 ³	2.6 X 10 ³	6 X 10 ²	5 X 10 ²
Air	7.7 X 10 ³	15.4 X 10 ³	17.3 X 10 ³	3.9 X 10 ³	3.3 X 10 ³
Highway	2.3 X 10 ²	4.7 X 10 ²	5.3 X 10 ²	1.2 X 10 ²	1 X 10 ²
Rail	2.4 X 10 ³	4.8 X 10 ³	5.4 X 10 ³	1.2 X 10 ³	1 X 10 ³
Water	6 X 10 ³	1.2 X 10 ³	13.5 X 10 ³	3 X 10 ³	2.5 X 10 ³
GHG Emissions					
CA GHG Emissions (in million metric tons CO ₂ equivalents)	450 (assuming AB32 targets)	400	900	350	275

	are reached)				
% GHG Emissions from Transportation	50	35	80	20	40
CA GHG Emissions from Transportation (in million metric tons of CO ₂ equivalents)	225	140	720	70	110
Public Transportation					
Ridership (riders/year)	894,931	6.2 X 10 ⁶	1.7 X 10 ⁶	9.2 X 10 ⁶	6.1 X 10 ⁶
Percent of commuters that ride public transportation	5.7%	20%	5%	70%	40%
Percent of transportation budget allocated to public transportation	30%	50%	10%	80%	80%
State of the Environment					
Land Quality					
Extent of developed land (acres)	9.7 X10 ⁶	10.5 X10 ⁶	12 X10 ⁶	8.5 X10 ⁶	7.5 X10 ⁶
Air Quality					
Days of unhealthy levels of ozone per year (measured within each air basin)	158	250	600	200	50
Peak 1-hr ozone concentration (ppm)	0.082	0.09	0.20	0.08	0.05
NOx emissions from mobile sources (tons/day)	270	100	650	200	125
VOC emissions from mobile sources (tons/day)	208	80	600	150	100
Days with PM10 exceeding state standard	12	25	100	10	0
Self-reported adult asthma prevalence	14.3%	20%	25%	10%	10%
Water Quality					
Days with MCL exceedances for drinking water	200	375	450	150	100

Beach closings & postings (days)	70	80	120	100	45
Resource use / efficiency					
Statewide waste diversion rate	75%	99%	50%	70%	99%
Total energy consumption (BTUs)	12.9×10^{12}	15.5×10^{12}	16.5×10^{12}	10×10^{12}	7×10^{12}
Energy consumption per capita (BTUs)	2.3×10^5	3×10^5	3.1×10^5	2.5×10^5	2×10^5
Biodiversity (Note: These are specifically species living within the state of California.)					
Total threatened species (plants & animals)	200	275	300	225	140
Total endangered species (plants & animals)	500	700	800	600	375
Total On Road Vehicles					
Total registered vehicles	38.81×10^6	142×10^6	163×10^6	55×10^6	19×10^6
Avg. Vehicles per person	1.2	3.5	5	1.25	0.5
Tourism					
% Hotel Beds Occupied	99%	90%	99%	55%	60%
# out of state travelers per year	3.354×10^8	4.5×10^8	6×10^8	2.5×10^8	3×10^8
# within state CA travelers per year	2.798×10^8	5×10^8	4×10^8	2×10^8	3.5×10^8
Transient Occupancy Tax Receipts	$\$18 \times 10^9$	$\$20 \times 10^9$	$\$23 \times 10^9$	$\$15 \times 10^9$	$\$14 \times 10^9$
Travel Time					
Mean commute time (minutes)	31.6	27	45	10	35
Median commute time	16.7×10^6	15×10^6	40×10^6	10×10^6	28×10^6
Vehicle miles traveled					
Vehicle miles traveled (miles)	534.1	6.3×10^{11}	8×10^{11}	5×10^{11}	4×10^{11}
Fuel economy (gasoline equivalent mpg)	28.4	50	24	27	38

3.2.1. Accessibility

Business as Usual

Accessibility is projected to increase overall, with some disparities between rural and urban areas. This is most likely to occur due to the many projects in development to address accessibility throughout the state and for different ethnic, demographic, and income groups. The assumption is that some of these projects will successfully increase accessibility to the targeted population.

Average fares are projected to increase to approximately \$1.75, to adjust for increasing wages, fuel prices, maintenance, infrastructure investments, and other factors. The percentage of rural low income residents utilizing public transportation is projected to increase to approximately 5%, due to projects targeting that specific group. However, barring any specific program that addresses urban populations, bus routes in urban areas will become more spread out, due to a predicted level of urban sprawl and increasing sizes of cities.

Scenario Future States

Changes to accessibility of transportation are correlated with many other system variables, such as alterations in public transportation, cost of mobility, total on road vehicles, vehicle miles traveled, total income, and Gross State Product. Increases in some of these variables, which are specifically quantifiable for each scenario, will decrease overall accessibility.

In “Green is Golden”, investment in public transportation and the desire of the government to enhance the infrastructure and maintain low fares will allow accessibility to stay high. Low income residents in urban and rural areas will be able to live close enough to a transit station, and will be able to afford the fares. California expands public transportation specifically to poor and rural neighborhoods, primarily in order to decrease congestion for commuters but consequently increasing accessibility. Overall, mobility is high for all residents, allowing accessibility to remain high.

In “Convenience Trumps”, however, areas are increasingly isolated and difficult to reach via public transportation as urban sprawl becomes the norm, creating hardships for low income residents that live far from work. Residents who are unable to easily access public transportation are forced to invest in personal vehicles, adding to the congestion and making transportation a larger percentage of personal income. Rural residents are unable to rely on public transportation, and urban sprawl has widely spread out bus lines in cities, making even urban residents have difficulty utilizing alternatives to cars. Average fares are prohibitively high, eliminating most low income residents from utilizing more expensive modes such as trains. Thus, accessibility in “Convenience Trumps” is the lowest overall.

“Holding Our Own” and “Grown from Grassroots” are dictated by low economic growth and a limited ability for low income residents to afford high mobility prices. In “Holding Our Own”, sweeping alterations to the technology of mobility have made public transportation more expensive, but an emphasis on modest energy use and alternatives to the typical commute has increased demand. Average fares are high but not unaffordable, so low income residents are willing to invest a slightly higher percentage of income to commute using alternatives to a personal vehicle. Fortunately, re-development has decreased urban sprawl and localized much daily travel, lowering the need for transportation assistance. While many people no longer commute due to alternatives such as telecommuting, the low income segments, particularly in the service industry, face increased hardships with the high fares, and are unable to afford the new vehicles or utilize outmoded fossil fuel cars. However, willingness to accept these difficulties maintains demand for public transportation by low income and rural populations, keeping accessibility relatively stable.

“Grown from Grassroots” manages the low economic growth in a different manner than “Holding Our Own”. The limited funds available have somewhat stunted increases in public transportation infrastructure, forcing many rural residents to live far from transit stations. However, fares are significantly reduced, as public transportation becomes the most viable, attractive option for residents of all income levels. Mixed use and urban re-development have decreased the overall need for mobility, making daily errands more accessible via walking and biking. This is an important aspect of maintaining accessibility, as the price of gasoline and taxes on vehicles, indicators of the overall cost of mobility, have increased dramatically and low income residents are unable to afford to drive on a regular basis.

3.2.2. Commercial Aviation

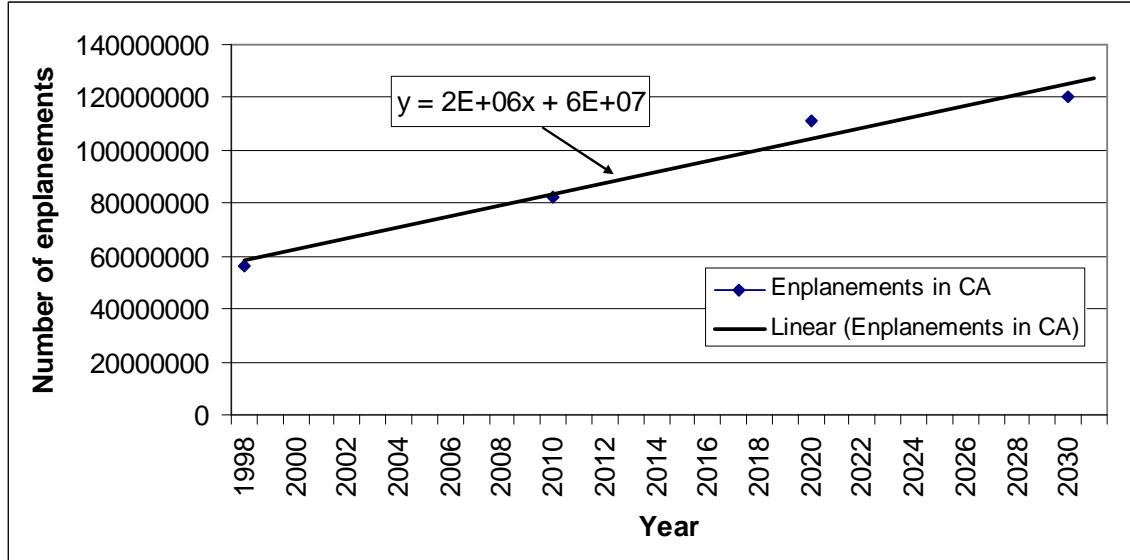
Business as Usual

Passenger demand at the three commercial airports in the San Francisco Bay Area is expected to increase from 56.5 million annual passengers in 1998, to 82.3 million in 2010, and doubling to 111.1 million annual passengers in 2020. It is anticipated that the Oakland and San Jose airports share will increase from the current 34 percent of passenger traffic to 45 percent by 2020.

Increasing demand will likely require increased airport capacity and improved ground access. Increasing capacity at existing commercial service airports is expensive since they tend to be surrounded by urban developments and subject to environmental concerns. Additionally, as demand grows closer to capacity, air traffic will be increasingly forced from larger commercial airports to surrounding general aviation airports. Increased demand at general aviation airports could stimulate opposition in the surrounding communities (Hansen 2002).

A linear extrapolation of current trends results in a projected 120,500,000 enplanements in the year 2030.

Figure 38: Passenger Enplanements per Year in California



(Data Source: Federal Aviation Administration 2007.)

Scenario Future States

California’s commercial aviation sector is currently facing steadily increasing demand and demand is projected to double by 2020. Yearly enplanements in California vary drastically in our four scenarios. In “Green is Golden” and “Convenience Trumps,” increased economic growth results in a higher number of enplanements than occurs today. However, in “Green is Golden,” the internalization of air travel’s environmental externalities has causes a large increase in ticket prices. The 100 million enplanement figure is significantly lower than a “business as usual” projection of about 120 million. In this scenario, fewer citizens can afford air travel. In contrast, “Convenience Trumps” presents a highly affordable and busy air travel industry. In this scenario, the capacity of California’s commercial airports is a crucial problem as demand will exceed supply.

“Holding Our Own” and “Grown from Grassroots” both have large decreases in air travel. In “Holding Our Own,” the aviation industry is subjected to a financial crash period, and then recovers to a much lower demand level than exists today. In “Grown from Grassroots,” air travel is unaffordable due to the low household incomes in California coupled with rising costs due to environmental protection.

3.2.3. Cost of Mobility

Scenario Future States

Overall, we expect the cost of mobility to be highest across all indicators in “Green is Golden.” This is a reflection of increasing economic wealth, increasing consumer demand, and environmental pressures to adopt new, cleaner technology. The lowest overall cost of mobility occurs in “Convenience Trumps”, where we expect governmental subsidies to keep fuel prices low and low environmental costs. “Holding Our Own” will also see an increase due to increasing economic pressure, but the lack of environmental pressures will keep it lower than in “Green is Golden”. It is also possible that there will be governmental subsidies in this scenario, but not to the degree witnessed in “Holding Our Own.” “Grown from Grassroots” has an interesting picture for total cost of mobility, with higher petroleum fuel prices and fuel taxes, but lower vehicle prices and fewer vehicle miles traveled. Thus, while certain elements of mobility are more expensive, the percentage of household income spent on transit decreases.

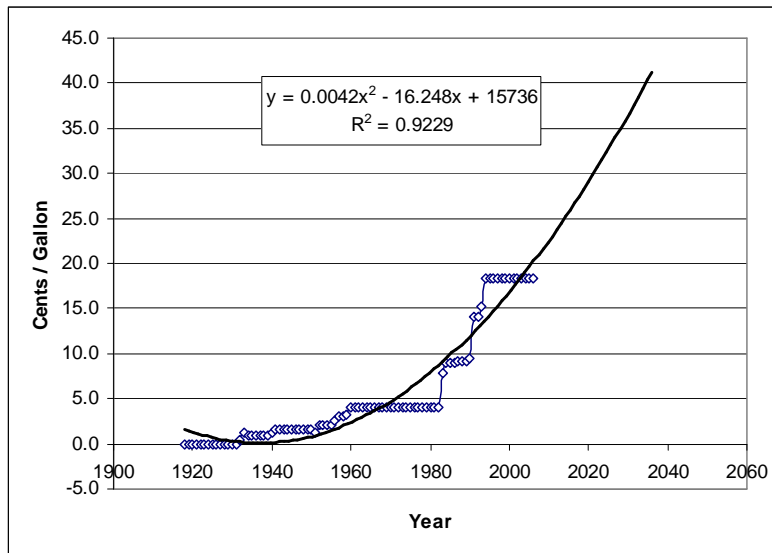
Fuel Price

Business as Usual

Given the substantial volatility and the extreme difficulty in predicting future trends, we have chosen the business-as-usual value for 2030 to be the value obtained from a consistent increase of 3% per year. This calculation results in a price of \$5.43 for gasoline and \$6.20 for diesel, in 2006 dollars. While we acknowledge that this is an unlikely trend for the fuel price, we have chosen this calculation in an effort to simplify the final analysis, which is focused on the relative differences between scenarios and not the method of prediction.

Business-as-usual projections using historic trends for the federal fuel tax show the tax increasing to 80¢ in the year 2030, and the state fuel tax increasing to 60¢ in the same time period.

Figure 39: Federal Fuel Tax



(Data Source: American Petroleum Institute 2006)

Future States

Fuel price is more associated with the environmental prioritization axis, than the economic axis, although both have notable effects. Thus, “Green is Golden” and “Grown from Grassroots” have substantially increased petroleum fuel prices, reflecting environmental pressures, but “Green is Golden” is greater than “Grown from Grassroots” because of the added economic pressures.

It is important to note that we have not included the price for any alternative fuels. We have done this because at this point, it is not clear which alternative fuel or which new technology will be the most successful, and we have chosen not to make predictions as to which technology will “win the race.” However, it is clear that in “Green is Golden” and “Grown from Grassroots”, the high environmental priority will create an environment in which alternative fuels will be highly successful. In these scenarios, as petroleum fuel prices increase, this will create an incentive to look for other alternatives, as well as making the currently expensive technologies more attractive and competitive. Thus, while we do not have a metric for this effect, we acknowledge that it will be a major aspect of the total cost of mobility in these two scenarios.

We also see alternative fuels as being an important aspect of “Convenience Trumps” and particularly “Holding Our Own”, but not for the reasons given above. As worldwide populations continue to grow and countries such as China and India continue to develop, the demand for petroleum products is expected to increase exponentially. In order to ensure the desired level of consumption, it will be important to reduce our dependence on foreign sources of oil. Thus, domestically produced alternative fuels will increase in importance and production. However, the type of fuels that will be successful in “Convenience Trumps” and “Holding Our Own” are very different than those described

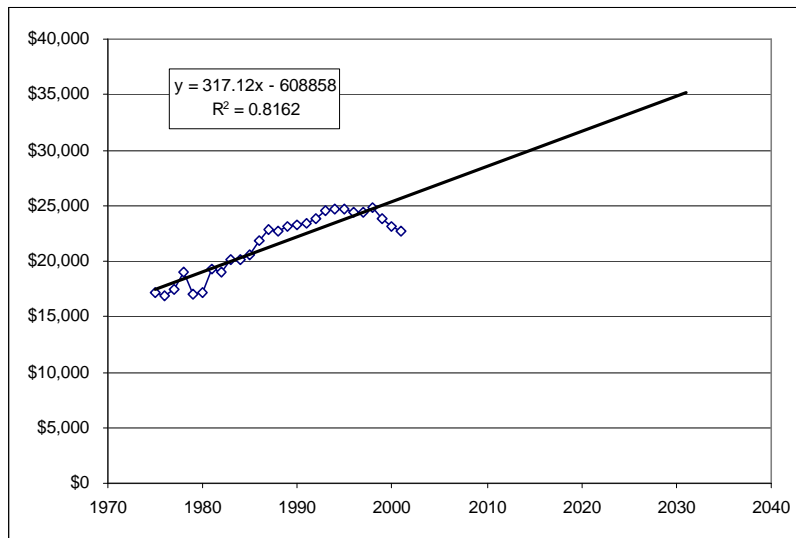
above as being successful in “Green is Golden” and “Grown from Grassroots.” Whereas those were motivated by environmental awareness, these may have severely negative environmental benefits.

Vehicle Price

Business as Usual

Using the trends shown in Figure 6, we project that the average domestic vehicle price will increase to \$34,896 (in 2001 dollars) by the year 2030.

Figure 40: Car Price- Overall Average



(Data Source: Abeles 2004)

Future States

Vehicle price can be seen as an indicator of the level of adoption of new technologies, since the initial adoption of these technologies tends to increase the average vehicle price. We see the highest vehicle price in “Green is Golden” and “Convenience Trumps.” The high price in “Green is Golden” reflects a high level of innovation and the need for low or zero emission vehicles. These vehicles represent a high initial investment that will then be paid off over the long term through improved efficiency. This high price tag creates issues with equality, as the percent of income spent on transport increases substantially more for lower income households than for middle- and upper-class households.

“Convenience Trumps” also has a substantial increase in vehicle price, although the type of technology adopted in this scenario is very different from that of “Green is Golden.” In this scenario, innovative technologies are focused on decreasing emissions and increasing the miles per gallon (or equivalent). However, in “Convenience Trumps,” new technological developments are focused on increasing performance and luxury, which have a negative environmental effect.

The lowest vehicle price is observed in “Grown from Grassroots,” reflecting a simplification of transportation. Although there will be technological innovations to improve environmental performance, they will not be the same sweeping changes made in “Green is Golden,” because the consumer base lacks the disposable income to make the high initial investment. Technologies that retrofit old cars to be more efficient will also decrease the practical vehicle price, because one will be able to pay a reduced amount to maintain and improve old cars, instead of having to invest in new.

Percent of Income Spent on Transit

Business as Usual

We project that in a business-as-usual case, the percentage of income spent on transportation will remain the same as the current state value and will continue to be 39% and 19% for low and middle income households, respectively.

Future States

Addressing the percentage of income spent on transit is important because it can highlight issues of inequality, when the percentages are vastly different for lower and middle income households. Typically, lower income households spend a significantly greater percentage on their income on transport, and this difference is expected to widen in “Green is Golden.” The difference is expected to remain about the same for “Convenience Trumps” and “Holding Our Own,” although the percentages themselves will decrease slightly and increase slightly, respectively.

Interestingly, the percent of income spent on transit is expected to be comparable for middle-income households in “Green is Golden” and “Convenience Trumps,” where new technologies increase vehicle price, but households also have increasing income. However, the percentage is significantly higher for lower income households in “Green is Golden.” This difference reflects the fact that the technologies adopted in “Convenience Trumps” are expensive, but not required, and thus lower-income families can simply choose not to purchase them. However, in “Green is Golden,” the new technologies are driven by increased environmental prioritization, and therefore required by all in order to reduce emissions.

3.2.4. Demographics

Population Distribution

Business as Usual

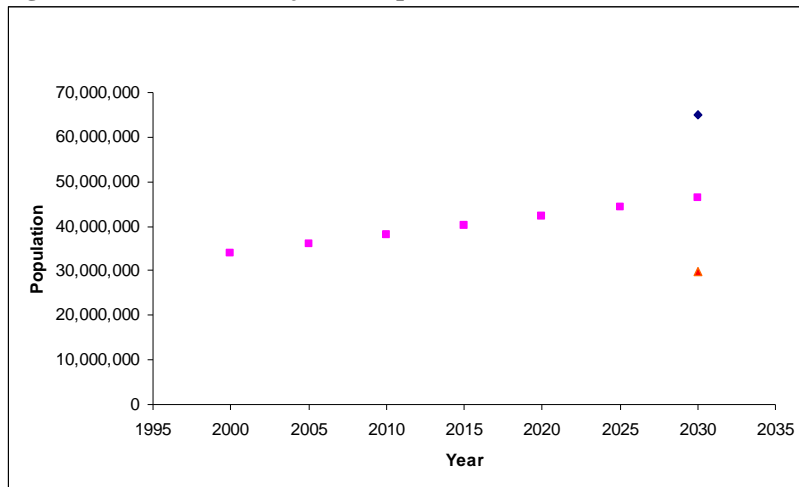
Population projections for the state of California are fairly uncertain. These projections must take into account immigration and emigration rates as well as birth and death rates.

For the purposes of scenario analysis, these influential factors are less important than knowing the physical limitations on population. In essence, population growth will be limited by the physical space available to house residents. Likewise, population decrease will slow as the supply of available housing increases in desirability to outsiders. Overall population will also fail to reflect changes in demographics, age groups, or other population fluxes. In the business-as-usual case the population of California will reach 46,400,000 in the year 2030.

Future States

In scenarios with high economic growth, the population growth will rise accordingly. Unburdened by regulation, population will reach 66 million people in 2030 in “Convenience Trumps.” By comparison, the population will only reach 53 million people in “Green is Golden” as immigration is somewhat constrained by environmental impacts of population growth. Due to the fact that environmental priority focuses more on businesses than individuals, population growth remains unregulated in this scenario. In “Holding Our Own” the population of California reaches 30 million by 2030. This low population reflects the mass exodus from California due to low economic growth and a consistently poor housing market. With more of a focus on communities, “Grown from Grassroots” sees a population of 35 million in 2030.

Figure 41: California Projected Population



(Source: US Census Bureau 2006)

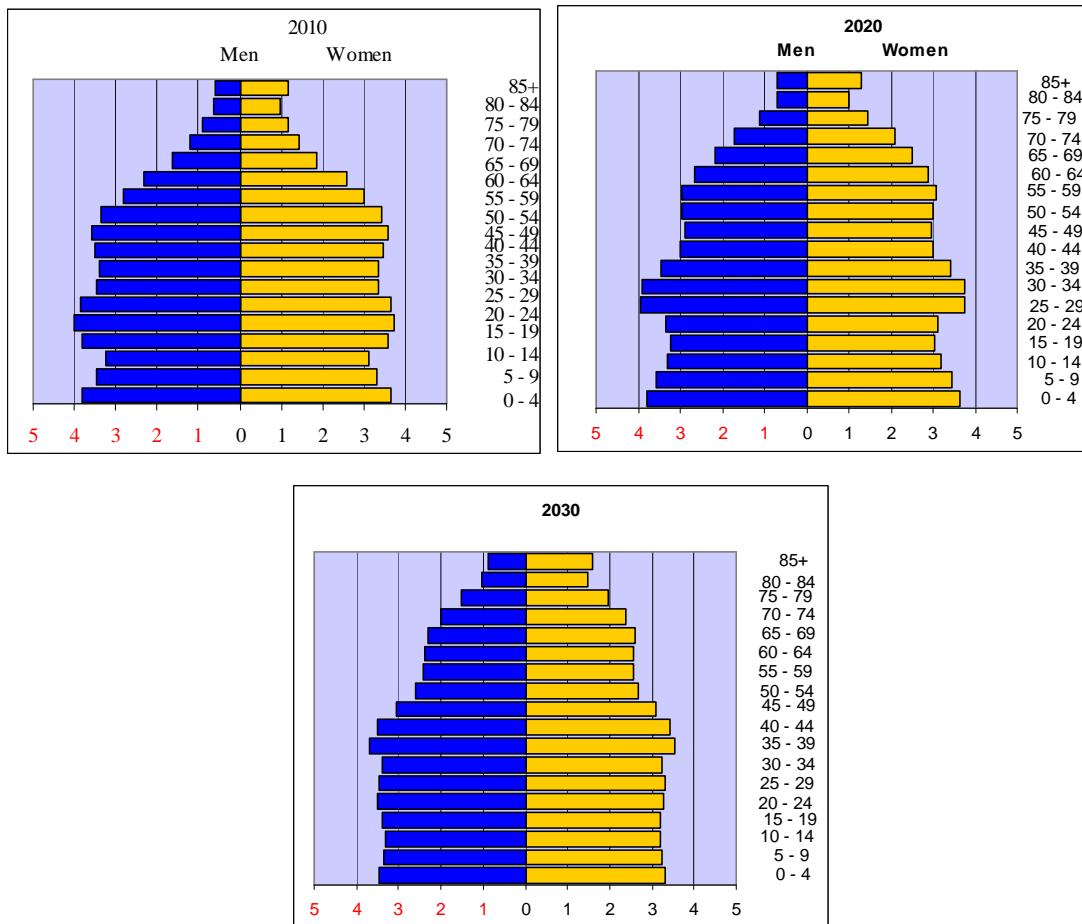
Age Distribution

Business as Usual

Age distribution will be highly affected by the economic state of California. A stronger economy will encourage growth in the working age sector, as well as provide a small push towards an increase in birth rates. Environmental priority will have less an effect on age distribution, but will most likely manifest itself from a health perspective for the

older generations. The proportion of elderly will have an impact on transportation if their behavior does not change with time. As shown in Figure 44 below, the age distribution will dramatically change by 2030. In that year the number of seniors will have doubled, with one out of every six Californians over age 65.

Figure 42: California Projected Population



(Source: California Department of Finance 1993)

Future States

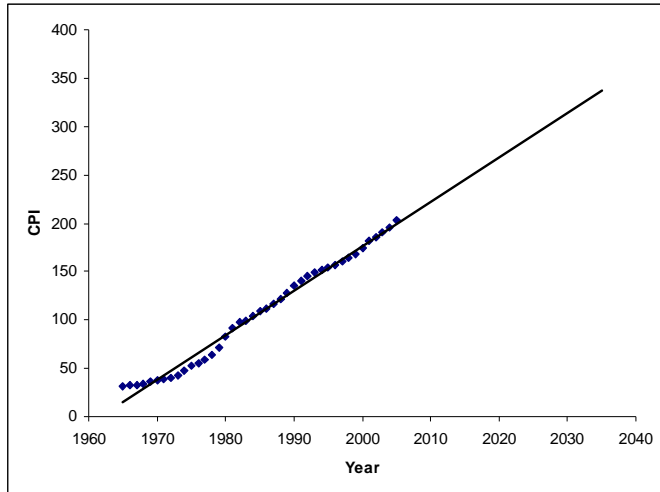
In the scenarios with high economic growth, the age distribution only changes in magnitude since people of all ages come to California. In “Holding Our Own” the middle-age population segment sees the largest decrease since many people age 25 – 55 could no longer afford to live in their homes and apartments and moved. As a result, the percentage of the elderly population will increase relative to other age groups.

CPI and Inflation

Business as Usual

By 2030 inflation will increase prices by around fifty percent. The projection for the business-as-usual case is shown below in Figure 43. This inflation value assumes the relative prices of goods such as food and energy have not dramatically increased.

Figure 43: California CPI 1965-2005, projected to 2030 (1982-1984=100)



(Data Source: California Department of Finance 2006)

Based on this regression, an annual inflation rate of about 2.5% was calculated. This annual rate is considered an acceptable rate of growth, but is sensitive to the price of energy and food, two commodities that could have significant price changes as climate change effects take place over the next thirty years.

Future States

Inflationary expectations for 2030 will be drastically understated in “Holding Our Own.” In this scenario inflation will be at its worst, accounting for rising energy and food prices. Real prices may also increase in “Green is Golden” and “Grown from Grassroots” due to regulation-imposed taxes on certain goods in reflection of their environmental impact.

Median Income

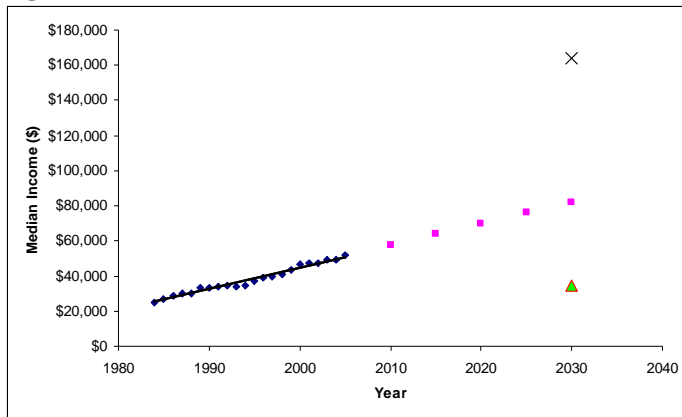
Future States

Median income is strongly related to the overall strength of the California economy. In scenarios with low economic strength, median Californian income is less than today’s by a noticeable margin. This difference has serious implications regarding household behavior and affordability of environmental goods and services. In the other scenarios, disposable income is high enough that a significant portion of the population will become

more price insensitive, further supporting more expensive goods and services, regardless of the environmental impact.

In “Green is Golden” median income is quite high, but not as high as “Convenience Trumps” due to earning potential restrictions stemming from environmental regulation. The same justification influences the income in “Holding our Own,” having a slightly higher median income than “Grown from Grassroots.” Income increases in line with high economy are greater in magnitude than the decreases associated with low economy. This difference is justified by the overall strength of the California economy and economic inertia that must be overcome to create such a drastic reduction in median income.

Figure 44: California Median Income



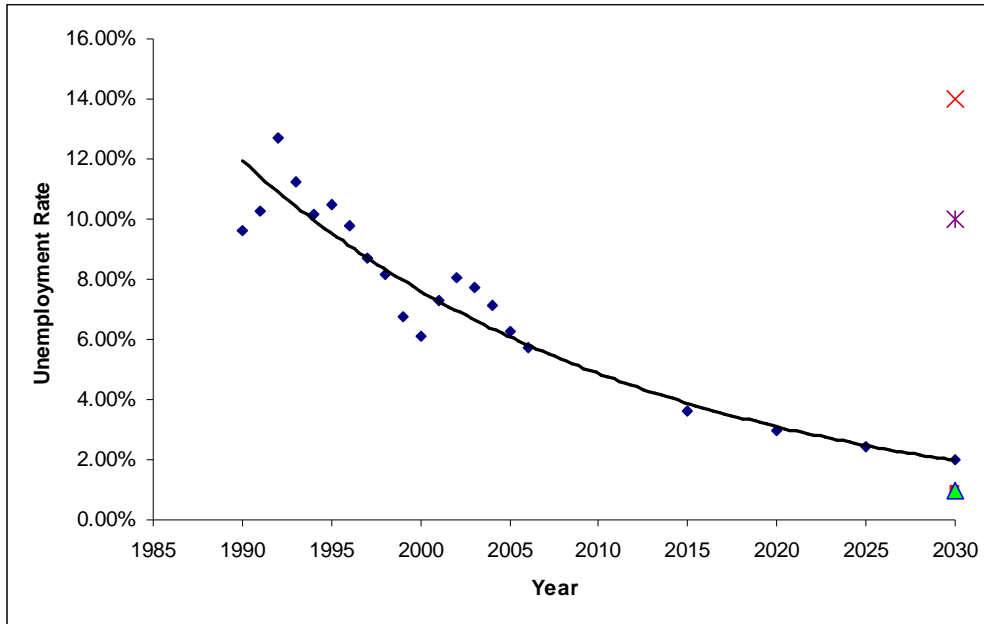
(Data Source: US Census Bureau 2006)

Employment and Unemployment Rates

Business as Usual

Unemployment rates remain a volatile statistic, bearing heavily on economic prosperity. Outside influences such as outsourcing of labor, undocumented workers, and part-time employment affect the unemployment rate uniquely in each scenario. By 2030 the unemployment of California should approach an annual average between 2 – 4%. Due to seasonal variability and other influencing factors, the unemployment will still fluctuate around this rate.

Figure 45: Average Unemployment Rates for California



(Data Source: US Department of Labor Bureau of Labor Statistics 2006)

Future States

While short-term unemployment was highest in “Holding Our Own” and “Grown from Grassroots,” gradual economic rebuilding keeps the unemployment rates in check. In “Green is Golden” and “Convenience Trumps,” unemployment rates slowly decrease but are never eliminated altogether. Long-term unemployment rates will balance job scarcity with the population of able workers and cost of living/mobility.

3.2.5. Freight

Business as Usual

Freight will always play an important role the California economy. The ports of Los Angeles and Long Beach, along with the San Francisco and Los Angeles airports, will remain the gateways to global trade for California and the United States in each scenario. Port utilization, and consequently environmental impact, will depend greatly on freight and transportation in each scenario. Energy consumption and air pollution will comprise two of the largest environmental impacts freight will have on California. Increased growth in air and ground freight will increase in value to \$200 billion and \$1 trillion, respectively, by 2030. This growth will be reflective of the increased trade with East Asia as it travels through California to other destinations in the US. At that time major ports of call, airports, and transportation hubs will be further strained. Without proper infrastructure improvements the system will eventually reach a choking point where the system cannot keep up with demand, forcing businesses to look elsewhere for support.

Future States

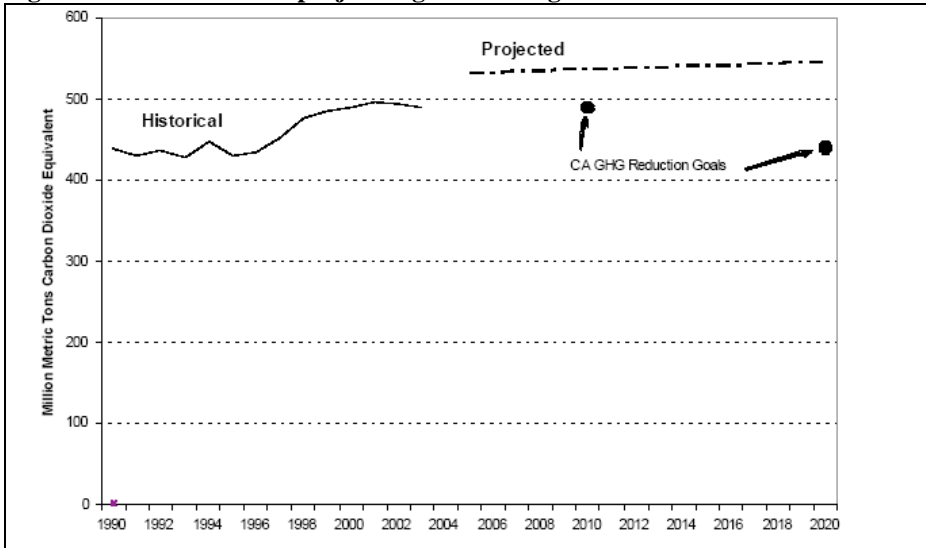
In “Convenience Trumps” freight is least restricted and features strongest growth. This, in turn, places enormous burdens on the ocean, air, and land. While coping with the tremendous shipping strains, the roadways in California and supporting infrastructure will remain highly vulnerable to disruptions. Stress easement could be capitalized with logistical improvements. Environmental regulation diminishes the quantity of freight some in “Green is Golden,” but not too much. “Holding Our Own” features a low economy, but a lack of environmental regulation and a push to do ‘whatever it takes’ to restore the economy leads to slightly better growth than in “Grown from Grassroots” with its environmental focus. While this environmental focus may lead to slower growth in freight, value to society may be added elsewhere in its place.

3.2.6. Greenhouse Gas Emissions

Business as Usual

Based on California’s Assembly Bill 32, greenhouse gas emissions are anticipated to level off and decrease, contrary to the projection of historical trends (Nunez 2006). These reduction goals are shown in Figure 46, juxtaposed with the projection.

Figure 46: Historical and projected greenhouse gas emissions trends.



(Data Source: California Energy Commission 2007)

Scenario Future States

Greenhouse gas emissions are likely to demonstrate a markedly different trend in each of the four scenarios. In “Green is Golden,” emissions are the closest to the business as usual because while environmental priority is high, so too is the economy. There is a desire to maintain a strong economy and retain businesses in the state, which includes shipping needs. For this reason, transportation contributes to half of the emissions.

“Convenience Trumps,” on the other hand, shows emissions as double that of the business as usual projection. This is due in part to the fact that additional businesses will be migrating to California to take advantage of the relaxation of monitoring and enforcement of environmental regulations, especially those concerning climate change issues. This is also reflected in the 80% of emissions generated from transportation means.

“Holding Our Own” paints an interesting picture in terms of greenhouse gas emissions. Despite a low environmental priority, they are very similar to “Grown from Grassroots,” the other low economic scenario, and have the least emissions due to a decrease in demand for transportation. With a high environmental priority on the other hand, “Grown from Grassroots” has low emissions because there is a great awareness of environmental issues, including greenhouse gas effects. Transportation contributes to 40% of emissions as older cars are still in use.

3.2.7. Public Transportation

Business as Usual

Projections of public transportation ridership and funding are difficult to make because they follow non-linear trends that depend on politics and exogenous economic factors. During the period of 1990-2000, the number of Californians that rode public transportation grew by 0.2 percent while funding increased 20 to 40 percent.

Scenario Future States

Californians’ ability to afford alternatives to public transportation determines its role in our scenarios. “Holding Our Own” has the highest rate of ridership due to the collapse of many other options with 70% of commuters using public transportation and almost all transit funding allocated for public transportation. “Grassroots Green” (40%) has a very high rate of ridership despite a lack of funding to improve and expand the transport system beyond current levels. While the percentage of transportation funding slated for public transport is high, the overall level is low.

“Green is Golden” includes a public transportation system that is very well funded, but is not used to its full capacity due to the ability of its citizens to afford private modes of transportation. 20% of citizens use public transportation to get to work. The concept of “induced demand” is at play in this scenario; the government limits personal vehicle travel times so that people use public transportation when they need to travel outside of their allotted times.

“Convenience Trumps” paints the bleakest picture for public transportation. There are many more commuters in its booming economy, yet the percent which chose public

transportation are consistent with the current rate of about 5%. Citizens of this scenario witness the influx of a significant number of travelers to an already congested road system. Funding in this scenario is allocated to road improvements before it is used for upgrades to the public transportation system.

3.2.8. State of the Environment

Scenario Future States

The economic axis has two primary effects on the overall state of the environment: first, higher economic growth means that there is more money available for environmental protection (and vice versa for lower economic growth); and second, a growing economy leads to expanding population and development. Whether this expanding population spends their increasing wealth on environmental protection is then determined by the second axis, environmental prioritization. Thus, for “Green is Golden,” the expanding population puts pressure on the environment, but their economic wealth can help to limit their total impact. In “Convenience Trumps,” this growth and development goes relatively unchecked. In “Holding Our Own,” the pressure from economic and population growth is reduced, but there is added strain from individuals and businesses looking to cut costs associated with environmental protection. Finally, in “Grown from Grassroots,” there is reduced strain from development, and although the total money available is reduced, a greater portion of it goes towards environmental protection.

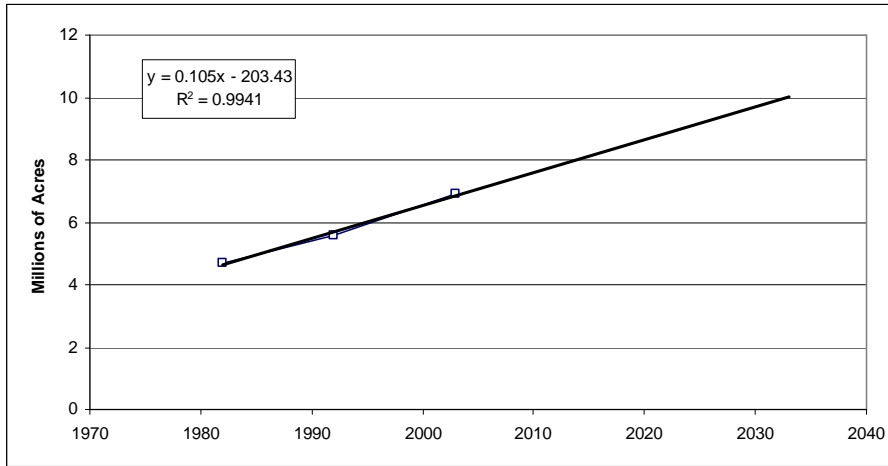
Overall, the state of the environment in “Grown from Grassroots” is the highest. However, it is possible that the high environmental priority characteristic of “Grown from Grassroots” is in fact caused by a severe deterioration in environmental quality. This pathway would look as if California is moving towards “Holding Our Own,” but the backlash against poor environmental quality then causes a “flip flop” into “Grown from Grassroots.” Thus, although the current treatment of the environment is highest in “Grown from Grassroots,” it may still be experiencing the results of the previous decades. (Note that this is not the only pathway to reach “Grown from Grassroots,” and we assume a more stable pathway in our further discussions.)

Land Quality

Business as Usual

Following the trend in Figure 16, it is predicted that the extent of developed land will increase to 9.7 million acres (or by about 40%) in a business-as-usual scenario.

Figure 47: Extent of Land Developed



(Data Source: Natural Resources Conservation Service, Department of Agriculture 2007)

Future States

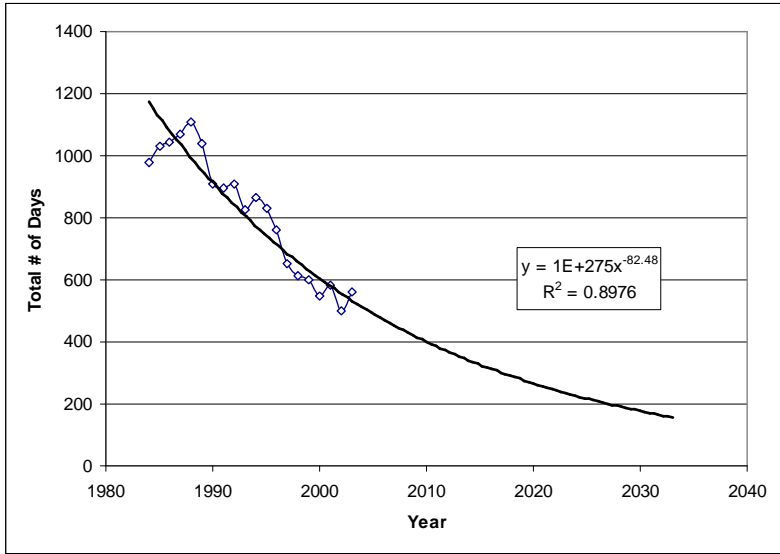
The land quality in each scenario is closely tied to the rate of population growth and development discussed above, as well as each scenario's environmental prioritization. For example, "Green is Golden" and "Convenience Trumps" both experience economic growth, but the extent of developed land in "Convenience Trumps" is substantially higher than in "Green is Golden", where there is an emphasis on mixed development and urban regeneration. "Holding Our Own" also has a growth in the extent of developed land, but for opposite reasons. The higher than average property values throughout the state of California are expected to drive middle and lower income families out of the cities and into the currently undeveloped lands in the desert and Central Valley, particularly the areas east of Los Angeles. "Grown from Grassroots" faces the lowest increase in the extent of developed land, as economic development is low and environmental pressures lead to limits on the taking of undeveloped lands.

Air Quality

Business as Usual

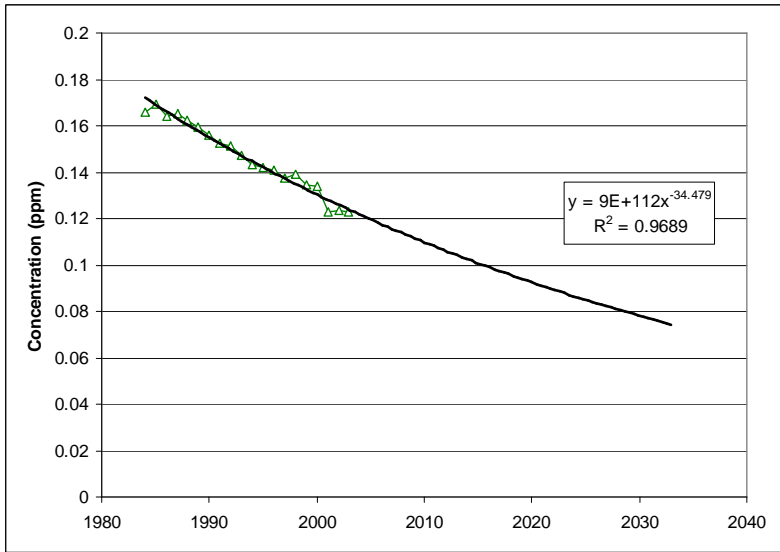
Decreasing trends can be observed for each of the impact indicators. It is predicted that in a business-as-usual scenario, these trends will continue, but the rate of decrease will slow and begin to flatten out as we get closer to 2030 (See Figures 48 through 52).

Figure 48: Total Days Above State Ozone Standard



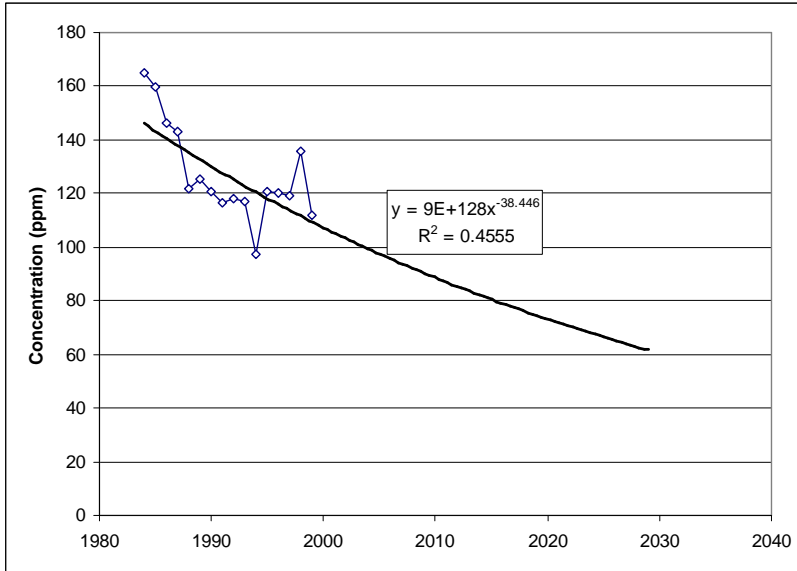
(Data Source: Air Resources Board, Cal/EPA 2006)

Figure 49: Overall Average Peak 1-hr Ozone Concentration



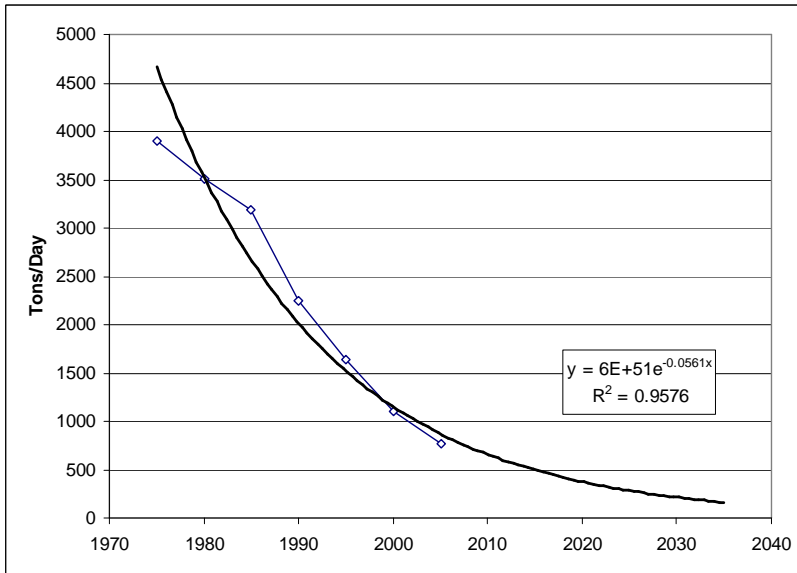
(Data Source: Air Resources Board, Cal/EPA 2006)

Figure 50: Overall Average Peak 24-Hr PM10 Concentration



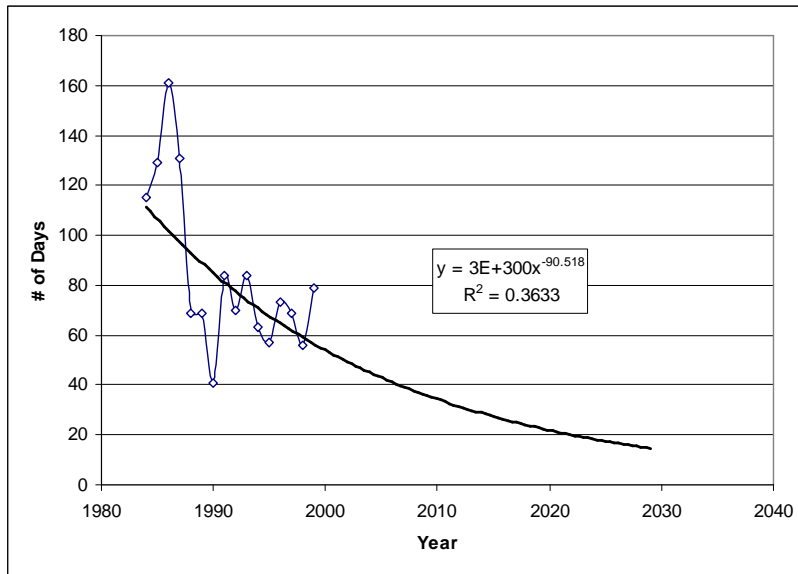
(Data Source: Air Resources Board, Cal/EPA 2006)

Figure 51: Mobile On-Road VOC Emissions



(Data Source: Air Resources Board, Cal/EPA 2006)

Figure 52: Total Days Above PM10 Standard



(Data Source: Air Resources Board, Cal/EPA 2006)

Future States

Air quality is the area of the environment most directly affected by the state of transportation. As such, scenarios with a high level of on-road vehicles and total vehicle miles traveled will necessarily have more days of high ozone levels, higher NO_x and VOC emissions, and more days with PM₁₀ levels exceeding the state standard. The percentage of adults reporting asthma cases will also be higher, as a secondary effect of these emissions.

However, technological developments can play an important role in reducing the amount of emissions, if innovative energies are focused on increasing fuel efficiency and other environmental goals. For this reason, “Green is Golden” has excellent air quality (as measured by VOC and NO_x emissions, peak ozone concentrations, and days above state regulatory standards) even though it has a high number of on-road vehicles and total vehicle miles traveled. In fact, it has better air quality than “Convenience Trumps” or “Holding Our Own,” despite having more vehicles that are driving further. Nonetheless, the combination of environmentally-focused innovation and low vehicle miles traveled creates the highest overall air quality in “Grown from Grassroots.”

Water Quality

Business as Usual

Historically, water supply and maintenance of acceptable drinking water quality has played a critical role in shaping the development of California, due to the water scarcity in much of the state. Over the long term, there have been vast improvements in overall water quality, with technological innovation and the implementation of more stringent

regulations. However, as the population continues to grow, particularly in the arid Southern California region, current water supply and water sanitation facilities will face increased strain.

Changing weather patterns associated with climate change also pose a significant threat to both water supply and water quality. It is uncertain whether supply will be adequate for California's growing population if there is a long term drought. On the other hand, current facilities may not be able to handle the runoff from increased precipitation or increased storm intensities. These trends are virtually impossible to predict, and are outside the scope of this project.

Based on the current trends, it is expected that these variables will continue to decrease, at a decreasing rate, i.e. flattening out as we approach the year 2030. According to these simple trends, the number of days with MCL exceedances for drinking water will be 200 and the number of beach closings and postings will be 70 in the same time period.

Future States

Although water quality can be seen as similarly negatively affected by the level of development and population growth, it is less likely to be positively affected by a "cure-all" type technology. This is particularly the case in California where the combination of increased demand on an already strained water supply may create an unstable, risky state for water quality. Thus, "Convenience Trumps" has poor water quality, as measured by the number of Maximum Contaminant Level exceedances and the number of beach closings, as a result of its vast development and low environmental priority. However, "Green is Golden" also has relatively poor water quality, due to its high level of development, and despite its high economic wealth and potential for technological innovations. In fact, "Green is Golden" has worse water quality than "Holding Our Own," even with "Holding Our Own's" low environmental priority. And again, "Grown from Grassroots" combination of low development and high environmental priority create the highest overall water quality.

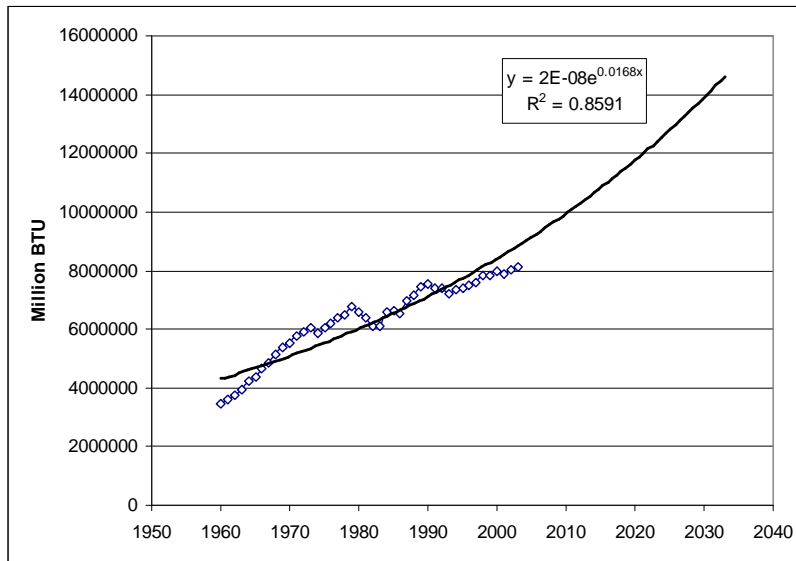
Resource Use Efficiency

Business as Usual

Following the current trend, it is expected that the state of California will consume around thirteen trillion BTUs per year in the year 2030. However, when coupled with the population growth rate, this represents only a small increase in the total energy used per capita.

At the present rate of increase, the statewide diversion rate will be approximately 75% by the year 2030.

Figure 53: Total Energy Consumption in California



(Data Source: Energy Information Administration, Department of Energy 2003)

Future States

Innovations in resource use and efficiency can stem from two different motivations: the need to reduce one's environmental impact and the need to decrease economic costs. Thus, "Green is Golden" is motivated by its environmental prioritization and strong, competitive business environment; "Holding Our Own" is motivated by its need to cut costs; and "Grown from Grassroots" is motivated by both its environmental prioritization and its need to cut costs. While there will be some minor motivation in "Convenience Trumps" due to the strong business environment, we believe that the readily available money will outweigh these needs, and leads to the only scenario in which resource efficiency is relatively unimportant. "Holding Our Own" is also an interesting case because its leading motivation – cost cutting – may not necessarily lead to environmental efficiency improvements, but rather efficiency in other areas of the economy (e.g. labor, capital). Thus, it has some improvements in resource efficiency, but lags behind "Green is Golden" and "Grown from Grassroots," which are motivated by environmental reasons.

Biodiversity

As discussed in relation to other environmental indicators, particularly land quality, biodiversity is strongly affected by the overall level of population growth and development. However, while environmental prioritization may aid in diminishing the effects of this growth on other aspects of environmental quality, biodiversity cannot be controlled through technological innovations. Limits to physical growth and expansion may help to mitigate negative effects on biodiversity. But, overall, "Green is Golden" and "Convenience Trumps" are expected to have the highest impact on biodiversity, even despite "Green is Golden's" high environmental priority. (In "Green is Golden," we

expect more money to be spent on endangered species, and thus more animals kept alive in captivity et cetera, but the total number listed will still be very high.)

We expect that environmental priority will also play a role in the number of species listed, in that “Convenience Trumps” will have a greater number listed than “Green is Golden” and “Holding Our Own” will have a greater number listed than “Grown from Grassroots.” However, economic growth and development will be the primary driver of the number of species listed, and thus “Green is Golden” and “Convenience Trumps” will be both higher than “Holding Our Own” and “Grown from Grassroots.”

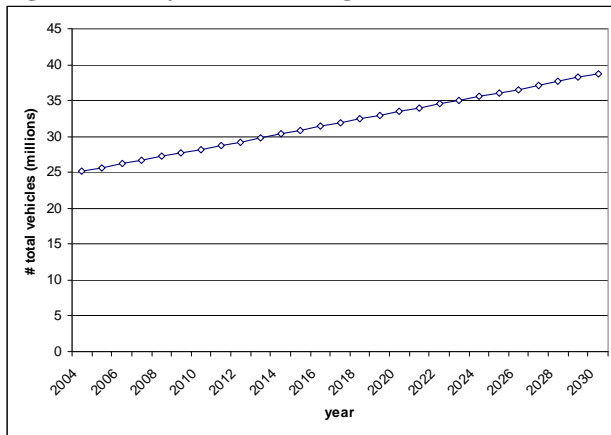
It is also important to note that in reality, the number of species listed is closely tied to the congressionally mandated budget allowed to the Department of Fish and Wildlife for the listing of species. Clearly, in scenarios with a lower environmental priority, the approved budget will be lower. We have considered the number of species listed, as if the funding were identical in all scenarios, and thus does not have an effect on the number of species listed. We have used this metric as an indicator of the state of biodiversity, not of funding, and have made this assumption to isolate the effects of the axes on overall species health.

3.2.9. Total On-Road Vehicles

Business as Usual

California Department of Transportation has created a projection of the total on-road vehicles through 2030. The business as usual forecast predicts total vehicles to increase at an average rate of 1.69% annually. This forecast is based on projecting a number of current trends, including population, socioeconomic factors, vehicle fuel economy and prices, legislation, and income. The business as usual projection by CalTRANS is 38.805 million registered vehicles.

Figure 54: Projected Total Registered Vehicles



(Data Source: Transportation System Information Program, California Department of Transportation 2005)

Scenario Future States

Table 8: Breakdown of Total On-Road Vehicles

Scenario	Total cars/person	Total Population (except ages 5-17)	Total Vehicles
BAU	1.2	35,398,721	38.805
1	3.5	40,708,529	142.4798515
2	5	32,637,186	163.18593
3	1.25	44,022,371	55.02796375
4	0.5	38,160,256	19.080128

Total on road vehicles and vehicles per person are related strongly to population projections and the state of the economy. Since a person can only drive one car at a time, no matter how many are owned or registered in California in each scenario, the total vehicles actually on the road at one time will be limited by the population of the driving age. In “Green is Golden”, the strong economy has allowed more people to be able to afford more than one vehicle, bringing the average up to 3.5 vehicles per person. Some vehicles are destined for specific uses, such as daily errands and commuting. Households in “Green is Golden” can also generally afford additional, more expensive cars with lower fuel economy, used for long car rides or special occasions. While these might emit more, they are driven less and tend to sit in the garage longer. In “Convenience Trumps”, the population again can afford multiple cars per household, up to 5 per person. People prioritize their disposable income by purchasing more fuel inefficient vehicles and few alternative fuel vehicles, which are not mainstream or easily accessible. The number of cars on the road increases dramatically, as people chose to drive more often.

In “Holding Our Own” and “Grown from Grassroots”, the lack of a strong economy prevents households from purchasing excess vehicles, other than as a necessity. “Holding Our Own” shows 1.25 vehicles per household, only slightly higher than California Department of Transportation projections. Many people still require vehicles for commuting, traveling, and running daily errands. However, households need to share vehicles, and many people are forced to purchase older, higher emitting vehicles.

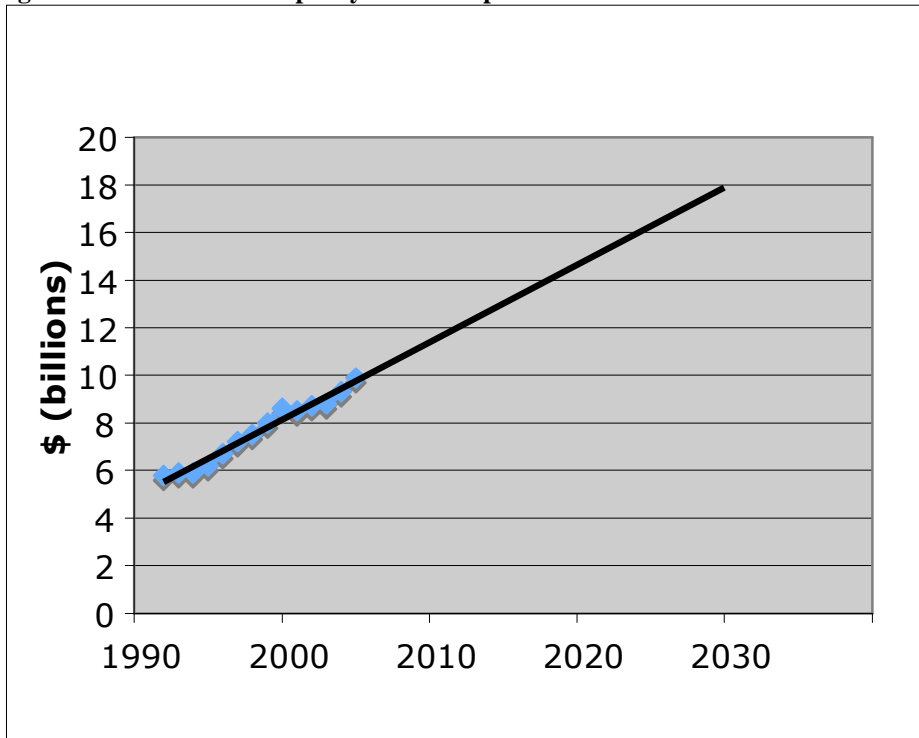
While the total on road vehicles and average number of cars per person is the lowest in “Grown from Grassroots”, approximately 0.5 autos per person, this is due to personal choice and different priorities for disposable income, as opposed to limits on spending due to the state of the economy. People have made the conscious decision not to purchase vehicles, or to limit households to one vehicle, and to drive significantly less. Other factors influence this decision as well, such as the high cost of mobility.

3.2.10. Tourism

Business as Usual

Based on historical trends of increasing numbers of visitors to California, overall tourism is projected to increase. Below is an example of the projection of one related variables: transient occupancy tax receipts (Figure 55).

Figure 55: Transient Occupancy Tax Receipts



(Data Source: California Transportation Commission 2005, California Travel & Tourism Commission 2007)

Scenario Future States

Travel to and within California will happen with or without a strong economy because people will always come to visit such attractions as Yosemite, Disneyland and the wine country. The patterns of travel will be very different, however. Hotels will be at nearing full capacity in “Green is Golden” and “Convenience Trumps” due to the strong economy; although “Green is Golden” will have a greater number of CA residents traveling within state. Transient occupancy tax receipts will be high reflecting this sustained increase in tourism.

“Holding Our Own” and “Grown from Grassroots” have notable tourism pattern changes. In “Grown from Grassroots” in particular, within state travel is increased from business as usual despite the weak economy and decrease in transient tax receipts. The majority of

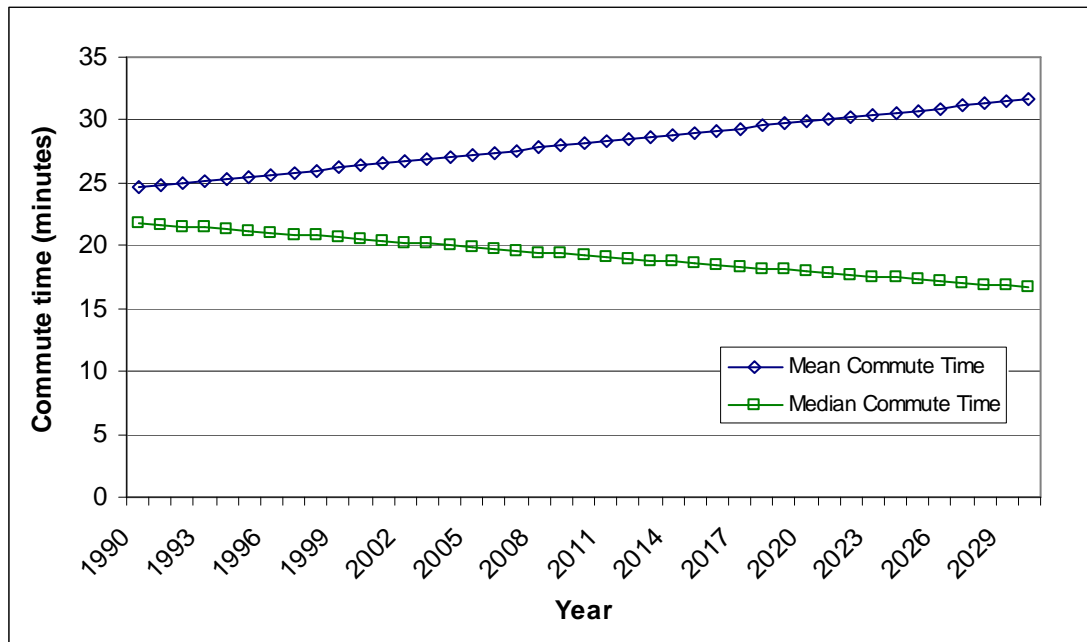
leisure travel in this scenario is comprised of day and/or overnight within state trips and therefore less tax revenue is generated and hotels are negatively affected. “Holding Our Own” has the least tourism in general due to its modest energy needs. Tax receipts are low because people are traveling economically and government officials receive heavy subsidies when traveling.

3.2.11. Travel Time

Business as Usual

Projections of commute times are based on geographic employment trends. The highest rate of employment growth is expected to occur in inland areas, while coastal area jobs will still outnumber inland jobs in absolute numbers. This is likely to increase inland-to-coastal commutes, which would require upgrades to transportation infrastructure to avoid further congestion. A linear extrapolation of current trends suggests that California workers will experience an average commute time of 31.6 minutes and a median commute time of 16.7 minutes. However, in a June 2007 press release, the California Public Policy Institute projected that travel time in general will increase by 48% by the year 2025. The decreasing trend in median commute times is unlikely to continue since it has been caused by a major shift from suburb-to-city into suburb-to-suburb commuting.

Figure 56: Mean and Median Commute Time of California Workers over 18 Years Old: Linear Extrapolation of Current Trends



(Data Source: US Census Data accessed online using American Factfinder 2000, 2005)

Other factors that are likely to affect travel time are demographic shifts in age, culture, and income. Past data has shown that older drivers, a growing population segment, are

more likely to drive alone, potentially adding to congestion. The growing Latino population, on average, has had a higher tendency for carpooling and compact communities, driving down congestion. However, this trend is most likely caused by income and will likely shift as cultural and economic assimilation occur. Household income and sex tend to have a stronger correlation to commute time than ethnicity.

Scenario Future States

Travel time, measured in mean and median commute times, shows a general increase in all of our scenarios due mainly to population increase. Median and mean commute times tend to differ when parts of the population engage in very long or very short commutes. Our scenarios reflect a general tendency for an increase in mean commute times while median commute times are more variable. Although median commute times decreased 9% from 1990 to 2004, our scenarios reflect a deviation from this trend.

In “Green is Golden,” California maintains similar commute times to the baseline year, with a 27 minute average commute time. While the scenario’s storyline involves a period of very bad congestion, the commute times become stabilized by the year 2030. In this highly regulated society, commutes are optimized by the government to mitigate the effects of a growing population and to limit environmental impact. The emergence of transit-oriented suburbs and suburb-to-suburb commuting also contribute to the relatively short commute time. The difference between mean and median commute is due to a division between those who drive personal vehicles and those who ride transit.

“Convenience Trumps” has the most extreme increases in commute times, with a mean of 45 minutes. Rapid economic growth coupled with freedom from environmental restraints has resulted in sprawling development. In contrast to “Green is Golden,” suburban development in “Convenience Trumps” is less compact, further beyond existing city boundaries, and not designed with transit in mind. Although the government would most likely attempt to mitigate the commute problems, the political will would not be strong enough to solve the problem with public transportation.

“Holding Our Own” has a disruptive effect on commute times. California’s economic crash and rebirth into a “modest energy” society has resulted in a ubiquitous dependence on public transportation and a reliance on telecommuting. Those who still commute travel very short distances due to the high price of mobility, so mean and median commute times have decreased to 10 minutes.

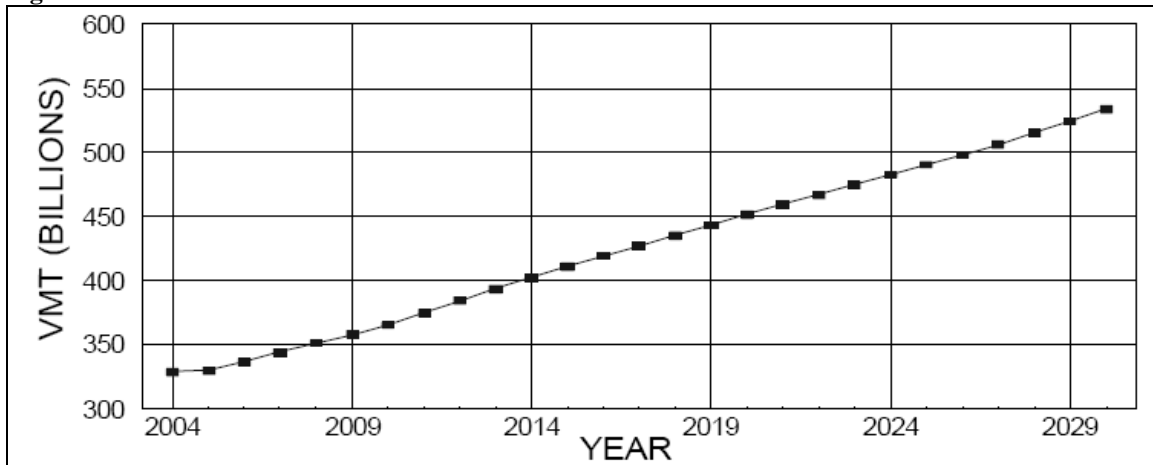
The “Grown from Grassroots” scenario has a relatively modest increase in mean and median travel times due to the emergence of a localized economy in which workers commute short distances to their jobs. In this scenario, non-motorized modes of transportation become more common, which drives commute times upward. Median and mean commutes are 35 and 28 minutes respectively, as almost all workers have the same commute times because their jobs are located near home.

3.2.12. Vehicle Miles Traveled

Business as Usual

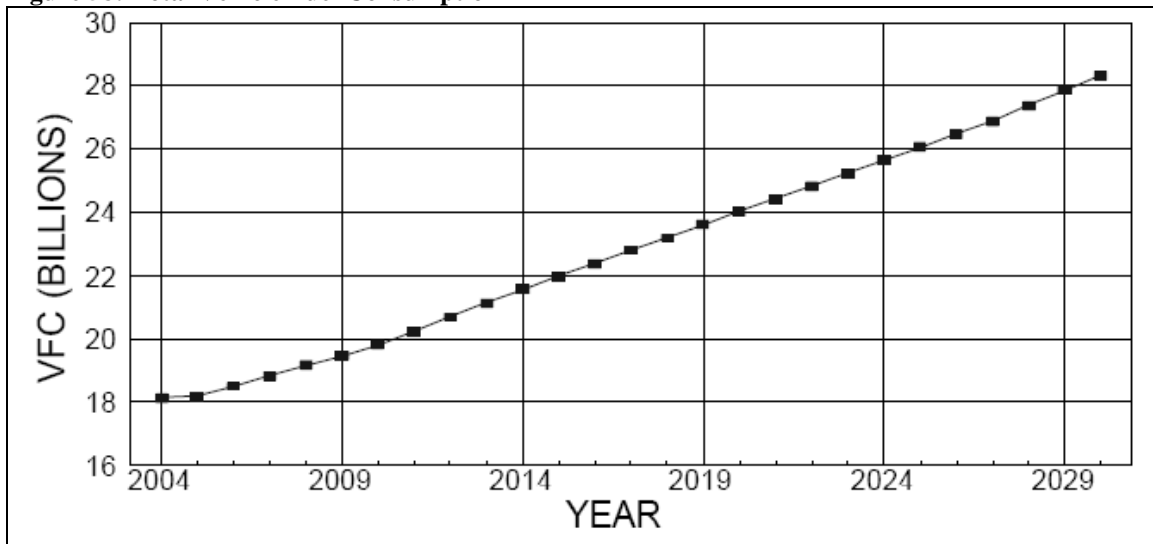
Due to expected population growth, the total number of vehicle miles traveled is projected to increase linearly at the historic rate. This rate of increase will result in approximately 534 billion vehicle miles traveled by the year 2030.

Figure 57: Total Vehicle Miles of Travel



(Source: Transportation System Information Program, California Department of Transportation 2005 -- Forecasts are based on a business-as-usual scenario.)

Figure 58: Total Vehicle Fuel Consumption



(Source: Transportation System Information Program, California Department of Transportation 2005 -- Forecasts are based on a business-as-usual scenario.)

Scenario Future States

Vehicle miles traveled is primarily affected by economic growth, and only secondarily affected by environmental priority. Thus, “Green is Golden” and “Convenience Trumps” have a greater number of vehicle miles traveled than “Holding Our Own” and “Grown from Grassroots.” Meanwhile, “Convenience Trumps” has a greater number than “Green is Golden,” and “Holding Our Own” has a greater number than “Grown from Grassroots.”

Thus, “Convenience Trumps” has the greatest vehicle miles traveled, as a result of high levels of both business and personal travel. There is a great deal of urban sprawl in this scenario with little mixed development, and people rely solely on their cars for personal travel, even for very short trips. Heavy congestion in this scenario also makes the vehicle miles traveled produce significantly more emissions.

There is a similar mentality in “Holding Our Own.” However, the funds available for transportation are significantly lower. Thus, people rely heavily on their cars, but overall mobility is reduced.

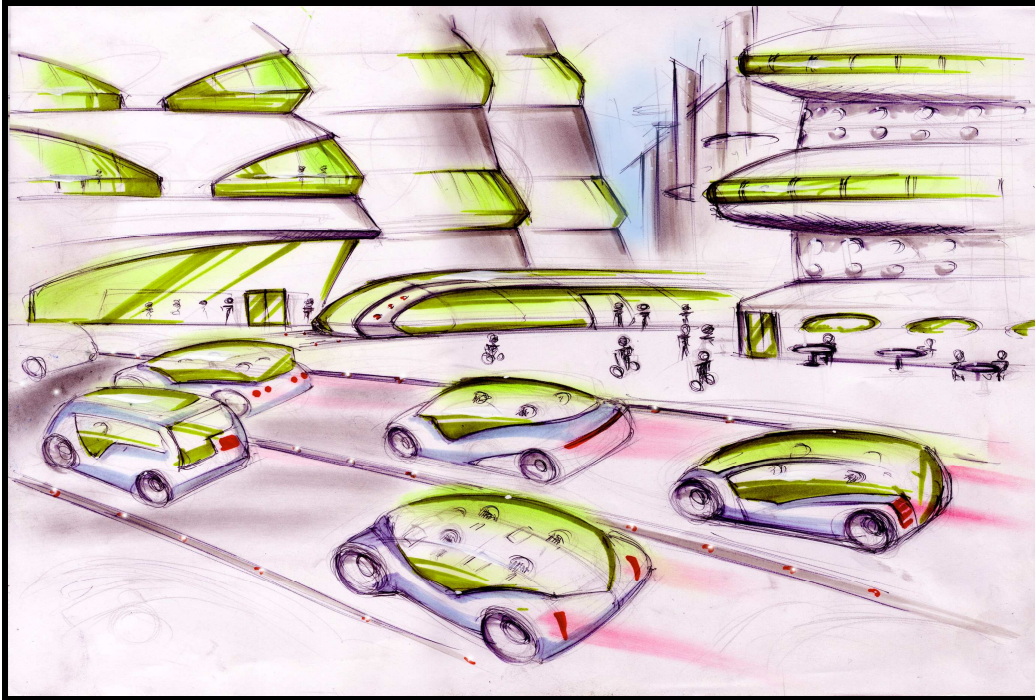
“Green is Golden,” with its hyper-mobility, is an interesting case, particularly when the high value for vehicle miles traveled is combined with the highest fuel economy of any scenario. Thus, while “Green is Golden” ranks second highest in the total number of vehicle miles traveled, it has significantly better air quality than “Convenience Trumps,” even though they have comparable values for vehicle miles traveled.

Finally, “Grown from Grassroots” has the lowest value for vehicle miles traveled, with somewhat improved fuel economy as well. In this scenario, there is an emphasis on shorter commutes and the use of public transportation and biking, as a result of both the poor economic state and the high environmental prioritization. Interestingly, the drastic reduction in the number of flights will have the opposite effect of increasing the number of vehicle miles travels related to leisure. In particular, there is a surge in local ecotourism at the states many national parks. Overall, however, total vehicle miles traveled is low.

4. SCENARIO NARRATIVES

The narratives are stories to help make the Future State values come to life. Narratives help tell the stories of the scenarios in an interesting, accessible way. The Future State values obtained for each system variable provide the inspiration and quantitative support for the scenarios, creating a skeleton of the transportation system. In contrast, the narratives do not focus on figures and values, but in the details that make the scenarios memorable. They paint the picture of what life and transportation will be like for various members of society and for California as a whole, and describe how the variables interact and play out to create a future society.

4.1. “Green is Golden”



(Illustration by Marcus Quach)

Snapshot:

- Californians strive for “green citizen” status.
- Citizens pay tax based on their “carbon footprint.”
- Government regulates commute times.
- Efficient cars dominate transport system.
- Green business flourishes in CA.

Breakout Box: A Day in the Life

Joe wakes up in his suburban condo to the smell of coffee from the café downstairs. He gets up just in time to make the 8AM commute shift. He grabs his car keys and transit card and walks out the door. He glances at a magazine on the rack in front of the local café—Business Week. On the cover is a story about the skyrocketing stock price of that Chinese solar company that he just invested in. He hopes his wife Joan saw it when she caught the 7:15 commute.

It is his turn to drive the carpool, so he inserts his transport card into the dash console and drives to the usual meeting spot. His coworkers climb in the car, talking about politics. Bruce says “I’m voting for Challenger. Anyone who is willing to try something other than this awful carbon tax can have my vote.”

On the way to work, they pass by ugly old neighborhoods that weren’t able to make the change to new, efficient transportation technology. The GHG taxes hurt them badly and their local economy is still adapting. He looked at the new light rail system with pride, as his firm had helped build it. Hopefully, it will provide the community with the mobility it needs to better connect to the global economy.

After a smooth commute, they arrive at the office. It didn’t take a lot of effort to drive with all the sensors on the road. They spot their boss, Bill, driving up in his car—conspicuously alone. “He must have gotten another raise,” Joe says. Bruce says, “See? The carbon tax is completely unfair. Why should that jerk be able to drive around, wrecking the climate, just because he’s overpaid?” They try to hide their gossip from the boss.

The office was getting quiet these days. A lot of people seem to be doing the telecommute thing. It’s hard to pass up when the government is handing out big tax breaks for not commuting to work. Joe missed the old days, when you could chat at the water cooler with co-workers, but as they taught in school—Global Warming is no joke. You wouldn’t want to see any more years of flooding down in the Gulf just so people could hang around the water cooler. The corporate instant messaging system got the job done, anyway.

After work, Joe has a quick trip back to the townhouse and takes a short walk to the grocery store, passing by busy restaurants and a small eco-hardware store. He wonders how much the apartment above the hardware store rents for. How long it would take before he could afford to buy his dream house near work instead of renting? Everyone wants to live in this commuter development, so prices are rising, making telecommuting ever more attractive to Joe.

Ever since large sections of the Greenland Ice Sheet began to fall into the ocean, global warming has become the defining struggle of the times and citizens are very conscious of greenhouse gas emissions. Almost every part of life in California is now regulated for eco-efficiency. California's transportation system has been re-structured to meet the high consumption demands of economic success and stringent environmental protection laws. The debates over whether climate change is real or caused by human activities have become moot because businesses and government have decided to take action against climate change. Business in California has flourished as they shift as spawned new opportunities in the technology and service sectors.

Horrible traffic congestion at the outset of the 2010s gave state government officials enough support within the electorate to enact the "Transportation Efficiency Act" which assigns permits for allowable commute times for each citizen and tracks their annual carbon footprint. The legislation was sparked by efforts to reduce both congestion and environmental impact. Enforcement is carried out by the Environmental Protection Agency's law enforcement division.

Breakout Box: A Senator's Campaign

"The preliminary polls just came in sir," the intern said with a telling grin. Jon Challenger had just become the youngest governor of California. His "GREEN JC" campaign established the value in matching the needs of the state with the needs of the environment

With a background in Environmental Law and a knack for bringing the complexities of the policy world down to dinner table basics, Jon appealed to both the burgeoning college-age population and the remaining baby-boomers. Voter participation in this election had been a record-setting 98%, highlighting the increased priority voters gave to environmental platforms (the opposing candidate had a significantly different perspective, focusing on increased carpooling, tax incentives, and nearly every other tried-and-failed plan under some new name).

John ran on a platform that challenged the status quo. Unlike his predecessors, Jon knew that statewide support of his agenda would allow him to create the most comprehensive and aggressive environmental welfare law the country had ever seen. Jon also worked out how to keep firms competitive in an ever-more-stringent environmental business climate and promote a GREEN standard (Environment, Equity, and Economics). He had promoted the idea of an incentive program for citizens to be environmentally conscious instead of the current, and outdated, tax system. Citizens could attain a GREEN status level based on how environmentally consciously they behaved. This GREEN status earned more than just tax reductions; it featured reductions or waivers of certain public fees, educational benefits, and additional savings at many of the companies co-sponsoring this widespread campaign. The program was simple: earn points by being environmentally conscious and earn your GREEN status.

In-home pollution reduction ranged from energy efficiency programs to waste reduction efforts. Grocery choices (domestic versus imported) made a difference. Financial contributions to conservation efforts and volunteer time all made a difference. Each effort earned points towards the GREEN status. But above all, transportation was the key. It held the most potential for change. Everything from car type to fuel consumption, time of travel to mileage, number of passengers to purpose of trips could all be compiled and appropriate points rewarded. No one could have ever predicted the impact on transportation the GREEN status would have.

Californians still have a high level of mobility, as long as they travel according to optimized travel times and modes. The distribution of “transport cards” has replaced drivers’ licenses as standard issue identification. These transport cards maintain a digital record of each citizen’s carbon footprint, for which they are taxed at the end of the year according to their income class. Travelers scan their cards when driving their cars and boarding at transit stations. Former toll booths had been retrofitted into scan stations. At the end of the year, citizens can receive a tax return if their carbon footprint is below a certain threshold.

There has been a minority resistance to the government’s “top-down” approach, however, with citizen groups claiming that their personal freedoms to mobility and economic opportunities are under attack. The “League for True Mobility” has emerged as an underground movement, rebelling against the highly regulated transport system by electronically disrupting automated systems in protest. Although it is a small faction, the government has grown wary of its growing youth ranks. A more mainstream group has begun to publicly question the efficiency of the carbon tax system, instead touting the benefits of tradable permits assigned to each individual and firm.

A popular sentiment is that California should spend resources preparing for the physical effects of climate change. Geo-engineering and carbon sequestration have emerged as successful industries, winning numerous government contracts. California’s coastal highway system and airports are identified as high-risk areas, spurring the construction of a coastal levee system. Some politicians have pointed out that California should secure its borders to prepare to handle a potential refugee situation in case its neighbors in the Southwest bear the effects of climate change induced drought. Although the success of the economy has created a relatively immigrant-friendly atmosphere, preparing for a potential mass immigration seems like a necessary precaution to many Californians.

The line between the automotive industry and the high-tech, Silicon Valley sector has been blurred. As the transportation system requires more and more automated vehicles, the two sectors have overlapped in mergers. Because Los Angeles became a testing ground for innovative solutions to transportation problems like pollution and congestion, many of these corporate partnerships have been located in Southern California. Just as

Detroit once stood as a symbol of American automotive ingenuity, Los Angeles is known as the home of the next wave of mobility innovation.

Businesses are given large tax breaks for carbon-reduction practices such as using telecommuting and hiring local employees. Businesses in the Silicon Valley have begun to rely on telecommuting and transporting their own employees on company-owned buses. Employee parking is taxed as part of income, so companies no longer offer free parking—this has created incentives for other modes of transport.

The shipping industry has shifted to favor land-based truck transport because shipping via air has become too expensive. The aviation industry has undergone some price changes to internalize their emissions costs. In this booming economy, new expanded sea ports have provided a means for California to increase shipment to and from the Far East. California's new green technology sector relies heavily on international manufacturing because environmental laws are so stringent that in-state production is not cost-effective. Businesses and individuals can also choose an “eco-shipping” option— which has a higher price and slower service, but reduces their carbon taxes.

A large black market—dealing in counterfeit transport cards and devices that bypass the automated transport—has arisen. Strong regulation has created a very high price premium for those who are able to circumvent the system, and there are many people willing to try. Auto companies and tech companies spend great resources combating the illicit market and often hire former hackers to develop new security software.

Fuel demand has been met by the introduction of an array of energy sources that are domestic, clean, and renewable, while substantially reducing zero greenhouse gases from previous levels. After an initial flooding of the market, some fuels emerged as winners. The auto companies that now dominate the market were those who prepared for this mix by selling vehicles that can run on a wide range of energy sources and by maintaining flexibility in their production lines. Although fuel mode remains uncertain, the replacement of old vehicles has become requisite by government mandate. Manufacturers have responded with take-back programs to attract buyers of replacement cars and “design for recycle” strategy. Some NGOs cry foul at the equity implications of this law, as the young and low-income populations are disproportionately affected.

Cars are still the most popular mode of transportation—for the middle and upper class who can afford the low carbon technology and taxes. The average household has three cars, but uses them sparingly. It is common to have an ultra-efficient commuter vehicle in addition to a vehicle used only for recreational trips. Because air travel is prohibitively expensive for much of the population, driving is the most common mode of vacation travel.

Breakout Box: A Family vacation in Yosemite

Bruce hadn't been able to concentrate at all this week at work. He had been thinking about his family's trip to Yosemite National Park. He had re-worked the logistics in his mind a hundred times—the four of them would pile into the weekend car even though they were actually leaving on a Tuesday. Finding time that the whole family could take off of work and school was a precarious balancing act now that the workweek was staggered to reduce road congestion.

This was their first vacation since the GREEN standards had been implemented. By selecting the most eco-efficient route for his vehicle type, purchasing GREEN food, and planning his stops according to the tourism board's guide to eco-efficient vacations, Bruce hoped to earn some credits toward the kids' enrollment in a GREEN status school. He wanted to provide them with the best education possible, so being eco-minded was a top priority for this trip. Although it required some extra planning time and added costs, it was worth the status points.

They would drive out of the Bay Area through the Livermore-Modesto highway. It was still a novelty to ride that stretch of road with its automated features. Bruce's kids would never know the Central Valley the way he did in his youth. It used to be farms and orchards as far as the eye could see, but that had all given way to rapid housing development as the population grew. Granted, it was supposedly "sustainable," but he felt that there was a certain appeal to the old lifestyle. By relying on the land, he had learned the importance of sustaining it.

That was precisely why he had chosen to take the kids to Yosemite for this year's vacation—he was afraid they were going to grow up without knowing what nature was really like. Yosemite was real nature, unlike those supposed eco-parks that are built into new developments. Another reason was that plane tickets were far beyond his financial means.

The mandated limits on mobility have driven land development patterns into pedestrian and public transport-oriented communities. Rather than an urban re-development, brand new suburban communities have arisen. Because a strong environmental sentiment prevents development into pristine natural areas, these developments are compact and contiguous. The reliance on telecommuting has created a demand for more complete communities in the suburbs because workers stay near home. New developments resemble a European mixed-use style and tend to sell units even before construction is completed, at very high prices. These developments are dominated by large chain businesses since they provide much of the up-front funding. In a departure from the early

part of the century, “big box” retail stores have been re-incarnated to meet the small size demand of new communities while maintaining large-scale business models.

Breakout Box: Media

Sample Headlines:

“Carbon Taxes or Carbon Permits: Gubernatorial Candidates Sound Off”

“Morning commute disrupted by computer virus”

“Government Officials Pledge to Incorporate Environmental Performance into Daily Life.”

Public transit plays a major role in moving people around, but to the chagrin of the state government, is under-utilized. Funding is steady and sufficient to invest in large-scale system upgrades like light rail in addition to new buses and extended route coverage. The Los Angeles-San Francisco-Sacramento express train, an extremely expensive investment by the state government, has been deemed a great success. Fleet and public transport vehicles have been replaced by low emission vehicles. In the past, transit riders represented strict ethnic, income, and age classes, but today public buses are a cross section of almost all types of citizens. State officials have initiated security initiatives to protect this vital piece of the transportation system.

Despite a few years of warmer-than-average weather and steady rises in sea level, California’s citizens did not shift to public transportation until the government started taxing cars based on carbon emissions. Climate change and traffic congestion have been unifying forces in determining government action, but not personal choices because the high average income allows citizens to choose based on convenience. The public transportation system is new and state of the art, but runs well below its capacity. People choose to ride transit when they must travel outside their designated commute time.

Although the US Government is still behind its OECD peers in greenhouse gas regulation American businesses have reaped the great profits by strategically maneuvering through new regulations around the world. Scientists are unsure, however, if global carbon-reduction efforts are enough to stave off an environmental Armageddon. As time goes on, projections for the future seem to get worse as a chain reaction of carbon releases from beneath the polar ice caps is poised to emerge. There is also a sense that while California is doing its part to combat climate change, it may not help solve the problem if other nations and states do not join the cause.

Breakout Box: Junior High School Science Fair

“Ok, settle down everyone!” said Mrs. Gibson, “this is really important!” The 8th grade students at Lincoln Jr. High had worked for 5 weeks on their science projects and were about to present them at the school science fair. “Stand next to your projects and the judges will come around and ask you some questions,” she said.

Mrs. Gibson surveyed the room, noticing that this year even a larger portion of the class had chosen greenhouse gas-related projects. Billy wrote an excellent report on polar bear recovery efforts. It was based on replacing the bears' melting habitat with chemically treated, non-toxic ice that had a higher melt temperature. He explored the risks and merits of various chemical treatments. This focus is great for the future, she thought, but were they limiting the students' creativity by pushing solutions to environmental problems so uniformly?

Three of these projects would go on to the state competition and it was easy to guess which ones would be chosen. Potential solutions to the state's transportation problems were en vogue, so Jimmy's project on which plant species should be planted along highways would certainly have a leg up on the competition. He examined the carbon-uptake performance of each species when subjected to the sounds of traffic.

Perhaps the strangest experiment was conducted by Judy. She stood there in the school cafeteria in her big white hat and white dress, telling the judges how painting every roof and road white would increase the amount of solar heat reflected by the earth. She had built a model of a reflective city, decorated with reflective helium balloons and people dressed in white (Benford 1997). It was a far cry from the old baking soda-vinegar volcanoes the teacher made when she was young, but then again, kids back then didn't have to worry about climate disasters.

4.2. “Convenience Trumps”



(Illustration by Marcus Quach)

Snapshot:

- Transportation channels at maximum capacity
- Need for time efficiency leads to extreme multi tasking while en route
- Fully equipped and luxurious homes and personal transportation means
- New markets open for audio visual technology, single purpose vehicles, and air purification devices

Breakout Box: A Day in the Life

Joe grabs his morning coffee at 5:30am. He's going to need it. As a civil engineer, he commutes from Camarillo to LA everyday. He has a meeting with his colleagues on the way to work and is waiting for the corporate shuttle to pick him up. He is always the first on the bus, followed by a few in Ventura, more in Thousand Oaks, and the majority in Irvine. In order to optimize their time while waiting in traffic, they have a meeting every morning en route at 6:30am on the dot. Most of the participants are on the bus and they telecommute with the rest. Once they reach the office, they begin work implementing the decisions made that morning. All his time right now is devoted to working on plans to add an alternative to the 101 in the Central Coast region. Ideally this freeway will have a raised light rail train alternative. However, there are concerns about whether or not people will opt for this over their cars.

Since the mornings are so early, Joe often takes a nap at noontime in the company break room. It is fully equipped with cots as well as showers. He always grabs another dose of caffeine before attending to his afternoon work. There is a coffee shop in the lobby of his building.

The shuttle home leaves the office at 3:30pm. They have another meeting on the way home which allows them to leave so early. Even still, he usually doesn't get home until after 6pm. Last week, he didn't get home until 9pm almost every day.

2030 California, and the United States as a whole, is a very isolated place as the economy continues to boom as environmental priority dwindles. Societal trends include personal freedom and prosperity, at the expense of community and environmental concerns. The benefits to this include overall financial security and low unemployment. For this reason, the migration of businesses and people to California exponentially increases, which puts stress on the transportation channels to and within the state. Immigration regulations of all kinds have become very relaxed.

Influence is denoted by economic status, and therefore, big companies have a strong bearing on the regulatory framework in place. California is no longer a frontrunner in the implementation of progressive environmental legislation. Around 2015 movement began to revoke some of the stronger standards. Of the regulations that do remain, monitoring and enforcement has become less rigorous and exploiting loopholes is the norm.

Businesses migrate to California to partake in these advantageous governmental deregulation conditions. Shipping and car companies find particularly favorable conditions here due to relaxed enforcement of emissions standards. Transparency and reporting of environmental impacts remain largely optional, as consumer demand for these has become a lower priority. Overall, any environmental motivation becomes a liability and may contribute to a loss of competitive edge. The environmental job market has dried up.

Different kinds of technological advances are maximized, however, with the impetus behind them being power and convenience. There is a strong societal consumerist sentiment, with an almost competitive flavor. Households become gadget oriented and automobiles push the envelope of luxury. In fact, the bar has been raised as a higher level of extravagance becomes the norm for lifestyles in general, including one's transportation means. Vehicles not only become more expensive, but also assume highly diversified purpose niches as households demand more than just a couple multi-purpose automobiles.

Multi-tasking is taken to the extreme and everyday travel is completely reformed. Both cars and trucks are not only bigger and more powerful, but are increasingly outfitted with cutting edge technology for navigational, sound, and physical/ergonomic attributes. Traffic avoidance; increased telecommuting and audiovisual needs; and comfort and air filtration needs are the respective reasons for these new developments, which are meant to enhance productivity while on the move. One's commute actually becomes part of his or her workday. Vehicles thereby have become specialized to serve as portable offices and/or conference rooms. Business meetings can be staged en route to work, to offsite meetings during the day, or on the way home. The demand for driver services exponentially increases.

Additionally, taxi, limousine, and commuter shuttle services are revamped and expanded in scale. In order to avoid congested roadways, helicopter taxis offer an alternative to those who can afford it. In addition, limousines and more luxurious and larger taxis are needed for aforementioned meetings and for work teams to travel together. It also becomes the norm for large and small businesses to have shuttles or buses to arrange employee carpools or schedule meetings on the way to annex office buildings or sites.

As mentioned, besides just a status symbol, vehicles are more luxurious because people are spending more time in their cars, and traveling in general. Congestion on roads and in airports has become a major problem because there are more people and freight on the move, especially during peak daytime hours. This is a result of an increase in urban sprawl, as well as an inability to expand freeways and roadways due to lack of space. When needed, roads cut through green-fields with less regard to environmental impacts than to relieving road congestion. Attempts to optimize existing roads are also being made (for example, tolls for peak road usage, permit requirements for certain access roads, closure of city centers to vehicular traffic, and other measures are tried by different communities).

Breakout Box: Media

News report: "Top scientists working with Shell, Exxon, Chevron, and other important California businesses published a report today disputing the benefits of public transportation and carpooling, encouraging the government to limit funding to support such programs. A spokesperson for the research team stated that the economic damage caused by investment in infrastructure changes and bus and train upgrading does more

damage than the emissions that would be released if each person drove instead. The scientists employed similar analysis methods that were utilized 20 years ago to support their theory that global climate change was not occurring, which allowed businesses to significantly cut costs by reducing burdens from environmental regulations. The study concluded that freeway expansion as a better way to deal with congestion.”

Like roads, airports also become extremely congested, which, incidentally, puts even more automobiles on the road as well as trains on the railways. Commercial flights from primary airports like SFO and LAX run at full capacity, with increasing overflow to secondary airports like San Jose and Burbank. These airports also must attempt to meet the greater shipping requirements imposed by the strong business sector. Lack of space limits new airports or expansion of existing ones. Railways therefore become a vital alternative for getting goods to their destination in a timely fashion. Thus trains are designed to be larger and increasingly powerful so that they can run faster and more frequently. Such a heavy dependency on ground transport makes for a vulnerable system in response to closures.

Overall, the national sentiment is that environmental impacts like climate change are happening, but the level of mitigation efforts needed is negotiable due to a global standstill in progress of scientific research since 2007. In fact, based on the unending lack of conclusive evidence, the United Nations minimizes its prioritization of climate change, which the U.S. uses as a cue to invest less money in environmental research and education and avoid involvement in international environmental agreements. Business management, language, and technological/engineering sciences become more predominant programs of study in school.

Breakout Box: A Scientist on the fringe

When had it happened? What was the turning point that had made climate science irrelevant? As Dr. Heinlein cleaned out his lab at UC Santa Cruz in anticipation of the move into the small basement office, he wondered if the state was putting itself in harms way.

When he started his career, it seemed like Californians were ready to take on climate change. The science pointed towards disaster if no action was taken and people genuinely cared! His funding, however, started to dwindle as the projected sea level rises and ice melting failed to materialize in any dramatic fashion.

The new hotshot scientists in the Nanotech department were practically swimming in grant money and new students, and here he was, his physical move a metaphor for the exile of his research. What the people could not understand was that the science was right! The perception was what was wrong! And to think people were still out cruising in their gas guzzlers. Someday, they would see the truth—that he had been right all along, but then it would be too late to do anything.

The media also begins to move its focus away from environmental issues, opting instead to highlight national advances in the technological field. Energy remains a hot topic as oil becomes expensive due to peaking global production of light oil, especially to the United States. Domestic oil sources are opened and emerging fuel markets, for example from Canada, are also turned to as an alternative. These are efforts to meet the increasing demand for oil, despite skyrocketing prices at the gas pump. Renewable fuels are being developed simply in response to scarcity. However, coal is being used as the primary means for electricity, regardless of its environmental impacts. Mining and drilling locations are seized, for example, in natural preserves because meeting the needs of humans is a top societal priority.

Growth and developmental expansion is another societal priority. Coastal epicenters sprawl into the fast growing Central California region where it is less expensive to live. However, many households opt to have 2nd homes despite an increasing scarcity of coastal property. The absolute number of jobs remains greater in this area, in which the San Francisco, Los Angeles, and San Diego metropolitan areas begin to approach each other. The Bay Area extends north past Napa and Sonoma, urbanizing the wine country further and impacting the formerly open space in this area.

Breakout Box: Renee Goes to the Gym

After a stressful day at work as a corporate strategist, Renee feels the need to run off some steam. She yearns to feel a gentle breeze on her face and hear the soft crackle of brush underfoot as she runs through a wooded pass. As soon as she steps outside, she feels shortness of breath that brings her back to reality. It looks like the gym will have to do. She hops in her car and tells her driver Dave make his way over to the gym. On the way, she programs her casserole to transfer from chill to bake so that dinner can be ready when she gets home.

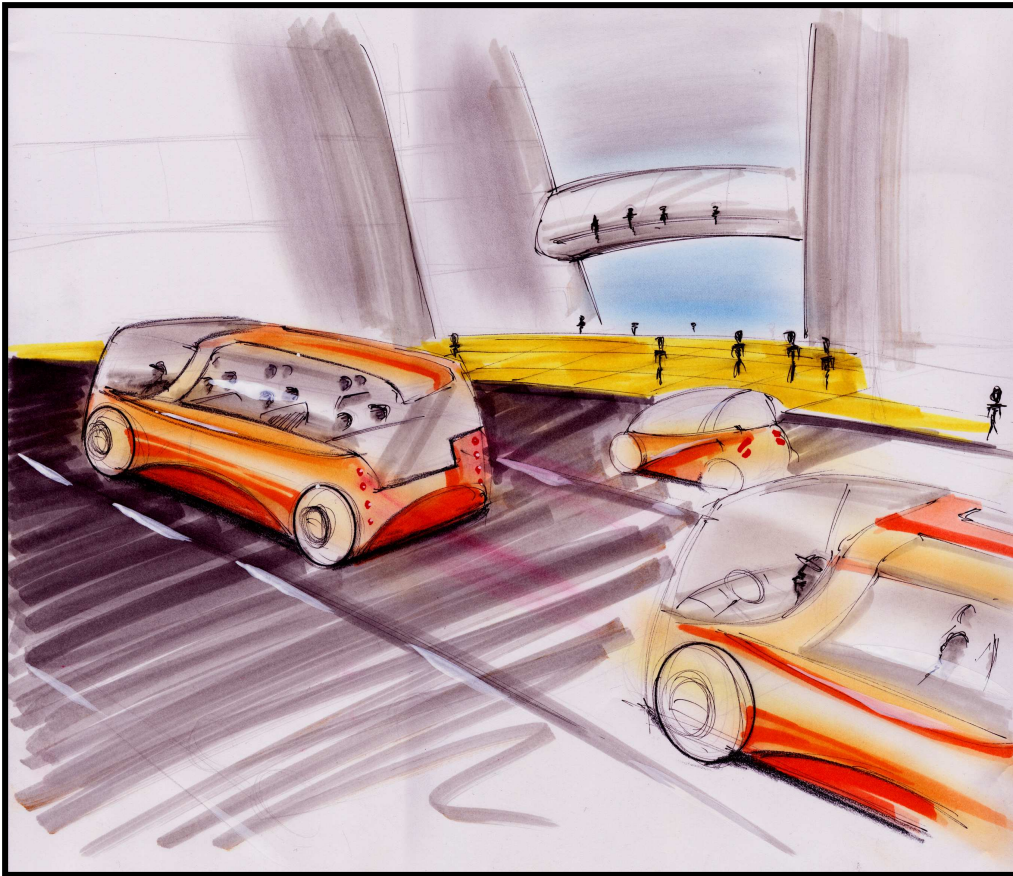
Luckily, there are a few new programs on the treadmill for her to pick from at the gym: Around Lake Tahoe, Yosemite Trails, and Sierra Nevada Hills. She opts for Tahoe as she remembers it so fondly from her youth. In the graphics of the program, they actually made the Lake look almost blue! The pine scented artificial breeze refreshes her and helps her clear her head. The stress is really getting to her, she can barely sleep at night lately and the only time she gets to see her family is for dinner. This upcoming bonus could mean a lot more money though! She has been eyeing a new computer for her car...

Biodiversity is diminishing as more and more habitat is converted into urban sprawl. Humans are rewarded in this “tragedy of the commons,” at the expense of other species, as well as the environment as a whole. “Nature” becomes an attraction as zoos and grandfathered protected land become the only means for future generations to see anything besides the urban landscape. Yosemite is commercialized to the degree that it begins to resemble an amusement park. Ecotourism is diluted to mean spending time in these contrived nature spots while staying at luxurious, fully equipped resorts. Since outdoor air quality is extremely poor, nature scenes are instead simulated inside, where

filtration devices have become more advanced in response to increasing air quality related public health concerns.

A lack of environmental urgency is what brought California to this point. Environmentalists only find diluted action channels for their missions. They invest in zoos and international environmental programs. In fact, there is a noticeable emigration of this segment of society to other countries. If environmental opinions change due to a wildcard event that aligns environmental priority with human welfare, a flip flop could occur.

4.3. “Holding Our Own: A Modest Energy Society”



(Illustration by Marcus Quach)

Snapshot:

- The years of Federal Emergency: cutting ourselves off outside energy dependence
- Abrupt shift to domestic energy sources to accommodate remaining demand
- Housing market crash began—and ended—in California
- On the road to economic superiority again: “Holding our own for the long haul as a modest energy society.”

Breakout Box: A Day in the Life

Joe awakes to the sound of rain. Most days in Camarillo are now either cloudy or rainy, but that does not bother him since he hardly leaves his apartment. Since he started working from home over ten years ago, Joe no longer misses going outside. Joe and his family do many things in his apartment complex: they shop, go to the movies in the first-floor resident theater, and even work out regularly in the apartment gym. Occasionally Joe visits a food court downstairs so he can dine out without having to travel anywhere.

Last week Joe took the bus to his company's main office in Huntington Beach for an "in-person" meeting. These meetings are held monthly, allowing Joe and his coworkers the chance to work with his company's clients directly. Joe's transportation engineering firm is one of the few remaining that still offered personal meetings.

During lunch Joe has to fill out a consent form for his son's upcoming field trip. As part of the 3rd grade curriculum, each student is required to take a "field trip" to at least three foreign countries and to write a report on cultural differences. Naturally, each trip only lasts half an hour each so that the rest of the teaching day is not wasted. But each trip is full of many highlights to help the students learn about the different cultures. This Friday Joe's son will travel to Japan and learn about the past 50 years of urban planning and transportation evolution. Joe opts to pay a little extra to download the extended trip for himself (he studies Japanese transportation systems as a hobby).

A whole generation now knows about gasoline only from stories and textbooks. Looking back, one might wonder what went wrong, while most people today are proud of how things turned out ("Every change that forever alters our history is an opportunity to change for the better," as the late governor Schwarzenegger presciently put it). To put things into perspective, it was seen as a sacrifice either way: fight for the 'old ways' of living and lose everything or risk everything to create a 'new way' of living. Now in 2030, California has slowly redeveloped its economic strength back towards 2010 levels.

The years leading up to 2010 saw some of the most dramatic changes in modern history. At first, the country's trade deficit reached a tipping point. While the economy struggled to deal with increasing debt the job and housing market bubbles burst. National oil and gas reserves were opened up to alleviate an extreme fuel shortage.

During the years of Federal Emergency each state was granted funding to maintain energy consumption levels of 1990 in whatever way they saw fit. California was no exception, and a lot of people left to the Midwest when California chose to build only nuclear reactors to supply its energy. The Midwest, by comparison, chose coal and oil shale as their primary sources of energy. A grandiose lobbying effort by the NRC and the opening of new burial sites in Nevada made the prospect of building nuclear reactors much more feasible. Many other people were outraged and left when the reactors were all

sited in the Central Valley. But when it came right to it, water consumption to support agriculture was one of the highest consumers of electricity in the state and was quickly viewed as an ‘area of improvement’ that would minimize urban impact during the drastic energy cutbacks. In addition to more state-sponsored electricity production, niche markets in local fuel supply began to develop in the 2010s. In the face of soaring gas prices, alternative fuels and engine technologies had to quickly adapt. After a decade of development, the California government began regulating the companies to offer their products under a “modest energy” label to set it apart from other alternatives.

To make matters worse the housing market soon crashed in the wake of rising cost of living due to high energy prices. California was hit hard, as were many other states in the southwest and northeast. Even though the market has since recovered, most people still avoid housing above 1500 square feet (too much space to maintain!). New building development required energy consumption from California’s electricity grid. Exclusive use of the grid went to fund its development. Those who did not wish to connect to the grid had the option of generating their own electricity on site, but importing power from outside California essentially became forbidden. Existing buildings soon became the biggest consumer of electricity from the nuclear grid. Even though nuclear energy is now seen as commonplace, some wonder if alternatives would have fared better. New reactor and fuel reprocessing technology have allowed the volume of nuclear waste to be reduced to just 1% of 2005 levels, but the waste that remains will remain for a long time.

Breakout Box: Transportation and the \$2 Trillion Question

As fuel prices soared above \$30 a gallon in the 2010s, immense pressure was put on government to put a cap on gasoline prices and provide adequate opportunities for public transportation. While reserves from the Gulf of Mexico and Canada allowed gasoline-powered vehicles to exist (such was a tragic death for gas-electric hybrids, but the technology lives on) for five more years, the state government had to create the most comprehensive public transportation network ever seen.

Since mobility was crucial to the survival of California, every effort was made to preserve what access existed and to quickly expand everywhere else. Commute times became prohibitively high and for a while nearly everyone telecommuted to work while people scrambled to find smaller housing closer to work since many could no longer afford to support large residences in the suburbs. Many companies dissolved their physical offices and created virtual businesses to allow their workforce to remain employed from home. For those not working in the e-service sector, these changes were but an unrealizable dream. Many people had to work overtime to initially afford to keep commuting to their jobs. Fortunately for those who survived, after a few years things settled down into the beginning stages of today’s “modest energy” society.

Today, over a decade later, one can see the final stages of last component of The Project (something that immense cannot be called anything else) coming to fruition—statewide “modest energy”-electric hybrid bus service to national parks and recreation sites. This

conclusion provides a marked contrast to the initial project components: chartered diesel bus service in major metropolitan areas.

Ask a retiree what life was like back in 2005 and they will probably say, “not worse than today, just way different.” Such a vague response hardly captures the immense differences California has experienced in the past 25 years. Even though the population experienced a short-lived exodus during the years of the Federal Emergency, today it has hovered around 30,000,000 for nearly five years. Until 2020 many Californians lived in communities far from or intimately close to urban centers. Those who lived far could afford the property and virtually commuted everywhere while those in urban centers benefited from the close proximity of work, school, and shopping. Many businesses fled the suburban areas to urban centers and a few of the outlying communities, beyond the reach of the urban centers. Supported by a new e-service sector, many people moved back to California to seek employment and subsidized urban housing (the California government subsidized the purchase of suburban houses under the condition they were retrofitted with renewable energy production units). This new e-service sector of employment focused on consulting and other basic services that no longer required a traditional physical workspace or office. While some viewed this as an extreme measure to avoid the problem, others saw it as the only alternative employment solution to preserve ‘virtual mobility,’ or the ability to function in society without much physical movement.

Older suburban neighborhoods were later redeveloped to increase the “urban efficiency” of those communities. This resulted in denser, close-knit neighborhoods, harkening back to the days of local shops with walking and biking more as a “modest energy” commute choice than for exercise. California remains the fittest state in the country in large part to the widely-popular bikeways on many former thoroughfares.

Many of the old roads still exist and are maintained, full of general traffic, and all owing to the resiliency of the American spirit. During the years of Federal Emergency the roads became eerily quiet as many cars remained in their garage for long periods of time and were eventually scrapped. Everyone wanting to replace their older cars applied for the federally-mandated rebate to be applied to the purchase of a new “modest energy” vehicle. Now highways are again filling with cars and one can only hear the ‘whoosh’ of air as they hum (noisy, inefficient internal combustion engines are an artifact of the past) along the road. Those who can afford to drive today do mostly to avoid the busy public transportation system or for leisure; much of California’s workforce has remained electronically mobile for its second consecutive decade. Service sector workers and those wanting ‘to get out of the house’ to work have since come to rely on The Project and “modest energy” cars for reliable transportation in every city.

Businesses and transportation infrastructure have managed to adapt rather resiliently over the past couple of decades. Many thought that industry would flee California abroad, but political instability and the “uniformity of energy plight,” as some analysts put it, made

relocation unfeasible. Many businesses recognized the importance of keeping their workforce intact where possible and accommodated where they could. Large companies began encouraging workers to carpool to reduce costs. Soon after, workers saw some of their pay cuts going towards funding company transportation systems. A company would reduce payroll by \$1,000,000 and spend half of it to provide these corporate buses to commuters to work. In turn, it would save the workers at least \$2,000,000 in transportation costs. Many similar reduction solutions popped up and became the norm for business commute for many years. During the years of the Federal Emergency and a few years afterwards, these transportation alternatives remained heavily subsidized in order to maintain a proper workforce. Home offices expanded exponentially as a means of counteracting the upended market, creating an e-service sector. As people began to work more from home, many startup companies grew into modest businesses in the niche markets we come to take for granted today.

Today's transportation infrastructure is not that different than that of 25 years ago. Many of the roads remain unchanged in location and capacity and are still maintained to accommodate the rise in interstate road leisure travel. Most people that can afford to own cars typically drive on the rare occasion for leisure. Today many of the roads are filled primarily with hyper-efficient trucks and other shipping fleet vehicles. What used to be gas stations now are "modest energy" stations; they are now exclusively dispensing domestically produced fuel. For every possible fuel—biodiesel, ethanol, natural gas, and electricity—exists a niche market and its customers, many served by these "modest energy" stations. To survive in the new "modest energy" car market many car companies developed novel engineering and economic solutions to cater to the energy conscious. Companies that thrived focused on safety, reliability, and above all, efficiency and minimal maintenance and usage costs. This new development required collaborative efforts with the electronic components industry. In a bold move, California legislation required all cars sold in California to use electrical components that were either made or developed in California.

Cars produced with California-made components would be the only vehicles that would qualify for the "modest energy" seal that essentially no car could exist without. The rise in electrical components in the auto industry gave Silicon Valley a much-needed second wind to become the poster-child industry to recover from the years of Federal Emergency. In response to widespread telecommuting, car companies began working with computer firms to not just restore, but enhance the usability of personal vehicles (e-life cars, as they're commonly called). These e-life cars became were "modest energy" mobile work stations, allowing telecommuters to work from—or near—their car, giving them the freedom to leave home and maintain a productive work schedule. This new hybrid industry (car and computer companies working together) has since helped jumpstart the reemergence of globalization and international trade.

Breakout Box: Business Wins Big in Government

With virtually all companies facing tightening budgets and employee layoffs, big business has gotten together with government regulators to try to come up with a solution. Many businesses complain that they are shackled, forced to pay high prices for regulations that no longer make sense in today's economy.

With these pressures in mind, large and small businesses alike have banded together to demand relief from the government, arguing that our economy will never recover when its corporate backbone is broken by excessive taxes. In their first big win, corporate lobbyists have succeeded in reversing the hated carbon tax. Although regulators have left open the possibility of re-instating it should the effects of climate change eventually materialize, businesses see this as the first step on the road to a better economy. With stocks spiking after the announcement, it seems that they are on the right track.

For many years concern existed over the limitations of California's seaports and airports for passenger travel and freight shipping. In light of the years of Federal Emergency, one could easily say that issue was promptly put to rest, at least for a long enough time so that planners could take their time to prepare solutions. While the economy recovered, managers from various industries began working with city planners to begin a statewide program, "Seeing California 2020 and Beyond," they called it. The plan utilized the vacancies in the airports and seaports to completely rebuild and reconfigure the ports to make them much more efficient and have a higher capacity (many believed that it was only a matter of time for demand to resurge). These "modest energy" airports and seaports were now capable of sustaining international trade and travel without requiring physical expansion.

Looking back, it was the best thing that could have happened to the ports in Los Angeles and Long Beach and airports in Los Angeles and San Francisco—such changes could have never occurred while they were operating beyond full capacity. Today many cargo ships arrive from all over the world and their goods quickly unloaded. While waiting, on-site electricity generated from the ocean powers the boats and avoids placing demand on the nuclear grid. This on-site power generation reduced the risk of brown-outs in the region and reduced the energy losses from transmission lines. The airline industry has taken less time to recover but has changed less overall, mostly due to international demand for air travel. Most planes still run on jet fuel. Current technology allows sub-orbital travel and high fuel efficiency, and due to the crash in petroleum-derived fuel demand of late, the airline industry remains fixed in its ways for jet propulsion. Some consider these planes, or the entire industry as a whole, the last remaining relics of early 21st century transportation. Ground freight experienced a unique change during the past couple decades as existing railroads and highways became clear of passenger travel. Railroads operating on electricity and coal required little extra capital expense and some businesses were able to apply alternative fuel technology to their shipping fleets with a

swiftness rivaled only by the development and expansion of the internet. Decreased shipping times and costs were coupled with increased demand in many commodity sectors nationwide. California's successful "at home e-business" during the 2020's led to sustained growth in the logistical and shipping industry, further reinforcing the recovering economy. Some say that domestic freight and telecommuting saved the Californian economy. To date, nobody has provided a counterpoint.

Breakout Box: Politics in a "Modest Energy" Society

"And in tonight's news, a much heated political debate over potential funding to refurbish roads into the old neighborhoods of Sherman Oaks for those wanting to relocate out of the community housing blocks.

Over the past decades the roads leading into these semi-abandoned communities have not received any funding for upgrades or road condition improvements. Originally, this was to provide further disincentive to remain in these sprawled out communities. Now, as people can begin to afford to live in their own houses again, the question arises: 'Should we pave the way for these people to move out?'

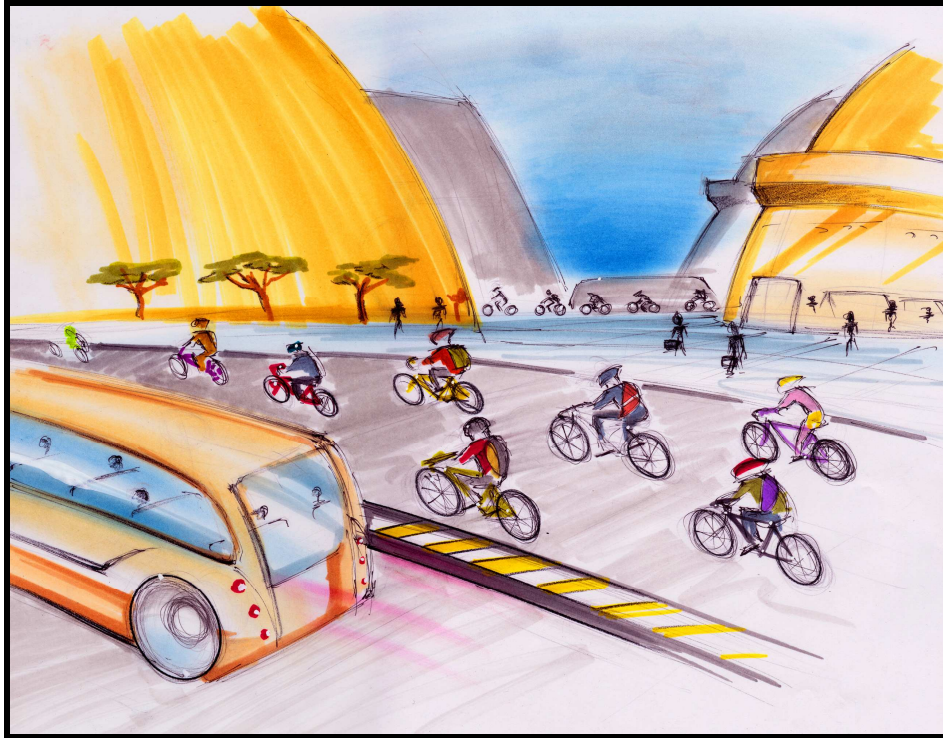
Local residents of these communities are showing outrage over the lack of oversight into road maintenance. However, all public roads used by The Project remain in top condition.

Many Project supporters have recently demonstrated outside City Hall to protest any changes to the Infrastructure Support System. They claim that re-expansion into the old neighborhoods will be an enormous drain on the energy supply.

This November will undoubtedly set the stage for many potential battles in the future. Should this measure pass, roads leading into the Sherman Oaks area will be upgraded to the same standards as Project roads. However, this will also open the door to other, much older communities to fight to relocate, ultimately threatening the Community Housing Project.

This Friday will be the first televised debate between proponents and opponents of this measure. Stay tuned in for full coverage."

4.4. “Grown from Grassroots”



(Illustration by Marcus Quach)

Snapshot:

- Main impetus for change local, grassroots activism
- Cooperation between government and businesses to create “green” market incentives
- Media plays exposes negative corporate practices
- Mobility and goods transport limited and localized; costs of transportation soar

Breakout Box: A Day in the Life

Joe got up for work early on Monday morning. Along with several of his neighbors, Joe walks through his backyard to a dirt path that connects his neighborhood with the business and commercial district where most local residents work. The path was created through a governmentally-organized Community Pathway Program, funded by donations from area stores and maintained through community and employee volunteers. Along the path, Joe grabs an apple from one of the many fruit trees planted as part of a holistic plan to make the path both efficient and pleasant for commuting.

Joe's civil engineering job is located in a small mixed use area, with restaurants and shops so he can run errands during breaks or on the way home. His building is LEED Platinum certified, and the entire complex is LEED MU certified (mixed use). A quick glance at the small parking lot reveals a handful of small alternative fuel cars, a large bike rack taking up over 1/3 of the lot, and a corporate carpool bus, small and a little run down but decorated by the neighborhood kids and fueled by wastes from local businesses and restaurants. As Joe walks up to his office building, the 8:34 bus pulls up, letting out people who live far from work but can't afford to drive daily.

On his way home from work, Joe stops at the local grocery store. Many items in the grocery store have extremely limited packaging, saving money for the manufacturer and decreasing personal and industrial waste. Joe skips the small produce section, as he, like most of his neighbors, has a personal garden and participates in the community organic garden, which together supply all of his fruit and vegetables, decreasing the need for industrialized agricultural land in CA.

Joe walks home along the dirt path, satisfied that his choices today helped him remain almost carbon neutral, an accomplishment he can log and report to the local news station in his attempt to be named Carbon Neutral Person of the Week.

Starting in the early 21st century, many California government-sponsored command and control regulations are enacted in an attempt to curb greenhouse gases and mitigate pollution from companies, particularly the transportation industry. As time progresses, more and more businesses are unable to meet or strongly oppose the stringent regulations, and begin migrating out of California. As tax revenue declines and unemployment increased, the government relaxes regulations in order to spur the economy. The state begins experiencing severe environmental degradation with no funding or responsible parties to pay for clean up.

In 2020, a privately funded research group, sponsored by wealthy Hollywood residents tired of the constant blanket of smog covering a large part of the Los Angeles area, publishes a report highlighting the extent of damage to the environment and the loss of economic benefits from degraded natural resources. The report emphasizes the health of the public at risk, including increased instances of asthma, cancer clusters from toxic

releases and polluted drinking water, extreme water scarcity, increased desertification, loss of agricultural lands, and increased signs of climate change affecting land value on the coast. Armed with this new information, the general public and scientific community finally reaches a consensus on the importance of the environment for the health and economic well-being of California residents. Spurred by regular media images of children bringing oxygen and masks to school on high ozone days, and frustrated by sitting in traffic for hours on end in vehicles with fuel efficiency standards set in 2000, Californians take up the challenge to alter how the environment is managed by the government and businesses.

By 2030, California citizens of all demographics, age groups, and income levels employ collective action, protesting, demonstrations, boycotting, and utilizing the media to influence government officials and businesses to change their practices. One of the major perceived threats is the out of control transportation in the state, which is by far the leading cause of air pollution and related health problems. By initially choosing not to pay for gasoline through a month-long “Car Ban” and through several highly public protests shutting down traffic on major highways 405 and 101 more people are drawn to the cause. Public officials begin campaigning based on their environmental record, as more environmentally- conscientious politicians are elected to office. This begins with local public officials, as residents elect mayors and city councilors that have the motivation and public support to enact change on a local level. This allows many far reaching public policies to begin at the local level, such as new development and zoning laws.

Breakout Box: Green Village Neighborhood Association

Meeting Agenda

January 1, 2030

- *California State Neighborhood Transportation Excellence Award*
- *Community Recycling Program (CSR)*
- *Compost Share*
- *Common Energy Grid*
- *New program ideas???*

This week the Green Village Neighborhood Association will continue to discuss its programs which have been implemented to work together and reduce our driving, and therefore our collective ecological footprint. This year our goal is to win the 2030 California State Neighborhood Transportation Excellence Award, after having been runner up for the last two years. Our projects like Walk for the Planet, Neighborhood Car Share, Compost-to-Fuel Share, and Common Energy Grid have helped us reduce our collective waste and driving needs, two of the main Award criteria.

New ideas for how we can work together to cost effectively implement environmentally

prudent community programs are always welcome! Innovation is the most important category of both the Award application and our Mission as a Neighborhood Association. With representatives from almost every household, we hope to generate ideas that can serve everyone in our community, and lead to statewide progress on the environmental front.

As a response to citizen demand, but with limited funding for environmental initiatives, the government develops and implements on the polluter pays and precautionary principles. Subsidies for potentially harmful or easily abused and misused goods such as gasoline, industrial agricultural, and water for irrigation decline precipitously, forcing consumers to prioritize purchasing. It becomes clear that highly stringent regulations are needed to manage pollution from businesses. Since the government cannot afford to clean up pollution retroactively or force regulations that will drive more companies and valuable tax dollars out of the state, but the public is demanding a cleaner environment and sweeping political action, the government turns to firms for solutions.

Fortunately, many small, locally-based businesses identify the competitive advantage from becoming environmentally conscious, and choose to work with the government to create the proper market incentives for businesses willing to cooperate, as well as sufficient taxes and other repercussions for firms that are unwilling to change their practices. The first of these cooperative regulations is the *Green Business Initiative*, which provides incentives for firms to operate with a comprehensive and sustainable “cradle to grave” mindset. Industry-wide standards for green practices are developed and implemented, through cooperation with government officials, NGOs, and individuals. Firms utilize these practices to cut operational, supply, and waste disposal costs, maintain positive relations with the government, and gain consumer support. The smaller, independent companies are able to take advantage of these changes more, forcing some of the larger, less flexible, higher polluting industries out of California and opening up markets to support local businesses.

Breakout Box: Retrofit Technology

Banking on a recent surge in do-it-yourself enthusiasm, coupled with a growing dominance of energy efficiency, new small-scale businesses are popping up all over that are offering a wide range of self-installed, retrofit technologies. The initial area of success in the 2010s centered on converting old petroleum-burning cars and trucks to renewable alternative fuels, which individuals could also manufacture and/or capture themselves with other, newly marketed systems. This market has rapidly grown to include other aspects of transportation, as well as many more aspects of the home and office.

Initially, market analysts and environmentalists were concerned about the effect of consumer’s dwindling disposable income on their ability to make substantive efficiency improvements. However, small companies have been able to harness consumer demand for new innovation, without requiring consumers to buy all new cars or appliances. This

is truly a modern business environment and just what our ailing economy needs.

One of the first major components of the Green Business Initiative is to decrease overall commercial freight transportation. Since consumers and regulations dictate a life cycle approach to production, where raw material extraction, production impacts of all inputs, and emissions from the long-distance travel are incorporated into the life cycle of a good, many goods can no longer be purchased overseas. Combined with increased prices for jet and truck fuel, freight transportation costs are skyrocketing. Firms instead focus on local markets, increased efficiency with supplies, internal production recycling and re-use, and the near elimination of virgin material extraction or use in order to cut costs and improve environmental performance. While there are some upfront costs, firms quickly see financial benefits of altering certain practices without having to completely overhaul production and manufacturing equipment.

In order to support and expand the market for green products, particularly alternative fuels and vehicles, California adopts a statewide Environmentally Preferred Purchasing Plan. All government spending must be proven to support sustainable and environmentally friendly products, from toilet paper in the state capital to alternative fuel fleet vehicles and buses, along with supporting infrastructure such as refill stations. This policy helps to establish the green market as economically feasible for the general public, instead of the organic market accessible only to the wealthier segments of the population.

Mobility has become highly limited and localized due to various factors. The main driver is personal choice. Lower income and higher awareness and concern for the environment decrease individual willingness to pay for fossil-fuels and high-polluting forms of transportation. Biking and walking become highly popular for rich and poor alike, through high profile events like Bike-to-Work Day, held weekly, and Carbon-Free Day, held monthly. Business donations, limited government funding, and volunteer efforts have expanded bike paths, which is a particularly attractive alternative for governments, as opposed to extremely expensive expansions of roads to accommodate the increasing population.

Fossil fuel prices have skyrocketed as government subsidizes for gas and oil are phased out, reserves are on the decline, and banks and investors make the conscious and environmentally-driven choice not to support increased drilling and mining activities. Consequently, the market for alternative fuels has expanded and prices for environmentally friendly fuels have decreased to become affordable for the middle and upper income residents. However, limited investment in developing new, high-tech alternative fuels has prevented much-anticipated products, such as hydrogen-powered cells and an expensive and infrastructure dependent light-rail, instead encouraging inexpensive, locally produced options with technology already significantly more developed. As the expansion of food from local, organic, or individual farms and gardens has decreased the need for industrial agriculture, traditional large-scale cropland is easily

converted to producing fuels based off agricultural or animal wastes, at a lower cost. This allows large farms to remain profitable, while continuing to encourage local produce production whenever possible.

Typical middle income households limit themselves to one vehicle per house, and the economic incentives for purchasing an alternative fuel vehicle switch the majority of personal and fleet vehicles from fossil to alternative fuel. High income households can generally still afford a car for every driving adult, but purchase higher-end alternative fuel vehicles produced by more progressive European countries. Low income households experience the most difficulty from the high gas and fossil fuel car prices, with many unable to afford a vehicle or the gas to drive more than once or twice a week. Fortunately, public transportation has become so popularized, with media attention and support from high-profile celebrities riding the bus, that accessibility is not significantly affected.

The overall need to travel long distances within CA is greatly reduced. Individuals view driving a car as a luxury for special occasions, long distances, or when public transportation or biking are not an option. Local governments recognize the need to decrease travel by car, so planning departments and agencies have favored dense, mixed use re-development of urban areas whenever possible. Since new development is slow due to the low economic growth, people are encouraged to live close to work, through government tax breaks and special benefits from employers. Businesses have altered the hours of the work day to allow alternatives to the typical commute, as well as sponsoring low-cost programs such as company shuttles and organized carpools. These investments have helped increase productivity, cut down on commute times, decreased the need to build parking lots, and create good will amongst employees. However, overall commute time has increased, as taking public transportation, walking, and biking are generally slower methods of travel.

Public transportation suffers slightly from the low economic growth, despite a sharp increase in ridership. In order to maintain accessibility for all users, the fees are kept artificially low, preventing California from receiving much revenue off riders. Limited investment in increasing or expanding infrastructure means that many communities are not able to offer new routes, build commuter trains, or invest in developing new high-tech and expensive public transport methods, such as a light rail. However, investment in alternative fuel buses increases the overall bus fleet size, as many fossil-fuel buses remain in use as well to keep up with demand for public transportation as much as possible. Prioritizing spending for the most congested areas allows express lines for commuters in areas that are highly commercial and unable to control or mitigate sprawl sufficiently, such as the Bay Area. Although buses and trains become more crowded, slower and less maintained, willingness to accept the inconveniences increases amongst riders.

Information dissemination is coordinated in a way that allows citizens to comprehensively look at the environmental performance of a company, in order to make

informed purchasing decisions. This is modeled after the Toxic Release Inventory and other sustainability indexes, and provides clear, synthesized information about all the environmental impacts, management systems, regulatory compliance, and personal reviews of the company by independent auditors. Media outlets report regularly on environmental performance of companies, both spotlighting the best companies and publicly criticizing the worst polluters. In order to discourage commuting by cars, major media outlets report every morning on the amount of cars on the road and how much CO2 they are emitting, as well as the number of public transportation users daily and how much greenhouse gas emissions they are preventing.

Breakout Box: Media

News Story: “We turn now to our EcoReport, our daily update on the environmental performance of businesses that affect you. McDonald’s agreed today to take on the restaurant industry’s Green Restaurant and Foodservice Challenge. The company will now buy only organic vegetables and bread, has adopted LEED Gold standards for all new buildings, and has begun developing beef, pork, and chicken production standards for its suppliers. McDonald’s efforts have earned a 7.5 out of 10 rating in the Green Challenge Scale. Remember, the Eco-Concerned Consumer Group encourages California residents to avoid eating at restaurants that score below a 6 on the Green Challenge Scale. Over half of all restaurants in California today participate in the Green Challenge.”

Overall, tangible economic and environmental benefits can be seen within this scenario. The environment as a whole improves from the shifts in priority. Transportation becomes the smallest contributor to greenhouse gas emissions in California, due to the limited number of personal vehicles and decreased car trips overall. The Polluter Pays principle provides real incentive for businesses to address environmental degradation holistically and throughout a product’s life cycle. Government regulations, building off and enhancing policy models like the carbon tax or emissions trading schemes, force reductions by willing companies, while also generating funds from polluters used to mitigate past environmental damages. Without significant investment in the transportation infrastructure, but with significant rethinking and retrofitting of production and manufacturing processes, changes in behavior and resource use significantly reduces environmental impacts overall.

5. WILDCARDS

Wildcards are plausible, high impact events that highlight the differences between scenarios. They have the potential to cause discontinuous changes to scenarios and may affect the driving forces. Wild cards can reinforce the importance of continually “thinking out of the box.”

We selected an earthquake and a disease outbreak because they both have clear transportation implications. They not only place strains on infrastructure, but they have implications on demand, security, and mobility.

5.1. *Earthquake*

5.1.1. “Green is Golden”

8.0 Earthquake hits Southern California

When “The Big One” hits Southern California on the morning of February 16th, 2030, Joe and his family are on their way work and school like most other Californians. Joe had left home in his car at the start of the 8AM commute shift. He and his carpool are almost at work when the entire street starts to shake as if someone was trying to tear it off the ground. He slams on the breaks and rear ends the car in front of him. Coffee sprays everywhere. Collisions happen all around him because traffic is densely packed on the expressway. Normally, cars’ sensors allow them to travel in dense arrangements without crashes, but something was wrong—a sudden blackout is affecting the automated system.

Joe immediately phones his son, Stephen, who was on his way to school. He can’t get through immediately; the network is either down or busy. He can’t reach his wife, Joan, either. Momentarily, he panics—there is no way this traffic mess will be cleared anytime soon. Then he thinks that they are most likely safe, wherever they are, due to the massive retrofitting efforts undertaken by the government in the last few years.

The earthquake, which had a magnitude of 8.0, had its epicenter on the Oak Ridge fault system between Santa Barbara and Los Angeles, sending aftershocks and small tremors up and down the coast. The Northridge fault also slipped. Traffic screeched to a halt and light rail passengers in Los Angeles were given a scare when they were stranded for a few hours mid-route. Significant damage occurred in the oldest parts of California’s freeway system near the coast. The newest developments in the Central Valley were virtually unscathed.

Once the violent shaking stopped, Californians were thankful that such great effort was put into preparing California’s transportation system. The physical impact of the quake

on transportation was relatively minimal because funding had been allocated for the seismic reconstruction of existing highways and the installation of brand new public transportation systems. This preparation had been spurred by a society that was very conscious of its impact on the environment and the potential impacts of the environment on society. The governor had called it a “culture of readiness.” Because air travel was not as essential to California’s transportation system as it was in the past, the damage to airports had a marginal effect on the state’s economic function.

The automated systems used to regulate transportation, however, had a major shutdown immediately after the earthquake. Electricity blackouts halted the system for hours before the governor declared a state of emergency and let traffic run unregulated. People traveled outside of their usual assigned times and did not have to scan their carbon footprint cards and gridlock ensued. It was clear that such a highly technology-dependent and consumptive society could come to a crashing halt quickly and easily.

The system remained inoperative for 3 chaotic days. The heroes of this disaster were not firemen pulling victims from the wreckage, but clever technicians who managed to help repair the automated tracking system. Through makeshift adjustments to local hubs, order was slowly restored region by region. Political leaders vowed to correct the technical problems by decreasing reliance on the central electricity grid and on such a centralized computer system.

Once the system was up and running again, it was very valuable to the recovery efforts. This system, normally used for tracking individuals’ carbon footprint, served a dual purpose during the disaster—emergency response agencies were able to track missing persons quickly and coordinate rescue efforts efficiently. Before the earthquake, government officials had claimed that the tracking system was used only for transportation and was anonymous. Now it was evident that they were capable of using this system to track citizens for security reasons.

The new suburban development pattern also helped stem some major problems. Because so many workers used telecommuting, these communities were relatively complete and people could purchase supplies and food without making long trips in their cars. In the political aftermath of the quake, huge funding grants were awarded to university programs that attempted to predict earthquakes. This way, in addition to preparing for the physical impacts, California could effectively manage its economic needs through a disaster.

5.1.2. “Convenience Trumps”

<i>8.0 Earthquake hits Southern California</i>
<i>The day is February 16th, 2030. It is 7:57am and Joe is running very late for work. He kissed his sleeping wife Joan goodbye over an hour ago before having his driver Dave</i>

drop off his 8 year old son Stephen at school, and his toddler daughter at daycare. Joe works in south LA and lives in Camarillo. Due to the construction of extra lanes, the 101 is backed up all the way to Thousand Oaks and he's been standing still in traffic for the past half an hour. He is trying to get some work done, but he keeps losing his internet connection. As a civil engineer, Joe actually has a big presentation today on a transportation project he's been working on for some time. To alleviate traffic, his team is proposing a widening of the 405 freeway similar to that that has been done for the 101. Oh how Joe wishes he was whizzing down one of those extra lanes right now. He tries to call in to the office, but all circuits are busy. As he stares out the window at the sea of cars, he regrets snapping at Stephen for taking so long to get ready this morning. In his rush, he himself had forgotten his wallet.

Thankfully, the car starts to move. The uncharacteristic momentum is not forward however, but more wave-like. Dave throws his hands up because he is not doing anything. Outside, the sea of cars is literally rocking back forth and a construction crane teeters back and forth as if in the wind. The dread sinks in: earthquake! He closes his eyes and his thoughts go to Stephen, Amelia and Joan. Joe remembers the Northridge quake from his childhood and his anxiety mounts. He was about Stephen's age at that time and his home was badly damaged. When the earthquake finally subsides, the scared cries begin to register. He sees a businessman trying to help a young lady who had fled from her car and gotten stuck in a roadside ditch. He sees the uneven pavement of the 101 suddenly disappear ahead in the distance. If he had been a few miles ahead, he would have been on an overpass that appears to not exist anymore, demolished under the collapsed crane. As he slowly emerges from the car, he notices that Dave is slumped over in the driver's seat, fainted. He goes to him and tries to revive him, but it is futile. A group starts to form up ahead by the roadside. He mops his sweat drenched brow and decides to momentarily leave Dave to go see what is going on.

That evening, Joe sits with Stephen in his elementary school. He has not been able to get hold of either Joan or Amelia's daycare. He walked all the way back to Camarillo, but he injured his foot and was weakened by dehydration because without any money on him, he couldn't buy any water. All grocery and convenience stores were flooded with hysterical people within minutes of the quake anyway. A grocery store in Thousand Oaks collapsed during an aftershock and is rumored to have crushed over 200 people.

Even with earthquake insurance, this disaster was sure to devastate Joe and his family financially. He hasn't been able to reach his office, for all he knows it could be demolished or on fire. More importantly, he didn't even know if his wife and daughter were still alive. His worries this morning about an extra lane on the 101 seem so futile now. He wishes he had called in sick today. He wishes he had spent more time with his family these past few years when he started putting in 12 hour days at the office. He holds Stephen close and does something he hasn't done in a very long time. He begins to pray.

What is left of the 101 freeway is full of gridlocked abandoned vehicles. A train derailed in LA, killing all passengers. Offshore aftershocks supposedly caused tsunami-like waves in Malibu. Most sinister, however, is the red tinged sky indicating fires in the distance. The Shell oil refinery in Bakersfield and a subsidiary in Oxnard were both unprepared for an earthquake of this magnitude. Hours after the 8a.m., 8.0 earthquake, the refineries and the surrounding area continues to burn depositing toxic smoke into the air. Parts of both facilities had ignited due to flying debris from a nearby roadway collision.

The earthquake ended up costing California millions of dollars. Much of the highway infrastructure along the central coast and in Los Angeles was demolished. More people than not were left homeless in this region, crowding makeshift emergency relief centers. With the 101 backed up and un-maneuverable, people were left isolated and unable to leave, much less find their loved ones amongst the tumult.

Unprepared for a natural disaster with so many ripple effects, government officials scrambled to find the means to provide long term reparation. Payments from the Federal Emergency Management Agency were long in coming and many residents were left in substandard temporary housing awaiting the financial means to rebuild their homes. Businesses were also demolished in much of this area, which means these people did not have jobs to go to either. Ultimately, many were forced to sell their land and move out of state.

Planners stepped in for the rebuilding phase of the highways, with notable priority shifts. Even with the bruised economy, they attempted to implement raised light rail in this area, with the intention of extending it throughout the state and replacing most city bus systems as well. The oil refinery scare emitted toxic chemicals into the air and thus increased the urgency of air quality issues. Other environmental concerns ride on its coattails and households, the government, and the media because to shift its convenience-centric views. Therefore, a flip-flop occurs based on economic and environmental changes.

5.1.3. “Holding Our Own: A Modest Energy Society”

8.0 Earthquake hits Southern California

When “The Big One” hits Southern California on the morning of February 16th, 2030, Joe first thinks that the power outage will only be temporary. He has been working at home for some time since it is less energy intensive than commuting to work. The earthquake and aftershocks certainly will prevent anyone from making it to work this morning, but really, who commutes these days?

When the power comes back on Joe flips on the news to find out more information while he tries calling his wife over to watch. “What a mess,” Joe thinks, watching the incoming footage of the carnage erupting out of the old refinery sites. For the next few years Joe might actually have to leave the house on a regular basis to manage the reconstruction process down there. “This time around,” he thinks, “we certainly won’t build so many roads.”

Today many think that the only way California survived the earthquake was its unequalled self-reliance and pervasive virtual mobility. After the earthquake hit, many people expected the worst. The epicenter was not far from the old refinery complexes outside Los Angeles, damaging or destroying most of the outlying infrastructure up to fifteen miles away. Despite all the initial damage, many of southern California's population will continue leading productive lives tomorrow.

A couple decades ago changes came to California which forced it to transform everything from its transportation infrastructure to energy sources. Most notably, communities shrank their boundaries and people reduced their living spaces to lessen the cost of commuting and energy consumption. Virtual mobility ensued as home-based and community-based jobs began to flourish. Energy dependence on domestic sources—coal and nuclear—were complimented by locally produced transportation fuel options such as biofuels, on-site generated electricity, and liquefied natural gas.

In the wake of the massive earthquake a lot of the old business and transportation infrastructure was lost. Fortunately for many, they were unused at the time. As part of the consolidation effort many buildings were abandoned and expensive modes of public transportation went into disuse. As a result, many buildings that were not built up to code and several subway walls fully collapsed. In addition, many roads were badly damaged. And yet despite all the destruction much of the functionality survived with little ill effect. Since so many people were able to work from home (and some from their e-life cars) the damage to old business parks and roadways made little impact. Certainly the disruption was felt for freight transportation and those who still drove around. The airports even had to shut down for a few weeks. But the people were able to survive the worst.

Some of the local fuel and energy suppliers suffered damage from the quake, but much of the sectors as a whole remained intact. During the rebuilding efforts fuel and energy were easily diverted through the surviving infrastructure, helping to lubricate the rebuilding efforts. Many of the old refineries suffered massive damage and would have taken years to rebuild. Luckily the prevalence of domestic energy producers—both in California and in neighboring states—kept the flow of energy and fuel nearly uninterrupted.

Many communities were able to survive the quake simply due to consolidation. Buildings housing denser communities were built stronger and were able to better withstand the earthquake. Sadly, many older homes with crumbling foundations and ground instability were not so lucky.

5.1.4. “Grown from Grassroots”

<i>8.0 Earthquake hits Southern California</i>
<i>Joe is walking to work on Monday morning, 8AM on February 16th, 2030. His typical commute constitutes a 20 minute walk down the dirt path that connected his Ventura</i>

neighborhood with the local business district, where he works as a Civil Engineer. Suddenly, he feels an earthquake, larger than any he had ever felt during his lifetime living in California. Remembering his childhood “duck and cover”, he hits the ground and covers his head. A few seconds later, the earthquake ends and he looks around. The crowds of people that joined him on his daily walk, also on their way to work or school, look shaken, but ok. Fortunately, the path to work was dirt, away from buildings and power lines, through undeveloped fields and gardens. Joe is not hurt, nor are the thousands of other Californians who commute to work in the same manner.

Fearing extensive infrastructure damage, Joe decides to head to work to see if he can help. Once he arrives, the full extent of the earthquake becomes apparent. Joe’s office building has been constructed within the past 15 years, so his building is not significantly damaged, thanks to stringent CA safety regulations regarding new structures withstanding earthquakes. Radio reports can be heard on the street, placing the earthquake as an 8.0, with an epicenter on the Oak Ridge fault system, only miles from Joe’s house.

As California recovers from the earthquake, more information about the various ripple effects become known, and it becomes apparent how much worse things could be. Damages are extensive, particularly to roads and power lines, but earlier efforts at preventing further environmental disasters had the secondary effect of preventing some potentially major damages. Issues such as explosions and fires at manufacturing plants or refineries were avoided, as very few of these remain in CA due to citizen demands. In fact, it has only been a few years since every oil refinery in Southern California had been shut down and replaced with open space, Brownfield redevelopment, and other less environmentally degrading businesses. Water supplies, one of the main concerns, are still intact, one step towards preventing a major breakdown. Levees had been reinforced years earlier, as part of an overall effort to clean and sustain the drinking water supply. Wetlands, estuaries, and other natural buffer zones have returned to much of California, further protecting water supplies and preventing major flooding. Many roads and parking lots had been replaced by permeable surfaces, preventing some of the small tidal waves caused by the earthquake from causing serious flood damage.

Over the few days after the earthquake, residents experience major difficulties traveling around California. Many roads are demolished, including most of the major highways, bridges, and main thoroughfares. Travel between large cities and around the state is crippled, as highways like the 101, 405, 880, and 126 are shut down for repairs. The devastation to roads is a problem, but does not entirely prevent people from getting around. Fortunately, dirt bike paths and walkways proved to withstand the earthquake and were located far enough away from buildings to remain safe. People maintain mobility through bikes and walking, already common modes of transportation.

The problems faced by buses, however, are much more severe. Many people depend on the buses and trains for longer distance travel, particularly in and out of the rural areas.

Alternate routes can be utilized to avoid the destroyed highways, but travel time increases dramatically, up to a five-fold increase getting in and out of the major cities. Corporate shuttles step up and begin running full time, helping employees and their families get to and from work and other important trips. Highways that are unusable to cars and buses become fast bike paths, and large groups of people that used to wait for the bus together begin biking together instead.

Transporting goods around, particularly for manufacturing, becomes a serious challenge. The grocery stores re-open the week following the earthquake for the first time, but do not have the same amount of food on the shelves. Fortunately, the localization of goods, the highly efficient use of resources, well-established recycling programs, and years of low economic growth resulting in a constant fear of shortages, have somewhat prepared businesses for the earthquake. Cooperative agreements are set up between neighboring companies, factories, and stores, so resources and wastes can be shared and utilized to the maximum extent. Food waste from a restaurant is donated to the local alternative energy supplier, powering the neighborhood where the restaurant's customers live. Residents are able to obtain basic necessities and local goods produced nearby, but the supply lines into the state had not been fully repaired, and many imported products are not available yet.

Neighborhood volunteer organizations form, containing individuals who have decided to work together to solve as many problems caused by the earthquake as possible, without demanding assistance from the already cash-strapped government. Although the small percentage of Californians who still choose to purchase energy from the grid are left without power, most residents have long since chosen to participate in the California Energy Commission's Chose Your Power Supply program, so the loss of power lines does not directly affect them. Community gardens and farmers markets, once used as a positive activity and low-cost alternative to industrialized farms, have full-time volunteers and turn out most of the food used in the neighborhoods and towns. A major trade and donation program for bikes, scooters, roller skates, and other non-vehicle forms of transportation emerges, allowing residents who had depended on cars new alternatives.

Although the government has little funding, the earthquake has mobilized residents and businesses to act together, raise funds, volunteer, and pitch in however possible. Government efforts at coordinating rescues, damage control, and major repairs follow the same vein taken to combine resources to address the severe environmental degradation of 10 years earlier. Thus, California does not fall further into economic squalor, and citizens do not lose hope or the belief that collective action can overcome. While resources are stretched to the maximum handling the aftermath of the earthquake, the severity of the situation does not dampen spirits or cause anarchy.

5.2. Disease Outbreak

5.2.1. “Green is Golden”

Disease Outbreak

The TV news blared warnings about the outbreak all morning. The disease had been confirmed simultaneously in patients in San Diego and San Francisco hospitals on the morning of February 16th, 2030. Some of the analysts are blaming climate change for the migration of this virulent strain from the tropics, but the true source is still unclear. The experts are now saying that this contagious strain is capable of killing 5% of infected people within five days of exposure and that it will take two weeks to ramp up vaccine production to meet demand.

Joe decides that his family should stay home from work and school, at least until more facts are confirmed. Joe and his wife Joan both have the capability of working from home, but Stephen will have to miss school. Amelia’s daycare is shut down. Joe and Joan can work from home, but they would most likely spend their time taking care of the kids indoors.

Joe takes stock of the pantry and decides that they have enough to survive for a week in a worst-case scenario. As soon as he can confirm that his neighborhood is not yet infected, he plans to stock up at the local grocery.

The sentiment in the cities was not one of panic, since people already dealt with warnings about the environment on a daily basis. There was already evidence that the people could band together in the face of serious problems. People stayed home if possible, but used their personal vehicles to get supplies from their neighborhood stores. The buses and light rail remained empty. The economy continued to function on some levels, as people already used telecommuting technology widely. Those who had jobs that required in-person labor were either left without employment or unable to work.

The suburban neighborhoods helped curtail the spread of the disease because people could live within their own development without depending on other neighborhoods. California was already prepared for a climate change-related disaster, so households had some stockpiles of food and water. The state government had engaged in long-range planning and had prepared for a potential mass-immigration due to climate disasters in other regions. Their preparation helped with this outbreak, as people fled infected city centers for the suburbs.

The regulation of individuals’ travel patterns could also be used to track the potential spread of the disease. Because data was available on peoples’ commutes and leisure travel, high risk areas could be identified and targeted for quarantine or treatment. Spread

by air travel was a lower risk than it had been in the past because fewer Californians were flying in 2030.

Authorized travel into and out of California ceased for two weeks. The economy took a big hit when shipments to and from Asia had to be halted to prevent further spread of the outbreak. The economy relied heavily on trade outside California and would not be able to sustain itself if a longer quarantine occurred.

The lasting response to the outbreak was the distribution of mobile testing stations at all border crossings, airports, and shipping ports. This equipment remains as another reminder to citizens that they live in an unsafe world. The disaster helped cement the place of telecommuting in to the California economy. Economic analysts claimed that moving toward a remote, service economy would prevent future shutdowns.

5.2.2. “Convenience Trumps”

Disease Outbreak

“8AM, February 16th, 2030. More and more cases of the Mysterious Mexican flu continue to surface in hospitals all over San Diego county. The outbreak surfaced five days ago from a group of Mexican migrant workers in Escondido, and the death toll in California has now reached 137 and continues to grow. Vaccinations are being developed, and continue to be in short supply while they remain in the trial phase. A handful of individuals in San Francisco have reported symptoms of the unknown disease, which means it is spreading throughout the state. Stay indoors and get your air purifiers out. At this point, that is all we can do...”

The news report did little to ease Joe’s nerves. He had stayed home from the office today because his daughter Amelia is sick. Thinking it was just a common cold, he put her to sleep so he could get some work done remotely. As Amelia’s temperature soared, however, her pain grew more acute and she began to develop mucous-filled abscesses on her legs. She had a doctor’s appointment for the following day. However, he was thinking of taking her into the emergency room now. As he packed her up to go, he caught on the radio that hospitals were flooded with hysterical people demanding treatment.

Highway 101 is completely backed up, so Joe tries to take side streets. By this point, three year old Amelia was crying out in pain that she couldn’t breathe. Joe was trying to get hold of his wife Joan, but she is at work at LAX where she is an air traffic controller. As he sits in standstill traffic, he begins to wonder if he should have just stayed at home where they have a state of the art air purification system. He tries to turn back, but cars and people are flooding the streets. Nobody knows what to do and people are growing weary of interacting with others who might be infected.

“BREAKING NEWS: LAX has been shut down and quarantined after reports of a man

collapsing at the gate. He had just flown in from Mexico City and appears to have a very serious case of the flu. This confirms that the disease does in fact originate from Mexico. I repeat, this disease does in fact originate from Mexico. I urge you to stay indoors. Hospitals and airports are shut down and roadways are being closed.”

Joe’s thoughts went to his Joan...

Joe and his son Stephan were ultimately able to receive vaccinations, paying a premium fee. After nearly 3 days of painful flu symptoms, Amelia and Joan, who had also contracted the disease, were also able to obtain treatment, albeit expensive: Amelia at the local hospital, and Joan down in LA using money Joe wired to her. It was a week before she could rejoin her family back in Camarillo because most transportation channels were shut down.

Both Amelia and Joan suffer long term health problems because it took so long for them to receive treatment. They consider themselves lucky to be alive, however.

The state became quarantined off which prompted mass hysteria, in addition to sore international relations with Mexico and discrimination of Mexican Americans. A few isolated incidences of the illness popped up elsewhere; however, these individuals were quarantined off and sent to California for treatment immediately. As a result of this disease outbreak, there was a mass efflux of people and businesses from the state as soon as they could leave. This severely bruised California’s economy, and left a permanent stigma on its credibility in national politics due to poor decisions and lack of preparation.

During the crisis, communication channels, as well as the transportation network, were congested. Cell phone lines were at maximum capacity and in many cases shut down to the public so that emergency officials could get through. This contributed greatly to major reforms in cellular telephone reforms, expanding their load capabilities. At the time of the crisis, the media attempted to report on what they knew, however, it was highly sensationalized. The government had remained tightlipped until nearly two weeks later.

It turns out that the outbreak most likely occurred from California grown produce, which explains the link to the migrant workers who were the first to consume this produce. It is still unknown whether this has to do with the fact that the produce was genetically modified, however, this fact has contributed to a large scale reversion to organically grown food. Many people have decided to begin growing their own food, leading to an increase in green roofing.

Unprepared for the flood of people, hospitals were not able to produce enough vaccination and many people perished, particularly those in the low income sector who lacked the means to get the help they needed. Health care reforms are also in the works. However, many people have begun to look into natural medicinal practices.

Changes in shipping have also stemmed from this outbreak. Stricter regulations for what comes in and out of the state were imposed by the government in order to save face nationally. Smaller, local businesses have increased in popularity, however, due to the remaining paranoia about products of unknown origins. All these changes have led to a flip flop from “Convenience Trumps.” The economic bruises from these shipping reforms and business emigrations, as well as the unintended shift in environmental priority, have contributed greatly to a changed society.

5.2.3. “Holding Our Own: A Modest Energy Society”

Disease Outbreak

Finally, the morning news reports of the outbreak got Joe’s attention. He stared in disbelief as reports of dozens of infections are reported in San Francisco and Los Angeles. The reporters are already jumping to the conclusion that an outbreak coming from Asia would severely cripple the California economy. “We’ve survived worse,” Joe thinks indifferently. So long as he stays home things re going to continue as if the outbreak is on the other side of the world.

Joan, his wife, asks if he wants anything from the store. He thinks about what he wants for dinner and then proceeds to put in a request for grocery delivery to the grocer later that afternoon. For a moment Joe wonders what it would be like if he had to drive to work or even to the store. Then, he might care a little more about the outbreak.

Looking back, it was difficult to decide which was more surprising: the rapid disease outbreak caused by a changing climate or the rapid recovery California experienced that far outpaced the rest of the world. During the transition into the 21st century the debate over climate change went on. And yet over thirty years after the beginning of this debate little progress was made. But more important was the fact that nobody cared any more. Night after night news would be full of gloom-and-doom stories but after a few years the sensationalism drifted elsewhere. More important were the impact and rebuilding efforts surrounding the years of Federal Emergency. This was the real story that defined a generation of people—most notably in California—and led people on a path away from environmental issues. And it was because of this lack of attention that the outbreak caught so many people off guard.

To determine the source of the outbreak would require a little detective work. Nearly two years back, scientists have now confirmed, the disease first mutated into a form more benign to humans and less contagious than its current form. Later that year record monsoons in Asia caused a less-sensational outbreak of the flu. The monsoon season lasted a full two months longer than ever before and caused massive flooding that displaced millions of people. During the ongoing recovery period this flu outbreak spread throughout displaced communities. And while people’s immune systems remained

weakened, the real disease found its way into many people it normally would not have infected. Out of the hundreds of thousands that were infected, a few contracted the strain that again mutated into a more contagious form. After that mutation occurred a couple months passed before the strain mutated into its current form. By then it had spread across much of southern Asia and infected millions.

In a response to this outbreak, many countries closed their borders while a cure was sought. During the first year a few cases popped up in Europe and in the US, but were quickly quarantined. Even though few people died in industrialized nations, the crippling effects of the disease's potential to kill permeated every border in the world. Border riots with Canada and Mexico led to more fatalities than the disease itself.

During the 18 months required to find a cure many countries suffered from the near-complete shutdown of global mobility. Even in the United States many states themselves suffered localized recessions while people refused to leave their homes. But in California life was able to continue. Virtual mobility had allowed many people to remain safe at home and continue working. The clusters of communities allowed the ability to quarantine if necessary and likewise give 'safe haven' status within their closed borders to its residents. While many suffered from massive disruptions in fuel and energy, the state of California was able to continue functioning surprisingly well. The Project was cut back dramatically, but local programs were able to quickly resume operation once granted "safe haven" status. It was in California the first immunizations were successfully tested. Soon after the outbreak diminished many began to adopt the virtual mobility lifestyle that had come to define California. Many others simply moved to California to live in the safer, healthier environment to enjoy the community and virtually mobile lifestyle.

5.2.4. "Grown from Grassroots"

Disease Outbreak

Joe and his family are on the way to the Santa Barbara airport at 7:45 AM on Monday, February 16th, 2030, in a free shuttle service provided by the airline. The family is about to leave for an out of state vacation they have been planning for two years.

On the way to the airport, a news report comes on the radio. A Pandemic flu outbreak has been declared as of 8AM in San Francisco and San Diego, confirming rumors that people around CA have been getting sick for weeks. According to the radio report, the government is placing a mandatory stop on all travel in and out of CA. The shuttle takes Joe and his family home, where they immediately turn on the news for more information.

The media, always willing to expose wrongdoing, runs horror stories about the pandemic, blaming the government for allowing vaccines to run low and for not acting

sooner to prevent an outbreak. Public Health officials are followed around the clock, hounded by accusations and harsh criticisms. Joe is used to the media acting as the mouthpiece of the public, conveying frustration and anger over government and corporate misdeeds. When he sees the news coverage of sick and dying people, he believes that a true pandemic has struck and the entire state is at risk.

News of the disease outbreak spreads rapidly over the next few days, with reports of people falling ill and dying. The prior economic slump has left many families with little disposable income, and expensive doctor bills are not in the carefully planned budgets. Many residents, weary of past exposure to environmental toxins and chemicals that left his wife with asthma and one child with a learning disability, choose to err on the side of caution and avoid public places. San Francisco and San Diego, as well as Los Angeles, San Jose, and other urban cities in CA, shut down entirely as residents attempt to avoid exposure while waiting for vaccines to arrive.

Government intervention kicks in immediately to prevent the spread of the pandemic outside of San Francisco and San Diego. For a few weeks following the initial outbreak report, tourism to major CA cities ceases entirely, caused by government restrictions and fears from visitors cancelling vacations into all CA cities. Even places that have not been touched by the disease experience a slump, particularly large urban areas. This is partly caused by the restriction of train and plane services around the state. National parks and wilderness areas, on the other hand, see an increase in visitors looking to get away from other people.

Daily life has become increasingly challenging and restricted. Most cities in CA, including ones that had not experienced the outbreak, have reacted swiftly to shut down the city and prevent the pandemic from entering. Bus services are suspended temporarily, as are commuter trains, sports and entertainment activities, and any events that would cause groups of people to congregate. Fortunately, most people work a few blocks from home, so they are able to get around without buses with little inconvenience. Neighborhood shops are silent, as people are stretching their possessions longer to avoid being in public. Trucks are unable to re-stock the store with imported items, due to restrictions on freight transport in and out of the state. Fortunately, many of the basic necessities are provided by local manufacturers, which maintain limited production of essentials.

Within a month of the initial outbreak report, the economy continues to deteriorate as supplies dry up, revenues for businesses in all sectors decline, and the public becomes more angry and demanding. Government restrictions and limited supplies of vaccines have not helped alleviate fears, completely eliminate the disease, or keep the economy from suffering, despite the fact that the pandemic did not end up spreading beyond San Francisco and San Diego. Fearing the political backlash experienced as a response to environmental degradation, the government decides to take decisive action, providing free screenings and health care for anyone suspected of contracting the disease. With

support from businesses, including the CA- based pharmaceutical companies that have been blasted by media reports of serious over-charging of vaccines and treatment medications, most residents are tested for the disease and those that require treatment receive it at little to no cost. The government and companies in CA remember the lessons taught by the environmental movement, taking measures to address the problem as well as prevent future outbreaks.

Less than 6 months after the initial breakout, the outbreak is under control and life returns to normal. Residents remember the businesses that helped keep CA afloat during the time of crisis, and are determined to show their support by once again traveling within CA.

6. CONCLUSIONS

6.1. Limitations and Potential Bias

In any exercise using scenario planning, there must initially be a decision made concerning breadth versus depth, specifically in choosing the number of drivers. In the Schwartz method, planners choose two drivers, and this project also uses only two. However, as discussed in the Methodology section, there is a potentially endless list of drivers, and typically several which fit the dual criteria of importance and uncertainty. At this point, it is tempting to choose more than two drivers, in an effort to cover more possible futures. However, even choosing only three drivers doubles the number of final scenarios to eight. First, it is unlikely that all eight scenarios will be different enough to warrant individual analysis. Second, and more importantly, the communicability of eight scenarios is substantially more complicated than that of four scenarios. Since the goal of our project is to facilitate discussion and promote consensus, the difficulty in communicating eight scenarios was deemed more important than the potential to cover more ground. Thus, we recognize that there are additional, important drivers which would add to the discussion of future transportation, but have purposefully chosen to limit our project to only two.

In performing this scenario planning analysis, we recognize that as researchers and planners, we have an inherent bias towards environmental awareness and focus. This bias can be most obviously seen in our selection of ‘environmental priority’ as a main driver of change. However, it also more subtly affects our descriptions of the scenarios, particularly when we discuss the possible effects of positive or negative environmental priority. While we are aware of this bias, we do not believe it is a shortcoming, since it fits our ultimate purpose – to address the future interactions between transportation and sustainability.

6.2. Recommendations

6.2.1. Methods of Scenario Planning – Lessons Learned

In going through the steps of using the scenario planning method, we have learned a great deal about the process of building scenarios. Accordingly, we make a few recommendations to those who wish to duplicate our methodology in the future.

First, we spent a great deal of time discussing and evaluating possible drivers. This time delay could have been avoided by simply picking a few drivers and performing quick, non-extensive ‘test’ scenarios. After briefly discussing the ‘test’ scenarios, it should become readily apparent which drivers make for interesting and informative stories, and which do not.

Second, we spent the majority of our time discussing and brainstorming the four scenarios, from the point of view of our system variables. This process caused us to lose sight of the bigger picture, which is to create compelling narratives that tell memorable and easily communicated stories about the four potential futures. After going through this process, we recommend that future scenario planners first discuss their scenarios and write up what the scenarios will look like in qualitative, narrative form. Subsequently, supporting data can be researched and developed, to add scientific rigor to the existing scenarios.

If quantitative variables are going to be used as the basis for the scenarios, as this project attempted to do, the number of variables should be limited. We used seventy-four variables in an effort to tell a “more complete” story. However, in practice, many of the variables were not helpful in establishing the scenario narratives, and weighed down the process of creating scenarios. In the end, we tended to focus on only ten to fifteen primary variables.

Lastly, we highly recommend that the scenario planning team be as multidisciplinary and diverse as possible. Much of the work of developing scenarios requires out-of-the-box, creative brainstorming about what events are possible in the future. Often, planners lapse in to ‘probabilistic’ thinking where they focus on the probable outcome and do not consider improbable, but possible futures. Diversity in the planning group can help to alleviate some of this type of thinking. Additionally, it may be necessary to appoint a ‘devil’s advocate’ to ensure that planners continue to question themselves and their ideas.

System Dynamics

The use of computer-modeled system dynamics is possible method for enhancing scenario planning projects. We believe that there are some potential benefits, as well as some limitations to this idea. System dynamic modeling can be a parallel method for adding quantification and confidence to the creation of scenarios. Given a set of two drivers, scenario planners could not only develop a future scenario, but also calculate probability that it might occur. This is not to say that the computer model will predict a probable future. However, using a more rigorous, quantitative model would ensure that the variables within each scenario are internally consistent and create a plausible story.

Modeling the complexities of scenarios can also clarify the reasoning behind each scenario to make it also more internally consistent, and thus more convincing to the audience. The modeling can give additional certainty and insight into unexpected deviations. Furthermore, system dynamics modeling will identify which variables are pushing the boundaries of plausibility, as well as which have the most influence on a given scenario. By highlighting dynamic characteristics that have the most influence in shaping the future, the scenario planning team will know which characteristics to emphasize most during their planning processes.

The use of dynamics modeling is limited by the abstract nature of many variables, such as political dynamics or funding, and their lack of simple quantification. In addition, using too broad a scope with too many system variables will make the modeling efforts cumbersome, and it will be difficult to gain insightful results.

Ultimately, system dynamics modeling can be a new step towards the future development of scenario planning. As computing power increases, well-researched system characteristics can be represented by a handful of system variables. By making some simplifying assumptions, a scenario team can generate a working model for the system and gain even more insight into possible futures.

6.2.2. Common Threads

The following elements were determined to be similar across two or more of the scenarios envisioned in this project.

1.) Increasing congestion

The rate of growth of the population over the next twenty five years is more or less determined by the current population, with most variation caused by immigration. This substantial growth leads to dramatically increased congestion on “Green is Golden” and “Convenience Trumps.” While there are technological ideas to minimize the negative impacts of congestion, we predict that they will not be sufficient to counteract the enormous momentum of a car-dependent society. Only “Holding Our Own” and “Grown from Grassroots” will be able to avoid the congestion, as the economic downturn forces behavioral changes within the population.

2.) Increasing use of public transportation

The increase in the use of public transportation will be in part promoted due to the increased congestion described above. Not only does public transportation reduce the total number of vehicles on the roads, it reduces the high price of mobility felt in many of the scenarios and allows for a more productive commute. The environmental benefits of public transportation are also important for “Green is Golden” and “Grown from Grassroots.” However, despite the prominence of public transportation in all four scenarios, it takes very different forms within each scenario. For example, the use of an expensive light rail system is envisioned in “Green is Golden,” while the cheaper bus system is more prominent in “Grown from Grassroots.”

3.) Corporate carpooling

Corporate-sponsored carpooling initiatives are seen as a complement to the public transportation initiatives described above. The scenarios with high environmental priority have corporations looking for efficiency improvements with environmental benefits. The scenarios with high economic growth are looking for increased productivity during the

commute. Finally, scenarios with low economic growth are looking for a way to cut costs.

4.) No clear technology winner

In 2007, there is a great deal of uncertainty over which fuel will power California's transportation system in the coming decades. Although the scenarios offer some insight into this question, we have not identified any clear winner across all four scenarios. In fact, the scenarios often visualize very different technological solutions for transportation and fuel. For example, the high-cost, ultra-clean hydrogen fuel cell cars might be very successful in "Green is Golden." Domestically-produced biofuels made from environmentally-friendly sources were foreseen in "Grown from Grassroots," while "Holding Our Own" relies on domestically-produced, non-environmental alternatives.

5.) Land use planning for transportation

With the exception of "Holding Our Own," we found that land use planning and development decisions would be made with transportation specifically in mind. Rising fuel prices and increasing congestion and commute times make reducing required transportation important. We visualize this through limiting sprawl, mixed-use development, and revitalization of urban centers. In each case, we saw individuals living closer to where they work and shop.

In addition to these specific commonalities, we observed a number of themes that appeared in multiple scenarios, but arose from very different circumstances. These themes were particularly illuminating because they show how different pathways can lead or be directed to similar positive outcomes. The following are the most important themes we have observed:

1.) Energy Efficiency – Scenarios 1, 3, & 4

We found that increasing energy efficiency played a major role in all scenarios, except "Convenience Trumps." Ultimately, both the need for economic efficiency and the need for environmental efficiency grow over the next twenty-five years, contributing to increased energy efficiency. Only "Convenience Trumps," with its high economic growth and low environmental priority, is unaffected. This finding is relatively unexpected, since energy efficiency is currently primarily associated with environmental priority.

2.) Higher environmental impacts result from high economic growth, not low environmental priority

After creating our four scenarios, we realized that "Holding Our Own" had a lower environmental impact than "Green is Golden." In other words, the low economic growth of "Holding Our Own," even when coupled with low environmental priority, was a stronger driver of reduced environmental impact than the high environmental priority of "Green is Golden," due to its high economic growth. Overall, we found that "Holding Our Own" and "Grown from Grassroots" had a lower environmental impact than "Green

is Golden” and “Convenience Trumps,” indicating that the economic driver was more important than the environmental priority driver in this respect.

Although this outcome was not intended, we determined that it was a result of the high environmental impact of economic development and increased consumption. While “Holding Our Own” and “Grown from Grassroots” brought about significant behavioral changes related to consumption, changes in “Green is Golden” focused on so-called “end-of-the-pipe” solutions, while maintaining a high level of consumption. This finding is particularly important because it shows that merely caring about the environment may not be enough to create long-term solutions to environmental problems.

6.2.3. How Others Can Use This Project

The ultimate goal of this project is to facilitate discussion and consensus-building about the future direction of transportation within the state of California, in hopes of promoting sustainability. It is our desire that this project can be used by diverse parties in business, government, and academia to actively plan for their future transportation-related decisions. We will address each group individually – business, government, and academia – to suggest how they might individually use the information in this project and how they could use scenario planning in general.

Business

Traditionally, business has been a primary user of the expertise gained from scenario planning. Ultimately, companies aim to create management strategies that allow them to thrive in a variety of possible futures. Given the current technology race described above, it is clear that businesses will need to remain flexible until a clearer solution is found. More specifically, this project can help business to make decisions about how to invest their money in technology development and research, as well as prepare businesses for changes in consumer preferences and regulatory environments.

Government / Policymakers

Although politicians are typically elected for only a short period of time, they will generally be more successful if they are able to create policies with long term viability. Accordingly, scenario planning is an excellent tool for analyzing the potential for policies to work in a number of different possible futures. Furthermore, it is also a useful tool when making funding and development decisions, in order to fund programs that will be useful across a range of possible futures. For example, public transportation was discussed above as a commonality across all four scenarios. Thus, investing in development of the public transportation infrastructure would be a sound funding decision.

Academia & Education

Scenario planning and the insights of this study can be used to analyze a number of decisions made within academia. Specifically, decisions regarding which areas should receive additional funding and which new areas of study should be introduced could be addressed by looking for commonalities between scenarios.

6.2.4. Signposts & Affecting the Future

In addition to making decisions based on a scenario analysis, planners often want to know which scenario is ‘coming true’ as time passes and the future becomes the present. Since each scenario is designed to be an extreme case, the future is unlikely to look exactly like any specific scenario and will likely contain elements of all four. However, the parties listed above can still have a substantial influence in shaping the future, based on their knowledge of the possibilities. These facts lead to two additional uses for scenario planning.

First, business, policymakers, academia, and households can look at the scenarios and decide which is best for them and for society as a whole. In this project, we have strived to show how each scenario could have a positive outcome. Nonetheless, we still advocate a future with high environmental priority. Making stakeholders aware of the drivers of change and of the possible outcomes of their actions can lead them to make choices with this long-term future in mind. For example, a primary method of creating a state of high environmental priority is to invest in education, both at the university and at the primary level. While the importance of this decision could be derived without scenario planning, the use of scenarios helps to emphasize the importance of such funding.

Second, long-term planners who use scenario planning can develop a series of signposts, which are designed to indicate which scenario is coming true. These might include:

- “Inconvenient Truth” wins Academy Award for best documentary.
- Schwarzenegger submits climate change bill.
- Dow Jones crash on February 27, 2008.
- The U.S. Climate Action Partnership lobbies congress for climate change legislation.
- Hybrid car sales trends.
- “BP selects UC Berkeley to lead \$500 million energy research consortium with partners Lawrence Berkeley National Lab, University of Illinois”

6.3. Conclusion

While descriptive scenarios are helpful in long-range future planning, we have concluded that a greater level of insight can be gained when planners participate in the scenario

planning process. Reading the scenarios can impart vivid accounts of possible futures, but creating the scenarios can give planners a sense of the interaction of the endogenous forces that shape each different future state.

Only time will tell what the future will look like, and it is unlikely to unfold exactly like any of the four scenarios. While the scenarios are not intended to be predictions of the future, they serve as planning tools for considering a broad range of possibilities. By exploring the boundaries of what is possible, organizations can become aware of coming changes to help prepare for the future.

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