



## AN ABSTRACT OF THE CAPSTONE PROJECT OF

Lily Leitermann for the degree of Master of Natural Resources presented on June 6, 2016.

Title: Eugene Residents Risk Perceptions of Water Scarcity

Abstract approved: \_\_\_\_\_

Lynette de Silva

Potential water scarcity and drought conditions are predicted in and around Eugene, Oregon due to decreased snowpack and subsequent decreased snowmelt in the Western Cascade Mountains. This phenomenon was triggered by a long-term trend of warmer winters scientifically linked to global climate change patterns (Dalton et al. 2013). Numerous stakeholders, ecological processes, and habitats are dependent on the water flow of Willamette Valley Rivers, in Oregon. Snowmelt is crucial for freshwater flows to feed these rivers during the dry summer months. Hierarchies of interrelatedness or coupled human and natural systems (CHANS) are concepts that can be used to understand human-nature relationships in this region. These intricate linkages may compound impacts leading to more severe drought, increased fire risks, water conflicts, and economic decline. Water managers and residents will need to prepare for risks and uncertainty related to future water availability in the region. This case study addresses the questions: “What are Eugene residents’ perceptions of risk related to severe water scarcity linked to climate change?” and “How does this perception of risk impact public participation and support of local sustainable water management strategies?” Qualitative approaches are employed to understand these and other related questions through content analysis of a “Risk Perceptions Survey” and in-depth literature review. This research project could be used to assist water management organizations and residents in creating sustainable solutions to prevent potential social and ecological ramifications. Natural resource managers in this region should consider increasing public outreach and education about water scarcity and preparedness while also improving collaboration and communication with residents. In addition, adaptive and mitigation management styles should be implemented before possible water scarcity. Water regulation agencies should consider the impact of outdated water laws on water use in order to encourage and improve water conservation and wise use.

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Eugene Residents Risk Perceptions of Water Scarcity

by  
Lily Leitermann

A CAPSTONE PROJECT

submitted to

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degree of

Master of Natural Resources

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Master of Natural Resources thesis of Lily Leitermann presented on June 6, 2016

APPROVED:

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Dean of the Graduate School

I understand that my thesis will become part of the permanent collection of Oregon State University libraries. My signature below authorizes release of my thesis to any reader upon request.

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Lily Leitermann, Author

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## I. Introduction:

### Statement of Problem:

Potential severe water scarcity and drought conditions are predicted in and around the City of Eugene, Oregon due to decreased snowpack and subsequent diminished snowmelt in the Western Cascade Mountains (Dalton et al. 2013). This phenomenon is triggered by a long-term trend of warmer winters scientifically linked to global climate change patterns (Dalton et al. 2013). Mountain snowmelt provides crucial freshwater flows to feed this region's rivers during the dry summer months (Dalton et al. 2013). Numerous stakeholders, ecological processes, and habitats are dependent on this snowmelt for surface water flow into rivers, groundwater recharge, and water storage in lakes and reservoirs. The City of Eugene depends on snowmelt to feed river water for hydroelectricity, groundwater recharge, agricultural irrigation, drinking water, municipal services, and recreation. The consequences of altered precipitation patterns and projected water related stresses are wide-ranging. Human and ecological systems are interrelated and the problem of water scarcity and climatic drought is complex.

Hierarchies of interrelatedness or coupled human and natural systems (CHANS) (Liu et al. 2007) are related concepts that can be used to understand human-nature relationships in this region. Expected growth of human populations will impact resource demand for competing needs such as instream water for aquatic habitat, irrigation, junior water users, over-appropriation, municipal water storage, climate change effects, adaptability of the system, and risk of drought-induced fire in the Wildland Urban Interface (WUI). These intricate linkages may compound impacts and lead to increased drought, increased fire risks,

water use conflict, economic decline, and other unforeseen challenges. Water managers and residents will need to prepare for risks and uncertainty related to future water availability in the region (Dalton et al. 2013). This study addresses the following questions, “What are Eugene residents’ perceptions of risk related to severe water scarcity linked to climate change?” and “How does this perception of risk impact public participation and support of local sustainable water management strategies?”

#### Purpose of Study:

Understanding public perceptions of water scarcity is necessary in order to gauge public support and participation with local water management conservation and risk mitigation strategies (Engle 2012). Currently, insufficient research has been conducted concerning Eugene resident’s perceptions of risk associated with water scarcity linked to climate change and resident’s level of support for potential water management strategies. Success in mitigating the impending stressors related to water scarcity depends on public support and stakeholder collaboration. This research study could aid water managers and local natural resource organizations in tailoring strategies to be more inclusive and reaching the public through appropriate and strategic messages. Related literature pertaining to risk perception theory, environmental risk perceptions, and the environmental values of Oregon residents provide a foundation for this study.

When the public perception of risk is misaligned with the reality of actual risks, implementing necessary water resource solutions can be problematic (Engle 2012). If risks are defined and perceived differently by distinct groups and demographics, this may also lead to conflict (Sjöberg 1998), which limits effective action. If a risk is perceived as low probability, groups or individuals may be less willing to accept or support a management

strategy directed to mitigate that risk, whereas the opposite may be true if the risk is perceived to be high. If groups or individuals perceive risks as less likely to personally affect themselves or the things they value, they may be less motivated to support management actions. Groups or individuals may also be influenced by their perceptions of the costs and benefits of actions and how these affect their own interests. In addition, the perception of a risk as low in controllability may inhibit action or support for management decisions (Sjöberg 1998).

Management agencies need to be well-informed on public perceptions of particular risks in order to predict how the public will react to the risk or the risk management policy (i.e., Integrated Water Resources Strategy implementation; Hubbard 2013). Enhanced understanding of how the public perceives a particular risk can create a possible framework mechanism for water management agencies to create communication and outreach strategies (Hubbard 2013), which ensure the public is well informed of the reality of the risk.

#### Regional Context:

Section (A) will provide a brief background of the landscape, climate, and ecology of the regional area that encompasses Eugene near the southern end of the Willamette Valley. These features provide the context to understand contributing factors related to this research topic. Section (B) will provide a background on human geography, with particular emphasis on social, economic and population patterns in the Willamette Valley as they relate to the research problem and the purpose of this study.

#### (A): Landscape, Climate, and Ecology of the Southern Willamette Valley:

Oregon's precipitation is geographically diverse, with some of the rainiest and also most arid locations in the United States. This ranges from over 10 feet of annual rainfall in

the temperate rainforest habitat of the Coast Range, to 8 inches or less in the driest deserts of eastern Oregon (Bastasch 2006). The City of Eugene, within Lane County, is situated in Oregon's southern Willamette Valley close to the confluence of the Willamette and McKenzie Rivers. Eugene lies between the Oregon Coast Range to the near west and the Cascade Mountains to the east. High precipitation in this region results from being on the windward side of the Cascade Mountains where the process of Orographic lifting occurs (refer to Fig 1 below). Orographic lifting involves the movement and lifting of moisture laden air masses over mountains (Bastasch 2006). The Pacific frontal weather systems including El Niño-Southern Oscillation (ENSO) and other Cyclonic patterns contribute to high quantities of rainfall on the Oregon Coast. Moisture laden air masses form offshore in the Pacific Ocean and release precipitation on coastal areas first. As Pacific air masses move east and ascend the Coast Range, the air cools 5 degrees for every 1000 feet of elevation, releasing heavy precipitation. The relatively low elevation of Coast Range, mostly under 4000 ft., causes the water vapor to condense and fall mostly as rain with very little snow. The southern Willamette Valley also receives abundant rain from the first release of moisture as air mass continues to move east. Air masses next rise over the Cascade Range, which is substantially higher in elevation. Depending on the temperature, precipitation falls as either rain or snow. Very little moisture remains in the air masses as they reach the eastern high plateaus; 20 inches or less of precipitation creates the high desert conditions on the eastern side of the Cascades (Bastasch 2006).

The accumulated winter snowpack in the Cascades has a far reaching impact on Oregon's hydrology and ecosystems. Oregon's Cascade snowpack regulates the timing and quantity of streamflow in many locations throughout the state, particularly for streams

reaching the Willamette Valley. A vast pure water reservoir is created from the recurrent processes of melting, refreezing, raining, and snowing over. The recurrent amassing of snow has formed glaciers on Mt Hood, Mt Jefferson, and the Three Sisters peaks. Even though these glaciers cover less than 5 square miles, the quantity of melted water they contribute to regional streamflow can be substantial. The Oregon Cascades also contain several sites with the highest snow accumulations in the continental United States (Bastasch 2006). The water quantity of snow and ice “varies through the season, from year to year, and from place to place” (Bastasch 2006, 5). Snow depths in the Cascades have measured over 20 feet by late winter. Ice and snow take up more volume than liquid water, with each foot of snowpack generating 6 inches of runoff. Snowmelt is a significant contributor to rivers throughout Oregon, accounting for up to 80 percent of annual streamflow in many parts of eastern Oregon. Even in the rainier western Oregon, 40 percent of annual streamflow originates from melting snowpack accumulations (Bastasch 2006).

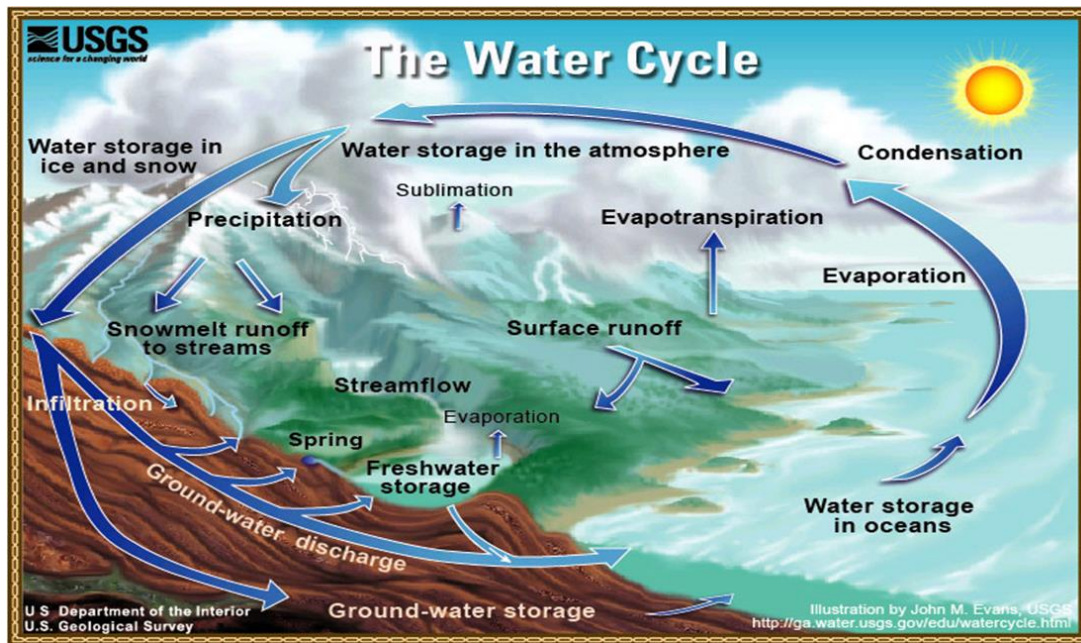


Figure 1 Map of Water Cycle and Orographic Lifting Process. (Map Courtesy of USGS 2016)

Oregon's Rivers/Basins:

Covering over 12,000 square miles, the Willamette basin is Oregon's largest watershed, covering approximately 12 percent of the state's total land area (Fig. 2). The Willamette basin yields over 27 million acre feet of water per year. The Willamette River's largest tributaries are from its Cascade streams, especially the Santiam and McKenzie rivers (Fig.3), with 5.6 million and 4.3 million acre feet of annual discharge, respectively.



Figure 2 Map of the Willamette Basin (Map Courtesy of US Army Corps of Engineers, 2016)



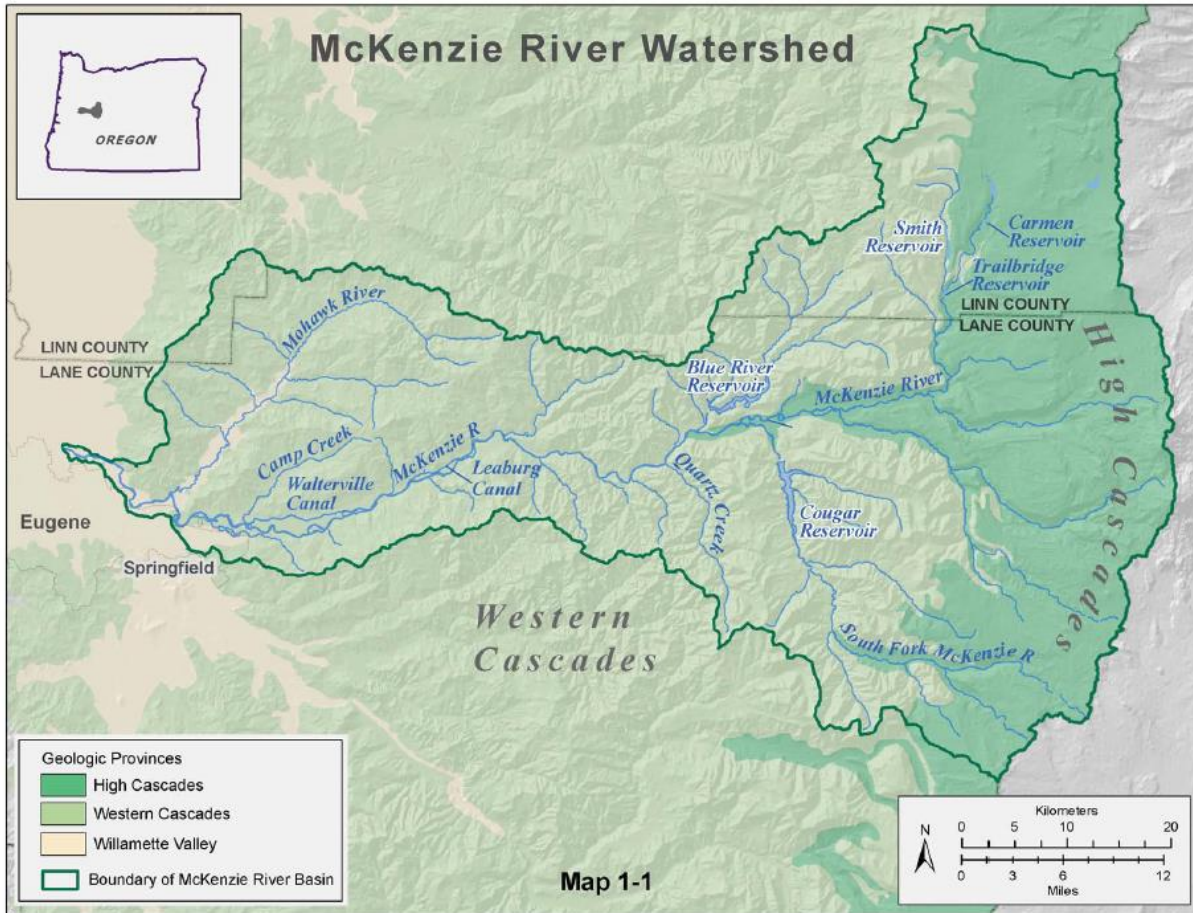


Figure 3 Map of McKenzie River Watershed (Map Courtesy of Eugene Water and Electric Board)

The amount and timing of a watershed’s runoff are a function of many factors, including basin size, elevation, precipitation, geology, soils, temperature, vegetation, and other variables. Most Oregon basins respond primarily to precipitation, with the highest runoff from Cascade streams occurring in December and January in response to rainfall (Bastasch 2006). The lowest stream flows occur in the summer. The Middle fork of the Willamette has winter flows three times higher than that of summer. Notable is the extent to which thirteen flood control dams, managed by the U.S. Army Corps of engineers, smooth out the Willamette basin’s annual discharge patterns (Bastasch 2006). The low summer flows



represent a risk for exasperated climate change impacts which are expected to produce longer, drier summers.

Oregon experiences an annual seasonal dry spell and also periodic dry spells which span multiple years. Both dryness and drought frequency increase from west to east across Oregon. In the Willamette Valley and Cascades, there has historically been a dry month nearly every year, a 2 month dry period every third year, and a 3 month drought period once every ten years (Bastasch 2006). However, these patterns are changing. Seasonal droughts typically experienced east of the cascades now frequently occur west of the Cascade Mountain Range. “Even the wettest parts of this mountain system experience seasonal drought since over 70% of annual precipitation falls from November to March, and only a small fraction falls during the July–September period” (Nolin 2012, S36 ). Between the 1920’s to 1990’s, Oregon experienced four significant droughts (Bastasch 2006). Taking precedence, in the last four years (2011-2015), Oregon has experienced record breaking severe statewide drought conditions (U.S. drought Monitor). In 2015, Governor Kate Brown declared drought for 20 counties and approximately 98 percent of the state. Governor Brown requested all state agencies to support the Oregon Water Resources Department in efforts to inform citizens about Oregon’s water resources challenges. This proclamation stated the causes as “the lowest snowpack level on record, the third warmest average temperature from January to May in the past 121 years; and below average rainfall” (Brown 2015).

*Future Water Projections: The role of Snowpack & Warming Temperatures to Eugene’s water*

Snow water equivalent (SWE) is the amount of stored water contained in snowpack. Typically, SWE is highest in spring (April 1) on the windward side of the Cascade Mountains (Serreze et al., 1999; Stewart, Cayan, and Dettinger 2004.) In the Pacific

Northwest (PNW), changing patterns are being noticed; substantial declines in April 1 SWE have been documented together with comparable shifts in streamflow (Service, 2004; Barnett, Adam, and Lettenmaier 2005; Mote et al. 2005; Luce and Holden 2009; Fritze, Stewart, and Pebesma 2011). This diminished SWE is being attributed to elevated winter temperatures (Knowles, Dettinger, and Cayan 2006; Mote 2006; Abatzoglou 2011; Fritze, Stewart, and Pebesma 2011).

There is a high probability that Oregon will experience sustained temperature increase based on scientific research of “Oregon’s regional climate patterns and projected future climate change impacts (Mote and Salathé, 2010).” Higher temperatures will transform additional snow into rain, resulting in reduced snowpack and lower summertime streamflow (Service 2004; Stewart, Cayan, and Dettinger 2004; 2005; Barnett, Adam, and Lettenmaier 2005; Mote et al. 2005; Stewart 2009; Mote and Salathé 2010).

The McKenzie River is the portion of the Willamette which contributes most water to the Eugene area. Oregon Cascade elevations over 1200m have been scientifically shown through isotopic analysis to account for 60-80% of summer streamflow in the McKenzie River (Brooks et al. 2012). This data indicates that the McKenzie River Basin’s (MRB) “reservoir” of snow above 1200 m is particularly paramount to the greater Willamette River Basin (303000 KM<sup>2</sup>), as it is to the City of Eugene. Although occupying 12% of Willamette River basin, the MRB contributes almost 25% of the late summer discharge at the Willamette’s confluence with the Columbia River, near Portland, Oregon (Hulse et al. 2002). In addition, findings from a study conducted by Sproles et al. (2013) affirmed that the MRB, averaging 1.26 km<sup>3</sup> of SWE, stores approximately five times the amount of water than the

most impressive human created reservoir in the McKenzie River watershed (Sproles et al. 2013).

The MRB is very responsive to higher temperatures; a 2 degree Celsius temperature rise will cause an estimated 56% decline in peak SWE Maritime snowpack. The melting cycle rate will also speed up, with peak SWE projected to occur 12 days earlier in the spring than the current peak SWE, and even perhaps even before the vernal equinox (Sproles et al. 2013). Losses in SWE and declining snow duration will impact years with high, low, and average snowpack and may change human perceptions of what high, low, and average snowpack represents. While temperature determines what proportion of precipitation falls as rain or snow, total precipitation will also be affected by climate change. With warmer conditions causing the MRB to experience more precipitation as rain rather than snow, areas currently in the rain/snow transition zone may experience rain exclusively. As more precipitation falls as rain, the timing and magnitude of runoff during winter, spring, and summer months will be drastically altered (Stewart, Cayan, and Dettinger 2005; Jefferson et al. 2008; Jefferson 2011).

(B): Human Dimension: Impact of Water Scarcity/Drought on Society:

The consequences of altered precipitation patterns and projected water related stresses are wide-ranging. Human and ecological systems are interrelated and the problems of water scarcity and climatic drought are complex. Over 70% percent of Oregon's population resides in the Willamette Valley, and this proportion is expected to increase. Both the human and ecological community of this region rely heavily on the Willamette River, especially during the dry summer months. Numerous stakeholders, ecological processes, and habitats are dependent on the snowmelt for surface water flow into Willamette Valley Rivers,

groundwater recharge, and water storage in lakes and reservoirs (Nolin 2012). The timing of water supply and demand plays a significant role in water scarcity. Geologic differences within a watershed also determine patterns of scarcity during the low-flow season. Human controlled factors of land-cover disturbance (e.g. fire, timber harvest), land use change (e.g. transition from forest-to-agriculture or agriculture-to municipal), water use patterns (e.g. consumption per unit of municipal or agricultural land use), dam operations, and population growth also determine the risk of water scarcity. Socioeconomic factors affecting land and water use include the skills and traditions of landowners, government regulations (Endangered Species Act), land values and water prices, and water management infrastructure (e.g. dams, irrigation, aquifer storage and recovery) (Nolin 2012).

Water resource managers are very concerned about the future water projections of the MRB and WRB and what this will mean for this region (Sproles et al. 2013). The McKenzie River is critical to Eugene's municipal water supply in the summer months, hence increased summer drought and evapotranspiration can play a significant role in creating seasonal water scarcity. For example, a 2°C temperature increase could cause the MRB to lose approximately 0.45 km<sup>3</sup> of water stored as snow (Sproles et al. 2013). Mountain snowpack is the most efficient and cost-effective reservoir, and the loss of water storage capacity from snowpack is approximately 1.8 times greater than the largest reservoir in the basin (Sproles et al. 2013). This dramatic reduction varies significantly from the historical conditions upon which present management plans are based (Sproles et al. 2013).

Changes in water demand will also impact water availability. Oregon's population is expected to grow by 400,000 between 2010 and 2020 (Office of Economic Analysis 2011). This population increase will certainly increase water demand, especially in the summer and

fall when stakeholders compete for an already limited supply (United States Army Corps of Engineers, 2001); Oregon Water Supply and Conservation Initiative, 2008).

The southeast hills Wildland Urban Interface (WUI) region of Eugene is densely populated and pushes against the margins of the city growth boundary (Fig. 6). Demographic studies for Eugene and the Willamette Valley Ecoregion are projecting rapid population growth (Hulse et al. 2002, Hulse, Branscomb, and Payne 2004, Lane Council of Governments 2006). The Eugene Water and Electric Board (Fig. 4) “relies on the McKenzie River as a sole source of drinking water for over 200,000 people and for hydroelectric power generation from our Leaburg, Walterville, Carmen-Smith, and Trailbridge projects, [and] we are very interested in how winter peak flows will impact river and channel dynamics, aquatic habitat, dam operations and water quality” (Morgenstern 2012).

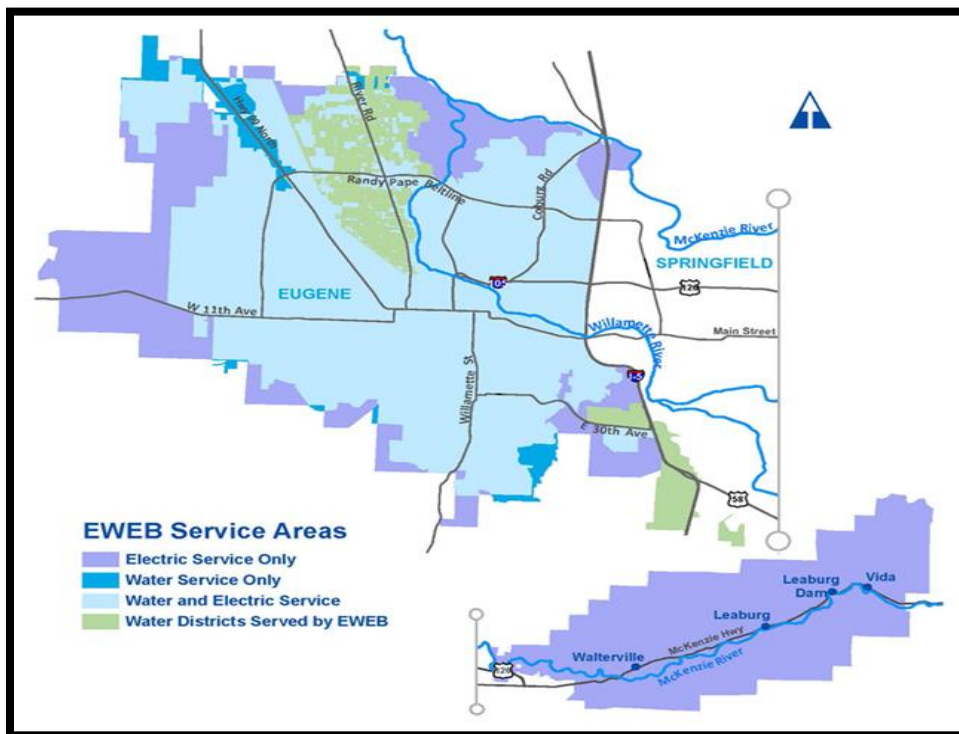


Figure 4 Map of EWEB Service Area (Map Courtesy of EWEB, 2016)

Fire and drought are interrelated natural resources issues that impact both society and ecosystems through multiple feedback loops. Residents of Southeast Eugene, the focus area for this study, live in a WUI region (Figure 5 below), which is a region located next to or within forested natural spaces (Figure 6 below).

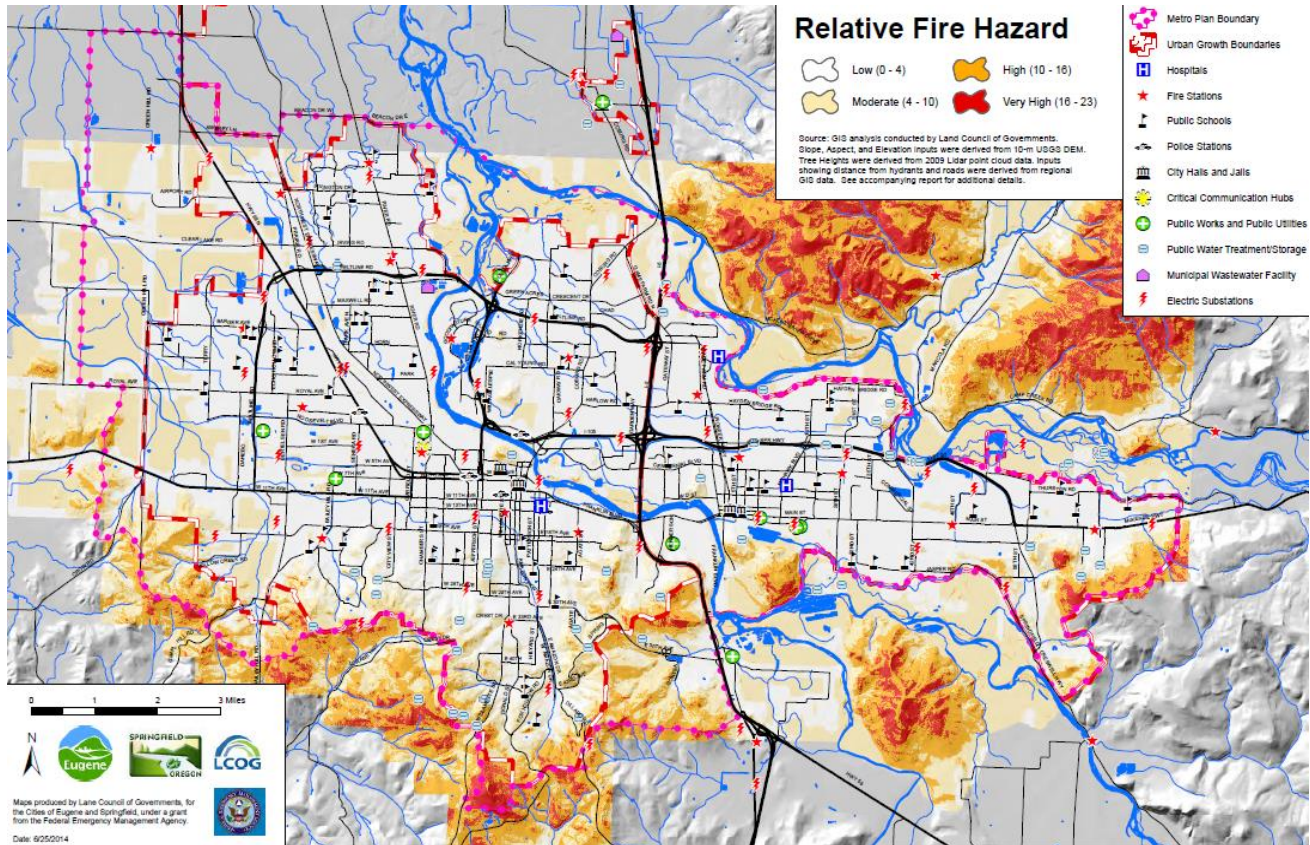


Figure 5 WUI Map of Southeast Eugene (Map courtesy of Lane Council of Governments)

At the same time that resident populations have exploded on the fringe of these natural spaces, so has the increasing threat of wildfire caused by drought. As people move out of urban centers in the hopes of finding a more satisfying lifestyle, they unwittingly create a serious natural resource issue; wildfire's that threaten human life. Natural systems often depend on wildfire which can act as an integral pattern promoting healthy ecosystems.



However, wildfire regimes and other management strategies may be incompatible with the amenity values of these new residents. Many residents value the forest for its specific uses, such as recreation, and understand the forest and its natural systems through that lens. A disconnect between managers and residents could emerge about what needs to be done to sustainably manage the forests and at the same time protect residents from fire (Shindler 2000). Extreme wildfire will likely increase with climate change, as drought increases throughout already fire prone areas. Humans are at risk, but managing the forests adequately to maintain natural ecosystems requires human populations to understand, be involved in, and accept management strategies.

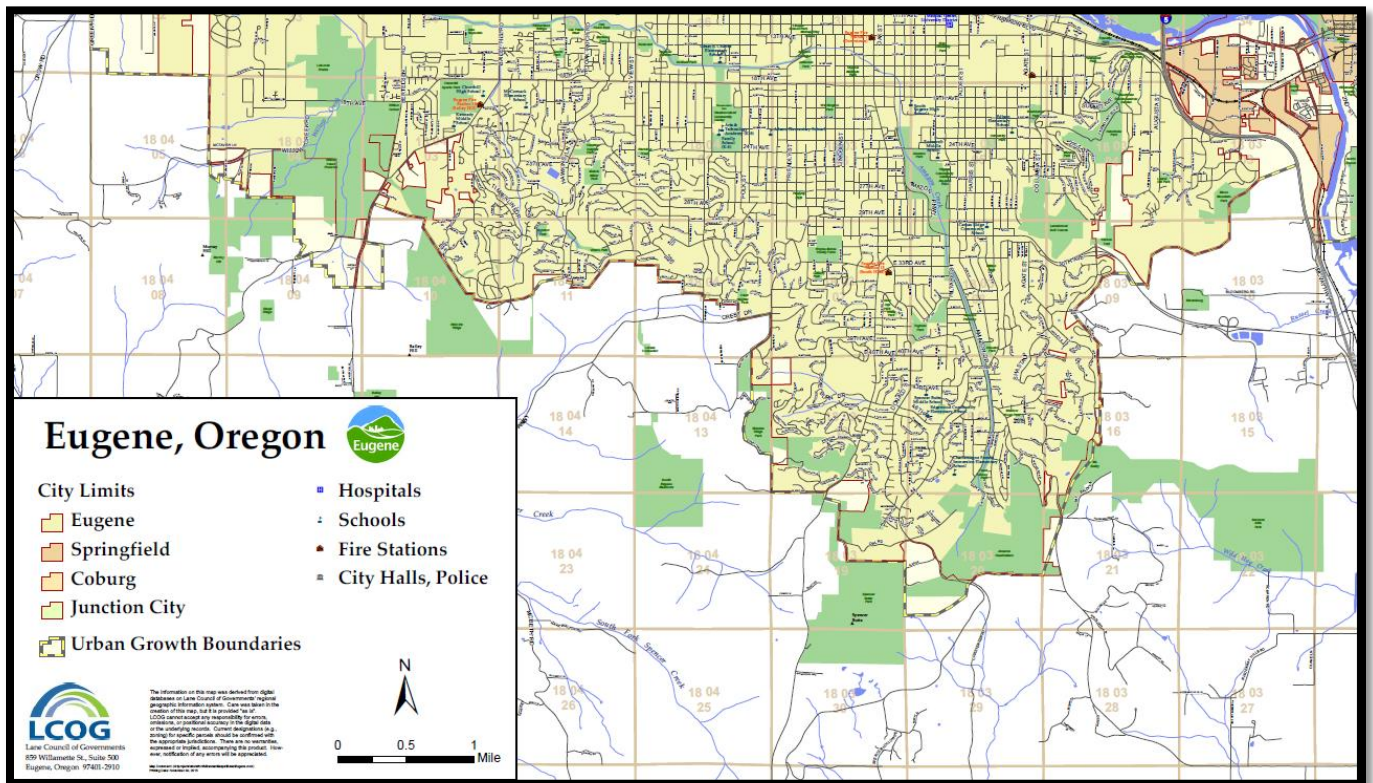


Figure 6. Urban Growth Boundary Southeast Eugene (Map Courtesy of LCOG 2016)

Economy:

The main economic sectors of this region, such as manufacturing, services, agriculture, forestry, and tourism, all rely heavily on water for hydroelectricity, irrigation, and municipal water supply. Increased temperatures along with the prolonged drought periods predicted by climate models, could disrupt reliability of hydroelectricity and water (Doppelt et al. 2009). Hydroelectricity cost will be a concern for both residents and water utilities who must be able to absorb the extra cost, otherwise other sectors of the economy will suffer. Water utilities, such as EWEB, work to keep costs low for rate-payers and water rates have stayed at a flat rate. If rate payers, such as those in Southeast Eugene are accustomed to flat rates that barely reflect their water use, there might be little incentive to conserve water (Leurig 2010). EWEB's hydroelectricity system on the McKenzie River is likely to face significant challenges in coming years due to increasing seasonal variability of water. Summer power capacity may be reduced along with stream-flows. Reservoirs may become depleted during summer droughts due to reduced snowpack and much earlier snowmelt. At the same time, demands for electricity in the summer will likely increase as rising temperatures drive the use of air conditioning. Significant costs may be required to update infrastructure and secure more water sources.

Agriculture is an important part of the Upper Willamette River Basin's economy. Agriculture accounts for ~ eighty percent of Oregon's water use making water vital to the Willamette Basin's economy. Agricultural sales brought in about \$119 million supported by \$20.4 million in payroll for all of Lane County, much of which lies within the Basin (OED 2008). The Eugene-Springfield area is a supply center for agricultural services and products for the entire southern Willamette Valley (Fig 7). Rising land prices caused by accelerating population growth and development have placed increased stress on local farmers. Climate



change is likely to add additional stresses while higher temperatures, especially warmer night temperatures, could stress certain crops. Farmers will likely require more water for crops, which will raise costs and become more problematic as reduced water availability forces farmers to compete with municipal and other users for available supplies.

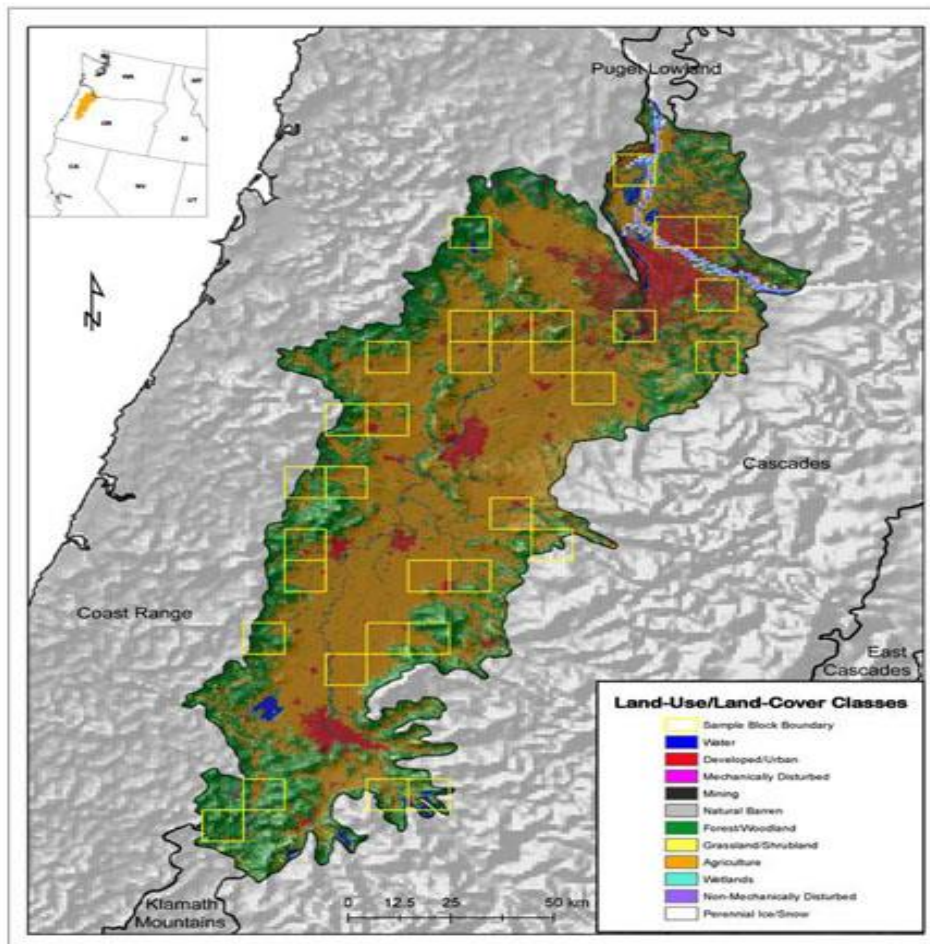


Figure 7. Land-Use in Willamette Valley (Map courtesy of USGS.gov, 2016)

Tourism is expected to grow in Lane County (Eugene is the Lane County seat), due to proximity to the rivers, ocean, and mountains. Tourism was a \$552.8 million industry in Lane County in 2005 (these numbers are only available at the county level, which expands to the

coast, not for the basin alone), and is expected to grow due to proximity to rivers, ocean, and mountains. However, reduced snowpack is likely to affect winter sports, and has caused shortened ski seasons in recent years. Increased incidence of forest fires may also lead to longer closures of National Forest recreation areas. Smoke intrusion may make summer camping, hiking, fishing and other recreational forest use less desirable, while reduced summer stream-flows may affect boating, fishing, and camping (Dopplet et al. 2009).

#### Regional Context Summary:

The regional context provided a background to help the author and readers to understand the full scope of the research problem and outline the factual risks that exist for this region. This research attempts to determine whether risk perceptions of Eugene (neighborhood) residents are aligned to the factual risk factors identified in the background sections above. If closely aligned, residents have accurate perceptions, there exists more opportunity for support of changes in management, adaptations, and policy-making. If less accurate risk perceptions, this research could aid in the design of messaging, education, and communication to achieve needed societal support. The next section includes the Research questions and hypotheses that guided this research and its methodology.

## II. Research Questions and Hypotheses:

The primary research question for this Capstone project is “How do Eugene resident’s perceptions of risk for potential severe water scarcity linked to climate change impact their public participation and support of local sustainable water management strategies?”

#### Secondary research questions were:

- “What are resident’s perceptions of risk related to potential water scarcity?”
- “What are resident’s perceptions about the causes of a potential water scarcity?”

- “What are Eugene residents’ perceptions of water management in the region?”
- “What social, economic, and political factors influence public perception of risks related to potential severe water scarcity in this region?”

### *Hypotheses*

Based on the questions above the following four hypotheses were proposed.

H1. A majority of residents will be unaware that a water scarcity risk that exists for this region.

H2. A majority of residents will be unaware that a potential severe water scarcity is linked to a several decade climatic trend, potentially climate change.

H3. A relationship will be discovered between public perceptions of risks related to potential severe water scarcity and the degree of public support and participation in water sustainability programs and management actions.

H4. Levels of education, income, and political affiliation will be found to influence resident's perception and awareness of a risks related to potential water scarcity in this region.

### **III. Research Project Methodology Part 1: Literature Review:**

The Purpose of this Literature Review is to provide a foundation for this capstone research project as a method to assess and understand the Southeast Eugene resident’s risk perceptions, and as a context for understanding results of survey. The second part of the research methodology will be the data, analysis and results of the survey, “Water Resources in Eugene Oregon.” The Literature Review will include research and theories for: a) Risk Perception b) Climate change risk and perception c) wildfire risk perception d) Water scarcity and risk perceptions in Oregon. Understanding risk perceptions allows a

more intentional focus on what people need to know about a hazard and how their understanding can lead to appropriate actions to mitigate risks to individuals or communities. Risk perception theory is helpful when considering how communities will adapt to potential water scarcity in Eugene, OR, because of the unique climate of this region, discussed in earlier sections.

### 3.1 Early Perception of Risk Theory

Social Science research on risk perception initially sought to understand how humans behave when encountering natural or technological threats (Slovic 1987). Early risk perception studies focused more on the risks themselves and not on the individuals. Later studies focused more on the individuals and also on the variability of risk perceptions within a society (Wildavsky and Dake 1990). Eventually, this focus on risk perception revealed that social, psychological, and cultural factors shape how people come to understand different types of risks and influence the individual's resulting actions (Short 1984; Douglas and Wildavsky 1982). Key predictors of risk discovered by this early research included knowledge, exposure, worldview, sociodemographic and socioeconomic status factors (McDaniels et al. 1997; McDaniels, Axelrod, and Slovic 1995; Rowe and Wright 2001; Slovic 1987; Wildavsky and Dake 1990). Another important early risk perception theory demonstrated that what people perceive as a risk is often shaped by the perceptions of those people who are most familiar to them (Short 1984).

Environmental risk perception research can enhance understanding of how risks associated with environmental hazards, such as drought, can predict the behaviors of citizens (O'Conner, Bord, and Fisher 1999). The central idea underlying early research in risk perception was that if people perceive great potential for dangerous occurrence, they are

more likely to take actions that reduce impact and support government programs with similar intentions, despite personal deprivation (O’Conner, Bord and Fisher 1999). Correlations have been discovered between risk perceptions and actions to reduce risk in research on environmental hazards such as water and air pollution (Baldassare and Katz 1992).

#### Climate Change Risk Perception and Water Scarcity:

Although there is a lack of direct research concerning public risk perceptions of water scarcity related to climate change, there is a growing body of literature on risk perceptions related to (other) climate change impacts. According to climate science, water scarcity is a predicted result of a significantly warming climate (Dalton et al. 2013). In Oregon, climate change is predicted to cause warmer, rainier winters with less snowfall in higher elevations (Dalton et al. 2013). Although scientists are unable to prove with absolute certainty that diminishing snowpack and subsequent drought increase are directly linked to a long-term climatic trend, there is ample evidence to support these hypotheses (Dalton et al. 2013). Riparian and aquatic ecosystems evolved to exist because snowmelt contributed a consistent supply of cool water to local rivers throughout the traditionally dry summer and early fall months. Drought and water scarcity can be considered a social threat because of impacts to public drinking water supply, hydropower, irrigation for agriculture, tourism, and recreation, and increased wildfire incidence (Barnett, Adam, and Lettenmaier 2005, 11). If the public perceives a pronounced level of risk associated with climate change impacts, then the public may be more inclined to take action to adapt and prepare for drought conditions, support policy decisions, and participate in programs that minimize these potential environmental threats (O’Conner, Bord, and Fisher 1999; Baldassare and Katz 1992). Lieserowitz’s (2005) research explains that public risk perceptions of climate change affect public opinion, which

plays a direct role in political decision-making related to climate change impacts. In addition, Leiserowitz's (2005) research found that Americans are only moderately worried about climate change, mostly perceiving it as something that will affect people in faraway places with low standards of living. This author argues that those who define what is dangerous and how it is dangerous will influence climate change risk perception in the U.S (Leiserowitz 2005). While scientific consensus remains high on climate change causes and risks, the problem is also one of social values and shifting perceptions. These statistics demonstrate how inconsistent public opinion is about climate change. The 2009 Pew Research found public belief in climate change fell from 71 percent to 57 percent from 2008-2009. Only three years later, a 2012 report by the National Survey of American Public Opinion on Climate Change stated that American belief in climate change rose to 62 percent (Hoffman 2012). Policy makers need to understand the causes of these variations because public perceptions of climate change risks may determine the level of support for government initiatives that seek to address climate change impacts.

Conversely, a related study on the impact of climate change belief on wildfire risk perceptions and mitigation actions by Brenkert-smith, Meldrum, and Champ (2015) found that individual's belief of climate change does not necessarily align with their wildfire risk perceptions and mitigation actions. Their study of residents in Front-Range, CO actually revealed a higher tendency of climate change 'deniers' to take wildfire risk reduction measures over the climate change 'believers.' This research reveals the complexity of the climate change wildfire nexus and perhaps water scarcity as well. It also shows the varied spectrum of climate change beliefs from 'deniers' to 'believers.' The popular national image of extreme polarized climate change belief is not necessarily the case when looking at the

complexity of local regional beliefs. This research highlights the need for community and place-based natural resources mitigation messages and management.

This capstone project will look at the connection between resident's understanding of local water scarcity being linked to climate change and if that understanding might impact residents support of water management decisions. Understanding how residents of Eugene perceive water scarcity as a risk linked to climate change, and illuminating which factors influence these perceptions, and may contribute to education and policy initiatives that are more intentional and effective in their approach.

### 3.3 Knowledge in Relation to Risk Perceptions:

Knowledge was discovered early on to be a key predictor of risk perception variability. Some early studies showed that increased knowledge about a risk leads to higher perceived risk, yet some risk perceptions reduced with greater knowledge (nuclear and technologies) (Wildavsky and Dake 1990). Experts have been found to perceive less risk than the public on certain issues due to their possession of greater knowledge (Rowe and Wright 2001) and knowledge itself does not necessarily lead to a behavioral change (e.g., Finger 1994; Willis et al. 2011). Experts in climate change, water scarcity, and wildfire tend to perceive more risk than the public generally possibly because of greater knowledge of issues and the supporting scientific evidence (Brenkert-Smith et al. 2013).

This current research project seeks to understand the level of knowledge Southeast neighborhood residents have of climate change and its potential impacts. Erika Wolters (2012) found that, in general, Oregon residents have knowledge of climate change impacts, of water scarcity, and of other water issues. Perceiving risk requires accurate knowledge which correctly signifies levels of risk and consequence. Related to risk perceptions of water

scarcity is the role that knowledge has played in affecting social acceptance and understanding of climate change as a scientific fact. Gaps in scientific knowledge exist for politicians, news media, and the public, which cause misinterpretations or dismissal of climate change science (Boykoff and Rajan 2007). For example, most Americans are insufficiently educated about climate science by academic institutions. Still, numerous Americans express a desire to learn the basics of climate science in order to be better informed (Leiserowitz 2010; Miller 2012). While science attempts to provide more research and better education, McCright and Dunlap (2011) argue that climate skepticism is not entirely a knowledge deficit issue. Improved instruction and education on climate science is actually associated with lower interest and action among conservatives and greater support among liberals (Hoffman 2012).

#### Drought and Wildfire Nexus: WUI, Wildfire, and Risk in the Willamette Valley:

Research on wildfire risk perceptions and wildfire risk mitigation actions can offer insight to this Capstone project's primary question: "How do Eugene resident's perceptions of risk for potential severe water scarcity linked to climate change impact their public participation and support of local sustainable water management strategies?" Wildfire risk perception studies are particularly focused on predictors of risk perceptions and understanding the management risk communication strategies that will adequately portray risks and garner support for mitigation strategies. Wildfire risk perception studies also relate to this project's secondary questions; "What social, economic, and political factors influence public perception of risks related to potential severe water scarcity in this region?" and "What are Eugene residents' perceptions of water management in the region?"



A growing body of literature and theory specifically focused on wildfire risk perception is motivated by the increasing frequency of catastrophic wildfire throughout the American West. Scientists predict wildfire to increase in magnitude and frequency, and to display atypical behaviors due to drought, higher temperatures, and past fire suppression management (Dalton et al. 2013)

Relevant wildfire risk literature includes studies on what primarily influences varying degrees of awareness and perception of risk. A host of variables contribute to risk perception: socio-cultural, socio-demographic, emotional/psychological, experience, beliefs, community, knowledge and types of wildfire communication. MacGregor, Finucane, and Gonzalez-Caban (2007) and Brenkert-smith et al. (2013) found that Social Amplification of Risk (SAR) Theory is a particularly useful tool to understand the impact of socio-cultural factors on water risk perceptions and reactions to those risks. (SAR), which is “the phenomenon by which information processes, institutional structures, social group behavior, and individual response shape social experience of risk, thereby contributing to risk consequences (MacGregor, Finucane, and Gonzalez-Caban 2007, 181).” Their research demonstrated that in order for risk communication to be received effectively by the intended audience, managers must understand how cultural influences might intensify or decrease risk perceptions. Identifying key cultural influences and the amplification or attenuation of risk requires looking at contextual cultural differences, beliefs, attitudes, values, gender, and communication preferences. From this information, managers can more effectively determine which types of communication residents will accept and at what level they will make choices to mitigate risks.

The southeast region of Eugene could be considered an “exurban”/amenity migrant demographic (Eriksen and Prior 2011). Studies show that “exurban” residents share unique values that influenced their decisions to live in Wildland urban interface locations (Garber-Yonts 2004). Research indicates that “exurban” residents are often “amenity migrants” who value living in or migrating to these places for specific recreational uses, personal reasons (beauty and aesthetics), ideological reasons (environmental paradigm), and health (getting away from city traffic) and understand these “natural” ecosystems only through this lens (Eriksen and Prior 2001; Hendrix 2012). Notably, Oregon is expected to be second only to Florida in the rate of net interstate migration, with an estimated average annual increase of 7 interstate migrants per 1,000 residents (Garber-Yonts 2004). A possible result of these amenity migrations could be disconnections between what needs to be done to sustainably manage natural resources (i.e. fire regimes and watershed protection) and the values/worldviews and personal interests of these citizens.

#### Perceptions of susceptibility to harm:

An individual’s perceptions of how susceptible they are to harm and its potential severity (MacGregor, Finucane, and Gonzalez-Caban 2007) are influences also noted to impact wildfire risk perceptions. If individuals in Eugene’s southeast neighborhood experience direct harm or increased wildfire from living in a drought stressed region, they might believe they are more susceptible to harm and perceive a high level of severity for drought/water scarcity. Perceptions of susceptibility may be influenced by seasonality and frequency of droughts and low incidence of past extreme droughts known to harm citizens in this region. In Eugene, seasonal dry conditions occur annually in the summer months (Bastach 2006). Residents are accustomed to these “drought” conditions, but expect these

dry conditions will be alleviated with seasonal fall conditions of heavy rain, because these local climatic patterns have predominantly persisted over time. Although extreme droughts have not been a very common occurrence in Eugene, they have become more frequent in recent seasons in the surrounding area (Bastasch 2006). Yet, the experience of most homeowners in these areas has historically been wet conditions for 6 months and dry for 4 months. Risk of water scarcity and wildfire threat in this region has historically been concentrated in those four months. Risk perceptions related to severity and harm might also be affected by the perceived level of protection from local, state, and federal fire emergency services (MacGregor, Finucane, and Gonzalez-Caban 2007) In the case of water scarcity and drought, urban residents might feel comforted by municipal water storage capacity and other management facilities that work to protect water sources and ensure delivery of water to residents. In reality, those facilities might be underprepared or adapted to current circumstances with limited preparation for future predicted conditions.

Personal Certainty, Capacity, and Responsibility:

Martin, Martin and Kent's (2009) research on wildfire risk perceptions, revealed that an individual's personal certainty in their capacity to handle a hazard will have a definite impact on their risk reduction behaviors. Martin, Martin and Kent (2009) also found that residents who felt responsible for reducing wildfire risks were more likely to take actions. The demography of this Eugene area might shape feelings of personal responsibility for residents to support water management and take risk mitigation actions. Correlating length of residency and feeling of responsibility for drought/water scarcity issues would be interesting, for example, renters vs. owners and long-time versus newer residents who might feel less invested in their community. Assessing these attributes of residents could lead to

understanding the interplay of risk perceptions, social interactions, and socio-cultural factors such as beliefs, as well as demographic indicators like age and length of residency.

Brenkert-smith et al. (2013) highlight the valuable function that social interactions and information sources have in determining an individual's wildfire risk perceptions. Although expert fire science communication and interaction is important for people to understand risk, social interactions are equally or more likely to influence these risk perceptions. The strongest relationships exist when individuals receive personalized information from both fire science experts and neighbors/friends. This study stressed the importance of one-on-one interaction and local sources of information as more effective than mass media because the former sources can provide more individualized risk information. They also found that residents who reported having not received wildfire information from any source, perceived less risk (Brenkert-smith et al. 2013). Talking with one's neighbor is considered the social interaction variable most strongly associated with the perceived probability of experiencing a wildfire in close proximity to an individual's home (Brenkert-smith et al. 2013). The second strongest association is from attending a fire-related event. Fire specific interactions, whether formal or informal, have more impact on resident's wildfire risk perceptions (Brenkert-smith et al. 2013).

These studies are relevant to water scarcity/drought risk perceptions in this Eugene neighborhood because this area is a densely populated residential community geographically separated by hills from the downtown and other neighborhoods, which creates a small town neighborhood atmosphere. The City of Eugene is divided into neighborhoods with active neighborhood organizations who work to engage and educate the community on local issues. The Eugene south hills community is connected through the efforts of a very active

neighborhood association (Southeast Neighborhood Association), multiple churches, schools, parks and informal gathering spaces. Understanding if residents of Eugene southeast hills WUI are receptive to receiving messages of local risk/hazards from neighbors, friends, neighborhood associations, local newspapers, radio, television, or city messaging campaigns would provide valuable insight for risk communication strategies and how messages influence risk perceptions related to drought/water scarcity and the likelihood of personal or community wildfire mitigation actions.

Predictors of water scarcity risk perception: Socioeconomic status (SES), education level, and political ideology:

A primary research question for this Capstone project was “What social, economic, and political factors influence public perception of risks related to potential severe water scarcity in this region?” Hubbard’s (2013) study on risk perception concerning Oregon’s water resources looked at predictors of risk perception for Oregon residents. Hubbard (2013) hypothesized that residents with higher levels of education would perceive lower risk than those without college. However, this author’s (Hubbard 2013) research discovered that those with more college education actually had a higher risk perception than those without. Also, contrary to Hubbard’s (2013) hypothesis that those with a higher income would perceive less risk, Hubbard’s (2013) research results revealed that respondents with an income higher than \$50k were found to experience higher perceived risk and the statistical testing showed no considerable significance. This research indicates that income might not be a very accurate predictor of risk for Oregonians. However, the findings of Hubbard (2013) are contrary to previous research (O’Conner, Bord, and Fisher 1999) that found an inverse relationship

between risk and education and income, observing that as income and education rise, risk perception is reduced. Hubbard's (2013) research also revealed that for Oregonians, political ideology was not significantly correlated to risk perceptions.

Hubbard's (2013) research on Oregonians did, however, reveal a strong connection between the strength of the New Environmental Paradigm (NEP) and risk perception for water. The NEP test revealed that as biocentrism increased, risk perception also increased. This finding is consistent with the ecological risk perception research of Slimak and Dietz (2006) who concluded that the NEP influenced "up to 42 percent of the variance explaining the global environmental risk index." Hubbard's (2013) research results found that those with more knowledge on the issue of water scarcity perceived higher risk. These results are contrary with the findings of Wildavsky and Dake (1990) whose work discovered that individuals with higher self-assessed knowledge on an issue perceived less risk. According to Hubbard (2013), another interesting factor contributing to higher risk perceptions of water scarcity for Oregon residents was that the information source (environmental groups) played a role in predicting water resource risk perception. Hubbard (2013) concluded that Oregon's water resource managers need to understand that Oregonians perceive higher risk to water resources from industry rather than climate change and population growth. Hubbard (2013) points to potential for perceptions of controllability and uncertainty as a factor contributing to these perceptions of risk. Hubbard (2013) claims that these incompatible perceptions could pose potential problems for Oregon's water managers when targeting climate change and population growth as potential risks to water resources. This Capstone project will aim to reveal if education, incomes, and political ideology are factors that contribute to levels of risk perception in Eugene.

In a related study on environmental beliefs and values, Erika Wolters (2012) found that, in general, Oregonians are concerned about water, the value of water, and protecting water resources. This study did not explore perceptions of risk related to water scarcity, but does offer valuable insights into the relationships between the environment and the socio-cultural foundations of Oregonians. Wolters (2012) discovered that differences in environmental values, including water quantity and quality, were influenced by gender, location, education, and socio-demographics. Wolters' (2012) research concluded that only education and the New Environmental Paradigm had a positive relationship to citizens concern about water scarcity, in Oregon. Political ideology and place of residence did not show significance to her hypotheses. Wolters (2012) noticed that education, unlike the other variables was "adjustable." And that it might provide the state with a mechanism to influence resident's water concerns. As a result, she suggested that the Oregon Water Resources Department put more focus into informal education, as a path to informing residents of water concerns.

These findings (Wolters 2012) suggest that Oregonians are aware of water issues and take personal actions and support government initiatives to protect water resources. However, the level of participation, support, and concern might not be enough when faced with extreme risk related to drought and water scarcity. Because of this, Wolters (2012) discussed the need for further research on risk perceptions of Oregonians related to water scarcity.

#### Literature Review Summary:

Eugene Oregon is a unique location with a history of very wet climate, but this trend is changing with climatic perturbations (Dalton et al. 2013). Risk perception studies are

important when considering the level of citizen support in Eugene, OR for government water initiatives and citizen willingness to act to mitigate and adapt to water scarcity. Studies demonstrate the role that risk perceptions play in how people react to hazards and what factors influence their perceptions (Slovic 1987). Environmental and climate change studies (O’Conner, Bord, and Fisher 1999) on risk perceptions contribute to an understanding of how water scarcity will be perceived as either a severe threat or a short-term climatic trend requiring only minimal adaptation or government intervention. Wildfire risk perceptions studies provide valuable insight predictors of risk, such as culture/worldview, perceptions of susceptibility to harm, personal certainty capacity, and responsibility, and social interaction and information sources (Brenkert- Smith et al. 2013; Martin, Martin and Kent 2009; MacGregor, Finucane, and Gonzalez-Caban 2007). Wolters (2012) showed that Oregonians have the potential to be environmentally concerned and highly involved. Hubbard’s (2013) work revealed the influence of education, incomes, knowledge, and political ideology on water resource risk perceptions. Research is needed to discover how residents of different locations in Oregon perceive water scarcity as a risk so that water managers can create successful policy, initiatives, and gain support from local citizens.

#### IV. Research Project Methodology Part 2: Water Resources in Eugene Oregon”

##### Survey:

The survey “Water Resources in Eugene Oregon” was used to answer the author’s primary and secondary research questions. This survey and research/data was chosen because of its scope, design, and context (location and topic), which laid the ground work for this capstone project. The details of the survey, including methodology, examination/analysis, and results are included in this capstone project to provide the reader with details that inform



the capstone project and lead the author to discussion, conclusions, and recommendations for further study. If water scarcity is perceived as a temporary situation related to climatic fluctuations and ranges over a 5-10 year period, a low level of risk may be felt, resulting in temporary changes in behaviors or a low level of sustained support for government measures to mitigate water scarcity. Eugene is a sub-population which does not reflect all of Oregon, but understanding the underlying factors which impact willingness to act will help local government and community organizations plan and implement initiatives to gain public support and participation. Eugene is the second largest metropolitan area in Oregon, and so far, there have not been studies concerning citizens risk perceptions of water scarcity. Obtaining a deeper knowledge about citizen's perceptions, reactions, and what they will support is vital to policy decision making and planning.

## V. Survey Methods:

This section will discuss the components of survey methodology including research design, survey questions types, research subjects, materials and procedures, examination/analyses performed, maintaining confidentiality and coding criteria. It is important to note that the results do not physically test the hypotheses, but helps stimulate thinking.

### Design

A quantitative research design approach was used to complete the original research study using the survey results. A Qualtrics on-line survey of 19 questions was designed to measure the following variables: perceptions of risk related to water scarcity, opinions of Eugene water management, experience of residents with Eugene water management, knowledge and awareness of snowpack conditions and the possible links to climate change and water scarcity in Eugene.

*Question types included:* Likert scale and binary types of questions were included in the survey. The first section of questions focused on hypothesis 1 and 2, which measured risk perceptions and awareness of Eugene water scarcity and drought, and perceptions/opinions concerning the link of Western Cascade Mountain snowpack conditions to local drought and climate change. Likert scales were used to reveal opinions, knowledge, and perceptions about water scarcity, climate change, and water management. Continuum scales differed for each question, from 5 options to 7. This type of question allowed for a more straightforward way to quantify respondent’s viewpoints and behaviors (Leedy and Ormrod 2012).

Q4 For this question we are interested in your opinions about water availability in Eugene. What is your level of agreement on these statements?

	Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
My drinking water supply is secure.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Water for all my needs will be met in the future.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Water is abundant in Eugene.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I can mitigate water shortage through personal action.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
My actions will not make a difference toward overall water scarcity.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Climate patterns are variable and humans can adapt.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Water Scarcity is an issue I am concerned about.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

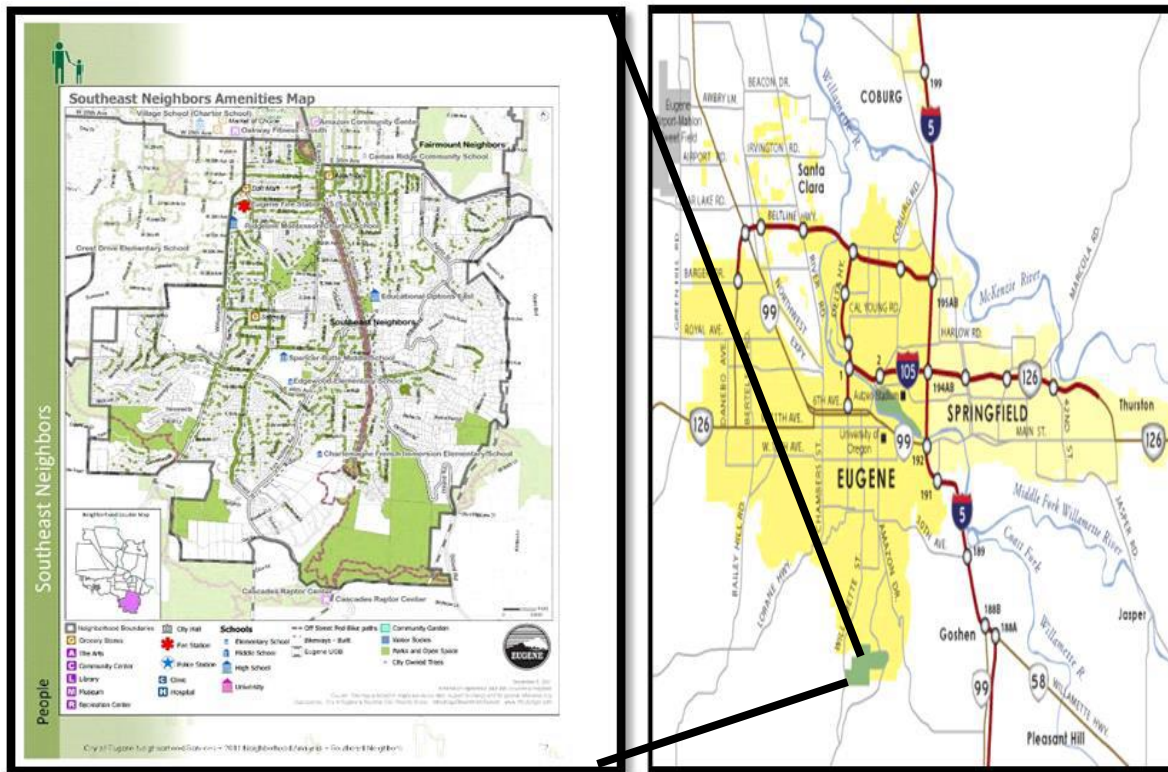
Figure 8 Question #4 What is your level of agreement on these statements?

The second set of questions focused on hypothesis 3, measuring opinions of Eugene Water management organizations and experiences with these types of organizations, such as, their outreach and education programs. See Appendix A.

The third set of questions covered demographics and sought to address hypothesis 4. These questions asked about gender, income, age, education level, political ideology, and residency in Eugene. Data gathered was both nominal and ordinal.

Research Subjects:

The survey was administered through an email list serve to 562 subscribing members of Southeast Neighborhood Association. The study site is a location named the Southeast Neighborhood of Eugene, Oregon. The city has a population of approximately 160,000 residents. Eugene is divided into neighborhoods with many neighborhoods providing a board of elected members, meetings, and residential support. This is provided without cost to the residents (Eugene-or.gov 2015).



Figures 9 and 10. Maps of South East Eugene Neighborhood and City of Eugene. (Maps Courtesy of Eugene.gov 2016)

Demographic data: Southeast neighborhood of Eugene, OR includes more than 13,000 residents, which is approximately eight percent of the Eugene’s population. The researcher’s survey link was emailed to 562 residents whose responses to demographic questions indicated respondent’s gender, age, income levels, education, political ideology, and length of residency in Eugene. The chart (Fig.11) below show a majority of women responded with fifty-nine percent, although thirty-nine percent males is a fair amount. The second chart (Fig. 12) below shows that most respondents, forty-one percent, were ages 61, while thirty-seven percent fell in the age range of 41- 60 years, and twenty-two percent were in the range of 22- 40 years of age. Education results (Fig. 13) forty-three percent of respondents hold a Master’s degree, twenty-one percent hold a 4 year degree, and fifteen percent hold a doctoral degree. This data indicates a higher than average level of education in this demographic. In a further study, this data should be compared to the demographics of the greater Eugene population to show the external validity of this study population.

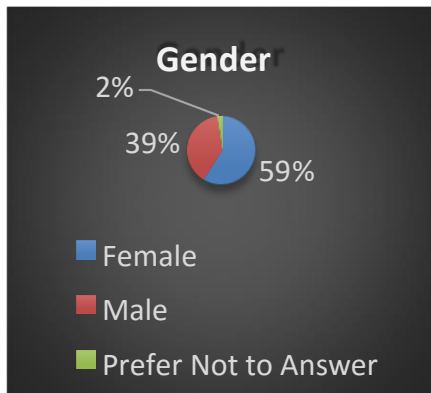


Figure 10 Gender Graph

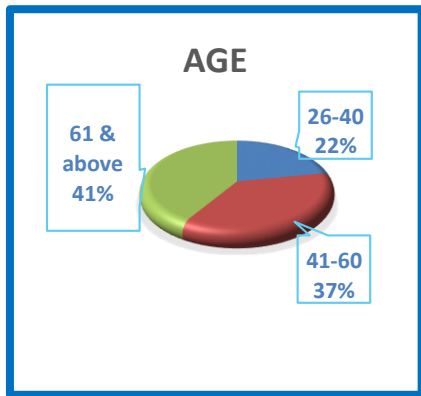


Figure 11 Age Graph

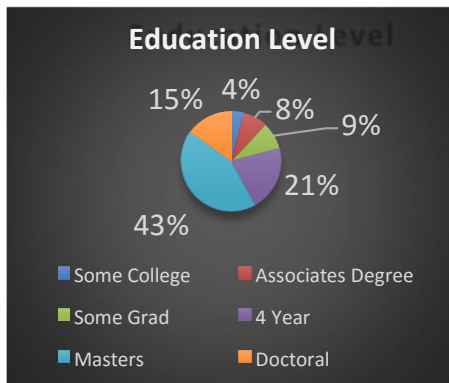


Figure 12 Education Level Graph

Materials and procedures: Qualtrics software provided the survey format and design elements of survey questions as well as the on-line distribution, collection, and organization of data.

The President of the SE Neighborhood Association emailed the Qualtrics anonymous link to a list-serve of 562 residents of the SE neighborhood. Of 83 respondents who began the survey, 73 completed and submitted the survey, with a response rate of thirteen percent. Residents were given one week to complete and return the survey to fit the researcher's

academic timeframes and the need to preserve respondent's anonymity. After one week, the survey was closed and examination of the survey results was initiated.

#### Examinations/Analysis:

Qualtrics provided statistical analysis options within its software such as crosstabs and chi-square tests. It also provided mean, standard deviation, min/max value, and variance, percentages, counts, graphs, tables, and filtering options. Statistical tests like chi-square, t-test, or correlations were not performed.

To measure variables of risk perceptions, the author examined the frequencies and calculated percentages of respondents for each option. In some cases, responses were combined into one, (agree and strongly agree were combined as one frequency and labeled "agree"). The author focused on percentages of respondents to each question and variables and also filtered results based on income, political ideology, and education level. Corresponding dependent variables were then examined to see how people in each demographic category, such as income level, responded to questions.

## VI. Survey Results:

It is important to note that the results of this survey did not physically test the hypotheses, but do help to stimulate thinking. Results are divided based on the hypothesis and analysis used to conclude whether or not the hypothesis was supported. Each hypothesis will be stated and then the results and analyses with graph, tables, or charts will be provided.

#### Hypothesis 1 Results:

**H1.** "The majority of residents will not be aware that risk exists for potential water scarcity for this region."

This hypothesis was unsupported based on the data gathered and percentages calculated for responses to specific questions that measured respondents perceptions of risk related to water scarcity. For example, survey results showed high frequency of knowledge and awareness that water scarcity is a potential problem for this region. Question #1 asked respondents “How would you rank your level of concern for these environmental issues in Eugene?” A list of Eugene environmental issues was provided which included drought and climate change. Respondents were provided with a Likert type scale with a continuum of responses ranging from “Not at all important” to “Extremely important.” Seventy-seven percent of respondents agreed that drought is an important environmental issue.

Question 4 asked, “What is your level of agreement on these statements?” and then several opinion statements related to water availability were presented. Some options on the response scale were collapsed and percentages combined for “agree” and “strongly agree.” Resulting percentages revealed that ninety-three percent of respondents agreed that water scarcity is an issue with which they are concerned. Only fifteen percent agreed with the statement “water for all my needs will be met in the future”. These percentages appear to signal respondents’ perception of water insecurity.

Question #2 asked “How knowledgeable do you consider yourself about the following issues? The scale ranged from “no knowledge” to “expert.” Three response scales (some knowledge, very knowledgeable, and expert) were collapsed into one category- “knowledgeable.” Results revealed that approximately ninety percent of respondents reported having knowledge about “water availability in Eugene.” Approximately eighty-two percent of respondents reported having knowledge of “social and environmental impacts of seasonal water scarcity.” Figure 14 is a graph depicting the Knowledge of water scarcity and

snowpack conditions response frequencies. The interpretation made based on response frequencies in these categories, is that it appears respondents actually do have knowledge and do perceive risks pertaining to water scarcity. Thus, hypothesis #1 is unsupported.

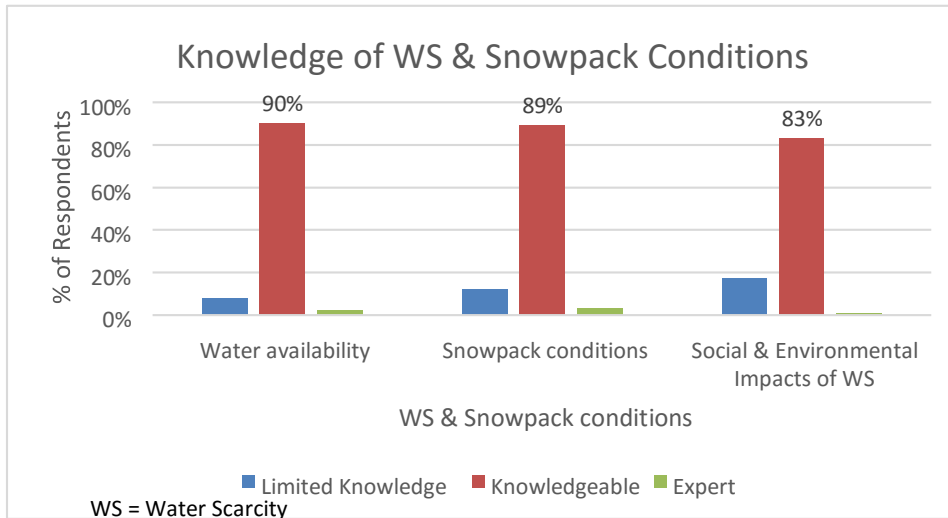


Figure 13 Knowledge of Water and Snowpack Conditions

Hypothesis 2 Results

**H2.** “The majority of residents will not be aware that a potential severe water scarcity is linked to a several decade climatic trend, potentially climate change.” This hypothesis was unsupported based on percentages of respondents and questions measuring these variables (Figure 15). For example, ninety-four percent of residents agreed that lack of snowmelt from dwindling snowpack will cause drought in this region, ninety percent agreed that snowpack conditions are linked to climate change, and seventy-one percent agreed that this would personally affect them.



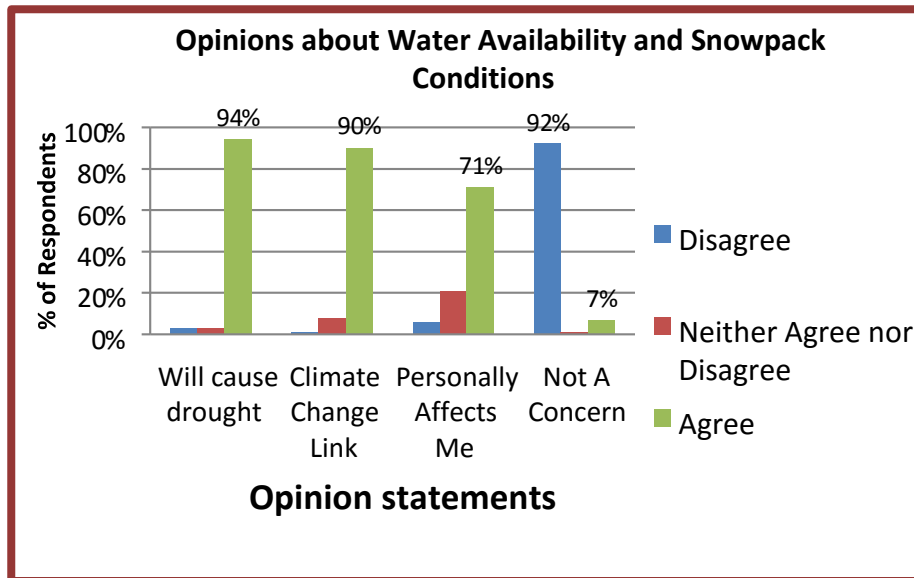


Figure 14 Opinions about Water Availability and Snowpack Conditions

Hypothesis 3 results

**H3.** “A relationship will be found between public perceptions of risks related to potential severe water scarcity and degree of public support and participation in water sustainability programs and management.” The analysis of the data couldn’t show definitive support or lack of support of the hypothesis, therefore hypothesis #3 is inconclusive.

The author measured the variable “degree of public support” by looking at percentages of respondents who answered questions related to experiences with and opinions of Eugene water management organizations. The question, “Have you participated in any water education/outreach programs initiated by local organization or government agencies in Eugene?” revealed that twenty-one percent of respondents have been involved with local Eugene water education/outreach programs. Most respondents (fifty-seven percent), who had experience with local water management organizations have helped as volunteers with

education/outreach. Forty-three percent attend meetings of some kind and twenty-nine percent have volunteered and eighty-six percent of these respondents have had experience with Eugene Water and Electric Board (EWEB). Sixty-four percent of residents who had experiences with local water education programs rated the quality of water resources/education outreach programs as “good.” This percentage was calculated by combining responses of good and very good. Of the respondents who have not had experiences with local organizations water education/outreach programs, thirty-seven percent would like to participate with outreach education programs.

For analysis purposes of all results to question #12, the author combined the responses, “somewhat agree,” “agree,” and “strongly agree” of the 7 point scale. For question #12, respondents were asked about their level of agreement with specific statements about Eugene water management. Close to twenty percent of residents agreed local water management education is adequate. The same method was used to determine the level of agreement with the statement “my local water management is prepared for water scarcity.” Twenty-two percent of respondents agreed with this statement. Approximately ninety percent of respondents agreed with the statement, “Water scarcity preparedness should be a priority for our local water management organization.”

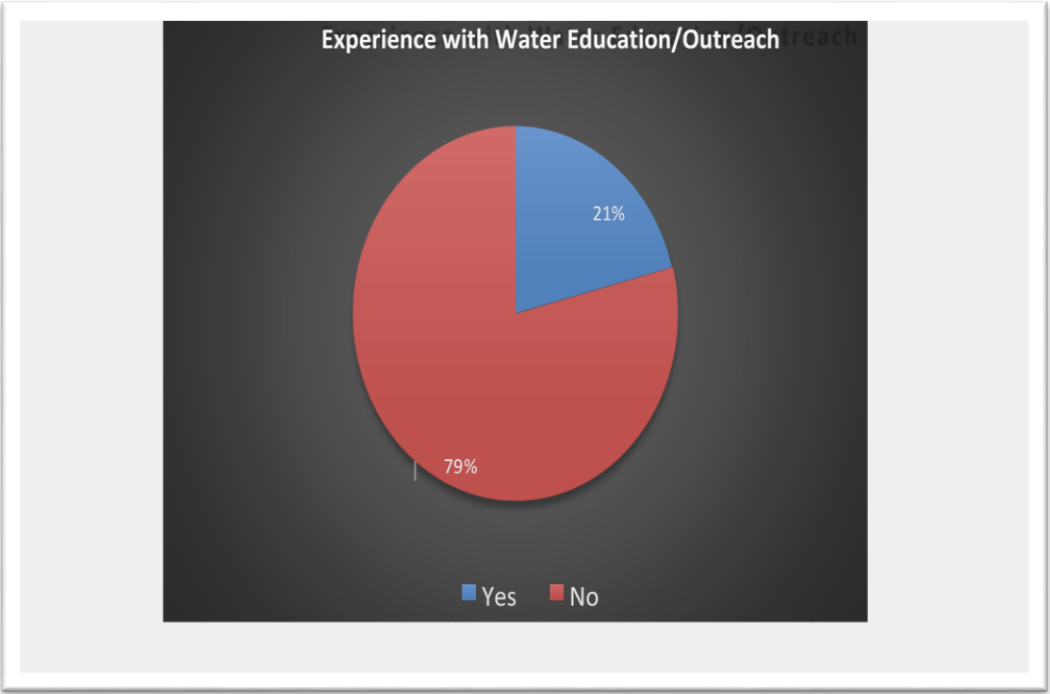


Figure 15 Experience with Water Education/Outreach Graph

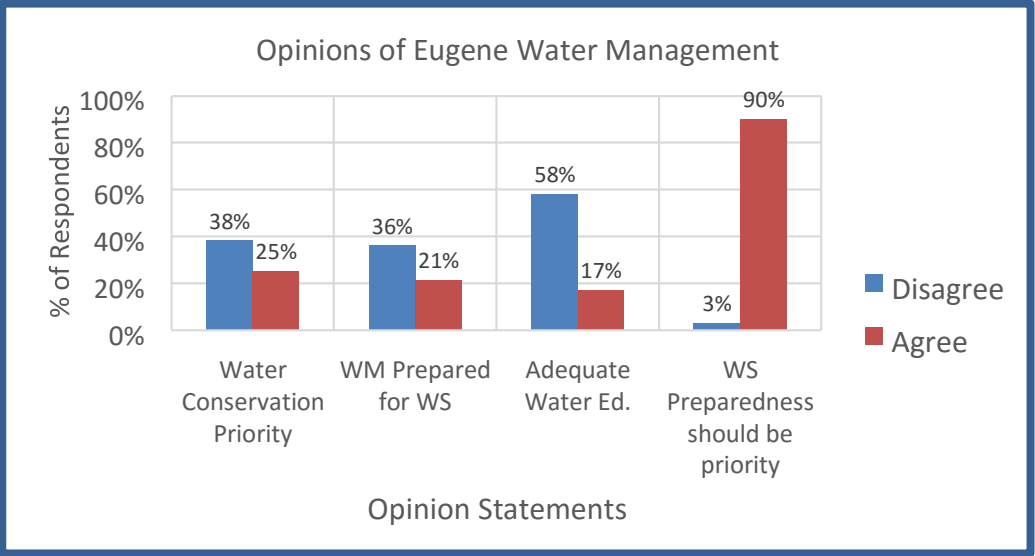


Figure 16 Opinions of Eugene Water Management Bar Graph.

In analyzing the degree of support relative to risk perceptions, the above percentages to responses indicated that it could not be concluded whether a significant relationship exists between these variables. This table provides a visual depiction.

Support of and participate in Water Sustainability & Management	Perceptions of Risk	Conclusions
21% have participated. <b>Participation Low</b>	74% agreed that drought is a concern for Eugene & 71% of respondents agreed that snowpack conditions will affect them personally and cause drought. <b>Risk High</b>	<b>Risk High, Participation Low Inconclusive!</b>
37% would like to participate in Water Sustainability Programs. <b>Support in the middle.</b>	Only 21% Agreed that Water Management is prepared for Water Scarcity. <b>Risk High</b>	<b>Risk High, Public support in the middle. Inconclusive!</b>
90% agreed water scarcity preparedness education should be priority for managers. <b>Support High.</b>	93% of Respondents agreed that water scarcity is a concern. <b>Risk High</b>	<b>Risk High, Public support High!</b> Appears to be a relationship between water scarcity concern and level of support for water scarcity preparedness education.

*Table 1 Relationship between Perceptions of risk and Support for water management Table.*

The degree of support based on experience and opinions of water management lies somewhere on the low to medium range. At the same time as shown here and in the analysis of hypothesis #1 and #2 results, the degree of risk perception is high for respondents. Hypothesis #3 meant to show that as risk perceptions increase, then the level of support and participation with local water organization and programs will correspondingly increase. This hypothesis couldn't be concluded as supported or unsupported based on the limiting factor of few statistical tests employed.

*Hypothesis 4 results*

**H4.** “Levels of education, income, and political affiliation will be found to influence resident's perception and awareness of a risks related to potential water scarcity in this region.” Results were generally inconclusive for this hypothesis. However, there does appear to be a possible relationship between income levels and perceptions and awareness of risks related to potential water scarcity. As income decreases, the respondents were more likely to agree that risk was high.

Water Scarcity Opinion statements	Percent who agreed with statement had income 100-500 K	Percent who agreed with statement had income 60-100 K	Percent who agreed with statement had income 30-60 K
Drinking Water Secure	45%	64%	39%
Water needs met in future	29%	18%	11%
Water Scarcity Concerned	88%	95%	99%
LSP will cause Drought	93%	97%	99%
Personally Affected by LSP	76%	60%	67%




Table 2 Relationship between income and risk perceptions

A relationship of influence between the independent variables of education level, political affiliation, and the dependent variables of awareness and perceptions of risk was difficult to conclude without statistical analysis (refer to Table 2). A cause/effect relationship or statistical significance could not be confirmed.

Surveys revealed that respondents at all education levels mostly agreed (ranging from eighty-three to one hundred percent in agreement) with statements related to water scarcity awareness and risk. The same results were present with political affiliation (with eighty-four percent to ninety-four percent) in agreement). Each category of political ideology showed nearly the same percent of agreement with the statement “Water scarcity is an issue I am

concerned about". This may be related to the population sample, which is not necessarily representative of the entire City of Eugene. The survey respondents living in southeast Eugene indicated no representation of conservative political ideology and most residents are educated holding at least a two year degree or higher, with a high percentage of graduate and postgraduate degrees. These factors point to an external validity issue because all of Eugene might be considerably more diverse. Additional research in this area and for this hypothesis is needed. In addition, a statistical test, possible chi-square or correlation should provide more significance and possibly support or disprove hypothesis # 4.

#### Survey Results Summary:

Hypotheses # 1 and 2 were unsupported. Southeast Eugene respondents are actually well aware of drought and water scarcity while also seemingly perceptive of their personal risks. Respondents were also very aware of the conditions of snowpack loss in the Western Cascade Mountains and agree that there is a probable link with climate change. Respondents strongly desire water scarcity and preparedness education from local water management organizations and believe water scarcity preparedness should be a priority. Hypotheses 3 and 4 were inconclusive. Lack of diversity within this population and small population size combined with the lack of statistical testing to show definitive significance, made it difficult to conclude relationships between risk perceptions and independent variables such as political ideology and education. Southeast Eugene respondents generally support Eugene water management organizations based on their experience and desire for experience with water management education outreach programs. However, this hypothesis was difficult to conclude based solely on frequencies; the author did not conclude whether or not there was a significant relationship between levels of income, political ideology, or education and support of Eugene water management organizations and policies. It is still important to note

that the analysis does seem to imply that respondents with lower incomes perceived greater risk and also displayed a higher percentage of certainty that water scarcity is a problem.

Southeast Eugene respondents are a unique demographic who have mostly attended college or achieved an academic degree from an institution of higher learning. While respondents self-report as being knowledgeable and concerned about environmental issues, these trends are not necessarily representative of greater Eugene.

## VII. Discussion:

This Capstone project primary research question sought to answer “How do Eugene resident’s perceptions of risk for potential severe water scarcity linked to climate change impact their public participation and support of local sustainable water management strategies?” Although the research was not able to answer this question conclusively, analysis did uncover relevant data illustrating the citizen risk perceptions of water scarcity, knowledge and awareness of water scarcity and its causes, and participation level and support for water management in this subpopulation of Eugene.

This section will discuss the research results in the context of related literature on risk perceptions. Additional exploration and research into these topics will be recommended for this study location and beyond. This Capstone research revealed valuable insights into Eugene resident’s risk perceptions of water scarcity along with information which can inform and guide water managers toward effective techniques to educate and engage residents toward a more unified purpose and understanding of water scarcity and mitigation options for this region.

### Water Scarcity Awareness and Risk perceptions:

The hypothesis that “the majority of residents will not be aware that risk exists for potential water scarcity for this region” was unsupported. In fact, this subpopulation of Eugene is actually very aware of potential water scarcity and drought, ranking these two issues high (seventy-seven percent) as important an environmental issue. Ninety-three percent of respondents agreed that water scarcity is an issue with which they are concerned, while only fifteen percent agreed with the statement “water for all my needs will be met in the future”, which signals a perception of personal risk related to water scarcity.

These findings are consistent with the results of both Wolters (2012) and Hubbard (2013) who found that Oregonians are concerned about water scarcity: However, Wolters (2012) and Hubbard’s (2013) research did not reveal whether or not residents express perception of personal risk. The survey results seem to indicate that respondents actually did perceive some level of personal risk from water scarcity. This could indicate to water managers that residents in this particular neighborhood do not require extensive convincing that water scarcity is an issue they should be concerned about. In addition, respondents to the SE Eugene Survey “Water Resources in Eugene” self-reported a high level of knowledge concerning water scarcity in their region and its potential causes. Water managers can use these findings to tailor public water outreach programs that are not heavily laden with information or messages of risk, but are instead more focused on solution and mitigation messages. A conclusion can be drawn that because the residents are aware and perceive risk from water scarcity they will be more likely to support and engage in water mitigation strategies.



### Perceptions of Water Scarcity Linked to Climate Change:

The results of testing hypothesis #2 show that respondents are aware of the complex relationships that exists between Eugene's water supply and climatic trends, including climate change. Ninety-four percent of residents agreed that lack of snowmelt from dwindling snowpack will cause drought in this region, ninety percent agreed that snowpack conditions are linked to climate change, and seventy-four percent agreed that this would personally affect them. Although, these results cannot definitively indicate that respondents will support management decisions targeting climate change, they may provide insight into Eugene residents risk perceptions of water scarcity as it relates to climate change. This is important because, Lieserowitz's (2005) research maintains the importance of public risk perceptions of climate change in shaping public opinion, which plays a direct role in political decision making related to climate change impacts. Individuals are more likely to support initiatives or take personal action to mitigate climate impact if they perceive definite risks or believe something is dangerous (Bord, O'Connor and Fisher 2000, Dessai et al. 2004). Additional research inquiry through survey or interview methods should ask residents which specific climate change management polices they will support in order to mitigate water scarcity risk.

Based on previous literature and the survey it seems very likely that residents of Eugene will take action to mitigate climate change impacts because they perceive risk and understand the relationship between water scarcity and climate change. Yet, this research doesn't uncover the level of concern or risk residents perceive about climate change as it relates to water compared to other risks, which could be important when residents are tasked with supporting one environmental initiative over another. For example, Hubbard (2013)

found that Oregon residents perceive industry as a greater risk to water resources than climate change and population growth. Hubbard explains that this perception exists even though the IWRS process does not list industry as a threat to Oregon's water quantity and quality (Oregon.gov 2016). Industry only uses two percent of Oregon's freshwater a year (Kenny 2009) and does not pose significant risk to water resources. Hubbard (2013) theorized that this inconsistency in perception of risk might be related to "controllability" of the risk. Industry has high controllability and the public is very familiar with the risks it has presented in the past (i.e., Love Canal), while climate change and population growth are projected risks, and therefore their probability and controllability are uncertain (Hubbard 2013). A challenge is presented for managers if Oregon's public perceives a risk as low probability and/or low in controllability and are less willing to accept or support a management strategy directed at that risk (Sjöberg 1998).

This research did not explore resident's perceptions of other climate change risks related to water scarcity. Water managers should consider the possibility that although residents in this neighborhood understand climate change as a risk to water, they might not understand the magnitude of its impact and the importance of expeditious mitigating action or what these actions entail. Although, the residents of southeast Eugene seem in agreement with climate change as a scientific fact, this sub-population is not necessarily representative of greater Eugene or broader Oregon populations. Although water scarcity and drought are not definitively linked to climate change, there is much evidence pointing in that direction (Dalton et al. 2013; Nolin 2012; Mote and Salathé 2010), and yet many American's reject the existence of climate change (Leiserowitz 2005). Thus, water managers will benefit from learning more about residents' understanding of water resources issues as they relate to

climate change and also a broader representation of underlying beliefs associated with climate change.

Risk and Support for and Participation in Water Sustainability programs and Management:

Hypothesis #3: “A relationship will be found between public perceptions of risks related to potential severe water scarcity and degree of public support and participation in water sustainability programs and management.” This hypothesis is inconclusive, as the data did not show definitive support or lack of support of the hypothesis.

The question, “Have you participated in any water education/outreach programs initiated by local organization or government agencies in Eugene?” revealed that twenty-one percent of respondents have been involved with local Eugene water education/outreach programs. Fifty-seven percent of the twenty-one percent of respondents who have had experience with local water management organizations have engaged in education and outreach, forty-three percent of the twenty-one percent who have had experience have attended meetings of some kind, and twenty-nine percent have volunteered, and eighty-six percent have had experience with Eugene Water and Electric Board (EWEB).

Approximately ninety percent of respondents agreed with the statement, “Water scarcity preparedness should be a priority for our local water management organization.” Although residents are concerned and want their local government and water organizations to be prepared and take action, there has been relatively inconsiderable involvement from residents with water management organizations (twenty-one percent). This research did not reveal if this lack of respondent involvement is because of the water management organizations not providing enough opportunities, or if residents are making a personal choice to avoid participation.

Studies of risk perceptions show that people with higher risk perception are more likely to take action and support mitigation efforts and policy (Engle 2012). Since the “Eugene Risk Perceptions Survey” analysis of results did not determine a definite relationship between support and level of perceived risk, further research should address residents support for and participation in water resource issues. Although residents seem educated on this issue, the results of that research and survey does not offer insight into perceptions on mitigation efforts.

Knowledge about an issue will not necessarily lead to environmental behavioral changes (e.g., Finger 1994; Willis et al., 2011), but has been found to be important for behavioral modification. Hubbard’s (2013) research results did find that those with more knowledge on the issue of water scarcity actually perceived higher risk. Most respondents in the survey reported being knowledgeable about “water availability in Eugene.” Approximately eighty-two percent of respondents reported having knowledge of “social and environmental impacts of seasonal water scarcity.” Respondents were both knowledgeable and concerned about water scarcity due to their perceived risk. Contrary to this relationship between knowledge and risk perception are the findings of Wildavsky and Dake (1990) whose work revealed individuals with higher self-assessed knowledge on an issue perceived less risk. Yet wildfire risk perception theory points to the degree of knowledge corresponding to level of risk perception. Some wildfire studies focus on the role of the information source on impacting the level of risk perception. Information sources that most increased perception of wildfire risk were local, informal, and social (Brenkert-smith et al. 2013). The social interaction variable most strongly associated with perceived probability of experiencing a fire is talking with one’s neighbors about fire and the second strongest

association is with attending a fire-related event (Brenkert-smith et al. 2013). Hubbard (2013) also discovered that the type of information source, (environmental groups or government agencies) played a role in predicting water resource risk perception.

This survey did not determine from what kinds of sources residents had received education/information related to water scarcity. Water managers would benefit from further investigation into the of information sources that residents have experiences with, what impact these sources have on their risk perceptions, and what relationship exists between risk perceptions and knowledge level.

#### Sociodemographic Variables and Water Scarcity Risk Perceptions:

Sociodemographic variables associated with risk perceptions studied for this research were income, political ideology, and education. This study assumed that relationships would be found between level of risk perceptions and levels of education, income, or political ideology. The intention was to uncover factors that might inhibit or contribute to the public's perception of water scarcity risk so that water managers could tailor message strategies and target audiences in order to effectively garner support and action on water issues.

Hypothesis #4: “Levels of education, income, and political affiliation will be found to influence resident's perception and awareness of a risks related to potential water scarcity in this region.” Although results were generally inconclusive for this hypothesis, discussion of the findings and avenues for further research should be addressed. For this research project, both education and political ideology seemed to show no significance in determining risk perceptions or were inconclusive. This is interesting because previous researchers of Oregon residents (e.g. Wolters 2012) in related studies have uncovered clear relationships between

these variables. Wolters' (2012) study found education to be an important indicator of water scarcity awareness. Hubbard's (2013) research also concluded that Oregon residents with higher education showed higher levels of concern for water scarcity. However, some risk perception research (O'Conner, Bord, and Fisher 1999) discovered that higher education leads to less perceived risk. The inconclusive results from the survey research project do not necessarily indicate no relationship exists, rather that there might be issues inherent with my survey population or data analysis. The survey respondents were not necessarily representative of a broader population. Most participants held at least a two year degree or higher, with a high percentage holding graduate degrees, leaving a lack of representation for the socio-demographic of those having little or no formal schooling beyond high school. This data indicates the need to study a broader sample to uncover a relationship, if one exists, between Eugene residents education levels and risk perceptions of water scarcity. The survey research does reveal that respondents in this particular area are educated and that most of them are concerned about water scarcity.

This data provides insight into the opinions of residents and knowing their education background provides a gateway for water managers to utilize appropriate communication strategies and language. Trust is a vital component of consensus building which ultimately leads to collaboration to solve natural resource issues. According to many experts in natural resources trust is built through communication with local citizens in a respectful manner, and an understanding of their cultural, personal, or economic connections. Using terminology and language residents can relate to opens up dialogue. The result can be emergence of collaboration and consensus building around how to solve difficult natural resource issues.

More research exploring relationships between perceptions and education levels throughout Eugene could lead to more effective communication between water managers and residents.

*Income and Risk perception:*

Hubbard's (2013) research determined that Oregon residents with higher income were more likely to perceive risk. These findings are possibly inconsistent with survey project research findings, which showed a potential correlation between lower incomes and higher perceived risk from water scarcity. The Eugene risk perceptions survey results related to income are also more aligned with previous research (O'Conner, Bord, and Fisher 1999) that found an inverse relationship between risk and education and income. Previous studies (O'Conner, Bord, and Fisher 1999) observed that as income and education rise, risk perception is reduced. Understanding the role of income level in risk perception is important. If income levels are a factor, then a significant portion of residents could perceive high personal risk of water scarcity. Within the City of Eugene, lower income residents do not seem to be more severely impacted by drought conditions than higher incomes residents, except for water costs to irrigate lawns and vegetation. Overall, respondents in lower income brackets may feel less capacity for adaption to extreme environmental hazards related to climate change and drought including wildfire, the potential for water rate increases, or economic impacts. For water managers, understanding the implications of this relationship between income and water scarcity risk perceptions could improve program initiatives that promote capacity. A higher risk perception does not necessarily equate with an increased motivation to take risk mitigation actions or support management regulations that require mitigation. Income does have a direct impact on an individual's capacity to adapt and cope with difficult situations, because it provides a buffer to some of the more immediate

concerns. For example, research of wildfire risk perceptions (Martin, Martin and Kent 2009) demonstrated the role of personal capacity as an indicator of risk mitigation actions; finding those with less capacity were less likely to follow guidelines to create a fire safe environment. In comparison, a study conducted by Corral-Verdugo, Bechtel, and Fraijo-Sing (2003) identified lower income respondents were likely to consume less water than wealthier respondents, potentially resulting from their continuous water scarcity experience leading to their realization that water must be sustained for livelihood. Although these respondents were already experiencing extreme water scarcity, this Capstone research shows that income might play a role in risk mitigation actions and therefore support for actions that alleviate water scarcity. Supplementary research should be conducted to fully ascertain if Eugene residents with lower incomes actually perceive risks from water scarcity and if that risk perception will lead to more or less actions to mitigate water scarcity and support water management leading to conservation and sustainable water use. Water management entities might also benefit from understanding how people at each income level perceive types of mitigation strategies, how mitigation actions related to risk will benefit or be a cost to them and how they weigh the value of those benefits and costs.

#### *Political Ideology and Water Scarcity Risk perceptions*

Wolters (2012) found that political ideology was not a strong indicator for Oregonian's level of concern for water scarcity. The Survey research on political ideology was inconclusive, which might be due to the population sampled. Most respondents to the Survey self-reported their political ideology to be "Liberal." Neither Hubbard's (2013) nor Wolters' (2012) research revealed political ideology as a significant predictor of water scarcity risk perceptions or water awareness. Yet, other studies (Rowe and Wright 2001; Buttel and Flinn



1978a; Dunlap, Xiao, and McCright 2001; Samdahl and Robertson 1989) found political ideology to have an important influence on environmental risk perceptions. In addition, political ideology has been strongly associated with acceptance of climate change and support of climate change policy. McCright and Dunlap (2011) found that liberals and democrats were more likely to disclose climate change beliefs congruous with climate science and convey personal concern about climate change than conservatives and republicans. Research on climate change risk perceptions also shows that these perceptions influence level of support for policy related to climate change impacts. Water scarcity and drought are scientifically linked to climate change for Eugene, the Willamette Valley, and Oregon (Dalton et al. 2013) These survey results indicated that residents are very aware of the relationship between drought/water scarcity and climate change impacts.

According to related studies (McCright and Dunlap 2011), the predominantly liberal political ideology of these residents should support the conclusion that residents of this area perceive a high level of risk associated with water scarcity related to climate change and that their political ideology plays into these perceptions and awareness. However, because the survey results were inconclusive due to the lack of a broad political ideology representation in the survey population, this research cannot adequately draw conclusions. A more in-depth research project covering a broader population with questions related to political ideology could reveal connections between water risk perceptions, climate change acceptance, and support of local water management/climate change policy.

## VIII. Limitations of this Research Project:

Limitations to this survey study include sample size, time and resources. The Southeast neighborhood of Eugene sample was chosen based on convenience. The study did not use a random sample population, lacks external validity, lacks a pilot study, and was conducted by an inexperienced researcher. The sample size of 562 Southeast neighborhood residents is not large or diverse enough to represent the entire City of Eugene. This sample was used for convenience and is not random because it targeted a small portion of the Southeast neighborhood, and respondents showed only slight demographic diversity. A large percentage of respondents had higher education degrees, middle class to upper middle class incomes, and were 60 years and above in age. Political ideology was skewed toward liberal and independent, but predominantly liberal. Sampling bias could be a limitation because the researcher also lives in Southeast neighborhood of Eugene and respondents could have answered questions a certain way especially if they had personal familiarity. Surveys were anonymous so this might eliminate this potential bias.

This research was conducted without extra funding or a support team. Time to complete the entire survey which informs this Capstone Project was limited by the length of the Semester course in spring 2015. Reminders were not sent to respondents to ensure privacy for research subjects. The researcher was not skilled in conducting surveys and also lacked a statistical background and familiarity with statistical software. A more thorough statistical analysis is in order.

## VIII. Conclusions:

Previous studies on risk perception combined with the results from the “Water Resources of Eugene Oregon Risk Perceptions Survey” make it clear that Southeast Eugene residents view water scarcity as a significant issue which poses risks to them personally. Respondents clearly understand the connection between climatic conditions of warming temperatures and melting snowpack and the strong link to climate change. Predicted impacts of climate change are widespread and clearly pose threats to human and natural systems throughout the Willamette Valley. Although the risk of water scarcity and drought from increasingly depleted snowpack is not definitively linked to climate change, the evidence is compelling enough for residents and managers to consider these natural resource issues as wicked problems and to address them within the coupled human and natural systems (CHANS) framework.

Climate change is both impacted by and simultaneously impacting natural resources and society through feedback loops and hierarchies of interrelatedness. Climate change affects where people will migrate to, and at the same time, these migrations are influencing climate change patterns. Some scientists call this an example of CHANS (Liu et al. 2007). Cities are rapidly expanding and expected to continue this trend. Simultaneously, rural “exurban” areas are expanding with rising influxes of amenity migrants. Human action is more tightly linked than ever before with natural systems. Release of CO<sub>2</sub> at an unsustainable rate leads to climate change which leads to problems of water scarcity and quality, drought, wildfire, habitat destruction and species extinction, which all have feedback loops into one another which then circle back to impact humans and each are embedded within a hierarchy of interrelatedness. Residents of Eugene and resource managers need to

understand these feedback loops and recognize the complexity of the problem. This research revealed the level of knowledge and awareness that a portion of residents have about the issue. Managers can take this into consideration when planning water conservation measures and programs to involve citizens.

Survey respondents also showed a strong desire to be involved with water resource issues and support water scarcity/drought policy, education, and outreach. This indicates that Eugene water management organizations may gain successful, sustainable public support of policy, funding, and programs if they create more inclusive public water outreach and education programs. While also prioritizing water scarcity preparedness education and drought mitigation strategies. Based on responses to the “Risk Perceptions Survey,” some residents may be very receptive to reducing their risks from water scarcity. Correlations have been found between risk perceptions and actions to reduce risk in research related to environmental hazards such as water and air pollution (Baldassare and Katz 1992).

However, it is unclear from this research if residents would or have taken action to mitigate water scarcity risks, or if they understand what the exact risks or effective actions might be, or even how they would become involved with water resource programs. More research targeting the aforementioned topics would improve the understanding of how risk perceptions impact residents’ engagement in and support of water resources management.

In addition, this research suggests that a more comprehensive study should be designed, which looks at differences in water scarcity opinions across neighborhoods, so that Eugene water management organizations can shape their water mitigation strategies accordingly. This survey revealed that southeast Eugene residents are very aware and concerned about water scarcity issues and causes, and may benefit from education focused on

risks to immediate lifestyle such as drinking water, power supply, economy, food, etc. However, other neighborhoods and residents of Eugene may vary in their degree of water scarcity awareness, knowledge, risk perceptions, support of and experiences with Eugene water management organizations. Sending out the “Risk Perceptions Survey” to encompass a broader, more diverse, and more representative Eugene population could better reveal relationships between sociodemographic factors and risk perceptions. A random survey should be conducted to reach all neighborhoods & demographics of Eugene.

Wolters (2012) discovered that differences in environmental values, including water quantity and quality, were influenced by gender, location, education, and socio-demographics. The research accomplished by Wolters (2012) cannot be concluded by this study. Additional research is needed to reach a larger more representative population. A pilot study should be conducted first to ensure internal validity and reliability of the survey instrument used.

Eugene water management organizations such as Eugene Water and Electric Board (EWEB), Eugene City government, Oregon state water resources department (OWRD), and local non-profit water organization could benefit from further research focused on risk perceptions of Eugene residents. This research project might also benefit from expansion to the greater Southern Willamette Valley region to provide a comprehensive look at a watershed level of residents’ concerns related to water resources. This research study might also be improved through a different research methodology approach. A mixed method approach, possibly exploratory, could begin with interviews of a randomly selected population of residents and water managers to provide completeness, complementarity, and triangulation to strengthen the research results and lead to more conclusive and credible

findings (Leedy and Ormrod 2012). The interviews could be followed by the quantitative survey and analysis using the themes revealed through the interviews and coding of themes.

Expanded research will help fully identify Eugene residents' risk perceptions, knowledge, and awareness of water scarcity and related snowpack conditions. Numerous possible directions exist for how this capstone project could be expanded on and further developed to serve as a tool for natural resources and water managers. For example, the relationships between income levels and possible links to greater perceived risks from environmental dangers such as drought could lead to local initiatives that help residents adapt and prepare for water scarcity impacts. Also research including a water scarcity risk perception survey of Eugene water managers to uncover their opinions about water resources, role of the local public, and reveal if the risk perceptions of residents are aligned with those of water managers. Moreover, ancillary research is necessary to reveal whether education and political ideology play any significant role in risk perceptions and water related government/management support. Surveying residents to uncover worldviews and beliefs such as NEP, DSP, amenity migrant, etc. should be a primary focus especially the strength of the NEP as a determinant of water scarcity concern and risk perception related to water resources as it did for both Hubbard (2013) and Wolters (2012). Their studies revealed that as biocentrism increased so did concern (Wolters 2012) and risk perceptions related to water resources (Hubbard 2103).

Additional research might also focus on the “amenity migrant” phenomenon; revealing whether or not residents of Southeast Eugene fit this demographic typology and share the attributed values. The “amenity migrant” has not lived in an area generationally or long enough to fully understand the natural systems, they therefore lack “local environmental

knowledge (LEK)” or their LEK might derive from outdated or misinformed community members (Erikson and Prior 2011). Community engagement is vital to work toward natural resources and water solutions, yet geographic trends of quickly changing human demographic patterns (Hendrix 2012) create new and complicated barriers to this engagement. Risk and uncertainty are barriers to communication and successful collaborative programs. The public distrusts natural resource planners when risk and uncertainty are not clearly communicated or adequately framed (Wilson et al. 2012). Climate change also contributes to the level of risk and uncertainty underlying natural resources management decisions. And risks are inherent in certain natural resource programs, i.e. fire remediation. Despite scientist’s technical expertise concerning many natural resource problems, the public often chooses to either deny, distrust, or become disengaged, instead of working toward agreement on solutions.

This capstone research could set the stage for more inclusive water management programs. Natural resource (NR) and water managers cannot achieve consensus to solve wicked problems through outmoded management strategies. Social science with primary focus on communication, values, consensus, and conflict resolution could effectively guide the natural resources field toward transformative approaches. Natural resources/Water experts should be trained in collaborative learning, conflict resolution, and team-work scenarios. Processes which underlie consensus-building must be explicitly articulated and taught to NR/Water managers (Bingham 1997). The goals of NR managers must also go beyond education of the public and top-down management decision making. Youth initiatives, community gathering in local places, trust-building through community events,

meetings that utilize agreed upon processes, community initiatives and partnerships, etc. have proven successful in NR management.

In order to gain public acceptance, Natural resource managers are now encouraged to focus on approaches that involve learning about the local culture to truly understand their relationship with the local environment (Shindler 2000). For example, Erikson and Prior (2011) point out that demographic shifts in the Australian bush have created complications for communication of wildfire risk. They recommend NR managers learn wildfire LEK and understand how it plays a role in community engagement. Making connections with locals through community gatherings with “fun days” creates opportunity for events like wildfire storytelling evenings. This program works because it is embedded in the cultural context (Shindler 2000) of these communities (Erikson and Prior 2011). Stankey and Shindler (2007) examined public acceptability in protecting rare and little known species (RLKS). Erikson and Prior (2011) found many key factors that promoted public acceptance of management decisions. These include being proactive, transparent, and inclusive with the public; involving the public at every level and utilize their knowledge and feedback, communicating risk and uncertainty so that citizens trust agencies, and incorporating continual monitoring of public values and judgements to foster the type of understanding agencies need to maintain public support.

As society shifts so do natural resource issues thus adding increased complexity and difficulty to NR management. The problems are wicked and messy: climate change, water scarcity/quality, wildfire, habitat destruction, and species extinction. The ability of the NR managers to gain consensus toward solutions to these problems could involve this strategy 1) Start with a collaborative goal and plan for it. 2) Build trust with the public; engage, invite,



ask, listen, and learn 3) Train professionals in conflict resolution, collaborative learning, and communication techniques 4) Build long lasting initiatives and partnerships from the bottom up.

The EWEB VIP program is an example of water managers working to gain consensus on solving wicked problems through collaboration, building public trust and long-lasting partnerships that support sustainable natural resource initiatives. The Eugene Water & Electric Board (EWEB) is Oregon's largest customer-owned utility and provides water and electricity to Eugene and to residents along the McKenzie River. EWEB has over 50,000 water customers who consume 9.6 billion gallons on average per year, and 68% of its power comes from hydro sources (Doppelt et al. 2009). The McKenzie River is the only source of water contributing to EWEB's drinking water and electricity generation. EWEB has become increasingly concerned about the long-term viability of the McKenzie River as its single source because of climate change, drought, wildfire, population growth, and water pollution. In response to these growing concerns, EWEB initiated a progressive program to protect the McKenzie River headwaters. This program, Voluntary Incentives program (VIP) engages landowners in riparian protection and enhancement to promote species habitat, clean water, shade to cool water, vegetation that inhibits nutrient pollution and slows erosion, and carbon sequestration potential. This capstone project could inform the VIP program, providing a foundation to understand the local context, risk perceptions, and knowledge of water issues.

### Summary

The author intends that the content, analysis, results and recommendations provided here will lead to more advanced examinations of this natural resource problem, it's societal connections, and the long-term solutions to promote balance in human and natural systems.

Recommendations made in this paper include: (1) qualitative research using interview methods on both Eugene residents, and water and natural resource experts/managers; (2) dissemination of surveys to a much broader population which captures a diverse and range of opinions existing in Eugene; (3) a more comprehensive analysis of other predictors of risk and awareness; and (4) research on the impact of transformative, creative collaboration between agencies, organizations, and residents, and (5) further support of coupled and human natural systems research related to water scarcity, wildfire, drought, and climate change.

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# Appendix

## Appendix A

### **Frequency Report of Survey: Eugene Residents' Perception of Water scarcity**

**Q1. How would you rank your level of concern for these environmental issues in Eugene?**

#	Question	Not at all Important	Very Unimportant	Somewhat Unimportant	Neither Important nor Unimportant	Somewhat Important	Very Important	Extremely Important	Re
1	Air pollution	-	-	2.78%	1.39%	19.44%	44.44%	31.94%	
2	Water Pollution	-	-	-	2.82%	12.68%	46.48%	38.03%	
3	Habitat Destruction	1.39%	-	-	-	13.89%	45.83%	38.89%	
4	Climate Change	1.39%	-	1.39%	2.78%	9.72%	30.56%	54.17%	
5	Drought	1.39%	-	-	2.78%	18.06%	34.72%	43.06%	
6	Species Extinction	1.41%	1.41%	-	4.23%	18.31%	39.44%	35.21%	
7	Invasive Species	1.39%	1.39%	-	1.39%	30.56%	47.22%	18.06%	

**Q2. How knowledgeable do you consider yourself about the following issues?**

#	Question	No knowledge	Little knowledge	Some knowledge	Very Knowledgeable	Expert	Response	Average Value
1	Water availability in the Willamette Valley	-	8.33%	69.44%	20.83%	1.39%	72	3.15
2	Climate conditions in the Willamette Valley and Cascades	-	5.56%	62.50%	29.17%	2.78%	72	3.29
3	Climate pattern impacts on Cascade snow pack	-	12.50%	54.17%	31.94%	1.39%	72	3.22
4	Role of Cascade snow pack on Willamette Valley ecosystems	-	13.89%	54.17%	30.56%	1.39%	72	3.19
5	Social and environmental impacts of seasonal water scarcity.	1.39%	15.28%	52.78%	29.17%	1.39%	72	3.14

*For this question we are interested in your opinions about how snowpack impacts our water supply.*

**Q3.What is your level of agreement on these statements?**

#	Question	Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree	Response	Average Value
1	Loss of snowpack in the Western Cascades Mountains will contribute to drought conditions in Eugene.	-	2.78%	2.78%	54.17%	40.28%	72	4.32
2	Loss of Snowpack in the Western Cascade Mountains is linked to climate change.	-	1.41%	8.45%	49.30%	40.85%	71	4.30
3	I will be personally affected by diminished water availability related to loss of snowpack in the Western Cascade Mountains.	2.78%	5.56%	20.83%	37.50%	33.33%	72	3.93
4	Loss of snowpack in the Western Cascade Mountains is not a concern for me.	68.06%	23.61%	1.39%	4.17%	2.78%	72	1.50

*For this question we are interested in your opinions about water availability in Eugene.*

**Q4. What is your level of agreement on these statements?**

#	Question	Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree	Response	Average Value
1	My drinking water supply is secure.	4.17%	23.61%	22.22%	44.44%	5.56%	72	3.24
2	Water for all my needs will be met in the future.	8.33%	27.78%	47.22%	13.89%	2.78%	72	2.75
3	Water is abundant in Eugene.	5.63%	21.13%	29.58%	39.44%	4.23%	71	3.15
4	I can mitigate water shortage through personal action.	-	12.50%	12.50%	54.17%	20.83%	72	3.83
5	My actions will not make a difference toward overall water scarcity.	16.67%	55.56%	19.44%	5.56%	2.78%	72	2.22
6	Climate patterns are variable and humans can adapt.	18.06%	34.72%	20.83%	23.61%	2.78%	72	2.58
7	Water Scarcity is an issue I am concerned about.	1.43%	1.43%	4.29%	50.00%	42.86%	70	4.31

**Q.5 Please rank order the following items by pressing and holding your mouse**

**button on any item, and dragging it up or down to change its rank.**

**The most important uses of water for me are**

#	Answer	1	2	3	4	5	6	7	Responses	Mean
1	Irrigation for food	7	37	13	12	1	1	0	71	2.52
2	Drinking supply	50	11	7	2	1	0	0	71	1.49
3	Irrigation for lawn	0	0	0	2	1	6	62	71	6.80
4	River flow	5	12	25	13	10	6	0	71	3.41
5	Recreation	0	1	2	9	13	40	6	71	5.51
6	Hydropower	0	5	10	13	31	12	0	71	4.49
7	Ecosystem Services	9	5	14	20	14	6	3	71	3.77
	Total	71	71	71	71	71	71	71	-	-

**Q6. Please rank order these amenities for reasons to live in Eugene by pressing**

**and holding your mouse button on any item, and dragging it up or down to**

**change its rank.**






#	Answer	1	2	3	4	5	6	7	8	9	Responses	Mean
1	Lifestyle	16	16	7	11	10	5	3	3	0	71	3.35
2	Access to outdoors/nature	11	19	24	6	4	7	0	0	0	71	2.92
3	Water availability	4	2	17	13	12	11	10	1	1	71	4.56
4	Recreation	0	3	2	8	10	16	16	12	4	71	6.11
5	Employment	5	3	1	2	5	8	8	18	21	71	6.82
6	Livability	23	8	5	11	14	3	4	3	0	71	3.35
7	Housing	1	0	3	0	4	5	19	22	17	71	7.35
8	Similar beliefs ideology	5	9	7	6	6	5	5	10	18	71	5.70
9	Weather/Climate	6	11	5	14	6	11	6	2	10	71	4.83
	Total	71	71	71	71	71	71	71	71	71	-	-

**Q7. Have you participated in any water education/outreach programs initiated**







**by local organizations or government agencies in Eugene?**

#	Scoring	Answer	Bar	Response	%
1	✓	Yes		15	20.83%
2	✓	No		57	79.17%
		Total		72	100.00%

**Q8. Which local Water related organizations or government agencies do you have experience with? choose all that apply.**

#	Scoring	Answer	Bar	Response	%
1	✓	Long Tom Watershed Council		5	35.71%
2	✓	Eugene City Government		5	35.71%
3	✓	EWEB (Eugene Water and Electric Board)		12	85.71%
4	✓	WREN (Willamette Resources and Educational Network)		1	7.14%
5	✓	Other		5	35.71%
		Total		28	100.00%






**Q9. Choose the types of experience you have had or do have with water related organizations or agencies in or around Eugene. Choose all that apply.**

#	Scoring	Answer	Bar	Response	%
1	✓	Volunteering		4	28.57%
2	✓	Collaboration		4	28.57%
3	✓	Attend meetings		6	42.86%
4	✓	Consultation		3	21.43%
5	✓	Outreach/Education		8	57.14%
6	✓	Other		5	35.71%
		Total		30	100.00%

**Q10.How would you rate the quality of Eugene water resources education/outreach based on your experience?**

#	Question	Poor	Fair	Good	Very Good	Excellent	Response	Average Value
1	Quality of Eugene water resources education/outreach based on my experience.	7.14%	28.57%	42.86%	21.43%	-	14	2.79

**Q11.I would like to participate in water education/outreach programs.**

#	Answer	Bar	Response	%
1	Strongly Disagree		4	5.71%
2	Disagree		3	4.29%
3	Neither Agree nor Disagree		37	52.86%
4	Agree		23	32.86%
5	Strongly Agree		3	4.29%
	Total		70	100.00%




*For this question we are interested in your opinions about Eugene water management.*

**Q12.What is your level of agreement with these statements?**






#	Question	Strongly Disagree	Disagree	Somewhat Disagree	Neither Agree nor Disagree	Somewhat Agree	Agree	Strongly Agree	Response	Average Value
1	Local water management is inclusive of public participation.	2.94%	5.88%	10.29%	32.35%	23.53%	22.06%	2.94%	68	4.46
2	There is adequate water education and awareness in this region.	4.41%	22.06%	27.94%	25.00%	17.65%	1.47%	1.47%	68	3.40
3	Water conservation is a priority for our local government.	5.80%	10.14%	21.74%	37.68%	10.14%	8.70%	5.80%	69	3.86
4	My local water management agency is prepared for water scarcity.	5.80%	14.49%	15.94%	42.03%	14.49%	5.80%	1.45%	69	3.68
5	Water scarcity preparedness is taught in my local community.	15.94%	21.74%	20.29%	24.64%	14.49%	2.90%	-	69	3.09
6	Water scarcity preparedness should be a priority for our local water management organizations.	2.90%	-	-	7.25%	24.64%	33.33%	31.88%	69	5.78







### Q13.What is your gender?

#	Scoring	Answer	Bar	Response	%
1	✓	Male		27	39.13%
2	✓	Female		41	59.42%
3	✗	Self-identify		0	0.00%
4	✗	Prefer not to answer		1	1.45%
		Total		69	100.00%





### Q14.What age range do you belong to?

#	Scoring	Answer	Bar	Response	%
1	✓	18-25		0	0.00%
2	✓	26-40		11	16.18%
3	✓	41-60		27	39.71%
4	✓	61 and above		30	44.12%
		Total		68	100.00%



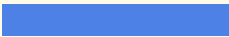
**Q15. Please specify your completed level of education:**

#	Scoring	Answer	Bar	Response	%
1	✓	Middle School		0	0.00%
2	✗	High School or GED		0	0.00%
3	✓	Some College		3	4.41%
4	✓	2 year Associates		6	8.82%
5	✓	4 year degree		14	20.59%
6	✓	Some graduate		6	8.82%
7	✓	Master's Degree		29	42.65%
8	✓	Doctoral		10	14.71%
		Total		68	100.00%

**Q 16. What is your yearly household income?**

#	Scoring	Answer	Bar	Response	%
1	✓	under 30,000		6	8.96%
2	✓	30- 60,000		18	26.87%
3	✓	60-100,000		26	38.81%
4	✓	100- 500,000		17	25.37%
5	✓	500,000 and above		0	0.00%
		Total		67	100.00%

**Q 17. How would you describe your Political Ideology?**

#	Answer		Response	%
1	✓ Strongly Conservative		0	0%
2	✓ Moderately Conservative		0	0%
3	✓ Neither Liberal nor Conservative		9	13%
4	✓ Moderately Liberal		19	28%
5	✓ Liberal		38	56%

6	✓ Other		2	3%
	Total		68	100%

**Q18. Did you move to Eugene from another state/country? If yes, please name place**

#	Scoring	Answer	Bar	Response	%
1	✓	Yes		58	85.29%
2	✓	No		10	14.71%
		Total		68	100.00%

**19. How Long Have you lived in Eugene?**

#	#	Scoring	Answer	Bar	Response	%
1	1	Response	0-1 years		4	5.80%

2	1	2-5 years		9	13.04%
3	1	6-10 years		13	18.84%
4	1	11-20 years		20	28.99%
5	1	21 years and above		23	33.33%
		Total		69	100.00%