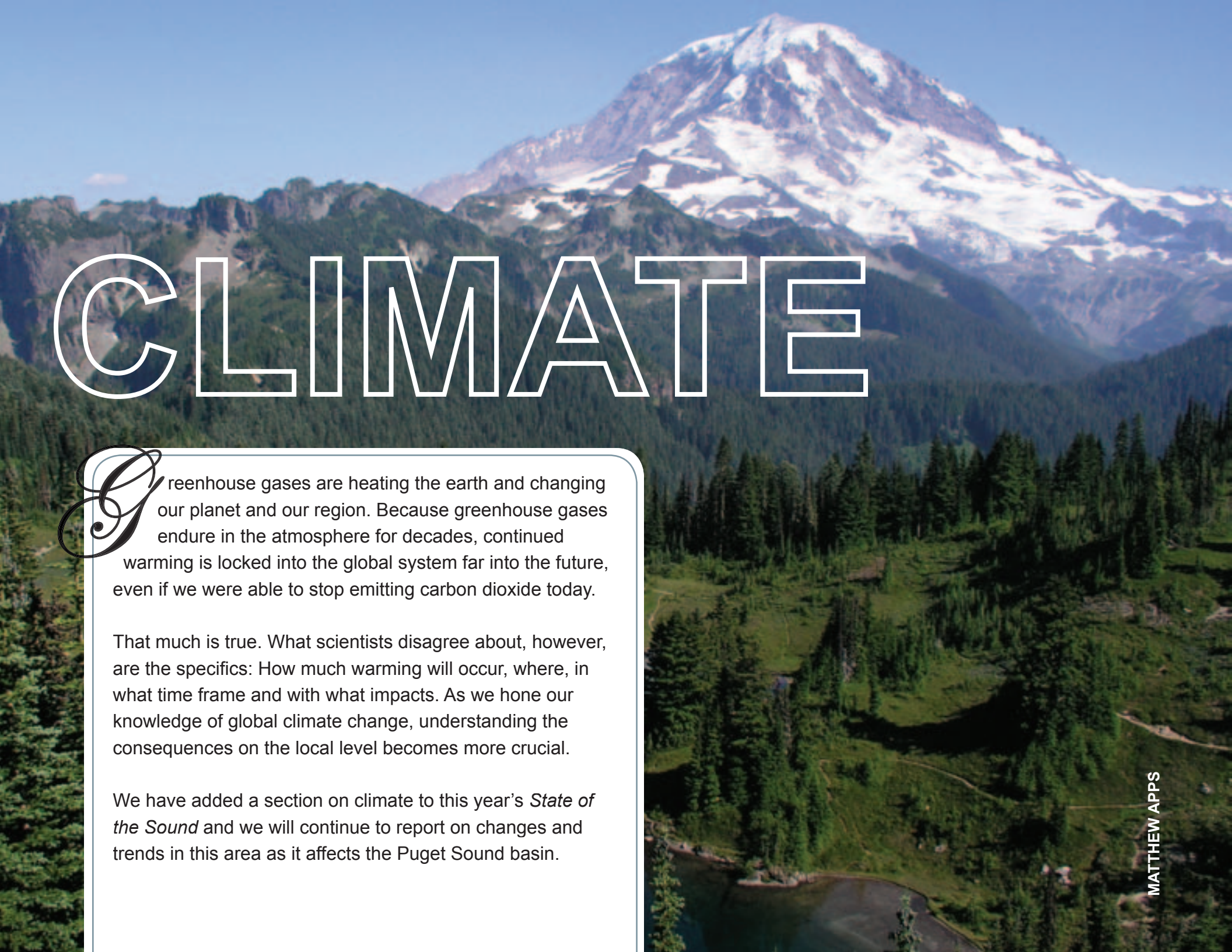
# CLIMATE

Greenhouse gases are heating the earth and changing our planet and our region. Because greenhouse gases endure in the atmosphere for decades, continued warming is locked into the global system far into the future, even if we were able to stop emitting carbon dioxide today.

That much is true. What scientists disagree about, however, are the specifics: How much warming will occur, where, in what time frame and with what impacts. As we hone our knowledge of global climate change, understanding the consequences on the local level becomes more crucial.

We have added a section on climate to this year's *State of the Sound* and we will continue to report on changes and trends in this area as it affects the Puget Sound basin.



MATTHEW APPS


# INDICATOR: TEMPERATURE


## AIR TEMPERATURE

### STATUS

During the past century, the Puget Sound region warmed at a rate substantially greater than the global warming trend. The average annual temperature increased by 2.3 degrees Fahrenheit (degrees are all noted in F), more than double the rise seen in global average air temperature, which is 1.1 degrees. Every climate record in the Puget Sound area showed a warming trend. Rural climate stations have warmed just as much as urban stations. Puget Sound winters warmed at an even greater rate, increasing 2.7 degrees since 1950.

### TRENDS

Climate models project a continued warming trend in the Pacific Northwest between 0.2 and 1.0 degrees per decade until 2050, with average warming of 1.8 degrees by the 2020s and 3.0 degrees by the 2040s (relative to the average temperature between 1970 and 1999.) Even the lowest estimated warming will change the Northwest's climate significantly, causing smaller snow packs, warmer rivers and more intense dry spells.

## SEA SURFACE TEMPERATURE

Water temperature affects whether habitats are suitable for marine organisms. It also affects the physical, biological and chemical processes important to maintain a healthy food web. Many Puget Sound species, such as salmon, oysters and groundfish, depend on cold water. Rising water temperatures will carry considerable consequences to the ecosystem, including likely declines in cold-water species and an increased abundance of species that thrive in warmer waters.

### STATUS

Of the water quality problems identified in the Puget Sound basin in 2004, 20 percent were related to river temperatures that exceeded critical threshold values. The extent to which these changes are related to global climate change is unknown, but future warming as predicted will continue to increase the number of rivers exceeding critical thresholds.

### TRENDS

While we do not have much information on trends in water temperature for fresh and marine waters in the Puget Sound basin, there is evidence of warming during the 20th century.

FIGURE 9-25 **Air temperature projections for the Puget Sound basin 2000-2100**

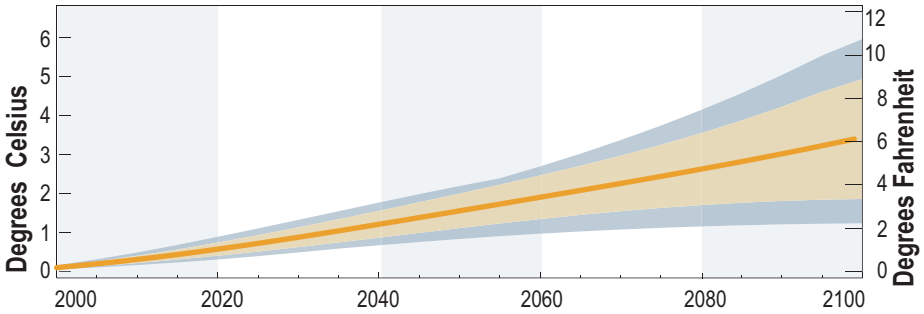



FIGURE 9-25: Projected changes in annually averaged temperature for the Pacific Northwest, compiled by considering climate scenarios from 10 global climate models. The orange line shows the average of all the models. The blue shading indicates the range from highest to lowest, and the yellow shading indicates the range in which about two-thirds of the scenarios fall. *Source: Uncertain Future: Climate Change and Its Effects on Puget Sound. Action Team, 2005.*

FIGURE 9-26 **Sea surface temperature at Race Rocks 1915-2005**

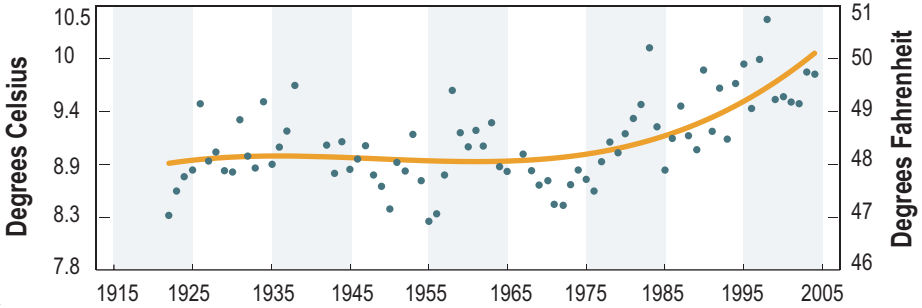
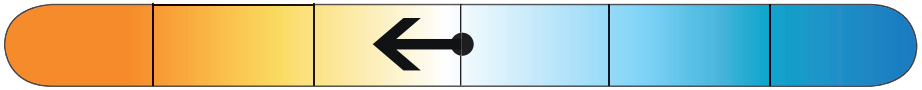



FIGURE 9-26: Average annual sea surface temperature at Race Rocks near Victoria BC. Each year's temperature is shown as a circle, and the smooth curve indicates a long-term warming trend of 1.7 degrees F since 1921 and 1.8 degrees F since 1950. *Source: Uncertain Future: Climate Change and Its Effects on Puget Sound. Action Team, 2005.*

PHOTOS: (indicator) Sunrise. | Shutterstock.com; (opposite page) Mount Rainier. | Shutterstock.com/Matthew Apps.


# INDICATOR: SEA LEVELS




The melting of polar ice sheets, glaciers and ice fields, along with the warming of the ocean's waters and the resulting thermal expansion, are causing global sea levels to rise, which can have a profound impact on Puget Sound.

## STATUS

Global sea levels increased an estimated four-to-eight inches during the 20th century. Geological factors that cause the rising of the earth's crust in the northwest region of the Sound and sinking in the southeast region produced different rates of sea level rise. This net local sea level rise in north Puget Sound was close to the global average while sea level rise in south Puget Sound was nearly double the global average.

## TRENDS

Future global sea level rise is likely to accelerate as a result of global warming, with changes projected anywhere from four to 35 inches during this century. Some climate models suggest we may see an additional eight inches in sea level rise in coastal waters because of changes in wind patterns.

## WANT TO KNOW MORE?

**about climate in Puget Sound?**

In November 2005, Action Team produced a report called *Uncertain Future: Climate Change and Its Effects on Puget Sound* that can be found at www.psat.wa.gov/climatechange.

FIGURE 9-27 **Predicted sea level rise for various Puget Sound locations**

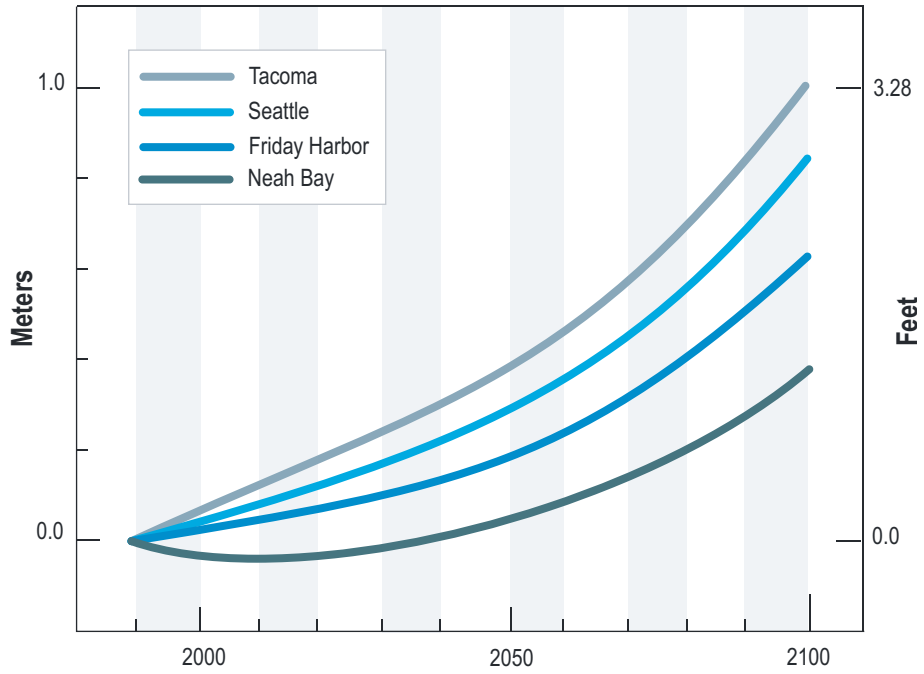



FIGURE 9-27: Future sea level rise scenarios for various locations in Puget Sound are shown. These sea level rise curves take into account projected global sea level rise, the increased rate projected for the NE Pacific and the sinking of local land. The degree of sea level rise projected at Tacoma for 2050 (about 1.2 feet or 0.4 m) would not occur at Seattle until around 2060 and at Friday Harbor until around 2080. Given continued uncertainty, the sea level rise scenarios could be 20 percent to nearly 200 percent of the mid-range scenarios depicted. *Source: Uncertain Future: Climate Change and Its Effects on Puget Sound. Action Team, 2005.*

PHOTO: A storm near the San Juan Islands. | Shutterstock.com


# INDICATOR: STREAM FLOW


Freshwater inflow to Puget Sound—the total flow of all of the major rivers—is an important element of the Sound's marine environment. The timing of regular yearly rainfall, and the timing and magnitude of winter and spring high-flow rain events influence water temperature, salinity, circulation patterns, habitat characteristics and marine life.

## STATUS

Across much of the western United States as well as in the Puget Sound region, scientists have observed hydrologic changes in the past 50 years that are consistent with the observed atmospheric warming, including reduced spring snow pack, earlier spring snow melt, increased winter flow and decreased summer flow.

These changes, most of which have been linked to rising temperatures, can lead to altered habitats for fish and other species. The observed changes also have implications for municipal and agricultural water needs that are dependent on surface water.

## TRENDS

From 1948 to 2003, freshwater inflow in Puget Sound changed in the following ways:

- Total annual inflow declined 13 percent because of changes in precipitation.
- Average snow melt is 12 days earlier, shifting 2.1 days per decade.
- The fraction of annual flow entering Puget Sound from June to September decreased by 18 percent.
- The likelihood of unusually high daily inflow increased, despite the decline in annual inflow.
- The likelihood of unusually low daily inflow increased.

FIGURE 9-28 **Average daily freshwater flow into Puget Sound 1948-2003**

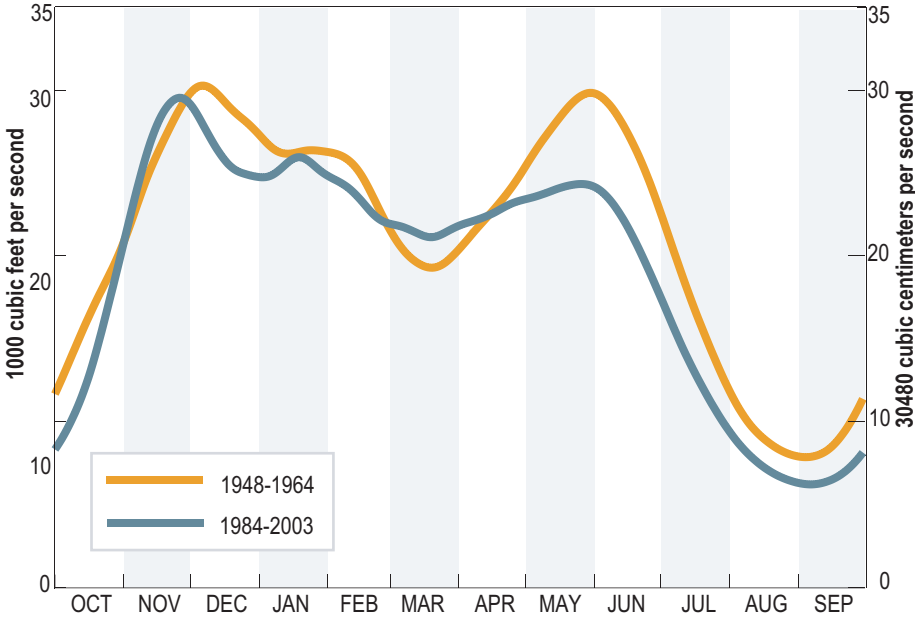



FIGURE 9-28: Average daily freshwater flow into Puget Sound (calculated by adding the flow of nine of the largest rivers) for 1948-1964 (orange) and 1984-2003 (blue). Note the decline in May-October flows and increase in March-April flows. *Source: Uncertain Future: Climate Change and Its Effects on Puget Sound. Action Team, 2005.*

PHOTO: (indicator) Northwest stream. | Shutterstock.com/Aaron Whitney.


# INDICATOR: SNOW PACK


Both the Puget Sound ecosystem and its cities depend on snow melt. Snow melt sustains flows in rivers and streams over long periods and it replenishes water reservoirs in the spring before the heat of summer sets in. Because temperatures are rising, climate models predict more precipitation falling as rain instead of snow. This means winter flooding will increase and our natural water stores will be reduced.

## STATUS

Snow pack measurements—the depth of water from melted snow, also known as the snow water equivalent, (or SWE)—taken on April 1 (roughly the date of peak snow pack) show a marked decline since 1950 almost everywhere in the Cascades. This decline exceeded 25 percent at most locations and tended to be greatest at the lower elevations.

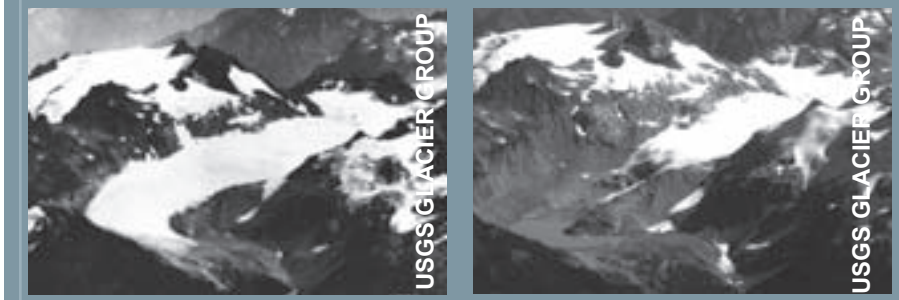
## TRENDS

If average temperatures rise approximately 4.1 degrees by as early as 2040 (but more likely later in the century), runoff from October through March might increase by about 25 percent, and runoff from April through September might decrease by 21 percent. These changes would increase the risk of flooding, change the circulation in the Sound and create higher water temperatures in streams, rivers and estuaries.


PHOTOS: Mount Rainier at Myrtle Falls. | Shutterstock.com/Micheal Thompson. (indicator) Ski lift. | Shutterstock.com/David Gaylor.

### Glaciers in retreat

Because of global warming, nearly every glacier in the Cascades and Olympics has retreated during the past 50 to 150 years. Small glaciers are disappearing rapidly, and glacial mass on the larger ones has been reduced. In the higher reaches of certain river basins, such as the Nooksack, and on some tributaries of the Skagit, melting glaciers provide a substantial portion of stream flow in late summer. This is also true for the Nisqually River, which is fed by receding glaciers on Mt. Rainier. Glaciers have significant local effects on stream temperature and water supply for aquatic plants and animals.




The South Cascade Glacier from the same viewpoint in 1928 and 2000. Not only has the glacier retreated substantially, leaving behind a meltwater lake, it has also thinned at higher elevations. *Courtesy of Dr. Ed Josberger, USGS Glacier Group, Tacoma, WA.*

## Local governments lead the way

Local governments have stepped up to the growing challenge of climate change.

In February 2005, Seattle Mayor Greg Nickels challenged fellow mayors across the country to join with his city in pledging to meet or exceed the Kyoto Protocol's emissions-reduction goals. So far, more than 300 mayors representing 51 million Americans in 46 states have signed the U.S. Mayors Climate Protection Agreement.

Seattle completed a climate action plan that aims, by 2012, to reduce greenhouse gas emissions to seven percent below 1990 levels, a goal equivalent to the Kyoto Protocol, which was not signed by the United States.

King County has also taken a leadership role on this issue, setting up a climate response action team, compiling an inventory of King County air emissions, preparing the county to enter into a carbon-trading market, accelerating the use of biodiesel fuel in buses, and producing electricity from methane at the Cedar Hills Landfill.

The county is also co-authoring a guidebook to help local and regional governments plan for the changes resulting from global warming. The guidebook will be published by Local Governments for Sustainability and distributed to its 193 U.S. member cities, towns and counties.

# The Action Team's work on CLIMATE

**What we said we would do**

Climate change will have significant impact on the Puget Sound ecosystem and food web as well as on those of us who live here. To plan for this growing threat, the Action Team recently began work on some projects to better understand the implications for Puget Sound.

**What's been done**

1. In October 2005, the Action Team released the first climate change report focused solely on the Puget Sound area: *Uncertain Future: Climate Change and Its Effects on Puget Sound*. The report, which can be found at www.psat.wa.gov/climatechange, was developed by UW's Climate Impacts Group. It presents existing and predicted changes in Puget Sound's climate and sea level, and outlines a wide range of possible impacts to the Sound's ecosystem.

2. The state formed an interagency climate change group to coordinate a statewide response to climate change and the reduction of greenhouse gas emissions. Agencies will also work with the public and local governments to help them prepare.

# Action needed on CLIMATE

The consequences of a warmer world will make sustaining Puget Sound ecosystems increasingly difficult.

Climate change cannot be fixed within a short period of time even if we had the necessary commitment and funding. Because of lags in the climate system, warming and sea level rise will continue for centuries, regardless of whether we can stabilize and reduce concentrations of greenhouse gases in the atmosphere today. And we are nowhere near achieving stabilization, much less reduction.

The ultimate impacts of climate change in Puget Sound depend on future levels of greenhouse gases, but also to some degree on the choices we make to prepare for those impacts. Because it is likely that climate change will severely disrupt the physical and biological environment of Puget Sound, we need to be prepared. We must:

- **Treat climate change as a serious threat.** We cannot ignore or deny this threat to our region. Climate change is already here and will create significant challenges far into the future.

- **Develop the local and regional capacity to manage risks.** We need to greatly enhance our institutional capacity to manage climate change. Government agencies at all levels need continually updated information on the projected impacts of climate change so they can adequately prepare for the future, ensuring that key investments and management activities can cope with projected changes.

- **Continue to improve our knowledge.** Although we do not know the exact scope and impact of the risks, we need to expand and sustain our regional expertise on the emerging climate change science and information, and create systems to adopt emerging science into management as rapidly as possible.

- **Monitor regional climate and ecosystems for ongoing change.** To understand these changes as they occur, and to improve our predictive capacity, we need to regularly monitor the key indicators of climate change.