Climate Change and the Potential Implications for California's Transportation System

By **Pierre duVair, Douglas Wickizer, and Mary Jean Burer**

Abstract

Increased frequency and intensity of storm activity combined with sea level rise is expected to worsen problems of beach erosion and cliff under-cutting. This is a serious issue for coastal road and rail systems, as well as California's system of levees. Warmer winter temperatures will lead to more precipitation falling as rain rather than snow. Increased runoff during the winter and spring months will increase the risk of flooding and landslides. Events such as the Mill Creek landslide along Highway 50 in January 1997 may become more common. Other potential climate impacts on the transportation sector in California are discussed in this paper, which concludes with a review of existing and potential climate change mitigation strategies for California's transportation sector.

Introduction

California's economy, including foreign and domestic trade, relies heavily upon its transportation infrastructure. The state's important role in the world economy makes its transport systems vital to people inside and outside its borders. "In 2000, shipments by land, sea, and air through California ports totaled $392 billion – an increase of nearly $100 billion since 1996."[1] Throughout the decade of the 1990s, California's transportation sector felt the destructive power that extreme climate events can yield. Its roads, highways, and railroads were closed due to landslides triggered by heavy rains. Low elevation roadways were flooded and washed out in places. A prolonged heat wave made freeways buckle to the forces of climate. California's transportation system will certainly face further challenges due to extreme weather events and other climate-related factors that are sure to yield important economic, environmental and social impacts.

Transportation accounts for nearly 60% of all anthropogenic carbon dioxide emissions from the combustion of fossil fuels in California. Although California's industrial sector consumes more energy, transportation accounts for more carbon dioxide emissions because of its near complete reliance on petroleum. While efforts to improve transportation system efficiency and reduce toxic and other emissions that impair public health have been positive, transportation-generated greenhouse gas emissions continue to grow. The California Regional Assessment report (see footnote #2) provides a vast amount of information on climate variability and the potential impacts to some of California's unique ecological, social, and economic systems.

California's population is projected to grow by 12 million people over the next 20 years, reaching 45 million. Increasing population coupled with growing numbers of vehicles, a continuing decline in average new vehicle fuel economy, and predicted increases in total vehicle miles of travel, pose substantial challenges within the state's transportation sector. Decisions made today regarding land use, technology investment, and transportation policies and practices will determine the extent to which travelers and freight movement impact and are impacted by California's climate in both the near and distant future. Efforts to prepare the transportation sector for both the anticipated and unanticipated effects of climate change will require collaboration among federal, state, regional and local agencies. California communities will need to become more involved and better educated about the possible consequences of maintaining the status quo in regards to emissions of greenhouse gases. Furthermore, climate change will require more investment in research, a commitment to alternative transportation technologies, reduced dependence on petroleum, and more effective land use and energy decision-making.

In this paper we first examine a set of climate-related implications for California's rural, coastal, and urban transportation infrastructure. This first section also notes potential air quality impacts related to climate change. In the second part of the paper we provide a review of some current and potential state greenhouse gas mitigation activities within the transportation sector - looking towards a less greenhouse gas intensive economy in the future.

Climate-Related Implications for Rural and Mountain Roadways

Much of California's landscape is vulnerable to flooding, landslides, or both and, importantly, both become more likely when precipitation levels are high, storms are frequent, and above-normal precipitation continues for several years. In higher elevation watersheds where surface water is stored as snow, flooding can result from unusually warm winter storms, a fast warming of the air, or early springtime melting of the snow. At all elevations landslides and slope failures are partly the result of precipitation and geology and partly the result of land-use practices that allow or encourage building of structures in risky areas. Mountain watersheds frequently generate floods during the spring snowmelt season. The 1997 flooding in the Central Valley was triggered by a warm, mid-winter storm. This storm caused an enormous amount of immediate damage, but it also brought future risks associated with the damage it caused to California's extensive levee system.

Figure 1. *Photo of a roadcut failure. Cut banks on rural roads are often very close to vertical. These banks are more prone to failure as warmer more intense winter storms increase proportion of rain versus snow. Access to rural locations will be lost more frequently and roadway maintenance costs will rise.*

Just as water supply infrastructure, crop choices, and electricity production choices have been developed with expectations regarding seasonal runoff patterns from mountain watersheds, California's transportation infrastructure has been developed based on typical temperature and precipitation regimes. Authors of the California Regional Assessment reviewed projections from two general circulation models – the Canadian and the Hadley models. Results from these models suggest that even modest precipitation changes expected to result from climate change can have proportionally large impacts on water runoff in California. As one might expect, these climate models predict that as average temperatures rise (especially winter and nocturnal) precipitation tends to fall more as rain than as snow. Most of this rainfall turns into runoff immediately. Increased runoff during the winter and spring months will increase the risk of flooding and landslides, both in the mountains and throughout most watersheds. Many rural roadways are especially at risk due to the increased chance of flooding in the winter and spring months.

Accessibility via the rural road system is a key concern to California's rural economy. The California transportation roadway system is at best a complex arrangement of private and local, state and federal government roads and highways. For the wildlands and forested areas in California portions of these intertwined yet independent road systems are extremely important. Increased water flows as a result of winter rainstorms will lead to both a greater number and greater severity of erosion events and consequent damage to roadways. These events in turn lead to additional restrictions in transportation system capacity. However, less snow on roads may also result in increased winter season accessibility. Nonetheless, it is expected that private landowners face more frequent loss of access to part or all of their property with increased climate variability.

Small parcel residential landowners may lose ingress and egress from their residences, with corresponding impacts to any agricultural practices such as livestock or orchards. For larger landowners (e.g., greater than 40 acres), potential impacts depend upon the types of land uses selected by the individual landowner. High intensity storms can easily result in high flows destroying watercourse crossings on rural roadways, thus eliminating access to properties. Flooding from such storms can also impact lower lands with a different set of human impacts. One can also anticipate damage to domestic water supply facilities and equipment relied upon by landowners with resultant impacts varying significantly across landowners. Inability to access properties will preclude all management practices such as tree harvesting, tree planting, vegetation thinning, and watershed maintenance activities.

Implications of Climate Change Related to Forest Road Accessibility[2]

Road access in California's forested lands is important for timber management, recreational activities, fire protection, and tree stand improvement practices. The state as a landowner faces the same potential climate-related problems as that of the private landowner only on a similar or larger scale. For example, the inability to access a state forest will not only impact the harvesting of trees, but also preclude measures to prevent fires and minimize sedimentation of watersheds. In fact, perhaps the most worrisome impacts are related to the increased risk of forest fires due to both warm and cold season implications of climate change. For example, the expected increased length of dry seasons could make fires more frequent in the summer. Subsequently, the effect on transportation of this phenomenon may be the closing of roads due to smoke and fire danger.

Some of the cold season implications of climate change such as increased flooding may also result in an inability to access the state's forests for prolonged periods of time. This has the potential to increase risks of large damaging fires by preventing vegetation management and resulting in increased fuel loads. One of the most significant short-term impacts will be reduced capability to respond to emergency situations.

Figure 2. *Photo of a levee breech in the Sutter Bypass. A warm winter storm in January 1997 caused this breach. A temporary bladder seen at left in the photo was used to protect the repair and prevent additional flooding from rising water levels in the bypass.*

Beyond the private, county and state maintained roads, there are the U.S. Forest Service, Bureau of Land Management, National Parks, Bureau of Indian Affairs and other federal land management agencies that own and maintain thousands of miles of forest and wildland development roads. While not intended to meet the transportation needs of the public at large, these roads are used to facilitate access to the national forests and other federal land ownership. In most areas, they are open to the public and are a key part of the transportation system for many rural counties. New roads are added each year in relation to land acquisition or projects such as timber sales. Roads are also decommissioned where the net financial and environmental costs would be lower if the roads were removed instead of improved. The national forests of the Sierra Nevada are estimated to contain approximately 24,500 miles of forest development roads.

The dominant use of these roads has changed from support of timber harvesting to recreational use by the public. While the U.S. Forest Service does not maintain many of the roads to the quality standards of most public roads, maintenance is required on road surfaces and drainages, bridges, and culverts. In the past decade, the backlog of undone or deferred maintenance has grown. This maintenance represents a multi-million dollar burden on the national forest system. An increase in intensity of storms will only result in additional backlog of maintenance and further reductions in access to these lands. The potential impacts to federal lands are the same as for state and private lands, only with the possibility for losing much larger areas of lands to wildfire or greater impacts on the quality of watersheds within the state.

A range of adaptation strategies related to fire hazards have been suggested and include: implementing pre-fire management (including limiting development in high fire hazard areas), prescribed burning, clearing brush from buildings, mapping fire behavior, increasing fire resistance of roofing, improving emergency access and increasing public education and information.

The California Department of Forestry and Fire Protection (CDF) and the US Forest Service conduct land cover mapping and monitoring to enhance fire protection and natural resource management on public and private lands in California (this program uses Landsat Thematic Mapper satellite imagery to map land cover types and derive land cover changes across all types of ownership). Fire-prevention methods include those suggested above. These measures make a great deal of sense both as a way of dealing with current stresses and as a hedge against future climatic changes.

The California Board of Forestry and CDF supported state Senate Bill 1075 (Rogers, 1987) related to minimum statewide standards for defensible space in State Responsibility Areas (SRA). This legislation was motivated by the limited response of local governments to the wildland fire protection problem over the previous 20 years. This comprehensive wildland

fire safety legislation required the California Board of Forestry to establish minimum fire safety requirements that applied to SRAs. These requirements covered topics such as emergency access and water supplies, address and street signs, and fuel modification related to new construction and development.

Climate-Related Implications for Coastal Roads and Railroads

In low-elevation coastal watersheds, flooding is most common when a wet winter results in frequent storm events. Numerous coastal mountain watersheds in northern California have rivers that flow over their banks once or twice every ten years. The Russian River exceeded flood stage (39 feet) six times between 1900 and 1950 and eight times between 1950 and 1990. In 1995 and 1997, Russian River floods created large economic losses that were amplified by the presence of many housing developments within the 10-year flood plain. Similar flood events occur in southern California coastal watersheds during severe precipitation events.

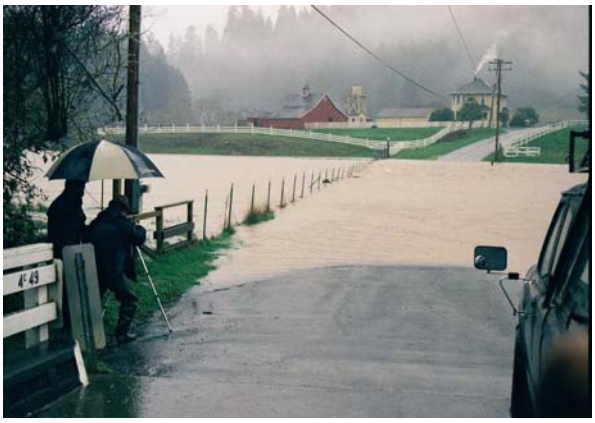

Figure 3. *Photo of inundated flood plain and bridge across Freshwater Creek in Humboldt County in January 2000. Increases in the intensity of storms will lead to more frequent isolations of populations with associated health and safety risks.*

Coastal erosion is another important climate-related impact in California caused by sea level rise and increased storm activity. Cliff under-cutting is a serious issue for coastal road, pipeline, and railroad systems. Stormy, turbulent seas and intense precipitation events can cause extreme erosion over time along the coast. Coastal erosion is already a significant problem in California. Further erosion due to climate change and rising sea levels will worsen already narrow or stressed coastal shorelines. Coastal roads and railroads are likely to be more vulnerable as a result of increased climate variability. Highway 1 already experiences frequent mudslides and high waves during mild winter storms, as well as washouts every year. Certain roadways could be closed permanently if there are significant increases in erosion, landslides or roadway undercutting. Coastal railroads have had similar problems during heavy storms, often resulting in the shutting down of passenger and freight traffic for days.

Adaptation is possible but likely at significant cost to society. Some roads near the coast may have to be moved or protected from additional exposure to the ocean. Regarding land use planning in specific regions, the Coastal Land Use group participating in the California Regional Assessment Workshop in March of 1998 provided a tiered response strategy. This group considered impacts and stresses from climate changes in three categories: the existing built environment, the natural environment, and future coastal development. They suggested establishing priorities in addressing impacts to the built environment:

- Defend with engineered fortifications assets of high strategic value such as airports, ports, and delta levees (for water supply security).
- Relocate (or engineer alternative solutions) vital assets to higher ground.
- For less strategic aspects of the built environment (housing on coastal bluffs), simply retreat and let nature take its course.[3]

This group and others have clearly recognized the need to consider potential risks associated with new coastal developments from future climate change and variability. Local and state land use decision-making in the coastal zone should be informed by careful consideration of climate-related factors such as

rising sea levels, increased frequency and intensity of storm events, rising average temperatures, and greater levels of climate variability.

One additional climate impact to California's roadways is the potential for softening and buckling of some pavements as extreme temperatures rise and the duration of the warm season increases. Finally, one can expect increasing temperatures to lower engine efficiencies on trucks in the summer months, leading to additional air pollution and fuel costs. At a minimum, we believe adaptive actions should involve preparing for higher costs of maintaining existing transportation infrastructure, the building of new - more climate-friendly - infrastructure, and progress towards a less carbon-intensive transportation system. Coordination between federal, state, and local transportation planners must bring a new focus upon ways to improve transportation energy efficiency.

Climate-Related Implications for Air, Sea, Railroad, Truck and Pipeline Transport Throughout California

California has several airports very close to sea level where maintenance of levees or embankment fortifications may become more difficult and costly with future climate changes. Rising sea level and higher winter water flows in the Sacramento River-Delta Region are likely to cause a variety of significant problems including: disruptions to sections of railroads, pipelines, and roadways within the coastal region, effects on the transport of water from north to south, and problems with shipping into and out of the ports of Stockton and Sacramento (e.g., more difficult to maintain channels depths). Climate changes may bring a lowering of water density in the Bay (due to warmer waters and greater volume of fresh water in some seasons), which would lead to ships riding lower in the water, and potentially affect navigation in the shallower channels.

The California Regional Assessment states: "Many coastal airports are vulnerable to flooding. Built on wetlands back when they were called swamps, many of these facilities, such as the San Francisco, Oakland, and Santa Barbara airports, are about 10 feet above current average sea level. Extreme high tides, coupled with flood conditions, can reach close to the existing levels. A recent tidal flux in the San Francisco Bay area closed Highway 101 north of the city due to eight-foot tides, two feet above what had been expected. With an additional meter of sea level, a number of critical facilities would be highly vulnerable. In the future, sea level rise, storm surges, and high tides could conspire to inundate runways. Harbors may suffer wave damage, additional siltation from storm runoff, and other navigation and safety problems. Jetties and seawalls may have to be raised and strengthened to protect harbors, which support commercial shipping, recreation, tourism, and many other economic sectors."[4]

Transportation via car or truck for commercial or industrial purposes may also be increasingly hampered by storms, flooding, the washing out of coastal, rural and mountain roads, landslides, and road damages due to climatic changes. Environmental Defense notes in its report "Hot Prospects" the impacts of inland flooding due to heavy rains during the 1997-1998 El Nino event. Some impacts included the repeated washing out of major highways and smaller roads during much of January and February, completely isolating some rural communities at that time, extensive mudslides and inland flooding, the destruction of 1,000 feet of the levee constructed along the Santa Maria River flooding hundreds of acres of agriculture lands in Ventura County, the undermining of the Union Pacific railroad trestle by the surging flow of the Ventura River, and a damaged rail bridge in San Clemente.[5] Thirty-five California counties were declared federal disaster areas, the event took 17 lives and caused the state $550 million in total losses and damages.[6]

When considering climate change impacts to inland river transportation, California can learn from experiences in the mid-western states. In 1988, the Mississippi River flows began to decline because of drought and reached record

lows during May that ended up continuing throughout the summer. By early July, Mississippi River traffic was reduced by one-fifth. Like the Mississippi River navigation system, many California rivers have control mechanisms which can be operated to maintain water levels and safeguard navigation during much of the year. But in 1988, even carefully timed water releases could not prevent low water levels on the Mississippi River brought about by drought that year. With increased risk of drought in California, such issues are of high concern. At one point in 1988, nearly 4,000 barges were stranded in Memphis, Tennessee. The economic costs of reduced access to inland water transport can mount very quickly, as alternative modes are typically less efficient and more costly.[7]

Potential adaptation actions for transport via rivers might include: 1) additional dredging in shallow areas; 2) limiting the number and weight of barges; 3) releasing more water from upstream sources (recognizing that this can interfere with other water uses such as hydropower generation, ecological resources, agriculture, municipal, industrial, and recreational); and 4) finding alternate navigation routes or modes of transportation.[8]

Climate-Related Implications for Air Quality

Another climate-related transportation impact results from higher temperatures increasing the formation of ground level ozone and particulate matter, making it more difficult to meet the health-based air quality standards for these pollutants. This expected outcome makes transportation planning even more challenging. Ground-level ozone has been shown to aggravate existing respiratory illnesses such as asthma, reduced lung function, and induced inflammation of the respiratory system. Ambient ozone also reduces agricultural crop yields and impairs ecosystem health. Warmer average and extreme temperatures will lead to increased use of air conditioners, resulting in additional air pollution from power plant and vehicle operation. Therefore, we expect that climate change and variability will impact California's transportation sector, air quality, and potentially the health of many of its residents.

Environmental Defense identifies some adaptation strategies in *"Hot Prospects: The Potential Impacts of Global Warming on Los Angeles and the Southland."*[9] The authors suggest: increasing public health education and warnings of risks, improving health-care for low-income groups, planting more trees, establishing parks, and increasing reflective surfaces to cool the urban environment. The report also recommends the maintenance of aggressive air emission controls.

Additional Background on California's Transportation Sector

Transportation-related greenhouse gas emissions are inextricably tied to energy use; a disconcerting point when one examines projections of California's transportation fuel consumption. Motor vehicle fuel consumption and attendant greenhouse gas emissions are projected to grow in California as a result of the increasing number of vehicles and vehicle miles traveled (VMT). VMT is expected to increase twice as fast as the population growth rate. Compounding the problem is the fact that average on-road fuel economy of new vehicles is eroding, primarily due to greater share of the personal vehicle market for light-duty trucks and sport utility vehicles. In addition, hotter days and a longer warm season will increase air conditioner use in cars, reducing their efficiency and miles traveled per gallon. Engines also tend to function less efficiently in hot weather, largely because the density of air entering the engine decreases.

In 2001, California drivers used an estimated 17.1 billion gallons of motor fuel with an estimated cost of over $25 billion, while traveling some 307 billion miles -- a 15 percent increase since 1990. If current growth trends continue, fuel use and related CO2 emissions in the state would increase approximately 40 percent over the next 20 years. This trend has significant economic and environmental implications. Such trends could mean an additional $10 billion in the cost of fueling

California's transportation system alone. Considering that over 50% of petroleum supplies in California are imported and that 98% of transportation is dependent upon petroleum, expenditures on transportation fuel will affect the state's economy and its balance of payments. Efforts to reduce greenhouse gas emissions and make transportation more energy efficient and less petroleum dependent will provide important economic, environmental and security benefits.

Activities to Mitigate Transportation Emissions and Prepare for the Future

The California Air Resources Board (CARB) conducts research on air emissions and is now mandated to adopt standards for greenhouse gas emissions from motor vehicles as described in AB 1493 (Pavley, 2002). The CARB evaluates vehicle system performance and emissions to promote development and use of clean fuel sources and advanced vehicle technologies. The California Energy Commission (CEC) and CARB are evaluating a range of strategies to reduce the state's dependence on petroleum. The CEC sponsors research and analysis of emerging transportation technologies and fuels, including studies of an in-state biomass-to-ethanol industry and ways to improve efficiencies of tires. The California Department of Transportation researches, demonstrates and implements energy efficiency and conservation measures, provides system operations and congestion improvements, and promotes smart transportation, livable communities, and effective fleet management. The Department of General Services (DGS) is working with CARB and CEC on ways to reduce energy consumption of the state's vehicle fleet by 10%. The DGS vehicle purchase policy requires state agencies to purchase Ultra Low Emission (ULEV) or Super Ultra Low Emission certified light duty gasoline vehicles, and requires commercial car rental companies under contract to the state to have alternative-fueled vehicles (AFVs) and ULEVs available to renters.

Building upon current state efforts, the outline below provides a framework for expanded and new initiatives, including incentives, tools and information to advance a clean and energy efficient transportation system that significantly reduces greenhouse gas emissions. It emphasizes actions that require collaboration and coordination to achieve the objectives of such an expanded initiative.

A potential framework might include the following major components:

1. Mainstream Energy Efficiency and Conservation Measures

Currently the statewide and regional transportation planning and project development programs require no energy and conservation element and analysis. The extent of transportation energy related activities at the state, local and regional levels is limited and disjointed with at times offsetting activities. This effort provides a strategic shift to focus on transportation energy and ensure that energy efficiency measures and analysis are systematically integrated into transportation plans, programs, projects, and investment decisions.

2. Vehicle and Fleet Efficiency

This program promotes and establishes a comprehensive plan with specific targets for improving vehicle and fleet efficiency beyond the current project-by-project approach to fleet greening.

3. Policy, Legislative, and Institutional Support

About 68 percent of advanced technology sales in the transportation sector are a result of federal and state mandates for fuel-economy standards, emission programs, technology implementation programs, or energy policy regulations. Similarly, air quality improvements and reductions in tail pipe emissions are in most part produced by air quality conformity rules and related mandates. Therefore, mandates on tail pipe greenhouse gas emissions may require similar rules to drive technology to the optimum level of greenhouse gas emission rate.

4. Improve Data Collection and Analysis

This program will enhance technical knowledge and capabilities of transportation planners and engineers and generate transportation related climate change and greenhouse gas emission statistics for transportation communities and policy makers.

5. Transportation Demand/Supply Management and Land Use Planning

This program would develop a comprehensive demand management and supply management program to optimize operational efficiency of the transportation system.

6. Increase Transit and High-Efficiency Mode Shares

Increasing transit share, use of alternative modes and intermodal connectivity is one of the most effective non-regulatory strategies to improve air quality and reduce energy consumption and greenhouse gas emissions.

7. Enhanced Education and Performance Standards

This program would provide information and support to the legislature and to policy makers to advance global warming related issues and funding sources. The intent is to explain greenhouse gas emissions in language that the public can readily understand, and explain immediate benefits and costs in terms of economic and strategic security and cost of transportation. Research proposed in the state includes developing an aggregate agent-based model of the California economy that includes representations of large-scale climate change impacts.

8. Financing Strategies to Support Proposed Activities

Information and support to legislature and policy makers on financial strategies is needed to advance global warming related issues.

9. Increase Freight Transport Efficiencies

Freight is responsible for a notable portion of energy use and carbon emission in transportation. Since cost reduction is a dominant factor in freight shipping, and energy use in the freight industry is driven by cutting costs and increasing speed, a mix of improvements in engine and vehicle design and in management and operations would be desirable.

10. Interagency Coordination and Cooperation

This framework for a clean and energy efficient transportation initiative can only be advanced through joint efforts and close coordination among state, federal and regional agencies, non-profit organizations and the private sector. Many of the proposed programs already exist in basic form at varying levels of implementation. Many of the strategies listed have been successfully demonstrated in California and elsewhere; however, their level of success is often constrained by lack of sufficient resources and effective coordination or comprehensive planning. Many of the initiatives pursued for decreasing emissions may also change how California adapts to climate change. For instance, a greater reliance on public transit in order to lower emissions will make climate impacts to transit infrastructure more important than they would be otherwise. Increased land-use planning and transit-oriented development that reduces emissions could also influence future travel patterns in ways that minimize the impacts of a changing climate.

Potential Benefits and Expected Results of Taking Actions

In addition to reducing greenhouse gas emissions from the transportation sector, a more sustainable transportation system will foster other short-term benefits including improved air quality, more efficient use of transportation resources, increased use of bio-fuels, reduced dependency on imported fossil fuels, greater energy security; improved mobility and travel options, and create more energy efficient and livable communities.

A clean and energy efficient transportation initiative can be cost-effective, flexible, equitable and good for the economy. Technology industries will benefit from improved markets for advanced transportation and communication systems both domestically and internationally, along with potential improvements in the safety and security of transportation facilities, vehicles and the supporting infrastructure.

[1] *The Potential Consequences of Climate Variability and Change for California. The California Regional Assessment*. A report of the California Regional Assessment Group for the U.S. Global Change Research Program. Draft Final Report, June 2002, p. 27.

[2] This section is based, in part, on the draft Forest and Range Assessment 2002, in preparation by the California Department of Forestry and Fire Protection, Fire and Resource Assessment Program (FRAP).

[3] Wilkinson, Robert, and Theresa Rounds. 1998. *Potential Impacts of Climate Change and Variability for the California Region. California Regional Workshop Report*. Report to the U.S. Global Change Research Program National Assessment, p.45.

[4] *The Potential Consequences of Climate Variability and Change for California. The California Regional Assessment*. A report of the California Regional Assessment Group for the U.S. Global Change Research Program. Draft Final Report, June 2002, p. 4-3-8.

[5] Environmental Defense. 2001. *Hot Prospects: The Potential Impacts of Global Warming on Los Angeles and the Southland.* Washington, DC.

[6] National Climatic Data Center. 1998. California flooding and Florida tornadoes. National Climatic Data Center, http://www.ncdc.noaa.gov/ol/reports/febstorm/february98storms.html.

[7] W. Riebsame, S. Changnon, Jr., and T. Karl, *Drought and Natural Resource Management In the United States: Impacts and Implications of the 1987-89 Drought* (Boulder, CO: Westview Press, pp. 43-112).

[8] U.S. Congress, Office of Technology Assessment. 1993. *Preparing for an Uncertain Climate--Volume I, OTA-O-567.* Washington, DC: U.S. Government Printing Office.

[9] Environmental Defense. 2001. *Hot Prospects: The Potential Impacts of Global Warming on Los Angeles and the Southland.* Washington, DC.

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