Oregon Task Force on Global Warming
Report to the Governor and Legislature

Part One:

POSSIBLE IMPACTS ON OREGON FROM GLOBAL WARMING

Part Two:

STATE AGENCY RECOMMENDATIONS AND PROPOSED ACTIONS

June 1990

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TABLE OF CONTENTS

PART TWO

STATE AGENCY RECOMMENDATIONS AND PROPOSED ACTIONS

Summary

BACKGROUND

Governor Neil Goldschmidt created the Oregon Task Force on Global Warming in late 1988. The task force is composed of 12 state agencies. He charged the task force to review current scientific knowledge and assess how global warming could affect the state. He also charged it to report back to him and the legislature on how the agencies propose to respond to the threat of global warming. This report summarizes the agencies' findings about potential impacts and the actions they intend to take.

Conclusions

The task force reached five basic conclusions:

- *Climate change from global warming is a serious threat.*
- *The rate of change and the impacts of change on the state are uncertain.*
- *Oregonians can insure themselves against some of the changes by taking prudent actions to slow the emission of greenhouse gases and by planning to adapt to changes.*
- *Many of the actions we should take will offer other, more immediate benefits through cost-effective energy and water conservation, environmentally benign energy development, reforestation, and wise resource planning.*
- *While this is a global problem, everyone must be part of the solution.*

Greenhouse Effect

Sunlight passes through the atmosphere and warms the earth's surface. The earth then radiates infrared energy, but trace gases and water vapor absorb part of the infrared radiation. The gases then emit some of the radiation back to earth, further warming the surface. This warming of the surface air is known as the *greenhouse effect.*

Scientists project that increased emissions of greenhouse gases will warm the earth rapidly. Climate change in 50 to 100 years could be as great as the change over the last 10,000 years. Climate models estimate the world risks a 3° F to 8° F warming. Such a rapid increase in temperature would disrupt natural and social systems. However, there is uncertainty regarding how much and how quickly the climate will warm. We do not have scientific predictions of change for the region or the state.

The gases that are of most concern are carbon dioxide, methane, nitrous oxide, and chlorofluorocarbons (CFCs). Carbon dioxide contributes 70 to 80 percent of the potential warming. Americans contribute about five times as much carbon as the world average per capita.

Oregon's Contribution

Oregon adds most to global warming by burning fossil fuels, which creates carbon dioxide. Oregon generates about 40 million tons a year of carbon dioxide from all sources. Transportation contributes the largest share of carbon dioxide, about 53 percent. Oregon has no CFC manufacturers. Apportioning U. S. use on a per capita basis, Oregon accounts for about 9 million pounds of CFCs. The largest amount of methane for Oregon from human activity comes from the cattle and other ruminants we raise. Natural gas use and landfills are also important. Human activity generates more than 200,000 tons of methane a year in Oregon.

POTENTIAL IMPACTS

Water

Changes in climate will change the amount and distribution of water in the state. Such changes would affect municipalities, forests, agriculture, fish and wildlife, recreation, and the state economy. Changes in precipitation, cloud cover, wind, temperature, and ocean currents could fundamentally alter historic storm patterns in the Northwest. There could be higher rates of evaporation from soil, lakes, and streams. If Oregon's climate becomes warmer with less snow pack and drier summers, the water levels and flows in streams, lakes, and aquifers could decline. Warmer water could also harm salmon and trout and cause water quality problems.

Competition for Oregon's water supplies is increasing regardless of climate change. Climate change could further reduce water supplies. A water shortage would limit the state's economic and population growth and impact irrigated agriculture, fisheries, and water-based recreation.

Sea Level

Sea level may rise one to three feet over the next 100 years. A rise in sea level could flood low-lying areas, causing estuaries and open coastal areas to retreat inland or disappear. Estuaries could lose species adapted to existing flow and salinity patterns. Surface water supply intakes in the tidal zones of coastal streams and water wells near the coast could become unusable as a result of salt water intrusion. Sea level rise could enhance the impact of coastal storms.

Forests and Wildlife

Changes in climate would affect the abundance and distribution of Oregon's plants and animals. Shifts in vegetation would affect the distribution of many plant and wildlife habitats. If the change is rapid, many species may not be able to adapt.

Higher temperatures could cause evapotranspiration to exceed precipitation, resulting in a drier climate with longer periods of drought. The frequency and severity of pests and wildfires may increase. The potential rate of climate change may cause trees to die faster than tree species can "migrate." Harsher conditions could increase the difficulty and cost of reforestation. The total amount of forested area may decrease. The make-up of our forests could be very different. What is now Douglas-fir could be replaced by pine and hardwoods.

Wildlife depend on the vegetation in the animals' home range for food, shelter, and seclusion. Without moderating vegetative cover, animals experience colder temperatures in winter and warmer temperatures in summer for longer periods each season.

Agriculture

Climate is the main factor that limits agricultural production. Global warming would probably shift crop growing zones northward. Net impacts on crop yields are unknown. Some crops could benefit. Warmer weather and more rain could make the growing season longer. Crops may mature earlier. However, the amount and timing of precipitation are critical in determining effects on crops. A warmer, drier climate could also increase the need for irrigation.

Energy

The largest impact of global warming on our energy system may be on the hydroelectric power system. Hydropower provides about 70 percent of the region's electricity. The

hydro system depends on the snowpack for water storage. That natural storage may decline, resulting in lower stream flows in the summer.

Air Quality

Global warming could aggravate air pollution. The amount of ozone pollution is directly related to the intensity of ultraviolet radiation and temperature. With more hot summer days and increased emissions from industrial and population growth, there could be more ground-level ozone.

The Economy

Rapid changes in our natural resource base--our forests, agriculture, fisheries, and recreation sites--would significantly affect our economy. In addition, most climate models predict severe drying in the mid-continental United States. This could cause a general migration to northern coastal states, such as Oregon.

Changes in water flows or flooding patterns could affect our water and sewage treatment plants. Roads and bridges could be damaged, especially along the coast.

Emergency Management

The chance of extreme weather events will probably increase with global warming. More precipitation could increase flooding and landslides. There could also be more droughts.

RECOMMENDATIONS AND PROPOSED ACTIONS

There are two basic strategies to address global warming. One is to stop or limit the contribution of gases that lead to global warming. The second is to adapt to the impacts of global warming. Both approaches are necessary. Each is a prudent response--an insurance policy in the face of the uncertainty of the extent of the changes.

This report lists proposed actions by agency rather than by topic. This approach allows each agency to say what it plans to do. This keeps the focus actions and the agencies responsible. This approach means some topics are discussed by more than one agency. The task force also makes general recommendations.

GENERAL RECOMMENDATIONS

In addition to the agencies' proposed actions, the task force makes recommendations that are broader in scope.

The State should:

1. Adopt comprehensive policies to promote maximum flexibility and resilience to climate change.

2. Reduce net greenhouse gas emissions.

3. Consider climate change in state agency programs and plans, beginning in the 1991-1993 biennium.

4. Create a permanent Global Warming Management Group headed by the governor's natural resources assistant.

5. Incorporate into the state's geographic information system data on climate change impacts on natural resources and socio-economic conditions.

6. Continue to pursue federal or private funding to support global warming research specific to Oregon and the Northwest.

7. Work with Oregon State University to fund jointly the position of State Climatologist.

8. Encourage, through the Oregon congressional delegation, an ample allocation of federal funding for long-range climate forecasting.

9. Develop materials and programs to inform the public about climate change issues, problems, and solutions.

AGENCY PROPOSED ACTIONS

DEPARTMENT OF ENERGY

ODOE will:

1. Work with the Oregon congressional delegation to adopt federal legislation to address global warming.

   1.a. Increase the average miles per gallon standards for automobiles; and/or, adopt a federal carbon tax.
   1.b. Work for an increase of funding for low-income weatherization programs.
   1.c. Support use of oil-overcharge funds for low-income weatherization programs.

2. Work with federal agencies to encourage actions to reduce the emission of greenhouse gases.

   2.a Work with the U.S. Department of Energy (US DOE) to develop a federal energy policy based on energy conservation and renewable energy resources.
   2.b Work to convince the U. S. Department of Housing and Urban Development to adopt manufactured housing standards at least as stringent as the Oregon Building Code.
   2.c Work to convince the US DOE to revise federal appliance efficiency standards to cost-effective levels.

3. Include global warming in its cost-effectiveness methodology.

4. Focus state incentive programs to capture conservation in the industrial and commercial sectors.

5. Fund two alternative fuel demonstration projects.

6. Work with others to adopt all cost-effective measures in Oregon's 1992 residential building code.

7. Work with utilities to help them increase participation in their new home programs to 45 percent built to model conservation standards in 1990 and 60 percent in 1991.

8. Work for adoption of new commercial building standards.

9. Work with the Building Codes Agency, local governments, and utilities to find ways to improve enforcement of the energy-related parts of residential and commercial building codes.

10. Train building operators to operate building energy systems efficiently.

11. Work with utilities to implement utility commercial and industrial conservation programs.

12. Work with utilities, Bonneville, the Power Council, and other states to increase participation in utility appliance efficiency programs.

13. Work with utilities and public agencies to increase effectiveness of weatherization programs.

    13.a Increase utility incentives to ensure all cost-effective measures are installed at one time in rentals and low-income housing.

    13.b Increase utility home weatherization efforts in line with utility least-cost plans.

14. Work with utilities to improve existing residential, commercial, government, and industrial programs.

15. ODOE and PUC should work with utilities and regional and national organizations to find a way to fund research and demonstration projects for renewable energy.

PUBLIC UTILITY COMMISSION

The PUC plans to continue work on issues related to global warming. The potential effect on global warming will be considered in Commission decisions whenever applicable. In addition, the PUC will:

1. Encourage industrial, commercial, and residential conservation as a first-priority resource, consistent with least-cost planning guidelines. Incentives that improve commercial lighting efficiencies will receive increased emphasis. By some estimates, cost-effective energy conservation can meet as much as one-half of new load growth by 2010.

2. Work with the Bonneville Power Administration and the Northwest Power Pool to promote increased engineering studies of the Columbia-Snake Basin to plan for global warming adaptation measures. Adapting to the new climate would require accommodating increased stream flow and runoff in the winter and reduced stream flow in the summer. PUC will also encourage the federal government toward greater cooperation with Canada in the interest of regulating stream flow.

3. Ensure that regulatory policies and actions encourage installation of cost-effective energy conservation measures.

4. Work with others to see that the plan for reducing greenhouse gases, as mandated in Senate Bill 576, minimizes resource misallocation by pursuing a least-cost approach. Ensure that such a plan divides the burden equitably among all industries and regions of the state.

5. Work with the Energy Facility Siting Council, the Northwest Power Planning Council, and the Strategic Water Management Group to evaluate the prospects for new hydropower development in the light of the threat of global warming.

6. Work with the Oregon congressional delegation on legislation affecting global warming.

7. Ensure that external environmental costs are appropriately included in least-cost planning.

8. Work with the Department of Environmental Quality and other agencies on the evaluation of externalities and assigning costs.

DEPARTMENT OF TRANSPORTATION

ODOT will:

1. Incorporate global warming information into the design of transportation facilities in Oregon.

2. Encourage the development of an energy-efficient transportation system in Oregon.

3. Coordinate land use and transportation.

4. Implement and investigate measures encouraging energy-efficiency in transportation services and facilities.

5. Cooperate with other agencies concerning global warming issues.

DEPARTMENT OF ENVIRONMENTAL QUALITY

DEQ will explore the need to:

1. Initiate and maintain an inventory of greenhouse gas emissions.

2. Conduct air conditioner leak checks in the DEQ auto inspection lanes.

3. Limit carbon-based emissions via the DEQ's permitting and offset program procedures.

4. Design contingency plans to mitigate the impact of any increase in air pollution formation caused by global warming.

5. Respond to reduced stream flows by reducing allowable pollutants in facility effluents and enhancing stream flows.

6. Respond to rise in sea level by requiring protection of existing low-level waste treatment facilities and elevated siting of new facilities.

7. The DEQ will investigate the following activities with the goal of doubling the recycling rates in Oregon in the next ten years:

7.a. Increased service standards for recycling collection programs.
7.b. Increased education and promotion requirements.
7.c. Minimum recycled content requirements for certain items that can be made from recycled material.
7.d. Increased recycling market development by the state and local governments.
7.e. Prohibition on landfilling of commercial loads of waste that contain significant amounts of recycled material.
7.f. Regulation of packaging to insure recyclability.
7.g. Require recycling by governments and institutions.
7.h. Establishing disposal rate incentives to encourage the use of recycling programs.
7.i. Mandatory recycling.

DEPARTMENT OF FORESTRY
ODF will:

1. Maintain high standards of reforestation through the Oregon Forest Practices Program.

2. Promote programs to increase tree planting on unstocked and understocked lands.

3. Encourage broad genetic diversity in commercial tree species.

4. Develop and encourage strategies to maintain broad biological diversity in forests.

5. Encourage programs and policies to reduce emissions from slash burning and wildfire.

6. Encourage ecologically sound forest management practices that encourage carbon uptake and storage.

7. Monitor insect and disease damage and population trends.

8. Promote policies to maintain Oregon's forest land base.

9. Provide information and training on forest practices that mitigate global warming to department clients and the citizens of Oregon.

10. Improve energy efficiency and conservation in department's facilities and operations.

DEPARTMENT OF AGRICULTURE

The department will:

1. Encourage the adoption of cost effective water conservation techniques and technologies.

2. Evaluate the potential benefits from the adoption of low input, sustainable agricultural practices where appropriate in order to reduce the emissions of greenhouse gases related to agriculture.

3. Assess the vulnerability of the components of Oregon's agricultural production to climate change and uncertain weather.

4. Evaluate the adequacy of Oregon's resources and capabilities to develop successful adaptive responses.

5. Consider establishing an agricultural weather service to support the increased weather informational needs of future agricultural management systems.

6. Continue to restore and preserve the natural botanical diversity in Oregon's rangelands, wetlands, and forest ecosystems.

WATER RESOURCES DEPARTMENT

WRD will:

1. Use climate change information to assess water availability and allocate supplies.

2. Consider the potential effects of sea level rise on water supply sources and systems along the Oregon coast.

3. Monitor projected demographic trends and implications for water management.

4. Assess water conservation potential.

5. Develop ground water information and identify vulnerable aquifers.

6. Consider climate change in water resources management and planning.

7. Consider how water laws and institutions may be affected by climate change.

8. Work with federal, state, and local agencies to evaluate the needs and strategies for optimizing the use of existing water supplies and protecting sites for future water storage.

9. Incorporate information on existing stored water supplies and identify potential storage sites as needed during basin planning. Participate in review of potential storage sites as warranted.

DEPARTMENT OF FISH AND WILDLIFE

ODFW will:

1. Maintain biological diversity of fish and wildlife through maintenance of Oregon's remaining habitat for indigenous fish and wildlife.

2. The agency will take steps to counter the effects of global warming in vegetative communities and their associated vegetative structure and microclimates. These steps include working with land management agencies and landowners to:

   2.a. Plant tree, shrub, grass, and herb species adapted to the warmer and drier climate, but indigenous to the region.

   2.b. Encourage a variety of timber harvest methods appropriate for the ecological site in both western and eastern Oregon that maintains the habitat conditions suitable for continuation of resident wildlife species.

2.c. Manage wildlife cover and forage stands according to topographic variables such as slope and aspect. Take advantage of the soils' inherent potential to produce the desired vegetation species.

2.d. Manage vegetation stands to maintain multiple layers (e.g., mature trees, young trees, shrubs, herbs, and grasses) to provide both thermal cover and forage for wildlife.

2.e. Increase control of evaporation from water sources (springs, seeps, and lakes).

3. Maintain biological diversity of fish and wildlife through regulation of harvest.

4. Prevent artificial introduction of exotic species and stocks that have the potential to reduce diversity among and within indigenous species.

5. Maintain diversity within and among artificially propagated stocks.

6. Promote, conduct, and/or synthesize research that will enable the agency to manage fish and wildlife in a situation of rapid and unpredictable climate change and increased UV radiation.

7. Reduce dependence on artificial propagation of fish and wildlife and increase energy-efficiency of remaining propagation activities to reduce emissions of greenhouse gases and ozone depleting chemicals.

8. Reduce emissions of greenhouse gases and ozone depleting chemicals at all agency facilities.

9. Provide public information on: (1) the potential effects of major climate changes and increased UV radiation on Oregon's fish and wildlife resources; (2) the need for maintaining biological diversity as insurance for sustaining these resources; and, (3) citizen actions to minimize releases of greenhouse gases and ozone depleting chemicals.

DEPARTMENT OF LAND CONSERVATION AND DEVELOPMENT

DLCD will:

1. Promote urban growth management strategies that foster the design and implementation of mass transit systems and that encourage more energy efficient, compact communities.

2. Encourage and support transportation plans that reinforce compact urban design, reduce the demand for additional highways, protect farm and forest land, and provide energy efficient transportation of goods and people.

3. Assist local governments to strengthen comprehensive plans and to implement ordinances for solar access and passive solar design.

4. Assist local governments, especially on the coast, to review and improve comprehensive plans to consider fully the effects of sea level rise and to take actions to direct private development and public facilities away from areas that may be flooded or affected by sea level rise.

5. Support economic development activities and land uses that conserve land resources, promote energy efficiency, reduce transportation demands, and contribute to compact urban design.

6. Coordinate with state and federal agencies and local governments to identify and protect areas where potential energy resources, especially geothermal, solar, and wind, could be developed.

EMERGENCY MANAGEMENT DIVISION

EMD will:

1. Work with members of state agencies, qualified experts, and representatives of local governing bodies to adapt and adjust current emergency plans to identified changes in the vulnerability of population, property, and resources in Oregon to existing and emerging hazards.

2. Ensure that proper protective procedures are in place for existing and newly developed water storage and/or energy generation projects that may be built to alleviate the effects of climatic changes.

3. Provide information and education to local emergency managers about the cause and effects of global warming in relation to their jurisdictions and about the help available to them from federal and state resources for disaster assistance.

4. Coordinate with local emergency management officials to mitigate the effects of increasing sea levels to shorelines and property in coastal areas.

5. Assist in the smooth transition of planning for changes in water supplies and quality.

6. Coordinate with federal, state, and local agencies to mitigate the effects of drought, severe storms, utility disruptions, and other threats to agriculture and forestry.

7. Adapt more sophisticated methods to determine which responses could reduce or control the potential threats to the State of Oregon.

ECONOMIC DEVELOPMENT DEPARTMENT

1. OEDD will designate one office to coordinate the agency's involvement in global warming issues.

2. The Oregon Progress Board will consider the potential impacts of global warming in its efforts to refine Oregon's strategic plan, *Oregon Shines.*

3. OEDD's Administrative Services Division will review the agency's policies and facilities to search for ways to reduce OEDD's contribution to greenhouse gas production.

PREFACE

Governor Neil Goldschmidt created the Oregon Task Force on Global Warming in late 1988. The task force is composed of 12 state agencies. He charged the task force to review current scientific knowledge and assess how global warming could affect the state. He also charged it to report back to him and the legislature on how the agencies propose to respond to the threat of global warming.

Part One provides an overview of global warming and shows the potential impacts on Oregon from global warming. Part Two provides recommendations and actions state agencies propose.

The potential effects reported in Part One report are speculative. They are not predictions. Little information is available now on how global climate changes might affect Oregon. The final section of Part One discusses the challenges to the concept of global warming.

State agencies on the task force wrote the recommendations and proposed actions in Part Two. The recommendations and actions address how to adapt to change and how reduce the emission of greenhouse gases. A later report, required by the Legislature, will provide a strategy for a targeted reduction of emissions.

This report and the emissions reduction strategy are the first steps by the State to address global warming. Agency responses and actions will evolve as the changes global warming may bring become more predictable. In the next few years, the region will have better information.

Part One:
Possible Impacts on Oregon from Global Warming

Oregon Task Force on Global Warming

GLOBAL WARMING

GREENHOUSE EFFECT

Sunlight passes through the atmosphere and warms the earth's surface. The earth then radiates infrared energy, some of which escapes back into space. But, trace gases and water vapor absorb part of the infrared radiation. They then emit some of the radiation back to earth, further warming the surface. This warming of the surface air is known as the *greenhouse effect.* Scientists have understood this effect for more than a century. The greenhouse effect is a natural phenomenon that plays a critical role in making the earth habitable. In the absence of this effect, earth would be about 58° F colder.

Concentrations of the trace gases have increased over the past century. Four naturally occurring gases and one family of manufactured gases are the major greenhouse gases: carbon dioxide (CO_2), ozone, methane, nitrous oxide, and halocarbons. Chlorofluorocarbons (CFCs) and halons are halocarbons, which are manufactured chemicals. Halocarbons also destroy the upper level ozone layer, exposing the earth to more ultraviolet light.

Human activity produces greenhouse gases as by-products. The concern about global warming arises from projections that emissions of greenhouse gases will warm the earth rapidly. Climate change in 50 to 100 years could be as great as the change over the last 10,000 years. Such a rapid increase in temperature would disrupt natural and social systems. Climate zones may shift 100 miles north for each 2° F of global warming. The sea level may rise one to several feet. Major weather patterns may change.

There is scientific consensus that concentrations of greenhouse gases are increasing. Most scientists also agree that increases in greenhouse gases will change the climate. However, there is considerable uncertainty regarding the amount of warming, its timing, and the regional patterns of change. (The final section of Part One reviews challenges to the global warming concept.) Worldwide climate models, called general circulation models, estimate the world risks a 3° F to 8° F warming from the equivalent of doubling the concentration of carbon dioxide. The information generated by these models is highly uncertain. Projecting regional effects is even more uncertain.

The National Academy of Sciences (NAS) states in *Global Environmental Change* that we are irrevocably committed to major global change. NAS believes society is at risk.

It believes we must take remedial or adaptive actions soon. In 1987, the NAS estimated the likely results from doubling carbon dioxide:

• *Large stratospheric cooling*	*Virtually certain*
• *Global mean surface warming*	*Very probable*
• *Global mean precipitation increase*	*Very probable*
• *Reduction of sea ice*	*Very probable*
• *Polar winter surface warming*	*Very probable*
• *Summer continental dryness*	*Likely in the long run*
• *High latitude precipitation increase*	*Probable*
• *Rise in global mean sea level*	*Probable*

Scientists at an international meeting in Villach, Austria in 1985 gave a warning that we should prepare for change:

> *Many important economic and social decisions are being made today on long-term projects--major water resource management activities such as irrigation and hydropower; drought relief; agricultural land use; structural design and coastal engineering projects; and energy planning--all based on the assumption that past climatic data, without modification, are a reliable guide to the future. This is no longer a good assumption since the increasing concentrations of greenhouse gases are expected to cause significant warming of the global climate in the next century. It is a matter of urgency to refine estimates of future climate conditions to improve these decisions.*

GREENHOUSE GASES

Many gases contribute to global warming. Both human activities and natural processes create the gases. Gases include carbon dioxide, methane, nitrous oxide, CFCs, ozone, and 20 or so other greenhouse gases.

Figure 1 shows the United States' contributions of greenhouse gases to global warming potential: carbon dioxide, 81 percent; methane, 6 percent; CFCs 9 percent; and, nitrous oxide, 4 percent.

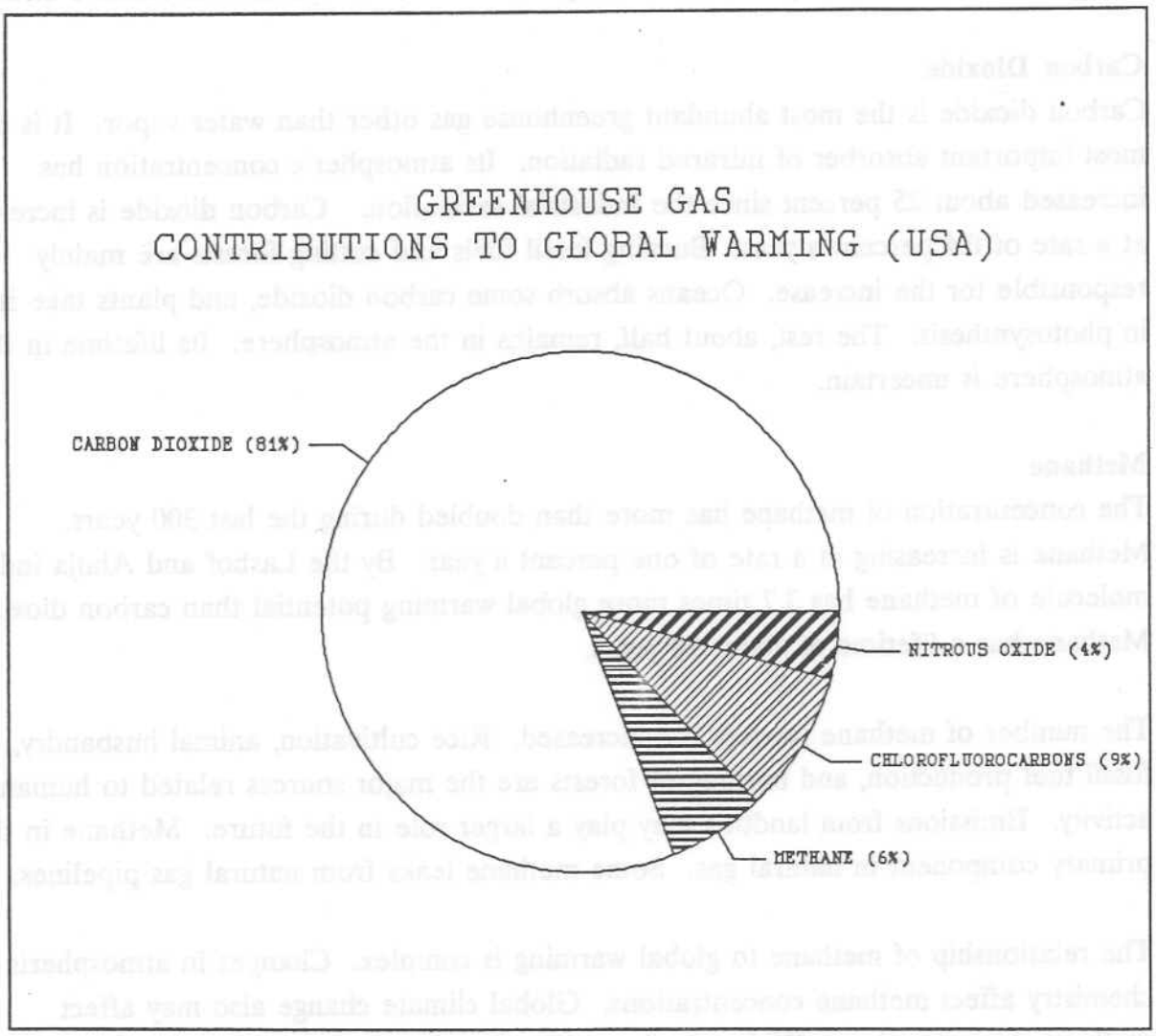

Figure 1

Source: Office of Policy, Planning,and Evaluation/ U. S. EPA

There is a convention of referring to a figurative doubling of the concentration of carbon dioxide from pre-industrial revolution times. This incorporates the effects of all gases, even though the common reference is to a doubling of the CO_2 concentration.

The different molecular structures of the gases affect their contribution to global warming. For purposes of understanding the relative global warming potential of different gases, Daniel Lashof and Dilip Ahuja have proposed an index that ranks the other gases relative to carbon dioxide. Their index accounts for the lifetime of the gases

and some to their interactions. While there is scientific uncertainty about the lifetimes and interactions of some gases, the index provides a useful indicator of relative strength.

Carbon Dioxide

Carbon dioxide is the most abundant greenhouse gas other than water vapor. It is the most important absorber of infrared radiation. Its atmospheric concentration has increased about 25 percent since the industrial revolution. Carbon dioxide is increasing at a rate of 0.4 percent a year. Burning fossil fuels and cutting forests are mainly responsible for the increase. Oceans absorb some carbon dioxide, and plants take it up in photosynthesis. The rest, about half, remains in the atmosphere. Its lifetime in the atmosphere is uncertain.

Methane

The concentration of methane has more than doubled during the last 300 years. Methane is increasing at a rate of one percent a year. By the Lashof and Ahuja index, a molecule of methane has 3.7 times more global warming potential than carbon dioxide. Methane has a lifetime of about 10 years.

The number of methane sources has increased. Rice cultivation, animal husbandry, fossil fuel production, and burning of forests are the major sources related to human activity. Emissions from landfills may play a larger role in the future. Methane in the primary component in natural gas. Some methane leaks from natural gas pipelines.

The relationship of methane to global warming is complex. Changes in atmospheric chemistry affect methane concentrations. Global climate change also may affect methane concentrations. With warming, permafrost in the Arctic may release methane. This potential effect is not included in the general circulation models.

Chlorofluorocarbons and Halons

CFCs are manufactured chemicals. CFC-12 is the most abundant form of the chemical. CFC-11 and CFC-113 are the two other major CFCs.

CFC-11 and -12 are used in refrigeration, in aerosol cans, and to blow various types of foam. The electronics industry uses CFC-113 as a solvent. CFC-114 is used for blowing foam and refrigeration. CFC-115 is used for refrigeration. Figure 2 shows common uses of CFCs and halons.

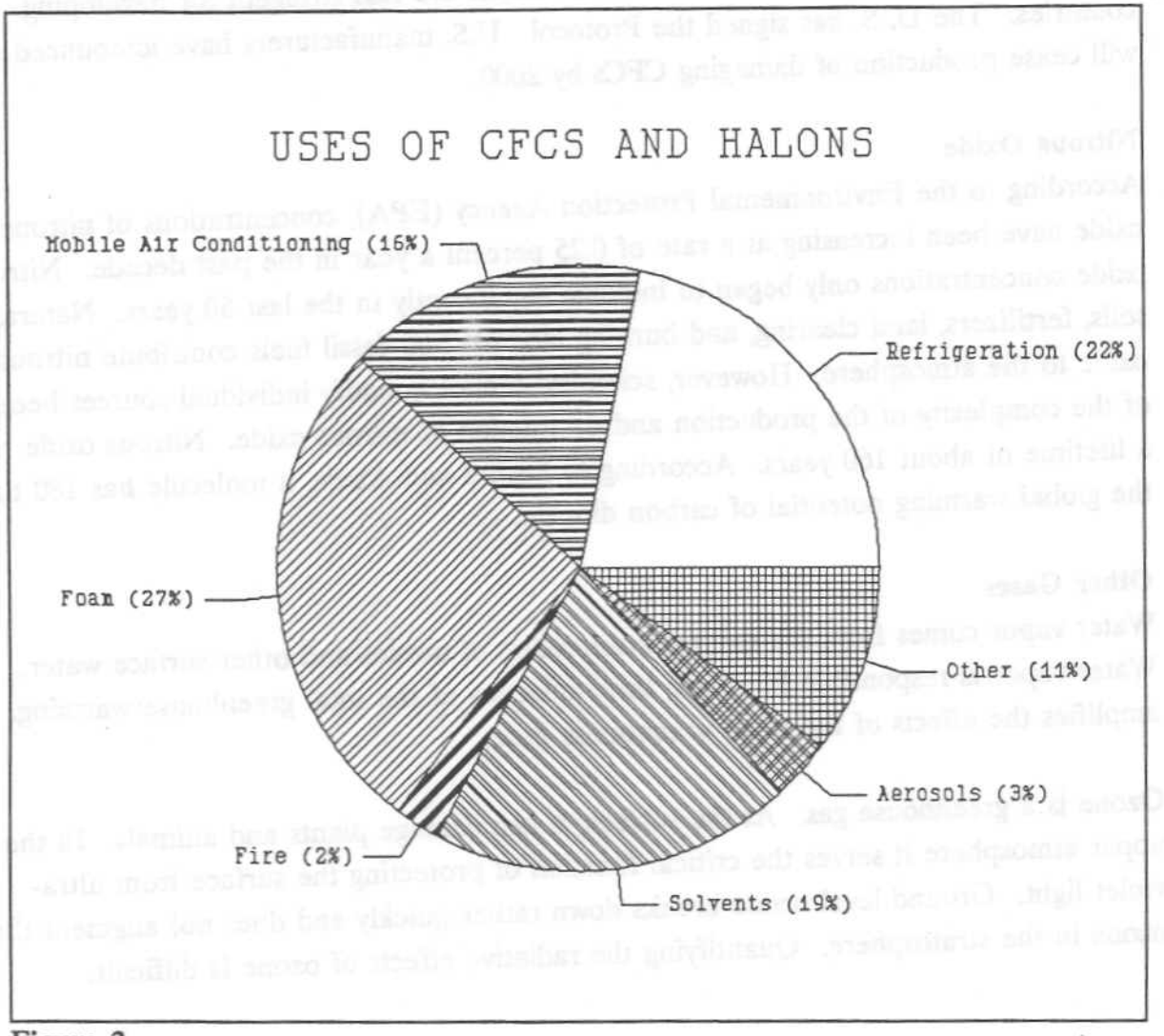

Figure 2

Source: EPA

Although the atmosphere contains only minute quantities of CFCs, they are important greenhouse gases. For example, according to Lashof and Ahuja, a molecule of CFC-11 has 4,000 times the global warming potential of carbon dioxide. CFC-12 has 10,000 times the effect of carbon dioxide. CFCs and halons remain in the atmosphere from 60 to several hundred years.

CFCs and halons also deplete stratospheric ozone, which filters ultra-violet light. Primarily because of damage to ozone, many nations agreed in the Montreal Protocol to reduce production of the more damaging halocarbons. The Protocol limits the

production of CFCs to 50 percent of 1986 levels in 1998 for developed countries. Halons are limited to 1986 levels in 1992. Limits are less stringent for developing countries. The U. S. has signed the Protocol. U.S. manufacturers have announced they will cease production of damaging CFCs by 2000.

Nitrous Oxide

According to the Environmental Protection Agency (EPA), concentrations of nitrous oxide have been increasing at a rate of 0.25 percent a year in the past decade. Nitrous oxide concentrations only began to increase significantly in the last 50 years. Natural soils, fertilizers, land clearing, and burning biomass and fossil fuels contribute nitrous oxide to the atmosphere. However, scientists cannot quantify individual sources because of the complexity of the production and destruction of nitrous oxide. Nitrous oxide has a lifetime of about 160 years. According to Lashof and Ahuja, a molecule has 180 times the global warming potential of carbon dioxide.

Other Gases

Water vapor comes from the natural evaporation of oceans and other surface water. Water vapor is responsible for about three-quarters of the total greenhouse warming. It amplifies the effects of the other greenhouse gases.

Ozone is a greenhouse gas. At the surface, it can damage plants and animals. In the upper atmosphere it serves the critical function of protecting the surface from ultra-violet light. Ground-level ozone breaks down rather quickly and does not augment the ozone in the stratosphere. Quantifying the radiative effects of ozone is difficult.

SOURCES OF GREENHOUSE GAS EMISSIONS IN OREGON

The purpose of this report is to look at how global warming could affect Oregon and what actions the State of Oregon should take. This focus is does not belittle the larger issues. Rather, the report should make the issue more immediate for Oregonians. To reverse the focus, to view the threat of global warming only as a global or international issue, can make it appear that it is someone else's problem. Neither singular focus is appropriate. This report complements the other reports that present the national and international aspects of global warming.

Oregon adds only a fraction of one percent to the worldwide global warming problem. Figure 3 gives the contribution of major countries and regions. According to the *1990 State of the World* by the Worldwatch Institute, Americans contribute about five times the world average carbon emissions per capita. For example, the U. S. contributes about 5 tons of carbon per capita, compared to about 2 tons for Japan, about one ton for Mexico, about three-fifths of a ton for China, and about two fifths of a ton for Brazil.

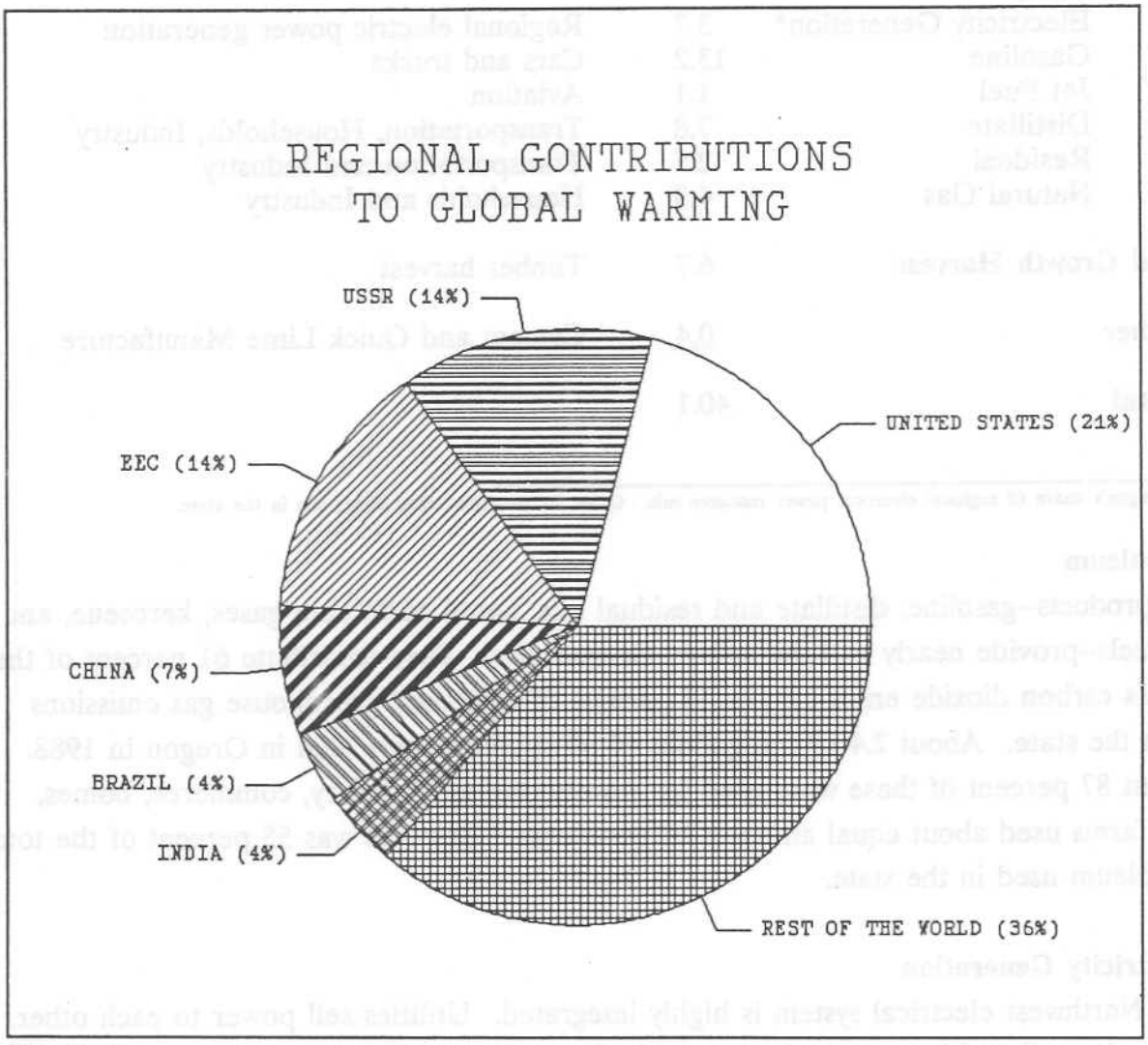

Figure 3

Source: EPA

CARBON DIOXIDE

Oregon adds most to global warming by burning fossil fuels, which creates carbon dioxide. Transportation contributes the largest share of carbon dioxide, about 53 percent. Table 1 and Figure 4 show Oregon's contribution to carbon dioxide.

TABLE 1

Oregon's 1988 Carbon Dioxide Emissions

	Millions of Tons CO_2	Uses
Fossil Fuels		
Electricity Generation*	3.7	Regional electric power generation
Gasoline	13.2	Cars and trucks
Jet Fuel	1.1	Aviation
Distillate	7.8	Transportation, Households, Industry
Residual	2.5	Transportation and Industry
Natural Gas	4.8	Households and Industry
Old Growth Harvest	6.7	Timber harvest
Other	0.4	Cement and Quick Lime Manufacture
Total	40.1	

* Oregon's share of regional electrical power resource mix. Other sources show only direct use in the state.

Petroleum

Oil products--gasoline, distillate and residual oils, liquid petroleum gases, kerosene, and jet fuels--provide nearly half the energy Oregon uses. They contribute 61 percent of the state's carbon dioxide emissions, or 43 percent of combined greenhouse gas emissions from the state. About 2.4 billion gallons of oil products were sold in Oregon in 1988. About 87 percent of these were used for transportation. Industry, commerce, homes, and farms used about equal amounts of petroleum. Gasoline was 55 percent of the total petroleum used in the state.

Electricity Generation

The Northwest electrical system is highly integrated. Utilities sell power to each other. They also sell and buy power from outside the region. Utilities shut down plants with high operating costs so others can run cheaper plants. An increase in load in one utility can lead to increased operation of other utilities' plants.

By apportioning Oregon's share of the regional load to the resource base, we can capture the integrated supply system. Oregon's load is about 29 percent of the region. Table 1 includes Oregon's prorated share of CO_2 generated by all coal, natural gas, and cogeneration plants that supply the region. For other sources of carbon dioxide, the report considers only those that were generated inside the state.

The region also gets almost 70 percent of its electricity from hydro power and 8 percent from nuclear power. These sources do not contribute greenhouse gases.

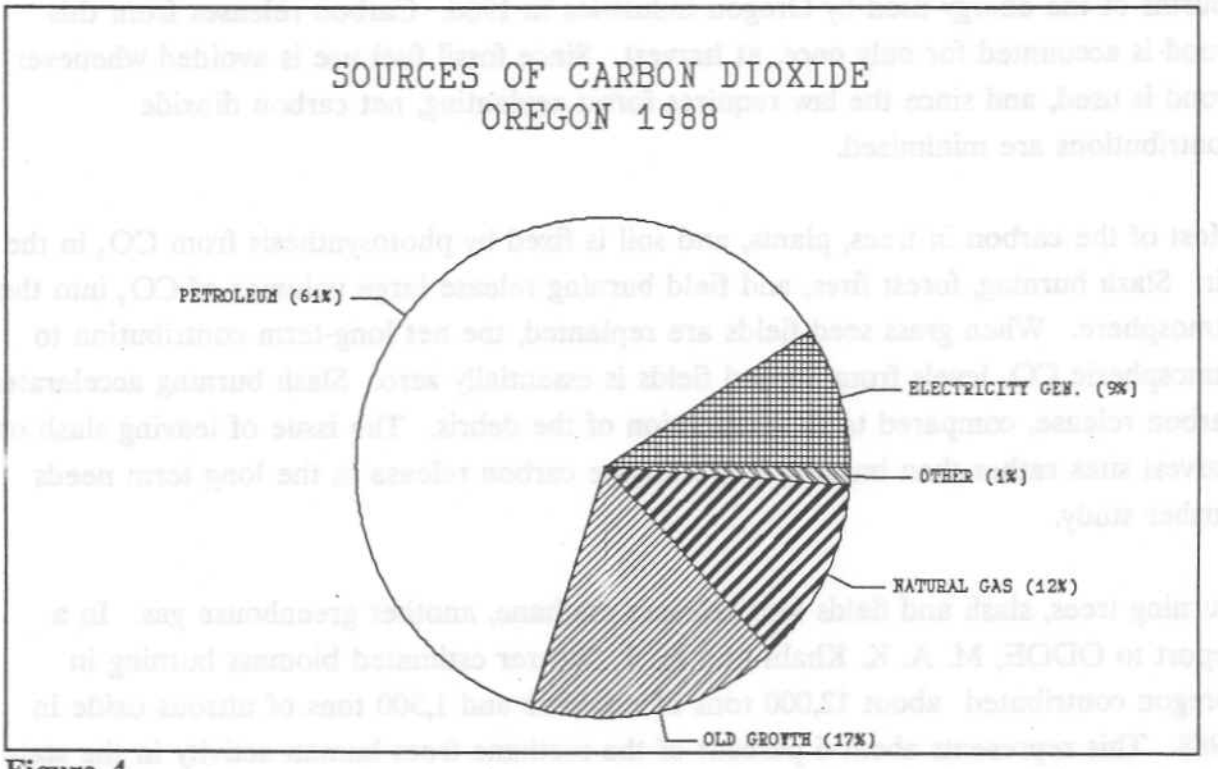

Figure 4

Source: ODOE, Regional ISAAC model.

Natural Gas

Industry used about half of the natural gas supplied in 1988. Households used about 27 percent. Nearly 300,000 Oregon homes are heated with natural gas. About 150,000 homes also use gas for water heating. Commercial firms, schools, and governments used about 23 percent of the natural gas for space heating, water heating, and cooking.

Biomass

Biomass refers to forest and agriculture resources. When forests are cut and replanted, the subsequent forest eventually stores most of the carbon dioxide released. In managed second growth forests with full replanting, CO_2 taken up just about equals that released, providing a full rotation period between cuts is allowed. Much of the carbon dioxide in old growth forests is released from the forest floor. It is not recovered when the forest is replanted, unless the forest is again allowed to become old growth. Cutting old growth trees at current harvest levels releases a net contribution of almost seven million tons of carbon dioxide a year.

Mill wood waste and pulping liquor (liquid pulping residue) supplied almost three-fourths of the energy used by Oregon industries in 1988. Carbon releases from this wood is accounted for only once, at harvest. Since fossil fuel use is avoided whenever wood is used, and since the law requires forest replanting, net carbon dioxide contributions are minimized.

Most of the carbon in trees, plants, and soil is fixed by photosynthesis from CO_2 in the air. Slash burning, forest fires, and field burning release large volumes of CO_2 into the atmosphere. When grass seed fields are replanted, the net long-term contribution to atmospheric CO_2 levels from burned fields is essentially zero. Slash burning accelerates carbon release, compared to slow oxidation of the debris. The issue of leaving slash on harvest sites rather than burning it to mitigate carbon release in the long term needs further study.

Burning trees, slash and fields also releases methane, another greenhouse gas. In a report to ODOE, M. A. K. Khalil and M. J. Shearer estimated biomass burning in Oregon contributed about 12,000 tons of methane and 1,300 tons of nitrous oxide in 1988. This represents about 6 percent of the methane from human activity in the state and about 20 percent of the nitrous oxide from human activity.

CFCS AND HALONS

Oregon uses CFCs in refrigeration and air conditioning, in aerosol cans, and as solvents in the electronics industry. The electronics industry uses CFC-113 as a liquid solvent. The industry imports CFC-113 from other states. As it uses the liquid, some evaporates and enters the atmosphere. Industry recycles the rest. Contaminated CFC-113 is destroyed out of state.

Halons, a type of halocarbon, are commonly used fire fighting chemicals for some types of fires. They are non toxic, and they leave no residue. However, halons are more powerful than CFCs in destroying the ozone layer. Fire fighting systems are tested by releasing the halons.

Oregon has no CFC manufacturers. Apportioning U. S. use on a per capita basis, Table 2 shows Oregon's current share of CFC use. This method accounts for in-state and out-of state use.

TABLE 2
Oregon Use of CFCs and Halons
Millions of pounds

Chemical	
CFC-11	2.44
CFC-12	3.90
CFC-113	2.36
CFC-114	0.12
CFC-115	0.27
Halon 1211	0.11
Halon 1301	0.18

Source: Energy Information Administration; state per capita from national figures.

METHANE

According to the Khalil and Shearer report, some sources of methane that are significant on a global scale, such as rice fields, may not be important for one state. For example, Oregon does not grow rice. The largest sources for Oregon from human activity are from the cattle and other ruminants we raise. Natural gas use and landfills are also important. Wetlands are the most important natural source. Natural and anthropogenic sources contribute about equal amounts of methane to the total of about 450,000 tons generated in the state in 1988. Oregon's total emissions are about 1.5 percent of the U.S. emissions and less than one tenth of one percent of worldwide emissions.

NITROUS OXIDE

According to Khalil and Shearer, the global nitrous oxide budget is not well understood. It is even more difficult to estimate the budget on a smaller scale, such as Oregon. Human related sources include automobiles, biomass burning, sewage treatment, agriculture and power plants. Looking at the ratio of Oregon population to world population, Khalil and Shearer estimate Oregon's contribution to be about 3,300 tons. Looking at the ratio Oregon land area to world land area, they estimate a contribution of about 11,000 tons. (For planning purposes, this report assumes it is 6,600 tons.)

SUMMARY OF GASES

Figure 5 shows the relative contribution of the gases, based on the Lashof and Ahuja index. Table 3 shows Oregon's contribution to the major greenhouse gases. The gases are listed separately. (Note that the units for the amount of sources vary in the table.)

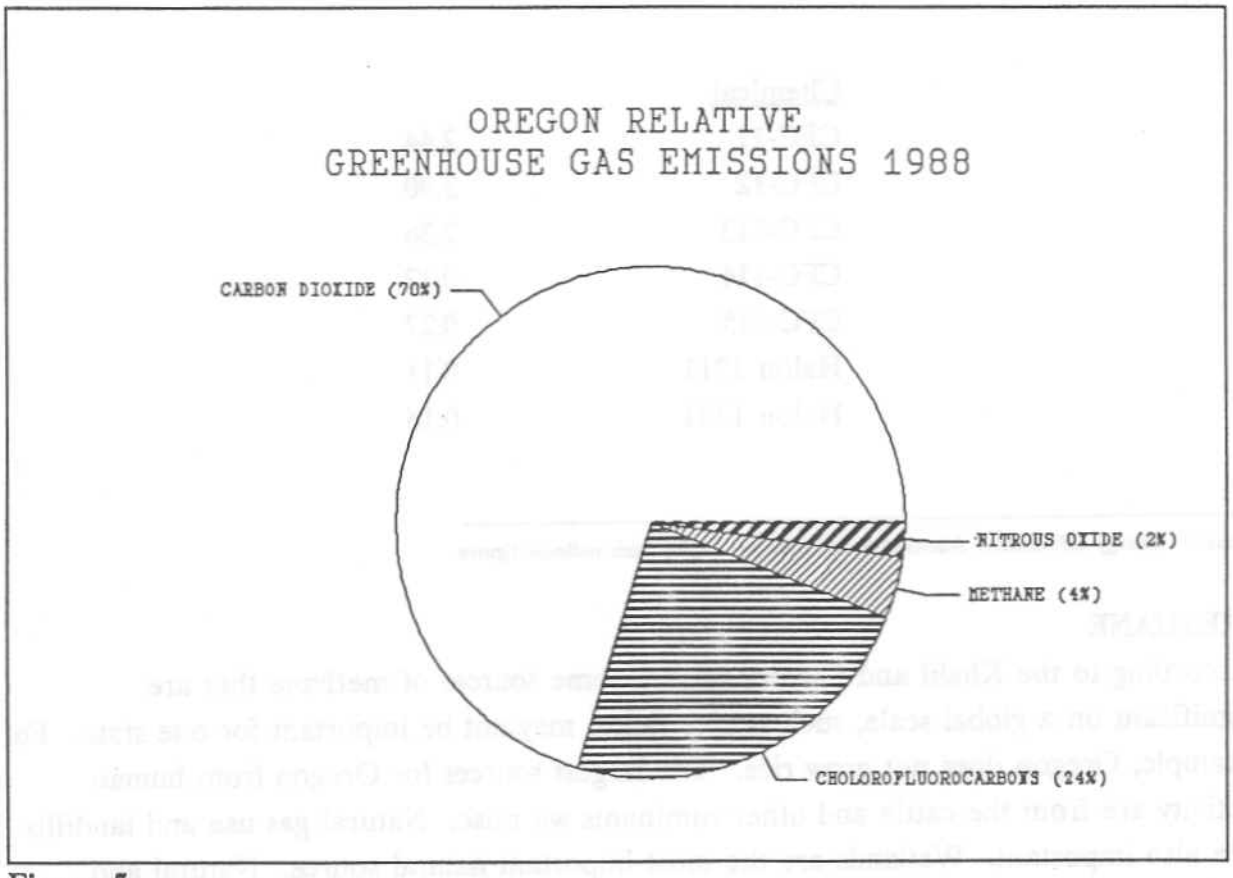

Figure 5

Source: ODOE, Regional ISAAC model.

TABLE 3
OREGON 1988 GREENHOUSE GAS INVENTORY

CARBON DIOXIDE

PRORATED ELECTRICITY GENERATED BY COAL AND NATURAL GAS

	Total Avg. Megawatts	Million Tons CO2	Percent of Total CO2*
Oregon's share of the region (29%)	4,742	3.7	6.5
	Trillion Btu		
NATURAL GAS	81	4.8	8.4
	Trillion Btu		
PETROLEUM			
Gasoline	170	13.2	23.1
Distillate	96	7.8	13.6
Residual Oil	30	2.5	4.4
Jet & Other	14	1.1	1.9
	---	---	---
Subtotal		24.6	43.1
WOOD	Acres Harvest		
Old growth	53,100	6.7	11.7
OTHER	Tons		
Cement	566,410	0.3	0.5
Quick Lime	102,182	0.1	0.1
Subtotal		0.4	0.6
CO2 SUBTOTAL		40.1	70.3

CHLOROFLUOROCARBONS

	Million lbs	Equivalent MMTons CO2*	
CFC-11	2.44	1.6	2.7
CFC-12	3.9	7.2	12.7
CFC-113	2.36	2.9	5.0
CFC-114	0.12	0.4	0.7
CFC-115	0.27	1.5	2.7
Subtotal	9.09	13.6	23.8

METHANE (Anthropogenic)

	Tons	Equivalent MMTons CO2*	
Cattle	88,200	0.88	1.5
Other Ruminants	6,600	0.07	0.1
Landfills	22,000	0.22	0.4
Transport	4,400	0.04	0.1
Natural Gas	37,500	0.37	0.7
Ag & Slash	12,000	0.12	0.2
Other	44,100	0.44	0.8
Subtotal	214,800	2.1	3.8

NITROUS OXIDE

	Tons	Equivalent MMTons CO2*	
Averaged estimate	6,600	1.19	2.1
COMBINED TOTAL		57.0	100.0

* Per Lashof and Ahuja index

Potential Effects

OREGON'S CLIMATE

Oregon has a temperate climate with a marine influence. The climate varies geographically because of its latitude, topography, and proximity to the ocean. The Cascade mountains separate the mild maritime climate of western Oregon from the continental climate of the east. Precipitation is plentiful west of the Cascades. Much of eastern Oregon receives limited precipitation. Many farmers in Oregon, particularly in eastern Oregon, irrigate their crops.

Average annual rainfall varies from less than eight inches in the dry plateau regions to as much as 200 inches in the Coast Range. Natural vegetation ranges from the sparse sagebrush and desert grasses of the central Oregon plateaus to the coastal rain forests.

Most rainfall occurs during the winter in Oregon. West of the Cascades, about half of the annual precipitation falls in the winter. Most of the rest falls in the spring and fall. Very little rain falls in the summer. East of the Cascades the seasonal differences are not as pronounced.

WATER

Global warming could affect both the quantity and quality of the state's water resources. The geographic distribution of water supplies could change. Changes in the amount and distribution of water supply would affect water quality. Climate changes could affect ground and surface water supplies on a seasonal and annual basis. Changes in stream flow and inflows to lakes could alter their chemical composition and ability to absorb pollutants.

WATER SUPPLY

Several components comprise the "hydrologic budget": precipitation, evaporation, transpiration, runoff, seepage, and discharge. Global warming effects on the hydrologic budget could magnify or offset each other. Changes in the amount and distribution of precipitation would affect water supply. The general circulation models predict an increase in precipitation worldwide. However, the direction and size of global warming effects on water supplies in the region or state are difficult to predict.

Evaporation affects water supplies. The effects of global warming on evaporation will depend not only on temperature, but on cloud cover, wind, and many other factors.

Changes in the types and distribution of plants and evapotranspiration rates could also affect water supplies. There could be higher rates of evaporation from soil, lakes, and streams.

The size and duration of the snow pack directly influence many stream flow levels. If Oregon's climate becomes warmer with less snow pack and drier summers, the water levels and flows in streams, lakes, and aquifers could decline even with an annual increase in precipitation.

Competition for Oregon's water supplies is increasing regardless of climate change. Climate change could further reduce water supplies. A water shortage would limit the state's economic and population growth. It would impact irrigated agriculture, fisheries, and water-based recreation. Less water in streams in the summer would compound the effects of higher water and air temperatures.

A rise in sea level could affect water users in Oregon's coastal areas. Surface water supply intakes in the tidal zones of coastal streams and water wells near the coast could become unusable as a result of salt water intrusion. Waste water treatment discharges in coastal streams and wetlands could also be inundated by salt water. Upgrading water treatment plants or securing new water supplies would be costly for coastal communities and industries.

If global warming reduces surface water supplies, communities that now depend on surface water may turn to ground water. More ground water pumping would impair the quality of some aquifers and could cause interference between users. Conservation could at least partially offset possible water supply deficits.

Changes in the characteristics of Oregon's hydrologic system could also affect flooding patterns. Many of Oregon's rivers are managed for flood control, storage, distribution, fisheries, and power generation. Changes in peak runoff periods, water demand, or energy demand could require changes to current flood management scheduling and reservoir coordination strategies. Adjusting the operation of storage and distribution facilities could lessen impacts from changing precipitation patterns. Construction of additional reservoir capacity could add runoff storage for use during dry periods.

WATER QUALITY

Water quality is affected by a dynamic, interrelated system of physical, chemical, and biological properties. These include aeration, temperature, turbidity, salinity, pH, nutrient level, dissolved oxygen, biochemical oxygen demand, pollutants, and aquatic flora and fauna.

Land use practices can affect water quality by causing sedimentation and contamination. Changes in the amount and distribution of water entering surface and ground water bodies would affect the physical, chemical, and biological characteristics of Oregon's waters. Lower flows would reduce the capacity of surface water bodies to moderate responses to warmer air temperatures.

Warmer water contains less dissolved oxygen to support fish and other aquatic organisms. Warmer water could reduce oxygen levels, particularly in deeper waters of lakes and reservoirs, if the water were stratified longer. Low dissolved oxygen levels can kill or damage fish. Warmer water would increase the amount of disease in cold water fish, such as salmon, steelhead, and trout.

Warmer water also speeds the growth of bacteria and algae. Algal growth would increase the fluctuation in dissolved oxygen content between day and night. Algal blooms can degrade the taste, odor, and appearance of water supplies. In addition, the chemical reactions between biological metabolic products in algae-laden water and chlorine can pose health risks.

Lower flows and warmer water would reduce the ability of water bodies to absorb pollutants. The U.S. EPA and the Oregon Department of Environmental Quality (DEQ) set state and federal water quality standards. During low flow periods or droughts, some streams cannot assimilate municipal and industrial waste discharges enough to meet water quality standards. Lower flows and warmer waters would also decrease the ability of water bodies to dilute other pollutants such as sediment, agricultural chemicals, nutrients, and road runoff.

Reduced snow pack could result in lower flushing rates through lakes and reservoirs. Pollution levels could increase, along with increased plant growth that depletes oxygen in the water.

The salinity of streams, lakes, and estuaries could also change. Streams and lakes may not be able to dilute saline ground water inflows and evaporation residue. In extremely dry conditions, lakes in closed basins--Goose Lake, Malheur Lake, and Summer Lake--could dry up. This could expose large areas of alkaline soils and cause a dust-bowl effect from wind erosion. It could also kill the fish in the lakes and affect the wildlife that rely on the lakes. Some species in these lakes are already threatened or endangered.

The effects of global warming on the quantity and quality of Oregon's waters is uncertain. This discussion focused primarily on a net drying effect. Global warming could cause seasonal or average increases in surface flows and ground water recharge. In this case, available supplies would increase and quality likely would improve. Increased flooding, however, could pollute water supplies from storm water and sewage overflows and sewage treatment and septic system failures. Flooding could also damage other property and increase soil erosion and water turbidity.

WETLANDS AND ESTUARIES

Global warming could affect Oregon's wetlands by changing ground water, runoff, stream flows, and shorelines. Both fresh water and salt water wetlands support fragile and biologically important habitats. Changes in stream flow or lake levels could either inundate or dry up wetlands along stream channels and lakeshores. Fresh water wetlands sustain unique plants, animals, and insects. Wetlands are important in nutrient recycling and chemical breakdown before nutrients enter streams and lakes.

Salt water wetlands, or estuaries, form from an interaction between ocean and fresh water. Estuarine species tolerate salinity. Estuaries are habitat for estuarine, marine, and anadromous fishes. For example, sea-run trout (steelhead and cutthroat), salmon, english sole, and Dungeness crab all depend on estuaries for habitat. If global warming changes either fresh water inflows to estuaries or sea level, estuarine characteristics and locations could change. For example, lower fresh water flows to estuaries in the summer or higher sea level would cause sea water to migrate further into bays and river channels. Higher freshwater flows in the winter could decrease the salinity in the winter. Estuaries could lose species adapted to existing flow and salinity patterns.

Shoreline retreat from permanent flooding has serious implications for tidal wetlands. The potential for wetlands to migrate and reestablish would depend on topography, soils,

development, and other factors. Marshes in Oregon often adjoin steep hillsides or developed shorelines. There are few ways for marshes to move inland.

Salt marshes are important elements of estuarine ecosystems. Salt marshes are highly productive habitats. They grow in a narrow band just above mean sea level. Salt marshes trap sediments from tides. They can, within limits, build at a rate to keep pace with sea level rise. However, the rate of sea level rise due to global warming may exceed the natural ability of marshes to keep pace through trapping sediment. Developments around marshes may constrain the ability of marshes to migrate.

Permanent flooding may occur in diked marshland areas used for agriculture. Many of these dikes are in poor condition. Winter flooding may damage the dikes permanently.

FISHERIES

Fresh Water

Warm water game fish (for example, bass, crappies, bluegills) favor water temperatures above 70° F. Coarse fish species such as carp, sucker, and squaw fish also thrive in warmer water. These fish can adapt to a wider temperature range than cold water fish, such as trout and salmon. Thus, the warm water species and coarse fish may compete better than the trout and young salmon for space and food as temperature rises.

Salmon may be affected by the availability of water for spawning, incubation, birth, growth of young fish, and migration. Low stream flows increase the time young salmon are in the stream. This creates a higher chance of predation or disease. More severe winter freshets and an increased winter flow from more rain could result in habitat loss and the scouring of eggs and spawning gravel.

Oceans

How global warming will affect Oregon's prevailing ocean currents and ocean fisheries is uncertain. The interactions between the atmosphere and the oceans are more complex and less understood than those between the atmosphere and land. The complex and poorly understood relationships lead to a high risk that slight changes may cause major impacts on the fish population.

Alterations of normal seasonal wind patterns can cause abrupt, large scale shifts in marine resources. Climate changes may affect wind patterns. A wind-driven current

system sustains many of the Northwest's highly productive fisheries. It causes nutrient-rich water to rise or "upwell" from the bottom.

Coho and chinook salmon contribute significantly to Oregon's commercial fishing industry. These salmon are at the southern end of their ocean range off Oregon's coast because of ocean forage. A change in ocean temperature and the patterns of upwelling may affect how well salmon mature in the ocean off Oregon's coast. This in turn could change the range of salmon and whether there are enough salmon to support a commercial fishery.

The 1982-83 El Nino event included a dramatic reduction in upwelling and a decline in the productivity of ocean fisheries. Scientists do not attribute El Nino to the greenhouse effect. The event does, however, provide an example of how dramatically marine resources in Oregon can change with a change in ocean currents.

SEA LEVEL

ABSOLUTE SEA LEVEL

Global warming could cause sea level to rise. Warmer sea water would expand, and melting glaciers could add more water. The rate and amount of sea level rise are matters of debate. Most debates focus on *how much* sea level will rise, rather than *whether or not* it will. Reports at the October 1989 conference of the American Geophysical Union suggested that Antarctica may play a significant role in slowing sea level rise for the next century. If that is the case, the sea level may rise one to three feet.

The great size of the oceans and the thermal properties of water delay by decades the response of sea level to climate change. Forecasters believe the sea level will rise more slowly during the first half of the next century than the second half. Measures taken today to slow global warming will likely not influence the rate of sea level rise until the second half of the next century. Much of the sea level rise expected in the first half of the next century may be inevitable.

LOCAL SEA LEVEL

Local sea level results from the interaction between earth movements and absolute sea level. Subsidence or uplift, wind direction and velocity, barometric pressure, tides, and absolute sea level all determine local sea level.

Local sea level in Oregon has not changed over recent geologic time. Earth processes have lifted the Oregon coast at a rate comparable to that of absolute sea level rise. Assuming the rate of coastal uplift in Oregon will not change during the next century, an increase in the rate of sea level rise from global warming would raise local sea level.

In some coastal areas, removal of ground water, oil, or natural gas may cause the ground to subside. Subsidence would exacerbate the affect of sea level rise. There is also evidence of catastrophic subsidence caused by subduction zone earthquakes in the Northwest.

Sea level rise may affect the Oregon Coast in many ways:

- The ocean could permanently flood low-lying areas, causing estuaries and open coastal areas to retreat inland or disappear. Beaches, dunes, and sand spits would erode landward as sea level rises. The public could lose access to estuaries and marine fishing areas.

- Areas now protected by dunes and sand bars at the mouths of estuaries and rivers may be directly exposed to surf, causing erosion.

- Sea level rise could exaggerate the impact of coastal storms. The impact of high tides may be more frequent and severe if sea level rises. During the 1982-83 El Nino event, changes of wind and ocean currents caused more than a one-foot increase in mean sea level. During this period, three storms occurred that would normally be expected only once every 100 years. The storms caused loss of vegetation, destruction of shoreline, and damage to buildings and highways. New flooding of coastal areas could affect developments not now susceptible to flooding.

- Salt water could intrude into fresh water areas. This could damage habitat for animals and fish. It could also affect water supplies for human use.

- There could be damage to roads and other development. The potential implications for parts of Highway 101 and cities such as Coos Bay, Cannon Beach, Tillamook, and other coastal cities are serious. We may need to take costly measures to protect developments. It would be difficult to anticipate the extent to which we should protect development. Scientists may not be able to predict how much, and at what rate, the sea level might rise, even after noticeable change begins.

- With sea level rise, the need to improve and construct coastal flood protection structures would be nationwide. Oregon may be a low priority to receive federal help because of the low intensity of development on the Oregon coast. Oregon communities and the State may have to pay for and build new flood control structures. The cost of protecting some areas may mean they have to be abandoned.

TILLAMOOK BAY

Figure 6 shows Tillamook Bay at present sea level and with a one foot rise in local sea level. There are qualifications to the estimated one-foot line. First, it is derived from a computer extrapolation from the actual 20-foot contour line. It is not based on a field survey. Even more importantly, the line is static. It does not reflect the erosion that likely would occur from dynamic ocean processes. To that extent, the line is probably a conservative estimate of the area that would be affected. Where the ground is relatively flat or sandy and directly on the ocean, the coast line may move inland one hundred feet for each foot in sea level rise.

It is hard to predict what will happen to the spit off Cape Meares. The spit may form again intact. If the spit breaches, it would put Bay City directly on the ocean. Crossing the Tillamook bar would change.

Highway 101 would have to be moved in places. Cape Meares would be more isolated. Parts of Garibaldi would be flooded. Tillamook would have a waterfront. It might have to move or protect its waste treatment plant.

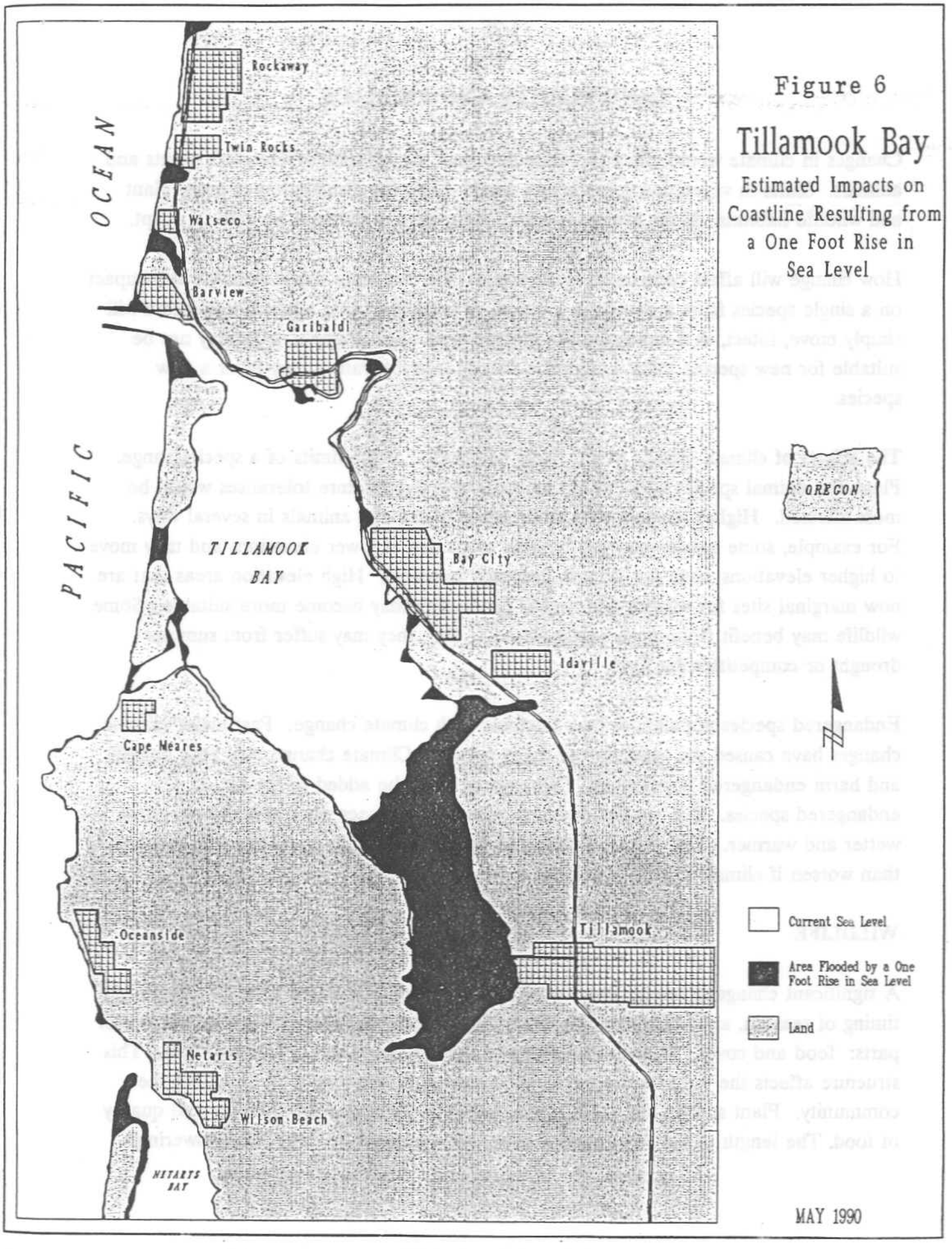

Figure 6

Tillamook Bay

Estimated Impacts on Coastline Resulting from a One Foot Rise in Sea Level

MAY 1990

LAND PLANTS AND ANIMALS

Changes in climate would affect the abundance and distribution of Oregon's plants and animals. Shifts in vegetation composition would affect the distribution of many plant and wildlife habitats. If the change is rapid, many species may not be able to adapt.

How change will affect ecosystems is uncertain. We can more easily estimate the impact on a single species from a change in climate. It is unlikely that a whole ecosystem will simply move, intact, to a more suitable environment. For example, soils may not be suitable for new species, even though the change in temperature may favor a new species.

The effects of climate change would likely be greatest at the limits of a species range. Plant and animal species with limited moisture and temperature tolerances would be most affected. Higher temperatures could affect plants and animals in several ways. For example, some species may not be able to survive at lower elevations and may move to higher elevations when the climate becomes favorable. High elevation areas that are now marginal sites for wildlife and timber production may become more suitable. Some wildlife may benefit from more benign winters. But, they may suffer from summer drought or competition for food.

Endangered species populations may fluctuate with climate change. Past major climate changes have caused the extinction of many species. Climate change may both benefit and harm endangered populations. Some species may be added to the list of endangered species. But, species diversity generally increases when the climate grows wetter and warmer. The overall diversity of species in Oregon could improve rather than worsen if climate change is not too rapid.

WILDLIFE

A significant change in temperature would change wildlife habitats, alter the length and timing of seasons, and change microclimates in habitats. Wildlife habitat has two major parts: food and cover. Vegetation influences wildlife cover through its structure. This structure affects the temperature, wind, solar radiation, and precipitation within the community. Plant species and their growth patterns determine the quantity and quality of food. The length of the days, precipitation, and temperature determine flowering,

seed production, new growth, and dormancy. As global warming changes these factors, the vegetation will respond. This will alter the quality, quantity, and type of vegetation.

The habitat changes that could result from an increase in temperature are comparable to the vegetation changes at different elevations or latitudes. In Oregon, the effect of elevation change can be seen during a drive from Madras to the tree line on Mt. Hood. Dramatic changes in vegetation are linked directly to average temperatures, periods of precipitation, and other climatic factors along the way.

Wildlife depend on the vegetation in the animals' home range for food, shelter, and seclusion. The shrub-steppe, high desert country around Madras is different from the fir and spruce forest near Government Camp. The differences between low sagebrush and bunchgrass and the stately firs and spruces relate to the different climates in which they grow. Their microclimates are also dissimilar. The closed canopy in a conifer forest is a much different world for wildlife than the ground hugging, sparse sage brush desert of eastern Oregon. White-footed deer mouse, Oregon junco, and mule deer must adapt to these microclimates and the food local vegetation provides.

As an example, some forests may shift from Douglas-fir to Ponderosa pine. Because the needles on the branches of Ponderosa pine are less dense than those of true fir and Douglas-fir, they provide less protection from solar radiation for black-tailed deer. As another example, if the central Oregon climate of Madras averaged 5° F warmer than now, the seeds of mule deer forage grasses would likely ripen months earlier. The earlier production and consumption of green leaves would force mule deer to cope with a longer period of poor summer forage than now.

Global warming could also affect areas recently denuded of vegetation, such as western Oregon forest clearcuts. The surface temperatures of unprotected soils in these areas could increase. That could extend and increase the frequency of temperatures lethal to tree seedlings. Temperatures of 150° F and more in clearcuts cause lesions in tree seedlings. Such lesions kill the seedlings. Higher temperatures from global warming would complicate re-planting clearcuts and replacing lost wildlife habitat.

When vegetative cover is inadequate or absent, animals have more thermal stress. Without moderating vegetative cover, animals experience colder temperatures in winter and warmer temperatures in summer. Extremes may last for longer periods each season. In response, wildlife move to warmer or cooler habitats to relieve the thermal

stress. However, this effort increases stress on the animals. Animals normally expend energy in feeding, storing fat for the winter, or producing milk for young. Instead, they may expend their energy moving to better areas. They may spend less time each day feeding. They may consume energy and protein, which could reduce survival and reproductive rates.

Wildlife managers strive for high productivity through stocking and management programs for some species. Managers of those species would most strongly feel the economic impact of climate change. Intensive management in an unpredictable environment is a gamble. But, no action by managers may lead to species extinction.

FORESTS

Distribution and Composition

The amount of moisture available to trees during the growing season affects the composition and growth of forests. Higher temperatures could cause water loss through evapotranspiration to exceed precipitation, resulting in a drier climate with longer periods of drought.

Forests and tree species can move, or "migrate," *slowly* in response to climate change. They may expand into areas not now occupied by trees when conditions are favorable for reproduction. Conversely, forests may recede from areas where conditions prevent establishment of young trees.

The possible rate of climate change may cause trees to die faster than forests or tree species can migrate. Near the edge of a species range, harsher conditions could increase the difficulty and cost of reforestation, both natural and human-assisted. As a result, the total amount of forested area may decrease. Forest species diversity may also decline.

The range and distribution of tree species could also change. In general such a shift would be northward, to higher elevations, and to north-facing, moister slopes. Current conditions at the base of a mountain could move upslope 1,500 to 3,000 feet in elevation and northward 120 to 300 miles. This change would be like moving the northern California climate to northern Oregon.

The greatest changes could occur in the forests of interior southwest Oregon where many species exist near their physiological limits. The area occupied by Douglas-fir and

true fir may decrease as pines become more prominent. Present-day pine areas could convert to oak or non-forested land.

In the Cascades, timberline could move upslope if snowpack decreases. Low-elevation tree species may migrate upward from the Willamette Valley. Ponderosa pine may become more prominent in west-slope Cascade forests. Douglas-fir could shift upslope from the Willamette Valley to mid- and upper-elevations. Hemlock, spruce and subalpine fir may become less prominent in the Cascades.

Higher average temperatures can affect where trees grow regardless of moisture conditions. Bud burst and seed germination depend on exposure to temperatures below a certain level during the winter. If mean monthly temperatures remain above this level, a species may fail. In coastal forests this could shift the range of Douglas-fir inland and upslope. Coastal western hemlock may then become prominent where Douglas-fir had grown.

When average annual temperature rises, maximum temperatures may also rise. Extreme high temperatures could injure or kill young trees, as noted in the wildlife section.

Carbon dioxide-enriched air may enhance growth of some trees by improving water use efficiency if there are no other stresses. This phenomenon may enhance tree growth in some areas and offset some of the adverse effects of a warmer and drier climate. However, extremes will continue to limit tree growth and survival.

Fires, Pests, and Storms

Pest outbreaks may occur more frequently and cause more damage in a warmer climate. Trees under stress are more susceptible to damage from many diseases and insects, especially bark beetles. Outbreaks of defoliating insects have also been correlated with weather extremes. Some pathogenic fungi may grow faster when it is warmer. Insects may reproduce faster in a warmer climate.

Warming and drought conditions could cause more frequent and severe wildfires. A drier climate could lead to fires in areas with large accumulations of organic matter. Fires in such areas are difficult and costly to contain.

With rapid climate changes, the land mass may warm significantly faster than the oceans. This contrast between land and sea could cause more frequent and harsher storms.

High winds could damage timber and increase tree hazard and maintenance costs in forested recreation sites.

Forest Management

Forest management requires long-term decisions based on assumptions about future conditions. Trees planted now may mature in quite different climatic conditions than we expect. Growth and yield predictions based on static indexes of site quality may be unreliable in the face of climate change. Forest management practices may have to change as reforestation becomes more difficult.

Forestry is Oregon's leading industry. Reductions in forested areas or major shifts in forest vegetation types within the state could affect sustainable harvest rates, local and regional timber economies, tax revenues, and the distribution of timber and other forest commodities. Changes in forests in other parts of the U.S. and elsewhere could alter the demand for Oregon forest products.

AGRICULTURE

Agriculture is Oregon's second leading industry. In 1988, cash receipts from farm production were $2.3 billion. Oregon produces about 200 commodities. The state is a national leader in the production of grass seed, filberts, caneberries, peppermint, hops, prunes, plums, sweet cherries, cranberries, onions, snap beans, fall potatoes, strawberries, pears, and cauliflower.

Climate is the main factor that limits agricultural production. Climate also determines a crop's suitability to a given area. Small changes in temperature or precipitation can have a major effect on crops and also affect the need for irrigation.

Oregon's agriculture is as diverse as its climate. The state has several agricultural areas:

Coast

- Ample rainfall and mild temperatures maintain lush pastures in the coastal region. The dairy industry is dominant. Sheep and cattle are grown for meat. The coastal region is one of the nation's leading cranberry production areas. Other specialty and horticultural crops include lily bulbs and cut flowers.

Willamette Valley

- With a long growing season and plenty of rain, the Willamette Valley is the state's most diverse agricultural region. Products include grass and legume seeds, grains, hays, mint, field crops of all kinds, small fruits and berries, wine grapes, Christmas trees, nursery products, dairies, poultry, beef, and spring lambs.

Southwest Inland Valleys

- Higher in elevation and more sheltered from the ocean, the inland valleys of southwestern Oregon are colder in winter and warmer and drier in summer. Sheep and cattle graze on the slopes. Pears, other tree fruit, hay, grain, and seed crops grow in the lower elevations. Irrigation extends pastures and horticultural crops.

Hood River Valley

- The Hood River Valley is a small but important region. High quality tree fruit, particularly apples, pears, and sweet cherries, grow there. With an average January temperature slightly above freezing and annual precipitation of 31 inches, this area is a transition zone between the maritime influence of the west and the arid continental climate to the east.

  This region's agriculture may be particularly sensitive to climate change. Orchards take 10 to 20 years to mature. They cannot adapt to changes as quickly as annual crops.

South/Central High Plateau

- The high plateau of south and central Oregon has a continental climate. Beef cattle dominate livestock in this area. Sheep, dairy herds, horses, and swine are also grown. Irrigation makes possible the production of potatoes, hay, mint, grass and alfalfa seed, and other field crops.

Columbia Basin

- Large dryland wheat farms dominate the agriculture in the Columbia Basin. However, irrigation along the Columbia River makes possible the production of alfalfa, potatoes, watermelons, carrots, onions, mint, peas, and other field crops.

Northeast

- Wheat, specialty grass seed, and fruit trees are the main crops grown in the northeastern highlands of the Wallowa and Blue Mountains. Cattle are also raised here.

Snake River Basin

- Crops in the Snake River Basin rely on irrigation. They include hay, grain, potatoes, onions, sugar beets, peas, tomatoes, berries, and sweet corn.

  The dry rangeland of Harney and Malheur Counties mainly supports cattle grazing. The climate is arid continental with cold winters, hot summers, and little precipitation.

Global warming would probably shift crop growing zones northward. Net impacts on crop yields are unknown. Some crops could benefit. Warmer weather and more rain could make the growing season longer. Crops may mature earlier. However, the amount and timing of precipitation are critical in determining effects on crops. For example, annual precipitation could increase overall despite decreases at critical times in the growing cycle. Higher temperatures could also cause more water loss through evapotranspiration than is made up by more precipitation. Changes in temperature and light intensity resulting from changes in cloudiness could affect crop maturity.

Climate change could affect irrigated lands. Irrigation demands are a function of soil moisture and precipitation. Demand for irrigation could increase during warmer, drier summers or where evapotranspiration rates exceed increases in precipitation. Irrigation demand could increase the demand both for water and for electricity for pumps.

It is likely the water supply would be more critical in eastern Oregon because this area is already heavily dependent on irrigation. However, areas west of the Cascades might also require spring irrigation for crops such as grains and cool season seed crops. If there is water for irrigation, a longer growing season could help agriculture. For example, if the growing season were just 20 days longer in areas east of the Cascades, double-cropping could be possible.

Price increases for certain crops could make irrigation more economical. Or, stable or lower crop prices could make irrigation infeasible. If ground water levels decline, the higher pumping costs could further reduce irrigation. State policies discourage ground

water pumping where there is a long-term decline in aquifer levels or lower water quality. Where irrigation is not possible, marginal lands may shift into grazing or be taken out of agricultural use entirely.

Some studies show that plants grow faster and use water more efficiently in carbon dioxide-rich air. However, these plants may have less protein per unit mass. Weeds could grow faster. Weeds often compete better than other plants in disturbed areas. Other studies show that some crops may be more susceptible to damage from ultraviolet rays in carbon dioxide-rich air.

Even if the impacts of global warming on crop mix and yield could be predicted, it is impossible to estimate the size or direction of changes on Oregon's agricultural economy. Impacts will depend on macroeconomic and policy responses to climate change and its effects on agriculture. For example, a decline in overall productivity of a crop nationwide would likely cause the price of that crop to rise. However, certain states or regions could suffer economic hardship if crop production declines while it stays stable or improves in other areas. The magnitude of hardship or gain would also be affected by governmental influences on pricing agricultural products and trade policy.

ENERGY

HYDROELECTRIC GENERATION

The largest impact of global warming on our energy system may be on the hydroelectric system. Hydropower provides about 70 percent of the region's electricity.

Warming would move the snow line higher and create a smaller snow pack. Snow may begin to accumulate later in the winter and melt earlier in the spring. Overall, there may be less water stored as snow. Therefore, less water may be available in the streams summer.

Runoff, soil moisture, aquifers, and evaporation all affect how much water flows in streams. Energy production may also face stronger competition for water from agriculture, recreation, industrial, and municipal uses, especially if summers are warmer.

Oregon State University conducted a study for the Bonneville Power Administration on *The Effects of Climate Change on Energy Planning and Operations in the Pacific*

Northwest. That study concluded that a warmer climate may be accompanied by reduced stream flow that peaks up to half a month earlier than it does now.

Most of the supply of hydroelectric energy comes from snow fields in Idaho, western Montana, and southeast British Columbia. Peak flows occur in late spring and early summer. However, in the Willamette River, peak flows occur in the late winter.

OSU also points out that higher temperatures decrease transmission line efficiency. Severe weather may increase distribution system failures.

Some scenarios predict more precipitation in the Northwest. It is not possible to say whether precipitation would be rain or snow or when it may fall. More precipitation may not mean more water in the rivers and streams, especially in the summer. Warming in the winter might lower the demand on the hydro system, which now has a winter peak. However, higher summer air conditioning loads, coupled with less snow pack, could increase demands on the system when it is least able to meet them.

Planning for the federal hydro electric system is based on historic stream flow records. A rapid change in climate might yield stream flows outside our historic experience. It may make the hydro electric system less reliable because managers would be less certain about when to store water in the system. It is unclear how higher demand would affect peak usage. Individual weather events determine the peak, such as the early February 1989 freeze. And, planning may have to anticipate more droughts and floods.

The OSU study also found that the Canadian contribution to Columbia River stream flow may increase from 40 percent to as much as 60 percent of the total flow in dry years. The U.S. will soon begin negotiating new agreements with Canada on how we operate the dams on the Columbia River. Global warming adds uncertainty to how the system can best be operated for the benefit of the two countries.

OTHER RENEWABLE RESOURCES

Changes in climate could alter clouds and wind patterns. This in turn would affect solar and wind energy. For example, more clouds would decrease the effectiveness of direct use of solar energy and photovoltaics. Drier, clearer weather would make solar energy more feasible. A change in the difference between the temperatures at the poles and the equator could change wind patterns. A change in climate would also change the amount and type of biomass that is available as fuel.

THERMAL PLANTS

Global warming would affect thermal generating plants. Thermal plants operate less efficiently in warmer weather. Warming could increase the demand for cooling water at thermal plants. It could also decrease the capacity of a stream to accept discharged cooling water. Geothermal plants would be less affected than other thermal plants.

Boardman is the only coal-fired generating plant in the state. It operated in 1983, 1984, and 1989, when it was needed during cold snaps. However, Oregon utilities produce and buy electricity from coal plants in other states. Restrictions on emissions of carbon dioxide, sulfur dioxide, nitrous oxide, or other gases from fossil-fueled plant could affect Oregon's power supply and cost of power.

ENERGY DEMAND

Commercial buildings would use more energy if global warming occurs. Researchers at the University of Oregon project that the annual heating and cooling load in commercial buildings in Seattle could increase by more than one-third with a doubling of carbon dioxide. However, the single family home heating and cooling load may drop by more than one-fourth. Overall, summer electricity loads could change greatly during a time when hydro resources are limited.

AIR QUALITY

Global warming could aggravate air pollution. Much of today's air pollution control is aimed at meeting local environmental health needs. Congress set national goals in the Clean Air Act. (It is now revising the Clean Air Act.)

The Clean Air Act mandated ambient air quality standards for pollutants. Pollutants now subject to standards are carbon monoxide, ozone, sulphur dioxide, nitrogen dioxide, and fine particulates. Carbon dioxide is not a regulated pollutant.

Problems of ozone are linked to climate. Ozone in the troposphere forms from a complex series of photochemical reactions involving sunlight, oxides of nitrogen, and volatile organic compounds. The amount of ozone is directly related to the intensity of ultra-violet radiation and temperature. With more hot summer days and increased

emissions from industrial and population growth, there could be more ground-level ozone.

Gases such as CFCs and halons thin the ozone in the upper atmosphere. This lets more ultraviolet radiation reach the earth. This speeds the formation of ground-level ozone. However, if higher temperatures lead to more clouds, less sunlight might reach the earth, possibly slowing ground-level ozone formation.

ECONOMIC EFFECTS

The Oregon economy would be affected by the profound changes in the structure of the U.S. and world economies caused by global warming. The Northwest may have an advantage of having relatively large sources of clean hydropower and a relatively mild, though warmer climate. However, changes in rainfall and seasonal temperatures would change the state's livability.

REGIONAL ECONOMIC IMPACTS

Coast

- Many coastal cities have low elevations: Cannon Beach, 10 feet; Coos Bay, 10 feet; Garibaldi, 10 feet; Florence, 11 feet; Lincoln City, 11 feet; Nehalem, 8 feet; Reedsport, 9 feet; Seaside, 13 feet; and, Warrenton, 5 feet. If sea level rises, these cities might flood, either directly or from storm activity. The costs of building seawalls are very high. Rising sea levels could jeopardize port facilities in Coos Bay, Newport, Warrenton, and elsewhere.

  Two major coastal industries, fishing and tourism, could be severely affected. Rising sea levels could damage sandy beaches on the coast, reducing a primary tourist attraction. The crab, clam, and oyster fisheries could also decline. Warmer oceans could produce more frequent occurrences of El Nino, which, along with lower river levels, could greatly reduce the salmon fishery.

  More rain in coastal areas might diminish their attractiveness to tourists. A rising sea level could require additional road maintenance or re-routing of some roads.

A change in upwelling in the ocean could change the summer climate on the coast. Any change in ocean temperature will affect the amount of fog in summer months.

Western Oregon

- Even in a moderately severe scenario, western Oregon between the Cascades and the Coast Range might simply become warmer and drier. The major economic impact would be due to drier soil conditions, which would affect agriculture and forestry. Douglas-fir may not be able to grow at lower elevations in dry conditions. Warmer and drier weather could devastate lower and middle elevation forests of interior southwest Oregon where long, warm, dry summers are already the norm.

- It is harder to know what changes to expect at other elevations. Comparable increases in temperature and evapotranspiration may have less negative impacts on coastal and high elevation forests. Growth could improve in some areas if climate change is not extreme. On the other hand, stress could shift species toward drought-tolerant, less productive vegetation.

Other industries in the Willamette Valley would be affected in a variety of ways. Air quality problems in western valleys could become more serious. These problems might require restrictions on industrial processes and transportation. Agriculture might become more productive with a longer growing season.

It is likely that ski areas would be affected by warming. The snow line would probably rise. The ski season would be shorter. And, the quality of snow would decline. There may be heavier snowfall at higher elevations. It is not possible with the information now available to predict where the snow line will be.

Central and Eastern Oregon

- Central and Eastern Oregon now receive relatively light precipitation. Lower precipitation or runoff in these areas would cause more harm than the same loss in western Oregon. If there were more rain rather than snow during the winter, it might not carry over to meet the needs of a warmer and drier summer. Soil could become so dry that Ponderosa pine and other species east of the Cascades would be less viable commercially.

Drier conditions could mean fewer croplands. Irrigation farming is already limited by competition for water. And, rangeland may not support as many cattle and sheep. However, warmer weather could result in longer growing seasons. And, if there were a more humid climate east of the Cascades, both agriculture and forestry might improve.

COST OF GOODS AND SERVICES

Measures to reduce CO_2 emissions could increase the cost of transporting goods to market. These costs are critical to an economy as geographically isolated as Oregon. The closest major markets and industrial centers are in California and the Midwest. Most goods must be transported 1,000 miles or more. However, migration to the Northwest could create larger markets here.

Increasing the cost of transporting goods to market will change Oregonians both as producers and consumers. Added costs would make products sold here from other regions more expensive. Costs would also make Oregon products less competitive. The lower the value/weight ratio of the product, the greater the impact.

Oregon's largest single industry is lumber and wood products. The major competition comes from southwestern Canada and the southeastern U.S. If supplies of timber from southeastern forests decline, Oregon lumber may remain competitive in North American markets despite transportation costs. The chief competitor would then be southwestern Canada, which is as geographically isolated as Oregon. The Pacific Northwest may become the site of massive reforestation of lands that now are poorly stocked. As for East Asian markets, Oregon may face increasing competition from developing lumber sources closer to these markets, such as Sumatra.

Transportation costs will affect services negligibly compared to products. Since services are intangible, they are consumed locally or transported in ways that have a high value/weight ratio. Examples of the latter are discs and tapes used for information storage. However, increased transportation costs could harm tourism, a service industry.

DEMOGRAPHICS

There are several major sources of demographic shifts. Each is dependent on the rate and severity of climate change.

Climate changes may shift comparative advantage in agriculture away from California toward Oregon. If so, agriculture operators and workers may move north. Water shortages in the southwest may also restrict economic activity there. A change in the forest industry might cause forestry workers to migrate to Washington or Canada.

Most climate models predict severe drying in the mid-continental United States. This could cause a general migration to coastal states, such as Oregon. If Oregon becomes a more desirable place to live, there may be greater pressure to use farm lands for housing and development.

Migration may chiefly involve retired persons for whom climate shifts might make retirement elsewhere in the West less desirable. This change would come from three types: Oregonians who today would spend half the year in the Southwest or elsewhere; Oregonians who would otherwise consider retirement in the Southwest or elsewhere; and, those who lived in the Southwest or elsewhere, for whom Oregon represents a welcome change of climate.

INFRASTRUCTURE

Roads and bridges may deteriorate along the coast due to flooding from rising sea level. Changes in the amount of fog at the coast could affect all modes of transportation. Increases in precipitation could cause some inland flooding and damage to roads and bridges. Public policy changes may promote greater reliance on mass transit as a mitigation response.

EMERGENCY MANAGEMENT

More precipitation could increase flooding and landslides. More severe weather events could require relief and recovery efforts from state and local emergency management offices. The chance of extreme events will probably change with global warming.

CHALLENGES TO THE GLOBAL WARMING CONCEPT[1]

SUMMARY

While most scientists researching global warming agree on the general dimensions of the problem, a few disagree with some, if not all, aspects of the global warming concept.

Even though most atmospheric scientists are unwilling to conclude warming has arrived in a manner projected by climate models, most do agree that the historic and continued emission of greenhouse gases could lead to global warming. There are some scientists, however, who disagree with some or all of the basic concepts and data supporting the theory of greenhouse warming.

These disagreements fall into three basic categories:

- *Some feel the historic temperature data are flawed. (These data show a rise of approximately 0.5° C (1° F) over the last 100 years.)*
- *Others feel feedback effects will limit substantial warming in spite of increases in greenhouse gases.*
- *A few think the earth is entering a cooling rather than a warming period.*

Some of these global warming critics point out acknowledged weaknesses in the atmospheric models used to derive warming projections. Others, particularly those contending a global cooling, have little scientific evidence to support their contention. The task force found no studies that use a sophisticated climate model that refute the theory that a significant warming is a probable result of increasing greenhouse gas concentrations.

Unfortunately, the uncertainty about whether or not the world faces a greenhouse warming may not be resolved for several years. Some scientists believe that greenhouse warming will be demonstrated if the current trend of increasing temperatures persists through the 1990s. Others feel that the concept will only be proven or disproved with much more complex atmospheric models that may not be available for 10 to 20 years.

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[1]*The discussion is adapted from "The Impacts of Global Warming on California, Interim Report," California Energy Commission, August 1989, pp 20-26.*

QUESTIONS ABOUT THE DATA

Some scientists question the accuracy of historic temperature data.

Several of the global warming skeptics feel that the historical temperature data records that indicate a 1° F rise over the last 100 years are fundamentally flawed. They contend many of the measuring stations are located in areas that have urbanized. Such stations may show warmer readings as a result of the influence of urbanization (the urban heat island effect). There are also some indications of changes in instrumentation and methods of temperature observation at some weather stations. In addition, some of these skeptics point to temperature records of some specific regions that show no temperature rise.

Of the scientists questioning the accuracy of historic weather data, most only argue that these flaws make it inappropriate to contend that a greenhouse-induced warming has begun. Others, however, conclude that because this preliminary sign of warming is questionable, the whole global warming theory is flawed.

The principal warming theorists have several specific responses to these arguments:

- *Global warming researchers feel it is inappropriate to base conclusions about global weather conditions on regional temperature records. The continental United States for example, represents less than 2 percent of the earth's surface. United States weather, be it hotter or cooler, is not an analog for global weather.*

- *In general, climatologists recognize the heat island phenomenon and add that many rural temperature stations have, conversely, been affected by the expansion of irrigated agriculture, which tends to cause cooler temperature readings.*

- *Several researchers have learned to filter out local distortions when analyzing historic temperature data. They conclude that, despite the distortions, the earth has still warmed approximately 0.5° C (1° F) in the recent past.*

- *Data taken over the last 30 years at an altitude high enough to avoid local temperature distortions show a nearly 0.3°C (0.5° F) global temperature rise. In addition, data from free troposphere temperature measurements high enough to*

avoid local temperature distortions. The free atmosphere records of the lower stratosphere show a slight, but distinct, cooling trend--also consistent with a global warming.

- *Finally, some climatic researchers note that global average temperature seems to change in short jumps over spans of a few years. Between the jumps the average temperature plateaus. Little overall change occurs until the next jump. These jumps are not consistent with a gradual temperature increase resulting from the urban heat island effect.*

POTENTIAL EFFECTS OF FEEDBACK MECHANISMS

Some scientists acknowledge the concept of a greenhouse effect, but feel feedback mechanisms will keep the earth's temperature relatively constant even in the face of higher concentrations of greenhouse gases.

The temperature of the atmosphere is a result of greenhouse gas concentrations and the atmospheric feedbacks they induce. Some scientists contend that even if greenhouse gas concentrations are substantially elevated, the net result of feedbacks (secondary reactions to initial greenhouse warming) will hold global temperatures relatively stable.

These scientists feel two feedbacks are particularly notable. First, they feel the overall precipitation increases expected from a warming would lead to more snow at high latitudes. This snow cover would, in turn, raise the earth's overall albedo. (Albedo is the fraction of the sun's incoming energy that is reflected back into space.) Since less solar energy would be absorbed by the earth's surface, this feedback would compensate for the otherwise warming effect of increased greenhouse gases. Another effect of increased snow at high latitudes could offset the increase in sea level rise from thermal expansion of the ocean. In particular, there may be increased snowfall in Antarctica if the southern hemisphere does not warm as rapidly as the southern hemisphere.

Second, essentially all atmospheric scientists agree that the initial increased heat resulting from elevated greenhouse gas concentrations will accelerate evaporation of surface water. Some feel that greater evaporation will lead to increased cloud cover. Some scientists also contend that these clouds will reflect more of the sun's energy back into space. This feedback would cool the atmosphere.

Proponents of the global warming concept respond as follows:

- *Three dimensional climate models factor changes in evaporation and consequent changes in snowfall into equations which project temperature changes due to an effective doubling of CO_2. The models conclude that snow cover would decrease, not increase, causing global temperatures to rise by 3° to 4.5°C (8.1°F).*
- *Many scientists agree that increased snowfall in Antarctica will offset the rise in sea level, but the rise still may be one foot to one meter.*
- *Most scientists studying global warming agree total water vapor in the atmosphere will go up. There is still uncertainty about how this will change cloud cover. There is a general sense that total cloud cover may go down because clouds are based on relative humidity, not total humidity. The increased atmospheric temperature may actually decrease relative humidity. There is also a general sense that high altitude clouds, which would exacerbate the warming, will increase.*

A GLOBAL COOLING THEORY

There is a very small minority in the scientific world that believes the earth is entering a cooling rather than a warming period.

One minority theory of global climate change contends that the buildup of atmospheric CO_2 is not the result of fossil fuel combustion. Rather, it is due to declining plant matter that has caused a disruption of the carbon cycle. These scientists contend that the root cause of this disruption is a progressive demineralization of the earth's surface. The disruption, they contend, is resulting in more biomass decomposition, and less biomass growth absorbing CO_2 from the atmosphere. This combined effect results in overall higher levels of atmospheric carbon dioxide.

This theory further contends that initial climatic response to elevated CO_2 levels will be a rapid warming at the equator. The equatorial warming would cause increased water evaporation and cloud formation. These clouds will then drift towards the poles, causing increased precipitation, and rapidly cover the high latitudes with snow. Once covered with snow, the increased reflection of solar energy would cool the earth, plunging the globe into a new ice age.

The proponents of this theory feel that past ice ages have been caused by similar disruptions in the carbon cycle, and that the earth could enter a new ice age in as few as seven years. They also feel there are signs we may already have entered that period.

Most scientists studying climate change respond in the following way:

- *There is conclusive evidence that part of the increasing atmospheric CO_2 concentrations is the result of fossil fuel combustion. There is also strong evidence that some of the CO_2 increase comes from deforestation. There is little evidence, however, that the existing biosphere is taking up less carbon. In fact, there is some evidence that portions of the North American forests are growing somewhat faster as a result of higher levels of CO_2 (increased concentrations of CO_2 may increase growth for some plants).*

  The economies of the world consume approximately five billion tons of fossil fuel carbon each year. They convert the fuel into energy while emitting virtually all the carbon into the atmosphere as CO_2 or carbon monoxide. Deforestation is thought to add approximately another 1.5 billion tons. Based on atmospheric CO_2 measurements, about 60 percent of these emissions stay in the atmosphere, while the other 40 percent are absorbed by the oceans or by plant growth.

- *Increased evaporation in the tropical areas will not necessarily mean increased overall cloud cover, nor does it mean an increased transport of air and water toward the poles.*

- *The cycle of ice ages over the last million or so years is an anomaly, at least for the past 250 million years. This historical data contradicts the basic hypothesis of demineralization cycles on which the above ice age theory is based.*

- *Climatologists have used their complex models to both replicate the earth's current (and recent past) climate and to calculate greenhouse gas-induced climate change. Because their models do a good job replicating the current and past climate, these researchers are confident their projections of climate change are also generally correct.*

  Climate modelers believe the climate will respond positively (warmer) to increases in greenhouse gases with temperature increases that are more pronounced at the high

latitudes than at the equator. They feel this will happen for three reasons. First, the initial warming will cause more precipitation to fall as rain rather than snow. This, in turn, will lead to less overall snow area, less solar heat reflected by snow, and thus more earth surface heating. Second, the initial heating will cause more stratification in the Northern latitude atmosphere. This will result in warmer air staying close to the earth's surface rather than mixing with colder air from higher in the atmosphere. Third, because there is relatively less solar energy used in evaporation at high latitudes than near the equator, the increased greenhouse gas concentrations can trap relatively more infrared heat in the areas near the poles. As a result of these factors, they foresee less snow cover in high Northern latitudes. And they consistently envision global warming rather than cooling in response to increased levels of greenhouse gases.

- *While most atmospheric scientists agree that the increased temperatures, rising sea levels, shrinking glaciers, and regional droughts of recent years do not prove a global warming has begun, they do see these events as consistent with warming rather than cooling.*

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Part Two:

State Agency Recommendations and Proposed Actions

Oregon Task Force on Global Warming

INTRODUCTION

There are two basic strategies to address global warming. One is to stop or limit the contribution of gases that lead to global warming. The second is to adapt to the impacts of global warming. Both approaches are necessary. Each is a prudent response--an insurance policy in the face of the uncertainty of the extent of the changes. A statewide strategy should have a balance of both approaches. The State should adopt policies that promote flexibility and resilience to climate change. As scientists refine the models of how climate may change and how natural and social systems may react, state agencies can refine their responses.

This report lists proposed actions by agency rather than by topic. This approach allows each agency to say what it plans to do. This keeps the focus on the actions and the responsible agencies. This approach means some topics are discussed by more than one agency. The task force also makes general recommendations.

Many of the policies that will best prepare us for climate change also lead to immediate benefits through more efficient and environmentally benign actions. And, the U. S. Environmental Protection Agency (EPA) projects that a delay in responding to the potential of global warming will significantly increase the rate and extent of change.

Everyone is familiar with the need to pay insurance today for risks that may occur in the future. Actions to slow global warming are the insurance paid to accommodate the risks from global warming. The insurance proposed in this report would also pay a dividend in a more efficient and resilient economy, cleaner air, and less dependence on foreign energy supplies. Responding to global warming is another reason to mange resources wisely.

State agency actions do not stand alone. As the EPA notes, *no single activity is the dominant source of greenhouse gases; therefore, no single measure can stabilize global climate. Many individual components, each having a modest impact on greenhouse gas emissions, can have a dramatic impact on the rate of climate change when combined.* State actions should fit into a national and international effort. The State is trying to

identify and act on those components it can affect. This report is the first assessment of the role of Oregon's state agencies in the context of potential global warming.

The actions the agencies propose are mostly within the current authority of the agencies. Agencies note in the text where they would need new legislation. The proposed actions reflect different levels of commitment. The reader should note whether agencies are stating they will take action, will consider taking action, or propose research.

Continuing Activities

The 1989 Legislature passed SB 576. The bill requires ODOE and other agencies to develop *a strategy for reducing the emission of gases that add to global warming. The purpose of the strategy shall be to reduce these emissions by at least 20 percent below 1988 levels by 2005 by giving priority to the use of conservation, renewable resources, and alternative fuels.* The strategy will be part of the ODOE's *Fourth Biennial Energy Plan* in 1991.

The Legislature's directive sets a goal for the state. The Governor earlier charged the task force to develop recommendations on how state agencies should respond to global warming. The legislation and the charge to the task force are complementary. The Governor's charge addresses implementation and adaptation as well as a policy for emissions reductions, while the legislation provides a goal.

The task force is releasing its initial recommendations and proposed actions before ODOE completes the strategy required by SB 576. When ODOE completes its strategy for SB 576, it may propose additional actions, either administrative or legislative.

GENERAL RECOMMENDATIONS

In addition to the agencies' proposed actions, the task force makes recommendations that are broader in scope.

The State should:

1. **Adopt comprehensive policies to promote maximum flexibility and resilience to climate change.**

   This recommendation is the foundation for all agency actions.

2. **Reduce net greenhouse gas emissions.**

   Several agencies have incentive programs or regulations that can reduce the production of greenhouse gases. The agencies list their specific actions in the following section. A number of agencies also list ways they will make their own facilities and operations more efficient. Finally, the Department of Forestry addresses how its actions can help sequester carbon dioxide from the atmosphere.

3. **Consider climate change in state agency programs and plans, beginning in the 1991-1993 biennium.**

   Agencies should take into account in their planning the threat of global warming. For example, water and forestry programs should make adaptation to potential climate change a program goal. Energy and transportation agencies should take actions to reduce greenhouse gas emissions. Agencies should also incorporate information about global warming in their public education programs. The following section lists the specific actions the states will take.

4. **Create a permanent Global Warming Management Group headed by the governor's natural resources assistant.**

That group should be responsible for preparing state agency global warming action plans every two years. Agencies should also evaluate the effectiveness of their actions.

The management group should develop methods to resolve conflicts between agencies or states. For example, changes in the distribution of water could cause conflicts between the goals of different agencies. Also, such changes could increase the pressure for large-scale, inter-basin, inter-state transfers. The management group should also be responsible for developing the State's position on and response to federal global warming initiatives.

5. **Incorporate into the state's geographic information system data on climate change impacts on natural resources and socio-economic conditions.**

6. **Continue to pursue federal or private funding to support global warming research specific to Oregon and the Northwest.**

Research should address the effects models do not adequately consider. There should be more monitoring of the environment. Research should also include analysis of legal, administrative, political, and economic management strategies. Research should find ways to reduce emissions without causing economic hardships. Research on how changes in temperature, precipitation, and sea level could affect Oregon's water supplies would help the State and local governments reduce hardships.

7. **Work with Oregon State University to fund jointly the position of State Climatologist.**

OSU abolished the position of State Climatologist because of lack of base-level funding from state agencies. The State Climatologist was answering thousands of questions each year from governments, businesses, agriculture, and individuals. It is paradoxical OSU abolished the position just as the State began studying climate change.

The State Climatologist has a role in climate research. The task force encourages research on predicting regional climate change. The task force, therefore, supports continued state compilation and analysis of climate data. Large scale models require reliable local data to verify the model predictions. Loss of local data would hamper modeling efforts.

8. **Encourage, through the Oregon congressional delegation, an ample allocation of federal funding for long-range climate forecasting.**

Key federal agencies are the National Weather Service and the National Oceanographic and Atmospheric Administration.

9. **Develop materials and programs to inform the public about climate change issues, problems, and solutions.**

Oregon needs an active program to inform citizens about the potential impacts of global warming and what they can do to adapt to or to mitigate the effects. The Global Warming Management Group should work with the Department of Education and others to implement a variety of educational actions. Such actions should promote citizen and private sector awareness of the issues. Education should prompt citizens to reduce emissions and adapt to climate change.

Universities are a good source of basic knowledge about global warming. State agencies should work with the universities and other knowledgeable groups to keep the public informed on global warming issues. The Energy Program of the Oregon State University Extension Service is a good conduit for public information. The State should also work with interested outside organizations.

Agency
Proposed Actions

DEPARTMENT OF ENERGY

Energy use is the state's major contributor to greenhouse gases. Therefore, the focus of state energy policies and actions must include the reduction or slowing of greenhouse gas emissions. Achieving greater energy efficiency will have the most impact on global warming in the near term.

State Energy Policy

State energy policy is consistent with the actions proposed below and the strategy of SB 576. State energy policy requires *special attention to the preservation and enhancement of environmental quality.* State policy gives first priority to energy efficiency to meet energy needs. For new electricity supplies, using renewable resources is the second preferred option. Fossil-fueled plants are least preferred. (Oregon has banned new nuclear plants until the nation has a permanent nuclear waste disposal site.)

The types of actions Oregon should take are already part of state policy:

- energy efficiency,
- use of renewable energy sources,
- use of environmentally benign energy sources,
- recycling,
- least cost utility planning,
- land use planning,
- transportation efficiency,
- reforestation of unstocked and underproductive lands; and,
- other actions to lead to a sustainable and environmentally sound economy.

The threat of global warming adds urgency to the need to implement these policies.

ODOE has four priorities in responding to global warming:

- Build energy efficient buildings.
- Improve energy efficiency in existing buildings and manufacturing processes.
- Assure development of cost-effective, environmentally-sound renewable resources.
- Assist utilities to develop and implement least-cost plans.

As noted in the introduction to this part, ODOE may propose additional actions once it has developed the emission reduction strategy required by SB 576. That strategy will suggest specific steps to reach its target.

PROPOSED ACTIONS
ODOE will:

1. **Work with the Oregon congressional delegation to adopt federal legislation to address global warming.**

   1.a. **Increase the average miles per gallon standards for automobiles; and/or, adopt a federal carbon tax.**

   1.b. **Work for an increase of funding for low-income weatherization programs.**

   1.c. **Support use of oil-overcharge funds for low-income weatherization programs.**

2. **Work with federal agencies to encourage actions to reduce the emission of greenhouse gases.**

   2.a **Work with the U.S. Department of Energy (US DOE) to develop a federal energy policy based on energy conservation and renewable energy resources.**

   2.b **Work to convince the U. S. Department of Housing and Urban Development to adopt manufactured housing standards at least as stringent as the Oregon Building Code.**

   2.c **Work to convince the US DOE to revise federal appliance efficiency standards to cost-effective levels.**

3. **Include global warming in its cost-effectiveness methodology.**

   The definition of "cost-effective" that guides ODOE decisions now includes consideration of direct environmental impact. The State also gives conservation a 10 percent additional credit as a surrogate for environmental benefit in some

programs. ODOE will recommend to the Energy Facility Siting Council, which sites large generation facilities, that it modify its rules to require consideration of environmental costs from global warming in reviewing siting requests.

4. **Focus state incentive programs to capture conservation in the industrial and commercial sectors.**

It will use the Business Energy Tax Credit and Small Scale Energy Loan Program incentives for conservation that would be forfeit if it is not captured now.

ODOE will fully implement SB 1060, which requires new state buildings to capture cost-effective energy savings. It will evaluate the program and request legislative changes to improve it if needed.

5. **Fund two alternative fuel demonstration projects.**

The State General Services Department and the City of Portland will demonstrate 15 compressed natural gas-fueled vehicles. ODOE will also seek funds to promote telecommuting.

6. **Work with others to adopt all cost-effective measures in Oregon's 1992 residential building code.**

Standards should reflect environmental costs.

7. **Work with utilities to help them increase participation in their new home programs to 45 percent built to model conservation standards in 1990 and 60 percent in 1991.**

8. **Work for adoption of new commercial building standards.**

ODOE will work with the Building Codes Agency and its boards to adopt the Northwest Power Planning Council's commercial model conservation standard by 1992. ODOE will also work with utilities to capture cost-effective savings that are not in the building code.

9. **Work with the Building Codes Agency, local governments, and utilities to find ways to improve enforcement of the energy-related parts of residential and commercial building codes.**

   This may require funding from utilities or higher inspection fees to improve code enforcement.

10. **Train building operators to operate building energy systems efficiently.**

11. **Work with utilities to implement utility commercial and industrial conservation programs.**

    New programs to capture commercial and industrial conservation that would other wise be forfeit should increase yearly participation to capture 85 percent of potential savings by 1992.

12. **Work with utilities, Bonneville, the Power Council, and other states to increase participation in utility appliance efficiency programs.**

    Utility programs should capture 85 percent of potential savings by 1995.

13. **Work with utilities and public agencies to increase effectiveness of weatherization programs.**

    13.a Increase utility incentives to ensure all cost-effective measures are installed at one time in rentals and low-income housing.

    13.b Increase utility home weatherization efforts in line with utility least-cost plans.

14. **Work with utilities to improve existing residential, commercial, government, and industrial programs.**

ODOE and the PUC wrote a report on the conservation activities of investor-owned electric utilities. The report recommends program changes and new programs to fill gaps in current programs.

15. **ODOE and PUC should work with utilities and regional and national organizations to find a way to fund research and demonstration projects for renewable energy.**

The state will need to turn to energy sources that do not release large amounts of carbon dioxide into the atmosphere. Sources include photovoltaics, geothermal, direct solar, wind, and use of waste biomass. Biomass includes capturing energy from slash and field burning if there is net energy gained and a net carbon decrease. (Hydropower is an established renewable resource; it does not need research and demonstration.)

Geothermal is a renewable energy source that has a large potential in Oregon. Estimates of the potential for electricity generation from geothermal energy range from 50 to 1,500 megawatts. Geothermal energy is relatively clean. It is the heat of the earth. Carbon dioxide emissions are typically low, both on an absolute basis and compared to other resources. Air pollution devices can control other gases released from geothermal power plants. In addition to generating electricity, geothermal energy is useful to heat buildings and water.

PUBLIC UTILITY COMMISSION

Least-cost Planning

The Public Utility Commission (PUC) requires each investor-owned energy utility (IOU) to submit a long-range, least-cost plan and a two-year action plan before the end of 1990. PUC also requires utilities to include external environmental costs as an evaluation factor in their resource decisions. Preliminary drafts of plans submitted to date have incorporated energy conservation as a key element in least-cost planning. Electrical utilities generally recognize that conservation is the least costly element in the resource acquisition stack.

Hydropower

One of the PUC's chief concerns about global warming is its possible effect on hydroelectric generation. Hydropower offers a non-polluting alternative to thermal power generation. Greenhouse gases generated by fabricating construction materials for hydroelectric dams are minimal compared to carbon dioxide given off in thermal generation. However, maximum use of hydropower must be balanced with other uses, such as irrigation, white-water scenery and recreation, and protection of anadromous fish runs.

Oregon has a potential for about 40 average megawatts of additional hydropower development within current constraints and climate. With increased uncertainty about water resources under global warming, the State needs to review its forecast of hydropower potential.

Natural Gas

Although use of natural gas entails CO_2 and methane emissions, this resource may find a role in the larger picture as a cleaner energy alternative to coal and oil. However, minimizing CO_2 emissions through the use of this fuel requires an evaluation of the relative efficiency of alternative uses. For example, do we replace coal-fired generation with gas-fired generation, or do we encourage end-use fuel switching? Such issues will be addressed in the least-cost planning process and other studies.

Conservation Report

PUC and ODOE have published a major report assessing the conservation activities of electric IOUs. The report focuses on two questions:

- Should the utilities be doing more to acquire conservation that will be lost if not captured now?

- Should the utilities be doing more to develop their ability to deliver other conservation savings when needed?

The intent is to help shape the IOUs' near-term activities and to provide a framework for reviewing least-cost plans.

A similar study for the natural gas industry has begun.

Ratemaking Incentives

PUC is currently evaluating the role of ratemaking in energy conservation. No rigorous estimate exists for the impact of such incentives on conservation. However, the operating hypothesis is that conservation should be a key component in least-cost plans.

Existing ratemaking practices may discourage acquisition of conservation by utilities, since conservation cuts utility sales and profits under current conditions. PUC is evaluating utility incentives to promote cost-effective conservation. The goal is to ensure that utilities have appropriate incentives to acquire resources, including conservation, that are consistent with least-cost planning. Ratemaking incentives may be need to keep IOUs on their least-cost paths.

Conservation Priority

To meet the requirements of Senate Bill of 576, conservation must be a top priority. PUC's role is to promote this goal on the broadest possible front so that Oregon's energy utilities acquire all cost-effective energy conservation resources.

Among other things, PUC will work with the SB 576 Advisory Group to see that no single source of greenhouse gases will unreasonably bear the brunt of the advisory group's policy prescriptions. Most sensitive is the issue of importing electricity from coal-fired plants outside the state versus importation of manufactured goods whose production generates greenhouse gases.

Competitive Bidding

As energy resources begin to be provided in competitive markets, an important concept is the potential role for conservation as a marketable resource. PUC is exploring the possibility of acquiring conservation through competitive bidding. As with least-cost planning, PUC will include externalities as an evaluation factor in competitive bidding. Thus, PUC is committed to ensuring that no competitive bidding will be adopted that discourages the acquisition of energy conservation resources.

PROPOSED ACTIONS

PUC plans to continue work on issues related to global warming. The potential effect on global warming will be considered in Commission decisions whenever applicable. In addition, PUC will:

1. **Encourage industrial, commercial, and residential conservation as a first-priority resource, consistent with least-cost planning guidelines. Incentives that improve commercial lighting efficiencies will receive increased emphasis. By some estimates, cost-effective energy conservation can meet as much as one-half of new load growth by 2010.**

2. **Work with the Bonneville Power Administration and the Northwest Power Pool to promote increased engineering studies of the Columbia-Snake Basin to plan for global warming adaptation measures. Adapting to the new climate would require accommodating increased stream flow and runoff in the winter and reduced stream flow in the summer. PUC will also encourage the federal government toward greater cooperation with Canada in the interest of regulating stream flow.**

3. **Ensure that regulatory policies and actions encourage installation of cost-effective energy conservation measures.**

4. **Work with others to see that the plan for reducing greenhouse gases, as mandated in Senate Bill 576, minimizes resource misallocation by pursuing a least-cost approach. Ensure that such a plan divides the burden equitably among all industries and regions of the state.**

5. **Work with the Energy Facility Siting Council, the Northwest Power Planning Council, and the Strategic Water Management Group to evaluate the prospects for new hydropower development in the light of the threat of global warming.**

6. **Work with the Oregon congressional delegation on legislation affecting global warming.**

7. **Ensure that external environmental costs are appropriately included in least-cost planning.**

8. **Work with the Department of Environmental Quality and other agencies on the evaluation of externalities and assigning costs.**

DEPARTMENT OF TRANSPORTATION

The Department of Transportation (ODOT) recognizes global warming could affect the future design, construction, operation, and maintenance of the state transportation system. This system includes public transportation, railroads, ports, highways, bridges, and snow removal. Also, emissions from transportation could have a significant impact on global warming itself.

PROPOSED ACTIONS

ODOT will:

1. **Incorporate global warming information into the design of transportation facilities in Oregon.**

   Over time, global warming could cause higher sea levels, an increase or decrease in rainfall and snowfall, and higher or lower stream runoff. These changes could all affect the future design, maintenance, and operation of the state's transportation system. Unless there is a significant and rapid rise in sea level, seasonal changes, or increases in precipitation, the design and operation of the transportation system can be gradually adjusted to these changing physical conditions. There is no clear consensus on what the climate changes for Oregon will be. When more specific information becomes available it will be incorporated, as economically feasible, into the design and operation of the state's transportation system.

   With global warming Oregon could become a more attractive place to live, especially if people move from dryer and warmer southern parts of the nation

to more moderate climates. This could cause an increased population growth with need and demand for expanded and improved transportation facilities.

2. **Encourage the development of an energy-efficient transportation system in Oregon.**

Transportation is one of the major uses of energy in Oregon. The consumption of petroleum products for transportation is also a major producer of greenhouse gases from the state.

The department will encourage innovative energy-efficiency improvements. This includes consideration of all appropriate modes in the transportation planning process, transit improvements, park-and-ride facilities, rideshare programs, telecommunications, and pedestrian and bikeway improvements. Improvements in the transportation system will include reducing congestion, adoption of new technologies, signal synchronization, and ramp metering. The department will continue to support light rail improvements in Portland, increased and regular funding for transit, and intermodal freight alternatives to improve the linking of truck, rail, water and air services.

3. **Coordinate land use and transportation.**

Oregon has a proud history in statewide and local land use planning. Planning for future land use patterns and transportation are closely interlinked.

Wise land use patterns and efficient urban areas are important for the development of transportation systems and livable cities and rural areas. ODOT will continue to work closely with other state agencies, regional and local governments, and the private sector to improve the coordination of land use and transportation. This coordination process will be described in the ODOT State Agency Coordination Program.

ODOT will work to protect the long-range efficiency and operation of the state transportation system by working with local governments and citizens to assure

compatible and supportive land uses near these facilities. Future development and access should not degrade the efficient movement of through traffic.

4. **Implement and investigate measures encouraging energy-efficiency in transportation services and facilities.**

The department will incorporate economically justifiable energy saving procedures and implement in its facilities and programs. This includes energy audits of buildings, efficient highway design specifications, research and technological innovation, and recycling of asphalt pavements.

The department sees opportunities for major technological innovation in the next 20 years in vehicle guidance and control systems, electronics, data processing, new construction materials, alternative fuels, and more efficient vehicles.

5. **Cooperate with other agencies concerning global warming issues.**

The department will coordinate with the Oregon Department of Energy on issues relating to global warming.

DEPARTMENT OF ENVIRONMENTAL QUALITY

Chlorofluorocarbons

Oregon has already taken steps to control CFCs that add to global warming. In 1977, Oregon was the first state to ban such CFCs as a propellant in aerosol containers. The 1989 Legislature passed a bill (SB 1100) to prohibit the sale of CFC-12 in containers smaller than 15 pounds. It also banned the sale of certain items containing halons and CFCs. The bill requires the DEQ to set up a CFC recycling program for automobile air conditioner servicing. The bill bans the sale of styrofoam for food packaging when it is made from such CFCs. Several cities and counties in the state have passed similar laws.

The 1989 Legislature also directed the State Fire Marshal to set up a program to lessen the dumping of halons when testing industrial fire extinguishing systems. The Fire Marshal is to report to the next legislature on progress on this program.

There is reason to be hopeful about controlling CFCs. Many countries, including the US, agreed in the Montreal Protocol to cut production of CFCs to 50 percent of 1986 levels by 1998. Du Pont, which manufactures one-half of CFCs used in the US, has pledged to stop production by 2000. Many companies are working on CFC substitutes that do not destroy the ozone or add to global warming. Some large companies have pledged to stop using or to recycle CFCs.

On the less hopeful side, China and India have not signed the Protocol. They could contribute significant amounts of CFCs as they develop their economies. Given the non-signers and the leakage of CFCs from products manufactured before the Protocol, the net effect of the protocol is likely to be only a 30 to 40 percent reduction by 2005. Also, halons are only frozen at 1986 production levels, not reduced.

Recycling

Producing goods from recycled materials usually uses much less energy than producing the same materials from virgin materials. Reusing items produces even greater energy savings. Using less energy produces less carbon dioxide and other greenhouse gases.

The energy savings from using recycled material can be significant. It takes more than 20 times as much energy to produce one ton of aluminum cans from virgin bauxite and other raw materials than it takes to produce the same ton of aluminum cans from recycled cans. One ton of recycled aluminum saves at least 9 tons of carbon dioxide.

Recycling other materials also saves energy. It takes 30 to 50 percent less energy to make paper and cardboard from recycled fibers than it does from virgin wood chips. Recycling steel and other metals requires 50 to 90 percent less energy than making the metals from virgin ore. On the other hand, only a small amount of energy (less than 10 percent) is saved by recycling crushed glass, since it takes almost as much energy to melt glass as it does sand. Washing and refilling glass containers results in a more than 90 percent energy savings.

Significantly increasing the amount of material recycled will require a major commitment on the part of the State and local governments. The State has already implemented numerous recycling programs and requirements. These include the "bottle bill," Recycling Opportunity Act, recycling tax credits, state procurement of recycled materials, and waste reduction program requirements. These saved 1.2 million tons of carbon dioxide in Oregon in 1989. Although these programs and requirements have helped Oregon achieve one of the highest recycling rates in the nation, the Department of Environmental Quality believes it is feasible to double the amount of material recycled in the next ten years.

PROPOSED ACTIONS

DEQ will explore the need to:

1. **Initiate and maintain an inventory of greenhouse gas emissions.**

   DEQ will explore the need to expand its air pollutant emission inventory to include greenhouse gases. DEQ should track carbon dioxide, CFCs, and methane. This inventory effort will broaden the public understanding of the global warming impact from all sectors. DEQ can use it to estimate total carbon-based emissions and total CFCs.

   Major users of CFC-113 now report their use to the State Fire Marshal under Superfund, section 313. However, only CFC-113 is reported and only those who use 10,000 pounds a year or more file reports. The reports do not give an accurate picture of CFC use statewide.

2. **Conduct air conditioner leak checks in the DEQ auto inspection lanes.**

   DEQ will consider adding a check for air conditioner leaks to the auto inspection program. This would be in addition to the recycling of CFCs required when servicing automobile air conditioners. The DEQ will also consider capturing CFC-12 refrigerant during automobile salvaging.

3. **Limit carbon-based emissions via the DEQ's permitting and offset program procedures.**

All major stationary air pollution sources have permits. Other sources, such as auto emissions and other emissions from individual activities, do not have permits. DEQ will consider a long-term plan to add carbon-based emissions to the general offset program. Adding these emissions would require a large effort. DEQ does not have a time table for adding these emissions. For the coming biennium, there is no money for such a massive restructuring of the emission inventory.

DEQ may link air quality permits with efficient use of energy or other sources of greenhouse gases. This could include encouraging alternative fuel use.

4. **Design contingency plans to mitigate the impact of any increase in air pollution formation caused by global warming.**

DEQ will evaluate the need to quantify the potential air quality impacts of global warming. If necessary, DEQ will then develop contingency plans to mitigate the impacts. For instance, if higher temperatures will adversely affect the state's ozone control strategy, DEQ should identify other emission reductions.

5. **Respond to reduced stream flows by reducing allowable pollutants in facility effluents and enhancing stream flows.**

DEQ will work with and support the other state and federal agencies that manage lands or regulate water use and flows to mitigate the negative impacts of global warming. If stream flows decline, as is possible, industrial and municipal sources may need to reduce their effluents. The State may need to enhance stream flows through improved plantings along the rivers and in watersheds.

6. **Respond to rise in sea level by requiring protection of existing low-level waste treatment facilities and elevated siting of new facilities.**

Sea level rise could cause flooding of some waste water treatment facilities. DEQ will consider evaluating the siting of new facilities and the protection of existing facilities in areas that may be susceptible to flooding.

7. The DEQ will investigate the following activities with the goal of doubling the recycling rates in Oregon in the next ten years:

7.a. Increased service standards for recycling collection programs.

7.b. Increased education and promotion requirements.

7.c. Minimum recycled content requirements for certain items that can be made from recycled material.

7.d. Increased recycling market development by the state and local governments.

7.e. Prohibition on landfilling of commercial loads of waste that contain significant amounts of recycled material.

7.f. Regulation of packaging to insure recyclability.

7.g. Require recycling by governments and institutions.

7.h. Establishing disposal rate incentives to encourage the use of recycling programs.

7.i. Mandatory recycling.

DEPARTMENT OF FORESTRY

The Oregon Department of Forestry (ODF) recognizes that the earth's climate will likely warm due to the greenhouse effect. However, current climate models cannot yet accurately predict regional climate changes. This creates uncertainty about the potential effects on forests. ODF therefore favors ecologically and economically sound forest management and energy conservation measures that have benefits whether or not global warming occurs at predicted rates. The department also supports actions to reduce greenhouse gas emissions. And, it encourages research to develop strategies to cope

with a changed climate. Increased confidence in climate predictions and forest effects may justify future department policy changes.

PROPOSED ACTIONS

ODF will:

1. **Maintain high standards of reforestation through the Oregon Forest Practices Program.**

   Because cutting trees releases CO_2 into the atmosphere for decades, reforestation is essential to maintain ecosystems in carbon balance. The department administers forest practices laws that require reforestation on all non-federal forest lands in the state. Over the past five years, 98 percent of the acres requiring reforestation have met the department's Forest Practices Program reforestation standards. The program will continue to maintain high standards of reforestation. Federal agencies have also agreed to meet or exceed ODF forest practices standards on federal lands.

2. **Promote programs to increase tree planting on unstocked and understocked lands.**

   Planting trees can help reduce the rate of increase in CO_2 because trees remove CO_2 from the air and store much of the carbon as wood. For example, one fully-stocked acre of vigorous Douglas-fir can offset annually the CO_2 released from the coal burned to generate about 3,500 kilowatt hours of electricity. In addition to the CO_2 offset, other benefits such as soil stabilization, wildlife habitat, and tree products help justify tree planting programs.

   About 1.4 million acres of timberland (all ownerships) suitable for growing native commercial trees are unstocked or underproductive. More definitive surveys are needed to fine tune the amount and location of acres that could be planted to trees. For example, many of the acres now classified as underproductive may already have hardwoods that should remain for a number of reasons.

ODF's Service Forestry Program aims to increase tree planting by providing technical help to non-industrial landowners regarding tax credits and federal cost-share programs. State and federal tax credits provide incentives to plant trees on suitable sites where commercial species do not now grow. The Conservation Reserve, Forestry Incentives, Agricultural Conservation, and Stewardship cost-share programs also encourage tree planting. The Agricultural Stabilization and Conservation Service and U.S. Forest Service administer these programs. ODF encourages research to test native and exotic trees for these purposes.

Tree planting in urban or rural areas can reduce energy use in buildings. It also has other benefits such as noise reduction and air filtering. ODF will continue to encourage the selection and maintenance of tree species for urban and rural areas.

3. Encourage broad genetic diversity in commercial tree species.

The potential rate of climate change may exceed the rate at which trees can naturally adapt to the altered environment. Following natural catastrophes or normal harvesting, trees suited to the anticipated climate should be planted. Establishment, growth, and survival of new forests will depend on selecting appropriate seed sources and species composition. However, planting trees now from warmer, drier seed zones seems unwise considering the uncertainty of regional climate change. ODF therefore promotes cooperative research programs to develop and implement provenance studies to evaluate the fitness of various tree seed sources. Results will help construct models to predict appropriate seed sources for future reforestation.

The department's Tree Improvement Program will continue to produce and collect tree seeds with broad genetic diversity. Reforestation with genetically diverse trees should help buffer some effects of climate change.

4. Develop and encourage strategies to maintain broad biological diversity in forests.

Forest vegetation shifts could reduce the distribution of threatened or endangered forest plant and animal species, particularly those with limited geographic ranges.

Natural or constructed barriers may prevent species from moving in response to climate change. They could result in localized extinctions. Land managers could provide corridors for movement of species to prevent this.

The ODF Resource Policy Division will continue tracking information from other agencies that monitor threatened and endangered species. The Forest Practices Program will consider climate change in developing rules to protect habitat for threatened and endangered wildlife species on forest lands.

The potential global climate change could increase the importance of species now growing in warmer and drier environments. ODF recommends research on the ecology of conifer and hardwood tree species of the Willamette Valley, southern Oregon, and northern California.

5. **Encourage programs and policies to reduce emissions from slash burning and wildfire.**

Burning logging residues and naturally accumulated debris (slash burning) reduces fire hazard, prepares sites for planting, and improves forage. Slash burning also adds methane, nitrous oxide, and large amounts of carbon dioxide to the atmosphere quickly. Because of restrictions on burning and the release of carbon dioxide, the department will promote alternative methods of fuels management.

ODF administers the Smoke Management Program, which aims to reduce particulate emissions from slash burning by 50 percent in western Oregon by the year 2000. This will also lower CO_2 emissions. ODF encourages research to describe the role of logging residues in long-term site productivity. It also encourages research to explore the use of logging residues for fuel (especially when it displaces fossil fuels) and other marketable products.

Forest wildfire can affect Oregon's carbon dioxide emissions. A warmer climate could lengthen the fire season and increase the number and severity of fires. Fires not only release large amounts of carbon dioxide, but also destroy trees that remove carbon dioxide from the atmosphere. The department's Fire Protection Program

will employ the best fuels and fire management technology and will track research on the relationships between climate change and fire.

6. **Encourage ecologically sound forest management practices that encourage carbon uptake and storage.**

Forest management practices likely will affect the response of forests to changes in climate. ODF will continue to encourage private landowners and other land managers to maintain healthy, vigorous forests capable of tolerating environmental stresses and pest attacks. It also promotes management practices that limit fuel build-ups and reduce fire hazard.

Harvesting old growth forests will likely reduce carbon storage and increase the amount of CO_2 in the atmosphere. However, this is a very small contribution on a global scale. Preservation of spotted owl habitat and other set-asides will reduce future old growth harvest levels and the net CO_2 release. Young replacement stands will not reach carbon storage levels equivalent to that of old growth for about 250 years. This emphasizes the importance of effective reforestation in managed forests and on those forest lands not fully stocked with long-lived forest tree species.

Some universities and federal agencies have begun research that should improve our understanding of the effects of climate change on Northwest forests and forest management. ODF recommends sustained funding of this research. ODF also encourages research to develop silvicultural strategies to mitigate effects of climate change.

Climate change will affect tree growth. This may affect harvest rates and timber supply in some areas. ODF will adjust long-term projections as more information becomes available about the effect of climate change on growth and yield.

7. **Monitor insect and disease damage and population trends.**

Damage from insects and disease could increase as changing climate stresses forests. Dead trees from pest damage may also increase fire hazard. ODF, through its

Insect and Disease Program, will continue annual aerial surveys to locate and track long-term trends of forest damage. It will monitor some diseases and insects through special ground surveys and sampling to provide early warning of population or damage increases.

8. **Promote policies to maintain Oregon's forest land base.**

Forests play an important role in reducing carbon dioxide. Loss of forest land to non-forest uses is decreasing the amount of forest land in the state. In 1987, for example, more than 2,000 acres of private forest land were converted to non-forest uses. The department strongly encourages stabilizing the size of the forest land base.

9. **Provide information and training on forest practices to mitigate global warming to department clients and the citizens of Oregon.**

ODF training programs for private landowners and state land managers will include climate change and related forest resource issues. The Insect and Disease Program will expand training on tree health, the effects of environmental stress on trees, and reducing pest-caused losses through integrated pest management. Training and education are often done in cooperation with the OSU Cooperative Forestry Extension Service.

10. **Improve energy efficiency and conservation in department's facilities and operations.**

ODF supports energy conservation measures and will continue to improve energy use efficiency in its facilities, employee activities, and vehicle fleets. It will adjust its purchasing rules as necessary. It will also provide containers for recycling paper in individual offices and centralized drops for non-paper recyclables. ODF also will discourage using chlorofluorocarbon-producing items in the agency. Through its actions, the ODF hopes to influence cooperators, clients, and other agencies to take similar conservation measures.

DEPARTMENT OF AGRICULTURE

The Department of Agriculture recognizes that there is now no clear picture of what to expect from climate change as it may affect Oregon agriculture. The department will need answers to many questions before it can make specific recommendations about changes in farm management systems. With this in mind, the department is focusing on measures that have other benefits as well as responding to the potential of global warming.

PROPOSED ACTIONS

The department will:

1. **Encourage the adoption of cost effective water conservation techniques and technologies.**

   Water availability is likely to be the most important factor affecting future cropping patterns in Oregon. If agriculture requires more irrigation, it will also need more energy to deliver the water.

   The Oregon Water Resources Commission has established a Conservation Advisory Committee and directed it to develop a water conservation plan for Oregon. The plan will focus on increasing irrigation efficiencies and reducing waste. A wide range of technologies to improve the efficiency of water use already exist, but have not been fully implemented. These range from automated systems that monitor crop needs and scientifically apply water to techniques that reduce the impact of direct sunlight and wind on crops.

2. **Evaluate the potential benefits from the adoption of low input, sustainable agricultural practices where appropriate in order to reduce the emissions of greenhouse gases related to agriculture.**

   Low input, sustainable agriculture is a conceptual approach that minimizes petrochemical and other purchased inputs while sustaining an economical level of crop production. It substitutes knowledge and managerial skills for many purchased inputs and develops technologies that maximize on-farm biological interactions.

This body of concepts encompasses a large array of farming practices. These include integrated pest management, minimum tillage, and legume-based crop rotations to maintain soil fertility and control weeds. The US Department of Agriculture encourages this approach largely out of concern for groundwater quality. The scope can be expanded to include concerns about the emission of greenhouse gases related to agriculture.

3. **Assess the vulnerability of the components of Oregon's agricultural production to climate change and uncertain weather.**

Oregon's agricultural production is diverse and specialized. Many of Oregon's nearly 200 commodities are produced in niche micro-climates. Products range from lily bulbs and cranberries on the coast, to cool season grass and legume seeds in the Willamette Valley, to a large variety of tree fruits in the Hood River Valley.

Much of Oregon's agriculture is dependent on irrigation. It is important to know how vulnerable Oregon's agricultural production is to changes in climate or to an increase in climatic variability. With this knowledge managers can assess the adequacy of resources to adapt and cope with change.

The diversity of Oregon's agriculture implies that this assessment would require a substantial effort. The first step of this effort should be a general sensitivity analysis. The analysis should qualitatively describe the sensitivity of the components of Oregon's agricultural sectors to climate changes.

4. **Evaluate the adequacy of Oregon's resources and capabilities to develop successful adaptive responses.**

The agricultural research establishment consists primarily of the federal Agricultural Research Service and the state Agricultural Experiment Stations, which are engaged in the development of efficient production methods. The transfer of research results to application on the farm is largely accomplished by the Cooperative Extension Service, which is supported by federal, state, and county governments. In addition, the U.S. Soil Conservation Service develops and implements conservation

methods through local Soil and Water Conservation Districts, which are subdivisions of state government.

In recent years financial support for these institutions has been declining while the needs of agriculture for solutions to problems have been increasing. The effects of a general decline in funding is compounded in Oregon by its agricultural diversity and specialization, which dilute the resources available for research in specific areas. Changes in chemical labels, introduction of new varieties, and the development of new environmental concerns are occurring so fast that the research establishment at its present level of support is having difficulty keeping pace.

Adaptation to climate change may require development of new, more drought- or heat-tolerant varieties, selection and trial of candidate varieties from other areas, and changes in cultural and farm management practices. Along with this, agriculture may need a substantially increased extension education and information program. Will existing programs, facilities and resources be adequate to meet Oregon's needs? It seems unlikely, but only an in-depth analysis can provide a full answer to this question.

5. **Consider establishing an agricultural weather service to support the increased weather informational needs of future agricultural management systems.**

More sophisticated management systems will evolve to support resource conservation needs and to cope with increased uncertainty, both on a short- and long-term basis. These will require increased attention to weather and climate information. For example, careful monitoring and accurate forecasting of local weather conditions on a real-time basis will be required to support integrated pest management systems and more efficient irrigation management systems. Moreover, in making long term investment decisions, such as planting an orchard and selecting a variety to be established, the assumption of a static or fixed climate may no longer be appropriate.

The technologies in weather forecasting and communication largely exist or can be developed to support future farming operations and help assure maximum harvests. The institutional support for providing meteorological data and climate information

to the agricultural sector is largely missing. The National Weather Service has progressively reduced its level of support for most weather dependent commercial operations. It has become, in effect, a "wholesaler" of weather information. Unfortunately, neither the private sector nor public institutions have been willing or able to provide adequate applications-oriented, or "retail," weather information for farm use. The Department of Agriculture should consider establishing a state agricultural weather service.

6. **Continue to restore and preserve the natural botanical diversity in Oregon's rangelands, wetlands, and forest ecosystems.**

The genetic diversity in the germplasm represented by native species is an important resource. Native species may provide important characteristics that can be imparted to commercial crops. And, a species that is genetically diverse should be better able to adapt to future climatic changes than one that is less diverse. Preservation of this diversity implies preservation of habitat.

By statute, the Oregon Department of Agriculture is the agency responsible for protection of threatened and endangered plant species on state lands. The department has a highly regarded program in place to meet this responsibility. However, federal funds have been declining and are not adequate to do all the work that needs to be done. In addition, there is a need to provide for more extensive inter-agency coordination. Concern over the potential for climate changes is a strong supporting argument for continuing to support and augment this program.

WATER RESOURCES DEPARTMENT

Global climate change presents a challenge for the Water Resources Department (WRD). WRD does not control activities that produce greenhouse gases. The department will focus on adapting to hydrological conditions and impacts on water uses as changes occur.

Because climate change is uncertain, it is premature for the department to make sweeping policy changes or to start new water management programs. It is prudent, however, to broaden the scope of existing water management programs to consider the potential effects of climate change.

Statewide policies and actions must be flexible. In *The Potential Effects Of Global Climate Change on the United States*, the EPA suggests that states should:

- Not invest in irreversible, inflexible, large-scale, and high cost measures.
- Design, modify, and rehabilitate structures and operating procedures that will provide robust and resilient water resource systems under different climate change scenarios.
- Implement a wide variety of measures for reducing demand, as long as they do not reduce the robustness and resilience of the systems.

These are sound guidelines for adapting water resources management activities to climate change. The EPA notes that water management projects should be designed to accommodate more extreme conditions. Historical data used to design projects may no longer be viable under some climate scenarios. The gathering and analysis of new data will be essential to understanding, planning for, and adapting to global climate change.

WRD program activities such as water conservation, drought management, flood control, reservoir coordination, water/land use planning coordination, evaluation of instream uses, and basin planning should reflect an awareness of the potential effects of climate change. Verifying water availability will aid WRD's responses to climate change.

PROPOSED ACTIONS
WRD will:

1. **Use climate change information to assess water availability and allocate supplies.**

   The department is evaluating water availability for use in its allocation activities. In addition, the department works closely with the Oregon Drought Council. The Oregon Drought Council is a subcommittee of the Strategic Water Management Group. The Oregon Water Availability Committee provides technical information

and advises the Drought Council. The Water Availability Committee will consider new climate information in developing recommendations for the Drought Council. The Drought Council will forward such recommendations, as appropriate, to the Strategic Water Management Group for its consideration.

2. **Consider the potential effects of sea level rise on water supply sources and systems along the Oregon coast.**

Many towns, industries, farmers, and individuals use water from coastal streams and aquifers. WRD should work with DEQ and the State Health Division to investigate how sea level rise could affect surface water intakes and water wells. State and local agencies could use such information in planning for and managing water supplies along the coast.

3. **Monitor projected demographic trends and implications for water management.**

WRD should monitor demographic trends projected for the Northwest and consider them in its water management activities. If global warming causes large numbers of people to move to Oregon, the competition for water could increase beyond existing levels. Municipalities might use water rights they have not yet exercised. The department may need to increase its regulatory efforts to protect senior water rights. Maintaining instream flows could become more difficult.

4. **Assess water conservation potential.**

Climate models do not estimate potential changes in water demand. However, studies show that water consumption rates vary between periods of abundance and drought. Demand rates also vary depending on the price of water. Water conservation may be a cost-effective method for adopting to climate change. WRD will continue to expand its understanding of Oregon's "conservation potential."

5. **Develop ground water information and identify vulnerable aquifers.**

Research on the potential effects of global warming on water resources has focused mainly on surface water. Climate change would likely affect ground water recharge

and discharge characteristics, availability, and the cost of pumping. WRD will continue to develop basic ground water data for the state. Ground water assessments will help agencies to identify aquifers vulnerable to climate change. The department will also continue to investigate the relationship between ground water and surface water. This information could be used when climate models can better predict the hydrologic impacts of climate change.

6. **Consider climate change in water resources management and planning.**

   The Water Resources Commission is required to develop and implement state water resources policies, plans and programs. Many other state agencies also have water management responsibilities. WRD will consider global climate change as a factor in its state water management efforts.

7. **Consider how water laws and institutions may be affected by climate change.**

   Oregon allocates water rights under the prior appropriation doctrine. The State also has a complex array of water laws addressing health and public interest issues. WRD will monitor potential global warming impacts and will assess whether existing institutions can accommodate these impacts.

8. **Work with federal, state, and local agencies to evaluate the needs and strategies for optimizing the use of existing water supplies and protecting sites for future water storage.**

   There is public concern that state and local planning processes do not sufficiently provide for the identification and protection of sites for future water storage. There is also a need to evaluate existing stored water supplies to ensure that the beneficial uses are maximized, given economic, environmental, and technological constraints. WRD will coordinate with other agencies in assessing available supplies, reviewing site inventories, and evaluating strategies for protecting sites.

9. **Incorporate information on existing stored water supplies and identify potential storage sites as needed during basin planning. Participate in review of potential storage sites as warranted.**

WRD designates the allowed used of water during basin planning. WRD will incorporate information on existing stored supplies and, as warranted, will evaluate the need for futures storage as part of the basin planning process. WRD amy update previous site inventories. The department will work with interested parties on initial review of new siting possibilities.

DEPARTMENT OF FISH AND WILDLIFE

The primary challenge for the Department of Fish and Wildlife in facing the potential of global warming is to maintain the ability of fish and wildlife to adapt to climate change. In addition to changes in global climate, fish and wildlife face human responses to environmental changes and increases in ultraviolet (UV) radiation caused by ozone depletion. The challenge is difficult because scientists cannot predict the rate and extent of changes in the state's temperature, precipitation, and UV radiation. Further, fish and wildlife production depends on the quality of habitats. Control of these habitats rests largely with other agencies and the private sector. Finally, scientists do not yet fully understand the habitats' role in providing ecological and long-term economic stability. And, fish and wildlife provide major sources of enjoyment as well as economic benefits.

The second challenge for the agency is to conduct its operations in a manner that reduces emissions of greenhouse gases. The agency activities that use the most fossil fuels and refrigerants may be production and transportation of hatchery fish. Yet these activities are necessary because artificial propagation may be a last resort to prevent extinction of some stocks or species.

PROPOSED ACTIONS

ODFW will:

1. **Maintain biological diversity of fish and wildlife through maintenance of Oregon's remaining habitat for indigenous fish and wildlife.**

   Protecting biological diversity is extremely important to sustain these resources in the face of uncertain changes in the environment. The agency needs to protect

diverse ecosystems throughout the state. It also needs to protect corridors for movement of species between ecosystems. To do this the agency needs to classify ecosystems and evaluate their health. The agency will prepare a statewide habitat priority list. This list will guide the agency in responding to changes in climate, changes from human activities, and violations of habitat protection. The agency will also use the list to develop cooperative management programs with other agencies and landowners.

The agency will use listings of sensitive, threatened, and endangered species to identify and protect species and their habitats. It will quickly complete basin management plans for fisheries and statewide species management and recovery plans. These plans will help identity and protect critical habitat.

The agency will help other public and private programs that restore and manage watersheds in their efforts to moderate peaks in flow and maintain adequate flows for aquatic-dependent animals. The agency will also emphasize programs that restore and protect riparian vegetation to moderate stream temperature and provide UV screening. The agency will give higher priority to habitat protection than habitat restoration for two reasons. First, scientists do not have adequate information on how to restore habitat for many species. Second, restoration consumes more energy and produces more greenhouse gases than does protection.

2. **The agency will take steps to counter the effects of global warming in vegetative communities and their associated vegetative structure and microclimates. These steps include working with land management agencies and landowners to:**

   2.a. **Plant tree, shrub, grass, and herb species adapted to a warmer and drier climate, but indigenous to the region.**

   The vegetative species should provide both cover and forage for diverse wildlife.

   2.b. **Encourage a variety of timber harvest methods appropriate for the ecological site in both western and eastern Oregon that maintains the habitat conditions suitable for continuation of resident wildlife species.**

More shade and milder microclimates near the soil surface would benefit both wildlife and tree seedlings.

2.c. Manage wildlife cover and forage stands according to topographic variables such as slope and aspect. Take advantage of the soils' inherent potential to produce the desired vegetation species.

2.d. Manage vegetation stands to maintain multiple layers (e.g., mature trees, young trees, shrubs, herbs, and grasses) to provide both thermal cover and forage for wildlife.

2.e. Increase control of evaporation from water sources (springs, seeps, and lakes).

This will extend the period of water availability to wildlife. The water savings can be gained by greater protection from timber harvests and from livestock grazing near water. Other techniques include plantings or restoration of natural stands of wildlife cover and forage. This will also increase survival of seedlings to replace harvested plants.

3. Maintain biological diversity of fish and wildlife through regulation of harvest.

The agency will regulate harvest to prevent the elimination of species, stocks, or diverse segments of stocks. Some species, stocks or segments of stocks that are not now productive are likely to be the most productive under new environmental conditions. The agency will update its lists of sensitive, threatened, and endangered species. It will also update its information on stock diversity within species and its information on diverse segments within stocks. This information will help the agency determine important habitat elements. It will also help the agency set harvest regulations and seek stiffer penalties for harvest and habitat violations that reduce biological diversity.

4. Prevent artificial introduction of exotic species and stocks that have the potential to reduce diversity among and within indigenous species.

Indigenous fauna are likely to be able to adapt to climate changes in the region. They evolved here through major changes in climate over thousands of years. Three factors affect the capacity of fauna to adapt. They are the diversity 1) of species, 2) of locally-adapted stocks within species, and 3) of individuals within stocks. Exotic species or stocks may diminish or replace indigenous ones under one set of environmental conditions. Then, they may not be able to sustain themselves over the range of conditions to which the indigenous stocks can adapt.

The agency has some control over artificial introductions. It will seek higher penalties for violators and more funds to monitor and control introductions. Legal introductions will have management plans. Plans must address why the habitat changes have made the introduction necessary or how to isolate the introduced animals.

The agency views introductions of new stocks or species through natural migration differently. Nearby species or stocks colonizing habitats altered by climate change is a natural process. It should result in the best adapted stocks and species establishing themselves in a geographical area. That is why maintaining biological diversity and migration corridors is important in sustaining overall fish and wildlife production.

5. **Maintain diversity within and among artificially propagated stocks.**

The chance of quickly adapting an artificially propagated stock to environmental change depends on the diversity of individuals in the stock. The agency will alter breeding and rearing practices to restore and maintain a diversity of individuals within and among these stocks. Practices will reflect the most probable range of environmental conditions to which these stocks must adapt.

6. **Promote, conduct, and/or synthesize research that will enable the agency to manage fish and wildlife in a situation of rapid and unpredictable climate change and increased UV radiation.**

The agency lacks information on how fish and wildlife individuals and populations will respond to rapid climate changes and increased UV radiation. The agency will pursue funding to conduct this type of research. It will promote funding of related studies by universities and other entities. And, it will help synthesize the information.

The agency will work with public and private landowners to set aside relatively undisturbed examples of diverse ecosystems throughout the state. These can serve as refuges to protect biological diversity and as bench marks to monitor long-term environmental and biological change.

7. **Reduce dependence on artificial propagation of fish and wildlife and increase energy-efficiency of remaining propagation activities to reduce emissions of greenhouse gases and ozone depleting chemicals.**

Artificial propagation of animals requires use of fossil fuels and refrigerants. This occurs during: (1) gathering or producing feed, (2) transporting and storing feed, (3) constructing and maintaining facilities, (4) maintaining environmental conditions (e.g., temperature) at facilities, and (5) transporting animals to release sites. In addition, decomposition of animal wastes releases methane at hatcheries and other sites. The agency will consider these contributions to greenhouse gases as it evaluates and changes artificial propagation programs.

8. **Reduce emissions of greenhouse gases and ozone depleting chemicals at all agency facilities.**

The agency will make energy-efficiency a primary concern in the design of new agency facilities and landscapes. It will insulate new facilities to the highest standards with CFC-free materials. It will insulate existing facilities in a similar manner. It will plant deciduous trees to increase energy efficiency of facilities by shading them from the summer sun.

It will use energy-efficiency as an important criterion for new or replacement appliances and lighting for all facilities. Where possible, it will install automatic set-back thermostats on heating/cooling systems and water heaters at office and

housing facilities. Where possible it will install passive solar water heating systems. And, it will install water saving shower heads and faucets.

The agency will make fuel efficiency an important criterion in buying vehicles. And, it will not include air conditioners for passenger compartments without strong justification. It will delay buying vehicles with air conditioners until it can buy units that do not use ozone-depleting chemicals.

It will use experts with CFC-recovery equipment, if possible, to repair air conditioners. If conditions permit, it will delay replacing worn-out units until units are available that do not use greenhouse gases. It will replace halon fire extinguishers without discharging the halon. If possible, it will store all fire extinguishers and worn-out equipment containing CFCs and halons until there is a process for recovery of these gases from the equipment.

The agency will help employes recycle as many types of waste as possible. The agency will buy products with higher percentages of recycled content if performance of these products can meet its needs and if extra costs are reasonable.

The agency will develop programs and incentives to increase car-pooling on the job and among employes commuting to work. It will develop similar programs and incentives to increase use of non-motorized or public transportation systems for work and commuting.

9. **Provide public information on: (1) the potential effects of major climate changes and increased UV radiation on Oregon's fish and wildlife resources; (2) the need for maintaining biological diversity as insurance for sustaining these resources; and, (3) citizen actions to minimize releases of greenhouse gases and ozone depleting chemicals.**

The agency provides the public with information and educational aids in various formats, including an agency magazine. The agency reaches a wide audience of fishers, hunters, and wildlife enthusiasts. The audience transcends many economic and social groups. This provides an excellent way to educate the public and promote changes in habitual activities that add to global warming and increased UV

radiation. The agency will gather information on these topics and relay it to the public in various formats.

DEPARTMENT OF LAND CONSERVATION AND DEVELOPMENT

The Department of Land Conservation and Development (DLCD) administers Oregon's statewide land use planning program. The program seeks to balance the conservation of Oregon's land and natural resources with the requirements and demands for growth and development. DLCD carries out this program through four main activities:

- Establishing statewide planning goals as standards that all city and county comprehensive land use plans and all state agency programs affecting land use must address;
- Reviewing city and county comprehensive land use plans for compliance with state goals;
- Providing grants and technical assistance to cities and counties; and,
- Coordinating the plans and programs of state and federal agencies with statewide goal requirements and approved local comprehensive plans.

Global warming will have profound impacts on land resources and land uses in Oregon. Likewise, land uses contribute to conditions that lead to global warming. Oregon's land use program gives the State a framework within which it can address a variety of land use issues and development trends that may contribute to global warming or may be affected by it.

Oregon's land use program encompasses all cities and counties, as well as state agency programs that affect land use. Under federal law, federal agency programs and actions must be consistent with Oregon's land use program for the coastal zone.

The land use program has broad goals and an emphasis on coordination. These allow state agencies and local governments to anticipate and respond to emerging situations

through flexible policies and mutually supportive programs. They also apply to federal agencies where appropriate. For example, regional transportation planning in the Portland metropolitan area is being coordinated with urban growth policies and practices among affected cities and counties. Coordinated planning and plan implementation are keys to reducing suburban sprawl and coordinating development patterns among many jurisdictions. They are a key to implementing effective mass transit systems to meet transportation needs in the region.

Statewide, agricultural and forest lands are being reserved and protected for continued food and fiber production. On the coast, local governments and state and federal agencies can consider sea level rises and take appropriate measures to reduce or avoid impacts on communities.

PROPOSED ACTIONS

DLCD will:

1. **Promote urban growth management strategies that foster the design and implementation of mass transit systems and that encourage more energy efficient, compact communities.**

2. **Encourage and support transportation plans that reinforce compact urban design, reduce the demand for additional highways, protect farm and forest land, and provide energy efficient transportation of goods and people.**

3. **Assist local governments to strengthen comprehensive plans and to implement ordinances for solar access and passive solar design.**

4. **Assist local governments, especially on the coast, to review and improve comprehensive plans to consider fully the effects of sea level rise and to take actions to direct private development and public facilities away from areas that may be flooded or affected by sea level rise.**

5. **Support economic development activities and land uses that conserve land resources, promote energy efficiency, reduce transportation demands, and contribute to compact urban design.**

6. **Coordinate with state and federal agencies and local governments to identify and protect areas where potential energy resources, especially geothermal, solar, and wind, could be developed.**

EMERGENCY MANAGEMENT DIVISION

Changes in climate will affect those natural disasters that the State now currently mitigates and may place Oregon at risk for disasters that are not currently experienced. The frequency and magnitude of disasters may be affected.

PROPOSED ACTIONS

EMD will:

1. **Work with members of state agencies, qualified experts, and representatives of local governing bodies to adapt and adjust current emergency plans to identified changes in the vulnerability of population, property, and resources in Oregon to existing and emerging hazards. These hazards include, but are not limited to, flooding, dam failure, earthquake, tsunami, storm, and earthquake damage.**

2. **Ensure that proper protective procedures are in place for existing and newly developed water storage and/or energy generation projects that may be built to alleviate the effects of climatic changes.**

3. **Provide information and education to local emergency managers about the cause and effects of global warming in relation to their jurisdictions and about the help available to them from federal and state resources for disaster assistance.**

4. **Coordinate with local emergency management officials to mitigate the effects of increasing sea levels to shorelines and property in coastal areas.**

5. **Assist in the smooth transition of planning for changes in water supplies and quality.**

6. **Coordinate with federal, state, and local agencies to mitigate the effects of drought, severe storms, utility disruptions, and other threats to agriculture and forestry.**

7. **Adapt more sophisticated methods to determine which responses could reduce or control the potential threats to the State of Oregon.**

ECONOMIC DEVELOPMENT DEPARTMENT

The Oregon Economic Development Department (OEDD) is responsible for promoting the economic health of Oregon. The agency accomplishes this task through the development of international trade, ports, business recruitment and expansion, tourism, local and regional economic development strategies, work force training, and statewide strategic planning. OEDD is concerned about the potential impact of global warming on the state's economy. The agency acknowledges the need to reduce the state's contribution to global warming as far as is economically and politically feasible.

The potential impacts of global warming on the state's economic health are vague at this time. While experts are confident the world's climate will become warmer over the next century, they have difficulty in making more specific predictions.

Oregon may see substantial migration to the state or within the state due to climatic change. Oregon's agriculture, forest products, and tourism industries may be adversely or positively affected. Such a potentially powerful factor must be considered when forming state strategy and economic development policy. OEDD will take the following actions to address the issue of global warming.

PROPOSED ACTIONS

1. **OEDD will designate one office to coordinate the agency's involvement in global warming issues.**

   The Policy and Research Section of OEDD's Partnership Division will coordinate the agency's involvement in global warming issues. This section will act as a

resource to the agency by maintaining information on global warming issues, scientific opinion on the potential environmental impacts of global warming, and actions being taken by state agencies and other states and nations to address global warming. This information will be condensed as necessary and distributed to managers of agency programs and local development organizations that may have a role in mitigating or preparing for the consequences of global warming. When appropriate, the Policy and Research Section will participate with other state agencies in evaluating alternatives and establishing policies related to global warming issues.

2. **The Oregon Progress Board will consider the potential impacts of global warming in its efforts to refine Oregon's strategic plan, *Oregon Shines*.**

   The Oregon Progress Board is responsible for updating and shaping the state's strategic plan. The plan currently addresses environmental issues, including air quality, but does not address the potential impacts of global warming or the measures that could be taken to reduce Oregon's contribution to global warming. The Oregon Progress Board will consider the major global warming issues in developing strategies contained in the State's strategic plan.

3. **OEDD's Administrative Services Division will review the agency's policies and facilities to search for ways to reduce OEDD's contribution to greenhouse gas production.**

   The agency will look for opportunities to reduce its contribution to greenhouse gas production through methods such as paper recycling, conservation of electricity, and reduction of single-occupancy automobile trips.

CONCLUSIONS

The agencies on the task force have learned much about global warming over the last year and a half. Based on its study, the task force offers the following conclusions:

- **Climate change from global warming is a serious threat.**
- **The rate of change and the impacts of change on the state are uncertain.**
- **Oregonians can insure themselves against some of the changes by taking prudent actions to slow the emission of greenhouse gases and by planning to adapt to changes.**
- **Many of the actions we should take will offer other, more immediate benefits through cost-effective energy and water conservation, environmentally benign energy development, reforestation, and wise resource planning.**
- **While this is a global problem, everyone must be part of the solution.**