9. Human Dimensions of Climate Change: Public Knowledge, Attitudes, and Barriers to Change; Impacts on Cultural and Built Environment; and Potential Public Health Impacts

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Summary and Knowledge Gaps

To date very little research has been conducted explicitly with Oregon citizens regarding their understanding or attitudes about climate change. In this chapter we discuss results of four recent studies (all completed within the last 18 months) in the context of a behavioral change model that suggests that while individuals and groups need to know something about climate change to make appropriate behavioral changes—to either mitigate greenhouse gas emissions or adapt to changing climate—they also need to believe changing their behavior is important and worthwhile, and any barriers to behavioral change must be identified and addressed.

Two of the studies examine how different groups (private and public sector professionals along the Oregon coast and County Health Department professionals) understand climate change and how it affects their professional responsibilities and obligations. In general, the studies find a widespread acceptance of changing climate, although rural County Health professionals are less likely than urban professionals to accept climate change. And, in both contexts all respondents believe they have the capacity and expertise to address the most pressing impacts of climate change if barriers are removed including funding, policy changes, and management support. The other two studies surveyed members of the general public to characterize attitudes toward climate change, finding that many respondents identified climate change as an important issue facing individuals, organizations, and government agencies. The national American Values Survey also suggests a substantial portion of the population (36% nationally) is currently involved in activities directed at mitigating or adapting to climate change. While Oregonians participated in this national survey, we are unable to isolate the Oregon responses; however, a follow-up focus group was conducted in Oregon to validate the national responses. We should use the results of this survey carefully, although it does support findings of research focused only on Oregonians.

These initial and small-scale studies suggest that Oregonians know something about climate change and many are likely to perceive it as a problem although they may not know all the scientific details. There are cognitive and perceptual barriers needing to be addressed if we expect individuals or groups to change behaviors for either mitigating or adapting to climate

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change, although there appears to be general acceptance of, and desire for, government policies to direct such behavioral change.

Recent projects conducted by the Climate Leadership Initiative (CLI) examined the impacts of climate change on cultural and tribal resources, and the built environment more generally. While a lack of understanding and awareness persists about Oregon tribes' vulnerability and capacity to adapt to current and projected climate change, dependency on natural resources, confinement to small portions of reservation land, and existing stressors will likely increase their vulnerability to climate change impacts (CLI and NCCSP 2010).

Projected climate changes in precipitation rates and temperatures are likely to threaten the integrity of the built environment, including buildings, roads, highways and railroads, water and sewage systems, and energy facilities throughout Oregon (CLI 2008, 2010). Direct costs will result from flood events and anticipated increases in wildfire intensity and frequency due to climate change, while indirect costs are likely to be many times larger and will result from more rapid depreciation of property from higher temperatures, more intense storms and other climate stressors (CLI and NCCSP 2008). The full extent of impacts on cultural and built environments remains to be assessed in Oregon.

Finally, climate change is likely to have an impact on public health issues in Oregon including the spread of communicable diseases as well as an increase in water-, food-, and air-borne infections. Predicted average increases in summer temperatures will make heat waves a greater likelihood, causing heat-related morbidity and mortality, especially among vulnerable populations, such as the elderly, low income populations, pregnant women and those who work in outdoor occupations. Indeed, an increase in injuries and cases of carbon monoxide poisoning (from using gas-powered generators) has been reported as a result of the recent winter storms and subsequent flooding in Oregon. Increasing temperatures in Oregon could raise the threat of vector-borne diseases and emerging infections. Respiratory insults, especially among persons with pre-existing lung health problems would be exacerbated by exposure to smoke from forest fires, as well as from the projected increases in air pollution levels in our region. Air pollution and increases in pollen counts (and a prolonged pollen producing season) may increase cases of allergies, asthma, and other respiratory conditions among susceptible populations.

Additional research is needed to set baselines in order to monitor changes over time to understand more fully: (1) how a wide range of Oregonians who are likely to be affected by climate change due to the place they live, the job they hold, or the organization they work for, experience climate change impacts; (2) the acceptability of specific policy and behavioral changes to a wide range of Oregonians; and (3) the barriers faced by individuals, groups, and organizations, including state agencies, as they start to respond to the observed impacts of climate change in Oregon.While the studies reported in this chapter focus primarily on individual understanding and response to climate change, we have no current research regarding organizational or institutional capacity for carrying out any policy or operational changes required to adapt to a changing climate in Oregon. The Oregon Public Health Department has an ongoing tracking and monitoring program for most of the infectious and communicable diseases likely to be affected by climate change. The best means of fending off

any changes for the worse due to climate change are similar to those already in place: ensuring that changes in disease patterns can be can detected, investigating as needed, and mounting an appropriate public health response as soon as possible.

9.1 Introduction

This chapter examines recent research exploring what is known about how Oregonians perceive the issue of climate change and reviews a small number of projects that have attempted to assess and characterize the climate change impacts on cultural and built environments, including tribal resources. Finally, we briefly describe the mechanisms and potential effects of climate change on public health. References and additional resources are included at the end of the chapter.

To date, only a limited amount of social science research has focused on understanding public views of climate change in Oregon; and, of the four recent studies discussed briefly below, one is a national study from which we are unable to extract Oregon-specific results although it does shed some light on general knowledge and perceptions of climate change among the public. There has been extensive research in social science, however, in understanding what motivates behavioral change. A simplification of one such model, the theory of planned behavior (Ajzen, 1991), proposes that in addition to knowledge about a specific phenomena, individuals' values, as well as perceived and real barriers, all contribute to any decision to take action. This suggests that effective climate policies aimed at changing behaviors need to be based not only on climate knowledge, but also address the range of attitudes and values people hold about climate change, and any real and perceived constraints on their behavior.

9.2 Public Knowledge and Perceptions of Climate Change

9.2.1 Oregon Coast Professionals

In a study conducted in 2008 by Oregon Sea Grant (Borberg et al., 2009), 300 Oregon coast professionals from both the private (e.g., fishing, tourism including hotel and charter services) and public (e.g., local government, watershed councils) sectors were surveyed using an internet-based questionnaire. The findings suggest these respondents are highly concerned about a range of climate change effects, and feel responsible for mitigating and adapting to impacts. They also report that they generally feel that they do not have enough information about climate change to do their jobs effectively (see Table 9.1). Respondents were also asked a series of questions about who is responsible for taking both mitigating and adaptive action in response to climate change. As displayed in Table 9.2, three-quarters or more of the respondents believe that both individuals and government agencies need to take action on climate change issues. There is a generally wide-spread sense of both individual and collective agency—that we can and should do something to mitigate climate changing activities and adapt to climate changes as they occur. However, climate change information needs were found to be high, with coastal professionals having low amounts of information on topics that they consider important for the performance of their job (Table 9.1). In addition, this study provides some insight into

perceived or actual barriers to taking action to adapt to climate change. In general, respondents agreed that they would be willing to take action to respond to climate change if they had information that applied directly to their responsibilities, new funding, and a sense of local urgency.

Table 9.1: Importance of Climate Change Issues to Oregon Coastal Professionals

Important Issue (n)	Climate Change Topic	Enough Information (n)
84% (179)	Changes in flood elevation, shoreline erosion, and beach width	7% (138)
79% (168)	Effects of sea level rise on existing shoreline protective structures	7% (148)
78% (166)	Climate change effects on community infrastructure: water systems, sewer, streets, bridges, and public buildings	4% (161)
78% (165)	Changes in ocean conditions that may affect Oregon's marine ecosystems, ocean productivity, or marine species composition	7% (132)
77% (163)	Updates on latest climate change scientific data and how the Oregon coast may be affected	5% (141)
76% (162)	Changes in rainfall, which may increase landfall	7% (147)
76% (164)	Climate change effects on coastal weather	7% (127)
74% (157)	Changes in frequency and intensity of storms and the potential effect on building design standards	5% (150)
74% (160)	Sea level rise predictions	14% (111)
71% (151)	Location-specific effects of climate change	4% (163)
68% (151)	Projected economic costs and benefits of climate change	4% (164)
66% (144)	Climate change impacts on energy resources	5% (155)
66% (139)	Changes in rainfall, which might alter ocean or bay salinity and other aspects of estuarine habitat	5% (154)
65% (137)	Changes in climate, which may introduce new diseases and pests to the area	3% (172)

Source: Borberg et al., 2009.

This study is limited by its convenience sample that is not representative of any population. We can use the results to deepen our understanding of public perceptions but cannot use the results to make predictions of other populations' perceptions or understanding.

Table 9.2: Individual and Government Responsibility for Climate Change Response in Oregon

Statement	Agree or Strongly Agree (n)
It's important for individuals to prepare for the effects of climate change that are predicted to occur in Oregon by reducing local vulnerability.	80% (210)
It's important for individuals to take immediate steps to reduce the apparent causes of global climate change.	78% (209)
It's important for governments to prepare for the effects of climate change that are predicted to occur in Oregon by reducing local vulnerability.	77% (205)
It's important for governments to take immediate steps to reduce the apparent causes of global climate change.	75% (200)

Source: Borberg et al., 2009.

9.2.2 General Public

In a second study conducted by OSU and other researchers (Pierce et al., 2010), a random sample mail survey of more than 1500 Oregon households asked respondents about the role of renewable energy in the face of climate change. However, in one question respondents also revealed general attitudes about climate change (see Table 3). As shown below, about one-quarter of the respondents do not perceive climate change as a serious problem (and do not see the need for new renewable energy policies) although almost two-thirds (63.5%) perceive climate change as a moderate or serious problem requiring policy changes regarding renewable energy. While this study is mostly concerned about respondents' knowledge of renewable energy sources, it does reveal something about their general attitudes toward climate change as at least a moderate problem to be addressed through new policy efforts.

This study supports the idea that increasing awareness and knowledge of complex issues can lead to enhanced public support for policy efforts to mitigate climate change (as through the use of renewal energy technology in this study). And, because the individual and collective activities of citizens contribute to climate change, it's important to continue exploring the strength of the link between policy-relevant knowledge and support for specific policy decisions. In addition, strong support of the New Environmental Paradigm (NEP)—a cultural rather than knowledge variable—also contributes to preferences for policy actions. Van Liere and Dunlap's NEP indicator (see Dunlap et al., 2007) contained a subset of five of the twelve items found in the original inventory and has been found to generate results virtually identical to those of the twelve-item version. The items are as follows: (1) The balance of nature is very delicate and easily upset by human activities; (2) There are no limits to growth for nations like the United States; (3) Plants and animals do not exist primarily for human use; (4) Modifying the environment for human use seldom causes serious problems; (5) Humankind was created to rule over the rest of nature. A Likert-type response format was provided for each item, taking the following format: "strongly agree," "agree," "neutral," "disagree," and "strongly disagree." A pro-NEP position consists of agreement on the first three items, and disagreement on the last

two items.

These findings suggest that while it is important for citizens to understand climate change (and related policy activities), understanding and addressing citizens' values is critical to the development of public support for such policy actions. Again, this study does not provide information about any perceived barriers to changing individual behaviors, but there does seem to be a general acceptance among respondents that government policy is needed to move forward on both mitigation and adaptation efforts as represented by preferences for renewable energy policies.

Table 9.3: General Attitudes of Oregon Citizens Regarding Climate Change and Renewable Energy

Recently there has been much discussion about climate change and global warming due to years of human use of fossil fuels such as petroleum and coal. Some have called for the development of renewable energy sources—such as wind, solar, wave and geothermal—to reduce our reliance on fossil fuels. In general, which of the following views best describes your opinion in this area?

Statement	% respondents agreeing
1. Do not know	1.6%
2. Climate change is not a problem; existing energy policies should be maintained.	25.6%
3. Climate change is a minor problem; only minor energy policy changes are needed to encourage the development of renewable energy sources.	9.4%
4. Climate change is a moderate problem; moderate energy policy changes are needed to encourage the development of renewable energy sources.	30.3%
5. Climate change is a serious problem; significant energy policy changes are needed to encourage the development of renewable energy sources.	33.2%
	N=1,480

Source: Pierce et al., 2010.

9.2.3 County Health Departments

The Climate Leadership Initiative (CLI) at the University of Oregon recently partnered with The Oregon Coalition of Local Health Officials, Environmental Health Committee to conduct a survey of public health care provider attitudes, practices, and preparedness for the health effects of climate change (Vynne and Doppelt, 2009). They received responses from 25 of 35 County Health Departments in Oregon. While 88% of respondents described climate change as a serious

or very serious problem, only about 40% of rural county representatives reported climate change as a serious problem. When asked whether their department is doing anything to change procedures or policies to reduce contributions to climate change, 53% reported changes in their department, primarily recycling programs (100%), energy conservation (46%), and purchasing practices (46%).

Only about 16% of respondents report that their department was doing anything to address potential health effects related to climate change although more than half of the departments report discussions have begun about potential human health effects. Among the more common concerns about human health impacts are vector-borne diseases, drought, forest fires, water quality, and health care service disruptions during climate-related emergencies (e.g., floods, fires, etc.).

Respondents were asked directly why they weren't planning for climate change and they reported that climate change related impacts were not a priority and other concerns are more critical; there is a general lack of awareness and/or interest by County Commissioners, clients, management, and staff; counties haven't seen impacts of climate change; and, not surprising, most (87%) report a lack of funding to address these types of concerns. This study also suggests County Health Departments' perceptions of their own capacity (generally low) to respond to impacts of climate change (see Table 9.4). More surprising, is the general lack of faith that the Oregon State Department of Health and Human Services or the federal government has the knowledge, expertise, and capacity to address these concerns.

Table 9.4: Oregon County Health Department Representative Perceptions of Capacity for Dealing with Human Health Impacts of Climate Change (Source: Vynne and Doppelt, 2009.)

	Strongly Agree	Agree	Disagree	Strongly Disagree	Don't know
My *health department* has the **knowledge and expertise** needed to develop strategies for dealing with potential public health impacts of climate change in my region.	13%	47%	41%	0	0
My *health department* has the **capacity** needed to develop strategies for dealing with potential public health impacts of climate change in my region	50%	38%	13%	0	0
The health care *delivery system* in my county has the **knowledge and expertise** …	22%	34%	25%	0	19%
The health care *delivery system* in my county has the **capacity** …	34%	44%	6%	0	16%
The *Oregon Health Department* has the **knowledge and expertise** …	3%	9%	41%	3%	44%
The *Oregon Health Department* has the **capacity…**	3%	32%	16%	3%	45%

The *federal government* has the **knowledge and expertise** …	3%	13%	41%	13%	31%
The *federal government* has the **capacity** …	6%	19%	22%	9%	44%

This study suggests to some extent how a specific set of Oregon professionals—County Health Care managers—frame climate change as a potentially serious problem for their constituents (and themselves). County Health Care managers report a limited set of climate-related health impacts that they consider potential future issues although they are not now perceived as such due to a set of real (and perceived) barriers that include funding, interest and attention by others, and a full plate of issues they already are not staffed to deal with. While County Health Departments view themselves with the capacity, knowledge, and expertise to handle future health impacts of climate change, they don't receive much support from state or federal agencies.

9.2.4 American Values Survey

Finally, the Climate Leadership Initiative (CLI) at the University of Oregon participated in collecting and analyzing national data for the American Values Survey (AVS) through the Social Capital Project (SCP) with a special emphasis on Pacific Northwest applications (Pike et al., 2008). More than 2000 adults participated in the project, answering a series of 800 questions about climate change and other topics. The national findings were validated through focus groups in Oregon and elsewhere. The AVS segments the respondents into ten distinct groups depending on how they think about the environment and their attitude toward its protection (see Table 5). The SCP "mapped" the presence of the different attitude segments in different communities in Oregon (and Washington). For more information and graphics visit the Social Capital Project website at www.thesocialcapitalproject.org/The-Social-Capital-Project.

In addition to characterizing the worldviews and perspectives of respondents, the AVS also characterized several interconnected perceptual barriers to changing behavior: (1) a sense that individual behavior is unlikely to make much of a difference; (2) it's expensive to be "green"; (3) the complexity of climate change makes it difficult to determine direct cause and effect relationships; and (4) the magnitude of the problems is overwhelming so attention is turned to more local and tractable concerns.

If Oregonians are anything like the general population described in the AVS, about 36% of the population is likely to be engaged in or willing to be engaged in environmental activities. And, another proportion who consider "global warming" to be an important issue may also be mobilized through effective outreach. This study also identifies several perceptual barriers citizens have to changing individual behaviors and/or becoming engaged in collective activities although it doesn't address other types of barriers (e.g., infrastructure, institutional practices, etc.).

Table 9.5: Importance of "Global Warming" to Populations with Different World Views

Segment	Percentage of Respondents	Percent ranking "Global Warming" as one of the most important issues
Greenest Americans: Everything is connected, and our daily actions have an impact on the environment.	9%	68%
Idealists: Green lifestyles are part of a new way of being.	3%	51%
Caretakers: Healthy families need a healthy environment.	24%	44%
Traditionalists: Religion and morality dictate actions in a world where humans are superior to nature.	20%	22%
Driven Independents: Protecting the earth is fine as long as it doesn't get in the way of success	7%	29%
Murky Middles: Indifferent to most everything, including the environment.	17%	34%
Fatalists: Getting material and status needs met on a daily basis trumps worries about the planet.	5%	46%
Materialists: Little can be done to protect the environment, so why not get a piece of the pie.	7%	25%
Cruel Worlders: Resentment and isolation leave no room for environmental concerns.	6%	29%
Ungreens: Environmental degradation and pollution are inevitable parts of America's prosperity.	3%	13%

Source: Pike et al., 2008.

9.3 Impacts on Cultural and Built Environments

In several recent projects, the Climate Leadership Initiative (CLI) and partners (e.g., CLI 2010; CLI and NCCSP 2007, 2009, 2010) looked at the impact of climate change on a range of factors including cultural resources for Oregon tribes and the built environment. A brief summary of their findings is provided below and can also be reviewed on their website at http://

climlead.uoregon.edu/.

9.3.1 Projected Impacts of Climate Change on Tribal and Cultural Resources

While a lack of understanding and awareness persists about Oregon tribes' vulnerability to climate change and their capacity to adapt to current and projected climate change (MacKendrick 2009), dependency on natural resources, confinement to small portions of reservation land, and existing stressors will likely increase their vulnerability to climate change impacts (Houser et al., 2001; Tsosie, 2007; Nilsson, 2008; CLI and NCCSP, 2010). Climate change may lead to loss of native species and fundamental shifts in ecosystems that have guided and formed the culture of many tribal communities, linking future generations and their ancestors (CLI and NCCSP, 2010). In addition, the loss of culturally important species and ecosystems is likely to lead to economic and functionality losses. For example, seasonal cues such as blooming plants and eel runs may no longer indicate when to collect important resources (CLI and NCCSP, 2010); forest species composition may shift and reduce tribal timber yields; fishing and oyster harvests may continue declining (MacKendrick, 2009); and species important for subsistence and culture could be entirely lost such as salmon, lamprey, trout, suckers, wocus (aquatic plant), shellfish, acorns, deer, elk, bear grass, Oregon blackberry and salmonberry (MacKendrick, 2009; CLI and NCCSP, 2010). Increases in wildfires and smoke could negatively affect the health of tribal members by causing increased respiratory disease and the need for greater access to hospitals and resources for care. Oregon's coastal tribes risk land inundation and loss from sea-level rise, increased wave height and intensity, and beach erosion (MacKendrick, 2009). Additional coastal impacts could damage burial sites, tribal infrastructure, and reduce income generation from tribal business enterprises (MacKendrick, 2009; CLI and NCCSP, 2010).

As many tribes work to rebuild their communities, governments, and cultures following decades of uncertain federal Indian policy, there is concern among tribes that climate change may negatively impact the ability to restore communities as well as the ability of the federal government to oblige by treaty agreements such as water allocation (USGCRP, 2003; Houser et al., 2001; MacKendrick, 2009; CLI and NCCSP, 2010).

In addition to impacts to Oregon's tribes, many areas and species of cultural importance to all Oregonians are likely to be impacted. For instance, glacier and snow pack loss from two important Oregon icons, Mount Hood and Crater Lake National Park, will change forest and species composition in those regions. Annually, Mount Hood attracts four million visitors (New World Encyclopedia, 2010) while Crater Lake National Park attracts 500,000 visitors (NPS, 2010). While no specific studies have been done on the impacts of climate change to Oregon's historical architecture and landmarks, assessments from King County, Washington, and Europe demonstrate that extreme events (heat, precipitation, wind), flooding, fire, snow pack melt, pest infestations, and sea-level rise are likely to have negative impacts on buildings and landmarks of historical and cultural importance (Snover et al., 2007; Sabbioni et al., 2006) and are discussed in more detail in the next section.

9.3.2 Projected Impacts of Climate Change on the Built Environment

Projected climate change impacts are likely to threaten the integrity of the built environment, including buildings, roads, highways and railroads, water and sewage systems, and energy facilities throughout Oregon (CLI, 2008, 2010). Projected increases in long-term, annual, and seasonal variability in precipitation and snow pack loss is likely to result in less dependable fresh water supplies, presenting a significant challenge for water managers and water infrastructure. Demand for dams, reservoirs, and wells is likely to intensify in response to declining groundwater and increasing seasonal flow variability as well as increase the pressure on the already limited off-stream water storage, particularly in the summer (CLI and NCCSP 2008, 2010). Increased runoff, intense storm events, and increased sedimentation may overwhelm drinking water and wastewater treatment facilities, which could lead to increased municipal water pollution and higher treatment costs. Many drinking water systems in Oregon, especially parts of Portland, are old and already degraded; failing pipes caused by more extreme flooding could lead to mixing of municipal water and sewage (CLI, 2010). The availability of fresh water is critical for agriculture and municipal purposes in much of Oregon and many areas of the state are already over-appropriated (CLI and NCCSP, 2008, 2009, 2010).

Electricity demand may increase with rising population; growing demand for home cooling, refrigeration, water (which requires energy to transport); and ever increasing production and purchasing of small electronics. At the same time, efficiency and reliability of power transmission and delivery is likely to decline as power lines are stressed by higher ambient temperatures, increased risk from wildfires, and reduced reliability of hydroelectric power with reduced stream-flow and increased sediment from wildfires, particularly along the Columbia and McKenzie Rivers (CLI and NCCSP 2008, 2009, 2010; CLI, 2010). As a result, more brownouts and blackouts are possible. Expansion of biomass-based energy production may also be limited due to loss of supply from forests and agriculture from increased wildfire (CLI and NCCSP, 2009).

Rail service may become more competitive and experience an increase in demand as fuel prices rise (CLI and NCCSP, 2010). In addition, both rural and urban areas in the Pacific Northwest are likely to receive an increase in population of people who are displaced due to climate-related events—a trend that is likely to accelerate the demand for local and regional mass transit, including rail, as well as increase congestion and deterioration of road systems. Severe flooding caused by storm and rain events as well as increased forest fires are likely to impact roads and impair movement of persons and equipment during storm emergencies. The most susceptible roads will be those bordering the coast, rivers and streams, running through valley bottomlands, and those in the vicinity of unstable slopes (e.g. highway s101, 6, 26, and 30 (CLI, 2010)). Maintenance of rural county roads may suffer as funding priorities shift to meet changing demands on local governments and the needs of growing urban areas (CLI and NCCSP, 2008). Air transport may also be affected by increased storms and smoke intrusion from wildfires (CLI and NCCSP, 2008). In addition, many bridges, culverts, and bike paths throughout the state will be more susceptible to flooding (CLI, 2010).

Infrastructure in floodplains and the urban/wildland interface may be lost to flooding and forest fire as a high number of homes are built in forested areas next to public lands

(Headwaters Economics, 2007). Direct costs will result from flood events and anticipated increases in wildfire intensity and frequency due to climate change, while indirect costs are likely to be many times larger resulting from more rapid depreciation of property from higher temperatures, more intense storms and other climate stresses (CLI and NCCSP, 2008).

9.4 Mechanisms and Potential Effects of Changes in Climate on Human Health in Oregon

Climate change poses risks for increased injuries, illnesses and deaths from both direct and indirect effects (Ebi et al, 2008). Incidents of extreme weather (such as floods, droughts, severe storms, heat waves and fires) can directly affect human health as well as cause serious environmental and economic impacts. Indirect impacts can occur when climate change alters or disrupts natural systems. This can give rise to the spread or emergence of vector-, water-, and food-borne diseases in areas where they either have not existed, or where their presence may have been limited.

Predicted average increases in summer temperatures will make heat waves a greater likelihood, causing heat-related morbidity and mortality, especially among vulnerable populations, such as the elderly, low income populations, pregnant women and those who work in outdoor occupations. An increase in injuries and cases of carbon monoxide poisoning (from using gas-powered generators) has been reported as a result of recent winter storms and subsequent flooding in Oregon. Increasing temperatures in Oregon could raise the threat of vector-borne diseases and emerging infections. Respiratory insults, especially among persons with pre-existing lung health problems would be exacerbated by exposure to smoke from wild land and forest fires, as well as from the projected increases in air pollution levels in our region. Air pollution and increases in pollen counts (and a prolonged pollen producing season) may increase cases of allergies, asthma and other respiratory conditions among susceptible populations.

This section of the chapter reviews the latest research and efforts in Oregon to address public health issues related to climate change. There are many additional diseases that may be climate change sensitive and affect Oregon residents, such as malaria, Chagas disease,and tuberculosis among others. At this time, there is no research that describes what those impacts are likely to be in Oregon. Increased surveillance for changes in the patterns and distribution of the diseases described in this chapter will yield additional data over time. A summary of public health issues, prepared by the CLI, is also available online (http://climlead.uoregon.edu/node/168).

9.4.1. Communicable Diseases

Many vector-borne pathogens are sensitive to temperature. West Nile virus (WNv) infection, for example, already exhibits strong seasonality with peak transmission in late summer in the Northwest; longer summers with higher temperatures may substantially increase the incidence of WNv fever and encephalitis in Oregonians. Oysters harvested in Oregon, Washington, and British Columbia during summer months have caused outbreaks of *V. parahaemolyticus* infection (Wechsler et al., 1998); but in 2004, an outbreak aboard a cruise ship implicated oysters

harvested from Prince William Sound, Alaska—1,000 km north of the pathogen's previously recognized northern outpost (McLaughlin et al., 2005). Warming waters in the Pacific Northwest could lead to higher concentrations of *Vibrio spp.* in shellfish beds and more prolonged periods of summer risk. The predicted increasing rain in the Northwest, with flooding effects multiplied by rain-on-snow events in the Cascades, may lead to the washing of *Cryptosporidium parvum*, a protozoan agent of diarrhea in cattle, along with other animal intestinal indwellers, into drinking water reservoirs (National Research Council, 2001).

The fungus *Cryptococcus neoformans* lives in dead or rotting trees and is a notorious cause of meningitis in patients with organ transplants or AIDS; but one variety has shown a particular ability to infect even healthy hosts (Speed and Dunt, 1995). This variety, known as *gattii*, was thought to have been restricted to tropical and subtropical areas; however, the pathogen emerged on the east coast of Vancouver Island, British Columbia, in 1999, and environmental sampling in a provincial park uncovered an ecological berth among several tree species there including Douglas fir. A novel genotype of *C. gattii*, VGIIc, has recently emerged in Oregon (Brynes et al., 2010) and infections appear to be more virulent and have a more complicated clinical course than the more common *C. neoformans*. Researchers hypothesize the establishment of *C. gattii* in this area may have been due to climatic changes (Kidd et al., 2004).

We cannot predict what the net health effect of climate change will be to Oregon. Given the dynamic interplay among disease reservoirs, vectors, human hosts, and the environment, we can predict that communicable disease patterns will change. The best means of fending off any changes for the worse are similar to those for addressing emerging infectious diseases: ensuring that we can detect changes in disease patterns, investigate as needed and mount an appropriate public health response. To that end, Oregon Public Health Division (OPHD) has made a number of diseases reportable under Oregon Revised Statutes (ORS).
• Chapter 433 (433.001-035) (http://www.leg.state.or.us/ors/433.html), Oregon Administrative Rules (OARS).
• Chapter 333, Division 18 - Health Services (http://arcweb.sos.state.or.us/rules/OARs_300/OAR_333/333_018.html).
• OAR Division 19 - Investigation and control of diseases (http://www.oregon.gov/DHS/ph/acd/oars/div19.shtml)

9.4.2 Waterborne Diseases

Climate directly impacts the incidence of waterborne disease through effects on water temperature and precipitation frequency and intensity (Portier et al., 2010). Waterborne disease are caused by a number of pathogenic microorganisms, biotoxins, and toxic contaminants found in water we use for drinking and food preparation, cleaning, irrigation, recreation, business, and even for cooling.

The range of infectious microorganisms causing waterborne disease include parasites responsible for cryptosporidiosis and giardiasis, bacteria causing legionellosis and cholera, viruses causing viral gastroenteritis, amoebas causing dysentery and amoebic meningoencephalitis, and algae causing neurotoxicity. The effects of climate change are anticipated to increase the frequency and range of waterborne diseases with rising temperatures

and more incidents of flooding as well as from the effects of other severe weather incidents. Oregon Public Health Dept. tracks cases of most waterborne diseases mentioned above as part of required disease reporting by health care providers and hospitals. Algae blooms in coastal marine and fresh water systems are monitored, and alerts are issued to advise people of risks and to reduce exposures.

9.4.3 Cardiovascular Disease and Stroke

Cardiovascular disease is the leading cause of death in the United States, and stroke is the third leading cause of death (CDC, 2009). Many Oregonians are living with some form of these diseases (including high blood pressure, coronary artery disease, heart attack, and abnormal electrical activity in the heart—cardiac dysrhythmias). The range of climate and weather changes can have both a direct or indirect effect on cardiovascular diseases (Portier et al., 2010).

There is evidence that climate and weather conditions have an exacerbating effect on cardiovascular disease and stroke (Portier et al., 2010). Under future climate projections for Oregon, heat and air pollution levels are likely to increase, and thus they may be expected to increase rates of cardiovascular morbidity and mortality. Likewise, decreases in extreme cold temperatures may reduce the risk of cardiovascular morbidity and mortality.

There are gaps in our understanding of the impacts of climate change on cardiovascular disease and additional research is needed to better measure the relationship between climate conditions and impacts on heart disease and stroke. While we can infer that increased ambient temperatures and more frequent episodes of extreme weather associated with climate change will likely have an adverse impact on those who already have cardiovascular disease, we need to focus public health attention on improved surveillance for these diseases to better measure changes in both outcomes of existing disease and the onset of new illness. We especially need to design research and tracking efforts to better understand the possible synergistic effect of long term temperature change, weather variability and stresses associated with displacement and interruptions of medical care due to severe climate change episodes on cardiovascular disease onset and outcomes.

9.4.4 Asthma, Respiratory Allergies, and Airway Diseases

Allergic diseases include asthma, hay fever, rhinitis and atopic dermatitis and all are considered climate-sensitive diseases because a number of environmental factors are known to trigger exacerbations or episodes of illness (Portier et al., 2010). Temperature increases related to climate change are expected to result in earlier flower blooming and a longer season for flower and pollen production. Increased carbon dioxide (CO2) concentrations are expected to affect plant photosynthesis and metabolism, which would increase pollen production through broader plant distribution and extending the duration of pollen production. Rising temperature and CO2 levels may make some aeroallergens more allergenic. Plants like poison oak appear to thrive with increased CO2 levels, and may produce more potent irritant and allergenic oils. Taken together, these factors will likely mean that people with allergies will be exposed to greater pollen levels for a longer blooming season. It is unclear whether more people will become sensitized to pollens as a result of increased exposures. About 5% of the population has

symptoms of allergic reaction when exposed to airborne mold spores.

We know most about people in Oregon who suffer from asthma—a chronic lung disease that causes shortness of breath, coughing, and wheezing, but information about the number and characteristics of people who suffer from allergies and atopic dermatitis is more difficult to assess because these are not reportable conditions in Oregon. Oregon has a higher burden of asthma than the overall U.S. population: 9.9% of Oregon adults and 8.3% of children have asthma. More than 355,000 Oregonians have asthma (Garland, 2009). Asthma symptoms can develop when a person is exposed to triggers such as tobacco smoke, animal fur or feathers, cockroaches, mold or mildew, dust mite feces, and pollen. OPHD tracks hospitalizations for asthma exacerbations and asthma deaths, using hospital discharge and Vital Records data.

We will need to build improved mechanisms for tracking environmental triggers for asthma and respiratory allergies in order to assess whether there is a measurable increase in the frequency and severity of disease exacerbations and an increase in the overall burden among those susceptible. We will also need to work with partners to do research on whether there are changes in the composition and levels of air pollutants and aeroallergens over time.

9.4.5 Food-Borne Disease and Nutrition

Food insecurity and under-nutrition are already a concern for a segment of the Oregon population (Nord et al., 2009). The Intergovernmental Panel on Climate Change Working Group and the U.S. Climate Change Science Program report a likely increase in the spread of multiple food borne pathogens and pests due to climate change (IPCC, 2007; Ebi et al., 2008). Drought, flooding, and other extreme weather incidents can also disrupt the transportation and distribution systems of food during times of crisis. Food borne illness is an ongoing problem in Oregon and the U.S., as indicated in the Communicable Diseases section above.

Oregon PHD is one of nine states that participate in the Food Borne Diseases Active Surveillance Network (FoodNet) program to track food borne illness using surveys of physicians and laboratories, case-control studies, and active case finding of the following pathogens.

- *Campylobacter*
- *Cryptosporidium*
- *Cyclospora*
- *E. coli O157*
- *Listeria*
- *Salmonella*
- *Shigella*
- *Vibrio*
- *YersiniaFT*

Health care providers are required to report any known or suspected common-source outbreaks. OPHD receives hundreds of case reports of food borne illnesses each year, as defined under Oregon Statute and Rule. OPHD tracks the number of cases by condition and actively investigates outbreaks of multiple cases of food borne illness to identify the source and

mechanism of spread in order to stop the outbreak. OPHD's active surveillance and response system is carried out in collaboration with the Portland Health Department and local health departments—and has enabled rapid identification to help stop food-borne outbreaks of both local and national significance. OPHD tracks changes over time to observe patterns of these illnesses by organism. These skills will continue to be applied in preparation for the potential contribution to food-borne illness cases from climate change factors.

9.4.6 Weather-related Morbidity and Mortality

Oregon and the Pacific Northwest experience a variety of extreme weather incidents ranging from severe winter storms and floods to drought and dust storms, often resulting in morbidity and mortality among people living in the impacted regions. Climate change is expected to increase the frequency and intensity of some weather incidents (Portier et al., 2010). The health impacts from extreme weather-related episodes can include both direct impacts such as death, injury, and mental health effects, and indirect impacts such as population displacement, drinking water contamination and waterborne disease outbreaks.

Populations at risk from severe weather incidents include people in most areas of Oregon. For example, flooding threatens people living in valley communities, and dust storms and drought are not uncommon in parts of rural eastern Oregon. Heavy precipitation episodes and flooding can compromise drinking water supplies, disrupt human systems, and displace people living in low-lying areas. Drought, like that currently experienced in the Klamath Basin, can adversely impact agricultural productivity, threaten the livelihoods and economic well-being of affected communities and increase food prices for others. Coastal and nearby inland communities are regularly impacted by severe winter storms. Sea-level rise combined with storm surge incidents are a special threat along the Oregon coast. Climate change related sea-level rise is expected to magnify the threat from storm surges that often accompanies severe weather incidents in coastal areas (CCSP et al., 2008).

9.4.7 Needs for Improved Adaptation Planning and Preparedness

State and local level public health agencies currently track individual and public health impacts associated with many natural disasters and disease outbreaks happening in their jurisdictions. This is accomplished through the Public Health Emergency Preparedness (PHEP) program. Laboratories and clinicians are required to report a number of conditions associated with communicable diseases, contamination of food and water, and illnesses spread by insect vectors. Public health agencies also have the capacity and methods to detect, investigate and respond to a number of chronic conditions and injuries affecting adults and children in Oregon.

Oregon public health agencies do not, however, currently have rapid access to medical information from emergency departments and hospitals that would be needed during emergency situations. Nor does public health currently mandate reporting the range of conditions likely to be seen during natural disasters that may be associated with climate change. These data are needed to improve our ability to accurately and rapidly understand human health impacts from these incidents; to recommend appropriate response and adaptations to emergency situations associated with extreme weather and climate incidents; to develop

culturally appropriate messages that can guide and empower communities to become more resilient; and to evaluate effectiveness of adaptation measures.

State and local public health agencies have made gains in understanding the capabilities needed to expand our tracking, prevention, response and planning efforts to include illness and injury outcomes resulting from weather and climate conditions previously not considered as part of the primary responsibility of public health services. OPHD is working with local health departments to conduct and refine public health hazard vulnerability analyses that will help identify and prioritize risks that communities face.

9.3 Summary and Conclusions

The studies and projects discussed above present different lenses for examining public understanding and reactions to climate change. Although these studies and projects use different approaches, measures, and methods, commonalities are revealed; it is likely many Oregonians perceive climate change as a problem although they may not know the scientific details. There are cognitive and perceptual barriers that need to be addressed if we expect individuals or groups to change behaviors for either mitigating or adapting to climate change, although there appears to be general acceptance of and desire for government efforts that will direct such behavioral change. It may be possible to use existing state assessment and monitoring programs to monitor climate change impacts on cultural resources, built environments, and public health.

We need additional research to set baselines in order to monitor changes over time to understand more fully: (1) how a wide range of Oregonians who are likely to be affected by climate change due to the place they live, the job they hold, or the organization they work for experience climate change impacts; (2) the acceptability of specific policy and behavioral changes to a wide range of Oregonians; and (3) the barriers faced by individuals, groups, and organizations, including state agencies, as they start to respond to the observed impacts of climate change in Oregon.

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