Speaking notes from Richard Gammon's presentation, "Climate Change Impacts and Greenhouse Gas Emissions in the Pacific Northwest," made on September 24, 2004, to the Commute Trip Reduction Task Force.

Slide2

The scientific community's consensus on global warming and the need to reduce fossil fuel dependence have received extensive coverage in recent months.

The September edition of *National Geographic* is devoted entirely to the issue, and the August 16 issue of Business Week makes a strong case for a concerted public-private response.

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100 nations (including all industrialized nations) have accepted these findings. Thousands of scientists— "mainstream scientists"—WG II 431 authors, 473 reviewers (from probably 70 countries).

Slide 4

Summary of Key Findings of Working Group II

- Climate change is underway and the early impacts are already visible. Based on empirical evidence, WG II authors are highly confident that many plants and animals— as well as physical processes (such as glaciers retreating)— are already responding to higher temperatures.

- Climate change and its impacts over the next 100 years will be *much* more significant than what we've seen over the past 100 years. The greater the magnitude and rate of temperature increase, the greater will be the adverse impacts. [Note: Vast changes have already occurred with only a ~1°F increase in global average temperature over the past 140 years; the IPCC projects an increase of 2.5 to10.4°F from 1990 to 2100.]

- Natural systems are the most vulnerable to climate change because of their sensitivity to climate and limited capacity to adapt. While some species may increase in abundance or range, climate change will increase the risk of extinction of already threatened or vulnerable species and increase the risk of biodiversity loss. Climate change will exacerbate the many human-induced stresses that species already face as well as raise new ones.

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Summary of Key Findings of Working Group II (cont)

- More frequent and more intense weather extremes are projected; hence, more severe impacts from these events can be expected. And get ready for some major surprises.

- Developing countries in general and poor communities within developed countries are most vulnerable to climate change.

- Adaptation, a necessary complement to mitigation efforts, can help reduce adverse impacts of climate change. But these are costly and some damages are inevitable.

- Win-win options are available, if we begin to take action now. Improving the management of natural resources and environmental risks while increasing the welfare of the poorest members of society can simultaneously advance sustainable development and equity and help people deal with the impacts of global warming.

  [For slides and information on mitigation/solution options, see WG III powerpoint file: TAR.5.Mitigation.WGIII.ppt]

Slide 6

Atmospheric CO_2 Concentrations are Increasing

- As a result of human emissions of greenhouse gases, the atmospheric level of carbon dioxide, the most important human-derived greenhouse gas, has increased steadily over the last 140 years - from **280** parts per million in **1860**, the beginning of the Industrial Revolution, to **378** parts per million in **2003**, a **35%** increase over the natural level.

- CO_2 concentration data from before 1958 are from ice core measurements (tiny air bubbles trapped in ice core samples) taken in Antarctica. Since 1957, scientists have been making continual measurements of atmospheric CO_2 at an observatory in Mauna Loa, HI. [Annual variation is due to CO_2 uptake by growing plants; the uptake is highest in the northern hemisphere springtime.]

- Over the same time period (from 1860 to present), levels of other potent greenhouse gases have also increased — **methane** concentrations have almost **tripled** and **nitrous oxide** concentrations have risen by about **15%.**

- Increases in all of these gases in the atmosphere last from decades to centuries, so yesterday's emissions are today's visible impacts on the climate while today's emissions will be affecting the climate well beyond the 21st century. [This is also known as our commitment to climate change.]

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Correlation Between CO_2 Concentration and Temperature Change

- Ice core samples show that there has been a very clear correlation between atmospheric CO_2 concentrations (shown in blue) and the global temperature record (shown in yellow). In other words, on a millennial time scale, fluctuations of CO_2 and temperature have roughly mirrored each other over the last 160,000 years. One can also see from this graph that the earth has, in the past, experienced some pretty major fluctuations in temperature and CO_2 concentration.

- Antarctic ice core studies reading back as far as 420,000 years ago yield the same results: CO_2 fluctuated between 180 and 280 ppm (as in this graph) and changes in CO_2 were strongly correlated with changes in temperature.

- **Significant points about the current situation**: First, the current level of atmospheric CO_2 is already far higher than it has been at any point during this period; it is *outside* the bounds of natural variability seen in the climate record of the last 420,000 years. When viewed from a long-term perspective, the *rate* of change in CO_2 concentration is also unprecedented.

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CO_2 Concentration and Temperature Change - Next 100 Years

- Second, if the world proceeds on what's called a "business-as-usual" path; in other words, nothing is done to slow greenhouse gas emissions and they continue to grow at their present rate of about **1%** per year, atmospheric CO_2 concentrations will likely be more than **700** ppm by the year 2100, and they will still be rising.

- This is nearly double the current level and much more than double the pre-industrial level of **280** ppm.

- State-of-the-art global climate models, computer models used by scientists to study the effects of global warming, project that anthropogenic emissions driving this CO_2 rise will result in a significant increase in global average

temperatures over the next 100 years, an increase ranging from **2.5** °and **10.4°F** (1.4 - 5.8°C).

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Fossil fuel CO2 has a very long atmospheric lifetime (~100 years). Stabilization at x2 natural level (~550 ppm) requires global CO2 emissions to peak by ~2040 and then decline sharply to 2100 and beyond.

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Global Warming Predictions of Earth's Surface

- Global climate models project that the warming will not be evenly distributed - land areas will experience greater warming than the oceans, higher latitude regions (regions closer to the poles) are expected to warm more than equatorial regions, and the northern hemisphere is projected to warm more than the southern hemisphere. The U.S. may experience warming of between 5 and 10°F.

- A 2.5 - 10.4°F global increase may not seem like a lot, but in fact, this temperature rise is happening at an extremely rapid rate (0.5-1.0 oF/decade), a rate of change not seen on the planet for at least the last 10,000 years.

- It is the combined threat of the unusually large magnitude of this temperature increase and the speed at which it is occurring that causes great concern among scientists.

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Climate Change Impacts

- The changes in temperature, precipitation patterns, and sea-level rise that have been observed and that are projected to occur will have wide-ranging and some potentially devastating impacts on the natural environment and human societies. [potential impacts are described in detail in TAR.4.Impacts.ppt]

- Our health, agriculture, forests, water resources, coastal areas, and species and natural areas are all vulnerable to the projected climate changes. For a small degree of warming, there is a mix of benefits and harms; harms increase dramatically for the higher projected temperature increases.

- Scientists have made estimates of the potential direct impacts on the various sectors listed here, but in reality the full consequences are more complicated because impacts on one sector can also affect other sectors indirectly.

- [Suggested transition to slides in next file: As scientists began to document warming and debate began over whether warming could be attributed to human activities and if so, what to do about it, this led to the formation of the Intergovernmental Panel on Climate Change(IPCC) in 1988, and an international policy framework (United Nations Framework Convention on Climate Change, 1992, Rio) for dealing with the issue.]

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In the extraordinary heat wave in Europe in the summer of 2003, more than 25,000 people died, and an estimated 10% of the glacial ice in the Alps melted.

Slide 16

Sea Level Rise

- Sea level is projected to rise with warming temperatures, primarily from thermal expansion of the oceans as they warm (water expands as it warms) and the melting of glaciers and landlocked ice caps.

- Globally, average sea level has risen between **4** and **8** inches (10 - 20 cm) over the past century. The IPCC projects that sea-level rise will accelerate, from **4** to **35** inches between 1990 to 2100.

- Rising sea level can erode beaches and coastal wetlands, inundate low-lying areas, and increase the vulnerability of coastal areas to flooding from storm surges and intense rainfall which will likely increase under global warming.

- Sea-level rise will continue for more than 1000 years, reaching several meters, as green house heating penetrates to the deep sea. Eventual future loss of either the Greenland Ice Cap or the West Antarctic Ice Sheet would result in a sea-level increase of ~6 meters, inundating most major coastal cities worldwide and displacing hundreds of millions of people.

[Picture from Ocean Shores, WA]

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Global re-insurance industry experts (Munich-Re, Swiss-Re) estimates that insured losses from extreme weather events are doubling every decade, and could average ~ $100 billion/yr by 2010-2015.

Slide 19

Asthma, Hanta virus, Lyme disease, West Nile, Dengue, Malaria as emerging infectious diseases, whose increase has been linked to changing climate (Paul Epstein, Harvard)

Each one degree (Centigrade) increase in global mean temperature is estimated to result in a 10% decrease in global grain production (Lester Brown).

Slide 21

Temperature trend(2-3 oF) in the Pacific NW during the past 100 years greatly exceeds the global average increase 1.2 oF). Dr. Phillip Mote, Washington State Climatologist

Slide 24

A predicted loss of more than half the Cascade mountain snowpack within the next 50 years, by mid-21st century, continuing down thereafter.

Slide 27

Results – Impacts on Hydrology

Percent difference from current climate cumulative seasonal flows.

	JFM 2020	AMJ 2020	JFM 2040	AMJ 2040
Sultan 32	-18	43	-30	
Tolt	16	-16	20	-21
Cedar	36	-23	49	-36
Green	28	-25	37	-37
Average	28	-20	37	-31

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Millions of acres of forest killed by beetles in Alaska, greatly increased risk of catastrophic forest fire.

Slide 30

International Solutions: UN Framework Convention on Climate Change (IPCC)

- The United Nations Framework Convention on Climate Change (UNFCCC) is the foundation of international political efforts to combat global warming. Introduced at the Earth Summit in Rio de Janeiro and ratified by the United States in 1992, its ultimate objective is to facilitate agreements that will "stabilize greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous human interference with the climate system."

- The Convention is implemented through the Conference of the Parties (COP), which comprises the 186 states that have ratified the agreement. COP meets

annually to try to come to an agreement on how each country will contribute to reducing their own GHG emissions.

- Note the main objective of the UNFCCC. Carbon stabilization is discussed in the next slide.

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This chart shows:

Washington's CO2 emissions in 2000

Washington's CO2 emissions, if the four gas-fired power plants that have received permits are actually completed. The red portion at the top of this bar shows the maximum effect of the CO2 mitigation requirements that were attached as conditions of the permit.

The third bar shows the emission level for Washington that would correspond to the McCain-Lieberman Climate Stewardship Act.

The fourth bar shows the emission level that would correspond to the hypothetical US target under the Kyoto treaty – 7% below 1990 levels

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This chart adds a fifth bar, showing the magnitude of the reductions required in order to achieve climate stabilization (~70 net global reduction in emissions).

Slide 34

This chart shows:

CO2 emissions from Transportation in the Central Puget Sound: King, Pierce, Kitsap, and Snohomish counties

Projected growth in these emissions between 2000 and 2020, absent major new emission reduction initiatives

The reduction in emissions in this area that would be achieved by the new California CO2 standard for new vehicles.

So, emission increases due to business-as-usual VMT growth would more than offset the emission reductions achieved by the strongest available state-level new vehicle standards.