Curbing and Preparing for Global Climate Change

Handbook for Rural Governments in the Pacific Northwest

Produced By:
The Climate Leadership Initiative
Institute for a Sustainable Environment
University of Oregon
541.346.0786
climlead.uoregon.edu

March 2007

Project Management and Authors

This handbook was prepared by faculty, staff and student interns from the Climate Leadership Initiative at the University of Oregon. UO Interns Kirsten Rudestam and Jenna Garmon authored most of the document with assistance from Sarah Mazze, Roger Hamilton and Bob Doppelt.

Acknowledgments

We wish to thank the Crane Creek Foundation and CLI donors for their support for this and other CLI projects.

For More Information Contact:

Bob Doppelt, Director, Climate Leadership Initiative, University of Oregon
Phone: (541) 346-0786 E-mail: bdoppelt@uoregon.edu

Sarah Mazze, Neighborhood Climate Council Program Manager
Phone: (541) 346-0786 E-mail: smazze@uoregon.edu

Roger Hamilton, Local Government Program Manager
Phone: (541) 686-4839 E-mail: grh@uoregon.edu

Curbing and Preparing for Global Climate Change

Handbook for Rural Governments in the Pacific Northwest

March 2007

Table of Contents

Overview and Summary

Every year since 1997 has been in the top 10 list of hottest years in recorded history. The year 2005 was deemed the warmest on record. Average global temperatures have risen by more than one degree Fahrenheit since the late 19th century. Globally, the warming in the 20th century is the largest of any century during the past thousand years and is roughly as warm as the Earth has been at any time in the last 420,000 years. A scientific consensus exists that natural processes cannot explain the increased temperature. The primary cause is the accumulation of human-produced greenhouse gases such as carbon dioxide and methane (and other human activities such as deforestation).[1] A growing number of scientists are also concerned that more than a 2-3° F temperature increase above pre-industrial levels may generate immense and possibly irreversible economic, social and ecological impacts worldwide, including in the Pacific Northwest.

Although climate change is driven by the global emission of greenhouse gases, the impacts will be felt at the local level. For example, rural local governments will deal with the effects of reduced summer water supplies on agriculture, the impacts of increased wildfires on forestry, and for those on the coast, the effects on property and infrastructure due to rising sea levels and increased wave heights during storms. Similarly, although action is required across the globe to resolve the problem, many solutions to climate change must begin at the local level. For example, emergency management and water contingency plans must be developed at the local level. Local governments, therefore, are ground zero for responding to climate change.

This handbook describes the current and likely future impacts and risks of global climate change for rural local governments in the Pacific Northwest. It introduces an approach that local governments can use to respond to those risks, including a "Vulnerability and Opportunity Assessment," which is a tool that can be used to identify ways to prepare for the effects of climate change and to capitalize on emerging opportunities caused by warming. It closes with case examples from communities as well as a list of resources that rural governments can use when preparing their approach.

I. What Climate Science Tells Us

The international scientific consensus on climate change is robust. At the global level, the Third Assessment Report of the Intergovernmental Panel on Climate Change (IPCC) provides the most authoritative summary of that consensus.[2] The IPCC is the international body of over 2000 scientists from across the globe established in 1988 by the World Meteorological Organization (WMO) and the United Nations Environment Program (UNEP) to study climate change. The IPCC does not carry out original research. It bases its assessment on peer reviewed and published scientific/technical literature on climate change produced by scientists worldwide. The IPCC Working Group found that during the twentieth century, Earth's average surface global temperatures increased about 1 degree F (1.5° F in Oregon and Washington), and sea levels rose between 4 and 8 inches.

The IPCC expects an additional global average temperature increase during the twenty-first century of between 2.5 and 10.4° F (the 8° F temperature range is not due to modeling unknowns--it reflects questions about how society will respond to the problem). To put a temperature increase of this magnitude into perspective, during the last Ice Age, the earth's average temperature was only 9° F cooler than it is today, so the potential warming represents a similar amount only in the opposite direction.

Sea levels are anticipated to rise between 4 and 23 inches this century, due to increased thermal expansion caused by rising temperatures and melting glaciers and ice sheets.[3]

Natural climate variation cannot account for today's temperature increases. The IPCC attributes increasing temperatures primarily to human activity including the emissions of "greenhouse gases" (carbon dioxide, methane, and others) from the combustion of fossil fuels including gasoline, fuel oil, natural gas, and coal. Warming is also attributed to land use changes and deforestation in particular.

The climate-forcing factor that has changed most over the past 150 or so years is human reliance on fossil fuels. Burning coal, oil, natural gas, and other fuels oxidizes carbon long stored deep underground in geological layers. The amount of carbon dioxide released by human activities has increased exponentially from negligible levels in the 1800s to more than 27 billion tons per year today, or over four tons for every one of the 6.4 billion people now living. Since 1850, the carbon dioxide concentration in the earth's atmosphere has increased by 36 percent. Emissions of CO_2 due to human activities continue to grow by 1 to 1.5 percent each year.[4] Figure 1 shows the global rise in greenhouse gases.

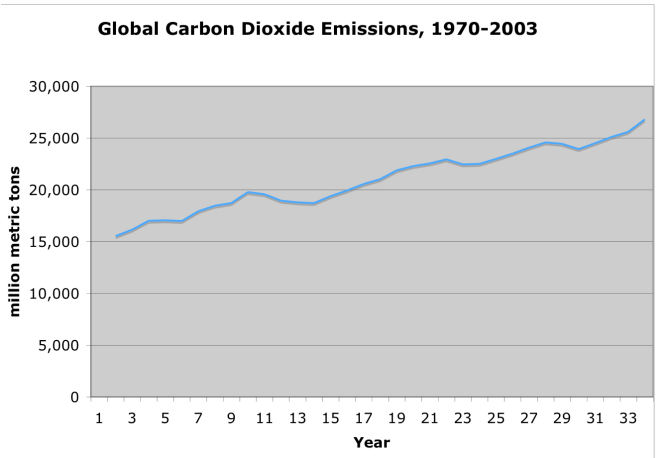


Figure 1. Global Carbon Dioxide Emissions, 1970-2003 (in millions of metric tons)
Source: Energy Information Administration, US Department of Energy.

The result of this transfer of stored carbon into the atmosphere is a physical change in the earth's ability to capture the energy of sunlight and hold it as heat. Carbon dioxide and other "greenhouse gases" act like a blanket that impedes the radiation of heat from the surface of the Earth back into space, with the result that temperatures increase at the Earth's surface. The more carbon dioxide and other trace greenhouse gases accumulate in the atmosphere, the more effective the heat trapping blanket.

Figure 2 shows the projected U.S. temperature increases under high and low future emissions scenarios.

Implications for the Pacific Northwest

In the Pacific Northwest, the climate has warmed about 1.5° F since the start of the 20th century. This warming has occurred primarily west of the Cascades.[5] The Climate Impacts Group (CIG) at the University of Washington reports that June of 2006 was exceptionally warm throughout the region, with the average temperature higher than the average temperatures of almost all the previous 112 years.[6] Temperatures in the Pacific Northwest since 1895 have been increasing steadily.[7]

Scientists at UW CIG and at other institutions expect continued warming during the twenty-first century. Snowpack, the timing and volume of

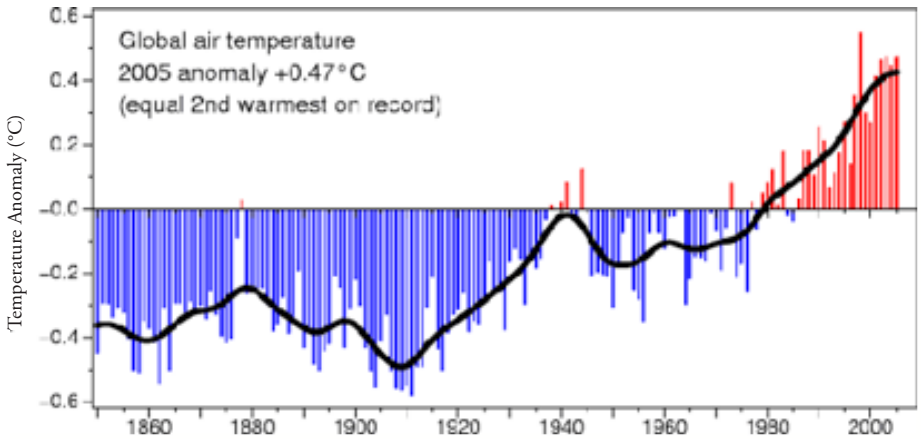


Figure 2: Global Air Temperature, 1860-2000

streamflows, and sea levels are expected to continue to change. Current regional models project an additional warming of 2.7°F above current averages by the decade of the 2020s, and approximately 5.4°F by the decade of the 2050s, or a warming of approximately 1°F per decade. The Pacific Northwest will experience a number of consequences due to this warming.

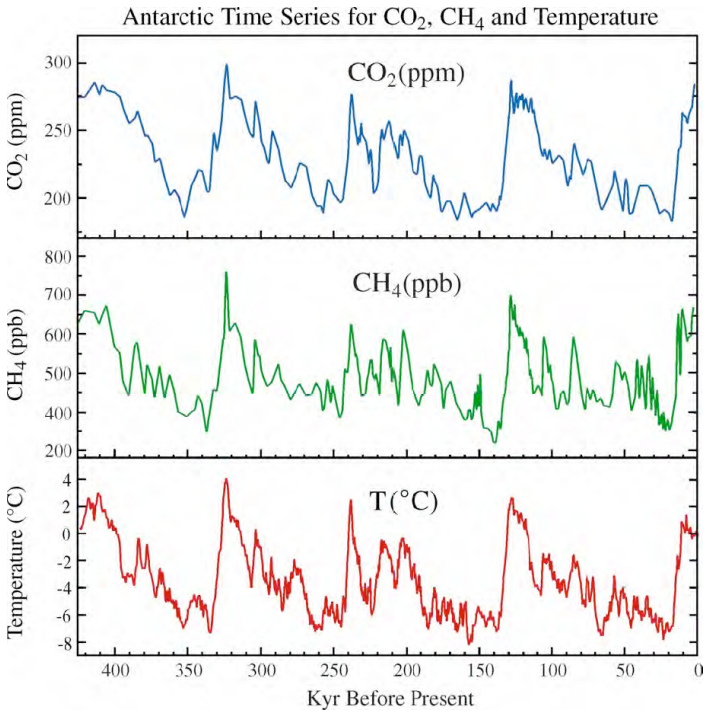


Figure 3: Link Between Increased Greenhouse Gas Emissions & Temperatures **Source**: Vimeux, F., et al [7.1]

Increase in Forest Fires Frequency and Scale.

Compared to an "average year" during the 20th century, an average year in the 2020s is projected to feature a 50 percent increase in the number of acres burned, and an average year in the 2040s is projected to feature a 100 percent increase in the number of acres burned. The full range of economic impacts, including lost timber value, costs for fire suppression and management, lost recreational and tourism dollars due to forest closures, and public health and other environmental costs related to air pollution are likely to increase a commensurate amount.

Effects on Agriculture

Effects of climate change on agriculture in the Pacific Northwest are likely to vary by sector and region. In general, heat sensitive crops are likely to be negatively affected, as will sectors dependent on surface water for irrigation, especially east of the Cascades. However, there are also projections of increased crop yield due to increases in carbon dioxide. Dairy production is sensitive to temperature changes, but the Northwest's average temperatures are likely to remain in a moderate range in which direct impacts on milk output are small. Washington State's two most productive counties would likely experience production declines no larger than 3-6 percent by the end of the century due to temperature effects alone. However, agricultural output in the Yakima Basin is highly sensitive to water availability and to climate change impacts that increase the probability of water shortages. Expected annual crop losses with water shortage rise from an historic average of $13 million to $79 million. Impacts on

High Intensity Forest Fire Burns in the Pacific Northwest
Source: British Columbia Ministry of Forests and Range[8]

the wine and grape industry are likely to be mixed. Warming could push Pinot Noir out of Oregon to cooler regions on the Westside of Washington while growing areas in Eastern Washington will be pushed toward the upper limits of existing grape temperature tolerance ranges. Cooler areas such as the Puget Sound may become more attractive. These and other warming-driven changes will challenge the adaptability of agriculture in the PNW.

Changes in Electricity Supply and Demand

Climate change is likely to affect both the supply of electricity (due to a reduction in hydro generation in the summer months) and demand for electricity (due to reduced consumption in the winter and increased consumption in the summer). The Northwest Power and Conservation Council estimates annual net impacts on power sales to range from a gain of $777 million to a loss of $233 million by 2020 and from a gain of $169 to a loss of $730 by 2040 compared to current sales (it acknowledges that gains are likely overestimated and losses underestimated because estimates of growth in air conditioning are not yet incorporated into the Council's demand projections). Impacts of altered flow regimes on wild fish may determine whether changes deliver more costs than benefits. Taking all factors into account, simulations of the power market by University of Washington researchers suggest a revenue impact of about 5 percent in Washington, which at today's rates would total a loss of $165 million annually. Impacts could be higher in Oregon because Oregon is less dependent on hydro than Washington and therefore more dependent on more expensive thermal fossil and renewables. Diminished hydro means that Washington will need higher priced sources of new supply relative to Oregon.

Impacts on Municipal Drinking Water

Climate change is likely to affect municipal water supplies where supplies are derived from streams in basins that will experience reduced snowpack. For example, Seattle's water supply is expected to be vulnerable to climate change impacts by mid-century. "Firm yield" of the Seattle water system is projected to decline by about 6.1 million gallons per day every ten years through the 2040s. Portland is also vulnerable. Many other small and large communities throughout the region may be at risk if they rely on snowpack for water storage. Water conservation, the

most cost-effective response (estimated at $500,000 per million gallons per day saved) has limits. Other alternatives may lead to larger costs for consumers (water rates) and municipalities (investments in new storage capacity). The uncertainties introduced by climate change increase the costs of water supply.

Likely Increase in Infectious Diseases and Heat-Related Illnesses

Some infectious diseases are associated with changes in temperature and precipitation. West Nile Virus is thought to be one such disease. Oregon reported its first human case of the virus in 2005 and Washington reported its first two human cases in 2006. Although it is not certain that West Nile Virus will spread in Oregon or Washington as it has in other states, costs for treatment and prevention in Colorado (estimated at $118 million over a five-year period) and Louisiana (estimated at $20.1 million for a single year) illustrate the magnitude of potential costs. Asthma, already estimated to cost the State of Washington over $400 million each year, could increase due to rising temperatures that may increase ragweed and urban smog. Efforts to reduce global warming emissions may provide the double benefit of reducing the risk of asthma. Heat-related illnesses and mortality are also likely to increase when temperatures exceed certain thresholds, as they did during the summer of 2006.

Sea Level Rise Will Impact Many Coastal Communities

Sea levels are rising due to melting glaciers, Arctic ice caps and marine thermal expansion. The effects will vary

Potential Consequences of Climate Change in the Pacific Northwest

- Reduction of the Cascades average snow pack, which declined by 30 percent since the 1950s, is expected to accelerate with possible reductions of more than 50 percent by 2040
- Increase in scale and frequency of forest fires due to persistent drought and disease
- Changes in the structure and productivity of certain agricultural sectors due to increased temperatures and reduced summer water
- Shifts in electrical supply and demand
- Reduced municipal water supply in snow sensitive basins
- Reductions in summer stream flows due to reduced snowpack and earlier spring runoff
- Continued sea level rise and potential flooding, especially from Florence northward in Oregon to the south Puget Sound area of Washington
- Increase in coastal wave heights during storm events
- Increasing frequency and intensity of storm events, leading to more floods and extreme weather conditions.
- Increased public health risks and costs due to new pests and pathogens

Surface Melt on Greenland
Source: Roger Braithwaife, University of Manchester

throughout the Pacific Northwest. The South Puget Sound between Tacoma and Olympia in Washington is a region vulnerable to early stage sea level rise. Tacoma could experience a two-foot sea level rise within 60 years. A two-foot rise in sea levels would inundate 56 square miles and affect a portion of the state's population larger than the current population of Olympia.

Portions of the Oregon coast from Florence north are also vulnerable to early stage sea level rise. Beach sand is likely to erode, affecting recreational and tourism opportunities. Higher wave heights during storm events are likely to impact roads, bridges and other coastal infrastructure. Engineering re-design of public infrastructure to account for new sea level rise projections can add 5 to 10 percent or more to total project costs. Estuaries may see an influx of seawater, affecting their productivity.

Summary

The impacts described above can be summarized into four overall categories, which are discussed in greater detail on page 24.

- *Direct economic output* is likely to be affected in many sectors of the economy.
- *Increased depreciation of capital* can be expected due to more intense and frequent storms as well as global and national market changes triggered by warming.
- *Adverse effects on human skills and health* such as increased illnesses and increased diseases may occur due to more frequent summer heat waves and heat-responsive pathogens.
- *Government may face increased challenges* resulting from the changes described above.

II. Strategies and Opportunities for Local Governments

Although global climate change poses significant risks for rural governments, it also opens the door to new ways of thinking and new opportunities. By taking two interrelated steps, rural governments can reduce a community's vulnerability to climate change and take advantage of economic opportunities:

- Inventory and reduce greenhouse gas emissions emitted by government operations and support similar actions within the broader community, a process called mitigation.
- Prepare now for the unstoppable effects of climate change, including supporting the growth of industries that produce low-carbon goods and services, a process called adaptation.

Inventory and Reduce Greenhouse Gas Emissions

Efforts to reduce (mitigate) GHG emissions will be needed across the globe in order to prevent warming from becoming worse and to eventually eliminate the problem. Emissions reduction will have costs. However, emissions reductions can also provide economic benefits. A recent examination of California's economy concluded that a combination of policies aimed at reducing greenhouse gas emissions could generate a net increase in gross state product and in employment.[9] Economic benefits were derived from two sources: decreased spending on energy due to increased energy efficiency and reduced energy imports, and benefits that accrue from investments in innovative technologies. The California economic model cannot be directly applied to the Pacific Northwest. We therefore have no way of knowing if the economic benefits of reducing greenhouse gas emissions will outweigh the costs in the long run. However, the underlying message of the California assessment may be true for The Pacific Northwest: Action to reduce greenhouse gas emissions can create economic opportunity.

In addition to potential benefits, greenhouse gas emission reduction is a good risk-management response to the possibility of future federal action to reduce carbon emissions. The sooner a community or business pursues mitigation, the easier the transition to a low-carbon world will be for them.

Inventory Emissions

Identifying the sources and amounts of greenhouse gas (GHG) emissions generated within a community (i.e., city, county, metropolitan area) is a crucial step toward reducing a community's climate change footprint. This analysis is commonly called a "greenhouse gas inventory." The purpose of an inventory is to create a clear picture of how a

community uses energy and generates pollutants and to pinpoint the activities and sectors contributing the most to global climate change.

There is no one standard way to prepare a community-wide greenhouse gas inventory. In fact, the need to adapt to the goals of the inventory, local conditions and available data dictate that the specific methodology used be tailored to the local community. However, some standard practices have emerged that provide guidance for a community undertaking a GHG inventory. Overall, an inventory should be accurate (relative to its intended purpose), efficient, transparent, consistent over time and thoroughly documented.

This overview is intended to provide a relatively simple and straightforward methodology for use by communities that are preparing an inventory in-house, without the assistance of a consultant or access to a computer model. This approach is based on that used by the Cities for Climate Protection, and on accepted national and international protocols.

Methodology

An inventory of greenhouse gas emissions for a community involves four main steps:

1. Define the goal and scope of the inventory.
2. Collect GHG emissions data.
3. Calculate GHG quantities and convert to CO2 equivalents.
4. Interpret inventory.

Step 1: Define the Goal and Scope of the Inventory

Defining the goal and scope of the inventory at the outset will help ensure that the methodology used and the data gathered are appropriate for the ultimate use of the inventory. The standard approach is to collect emissions data for a baseline year, an interim year, and a forecast year. Setting a baseline year allows a community to establish a reference point against which to measure changes in greenhouse gas emissions over time. Note that greenhouse gases include carbon dioxide, methane, and chlorofluorocarbons. Each can be inventoried separately.

Step 2: Collect GHG Emissions Data

The next step is to identify and record the quantities and activities associated with the release of GHGs. Community GHG inventories generally focus on three primary emission sources: energy consumption, vehicular transportation, and waste generation. Most community-level inventories focus on the predominant GHGs - carbon dioxide (CO_2) and methane (CH_4). They generally do not include

the other GHGs covered in the Kyoto Protocol ($N0_2$, HFCs, PFCs, and SF_6). The rationale for omitting these other gases is that emissions from fossil fuel combustion (CO_2) and solid waste decay (CH_4) generally make up the vast majority of a community's climate change-inducing emissions, with the other GHGs contributing only marginally to the overall inventory.

Step 3: Calculate Emissions

The next step is to calculate quantities of greenhouse gases and convert them to CO_2-equivalents (CO_2e). Different GHGs have varying degrees of impact upon global climate change per unit of gas emitted. The degree of impact is described as the *Global Warming Potential (GWP).* GWP is a scale used to convert greenhouse gases to CO_2 equivalents using CO_2 as the reference point and base unit. Since methane is 21 times more potent a greenhouse gas than carbon dioxide, the relative global warming potential of carbon dioxide = 1, and methane = 21.

Step 4: Interpret Results

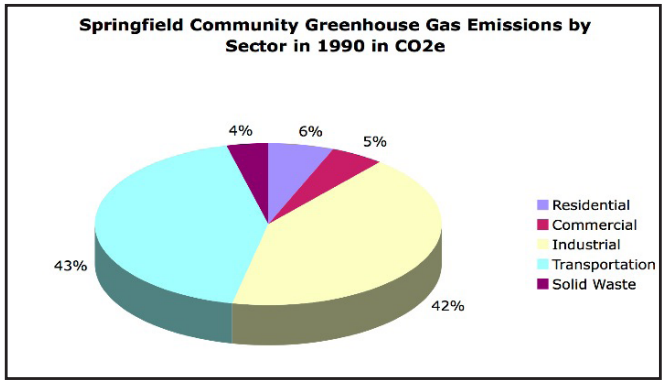
The results of the inventory will highlight which sectors are the greatest contributors to greenhouse gas emissions. A community can use these results to set a greenhouse gas reduction target and to develop a plan for meeting the target. The inventory can also be used as a baseline to track progress in meeting the plan's goals.

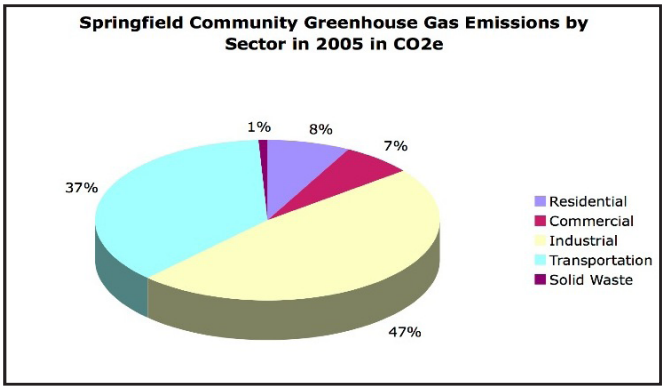
It is recommended that a community conduct inventories on a regular basis to evaluate the results of efforts to reduce GHG emissions.

Example

Greenhouse Gas Inventory for Springfield, Oregon

This approach was used to prepare a greenhouse gas inventory for the community of Springfield, Oregon. In the base year 1990, Springfield generated approximately 444,803 metric tons of CO_2 equivalent emissions. In 2005, CO_2e emissions were 532,340 metric tons. As the following figures demonstrate, most of these emissions are from the transportation and industrial sectors. Therefore, emission reduction efforts should target activities within these sectors.





Implement Reduction Strategies

Once your sources of emissions are identified, a variety of actions can be taken to reduce them including:

- Invest in energy efficiency
- Maximize fuel efficiency
- Utilize green building design
- Invest in renewable energy
- Capture methane at landfills
- Use smart growth practices
- Sequester CO_2 through restoring and planting forests

Examples

Invest in Energy Efficiency

Energy efficiency can be accomplished in numerous ways. Compact florescent light bulbs, for example, use far less energy than conventional light bulbs. The light from a 7 watt CFL bulb is equivalent to a regular 40 watt bulb. Though initially more expensive, this saved energy results in a cost savings that can surpass $40 a bulb.[10] Another small step to reduce energy use is to resize motors to limit excess capacity. Super energy efficient windows and appliances as well as increased insulation can be installed in existing businesses. Light-emitting diodes (LEDs) can be installed in traffic signals. LEDs consume less energy, have a longer life, and require less maintenance than incandescent traffic signals. In 2001, the City of Portland replaced almost all of its red and green incandescent traffic lights with LEDs. This project saves 4.9 million kilowatt hours of electricity every year, and reduces the city's greenhouse gas emissions by 3%. The annual energy and maintenance savings accrued totaled $400,000.[11]

Maximize Fuel Efficiency

Maximizing fuel efficiency is another strategy to curb greenhouse gas emissions that can offer significant economic benefits. One initiative under Portland's climate change plan was the purchase of more than 30 highly fuel efficient hybrid vehicles for the city vehicle fleets. Portland has also implemented a number of larger scale transportation projects to reduce vehicle congestion, traffic, and excess greenhouse gas emissions such as light rail lines and improvements to their public transit network. Since 1990, Portland has seen a growth of 75% in the use of public transit.[12]

Use "Green" Building Design, Construction, and Landscaping

Green building and design minimizes the consumption of natural resources, reduces energy, water use, and waste, and in general produces fewer impacts on the local environment. For years Seattle has been a leader in the international movement towards creating green buildings and in 2005 Washington became the first state in the nation to require new prisons, offices, school, colleges and other publicly funded buildings to meet a national environmental standard. A pilot project

conducted in green buildings within five school districts around the state found a 5% increase in student test scores, 5% reduction in teacher turnover, a 15% drop in absenteeism, and a 25% reduction in energy use.[13]

Invest in Renewable Energy

Potential exists in Oregon and Washington for growing primary and secondary energy sources that produce fewer greenhouse gas emissions than fossil fuels and even, down the road, reduce costs. It is possible that the states may avoid future costs imposed by carbon taxes or cap and trade systems, should they occur, by moving early to reduce GHG emissions through investment in renewable energy infrastructure. This opportunity will expand as existing generating capacity reaches the end of its operating life and energy demand increases.

One innovative approach to supporting alternative energy in the Pacific Northwest is "Our Wind Co-op," a cooperative that invests in small-scale wind turbines for farms, ranches, and public and private facilities across the Northwest. Initially supported by federal grants, this collaborative effort has installed turbines at numerous rural sites serviced by publicly-owned utilities.[14]

Source: www.edie.net/news/images/2238.jpg

The Northwest is also positioned to be a leader in the growing bio-fuels industry. In 2006, the Washington legislative session called for new energy independence strategies and passed a bill establishing market access for ethanol and biodiesel, in the process opening up a large new market for bio-fuels in the state. The renewable fuel standards will begin to take effect in 2008, and these are expected to attract significant investments in the local biofuel industry.[15]

Capture Methane at Landfills

Decomposing trash in landfills produces gases, about half of which are methane, the most powerful greenhouse gas. If harnessed, this can be used to provide heat, hot water, and electricity to nearby facilities. The Emerald People's Utility District's Landfill gas to-electricity facility at the Short Mountain landfill in Lane County, Oregon generated $739,101 in 2005. EPUD paid Lane County $21,157 directly and an additional $12,557 in property taxes.

Use Smart Growth Practices

Smart Growth is a strategy of city planning that places living spaces within walking distances of workplaces, stores, and entertainment. Planning housing and other development around public transit and alternative modes

of transportation significantly cuts down on vehicle use and subsequent greenhouse gas emissions. Though this type of development requires an initial investment, the property value of Smart Growth neighborhoods may be quite high. For example, The Crossings, a smart-growth neighborhood built in Mountain View, California now has some of the fastest selling homes in the region, and much of this interest has been attributed to its Smart Growth development.[16]

Sequester CO_2 Through Restoring and Planting Trees

Another means of reducing GHG emissions and generating economic opportunity resides in the maintenance or expansion of carbon "sinks," biological systems that absorb atmospheric carbon dioxide and keep it out of the atmosphere. Both topsoil and forests can serve as carbon sinks with specific management practices such as no-till farming and longer rotations on timberland. These practices can generate additional revenue streams for land and resource owners through the sale of carbon credits to offset emissions of carbon dioxide by utilities, industry, and others in the Pacific Northwest and beyond. However, these forms of carbon storage can be temporary, because if the soil is tilled or the forests logged or burned, GHGs are released into the atmosphere, and what once was a sink becomes a source of carbon.

Like energy efficiency measures, the amount of sequestration that is practical as well as technologically and economically feasible depends on policies and cultural values, which largely dictate the price of carbon offsets and the alternative opportunity costs of the land. The costs of sequestration thus vary from site to site.

New scientific studies have raised questions about the sequestration benefits of planting trees in the Pacific Northwest. What works in tropical rainforests may not be effective in temperate forests at high latitudes. These concerns should be fully investigated before planting trees as a form of sequestration.

Summary

By increasing energy efficiency, investing in renewable energy, and taking other steps to reduce greenhouse gas emissions, rural governments can do their part to prevent climate change from growing worse while also potentially saving money and helping to support the growth of new industries. Additional case studies are included in Appendix 1.

Prepare Now for Likely Climate Impacts

No matter how aggressive efforts are at the global scale to reduce greenhouse gas emissions, the existing build up of emissions in the atmosphere means that temperature increases are now inevitable. Preparing for the effects of this change is therefore a prudent step to prevent and reduce the impacts. Preparation should be linked with efforts to grow local economic development opportunities.

This section discusses ways to think about preparing for climate change. It offers an approach for considering potential future impacts and outlines strategies for responding to them.[17]

- *Direct economic output* is likely to be affected in many other sectors of the economy. Some sectors may see costs rise, some may see slight (through likely short term) benefits, and others may find their resource base deteriorates. For example, the forest products industry may be affected by the increased frequency and scale of fires. Reduced water availability, increased temperatures, and additional pests may affect certain agricultural sectors. The interaction between the affected sectors is likely to generate cumulative effects on the entire economy.

- *Increased depreciation of capital* can be expected due to more intense and frequent storms as well as global and national market changes triggered by warming. For example, public infrastructure such as roads, bridges and stormwater systems may need to be replaced at accelerated rates because they will be exposed to weather conditions they were not designed for.[18] Businesses may find that capital expenditures expected to depreciate over a long time period may need to turn over faster as markets adjust to new climatic conditions.

- *Adverse effects on human skills and health* such as increased illnesses may occur due to increased summer heat waves, higher pollen counts and increased diseases caused by pathogens such as West Nile virus and respiratory conditions such as asthma.[19] These effects may increase employee illness and absenteeism and thus economic productivity. They may also increase the costs of health care.

- *Government may face increased challenges* resulting from the changes described above. The possibility that some economic activity (e.g. the wine industry example discussed in chapter three) may shift to different regions of the state to adapt to new climate conditions, may affect local employment and tax bases. Flooding due to sea level rise or more intense or frequent storms may pose new challenges to government related to questions of liability, insurance, property abandonment, and increased costs to maintain public services.

Vulnerability and Opportunity Assessments

A useful tool that can be used to plan for the effects of climate change is a Vulnerability and Opportunity Assessment. The process embeds climate change into future planning. It also identifies opportunities to prevent or reduce the potential damage or losses that may occur from climate change before they occur. Vulnerability/ Opportunity assessments are a form of risk assessment. They utilize current and future projections of economic and climatic conditions as well as decision support tools to analyze

potential impacts, project economic and environmental costs and benefits of different response strategies, and incorporate chosen strategies into future planning.

Vulnerability/Opportunity assessments usually begin with two steps: a) a decision to incorporate climate change into future planning and decision making, and; b) an inventory of existing systems that may be at risk due to adverse climate impacts. The systems to consider should include: [20]

- *Built systems.* Roads, bridges, sewage treatment, stormwater collection, water purification, waste disposal, communication and other forms of public infrastructure, commercial and residential buildings, and other aspects of the human-constructed environment. It is particularly important to consider climate change in any large, long-term infrastructure investment, such as the Seattle seawall and water storage and conveyance systems. Safe and reliable built systems are important for a well-functioning economy.
- *Human systems.* Emergency and medical response, disaster management, health care, social welfare, food delivery and security, public safety, equipment and building maintenance, agriculture and forest research, cooperative extension, and other systems that depend on human coordination and responses. Human systems provide the management apparatus and safety nets for a well-functioning economy. For example, agricultural research must be robust to monitor and respond to pests, plants, diseases and changes in water flows and temperature.
- *Natural systems.* Watersheds, lakes, groundwater and aquifers, wetlands, forests, soils, coastal and marine ecosystems, plants and animals and other elements of ecological systems. Resilient ecosystems and biodiversity are the critical sources and sinks that support life on Earth and form the basis for all human economic activity.

In a vulnerability/opportunity analysis, the current condition of each system is assessed against relevant climate scenarios, such as those discussed in this report, to determine the degree of probability and severity of adverse effects. This means determining the likelihood of adverse effects occurring

Steps in a Vulnerability/Opportunity Assessment

1) Develop/utilize climate impact scenarios
2) Assess risks to existing systems
3) Assess existing systems against climate scenarios
4) Estimate the gaps between existing capacity and what will be needed under different climate scenarios
5) Identify and assess strategies for closing gaps
6) Choose strategy and implement

and, if realized, the likely seriousness of the consequences (e.g. slight, modest or severe damage). For example, roads, bridges, culverts and other infrastructure can be assessed to compare the conditions they were initially designed to withstand against likely future increases in storm frequency and intensity, or sea level rise.

Over the past few years it has become increasingly possible to examine climate impacts on a finer scale such as that needed for regional vulnerability/ opportunity planning purposes. The Climate Impacts Group at the University of Washington and other researchers have made great strides in teasing out regional trends from global climate data. However, it still may be difficult to obtain the fine resolution data required for local analysis. In this case estimates can be used based on regional data. Investment in further research is needed to continue to produce the refined level of data required to complete localized vulnerability/opportunity assessments.

Once potential vulnerabilities are identified, strategies can be examined for closing the gaps. The economic and environmental costs and benefits of the various strategies are assessed. Finally, the most cost-effective strategies are chosen and implemented. For example, upgraded cleaning schedules may be deemed the most efficient way to ensure that certain culverts can carry water during regular storm events, while plans may be adopted to install larger culverts in other locations that must carry higher water volumes during major storm events.

Case Study:
Olympia Sea Level Rise Plan

In 1991 a Global Warming Task Force was appointed in Olympia. Through a six-year study it found that even moderate projections of sea level rise could have catastrophic effects on its coastal land. In order to act rapidly to prevent future risks, Olympia's task force recommended a number of options that include renewed waterfront zoning measures, increasing building standards, acquiring coastal land as a buffer, initiating storm water and flood controls, relocating sewer lines and relocating the principal water-source to a safer location. Since completing the research the city is investigating where best to direct its resources. A 100-year plan is being prepared which will consider various options. In the meantime, new municipal projects are being designed with climate change impacts in mind. For example, flood proofing has been a priority in the construction of the new city hall.

Quantitative methods for measuring risk can be used in a vulnerability analysis where the probability is expressed as the event frequency per unit of time or activity, and the consequences are expressed as loss of dollar value or through other metrics such as illness days or lost recreational days that don't readily lend themselves to agreed-upon dollar values (e.g. Risk= Probability of occurrence x Consequence of occurrence). Qualitative decision-making tools can also be used such as a "Fault Tree Analysis" that graphically represents logical combinations of causes that may lead to a defined negative outcome.

At least six strategy options can be considered when deciding how to close the gap between current conditions and future climate risks.[21] The examples provided under each option below are by no mean exhaustive. They are provided simply to illustrate the type of activity that can occur under the strategy option.

TYPES OF ADAPTATION MEASURES

CATEGORY	MEANING	EXAMPLE
Status Quo	Do nothing to reduce vulnerability & absorb losses	Rebuild, or abandon affected structures
Prevent the Loss	Adopt measures to reduce vulnerability	Engineer structures for big winds, floods, drought
Spread or Share the Loss	Spread the burden of losses across different sectors	Establish public funding for emergency food and shelter
Change the Activity	Stop activities that are not sustainable under new climate regime and substitute others	Prevent development in low lying coastal areas, rebuild wetlands
Change the Location	Displace the infrastructure or system	Relocate infrastructure out of risk zones
Enhance Adaptive Capacity	Enhance the resiliency of the system to improve its ability to deal with stress	Preserve or rehabilitate natural systems, increase emergency response capacity

Modified from *Adapting to Climate Change*, Canadian Climate Impacts and Adaptation Research Network

- *Status Quo:* This approach assumes that no action will be taken to reduce vulnerability to climate-related damage. It is accepted that losses will be absorbed and that damaged areas will be rebuilt, restored or abandoned.

- *Prevent the Loss:* Preemptive actions are taken to reduce vulnerability and blunt the effects of climate change. For example:
  - Critical infrastructure, especially those expected to last 50 or more years such as bridges, stormwater collection, sewage and drinking water treatment systems, and seawalls, can be engineered to account for sea level rise expected over that time period.
  - Stormwater collection systems can be rebuilt and expanded and road culverts enlarged on normal replacement schedules to accommodate more extreme precipitation events.
  - Routine maintenance practices for public infrastructure can incorporate climate change so that, for example, debris is regularly removed from culverts to ensure stormwater flows smoothly.
  - Urban heat sinks can be eliminated by repainting surfaces with light colors, planting trees, and creating open spaces.[22]

- *Spread the Loss:* Policies and programs can be instituted to share and spread climate-related losses across the population. For example:
  - Insurance could establish programs to provide added protection for wind, rain, or drought damage (although care must be taken to ensure this does not delay permanent adaptation). ○
  - Short term financial support can be provided to communities that may be affected by smoke intrusion, public health impacts, lost tourism and recreational

opportunities, or lost timber jobs due to increased forest fires.

- *Change the Activity:* Activities that are not sustainable under new climate conditions can be prohibited and activities that make sense due to the new conditions can be initiated. For example:
  - Land use plans can be changed so that development is restricted and seashore setbacks are adopted in areas such as the south Puget Sound likely to be impacted by sea level rise, and in river floodplains such as the lower Snohomish, that are susceptible to flooding in major storm events.
  - Wetlands can be restored to increase the buffering effects they provide against large storms.
  - Public policies that encourage activities that may be at risk of harm due to climate change, such as building in floodplains or areas at risk of sea level rise, can be changed to eliminate the incentives.
- *Change the Location:* Infrastructure and built structures can be relocated to safer locations. For example:
  - Roads, bridges, stormwater collection, communication and other public infrastructure systems can be relocated out of low-lying coastal areas, floodplains, avalanche zones and other at-risk locations.
  - Buildings constructed in 100- and 500-year floodplains can be relocated to higher ground.
- *Enhance Adaptive Capacity:* The resiliency of built, human, and natural systems can be enhanced to improve their ability to respond to climate change. For example:
  - Early warning systems and emergency response systems can be enhanced to anticipate extreme temperature or storm conditions and trigger special care for sensitive populations such as the elderly, infirm, and children.
  - Building codes can be adopted to increase energy and water efficiency so that when supplies are more constrained in 40 years, demand will have been reduced.
  - Forests, wetlands, and other natural systems can be preserved and restored so that as warming intensifies they have greater capacity to survive fires, drought, heat waves and other events and buffer their effects.
  - Water storage, conveyance and treatment systems can be improved to ensure secure water supplies and delivery in the future when snowpack and summer streamflows are reduced.

The environmental costs and benefits of each option should be determined through careful analysis. They will be location and time specific. However, for comparison purposes it may be helpful to look at the outcomes of the CLIMB report completed for the

Boston, MA region, which is one of the few detailed studies completed on the topic in the nation. It found that the "Status Quo" option would result in the greatest amount of damage and the highest costs to government and residents. In contrast, the study found that investing now in measures to prepare for the impacts of climate change would significantly reduce the amount of damage and lower the costs of preparation.

'Multiple Benefit' Options

Some of these strategy options may prove beneficial to pursue even without their contributions to reducing the costs of climate impacts. For example, coastal development policies may address ongoing risks associated with storm surges and tsunamis in addition to reducing the risks of sea level rise. Restoring floodplains may buffer the effects of extreme flood events and also be beneficial for water management under current conditions. Careful analysis should be completed to identify these "multiple benefit" or so-called "no regret" options.

Economic Opportunities

Economic opportunities may also emerge through many of these strategies to prepare for climate change. Because the risks of climate change may be experienced in similar forms in other states and nations, new processes and technologies produced in Oregon and Washington may have appeal to national and worldwide markets as well as to local consumers. For example:

Case Study:
Lake Chelan Air Quality Advisory

Chelan-Douglas County recently rewrote their Natural Event Action Plan (NEAP) for air quality and weather predictions due to wildfire. They define several wildfire health advisory levels, contingent up on the severity of air quality conditions. The Chelan Douglas County Health District then faxes these health advisories to local radio stations, school districts, hospitals, day care, nursing homes, and local government agencies. Each advisory includes specific recommendations for individuals to reduce potential health risks. The success of this protocol hinges upon the communication between various governmental agencies. For example, in times of emergency, close contact must be maintained between agencies responsible for transportation, communication of information, fire control, and public health.

- Reduced summer water supplies may spur the need for technologies to increase water use efficiency, from waterless and low-flow toilets to water-efficient agricultural practices and water efficient products. For example, only California, Nebraska and Texas in 2003 had more farms than Washington implementing irrigation improvements, illustrating the fact that Washington agriculture is already a leader in advanced irrigation technologies and techniques.[23] Reduced water supplies around the globe may

present Washington with an opportunity to export their expertise and products.

- Shifts in growing zones may create opportunities for high-value crops that were previously grown only in warmer climates. For example, as previously discussed, varieties of wine grapes that previously could not be successfully grown in Washington may in the future find the climate in parts of the state more hospitable. Similarly, if California's dairy cows experience heat-related reductions in output, the Washington dairy industry may have the opportunity to fill the void in the national market (although the state's dairy industry may also feel some of the effects).

- Increased risk of forest fires may lead to a need for large-scale thinning, especially in the wildland-urban interface. Biomass from thinning projects can be efficiently used for energy or heat production in large or small applications, such as in lumber mills or rural schools close to where the wood is harvested. If burned cleanly, this can provide a source of carbon neutral renewable energy using local feedstocks. The Washington Department of Ecology reports that the state contains woody biomass sufficient to produce 43 percent of Washington's current residential electricity consumption, although much of that material may not exist close enough to population centers to make it cost-effective, due to transportation costs. Washington businesses and communities not only can capitalize on the state's abundant biomass as a source of fuel, but also on the chance to develop technology and products within this growing sector. The same may be true in Oregon.

In sum, if done effectively, the costs of preparation may be very small in comparison to the costs of not doing so. Many preparation activities may also prove beneficial no matter how climate change plays out in the future, and some may generate economic opportunities for local entrepreneurs. Additional case studies of activities taken to reduce the potential impacts of climate change are included in Appendix I.

III. Local Governments Across the Nation Are Responding

Local governments across the U.S. are taking action to address the risks and capture the opportunities posed by climate change. For example, on June 23, 2006, 250 mayors from 42 states representing over 46.3 million Americans, including Mayors from many Northwest cities, endorsed the U.S. Mayors Climate Protection Agreement. Among other actions, it calls for cities to "take actions in their own operations and communities" to "strive to meet or exceed Kyoto Protocol targets (reducing global warming pollutants to 7 percent below 1990 levels) by 2012."

On June 5, the U.S. Conference of Mayor's adopted the "2030 Challenge" (Resolution #50) which sets the goal of "carbon-neutral" city buildings by 2030. Carbon neutral means, "new city buildings will use no fossil-fuel or greenhouse gas emitting energy sources to operate" for ALL buildings. Becomming climate neutral is possible. In 2001, Seattle City Light adopted Resolution Number 30359 to become the first major utility in the country to achieve zero net greenhouse gas emissions. The utility achieved this goal in November 2005 through a combination of energy conservation programs, divesting from a coal plant, purchasing renewable energy, and buying the equivalent of about $2 per person annually in emissions offsets. (See Appendix for the U.S. Mayors Agreement, the U.S. Conference of Mayors resolution).

These resolutions indicate the growing level of support among the nation's municipal leaders for responding to climate change.

IV. Action is Needed at All Levels of Government

Steps can be taken to respond to global climate change at all levels of local governments. For example:

Mayors, council members, commissioners and elected officials can:

- Adopt resolutions (reduce GHG, join U.S. Mayors resolution etc)
- Set goals (greenhouse emissions, zero waste, renewable energy use)
- Measure and monitor progress
- Adopt green purchasing policies
- Adopt green building standards

Agency employees can:

- Become educated
- Inventory greenhouse gas emissions
- Complete an internal audit of practices
- Look for low hanging fruit—easy steps to get started

V. Resources

This section includes resources rural governments can utilize as they engage in climate change activities.

Climate Leadership Initiative, University of Oregon

The Climate Leadership Initiative (CLI) in the Institute for a Sustainable Environment at the University of Oregon is an educational, research, and technical assistance consortium aimed at increasing public understanding of the risks and opportunities posed by global warming. The CLI assists government in inventorying greenhouse gases, assessing the risks posed by climate change, developing policies and programs appropriate to each community, and growing low-carbon economic development opportunities. It also conducts vulnerability assessments for local governments, firms, regions and industries.

http://climlead.uoregon.edu

King County/CIG Guidebook

As of September 2006, Washington's King County Executive Ron Sims, the Climate Impacts Group, and the King County global warming team are in the process of creating a guidebook for local and regional governments that will help them prepare for impacts of global warming. International Council for Local Environmental Initiatives (ICLE) will publish and distribute the guidebook to its 193 United States member cities, town and counties. The booklet is intended to serve as a guide for cities to prepare for changes in extreme weather, water supply, sea level rise and health risks.[24]

ICLEI

A final resource for local governments is ICLEI, the International Council for Local Environmental Initiatives. ICLEI was founded in 1990 to provide effective and cost-efficient ways to support local governments in implementing sustainable development practices. As efforts to reduce greenhouse gases requires significant time and resources, local governments, as members of ICLEI, can receive technical consulting, training, and information services.[25]

http://www.iclei.org

Additional Website Resources

- Climate Leadership Initiative list of internet links:
  http://climlead.uoregon.edu/linksresources/linksresources.html

- Cool Mayors for Climate Protection:
  http://www.coolmayors.com/common/11061/?clientID=11061&ThisPage=0

- Renewable Energy:
  US Department of Energy: Renewable Energy
  http://www.eere.energy.gov/consumer/renewable_energy/

  US Department of Energy: Wind Powering America
  http://www.eere.energy.gov/windandhydro/windpoweringamerica/

  American Wind Energy Association
  http://awea.org/

  American Solar Energy Society
  http://ases.org/

  Database for State Incentives for Renewables & Efficiencies
  http://dsireusa.org/

- Carbon Offset Purchases::
  http://www.nativeenergy.com/ClimateCrisis.html

- Alternative Fuels:
  http://www.eere.energy.gov/afdc/index.html

- Carbon Audits:
  http://carboncounter.org/Default.aspx

- Buildings:
  www.architecture2030.org/

Appendix

I. Additional Case Studies

County and municipal governments across the Pacific Northwest and elsewhere have started to address climate change by adopting mitigation and adaptation programs. The following provides some examples of initiatives enacted by local governments.

Portland's Municipal Water Supply Study

In 2002 the city of Portland's Water Bureau initiated a study on the projected impacts of climate change on the Bull Run Watershed and Portland's subsequent ability to provide municipal water to its customers.[26] The study demonstrated that climate change would result in decreasing supply of and increasing demand for water, and investigated two alternatives to help meet these demands. One is to increase reliance on the present dams and on groundwater supply, while the other is to create a new dam. Both require a significant amount of new infrastructure in order to succeed. Currently the city has not yet acted on either of these options, which necessitate a greater commitment, both financially and politically.[27]

Confederated Tribes of Warm Springs

A stated goal of the Confederated Tribes of Warm Springs is "to promote self-sufficiency based on the development of sustainable resources on tribal land." In order to achieve this objective, the Confederated Tribes have formed a Warm Springs Wind Energy Assessment Program that assesses wind energy potential on several parcels owned by the tribes to determine if there are sufficient reliable wind energy resources to develop electric power. Warm Springs Power Enterprises is the manifestation of this, a corporate entity owned and operated by the Confederated Tribes of Warm Springs. It is currently conducting its 36-month comprehensive wind energy resource assessment and development feasibility study.[28]

Sept-Iles, Quebec

Though adequate research is an important preliminary phase in adapting to climate change, residents of Sept-Iles, Quebec, took measures into their own hands even before studies were completed. The shoreline of Sept-Iles experiences up to 8 meters of land loss a year from rising sea levels and severe storms. Property owners are increasingly vulnerable to life threatening storms and flooding. In March 2000 an agreement was signed between provincial Ministries and the North Shore Regional Conference that allocated funds to research the current status of the shoreline, implications of climate change, and to design a preliminary

integrated management plan for the region.[29]

Over the next four years, a team of researchers concluded that the changing climate was indeed increasing current erosion rates and a group of experts explored different adaptation measures. The proposed scenarios were then evaluated by several committees of regional experts and stakeholders. Though the research was not then complete, the city proceeded to take action and undertook three initiatives: 1) public education to explain and inform residents of shoreline erosions; 2) limited development and prohibited construction in the most erosion vulnerable areas; and 3) the creation of a technical committee that will create a master plan for addressing coastline erosion over short, medium and long time-frames.[30]

Annapolis Royal, Nova Scotia

Annapolis Royal is another coastal community concerned with the projected impacts of global warming on their municipal infrastructure. In 1998 a citizen-based group, Clean Annapolis River Project (CARP), completed an assessment to gauge the vulnerability of their town to intense storms and flooding. They used future climate change scenarios, historical data and precise elevation data, and mapped areas of potential risk in the region. The provincial government has responded to their study, and has instigated proper dike maintenance as well as modified the fire department, which was discovered to be isolated from the rest of the community in a potential flood.[31]

Seattle's Climate Action Plan

Seattle's Climate Action Plan, developed by the Green Ribbon Commission on Climate Protection, aims to meet or beat Kyoto's global warming reduction targets.[32] The plan has developed some creative strategies to mitigate the effects of climate change. It encourages "smart growth" practices in urban centers to reduce the dependency on cars, which includes expanding its bike and pedestrian opportunities and light rail and streetcars. Its electric utility, Seattle City Light, has become the only electric utility in the country committed to having no net greenhouse gas emissions.[33] Seattle also banned commercial logging in the Cedar River watershed and aims to restore thousands of acres of urban forests, in the hopes of creating additional carbon sinks for greenhouse gases.

Portland's Local Action Plan on Global Warming (April 2001)

The city of Portland has been equally concerned with the expected impacts of climate change on water, human health, agriculture, ecosystems, and the coast. Several mitigation measures that the city has enacted with response to these threats have been: 1) to fuel all municipal vehicles and equipment with a 20% biodiesel blend; 2) to cut energy bills by $15 million in the last decade by encouraging conservation and increasing efficiency; 3) to aim to have 100%

renewable electricity for all City facilities and operations (currently 12% of municipal energy comes from renewable sources); 4) retrofitting incandescent traffic signals with LED bulbs; and 5) purchasing hybrid gasoline-electric vehicles for municipal uses.[34]

Confederated Tribes of the Umatilla Indian Reservation

Recycling and reuse increases energy efficiency and decreases waste, which ultimately play a role in mitigating the effects of global warming. The Confederated Tribes of the Umatilla Indian Reservation have committed to substantial waste reduction goals on their tribal land. In addition to purchasing recycled materials whenever possible, one innovative method used by the tribe is to reuse milk jugs as slow-watering devices and as warning signs to cattle near barbed wire fences. The tribal operations manager promotes reuse by running an informal materials exchange via email, and the reservation's quarterly newspaper educates residents about waste prevention and highlights the community's progress in reducing waste. In addition, in 2001 they installed a new recycling and waste disposal facility.[35]

Lake Chelan, Washington

Forest fires are expected to become more frequent with warming temperatures and increased drought, and preparing an emergency protocol is a useful step to ensuring the continued safety of communities and ecosystems amid potential emergencies. Chelan-Douglas County recently rewrote their Natural Event Action Plan (NEAP) for air quality and weather predictions due to wildfire. Many of the advisories ensure close contact between various departments concerning transportation, communication of information, health advisories, fire control, etc. Included in the protocol are the descriptions of three health advisory levels, which the Chelan Douglas County Health District will call upon, contingent upon the severity of air quality conditions.[36]

King County, WA

One area in which Washington's King County has recognized there is extreme risk is in its extensive system of levees. Five hundred aging levees and revetments line 115 miles of riverbank nd protect thousands of homes, downtown and industrial sections and more than $4 billion dollars in infrastructure. King County's Global Warming Team, which was given permanent status in May 2006, found that climate change would increase the likelihood of more serious and frequent flooding in the region. Subsequently, King County has proposed the creation of a flood control district that would finance major levee upgrades and buyout homes and businesses that are located in the floodplains.[37] If approved by the County Council, the district would spend up to $335 million on local flood-control projects.[38]

King County has also emphasized increased coordination and regional partnerships with other governments,

businesses and companies to ensure that in an emergency people at all levels will be able to communicate and efficiently safeguard transportation systems, ports, utilities, and industries. The county's Emergency Management Director, Eric Holdeman, is taking a regional approach to emergency preparedness.[39] In addition, in 2006 King County Mayor Sims launched Brightwater, a regional water supply plan designed to ensure adequate water supply in times of drought and emergencies. One component of this plan is a reclaimed water system that provides 21 million gallons of water daily.[40]

Sonoma County Climate Protection Campaign

In 2002 representatives from Sonoma County and its nine cities pledged to protect the climate by reducing greenhouse gas emissions. The county is the first in the U.S. to collectively work toward the target goal for reducing emissions 25% below 1990 levels by 2015. As part of this agreement, all cities and the county measure emissions from their internal municipal operations, set specific targets for each, and also set targets for community wide emissions.

Some examples of the ways in which the County has curbed greenhouse gas emissions include installing efficient air blowers at the Laguna Wastewater Treatment Plant in Santa Rosa (which use 50% less energy than the previous blowers), retrofitting traffic and streetlights with LEDs, and hiring green building consulting services to provide training opportunities and enticements for builders to use green building techniques. In addition, cities within the County have been emphasizing the use of local resources for these new materials and services, thus contributing to the local economy.

Sonoma County's landfill captures 70% of its emitted gases, which it then converts to electricity. Metal and yard waste are diverted from the landfill, the former of which is recycled, and the latter of which is turned to compost and sold. In addition, Sonoma County transit is recognized as a model for its extensive use of natural gas-fueled buses.[41]

Humboldt County's Alternative Energy Initiatives

Humboldt County is also engaged in efforts to reduce its greenhouse gas emissions. Humboldt County Rural Electric Cooperative receives all of its wholesale electricity from Corn Belt Power Cooperative, which arranges to purchase alternate energy from new and existing generation sources. Though purchasing "green" energy from wind sources exceeds the cost to generate power from other generation resources, members of the county can contribute money to the alternative energy program by adding a contribution to their electric bill.[42]

II. Endnotes

[1] Although a few skeptics have raised doubts about warming, on May 3, 2006, the federal Climate Change Science Program, established by the Bush Administration in 2002 to address 'unresolved questions,' issued its long awaited report that confirmed that the Earth is warming and that there is "clear evidence of human influences on the climate system." Thus, the debate about the actuality of warming and the human contribution to it appears to be over.

[2] International Panel on Climate Change, Third Assessment, 2001. Online: http://www.ipcc.ch/. Accessed July 2006. Updated assessment will be out in 2007.

[3] International Panel on Climate Change, Third Assessment, 2001. Online: http://www.ipcc.ch/. Accessed July 2006. Updated assessment will be out in 2007.

[4] Hansen, J., "The Threat to the Planet", New York Times Review of Books, Volume 53, Number 12, July 13, 2006

[5] Climate Impacts Group. "About Pacific Northwest Climate." Online: http://www.cses.washington.edu/cig/ Accessed August 2006.

[6] Climate Impacts Group. "About Pacific Northwest Climate." Online: http://www.cses.washington.edu/cig/ Accessed August 2006.

[7] National Oceanic and Atmospheric Administration. Online: http://www.ncdc.noaa.gov/oa/climate/research/cag3/wa.html. Accessed August 2006.

[7.1] Vimeux, F., K.M. Cuffey, and Jouzel, J., 2002, "New insights into Southern Hemisphere temperature changes from Vostok ice cores using deuterium excess correction", Earth and Planetary Science Letters, 203, 829-843.

[8] Photo online: http://www.for.gov.bc.ca/ftp/His/external/!publish/Radio/Photos/Regions/SIRKamloops/2003%20fire%20photos/forest%20fire%20July%2016%20night6.jpg. Accessed 10/20/06.

[9] Economic Growth and Greenhouse Gas Mitigation in California, 2006, used the Berkeley Energy and Resources (BEAR) model to evaluate the linkages between climate policy and economic activity. For full report see California Climate Change Center, University of California at Berkeley. http://calclimate.berkeley.edu/

[10] Online: http://www.nef.org.uk/energyadvice/lighting.htm. Accessed 10/20/06.

[11] ICLEI. Online: http://www.iclei.org/index.php?id=1190. Accessed 10/20/06.

[12] The Climate Group. Online: http://www.theclimategroup.org/index.php?pid=567. Accessed 10/20/06.

[13] Harrell, Debera. Seattle PI: "Seattle leads green wave in building." April 22, 2005. Online: http://seattlepi.nwsource.com/local/221169_green22.html.

[14] Climate Solutions. Online: http://www.ourwind.org/windcoop/. Accessed 10/20/06.

[15] Golden, K.C. Climate Solutions. "Washington State Passes Biofuels Standard." Online: http://www.climatesolutions.org/. Accessed 10/20/06.

[16] Natural Resources Defense Council. http://www.nrdc.org/cities/smartGrowth/solslide/solslide4.asp

[17] Adapted from "The Economic Impacts of Climate Change in Washington: A Preliminary Analysis." Prepared for the Department of Community, Trade, and Economic Development and Department of Ecology, State of Washington. Climate Leadership Initiative, University of Oregon, November 2006

[18] Pisano, P., L. Goodwin, and A. Stern, 2002. Surface transportation safety and operations: The impacts of weather within the context of climate change, Washington, D.C. pg. 165-184. http://climate.dot.gov/workshop1002/pisano.pdf and Andrey, J., and B. Mills. 2003. Climate change and the Canadian transportation system: Vulnerabilities and adaptations. Weather and Transportation in Canada, J. Andrey and C. K. Knapper, Eds. University of Waterloo. andWaters, D., W. E. Watt, J. Marsalek, and B. C. Anderson, 2003. Adaptation of a storm drainage system to accommodate increased rainfall resulting from climate change. Journal of Environmental Planning and Management, 46, 755-770.

[19] Ziska, L. H., D. E. Gebhard, D. A. Frenz, S. Faulkner, B. D. Singer, and J. G. Straka, 2003. Cities as harbingers of climate change: Common ragweed, urbanization, and public health. The Journal of Allergy and Clinical Immunology, 111, 290-295.

[20] Canadian Climate Impacts and Adaptation Research Network, February, 2006. Adapting to Climate Change.

[21] Adapted from Canadian Climate Impacts and Adaptation Research Network, February, 2006. Adapting to Climate Change.

[22] Sonne, J K and R K Viera, 2000. Cool Neighborhoods: The Measurement of Small Scale Heat Islands. Proceedings of 2000 Summer Study on Energy Efficiency in Buildings, American Council for an Energy-Efficient Economy. And Andrew D. Carver and Unger, DR and Parks, CL, 2004. Modeling Energy Savings from Urban Shade Trees: An Assessment of the CITYgreen® Energy Conservation Module. Environmental Management, Vol. 34, No. 5, pp. 650–655.

[23] USDA National Agriculture Statistics Services. "2003 Farm and Ranch Irrigation Survey, Census of Agriculture." http://www.nass.usda.gov/census/census02/fris/fris03.htm and Tom Kimmell, Irrigation Association, Executive Director. Personal Communication, 28, September, 2006.

[24] King County News Release. Aug. 2, 2006 "King County and climate scientists write the book on coping with global warming." Accessed: http://www.metrokc.gov/exec/news/2006/0802warming.aspx

[25] International Council for Local Environmental Initiatives. Online: http://www.iclei.org/index.php?id=643. Accessed July 2006.

[26] Palmer, R. and Hahn, M. "The Impacts of Climate Change on Portland's Water Supply: An Investigation of Potential Hydrologic and Management Impacts on the Bull Run System." Department of Civil and Environmental Engineering, University of Washington. January 2005

[27] Conversation with Michael Armstrong, City of Portland Office of Sustainable Development. July, 2006.

[28] http://www.eere.energy.gov/tribalenergy/projects/fy02_warmsprings.html

[29] Canadian Climate Impacts and Adaptation Research Network, Adapting to Climate Change, February 2006

[30] Canadian Climate Impacts and Adaptation Research Network, Adapting to Climate Change, February 2006

[31] Canadian Climate Impacts and Adaptation Research Network, Adapting to Climate Change, February 2006

[32] Seattle Climate Action Plan.
Online: http://www.seattle.gov/climate/actionPlan.htm. Accessed July 2006.

[33] Best, Lynn. "Seattle City Light Responds to Climate Change." Seattle Climate Action Plan Fact Sheet. August 17, 2006.

[34] Portland's Local Action Plan on Global Warming. April 2001. City of Portland and Multnomah County.

[27] Source: EPA WasteWise. 2002 Annual Report.
http://www.epa.gov/wastewise/pubs/progrpts/pdfs/report8.pdf#page=4

[35] EPA WasteWise. 2002 Annual Report.
Online: http://www.epa.gov/wastewise/pubs/progrpts/pdfs/report8.pdf#page=4

[36] CDHD NEAP Excerpt. Okanogan-Wenatchee National Forests, WA.

[37] Sims, Ron. King County Speeches: A Policymaker's Challenge.
Online: http://www.metrokc.gov/exec/speeches/20060806globalwarming.aspx.
Accessed July 2006.

[38] Ervin, Keith. "They're Not Laughing at Ron Sims Now." Seattle Times.
Wednesday, July 12, 2006.

[39] Sims, Ron. King County Speeches: A Policymaker's Challenge.
Online: http://www.metrokc.gov/exec/speeches/20060806globalwarming.aspx.
Accessed July 2006.

[40] Sims, Ron. King County Speeches: A Policymaker's Challenge.
Online: http://www.metrokc.gov/exec/speeches/20060806globalwarming.aspx.
Accessed July 2006.

[41] http://www.skymetrics.us/index.php

[42] http://www.humboldtrec.coop/aspx/Announcements/Default.aspx?AnnouncementID=470

This Report produced by
The Climate Leadership Initiative
Institute for a Sustainable Environment
University of Oregon

March 2007