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K. ANSJE MILLER
WITH GAUTAM SETHI AND GARY H. WOLFF

WHAT'S FAIR?
CONSUMERS AND CLIMATE CHANGE

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REDEFINING PROGRESS
ONE KEARNY STREET, FOURTH FLOOR
SAN FRANCISCO, CA 94108

1.800.896.2100

TEL 415.781.1191
FAX 415.781.1198
E-MAIL info@rprogress.org
WEBSITE www.rprogress.org

K. ANSJE MILLER

Ansje Miller is a research associate in the Accurate Prices Program at Redefining Progress. She is an economic researcher and policy analyst whose interests lie at the intersection of urban economic development, public finance, and environmental sustainability. She joined RP in 1995 and has focused on the equity components of environmental tax reform. Her previous research ranges from the determination of a tipping point for "white flight" from public schools via economic modeling, to a comparative study of the impact of stress on coaches in revenue versus nonrevenue sports, to an analysis of international tax treaties on foreign investment in U.S. equities. Ms. Miller is a graduate of Oberlin College, with a bachelor's degree in economics and English.

GAUTAM SETHI

Gautam Sethi is a Ph.D. candidate at the University of California at Berkeley. Prior to this, he was a researcher at the Tata Energy Research Institute in New Delhi, India. His research interests include stochastic dynamic modeling in the context of renewable resources and analyzing the philosophical underpinnings of economic theory. Currently, he is working on optimal fisheries management when there is limited information. In the spring of 1998, he devised and taught a class called "Rethinking Economics" at the University of California at Berkeley. In India, Mr. Sethi worked on a wide range of issues, including: groundwater management, impact of removal of energy subsidies on the Indian economy, and the economic viability of laying a natural gas pipeline from the Middle East to the Indian sub-continent. Mr. Sethi holds a master's of philosophy degree from Jawaharlal Nehru University, a master's degree from the Delhi School of Economics and a bachelor's from the University of Delhi.

GARY H. WOLFF, P.E., PH.D.

Gary Wolff is the former director of the Incentives Program at Redefining Progress. He is a licensed civil engineer in the state of California and an environmental and resource economist. He holds a master's degree in civil engineering from Stanford University and master's and doctoral degrees in environmental and resource economics from the University of California, Berkeley. His fields of expertise include energy technology, water and wastewater, and solid waste management. Dr. Wolff has worked for an environmental regulatory agency (the State of California Regional Water Quality Control Board, San Francisco Bay Region), a public provider of wastewater services (the Central Contra Costa Sanitary District), and as a consulting engineer and economist. He founded 3E Engineering, an environmental engineering consulting firm, in 1986 and sold it in 1994. His clients have included numerous governmental entities, including special purpose utility districts and entities such as the World Bank, and private corporations and nonprofit organizations.

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I. INTRODUCTION

Every year the world's leaders gather to discuss global climate change and what we should do about it. Scientists tell us that the earth is getting warmer, global sea level is rising, and droughts and floods are becoming more frequent. Despite uncertainty about the precise timetable and effects, the international scientific community agrees that human activity is causing global climate change, and that we must take steps to slow it.

But what does slowing global climate change mean to the American consumer? How will a changing climate affect households[1] in the United States? How might consumers act to reduce the impacts of climate change? Can everybody adjust or adapt[2] to the same extent? How might government policy help people to adapt? This paper launches a discussion of fairness critical to the climate policy debate: How can we mitigate the uneven impacts of climate change and policies designed to reduce climate change? Can we create an "equal ability to adapt" for all American consumers?

Since most discussions of consumers and climate change have focused on the changes in consumer prices that might result from climate change policy, we focus first on the effects of climate change itself. Chapter 2 assesses the changes that will occur whether we adopt policies to reduce climate change or not. It is important to understand not just the overall effects of climate change, but also who will be affected and how. Therefore, we discuss the qualitative impacts that consumers and households in the United States will probably experience as our climate changes, noting which groups appear most vulnerable to each type of impact.

Chapter 3 discusses the distribution of effects of climate change policy itself. To our knowledge, there has been no comprehensive investigation of the impacts on various types of consumers of climate change and climate policy combined. Yet both climate

1. We use "household," "consumer," and "people" interchangeably in this paper. To understand how many people the various impacts will affect, some facts about American households are helpful: There are approximately 103 million households in the United States. Eighty-three million of them are located within a metropolitan area; twenty million are in rural areas. The Northeast is home to 20 percent of the nation's households, while 24 percent reside in the Midwest, 35 percent in the South, and 21 percent in the West. A little over one-third of American households have one or more children.

2. Adjust implies a small change, such as increased use of air conditioners or sunscreen. Adaptation involves larger changes, such as buying a new house or tinting the glass in one's car. For simplicity, we use the word "adapt" throughout this paper.

change and climate change policy will affect households, and these impacts will differ significantly by region, income, age, and other factors. This section also discusses other social trends (such as electricity deregulation) that distributional analyses have not yet addressed—trends that are likely to considerably alter the distribution of impacts on consumer groups.

Chapter 4 briefly discusses the importance of fairness: designing public policies to alleviate the uneven impacts of climate change and climate policy on different households and to enhance people's ability to adapt. It sets the stage for the primary point of this paper—that policies that help people to adapt to change are superior to the compensation policies that are usually discussed.

Some harm from significant national policy may be unavoidable. For example, yearly job losses among coal miners will increase even faster than the current rate when substantial climate policy is adopted. Even without policy action, those who live in floodplains will be flooded more often. But some damage can be avoided—by moving out of the floodplain, for example—and will be avoided best by those who can adapt to a changing world. Change is a constant characteristic of modern societies, including the globalization of the economy, technological advances, cultural trends, electricity deregulation and other governmental practices—and both climate change and policies to control it. The key social equity question, then, is how to create an equal "ability to adapt" for all American households.

To foster broad public discourse on the type of future Americans desire and how best to achieve it, Redefining Progress has previously issued three discussion papers on climate change. In *The Economics of Climate Change* (October 1997), Stephen J. DeCanio explores the common ground for reasonable policies to control human-induced climate change. "What's Fair? An Equity Framework for Global Climate Change" (March 1998) by Eileen Claussen discusses concepts of fairness that are applicable between nations as well as within nations. In "What's Fair? Workers, Investors, and Global Climate Change" (December 1999), authors Gary Wolff and Gautam Sethi find that policies that capture revenue from users of the atmosphere as a sink for greenhouse gases are much fairer than policies that do not. Only revenue-capturing policies allow a climate policy package to include the compensation and transition assistance that is needed to reduce climate change in ways that are fair to both workers and investors in the United States.

This paper evaluates policies designed to help consumers handle the effects of both climate change and climate change policies. Building on our previous papers, we assume that any climate change policy will collect revenue from those who emit greenhouse gases. One way to expend that revenue to help households cope would be to provide cash reimbursements for any damages they suffer. However, such a policy would not account for the fact that some people can diminish their losses by relocating or purchasing, while others cannot. The key response to change is adaptation.

We believe policies that help people to adapt are superior to those that merely compensate for damages, and that fair climate change policies would give all households an *equal opportunity to adapt.* To illustrate these points, we discuss five examples of adaptation policies in the final chapter. We hope that this paper will stimulate others who are interested in climate change policy to investigate many other promising adaptation policies.

II. IMPACTS OF CLIMATE CHANGE ON AMERICAN CONSUMERS

Suppose that political gridlock prevents the United States and most nations of the world from taking effective action to control climate change. How would the lives of American consumers be different? This section describes, qualitatively, the overall pattern of impacts that scientists believe are likely and, when possible, identifies the groups that would be most affected by each.

Unfortunately, very few economic analyses study the quantitative impacts of climate change itself. The financial section of the appendix includes estimates from these studies (Titus 1992; Fankhauser and Tol 1996; Cline 1992). However, as Repetto and Austin (1997) note, all rely on a short list of simplifying assumptions. Estimates vary in a wide range depending on the particular choice of assumptions in each study. They must therefore be interpreted with caution. DeCanio (1997) details these limitations of the economic analyses of climate change.

According to our research, analyses of the overall distribution of impacts of climate change in the United States do not exist. Even those that do exist in a rudimentary form—for example, the energy price rise impact discussed in the section below—do not necessarily describe the distribution of impacts after climate policy is adopted. Chapter 3 explains why this is the case.

OVERVIEW: THE PATTERNS OF IMPACTS

The estimates in this section are drawn largely from the Intergovernmental Panel on Climate Change (IPCC 1996). However, the most recent study conducted using their model shows higher average mean temperature and sea level rises, so the effects of climate change could be more dramatic then described here (Wigley 1999). In addition, the impacts of climate change may be magnified by people's efforts to adapt. For example, increasing the use of air conditioning systems emits more pollution from energy production and could increase the urban heat island effect. Since not everyone will have an equal ability to adapt, those who have the greatest ability may diminish impacts on themselves at the expense of society in general or others who are less able to adapt. This paper does not discuss the secondary effects of adaptation.

For conceptual clarity, we classify the wide range of effects that experts predict as impacts on health, culture, and finances (see the appendix for more detail on each); but in reality these categories overlap and their boundaries are somewhat fluid. For example, human health impacts would cause the financial costs of lost work time, visits to a hospital or doctor, and so forth, but they also involve intangible effects, like the discomfort of being ill or the emotional stress of having sick friends or relatives.

Health impacts are significant and varied, even if medical insurance blunts the financial costs. While more difficult to quantify, cultural impacts include changes in everyday life that would result from effects such as more extreme weather or population migration. The financial impacts are simplest to quantify; however, estimates vary widely and should not be thought of as somehow more accurate or "real" than other effects.

To reveal the pattern of impacts without climate policy on different groups of Americans, we've divided consumers by location, by age, and by income. Table 1 shows the groups expected to be most vulnerable to specific climate effects and lists at the bottom all the climate impacts discussed in the paper. (The appendix provides a more detailed discussion of the effects of climate change and the groups most vulnerable to each.) People who face the greatest impacts are those located in urban and rural areas, far southern and northern areas, and coastal regions; the youngest and oldest Americans; and those with low incomes.

People in urban and rural areas are particularly susceptible to health effects because their local environments will change more due to climate change than suburban areas. For example, the heat island effect is an urban phenomenon: Less vegetation produces less vegetative cooling, while more air conditioning pushes heat from the indoors to the outdoors. Similarly, air pollution is generated and concentrates most in urban areas; it also affects rural areas, but to a lesser extent. Residents of rural areas are particularly susceptible to health impacts due to more potential disease vectors (insects, rodents, and the like), greater distances to hospitals, and often lower-quality health care than in urban and suburban areas.

The far southern areas will suffer most from heat effects, tropical diseases moving north, and increased illegal immigration as people in countries further south are displaced by climate change. The far northern areas will suffer most from cultural changes. Alaska, now sparsely populated, in part because of its weather, may grow in population. This would not only alter the unique way of life for many "old-timers" and Native Americans, but could increase pressure to develop mineral, oil, and land resources to the detriment of both humans and other species for whom Alaska is a last refuge. While some people might see these changes as benefits rather than costs, in terms of cultural preservation and natural resource conservation, these changes would clearly be losses.

As sea level rises and peak storm flows in rivers increase, coastal areas will suffer loss of land and increased expenses due to flooding or efforts to protect land from flooding.

TABLE 1: **PRIMARY CLIMATE CHANGE IMPACTS FOR SELECTED VULNERABLE GROUPS**

GROUP	PRIMARY CLIMATE CHANGE IMPACTS	SOURCE
LOCATION		
Rural Residents	infectious diseases and other health problems respiratory ailments due to air pollution	Shindell and Raso 1997; U.S. EPA 1999. Cline 1992; U.S. EPA 1999.
Urban Residents	urban heat island effect exposure to thermal extremes infrastructure damage	Klein and Tol 1997. Kalkstein 1992; Klein and Tol 1997. Clarkson et al. 1995.
South	vector-borne diseases extremely hot summers increased transportation costs increased immigration	IPCC 1996a; Klein and Tol 1997. Kalkstein 1992. Casler and Rafiqui 1993; Cline 1992; DeWitt et al. 1991. IFRCRCS 1999; Knight Ridder Newspapers 1999; Page 1997.
Far North	extreme weather events permafrost thaw infrastructure damage immigration cultural and natural resource loss	Kalkstein 1992; Klein and Tol 1997. Kochmer and Johnson 1995; Rozell 1997. Kochmer and Johnson 1995; Rozell 1997. Kochmer and Johnson 1995. Kochmer and Johnson 1995.
Coastal Residents	sea level rise with resultant population dislacement and damage to infrastructure extreme weather events red tides and associated poisonings of fish or people	Clarkson et al. 1995; Titus et al. 1991; U.S. EPA 1999; U.S. NOAA 1998. Lashof 1999. EDF et al. 1998.
AGE Elderly & Youth	respiratory ailments due to increased air pollution vector-borne diseases such as malaria and dengue fever red tides exposure to thermal extremes forced relocation	Cline 1992; U.S. EPA 1999. Cline 1992; EDF et al. 1998; Fankhauser and Tol 1996; Glick 1998; IPCC 1996a; IPCC 1996b; Martens et al. 1995; New York City Department of Health 1999; Revkin 1999; Schulze 1992; Shindell and Raso 1997; Shope 1992; Strock 1992; Titus 1992; U.S. EPA 1999; Watson et al. 1998. EDF et al. 1998; IPCC 1996a; U.S. EPA 1999. Kalkstein 1992; Strock 1992; Titus 1992; Watson et al. 1998. IFRCRCS 1999; U.S. EPA 1999; U.S. NOAA 1998.
Young & Middle-Aged Adults	health needs of their children and parents changing recreational opportunities	See citations under "Elderly and Youth." Cline 1992; U.S. EPA 1995; Watson et al. 1998.
LOW-INCOME	infectious diseases and other health problems respiratory ailments due to air pollution exposure to thermal extremes and other extreme weather events increased food prices social, economic, and demographic dislocations	Shindell and Raso 1997. Cline 1992; Gelobter 1993; U.S. EPA 1999. Kalkstein 1992. Cline 1992; Rozenzweig and Hillel 1995. IFRCRCS 1999; U.S. EPA 1999; U.S. NOAA 1998.
ANYONE, POTENTIALLY	human health impacts such as respiratory ailments due to increased air pollution vector-borne diseases such as malaria and dengue fever red tides exposure to thermal extremes cultural impacts such as migration extreme weather events change in leisure activities financial impacts such as agriculture, insurance, buildings and infrastructure, and energy use.	Clarkson et al. 1995; Cline 1992; EDF et al. 1998; Fankhauser and Tol 1996; Gelobter 1993; Glick 1998; IPCC 1996a; IPCC 1996b; Shindell and Raso 1997; Strock 1992; Titus 1992; U.S. EPA 1999; Watson et al. 1998. See citations for vector borne diseases under "Elderly and Youth." EDF et al. 1998; IPCC 1996a; U.S. EPA 1999. Kalkstein 1992; Klein and Tol 1997. IFRCRCS 1999; U.S. EPA 1999; U.S. NOAA 1998. EDF et al. 1998; Glick 1998; IPCC 1996a; Kalkstein 1992; U.S. EPA 1999. Clarkson et al.1995; U.S. EPA 1995; Watson 1998. Adams et al. 1999; Cline 1992; Rozenzweig and Hillel 1995. EDF et al. 1998; Glick 1998. Clarkson et al. 1995; Kochmer and Johnson 1995. Cline 1992; EDF et al 1998; Glick 1998, Titus 1992.

Mountainous areas that currently earn significant revenue from snow (for example, ski areas) may suffer financial losses in the winter, although summer tourism may increase as people seek pleasantly cool vacation surroundings.

Children and the elderly are more susceptible to disease and thermal extremes than are young and middle-aged adults. Given that medical funding for them is already inadequate, increased medical expenses for these groups would exacerbate this problem. Young and middle-aged adults may find themselves no less healthy, directly, but increasingly burdened by the health needs of their children and parents. While this trend clearly has financial implications, we emphasize the significant cultural impact on middle-aged persons.

Finally, people with lower incomes will bear a disproportionate share of the burden of climate change, primarily because those with fewer financial resources will be less able to avert the worst impacts by relocating or making adaptive investments, such as home insulation and fuel-efficient automobiles.

Within these groups, many individuals or subgroups may be affected disproportionately. For example, farmers in Oklahoma, Kansas, and Colorado may have a tough and expensive time coping with dryer summers; the Southern Plains, Delta states, and possibly the Southeast and portions of the Corn Belt could see productivity fall, while farmers in the northern Great Plains and Great Lakes states may experience longer growing seasons (Adams, Hurd, and Reilly 1999; Rosenzweig and Hillel 1995). For the sake of brevity, many of these more confined patterns of impact on individuals or subgroups of consumers have been omitted from this section; please see the appendix for a more detailed description.

SPECIFIC IMPACTS

Because the range of effects is so broad, and some impacts are difficult (or impossible) to estimate in financial terms, we provide four examples below. The first describes a health impact, the second and third illustrate cultural and social impacts that are hard to express in dollar terms, and the fourth presents one estimate of the effect of climate change on prices.

Infectious Diseases

As the earth warms, the ecology of different areas will change, creating new habitats for disease-carrying agents (called vectors), such as mosquitoes, rodents, algae, and ticks. Most vector-borne diseases are not fatal when treated early. However, these diseases may kill many Americans who do not have information about them or access to health care. People who have never been exposed to diseases such as malaria are most vulnerable, since they have not acquired immunity (Klein and Tol 1997). According to the 1996 study *Global Burden of Disease*—a worldwide public health survey compiled by the World Health Organization, the Harvard School of Public Health, and the World Bank—poverty increases the incidence of death from vector-borne diseases (Shindell and Raso 1997).

Already, tropical diseases like malaria have appeared in areas north of their usual ranges due to climate change. In 1991, the family of an eight-year-old New Jersey boy was relieved to hear that their child did not have leukemia. They discovered, instead, that the boy's white blood cell count was so low because he had contracted malaria. During the same summer, a twenty-nine-year-old woman several counties away was also diagnosed with malaria (Schulze 1992; Chomsky 1992). Although malaria is most commonly found in tropical and subtropical areas such as Southeast Asia, Africa, and Central and South America, neither of the victims had ever been out of the country. The exceptionally hot and humid weather in New Jersey that summer had enabled the native mosquitoes to become infectious.[3] Over the past decade, an increase in hot and humid weather has provoked similar infections in other areas previously free of the disease, including parts of Virginia, New York, Michigan, and California.

If global warming increases the earth's average surface temperature 5.4 degrees Fahrenheit in the next century, scientists estimate that the risk of contracting malaria in temperate countries like the United States could become 100 times greater than today (Martens et al. 1995). Worldwide, climate change is expected to cause several million additional malaria cases by 2100. In an era of global mobility, an increase of this magnitude in other countries could greatly increase risk in the United States through travel and immigration.

Dislocation

Changing climate will displace people from their homes both outside and within the United States. The impact of domestic dislocation is relatively easy to envision—for example, sea level rise could cause homes along the U.S. coasts to flood. Families that have lived in an area for generations may find that their homes are now on a floodplain, and they must move to drier land. As drought becomes more frequent, the risk of forest fires increases for households located on the dry forested hills of California and other regions.

But the impacts of international dislocation on U.S. households may be greater, due to increased immigration. There were 25 million environmental refugees in 1998, more

3. Mosquitoes are only infectious if the malaria sporozoites have fully developed. In the conditions in North America prior to climate change, the mosquitoes generally die before that can happen. However, hot and humid weather causes the sporozoites to develop more rapidly.

refugees than war and conflict caused (International Federation of Red Cross and Red Crescent Societies [IFRCRCS] 1999). Climate change is expected to increase this number. For example, in 1998, Hurricane Mitch killed 9,000 people and left 500,000 homeless in Honduras, Nicaragua, Guatemala, and El Salvador. A Gallup poll of Central Americans, intended to measure the impacts of the hurricane on the United States, estimated that 600,000 adults in those countries were willing to brave the 1,000-mile desert trek into the United States to escape the devastation (Knight Ridder Newspapers 1999).[4]

Immigration is a cultural and political issue of great importance in the United States. A 1997 poll found that 79 percent of Americans are very or somewhat concerned that immigrants will overburden the welfare system and raise taxes (Page 1997). Increases in the pressure to immigrate to the United States induced by climate change would intensify the already considerable cultural friction over immigration.

Disruption of Customary Activities

Climate change will affect many customary activities. Cultural impacts include Christmas without snow or fewer snow recreational opportunities. Skiing and other snow sports, for example, are likely to become less available. One study predicts a 60 percent decrease in skiing overall (Cline 1992). A widespread snowmelt in January or February can end the New England ski season. In eighty years, climate change is estimated to decrease the snowpack in the Cascades of the western United States by as much as half during the ski season, while the snowpack in the Rockies is estimated to fall almost 30 percent (Leung 1999). In some southern areas of the United States, such as the South Georgia Bay, the downhill ski season may be completely eliminated (Watson 1998).

Moreover, rural communities will face yet another challenge to their traditional ways of life, because climate change will alter the best areas for various kinds of agriculture. For example, the corn and wheat belts are likely to shift northward, so that more grain farms would be in Canada and fewer in the United States (see the financial section of the appendix). The disruption of wildlife migration patterns will affect those who enjoy hunting and sport fishing. An extreme example is the native people of Alaska, but many other communities that depend on the land and climate (such as fishing communities) will experience significant social and cultural changes in their way of life.

Because Alaska has already begun to experience these changes, data is available to show how climate change will affect many native people. Alaska's average temperature has already experienced a warming of four degrees Fahrenheit (°F) over the last 41 years

4. In February 1999, the Gallup Organization of Costa Rica surveyed a representative sample of 1,000 adults in the four affected countries for the U.S. Information Agency. The survey found that 292,000 residents of those countries had already left—most for the United States.

of available data (EPA 1999). By 2100, America's most northern state is expected to see another 5°F rise in temperatures during spring, summer, and fall, and 10°F in winter. For some residents this warming might be welcomed as enhancing personal comfort. But it will disrupt fisheries and thaw permafrost,[5] damaging buildings, roads, railroads, and other infrastructure, including the Alaskan pipeline.

The relatively rapid population growth that Alaska has experienced over the last century is expected to continue. As the warming creates a more hospitable climate, even more people will be attracted to the state. But warming is also expected to change the wildlife (fish, seals, and the like) that many native people rely upon for survival. This will increase competition for natural biological resources. Since native culture is intimately tied to the land, increased pressure on these resources means increased pressure on native communities. The effect could undermine the native tribal sovereignty movement (Kochmer and Johnson 1995), which has recently been revitalizing traditional ways of life.

Price Impacts

Most studies suggest that prices due to climate change are likely to rise across all sectors, although the increases in most are likely to be slight. American consumers would find that the dollar buys less than it does today (Fankhauser and Tol 1996). The most significant increases in prices would derive from changes in agriculture, due to changing and unpredictable growing conditions (Adams, Hurd, and Reilly 1999; Rosenzweig and Hillel 1995); increased costs of electricity generation, due to increased demand for air conditioning and irrigation; and the effects of sea level rise (for example, increased costs of insurance and infrastructure).[6] More modest price increases would occur for tobacco, lumber, and textiles, due to changing and unpredictable growing patterns. (The best comprehensive discussion of price impacts is Scheraga et al. 1993; see also Cline 1992; EDF et al. 1998; Titus 1992; and Watson 1998). Worldwide agricultural production is expected to decrease 10 percent by 2050, which could increase global food prices as much as 20 percent (Scheraga et al. 1993).

As consumers get less for their money, the decrease in real household consumption in the United States in 2050 is estimated to be $201 billion (in 1990 dollars); of this $143 billion would be a decrease in real consumption of agricultural products (Scheraga et al. 1993, 123). This translates into $711 (in 1990 dollars) per person in 2050.[7] Since low-

5. Eighty-five percent of Alaska's surface area is covered with a permanent layer of snow and ice, called permafrost. As the permafrost thaws, the land beneath it could become unstable.

6. The financial section of the appendix discusses in more detail the effects of climate change on agriculture, the insurance industry, buildings and infrastructure, and energy use.

7. The U.S. Census projects the American population to reach 282,524,000 in 2050.

income households spend proportionally more of their income on food and energy, their decline in real consumption from the impacts of climate change will probably be greater than that of wealthier households. Forced to spend more for basic necessities, low-income households will have even less potential to purchase less-essential goods.

POLICY IMPLICATIONS

The effects of climate change in the United States are likely to be subtle, varied, and pfar-reaching. Most studies that have attempted to quantify the overall economic impact of climate change by 2050 or so[8] estimate costs ranging from 1.0 to 1.5 percent of U.S. gross domestic product (GDP) each year (roughly $80 to $120 billion per year, in today's dollars). These numbers include not just actual expenditures, but monetary estimates of some of the costs described above, for example, impacts on human health, traditional culture, and biodiversity. Whatever the average cost increases per year, it is important to recognize that the burden of climate change will not be distributed equally.

It is quite difficult to estimate quantitatively the distribution of impacts of climate change on various groups of Americans, because the issue has been little studied. And the pattern of qualitative impacts is uneven. Clearly, farming communities and others who depend on the land for their livelihoods will experience certain types of effects much more than the average American. And the nearly 43 million Americans who lack health insurance will be more burdened by health impacts of climate change than those with insurance.

As table 1 demonstrates, the groups that face the greatest impacts are those in urban and rural areas, far southern and northern areas, and coastal regions; the youngest and oldest; and those with lower incomes. However, within the most affected groups, some will bear a greater burden than others. Those who can relocate and purchase other forms of protection will be spared the most dramatic effects. But not all losses can be avoided by moving and purchasing. Even the wealthiest may lose special places of recreation and natural beauty, or contract diseases that were once rare or unknown within the United States. Variations in the ability to adapt will prove critical in determining who actually bears the burden both of climate change and of the policies adopted to diminish climate change.

8. Based on a doubling of CO_2 concentrations by the mid-twenty-first century.

III. IMPACTS OF CLIMATE CHANGE POLICIES ON AMERICAN CONSUMERS

THE SIGNIFICANCE OF A CARBON TAX OR EMISSIONS PERMITS

If the U.S. Congress eventually approves a global climate change treaty, policies to slow the process of climate change would certainly affect American consumers. However, the precise impacts are hard to predict, as economic analyses of the effects of climate change policies usually suffer from significant methodological flaws.

Economic studies compare the financial impacts of various policies with one another and with a baseline estimate of economic performance. Many are designed to assess the costs and benefits of climate mitigation policies; however, they often omit the costs of climate change itself from the model. That is, the baseline U.S. economy is modeled as if climate change were not occurring, then the policy to reduce climate change is compared to that baseline. As a result, the costs of the policies are exaggerated, because the benefits of climate change mitigation are left out.

Some analyses express the benefits of reduced climate change in financial terms (Nordhaus and Young 1996; Jorgenson et al. 1995; Nordhaus 1994, 1993). Some quantify the benefits of reductions in other pollutants from fossil fuels (such as sulfur dioxide or nitrogen oxides) (Jorgenson et al. 1995).[9] But more often than not, the impacts that are difficult to quantify (discussed in the previous chapter) are either omitted from policy analysis or reduced to the incomplete, tangible measure of these impacts that was feasible given the data available.

The most commonly discussed climate change policies involve a tax or permit system for emissions of carbon dioxide from energy use. In addition, most distributional analysis has focused on price effects of a carbon tax or tradable carbon emissions permits. Since the U.S. Energy Information Administration (EIA) estimates that 85 percent of U.S. greenhouse gas emissions derive from energy use, these policies are most important.

9. Neither type of study includes a distributional analysis, the focus of this paper; however, it is important to understand the models that exist.

SIDEBAR 1: **CO-BENEFITS**

Looking at carbon dioxide alone, it would be less expensive for the United States to reduce emissions if American companies were permitted to invest in emissions reductions or buy permits internationally. This is because there are some very low cost (or profitable) opportunities to reduce carbon dioxide emissions outside the United States. But when abatement of emissions occurs outside rather than in the United States, American citizens do not capture the co-benefits of reduced fossil fuel use domestically. These co-benefits—such as less sulfur dioxide and nitrogen oxides emissions leading to less acid rain and smog, or less coal use leading to lower emissions of mercury from coal—are more valuable to some groups of Americans than to others. We do not argue that international emissions permit trading is uneconomical for the United States, but that significant differences in fairness are embedded in different climate change policies.

When abatement occurs outside rather than in the United States, those who live near or downwind of the U.S. emission source are the losers, usually suffering from increased health impacts. Gelobter's (1993) summary of studies finds that almost all pollution effects particularly impact lower-income households, nonwhite households, and renters. If climate change mitigation policies were to reduce co-pollutants in the United States, the co-benefits would be progressively distributed. Reducing this pollution would disproportionately *benefit* the elderly, the very young, those in generally poor health, and those without health insurance, who are more vulnerable to pollution's adverse effects on health.

Both carbon taxes and permits for carbon dioxide emissions increase the cost of using fossil fuels that release carbon dioxide, encouraging individuals and businesses to reduce their use of fossil fuels and hence their emissions of carbon dioxide. Carbon taxes are charged based on the carbon content of a fuel, because nearly all carbon in the fuel becomes carbon dioxide when the fuel is burned. Carbon permits directly restrict the emissions of carbon dioxide from energy production, so that less fossil fuel can be burned.[10] In both cases, the price of using fossil fuels rises. Either one pays more for the fuel directly (carbon taxes), or one pays about the same for the fuel but also purchases a permit to emit (emissions permits).

Other policies—such as reforestation and control of fugitive methane gas emissions from natural gas pipelines and petroleum refineries—will also be significant, but, unfortunately, we have found no analysis of the distribution of impacts of these policies on U.S. consumers. Based on available research, most of the following section discusses the impacts of a carbon tax or an emissions permit system. However, *nearly all previous analyses of the distributional effects of climate policy are incomplete due to common insufficiencies.*

10. In several or more decades we may have technologies that can economically remove carbon dioxide from exhaust gas and bury it or otherwise dispose of it someplace other than the atmosphere. But such technology might never be economical, and is only an engineer's dream today.

Three types of insufficiencies appear in most of the distributional analyses, although some studies suffer from only one or two of them. First, as noted above, many studies fail to compare a world with climate change and climate policy to a world with unabated climate change. Second, many studies fail to account for other significant social changes likely to occur in the next decade or two. An example we discuss below is the trend toward deregulation of electricity production, which may reduce electricity prices more than climate change policy increases them, at least in some parts of the country and for some groups of Americans. Third, some studies (usually those that focus on the energy prices consumers will pay directly) fail to account for the full change in prices that will occur. As energy prices change, so do the prices of nearly all products that consumers buy.[11] In addition, fair climate change policies would account for the price impacts of international trading of emissions permits, but distributional analyses of climate policy rarely include this (see sidebar 1 above).

CONSUMERS AS WORKERS

This paper focuses on the costs of climate change to consumers, who would all purchase goods and services at higher prices; however, most consumers are also workers, whose purchasing power could decline due to job loss or lower wages. The second paper in Redefining Progress's "What's Fair" series addresses the issues of displaced workers and depressed wages in detail (Wolff and Sethi 2000). Their findings are useful to understand the price changes that consumers are likely to experience from climate change policy; for a synopsis, see sidebar 2 below.

CONSUMERS AS PURCHASERS OF GOODS AND SERVICES

Direct Price Effects of Climate Policy on Energy Prices

A number of studies have estimated the direct effects of climate policy on the prices of electricity, natural gas, and gasoline. Direct price impacts are the ones most people would recognize as the consequences of climate policy. Indirect price impacts from climate policy (discussed later in this chapter) might be more or less significant for any given individual, but most people won't recognize that the indirect impacts result from climate policy. We begin with a discussion of the range of direct price impacts that have been estimated by various researchers.

The estimates are based on models with differing assumptions. For instance, the policy decision on whether and how the revenue from taxes or permits is distributed back

11. This is because energy is used to create almost all products. So, if a producer has to pay more for energy, the cost (and therefore the price) of the good increases as well.

SIDEBAR 2: **CLIMATE CHANGE AND WORKERS**

In "What's Fair? Workers, Investors, and Climate Change," Wolff and Sethi (2000) find that even the most unfavorable models predict that the number of workers who lose their jobs due to a carbon tax would be fairly small (perhaps 300,000 over a ten-year period). This actual job loss (displacement) should not be confused with claims that climate policy would cause the economy to generate fewer jobs than it would without climate policy. Even if fewer jobs were created, this would have the effect of depressing wages in the economy in general, rather than actually causing people with jobs to lose them. Although one study (WEFA 1998) estimates that 2.4 million fewer jobs would be created if we adopt climate policy, another report (Bernow et al. 1999) estimates that nearly 900,000 more jobs would be created if we adopt climate policy. If this latter estimate were correct, climate policy would create upward pressure on real wages, not downward pressure.

The models that predict wage decline also usually state their conclusions relative to an imaginary scenario. That is, they compare estimated wages with climate policy against estimated wages that might occur if climate policy were not adopted and in an economy where climate change were not occurring. All of the existing models, even the most pessimistic, predict that real GDP per capita and per employee would rise in 2010 with Kyoto Protocol compliance. This means that real wages per worker (on average) would rise during this period. Although nominal prices (the dollar price one pays for a good or service) would rise, wages would rise even more on average. This is because the U.S. economy is projected to continue to grow faster than population and the labor force, even if climate change policy were adopted. So the purchasing power of the average American worker will continue to rise despite climate change policy. At worst, it would simply rise at a *slower rate* than it would have risen if no policy were introduced and if climate change did not exist.

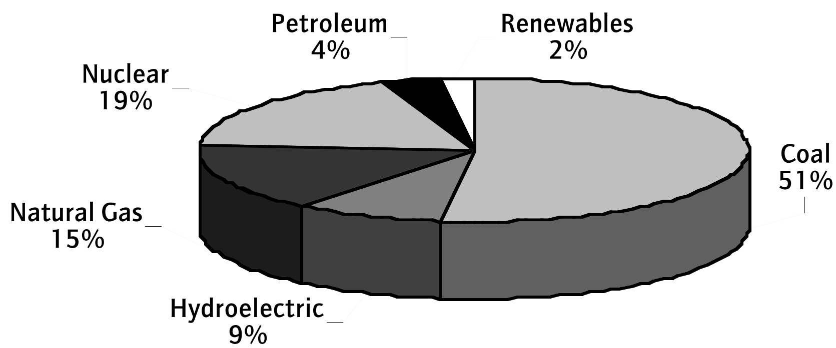
However, the lowest-income Americans—nearly 40 percent of U.S. households—have suffered from stagnant real wages for the last two to three decades. So although the American household on average would not suffer a loss of purchasing power due to climate policy, many lower-income households may indeed suffer such losses. This extremely important equity issue has not been fully addressed in previous discussions of climate policy and consumers.

into the economy varies in different models, significantly affecting the change in prices, as well as the effect on the overall economy. Repetto and Duncan (1997) discuss the various assumptions and how they affect estimates of the total impact on U.S. GDP from policy to abate climate change.

Nearly all models show energy prices declining without climate policy (shown in the "Reference Case" columns of the following tables). This means that the energy price increase of climate policy alone (if any) would not be entirely visible to consumers. Some of the price increase would just reduce the benefit to consumers from the downward trend in energy prices.

Electricity Prices | Fossil fuels account for about 70 percent of the electricity generated in the United States. Because coal, the most carbon-intensive fuel, is the source of 51 percent of U.S. electricity generated, electricity prices would be significantly affected by carbon taxes or a carbon permit system. (Figure 1 provides a breakdown of the primary sources of electricity in the United States.)

FIGURE 1: **U.S. ELECTRICITY GENERATION BY SOURCE**



Source: U.S. Energy Information Administration 1999, table 55

How much would electricity prices rise? That depends on many factors, including how costly it would be to substitute away from coal, petroleum, and natural gas, and how fast technological innovation or institutional changes like deregulation would lower the price of electricity if neither carbon taxes nor carbon permits were implemented. Table 2 shows the range of average price increases in electricity as estimated by the various models, using data assembled by the U.S. Energy Information Administration (EIA).

The models result in different prices because they are based on varying assumptions and include different features or limitations. For example, models that assume a higher rate of technological innovation result in lower price estimates.[12] Since a tradable permit scheme would lower the cost of climate policy, models that assume international trading also have lower price estimates.[13] The three cases from DRI and the CRA comparison of

12. For example, EIA assumes technological innovation will lower prices, while WEFA does not. In 2010, the EIA estimates electricity prices at 11.0¢ per kWh, while WEFA's estimate is 9.8¢. In 2020, however, EIA estimates technological innovation will drop prices to 9.3¢, but WEFA, assuming no technological innovation, estimates an increase to 10.3¢.

13. WEFA does not model international trading because it does not believe it will be agreed upon, and the EIA does not have the capability of modeling trading. CRA's models estimate without trading and with Annex I trading (trading among industrialized nations). DRI's models estimate without trading (Case 1) and then with increased levels of trading (Cases 2 and 3).

TABLE 2: **ELECTRICITY PRICE ESTIMATES**
(1996 cents per kilowatt hour, unless otherwise noted)

Study	1996	Reference Case in 2010[14]	Kyoto Protocol Case in 2010[15]	Reference Case in 2020	Kyoto Protocol Case in 2020
EIA 1998b	6.9	5.9	11.0	5.6	9.3
WEFA 1998	6.9	5.9	9.8	5.6	10.3
Charles River Assoc. (CRA) 1998	6.9	5.9	8.3	5.5	7.7
CRA 1998 w/Annex I Trading	6.9	5.9	6.6	5.5	6.6
Data Resources Inc. (DRI)1998, Case 1	6.9	5.4	8.4	5.3	8.2
DRI 1998, Case 2	6.9	5.4	7.5	5.3	7.3
DRI 1998, Case 3	6.9	5.4	6.3	5.3	6.5
Average delivered prices	6.9	5.69	8.27	5.44	7.99

Source: Summarized from EIA 1998b

a tradable permit system with and without permit trading among industrialized countries (Annex I) clearly show the impact of each model's assumptions on the results. (See Repetto and Austin 1997 or EIA 1998b for a thorough description of the underlying assumptions of each model.)

The table suggests that between 1996 and 2020 the average delivered price of electricity (a weighted average of residential, commercial, and industrial use) would increase by only about 1¢ per kilowatt-hour (kWh) after implementing the Kyoto Protocol. In the most optimistic result, Data Resources Inc. (DRI) Case 3, the real price of electricity would drop 0.4¢ by 2020. The least favorable model output (WEFA 1998) predicts the real price increasing by 3.4¢ per kWh by 2020.

A 3.4¢ increase per kWh of electricity would be significant for consumers, if it occurred. But the trend toward deregulation of electricity production in the United States is politically very strong and would almost certainly affect both the total price impact and the distribution of electricity price rises from climate policy. Therefore, the distribution of impacts from climate change policy must be evaluated in the context of electricity deregulation.

The primary consumer rationale for deregulation is the high price variations among regions. Currently, the residential price of electricity across the country varies by about a factor of three. In 1999, Idaho had the lowest rate of 5.0¢ per kWh, while Hawaii resi-

14. The reference case is the model's estimate of prices in the future year (2010 or 2020) if no action were taken to prevent climate change. As described above, the reference case also frequently assumes that climate change itself would not occur.

15. The Kyoto Protocol is the most recent global climate change treaty. The treaty calls for the United States to reduce its carbon emissions by 7 percent below 1990 levels.

dents were paying 14.5¢ per kWh (Energy Information Administration 1999, table 55). In 1998, the average price of electricity for households was 7.9¢ per kWh. However, in Oregon residents paid only 5.7¢ per kWh for electricity while their neighbors across the border in California paid 14.5¢ per kWh. This is why deregulation is being pursued in California and other regions with high electricity costs, like New England. Deregulation would tend both to equalize rates across the country and to make the average rate lower, because low-cost producers could compete with (and replace) higher-cost electricity producers who were guaranteed a profit by ratepayers before regulation.

As a result, deregulation could potentially more than offset the electricity price increases from climate change policy.[16] Further distributional research is needed to determine how deregulation and public investments in energy efficiency and renewables would affect these potential price increases of electricity on average and for various groups.

Natural Gas Prices | All of the models predict that natural gas prices would increase disproportionately from a carbon tax compared to other fuels. At first glance, this would seem paradoxical, since natural gas is the least carbon-intensive of the three most utilized fuels. However, as coal and petroleum prices rose, buyers would increasingly look to natural gas as an alternative. As the demand for natural gas increased, so would its price.

Table 3 shows the price estimates for natural gas after a carbon tax. Average delivered prices for all users, including residential prices, are estimated to roughly double by the year 2020. Again, this would be a significant impact if it occurred. But there is a key contextual question, just as there was for electricity,[17] for these estimates of changes in natural gas prices: How much will demand for natural gas actually increase?

The models in table 3 assume that opportunities to use all types of energy much more efficiently are very limited.[18] So the market demand for natural gas skyrockets in response to climate policy. But if businesses and people respond to a rise in energy prices by using less energy and investing in increased efficiency, rather than by switching fuels, demand for natural gas would not increase nearly as much as these models predict. It is difficult to say what the increase in natural gas prices might be if energy efficiency opportunities are as large as many analysts claim (Geller, DeCicco, and Nadel 1993; Bernow et al. 1999; Interlaboratory Working Group 1997). Taking this into account, a doubling of natural gas prices should be understood as a worst-case estimate.

16. Suppose that the average price of electricity in the United States does not decline due to deregulation, but that rates equalize across the country. This would essentially double rates for some households (from about 5¢ to about 10¢ per kilowatt hour) while cutting rates by one-third for other households (from about 15¢ to about 10¢ per kilowatt hour). These changes are about 1.5 times the maximum changes from climate policy (5¢ divided by 3.5¢).

17. Deregulation of natural gas took place over a decade ago and lowered its price significantly.

18. This is also one of the questionable assumptions embedded in some analyses of electricity prices.

TABLE 3: **NATURAL GAS PRICE ESTIMATES**[19]

(1996 dollars per thousand cubic feet, delivered prices, unless otherwise noted)

Study	1996	Reference Case in 2010	Kyoto Protocol Case in 2010	Reference Case in 2020	Kyoto Protocol Case in 2020
EIA 1998b	4.25	3.87	9.57	9.57	9.35
WEFA 1998	4.25	3.92	7.61	7.61	8.95
CRA 1998	4.25	3.19	8.74	8.74	11.82
CRA 1998 w/Annex I Trading	4.25	3.19	5.17	5.17	8.03
Average delivered prices (all users)	4.25	3.54	7.77	7.77	9.54
EIA 1998b, Residential prices only	6.37	5.72	11.98	11.98	11.7

Source: Summarized from EIA 1998b

Gasoline | Gasoline prices are expected to increase by a lower percentage of current prices than other fuels (table 4). This is partially because liquid and gaseous fossil fuels have much lower carbon content per dollar of market value than other fuels (such as coal), and partly because gasoline is already taxed much more heavily than natural gas and electricity.

In 1996, the average American paid $1.23 per gallon for gasoline, compared to $1.54[20] per gallon today. The model results in table 4 suggest that the average gas station in 2020 would charge $1.40 per gallon (in today's dollars) if climate policy were not adopted. (Of course, climate change itself may increase this price, as automobile air conditioners are run more frequently, and so forth, increasing demand for gasoline more than the models predict.) As table 4 suggests, with a carbon tax or permit system that allows the Kyoto Protocol emissions targets to be met, the average price of gasoline would be $1.83 (in today's dollars) in 2020. With a percentage increase of 19 percent (1.83/1.54 = 1.19), over a twenty-year transition period this would amount to an increase of just over $0.01 per gallon per year. Although this absolute rise in prices may seem small, a 19 percent increase in gas prices is clearly quite significant, especially for people with low or fixed incomes or people who must drive long distances.

While the price of gasoline may rise, the cost to the average consumer of traveling a certain distance might stay the same or even decline. The average gasoline-powered

19. See section on electricity prices for a description of model assumptions and footnotes 14 and 15 for explanations of the reference and Kyoto Protocol cases.
20. This is the national retail average self-service price of gasoline, including taxes, for the week of 3 April 2000 (EIA 2000).

vehicle in 2020 will probably get many more miles per gallon than today.[21] An increased efficiency of 31 percent would completely offset a gasoline price rise from $1.40 to $1.83 per gallon. Although such a large efficiency increase might seem unreasonable to expect, the combined gasoline and electric vehicles (hybrid vehicles) to be sold in the United States by Honda and Toyota next year get about twice the mileage per gallon of similarly sized and equipped pure gasoline counterparts (that is, 100 percent increase in fuel efficiency). Cobb (1998) has estimated that fuel efficiency will increase about 30 percent per decade, even without gasoline price increases caused by climate change policy.

TABLE 4: **MOTOR FUEL PRICES**[22]
(1996 dollars per gallon)

Study	1996	Reference Case in 2010	Kyoto Protocol Case in 2010	Reference Case in 2020	Kyoto Protocol Case in 2020
EIA 1998b, Motor gasoline	1.23	1.25	1.91	1.24	1.8
WEFA 1998, Motor gasoline	1.23	1.24	1.83	1.3	2.08
DRI 1998, Case 1	1.23	1.31	1.70	1.48	1.89
DRI 1998, Case 2	1.23	1.31	1.56	1.48	1.76
DRI 1998, Case 3	1.23	1.31	1.41	1.48	1.64
Average gasoline	1.23	1.28	1.68	1.40	1.83

Source: Summarized from EIA 1998b

Again, the context assumed for climate change policy enormously affects the estimated impacts. Estimates without technological and behavioral change represent the initial, worst-case effect a driver might experience. As people change their driving or transportation behavior, including purchasing more fuel-efficient cars, the impact of higher gasoline prices would be reduced. However, people with the least ability to adjust their transportation behavior or to purchase higher-efficiency vehicles would end up bearing a larger *percentage* of the burden of the climate policy than those who can adjust more. (Please see the discussion of transportation adjustments in chapter 5.) Further, the higher transportation costs would be passed on to consumers in increased prices of many other goods, as indirect price effects.

21. According to the American Council for an Energy-Efficient Economy, the technological improvements most likely to increase automobile efficiency in the near future include aerodynamic improvements (drag reduction), continuously variable transmissions, electronic transmission controls, cylinder friction reduction technologies, advances in low-rolling-resistance tires, variable valve timing, and accessory control units.

22. See section on electricity prices for a description of model assumptions and footnotes 14 and 15 for explanations of the reference and Kyoto Protocol cases.

Indirect Price Effects

Energy is used to make and transport virtually every product that we buy. In fact, in 1985, the industrial sector consumed 32 percent of all gasoline, 99 percent of all coal, 89 percent of other refined petroleum products, 64 percent of all electricity, and 69 percent of all natural gas to make other products (Casler and Rafiqui 1993). How much climate change policy affects a particular product depends upon how energy-intensive that product is. By definition, a good is "energy intensive" if more energy is used to produce it than the average good, that is, if energy accounts for a higher than average percentage of its cost.

Energy intensiveness can be measured in two ways. First, one can measure the energy directly used in producing the good, like the electrical energy used to type and to print this manuscript. Second, one can measure both this direct energy use and the energy used in producing other goods that are used to produce the final good. For example, the paper and ink used to print this manuscript required energy to manufacture. This second type of energy use is called "indirect" or "upstream" energy use. To estimate how much an energy price rise would increase the total price of a good requires evaluating both direct and indirect energy use.

To include indirect effects in estimates of price increases, one must estimate how the increased cost of providing some good or service would be divided between consumers and producers. Adopting the assumption used in many analyses, we assume that the full increase in energy prices would be passed through to consumers in the form of higher consumer prices. But this assumption is almost certainly incorrect for some industries,[23] so the results below should be taken only as rough estimates.

Table 5 shows the estimated indirect price increases from a $50 per ton carbon tax for a handful of important products in the U.S. economy, assuming that there are no offsetting factors like revenue recycling. (Although it is controversial, Casler and Rafiqui (1993) estimate that a $50 per ton carbon tax would meet the Kyoto Protocol targets.) These products accounted for about half of the output of the U.S. economy in 1987 (the year of the source data). The price rises include direct and indirect energy costs. The percentage increase in price varies widely—from 0.2 percent to nearly 16 percent.

The table presents reasonable estimates of the price changes that might occur immediately after an energy tax is imposed, but these price rises are unlikely to be accurate 10 or 20 years after climate policy is adopted, as consumer choices would likely shift. Over time, substitution to less carbon-intensive fuels and less energy-intensive production processes would both reduce the overall price effect and change its pattern. Since the possibilities for fuel switching and for technological improvements are so widely disput-

23. For example, industries with an elastic demand or that compete with another less carbon-intensive energy source.

TABLE 5: **INDIRECT PRICE INCREASES FROM CARBON COSTS**

Industry Name	Carbon cost per dollar of output ($)
Meat animals	0.010
Crude petroleum and natural gas	0.015
New, maintenance, and repair construction	0.008
Apparel made from purchased materials	0.009
Commercial printing	0.013
Industrial inorganic and organic chemicals	0.029
Drugs	0.006
Miscellaneous plastics producers, n.e.c.	0.015
Electronic computers	0.005
Motor vehicles and passenger car bodies	0.010
Air transportation	0.023
Communications, except radio and TV	0.003
Electric services (utilities)	0.159
Wholesale trade	0.005
Retail trade, except eating and drinking	0.007
Banking	0.004
Insurance carriers	0.002
Real estate agents, managers, operators, and lessors	0.002
Management and consulting services, testing and research labs	0.006
Legal services	0.004
Eating and drinking places	0.008
Automotive repair shops and services	0.006
Doctors and dentists	0.004
Colleges, universities, and professional schools	0.006
Other state and local government enterprises	0.034

Source: Calculations by author based on data from Norris 1988

ed, we can't foresee how prices would change for many products 10 or 20 years after implementing carbon taxes or tradable emissions permits. Some analysts claim to know, but there is no consensus among the community of people who study and model such changes. We can estimate that prices would almost certainly rise no more than the estimates in table 5, because new technology is not adopted unless it saves money or improves product quality per dollar of expenditure (which is similar to a price decrease from the consumer's point of view).

The impact on various consumer groups would depend on their purchasing patterns. One could estimate the effect on such groups by using data from the consumer expenditure survey or other data on consumer purchasing patterns. As with other impacts of climate change, indirect price increases from rising energy costs would not have equal effects on all households.

The importance of including indirect effects in an analysis of the distribution of burden is developed in a seminal paper by Casler and Rafiqui (1993), which is summarized below in sidebar 3.

To compensate for the uneven distribution of price effects, the revenue from carbon taxes or auctioned emissions permits could be returned to consumers in a variety of ways referred to as "revenue recycling." For example, revenue recycling could take the form of an equal check to each citizen a few times a year or a reduction in payroll or income taxes. A recent paper sponsored by Redefining Progress and the Center for

SIDEBAR 3: **INDIRECT EFFECTS AND DISTRIBUTION**

The result of including indirect costs can be seen in the following table, in which energy expenditures of the poorest fifth of the income distribution are compared with those of the richest fifth. The second column shows the ratio derived from comparing the percent of annual income spent on direct energy costs for the bottom fifth of the population to the percent of annual income spent on direct energy by the wealthiest fifth. The third column shows how the numbers change when indirect costs are included.

TABLE 6: **DISTRIBUTION OF INDIRECT PRICE EFFECTS**

	RATIO OF POOREST FIFTH TO RICHEST FIFTH	
TYPE	**Direct Expenditures Only**	**Direct Plus Indirect Expenditures**
Gasoline	114.5	110.8
Coal	333.2	114.2
Refined Petroleum	127.1	92.2
Electricity	147.5	118.5
Natural Gas	182.7	131.3
Total	135.3	107.7

Source: Based on Casler and Rafiqui 1993

Note that when these indirect effects are accounted for, the difference between the percentage of income spent by the poor relative to the wealthy decreases significantly, thus indicating that direct and indirect energy expenditures of different income groups are much more proportional to total income than direct expenditures alone (still regressive in most cases, but to a far lesser degree). This is because higher-income households tend to spend more on energy-intensive goods and activities (such as purchasing imported products) than lower-income households. In particular, note the significant drop in the ratio for coal (a drop of 219 percent) and that the well-off actually spend a *higher* percentage of their income on refined petroleum than do the poor.

a Sustainable Economy (Hoerner 2000) finds that revenue recycling not only greatly offsets the estimated price increases caused by climate policy, but could actually cause some consumer prices to fall. For example, industries that are labor rather than energy intensive (such as health services and information technology) would receive a greater financial benefit from the use of carbon revenues to reduce payroll taxes, thereby offsetting the financial burden imposed by higher energy prices.

DISTRIBUTION OF PRICE IMPACTS

As stated earlier, the impacts of climate change policy will vary substantially by income, age, gender, and location. Due to the limitations of distributional analyses to date (discussed at the beginning of this section), it is difficult to draw conclusive results overall. Nonetheless, some findings and key questions for future research in this area can be highlighted. Table 7 summarizes the primary impacts of climate policy for selected vulnerable groups.

TABLE 7: PRIMARY CLIMATE MITIGATION POLICY IMPACTS FOR SELECTED VULNERABLE GROUPS

GROUP	PRIMARY CLIMATE CHANGE POLICY IMPACTS
Location	
Rural Residents	Gasoline prices
South	Home heating and electricity costs; gasoline prices
West	Gasoline prices
Midwest	Home heating and electricity costs
Low-Income	Home heating and electricity costs
Age	
Under 25	Overall energy costs
Elderly	Home heating and electricity costs
Middle-Aged with Dependent Children	Gasoline prices
Women	Gasoline prices

Income Group

While heat and electricity are necessities for everyone, households with lower incomes spend a greater proportion of their income on these items than households with higher incomes. As a result, historically, energy taxes have been viewed as highly regressive. However, as sidebar 3 explains, energy price increases appear less regressive when indirect effects are considered.[24]

24. Energy price increases look even less regressive when examined as a percentage of lifetime, rather than annual, income. But the lifetime income approach, although intellectually useful, is often not politically useful. See Hamond et al. 1999 for a brief but more complete discussion of this issue.

For the lowest-income families, higher costs for home heating and electricity may be much more significant than gasoline price increases. More than one-quarter of the poorest households in the United States do not own cars.[25] Those that do own cars drive less than half the distance and are twice as likely to walk or take public transportation as those in wealthier households. However, the poor households that do own cars drive older, less fuel-efficient cars[26] (Murakami and Young 1997).

Again, revenue recycling can greatly change both the magnitude and pattern of impacts. If revenue is recycled, for example, by reductions in other regressive taxes or equal lump sum payments for each person, wage-earner, or household, the overall distribution of impact can be made neutral or progressive (Casler and Rafiqui 1993; Metcalf 1998; Jorgenson, Slesnick, and Wilcoxen 1992; Pearson 1992; Barnes and Breslow 2000). That is, the effect of climate change policy on low- or fixed-income consumers is uncertain—it depends on the details of the climate change policy and revenue recycling measures that are adopted.

Age

The studies that model age distribution of an energy tax find that the burden, when indirect effects are accounted for, is greatest for those under 25 and smallest for those over 65 (Casler and Rafiqui 1993; Jorgenson, Slesnick, and Wilcoxen 1997; Sherry 1997). With a Btu tax[27] on all energy, the youngest group would pay 2.7 percent more than the oldest (Casler and Rafiqui 1993). Similarly, a household headed by someone under 25 would experience a 4.6 percent greater decrease in wealth from a carbon tax recycled through labor taxes than a household headed by a working person 65 years or older.[28] On the other hand, some elderly persons who live on fixed incomes and in older buildings with less fuel-efficient equipment and appliances would be more vulnerable and less able to adjust and mitigate the effects.

Finally, middle-aged parents with dependent children are especially vulnerable to rises in gasoline prices. The National Personal Transportation Survey finds that people ages 21 to 65 drive more than those who are older or younger (Hu and Young 1999, 24).

25. Compared to only 4 percent of other households (Murakami and Young 1997, 1). Murakami and Young define poor households as those whose annual household income is under $10,000 for one to two persons, under $20,000 for three to four persons, and under $25,000 for five or more.

26. The average age of a car owned by a low-income household is 10 years compared to 7.3 years for households in other income groups.

27. A Btu tax is a tax on fuel based on the amount of heat generated by that fuel, as measured in British thermal units.

28. These studies do not address potential changes in energy consumption by different age groups: for example, whether those currently under 25 will have higher energy consumption in middle age than those who are currently middle-aged.

Several estimates of the burden from gasoline taxes suggest they fall most heavily on older married couples with dependent children, followed by those under the age of 25, while the elderly are burdened the least (Greening, Schipper, and Jeng 1993; Casler and Rafiqui 1993).

Gender

Although gender equity is often overlooked in transportation policy, many women have different transportation concerns than men. For example, personal safety is a more important issue for women (U.S. DOT 1981, 440). Higher gasoline prices might incline more women to ride on public transportation, which many feel is less safe than a personal automobile. However, if higher gasoline prices encouraged more people to ride public transportation, those who already depend on mass transit might benefit from a safer ride with expanded service.

In addition, male and female transportation patterns differ significantly. In families with children, women are still overwhelmingly responsible for domestic activities involving driving, such as shopping, errands, transporting children, and responding to household emergencies (McGuckin and Murakami 1995). Due to these responsibilities, women with children tend to make multiple stops along their commute, which discourage the switch to public transit or carpools. When these costs are borne by a married couple, they probably don't impose different burdens depending on gender. But single female heads of households will likely be burdened more by gasoline price rises because they have less flexibility in their dependence on automobiles.

Location

As discussed earlier, current residential energy prices vary widely across regions that rely on different types of energy sources. Similarly, carbon prices affect electricity prices differently in various regions. For example, two-thirds of California's electricity is generated from hydro, nuclear, and renewables (EIA 1998a, table 10). Since none of those sources has any carbon content, two-thirds of California's electricity would *not* be subject to a carbon tax.[29] The other third of the state's electricity is generated from natural gas,[30] which has the lowest carbon content of all of the fossil fuels (but whose market price is likely to rise the most over time because of increased demand). This means that the price of electricity in California might rise only slightly at first, and move upward over time only if natural gas prices rise significantly.

29. While the fuels themselves would not be subject to a carbon tax, the generation process does utilize some fossil fuels that would be taxed. However, this amount would be insignificant.

30. Less than 1 percent of California's electricity comes from petroleum, none from coal.

Kentucky, on the other hand, gets 96 percent of its electricity from coal and would be heavily burdened as soon as climate policy were implemented. The Midwest also relies heavily upon coal-fired electricity generation. Where electricity is inexpensive, houses are more likely to rely on electricity and use very little natural gas. More homes in the South are all-electric than in other regions (EIA 1998b). So Southern states with inexpensive coal-based electricity (such as Alabama, Kentucky, and West Virginia) are likely to be affected more than other regions.

An increase in gasoline prices would affect consumers differently depending upon the density of their communities and where their homes are located. The more densely developed an area is, the less distance people have to travel, and therefore the less motor fuel they use. Rural residents often live a mile or two from their nearest neighbors. Commonly visited places, such as a market, doctor, or church, are even farther. Also, the greater distances between destinations in rural areas make carpooling, public transportation, or other means of reducing gasoline use impractical. Economists estimate that rural residents spend almost 30 percent more of their income on gasoline than urban residents (Casler and Rafiqui 1993).

Impacts of increased gasoline prices would also differ regionally: For example, consumers in the South and the West travel longer distances than those in the rest of the country. Modeling the effect of a $22 per ton carbon tax on gasoline prices, DeWitt, Dowlatabadi, and Kopp (1991) find that, after making adjustments, a typical household in the Mountain region would pay 23 percent more than the national average, while a similar household in the Mid-Atlantic region would pay 25 percent less than average.[31] An increase in gasoline prices would probably be a greater burden for households in the West than the national average.[32] We must consider such regional differences in crafting equitable climate change policies.

Last, the overall burden by region is not necessarily the same as the regional burden for gasoline or electricity. For example, the Western states' burden of direct plus indirect energy use, overall, from a carbon tax would be lower than for the rest of the country (Casler and Rafiqui 1993), despite their higher burden of the gasoline tax. The full array of factors must be considered in calculating regional effects.

31. This estimate neglects indirect effects of the gasoline price increase. Accounting for indirect effects tends to reduce the differences based on location. For example, urban residents consume only 76.9 percent as much direct energy as rural residents, but consume 87.2 percent as much direct plus indirect energy (Casler and Rafiqui 1993).
32. Some have argued that increased gas prices could balance previous inequities in the use of national gas tax revenues to fund highways. Since roads in four-fifths of Western states are driven less than the national average, some argue that the West has received more than an equal share of transportation revenues, per driver (French 1989).

IV. INCORPORATING EQUITY IN CLIMATE CHANGE POLICY

INTRODUCTION

As the previous chapters described, climate change and policies to mitigate climate change will affect households differently; the ability of households to adapt to these impacts will also vary widely. These differences depend on factors such as income, age, gender, and region or subregion (for example, urban or suburban). Recognizing that neither the impacts of climate change nor the ability to adapt will be uniform across households, fair climate change policies should reduce these inequities. This goal raises two key questions of fairness: first, how to mitigate the effects of climate change and climate policy on the households that will be hardest hit and least able to adapt; second, how to enhance people's abilities to adapt to climate change and climate policy and thereby reduce the adverse impacts.

Ability to adapt is a crucial aspect of fairness that is often ignored in discussions of climate change policy. It should be considered along with income, age, region, and other more commonly recognized issues of equity in assessing people's relative risks of damage from climate change and climate policy impacts. Fairly enhancing people's ability to adapt is a more humane approach than providing compensation for damages, because it prevents or diminishes harm. It is also more economically efficient than compensating people for damage after it has occurred.

Why should a policymaker addressing climate change be concerned about fairness? First, since public policy is designed to improve the well-being of society as a whole, an ethical perspective is inescapable. One cannot improve society unless "better" and "worse" are defined in relation to moral standards of fairness. Second, at a pragmatic level, it is easier to get broad-based political support for policies that are widely perceived as fair—and we think such support will be needed to get climate policy adopted.

People take a wide range of approaches to integrating fairness in public policies, seeking different results including: equalizing absolute losses in well-being for all households;[33] reducing losses or changes in living standards by equal percentages across house-

33. Equalizing absolute losses suggests that if climate change hurts both households A and B, the government should compensate them both until their losses are the same. So, if the government sets a threshold of losses at $2, and household A's costs are $5 but household B's costs are $10, it would compensate household A by $3 and household B by $8.

holds;[34] and minimizing the losses or increasing the well-being of those who are least well-off, to achieve a more equitable quality of life for all households (Rawls 1999). Rather than seeking equity across currently existing households, others emphasize our ethical responsibility to future generations, to minimize the damages that they inherit due to climate change and policies to diminish climate change (Howarth 2000). Reasonable people may argue over which of these approaches most effectively promotes fairness; however, all should include consideration of the ability to adapt.

This chapter explains why considering the ability to adapt is a policy direction that the United States should take regardless of one's personal notion of fairness. The discussion assumes that any fair climate policy will raise revenue from emissions charges or auctioned emissions permits. The basis for this assertion is explained in another paper in this series, "What's Fair? Workers, Investors, and Climate Change" (Wolff and Sethi 2000).

All of the approaches to fairness discussed above conceptualize equity as minimizing decreases in quality of life or compensating people fairly for the impacts of climate change and climate policy after the harm has occurred. The fact that people take steps to adapt and to prevent damage gets lost in that argument. Regardless of the moral approach one favors, policies that account for and enhance households' differing abilities to adapt will lead to the fairest outcomes. This would help to avert or minimize losses in quality of life and reduce the total adverse impacts of climate change and climate policy.

Granted, even the most thoughtful climate change policies focused on helping people to adapt may not be able to avert all damage; climate change still may cause disasters and we will still need to consider how to compensate people fairly for their losses. But even if we will need a series of policies, our first priority should be enhancing people's ability to adapt.

CONSIDERING ABILITY TO ADAPT

Focusing on compensation policies, as many discussions of climate change policy do, implicitly assumes that individuals and households are passive agents who would take little or no action to reduce the adverse effects of climate change or climate change policy. Clearly, this is unrealistic. Given households' widely divergent capacities to adapt to the changed situation, it would be unfair to base help from the government on the estimated losses before adaptation. Assuming that households will avoid or mitigate damages if

34. Reducing losses by equal percentages across households recognizes that a $2 loss is much more painful to a poor household than to a wealthy one. Instead of setting a threshold of $2, the government would set a threshold of, say, 10 percent. So, if household A had $20 before any losses and household B had $50, then they would be compensated so that their costs were no more than $2 and $5 respectively. In other words, household A would still receive $3, but household B would receive $5.

they can, common sense suggests that it is fairer to help households to adapt as much as possible, thereby minimizing the burden that climate change will impose.

To consider people's variable abilities to adapt in constructing climate change policies, we need a better understanding of what contributes to the ability to adapt. Ability to adapt depends in part on access to resources, including physical capital, human capital, health and health care, and mobility.

Many of the adverse impacts of climate change and climate policy can be averted or minimized if one has sufficient capital to invest. Thermal extremes combined with energy price rises, for example, will not increase the costs of heating or cooling as much—not to mention the risks of serious illness or death—if one has money to invest in insulation and more energy-efficient heating and cooling systems. Higher gasoline prices will not require radical changes in transportation behaviors if one can afford to pay the higher prices or, better yet, invest in a more efficient vehicle.

Human capital—education and skills—may not only contribute to developing an awareness of the need to adapt, but may also prove an invaluable resource in determining how best to adapt and making the adaptation feasible. For example, the worker with an education that provides a variety of skills may be more able to anticipate the need to change jobs, before climate change or climate change policy causes job displacement, and may be more able to make such a shift without any loss in income or other sacrifices in quality of life.

Health and health care are also crucial resources that decrease an individual's vulnerability to the impacts of climate change. People with generally better health will be better able to resist serious illness from climate change–induced pollution or to endure thermal extremes or more extreme weather events with less discomfort, serious illness, and risk of death. People with greater access to health care will be more able to avert serious illness by getting preventative advice and earlier, more effective treatment. In cases such as asthma, access to health care and to early treatment significantly decreases the risks of acute illness, while diseases like malaria, easily managed with timely treatment, can be fatal without that treatment.

Mobility depends in part on physical capital and human capital, which are significant assets when one must relocate from a floodplain or move after a hurricane has decimated the community and way of life. But mobility may also depend on more subjective factors, such as degree of emotional attachment to local friends and family, a home, a region, or an accustomed way of life. In some cases this attachment may be cultural as well as emotional, so that moving would entail severe damage to quality of life: loss of cultural rituals; severed connections with a community, a civic or political organization, or a tribe; or inability to participate regularly in a favorite leisure activity, such as fly-fishing or ocean swimming.

Further, family structure may enhance or diminish ability to adapt. Families with young children may find it much harder to relocate, with the added considerations of child care, school districts, and their children's emotional distress at the prospect of leaving their schools, group activities, and friends. On the other hand, people with large families and extensive friendship networks may find it easier to relocate, with more people in more different geographical areas who would be willing to help them with temporary housing, job contacts, child care arrangements, or emotional support. In adapting to rising gasoline costs, a single mother may find it more difficult to reduce the amount of driving required by her children, her work, and her household responsibilities combined.

To some extent, the ability to adapt also depends on personality and preferences: the challenge of changing accustomed routines and habits causes some excitement, others distress. While the ability to adapt is complex and the psychological aspects of adaptation may be beyond the scope of climate change policies to address, clearly the more concrete aspects of variations in ability to adapt should be considered a critical aspect of fairness in climate change policies. Enhancing people's ability to adapt may not only minimize total harm and costs of climate change, but also represent a much more humane approach than compensating people for damages that have already occurred. As we discuss in the next chapter, which suggests some specific policies to enhance people's ability to adapt, this strategy is also more economically efficient.

ENHANCING ABILITY TO ADAPT

This tack suggests a particularly important avenue for further policy research: analyzing the most effective and economically efficient ways to enhance people's ability to adapt to climate change and climate policy and minimize their adverse impacts. Usually discussions of climate change policy focus on how to compensate people for their losses—that is, whether people should be compensated based on the absolute value of their loss or their percentage loss, or by starting with those who are least well off. But at least some of the revenue could be used to *prevent* the loss in the first place by enhancing people's ability to adjust, through adaptation policies. Conceivably, some households could attain an even higher level of well-being than their initial conditions.

Compensation versus Adaptation Policies

Regardless of the notion of fairness applied, compensation policies would simply transfer carbon tax or permit revenues to those who are considered most in need, to minimize their losses in quality of life. Adaptation policies could create incentives (via the creation or expansion of institutions) that could help households to attain at least the same level of well-being as they could have under a compensation policy. For example, suppose climate change policies lead to an increase in electricity bills for those on fixed incomes. Policymakers could choose to reimburse qualifying individuals for their higher electricity costs. On the other hand, using the same amount of revenue, policymakers could facilitate the installation of energy-efficient lighting and appliances to help people reduce their electric bills—perhaps even to below the level before climate change and climate change policy took effect.

Compared to adaptation policies, compensation policies are inefficient for at least two reasons. First, they generate perverse incentives. In our example above, if households anticipate getting compensated for higher costs, they may actually increase their electricity use. Although they might have to pay for part of the increase in their bills, it might be worth it to them, since the compensation payment is practically equivalent to an electric rate subsidy to those who qualify.

Second, compensation policies can lead to inefficient long-term allocation of resources. In the long run, purchasing more energy-efficient lighting and appliances is better for society than merely paying a higher electric bill. Technological progress is a source of increasing productivity and wealth in a modern economy. Compensation policies reward people for old, and perhaps inefficient, patterns. Adaptation policies encourage people to change in ways that over time could reduce the impacts of climate change and climate policy. In theory, creating the environment for individuals to take more actions of their own choosing is less costly and more empowering than directly compensating them for their losses.

In addition, policies that help people to adjust to climate change and climate policy could provide benefits for the country beyond their relationship to climate change. For example, stimulating the development and spread of energy-efficient technologies would not only reduce energy costs, but also conserve resources. Similarly, health insurance for the 38 million uninsured Americans would not only help to reduce the health effects of climate change, but would probably also increase their productivity in the workplace and their general enjoyment of life. This and other possibilities are discussed in chapter 5.

The significant advantage of adaptation policies fits into a rich and growing philosophical tradition that advocates increasing people's agency: recognizing that agency is as crucial as resources in enhancing quality of life. In Development as Freedom, Amartya Sen (1999) argues that "capability deprivation is more important as a criterion of disadvantage than is the lowness of income, since income is only instrumentally important and its derivative value is contingent on many social and economic circumstances." Because it increases capability, enhancing people's ability to adapt contributes more to their quality of life than merely compensating for monetary losses from climate change or climate policy.

Practical Difficulties of Implementing Policies

Varied approaches to fairness are susceptible to similar practical difficulties. These difficulties make the choice among specific fairness approaches less important and the choice between compensation and adaptation policies more important.

Consider two households, Smith and Jones, living on a floodplain that will be submerged as a result of climate change. The Smiths have been living there for generations and are deeply attached to their home, neighborhood, and lifestyle. The Joneses also like the floodplain, but have less attachment to it. Equal percentage compensation for these families (either as a percent of total well-being or of their losses) would require a policymaker to compensate the Smiths more than the Joneses. However, if the Jones family knows this, nothing prevents them from claiming an equal, or even deeper, emotional relationship with their neighborhood.[35] While recognizing that emotional ties and costs are real and widespread, any policy that includes them as indemnifying factors is bound to run into practical difficulties. Worse, if the government announced the implementation of such a policy at some point in the future, the floodplain could attract households who relocate due to the policy's perverse incentives.[36]

Practically speaking, policies must be based on tangible and "objectively" measurable criteria. Although this may be unsatisfactory theoretically, it is the most practical approach. But still it is fraught with difficulties. Once we acknowledge that not all impacts can be estimated in monetary or other tangible units, any of the approaches to fairness can go wrong. How can we claim to have created equal absolute losses, or equal percentage losses, or to have protected the least well-off, when we cannot observe *all aspects* of the well-being of individuals? Another practical difficulty is the enormous uncertainty involved in all estimates of the distribution of impacts of climate change and climate policies.

But both of these practical difficulties are less problematic for adaptation policies than for compensation policies. Logically, we cannot compensate someone for losses that we can't measure and verify. But adaptation policies do not require assessing the actual harm people suffer, but only observing that they have less ability to evade harm than do other, more fortunate people.

There is a lot of work to be done to develop equitable policies that will help people to adapt. A great deal of adjustment will be required to reduce climate-damaging emissions significantly and to adapt to both the changing climate and the changing economy that will result from it. We hope that this paper will spur others to analyze the most effective ways to enhance people's ability to adapt and to develop policies that enhance the ability to adapt for the most vulnerable groups within the United States.

35. This kind of behavior is known as "moral hazard" in economics.

36. The technical term for this phenomenon is "adverse selection."

The advantages of adaptation policies over compensation policies for addressing climate change are even clearer when we consider that, in the real world, few policies fit the pure cases described in this chapter. Although aspects of compensation and adjustment can be combined in one policy, policies focused on encouraging adjustment are superior to those focused on compensation for damages. Chapter 5 suggests some specific examples of promising adaptation policies that might address five different climate change and climate policy impacts, comparing their costs and effectiveness with those of comparable compensation policies.

V. ADAPTATION POLICIES TO HELP CONSUMERS

To assess adaptation policies that might be desirable in the United States, we analyze five impacts: home heating and cooling costs for low-income households, transportation costs for homeowners with long commutes, transportation costs for low-income owners of automobiles, disaster relief or prevention for those who live in areas likely to be flooded more often as climate changes, and medical insurance for those who cannot currently afford it. Since these five examples are all being used in some form or another in the United States, at least rough data about each is available. Table 8 lists these impacts and the possible adaptation policies to address them.

TABLE 8: **SELECTED IMPACTS AND POSSIBLE ADJUNCT POLICIES TO MAKE CLIMATE POLICY MORE FAIR**

Impacts	Adaptation Policies
Home heating and cooling costs for low-income households	Expand the federal Weatherization Assistance Program (WAP)
Transportation costs for homeowners with long commutes	Location-efficient mortgages
Transportation costs for low-income owners of automobiles	"Clunker" repair/trade-in
Increased flooding	Expand FEMA's acquisition, relocation, and elevation program
Health problems for the uninsured	Federal provision of health insurance

HOME ENERGY COSTS FOR LOW-INCOME HOUSEHOLDS

When faced with higher energy costs, consumers can adapt in three ways. They can (1) simply pay more for their energy bills; (2) reduce their usage of electric appliances, cooling, or heating (for example, wear a sweater inside); or (3) invest in energy-efficiency improvements to get the same amount of heating, cooling, and appliance for less energy. Compensation policies that help low- or fixed-income households to pay more actually undermine the environmental benefit that society is seeking—to reduce fossil fuel use. On the other hand, while use reductions are desirable when they curtail unnecessary use, they are undesirable if necessary use is diminished only because a household can't afford to pay for it. Investments in efficiency are the best adaptation consumers can make. They reduce energy use—the social goal—and they reduce the financial burden of paying higher energy bills. However, most people will not invest in energy efficiency unless it saves more money than it costs within a relatively short period. A thoughtful climate policy package should make such investments easier for those who have difficulty doing so.

Low-income consumers already spend a large share of their income on home energy and may not be able to invest in energy-saving devices. This may occur due to lack of cash, or because these consumers do not own the homes they live in or the appliances they use. Investing in ceiling insulation makes little economic sense for a renter with only a twelve-month lease. The split incentive problem—those who pay the energy bills don't own the energy-using structure or machine—has been widely discussed in the energy conservation and efficiency literature. Any policy to promote investments in energy efficiency must identify those with the least ability and incentive to adapt, which could include households and businesses other than low- and fixed-income households.

The American government has historically helped to defray increased home-energy costs in two ways: bill-paying assistance and energy-efficiency improvements. In response to the energy crisis of the 1970s and 1980s, the federal government enacted two programs for low-income households: the Department of Energy's Weatherization Assistance Program (WAP) and the Department of Health and Human Services' Low-Income Home Energy Assistance Program (LIHEAP). Neither program creates an entitlement; instead, a budgeted amount is allocated annually to the states to distribute according to broad guidelines.

Option 1: Expand LIHEAP

The Low-Income Home Energy Assistance Program (LIHEAP) currently provides block grants to states to be distributed for heating and cooling assistance. Four to five million households each year receive aid; nearly half are families with children under eighteen. Senior citizens, persons with disabilities, and working poor people are also served by this program. Seventy percent of these households have incomes below $8,000 per year (U.S. Department of Health and Human Services 1999). The money may be used to pay heating and cooling bills, buy air conditioners, or provide other means of assistance to low-income households. However, only 19 percent of households eligible for LIHEAP assistance[37] actually receive it (Campaign to Keep America Warm 1999).

37. Low-income households are defined as households whose income is the greater of either 150 percent of the national poverty level or 60 percent of the state median income.

The average LIHEAP benefit per household is approximately $200 per year, but the amount varies greatly from state to state. Since LIHEAP funds are block grants given to the states, the money is used until it runs out. As federal funding has been cut back over recent years, states have restricted who can receive assistance in various ways. Some states provide assistance on a first-come, first-served basis, while others give priority to households with elderly residents or children. One policy approach would be to increase the funding enough to provide the same level of benefits to *all* of the eligible households. In 1998, LIHEAP had a $1.15 billion budget (LIHEAP Clearinghouse 1999), so funding all eligible households would require an additional $4 billion.

Increased LIHEAP funding is an example of a direct compensation policy targeted to a hard-hit group of consumers—those with low income. But it does little to reduce energy use by low-income households. In fact, it may increase energy use (for example, by helping an elderly person to purchase an air conditioner). So, although it would ease the financial burden of climate change and climate policy on qualifying households, it would not enhance the ability of low-income persons to simultaneously save energy and live comfortably.

Option 2: Expand WAP

Since 1977, the Weatherization Assistance Program (WAP) has weatherized 16 percent of the total eligible housing stock (4.7 million of 29 million homes). Households with incomes at or below 60 percent of the state median are eligible. WAP trains and employs local residents to weatherize homes, which has the added benefit of creating much-needed jobs and training for low-skilled workers in low-income communities. On average, a weatherized residence realizes a primary heating saving of 23 percent, but the saving is often 25 to 30 percent. Although the program's efficiency per household has increased considerably from 1987 to 1997, its annual funding has dropped $200 million.

A committee considering the future of WAP estimated that increasing the funding from its current $300 million budget to its previous budget of $500 million per year, between 2000 and 2010, would save an additional 530,000 households a total of $563 million during that period (Millennium Committee 1999). The gross cost for this expansion (ignoring energy savings) would be about $3,800 per eligible household.

Although this expenditure is much higher than the LIHEAP expansion cost per household, WAP actually reduces energy use. Energy-efficiency improvements are durable investments with lifetimes of 30-40 years. A saving of $563 million in the first ten years suggests that the $2 billion of additional expenditures ($200 million per year) would be saved within 30 to 40 years. WAP is a policy that adapts the housing stock to increased energy prices. Although initially this requires more government spending, it is much more cost-effective over time than simply paying higher energy bills, as LIHEAP does. However, a compensation policy like LIHEAP might be needed after weatherization, if occupants still couldn't afford the heating or cooling bills of an energy-efficient home. So WAP and LIHEAP are complementary policies. WAP should be used first and LIHEAP used only when weatherization cannot reduce bills to levels that low-income households can afford.

TRANSPORTATION COSTS

If climate policy increases the cost of gasoline, consumers who own cars have the same types of options. Auto owners can: (1) drive the same amount and pay more, (2) drive less, or (3) purchase a more energy-efficient or cleaner-fuel vehicle (for example, electric or natural gas). Again, the first response is not socially desirable—some households may be unable to pay more for necessary transportation, and climate change policy aims to reduce gasoline use. The second response is desirable only if unnecessary transportation miles or wasteful methods (such as one person per car) are reduced. Otherwise, less driving can mean a real loss of mobility and decline in quality of life. And again, the third response creates a substantial short-term financial burden that is most difficult for low-income households.

In the following two sections, we present some innovative policies that are beginning to be used in the United States and that might be desirable to expand as part of a climate policy package. The first is location-efficient mortgages, which provide financial incentives to reduce automobile commute miles by living closer to work. The second is "clunker trade-in" programs that encourage low-income persons either to use other forms of transportation or to invest in more energy-efficient cars.

Homeowners with Long Commutes

In chapter 2, we noted that families with dependent children are expected to bear a higher burden (as percent of income) of gasoline tax increases than many other groups. This is because many families with children live in suburban areas and have long commutes to work. Because affordable housing near job centers has become difficult to find in many American cities, increasingly families must choose between living in older, more expensive housing stock near their work places or in newer more affordable houses farther from work. On the other hand, there are some (but fewer) urban dwellers who work in recently developed outlying areas but can't afford housing in the new suburbs.

Some of these commute miles are unnecessary, caused by the desire to own a home combined with location-blind credit policy. The home loan market typically limits borrowing to the amount that can be amortized with a fixed percentage of gross income, regardless of the location of the home or workplace. This means that standard bank practices prevent some families from using their commute savings to pay more for a home nearer work.

Location-efficient mortgages address this issue by allowing lenders to loan more to those who live near their jobs. Since commute costs are saved and used to pay back the higher loan, the family actually spends less (or the same) on house payments and commute costs combined. As long as they continue to work near their home, their loan has no more risk than the average home loan.

The location-efficient mortgage is currently being test-marketed in five areas in the United States: Atlanta, Chicago, Los Angeles County, the San Francisco Bay Area, and Seattle. The Federal National Mortgage Association (Fannie Mae) is providing $100 million for lenders to offer mortgages to low- and middle-income consumers who wish to live in densely populated urban areas with access to public transportation. The average estimated commute savings could be as much as $7,000 per household per year (Hoeveler and Liu 1999), which increases their qualifications for a loan.

The additional cost of such mortgages is relatively small. There is an administrative cost involved, and a slightly higher risk of loan default if the purchaser should later change to an equal or lower-paying job located far from the house. Suppose the average home loan is $200,000 and the risk of default is increased by 0.1 percent. This would impose an additional $200 cost on each borrower. Adding an additional administrative cost of, say, $100 per loan would require an investment of $300 per mortgage of this type, with an expected saving for the household of $7,000 per year. Of course, the household will spend much of the saving in purchasing a more expensive (but location-efficient) home. But this example clearly illustrates that such an adaptation policy is much more cost-effective than giving each household a payment of the same amount to compensate for higher commute costs. If each participant in the program paid a $300 processing fee for the loan (still leaving them with a $6700 commute saving on average), the program would have no cost to the public.

Low-Income Owners of Fuel-Inefficient Automobiles

Consumers who drive less fuel-efficient vehicles will bear a greater burden, per mile, than others if gasoline prices increase. Unfortunately, many of the gas guzzlers on the road today are older vehicles owned by low-income consumers—those who have the least ability to repair or upgrade to more fuel-efficient or alternative-fuel vehicles. Moreover, as the cost of gasoline increases, the demand for (and the value of) those less fuel-efficient vehicles will decline. This decreased value will make it even more difficult for low-income people to upgrade to cars with higher efficiency.

For rural residents who have limited transportation options, this could impose a significant burden. Several states, including California, Delaware, and Illinois, have smog programs that buy polluting vehicles to permanently remove them from the roads. California also has a program that will help low-income[38] car-owners pay for repairs that reduce their pollutant emissions and increase their gas mileage. These programs currently target polluting vehicles to combat smog. However, most of the polluting vehicles are also less fuel-efficient. With minor adjustments, these programs could target vehicles with low gas mileage as well.[39]

The Illinois program purchases vehicles made before 1980, at an average cost per vehicle of $860. In California, the Department of Consumer Affairs will pay a flat fee of $1000 for a vehicle that has failed a smog check. Although the program has just begun, the Department expects to retire 26,000 vehicles each year. A similar program with similar participation applied to the entire United States would retire about 270,000 "clunkers" each year. At $1,000 each, owners of old, energy-inefficient cars would receive about $270 million in the year they retire their cars. Presumably, this $270 million each year would be spent on newer, more fuel-efficient cars and on alternative forms of transport such as bicycles and public transportation.

Subsidies to retire inefficient vehicles help low-income auto owners meet their transportation needs while emitting less greenhouse gases. This type of program would spend $270 million each year to help low-income auto owners to adapt, rather than merely helping them to pay for higher priced gasoline—a compensation policy that would not reduce fossil fuel use.

FLOOD RELIEF AND PREVENTION

Climate change is increasing the frequency and magnitude of rainfall, causing more water in creeks, rivers, and lakes and more flooding during the wettest seasons. Recent experience throughout the United States seems to confirm this trend. Federal Emergency Management Agency (FEMA) expenditures have increased (in inflation-adjusted dollars) from approximately $0.5 billion per year in the 1950s to over $2 billion per year in the 1990s. The United States has historically helped people damaged by natural disasters such as floods. Public policy will probably continue to do so, but at increased financial cost to the public. We can improve quality of life more for less total cost by helping people to avoid or reduce flood damage.

Some homes, particularly in flood-prone areas, cannot be hazard-proofed. Further, if a homeowner wants to move in order to avoid the natural hazard, selling the property

38. Low income is defined as 175 percent of the federal poverty level.

39. Drivers of newer gas guzzlers such as SUVs or pickup trucks won't benefit from these programs, because the market value of these vehicles is greater than the program allows. The programs appropriately target consumers that would have the most difficulty adjusting to higher gasoline prices.

only pushes the flood hazard onto a new buyer. In some flood-prone communities, FEMA offers funds to purchase, relocate, or elevate homes in vulnerable areas after flood disasters, reducing the financial and psychological impacts and diminishing the costs of future bailouts. To date, FEMA has spent $533 million on acquisition, relocation, and elevation of over 21,000 properties vulnerable to flooding.[40] This costs $25,000 per home on average. Although generally used to address river flooding, funds have also been used for landslides and flooding in coastal areas.

The grant program is currently available only to communities that have previously experienced disasters. This provision is designed to prevent the adverse selection problem described in chapter 3: encouraging people to move into the floodplain by offering the perverse incentive of disaster bailouts.

However, this policy ignores the probability that climate change will make more communities vulnerable to hazards. Although FEMA lacks funding to assist households before a disaster occurs, the agency currently assesses the risks to communities throughout the country to determine which homes may warrant mitigation funds. As risk levels increase, new homes become eligible for future mitigation assistance. These risk assessments could be used to relocate homes before a flood occurs. To avoid adverse selection, homeowners should receive assistance only if they have owned the property for a minimum period of time, such as five or ten years.

There are currently 98 million occupied housing units in the United States. Of all the housing units in the country (not necessarily occupied), 7 to 10 percent are located on 100-year floodplains—land with a 1 percent chance of flooding each year.[41]

Climate change is expected to slightly increase those risks. If the policy goal were, for example, to assist 10 percent of the homes located in 100-year floodplains, and the average cost per housing unit remains the same, such a program would cost about $25 billion. Amortized over 30 years at 7 percent interest (say by selling thirty-year treasury bonds), this would cost $2 billion per year, a surprisingly low figure for permanent flood protection for 1 percent of the total U.S. housing stock and 10 percent of the housing stock at risk of flooding in a 100-year event.

If FEMA selected a larger percentage of homes with higher risks of flooding (for example, every 10 years), the benefits of helping to relocate or floodproof these homes would be much higher relative to the costs. Once an area has been floodproofed, it can be flooded deliberately to reduce the risk of flooding for downstream communities. Hoping to find more cost-effective methods of flood protection than dikes and levees, the U.S. Army Corps of Engineers is currently studying the feasibility of "nonstructural" flood control in three test areas. This method also offers the ecological co-benefit of restoring or protecting riparian habitat. Such an adaptation policy built on the founda-

40. Matt Campbell, program specialist with FEMA, telephone conversation with the author, 23 July 1999.

41. Matt Campbell, program specialist with FEMA, telephone conversation with the author, 23 and 28 July 1999.

tion of the current FEMA relocation and flood-proofing program could provide financial incentives to people who live in floodplains to adapt to climate change, rather than just compensating them after damage has occurred. In addition, the FEMA program could also include housing units that are at risk from other types of disasters caused by climate change, such as landslides or fires.

ACCESS TO MEDICAL CARE

As discussed in chapter 2, access to healthcare significantly helps people to adapt to climate change. For example, better access to health care can significantly reduce the spread of infectious diseases such as malaria and Lyme disease, the seriousness of respiratory ailments due to climate-related air pollution, and the incidents of heat-related mortality.

Access to health care will be critical in adapting to climate change for two reasons. First, the healthier people are in general, the less likely they will suffer from the potential health problems related to climate change. For example, climate change would increase rates of asthma, which is a highly manageable disease with timely medical treatment. However, at least in part because they lack sufficient preventative care and early treatment, low-income children suffer more from the disease. A recent study by the Mount Sinai School of Medicine found that children from poor neighborhoods are more likely to be hospitalized for an asthma attack than children from wealthier neighborhoods (Claudio 1999).

Second, once someone is ill, access to healthcare is critical in minimizing the harm and the cost. In 1996, nearly 18 percent of Americans did not have healthcare that provided access to a doctor's office, clinic, health center, or other source of health advice or treatment (Weinick and Zuvekas 1997). Weinick and Zuvekas estimated the total number of uninsured in 1996 to be almost forty-four million; almost eight million people had difficulty accessing healthcare because they could not afford it.

Providing healthcare may be a cost-effective investment in reducing the costs of climate change effects. Covering the eight million Americans who cannot afford healthcare would cost $18 million annually, at a cost of $2,290 per person (the June 1999 average cost).

A less expensive option might limit coverage to health problems related to climate change, such as malaria, health effects of thermal extremes, and respiratory problems related to air pollution. This coverage could function like Medicare, offering reimbursement at usual and customary rates for any qualifying American citizen visiting any physician or medical facility in the United States. Or one might selectively invest in existing public health systems in the geographic areas that are most likely to experience these problems (urban centers and rural areas, especially in the South).

BENEFITS OF ADAPTATION POLICIES

The adaptation policies described above are illustrative examples worthy of further, more-detailed analysis. Many other adaptation policies can be considered. A cursory comparison of the cost of avoiding harm and expenses through these policies with the cost of compensating individuals for harm or expenses suggests significant financial savings.

Failure to consider adaptation policies (in contrast to or along with the compensation policies that are more widely discussed) would be financially irresponsible, for two reasons. First, adaptation policies help people to avoid damages, rather than helping after the damage has occurred. Second, adaptation policies often have positive spillover effects for the rest of society, apart from the benefits related to climate change impacts. For example, health insurance for eight million currently uninsured Americans could significantly reduce chronic, debilitating health problems, by providing preventative advice and earlier treatment to reduce the incidence of advanced disease and diminish the spread of communicable diseases.

Climate change and mitigation policies will have varying costs for different Americans. Others have argued that fair policies to slow climate change will raise revenue (Wolff and Sethi 2000); the use of that revenue is also a matter of fairness. We believe it is crucial to take into account people's varying ability to adapt when evaluating who should benefit from this revenue. Moreover, since adaptation is so critical to successfully coping with these changes, this revenue should be spent on policies that actually help people to adapt, preferably before the damages have occurred.

Even when the financial costs of adaptation policies seem slightly higher than comparable compensation policies, usually these are short-term costs that are offset by long-term gains, as when investment in fuel-efficient cars or appliances saves energy costs for many years. In addition, adaptation policies advance social goals to reduce emissions and wasteful energy use, whereas compensation policies may provide perverse incentives to continue polluting and energy-inefficient behaviors. Further, adaptation policies generally have far greater benefits to consumers in reducing the costs of climate change and climate policy, enhancing human agency, and improving quality of life.

Scientific debate has moved from speculating about whether or not climate change will occur to analyzing the degree of probable changes and extent of their impacts. It is time for the policy community to follow suit by analyzing who will be most vulnerable to these impacts and how policies can most effectively prevent or mitigate the predicted costs and declines in quality of life. We hope that the policies described in this paper will serve as guides in spurring others to think about how to help the most vulnerable Americans to adapt to the climate and economic changes that we all will face.

APPENDIX

This appendix synthesizes research on the impacts of climate change for consumers and households, describing the probable overall effects and identifying the groups most vulnerable to particular impacts. No person or household in the United States is entirely immune to the effects of climate change, but impacts will vary widely. Low-income households in the United States will experience greater vulnerability for much the same reasons as developing nations: lack of infrastructure and the tendency of impacts to exaggerate the effects of poverty. Impacts will also differ depending on where the household is located, the ages of its members, and their activities. Table 1 (in chapter 2) provides a summary of the primary climate change impacts for selected vulnerable groups.

The effects of climate change will interact with many other factors that influence ecological and economic systems, such as temperature, precipitation, air pollution, water availability, and population growth. Because the indirect impacts of loss of species or disruption of natural systems cannot be easily related to individual households, this paper discusses only the direct effects of climate change—diseases, heating bills, and so on.

The estimates in this section are drawn largely from the Intergovernmental Panel on Climate Change (IPCC 1996). However, as noted in chapter 2, the most recent study conducted using their model shows higher average mean temperature and sea level rises, so the effects of climate change could be even more dramatic (Wigley 1999).

EFFECTS ON HUMAN HEALTH

Although the exact kind and magnitude of health effects are still unknown, climate change is expected to affect human health in three major ways: infectious diseases, respiratory illnesses related to increased air pollution, and deaths and illnesses related to thermal extremes. The average healthy, young, middle-class consumer would probably not experience a significant health impact. However, groups that are more vulnerable are expected to be substantially affected.

Increased Air Pollution

Air pollution occurs when various chemicals interact with sunlight to produce noxious gases such as ozone. Higher temperatures and a decrease in cloud cover would aggravate air pollution, particularly in urban areas. The Environmental Protection Agency (EPA) estimates that the rise in temperature expected for the United States would increase peak ozone concentrations by 10 percent. That would double the number of cities that currently exceed air quality standards, adding most of the midsize and some small cities in the Midwest, South, and East (Cline 1992). Ground-level ozone is associated with respiratory illnesses such as asthma, reduced lung function, and respiratory inflammation (EPA 1999).

Because air pollution tends to concentrate in cities, urban residents would be hardest hit. Warmer temperatures also increase smog, the haze that results from ground-level ozone and fine particles. The EPA estimates that a 5°F increase in temperature results in a 10 percent increase in smog, decreasing visibility and making breathing uncomfortable (Clarkson et al. 1995, 180). People who live in areas with poor or borderline air quality are more likely to see adverse health effects. Moreover, people who currently have respiratory problems[42] or weakened immune systems would be more vulnerable to increased air pollution. Since people with low-incomes tend to live in areas with poor environmental quality and to have poorer health, they would bear a heavier burden from any increases in air pollution.

Infectious Disease

Mosquito-carried disease | As described in chapter 2, many states are already witnessing the emergence of malaria due to the changing climate. Other mosquito-borne diseases also show evidence of changes in geographical range, including dengue fever, encephalitis, and West Nile–like virus (New York City Department of Public Health 1999).

People who have never been exposed to such diseases are most vulnerable, since they have not acquired immunity (Klein and Tol 1997, 11). Rural residents are more likely to be bitten by disease-carrying insects, since they are more exposed to the natural environment. As coastal areas maintain wetlands to try to protect themselves against floods, the risks of disease may increase with more stagnant water, which is prime mosquito habitat.

While public health measures could significantly decrease the risk of insect-borne diseases, the primary public health response has been spraying with insecticides such as Malathion. Although this spraying reduces the risk of infection, evidence shows that it can also increase or cause other illnesses (Revkin 1999).

Tick-carried disease | Rural residents are more vulnerable to tick bites since ticks commonly fall onto the skin from overhead trees or jump from tall grasses. The deer tick infects over 10,000 people each year with Lyme disease. While it can be fatal, most

42. According to the American Lung Association, 16.4 million Americans have chronic bronchitis and emphysema, and 14.9 million Americans suffer from asthma.

infected people receive early treatment, which reduces their symptoms to arthritis and nervous system problems. In the southern United States, ticks transmit Rocky Mountain spotted fever, which starts with flu-like symptoms, but can be fatal within three days if not treated. Various other tick-borne diseases cause symptoms resembling the flu or malaria.

While climate change is not likely to affect the overall rate of infections, it is expected to change their distribution. Temperature, seasonal timing, land use and cover, soil type, humidity, and elevation all affect the rate of infections from tick bites through their influence on the tick's life cycle and activities.[43] Regions of the country that become drier will find some relief from tick-carried disease, while regions that become warmer and more humid might experience these infections for the first time. The elderly and those with compromised immune systems are most likely to develop severe infections, and account for the majority of deaths.

Rodent-carried disease | Climate change would increase the frequency and severity of droughts, particularly in the Southwest, which will in turn increase the transmission of hantavirus and other rodent-carried diseases. Climate change increases rodent populations when drought kills their predators or when rains increase their food supplies. In 1993, there was an outbreak of hantavirus pulmonary syndrome in the Southwest. The hantavirus is initially marked by flu-like symptoms; however, within three to five days, victims experience extreme coughing and shortness of breath, then acute respiratory distress.

Water-related disease | Brown algal tides and toxic algal blooms occur along the Atlantic and Gulf coasts, causing red tides. As climate change warms the seas, the intensity, duration, and extent of these blooms would increase. Red tides damage habitat and shellfish nurseries, can be toxic to humans upon contact, and can carry bacteria like those causing cholera. People who eat shellfish infected with algal toxins fall prey to diseases[44] with effects ranging from minor gastrointestinal irritation to acute respiratory failure.

Inland, increased runoff from heavy rainfall would increase water-borne diseases such as giardia, cryptosporidia, and viral and bacterial gastroenteritis—all gastrointestinal diseases with symptoms such as diarrhea, stomach cramps, and vomiting.

43. For example, one major type of disease-carrying tick lays eggs that hatch, develop, and are active only if the temperature and humidity range is right for each stage. The tick will not deposit eggs at temperatures below 46°F. The larvae will not emerge at temperatures below 54°F, and the remaining two stages of the development of the tick each require a certain number of days at 77°F. Furthermore, the activity of an adult tick depends upon a humid environment and temperatures above 39°F.

44. These diseases include Amnesic Shellfish Poisoning (ASP), Ciguatera Fish Poisoning (CFP), Diarrhetic Shellfish Poisoning (DSP), Neurotoxic Shellfish Poisoning (NSP), and Paralytic Shellfish Poisoning (PSP).

Thermal Extremes

In July 1995, a heat wave struck the Midwest, taking the lives of over 700 people in the Chicago area alone. While this event has not been tied directly to global warming, scientists expect such thermal extremes to occur more often as the climate changes. Since the United States is a temperate region, it is expected to warm more than tropical or subtropical regions. During the winter months, the number of cold-related deaths and illnesses may decrease. On the other hand, heat-related illnesses and deaths are expected to increase.

For a number of reasons, the increase in summer climate-related deaths would probably outweigh the decrease in winter deaths. First, climate trends indicate an increase in maximum seasonal temperatures, but not in minimum seasonal temperatures (Watson 1998). Twice as many people die in the United States from extreme heat as from extreme cold. Moreover, cold-related deaths are usually the result of occasional cold spells in areas with mild winters or of rare extreme snowstorms or cold snaps, which climate change is not expected to affect (Watson 1998; EPA 1999).

One study using current population statistics estimates that a doubling of CO2 would reduce annual cold-related deaths by 59 to 123 among the elderly and 25 to 68 among other age groups (Titus 1992, 38). However, in the fifteen largest American cities it would also increase heat-related deaths by 529 to 3878 among people over sixty-five and 513 to 2368 among other age groups (Kalkstein 1992, 378–9). That translates to a 90 to 540 percent increase in total deaths, depending upon how well people acclimate to the heat![45]

Surprisingly, heat-related deaths occur more often from complications of pregnancy, ischemic and coronary heart disease, injuries, and cerebrovascular disease than from heat stroke and exhaustion. However, cases of heat stroke and exhaustion may also increase along with other heat-related illnesses such as heat cramps, heat rash, and fainting (Kalkstein 1992; Strock 1992; Watson 1998).

Most studies on the effects of heat-related deaths find different mortality and morbidity rates based on age, race, and sex. All studies find that the elderly are at a particular risk of dying from heat, partly because sweating efficiency decreases with age, as does the ability of the heart to adjust its output. In addition, the medications taken by many elderly patients make them more susceptible to heat.

The studies, however, do not find consistent results based on race or sex. For example, some find women more likely to die in heat waves (attributed to differences in

45. The range of effects is due to various scenarios assumed in the models. Scientists expect some acclimatization, but they do not know how quickly or successfully. People in warmer climates are less likely to die in heat waves than residents of cooler climates. This is because they are both physically acclimatized to the heat and have adjusted their lifestyle and environment to accommodate heat.

attire), while others find men more susceptible. As table 9 demonstrates, a study in St. Louis finds that nonwhites (mostly blacks) are more affected by the heat than whites.[46] However, a study in New York finds whites more susceptible. The difference probably means that socioeconomic status is a more significant factor in susceptibility to heat-related death than race. Many people who die in heat waves are poor inner-city residents who cannot easily escape to a cooler space (Kalkstein 1992).

TABLE 9: **MEAN DAILY MORTALITY FOR EACH TYPE OF SUMMER WEATHER IN ST. LOUIS**

Type of Weather	Whites	Nonwhites	Elderly	Total
cool, continental	69	25	60	94
transitional	71	29	63	100
maritime	71	27	63	98
overrunning	68	25	59	93
maritime tropical, cloudy	72	28	64	100
maritime tropical, sunny	73	30	64	103
transitional to maritime	70	27	60	97
frontal wave	70	25	60	95
oppressive, tropical	88	41	84	129
cold front passage	68	25	59	93
overall mean excluding oppressive, tropical	70	27	62	97
percent that oppressive, tropical exceeds overall mean	26	52	36	33

Source: Kalkstein 1992, 375

Since many people in the warmer, southern states are more acclimated to heat, people in northern and western states are more likely to be at risk. However, some research indicates that the increased heat waves in currently hot areas may make those areas intolerable.

Many studies find that urban residents are more susceptible to heat waves than suburban and rural residents, due to the urban heat island effect. The heat island effect occurs when warmer temperatures and bright sunlight combine with air pollution to cause cardiovascular and respiratory disease. Also, urban areas tend to experience other socioeconomic conditions that make people more vulnerable to heat (Klein and Tol 1997, 18).

46. The weather condition "oppressive, tropical" is the type of weather equivalent to the heat waves that are likely to increase from climate change. Notice that periods of this weather condition have many more deaths than any other. Further, the bottom row indicates that heat waves affect nonwhites more than whites—heat waves increase nonwhite deaths by 52 percent, while only 26 percent for whites.

Kalkstein (1992) finds a strong relationship between hot weather and mortality in Boston, Memphis, New York City, Philadelphia, and St. Louis; moderate risks in Chicago and San Francisco; and little risk in Atlanta, Dallas, and Seattle. A different study projects that Atlanta would see an increase in heat-related deaths from the current 80 per year to 150 to 440 per year in 2050 (IPCC 1996; Environmental Defense Fund et al. 1998).

Vulnerability

The impacts of climate change would fall most heavily upon those who are most susceptible to health problems: the elderly, the very young, the infirm, and those without access to healthcare. The elderly and infirm are at high risk because their organs and immune systems are compromised; the very young because their organs and immune systems have not yet fully developed; and those without access to healthcare because they are more likely to have poor health and less access to treatment.

Access to healthcare plays a major role in the vulnerability of Americans to the impacts of climate change. An estimated 43 million Americans do not have health insurance, often making the cost of a doctor's visit beyond their reach. Even if they have the financial resources, many rural residents must travel great distances to see a family doctor, and even further to visit a hospital with adequate medical equipment. These households are more likely to have health problems, rendering them more susceptible to the adverse impacts of climate change such as thermal extremes and increased air pollution. Most of the infectious diseases that are expected to increase can be kept under control by early diagnosis and treatment. However, for households without adequate access to healthcare, those diseases may prove fatal.

SOCIAL AND CULTURAL EFFECTS

Climate change will also have less quantifiable, but equally real social and cultural effects on consumers. Changing ecosystems will displace people from their homes both outside and within the United States. Extreme weather events such as hurricanes, flooding, landslides, and wildfires are expected to disrupt an increasing number of lives, as would periods of drought punctuated by heavy rains. Changing agriculture and industries could force people to abandon their hometowns in search of employment. As noted in chapter 2, in 1998, there were 25 million environmental refugees, more refugees than caused by war and conflict (International Federation of Red Cross and Red Crescent Societies 1999). Climate change is expected to increase this number.

TABLE 10: POSSIBLE IMPACTS OF CLIMATE CHANGE ON HUMAN HEALTH AND VULNERABLE GROUPS

CLIMATE CHANGE EFFECTS	HEALTH OUTCOMES	VULNERABLE GROUPS
DIRECT		
Exposure to thermal extremes	Altered rates of heat- and cold-related illness and death	Elderly; those living alone; infants; low-income people; those with preexisting cardiovascular, cerebrovascular, and respiratory disorders; Northeastern and Midwestern residents; urban residents
Altered frequency and/or intensity of other extreme weather events	Deaths, injuries, psychological disorders; damage to public health infrastructure	Coastal residents, residents in floodplains, those predisposed to psychological disorders, low-income people, residents of the far north
INDIRECT		
Disturbances of ecological systems:		
• Effects on range and activity of vectors and infective parasites	Changes in geographic ranges and incidence of vector-borne diseases such as mosquito-carried malaria, dengue fever, and encephalitis; tick-carried Rocky Mountain spotted fever and Lyme disease; and rodent-carried hantavirus and leptospirosis	Rural residents; southern, humid area residents will be at a higher risk for mosquito-borne diseases; areas that become drier might see lower tick-borne diseases, while areas that become warmer and wetter might see an increase; areas such as California and Arizona at risk for rodent-borne diseases
• Altered local ecology of water-borne and food-borne infective agents	Changed incidence of diarrheal and other infectious diseases, red tides	People with compromised immune systems, coastal residents, children, elderly
• Altered crop (especially food) productivity, due to changes in climate, weather events, and associated pests and diseases	Malnutrition and hunger, and consequent impairment of child growth and development	Children, low-income people, elderly, people tied to the land
Sea level rise, with population displacement and damage to infrastructure	Increased risk of infectious disease, psychological disorders	Coastal residents
Levels and biological impacts of air pollution, including pollens and spores	Asthma and allergic disorders, other acute and chronic respiratory disorders and deaths	Urban residents, those with preexisting allergies and respiratory disorders
Social, economic, and demographic dislocations due to effects on economy, infrastructure, and resource supply	Wide range of public health consequences: mental health and nutritional impairment, infectious diseases, civil strife	Low-income people, children, elderly, low-skilled workers, people tied to the land

Source: Adapted from Intergovernmental Panel on Climate Change 1996, 565.

Migration

Two types of human migration will likely increase: (1) migration within the United States as people are displaced by forest fires, floods, drought, and sea level rise; and (2) increased immigration from other nations.

More than half of the American population lives within 50 miles of the coast. Some states, such as Florida and California, have hundreds of miles of coastline that are vulnerable to rising sea levels. As sea levels rise, people would be forced to leave their homes. Workers in adversely impacted industries may have to relocate. For example, residents of areas that depend upon declining tourism might not be able to find work nearby.

Particularly vulnerable are residents of barrier islands and coastal areas such as Long Beach Island, New Jersey, and Miami, Florida; people living near floodplains such as St. Louis, Missouri, and Sacramento, California; and population centers near dry, fire-prone areas such as Los Angeles and San Francisco. Forced migration within the United States could mean cultural losses both for those who must leave areas they have lived in for many generations, and for those in the areas where people resettle. Pressure on urban infrastructure and more suburban sprawl are likely outcomes of forced migration within the United States.

While habitat in the United States is expected to experience relatively mild effects of climate change, island nations and tropical areas may become unlivable. Some island nations may be completely submerged. Warming in some areas may disrupt their populations enough to increase immigration to the United States. Sea level rise and hurricane damage are expected to hit the Caribbean hard. Mexico, the leading source of immigrants to the United States, would see increased drought.

Extreme Weather Events

Scientists believe that warming temperatures have already increased the frequency of extreme weather events. The Federal Emergency Management Agency (FEMA) declared less than twenty natural disasters per year in the 1950s and 1960s, but over 40 per year in the 1990s. The 1995 Atlantic hurricane season was the most active on record. However, by the middle of the next century, the destructive power of these hurricanes is expected to increase 40 to 50 percent (Lashof 1999).

While the dollar figures presented in this section are significant, the losses associated with these disasters go far beyond what can be quantified. More difficult to measure are the social and psychological effects of losing one's family members, home, irreplaceable family heirlooms, mementos, and other items that help people form and retain a sense of identity, belonging, and personal and community history. Hurricane Floyd perpetrated such loss as it swept over much of the eastern seaboard in 1999. North Carolina residents stranded on their roofs were stunned to watch chairs once used by George Washington float down the street (Kilborn 1999).

Much of the public discussion on the effects of climate change has focused on hurricanes in the Southeast, but other regions of the country would likely see increased natural disasters. For example, erratic rainfall will contribute to wildfires, flooding, and landslides. Forest fires are likely to increase where summers become warmer and drier. The increase in fires would be particularly dangerous since many would occur in mountain areas, such as the coastal ranges of California, which border on densely populated areas. Residents in the hills of Oakland, California, discovered the danger of years of drought when the 1991 fire destroyed 3,000 homes, killed 25 people, and cost over $1.5 billion in damages.

While insufficient rain can devastate drier areas, too much rain plagues residents along waterways. The Midwest felt the force of heavy rains in 1993 when the flooding of the Mississippi and Missouri rivers took the lives of thirty-eight people (CEQ 1995). All climate models predict an increase in winter snow and rainfall in northern latitudes, from the Great Plains to the Northeastern states (Wigley 1999). The Northwest is predicted to see less snow but increased rainfall during winter months (Leung 1999).

Renters are particularly vulnerable to natural disasters. While 95 percent of homeowners have insurance to cover their economic losses, only 22 percent of renters have property insurance (Insurance Information Institute 1999).

The statistics on disaster-related losses are already striking. The disaster numbers in the next century are likely to dwarf these figures as climate change combines with increased populations in disaster-prone areas.

Leisure Activities

The advent of climate change would have different impacts on different leisure activities (table 11). The ski season is expected to be shorter in many areas of the United States, as described in chapter 2. Tennis players, golfers, boaters, and other participants in outdoor summer sports would enjoy a longer season. However, in warmer areas, the expected tripling of heat waves and increase in rainfall might make outdoor sports less appealing.

While warmer temperatures may mean more time spent on some water sports, those who enjoy scuba diving and snorkeling would experience fewer opportunities to enjoy coral reefs. A recent study predicts that coral reefs could be eliminated from most areas of the world by 2100 (Hoegh-Guldberg 1999). Cool-water fishing is expected to disappear in eight to ten states, while eleven to sixteen states are expected to see a 50 percent loss (EPA 1995). Likewise, hikers and mountain bikers may find meadows with fewer wildflowers, and forests damaged by pests, diseases, and wildfires.[47] Sea level rise threatens 25 to 80 percent of U.S. wetlands. Losses of wetlands would reduce biodiversity, limiting hunting, fishing, and birdwatching (Clarkson et al. 1995).

Every year, over 286 million people visit National Parks. However, climate changes will alter their plant and wildlife habitats. For example, areas that once grew cone forests may become too warm for the trees to develop, but the areas that could support cone forests may lie outside of the park and already be developed.

TABLE 11: **CLIMATE CHANGE IMPACTS ON LEISURE ACTIVITIES**

	POSSIBLE POSITIVES	POSSIBLE NEGATIVES
Winter Recreation	winter hiking, outdoor sports more tolerable	shorter ski season, elimination of ski season in some areas
Summer Recreation	longer warm season in cooler areas	warm regions could have more hot days that interfere with golf, tennis, other outdoor sports
Water Recreation	less snow, longer warm weather days	coral bleaching affects snorkeling, scuba; reduced cool water fishing; flooding and droughts
Biodiversity		loss of wildflowers, forests; species loss affects hunting, fishing, birdwatching

FINANCIAL IMPACTS

As mentioned in chapter 2, most studies that have attempted to quantify the overall economic damage due to climate change[48] estimate costs ranging from 1.0 to 1.5 percent of U.S. GDP each year. These numbers include not just actual expenditures, but monetary estimates of other costs, such as human health, human amenity, and biodiversity. Even if these estimates are correct, the distribution of those costs on individual households and consumers is difficult to calculate. Those impacts that would not affect households through prices of goods or through wages and employment are even more difficult to estimate. The following discussion focuses on estimated impacts via changes in prices, wages, and employment. Since climate change is expected to raise the price of necessities such as food and energy, low-income households, who spend most of their income on these goods would bear a larger proportion of the burden. However, no household will be free of impacts.

47. For example, every summer millions of people visit the alpine wildflower meadows of Washington State's Mount Rainier. The warming climate has already encouraged subalpine trees to begin displacing the meadows, reducing the diversity of the species (Environmental Defense Fund et al. 1998).

48. Based on a doubling of CO_2 concentrations by the mid-twenty-first century.

Agriculture

Agriculture will likely experience the most changes. Worldwide agricultural production is expected to decrease, leading to a likely increase in global prices. In the United States, longer growing seasons in the colder areas, heat stress in the South, increased evaporation, changes in precipitation, the CO_2 fertilization effect,[49] and changes in pest populations will all impact agriculture. Many farms in Hawaii, the Great Plains, and Great Lakes may experience higher yields. However, production is predicted to decrease by 16 percent in the Southern Plains and 21 percent in the Delta states (Adams, Hurd, and Reilly 1999). Dry land farming, which uses crop rotation to farm arid areas in Oklahoma, Kansas, and Colorado, might be eliminated by drier weather. Also in the Great Plains, increased temperatures combined with decreased forage quality would decrease the number of livestock each acre of land could support. In the South and Southeast, corn and soybean yields may decline.

Households that rely upon farming in the Southern Plains and Delta states will see their incomes fall from decreased agricultural production. Because low-income households spend a greater proportion of their income on food, increased food prices strain their household budgets more than those of middle- and upper-income households.

Insurance

After agriculture, the insurance industry is perhaps the sector most vulnerable to planetary warming. Changes in the insurance industry could mean higher premiums, loss of coverage, and even a crippling of the industry.

Insurance companies rely upon historical evidence to predict the likelihood of catastrophic events and the magnitude of damage. Climate change is expected to increase the threats to insured property (for example, hurricanes and fires), making predictions based on historical trends inaccurate. Since average temperatures are not expected to increase at a steady rate, the effects of this warming would be even more difficult to forecast. Insurance companies would pass on the increased risk to consumers in the form of higher premiums.

An insurance industry research study estimates that a class-5 hurricane (equivalent to the Caribbean's Hurricane Mitch in 1998) hitting Miami or a class-4 hurricane (equivalent to Florida's Hurricane Andrew in 1992) in New York City would cause $50 billion in damages. Such an event could seriously weaken the U.S. insurance industry, potentially leading to regional blight and low availability of insurance (World Press Review 1995). A series of unanticipated disasters could raise insurance premiums and cause companies

49. Carbon dioxide is a natural fertilizer. Just as humans breathe in oxygen and exhale carbon dioxide, plants take in carbon dioxide and release oxygen. Increases in the concentrations of CO_2 will increase the productivity of agricultural crops.

to withdraw entirely from some areas. This would make coverage for hurricane damage considerably more expensive, just as earthquake insurance premiums rose significantly in the years following the 1989 Loma Prieta earthquake. Coastal property is most at risk as sea levels rise and tropical and marine storms increase in frequency and intensity. Such risk is significant: There is over $2 trillion in insured property along the Atlantic and Gulf coasts alone.

Moreover, banks will not lend money to homeowners if they do not have insurance. This could require people with hurricane-damaged property to pay out of pocket—or not make the repairs. Without insurance, a household that fell prey to violent winds could lose everything without the ability to rebuild their lives.

In addition to consumer concerns, the insurance industry itself could suffer greatly from climate change. For example, the damage from Florida's Hurricane Andrew in 1992 left eight insurance companies bankrupt. A series of major disasters that left the industry crippled could force taxpayers to bail out the industry, as in the S&L crisis, in order to retain insurance coverage.

Buildings and Infrastructure

The impact of climate change on the construction industry, which underlies every segment of the economy, is unclear. Climate change may increase the length of the construction season, but increased rainfall and heat waves would delay projects, while increased hurricanes and tornadoes would damage existing buildings and infrastructure such as roads and sewer lines.

Construction delays increase building costs, which would be passed on to consumers in the form of higher product prices. In addition, older urban buildings, in particular, may not be designed to withstand the increase in severe weather, and so would have higher maintenance costs (Clarkson et al. 1995). These older residential buildings are primarily occupied by the elderly and low-income families, who would already be more susceptible to climate changes.

Energy Use

An overall warming would reduce the amount of energy needed to warm homes. On the other hand, households would increase their use of air conditioners. Unfortunately, cooling a space by one degree costs more than heating a space by the same amount.[50] Consequently, scientists predict an overall increase in demand for ener-

50. This is because air conditioners and fans require electricity, which is a more expensive form of energy. Also, most cooling is done during the peak daytime hours, whereas people usually heat their homes at night. Additional energy at peak times is more expensive than additional energy at peak times because facilities (e.g., powerplants, powerlines, or gas pipelines) must be sized to handle peak loads.

gy. In Texas, for example, energy use is expected to rise by 10 to 15 percent (North et al. 1995).

This rise in energy demand would increase prices. In northern California, changes in water management would also affect the production of hydropower. Currently hydropower production is greatest in the summer months, when electricity demand is also greatest. However, climate change would shift the bulk of hydropower production to the winter months (because of the change in rainfall), while the demand would still be greatest in the hot summer months. As a result, power companies would have to rely more heavily upon fossil fuels, increasing the cost of electricity almost 13 percent (EDF et al. 1998).

Warmer temperatures would induce people to use air conditioning not only in their homes but in their automobiles, as well. Drivers in the United States currently use up almost four billion gallons of gasoline per year air conditioning their cars (Titus 1992, 389). For every 10,000 miles driven, the air conditioner uses twenty gallons of gas. Titus estimates that climate change would cost American drivers around $2 billion in 2060. This cost would fall hardest on rural households, who drive over 4,000 more miles per year on average than urban households, as well as on drivers in warmer states.

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