Health Element

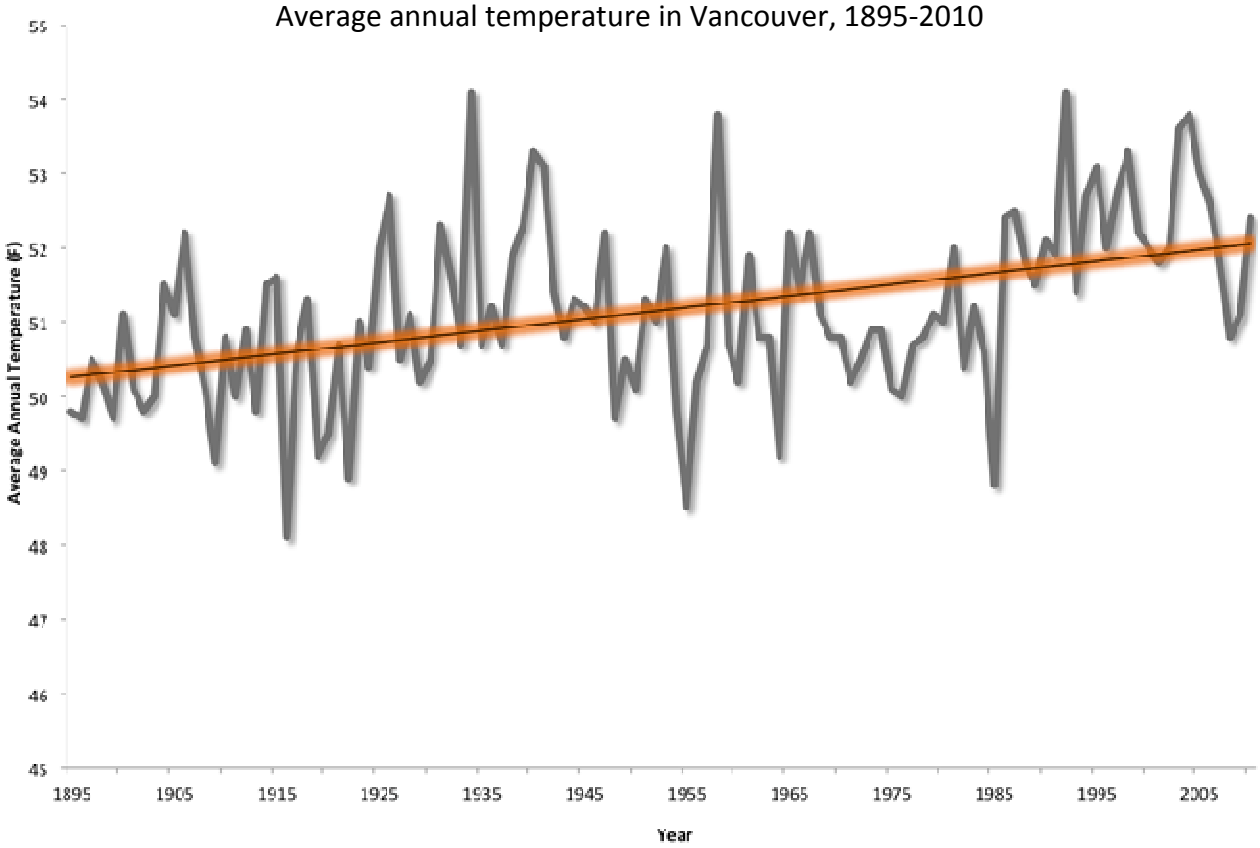
Clark County Comprehensive Growth Management Plan

Growing Healthier

Pathways from the built environment to health:

Climate Change and Human Health

Average annual temperature in Vancouver, 1895-2010



Introduction

Human beings are inextricably connected to and dependent on the natural environment, as it is the physical source of all that protects and sustains communities and individuals. The science of climate change provides clear and convincing evidence that our environment is changing in ways that present a profound threat to human health and the health of the planet. Many individuals, cities, counties, states and countries have, to varying degrees, taken some action to lessen that threat. Such efforts focus on *mitigation*, the adoption of strategies and policies designed to slow the rate of climate change by decreasing greenhouse gas emissions, and/or *adaptation*, the adoption of strategies and policies designed to minimize the impact of climate change on human health, the environment and the economy.

Public Questions about Climate Science

Before discussing the potential health effects of climate change in the Pacific Northwest and actions Clark County can take to manage risk, it is important to directly address the fact that a portion of the public finds this to be a controversial topic, and one which raises questions as well as attempting to answer them. The position held by the vast majority of scientists, world health organizations, and United States public health organizations, as will be documented, is that every indicator of climate change points to the same conclusion: the earth's climate has already changed irrevocably, will continue to change for centuries to come, and if the rate of change is unchecked there will be catastrophic consequences on a global scale. Some of the questions raised by such a position are discussed in the following section.

Question 1: Is there scientific consensus about climate change?

Even before newspaper headlines were informing us that the "World's oceans move into 'extinction' phase," or "Global warming underestimated" and "much worse than previously

believed," the degree of consensus in the scientific community was remarkably high.[1,2] A published 2007 survey of randomly selected climate scientists found that 97% believed "global average temperatures have increased" during the past century, 84% personally believed human-induced warming was occurring, and 74% agreed that "currently available scientific evidence" substantiates its occurrence.[3] In terms of public opinion, a 2010 nation-wide, randomized survey by a Stanford University researcher found that three out of four Americans believed that the Earth was gradually warming and that human activity has been a primary or at least partial influence.[4] Another study conducted in 2010 by Yale University's Project on Climate Change Communication found that 78% of the public "somewhat or strongly trusts" scientists. Yet in that same study, when asked what percent of scientists had reached consensus on climate change, only 13% correctly selected the option of "81%-100%". The researchers concluded "most Americans have overwhelming trust in the science and trust in the scientists, but are largely unaware of the consensus."[5] That trust was undermined in 2009 when two climate scientists were accused of falsifying data to exaggerate warming trends (both later cleared of wrongdoing in independent investigations).[6] The irony is that twenty years of projections by the Intergovernmental Panel on Climate Change (IPCC) have underestimated, rather than overestimated, the rate and degree of change that is occurring.[7] Finally, it is unlikely that most Americans have heard about the degree of consensus among scientific, government, and corporate groups from around the world, or knows that every major public health organization in the US has made climate action a priority.

Scientists and Scientific Organizations that Concur the Climate is Warming and Is Due to and/or Exacerbated by Human Co2 Emissions[8]

Scientists

97% of 20,000 Scientists who are members of the American Geophysical Union working in the following climatology fields (1,956 Atmospheric sciences, 1,564 Biogeochemistry, 334 Cryosphere, 75 Global climate change, 4,736 Hydrology, 2,326 Ocean sciences, 634 Paleoclimate, and 2,004 canVolcanology).

National Academies of Science in the Following Countries and Districts:

United States	Canada	United Kingdom	Russia	Brazil	Belgium
France	China	Germany	India	Italy	
Japan	Indonesia	Ireland	Malaysia	Mexico	
New Zealand	Russia	South Africa	Switzerland	Australia	

Scientific Organizations/Agencies

American Association for the Advancement of Science
American Association of State Climatologists
American Astronomical Society
American Chemical Society
American Geophysical Union
American Institute of Physics
American Meteorological Society
Australian Meteorological And Oceanographic Society
Canadian Foundation for Climate and Atmospheric Sciences
Canadian Meteorological and Oceanographic Society
Environmental Protection Agency
Federal Climate Change Science Program
Geological Society of America
Geological Society of London
Intergovernmental Panel on Climate Change
Institution of Engineers Australia
International Council on Science
NASA's Goddard Institute of Space Studies
National Center for Atmospheric Research
National Oceanic and Atmospheric Association (NOAA)
National Research Council
Pew Center on Climate Change
State of the Canadian Cryosphere
United Nations Framework Convention on Climate Change
United Nations Project on Climate Variability and Predictability
US Geological Survey
UN Environmental Program
Union of Concerned Scientists
Woods Hole Research Center
World Meteorological Organization

Question 2: Isn't climate change just a natural variation in weather?

In order to address this question, it is first necessary to understand the major differences between climate and weather, as captured in the table 9.1 below. [9,10,11]

Table 9.1. Differences between Weather and Climate

Differences	Weather	Climate
Scientific basis	Meteorology	Climate science and many other disciplines (e.g. chemistry, marine science, volcanology) depending on climate related question studied.
Focus of study/research	***Troposphere:*** the densest layer of the atmosphere and the region that contains essentially all of earth's weather	***Atmosphere:*** layers of air and gases surrounding earth (includes troposphere) ***Cryosphere:*** river ice, sea ice, glaciers, ice caps, ice sheets, permafrost ***Hydrosphere:*** combined mass of water over, under, on planet ***Climate Change:*** interaction of all influences on the climate system ***Biosphere:*** the total ecosystem supporting life on earth ***Lithosphere:*** earth's crust ***Other Environmental Sciences:*** Ecology, Physics, Chemistry, Biology, Soil Science, Geology, and Geography
Forecasts	Describe and predict atmospheric conditions (weather) that are current (temperature, prevailing winds, storm fronts, etc.) and change relatively quickly (days to weeks)	Describe decade long trends in weather and make future projections regarding location specific and global climate patterns.
Timescale	Days or weeks	Standard is to examine trends based on averages over 30 year periods; may also look at trends over shorter periods or over centuries or millennia depending on available data (as in ice core sampling).

People are correct in believing that weather naturally varies over days or weeks, and it seems counter-intuitive for winter storms to engulf half the country in a warming climate. However,

climate projections take such variable weather into account in their longitudinal analyses of trends, as in Chart 9.1 and 9.2 below.

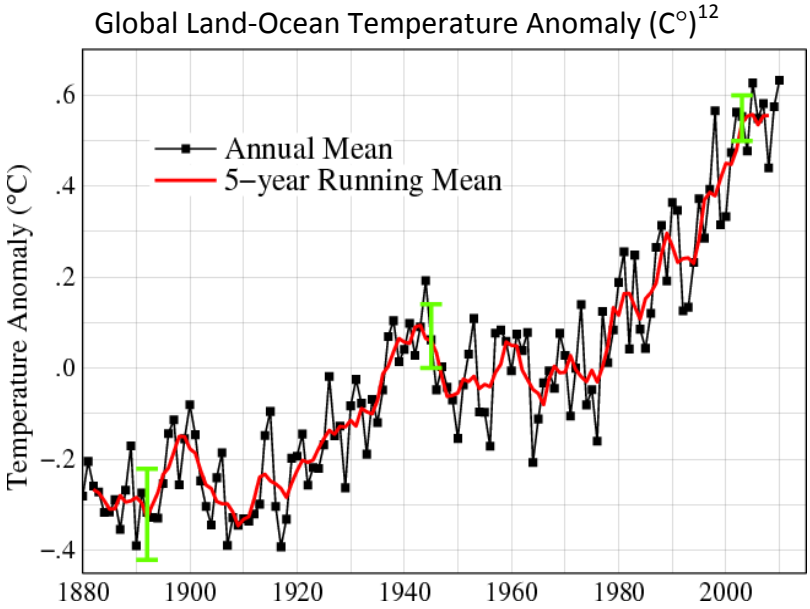


Chart 9.1: *The black lines indicate global land-ocean temperature averages for each year between 1880 and 2000; the red line indicates the average over 5-year period; the chart as a whole shows the deviation (anomaly) from average temperatures since 1880.*

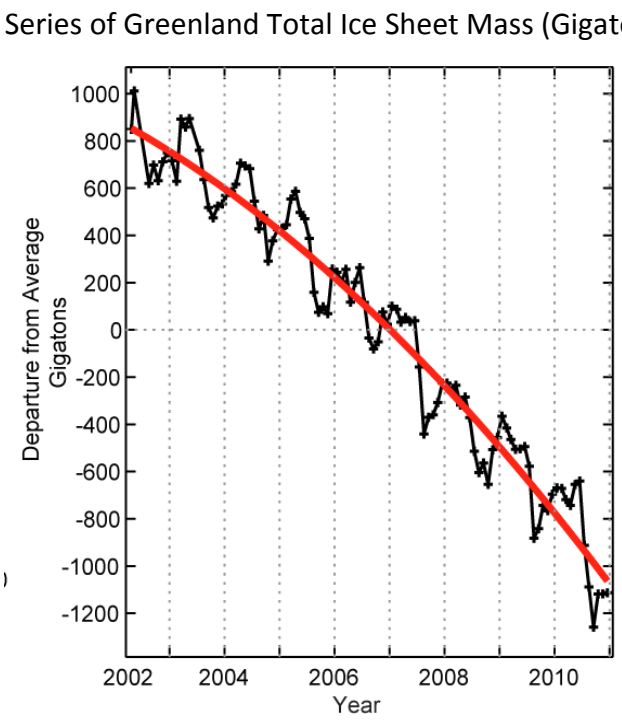


Chart 9.2: *Greenland ice mass anomaly - deviation from the average ice mass over the 2002 to 2010 period. This Greenland's ice sheet lost more mass in 2010 than at any time in the past ten years.*

Although there is significant year to year variabilitiy in these graphs, Chart 9.1 demonstrates a 120 years trend of increasing global temperatures on land and sea (with a multitude of other consequences such as rapid melting of the Greenland ice sheet as shown in Chart 9.2). Climate science also looks much farther back in time in order to understand how typical these trends are, since climate too has natural variations, and as it turns out they are extraordinary. As one NASA atmospheric scientist explained "the changes in ocean heat are unprecedented in the past ten thousand years. At the same time, climate warming from greenhouse gases is at its highest levels in at least 800,000 years." [14]

Question 3: Is the warming climate really the result of human activity?

Earth has experienced climate change in the past, both warming and cooling, without help from humanity. So why have tens of thousands of climate scientists around the world, and a majority of the public, come to the conclusion that human activity inadvertently caused the climate to warm and is continuing to escalate this crisis? Consider the following two indicators. First, CO_2 levels remained relatively stable throughout human history until around 1750, when the Industrial Revolution began and burning of fossil fuels and biomass (living matter such as trees) substantially added to the amount of heat-trapping greenhouse gases in the atmosphere. In the past 100 years the rate of increase in CO_2 has accelerated with the discovery of crude oil and a tripling of world population.[15] Second, based on data from the National Aeronautical Science Administration (NASA), the rate of warming is *much more rapid* than at any time in the past two million years. Historically it took about 5,000 years for the earth to warm by 5° Celsius (9° Fahrenheit). Yet in just the past 100 years, warming is occurring ten times faster than ever before and is projected to accelerate to a rate twenty times faster by the start of the next century.[16] Past warming was slower because the amount of CO_2 in the atmosphere was more

stable, e.g. remaining in a range of about 260–280 parts per million (ppm) for the past 10,000 years. Yet since the early 1800's, CO_2 levels have risen by 70%, to 393.69 ppm in 2011 and increasing by about 20 ppm per decade.[17] If the current rate of change continues, it will take less than 30 years to reach a CO_2 level of 450 ppm. The last time the earth's CO_2 was that high, the planet was ice-free and the oceans were 250 feet higher than they are today.[18] Among many hypotheses about why these rapid changes are occurring, the only one fully supported by applied scientific research is that human beings have altered the environment at a global scale.

Pathways

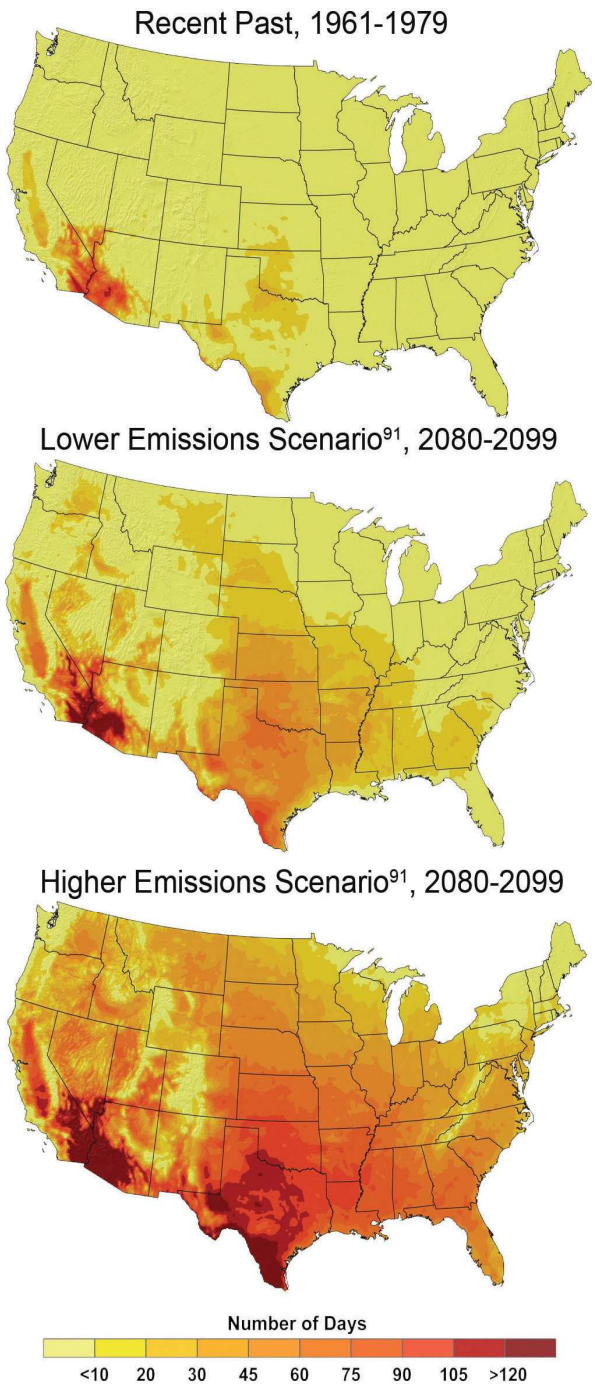
This literature review examines projected health impacts due to climate change that would adversely influence Clark County resident's physical, psychological and economic well-being. Washington data is primarily from the work of a 2010 statewide interdisciplinary committee that examined climate related health threats,[19] with additional findings from the Washington Climate Impacts Group (CIG), the Intergovernmental Panel on Climate Change (IPCC) and other peer reviewed research.[20,21]

Key Health Impacts of Climate Change in the Pacific Northwest

1. Extreme heat days
2. Deteriorating air quality
3. Flooding and drought
4. Shifting disease vectors
5. Injuries
6. Mental health issues
7. Dislocation and in-migration

1. Extreme Heat Days

Extreme heat days are the most prominent cause of weather-related human mortality in the United States. They are responsible for more deaths annually than hurricanes, lightning, tornadoes, floods, and earthquakes combined.[22] In the United States between 1999 and 2003, 3,442 reported deaths resulted from exposure to extremely hot weather.[23] Mortality is significantly greater if heat events last 3 or more days.[24] Urban areas present a higher risk since buildings, asphalt and cement capture and hold heat, creating a "heat island effect". The largest increase in mortality in Washington is expected in cities that have higher population density, historically milder summers, and less air conditioning.[25]



Projected US temperatures 2080-2099

Figure 9.1. *The number of days per year in which temperatures are projected to exceed 100°F by late this century compared to the 1960s and 1970s under two different scenarios of future GHG emissions (IPCC SRES scenarios B1 and AIF1. SOURCE: USGCRP Global Climate Change Impacts, p. 90.*[26]

2. Deteriorating Air Quality

Particulate matter (PM) such as black carbon and diesel particulates are associated with an increased risk of cancer and a variety of non-cancer health effects, including respiratory diseases and increased mortality.[27] Fine particulates are also associated with negative cardiovascular outcomes such as heart attacks, formation of deep vein blood clots, and increased mortality from other causes.[28] Exposure to more than one air-borne particulate significantly increases the risk of death.[29] The National Morbidity and Mortality Air Pollution Study identified a number of additional acute and chronic respiratory and cardiovascular health risks from exposure to poor air quality: aggravation of asthma, rhinitis, exacerbations of chronic obstructive pulmonary disease, hospitalizations for respiratory and cardiovascular diseases, low birth weight and premature mortality among infants and premature mortality among adults, and increased incidence of serious respiratory infections, lung cancer, heart attack and stroke.[30] Warming temperatures contribute to deterioration of air quality through three main mechanisms: 1) warm, wet weather lengthens the spring pollen season, resulting in more potent allergens more prolific growth of molds, ragweed, grasses and flowering trees;[31] 2) increased air pollution from smoke and ash due to a projected doubling of climate-influenced fires; [32] and 3) exacerbation of ground-level ozone (the primary component in smog) triggered by heat and sunlight.[33] Ozone alone could result in 2.8 million additional serious respiratory illnesses in the US by 2020.[34]

3. Flooding and Drought

In the Pacific Northwest, warming temperatures will bring an increase in rain in western Washington in the winter, a decrease in snowfall and snowpack in the Cascades, and hotter, drier summers. High temperatures will lead to more rain-on-snow events, which is a major

trigger of the periodic river flooding that is already a frequent occurrence in the state.[35] Outbreaks of waterborne diseases frequently follow heavy precipitation and flooding due to contamination of ground or surface water with infectious organisms, including intestinal bacteria such as E. coli, Salmonella, and Shigella; Hepatitis A Virus; and agents of typhoid, paratyphoid and tetanus.[36] People coming into contact with floodwaters or residue may be exposed to hazardous materials such as pesticides or propane through skin or vapor contact; to respiratory hazards due to bacteria and molds in wet organic/agricultural materials such as hay or grain; and to fermenting agricultural materials that can release potentially fatal toxic gases.[37] In addition to vulnerability to flooding, Western Washington is also vulnerable to drought. The most recent example is 2005, when water shortages after a long, dry summer led to a statewide declaration of emergency.[38] In 2010 a state of emergency was again considered when during the first three months of the temperatures were among the warmest in the last 40 years; there was virtually no snow below 5,000 feet by mid-March; and total snowpack in most basins was 50% to 70% of normal. Scientists predict early snow melt and, long, dry summers, raising drought concerns especially for water systems dependent on wells and groundwater.[39] More research is needed to provide reliable projections as to the hydrological impact on the state's agricultural and drinking water supply as it shifts from sources supplied primarily by snowmelt to those supplied primarily by rain.[40]

4. Shifting Disease Vectors

Increased temperatures not only affect humans directly, but also affect many species in our environment. Of particular concern is that a warmer and wetter Pacific Northwest will become a prime habitat for a number of disease carrying, ticks, mosquitoes and rodents that could not

previously survive here.[41] For a detailed description of each of the diseases that are described below, see the CDC Health Topics A-Z Index at http://www.cdc.gov/az/.

Mosquitoes

There are two threats from disease-carrying mosquitoes. First, vectors already in the United States (carrying West Nile Virus and the neuro-invasive diseases St. Louis encephalitis, eastern equine encephalitis, western equine encephalitis, and La Crosse encephalitis) may proliferate in a warmer climate. Second, there is a high likelihood that climate change will increase global migration, bringing exotic new or re-emerging pathogens from around the world. These could include mosquitoes that would find Washington habitable and bear diseases such as Rift Valley fever, dengue, chikungunya fever, Japanese encephalitis, and Venezuelan equine encephalitis.

Ticks

Longer, drier summers and milder winters will make more favorable habitats for ticks. When disease-carrying ticks that are already in the United States proliferate, they will increase transmission of diseases such as Q fever, Rocky Mountain spotted fever, Lyme disease, and most recently Powassan, a virus that can also cause encephalitis.[42]

Rodents

The potential of increased forest decimation through pine beetle infestations, with the increased risk of severe forest fires, may impact the habitat and distribution of 6 different rodent populations, which would increase risk of exposure to the diseases they can carry, such as Hantavirus pulmonary syndrome.[43]

5. Injuries

Injuries in Washington are expected to increase due to severe weather events such as storms, rapid snow melt, or flooding precipitated by rain on snow events. The risks of injury during

such events or when cleaning up include:[44,45]

- Electrocution from downed power lines
- Carbon monoxide poisoning from indoor use of fuel powered pumps or generators
- Structural instability of natural walkways, sidewalks, roads, bridges and buildings
- Drowning, a particularly high risk for people in vehicles
- Direct injury from debris
- Direct injury from landslides, mudslides and avalanches
- Musculoskeletal injuries from cleanup activities
- Injuries from use of machinery such as chainsaws

Since 2001, Washington state has had had 8 major disaster declarations due to severe storms or winter storms and/or flooding, landslides, and mudslides.[46] The frequency and intensity of such events are expected to increase and to put more people in harms way.

6. Mental health

Climate change and mental health intersect in two ways. First, catastrophic weather events such as hurricanes directly impact mental health, and are expected to occur with greater intensity and frequency as climate change intensifies. After hurricanes Katrina and Floyd, mental health impacts included high rates of post traumatic stress disorder, depression, and increased frequency of domestic violence, child abuse, and suicide attempts and completion; the severe drought that affected rural Australia led to stress, social isolation, and increased rates of suicide. The vulnerabilities that increased the likelihood of adverse impacts in those and other disasters included but were not limited to:[47]

- Forced relocation, leading to loss of connection to place and community
- Economic insecurity and hardship.
- Lack of social or material support.
- Age, ethnicity, socio-economic status, or other determinants that lead to disparate health outcomes.
- Pre-existing mental health conditions.

Yet there are limitations in extrapolating from research on survivors of natural disasters, such as a hundred year flood, since those are theoretically anomalies, not the new face of the planet. A similar concern is true of the second climate change-mental health connection, which is the loss of the planet that was familiar and relatively predictable, but is now changing in ways that make it less habitable. Some lessons can be drawn from research showing that significant mental health issues are often experienced by people living in disaster prone areas who must live with ongoing uncertainty, anxiety and dread.[48] A 2007 survey of Australian children, who had living in country in severe drought for several years, found approximately 25% "so troubled about the state of the world that they honestly believe it will come to an end before they get older."[49] Much more research needs to be done on understanding how mental health is impacted not just by disasters, but by living with the knowledge that the world as we know it is rapidly changing for the worse, and that the farther climate change advances the less ability we have to protect ourselves.

7. Displacement and In-Migration

Climate change is likely to increase displacement and in-migration. Regarding the first of these, the CDC states that, "Extreme weather events, sea-level rise, destruction of local economies, resource scarcity, and associated conflict" are projected to displace millions of people worldwide by 2050, people who will experience place-based distress due to loss of home or home environment.[50] The United Nations has been engaged in and studying the issues facing and needs of refugees for 60 years, so provides a valuable resource on the physical and mental health impacts on diverse populations displaced by natural disasters, famine or war.[51] The ability to predict if and when citizens of another country will seek refuge in the US due to climate related factors is an area of great uncertainty, as is the response of the US in that event.

We do know that that many intervening variables (cultural, socioeconomic, institutional) influence decisions to leave home and homeland, and that the events likely to prompt migration include sudden onset events (e.g. hurricanes), persistent conditions (e.g. drought and famine) and knowledge of impending events (e.g. melting ice caps) that they anticipate having disastrous consequences.[52] In the US, it is likely that the first climate refugees will be from within, as people move after losing a home to a hurricane, or facing persistent drought, or finding they cannot tolerate weeks or months of temperatures over 100 degrees. Four years after Hurricane Katrina, New Orleans still had over 100,000 fewer residents than it did before the storm.[53] Climate refugees may be drawn to the Pacific Northwest as it is projected to have milder weather conditions and fewer extreme risks than much of the country. Their success in relocating may depend in part on Clark County's capacity to respond to their housing, economic, physical and mental health needs.

Exacerbating Trends

There are four additional influences that will be briefly reviewed in terms of their role in exacerbating climate change and its impacts.

Population Growth

Chart 9.4 shows the world's population growth from 1950 to 2025, when it is projected to increase by over 300% from 2.5 billion to 7.9 billion people. Projections from the United Nations are that we will then add 74 million people per year, reaching 9 billion by 2050 and 10 billion by the end of the century.[54] The United States population is projected to increase over 233%, from 151.9 million in 1950, to 312.2 million today, to 351.4 million in 2025.[55] This exponential growth of world population will create an increased demand for food, energy, and water, resources that will be increasingly scarce as a result of climate change.

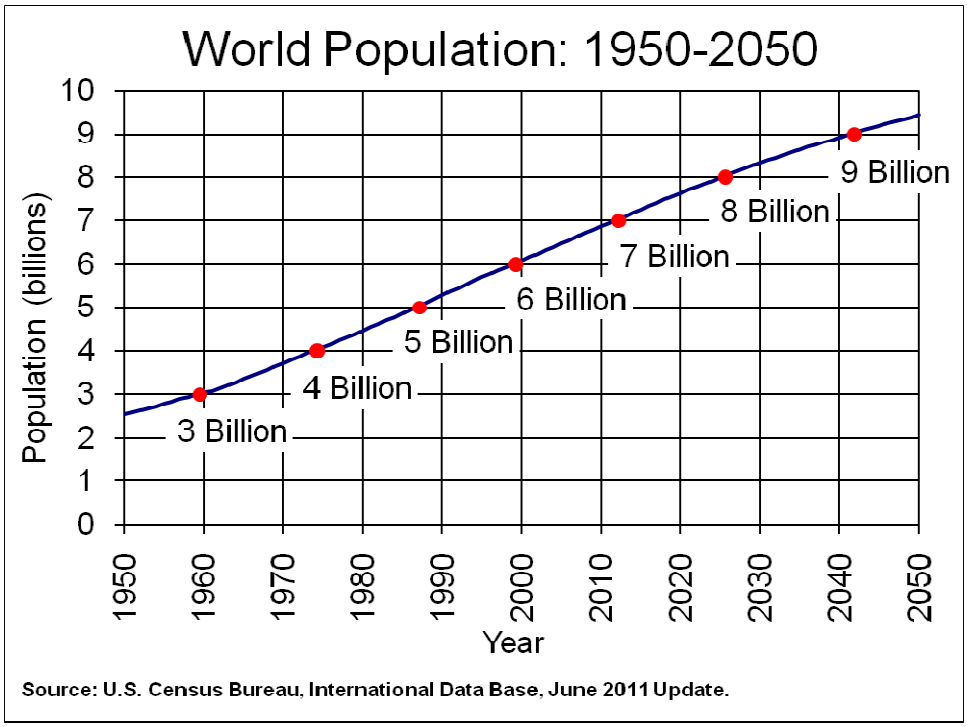


Chart 9.4. *World population growth from 1950 to the present, projected to 2050.*[56]

Increasing Food Insecurity

Why do we face food insecurity when, for the past 5 decades, world food production has exceeded population growth and the quantity of food produced per person has increased? As explained in a Security and Sustainability Forum in Washington D.C. Climate change is expected to increase global temperatures and the frequency and severity of extreme weather, which will result in depressed agricultural yields.[57] The seriousness of this is heightened by the fact that three-quarters of the genetic diversity found in agricultural crops has been lost over the last century due to the industrialization of agriculture. There were once an estimated 10,000 types of food crops, but today only 150 crops feed most of the world's population, and just 12 crops provide 80 percent of dietary energy from plants, with rice, wheat, maize, and potato alone providing almost 60 percent.[58] The world's food supply is left dangerously vulnerable to widespread crop failure akin to that of the Irish potato famine.[59] Further, when crops are subjected to temperatures above a certain threshold — about 84 degrees for corn

and 86 degrees for soybeans — yields fall sharply, and at the temperatures projected for the end of the century could decline by 30% or more.[60] Of equal if not greater concern for food supplies are the findings a report released by the International Programme on the State of the Ocean in June 2011. They concluded that the ocean is already going through a severe decline in many species and habitats, some to the point of commercial extinction, and oceans are now facing the loss of entire marine ecosystems. They go on to warn that "unless action is taken now, the consequences of our activities are at a high risk of causing, through the combined effects of climate change, overexploitation, pollution and habitat loss, the next globally significant extinction event in the ocean," unprecedented in human history.[61]

Declining Oil Reserves

As the population grows, so does demand for goods and services, and the energy needed to meet that demand. According to the US Energy Information Administration (EIA), in 2009 the United States consumed 23% of the world's oil though home to only 4% of the world's population and 2% of world oil reserves. For the past 30 years the clear trend in the United States has been declining production, declining reserves, and declining exports, with rising consumption and imports.[62] Of the remaining oil reserves, 63% are in the Middle East (Saudi Arabia, Iraq, Kuwait, Iran, and United Arab Emirates). The International Energy Agency (IEA) of which the US is a member, states that crude oil production peaked (reached the point at which half of the *world's* original oil reserves have been used up and production enters a period of *terminal decline*) at 70 million gallons per day in 2006. While the timing of peak oil is often contested, there is no question that this is a finite natural resource. As fossil fuel becomes scarcer it will become more expensive to produce food, transport goods, or manufacture countless products in which oil is an ingredient (fertilizers, medicines, plastics), making it even more difficult to obtain resources already directly threatened by climate change.

Economic Impacts

Oxfam has projected that by 2030, food prices will more than double from today's highs, with climate change responsible for half of the increase. Today's worldwide production of approximately 70 million barrels a day is projected to decline to no more than 20 million barrels per day of oil by 2035, and our new sources of "green" energy are simply increasing along with, rather than displacing, all of the traditional ones.[63] The IEA's Director stated that "The days of cheap oil are over" and pointed out that unrest in other parts of the oil-producing world would further drive up costs.[64] Rising demand from a rapidly growing population, disrupted food production, and higher oil costs equal rising prices for food and for every product that requires crude oil as an ingredient (from fertilizers to plastic to medicines) and every product that must be transported to reach us.

Disparities

The most vulnerable populations are those whose socioeconomic status limits their ability to access resources, the very young and very old, those with already compromised health status, and those with location-based exposures.

Socioeconomic Status (SES)

Because they have the fewest resources for adapting to a changing environment, those in lower socio-economic brackets disproportionately suffer the health impacts of climate change. All of the SES associated disparities previously discussed in this Element would still be there in a changing climate. For instance, obtaining needed resources such as food, medical care, transportation or affordable housing will be increasingly difficult in a time of dwindling resources and undoubtedly fierce competition. There is thus some urgency in addressing health disparities at a local level in order to provide persons with limited financial resources at

least some protection against the threats to come.

Race and Ethnicity

Racial and ethnic minorities disproportionately experience climate change impacts. In a study of the "climate gap" in California, researchers found that low SES populations and communities of color disproportionately suffer from extreme weather events, are more likely to be exposed to deteriorating air quality, and face greater challenges coping with the economic aspects of climate change.[65] For example, the report found that African Americans in Los Angeles die at nearly twice the rate of White Angelinos during extreme heat events, partially due to low levels of access to air conditioning, automobiles, and health insurance.

Age

Aging, young and medically vulnerable populations are higher risk. Under excessive heat stress, adults over 65, children, and infants under 1 year of age have shown greater sensitivity to all-cause mortality. As the number of persons 65 years and older is expected to increase from 12.4% in 2000 to 20% in 2060, we should expect a substantial rise in weather related deaths.[66] Extreme heat and the air pollution that accompanies it also disproportionately impact pregnant women, persons of low SES and those with existing respiratory or cardiovascular disease.[67]

Geography

Health risks may vary by where people live or work. People living in rural areas are especially vulnerable to the air quality effects of wildfires,[68] while those who work outdoors face exposure to extreme heat and to disease carrying vectors and rodents.[69] People living near the coast or rivers are at greater risk from extreme weather events such as flooding with its potential for food and water contamination. Finally, populations who are dependent on drinking water that

originates in glacially fed aquifers are at risk of water shortages; populations who rely on drinking water from river fed aquifers are at risk of salt-water intrusion depending on the extent of sea-level rise.[70,71]

Conditions Needed to Thrive

Climate change is a public health emergency that requires immediate action. To thrive, it is critical that the global temperature be stabilized so the warming process stops. This requires mitigation, a collective effort at a local, national and international level to decrease emissions of CO_2 and other greenhouse gases in order to slow and eventually reverse the rise in temperature.

To thrive, it is critical that people be protected from climate related threats that are already occurring, such as an increase in extreme heat days and the dwindling of glaciers that replenish our water supply, or that are projected to occur. This requires adaptation, the effort to anticipate and implement strategies to protect people from threats such as extreme heat events, loss of crops or water due to drought, or increased flooding due to sea level rise. In an unprecedented time of increasing population, decreasing resources, and increasing risks from climate change, *<u>both</u> strategies are necessary if we are to survive and thrive*.

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Health Element

Clark County Comprehensive Growth Management Plan

Growing Healthier

Current Conditions:

Climate Change and Human Health

Climate Change has already begun in Clark County. The temperature already warmed by about 1.5 degrees Fahrenheit between 1920 and 2003, and will likely continue to warm by about .5 degrees per decade.[1] Many effects of this warmer climate may not be realized for several years, making the theme of this report, "current conditions", a partial misnomer. We therefore provide a mix of recent data, trends, forecasts, and current policies that can help us understand the risks and adaptive capacity of Clark County. We begin with health data, and then summarize conditions by the seven key health impacts identified in the literature review (right), concluding with information on disparities.

Key Health Impacts of Climate Change in the Pacific Northwest

1. Extreme heat days
2. Deteriorating air quality
3. Flooding and drought
4. Shifting disease vectors
5. Injuries
6. Mental health issues
7. Dislocation and in-migration

Health Data

Health data for some of the key health impacts of climate change is unavailable, out-dated, or not relevant enough to include in this report (e.g. fire fatalities during events in the distant past). We therefore focus only on health impacts from extreme heat, deteriorating air quality, disease vectors, and mental health issues.

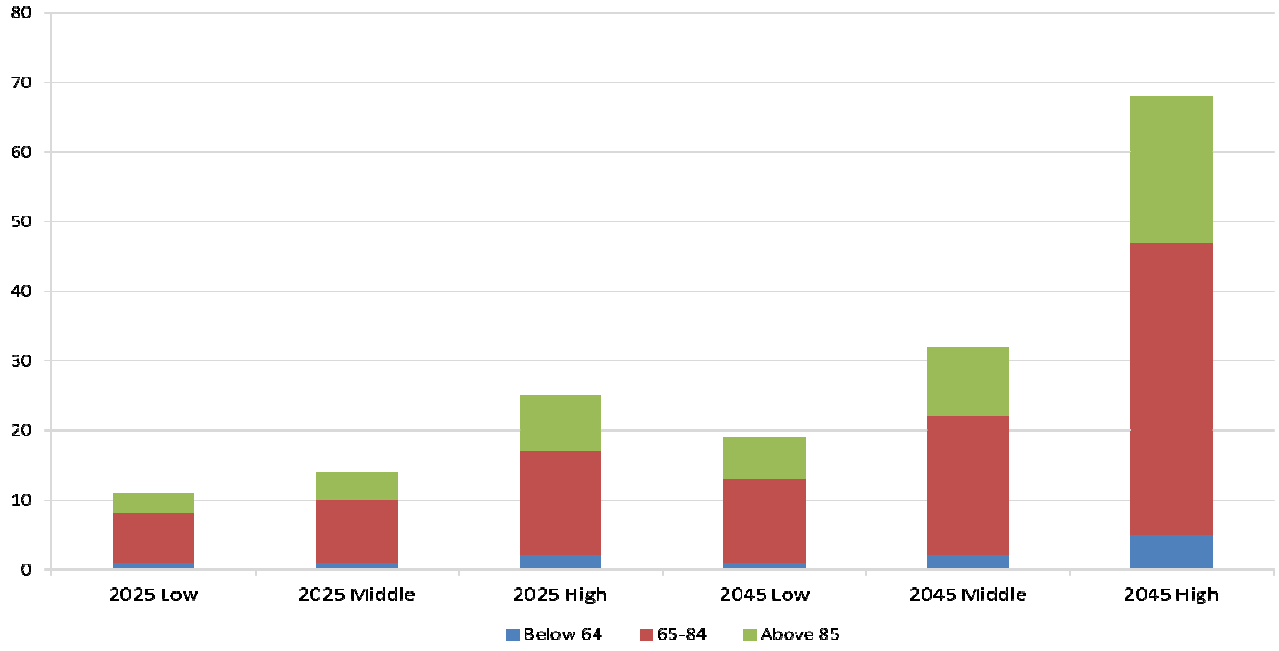
Health Outcomes Associated with Extreme Heat

Scientists from the University of Washington Climate Impacts Group teamed with the Northwest Center for Public Health Practice to study the past and projected impacts of extreme heat events in Clark County. Based on data from 1980-2006, researchers concluded that locally there has been a 4% greater risk of non-traumatic death on an **extreme heat day**.[2] Among older age groups, this risk is higher. Researchers used this data to create forecasting models to estimate excess deaths due to future extreme heat in Clark

An **extreme heat day** is among the warmest 5% of all days since 1980.

County in the years 2025 and 2045 (Chart 9.5).[3] There is a certain amount of mortality associated with any extreme heat day, but researchers focused on only the excess deaths due to climate change, or the number of people who will die because of climate change who would not have otherwise died. The same research team plans to release estimates of climate change-related morbidity in Fall 2011.

Chart 9.5. Estimated Excess Mortality from Extreme Heat Events Related to Climate Change in Clark County, 2025 and 2045



In 2045, Clark County can expect over 30 excess deaths on hot summer days due to extreme heat related to climate change. Source: UW CIG and NWCPHP, 2011

Health Outcomes Associated with Deteriorating Air Quality

From 2004 to 2008, the hospitalization rate for asthma in Clark County was 63.2 per 100,000 population.

Health Outcomes Associated with Disease Vectors

In the recent past there have been very few, if any cases of diseases associated with vectors that could spread to Clark County in a warmer climate. Detailed information is reported below on page 13.

Health Outcomes Associated with Mental Health

Among the anticipated health impacts of climate change is the toll it will take on mental health. About 10 percent of adults in Clark County reported poor emotional health in a survey conducted in 2008 & 2009. Of these, about a quarter (6,892) did not have health care coverage.[4]

Current Conditions

Green House Gas (GHG) Emissions Inventories

The Washington State Department of Ecology issues GHG emissions inventories for the state every two years. The most recent edition, issued for 2008, indicates that the single largest source of GHGs in Washington is transportation (Chart 9.6). Within the transportation sector, gasoline (52%), diesel (20%), and liquefied petroleum gas (2%) consumption account for 74% of GHG emissions, with the remainder emitted by marine, aviation, and rail use. Although Washington's per capita gasoline consumption is similar to the US average, it accounts for a larger portion of overall GHG emissions because of the prevalence of low-carbon electricity sources in the Northwest, mostly hydroelectric. In Clark County, the percent of total emissions coming from the transportation sector is likely higher as a result of high rates of drive-alone commuting and relatively low-carbon electricity sources.

The City of Vancouver commissioned a greenhouse gas inventory for the year 2007. Taking a different approach, the City includes indirect emissions resulting from the production of material goods. This approach is supported by the EPA and the International Council for Local Environmental Initiatives, and has been used by Oregon Metro in an emissions inventory for the region. The Vancouver inventory uses three broad categories: energy, transportation, and materials, goods, and food. Examples of each can be found in Table 9.3. A break down by percent of total emissions is provided in Chart 9.7.[5]

Chart 9.6 Washington State GHG Emissions by Sector, 2008

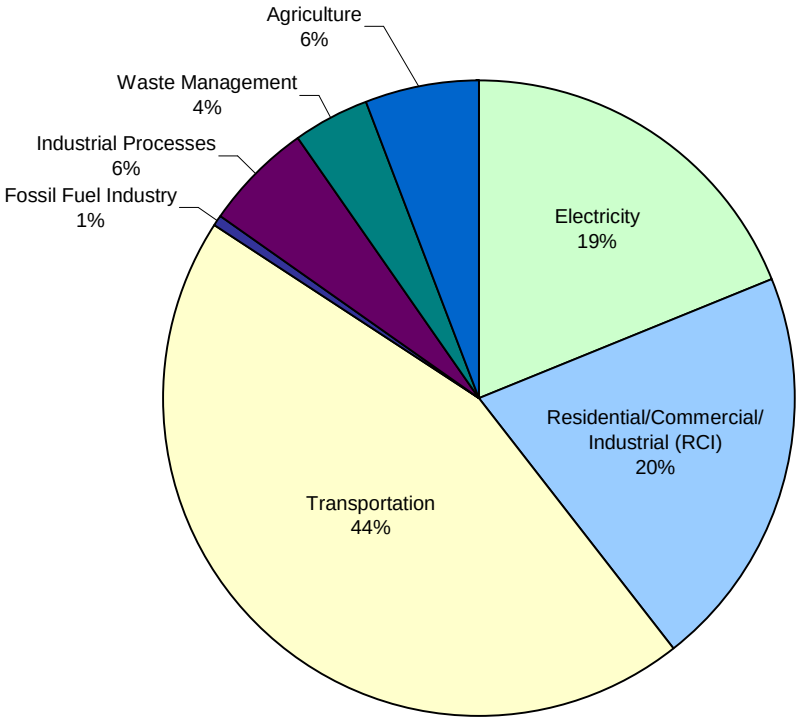
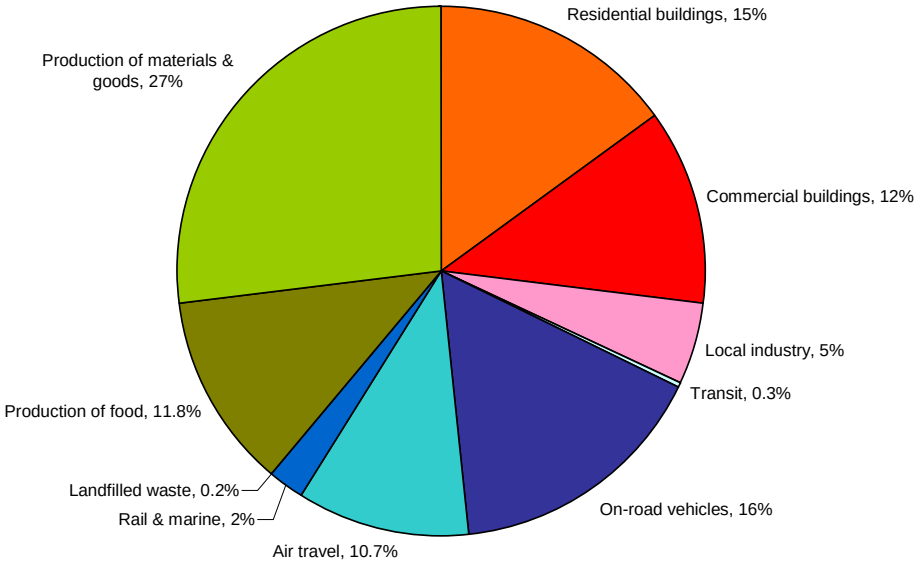


Table 9.3. Examples of Vancouver Emissions by Sector

Transportation	Energy	Materials, Goods, & Food
• Vehicle miles traveled by passenger vehicles and light trucks • C-Tran public transportation emissions • Marine / Rail / Freight • Air travel by Vancouver citizens at Portland International Airport and Pearson Air Field	• Natural gas consumption from residents, businesses and industry • Electricity consumption from Clark Public Utility District's (PUD) River Road Plant • Fossil fuel consumption from Clark PUD's imported electricity	• Production and transport of materials and goods consumed in the city • Production and transport of food consumed in the city • Landfilled waste

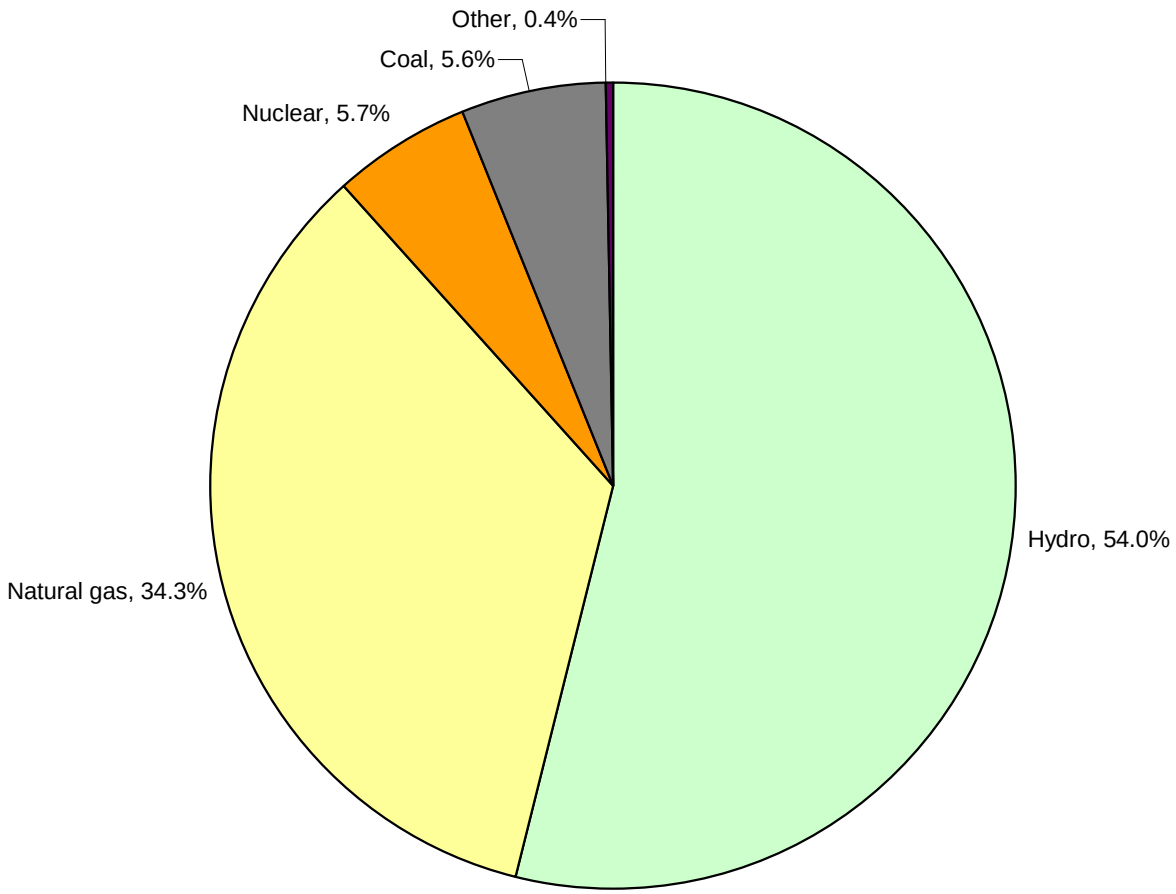
Chart 9.7. Vancouver GHG Emissions by Sector, 2007



In Chart 9.7, green hues represent emissions from materials, goods & food (39%), blue represents transportation (29%), and red represents emissions from energy use (32%).

Clark Public Utilities is the electricity utility for Clark County, serving approximately 183,000 residential and commercial customers. Clark Public Utilities relies on hydroelectric and natural gas as the two largest sources of electricity, resulting in a relatively low carbon footprint per unit of energy (Chart 9.8).

Chart 9.8. Electricity Sources for Clark Public Utilities



As of 2011, about 0.5% of Clark County customers participated in the Green Lights program, which offers the option to purchase renewable electricity. This compares to 14% of Portland General Electric and Pacific Power customers.[6] Elsewhere in Washington, Lacey and Bellingham have been recognized for achieving 6% and 16% of customers purchasing renewable power. [7] This success is partially due to efforts of Puget Sound Energy, which provides solar energy project grants for communities that meet their renewable energy goals, and a rewards program that provides incentives for individuals and businesses to participate in Green Power initiatives.

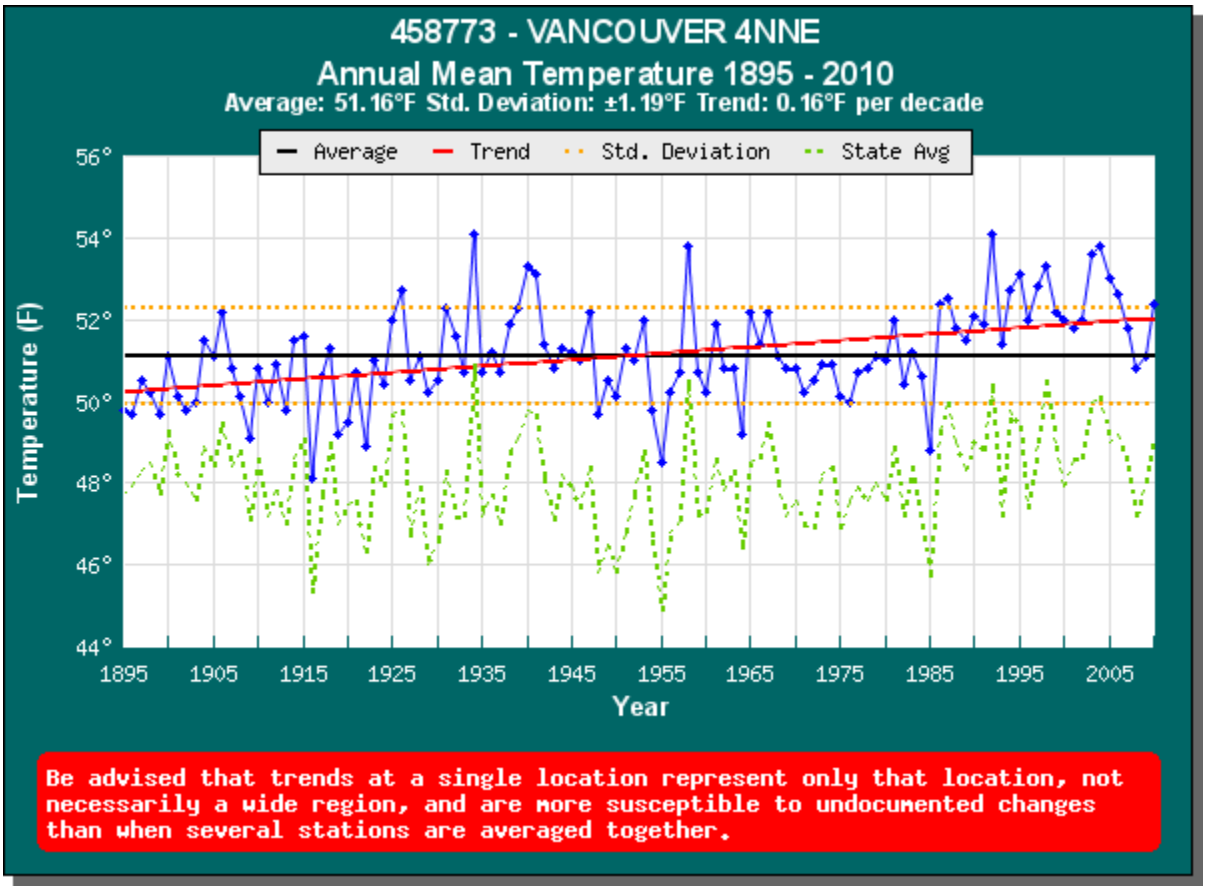
Extreme Heat Days

An **extreme heat day** is among the warmest 5% of all days since 1980.

Calculations by University of Washington researchers estimate that by 2045, Clark County will experience between 35 and 68 extreme heat days per year with a humidex (combined heat and humidity or "feels like" temperature) above 37.5 degrees Celsius (96.3F). Similar calculations from the National Resource Defense Council found that from 2000-2009, Clark County has experienced more extreme heat days than would be expected if the climate had not changed from that of 1961-1990.[8] Data from the Office of the Washington State Climatologist show that the Vancouver area has warmed by about .16 degrees Fahrenheit per decade (Chart 9.9).[9]

CRESA does not have a specific response plan for an extreme heat event. During an extreme heat event, CRESA works with Clark County Public Health, the National Weather Service, and other agencies to

Chart 9.9. Vancouver Annual Mean Temperature 1895-2010



ensure that updated information is available. This includes distributing information about the CCPH response and any cooling centers that may be opened by local governments or private organizations. Cooling centers include fire houses, libraries, and other public buildings. These centers will allow individuals to loiter in non-operational areas until closing. However, the CRESA HIVA explicitly

Deteriorating Air Quality

Current health risks from deteriorating air quality are relatively low. An analysis of 2005 data showed that Clark County had zero unhealthy ozone days, and also did not have observed occurrences of ragweed.[10] From 1998 to 2008, there were zero days with unhealthy air quality in Clark County, and an average of 1.9 days that were unhealthy for sensitive populations.[11] The Vancouver area is currently a designated maintenance area for Ozone and Carbon Monoxide, meaning that it was previously in non-compliance with air quality standards for these pollutants.[12]

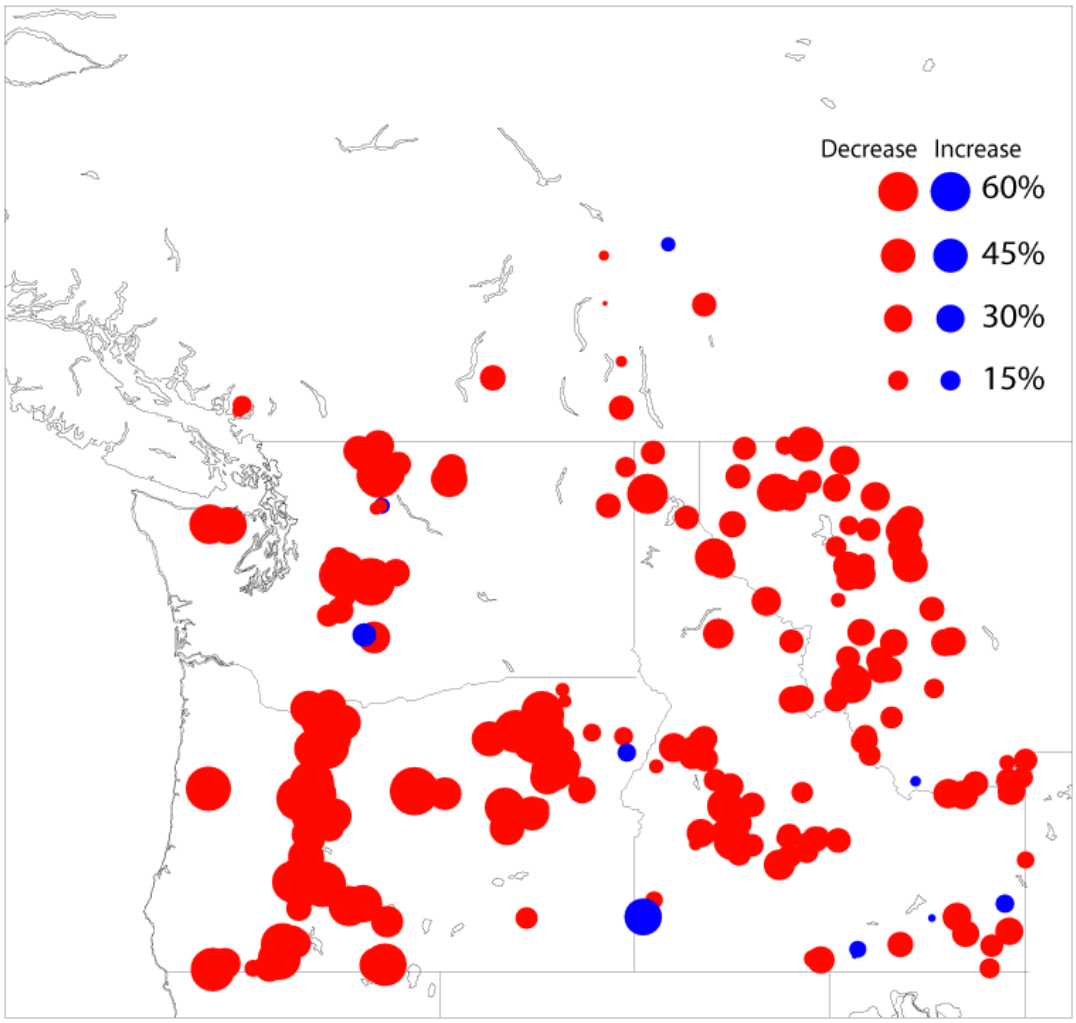
Flooding and Drought

Flooding and drought are two sides of the same coin, as they are both results of increased precipitation falling as rain rather than snow. The Northwest is expected to experience wetter winters as a result of a warming climate. Researchers forecast that precipitation will come in the form of rain rather than snow and will increase stream flows during the winter, which could lead to flood events. However, this also will result in an elevated snow line, decreased snow pack, and earlier melting time, causing an increase in the number of extreme low-flow water days associated with droughts.[13]

Drought

Clark County has already been experiencing extreme low-flow water days (< 5th percentile) from 2000-2009, averaging 15-33 days annually.[14] Snowpack in Washington has decreased since the mid-20th century and is expected to continue to decline.[15] Map 9.1 reflects this trend, representing the change in snow water equivalent over the period from 1950 to 2000. Nearly all monitoring points in the Northwest saw a decrease, which was more pronounced at lower elevations.[16]

Map 9.1. Relative trend in April 1 Snow Water Equivalent, 1950-2000



Source: Climate Impacts Group, University of Washington

Scientists have estimated the impact of climate change on water supply in the Portland metropolitan region.[17] While their analysis was limited to the Bull Run water shed, similar effects can be expected in Clark County. Over the next 30 years, population growth is expected to increase demand for water substantially, and scientists have estimated the increase in water supply needed to accommodate population growth. They also concluded that there are two key ways that climate change will impact water resources in the Northwest: (1) a diminished summer water supply and (2) an increased water demand due to warmer summers. As a result of climate change, water suppliers will have to come up with 50% more water than they would have to supply just to keep up with population growth. In Clark County, there are many homes relying on private wells for drinking water. There is no study indicating how many of them would experience water resource problems during a drought that dropped the level of the aquifers, but it is certainly a possibility that some wells would go dry.

Flooding

Clark County has routinely experienced flood conditions and has established flood zones in conjunction with the Federal Emergency Management Agency (FEMA). These zones are identified in Map 9.2. The Clark County Hazard Identification Vulnerability Analysis (HIVA) report documents an extensive history of flooding and finds that it has high probability of occurring.[18] The analysis notes that there are many homes in the 100-year flood plain, and that many of the owners do not carry flood insurance despite a 26 percent chance of flood damage over the 30-year term of a typical mortgage. The Clark Regional Emergency Services Agency (CRESA) also identifies the increasing risk as more marginal land is developed under pressure from growth, and as more impermeable surface is added to the landscape.

Flood damages in Clark County exceed damages by all other natural hazards.

Clark County Public Health estimates that about 3% of the county population lives within the existing 500-year flood zone, defined as having a .2% chance of flooding in a given year.

The Columbia River Basin is expected to experience an overall 2% increase in stream flow over the next 20 years, but this will vary dramatically by season and location. For example, flows at the Bonneville Dam are expected to increase 35% between November and May, but will decrease 9% between June and August.[19]

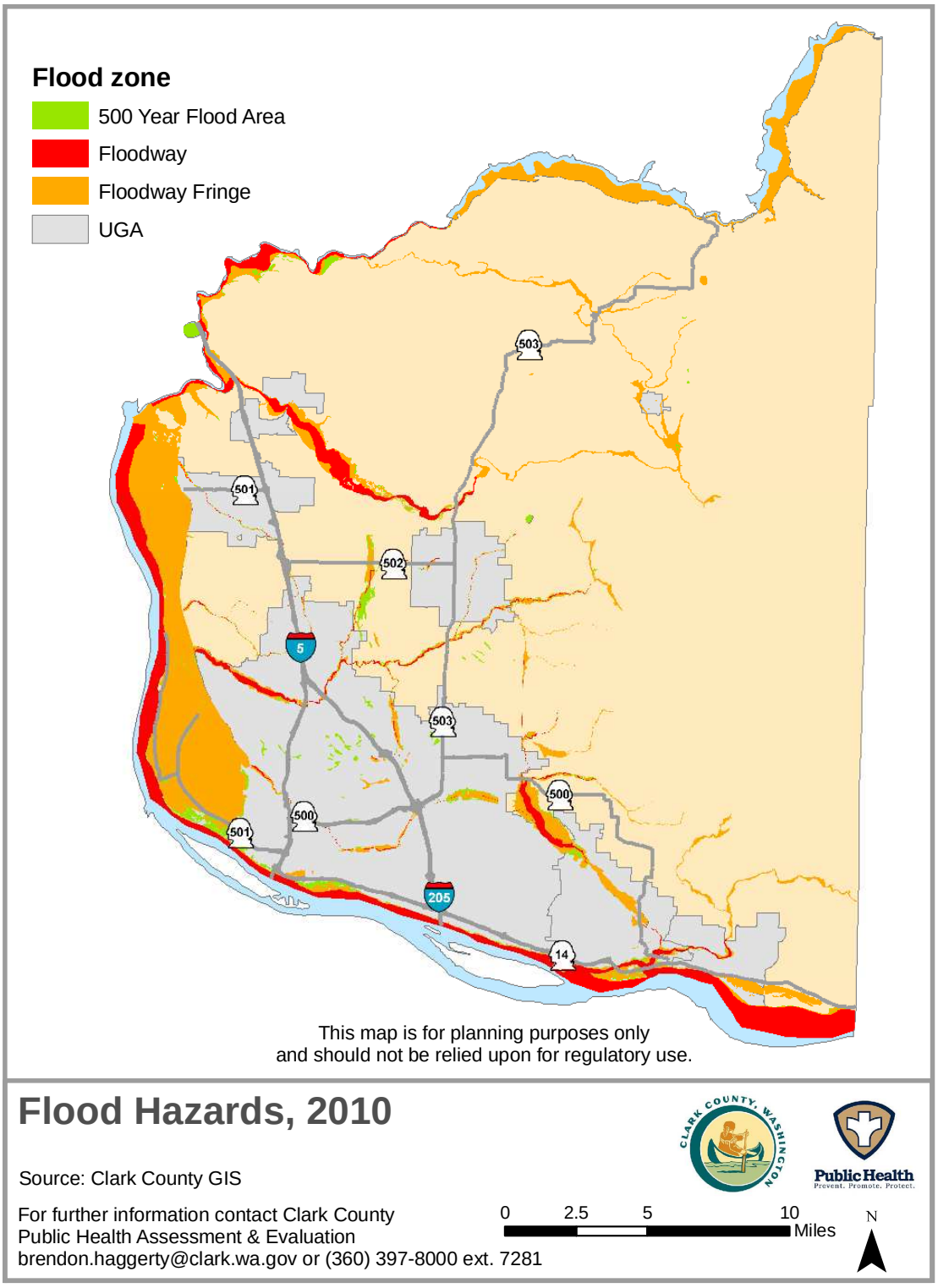
Flood & Drought Response Capacity

University of Washington researchers surveyed the capacity of Northwest resource management organizations to adapt and respond to drought and flood conditions. They found that the region is better prepared to respond to flood conditions as a result of integrated and centralized institutions, but that the fragmented response to droughts is a vulnerability.[20] The Clark County HIVA report finds that all areas of the county are vulnerable to drought, and that there is a high probability of occurrence. The analysis further finds that effects of droughts would be mostly on agriculture and wildlife habitat, and that transportation and telecommunications infrastructure would be unaffected. However, it also states that any prolonged period without precipitation increases the risk for fire, concluding that there is a moderate risk of fire hazard in Clark County.

Shifting Disease Vectors

There are some diseases associated with vectors thought to be able to expand their range in a warming climate. There have been very few, if any cases of these reported within Washington State, and they are extremely rare in Clark County (Table 9.4). The vast majority of cases have been the result of exposure outside of the county or state.[21] For example, although there were 16 cases of lyme disease in Washington in 2009, only 3 were from exposures in-state.

Map 9.2. Flood Zones in Clark County, 2010



Nationally, many are concerned about the potential spread of dengue fever. Clark County is not considered vulnerable to the spread of dengue fever, and there were no mosquito vectors reported for dengue fever during the period 1995-2005.[22] Epidemiologists caution, however, that it is extremely difficult to accurately forecast shifts in disease vectors due to climate change. It is theoretically likely that the risk for many diseases will increase with climate change.[23]

Table 9.4. Human Cases Identified in the Past 5 Years

Disease	Clark County	Washington	NW Region	U.S.
West Nile Virus				
St. Louis Encephalitis				
Eastern Equine Encephalitis				
Western Equine Encephalitis				
La Crosse Encephalitis				
Powassan Virus				
Q Fever				
Lyme Disease				
Dengue Fever				
Hantavirus Pulmonary Syndrome				
Rift Valley Fever				
Rocky Mountain Spotted Fever				
Chikungunya Fever				
Japanese Encephalitis				
Venezuelan Equine Encephalitis				

Injuries

Injuries can be related to extreme weather events such as floods, storms, and droughts. The Clark County HIVA report describes the history of such events in Clark County and their associated current risk

levels (Table 9.5). The reported risk levels are based on a combination of the probability of such an event and the vulnerability in terms of injuries, fatalities, and property damage.

Table 9.5. Weather and Climate-related Hazard Risks in Clark County

Hazard type	Dates of Significant Events in Clark County	Risk level
Drought	1902, 1919, 1921, 1944	Moderate
Flood	Major Flooding: 1933, 1948, 1956, 1972, 1977, 1996 Minor Flooding: 2003, 2006, 2009	High
Wild Fire	1902, 1919, 1929	Moderate
Landslide	1996, 1997	Moderate
Tornado	1951, 1953, 1972, 1974, 1984, 1989, 2008	Low
Storm	Heavy snowfall: 1892, Severe windstorms: 1962, 1981	High

Mental Health Issues

As mentioned in the above discussion of health data, about 10 percent of Clark County adults report poor emotional health.[24] The entire population of Clark County will likely be at greater risk of mental distress associated with health impacts of climate change, and the effects are likely to exacerbate current problems among the population already struggling with mental health issues.

Dislocation and In-Migration

Dislocation and in-migration are difficult to forecast, and in their current status, these issues are not cited as a problem in the state of Washington. In 2009, approximately 192,000 people moved to Washington from elsewhere within the US.[25] Of all domestic migration to Washington, the most common origins were California (22%), Oregon (14%), Texas (5.6%), Arizona (4.9%), Idaho (4.2%), and Florida (3.5%). Of these, the states that do not share borders with Washington are also states with among the highest average annual temperatures from 1971-2000, although the extent to which climate was a factor in this migration is unknown.[26] In consideration of this pattern, it is reasonable to expect

that in-migration will increase as climate change impacts these regions of the country that have higher average temperatures.

Exacerbating Trends

Population Growth

Clark County has grown very rapidly due to in-migration. Between 2000 and 2010, the county added over 80,000 residents, growing 23% over the decade.[27] Population growth within Clark County accounted for about 10% of the total statewide growth during the same time period, despite accounting for only 6% of the population.

Increasing Food Insecurity

Measures to improve community food security in Clark County have been increasing in recent years. The expansion of community gardening has contributed to this trend, as has the increase in the number of farms in Clark County from 1,596 to 2,101 between 2001 and 2007.[28] These are positive signs, but there are threatening trends that jeopardize community food security as well. The total acreage devoted to crop land decreased by 26% over the same time period, the value of land doubled from 1997 to 2007.[29] More importantly, of the $807 million Clark County residents spent on food in 2007, nearly 90% of it was imported from outside the county.[30]

Declining Oil Reserves

Clark County is heavily dependent on petroleum for transportation. With approximately 79% of workers commuting alone by automobile, the county has developed in a pattern that reinforces automobile travel and discourages modes that are less dependent on oil such as walking, bicycling, and transit.[31] There is a lack of alternative fuel infrastructure such as fueling stations for biodiesel or electrical

charging stations. The first charging station was installed by Clark Public Utilities at their Vancouver headquarters in 2011, and an additional station is anticipated at Gee Creek as part of a federal project to provide charging stations along Interstate 5. Furthermore, whereas electric vehicles and alternative fuel vehicles offer some insulation from rapid fluctuations in oil prices, they comprise a very small portion of the overall fleet in Clark County. This leaves residents relatively vulnerable to increases in oil prices.

Economic Impacts

The economic impacts discussed in the literature review – higher oil and food prices – already affect Clark County residents and will continue to do so. Recent food price increases and oil price fluctuations have impacted Clark County just as they have impacted other areas. In a global system of food and fuel distribution, it is difficult if to shield any population from negative impacts.

Disparities

Climate change will affect everyone, but some groups are better equipped to cope with challenges that will be experienced as the climate changes.

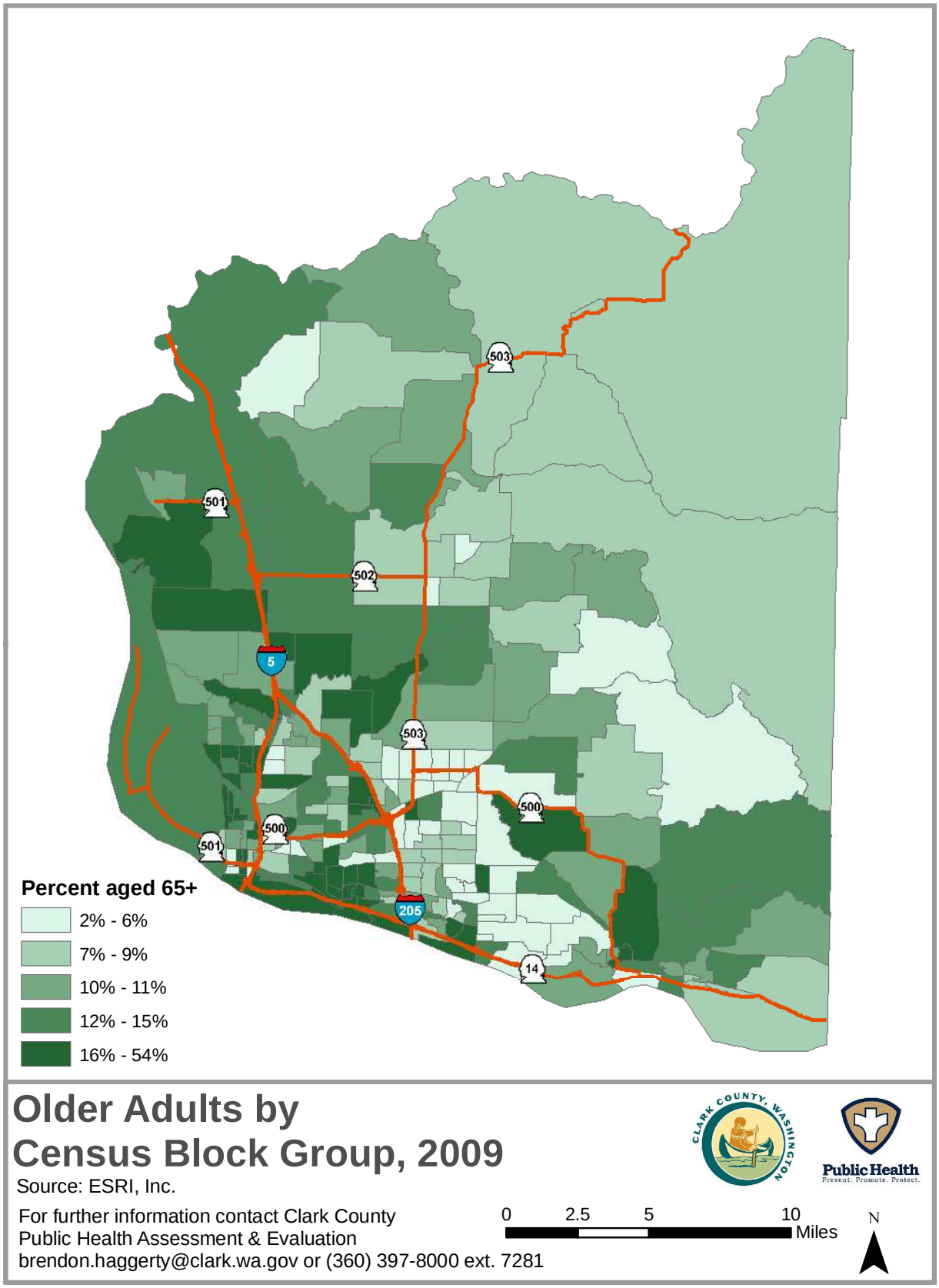
Socioeconomic Status (SES)

Fewer resources in general mean fewer resources to deal with problems arising as a result of climate change. The ability of the low SES population in Clark County to prepare for, react to, and recover from the climate change impacts on health is at a lower level than high SES populations. As described in other sections, about 11% of Clark County residents live in poverty.[32]

Age

Older adults are disproportionately affected by extreme heat events. In Clark County, approximately 12 percent of the population is over the age of 65, and is somewhat unevenly distributed throughout the county. Map 9.3 displays the percent of the population of each census block group that is age 65 or older. Block groups bordering the Columbia River and those in the western portion of the county have a higher percentage of older adults. In contrast, areas of central and east Vancouver have noticeably low percentages of older adults. Forecasts by UW climate scientists indicate that all residents face a heightened risk of mortality during extreme heat events, especially those over age 64.[33]

Map 9.3. Older Adults by Census Block Group, 2009



Race and Ethnicity

Race and ethnicity themselves do not exacerbate any of the climate change impacts described above. Minority populations in Clark County will be disproportionately affected only insofar as race and ethnicity correlate with lower SES. In some respects, these populations are better prepared to endure some climate change impacts, such as higher energy costs, as they currently occupy some of the densest neighborhoods in the county. In their study of impacts in Clark County, the UW Climate Impacts Group found that there are not disproportionate impacts on racial and ethnic minorities.

Table 9.6 summarizes the research literature and current conditions in Clark County.

Table 9.6. Literature Findings Compared to Current Conditions

Finding	Current Conditions	Level of Concern
Extreme heat days are the most prominent cause of weather-related human mortality in the United States.	Locally there has been a 10% greater risk of non-traumatic death on an extreme heat day.	High
Particulate matter (PM) particulates are associated with an increased risk of cancer and a variety of health effects, including respiratory diseases and increased mortality.	From 2004 to 2008, the hospitalization rate for asthma in Clark County was 63.2 per 100,000 population. From 1998 to 2008, there were zero days with unhealthy air quality in Clark County, and an average of 1.9 days that were unhealthy for sensitive populations.	Medium
In the Pacific Northwest, warming temperatures will bring an increase in rain in western Washington in the winter, a decrease in snowfall and snowpack in the Cascades, and hotter, drier summers.	Since 1895, the Vancouver area has warmed by about .16 degrees Fahrenheit per decade.	High

Increased temperatures affect many species, including disease vectors.	There have been very few exposures to diseases expected to become more common in Washington, but conditions could become more hospitable to some vectors.	**Low**
Injuries in Washington are expected to increase due to severe weather events.	There is a high risk from flooding and from severe storms in Clark County.	**High**
Climate change and mental health intersect.	10% of adult residents report poor mental health.	**Medium**
Climate change is likely to increase displacement and in-migration.	States with high temperatures are some of the largest contributors to domestic migration to Washington. Additional migration can be expected.	**High**
Climate change will be exacerbated by population growth, food insecurity, declining oil resources, and economic impacts.	Clark County has already been affected by these impacts and will continue to be in the future.	**High**
Because they have the fewest resources for adapting to a changing environment, low SES populations disproportionately suffer the health impacts of climate change.	About 11% of Clark County residents live in poverty.	**High**
Aging, young and medically vulnerable populations will be at higher risk.	12% of Clark County residents are age 65 or older. They face a higher risk of mortality during extreme heat.	**Medium**
Racial and ethnic minorities disproportionately experience climate change impacts.	Researchers found no significant differences in excess mortality from extreme heat in Clark County by race or ethnicity.	**Low**
Health risks may vary by where people live or work.	About 16% of the county population lives in rural areas. About 3% of the population lives within the 500-year flood zone.	**Medium**

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