



Thurston County Public Health & Social Services

**Planning for Health Consequences of Climate Change**  
A NACCHO Demonstration Project 2009-2010

***White Paper:***  
***Projected Health Impacts of Climate Change in Thurston County***

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## **Scope of this Paper**

This paper is a summary of the public health effects that can be expected due to climate change impacts in the Thurston County area. The information is based on a review of literature, websites, and conversations with local researchers. This review was conducted in September of 2009, as one of the early steps in carrying out a grant award from the National Association of City and County Health Officials (NACCHO) towards Goal 1: “Build Health Department understanding of and capacity to plan for the public health consequences of climate change.”

The Centers for Disease Control and Prevention states (CDC 2009):

There is widespread scientific consensus that the world’s climate is changing. Some of the effects of climate change are likely to include more variable weather, heat waves, heavy precipitation events, flooding, droughts, more intense storms such as hurricanes, sea level rise, and air pollution. Each of these changes has the potential to negatively affect health.

## **Future Thurston County Climate**

The University of Washington’s Climate Impacts Group examined numerous models of future climate and produced scenarios of future climate for the Pacific Northwest (PNW) (CIG 2009). They are developing a regional climate model to look at regional-scale climate change impacts but this is not available at the time of this writing. Most of the following changes in temperature, precipitation, sea-level rise, and extreme weather events are taken from their scenarios project, with several other local research sources added in.

### Temperature:

In comparison with the 20<sup>th</sup> century, the PNW climate will be warmer in the 21<sup>st</sup> century.

- Temperature corresponds to CO<sub>2</sub> and other greenhouse gasses. Estimates of future carbon dioxide (CO<sub>2</sub>) concentrations range from 549 to 970 ppm by 2100. This increase is 2 to 3.5 times the pre-industrial (circa 1750) value of 280 ppm (CIG 2009).
- Climate models project an average rate of warming of approximately 0.5°F per decade through the 2050s; the observed rate of 20<sup>th</sup> century PNW warming was approximately 0.2°F per decade. The rate of change after the 2050s depends increasingly on the choice of greenhouse gas emissions scenarios.
- Recent reports (United Nations Environment Program 2009) project an even greater temperature rise, of 6.3°F by the end of the century.

- All seasons will be warmer. Temperatures are projected to increase across all seasons with most models projecting the largest temperature increases in summer (June–August).
- Average annual temperature will likely exceed the range of 20<sup>th</sup> century variability. Average annual temperature in the 21<sup>st</sup> century could increase beyond the range of year-to-year variability observed in the PNW during the 20<sup>th</sup> century as early as the 2020s.

Precipitation:

- Average annual precipitation in the PNW will likely stay within the range of 20<sup>th</sup> century variability. Taking an average of all models, CIG estimates that annual precipitation will increase only 1 to 2%.
- Existing seasonal patterns of precipitation could be exaggerated. Just over half (59%) of the models and scenarios analyzed show an increase in winter (Dec–Feb) precipitation in the 2020s and 2040s. By the 2080s increases in winter precipitation are more likely. More than 70% of models and scenarios analyzed agree that summer precipitation will decrease. Regardless of how much total winter precipitation changes, a larger percentage of overall winter precipitation is expected to fall as rain rather than snow due to warmer winter temperatures.
- Romero and Biever (2009) identified six precipitation patterns that regulate peak flow in our region’s streams and lead to ground water or stream flooding. Four of these are from heavy rainfalls within a few days. The other two are from cumulative high rainfalls, greater than 15 inches in a month. Looking at the frequency of these six patterns over the last decade, Romero and Biever found they occurred 10 times from 1999 to 2009. However, during the previous five decades only one to four of these heavy precipitation patterns was found, per decade. (Note: The rain-on-snow event, such as we saw in the major flood of 2007, is not one of these six patterns and has a more anecdotal connection with flooding but clearly remains another pattern for peak floods [TRPC 2009].) Their research implies that heavy monthly rainfalls may become the norm and identification of the precipitation patterns early on could help emergency responders prepare.

Sea-level rise: Mote et al. (2008) project a “medium” estimate of 21<sup>st</sup> century sea-level rise for Puget Sound to closely match that of global sea-level rise. The Intergovernmental Panel on Climate Change (IPCC) projects global sea-level rise over the course of this century to be between 18 and 38 cm (7–15”) for their lowest emissions scenario, and between 26 and 59 cm (10–23”) for their highest emissions scenario.

Sea level is already rising in Olympia by about one foot per century due to post-ice age warming of the oceans and possibly subsidence of the land (City of Olympia 1993). Downtown Olympia lies only one to three feet above the current highest high tides. The one-foot sea level rise predicted by 2050 would result in ponding on some streets and flooding of low-lying structures once or twice a year during extreme high tides. Tidal waters flow “up” the storm water pipe systems and discharge into streets (A. Haub, personal communication 2009). If sea level rises more rapidly than assumed in that projection, the two-foot rise could result in stormwater not being able to discharge in several areas during extreme precipitation events. Flows could reverse during high tides and storms and the sea would flow from street drains into the streets.

Downtown Olympia has a network of wastewater lines, some of which are combined with stormwater pipes. Recent work has identified the areas that could overflow with mixed sewage and stormwater under different scenarios. The storm water and wastewater pipes are not definitively segregated into different areas of downtown (A. Haub, personal communication 2009).

#### Extreme Weather Events:

The Climate Impact Group (2009) does not speculate on how climate change may affect extreme weather events in the northwest in the future, stating that “Many key aspects of climate (e.g., windstorms, heat waves) either are not well simulated by models or cannot be studied using monthly mean values which are the standard model output.” They go on to state:

However, droughts may become more common due to the effects of warmer temperatures and reduced winter snowpack on late summer streamflows. Changes in the intensity of precipitation are uncertain, although a preliminary analysis suggests that average monthly (Nov–Jan) winter precipitation could become more intense by the end of the 21st century. Additionally, ongoing work at the CIG suggests that extreme daily precipitation could increase by the end of the century.

### **Major Climate Impacts and Related Health Impacts**

The Climate Action Team identifies five mechanisms through which climate change is likely to affect health (CAT 2008):

1. Thermal stress from heat waves
2. Degradation of air quality
3. Infectious diseases, especially vector-borne and zoonotic diseases (VBZ)
4. Extreme weather events affecting public safety

## 5. Psychological stress, social disruption and economic disparities

### Heat Waves

Short, intense heat waves have been responsible for hundreds of deaths in the United States and thousands in Europe in recent years. As heat waves become more frequent, more intense and longer lasting, the greatest impacts will be felt in cities with historically milder summers, less air conditioning and higher population densities. This describes the major cities of Washington State (CAT 2008), and the combined metropolitan areas of Olympia–Tumwater–Lacey may experience heat wave conditions of a greater intensity than years past (P. Brewster, TRPC personal communication 2009). One of the reasons heat waves are problematic is there is a lack of cooling overnight (Easterling 2009).

Elderly and very young populations, pregnant women, and the chronically ill are particularly vulnerable to thermal stress, also called hyperthermia. Effects include heat cramps, brief loss of consciousness, heat exhaustion, and heat–stroke (PAWG 2009). Others at greater risk include (Appendix P):

- Exercising children in particular are slower than adults to adapt to heat stresses
- Poor and isolated populations
- Urban dwellers and those living in heat islands (areas with more asphalt and fewer trees) within cities
- Adults engaged in heavy outdoor labor
- People with chronic disease (diabetes, heart disease, asthma, obesity) due to illnesses themselves and medications used
- Mentally ill, because of behavioral factors and the effect of psychoactive medications

Jackson et al. (2009) projected heat–related mortality due to increased temperatures and ran scenarios for three areas of Washington – King/Snohomish/Pierce, Spokane, and Tri–Cities. Looking at the King County area scenario, projected warming would likely result in 101 additional deaths among persons aged 45 and above during heat events in 2025 and 156 additional deaths in 2045 in the greater Seattle area alone (relative to 1980–2006). This specific review could also be done for Thurston County although the basic conclusion is that as summer heat increases and as the population grows, we can expect an increase in heat–related deaths, especially for people over age 45.

### Air Quality

Air quality is adversely affected by higher temperatures, causing increases in both ground–level ozone levels and particulates. Poor air quality has direct impacts on respiratory and cardiac function; both acute and chronic pulmonary and cardiovascular disease are sensitive

to air quality. An additional health factor is a longer pollen season with increased allergenicity of some aeroallergens. Potential health effects are serious and include increased in numbers who develop chronic lung disease, asthma, lung cancer, and cardiovascular disease, and an increase in low birth weight or prematurity in newborns (CAT 2008).

- Ground-Level Ozone: Levels of ozone are highest in the summer, when temperatures rise and accelerate ozone-forming reactions. There will be an increase in the number of days in summer when ozone concentrations exceed regulatory standards and compromise health, particularly for individuals with asthma, chronic obstructive pulmonary disease, and those who work or play outside for extended periods of time (PAWG 2009).
- Particulates: Large wildfires (greater than 200 acres) contribute to air pollution, particularly in rural areas. Most wildfires in Thurston County are quite small (one acre or less) (Paul Brewster, TRPC, personal communication 2009). Between 1972–2007, a total of 2,473 fires occurred in Thurston County, about 70 per year on average. The largest recorded wildland fire was a grass fire off Old Highway 99 near Offut Lake in August 1998. It burned 140 acres. To Brewster’s knowledge, wildfires have not caused significant loss of human life, injury, or damage to public infrastructure or private property in Thurston County. Larger fires could pose greater risks to people and property in the future as the fire season lengthens due to higher temperatures and drier conditions. Wildfires are a source of PM<sub>2.5</sub>, the fine fraction of particulate matter that is a health concern. (Vehicle exhaust is another source of PM<sub>2.5</sub>.) Higher temperatures would increase the frequency of wildfires; particulate matter is also trapped by temperature inversions. Increased particulate matter is associated with increases in both acute respiratory and cardiovascular effects which in turn will increase physician and emergency department visits and hospitalizations for asthma, heart attacks, and other cardiopulmonary conditions (PAWG 2009).
- Pollen/Fungal Spores: There will be an increase in some aeroallergens (pollens, fungal spores), an increase in the duration of the pollen season, and increased allergenicity of these aeroallergens (due to biological factors and combined exposure with increased particulate matter). Thus there may be an increased number of individuals who develop allergic symptoms and worsened symptoms in those already affected (PAWG 2009).

Heart disease is the leading cause of death in Washington State citizens over 65 years of age. By mid-century, King County will likely experience 132 additional deaths between May and September annually due to worsened air quality caused by climate change (Jackson et al 2009). In general, worsening air quality will have a disparate impact on elderly, young, urban

and rural poor, and those who spend more time outside, including the homeless, children active in sports, and outdoor laborers.

### Infectious Disease

Increased temperatures and flooding may contribute to communicable diseases by influencing the habitat and range of disease reservoirs and vectors, by shaping human behaviors that might lead to increased exposure to a disease or vector, and through effects on the characteristics of the disease pathogen, or on the immune response of the host. More than 30 infectious diseases may be affected by climate change, and the whole spectrum of vector-borne and zoonotic disease (e.g., rabies, which can be transmitted from animals to humans) could change as temperatures rise. Changes in disease epidemiology should be expected. Important vector-borne and zoonotic diseases in Washington include Hantavirus pulmonary syndrome (spread by rodents), Vibriosis (raw shellfish), and mosquito-borne diseases such as malaria and West Nile virus (CAT 2008).

Human behavior may change due to recreational water use, outdoor food preparation and consumption, and increased or decreased clothing coverage. Extreme precipitation and flooding may increase exposure to waterborne pathogens that may contaminate surface and ground water supplies.

Expansion of the range of important insect and animal vectors and the diseases they transmit is one of the first impacts of rising temperatures. Many of these conditions – such as West Nile Virus and Hantavirus – are already targets of public health monitoring and surveillance. Other potential disease problems such as malaria, dengue fever, and certain vector-borne encephalitides would be new to Thurston County. However, there are limited studies on the effects of climate change on vectors like ticks and mosquitoes, thus it is not known whether increased disease will coincide with increased range.

- Arboviral diseases: Arboviral diseases are arthropod-borne viral diseases and include malaria, dengue, and West Nile. While no malaria has been contracted within the United States recently, the disease vectors for malaria do exist in Washington. West Nile Virus has been detected in 19 birds, 64 horses, and 326 mosquitoes, and there have been 25 human cases in Washington State as of fall 2009. (<http://www.doh.wa.gov/ehp/ts/Zoo/WNV/WNV.html>). Dengue is moving up into lower USA. Arboviral diseases are required to be reported to local health officials in Washington State (PAWG 2009).
- Food- and Water-Borne Illnesses: Climate change may influence pathogens' growth, virulence, and persistence or people may come in increased contact with the pathogens through climate events such as floods. The most commonly reported

enteric disease in Washington is *Campylobacteriosis*, with nearly 1000 cases reported in 2006. This disease appears to peak in warmer seasons. *Salmonella* also peaks in summer months, although this may be due to people's eating habits rather than a property of the bacterium. *Gastroenteritis* is caused by viruses and may be transmitted via food, drinking water, or recreational water. No studies have clearly linked temperature to disease occurrence. Gastroenteritis is not a reportable condition in Washington. *Vibriosis* is mainly contracted through consumption of raw or undercooked shellfish; there were 113 cases in 2007. Vibriosis is very likely to be an increasing threat to human populations with warmer summer temperatures. Outbreaks of water-borne diseases frequently follow heavy rain, flooding, and hurricanes; surface water contamination is a greater risk than ground water. Crops may become contaminated with *E. coli*, salmonella, or other pathogens during floods (PAWG 2009). *Cryptosporidiosis* and *giardiasis* are caused by parasites and associated with warm-weather recreational water use. Nearly 100 cases of cryptosporidiosis and over 400 cases of giardiasis were reported in 2006.

- Hantavirus Pulmonary Syndrome: Hantavirus is carried by deer mice (*Peromyscus maniculatus*) and other rodent species, and humans are infected by inhaling dust containing contaminated excreta. Populations of rodents increase following floods due to increased habitat.

Groups at risk for infectious disease include: infants, children under five years of age, the elderly, pregnant women, those with compromised immune systems, the rural poor, outdoor laborers, and socio-economically disadvantaged groups.

#### Impact of Extreme Weather Events

Many climate models suggest an intensification of storms that reach the Pacific Northwest coast. Coupled with rising sea levels from thermal expansion of the oceans and melting of land-based ice sheets world-wide, coastal erosion is expected to become severe. Various factors increase the likelihood of destructive river flooding. Coastal inundation, flooding, and landslides create direct hazards to humans who are living or traveling in harm's way. Landslides can hurt and kill people through destruction of structures and roads. Flooding can spread toxins and negatively impact water sources, local septic systems, and combined sewer outflows, each of which can threaten human health in the short and long term (PAWG 2009). Romero and Biever (2009) predict an increase in heavy precipitation patterns and note that in the last decade, flood damage from storms that led to ground and surface water flooding cost \$100 million.

- River flooding: Flooding can disrupt water supplies and sewage treatment facilities, and potentially lead to the spread of toxins, vectors of disease (such as mosquitoes

and rodents), and human pathogens. Flooding can also cause injuries, drowning, and displacement, as well as serious disruption in transportation and services.

- Storm Water and Urban Flooding: Increased precipitation events will overwhelm urban stormwater conveyance systems that were designed for capacities based on historic projections. Commercial and residential neighborhoods and city streets will be susceptible to property damage and transportation delays.
- Sea-level rise: Sea-level rise will have acute impacts during extreme high tides, as well as longer-term incremental impacts. Impacts include saltwater intrusion, displacement of population, and increased water and vector-borne illness. McAllister Springs – the major water supply for Olympia and Lacey – is vulnerable to saltwater intrusion; however, a new wellfield is being developed that will be less vulnerable to this as well as other sources of potential contamination (A. Haub, personal communication, 2009).
- Drought: Due to extreme heat together with lack of snow melt, water supplies will be strained. Drought (as well as flooding) could have impacts on food producers (dairy farmers, CSA's, farmer's market vendors). The increasing number of households that rely on local agriculture for a significant portion of their seasonal diet could also be impacted.

### Social and Psychological Impacts

Socially and economically vulnerable groups will be most affected by climate change, although all segments of society are at risk. The poor and the isolated often have difficulty gaining access to medical services, and also live in areas that are most susceptible to poor air quality and some kinds of flooding. Climate change also has the potential to undermine the social institutions that allow us to prepare for, adapt and respond to public health threats. The possibility of uncontrolled migration of climate refugees from even more heavily impacted parts of the world may further strain society's capacity to respond.

- Migration: Two streams of migration must be considered: immigrants into this region from harder hit areas that are seeking employment and escape from more extreme weather, and internal displacement within Thurston County for the same reasons.
- Social services and public health: Displaced persons will require shelter, food, clothing, health care, and job placement. Those in poverty will lean more heavily on social services; impacts on economics and industry will mean more people with lower wages or unemployed. At the same time as demands are higher, public health, fire, and other emergency response services will be overloaded.
- Energy demand: During summer the demand for cooling, coupled with less hydropower capacity, could lead to supply shortfalls during heat waves (PAWG 2009).. The Chicago heat wave of 1995 led to brownouts; in this city unaccustomed to very

high temperatures, 600–700 people died and 3300 were hospitalized with heat-related illnesses related to the 5-day event (National Assessment Synthesis Team, 2005).

**Stress, alienation, and health:** The effects of stress on illness are well established: stress affects immune and inflammatory responses and is implicated in cardiovascular disease, depression, infectious disease, and other ailments. Socio-economically disadvantaged populations suffer disproportionately (PAWG 2009).

## Summary

The following table is copied from the CDC’s Public Health Grand Rounds webpage.

Climate change has the potential to impact health in many ways. While some of these are unpredictable, others (shown in the table) are supported by considerable evidence.

Weather Event	Health Effects	Populations Most Affected
Heat waves	Heat stress	Extremes of age, athletes, people with respiratory disease
Extreme weather events, (rain, hurricane, tornado, flooding)	Injuries, drowning	Coastal, low-lying land dwellers, low socio-economic sector
Droughts, floods, increased mean temperature	Vector-, food- and water-borne diseases	Multiple populations at risk
Sea-level rise	Injuries, drowning, water and soil salinization, ecosystem and economic disruption	Coastal, low socio-economic sector
Drought, ecosystem migration	Food and water shortages, malnutrition	Low socio-economic sector, elderly, children
Extreme weather events, drought	Mass population movement, international conflict	General population
Increases in ground-level ozone, airborne allergens, and other pollutants	Respiratory disease exacerbations (COPD, asthma, allergic rhinitis, bronchitis)	Elderly, children, those with respiratory disease
Climate change generally; extreme events	Mental health	Young, displaced, agricultural sector, low socio-economic sector

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