AN ABSTRACT OF THE DISSERTATION OF

Derric B. Jacobs for the degree of Doctor of Philosophy in Environmental Science presented on December 9, 2014.

Title: Utilizing Relational and Social Network Analysis to Inform Community-based Climate Change Adaptation: A Central Oregon Case Study

Abstract approved:

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Lori A. Cramer

Central Oregon's landscape is rich in dry forests prone to frequent wildfires. Climate change studies and improved modeling indicate this region could experience conditions that result in an increase in number and severity of wildfires. With the potential for increased environmental hazards, the nearby communities face potential risks and vulnerabilities to their social, political, cultural and economic conditions. This dissertation utilizes an innovative social network methodological framework to examine current socio-political conditions and information network systems associated with wildfire and climate change in two Central Oregon communities. Research focused on the communities' social and information networks on climate change and governmental activities, the degree of network connections to professionals, and measures of community social capital. The results illustrate that both communities have a high percentage of community members that are disengaged with the subject of climate change. It was also found that within the community social network exchanges, climate change is rarely discussed nor did it overlap with other informational issues such as wildfires and community politics. Information networks on climate change are complex, and ties to climate change information sources do not always reflect one's position on climate change or its local risks. Informational resources regarding governmental activities are mostly media based in the incorporated community and social systems appear more important in the rural communities. When expressed, social capital and more specifically, governmental trust appears to be linked to the degree of concern respondents have on climate change, suggesting that addressing scientific illiteracy may not

be as important as establishing or maintaining positive governmental relations. Furthermore, this research may have policy implications for increasing local adaptive capacity, as well as research implications for the use of social network analysis as a tool to address future research.

Utilizing Relational and Social Network Analysis to Inform Community-based Climate Change Adaptation: A Central Oregon Case Study

by
Derric B. Jacobs

A DISSERTATION

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APPROVED:

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Major Professor, representing Environmental Sciences

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Director of the Environmental Sciences Graduate Program

_____

Dean of the Graduate School

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

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Derric B. Jacobs, Author

ACKNOWLEDGEMENTS

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If all that changes slowly may be explained by life, all that changes quickly is explained by fire. Fire is the ultra-living element.

-Gaston Bachelard
The Psychoanalysis of Fire, 1964[1]

Introduction

Central Oregon's landscape is rich in dry forests prone to frequent wildfires. Climate change studies and improved modeling indicate this region could experience conditions that result in an increase in number and severity of wildfires. With the potential for increased environmental hazards, the nearby communities face additional risks and vulnerabilities to their social, political, cultural and economic conditions. The goal of this dissertation is to utilize an innovative social network methodological framework to examine current socio-political conditions and information network systems associated with wildfire and climate change in two Central Oregon communities. This chapter provides a rationale for the research project, a brief background on human settlement in the region, wildfire and climate change issues in Central Oregon, and the format of the dissertation**.**

Rationality for Research

Wildfires are a salient issue in North American forested ecosystems and developed regions where every year wildfires claim lives, homes, private and public property. In addition to the loss of lives and physical property, wildfires can cause significant damage to human health, economic losses in the private sector, psychological damage, and negative effects to ecosystems and ecosystem services (Jewell and Vilsack, 2014; Morton, Roessinger, Camp and Tyrrell, 2003; Spies et al, 2010). It can take decades or more for the socio-ecological system to fully recover, and in some cases a full recovery may not be possible. As a result of the negative and dramatic impacts of wildfires, fire policy in the U.S. has been focused on prevention and suppression. The annual costs of wildfire suppression to federal, state and local

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[1] Stephen J. Pyne's "The Fire of Life: Thinking about the biological basis for fire" in *Wildfire: A century of failed forest policy* (2006 pp. 5-7).

agencies can be in the range of a billion dollars. In 2012 and 2013 the federal firefighting cost for suppression alone was $1.9 and $1.7 billion respectively (National Interagency Fire Center, 2014). In the Pacific Northwest large segments of the forested landscape are titled to the federal government, divided between the U.S. Department of Agriculture's Forest Service (USFS) and the Department of the Interior's Bureau of Land Management (BLM). Roughly 60 percent of the public land in Oregon is owned by the federal government (most of it with the USFS and BLM), three percent is owned by the state and one percent is owned and managed by other public interest holders (Oregon Department of Forestry, 2009). This scale of land ownership and management demonstrates the importance and dependence on federal land management agencies and congressional oversight on land management. Many wildfires in Oregon start on federal lands and then become trans-boundary issues.

In Oregon wildfires are much more prevalent in the dry forests and rangelands on the eastern side of the Cascade Mountains than in the temperate rainforests of the west. In these forested regions, as in many other states, wildfires have been a part of the socio-ecological systems as long as the area has been inhabited. Today, however, wildfires and their risks in these dry forests are ubiquitous in public and social debates. Many of the increasing monetary, social and ecological costs from more frequent and severe wildfires arise from a combination of socio-economic transitions to the demography such as increases in development into the Wildland Urban Interface (WUI) as well as the increasing awareness of the impacts that forestry practices, especially fire suppression have had on fuel loads in these forests (Barringer, 2013; Hammer, Stewart and Radeloff, 2008; Pyne, 2008; Vose, Peterson and Patel-Weynand, 2012).

Climate change could play a significant role in the risks of wildfires, especially in light of the current risk factors attributed to historical forestry and management practices. Despite significant uncertainties about climate change, there is a general consensus among climate scientists that the scope and trajectory of climatic changes will occur on a global scale (IPCC, 2014; Stocker et al, 2013). Scientific consensus about climate change includes the following points: 1) climate change today is being driven in part by human and industrial processes that increase greenhouse gases that accumulate in the ocean and atmosphere (anthropogenic climate change); 2) by continuing these processes we will continue

to push the global climate into the unknown; and 3) climate research and modeling, although far from perfect, shows that unless there is a naturally embedded buffer in the climatic system that we are unaware of, climate change will significantly change the biosphere and most of the world's ecological systems (Maslin, 2009).

Diverse natural scientists are integrating into climate research and modeling through institutions such as the Intergovernmental Panel on Climate Change (IPCC) to conclude that the current global trajectory with regard to climate change warrants significant concern for numerous regions and ecosystems (Weart, 2013). Forestry and wildfires in the Pacific Northwest, with its extensive forest systems in public holding, are no exception (Oregon Department of Land Conservation, 2010; Spies et al, 2010). A strong correlation between wildfires and climate change variability with the El Nino/Southern Oscillation and the Pacific Decadal Oscillations (natural cycles generated by the Pacific's oceanic and atmospheric systems), has been identified (Oregon Climate Change Research Institute, 2010; Marlon et al, 2012). Many of these reports and studies in the region conclude that increasing temperatures and drought cycles are likely to impact the number and severity of wildfires in the region, including Oregon.

Current political and economic conditions across the U.S. and Oregon are negatively impacting the effectiveness of federal, state and county governance in their ability to address many issues, including climate change adaptation programs and efforts. While collaboration between local populations and governmental agencies may be imperative to the overall success in adapting to climate change, strong grassroots or local efforts may be the most critical. With the existing threat of devastating wildfires in central Oregon, and a future with seemingly negative impacts from climate change, the communities in this region must develop social, economic and political systems, and foster cooperation to address both the immediate and future threats.

Communities facing a threat from a wicked problem like climate change must enhance their resilience by ensuring they are able to rebound quickly from symptomatic effects and to cope efficiently with new norms. Resiliency has been defined as the state of being prepared for a socio-ecological or environmental impact (Walker and Salt, 2006). Resilient communities often have integrated policies and

actions that address risk reduction, prepare a community for an event, and strategies to deal with the results of the event. In the case of wildfires, communities may address risks related to fuel reductions in the WUI, develop defensive space on private properties, have evacuation plans and risk assessments and community support programs for post-fire actions.

This dissertation examines two communities in central Oregon, La Pine and "Greater Crescent," an area composed of three small rural communities (Crescent, Gilchrist and Crescent Lake). These two communities, as with many others in the region, are representative of rural communities that face the challenges of addressing wildfire risks and the additive challenge of adapting to climate change. The survival of these communities may depend on their resilience in the face of increasing wildfire frequency and severity, and their ability to develop an effective adaptive strategy.

Local efforts may be a required catalyst to enable positive collaboration with state and federal agencies. For localities to address community-based adaptation to climate change, an understanding of the social and political contexts is necessary to identify local collaboration efforts and develop future strategies to address the issues. It is important for residents and policy makers to understand existing social systems and how these social systems might be advantageous or detrimental to developing an adaptive strategy to climate change and potential dramatic increases in wildfires.

Dissertation Purpose and Organization

The goal of this dissertation is to utilize social capital and innovative relational and social network methodological frameworks to examine current socio-political conditions and information network systems associated with wildfire and climate change in two Central Oregon communities. Additionally, the study will assess potential differences between a newly incorporated city (La Pine) and a traditionally rural community (Greater Crescent). This research will focus on three objectives: 1) to assess the existing state of social and political capital in each community and compare and contrast their conditions for adaptive capacity; 2) to model and compare relational information ties to climate change perceptions among the communities' residents; and 3) to identify how residents in these communities acquire information regarding governmental activities.

Each of these three objectives is examined in a separate stand-alone chapter within this dissertation and each is theoretically relevant for community-based adaptation. Social and political capital may be vital for community-based adaptive capacity as they provide embedded resources in the social structures (Lin, Cook and Burt, 2001; Burt 2005). These resources include trust, solidarity and inclusion, cooperative potential and information control and access. All of these resources can influence how a community and its residents operate together. Social network analysis (SNA), a formal field within the social sciences (Freeman, 2004 p. 3), is used in the remaining two manuscripts to address information diffusion and multiplexity. In chapter 3, relational analysis is also conducted to test information sources on climate change perceptions while chapter 4 looks at the network structures on governmental activity information sources. Social network analysis addresses two distinct network types: two-mode networks operating on two distinct types of nodes such as people and events, and ego-network which focus on one type of node such as people (Wasserman and Faust, 1994; Scott and Carrington, 2011; Prell, 2012). A two-mode network analysis was used to uncover institutional and formal forms of information. Ego-network analysis is also applied to both communities in an attempt to confirm a developing theory about the need for exchange multiplexity in a community's social networks which may increase adaptive capacity. Social capital, relational analysis and social network analysis are discussed more in the background section below.

Preceding the manuscripts, context for the research is provided through background material for the overall research. Each manuscript will include a literature review, and a theory and methods section for each subject matter. There is also an expanded methods section in Appendix A of the dissertation[2]. The conclusion chapter of the dissertation will draw from all three manuscripts, describing their relevancy to each other and discussing the adaptive capacity of the communities. The conclusion will also address the limitations of the research as well as address future research goals.

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[2] The chapters are formatted to fit specific journal requirements which may limit the discussion of specific methods. Therefore, for the purposes of this dissertation, an expanded methods discussion will appear in an appendix.

The Research Context

The following is a narrative relevant to the three manuscripts in this dissertation. It discusses the ecology and climate of Oregon, some relevant history and current issues related to wildfire policy and climate change. The narrative then discusses current trends in demography and the effect on social and cultural systems. Finally this section introduces La Pine and Greater Crescent (consisting of Crescent, Gilchrist and Crescent Lake), the two communities studied in this dissertation.

Oregon's Ecology and Climate

Oregon can be divided into three major socio-ecological regions: western, central and eastern that have a number of subtitled ecoregions (Figure 1). The western region of Oregon begins at the coast, extends over the coastal range, and across the valley, up the western side of the Cascade Mountains. The central and eastern regions of Oregon both reside on the eastern side of the Cascade Mountains and extend to the eastern borders of the state. The Oregon Master Naturalist and the Environmental Protection Agency recognize eight major ecoregions in Oregon. Ecoregions are defined by their distinct geographical area where geology, vegetation, climate, hydrology and other ecosystem dimensions are similar (U.S. Environmental Protection Agency, 2012). The significance of ecoregions for this dissertation are the climatic factor and the impact that changes to this system can have on the landscape, followed by impacts to the socio-ecological system.

Figure 1. Map of Oregon's Ecoregions
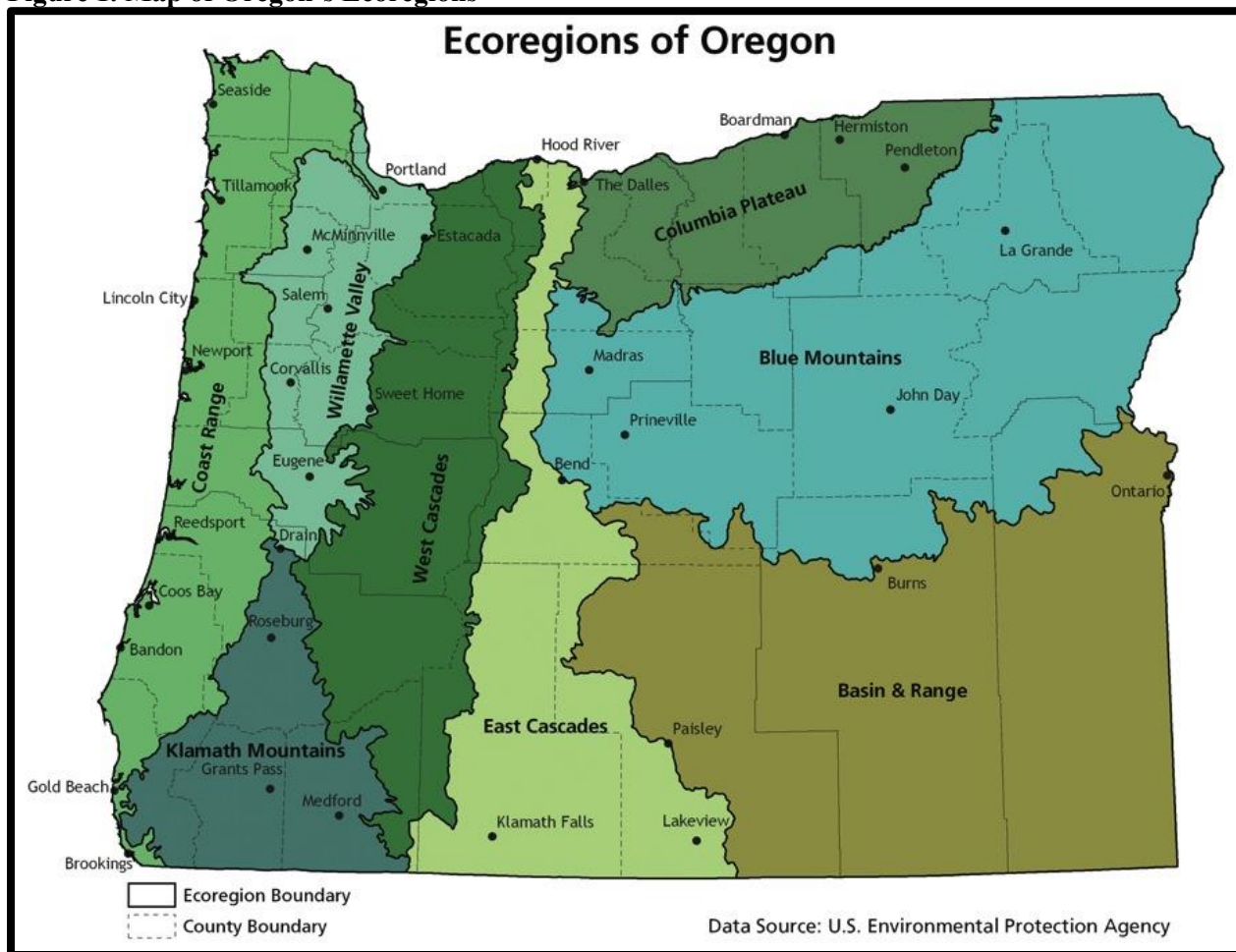
Figure 1: Map of Oregon's ecoregions from the Oregon Master Naturalist Program, Oregon State University: http://www.zephyradventures.com/blog/oregon-is-awesome-for-travel-and-wine/

The Cascade Mountains play a major part in Oregon's ecology and its ecoregions through a "rain shadow effect." A rain shadow is the impact that terrestrial elevations and mountain ranges have on the precipitation of a landscape (Atkinson, 1983; Wallace and Hobbs, 2006). In the case of Oregon, moisture-laden air from the Pacific Ocean moves in an eastern direction where it is lifted by the landmass, cooled and then expels the moisture through rain and snow. As the air continues to move in an easterly direction, the majority of the moisture is eventually expelled on the western side of the Cascades Mountains, leaving the eastern side of the Cascades with a much lower rate of annual precipitation. This has generated a stark division in the ecological systems based on geography in relation to the Cascades.

Figure 1 shows the ecoregions of Oregon: the Coast Range, Willamette Valley, Klamath Mountains and West Cascades are all west of the Cascades and receive the bulk of precipitation. The forests in these regions are mostly temperate rainforests and mixed coniferous forests of fir, spruce, hemlock, cedar and lodgepole pine (U.S. Environmental Protection Agency, 2012). On the eastern side of the Cascades are the East Cascades, Columbia Plateau, Blue Mountains and the Basin and Range ecoregions. The forests here are acclimated to much drier conditions and have the prized ponderosa pine embedded with mixed grand firs, pines and juniper. For Oregon's timber industry, both the western and eastern forested regions provided significant economic opportunity for many years.

The significance of the wet western and dry eastern forest typologies is the relationship these landscapes and vegetative distributions have to fire. Due to the wetter conditions in the west, wildfires are much less common and can have a more dramatic impact on the landscape (Knapp, Estes and Skinner, 2009). On the eastern side, wildfires occur much more frequently, yet often with lower intensity and less profound impacts on the landscape (Campbell, Azuma and Weyermann, 2004; Knapp, Estes and Skinner, 2009). More importantly, wildfires in the eastern forests provide a natural system of fuel reduction where woody biomass is burned away. This prevents fuel ladder development and helps prevent ground fires from traveling up into the tree canopy, which impacts the spread and impact a wildfire can have on the forest. Along the eastern side of the cascades, much of the forested landscape is now cataloged as class 3 or higher for catastrophic wildfire risks as seen in figure 2.

Figure 2: Map of Oregon's High-Risk Fire Regions
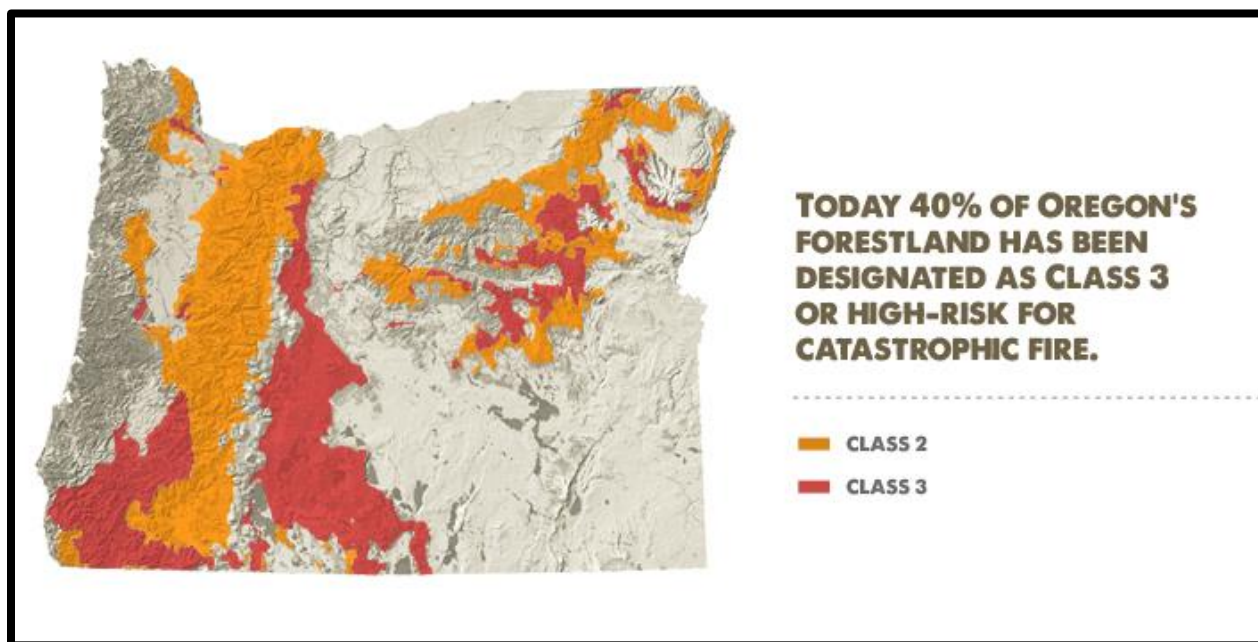
Figure 2: Oregon's forested fire risks. La Pine and Greater Crescent rest in the Class 3 shown in red to the east of the Cascade Mountains (Oregonforests.org, 2013: http://oregonforests.org/content/fire).

With the growing frequency and impact of wildfires across the Pacific Northwest, there is a rising concern about whether a link to climate change exists, and if so, what are the future impacts on this socio-ecological landscape (Lal, Alavalapati and Mercer, 2011; Western Governor's Association, 2010; Oregon Department of Land Conservation and Development, 2010). The forests and their resources are only part of the concern as many communities are also growing as people purchase and develop properties within forested boundaries (Hammer, Stewart and Radeloff, 2008; Vose, Peterson and Patel-Weynand, 2012). Additionally, changing demographics such as aging populations are susceptible to health risks related to smoke inhalation (Delfino et al, 2009; Foresburg et al, 2011; Gill, Stephens and Cary, 2013; Oregon Department of Land Conservation and Development, 2010), and reduced mobility for evacuations (Cramer, 2012).

Oregon's Historical Relationship to the Forests

For centuries Native American tribes in Oregon have utilized natural resources, including the forests, for their myriad of ecological and human benefits. Settlement by Euro-Americans changed the

utilization of many of the landscapes, with socio-economic conditions increasingly driving the relations between man, management and forests. Early Euro-American settlement of Oregon, much like current trends, was not driven by timber or timber extraction. Despite the decline of forests as economic extraction capital, they have increased as recreational and aesthetic forms of economic capital for many communities. The amenity value is transforming the socio-economic structure of many of the communities within Oregon, most dramatically in central Oregon.

This region of Oregon became the focus of a joint research venture between the U.S. Forest Service's Pacific Northwest Lab and Oregon State University known as The Forest-People-Fire (FPF) project. This interdisciplinary research project was funded by the National Science Foundation and set out to better understand and model the complex coupled human and natural systems of central Oregon and the relationship to wildfire and its current and future risks. The FPF project's boundary is seen in Figure 3 below and constitutes a general boundary for the research of this dissertation. Nestled in the middle of the FPF boundary rests La Pine and Crescent, Gilcrescent and Crescent Lake (Greater Crescent). The geographic relationship between these communities and the FPF project can be seen in Figure 4.

Figure 3. Map of Oregon and the Forest-People Fire Study Area
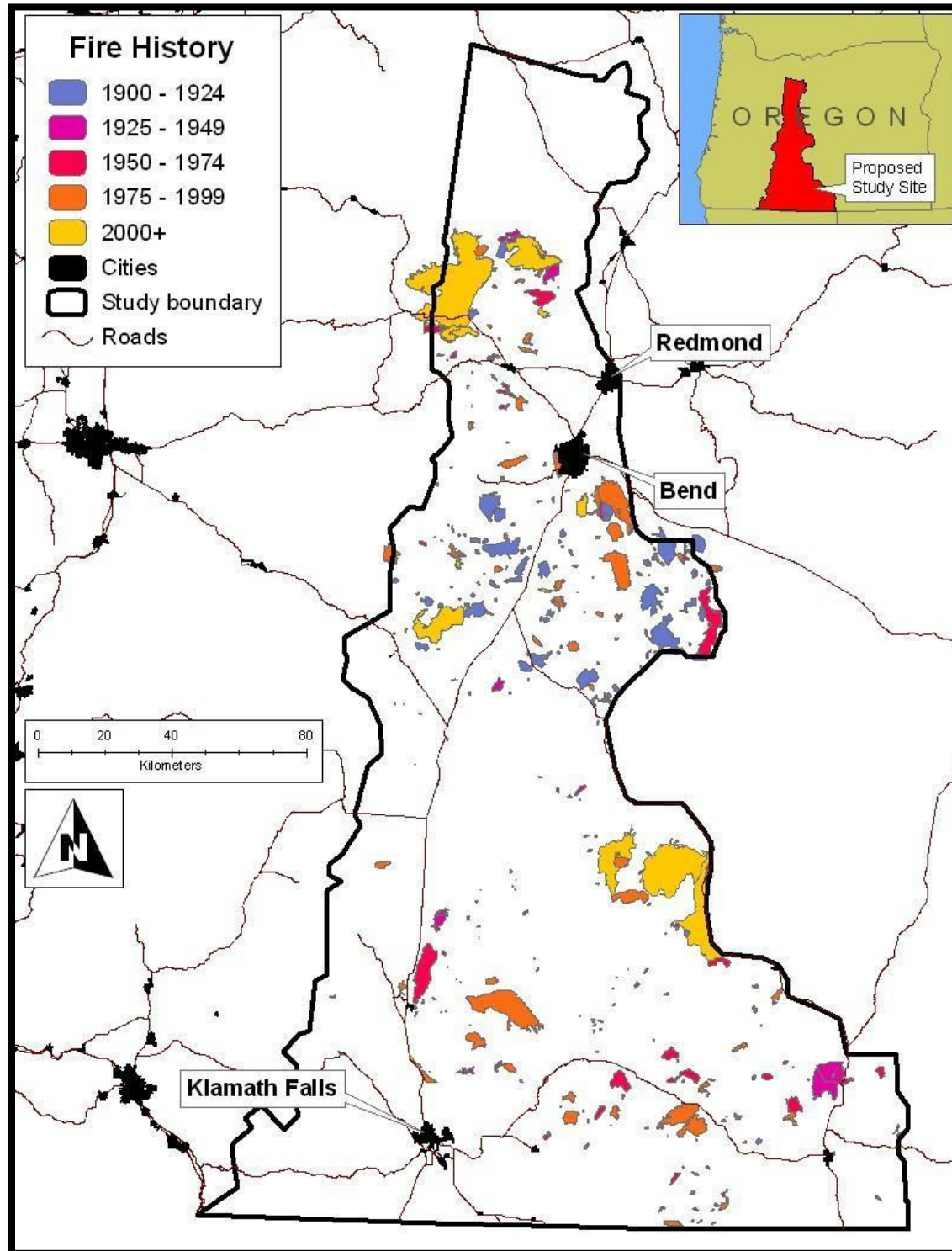
Figure 3: This map shows the Forest-People-Fire study area and relation to the state of Oregon. Also included is the fire history of central Oregon between 1900 and from 2000 on.

Figure 4. Map Showing the Location of La Pine and Crescent Oregon
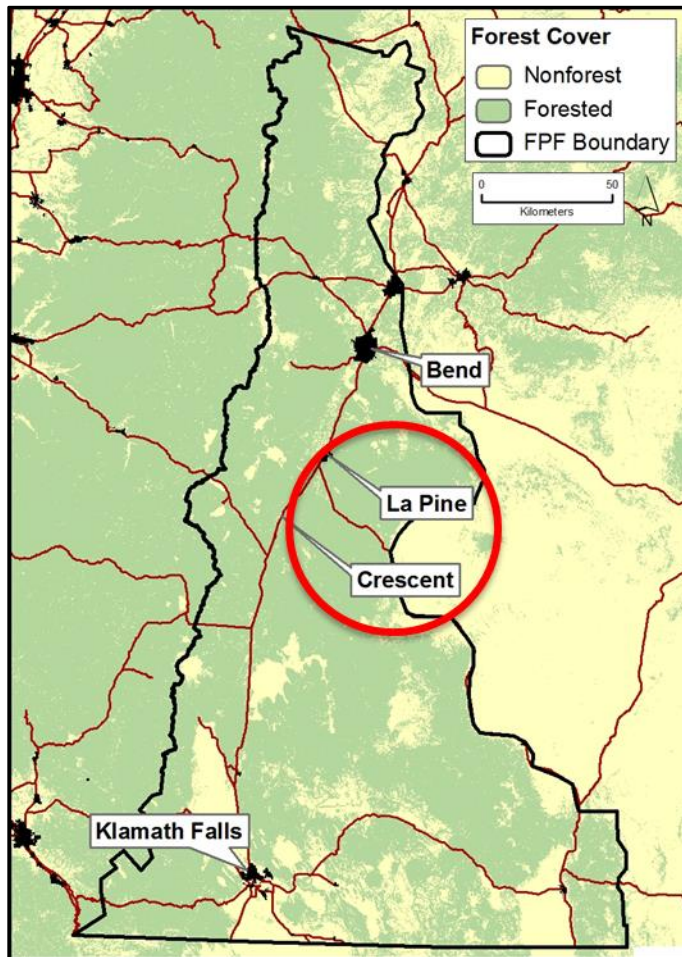
Figure 4 shows the Forest-People-Fire study boundary and the general location of La Pine and Crescent, one of the three communities that makes up Greater Crescent in this study.

Oregon's natural resources have provided for the well-being of human inhabitants for centuries (Coon, 2007). Even before the arrival of the Euro-Americans, Native Americans had occupied the lands and embraced the abundance of its natural resources. The first Euro-Americans that found their way to what is now Oregon came by sea with English, Spanish and Russian explorers in the 1600 and early 1700s (Horner, 1924; Brown, 2004; Coon, 2007). These explorers established a vibrant fur trade, much of which came from beaver pelts. Even before the famous Lewis and Clark expedition in 1804, Euro-American settlements in the Oregon region were established mostly within the coastal, coastal mountain range and valley regions west of the Cascade Mountains. The climate and soils in these regions provided

for settlers' agriculture and the forests offered hunting and trapping for subsistence and economic opportunity.

In November of 1805, Lewis and Clark reached the mouth of the Columbia River and paved the way for the new America's western expansion from the east (Horner, 1924). In the early years of the western expansion and settlement, Oregon's massive forests and timber were not an economic interest; instead it was land acquisition, agriculture and missionary goals that drove civil interests. Yet, in 1827 the first timber mill west of the Mississippi was established on the Columbia River (Brown, 2004; Andrews and Kutara, 2005) setting the stage for what would become a significant driver for Oregon's development and its economy. Oregon became an official American territory with a governing body in 1848 and then became the 33rd state of the Union in 1859 (Horner, 1924; Coon, 2007).

Since its statehood, Oregon has maintained its agricultural fervor in the Willamette Valley, and settlements east of the Cascades also found opportunity for both agriculture and ranching (Coon, 2007). In 1849, gold was discovered in Gold Hill, Oregon, and then in eastern Oregon in 1861 (Horner, 1924) stimulating further migration to the state. Development of the state drove the need for timber, driving loggers from as far east as Maine to come and capitalize on Oregon's great forests (Coon, 2007). This industry would later generate a boom-bust cycle that continues to resonate passionately in even the most current political and economic debates in the state as communities face declining timber revenues and losses in industry.

The first mill was established in 1827 along the Columbia River, and though the state and regional timber industry was developing, it was not yet recognized as a major economic sector. Wildfires at this time were only a concern when they came close to developed regions where life and personal property were threatened. During this time, a number of major fires occurred in Oregon's forests: "The Great Fire" of 1845 (1.5 million acres burned); the "Yaquina Fire" in 1853 (450,000 acres burned), the "Silverton Fire" in 1865 (1 million acres burned), and the "Coos Fire" in 1868 (300,000 acres burned) as well as others (National Interagency Fire Center, n.d.; U.S. National Park Service, n.d).

By 1900 the timber, its capital, and industrial extraction and processing were one of Oregon's leading economic forces (Andrews and Kutara, 2005). Through the early 1900s, perspectives on wildfires changed. Not only were they viewed as a threat to lives and communities, but also as a threat to natural resources and physical capital. In 1911 the state created the State Forestry Department, a Board of Forestry and a State Forester position to manage the forests and address risks and impacts from wildfires.

Between 1849 and the 1950s, Oregon's timber industry had a general increase in harvest with a significant dip during the "Great Depression" and pre-World War II years. (Andrews and Kutara, 2005). After four decades of growth the Oregon timber harvest plateaued in the 1950s at about 8.5 billion board feet before seeing a major decline. In the 1980s competition with Canadian timber and high inflation contributed to a decline in demand for Oregon's timber. The 1990s saw a dramatic transition in federal forestry policy with the Northwest Forest Plan that moved from a mandate on sustainable timber yield to a new focus on biodiversity and ecology (Spies et al, 2007; Thomas et al, 2005). Today, Oregon's timber industry is a fraction of what it was in the 1980s. The majority of today's timber production in Oregon now rests in the hands of private industrial forests, while most federal and state agencies have dramatically reduced the amount of allowable timber harvests on their lands.

This decrease in timber production has had a significant impact on the economic stability of several Oregon counties including Klamath County, where Greater Gilchrist communities reside . Additionally, it has had a dramatic effect on the landscape, the structure of the forests and the resiliency of the forests' ecosystems to natural processes such as wildfire (Johnson, Franklin and Johnson, 2008). Many of the forests in the study region are considered unhealthy or lacking resilience due to forest density and biomass loads that act as fuel for wildfires.

Unhealthy forest structure and landscapes translate directly to the risk of wildfire, yet perceptions and values of forests seem to negatively impact the support and trust of the community in forest management (Abrams et al, 2005; Shindler and Cramer, 1999; Steel, List and Shindler, 1994; Tindall, 2003). This can hamper wildfire prevention efforts as agencies divert resources to education and information programs in an effort to manage discontent. They may also be blocked by interest groups

from performing healthy forest restoration activities. Agencies at many levels are stretched thin with economic resources, forest structures are full of biomass and fuel for wildfires, and people who have grown up in "managed" or "mismanaged" forests, new immigrants to Oregon's forested communities may mistake the forests they see with what an ecologically sound forest might be.

Today, much of the economic value from the forest comes as positive externalities such as scenic beauty for residents who wish to live within a "natural" landscape and a place that provides habitat for biodiversity, and as a source for recreation. Recreation and tourism have become significant economic industries for central Oregon and their role may increase in the coming years. More discussion about this possibility is included in the sections *A New Geography for Central Oregon* and *La Pine and Greater Crescent*. New markets are also being considered for forest biomass in an attempt to overcome the loss of timber as economic capital. These include biomass-based energy, biochar, and biomass as carbon storage markets for addressing climate change.

Federal and state forests and parks surround the La Pine and Greater Crescent communities. The federal government owns and manages 60 percent of Oregon's forests in the public interests, and the State owns 3 to 4 percent, while the remaining ownership is divided between tribal and private lands (See Figure 5 below) (Oregon Department of Forestry, 2009; Oregon Forest Resource Institute, 2010). Given these statistics, the perception, understanding, support and collaboration of the public in these communities is fundamental. The perception of forests and understanding of risks, vulnerabilities and opportunities attached to changing socio-ecological conditions and the support and collaboration these communities members can have with local agencies and landholders, can make socio-economic and political processes work toward positive and efficient change.

Figure 5. Map of Oregon's forest ownership
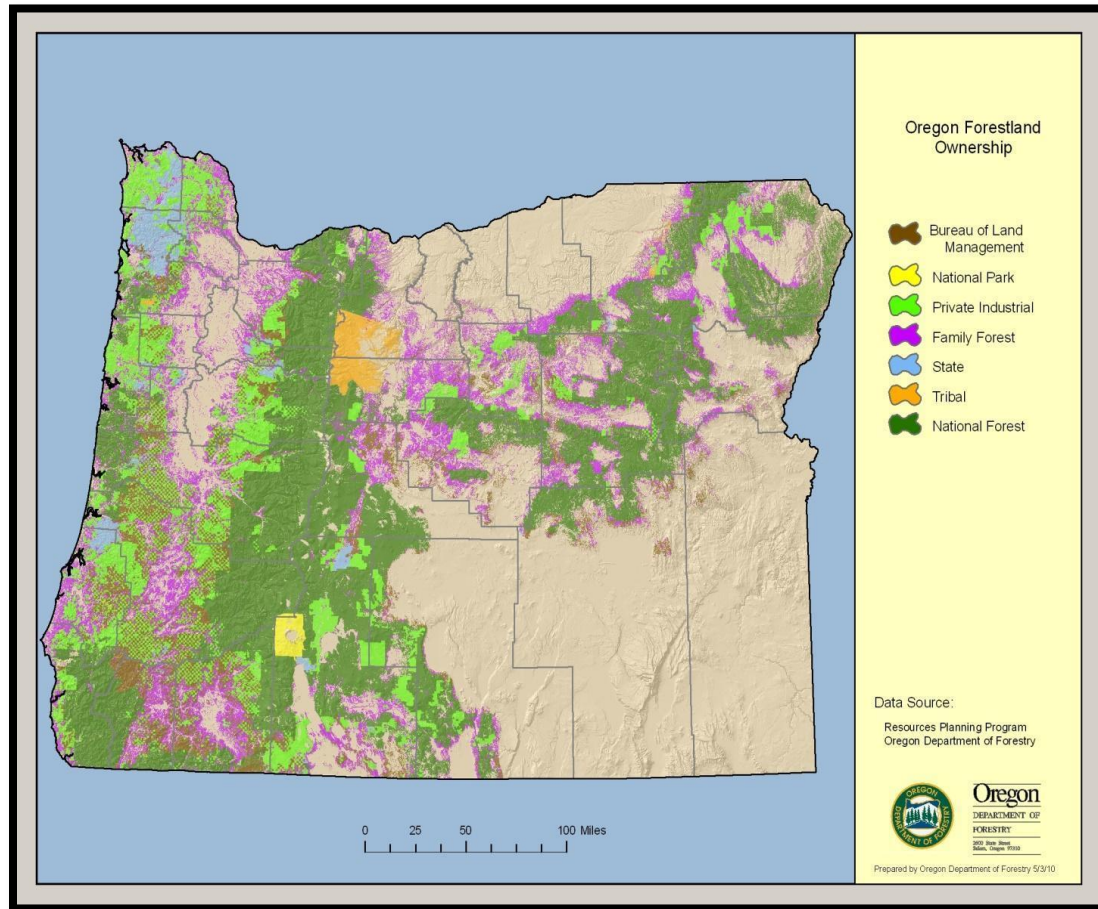
Figure 5. Map shows the extent of federally owned public lands in Oregon.

Forests and Wildfire: A Brief History on Issues and Policy

This section, while not comprehensive, provides some examples of federal wildfire policy and illustrates how federal policy has impacted states and local fire institutions. It also examines the complexity of the socio-ecological and political conditions surrounding wildfires and the best way to deal with them. For this dissertation, the case studies of La Pine and Greater Crescent are two communities surrounded almost entirely by federally owned forests. This research-specific geographic location and the politically responsible boundaries for forest management and wildfires leave this section to focus more on federal policy and management.

Across the United States, wildfires are usually perceived and treated more as natural disasters than a natural ecological process with environmental benefits. Although the dominant American culture

continues to view fire in some negative terms, there is an emerging culture that understands the biological, ecological and economic benefits to wildfire. There is a long history between people and fire in which culture plays a significant role in how people view and treat the landscape and fire (Vale, 2006; Preece, 2013). One cultural difference can often be found between aboriginal cultures and European-based cultures. For a number of aboriginal societies, fire was viewed not only as a natural process but to some cultures, a tool that provided social benefits to the people, such as establishing desirable plants and vegetative compositions to promote both vegetative and wildlife food sources. Europeans and their colonial extensions evolved a fear of fire; perceiving fire as a natural enemy and something that should be fought.

As fire is often seen as a damaging force of nature, wildfires are often treated with aggressive suppression tactics. The U.S. Forest Service's "10 A.M. Policy" illustrated this aggressive suppression of wildfires well; it "required that all new fires reported be controlled at less than 10 acres by no later than 10 a.m. the following day" (The Wildland Fire Leadership Council, 2003). This policy not only illustrates the socio-political concerns to wildfire but also begins a process that has since changed forests' structure and ecology. It has in short generated an even greater threat than what would exist within a healthy forested ecosystem.

The paradigm of the U.S. forest management and policy prior to the 1960s was dominated by human exemption beliefs and utilitarian values such as promoting marketable timber. Much of the focus on U.S. forests was on yields, and Gifford Pinchot's conservation values for future yields despite the emerging preservation values of John Muir and President Theodore Roosevelt in the late 1800s and early 1900s. Wildfires may be a natural part of many forest systems, yet social and political values and beliefs maintained fire as a threat to resources and capital. This fear translated to forestry and land management policies that have had significant impacts on forest structure and ecology. In central Oregon and elsewhere, the management of wildfires as discussed above has generated two forest structural issues. The first, wildfire suppression has increased the density of forests and increased fuel loads overall; the second

issue, is the complex forest structures that have allowed fuel ladders that enable ground fires to travel to the crowns of trees and increase the spread of the fire.

In the 1960s shifts in scientific understanding and policy perceptions about the forests and the impacts humans have on the landscape began to change. The 1964 *Wilderness Act,* for example, illustrates a significant shift in perception and policy as it defines wilderness as:

"an area of undeveloped federal land retaining its primeval character and influence, without permanent improvements or human habitation, which is protected and managed so as to preserve its natural conditions and which (1) generally appears to have been affected primarily by the forces of nature, with the imprint of man's work substantially unnoticeable…"[3]

While this language illustrates a transition from past U.S. federal policy, it does not completely translate to a new U.S. policy culture on wildfires. In the 1970s, federal policies moved toward a more ecological approach in dealing with wildfires (The Wildland Fire Leadership Council, 2003). While suppression remained dominant, this approach included some anthropogenic burning and allowed some natural burning to occur when not threatening developed areas. After the 1988 Yellowstone fire where an escaped fire caused extensive damage, many of these proactive activities were suspended. After the 1994 South Canyon fire the 1995 *Federal Wildland Fire Policy* was created, and after a record-breaking fire season in 2000, Congress issued the *National Fire Plan* (The Wildland Fire Leadership Council, 2003; Pinchot Institute for Conservation, 2002; Fire Executive Council, 2009). This policy and plan recognized a need for extensive collaboration between federal, state and local fire institutions with local decision making powers, public education systems, prevention efforts and continued suppression. The language in these policies included directives to reduce "hazardous fuels" in forests, "restore" fire-adapted ecosystems and to promote "community" assistance (Pinchot Institute for Conservation, 2002; Fire Executive Council, 2009).

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[3] Taken from the Wilderness Act provided by Wilderness.net at
http://www.wilderness.net/NWPS/documents//publiclaws/PDF/16_USC_1131-1136.pdf

In 2003 the *Healthy Forest Restoration Act* introduced the Community Wildfire Protection Plan (CWPP) (108th Congress, 2003). The CWPP is a voluntary program that allows communities at risk of wildfires to receive benefits that assist them in education and planning for wildfires and prioritizing fuel reduction actions on both federal and non-federal lands with the collaboration of multi-level agencies (Project Wildfire, 2009). *The Federal Wildland Fire Management Policy* (1995, 2001) and the *National Fire Plan* (2000) were linguistically aggressive in comprehensively addressing the complex issues surrounding wildfires. Agency collaboration, efforts to address the needs of local communities, and valuing ecosystems and ecosystem processes were now clearly articulated in the national dialogue on wildfires. *The Healthy Forest Restoration Act* then gave legitimacy to community programs and federal assistance. With this act the federal government linked federal, state and local agencies and provided a budgetary system designed to reach down the hierarchical ladder to the individual landowner offering financial assistance for education and fire protection programs. Some critics of these policies focus on the economics, but there are other questions as well: do extensive federal policies on wildfire create a dependence on agencies or a false sense of security for local communities?

This comprehensive tactic for addressing wildfires has continued with some adjustments. The 2009 *Guidance for Implementation of the Federal Wildland Fire Management Act* (Fire Executive Council) stated that the original policy was "sound" yet some issues around the "Wildland-Urban Interface" required revision as did some confusing terminology. Also in 2009 *The Federal Land Assistance, Management and Enhancement Act* (FLAME) and its companion, the *National Cohesive Wildland Fire Management Strategy* were delivered by report to the U.S. Congress (Jewell and Vilsack, 2014). The FLAME Act introduced two new issues in forest and wildfire management. The first, "Element 7", calls for coordination and cooperative agreement in assessing the effects of invasive species on ecosystems. The language on invasive species in FLAME focuses on invading grasses, yet sets the stage for other species that may invade an ecosystem and impact wildfire systems. The most significant introduction FLAME offers is "FLAME ACT Element 6: Assessing the Impacts of Climate Change on the Frequency and Severity of Wildfire."

Climate Change

Climate change as it relates to forests and wildfires is largely an emerging issue, although work is appearing more frequently in scientific literature within the last decade. This section offers a very brief discussion on the issue of climate change and its relevance to this dissertation; it is not intended to provide a thorough review of the science or the politics of climate change.

Climate and climate regulation systems have been an interest in science since 1896 and has been a significant political interest since the 1950s (Maslin, 2009). The Earth's climate is regulated by complex systems that include greenhouse gases and aerosols in the Earth's atmosphere which regulate solar radiation coming from the sun and reflecting from the Earth's surface (Wallace and Hobbs, 2006). Greenhouse gases act like a blanket in the Earth's atmosphere keeping things warm relative to what would exist without them. Human industrial and energy systems have dramatically increased greenhouse gases (Wallace and Hobbs, 2006; Stocker et al 2013; Schnider, 2009) that seem to correlate, and more than likely, cause warming in the atmosphere (Stocker et al, 2013; NOAA, 2013; NASA, 2013)

The link between greenhouse gas increases and atmospheric warming was first observed with Dr. Roger Revelle, Dr. Hans Suess and Dr. David Keeling's implementation of measuring CO_2, a dominantly present greenhouse gas, in 1958 at Mauna Lao, Hawaii and in the South Pole (Hulme, 2009; NOAA, 2013). These observations have been continued by the Scripps Institute of Oceanography and the National Oceanic and Atmospheric Administration, and the pattern persists (NOAA, 2013). Today, there is a general consensus among climate scientists and professional scientists in related fields that global warming is occurring and that this warming influences climatic changes (Stocker et al, 2013; Maslin, 2009; Schnider, 2009).

Some of the implications of climate change include alterations in weather systems, seasonal variations and impacts to natural systems that bring about disasters such as hurricanes, tornadoes, droughts and floods, ecological and landscape changes with ecosystem service losses and wildfires (Stocker et al, 2013; U.S. Forest Service, 2011; NASA, 2013). Current modeling efforts aimed at understanding the climate dynamics and effects are still mainly at a global scale with global climate

models (GCM) (Stocker et al, 2013; OCCRI, 2010). These effects may then impact social, political and economic systems in various ways depending on locations on the globe; it may be speculated there will be winners and losers, yet losses may outweigh the gains. The most significant meaning of spatial variation on impacts from climate change is that adaptation should be considered at regional and local levels and site specific considerations for both risks and opportunities should be considered by residents and policy makers.

Currently there is limited data to predict the effects of global warming for regional and local climates. Efforts to increase the resolution of climate models and capture regional scales with regional climate models (RCM) are under way at several research institutions. A few of these institutions include NASA with its "Regional Climate Model Evaluation System" (NASA, 2013), the "Nested Regional Climate Models" at the National Center for Atmospheric Research (2013), and the Oregon Climate Change Research Institute that is investigating the effects of climate change on the Pacific Northwest and Oregon (2010).

Oregon's Climate Change Research Institute (OCCRI) has been at the forefront of researching and translating global warming and climate change in Oregon. In response to significant uncertainties about climate change and its impacts at the global and regional level, OCCRI generated the *Oregon Climate Change Assessment Report* (2010), which contributed to the *Oregon Climate Change Adaptation Framework* in 2010. Governor Kulongoski requested that the *Oregon Climate Change Adaptation Framework* include collaborations between state agencies, research institutions and universities as well as extension services to determine the possible effects of climate change in Oregon, and how to address them (Oregon Department of Land Conservation and Development, 2010). Chapter 3 of the *Framework* discusses specific risks to the state, specifically focusing on wildfires (pp.26-31). These two documents contribute to a state level public policy that advocates adapting to climate change through education and provides recommendations for actions, as well as identifies needed research and resources. Although the State of Oregon has made these documents available online there is no system in place to track the

number of downloads or views, and so there is no accurate count of how many Oregonians review these documents.

Although there is now a connection to climate change and wildfires both at the federal level in the *FLAME Act* and at the state level in the *Oregon Climate Change Adaptation Framework*, these are governmental institutions and may not reflect the views of the public. The risks from global warming and regional climate change recognized by scientists may not be shared at the local level and in specific communities such as La Pine and Greater Crescent. This is illustrated in the national global warming and climate change portfolio found in the Yale Project on Climate Change Communication's *Global Warming's Six Americas* (Leiserowitz *et al*, 2012; Maibach, Roser-Renouf and Leiserowitz, 2009). In this longitudinal study of Americans' perception and values about climate change, Americans fall into one of six positions (percent values are from 2012 report): Alarmed (13 percent), Concerned (26 percent), Cautious (29 percent), Disengaged (6 percent), Doubtful (15 percent), and Dismissive (10 percent). This suggests that Americans may not yet share the same perceptions and values as most formal institutions managing forests and wildfires at the federal and state level. This discrepancy may have impacts on the development of public policy at institutional levels, but what are the impacts to local policies and efforts to address risks?

La Pine, Crescent, Gilchrist and Crescent Lake: History and Transitions

La Pine, Crescent, Gilchrist and Crescent Lake are communities located in central Oregon. La Pine, Gilchrist and Crescent are located along historic Highway 97 that runs along the eastern side of the Cascade Mountains and through Oregon to the California border to the south, and to the Washington border to the north (See figure 6). Crescent Lake is just west of Highway 97 along the Oregon 58/Willamette Highway, which bridges the central Oregon's Highway 97 to the west side of the Cascades and Interstate 5. La Pine is located in Deschutes County, while Crescent, Gilchrist and Crescent Lake are part of Klamath County. These communities are within 25 miles of each other, share the same forests systems, and have similar socio-economic conditions.

Figure 6: Central Oregon Map
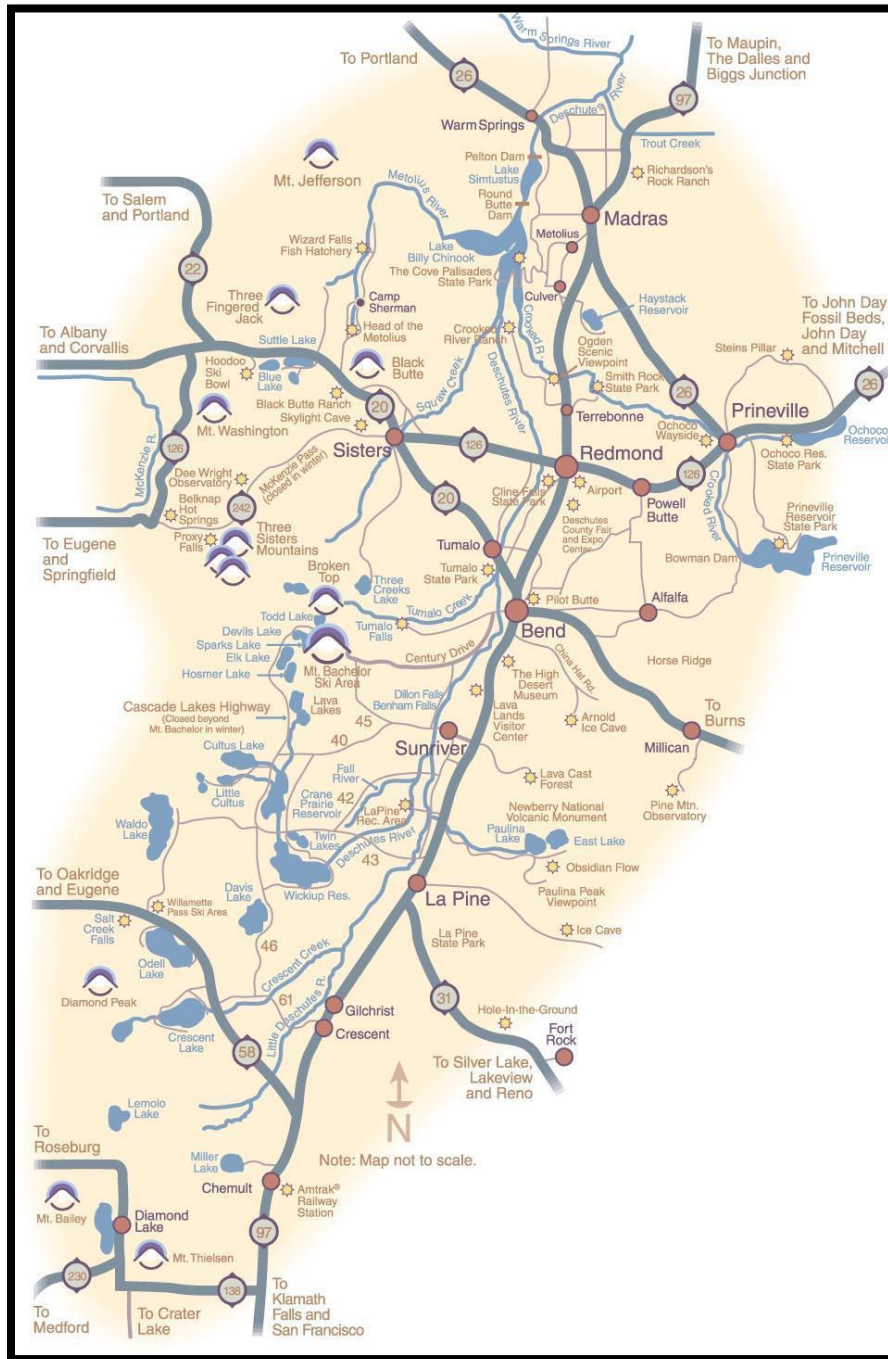
Figure 6. Central Oregon map showing Highway 97 and 58 with reference to study sites.
http://www.outdoortherapy.org/images/CentralOregonMapLarge.jpg

La Pine began as a logging camp in 1910 after a timber mill was constructed about 30 miles north in Bend, Oregon (Metcalf, n.d.). In 1917 the building of Highway 97 provided La Pine an opportunity for growth and development as a link to a major commercial corridor. In the 1960s regulations allowing septic tanks further bolstered development in the community. In 1966 zoning laws in Deschutes County were repealed by La Pine residents resulting in sprawl without the resources and planning for upkeep. La Pine created the La Pine Volunteer Fire Association in 1968 that transitioned to the La Pine Rural Fire Protection District in 1971.

Despite several failed attempts at industrial growth, the community of La Pine has capitalized on the abundant natural resources in the area (Metcalf, n.d.). Farming and ranching continue outside the municipality in La Pine yet the contribution to the local economy is not relatively significant (Oregon Explorer, 2014). In the 1950s La Pine and its neighboring communities began to see an increase in recreation and tourism with the abundant hunting and fishing opportunities. Additionally, in 1990, the Newberry National Volcanic Monument was created by the U.S. Forest Service, followed by the Lava River Caves and the Lava Lands Visitor Center which brings tourists to the area (U.S. Forest Service, 2013).

From La Pine's official inception in the year 1910 until 2006 the community remained unincorporated in spite of significant growth. After three failed attempts at incorporating, La Pine was finally incorporated in 2006. Today, La Pine is divided by its official incorporation with roughly 1,600 residents and an area referred to by residents as the "Greater La Pine" area that consists of about 6,000 residents (Jacobs, 2013; Jacobs and Adams, 2013). The city has an established governing body as well as its own police and fire services. This incorporation has generated significant changes in La Pine and in a focus group conducted in 2013 residents and officials expressed their belief that continued and rapid change will remain a part of La Pine's socio-political climate for many years (Jacobs and Adams).

Crescent, Gilchrist and Crescent Lake have remained rural and unincorporated communities. Gilchrist was officially founded in 1938 when the Gilchrist mill was opened by the Gilchrist Timber Company (The Oregon Encyclopedia, 2014). Crescent became a railroad town where trains still pass

through. Crescent Lake was, and remains, a recreation hub with few owner-occupied homes and a large number of secondary homes and rental cabins. As of 2013, the mill in Gilchrist is still operating and remains one of the last timber mills in the area. These three communities have in many ways merged into one socio-economic unit, sharing resources such as a post office, markets and services. They also utilize services found in La Pine. As with La Pine, these communities operate with recreational, tourism and commercial opportunities available from Highway 97.

Together these communities illustrate two dimensions of a transitioning rural west. La Pine has begun a transition to urbanization and cityhood. The northwest chain store Bi-Mart opened in 2003 (Lerten, 2003) and the new McDonald's in 2009 (La Pine Chamber of Commerce, 2009). The Greater Crescent area maintains a rural culture with few mainstream operations and mostly private businesses. In personal interviews and a preliminary focus group for this project, residents of La Pine in 2013 identified a slight disconnect with their southern neighbors in the socio-ecological and cultural connection that these communities have to forests and natural resources (Jacobs; Jacobs and Adams, 2013).

The Research Study Area

Several communities on the eastern side of the Cascade Mountains formed as a result of the timber industry and other natural resource-based economies. In the last few decades many of these communities have experienced shifting demographics and socio-economic changes that challenge traditional rural descriptions. Many of these changes began with adjustments in federal forest and natural resource policies that slowed timber harvests and damaged local economies. These economic transitions further encouraged the youth in these communities to pursue higher learning and better economic opportunities elsewhere. Today, many of these communities struggle to survive, yet some have found new life by changing their relationship to the forests and building an amenity-based economy that appeals to former city dwellers and retirees. Despite these changes, both "traditional rural" and "transitioning" communities are highly dependent on surrounding forests for cultural, economic and social vitality.

This study examines two communities, La Pine and "Greater Crescent", a set of small rural communities. It investigates the communities' ability to adapt to climate change, a new challenge that

may threaten their future. Furthermore, these two communities were chosen for practical and theoretical reasons including their traditional rural essence, of the existence of remaining mills in central Oregon, and a continued reliance upon a natural resource extraction culture. La Pine, on the other hand, began a transition from the traditional rural to a "new rural" existence when it became an incorporated city in 2006. These two communities, only 17 miles apart, represent two examples of rural transitions occurring in many regions of the U.S. By utilizing these communities, this research attempts to uncover possible variations around climate change adaptation.

Climate Change: Impacts and Risks to La Pine and Greater Crescent

The dry climate of central Oregon creates highly fire-prone forested landscapes. Plant species have evolved within this fire system which is largely based on small to moderate fires during relatively regular and frequent intervals, and some more intense fires during naturally occurring drier years based on natural climate cycles (Heyerdhal, Brubaker and Agee, 2001). The fire-based ecosystems that have evolved have been fairly successful at avoiding large scale, stand-replacing fires that challenge regrowth of native plants, in part due to higher frequency and milder fires that clear the understory of vegetation-based fuels (Meigs et al, 2009). The influence of policies that work to suppress wildfires, in part to protect local communities as well as natural resources, has increased fuel loads in the understory of the forests, presenting an increased opportunity for large-scale stand-replacing wildfires, as well as an increase in the spread and impact these fires may have on communities within these socio-ecological systems (Graham, MacCaffrey and Jain, 2004).

In addition to existing concerns over wildfire risks in central Oregon, growing evidence regarding climate change is working to increase concern about wildfires in at-risk forests (Vose, Peterson and Patel-Weynand, 2012). A few of the projections for the region include later winters and earlier springs, decreasing mountain snowpack and further declines in precipitation in an already dry landscape (OOCRI, 2010). Reduced mountain snowpack is enough to dramatically impact the forest ecosystems and further increase wildfire risks. Attempts to reduce fuel loads with forest restoration efforts have been hampered by many factors including declining economic drivers for timber and forest byproducts, declining

infrastructure to deal with forest biomass, and environmental and forest amenity protection interests by the public. These issues may ensure the continuance of high fuel loads in the forests as anthropogenic climate change pushes the risks to these forests by threatening ecological resilience to the threshold of ecological collapse. Coupled with ecological threats are the threats that this collapse could have on the communities within the forested landscape.

Wildfires impact these communities in a number of ways. One of the most obvious is the threat to infrastructure (Pyne, 2008). Some of the most vulnerable and sometimes costly losses from wildfire are to individual homes and their contents. When homes are burned in a wildfire the monetary value of the home can be costly to the homeowner, but often the loss of personal property, keepsakes and mementos can produce emotional costs far beyond the cost of the home. Loss of life is yet another major threat of wildfires to forested communities, as was seen recently when 16 firefighters died fighting a wildfire in Arizona (Yan, McLaughlin and Hanna, 2013), and in the deaths of a 19-year-old firefighter and a senior firefighter in two separate Oregon fires (Mistreanu, 2013). Most often this threat is illustrated by the loss of firefighters who are on the frontlines of the blaze. These losses are traumatic to the families and to the communities at large. One often overlooked threat from wildfires is the impact these fires can have on human health (Morton et al, 2003). Smoke from wildfires can travel great distances and have dramatic effects on individuals with existing respiratory health problems, especially the young and elderly. Another impact that wildfires have on the community and the economy is the loss of natural resources within the forest including harvestable biomass and the loss of the picturesque forests valued by residents and recreationists (Morton et al, 2003). This is not a complete list of wildfire impacts to residents and communities, but only a sample of the factors that threaten them.

Adapting to Climate Change

Around the world governments, non-governmental organizations and individual communities are discussing climate change in very different ways. Mitigating climate change is still an important issue, yet mitigation is concentrated mainly in the hands of nations and international treaties. With growing awareness of failed agreements to mitigate anthropogenic climate change, shifting concerns at local levels

are focused on the impacts of climate change and how to adapt to new systems. For some regions, climate change is much more of a benefit than a cost as in higher latitude nations. For others, such as small island nations, climate change poses the ultimate threat of complete annihilation by rising sea levels. Yet for many regions the impacts may not be desirable, but are not yet as dramatic as the cases cited above. These are the regions where adaptations will be challenging yet theoretically possible. Although adapting to potentially significant changes can be viewed through different disciplinary lenses, the focus for this study is through a strictly social lens. Here, adaptation refers to the social adaptation of the communities and its members.

A few important factors for communities adapting to climate change include: developing an understanding of climate change and its potential local impacts, developing and maintaining a collective community dynamic, and developing and/or maintaining a collaborative relationship with government and non-governmental organizations that promote avenues for grassroots mobilization efforts to advocate for policy changes. The first two factors are prudent for community-based adaptive capacity, while the third enhances adaptive capacity by providing resources often limited in small communities (Ensor and Berger, 2009). To better understand the adaptive capacity of La Pine and Greater Crescent, a theoretical framework capable of analyzing these three dimensions of adaptation is needed. To date, a single theoretical framework is unavailable, so three were used in the study.

There are several important approaches to studying climate change adaptive capacity that shape this study. Jonathan Ensor and Rachel Berger's *Understanding Climate Change Adaptation: Lessons from Community-Based Approaches* (2009) has uncovered two important elements for studying adaptation. The first element is a focus on vulnerability analysis with two approaches, the "Starting-point" and "End-point" approaches. In short, a "Starting-point" takes a much closer look at existing social systems and community dynamics. This approach does not rely on any future impacts of climate change, models or scenarios. It allows climate change to be abstract and the future to be uncertain. "Starting-point" is the approach used in this study.

The second approach, "End-point" vulnerability assessment examines what would happen to a community given a hypothetical outcome of climate change. This approach focuses less on the social systems and dynamics and more on tangible outcomes that would result given climate change and a prospective impact. It is a more useful analysis of how community infrastructure is likely to be impacted and takes a cost/benefit approach to avoiding damages. One important note on "Starting-point" and "End-point" is the potential for feeding adaptation efforts. Given the uncertainty of climate change for the future, there is a danger of generating maladaptive approaches and policies. By focusing on social systems and addressing information systems, networks, community solidarity and collective action ability, the costs are not lost if climate change does not follow a given model. The community still benefits by an improved degree of civility. This is sharply contrasted with "End-point" assessments, which require a given outcome in the future. Policies and efforts at improvising infrastructure or managing forests for a certain outcome can become a loss if the future differs from a climate model.

The second important element that Ensor and Berger (2009) discuss is the focus on adaptation types, namely "First generation adaptations" and "Second generation adaptations." "First generation adaptations" refer to tangible impacts. In order to deal with sea level rise in a coastal community, an adaptation policy that generates a new levy system to overcome flooding is an example of a "First generation adaptation." It is generated within a single generation and the following generation reaps the rewards, or pays the cost of poor strategies. Much like "End-point" vulnerability assessment, the "First generation adaptations" can be more susceptible to high costs or becoming maladaptive if the adaption was not necessary or not efficient enough to deal with the impact of climate change. "Second generation adaptation" focuses more on social and cultural elements of the community. It works by changing belief systems, values and behaviors that can be passed down to the next generation. These adaptations are more fluid and are not at risk of high cost/low benefits or to maladaptive effects. This study will focus on "Second generation" adaptations.

The Framework for Analysis

As discussed above, this dissertation has three individual manuscripts. Within each manuscript a framework and methodology will be provided. Below is a brief discussion outlining the general frameworks and methodological approach relevant to each manuscript. A more thorough discussion of the methods is included in Appendix A. Each framework is introduced by the argument for community-based adaptation to climate change and wildfires that this research investigates. These manuscripts address: 1) climate change and its potential risks; 2) the social and political capital of the communities that impact collective action; and 3) the network to governmental action information for collaboration. All three manuscripts look at the social impacts, variables impacting values and beliefs and use statistical models to show degrees of impacts on these social systems.

The first factor in community-based climate change adaptation capacity in La Pine and Greater Crescent is the collective action potential of the community members themselves, or social capital. In the rural community literature, social capital "involves mutual trust, reciprocity, groups, collective identity, working together, and a sense of a shared future" (Flora and Flora, 2013:11). Furthermore, social capital is often understood as the resources embedded in social networks (Lin, Cook and Burt, 2001). Social capital is generally researched through social networks know as instrumental social capital or through the impact these networks make in a bounded community known as expressive social capital (Harshaw and Tindall, 2005 p.429). Instrumental social capital can be studied through theoretical and methodological approaches such as Ronald Burt's network "brokerage" and Nan Lin's "prestigue index" while expressive social capital resources can include norms and values and can include measures of community trust and collaborative potential. In this study, the instrumental social capital is measured through reported ties to information sources and other residents and expressive social capital through the perceptions the residents have on their communities. This study is attempting to correlate the dependence of instrumental social capital through residents' social networks to the expressive social capital institutionalized by the community.

The second factor for addressing climate change adaptation is to understand the relationship that climate change information sources have on residents' perceptions of the issue and the local risks. Today's mass media culture presents an array of information outlets such as television with specific programs and personalities, websites, radio and printed words in books. These many sources of information available to the public can generally be categorized into two fields; those that support the scientific consensus that climate change is occurring due to anthropogenic activities with significant ramifications to socio-ecological systems, and those that fail to support the scientific consensus viewpoint. Using a relational analysis approach to a set of diverse information sources on climate change, the question of whether or not these information sources have an impact on perceptions will be better understood. This could play a pivotal role in managing local campaigns for promoting awareness and understanding of issues and risks the community could face with grassroots mobilization and campaigns for climate change adaption.

The third factor of community-based climate change adaptive capacity is the relationship communities can have with formal governmental institutions. Governmental bodies including local, county, state and federal, can all play vital roles in a collaborative process to generate adaptive capacity. At the time of researching and writing this dissertation, public sentiment on government has been significantly low. Yet a number of facts remain, these communities are encircled by large tracts of state and federal land and budget and management of these lands dramatically impacts the risks these communities face. Governmental bodies may also play significant roles in collaboration by providing resources and capital to assist locals in preparing for climate change and their local vulnerabilities. It is probable that the information systems used by residents would impact their advocacy for policy and action within a collaborative effort. Knowing what types of information sources these residents use may have significant impacts in grassroots efforts as well as the relationship these sources have to governmental trust and collaboration.

When combining these three dimensions of adaptive capacity and the formal frameworks for studying these dimensions, this dissertation and its manuscripts will provide a better understanding of the

existing social and political systems and potential dynamics to adapting to climate change in the communities of La Pine and Greater Crescent. As discussed above, the focus of all three dimensions will be on a "Starting-point" assessment of community vulnerability and an attempt to address "Second generation" adaptations. The efforts in this study have a further goal of establishing a foundation for a longitudinal study.

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Social Capital in Forested Communities: Adapting to Climate Change and Increasing Wildfire Risks in Rural Communities in Central Oregon[4]

"The common person, those are the people, not the heroes, who solved all the global problems for thousands of years, and will continue to."   All.I.Can, 2011[5]

Introduction

This research investigates community-based climate change adaptability in two rural communities in central Oregon. Community-based adaptation is emerging as a response to failures in international and national efforts to significantly address the local risks of climate change with mitigation policies and action. Local adaptability includes social systems that promote and encourage information diffusion, social influence, collective action and cooperation, and trust between community members and with formal institutions. This is often referred to as social capital. Social capital is the embedded resources in social networks that enhance the individual and improve the social systems. Within the social network literature, social capital can be examined through the investigation of expressive or instrumental social capital (Harshaw and Tindall, 2005 p. 429; Lin, Cook and Burt, 2001). Expressive Social capital, also referred to as community social capital, allows communities to address complex and contentious issues where divergent worldviews, beliefs and values exist (Coleman, 1988; Flora and Flora, 2013; Harshaw and Tindall, 2005 p. 429; Hoult, 1977; Putnam, 2003). Expressive social capital is reflected in the collective expression of the community's networks, and includes such variables as trust, collaboration and solidarity. Instrumental social capital among community residents is explored through the use of social networks analysis; in this case, a position generator tool measuring ego-based social networks (Harshaw and Tindall, 2005 p. 429; Lin, Cook and Burt 2001; Lin and Erickson 2008). Finally the connection between instrumental and expressive social capital and their role in understanding community-based climate change adaptation is addressed.

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[4] To be submitted to Rural Sociology.

[5] Documentary Film

Climate Change, Central Oregon and Adaptation

There is steadfast acceptance in the scientific community that climate change is occurring. Impacts of climate change will vary depending on geography and the social and ecological systems in specific regions. For the intermountain west of the United States, there are many microclimates that range from deserts to temperate rainforests. Communities located in these microclimates have evolved social, cultural and economic systems tied to their ecological environments. One particular microclimate found in the intermountain west is the dry forests on the eastern side of the Cascade Mountain range, which stretches from California to British Columbia, Canada. In Oregon, the location of this study, communities have developed timber, agriculture and recreation industries tied to the forest ecosystems and rangelands in the area.

Frequent and low intensity wildfires are a natural part of central Oregon's dry forested ecosystem. The wildfire ecology in this region faces increasing risks to fire frequency and severity due to climate change. These risks are exacerbated by decades of forest management that has focused on wildfire suppression, resulting in an unnatural accumulation of biomass. Evidence of climate change across the Pacific Northwest and potential impacts from wildfires are raising further concerns with public agencies and land managers (Oregon Department of Land Conservation and Development. 2010: U.S. Department of Interior and Department of Agriculture, 2014; Western Governors' Association, 2010) who are charged with addressing wildfire risks to forests and human settlements.

Public knowledge about climate change is limited by the complexity of the climatic system and mixed acceptability of climate change science, making support and collaboration for managing natural resources between formal institutions and the public difficult. This difficulty may be compounded as knowledge may not translate into behavioral changes either in political action (Grundman, 2007; Oreskes and Conway, 2011; Schneider, 2009) or in public actions (Patchen, 2006); that is, even if people accept climate change as occurring, they may not act in ways to either forestall the impacts or to adapt to likely socio-ecological impacts. Deep-rooted worldviews and values also play a role in climate change perspectives (Patchen, 2006). While public sentiment toward climate change is growing, many areas of

the public remain divided on the issue (Borick and Rabe, 2012; Leiserwitz, et al, 2012) contributing to the difficulty in natural resource management attempts to address the potential risks across the diversity of public feelings and beliefs. Despite the division by the public and the challenges that public agencies and land managers face, the potential for a community to adapt to new socio-ecological systems is an important consideration, if not a necessary condition, in the implementation of sustainable climate change policies and practices.

This paper examines central Oregon rural communities located within the same national and state forests and share similar socio-ecological conditions in which their social systems are dependent on the natural systems for recreation, capital and amenities. Crescent, Gilchrist and Crescent Lake are three small communities (populations of roughly 906, 238, 122 respectively) that are geographically proximate (within 20 miles of each other), and have shared economics and amenities, and are treated in this research as one community: Greater Crescent. La Pine's incorporated city has a population of about 1653 and is located 17 miles north of Gilchrist. La Pine and Greater Crescent differ in two fundamental ways: 1) La Pine is a part of Deschutes County while Greater Crescent is a part of Klamath County; and 2) La Pine became an incorporated city in 2006.

The incorporation of La Pine provides an opportunity to assess potential differences between a traditional rural community and a newly emerged municipality with regard to climate change, wildfire risks, social capital and networks for community-based adaptability. Understanding variations between these communities may help direct future research in similar community types. Further, the existence of a formal local government may have significant policy implications where La Pine may have more institutional support, while the communities that comprise Greater Crescent lack localized institutional bodies with formal ties to county, state and federal resources.

Climate Change

In 2013 the Intergovernmental Panel on Climate Change (IPCC) published the fifth Working Group 1 (the physical science group) climate change assessment report expressing increased confidence in the scientific predictions, as well as a general consensus are three important principles: 1) the global climate is changing; 2) the global climate is being influenced by anthropogenic activities and; 3) continued changes pose risks to many communities around the globe (Stocker et al, 2013). Despite the consensus and confidence expressed in the report, uncertainties remain. These include the proportional impact of anthropogenic contributions to climate change, the future rate of anthropogenic (and natural) contributions that affect the climate system and the systemic effects of positive and negative feedback loops (Stocker et al, 2013).

Uncertainties expressed by the climate science community include questions about ecological resilience and thresholds in the climate system (Stocker et al, 2013). Ecological resilience is the ability of the biosphere to integrate the increasing bombardment of greenhouse gases. A threshold is a point where rapid transitions to a new environmental (including climatic) system occur, and a return to the status quo is not possible (Stocker et al, 2013; Walker and Salt, 2006).

Furthermore, the general focus of climate change conversations on global climate change rather than localized changes may impact community-level social and political systems. Such uncertainties may delay political action that could mitigate anthropogenic activities, as well as generate confusion and ambiguity in the public domain (Schneider, 2009; Oreskes and Conway, 2011). Ongoing studies by the *Yale Project on Climate Change Communications* and the *George Mason University Center for Climate Change Communication's* "Global Warming's Six Americas" (Maibach, Roser-Renouf and Leiserowitz 2009; Leiserwitz et al 2011, Leiserowitz et al 2012) have found that Americans fall into six categorical positions on climate change: alarmed, concerned, cautious, disengaged, doubtful and dismissive. Attempts to explain the diversity of public positions on climate change include religious perspectives (Adger et al, 2009; Hulme, 2009; McCright and Dunlap, 2011), communication discourse (Carvalho, 2007; Hulme, 2009; Oreskes and Conway, 2011) and risk perceptions (Adger et al, 2009; Lorenzoni and Pidgeon,

2006). Thus, the general public develops perceptions about climate change based on complex social and cultural systems rather than as patrons of scientific inquiry and understanding.

The diversity of climate change perceptions has likely contributed to the failure of both political and market-based solutions to mitigate anthropogenic climate change over the last 50 years. Furthermore, as the U.S. continues to emerge from a great recession, it seems unlikely that the federal Government and its public agencies will have the financial and political resources to efficiently develop adaptation strategies and programs on the scale needed to address local risks and needs. Similarly, many rural communities have little human and monetary capital of their own to begin such an endeavor. Collaboration between communities and formal institutions at different hierarchical positions would likely generate the greatest efficiency in adaptation development. Local strategies may be the most effective way to stimulate grassroots efforts and collaboration to address climate change adaptability.

Despite the heterogeneity of climate change beliefs and values in the U.S. and within most communities, it is a local public that will need to find common ground and pursue adaptations specific to local threats and vulnerability (Ensor and Berger 2009). Grassroots efforts to establish learning programs and discussion platforms for climate change risks and localized vulnerabilities may be an important groundbreaking effort toward adaptation development strategies.

Climate Change in Central Oregon

In central Oregon climate change poses risks to the hydrological system (Oregon Climate Change Research Institute, 2013) that may burden the region's socio-ecological systems in many ways. The communities in this region are dependent socially, culturally and economically on the natural landscape and forests that is fed by a hydrology of rain, snowmelt, rivers and streams and lakes. Many of the communities in this region evolved from the timber industry, ranching and farming, and the railroad and transportation corridors. Today much of the timber industry in Oregon is in decline and many of the communities continue to struggle to maintain their timber identity, while other communities are attempting socio-economic transitions to capitalize on amenity recreation and tourism, and retirement destinations (Charnley, 2006; Kelly and Bliss, 2012).

Regardless of the state of the economy, central Oregon communities have always faced the risks of wildfires. This region and its dry forests have evolved and adapted to high frequency, low intensity fires (Campbell, Azuma and Weyermann, 2004; Perry et al, 2011). With human settlement and development, fire suppression coupled with timber boom-bust cycles and other forest management practices, the forests have become laden with biomass fuel loads (Spies et al, 2010; Wimberly and Lui, 2013). This unnatural state generates a greater increase in wildfire risks and wildfire intensity. Today, most of the fire risk attention is placed on fuel conditions, yet the Pacific Northwest forest agencies at both federal and state levels are becoming more vocal about the frequency and intensity of wildfires that may accompany climate change.

In central Oregon the risk of wildfires that may result from climate change are largely a result of the decline in precipitation in the form of mountain snowpack and changes in seasonality (OCCRI, 2010). This region is impacted by a rain shadow effect that draws the moisture out of the westerly air as it is raised by the Cascade Mountains (Zhang et al, 2013). Most of the atmospheric moisture is extracted as rain and snow in the western area of the state and across the mountain range. If climate change models for the Pacific Northwest are close to accurate, central Oregon runs the risk of becoming significantly more dry and much more prone to wildfires (Oregon Climate Change Research Institute, 2010). This dryness will come from extended summers and with less snow during the winter, and therefore less snowmelt. Some studies have reported a 200 to 400 percent increase in wildfire burning area by 2050 (National Research Council, 2011; Spracklen et al, 2009).

Climate change, social capital and community-based adaptation

Communities around the globe are facing the reality that climate change may dramatically impact their socio-ecological systems. Many communities are beginning to assess their risks and vulnerabilities, and to develop strategies that address these challenges. They are looking to their fellow community members and leaders for answers. Community-level adaptive capacity can be influenced by social, cultural, economic and political capital, as well as infrastructural and ecological conditions (Ensor and Berger 2009, p 17). Adaptive capacity will be unique to each community facing impacts from climate

change, given their levels of capital and specific risks and vulnerabilities. Much like many other local and regional efforts to address environmental issues, community-based adaptation to local risks and vulnerabilities will take grassroots mobilization and will require collaborative efforts with formal institutions. Social capital has been shown to play a vital role at both individual levels and community levels of adaptation (Flora and Flora, 2013; Lin and Erickson 2008; Lin, Cook and Burt; 2001; Putnam and Feldstein, 2003).

Community level social capital (Expressive social capital) refers to social goods or resources that contribute to the cohesiveness of region and may prove more helpful in building and sustaining a community than monetary and infrastructural capital (Flora and Flora 2013; Harshaw and Tindall, 2005 p. 429). Resident level social capital (instrumental or network capital) assists in the development and well-being of individuals (Harshaw and Tindall, 2005 p.429; Lin and Erickson 2008). Social capital is established in the literature to be vital for overall community health (Putnam, 2003; Flora and Flora, 2012; Lin Cook and Burt, 2001; Burt, 2005). In studies on individual social capital, such as the work done by Nan Lin, Bonnie Erickson and others, it has been shown that social connections tend to significantly improve a person's social position (Lin, Cook and Burt 2001).

In Robert Putnam's *Better Together: Restoring the American Community* (2004), both rural and urban communities benefitted from the development of social capital. In the case of Tupelo, Mississippi (pp 98-118), Putnam shows how a poor and devastated community in the 1930s and 1940s overcame adversity and economic struggle with leadership and social capital to become a thriving community. Richardson, Erickson and Nosanchuk (1979) showed how community size affects information networks as well as bonds within the community, especially with outside-the-workplace communities. Work communities are major transmission lines for information in both large and small communities, but in smaller communities social relations are denser and more active, so information moves more quickly and efficiently. Furthermore, the work of Jan and Cornila Flora empirically shows the values of social and other forms of capital (their Community Capital Framework) in developing and maintaining community health and prosperity, especially in rural regions (Flora and Flora, 2013).

In individual scales of social capital Bonnie Erickson (2003; Lin, Cook and Burt, 2001, pp 127-158) has shown that network ties, both strong and weak, are important for health and happiness and that diversity within a social network acts as a resource for self-improvement. Ronald Burt's work investigating structural holes in networks also shows the advantages of personal networks and the resources created through these relationships that aid learning and contribute to the spread of ideas, ultimately increasing opportunities and adaptation (Burt, 2005). There is a wealth of social research on the advantages of personal social capital and how social capital expands from the individual level to empower larger social systems (Lin, Cook and Burt, 2001; Weber, 2003; Putnam, 2003).

Ed Weber's *Bringing Society Back In* (2003) illustrates the importance of local initiatives and cooperation when addressing environmental issues and the development of sustainable communities. Weber's case studies on the Applegate Partnership, the Henry's Fork Watershed and the Willapa Alliance all illustrate the importance of localized mobilization, collective actions with both non-governmental organizations and governmental agencies and social capital. These examples illustrate the importance of building trust and overcoming adversity both within local communities and between the communities and institutions. In Örjan Bodin and Christina Prell's groundbreaking work *Social Networks and Natural Resource Management: Uncovering the Social Fabric of Environmental Governance* (2011), the case studies further illustrate how social networks and social capital operate in communities around environmental issues and natural resource governance.

These case studies illustrate how social capital and networks operate with regard to learning, problem solving and collaboration in addressing environmental and natural resource issues in very different social and cultural settings. The cases show how the resources embedded in social networks such as trust and norms, learning and information flow, influence and reinforcement, and support enable communities to address diversified interests around complex problems. Although these literary editions do not focus solely on climate change and climate change adaptation, the cases demonstrate vital lessons for climate change adaptation efforts for researchers, formal institutions and community leaders.

On the subject of climate change and adaptation, Jonathan Ensor and Rachel Berger edited a literary work, *Understanding Climate Change Adaptation: Lessons from Community-Based Approaches* (2009). This work compiles cases where communities are facing climate change in diverse regions of the globe, and with diverse risks and vulnerabilities. Much like Weber's (2003) and Bodin and Prell's (2011) work above, the embedded social structures and resources are perceived as necessary elements of adaptive capacity. While collaboration with formal institutions is arguably the more efficient and effective model, some communities may be limited to more grassroots efforts when formal institutions have limited capital.

The focus of this paper is on the role of social capital to facilitate or impede adaptive capacity to climate change in two communities in central Oregon, and hence, their risk of increasing wildfires. This paper utilizes both resident (Instrumental) and community (Expressive) levels of analysis, and examines community social capital as it is reflected from network social capital within La Pine and Greater Crescent. The analysis investigates how resident level social capital impacts community level social capital, and the connections to adaptive capacity and climate change. It also compares these two communities to assess potential differences to community-based climate change adaptation.

The Research Question and Inquiry

This article explores four research questions that examine the influence of social capital and social networks in the formation of beliefs regarding climate change in central Oregon's La Pine and Greater Crescent communities. It explores community social capital measures that capture how bonded the residents see their community and its formal governmental institutions and how these measures impact climate change and local risk perceptions. This article also explores network capital and how residents' personal ties to diverse professionals with expected information and knowledge capacity for climate change and local environmental risks impact risk perception on climate change and local risks. Finally it explores the relationship between residents' network capital to perceptions on community capital. The following are the questions and hypothesis leading this research:

Q1: Does community matter in explaining residents' positions on climate change and on concerns for the potential local impacts to the community and its environment?

H1: The community of La Pine has transitioned from a traditional rural community to a newly incorporated city signifying possible socio-political and demographic transitions. Given that the Global Warming's Six Americas' study has found that rural American residents tend to have a lower overall percentage of residents that share concern for climate change, we may expect to see La Pine's residents having higher concern for climate change than residents in the traditional rural communities that make up Greater Crescent.

H2: The incorporation of the geographic core of La Pine and its transition from a traditional rural demographic makeup is expected to have significant effects on the socio-ecological positions of the residents. Due to less spatial and economic dependence on the physical capital of the local forests, it is expected that a greater concern of climate change does not reflect a greater concern for local impacts. Therefore being a resident of La Pine may have a more negative impact on local concerns from climate change than residents of Greater Crescent.

Q2: Do network ties to professionals in the communities that are expected to have either traditional or tacit knowledge on climate change, forest ecology and wildfire, explain a greater concern for climate change and concerns for potential local risks?

H1: Many professions bring the employee closer to a working knowledge on specific topics and issues. These professions are not all equal in their degree of expected traditional and tacit knowledge and some professions may carry greater working knowledge on climate change and how it may impact local forests. It is expected that residents' ties to professionals (their instrumental social capital) with varying degree of knowledge on climate change, forests systems and wildfires and how these may overlap

should have a greater degree of concern for both climate change and for the local impacts climate change may bring.

Q3: Does being a resident with a strong sense of community inclusion, shared willingness to work with others and a degree of trust in formal authorities impact one's position of concern for climate change and for the concern for the local impacts climate change could have on the region?

H1: Communities are usually better at seeing and understanding issues when there is a stronger collective sense of being and they feel that something can be done when they can work together. Therefore residents that have a sense of community solidarity and a belief that the community can work to address its issues may register a greater degree of concern for climate change and for its local impact risks.

H2: The Global Warming's Six Americas studies have identified that political associations and degrees of trust are correlated to positions on climate change, mainly that respondents that have a lower degree of concern and lack of belief in climate change also share a lower degree of trust in government and carry more Conservative political ideological positions. Therefore it is expected that in these communities, residents that have a higher trust in government may also have a higher degree of concern for climate change and its local risk potential.

Q4: Does one's network ties to professionals working in the fields of science, public agencies and administration, forestry and media impact their position on the community's solidarity, their understanding of its ability to work together and the trust they have in the overall governing bodies?

H1: The network and social capital literature is consistent that networks and trust are correlated. Furthermore, some studies have shown that there is often a negative correlation associated with education and anti-government sentiment. In this research many of the professions inquired upon have a higher degree of educational expectation as

well as having some ties to governing bodies if they are not a governmental agency themselves. It is expected that the greater the ties to these selected professions may impact the resident's sense of trust in government overall.

Methods

Study Sites

This research is part of a National Science Foundation funded project between the U.S. Forest Service and Oregon State University. This project was bound by design in central Oregon. Within this geographic region exists many communities that range from small rural to larger urban. Most of these communities, regardless of demographic classification, exist within the boundaries of forested ecosystems and much of these forests are owned and managed by the U.S. Federal Government.

La Pine is located at the southernmost edge of Deschutes County, while Crescent, Crescent Lake and Gilchrist (Greater Crescent) are at the northernmost edge of Klamath County. The La Pine and the Greater Crescent communities are often described as rural communities and evolved in socio-economic dependence with the natural resources surrounding the area (Coon, 2007; Metcalf, 2010). The communities are geographically located within 20 miles of each other, so social and economic connectivity is likely, yet La Pine also shares a reasonable commuting distance of 35 miles to Bend, Oregon, a rising metropolitan center in the region. The connectivity between a rural and metropolitan center is likely to have significant social, cultural and economic impacts on residents (Rasker *et al* 2009).

In 2006 the community at the geographic core of La Pine voted to incorporate and La Pine became an official city, which began a demographic and political transition that may distinguish it from Greater Crescent. La Pine now has formal city leadership and services such as law enforcement and fire and rescue. This episode in La Pine's evolution encouraged the selection of this community for the research presented here. With the close proximity, socio-ecological homogeneity and historic interdependence with the Greater Crescent communities to the south, it seemed logical to consider La Pine and the Greater Crescent communities as case studies. La Pine and Greater Crescent provide fertile ground for case studies as they illustrate an emergent rural-urban demography and a traditional rural

community. In this way they can provide insight regarding their social capital and how this might influence views about climate change and its potential risks to the communities and residents.

Data Collection

This research is based on a questionnaire mailed to 683 owner-occupied households in the city of La Pine and the Greater Crescent communities, 345 in La Pine and 338 in Greater Crescent. Owner-occupied residents were chosen due to a high number of secondary homeowners in the region. In early scoping for the research it was discovered that many homes are seasonally occupied and owned as investment properties. The approach for the mailed questionnaire began with a notification card followed by two waves of the mailed questionnaire (Dillman, 1999). The response rate for the 345 mailed questionnaires and the 338 Greater Crescent questionnaires is 23 percent and 30 percent respectively and a total response rate of 27 percent (Table 1).

Table 1. Response rate for mailed questionnaires

	La Pine:	**Greater Crescent:**	**Total**
Mailed:	345	338	683
Returned:	79 (23%)	102 (30%)	181 (27%)

The questionnaire was first mailed in mid-November, with a second mailing in the beginning of January. The questionnaire consisted of four sections (community social capital, climate change and wildfires, social networks and demographics) and asked 24 questions. The response rate is fair for contemporary mailed questionnaires to general populations; yet a non-response survey for sample-bias was conducted on randomly selected non-respondents to the questionnaire to increase confidence that data was representative for each community. This survey consisted of sample questions from three of the four sections of the mailed questionnaire (Vaske, 2008): the community social capital, climate change and the demographics section. The overall results showed that the variation between the mailed questionnaire

group and the non-response survey was negligible if not absent. The data and results incorporated here can also be found in the Appendix.

Community and Resident Level Measures of Social Capital

This analysis draws on a set of sixteen questions about community level social capital (Expressive social capital) within the communities. These questions were modeled after *Measuring Social Capital: An Integrated Questionnaire* (Grootaert et al 2004) in an effort to capture multiple dimensions of the communities' social capital such as trust, collective action and cooperation, information and communication, social cohesion and inclusion, empowerment and political action. The questions were chosen from the set of "core questions" and modified for a locally-relevant focus. Key words such as fire, wildfire, and community names were added to focus the subjective nature of the research for the respondents. An example of a modification to the question is, "If there was a water supply problem in this community, how likely is it that people will cooperate to try to solve the problem" where "water supply" was changed to "fire" (Grootaert et al 2004, p47). Multiple levels of governmental institutions for geographic considerations led to the addition of the terms federal, state, county and local governments rather than "local" and "central" for governmental trust (see Appendix).

Resident level social capital (Instrumental social capital) analysis is based on a position generator (Lin, Cook and Burt, 2008). This methodology uses a roster of relevant occupations and/or authorities and asks respondents to identify their social ties to various positions. From the responses, researchers can capture the range, extensity and upper reachability of a resident's social relationships (Lin, Fu and Hsung, 2008 p 37-81). This research uses a novel approach to the position generator to assess how professional ties believed to have both explicit and tacit knowledge associated to climate change, forest systems and wildfire will impact residents' concerns. A set of eight professions were introduced that may correlate to exposure to information about climate change and wildfire and/or forest conditions in these communities. To capture locally-based professionals, the questionnaire specified the positional tie be a local resident. The professions included: professional scientists, science teachers, public land managers, local

community officials, non-governmental organization members, forest/city firefighters, local news associates and timber employees.

The position generator is often used to analyze the effects of the diversity of social ties on health and prosperity of an individual. In some cases, however, the positions are weighted for theoretical considerations. In the case of climate change information, certain positions have a more likely probability of receiving, understanding and disseminating climate change information and its potential impacts to forest ecosystems and for local risks (wildfires). For this research a weighted index (Lin, Cook and Burt, 2008) is used to identify residents' ability to acquire professionally based climate change information that may influence beliefs on climate change and its potential local risks. This weighted index was developed with consideration about educational demands of the position, professional focus in relation to the issue and potential exposure to the diversity of the issues. A professional scientist is often highly educated, able to understand complex scientific information and may often be exposed to scientific issues beyond their professional focus. Conversely, a timber industry employee often has lower formal educational demands and is less likely to have the working knowledge to understand the complex interrelated aspects of climate change, yet they often have tacit knowledge evolved from exposure to forestry issues that may include wildfires. The weighted scores are available in table 4 below where weighted scores range from 8 for professional scientists to 1 for a timber industry employee.

Both resident and community social capital measures become independent variables for the regressions explaining both climate change and local risks to answer 2 and 3. The community social capital is analyzed for factors and then indexed and the resident social capital becomes a weighted index. The resident social capital then becomes an independent variable for a regression explaining the community social capital. In all the following regressions community is also included as an explanatory variable to investigate differences between the rural Greater Crescent communities and the incorporated La Pine.

Climate Change Measure

Perceptions about climate change were measured on two scales, a global or broader position on climate change and local position for concerns on risks. The first scale (global) is based on the question, "How would you define your position on climate change?" The questionnaire provided the options: alarmed, concerned, cautious, disengaged and doubtful. These options were taken from the *Global Warming's Six Americas* (Maibach, Roser-Renouf and Leiserowitz, 2009; Leiserowitz *et al* 2012). In this study the opinions were condensed into brief statements. For example, *alarmed* was presented as "Climate change is occurring and risks to this region are high" while at the other end of the scale, *dismissive* was presented as "Climate change is not real." In between these two extremes was *concerned*, which stated, "Climate change is occurring and risks may be harmful to this region" and the *Cautious*, stating, "Climate change is occurring but I am unsure of any risks to this region." Additional categories included the *disengaged* : "I feel there are more important issues to worry about in this region than climate change" and the *doubtful*, described as "Climate change has not been proven and risks are unknown at this point in time."

The results for each community are presented in Table 2 along with the results from *Global Warming's Six Americas* (2012) to demonstrate national comparisons. We see that high percentage of residents in both communities share the *concerned* and *cautious* categories for climate change, meaning they do agree that the overall climate is changing (In La Pine 15.9% and 26.1% respectively and Greater Crescent shows 20.2% and 27.7%). A distinct variation is found between the broader U.S. studies of the Global Warming's Six Americas and the residents in La Pine and Greater Crescent is the position of *disengaged* (34.8% in La Pine and 23.4% in Greater Crescent compared to a mere 6% from the Global Warming's Six Americas' study). This group fails to recognize climate change as an issue and chooses to worry about other more immediate concerns.

Table 2. A Comparison of Positions on Climate Change between La Pine and Greater Crescent and those found in the 2012 *Global Warming's Six Americas' Study*

	Alarmed	Concerned	Cautious	Disengaged	Doubtful	Dismissive
La Pine	8.7	15.9	26.1	34.8	14.5	0
G. Crescent	10.6	20.2	27.7	23.4	17.0	1.1
SixAmericas	13	26	29	6	15	10

Table 2. shows the percentage of the respondents that indicate each of the six positions for La Pine and Greater Crescent and from results of the *Global Warming's Six Americas Study, 2012 report.* Sampling bias for the communities was tested using independent t-tests for mean differences between questionnaire respondents and a random sub-sample of non-respondents in both La Pine and Greater Crescent. Independent t-tests show t= 1.047 (sig= 0.298) and t= 0.884 (sig= 0.379) and point-biserial correlation effect size of *r= 0.11* and *r= 0.08* respectively.

For local concerns on climate change the question, "To what extent are you concerned with potential regional negative impacts from climate change on the following" was asked. This question included five broad areas of concern and were listed as "Impacts to industry, outdoor recreation activities, local culture and identity, public and private natural resources, and risks to natural hazards and disasters." For each of these items a four-point Likert scale was presented ranging from "strongly concerned" to "not at all concerned" with "unsure" as the fifth option. These are then compiled into a single index for local concern to become the independent variable for questions two and three.

Statistics and Modeling

All statistical analysis was done using IBM's SPSS versions 20, 21 and 22. Hierarchical multiple regressions were run to test for impacts by community specificity and community and resident social capital measures on both climate change positions and on concerns for local risks (research questions two and three). Additionally, multi-regressions were made to assess the impact of residents' network ties to professions and the impacts these ties have to the community capital measures (research question four). These regressions also included community as an explanatory variable. These research variables are controlled with demographic variables notably correlated to climate change beliefs positions. The small sample size of responses limits the number of independent variables for multiple regressions, so demographic control variables were selected with specific considerations.

Bivariate correlations that were run on age, gender, education and income, were often found to be correlated to climate change. In these cases, no correlations were found between any of these

demographic variables. Furthermore, for education, 71 percent of the respondents have less than a four-year college degree heavily skewing this variable. For income, respondents work status was evaluated and only 22 percent of respondents are employed full time, and 92.6 percent were identified as retired. Given these two variables both fail to correlate with climate change and local concerns on risks and because they are highly skewed, these variables were left out of the models. Consequently, the two demographic variables of age and gender were selected as control variable although they also failed to correlate with the dependent variables. These two variables were tested in a non-response bias check and results showed that both had means varying from the questionnaire sample, yet the effect size was minimal (point-biserial effect size r=0.14 for La Pine and r=0.12 for Greater Crescent and for age and phi= 0.08 for La Pine and for Greater Crescent). We then have statistical confidence that we are close to capturing the communities' age and gender positions with these two as control variables.

Analysis and Results

Community Level Social Capital

Community level social capital refers to the respondents' identification of the community's overall trust in varying levels of the hierarchal governmental bodies, its solidarity and willingness for collective action. Respondents were asked a series of questions developed by Grootaert, Narayan, Nyhan Jones and Woolcock's *Measuring Social Capital: An integrated questionnaire* (2004). The questions were analyzed using factor and reliability analysis (Field, 2013). These dimensions of community-level social capital are reported in Table 3. The sixteen questions load onto three factors related to *governmental trust*, *collective action* and *solidarity*.

The *governmental trust*, *collective action* and *solidarity* indices score above a Cronbach's α of 0.700, signifying a reliable index based on the given factors (Field, 2013; Vaske, 2008). Also included in Table 3 are the removal impacts, which indicate how the factor would change if the question was removed. The removal of any of the factors from the index does not increase the Cronbach's α, yet a few are fairly close. All remaining items reflect both statistical and conceptual fits and correlate well with the dimensions of social capital identified by Grootaert et al (2004).

3. The three community level social capital measures uncovered through factor and reliability analysis with corresponding Cronbach's α, community means and standard deviations, and the Cronbach's alpha if question is removed.

	α	La Pine	Greater Crescent	α if Removed
Governmental Trust	**0.904**	**2.89 (0.86)**	**2.93 (0.90)**	
Local government agencies can be trusted				0.870
County government agencies can be trusted				0.882
Oregon state government agencies can be trusted				0.852
Federal government agencies can be trusted				0.897
Collective Action	**0.815**	**3.22 (0.56)**	**3.32 (0.64)**	
Most people in… would attend public fire education & emergency preparedness presentation				0.786
If there is a community event to assist people with becoming prepared for wildfire, most will participate in some way				0.784
The people in… prepare for the unexpected				0.789
Most people in… participate in community activities				0.798
If there is a major fire in or near…, people would come together to solve the problems				0.782
… has a fire preparedness program with information that is readily available				0.800
People in… work together with community leaders for the benefit of the community				0.795
Solidarity	**0.727**	**3.46 (0.58)**	**3.66 (0.62)**	
In…, most people can be trusted				0.606
Most people in… are willing to help if you need it				0.664
In…, you can express different points of view in public conversations without fear or concern				0.709
I feel like I have power and control over my life and property				0.720
The people of… have similar values				0.699

Table 3 shows the means of La Pine and Greater Crescent, along with the standard deviations for each dimension of social capital. The values rest in a range from 0 to 5, where 5 indicates a strong agreement and 0 indicates a strong disagreement in the individual questions. The residents in both La Pine and Greater Crescent feel some trust in the four governmental bodies with mean values of governmental trust at 2.89 and 2.93 respectively. Overall these communities have just a slightly higher value in trusting of governmental institutions than a mid-value of 2.5 would indicate. The results from Greater Crescent are also contrary to the perception that rural communities might not trust governmental institutions as

they may be perceived as outsiders (Hourdequin et al, 2012; Lokocz, Ryan and Sadler, 2011; Steel and Weber, 2001).

In the collective action factor we also see a higher than mid-value measure with 3.22 and 3.32 for La Pine and Greater Crescent. This shows that residents in these two communities feel their community is willing and able to come together and address issues including wildfire preparedness and wildfire response. This is followed by the solidarity factor of social capital or the idea that people are unified in feeling and action and they may share a common interest and support each other despite some degrees of diversity. Here we see the trend continue where the resident respondents in both communities feel a degree of community solidarity above a mid-value of 2.5. Here residents in La Pine reached a mean value of 3.46 and Greater Crescent's residents appear to feel slightly more solidarity with a mean of 3.66. For both of these communities the residents do appear to feel that overall their neighbors are there for them and would come together if called upon to address issues including wildfire.

Resident Level Social Capital

To assess residents social capital, a position generator was used (Lin, Cook and Burt 2001; Carrington, Scott and Wasserman 2005). The position generator lists occupational and professional positions that may correlate with the subjective nature of climate change such as professional scientists or science teachers, and with the risk of wildfires such as firefighters and public land management agents. Respondents were asked to identify someone with whom they have a relationship with from the community and from a set of eight professions. Positions were assigned a weighting score based on analytical ability in understanding climate change and its potential to impact forest wildfire ecology. This weight value is then used in generating an overall index based on ties and weight scores. Table 4 indicates the professions, the score assigned and the percentage of respondents from each community who know someone in that position.

Table 4. Percentages of resident level social capital: Diversity and weight of residents' networked ties.

Position	Weighting Score	La Pine	Greater Crescent
Professional Scientist	8	7.9%	5.0%
Forest/City Firefighter	3	**22.4**	**40.6**
Public Land Management Employee	7	10.5	**21.8**
Non-governmental Organization Member	4	14.5	12.9
Science Teacher	6	6.6	3.0
Local Community Official	5	**23.7**	10.9
Timber Industry Employee	1	19.7	9.9
Local News Associate	2	15.8	7.0
Diversity Index		0.151(0.25)	0.140 (0.21)
Weighted Information Index		0.130 (0.23)	0.127 (0.20)

Table 4. This table shows the assigned prestige score for each occupation residents are asked to report a tie with. The percent of each community's respondents' ties to each occupation is reported. This is followed by the mean and standard deviation of La Pine and Greater Crescents residential reporting indexed for both diversity and prestige.

Diversity and weighted information index means and standard deviations are given at the bottom of Table 4. The diversity index is a measure of the sum of respondents who reported knowing someone divided by the number of total positions; while the weighted information index measures the sum of the ties and each of their values divided by the highest possible score. Both index values then range between 0 for no ties and 1 meaning ties to all. The means for these indices are very low, and the standard deviations are high, indicating significant spread among the residents. In general, residents seem to identify ties to a small number of these professions and as for the weighted information index, few residents identified with higher traditional knowledge professions.

Diversity in relationships is important for social capital as different types of positional relationships can convey a variety of information and diverse perspectives about a subject or correlated subjects (Putnam, 2003; Lin, Cook and Burt, 2001; Burt, 2005). Weighted values suggest that not only is diversity in social networks important, but that not all informational sources would be created equal; the positions with the highest degree of weight in a network may also be significant (Lin, Cook and Burt, 2001; Lin, Fu and Hsung, 2001 pp 62-65).

The percentages in Table 4 help to illustrate the lack of diversity in professional ties, yet highlight some important elements each community has in terms of ties to information sources important for community-based adaptation to climate change. In both La Pine and Greater Crescent, a relatively high percentage of residents reported network ties to firefighters, 22.4 and 40.6 respectively. Yet in Greater Crescent a significant percentage of respondents also have ties to public land management employees (21.8%) versus La Pine (10.5%). La Pine residents are more tied to local community officials (23.7%) than residents in the Greater Crescent communities (16.4%). La Pine residents share slightly more ties than those in Greater Crescent to all of the professions except public land management employees and firefighters.

Regression modeling

Hierarchical multiple regressions were run using SPSS to test the social capital measures explanatory value to climate change and concerns for local risks as well as resident information ties to community social capital variables of governmental trust, solidarity and collective action. In all regressions the community variable was added into the model to test for community effects on the dependent variables. Additionally, demographic variables of age and gender were incorporated to control for both community and the specified interest independent variables. Income and education, commonly used in climate change research due to their correlations were left out. These variables did not show correlations with our samples and they were highly skewed variables for these communities with 71 percent of respondents having less than a college degree and more than 90 percent being retired.

The regression modeling for this study is presented in Tables 5a through 5e. All regression coefficients are reported using standardized coefficients. Each regression uses three models, first with only the control variables, the second model adds the community dummy variable (1 for La Pine and 0 for Greater Crescent), and the final model includes the key dependent research. The number of cases, the R^2 and adjusted R^2 are reported for each regression. Reporting for statistical significance ranges from the p. $\leq$ 0.10 to p. $\leq$ 0.001.

Table 5a and 5b below address questions 1, 2 and 3 where it investigates the explanatory value of the key dependent variables of community and social capital on climate change (table 5a) and local concerns of climate change risks (5b). In table 5a and 5b model 1 we see that neither of the demographic variables show statistical significance for explaining climate change positions and concerns on local risks. Yet in table 5a we do see that the signs of the standardized coefficients are as expected, a negative coefficient for age (the older the respondent the less the concern on climate change) and positive coefficient if the respondent was female (females tend to share more concern for climate change than males do). In Table 5b, the results of gender changes sign and if the respondent is female she has less concern over the local risks, yet again these coefficients indicate the models lack statistical significance.

In model two of Tables 5a and 5b the community variable is added into the equation. The models themselves do improve with the R values but lack statistical significance. In table 5a on climate change we see that the age variable remains negative and gains some significance (p. ≤0.10) meaning that older residents in the community do feel less concerned over climate change. What is surprising in the model is that the added variable of community has a negative coefficient, and that if a respondent comes from the incorporated city of La Pine, they feel less concerned for climate change in general. This finding does not support the hypothesis to question 1 hypothesis 1. This variable fails to gain statistical significance yet it does gain significance in the subsequent regressions incorporating concerns of local climate change risks.

In Table 5b model 2 we do see that the La Pine variable does gain statistical significance (p. ≤ 0.10) and maintains a negative coefficient. In question 1 hypothesis 2, it is believed that La Pine residents would have less concern over the local impacts of climate change. Here the variables that are included in the index for this dependent value include the local economy, recreation, culture, natural resources and natural hazards such as wildfires. As La Pine has transformed from a traditional rural community to an incorporated city, it has gained some modern traditional economic opportunities such as Bi-Mart, a large box store. The culture is shifting to a forest amenity culture where traditional recreation is seen as outside the community instead of within. Finally the incorporated city is buffered by what is known as Greater La Pine, segments of housing and development that have not become incorporated. These may be giving

these residents pause when it comes to concerning themselves with the local impacts to risk from climate change.

Model 3 in both the climate change and local concerns regressions adds the key social capital variables. The model's R values improve and become statistically significant (p.≤0.005 for the climate change regressions and p.≤0.01 for the local concerns index). In the climate change model age maintains a low degree of statistical significance and remains negative but in the local concerns model age lacks significance. Furthermore, in the climate change regression community remains negative yet insignificant but in the local concerns regression it maintains a low significance as well as a negative coefficient.

These models address research questions 2 and 3. The models clearly shows two important results; one is that community level social capital does impact the concerns the residents in these communities have to both climate change and local concerns and that network ties to the specific professions does not. In question two, the network ties to a range of weighted knowledgeable professions fails to statistically explain either the residents' concerns for climate change or their local concerns for the impacts. This does not support the hypothesis for question 2 and cannot explain a resident's ties to these professions as having an impact on their beliefs and concerns.

Despite the lack of an impact by network ties, community level social capital (as used in this study) measures do impact residents' beliefs and concerns. For the explanation of climate change positions, governmental trust is highly significant (p. ≤ 0.005) and its explanatory power is much higher than the other variables coefficients. When explaining climate change positions residents that share a higher degree of trust for the various governmental bodies share a greater concern for the climate change. This result conforms to findings by the "Global Warming's Six America's" studies and illustrates a political dependence toward climate change beliefs and concerns over one of the potentially pertinent issues of our time. Yet governmental trust seems to have little if any effect on the local concerns on climate change, possibly implying that governmental bodies are still focused on the global implications and mitigation rather than transmitting what climate change can mean to localized regions. This could

have implications to the U.S. Forest Service in the region, the state of Oregon, Deschutes and Klamath County governments and the local government in La Pine.

In the regressions for the concerns of local risks (Table 5b) we see that the community social capital factor governmental trust is replaced with both collective action and solidarity with statistically significant coefficients (p.≤0.01 for the collective action and p.≤0.10 for the solidarity). Both of these coefficients (0.31 for collective action and -0.21 for solidarity) show a higher impact value to explaining residents' concerns than the third significant variable of community (-0.19). As expected in question 3, hypothesis 2, a resident's sense of the community as a working body for action that can address issues such as wildfires does positively impact their concerns for local risks of climate change. An unanticipated finding was the results on community solidarity effects. Here the results show a lower effect but the results are negative. The more residents feel unified and connected with their community neighbors the more the less these residents feel concerned by local impacts. This result counters our original hypothesis but may make some sense. If the communities have a significant proportion of residents that feel a sense of community solidarity and that there is a significant proportion of residents that feel disengaged with climate change and feel there are more important things to worry about in their area, it makes sense that this sense of solidarity would negatively impact these communities sense of concern.

Table 5a. Hierarchical multiple regression analyses explaining climate change position for residents in La Pine and Greater Crescent using standardized regression coefficients.

	Model 1	Model 2	Model 3
Socio-demographic control variables			
Gender (Female= 1)	0.04	0.04	0.03
Age	-0.12	-0.15†	-0.16†
Community			
La Pine (La Pine residents= 1)	-	-0.11	-0.11
Social Capital Measures			
Network Ties Index	-	-	-0.07
Governmental Trust Index	-	-	0.29***
Collective Action Index	-	-	0.13
Solidarity Index	-	-	-0.13
R²	0.02	0.03	0.13**
Adjusted R²	0.01	0.01	0.08**
N	145	145	145

Note: † p.≤0.10, * p.≤0.05, ** p.≤0.01, *** p.≤0.005, **** p.≤0.001

Table 5b. Hierarchical multiple regression analyses explaining concerns for local climate change risks for residents in La Pine and Greater Crescent using standardized regression coefficients.

	Model 1	Model 2	Model 3
Socio-demographic control variables			
Gender (Female= 1)	-0.10	-0.09	-0.12
Age	-0.11	-0.13	-0.05
Community			
La Pine (La Pine residents= 1)	-	-0.18†	-0.19†
Social Capital Measures			
Network Ties Index	-	-	0.11
Governmental Trust Index	-	-	0.16
Collective Action Index	-	-	0.31**
Solidarity Index	-	-	-0.21†
R²	0.02	0.05	0.17*
Adjusted R²	-0.00	0.02	0.11*
N	98	98	98

Note: † p.≤0.10, * p.≤0.05, ** p.≤0.01, *** p.≤0.005, **** p.≤0.001

Table 5a and 5b addressed the impacts of community and social capital on climate change and local concerns on its risks. Tables 6a, 6b and 6c address the impacts of residents' social capital (their network ties) to the community social capital factors of governmental trust, collective action and solidarity. In table 6a, the regression models address the impact that the network ties have on a resident's sense of governmental trust given this showed the strongest impact to climate change positions. Then in table 6b and 6c, the effect of the network ties to community residents sense of collective action potential and their sense of solidarity with the community neighbors.

In Table 6a below we see the three models seeking to explain governmental trust values in La Pine and Greater Crescent. Again we start the models with the control variables of gender and age and these variables and the models show a lack of statistical significance which persists over the remaining two models. This implies that gender and age cannot be relied upon in these communities to explain the degree in which residents feel trust toward formal governing bodies that reside over their communities. Likewise, adding community as a variable fails to significantly change the models statistical significance and it fails in both model 2 and 3 to show as a reliable variable for explaining degrees of trust in government. In model 3 we add the key variable for question 4 on whether or not the weighted network ties affect residents' community social capital, and in this case their feelings of trust in their governments.

The results of model 3 answers part of question 4 and the hypothesis that these network ties will positively impact the residents' trust in government. From the results seen below (table 6a) we do conclude that the weighted network ties do positively and with statistical significance (p. ≤ 0.001) impact the residents' degrees of trust. That the more ties to professionals and professionals with expected higher degrees of traditional knowledge on climate change and its local risks increases the residents' trust in their governments. This becomes more pertinent when we review Table 5a above and see the impact that the level of trust a resident has in their governments significantly impacts their position on climate change by increasing their overall concern on the issue.

In exploring the relationship between the network ties and the other two community social capital factors of collective action and solidarity, Tables 6b and 6c show that the network ties to the weighted professions do not explain the residents' feelings of being a part of a community that collectively works together and that has a sense of solidarity within its neighbors. This may be important when reflecting on Table 6b for the exploration of residents' concerns for local risks from climate change. In this table we see to that residents' network ties to these professions fails to account for residents' levels of concerns yet collective action has a significant and positive relationship to the concerns of local risks and solidarity shows a slightly significant negative relationship. In conclusion of the given analysis we see a path of social capital factors leading to residents' positions on climate change and two independent factors of community capital that impacts residents' concerns for local risks (see figure 7 below)

Table 6a. Hierarchical multiple regression analyses explaining the expressive social capital index of *governmental trust* for residents in La Pine and Greater Crescent using standardized regression coefficients.

	Model 1	Model 2	Model 3
Socio-demographic control variables			
Gender (Female= 1)	0.001	0.002	-0.025
Age	-0.019	-0.023	0.063
Community			
La Pine (La Pine residents= 1)	-	-0.023	-0.009
Social Capital Measures			
Network Ties Index	-	-	0.270****
R^2	0.019	0.029	0.255*
Adjusted R^2	-0.012	-0.018	0.042*
N	166	166	166

Note: † p.≤0.10, * p.≤0.05, ** p.≤0.01, *** p.≤0.005, **** p.≤0.001

Table 6b. Hierarchical multiple regression analyses explaining the expressive social capital index of *collective action* **for residents in La Pine and Greater Crescent using standardized regression coefficients.**

	Model 1	Model 2	Model 3
Socio-demographic control variables			
Gender (Female= 1)	-0.015	-0.012	-0.010
Age	0.012	0.000	-0.006
Community			
La Pine (La Pine residents= 1)	-	-0.071	-0.072
Social Capital Measures			
Network Ties Index	-	-	-0.019
R^2	0.000	0.005	0.006
Adjusted R^2	-0.012	-0.013	-0.019
N	166	166	166

Note: † p.≤0.10, * p.≤0.05, ** p.≤0.01, *** p.≤0.005, **** p.≤0.001

Table 6c. Hierarchical multiple regression analyses explaining the expressive social capital index of *solidarity* **for residents in La Pine and Greater Crescent using standardized regression coefficients.**

	Model 1	Model 2	Model 3
Socio-demographic control variables			
Gender (Female= 1)	-0.137†	-0.131†	-0.141†
Age	0.100	0.078	0.106
Community			
La Pine (La Pine residents= 1)	-	-0.123	-0.121
Social Capital Measures			
Network Ties Index	-	-	0.083
R^2	0.033†	0.047*	0.053†
Adjusted R^2	0.021†	0.030*	0.030†
N	164	164	164

Note: † p.≤0.10, * p.≤0.05, ** p.≤0.01, *** p.≤0.005, **** p.≤0.001

Discussion and Conclusion

This research study set out to explore residents in the newly incorporated city of La Pine and three neighboring rural communities of Crescent, Gilchrest and Crescent Lake (Greater Crescent) on factors that may impact their ability to develop community-based climate change adaptations. It asked if the communities' residents, one incorporated and the other rural, differ in their positions on climate change and social capital. Furthermore, it asked if residents' social capital through network ties to professions expected to have both traditional and tacit knowledge on climate change, forestry and wildfires has an impact on climate change, concerns of local risks and on community levels of social capital. Finally it also explores the residents' feelings on their community's level of social capital factors that include trust in their governing bodies, their community's ability to act collectively and the feeling of the community's solidarity and how these community social capital measures impact the residents' concerns for climate change and its impacts to their region.

The statistically significant findings of the research can be summed up in Figure 7 below which shows the path of statistically significant relationships between variables through hierarchal multiple regression models. The first exploratory regression models (Table 5a above) investigate the impacts of both residential and community level social capital on positions and concerns of climate change. The findings only partially support our hypothesis that the varying factors of social capital would positively impact the residents' positions on climate change, and the community social capital factor of governmental trust did in fact have this relationship with a positive standardized coefficient of 0.29 (p. $\leq$ 0.01). All other variables lacked statistical significance.

Figure 7: The path of resident's social capital and community social capital to the effects on climate change positions and concerns for local risks with standardized regression coefficients and significance levels
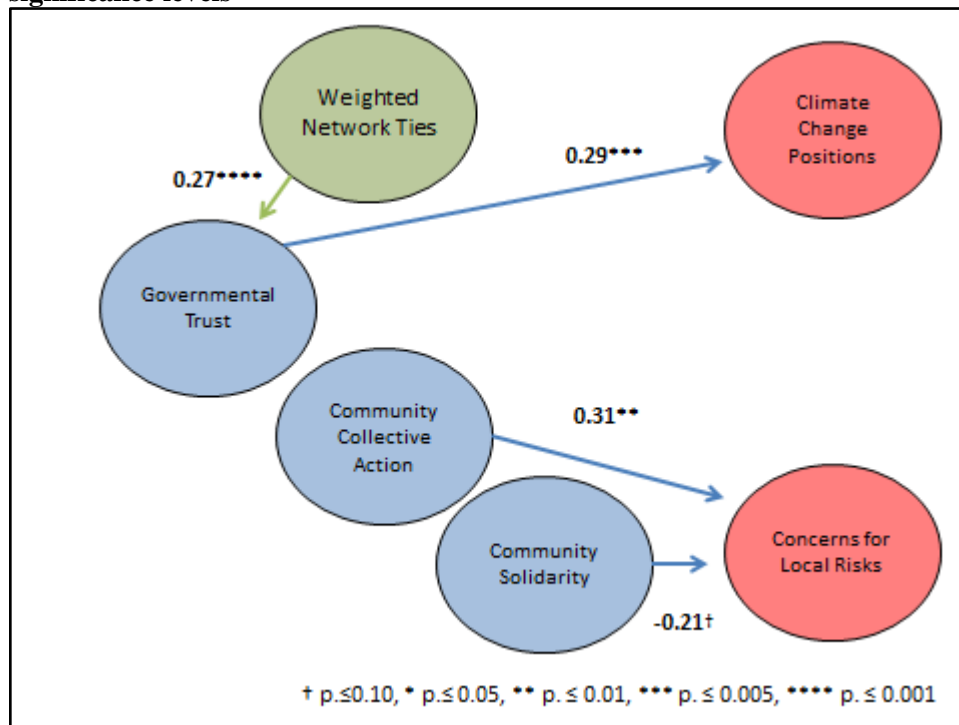
In Figure 7, the exploration of the social capital variables on concerns for local risks is also shown from the results found in Table 5b above. In this regression analysis it was discovered that governmental trust had no statistically significant affect to residents' concerns for local risks yet both residents feelings of communities ability and willingness to work together through collective action had a positive impact (standardized coefficient= 0.31) and residents feelings of community solidarity had a negative impact (standardized coefficient= -0.21). In this regression the community variable did show up as significant (p. ≤ 0.10) with a standardized coefficient of -0.19, showing that being a resident of La Pine influences the concern of local impacts from climate change inversely but not as strongly as the residents feelings on community's collective action potential.

Finally the regressions exploring the residents' network ties to the given professions shows one significant relationship with residents' measures of community social capital. This relationship is addressed in Table 6a above and is seen in Figure 7 in the relationship between the weighted network ties

to governmental trust (standardized coefficient 0.27, p. ≤ 0.001). This relationship is theoretically important as it ties the residents' social networks to their position and concern on climate change through a mediating variable of governmental trust. Yet the hypothesis that the residents' networks with given professions failed to correspond directly or indirectly to residents' local concerns of climate change risks.

This research and its results have a couple of implications for the community members, non-governmental and governmental leadership and for future research. First, to address non-governmental and governmental leadership in an effort to stimulate and engage in community-based adaptation strategies, it seems prudent to increase the level of awareness and address the uncertainties of what climate change is and how it could impact the region. It seems that this effort may be slightly more important in La Pine than it is the rural communities that make up Great Crescent. Yet increasing awareness and addressing possible risks and vulnerabilities is not easily transmitted in issues that lacks tangibility, is temporally displaced leaving many people to forget or displace experiences and observations to real change, and finally people have deep-rooted worldviews that affect their perceptions and feelings on issues that they encounter.

From this research we can conclude that leadership in the community either in grassroots movements or in collaboration with formal institutions could benefit immensely from improving governmental perceptions and increase levels of trust. Many of the legitimate scientific efforts to better understand the complexity of climate change and to address its risks to people and our social systems are linked in some manner to various levels of government. Whether it is research conducted by or information transmitted by a formal agency such as the National Oceanic and Atmospheric Administration or federal grant funded research conducted through academic institutions, or a research institution such as the Oregon Climate Change Research Institute, increasing governmental trust will have a significant impact in these communities' ability to raise concerns on climate change that may be the precursor to increasing local concerns. It seems that improving professional ties may be a good place to

start increasing trust in government. It may be possible to engage the residents through public media and public engagements with local professionals.

Overall it seems that when addressing local risks, the residents and leadership should have confidence in those that have willingness and see their neighbors as willing to work collectively. The communities do seem to have a healthy degree of collective action potential and those residents do have an increased degree of concern for local risks to the economy, recreation, community culture, natural resources and natural hazards (wildfire) for their area. The community solidarity (with the negative effect on local concerns) may be a function of community unity on focusing on other issues. We see in the six degree climate change position scale that these communities have a significantly higher percentage of residents that feel disengaged with climate change compared to the average American. Economic conditions in the region, development and infrastructure issues may be more salient issues to the residents and as the collective focuses on these issues, climate change and its local impacts become an afterthought for another day.

This research was exploratory in nature, to this date no specific research has focused on a community's ability to address localized climate change through community grassroots efforts. It was developed to establish a foundation for longitudinal studies to assess how communities' social networks and social capital affect their ability to address climate change and the impacts that may occur over time. There are significant limitations to this current research that includes the overall response rate. Despite these limitations, some confidence in generalizability can be assumed, due to the sample-bias non-response survey. Yet in future research it is suggested that a mixed methods approach is used. Researching social networks and social capital has significant personal inquiry into the subjects and mailed questionnaires may not always be suitable for data collection. Furthermore, asking for network ties does not necessarily imply that names need to be asked, it is believed that in future research it may be possible to design and implement research on residents' social capital by refraining some of the more personal inquiries that includes names and relationships which may have affected question non-response.

Overall this research has established important links these communities can focus on for addressing climate change. It has implications not just for formal institutions, but for those interested in grassroots mobilization. Addressing climate change and local risks will most likely require both and collaboration between the two.

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Exploring Climate Change Information Relationships in Central Oregon

Introduction

Climate change is a critical issue that transcends location and emerges as one of our most "wicked problems." While a shifting global climate has complex implications for an increasingly interconnected world, the scale of the impacts will be uniquely local. Some northern regions of the globe may benefit from new opportunities associated with climate change, such as longer growing seasons (Iglesia et al., 2012; Palmer, 2012; Gray 2011); while other communities may experience negative impacts associated with social and economic costs of climate change such as community relocations (Reckelshaus et al., 2013; Kates, Travis and Wilbanks, 2012; Maldonado et al., 2012). Risks and vulnerabilities do not challenge each community equally; a community's ability to adapt is shaped by complex social systems, enmeshed in economic, technological, infrastructural and educational capacities (Ensor and Berger, 2009; Flora and Flora, 2013). It is the social organizations and structures embedded in a local, bounded place that are the foundation for understanding local perspectives toward changes in a society (Simmel, 1955; Coleman, 1974; Burt, 1982). Learning occurs through social systems and structures and generates the core of issue awareness and public perceptions of risks and vulnerabilities. Furthermore, within a locale, existing power structures may exert formal or informal influence over public perceptions of local issues, such as the potential risks and vulnerabilities of climate change. For a community to address potential impacts of climate change, it must address the vulnerabilities and risks that their community faces. Furthermore, successful adaptation will require, a shared vision for the future, an understanding of political and social capital, and collaboration with informal and formal institutions.

This paper explores relations between climate change information sources consumed and valued by residents and their positions on climate change. It also investigates social networks that may influence climate change adaptation within two rural communities in central Oregon: La Pine (a recently incorporated city) and Greater Crescent (composed of Crescent, Gilchrist and Crescent Lake) that

represents traditional rural Oregon. For both of these communities climate change could significantly impact the fire ecology of the region, by increasing the frequency and severity of wildfires (Vose, Peterson and Patel-Weynand, 2012; Westerling et al., 2006). This shift in wildfire patterns threatens to significantly impact the wellbeing of these communities, yet how each community approaches the increased wildfire risk will be dependent on the social characteristics of each community, including their social networks.

Climate Change: the Certainty of Uncertainty

A climate can be defined as a long-term "average weather" system in a particular geographic location (Wallace and Hobbs, 2006; Maslin, 2009). Recent decades have witnessed increased concern about changes to global and regional climates, with a corresponding increase in the debate about the causes of these changes, and potential impacts to local ecological systems and residents. Climate change itself is an example of a global socio-ecological systemic process. A significant challenge to addressing many socio-ecological issues including climate change mitigation and adaption is the fact that they are often considered *wicked problems*: issues or problems that have value-based, socio-political, moral and/or spiritual dimensions, and that have no "solution" (Rittel and Webber, 1973; Shindler and Cramer, 1999). Adding to the complexity is the relative degree of scientific unknowns and due to system variation across the biosphere, therefore necessitating a localized knowledge and understanding of specific geographically bound systems.

Communities in different ecological systems have diverse risks and concerns when it comes to climate change and adapting to new systems. Desert regions may face further water stress or see increases in precipitation and flooding while coastal communities may face sea level rise and risks of storms. Forested regions, due to shifting patterns of precipitation, may experience a range of transitions from changes in species composition to increasing wildfires. In many forested landscapes where wildfires may be a threat, policies that implement evacuation and emergency planning, building codes and insurance against fire damage may be effective in addressing many of the risks and vulnerabilities.

The saliency of climate change impacts to community residents may not only be a function of whether or not it is happening, but also, if it is happening, what can be done about it? Unlike a weather event such as a drought or hurricane, climate change occurs over a large time scale and the connections to a specific event are less clear and may result in residents feeling helpless or indifferent to their ability to mitigate climate change impacts. Other members of the public may have a high degree of confidence in science and technological ingenuity to address climate change and believe that leaders in governance and markets will make required changes prior to catastrophic consequences. As noted above, some scientists and political entities promote climate change as having a benign or even net benefit to the biosphere based on regions that are expected to see increases in precipitation, and warming of regions that have colder climates that are currently unsuitable for extensive agricultural production (Oreskes and Conway, 2011; Hulme, 2009).

On a community scale, the diversity of scientific and public perspectives, worldviews, beliefs and values may significantly restrict many actions aimed at addressing adaptation to climate change. Therefore, to assess a community's adaptability to climate change, it behooves community planners and policy makers to better understand the information flow within their local social systems.

Information Dependence of Climate Change in Social Systems

Empirical research on information networks and the impact that diffusion and the structure of the network have on social systems has been going on for decades. Paul Lazarfield studied political communication networks and their influences in the 1940s, and James Coleman's work on medical networks and prescription drug adoptions are classics in the information dissemination literature (Dhanjal et al., 2012). Richardson et al. (1979) showed the variation between large and small communities and the social networks of emergency information flow among residents. Tindall and others have also shown impacts of information and networks on environmental issues, movements, mobilization and civic engagement (Tindall, et. al., 2012; Bodin and Prell, 2011; Tindall, et al., 2011; Stoddart, et al., 2013). Despite this recent work, surprisingly little work has been done on climate change information networks and impacts to local communities until recently.

Sources of climate change vary in their availability and use by the general public. Sources include objective scientific information, as well as subjective positions derived from an interpretation of data and scientific information. Information outlets include the mass media (e.g., television, websites, newspaper and magazines), institutional and personal contacts (including social media). Once a community member receives information about climate change from a source (an informational tie), they may incorporate that information into their personal position about climate change. Residents may also share this new information with others in their social network. The transmission of this information is known as diffusion (Valente, 1996; Agrawal et al, 2011).

Information diffusion, or the transmission of information within a bounded network, requires more than a connection between two subjects (a dyadic relationship). The information that flows (in this case, climate change information) from the sources transmits through personal social (ego) networks within the community (Valente, 2005; Dhanjal et al., 2012). Many studies have begun investigating the impacts of climate change information on consumers yet relational and network analysis is still in its early stages of theory development. In order to develop a formal theory on the network information diffusion of climate change information and the impacts it has on consumers, an initial look at the dyadic relationships between information sources people may consume and the impact it has on their values may be important.

 Multiplexity or the idea that a dyadic relationship can have multiple types of relationships has profound theoretical weight in mobilization and collective action research (Diani and McAdams, 2003). This research looks at exchange multiplexity in social relations that may act as a contributing factor to the diffusion of information. Multiplexity refers to various ties between the same two pairs of actors (Koehly and Pattison, 2005). It can be explored through the relationship ties between actors where multiplexity quantifies the strength of ties or it can be explored in networks where multiplexity quantifies overlap between multiple networks. Exchange multiplexity is used to refer to the various types of subjective exchanges the relational ties within the community can have; such as the tie where two community members exchange information on climate change and wildfires together, as opposed to only exchanging information on wildfires. Exchange multiplexity within a community may add subjective complexity that

can be fundamental in the development of community-based adaptive capacity by drawing subjective issues together in the overall network. For information diffusion about climate change ego-networks should include exchanges of climate change information along with topics such as personal fire protection, wildfires, the community's future and community politics. This overlap in exchange may increase the awareness of the ties between each subject on each other, such as how community development can increase and decrease adaptive capacity to changing ecological systems.

Central Oregon, Climate Change and Wildfire

Central Oregon is a region dominated by dry forests, rangelands and high deserts. The U.S. government owns and manages much of the forested landscape, yet the forest provides many resources for local communities. These resources include biomass for economic institutions, recreation and tourism, natural resources for local residents, as well as amenity and cultural resources. This ecological region evolved as a system dependent on frequent low intensity wildfires, much of which has been significantly altered by land management policies. For central Oregon, climate change may threaten the already dry ecological system with increased drought conditions and reduced snowpack in the mountains that feed the hydrological system (OCCRI, 2010). Coupled with forests loaded with biomass fuels from land management policies and actions, climate change may significantly increase the numbers and severity of wildfires (Hagmann, Franklin and Johnson, 2013; Spies et al., 2010).

Wildfire risks to local communities are numerous (Morton et al., 2003). Property and infrastructure damage and loss are among the most commonly reported in public media events (Gill, et al., 2013). Loss of life, such as the 19 firefighters killed in Arizona in June 2013 (Yan, et al., 2013) is rare, yet significant, and can be traumatic to tightly networked rural communities where the fire defense system is made up of locally-based volunteers. Less conspicuous impacts are risks to health, and health complications in elderly populations, and to individuals with existing health conditions such as asthma (Morten et al., 2003). Impacts to both the economy and local culture are a result of the damage and loss of the forests, which in turn impact fisheries and wildlife ecosystems, and recreation and tourism (Hall, et al., 2011; Thomas et al., 2013). A negative externality of a burned forest is also the loss of aesthetic

beauty that residents connect with and that often encourages tourism. Furthermore, the landscape of a community can also generate migration and business interests when people and companies relocate to escape larger urban areas.

Central Oregon's Case Study Communities

The small, rural communities in Central Oregon depend on natural resources for economic stability. Some communities developed with a timber industry economy, some through farming and ranching, and others with the western expansion for gold. The emergence of auto and rail transportation systems through the region also generated growth. Several rural communities in the region have experienced boom-bust cycles and struggle to maintain economic viability, while others have successfully navigated economic change. Yet a few are in the midst of significant socio-economic transformations from their traditional rural status to a "new rural" demographic position.

Crescent, Oregon evolved with the advent of the rail system as well as its location on Highway 97. Gilchrest developed as a timber town and maintains one of the last lumber mills in the region. Crescent Lake capitalized on the scenic landscape with its forests and alpine lakes and remains a community of secondary homes and cabins for tourists and recreationists with a small community of permanent residents. As these three small rural communities overlap in socio-economics, they are treated as one community and referred to as Greater Crescent for this research. La Pine grew as a logging camp coupled with farming and ranching. Today La Pine represents a changing demographic landscape found across the west. La Pine became an incorporated city in 2006 and remains in transition from its historic rural identity to a municipality with its own social services that include law enforcement and a fire department.

La Pine and Greater Crescent: a look at community-based adaptation to climate change

Both La Pine and Greater Crescent provide an opportunity to observe community-based adaptation to climate change in western rural communities. These communities share the landscape, yet vary in their socio-economic systems. These variations may reveal dimensions of community-based adaptation that could expose strengths and weaknesses in the social structures and attributes of these

communities. The focus of this research is on the social systems pertinent to climate change adaptation. It includes a study of the sources of information about climate change, how climate change is discussed in the community in relation to other issues, and how it is likely to impact adaptive capacity. Of research interest is the correlation between information sources, the impact the information position has on residents' climate change beliefs and local concerns, as well as the relational structure of the community based on these beliefs and concerns. In order for community-based adaptation to evolve, information sources about climate change and its local risks must be present. As described above, sources such as the media, public and formal institutions and personalities present scientific data, but they also convey ideas that impact meaning, perceptions and behaviors. These sources and viewpoints are diverse, and generally take one of three positions on the climate change issue: they accept the scientific consensus, they challenge it, or they maintain a position of neutrality. In many of the public information resources, there is little neutrality and positions lean toward accepting the scientific consensus, denying it outright, or denying at least one of the major components discussed above. Yet the question remains, what is the impact of the information sources on personal beliefs and positions?

The following analysis empirically considers the relational structures of climate change information to La Pine and Greater Crescent residents. It examines how existing information conditions may shape diverse viewpoints about climate change and how these conditions may predispose or impede the development of community-based adaptive capacity policies. Each of these communities is investigated individually and the results combined to examine variations between them that may be explained by the different types of communities.

The Research Question and Hypotheses

Pertinent questions remain regarding climate change information, its impact on residents and how this information and its influence manifests through social structures and networks. These questions are important for understanding and managing campaigns on public education and for mobilization by both public institutions and for grassroots movement leaders toward localized climate change adaptation. It has been established that two important events are occurring; one is that climate change information

campaigns to promote as well as discredit anthropogenic climate change theory and science has been occurring, and second, the public is not simply dichotomously divided on the subject, yet spread across a range of belief and perception values.

The research presented here is the starting point in the investigation of how information on climate change enters into a community, how the perception of the source and what it conveys in values by the recipients, and how the information may be transmitted along with other subject matter believed to be pertinent for climate change adaption in a given community. The research examines the methodological approach and design to establish both a guideline and a foundation for additional research in the field of social network analysis and climate change adaptation, especially the role of climate change information. The research questions for the network of climate change information sources, their impacts and the potential diffusion of information are:

Q_1: There are many mass media and institutional information sources available to citizens regarding climate change. What is the relationship between these information sources and recipients' perceptions of climate change and concerns to local risks? Does *reading material*, belief that the source is *reputable* and whether they *agree* with the source's relationship to a resident's position on climate change correlate to local risks?

H_1: The transition of La Pine into an incorporated city is indicative of social and infrastructural transitions occurring that may have an impact on internet and television resources. It is expected that La Pine residents have more ties to these resources regarding climate change.

H_2: There is some question as to the relationship between information sources and the impact it has on a recipient's position on climate change. It seems plausible that residents may read information from sources that do not correlate to one's positions, yet when residents have information sources they feel are reputable and that they agree with, the relationship should correlate positively with one's position whether it is supportive or oppositional to the scientific consensus.

Q₂: Climate change information and understanding is only one substantive issue in the adaptation to climate changes localized manifestations. Other issues may include localized politics, the development and future of the community and in this case the issues of wildfire which is an expected result of climate change seasonality and increasing drought in the region. Do residents' social exchanges on climate change correlate to the other substantive exchanges?

H₁: La Pine has become an incorporated city with a larger suburb of residential housing outside the incorporated city and some commuter residents. It is plausible that social exchange rates are decreased in La Pine and that although community members discuss some aspects of community life such as politics with some residents, the opportunity to discuss other interests such as climate change may be with a different resident. It is therefore believed that La Pine residents will lack correlations between the inquired substantive exchanges where Greater Crescent residents, more socially embedded with one another as a result of community size will discuss these different subjects with the same residents.

Methods

The Research Design

The research on La Pine and Greater Crescent's adaptive capacity takes a multi-dimensional approach based on the proposition that community-based climate change adaptation will require a variety of social structures and conditions to come together for efficient development and implementation of localized grassroots mobilization and collaboration with formal institutions. The sources of information about climate change and the diffusion of this information with other substantively relevant topics within the community are addressed. This research explores how formal information sources that support and oppose the scientific consensus on climate change may be impacting beliefs about climate change and its risks to the local economy, recreation, culture, natural resources and natural disasters and hazards.

This research utilizes a questionnaire mailed to all identified owner-occupied residents in the municipality of La Pine and the Greater Crescent communities. Identification of owner-occupied status was gained by an examination of existing tax records. From the tax records, non-local mailing addresses

to tax lots were removed as well as tax lots that did not have structures. This procedure was conducted due to a high number of secondary homes and investment properties in these communities.

The questionnaires were mailed in two waves after a preliminary postcard was mailed out following established survey protocols (Dillman, 1999). Names and addresses from returned postcards were removed from the mailing list prior to the first wave of mailed questionnaires. The first wave went out the second week of November 2012. A small number of invalid names and addresses were returned, those with a local forwarding address were noted and changed for the second wave, and those with no forwarding address were removed from the list. The second wave was dispatched the first week of January 2013. Only two waves were possible due to time considerations for this research.

The questionnaire response rate was moderate considering the length, complexity, timing and personal nature of the questions. The timing of the mailing was problematic as the first wave went out one week prior to the U.S. Thanksgiving holiday, and the second mailing was sent out following New Year's Day. Additionally, some residents may not reside in their properties during the winter months and were not identified for removal from the list. The quantity and response rates for the questionnaire are shown in Table 1. La Pine had a final mailing of 345 questionnaires with a response of 79 and a rate of 23 percent. Greater Crescent had a final mailing of 338 questionnaires with 102 returned, for a rate of 30 percent. The return rate for the combined cases was 27 percent with 181 returned questionnaires.

Table 7. Response rates for mailed questionnaires

	La Pine:	**Greater Crescent:**	**Total**
Mailed:	345	338	683
Returned:	79 (23%)	102 (30%)	181 (27%)

A phone sampled non-response survey was also conducted and analysis for sampling bias was run. A set of key variable questions from each section was drawn upon to test for sampling bias. These included community social capital, survey respondents' perception on climate change and concerns on local impacts, and age and gender. Results show little to no difference between the mailed questionnaires

and the non-respondent samples and impact was negligible when divergence was identified. This analysis strengthens the confidence in the results described below.

To attain formal information sources on climate change, a list of institutions and personalities that are active in the climate change dialogue and debate was created through a series of web searches and a review of existing literature. Careful consideration was given to identify and list institutions and personalities with publicly available information resources or that use public media sources for outreach. Examples of public personalities include authoring a book, promoting a blog or internet site, or news media reporting. Furthermore, institutions that promote a supported view of the scientific climate change consensus, as well as those that promote oppositional views were listed. It should be noted that these two positions are not equally distributed in the list as many more sources that support and promote the scientific consensus exist than sources that oppose it. This list consists of 23 supportive entities and 11 entities in opposition, for a total of 34 institutions and personalities (see Appendix A, Figure 7).

This list is presented as a name interpreter question set and becomes one of two-modes in a bipartite network for analysis as well as a relational analysis conducted using a binary sample of ties to the impact on how information sources are impacting their perceptions of climate change and localized concerns. The name interpreter is a technique used in the analysis of social networks that acquires additional information about the relationship between network nodes (Lin, Cook and Burt, 2001; Lin and Erickson, 2008; Knoke and Yang, 2008; Prell, 2012). In the case of the networks between a formal source of information and its receiver, the name interpreter captures degree awareness, activism and confidence in the information source. The name interpreter asked respondents if they have heard of the institution or the personality, if they have read their material on climate change, and if the respondent feels that this source is reputable and if they agree with the source's position on climate change. The names were presented in the questionnaire in a random order to mix the supporters from the opponents of climate change. A bipartite network or two-mode network is one where two different types or classes of entities exist and a relationship connects them (Wasserman and Faust, 1994; Everett and Borgaitti, 2005). In this case there is a formal information source and a receiver of the information. The information is assumed to

be one way where respondents do not actually engage socially or professionally with the information source.

The questionnaire data is analyzed in three quantitative means. First, the interpretations for *reading*, *reputation* and *agreeing with* are analyzed in Bivariate correlations to each other, climate change positions and perceptions of localized risks. Second, the correlations lead to the use of hierarchical multi-regression analysis to test for relational impacts on interpreted *agree with* information sources on climate change and local risks against control variables of community, age and gender. Finally, for core information sources that residents indicate they have an *agree with* tie, each of the two communities' resident ties to information sources are analyzed using two-mode degree centrality with normalized scores for appropriately scaled measurements, resulting in the core information sources utilized in these communities.

In order to capture exchange multiplexity in ego networks the questionnaire asked respondents a series of free recall name generator questions. The name generator is a technique in social network analysis used to identify relationships with the respondents when no assumption can be made, or the potential quantity of possible relations is too large to list (Wasserman and Faust, 1994; Lin, Fu and Hsung, 2001). For this questionnaire, respondents were asked to list up to six relations with whom they have discussed climate change, personal fire protection, wildfires, community politics and the future. For each entry on the list a follow-up question about the type of relationship was added: family, friend, coworker, acquaintance or other. Finally, each question presented an option that read, "I have not discussed (personal fire protection, wildfires, etc.) with a community resident." This option was added because it could be assumed that some residents may not discuss all the given topics with local residents and that incomplete questions warrant the assumption that respondents did not feel comfortable with listing names. Each of these exchange questions is incorporated into a relational matrix and analyzed in UCINET software to quantify the exchange multiplexity or the correlation between residents' exchange types with other residents.

Analysis

The analysis for this paper uses Bivariate correlations, reliability analysis for the single index on the concerns of local impacts from climate change, hierarchical multi-regressions in SPSS and multiplexity analysis in UCINET. The Bivariate correlations and the subsequent regressions were run on dichotomized variables for *read*, *reputable* and *agree with*. Respondents' ties to interpreted source type were summed up and transformed into a 1 for having a source of the selected type or a 0 for no sources of the selected type. Next, the the relationships between residents that have or do not have at least one source of information that they identify with as being one they have *read,* one that they identify with as *reputable* or one having at least one source they *agree with* to the position they have on climate change and to the concern they have for local impacts was analyzed. The *agree with* item then becomes an independent variable in subsequent regressions.

The two dependent variables for the following regressions include respondent beliefs or positions on climate change, and their concerns about local impacts from climate change. The belief in climate change is based on positions in *Global Warming's Six Americas* (Maibach, Roser-Renouf and Leiserowitz, 2009; Leiserowitz et al., 2012). Respondents were asked to identify their position about climate change in descending order of concern from one of these six positions: *alarmed, concerned, cautious, disengaged, doubtful and dismissive*. The options on the questionnaire were one-line statements based on each position description in the *Six America's* report (Maibach, Roser-Renouf and Leiserowitz, 2009).

The concerns for local climate change impacts are based on a developed index. This index was generated from a series of questions where respondents were asked to identify their level of concern for each of five subjects: *the local economy*, *local impacts to recreation*, *concerns to local culture*, *natural resources,* and *impacts to natural disasters or hazards*. A Likert scale was used with 1 for not at all concerned, to 4 for strongly concerned. This index has a Cronback's α of 0.908 reliability based on the five subjects showing significant support that these subjects can be incorporated into a single index (Field, 2013). The removal of any of the five subjects would also fail to increase Cronbach's α.

Results

The first analytical results are focused on simple Bivariate correlations between all anticipated variables. This analysis was conducted to ensure that variables have a relationship that corresponds to the question regarding information impacts beliefs and values on climate change. The results are not what was expected and they show some interesting patterns that appear relevant to this study. The Bivariate correlations are shown in Table 8.

Table 8: The Bivariate Pearson correlations showing relationships between interpretations of information sources to each other and to the residents' positions on climate change as well as their concern on local risks.

		Climate change position	Local concern for climate change risks	Reading supportive Climate change Information	Feeling supportive climate change Information is reputable	In agreement with supportive climate change Information	Reading oppositional Climate change Information	Feeling oppositional climate change Information is reputable	Agreeing with oppositional climate change information
Climate change Position	Pearson Correlation	1	.449***	.018	.133	.254**	-.032	-.146	-.132
	N	163	104	106	106	106	106	106	106
Local concern for climate change risks	Pearson Correlation	.449***	1	-.091	-.060	.047	-.233*	-.086	-.163
	N	104	111	75	75	75	75	75	75
Reading supportive Climate change Information	Pearson Correlation	.018	-.091	1	.227*	.392***	.206*	.198*	.147
	N	106	75	109	109	109	109	109	109
Feeling supportive climate change Information is reputable	Pearson Correlation	.133	-.060	.227*	1	.469***	.174†	.115	.003
	N	106	75	109	109	109	109	109	109
In agreement with supportive climate change information	Pearson Correlation	.254**	.047	.392***	.469***	1	.288***	.074	.078
	N	106	75	109	109	109	109	109	109
Reading oppositional Climate change Information	Pearson Correlation	-.032	-.233*	.206*	.174*	.288***	1	.437***	.267***
	N	106	75	109	109	109	109	109	109
Feeling oppositional climate change Information is reputable	Pearson Correlation	-.146	-.086	.198†	.115	.074	.497***	1	.306***
	N	106	75	109	109	109	109	109	109
Agreeing with oppositional climate change information	Pearson Correlation	-.132	-.163	.147	.003	.078	.267***	.306***	1
	N	106	75	109	109	109	109	109	109

† $p. \leq 0.10$, * $p. \leq 0.05$, ** $p. \leq 0.01$, *** $p. \leq 0.005$, **** $p. \leq 0.001$

As indicated in Table 8 that the correlation between a respondent's position on climate change and the concerns for local impacts (0.449, p. ≤0.001) is expected, the greater concern respondents have with climate change, the greater their concern with local impacts. It also seemed logical that the relationships with information sources such as ones that people *read*, ones they feel are *reputable* and ones they *agree* with would all correlate to one's positions on both climate change and concerns on local risks, but this did not appear as would be expected. When looking at the relationship between reading supportive and oppositional climate change information, the correlations were not found except in one case. Here the results show that there is a relationship between *reading* information that opposes climate change and the residents' concerns over the *local impacts* (-0.233. p.≤ 0.01). Specifically, those that have read oppositional information also have a reduced concern for local risks but a similar relationship is not apparent that having read information that supports the scientific consensus has any relationship with either one's position on climate change or its local impacts.

Reading material on climate change is probably one of the most important contributions for developing knowledge and establishing an educated position on climate change and how this global issue could impact local communities. It is different from feeling that information sources are reputable in that a person may identify reputation based on other factors that may have little to do with climate change itself. An individual may identify that an organization or a person they have encountered in the past and found their positions appealed to the individual's feelings and world view could lead them to attach reputation to their other issues. Furthermore, an individual may identify an information source as agreeable yet not have a contribution to true knowledge. An individual may have read or even heard an organization has a specific position on climate change or local risks and then attach a feeling of agreement without investigating the nature of the source's position. Of the three identifiable relationships a resident can have to a source, reading their material is the most critical for adaptive capacity and its relationship to the other identifiable relationships is critical. In other words, if reputation and agreeability are correlated to reading then there is a better sense that reading material is contributing to the other positions.

In table 8 the correlations between the information interpretations illustrate a number of noteworthy relationships between *read*, *reputable*, and *agree with* and between the supportive and oppositional classifications. As anticipated, the interpretations correlate within the two support and opposition types, almost completely dividing the two categories and signifying that respondents either identify with one position and its sources or the other. Residents identifying with opposition sources they read also identify the sources in this category as reputable and agreeable and they will read material from whom they agree with and feel are reputable. These relationships also hold for the supportive classifications in climate change information. Of particular interest, is the overlap between reading materials across the classified information types.

There is a noteworthy relationship between reading opposition information sources and reading supportive information sources as well as agreeing with supportive information sources. The Bivariate correlations suggest that people in these communities that read climate change information tend to read both supportive and oppositional sources, they are active in knowledge building by investigating divergent positions. Those people that read climate change information sources that oppose the scientific consensus also have at least one tie to a supportive climate change information source with which they agree. These correlations suggest that some people with positions of more concern for climate change are actively pursuing information from both classifications, yet reading oppositional sources may fail to lead to an oppositional position to climate change but it does reduce their local concerns.

After reviewing the Bivariate correlations in table 8 above, two relationship were investigated deeper. The first is that residents with information sources they agree with from the supportive consensus camp have a positive relationship (0.254, p≤0.05) and the second is the relationship between reading oppositional climate change information and having a decreased concern for local impacts (-0.233, p≤ 0.05). These relationships were investigated further by testing these variables with control variables and with a community variable to see if there is a statistically identifiable difference between the incorporated city of La Pine and the traditional rural community (Greater Crescent). The results of the hierarchical multiple regressions are presented in table 8a and table 8b below.

Table 9a: The hierarchical multivariate regressions exploring the impact of having an information source that supports the scientific consensus has on one's perceptions of climate change with the community variable and gender and age as control variables.

	Model 1	Model 2	Model 3
Climate change information position			
In agreement with supportive climate change information (Identifies with= 1)	0.24*	0.24*	0.21*
Community			
La Pine (La Pine residents= 1)	-	-0.02	-0.04
Demographic Variables			
Gender (Female= 1)	-	-	-0.02
Age	-	-	-0.13
R^2	0.06*	0.06*	0.07
Adjusted R^2	0.05*	0.04*	0.04
N	104	104	104

Note: † p.≤0.10, * p.≤0.05, ** p.≤0.01, *** p.≤0.005, **** p.≤0.001

Table 9b: The hierarchical multivariate regressions exploring the impact of reading an information source that opposes the scientific consensus has on one's perceptions of local risks from climate change with the community variable and gender and age as control variables.

	Model 1	Model 2	Model 3
Climate change information position			
Reading oppositional climate change information (Identifies with= 1)	-0.24*	-0.24*	-0.23*
Community			
La Pine (La Pine residents= 1)	-	-0.04	-0.05
Demographic Variables			
Gender (Female= 1)	-	-	-0.15
Age	-	-	-0.73
R^2	0.06*	0.06	0.10
Adjusted R^2	0.05*	0.03	0.04
N	73	73	73

Note: † p.≤0.10, * p.≤0.05, ** p.≤0.01, *** p.≤0.005, **** p.≤0.001

In table 9a there is a positive relationship between residents with ties to supportive information sources that they *agree with* and having an increased concern over the issue of climate change (standardized regression coefficient is 0.24 in both Model 1 and 2 and 0.23 in Model 3). The first model only incorporates the variable of interest, whether or not a resident has ties to supportive information sources they agree with. The second model incorporates the community variable (1 for La Pine and 0 for Greater Crescent). Results indicate that community is not a significant variable and whether or not a resident is from La Pine or Greater Crescent has little effect on their position on climate change. The third model adds two demographic variables that are both known to correlate with climate change beliefs and that were additionally tested in the non-response survey for sampling bias. Gender and age also lack significance, leaving the only variable in this model as the one in question, having ties to climate change they agree with. The results are challenged by low sample size (N=104) yet the statistical significance (p≤0.05) remains constant across the three models for the test variable. The first two models have low R^2 and adjusted R^2 yet statistical significance is present (p≤0.05) and the third model drops its significance. This is likely caused by the low sample size and contributing explanatory variables within the model (four explanatory variables total).

Table 9b further confirms that reading opposition climate change information may negatively impact a resident's concern over the local risks caused by climate change. Similar to results in Table 8a, the hierarchical multi-regressions begin with the principal explanatory variable in question. The second model adds community to test for a difference between the incorporated city of La Pine and the traditional rural communities that make up Greater Crescent. The final model adds the control variables used in the previous regression. The results closely mimic the results from the previous regression, the explanatory variable in question remains statistically significant across the three models (coefficients of -0.24, -0.24 and -0.23 with p≤0.05), the community variable shows that there is no indication that a difference between these communities exists and that the control variables also have little to no impact on the concerns for local risks. The first model remains statistically significant with low a R^2 and adjusted R^2 and the subsequent two models drop significance which may be caused by the low sample size (N=73).

In conclusion of the Bivariate Pearson correlations and the multi-regression models in both of these central Oregon communities suggest a relationship with actively reading climate change information and personal perceptions of climate change and its risks to the local community. The results show that making information material available and from sources the community is likely to find respectable may lead to an acceptance of climate change as a potential global problem, yet this may not develop a local incentive to address local risks. Many sources of climate change information focus on the global problems andalthough oppositional sources may not significantly impact a global perception of climate change, it does impact how people perceive their local risks by decreasing the risk perception. It may be that localized grassroots efforts to instigate the mobilization of action on community-based adaptation to climate change should focus as much energy on presenting localized evidence as well as research and risks to the public, rather than drowning out the message with an overabundance of globalized climate change information.

Finally, this research investigates the exchange multiplexity of the social networks in La Pine and Greater Crescent. It seeks to uncover whether climate change, wildfire and fire protection, and community politics and future interests overlap within social network exchange ties. This analysis used the Quadratic Assignment Procedure (QAP) in UCINET to test possible correlations between each social network. The social networks on some subjective exchanges are correlated, showing that social networks have some exchange multiplexity and that residents discuss multiple subjects with many of the same residents. Table 9 shows the results of the QAP for both the exchange networks in La Pine and Greater Crescent.

Table 10. Correlations of social network exchange multiplexity for La Pine and Greater Crescent

	Climate Change	Wildfires	Personal Fire Protection	Community's Future
La Pine:				
Community Politics	0.000	0.224	0.000	0.316
Greater Crescent:				
Community Politics	0.000	0.227	0.000	0.382
Wildfire	0.000	0.000	0.114	0.000

Note: All Personal Correlation values carry with it a significance of p≤0.01

The QAP analysis shows the Pearson correlation values between variables; each having a statistical significance of p-value of 0.01. Each of the five variables in Table 10 (*Community politics, wildfires, personal fire protection, community future and climate change*) were drawn from five ego-network name generators on the questionnaire in which respondents were asked to name the community members they had discussion exchanges with on each of these subjects. The subject of exchange most correlated with *community politics* in both La Pine and Greater Crescent and is presented on the rows in Table 10. This subject significantly correlates with the exchange networks of both *communities' future* and on *wildfires,* meaning that people in the community discuss the issues of *community politics* with many of the same individuals they discuss the issues of *community future* and *wildfires,* yet they discuss the issue of *climate change* within a different exchange network .

In Greater Crescent there is also a small correlation between the subjective topic of personal fire protection and wildfire (0.114). In both communities the subjective exchange in social networks with climate change fails to overlap with any other subject in the questionnaire. This may imply that either the subject of climate change is not significantly discussed in either community, or that it is only discussed among certain people where other exchange topics are more prevalent and freely considered. Despite no

correlation, the evidence suggests social exchanges are apparently low and implies that information diffusion may be challenged by the inner social relationships of the community.

Discussion and Conclusion

Community-based climate change adaptation is the act of civic mobilization in the face of complex socio-environmental factors. Yet most important, it is an act that requires information and influence moving into and through social ties in a community. Anthropogenic climate change has received a general scientific consensus yet has not evolved into public or political unanimity. Available information sources offer diverse positions about both climate change and its implications. The sources of information can play important roles in the positions that a citizen has on climate change and what it means locally, and in turn, can influence subsequent behavior toward mobilizing for adaptive capacity.

In this exploratory research on climate change information sources, information transmission into and through La Pine and Greater Crescent is investigated, The focus is on potential impacts to influence residents' perceptions and positions on climate change and its localized risks through informational relationships. A few noteworthy results have been uncovered. Some of these results have implications for future research as well as practical implications for policy and administration within the communities. These will be discussed below as well as expectations for future projects.

With so many sources of information on climate change being transmitted across society in various forms of media and by a wide spectrum of interest groups, stakeholders and personalities, it is important to process the degree to which information sources have an influence on a resident's perception and position on the issue. Does it take reading material to influence or is does a resident's need to feel that the source itself is a highly valued and respected source, and does agreeing with a source really translate to a position that resembles the information source's position? The analysis shows some interesting results.

Despite having an emerging socio-political shift by city incorporation in La Pine, residents of La Pine and Greater Crescent show similar relations to their values and beliefs on climate change and local risks. What is most pertinent is that the residents' relationship to information sources have different

impacts when it comes to the issue of climate change as a whole and when it comes to how people feel about the local risks and impacts that may emerge. The community's residents appear to be more impacted toward a concern for climate change by information sources that they agree with; yet only when it comes from climate change information sources that support the general scientific consensus and not with oppositional sources. Residents that have an agreeable tie to information sources that reject the general scientific consensus of climate change are not influenced to conform to the information source's positions.

What is also intriguing is that when it comes to influence on the concerns for local impacts, having at least one tie to an oppositional source that a resident reads, does impact the resident's position and discourages them from having concerns over local impacts. This may be caused by a form of cognitive dissonance where mass media focuses on the broader global issues and regions expected to have the earliest and most dramatic impacts to climate change. Little information is directly transmitted to these local regions and the climactic expression of emerging wildfire risks these residents would face. When translating local impacts, the message fails to break the barriers of beliefs and values that detrimental impacts to these communities could occur, it is a protective psychology that climate change will hurt others and not these communities. Therefore, the oppositional information sources read by residents resonate toward the beliefs and values that these communities could not possibly have risks they should be concerned about. This is an intriguing proposition yet requires much more empirical evidence and should be encouraged in future research. It does appear that as a resident reads information on climate change, they read both positions, yet it translates into a concern for climate change but less concern for local impacts.

Adaptability to climate change should be significantly improved when the information on climate change and factors that contribute to the adaptability are transferring along the same channels. Many other issues may be as important if not more so to a grassroots movement for developing action to increase the adaptability of communities to localized risks. Politics is a major factor in both climate change and mobilization in community building including community-based climate change adaptation. Considering

that climate change is a process occurring over time, climate change adaptation development should also consider the evolution of the community itself. The significant impacts of climate change to this area are likely to come from increasing wildfires, loss of natural resources, loss of property, loss of lives and increased smoke, giving discussions on wildfire a monumental role for discussion among residents for increasing adaptation potential. Finally, connecting climate change and its risks to the individual is an element for motivation to participate, it is not just a risk to someone else, it is a risk to me. If residents in a community shared these discussion points within their same social ties, the overlap could foster a deeper understanding and may act as a motivational tool for engaging in action.

Using social network analysis' multiplexity as a framework for evaluating the diversity of social exchanges between the same ties, researchers can measure and evaluate how these exchanges overlap and could foster community-based adaptive capacity. The results indicate that several of these subjects are indeed correlated within similar ties between residents. Community politics, the future of the community, and wildfire are discussed within the same networks within both communities. This is encouraging in that wildfire, the fundamental impact from climate change is transmitted along the same lines as local politics and that people may be considering wildfire risks as they process their desires and concerns for the future of their community. Despite this encouraging news, the results further show a deeply discouraging and significant relationship between the residents and their subjective exchanges, they are not discussing climate change at all with the same ties they share with their other subjective talking points. This may indicate that the issue of climate change is discussed with such a small proportion of residents to begin with or that the issue may not be discussed within the same ties and selective relationships are being used.

Regardless of the reasoning as to why climate change fails to correlate with the other talking points between similar ties, it is a fundamental barrier to community-based climate change. In order to formulate informed climate change decisions, residents need to articulate their feelings, beliefs and values. Increasing wildfires in the area are clearly a risk to the residents of the communities yet vulnerabilities may often be subjective. Understanding what specific wildfire risks the communities have the greatest concern over and how they view future changes to the wildfire frequencies and severity are a

key factor in bringing in political action and development planning. Take for example that the communities are showing an increase in the aging population due to the export of youth for education and employment, and in migration of retirees seeking the amenities provided, now have two fundamental vulnerabilities to address, risks to health from smoke which often injures the young and elderly more, and the loss of amenities such as forest views for residents. Yet the community vulnerabilities could be fundamentally different if the community was planning the development of the economic sectors that would encourage younger migrants and demand more natural and infrastructural capital for an increasing economic growth. Here the vulnerabilities would be focused on the loss of that capital directly associated with burning.

In conclusion, information impacts residents in ways not completely expected and that climate change information is not transmitted within the same social networks as those of local politics, the community's future, wildfires and personal wildfire risk protections. This analysis and the results have both research and public policy implications. In order to formulate a formal social network framework for information on climate change and its role in community-based climate change information, additional research should be conducted to model information sources network structures. Yet without more empirical work in this area, addressing the policy implications and delivering expert opinions to a community and its leadership on ways to motivate and develop the social and informational networks for increasing adaptive capacity should proceed with caution.

This research investigated the relationships between information types and how these information sources impact recipients' positions on climate change and the local risks these changes can have on the communities of La Pine, Gilchrist, Crescent and Crescent Lake. The relationship to information types impacts the perceptions of climate change and the concerns for local risks in different ways. What needs to be better understood is how the network of information types and the roles specific sources play in the development and maintenance of public perceptions. Refining and testing the methodologies used here in more empirical research applications can take the relational approach and develop it into a social network framework that can be used to address information gaps and mobilize awareness for community-based

adaptation. Furthermore, expanding on the rural research to include other socio-economic and demographic areas and regions that face diverse climate change risks and vulnerabilities would be imperative for the development of a formal framework and theory.

Despite the need for more extensive work in this field, this research can deliver a take-home message to the communities toward addressing the development of their adaptive capacity to climate change. Mainly, that increasing information that illustrates that the global climate change issue has a direct impact on the future of these of communities and that increasing opportunities to discuss this issue along with the other issues believed to be a fundamental part of increasing adaptive capacity should be considered. Community leaders and local media outlets can simultaneously address both of these by increasing a focused dialogue on what climate change means to central Oregon. This can occur with increasing articles in the local paper and by inviting climate scientists from diverse fields to discuss the local issues of climate change on radio and in public forums. With increased information transmission, the likelihood of diffusion increases and the potential to stimulate mobilization also increases. The fundamental issue here is gaining the trust and delivering the message that these communities face a new paradigm in local wildfire ecology today and into the near future and that proactive adaptive measures may be more efficient and less costly than post hoc policy development and reactive actions.

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Centrality of information sources on governmental activities in an incorporated and rural community in central Oregon

Introduction

A changing climate is more of an accepted phenomenon now than ever before. With the scientific community expressing unprecedented consensus (Stocker et al, 2013; Field et al, 2014), the popular media reporting rising temperatures (Gills and Change, 2014), destructive weather patterns (Kottasova, 2014) and reports covering the human contributions to climate change, community leaders are left to wonder how best to prepare for climate change impacts. Despite scientific consensus, the manifestations of climate change are as diverse as ecological landscapes, and complicated by socio-ecological diversity. In Oregon, and specifically central Oregon, one of the major risks generated by climate change is an increase in wildfires both in severity and frequency.

This research focuses on two central Oregon communities, one a recently incorporated city, and the other a traditionally rural collective of smaller communities. A key component to community adaptation to change, including potential impacts from climate change is the relationships with formal institutions (governmental and non-governmental). Utilizing an innovative social network methodological framework each community's ability to receive information regarding governmental activities and its relevance to policy advocacy and development is examined. This kind of socio-political information may be pivotal for each community to develop grassroots collaborative relationships, as well as relationships with formal institutions such as federal, state and county governments. It is anticipated that a difference exists between the rural and incorporated communities, not only in their selections of information sources, but in the ways that information on different subjects is correlated and diffused throughout the community. Social network data was gathered using a mail questionnaire distributed to residents in both communities to assess how information enters the community, and how it diffuses among community members. Finally, policy recommendations regarding climate change information dissemination are offered.

Climate Change and Central Oregon

Disciplinary diverse natural scientists are integrating climate research and modeling through institutions such as the Intergovernmental Panel on Climate Change (IPCC) to conclude that the current global climate change trajectory warrants significant concern for numerous regions and ecosystems (Weart, 2013). The Pacific Northwest is no exception. A strong correlation between wildfires and climate change variability and the Pacific Decadal Oscillations (natural cycles generated by the Pacific's oceanic and atmospheric systems), has been identified (Oregon Climate Change Research Institute, 2010; Oregon Department of Land Conservation, 2010; Marlon et al, 2012: Spies et al, 2010). Many of these reports and studies in the region conclude that increasing temperatures and drought cycles are likely to impact the number and severity of wildfires in the region, including Oregon.

Climate scientists are beginning to better understand how regional geography, such as the Cascade Mountain range, will affect areas like central Oregon. Projections for central Oregon show that a decrease in the precipitation and snowpack in the mountains in the coming decades may impact the region (OCCRI, 2010). If the projections are correct, the combination of the decrease in precipitation along with the buildup of biomass in the forests (Perry et al, 2011; Wimberly and Liu, 2013), may lead to increased wildfire frequency and severity.

In the Pacific Northwest large segments of the forested landscape are titled to the Federal Government, divided between the U.S. Department of Agriculture's Forest Service (USFS) and the Department of the Interior's Bureau of Land Management (BLM). Roughly 60 percent of the public land in Oregon is owned by the federal government (most of it with the USFS and BLM), three percent is owned by the state and one percent is owned and managed by other public interest holders (Oregon department of Forestry, 2009). This scale of land ownership and management demonstrates the importance of and dependence on federal land management agencies and congressional oversight on land management. Many wildfires in Oregon start on federal lands and then become trans-boundary issues.

In Oregon, wildfires are much more prevalent in the dry forests and rangelands on the eastern side of the Cascade Mountains than in the temperate rainforests of the west. In these forested regions, as

in many other states, wildfires have been a part of the socio-ecological systems as long as the area has been inhabited. Today however, wildfires and their risks in these dry forests are ubiquitous in public and social debates. Many of the increasing monetary, social and ecological costs from more frequent and severe wildfires arise from a combination of socio-economic transitions to the demography such as increases in development as well as the increasing awareness of the impacts that forestry practices, especially fire suppression, have had on fuel loads in these forests (Barringer, 2013; Pyne, 2008; Vose, Peterson and Patel-Weynand).

Current political and economic conditions across the U.S. and Oregon are negatively impacting the effectiveness of federal, state and county governance in their ability to address many issues including climate change adaptation programs and efforts. While collaboration between local populations and governmental agencies may be imperative to the overall success in adapting to climate change, strong grassroots or local efforts may be the most critical. With the existing threat of devastating wildfires in central Oregon, and a future with seemingly negative impacts from climate change, the communities in this region must develop social, economic and political systems, and foster cooperation to address both the immediate and future threats.

Communities facing a threat from a wicked problem like climate change must secure their resilience by ensuring they are able to rebound quickly. Resiliency has been defined as the state of being prepared for a socio-ecological or environmental impact (Walker and Salt, 2006). Resilient communities often have integrated policies and actions that address risk reduction, prepare a community for an event, and strategies to deal with the results of the event. In the case of wildfires, communities may address risks related to fuel reductions, develop defensive space on private properties, have evacuation plans and risk assessments and community support programs for post-fire actions.

The Communities

Embedded in this central region of Oregon are several small rural communities. Along Highway 97 and the east-west linking Highway 50, Crescent Lake, Crescent, Gilchrist and La Pine have developed in socio-ecological and economic relation to their surrounding forests. La Pine and Gilchrist evolved with

the timber industry, Crescent with the railroad expansion and Crescent Lake with recreation and tourism (Coon, 2007; Horrmer, 1924; Metcalf, 2010). Over time, Crescent, Gilchrist and Crescent Lake, located in Klamath County, have evolved into a socio-economically interlinked system referred to here as Greater Crescent. La Pine is located in Deschutes County, and in 2006 La Pine became an incorporated city (Metcalf, 2010).

The incorporation of La Pine marks a significant political change and represents a diversification of socio-political structure from their traditional rural neighbors. This distinction between rural and incorporated municipality reinforces the theme for this research on community-based climate change adaptability. That is, it is plausible that both rural and incorporated communities not only differ in their social structure, but that each has structural elements that benefit *and* impede adaptation development and implementation. Understanding the strengths and weaknesses of the socio-political structures in each community would benefit leaders in the development of advocacy and collaboration in both local efforts, and with formal institutions. These collaborations may serve the communities in moving toward establishing adaptability strategies for climate change.

Despite incorporation, La Pine continues to share similar socio-economic conditions with Greater Crescent. Data from Oregon's Rural Community Explorer 2010 shows La Pine and the Greater Crescent census dominated by a white, non-Latino population. Both communities are composed of migrants that come either from other regions of Oregon or from the western U.S. but little migration from beyond these destinations. Both communities share a similar educational portfolio such as the 35.6 percent and 31.9 percent high school education rates for La Pine and Greater Crescent area respectively and the 27.8 percent and 29.7 percent with some college. Furthermore, both communities have lower median home values ($216,100 for Oregon, $103,704 in La Pine and $141,286 in Greater Crescent), higher percentages in seasonal and recreational homes, as well as higher vacancy rates (Rural Community Explorer, 2014)

The communities of La Pine and Greater Crescent diverge in some areas as well. La Pine has a much lower median age than Greater Crescent, 31.9 and 52.6 respectively. Both communities have higher unemployment rates than the state, yet Greater Crescent has a much higher percentage of residents with

retirement income (27.81% and 9.05% respectively) and social security income (52.53% and 40.57% respectively). La Pine has a much higher percentage of individuals in extreme poverty (21.95%), while Greater Crescent is relatively in line with state percentages (5.52%) (Rural Communities Explorer, 2014).

Political Frameworks

The following discussion focuses on the issue of community-based climate change adaptation. It lays the foundation for the role of government and governmental collaboration for policy and action in the adaptation to climate change in these fire prone landscapes. Specific attention is given to the role of information networks that community citizens use to be informed on governmental actions that can assist in bridging efficient and effective collaboration or allow grassroots mobilization efforts to emerge in the face of inadequate and inattentive governmental action.

Wicked problems such as climate change are not single-issue concerns and present many potential sub-issues across a range of societal and cultural dimensions. The cultural and economic vulnerabilities to localized climate change manifestations are heavily dependent on demographic and infrastructural development. As such, it is believed that developing adaptive capacity to climate change should begin at the community and grassroots level; this is not to say that collaboration with formal and governmental institutions should not be developed. It is often the case that locals have a knowledge base concerning cultural risks and vulnerabilities that outside formal institutions do not, and locals also have the most to lose (Weber, 2003; Ensor and Berger, 2009). Despite the information gap many formal institutions such as governments have resources and powers the local communities lack. In communities such as La Pine and Greater Crescent which are immersed in federal forests, the power to address forest management and address wildfire risks is largely in the hands of federal agencies. Furthermore small communities may benefit from government resources such as assistance programs designed to inform and develop strategies to mitigate climate change risks.

Ensor and Berger (2009) illustrate some important empirical lessons on community-based climate change adaptation in rural communities in less-developed nations such as Bangladesh, Niger, Peru and Sudan. Many of these lessons are not specific to the developmental status of a nation or state, yet many of

their arguments can easily be applied to rural American communities. Significant lessons they share include the importance of the community's access to resources such as information, technologies and networking capacities with diverse stakeholders and institutions. They illustrate how vulnerability applies not only to infrastructure and economics, but to social and cultural aspects as well. Vulnerability can be assessed through the current or pre-existing conditions of a community, and not based on any climate model assessments and predictions.

Ensor and Berger's discussion on policy, politics and power (2009:174- 177) is highly relevant for this research, as they establish that governmental institutions are not always willing or able to invest in some of the poorest communities. This may apply to the communities in central Oregon as federal, state and county governments, especially in hard fiscal times, they may see more potential in investing in larger, developed communities in the regions such as Bend or Klamath Falls. Larger community size and infrastructure development may appear to present greater economic potential for investors over opportunities in smaller communities with less developed infrastructure. Finally, Ensor and Berger conclude that governmental institutions and their policies may not always *act* in accordance with producing adaptive strategies for local systems. In central Oregon, federal forest policies over the last several decades have increased wildfire risks by suppressing wildfires and placing some barriers on agencies to restrict the extraction of biomass and reduce fuel loads (Hagmann, Franklin and Johneson, 2013). Despite a growing awareness that climate change could have an additive effect on an already threatened system, political and market barriers are unlikely to change significantly to reverse the existing threats. Community-based adaptation is a way of reducing dependence on institutions that may not always be willing or able to act in a manner that is best for the local socio-ecological systems.

Communities can gain strength for advocacy toward adaptive capacity through social networks, information networks, and through social, political, and other forms of capital that bridge diversity that inevitably surround complex issues such as climate change (Adger et al, 2005; Adger, Arnell and Tompkins, 2005; Engle and Lemos, 2010; Hale, 2011; Bodin and Prell, 2012). Citizens can use social networks to be informed on issues and factors of localized risks and vulnerabilities and use social and

political capital to position themselves and advocacy groups to move the public policy process toward adequate and efficient changes relevant to the community.

Today, most Americans have access to some formal yet impersonal information source whether it is television, the Internet, radio, and printed works or through social relations with relevant professionals. In the case of climate change adaptation, the structure of formal information may be vital. In diffusion theory, information can begin at a source and is transmitted through a set of actors in which the structure of a network affects its speed and efficiency (Wasserman and Faust, 1994; Prell, 2012). One important element of a network's structure that can impact information diffusion is centrality, the notion that central sources of formal information have significant clout on the speed and influence of information. Central information sources should be relevant to adaptation as they speed up information from primary sources to community residents and influence the collective group by spreading the information throughout the whole of the community.

In terms of social networks between citizens (actors), it is proposed in this research that exchange multiplexity will be an important component to adaptability. Multiplexity refers to various network relationships (ties) between the same two pairs of actors (Koehly and Pattison, 2005). Exchange multiplexity then refers to the various types of subjective exchanges the relational ties can have; such as a tie of two community members that may exchange information on climate change and wildfires together as opposed to only exchanging information on wildfires. The exchange multiplexity framework used here suggests that community-based adaptation development is improved when a generalized network structure of relationship associated with climate change is expanded to include other issues strongly associated with climate change and its risks. This is based on empirical research on multiplexity in mobilization and collective action throughout the last couple of decades (Diani and McAdam, 2003; Gould, 1991). The multiplexity argued here should consist of five exchange networks: A personal risk network and a localized natural risk network, which in this case is 1) wildfire and 2) fire risk to one's family, home and property. Community politics (3) is an important exchange network and politics is the substance of government and its actions, as is a social network focused on the 4) community's future.

Finally, social networks may transmit not only topic specific information such as the subject of fire or politics, but also the relationship and relevance between these network exchanges to one another including the most important subject here, 5) climate change.

The general questions and hypotheses posed in this research seek implications for both the development of community-based adaptation to climate change and a foundation for longitudinal data and analysis. It addresses existing socio-political conditions within these communities as a way to establish current patterns of social and informational networks that can be explored and tested further with focused research. This data and analysis then becomes the foundation to understand how the structures of community information networks and social networks affect the diffusion of information that may influence advocacy coalition development by bridging gaps to critical information around issues, policy and actions of interest to advocacy groups mobilizing for change; therefore generate a community resilient to localized climate change risks. At this exploratory stage the goal is to answer some basic questions, and discuss their potential implications. The questions asked, and hypotheses posed are:

Q1: In today's mass media environment, citizens can acquire information on governmental activities through a wide range of resources. Yet for smaller communities the sources may come from outside the community itself and may lack local context. For establishing collaborative action, often believed to be vital to development and community-based adaptive capacity, it is important to know where residents are collecting their information. Where does both Greater Crescent and the La Pine community acquire information on governmental activities and what is the relationship these sources have to developing or impeding collaboration with governmental institutions?

H1: Given that smaller communities often maintain tighter social ties and can often be more dependent on each other for information relevant to the community, it is plausible that Greater Crescent maintains social and personal ties as significant information sources for residents. It is expected that Greater Crescent residents would identify sources of

information that are found with personal ties within the community such as personal relations, community leaders, agents and work associates.

H$_2$: With La Pine's demographic transition and development into an incorporated city, it is plausible that the residents would transition to more impersonal information sources on governmental activities. It is expected that the residents in La Pine would identify with more mass media outlets than Greater Crescent such as television, radio and even more, the internet.

Q2: Developing community-based adaptation to a complex issue such as climate change may require more information transmission than just the issue itself. Exchange multiplexity seeks the correlations between diverse subject discussed between ties, in this case, climate change, wildfire, property fire protection, community politics and the community's future. These subjects should transfer across the same ties to build on each other and encourage adaptive capacity. Is exchange multiplexity present in both Greater Crescent and in La Pine?

H$_1$: Exchange multiplexity and subject specific correlations among theoretical concepts pertaining to community-based adaptive capacity will be stronger in rural communities than newly incorporated communities.

H$_2$: Rural communities that are adjacent to the forests will perceive their risks to climate change (in the form of wildfires) as more salient than residents in incorporated areas that are not adjacent to the forest. The communicative ties to wildfire will be correlated with the same ties as community politics and the community's future, showing that collaborative capacity is more developed to address increasing wildfire risks from climate change.

Methods

To collect data on community-based adaptation to climate change and wildfire risks, a questionnaire was mailed to all identified owner-occupied residents of La Pine, Crescent, Gilchrist and

Crescent Lake. Social network analysis is often hampered by missing data; therefore random sampling of the community was not preferred over attempting a census of the most relevant citizens, those that live in the community year round. Using county tax records owner-occupied addresses were selected, paying particular attention to remove tax lots that had mailing addresses outside the area or were titled to trustees, LLCs and businesses. Post Office boxes are commonly used in this region; therefore tax lot mailing addresses located at local post offices were included. Preliminary notifications were sent out several weeks prior to the questionnaires to alert the residents of the research intent and incoming questionnaire (Dillman, 1999). The La Pine local newspaper also printed a story about the research and notified residents of the mailed questionnaire (see Appendix, Figure 12). Two phases of questionnaires were mailed out, the first during the second week of November 2012, and the second, to non-respondents, during the first week of January 2013.

The questionnaire consisted of four sections, with a total of twenty-four primary questions (see appendix). The first section consisted of sixteen sub-questions focused on social and political capital. The second section focused on climate change with social and political dimension questions. The third section covered social and information networks, and the final section focused on demographics.

The questionnaire response rate was moderate considering the length, timing (November-January), complexity, and personal nature of the questions. Additionally, some residents may not reside in their properties during the winter months and were not identified for removal from the list. The quantity and response rates for the questionnaire are shown in Table 11. La Pine had a final mailing of 345 questionnaires with a response of 79 and a rate of 23 percent. Greater Crescent had a final mailing of 338 questionnaires with 102 returned, for a rate of 30 percent. The return rate for the combined cases was 27 percent with 181 returned questionnaires.

Table 11. Response rates for mailed questionnaires

	La Pine:	Greater Crescent:	Total
Mailed:	345	338	683
Returned:	79 (23%)	102 (30%)	181 (27%)

For the purposes of this paper, questions related to political and informational networks will be analyzed. Within the network section of the questionnaire there were five ego-network questions designed to collectively capture exchange multiplexity; that is the proposition that a social tie can have more than one type of relationship or in this case may have more than one type of issue/topic exchange. The exchange questions used a name generator approach (Wasserman and Faust, 1994; Prell, 2012; Scott, 2011) in which each of the five exchange inquiries hold six possible nominations and relational positions: Family, Friend, Coworker, Acquaintance and Other. Each of these issue-focused networks were then joined in UCINET 6.377 (Borgatti, Everett and Freeman, 2002) and analyzed for multiplexity. The network exchanges are tested for correlations using Quadratic Assignment Procedures (QAP). The QAP was run using UCINET's default of 5000 permutations and set at "detailed" to allow for missing values.

Two formal information network questions, one on governmental activities and the other on climate change information, used a roster approach (Wasserman and Faust, 1994; Prell, 2012; Scott, 2011). The roster approach involves providing a list of nominations within which a respondent can identify a tie. For this study, a list of 14 information source nominations were provided to assess where respondents receive governmental activities information and respondents were asked to identify the three most frequently used sources.

The formal information networks are analyzed using two-mode network analysis. Two-mode degree centrality with normalized reporting is provided. This two-mode normalized degree centrality is for the information source, and being normalized is calculated to include the number of possible residents that could identify the source (Everett and Borgatti, 2005). This is then reported on a 0 to 1 scale where 0 indicates no residents selecting this source, and 1 representing 100 percent of the residents reporting this specific source as a top three information source for governmental activities. For La Pine the total residents possible would be 79 and Greater Crescents would be 102. The normalization allows us to look across the two case communities as well as within the cases to see what the most used information sources are.

Analysis

The first analysis focuses on the ego-networks of the respondents within La Pine and Greater Crescent and the exchange multiplexity. Five subject-focused exchange networks are measured: community politics, personal or property fires, wildfires, the community's future, and climate change. For each subject, respondents were asked to indicate who they talked to within their community on each subject. Correlations for each set of exchanges that are greater than zero are reported below (see Table 12) using QAP in UCINET. Each community is reported separately to illustrate potential variations.

The table illustrates correlations between respondents exchanged networks with other residents on *community politics* shown in the rows, and the subject exchange networks of *fire protection*, *wildfire*, *community future* and *climate change* are presented in the columns. In Greater Crescent, a second row is presented for correlations with exchanged networks on *wildfire*. Both La Pine and Greater Crescent share similar correlations in exchange multiplexity such as the lack of correlation of *climate change* to any other issue/topic exchange and *community politics'* correlation to *wildfire* and to the *community future* (the set of all correlated networks or possible networks), yet vary in the *fire protection* network, a significant fire related exchange.

Unlike Greater Crescent where social exchange networks on the subject of personal property *fire protection* are correlated to the social networks on *wildfire*, La Pine's two networks shows a zero correlation. The correlation between these two exchange networks in Greater Crescent is low at 0.114 and statistically significant with a p-value of 0.01. This suggests there is no overlap between the residents who talk to each other about *wildfire* and who they talk to about personal *fire protection*. The correlations between *wildfire* and *community politics* in both La Pine and Greater Crescent are moderate with correlation coefficients of 0.224 and 0.277 respectively, and significant with a p-value of 0.01. The strongest correlation is between respondents exchange networks on the subject of *community politics* and the exchange networks on *community future* where La Pine's correlation coefficient is 0.316, Greater Crescent's correlation coefficient is 0.382, and both are significant with a p-value of 0.01. In both

communities the *climate change* exchange network failed to correlate with any of the other exchange

networks.

Table 12: QAP on the multiplexity of community exchange networks

		Property Fire	Wildfire	Community Future	Climate Change
La Pine	**Community Politics**	0.00	0.22*	0.32*	0.00
Greater Crescent	**Community Politics**	0.00	0.28*	0.38*	0.00
	Wildfire	0.11*	0.00	0.00	0.00

Note: *p-value: 0.01

Access to information about governmental activities for both communities is shown in Table 13

where the two-mode normalized degree centrality measurements are provided. Table 13 also lists the

fourteen potential sources for information about governmental activities offered on the questionnaire. The

bolded centrality scores in Table 13 indicate the top three choices made by the community respondents

(e.g., *Local Newspaper*, *Television*, and *Internet*).

Table 13: The normalized two-mode degree centrality analysis of residents in Greater Crescent and La Pine on the sources they use for governmental information.

Media Agent:	Greater Crescent	La Pine
Personal/Social Relations	**0.353**	0.286
Community Bulletin Boards	0.275	0.091
Local Markets	0.059	0.065
Membership Groups/Association	0.108	0.143
Business/Work Associates	0.118	0.169
Political Associations	0.078	0.169
Community Leaders	0.127	0.182
Governmental Employee/Agent	0.157	0.104
Non-Governmental Organization	0.020	0.078
Local Newspaper	**0.431**	**0.468**
State/National Newspaper	0.069	0.065
Radio	0.284	0.195
Television	**0.431**	**0.494**
Internet	0.333	**0.429**

Table 13 illustrates similarities in La Pine and Greater Crescent, as well as some variation in how they receive information about governmental activities. La Pine's primary information sources are all mass media based as was expected. La Pine respondents primarily use the *local newspaper*, *television* and the *Internet* to learn about government activities. The analysis also shows that *television* has the highest centrality score with the *local newspaper* having the second, and the *Internet* the lowest score of the three. This suggests that residents are dependent on the local newspaper for information on localized governmental action or localized context of actions as these communities do not have a localized television station. The local newspaper, the *Newberry Eagle* does operate an internet site and this could be extremely valuable for residents.

Greater Crescent shares similar results in terms of the normalized degree scores with the local *newspaper* and *television.* This community differs however, in the selection of *personal and social relations* rank higher than the *Internet*. This indicates that the respondents in the rural communities that make up Greater Crescent are dependent on social ties as a source of information on what governments are doing, whereas the incorporated community appears less dependent on personal social ties as expected.

Social ties as a significant information source have several important factors for information transmission and efficiency. One is that the rate of information transmission can be increased with social networks especially in the case of urgent information associated with emergencies. This can occur because information from media sources are dependent on both the time the information is presented and the time received by the recipient. Efficiency of information transmission can also be enhanced as the transmission is conducted in a dialogue allowing for localized context to be discussed and debated.

Yet the information sources residents in La Pine and Greater Crescent chose only tell where the information is coming from and not if this information has any possible relationship with how the residents are impacted by the information and their ability to use it for collaboration with formal governing institutions. The two social capital measures identified as pertinent for a collaborative and collective action with governmental institutions are *governmental trust* and *collaboration and collective*

action. In Table 14a and 14b below, Bivariate correlations to *governmental trust* and *collaboration and collective action* are presented, 14a shows results for Greater Crescent and 14b for La Pine.

Table 14a: Bivariate Pearson Correlations for sources used to acquire governmental information and the relationship these sources have on governmental trust and collaborative action for Greater Crescent.

	Governmental Trust	Collaboration and Collective Action
Personal and Social Relations	-0.15	-0.15
Community Bulletin Boards	-0.11	-0.17
Local Markets	-0.02	0.19
Membership Groups and Association	0.13	0.01
Business and Work Associates	-0.00	0.03
Political Associations	0.01	-0.04
Community Leaders	0.01	0.05
Governmental Employee/Agent	0.13	-0.01
Non-Governmental Organization	**-0.24***	**-0.22***
Local Newspaper	0.03	-0.09
State/National Newspaper	0.15	-0.10
Radio	0.03	0.01
Television	0.09	0.05
Internet	0.00	0.04

Note: * p≤0.05

Table 14b: Bivariate Pearson Correlations for sources used to acquire governmental information and the relationship these sources have on governmental trust and collaborative action for La Pine.

	Governmental Trust	Collaboration and Collective Action
Personal/Social Relations	0.00	0.07
Community Bulletin Boards	0.09	0.02
Local Markets	0.16	0.01
Membership Groups/Association	0.05	0.08
Business/Work Associates	0.01	-0.01
Political Associations	-0.09	**-0.20**
Community Leaders	**0.23**	-0.13
Governmental Employee/Agent	0.08	-0.08
Non-Governmental Organization	0.02	0.15
Local Newspaper	-0.07	-0.19
State/National Newspaper	0.04	.00
Radio	**-0.28***	-0.05
Television	-0.07	0.03
Internet	**-0.30***	-0.07

Note: * p≤0.05

The results of the Bivariate Pearson Correlations found in table 14a and 14b show some results that were as expected yet also show some disturbing outcomes when considering collaboration for the development of community-based adaptation to climate change. Furthermore, we see that the results do seem to indicate some divergence in the structures on informational use and impacts to residents' positions on governmental bodies.

The first thing to consider is the overall lack of impacts the sources provided on the questionnaire seem to have on residents' positions of trust in the governing institutions and in communities' collaborative potential. This does not deviate from our expectations as seen in the hypothesis above. Yet what has been identified in the overall results that is disturbing is that of all the correlations identified above the 0.20 threshold except one, the correlation are negative and indicate that the information sources may discourage both governmental trust and collaborative potential with residents and institutions. The one remaining positive correlation identified is found in La Pine between information ties to community

leaders and governmental trust (r= 0.23) yet this lacks statistical significance. This does suggest that personal ties to local leadership may have positive impacts for trust and collaboration which is expected.

The remaining correlations identified remain negative, they have relationships that may suggest anti-government sentiment and may discourage cooperative and collaborative development. In Greater Crescent, the residents seem to have ties to non-governmental organizations and that this informational relationship is negatively correlated to the two social capital measures of governmental trust and collaboration (r= -0.24 and r=0.22 respectively) and these are statistically significant (p≤0.05). In reviewing table 13 above it is important to note that informational ties to NGO's do not score high as utilized sources of information but table 14a suggests that at least in Greater Crescent, the impact is significantly negative.

La Pine residents show a distinctly deviated relationship to information sources as seen in 14b, In La Pine it seems that political associations used as information sources for governmental activities may have a discouraging effect on collaboration (r=0.20) yet not on the trust in government, yet it is important to note this lacks statistical significance. More importantly, La Pine residents use the mass media information sources (local newspaper, television and internet from table 13) and although the local newspaper and television fail to correlate either negatively or positively, the internet does share a negative correlation with governmental trust (r= -0.30) and is statically significant (p≤ 0.05). Additionally, the results show that the radio, another information sources that scores lower in its utilization from table 13, also has a negative relationship to governmental trust and not a noteworthy correlation to collaboration.

Overall the results identified in this analysis show that of the top three utilized governmental information sources in both communities, only the internet has a distinct and significant correlation to residents' positions on governmental trust and collaboration. What is discouraging is that this correlation is negative and that La Pine residents that are using more mass media instead of social ties are choosing a source that is not generally regulated and often fails in accountability. The end result may deter collaboration by generating a lack of trust in the governing bodies that retain many of the resources beneficial to community adaptation as well as title to the forests that run the risks of wildfires. The other

commonly used resources, social relations in Greater Crescent and local newspaper and television in both communities (Table 13) lack correlations to residents' positions on governmental trust and on collaboration and collective action.

Discussion and Conclusion

This research investigates La Pine and the Greater Crescents community-based climate change adaptive capacity through the network of governmental information sources and on the exchange multiplexity between residents. It examines the resources the community's residents use most often and what the correlations are with resident's trust in government and their measures of community collaboration and collective actions. It further looks at how community politics and the communities' futures are discussed between residents who also discuss climate change, wildfire, and personal fire protections.

The research shows some discouraging results when approaching community-based adaptation. The first is that community members seem to discuss community politics, the community's future and the issue of wildfire within the same circles of ties which is positive, yet they fail to discuss climate change within the same ties. This suggests that wildfire may be a political issue and one that the residents can integrate into discussing and negotiating the communities' future with other community members, yet climate change is not. Given that climate change may significantly alter the traditional wildfire ecology, it is pertinent that this develops into the dialogue with the other subjects. In order for the community to mobilize and develop policies and actions that best address the risks of increasing wildfire and the communities' vulnerabilities, the issue of climate change must enter into the same social exchange networks as the other subjects.

Politics and these communities' future are integrated with trust in local, county, state and federal government. Local and county governments can provide support and integrate local policies and action for future development as well as bridge divide between the state and federal governments and the needs of the local residents. The state and federal government hold title too much of the forests around the communities and manage these forest for the common good and for future generations. Trust in these

institutions is pertinent for collaboration which should provide support in the development and maintenance of adaptation through a range of resources including information on risks, instituting support programs for the residents and the communities, and providing capital and infrastructure to address these communities' vulnerabilities. Furthermore, collaboration within the communities' residents is the initial tool for grassroots mobilization for community-based policies and actions to develop adaptive capacity.

This research takes an initial step toward understanding how information sources which deliver information on governmental activities may be impacting the positions of trust and collaboration for La Pine and Greater Crescent. It is logical that information sources have an impact on residents' positions on governmental trust and community collaboration. By utilizing Bivariate correlations between sources and indices on governmental trust and on collaboration, a better understanding of how information source can encourage or discourage adaptation can be made. As was illustrated above, the results showed that little correlations are made between these factors. Yet what was correlated as well as statically significant showed a negative relationship. This may have some profound implications for community-based adaptation.

When investigating the most commonly utilized information resources for governmental activities the results show, as was expected, that the more rural communities of Greater Crescent still maintain a dependence on social and personal relations for information resources, even on governmental activities. This deviates from La Pine's greater dependence on mass media. Both Greater Crescent and La Pine residents have a greater dependence on the local newspaper and television for governmental information, yet the incorporated city of La Pine integrates the internet into a primary source for information.

The greater use of the local newspaper in both communities has a significant and positive impact when considering community-based climate change adaptation. As a local news source the information that is channeled through this resource is likely to local issues and even when addressing federal legislations and action, is likely to communicate local context. Federal funding and congressional initiatives addressing increasing risks of wildfire on a national level are likely to channel through the local newspaper and present local context and information that is pertinent to local residents. Likewise, federal

forest management actions can have dramatic effects on these local communities yet residents may not find the localized context through broader focused television and internet site.

What may not be surprising but may be alarming for this study is the statistically significantly negative correlation that the internet has on governmental trust in La Pine. The internet is both a primary information source in this community and is one of the three sources of information in both communities that has any statistically significant relationship to governmental trust and collaboration and collective action. This indicates that in order to generate collaboration between the community and governmental institutions, grassroots mobilization leaders in La Pine must overcome the seemingly detrimental effect of the internet, a mass media source that is often unregulated, unstructured and whose sites are without responsibility. The pervasiveness of the internet into the incorporated city may become a challenge unless mobilization leaders can utilize it as a tool.

The remaining two information sources that show a statistically significant correlation to governmental trust and community collaboration are, radio in La Pine and non-governmental organizations in Greater Crescent. Both of these information sources for governmental activities also have negative correlations, in Greater Crescent the source negatively correlates to governmental trust and collaboration and radio in La Pine is only negatively correlated to governmental trust. The only positive correlation that is noteworthy is the one found between ties to local leaders as information sources and that of governmental trust found only in La Pine, yet this lacks statistical significance. This may suggest that having a localized governing body has a positive impact on overall perceptions of governmental trust. Given that Greater Crescent as a set of rural communities that do not have a formal governing body, these results may indicate that local mobilization for collaboration between community and governmental institutions will need to reach out to the non-local governing county, state and federal institutions.

This research set out to explore these four central Oregon communities, La Pine and Crescent, Gilchrist and Crescent Lake (Greater Crescent) in terms of the community-based climate change adaption. It sought to establish a foundation for further research and to provide policy and action-relevant information to the communities themselves.

The implications of the results for this study on future studies is primarily to uncover more specifics about information sources used in these communities. Results identified that more focused research should focus on mass media sources of radio, television and the internet. Radio and internet showed negative correlations to governmental trust yet it remains unclear what radio stations and internet sites these communities are using. In order to better understand why mass media sources have the relationships they do for residents' trust in government and to overcome these for collaboration between the communities themselves and government institutions that can provide resource for increasing adaptive capacity, we need to know if these sources are formal or informal and what ones specifically.

Implications for the community leadership and grassroots movements is fairly limited at this stage, but not empty. Both of these communities can utilize the local newspaper to generate information campaigns that drive localized movements to consider climate change and its risks to the communities and to instigate dialogue on generating collaboration within the communities and between the communities and governmental institutions to generate adaptive capacity. Given that the local newspaper maintains no significant correlation, neither positive nor negative on governmental trust and community collaboration, the media source may be able to reach more diverse groups through its neutral positioning and greater outreach.

Central Oregon's forests are under threat of significant changes to its wildfire ecology through climate change. Much of these forests are titled to the state and even more so the federal government who have the responsibility to care for and manage these for national interest and for future generations. State and federal policy in these forests directly impact both La Pine and Greater Crescent and are likely to shape the risks that climate change has to these communities. Information on governmental action should be pivotal to community-based climate change adaptation. Furthermore the social ties within residents of the communities should include diverse and relevant subject matter for generating adaptive capacity. This research has shown two fundamental flaws in social and information networks in these communities, the subject of climate change is not transferred along the same social ties as community politics, community

future, wildfire and personal fire protection and that governmental information sources show little or negative correlations to governmental trust and collaboration and collective action.

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Conclusion

Introduction

Climate change is often presented as a wicked global issue. It is a complex problem without definitive answers and is convoluted by social, cultural, political and economic factors (Hulme, 2009). What makes climate change even more challenging to address is that the local, geophysical manifestations will be varied and are uncertain. It is speculated that on a global scale there will be both winners and losers, and some communities will have the capacity to adapt to localized conditions and others may not.

Due to the nature and complexity of global climate change, it can be argued that adaptations are best managed at local levels where specific social, cultural, political and economic conditions are matched with local risks and opportunities (Ensor and Berger, 2009; Hulme, 2009). Each geographic community has unique relations to the local environment, from being economically dependent on natural resource extraction or amenity-based recreation, to having little direct social, cultural or economic correlation to the local environment. This dissertation utilizes a case study approach to examine climate change adaptive capacity of two central Oregon rural communities located adjacent to the same national and state forests, with similar socio-ecological conditions where their social systems are dependent on the natural systems for recreation, capital and amenities.

The two Oregon communities are likely to face risks of increasing wildfires driven by climate change resulting in shifts to the region's dryness (Spies et al, 2010; Lal, Alavalapati and Mercer, 2011). Climate scientists and modelers expect that increases in regional warming will expand summers and shorten winters, decrease snowpack in the mountains which feeds the region's hydrological cycle and will likely lead to more drying and drought conditions thereby lengthening wildfire seasons and increasing their severity (OCCRI, 2010). Additionally, shifts in forest composition by altering vegetative speciation could impact the severity of wildfires as species less resilient to wildfires yet capable of sustaining in dry

environments migrate into the region's forests. Although some general environmental changes can be expected, the rates of change and even the extent of these changes cannot be certain.

Therefore, communities in central Oregon such as La Pine, Gilchrist, Crescent and Crescent Lake must develop an adaptive capacity to the uncertainty of climate change. Three components of adaptive capacity were addressed in this dissertation and assessments were made with statistical modeling on how various social variables impacted beliefs and values of the residents. The first significant adaptation component is to build and maintain social capital that focusses on the residents' interpersonal networks and community-level social networks (Chapter 2). A second adaptation component is residents' perception of climate change, its local risks and their specific vulnerabilities. Furthermore, the union between which climate change and other subjects believed to be of importance for climate change is transmitted across the same social ties and generating a diversified understanding in the complexity of adaptation is also studied (Chapter 3 and 4). A third community-based adaptation component is the ability to remain informed on governmental activities (Chapter 4). These three components for community-based adaptation are not intended to represent the only significant components; rather, they are applicable components for the research of the field of relational and social network analysis, the primary conceptual and methodical foci for the dissertation.

In addition to understanding these three community-based adaptation components to climate change this research investigated potential variations between the two communities. The incorporation of La Pine provides an opportunity to assess potential differences between a traditional rural community (Greater Crescent) and a newly emerged municipality with regard to climate change, wildfire risks, social capital and community-based adaptability.

The three components of community-based adaptation were presented in this dissertation in three manuscripts. Each chapter is briefly discussed followed by a discussion of the interconnectedness of the three components. Next is a discussion of how this research is expected to contribute to goals and objectives set forth: to establish a foundation for longitudinal research and to present these communities with a foundational understanding of their existing social and informational networks in relation to

climate change and adaptive capacity. Finally, there is a discussion of the limits of this research and how future research may be addressed.

The Three Community Based adaptation Components

Having the capacity to adapt to climate change and the uncertain future of climatic conditions and what these conditions present is advantageous to any community facing risks and opportunities (Ensor and Burger, 2009; Adger, et al., 2009). This includes the four communities of La Pine, Gilchrest, Crescent and Crescent Lake. For this dissertation, Gilchrist, Crescent and Crescent Lake were drawn into a single case as the community of Greater Crescent based on the interdependence of the communities and their maintained rural status. These two community cases face what is believed to be an increasing risk of wildfires caused by changing seasonality which will increase the length and severity of the dry conditions found in the region. The three adaptation factors investigated here include the relationship in information on climate change, the communities' social capital and the information networks on governmental activities.

Social Capital in the Community and its People

Social capital encompasses multiple dimensions that enable a community to strengthen internal cohesion; however, in this dissertation, it is researched within two methodological fields, the expressive and the instrumental. Social science researchers examine social capital through relationships and structures of social networks, such as Nan Lin (2001; Lin, Cook and Burt, 2001; Lin and Erickson, 2008), Ronald Burt (1982; Lin, Cook and Burt, 2001;2007) (instrumental social capital) and through community levels of trust, solidarity and collaborative capacities (expressive social capital) such as Cornelia and Jan Flora (2013) and Robert Putnam (2004). Empirical research on both aspects of social capital has shown the power of social networks in both individual empowerment and the success of a number of bounded communities to improve their positions in addressing a number of issues. In Chapter 2 of this dissertation, social capital was examined through the network ties to professionals within the communities believed to be exposed and/or able to understand the complexity and importance of climate change and its local impacts. This also included analysis on the degrees of community level measures of social capital such as

governmental trust, collective action, and solidarity as measured by perceptions of the residents. Both of these degrees of social capital were tested for impacts on climate change perceptions and the residents' social networks on degrees of community level social capital.

This research examined network capital through professional ties and its correlation to both perspectives on global climate change and on local risks, and on the correlation to community measures of social capital (governmental trust, collaboration and solidarity). It was hypothesized that the more ties to professionals associated with sciences and localized natural resources and forests, the more concern a resident would have on climate change and local risks. The hypothesis on network ties to professionals on climate change was largely unsupported. Residents with ties to these professions do not have a significantly higher or lower perception of either climate change or local risks. It could be that the ties are there but the dialogue on climate change is not part of the relationship.

What did come out in the regressions was that the incorporated city of La Pine does show a statistically significant (although low) and negative impact to the perceptions on local risks due to climate change. This implies that although the perceptions of climate change are not different between these communities, La Pine residents do feel less concern for what climate change will mean to their community in terms of their economy, recreation, their cultural identity, natural resources and natural hazards. Whether or not this is caused by the transitioning socio-political demographic identity of the newly incorporated city is yet to be resolved and beyond the scope of this research, but could remain important. It could be possible that the incorporation of La Pine's core has developed a disconnect from the forests created by the residential development between the city core and the forests and that residents are more concerned with the immediate development of city infrastructure.

The impact of social networks on community social capital may also play an important role in the structure of local mobilization and generating coalitions for public policy. A community's collaborative potential with formal institutions and governmental agencies to maximize the adaptive capacity may make efficient and effective adaptation possible. Yet, many communities, especially rural, often lack resources for generating adaptive capacity. Despite the importance of governmental assistance by

providing resources, it is the local context of climate change and what it means to the community that directs the risks and vulnerabilities. This suggests that collaboration between local, state and federal governmental institutions is important, so local networks impacting a community's social capital measures, especially governmental trust could be valuable.

Using regression models it was found that the social networks with the professions did impact the degree of governmental trust in both communities. Specifically, the degree of professional ties positively impacts a resident's trust in governmental bodies which include local, county, state and federal. The community variable was added to the regression model to test for a difference between the incorporated city of La Pine and the rural communities of Greater Crescent. The community variable does not show an impact and we can then assume that the communities share the statistically significant impact of residential ties to professions increasing the levels of trust in their governmental institutions. Therefore, the incorporation of La Pine has not significantly increased or decreased governmental trust.

The Relationship of Information Sources on Climate Change

In order to address communities risks and opportunities, establish and maintain adaptation, and prepare for resilience to climate change, these communities need to establish a robust information system. This information system should deliver appropriate information on climate change to the community and diffuse it between community members in a manner that captures local contexts across diverse interests. By doing so, a community will be better prepared to address risks and opportunities across broader interest within a community. In this region climate change is predicted to manifest itself significantly through the impact of wildfires. Potential impacts include the risks of loss of life, property and infrastructure, increased frequency and severity of smoke to the elderly and young, impacts to natural resources utilized by community members for subsistence and marketable capital, and amenity services such as the scenic landscape and recreational opportunities.

Information sources on climate change are extremely diverse. They come from media sources such as television, professional reports and internet sites as well as from diverse types of people such as authors, activists, political personalities and even religious leaders. Each source can take a range of

positions on climate change but generally position themselves to reflect either supporting or doubting the scientific consensus on climate change. These information sources present not just scientific data but perceptions on data through individual and institutional worldviews. These information sources may impact the perceptions and understandings of climate change onto the recipient. This research investigates the diverse information sources on climate change and their impacts on the recipients' perceptions and concerns.

Results indicate that information networks on climate change are more complex than one might believe. The sources of information from the roster were transformed into to a binary variable for information sources that a resident reads, feels is reputable, or agrees with from either side of the climate change debate (the roster offered 'heard of' as a fourth option yet this was removed). This offers six possible information sources that a resident can have, they have a source that supports the scientific consensus that they read, one they may feel is reputable and/or one they agree with or they may have ones that do not support the scientific consensus.

The analysis first examines Bivariate correlations between these six information sources and the perceptions that residents have on climate change and their concerns for local risks. This analysis found that both supportive sources and oppositional sources statistically and positively correlate to each other within their support or oppositional perspectives, this seems fairly intuitive. Yet what was not expected is that residents who have a tie to supportive information sources have a greater concern for climate change while there is no supportive correlation to residents' ties to oppositional information sources and a lower position to the perception of climate change. What was also noteworthy is that residents who read material that supported climate change also read material that opposed the issue, yet this correlates to a greater position on the concern for climate change as a global issue and a counterproductive correlation to concerns on local risks. It seems that as residents read both supportive and oppositional climate change together, they actually form less concern for the local impacts that climate change may have despite having a greater concern or position on climate change as a global issue. These results did not come as expected, yet they have implications for community-based adaptation. Residents may acknowledge that

climate change is occurring, is being driven in part by human activities, is likely to progress into the future and likely to cause significant impacts to mankind and communities around the globe, yet they do not find in these information sources the argument that they should be concerned for the health and wellbeing of their community by local manifestations of that same climate change. This could be a result of entrenched world views or may be caused by a form of cognitive dissonance where they acknowledge the greater global issue, yet fail to grasp the local context in which it has. Either way the results show that both of these communities require information that articulates climate change as a global phenomena, and more importantly that it has direct implications to the future of these communities, namely to the significant increase in wildfires this region is likely to experience.

Governmental Activity Information Networks

Most communities, regardless of geographic locations will require some degree of collaboration with higher governmental institutions or at least be aware of what varying levels of the governmental hierarchies are doing. Awareness can include national climate change adaptation policies, what local state agencies are doing for instituting climate change information programs and campaigns, or even what county and local governments are doing with development and natural resource planning that may increase or decrease risks and vulnerabilities from climate change impacts. Central Oregon communities such as La Pine and Greater Crescent are especially dependent on the federal governments when it comes to climate change and wildfires due to the extent of federal forests surrounding these communities, the national parks and the addition of a parcel of previous timber production land obtained by the state of Oregon.

The large scale of publicly owned forests are managed under the goals and objectives of providing multiple natural, economic and social benefits for the U.S. public with the lowest possible costs to the taxpayers. Extensive spending is made to address wildfires in federally owned forests across the United States. With expected extensions in wildfire seasons and increasing dryness in the area, spending on wildfire responses is expected to increase and likely without a corresponding increase in funding for

management agencies. In short, these communities are vulnerable to federal land management actions and can dramatically benefit or be compromised by the decisions of federal and state governments.

Understanding how these communities receive information on governmental activities may be of pivotal importance to mobilizing for adaptation on climate change and for efficient collaboration with governmental and non-governmental institutions. With today's abundant media sources, citizens have many choices, from mass media outlets like television news and the internet, local printed works such as local newspapers, to social networks and neighborly social ties. Empirical work on information networks has shown that larger communities often utilize more mass media and impersonal news sources for information gathering, whereas smaller communities utilize information sources through personal relations among community members.

Mass media can be geographically impersonal; reporting on what may be occurring on a national scale yet unable to translate those activities into a localized context. Mass media is also only absorbed when people are connected, either by watching the television or listening to the radio at the time of the transmission or they are using specific internet sites. Social networks may speed up information diffusion in some cases where a single transmission of information can dissipate through social ties across a community. It is generally believed that a blend of information sources should be utilized; that includes mass media and localized sources, capturing more broad governmental information and localized context.

This research found that La Pine and the Greater Crescent communities utilize information sources as expected. The questionnaire asked residents to report the three most common sources of information on governmental activities. Using two-mode network degree centrality and Bivariate correlational analysis on two social capital measures found in this research (chapter 2), results indicate that these communities use information sources in somewhat expected ways, and that these correlate to positions of governmental trust and collaboration and collective action. In the larger incorporated La Pine, mass media sources were identified as the most important information network sources using UCINET's normalized two-mode degree centrality: *television*, *internet* and the *local newspaper*. Similar results were

found for Greater Crescent, yet in this case *personal and social relations* were identified as the third most important information source rather than the internet.

These results illustrate that La Pine behaves more like a larger community, reliant on a few sources of impersonal information sources. Yet they did identify the *local newspaper* as a central source of information for the community overall. Greater Crescent communities identified more diverse sources of information important for the community, but more importantly the residents identified *social and personal relations* as a core information source on governmental activities. This could indicate that not only raw information is transmitted but that it is being transmitted in conversations that could add values and local contexts that can play roles in adaptation and collaboration.

This analysis has significant implications for community-based adaptability. It suggests that the local newspaper has a heavy burden of transmitting information on governmental activities as well as the local implications these actions may have when it comes to increasing wildfires from climate change. It also suggests that the local newspaper can gain an even greater audience and have more impact in the role in community-based climate change adaption arena if they maintain an active internet site that focuses on this subject matter. The results also indicate that the Greater Crescent communities have an advantage in capturing information and transmitting it along with local context through their personal and social relations. Regardless of the most prominent information sources that these two communities use, the Bivariate correlational analysis suggests that these sources do not significantly impact the residents' trust in governments nor in the communities' collaboration and collective action potential.

The Bivariate correlational analysis was run on each information source and on social capital measures of governmental trust and on collaboration and collective action. This analysis found that except for the internet in La Pine, none of the other core information sources had a statistically significant correlation to either social capital measure. Furthermore, the statistically significant information sources that were identified are all negative; implying that these sources may discourage trust in the governing bodies these communities have as well as discouraging the communities' collaboration and collective action potential in Greater Crescent. In Greater Crescent, the ties to non-governmental organization have

negative correlations to both social capital measures and in La Pine the radio and internet also has negative correlations yet only to governmental trust.

Although these have implications on community-based climate change adaptation, it has more implications for future research. For community-based climate change information these results suggest that an improved information system to increase trust and and collaboration is needed in both communities. Furthermore, the local newspaper could do more to encourage trust and collaboration with governmental bodies. For future research, this research failed to identify specific non-governmental organizations, radio stations and internet sites used and that generate these negative correlations. A focused research design that inquires a list of specific sources used may improve our understanding of these relationships and progress our understanding and the implications on community-based climate change adaptation.

Multiplexity

Multiplexity plays a special role in mobilization and collective action efforts (Diani and McAdams, 2003). Multiplexity refers to multiple relationships that can exist between a pair of ties and often gives a measure to the strength of those ties. This research utilized exchange multiplexity or the idea that a pair of ties can exchange in multiple issues and transmit multiple forms of information. In this research the idea equates to the expansion of knowledge on the overwhelming complexity climate change adaptation through the overlapping diversity of subjects believed to play a role in that adaption. The specific topics or issues of exchange utilized in this research are *climate change*, *wildfire*, *fire protection* of one's home and property, *community politics*, and *community future*. Each of these issues is believed to play an important role in climate change adaption for this region. Exchange multiplexity is addressed specifically in Chapter 3 on climate change information and Chapter 4 on governmental information of this dissertation.

The analysis on exchange multiplexity in the social networks among residents, suggests that the issue of *climate change* remains an isolated subject to the other issues believed to be relevant to adaptation. Results illustrate that correlations exist between the exchange networks on *wildfires* and on

community politics in both communities and between *wildfire* and *fire protection* in Greater Crescent. Yet correlations between the *community's future* and *community politics* and *wildfires* and *property protections* are missing. Overall the correlations between diverse exchange networks on subjects believed to be relevant for increasing adaptive capacity policies are fairly low.

Discussion and Conclusion

The implications of these findings may suggest that mobilization efforts in generating community-based climate change adaptation efforts may gain ground by increasing the dialogue with other subjects. One example may be increasing the substantive nature of climate change when discussing wildfires which we know already has subjective correlations with community politics. It is a commonly held belief by climate change researchers and modelers that this region is likely to see a significant increase in wildfires as a result of climate change. A second example is communities' political campaigns and discussions of the community future could also begin to add the subject of climate change to encourage the awareness of the subjective link between these topics. The community's future will be impacted by climate change over time and it will take political will and collaboration with governmental bodies to address the risks.

Based on the analyses in this dissertation, results suggest residential ties and their exchange multiplexity may contribute to the overall degree of community-based adaptation. In chapter 4 the results show that information sources on governmental activities (associated to community politics and community future) has an impact (negatively) on governmental trust. We also see that governmental trust positively impacts perceptions of climate change. It also appears that climate change information is positively impacting climate change perceptions, but negatively impacting perceptions on local risks. Finally, that the network ties to professions believed to be associated with climate change and wildfire information and lives in these communities has a positive impact on governmental trust.

The results suggest that these communities are challenged by access to information on climate change in a local context. It appears climate change perception itself may not be a limiting factor in these communities' adaptive capacity but how they perceive their local risks. This may be alleviated by a

number of possible actions. One is that information on climate change needs to include local and regional risks and local and regional solutions through collaboration with governmental bodies. The role of the local newspaper cannot be understated; they play a pivotal role in governmental activities information and based on the link between governmental trust and climate change it seems possible that the local newspaper (including an internet website) could be the most valuable tool to both La Pine and to Greater Crescent.

The results from this research also have implications for future research. It has identified relationships between information sources and residents' perceptions of climate change. It has also identified that climate change is not transmitted along the same ties as other relevant issues believed to be associated with adaptive capacity. What is not clear is the structure of the networks of climate change information coming into and diffusing into the communities. It seems that the network structure may explain a little more on how residents are developing their climate change perceptions and why it is not having the same relationship of increasing the residents' local concerns for climate change impacts. Another uncertainty is the details in governmental activities information sources. The data shows the general network structure and the impacts these source types have on the residents' perceptions of governmental trust, but it fails to include the details behind the networks. It shows that television and the internet are significant to the information flow of governmental activities but it fails to tell us what shows or channels and what internet sites are used. The analysis also shows that radio and non-governmental organizations have a negative relationship to governmental trust but lacks specifics as to what radio stations and what organizations are making this occur. It seems plausible that the sources being used may be national radio stations and non-local organizations that are really impacting perceptions on the larger federal or even state levels and would not impact the collaboration between local agencies themselves.

The results of this research have presented some insight into these communities and may explain some of their adaptive capacity to climate change and increasing wildfires. It has also generated questions for future and longitudinal research. The results here do not have the power to explain either community's likelihood to adapt to climate change and wildfire risks, but it does show some interesting areas that

grassroots mobilization efforts can focus on to generate interest and dialogue among residents. For instance, data was not collected on resident's political ideology. While county level voting data could be used as a proxy measure, it would be approximate, at best. Future research is strongly encouraged in this area and in these communities to better understand the process that is taking place on such a complex issue.

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Appendix

Methodological Approach

This section is a detailed report of the methods used for this dissertation. It includes subsections that cover the survey respondents, survey instrument, and the approach to analysis. The data was collected through a mailed questionnaire to residents in La Pine and Crescent, Crescent Lake and Gilchrest (Great Crescent). The mailed questionnaire was sent to all identified owner occupied residents in the communities. A mailed questionnaire was chosen over formal focus groups or personal interviews. Although mailed and internet questionnaires, focus groups and personal interviews are all accepted forms of data collection for social network analysis (Knoke and Yang, 2007; Prell, 2011; Scott, 2000; Wasserman and Faust, 1994), questionnaires have many benefits to the latter. The most relevant here is the ability to sample larger populations at reduced costs and under time constraints. Both focus groups and interviews are much better at working within small focused populations or with special needs populations such as those with language barriers.

Respondents

The mailed questionnaire was intended to capture data from owner occupied residents of La Pine and the Greater Crescent communities. Many of the residential homes in the region are seasonal residents and it is believed that these residents would not have as much incentive to become deeply engaged in grassroots mobilization efforts to address climate change risks. Furthermore, seasonal residents would be harder to capture in the time allotted for the research. Prior to mailing, the owner-occupied residents were identified by utilizing tax lot records. All tax lots that belonged to a business or estate were removed. This was followed by removing all tax lots that had mailing address outside the area.

The questionnaires were mailed in three stages. The first stage included two notifications for the residents in the communities: 1) was a news article in the local paper and 2) a notification card (Dillman, 1999). The news article informing the residents a mailed questionnaire was being sent out and about the

research and the importance it has for La Pine and surrounding communities (see figure 9 below). The

questionnaire was mailed in two phases. The first was mailed mid-November 2012 and the second the

beginning of January 2013. The total mailed and response rates were as follows:

Table 15. Response rate for mailed questionnaire.

	La Pine	Greater Crescent	Total
Mailed	345	338	683
Returned	79 (23%)	102 (30%)	181 (27%)

Addressing Sampling Bias

Surveyed Non-Response Bias Check

Due to the low response rate (23 percent for La Pine and 30 percent for Greater Crescent) a

secondary survey of randomly sampled non-respondents was conducted to address non-response bias. In

order to improve our confidence to a 95 percent confidence level we needed to acquire data from roughly

10 percent of non-respondents, and after adjusting for a small number of undeliverable, 25 surveys were

selected for each community. This survey was conducted using random phone calls of non-respondents.

Name and phone numbers were acquired by (Please acquire from Prof. Steel) and names were cross

checked with the mailed questionnaires response list to identify non-respondents. Phone calls were made

between August 18 and August 25 of 2014.

This survey consisted of a subset of questions from the original questionnaire to avoid contact

burden (Vaske, 2008 p. 2012) and was designed to take up roughly two minutes of respondents' time. The

subset consisted of seven questions from the original mailed questionnaire that included two questions

from section 1 of the questionnaire on expressive social capital, three questions from section 2 on wildfire

risks and climate change, and two demographic questions from section 3. Questions on personal networks

found in section 3 of the questionnaire were not included due to the sensitive nature of these questions.

The non-response bias survey script is available in figure 8 below.

Figure 8: Non-response bias check survey script

The Role of Social Networks for Communities Facing Wildfire Risks

Non-Response Telephone Survey Script

ID number:_____

Hello, my name is Derric Jacobs and I am a graduate student at Oregon State University. I'm calling in regards to a mailed questionnaire about wildfire risks that was sent out last year.

We noticed that you did not respond, but your input is very valuable. Instead I would like to ask if you take about 2 minutes to answer 7 quick questions?

No: Sorry to bother you and have a good day/evening

Yes: Thank you, this should be fast.

These first two questions are asking to what degree you agree with the statement, Measured as strongly agree, agree, unsure, disagree and strongly disagree.

1. If there is a community event to assist people with becoming prepared for wildfire, most people will participate in some way?
    a. Do you strongly agree____, Agree____, Unsure____, Disagree____, or Strongly Disagree____

2. People in your community work together with governmental leaders for the benefit of the community.
    a. Do you strongly agree____, Agree____, Unsure____, Disagree____, or Strongly Disagree____

3. How would you define your position on climate change from these six options?
    a. Climate change is a risk to your area____
    b. Climate change may be harmful to your area____
    c. Climate change is occurring but not sure of any risk____
    d. More important issues to worry about____
    e. Climate change has not been proven and risks unknown____
    f. Climate change is not real____

The next two questions ask about your concerns on local climate change issues with strongly concerned, moderately concerned, slightly concerned, not at all concerned or unsure.

4. To what extent are you concerned negative impacts of climate change in your area to natural hazards and disasters?
   a. Strongly concerned___, Moderately concerned___, Slightly concerned___, Not at all concerned___, or Unsure____

5. To what extent are you concerned negative impacts of climate change in your area to outdoor recreation?
   a. Strongly concerned___, Moderately concerned___, Slightly concerned___, Not at all concerned___, or Unsure____

Finally...

6. What is your age_____

7. What is your sex/gender_____

That's all the questions I have. I would like to thank you for your help and I hope you have a great day/evening.

The responses from the mailed questionnaire and the non-response phone survey for each community were compiled and analyzed in SPSS. Questions 1 through 6 were tested for mean differences and effect size using independent sample t-tests in SPSS and the binary variable of sex/gender with a chi-square test. Effect sizes are reported with point-biserial correlation effect sizes (r) for questions 1 through 6 with dichotomous dependent and continuous independent variables. The sex/ gender question at the end of the non-response survey is tested with a chi-square tests and phi for effect size.

Results of the tests for difference in means between the questionnaire respondents and the non-response calls are shown below in table X. The first two questions were drafted from the expressive social capital section of the survey, "If there is a community event to assist people with becoming prepared with wildfire, most people will participate in some way" and "People in your community work together with governmental leaders for the benefit of the community". In La Pine the t-test for equality of mean for

question 1 and 2 show that the mean scores for the questionnaire and non-response calls are statistically equivalent (p= 0.022 and p=0.002 respectively). In Greater Crescent the tests showed different results and the means for question 1 are not statistically equivalent (p= 0.683). The effect size is reported using *a point-biserial correlation effect size*. The effect size for the disparity between means is *r*= -0.044 which indicates a minimal relationship (Vaske , 2008).

Questions 3, 4 and 5 were derived from section 2 of the mailed questionnaire and deal with wildfire and climate change. Question 3 on the non-response calls repeats question 2 of the questionnaire "How would you define your position on climate change from these six options?" with the 6 point scale derived from Leiserowitz et al's Global Warming's Six Americas' Studies (2009-2012). In both La Pine and Greater Crescent the means from the independent t-tests were not statistically equivalent (La Pine's p= 0.298 and Greater Crescent's p= 0.379). In both La Pine and Greater Crescent the *r* effect size is reported (Vaske, 2008 pp 361-362). For La Pine the effect size is *r*= 0.109 and in Greater Crescent *r*= 0.081; both are showing minimal effect sizes.

Question 4 and 5 on the non-response survey addressed local concerns over the impacts of climate change. Question 4 asked "To what extent are you concerned with negative impacts of climate change in your area to natural hazards and disasters?" and Questionnaire 5 asked "To what extent are you concerned with negative impacts of climate change in your area to outdoor recreation?". For the independent t-tests between the two samples of mailed questionnaires and non-response calls in both La Pine and Greater Crescent, the results show the means to be significantly equivalent. In La Pine question 4 means between the two samples is p= 0.001 and for question 5, p= 0.000. For Greater Crescent, p= 0.005 and 0.001 for questions 4 and 5 respectively.

The final two questions on the non-response survey covered demographic variables; the first is age and second is gender/sex. The first demographic variable is continuous and tested with the independent t-test, yet the second is dichotomous and tested with a Pearson's Chi-square test. For La Pine

the demographic disparity between the means on question 6 (age) has a t-value of -1.335 and a significance of 0.185 meaning that there is statistical evidence that the means vary between the questionnaire survey group and the non-response survey group. We follow this with analysis of a point-biserial correlation effect size of $r= 0.135$ or a minimal relationship. In Greater Crescent the t-value is 1.294 and the significance of 0.198 which is again showing a statistical difference between the means of the samples. The point-biserial correlation effect of $r= 0.115$ shows again a minimal relationship between the difference in means of the questionnaire sample and the non-response survey sample.

For the final question of the non-response survey, sex/gender, the Chi-square test is used with a phi effect size. Here the Pearson Chi-Square value for the La Pine case is 0.656 and a significance of 0.418, we therefore conclude that there is a significant difference between the questionnaire cases and the non-response survey. The effect size of the association between sex/gender and the questionnaire or the non-response survey is $phi= 0.081$ or negligible association. In Greater Crescent the Pearson Chi-square value is 0.721 and a significance of 0.396, therefore we investigate the effect size in which we see $phi= 0.076$. Again we see a difference in the questionnaire sample and the non-response sample yet the effect size is very low.

Based on a non-response bias check using the seven questions drawn from the mailed questionnaire, we can conclude that there is little to no deference between the responses of the mailed questionnaire to those of the communities at a 95 percent confidence interval. Either the t-tests resulted in statistical equivalence of the means of the two cases or the effect size was near the minimal relationship value for either the r or the phi effect sizes. We should proceed with the assumption that the data collected will represent the communities overall positions and that the indices and values incorporated into the statistical models are valid.

Spatial Distribution of Respondents in La Pine and Greater Crescent

The spatial distribution of the returns can be seen in Figure 7 for La Pine and in Figure 8 for Greater Crescent. Returns are spatially distributed within the major residential regions in both communities, implying that specific residential areas of the incorporated city of La Pine or that certain housing areas located in the Greater Crescent area were not represented. In Figure 7, the incorporated city of La Pine is labeled and shown with a blue border. Here it is illustrated that the bulk of the returned questionnaires did come from within the city limits. Yet we also see that a small sample of the questionnaires were returned from outside city limits, these are most likely secondary homes to residents of the La Pine area. In contrast, Figure 8 illustrates the respondents from the rural communities that make up Greater Crescent and there are no definitive boundaries for each community. The major housing developments are all represented except for a small patch of identified tax lots east of the 97 and south of the 58. This was investigated with satellite footage and was found to consist mostly of what appears to be large farm parcels and not residential properties.

Figure 9: This map illustrates the spatial distribution of the mailed responses from the La Pine sample. The incorporated city is shown with a blue border.
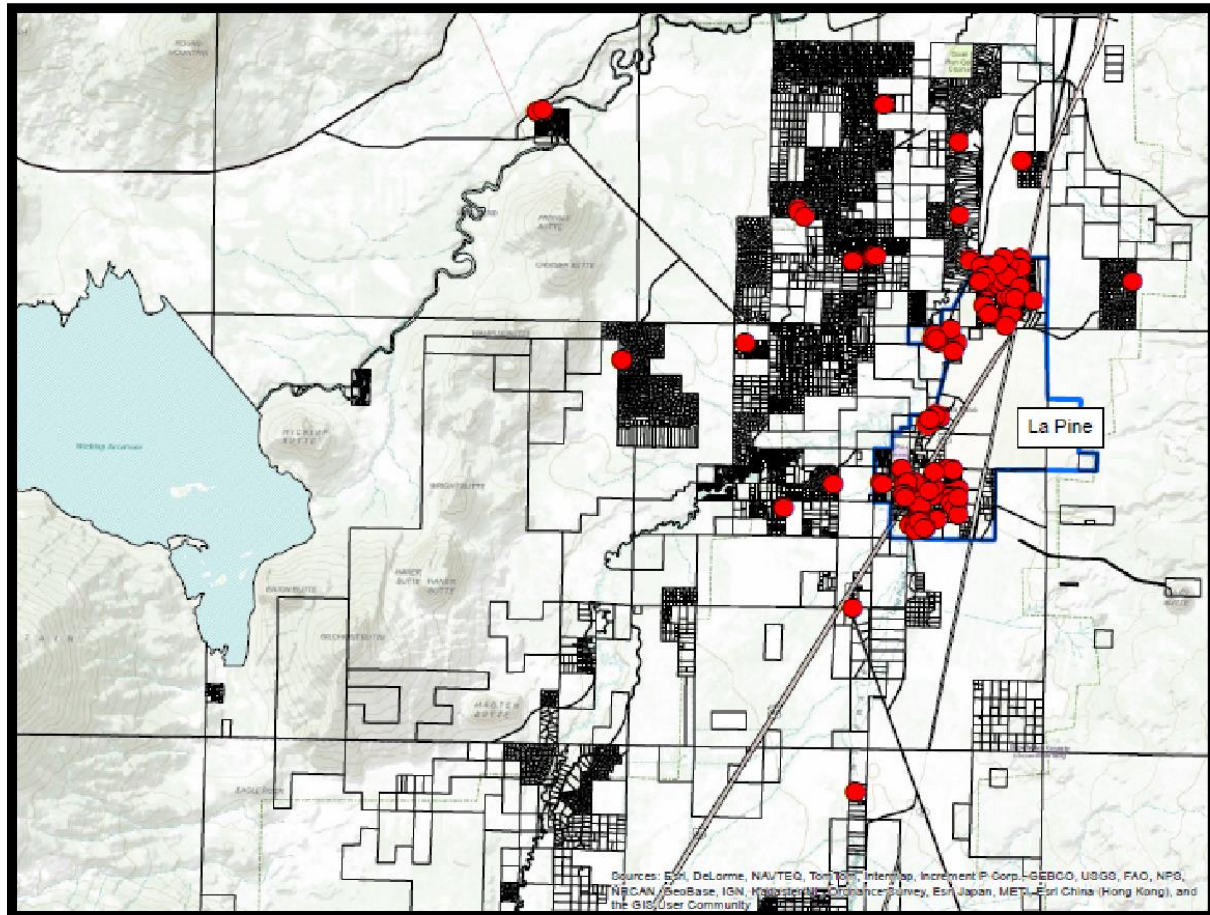
Figure 10: This map illustrates the spatial distribution of the mailed responses from Greater Crescent's sample.
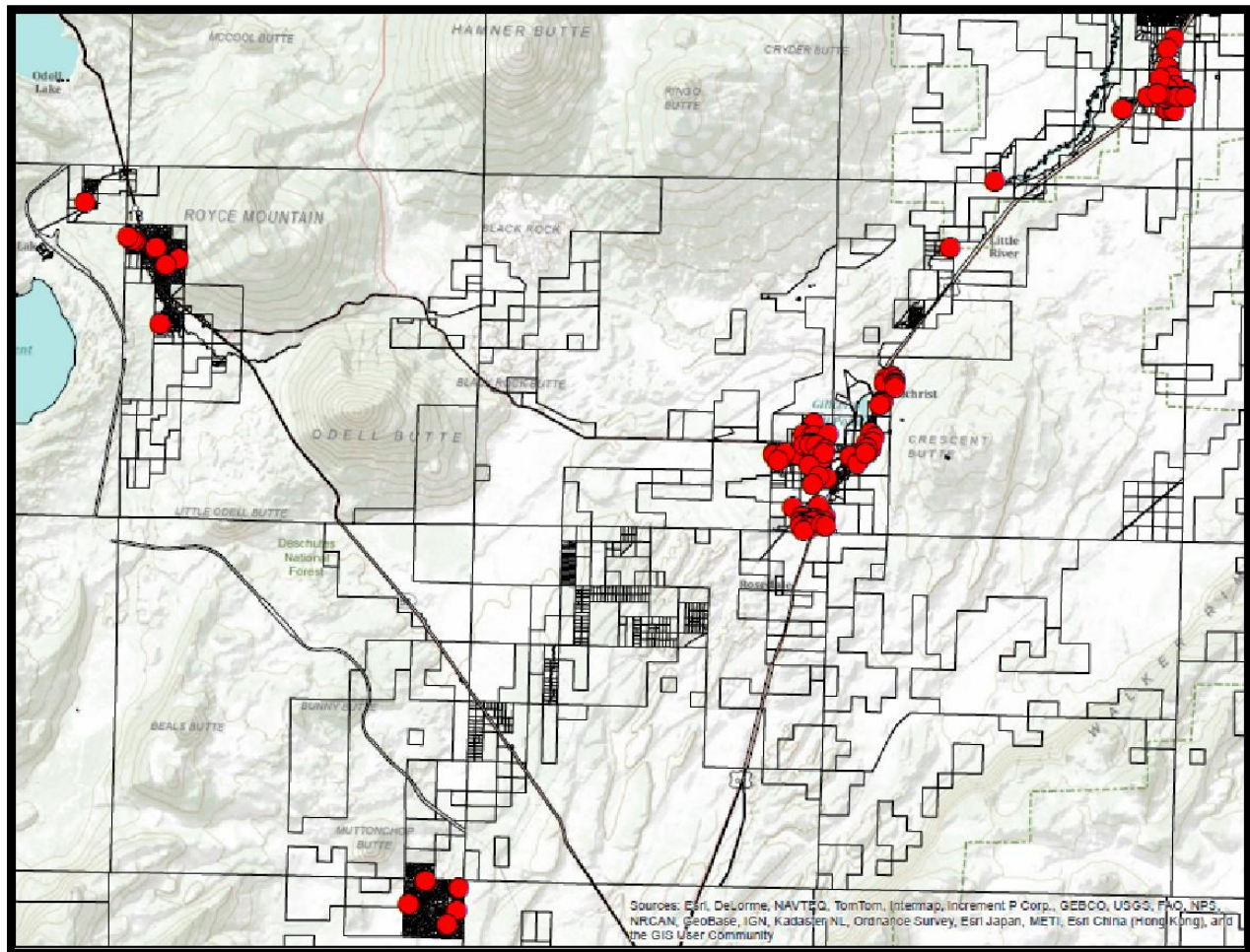
Survey Instrument

The survey instrument for this study was distributed as a mailed questionnaire. The questionnaires were formatted from a thorough review of literature on social network analysis and social capital. This literary review included Wasserman and Faust's *Social Network Analysis: Methods and applications* (1994), Prell's *Social network analysis: History, theory and Methodology* (2011), Lin, Cook and Burt's *Social Capital: Theory and research* (2001). Specific examples of previously utilized questionnaires were obtained from Professors David Tindall and Howard Harshaw at the University of British Columbia. Further examples for question design came from the Grootaert *et al's* Measuring *Social Capital: An Integrated Questionnaire* (2004), Social Network Analysis questionnaires found online at "Social Network Analysis Instruments", http://socialnetworks.soci.ubc.ca/SocNets/Home/Home.html. Though informed with items from the literature, the questionnaires utilized in this dissertation were distinctly written for the communities in this study. To personalize each community, the cover sheet and some of the texts were altered to reflect community-specific contexts. This was done to appeal to a sense of place and community involvement, and to ensure that the respondents were answering the questions with their community in mind, critical to several of the social capital and ego-network questions that will be discussed below.

The questionnaire was eight pages long (not including the cover page), composed of four sections with 24 primary questions and a number of sub-questions, which will be covered below. This length of a mailed questionnaire for the general public may be lengthy yet the subjective nature of wildfires in the questionnaire was believed to be a motivating factor for the residents to participate. In order to address discouragement generated by an overwhelming survey, the questionnaire used large print and white space which may have also increased the overall length.

Section 1 of the questionnaire was focused on social capital, had one primary question followed by 16 sub-questions. These questions were taken from the World Bank's social capital publication's (2009) list of core social capital questions and modified to capture the wildfire focus of this research.

Section 2 focused on climate change and wildfire beliefs with six primary questions and 19 sub-questions. Section 3 was on networks with nine primary questions, two sub-questions and up to six possible nominations for five ego-network questions. The last section closed the questionnaire with eight demographic questionnaires for the respondents. The questionnaire is available in Figure 10 below.

Section 1: Social Capital

The questions for the social capital section of the questionnaire were designed to capture the respondents' perceptions of local community social capital. The section includes 16 sub-questions that ask about levels of trust, assistance and cooperation, education and planning, as well as relations between citizens and formal institutions. Each question utilized a five-position likert response scale that ranged from "Strongly Agree" to "Strongly Disagree" with "Unsure" in the middle. These sets of questions, drawn from *Measuring Social Capital: An Integrated Questionnaire* (2004) are designed to capture a number of dimensions of social capital such as the community's degree of collaboration, the rate at which the residents feel included in the community, how much trust they have for each other and for governing bodies.

Section 2: Climate Change and Wildfire

Section two of the questionnaire was designed to uncover personal beliefs and values on climate change and wildfires from core and general beliefs to local dimensions. The first set of questions covers the general beliefs and perspectives on climate change. The core question on climate change asked, "How do you define your position on climate change?" This was followed by six choices taken from Leiserowitz, Maibach and Light's with the Yale School of Forestry and Environmental Studies *Global Warming's Six Americas* (2009). These options identify the respondents as being *Alarmed, Concerned, Cautious, disengaged, Doubtful* or *Dismissive* on the issue. This was then followed by three supplemental questions based on whether or not their responses fell into the *Alarmed, Concerned, or Cautious* category, the *disengaged*, or the *doubtful or Dismissive*. A final open-ended question was also presented for further

expression. Another set of five questions were asked to uncover the areas of concern on the impacts of climate change to the community with a five-point likert scale. These areas are economic, recreation, cultural, natural resource and natural hazard impacts.

A second set of questions was designed to understand how respondents viewed responsibilities on a variety of topics on climate change and wildfire. This set of seven questions included six choices for each "responsibility question" that included federal, state, county and local agencies, non-governmental organizations, and the individual. Climate change questions that were asked included responsibility for researching, informing, creating adaptive strategies and financing adaptive strategies. Questions on wildfire included responsibilities for risk, preparedness, and fuel reductions.

Section 3: Networks

The third section of the questionnaire covers networks. This section has two questions designed to uncover information networks on government activities and information on climate change. The government information question asked respondents to select the three most common resources for information on governmental activities out of 16 choices in the roster. The climate change information question is designed around a name interpreter design. It offers a total of 34 information sources that were found to be active on disseminating climate change information. These include individual personalities, organizations of one source or another, and mass media sources such as internet websites and blogs. These include 23 sources that either accepts the general scientific consensus that climate change is occurring, is being influenced by human activities, and poses some level of threat to human well being and 11 entities that promote skepticism and denial. The interpretation component of this question is for respondents to identify whether they have heard of the source, they have read their material, they feel they are reputable and if they agree with this source. These two questions are designed to be analyzed using two-mode network analysis techniques (Wasserman and Faust, 1997; Prell, 2012).

The second set of network style questions was designed to uncover the respondent's ego-networks or personal social networks. There are five ego-network questions to capture exchange multiplexity in the network. Exchange multiplexity refers to the concept that an individual's network with other individuals may capture multiple forms of information exchanges (multiplexity refers simply to multi-relational (Prell, 2012) and here we address the exchange of multiple forms of information exchanges). A person may have a set of persons they network with around recreational activities and a set of persons they network with around academic or work issues and activities. Some of these social relations may overlap while others are single-issue focused. The questionnaire identified five potential networks that could be valuable for adaptive capacity. These include individual fire protections of one's property, networks around wildfire risks, networks on climate change, on the communities' future and networks on community politics. Each of these ego-network questions uses a name generator approach (Prell, 2012) and a strength of tie inquiry. The strength of tie is relationship based and includes family, friend, coworker, acquaintance and other.

Figure 11: The mailed questionnaire

The Role of Social Networks for Communities Facing Wildfire Risks

Dr. Lori A. Cramer

School of Public Policy

Oregon State University

307 Fairbanks Hall

Corvallis, OR 97331-3703

(541)737-5382

lcramer@oregonstate.edu

Derric B. Jacobs

Environmental Science Graduate Program

Oregon State University

301 Gilkey Hall

Corvallis, OR 97331

(541) 737–1421

jacobsd@onid.orst.edu

Section 1: In this section we are interested in your opinions about the quality of life in your community.

Q1. To what extent do you agree or disagree with these statements?

(Please check the circle that best represents your opinion)

Strongly Agree   *Agree*   *Unsure*   *Disagree*   *Strongly Disagree*

Statement	Strongly Agree	Agree	Unsure	Disagree	Strongly Disagree
Most people in La Pine are willing to help if you need it.	◯	◯	◯	◯	◯
In La Pine, most people can be trusted.	◯	◯	◯	◯	◯
In La Pine, you can express different points of view in public conversations without fear or concern.	◯	◯	◯	◯	◯
Most people in La Pine participate in community activities.	◯	◯	◯	◯	◯
If there is a major fire in or near La Pine, people would come together to solve the problems.	◯	◯	◯	◯	◯
If there is a community event to assist people with becoming prepared for wildfire, most people will participate in some way.	◯	◯	◯	◯	◯
The people of La Pine have similar values.	◯	◯	◯	◯	◯
I feel like I have power and control over my life and property.	◯	◯	◯	◯	◯
People in La Pine work together with government leaders for the benefit of the community.	◯	◯	◯	◯	◯
La Pine has a fire preparedness program with information that is readily available.	◯	◯	◯	◯	◯
The people of La Pine prepare for the unexpected.	◯	◯	◯	◯	◯
Most people in La Pine would attend public fire education and emergency preparedness presentations.	◯	◯	◯	◯	◯
Local government agencies can be trusted.	◯	◯	◯	◯	◯
County government agencies can be trusted.	◯	◯	◯	◯	◯
Oregon state government agencies can be trusted.	◯	◯	◯	◯	◯
Federal government agencies can be trusted.	◯	◯	◯	◯	◯

Section 2: The following questions ask about your views of wildfire risks and the climate. There is no right or wrong answer and all views on these issues are important for this study.

Q2. How would you define your position on climate change (Please check ONE)?

A. Climate change is occurring and risks to La Pine are high.	⬭
B. Climate change is occurring and risks may be harmful to La Pine.	⬭
C. Climate change is occurring but I am unsure of any risk to La Pine.	⬭
D. I feel there are many more issues to worry about in La Pine than climate change.	⬭
E. Climate change has not been proven and risks are unknown at this point in time.	⬭
F. Climate change is not real.	⬭

Q2a. In Q2, IF you answered A,B, or C, which ONE of the following most closely represents your opinion?

Mostly caused by man	Somewhat caused by man	Completely natural	Other
⬭	⬭	⬭	⬭

Q2b. In Q2, IF you answered D, which ONE of the following most closely represents your opinion?

I don't know enough	I can't make a difference	It's not my responsibility	Other
⬭	⬭	⬭	⬭

Q2c. In Q2, IF you checked E or F, which ONE of the following most closely reflects your opinion?

The science/ scientists are misleading	The politicians are misleading	The media is misleading	Other
⬭	⬭	⬭	⬭

Q3. Which ONE of the following has the most influence on wildfire risks around La Pine?

Climate	Land Management	Both climate and Land Management	Other
⬭	⬭	⬭	⬭

Q4. If you answered 'other' in Q2a, Q2b, Q2c or Q3, please explain:_____

_____

_____

Q5. Thinking about the last 5 years, please answer the following.

Has federal forest management decreased fire risks around La Pine?	Yes ◯	NO ◯
Have you fire-proofed your home and property?	Yes ◯	NO ◯

Q6. In your opinion, which agencies or organization are responsible for the following? (Please check all that apply)

	Federal Agencies	State Agencies	County Agencies	Local Agencies	Nongovernmental organization	Individual
Researching climate change and its impacts to your area?	◯	◯	◯	◯	◯	◯
Accountable for information on climate change and its impact to La Pine?	◯	◯	◯	◯	◯	◯
Accountable for wildfire risks to La Pine from public lands?	◯	◯	◯	◯	◯	◯
Responsible for developing and informing wildfire preparedness strategies? (home defense, evacuations, etc.)	◯	◯	◯	◯	◯	◯
Responsible for planning and operating forest fuel reduction operations on public lands around La Pine?	◯	◯	◯	◯	◯	◯
I do not believe in climate change or that it is a risk to La Pine. (Please check the circle and skip to Section 3 on page 4)	◯					
Responsible for creating adaptive strategies for climate change in La Pine?	◯	◯	◯	◯	◯	◯
Responsible for financing adaptive strategies for climate change in La Pine?	◯	◯	◯	◯	◯	◯

Q7. To what extent are you concerned with potential negative impacts in La Pine from climate change on the following?

	Strongly concerned	Moderately concerned	Slightly concerned	Not at all concerned	Unsure
Impacts to industry and the economy	◯	◯	◯	◯	◯
Impacts to outdoor recreation activities	◯	◯	◯	◯	◯
Impacts to local culture and identity	◯	◯	◯	◯	◯
Impacts to public and private natural resources	◯	◯	◯	◯	◯
Impacts to risks of natural hazards and disasters	◯	◯	◯	◯	◯

Q11. Please list up to 6 people in LA PINE that you have discussed wildfire risks with and check the MOST accurate relationship. (Please provide full names)

I have not discussed wildfire risks with a La Pine resident: ◯

	Family	Friend	Coworker	Acquaintance	Other
1.	◯	◯	◯	◯	◯
2.	◯	◯	◯	◯	◯
3.	◯	◯	◯	◯	◯
4.	◯	◯	◯	◯	◯
5.	◯	◯	◯	◯	◯
6.	◯	◯	◯	◯	◯

Q12. Please list up to 6 people in LA PINE you have discussed the issue of climate change with and check the MOST accurate relationship. (Please provide full names)

I have not discussed climate change with a La Pine resident: ◯

	Family	Friend	Coworker	Acquaintance	Other
1.	◯	◯	◯	◯	◯
2.	◯	◯	◯	◯	◯
3.	◯	◯	◯	◯	◯
4.	◯	◯	◯	◯	◯
5.	◯	◯	◯	◯	◯
6.	◯	◯	◯	◯	◯

Q13. Please list up to 6 people in LA PINE that you have discussed the future of the community and check the MOST accurate relationship. (Please provide full names).

I have not discussed La Pine's future with a resident: ◯

	Family	Friend	Coworker	Acquaintance	Other
1.	◯	◯	◯	◯	◯
2.	◯	◯	◯	◯	◯
3.	◯	◯	◯	◯	◯
4.	◯	◯	◯	◯	◯
5.	◯	◯	◯	◯	◯
6.	◯	◯	◯	◯	◯

Section 3: The following questions measure social and communication networks within La Pine. Please remember that ALL responses will be confidential. All names will be given a code for analysis. NO names will be made public. If we are to have scientifically accurate data, your input is important.

Q8. How do you obtain information on government activities? (Please select the THREE most frequently used)

Personal/ social relations	○	Government employee/ agent	○
Community bulletin boards	○	Non-governmental organization	○
Local markets	○	Local newspaper	○
Membership groups/ associations	○	State or national newspaper	○
Business/ work associates	○	Radio	○
Political associations	○	Television	○
Community leaders	○	Internet	○

Q9. Please List up to 6 people in LA PINE that you have discussed fire proofing your home or property with. (Please provide full names and check the box MOST accurately reflecting your relationship)

	Family	Friend	Coworker	Acquaintance	Other
1.	○	○	○	○	○
2.	○	○	○	○	○
3.	○	○	○	○	○
4.	○	○	○	○	○
5.	○	○	○	○	○
6.	○	○	○	○	○

Q10. How important are the following social relations for making decisions on fire proofing your home and property?

	Very important	Important	Slightly Important	Not important	Unsure
Family	○	○	○	○	○
Friends	○	○	○	○	○
Neighbors	○	○	○	○	○

Q14. Please list up to 6 people in LA PINE you have discussed community politics and leadership with and check the MOST accurate relationship. (Please provide full names)

I have not discussed politics and leadership with a La Pine resident: ◯

	Family	Friend	Coworker	Acquaintance	Other
1.	◯	◯	◯	◯	◯
2.	◯	◯	◯	◯	◯
3.	◯	◯	◯	◯	◯
4.	◯	◯	◯	◯	◯
5.	◯	◯	◯	◯	◯
6.	◯	◯	◯	◯	◯

Q15. Do you know someone with one of these titles, do they reside in LA PINE and what is your relationship? If you know more than one person with one of the titles, please list the individual you have the CLOSEST relationship with. (Please check only ONE relationship)

Title:	Name:	Lives in La Pine	Family	Friend	Coworker	Acquaintance	Other
Professional Scientist		◯	◯	◯	◯	◯	◯
Forest/ City Fire Fighter		◯	◯	◯	◯	◯	◯
Public Land Management Employee		◯	◯	◯	◯	◯	◯
Non-governmental Organization member		◯	◯	◯	◯	◯	◯
Science teacher		◯	◯	◯	◯	◯	◯
Local Community official		◯	◯	◯	◯	◯	◯
Timber industry employee		◯	◯	◯	◯	◯	◯
Local news associate		◯	◯	◯	◯	◯	◯

Section 4: In order to make sure our survey represents the opinions of people in La Pine, we need to ask some questions about your background. Remember all answers are completely confidential.

Q17. What is your gender? ◯ Male   ◯ Female

Q18. What is your current age in years?_____

Q19. What is your ethnicity?

◯ White   ◯ Hispanic   ◯ African

◯ Native American   ◯ Asian   ◯ Other_____

Q20. How many years have you lived in Oregon?_____, years in La Pine?_____

Q21. If you moved to La Pine from somewhere else, previous city/town?_____

Q22. What is your highest education level?

◯ Less than High School   ◯ High School Graduate   ◯ Some College

◯ College Graduate   ◯ Graduate School   ◯ Vocational School

◯ Other_____

Q23. Which of the following describes your current work situation?

◯ Employed Full time   ◯ Employed part time   ◯ Unemployed

◯ Retired   ◯ Student   ◯ Other:_____

Q24. Which category best describes your household income before taxes in 2011?

◯ Less than $10,000	◯ $10,000- $14,999	◯ $15,000- $24,999	◯ $25,000- $34,999
◯ $35,000- $49,000	◯ $50,000- $74,999	◯ $75,000- $99,999	◯ $100,000- $149,999
◯ $150,000- $199,999	◯ $200,000 or more		

THANK YOU for participating in this survey. Please return this completed survey as soon as possible in the enclosed addressed and postage paid envelope. We look forward to presenting the analysis of the study to the people of La Pine in the Summer of 2013.

(For Office Use Only) Tracking Number:_____

Q16. In this question we would like to know how familiar you are with people and organizations related to climate change. We would also like to asses if you know their views, if you think they are reputable and if you agree with their position? All names and organizations were selected from public records and represent diverse positions. (Please leave blank if you have not heard of the individual or organization)

	You have heard of the following	You have read their material	They are reputable	I agree with them		You have heard of the following	You Have read their material	They are reputable	I agree with them
National Oceanic & Atmospheric Administration	◯	◯	◯	◯	ConservAmerica	◯	◯	◯	◯
Junk Science	◯	◯	◯	◯	What's Up with That	◯	◯	◯	◯
Michael Mann	◯	◯	◯	◯	Stephen Shneider	◯	◯	◯	◯
Oregon Climate Change Research Institute	◯	◯	◯	◯	Art Robinson	◯	◯	◯	◯
James Dobson	◯	◯	◯	◯	Fred Singer	◯	◯	◯	◯
Pat Michaels	◯	◯	◯	◯	Philip Motte	◯	◯	◯	◯
350.org	◯	◯	◯	◯	Center for Climate & Energy Solutions	◯	◯	◯	◯
Richard Muller	◯	◯	◯	◯	Skeptic Science	◯	◯	◯	◯
Real Climate	◯	◯	◯	◯	James Hanson	◯	◯	◯	◯
Ted Haggard	◯	◯	◯	◯	National Academy of Science	◯	◯	◯	◯
National Center for Atmospheric Research	◯	◯	◯	◯	E.Calvin Beisner	◯	◯	◯	◯
Steve Milloy	◯	◯	◯	◯	World Meteorological Organization	◯	◯	◯	◯
Rick Warren	◯	◯	◯	◯	National Aeronautics & Space Administration	◯	◯	◯	◯
Climate Institute	◯	◯	◯	◯	Climate Depot	◯	◯	◯	◯
Bjorn Lumborg	◯	◯	◯	◯	U.S. Global Change Research Program	◯	◯	◯	◯
Bill McKibben	◯	◯	◯	◯	Alliance for Climate Protection	◯	◯	◯	◯
U.S. Climate Action Network	◯	◯	◯	◯	Intergovernmental Panel on Climate Change	◯	◯	◯	◯

Approach to Analysis

Analyses for this dissertation were conducted using SPSS versions 20, 21 and 22 and UCINET versions 6.3 to 6.5 software packages. The statistical analysis for Chapter 2 and Chapter 3 were all hierarchical multi regressions testing the impact of independent variables on the two dependent variables. All reporting are standardized coefficients, the standard errors and significance on a two-tailed test. In Chapter 4 Bivariate Pearson Correlations are reported from SPSS version 22.

The dependent variables for all regressions included both climate change positions from Question 2 of the questionnaire in figure 10 and for the index created from the local concerns on climate change impacts drawn from Question 7. Climate change positions and concerns of local risks are two variables that should play a core function in preemptive mobilization for grassroots community-based adaptation and on any development of collaboration between community and formal institutions.

Social network analysis for this work was conducted using UCINET 6.3 through 6.5. All relational data collected (family, friend, etc.) was joined into a single network for analysis. In the Quadratic assignment procedures utilized in Chapters 3 and 4, the analysis was run to allow for missing data and with 5000 permutations. The reported correlation coefficients are Pearson Correlation coefficients and reported p-values (all found at or below 0.001).

Figure 12: Newspaper article published in the local newspaper explaining the research study and advising a mailed questionnaire.