The Rogue Basin Action Plan for Resilient Watersheds and Forests in a Changing Climate

Southern Oregon Forest Restoration Collaborative

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Foreword

The Southern Oregon Forest Restoration Collaborative (SOFRC), the Model Forest Policy Program (MFPP) and the Rogue River-Siskiyou Forest Service (RRSFS) have a shared vision to enhance the resiliency of our communities and forests. In 2012, the Collaborative took the leadership role to engage in the Climate Solution's University (CSU) Plan Development Program created by the Model Forest Policy Program in partnership with the Cumberland River Compact. The goal of CSU is to empower rural, underserved communities to become leaders in climate resilience using a cost effective distance learning program. This climate action plan for the Rogue Basin is the result of a year of community team effort, bringing in an array of stakeholders and expertise, building partnerships, extensive information gathering, critical thinking, and engaged planning. The result is a localized, actionable plan that the community can support and implement in the coming years. The outcome will be a community that has strengthened capacity to be resilient to the inevitable impacts of climate change; a community with awareness, shared vision, and partnerships enabling it to withstand the impacts of climate change upon the natural resources, economy, and community.

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Executive Summary

The Southern Oregon Forest Restoration Collaborative, in conjunction with several partners and under the guidance of Climate Solutions University, has put together a plan for resilient forests and watersheds in a changing climate. Climate changes are and will continue to affect our natural resources regardless of measures taken. Key climate impacts in the Rogue Basin include increase in severity and frequency of wildfires; decreased snowpack and earlier snowmelt affecting water quality and quantity for humans and wildlife; increase severity in droughts and flooding; higher elevation transition from snow to rain; increasing stream temperatures which are already a large issue in the Basin; and biogeographic shifts in species' ranges. However these impacts can be mitigated, or even capitalized upon, if actions are taken now to prepare for the changes and increase local resiliency. Collaboration on forest restoration has been critically important in building shared understanding and community support for management to address current conditions, and promote forest health and resilience in southwest Oregon. On-the-ground projects including the Medford District Secretarial Pilot Project and Ashland Forest Resiliency Project have helped to advance stakeholder understanding and support. This plan is an opportunity to build upon partnerships and incorporate important climate adaptation measures into current and future planning efforts, strengthening the capacity of the community to respond to and prepare for climate change. It is our hope that the science and recommendations put together by the Climate Action Planning team and partners will lead to an all lands approach to forest management to increase resilience to climate change.

Figure 1. A view of the Rogue Basin from Upper Table Rock, Mt. McLoughlin is the highest peak in the basin. *Photo Credit: Gwyn Myer.*

The Rogue Basin of southwestern Oregon occupies part of the Klamath Province identified in the Northwest Forest Plan. The basin drains water from both the Klamath Mountains (Siskiyous) and the Cascade Mountains and forms a regional confluence of Western US floristic provinces as well. The variety of inland forests here follow complex environmental gradients reflecting hot dry summers and cool moist winters contributing to historically very frequent fire and fire-adapted vegetation. Oregon's Klamath Province is one of four dry forest regions in the home range of the Northern Spotted Owl. Fire suppression, widespread even-aged stand management, land use, and other stressors have dramatically reduced and degraded critical wildlife habitat and generated dense overcrowded stands, leading to tree stress and low vigor, and placing the oldest most structurally important trees at risk of uncharacteristic wildfire. Younger stands are threatened by density driven wildfire risk, and moisture competition; without active management their development into mature stands dominated by large trees is slowed. Forest diversity, a hallmark of the region, has been reduced at both the landscape and stand scale.

Climate change is happening. There is strong scientific consensus that it is happening and is anthropogenically (human) caused. Climate change is exacerbating the aforementioned stressors to the Rogue Basin (i.e., wildfire, loss of habitat, declines in water quality), and projected climate change impacts will continue to increase stressors as well as bring new risks. Global average temperatures are rising, and are expected to rise in the Rogue Basin between 2.3 and 4.5^{0}C (4.3 and 8.2^{0}F) by 2075-2085 (USFS MAPSS data), even if efforts are taken to mitigate climate change. It is imperative that the Rogue Basin prepare for climate change and increased stressors so as to protect and enhance its communities, natural resources and local economy.

This planning process included an assessment of the risks and opportunities related to the economy, forest, and water of the Rogue Basin. A variety of stakeholders and experts provided their input. After gathering data and information to assess the past, current, and projected future conditions of the Rogue Basin, a list of risks and stressors was created. From that list, relative risk values were assigned to the emergent risks (high, medium, low), as well as priority values and the capacity to respond. From that exercise, goals, objectives, and specific, on-the-ground strategies were developed. This plan calls for identifying restoration need, management that plans for projected changes in the climate, and economic opportunity. It gives equal weighting on economic, ecological and social goals for forest management consistent with the Productive Harmony Guidelines of the Southern Oregon Forest Restoration Collaborative. The plan explicitly integrates climate change projections, habitat protection, riparian and forest restoration, fire safety, ecosystem services, and economic activity. The key risks identified include uncharacteristic impacts of severe wildfire to forest ecosystems; increase in severe fire risk to communities and infrastructure; declines in water quantity and quality; and risks to the various values (ecosystem services) people receive from the forests.

Key solutions and opportunities identified are: an opportunity to utilize SOFRC's integrated forest restoration approach and incorporate ecosystem services in multi-party collaborative processes to move projects forward while meeting objectives of federal agencies; the opportunity to restore natural forest structure, function, and fire regimes; and an opportunity to provide alternative management recommendations, supported by a variety of partners, that could increase resiliency and resistance to the impacts of climate change while providing economic benefits and a potential solution to the current land management issues present in the Rogue Basin.

Broad goals include:

- Manage risk and reduce uncharacteristic impacts of fire
- Ensure the highest possible water quantity and quality
- Use an ecosystem services approach to incorporate values into planning outcomes and provide economic rationale for restoration/resilience focused management

The ultimate goal of local collaborative actions should be to promote diverse, resilient forests that support clean water, abundant wildlife, and local economies. A critical strategy to accomplishing these goals is to restore fire's role in maintaining resilient, healthy forest ecosystems capable of adapting to environmental disturbances. This will involve thinning the forest in identified priority areas, promoting shade-intolerant species and returning spatial heterogeneity through gap creation, and appropriate fire use. A second strategy is to identify those forest communities most at-risk, buffer them from the more direct impacts of climate change (i.e., severe fire), and ensure that corridors are open for species migration and community adaptation to future climate. A third strategy is to prioritize riparian restoration efforts to enhance water quality and quantity. Restoration and thinning activities will support local economies. Payments for ecosystem services can provide an alternative source of revenue to counties, as can local sales tax initiatives, state taxation of log exports, and appropriate county property tax rates. Collaborative management of the federal lands can make it possible to approach ecosystem restoration at a landscape level approach, which is necessary to create truly resilient watersheds, forests, and counties.

Introduction

Warming of the climate system is unequivocal, and since the 1950s, many of the observed changes are unprecedented over decades to millennia. The atmosphere and ocean have warmed, the amounts of snow and ice have diminished, sea level has risen, and the concentrations of greenhouse gases have increased" (IPCC 2013). Climate change is happening, and humans are the cause. With unprecedented levels of fossil fuel emissions, regardless of actions we take, it will continue and it will impact our natural resources, with an increase in natural disasters (IPCC 2013). But we can do something about it. We can prepare, adapt, and mitigate the impacts. The time to act is now.

Comprising an area with heavily forested landscape and abundant water amenities, the Rogue Basin is highly dependent on natural resources. These not only provide invaluable life support services through food, fiber, and clean drinking water, they also support agriculture, forestry, and recreation. These abundant natural resources are also in need of improved and more sustainable management. Our forests are unnaturally dense due to past management practices and at a high risk of uncharacteristic wildfires, which are projected to increase in severity and frequency with climate change. Our homes in the wild land urban interface (WUI) are some of the most at risk in the country. Our watersheds are threatened by wildfire as well, as sediment can enter the streams post fire, and lack of shade post fire will exacerbate the high stream temperatures that are already threatening our aquatic habitats and endangered species. The Rogue Basin is an incredibly diverse region, with a community that is keenly aware of its natural resources and the present risks. Now is the time to increase our capacity to adapt to the changing conditions, to increase our ecosystem's and community's resilience to natural disasters, and to poise ourselves to be a leader in preparation and adaptation for a changing climate.

An Introduction to the Rogue Basin

Human communities of the Rogue Basin have strong ties to the natural resources and environment. Humans have occupied the Rogue River and its tributaries for at least 8,500 years (Rogue River Keeper, 2013). It is an important source of food and culture for Native Americans. Gold mining brought settlers to Oregon, and then the boom of the timber industry in the 1970s was a major source of jobs and income. However due to industrial slow down and political and environmental reasons, the timber and wood products industry has declined. The key revenue generating industries in the region today are retail trade, manufacturing, and healthcare. The major employment sectors are retail trade; health care; federal, state, and local government; and manufacturing (U.S. Department of Commerce, 2012). The region is also an ideal retirement location due to its mild climate and affordability. This increases opportunities for retail trade and services. However the Rogue Basin area is listed as 'economically distressed', because new jobs, average wage, and personal income are decreasing and unemployment is increasing.

Nearly 300,000 people live in the Rogue Basin. The area is highly valued for its scenic attractions and cultural significance. Many enjoy recreational uses, such as fishing, rafting, hiking, Off Highway Vehicle trails, wine tasting, hunting, camping, parks, scenic byways, horseback riding, boating, and nature viewing. The Rogue Basin provides clean drinking water, critical wildlife habitat, wood products, and non-timber forest products; it's also a large pear exporter, and is one of the most biologically diverse regions in North America. The Rogue River was named one of the original eight rivers in the Wild and Scenic Rivers Act of 1968 (National Wild and Scenic Rivers System). There are more than 4,000 miles of fish-bearing tributary streams found throughout the Rogue Basin. The Klamath-Siskiyou temperate coniferous forests are among the four most diverse of its kind in the world (World Wildlife Fund, 2008). The ecosystem services provided by the Rogue Basin are integral to the survival of the local culture and economy. It is important that we assess and plan for stewardship of the watershed to protect the values of the residents and the unique biodiversity of the region, as well as to ensure our supply and quality of drinking water and increase ecological and community resilience to a changing climate.

Figure 2. Crater Lake National Park. *Photo Credit: Gwyn Myer.*

The beautiful Rogue River's headwaters begin in Crater Lake National Park at 5,300 ft. in elevation. The river curves through a volcanic legacy, enters the valley where urban development is concentrated, cuts through the biologically diverse Klamath-Siskiyou Mountains, and opens up to the Pacific Ocean 215 miles from its beginning. The Rogue Basin is comprised of 5 sub basins that drain to the Pacific Ocean (Figure 3): the Lower Rogue River, Middle Rogue River, Upper Rogue River, Illinois, and Applegate.

These sub basins range from near the Pacific Ocean to more than 9,000 feet in elevation in the Cascade Mountains, with a total land base of 3,300,000 acres. Climatic conditions range from temperate, relatively moist near the Pacific Ocean to interior valleys with characteristically hot and dry summers to mountains where the majority of the annual precipitation comes in the form of snow during the winter months.

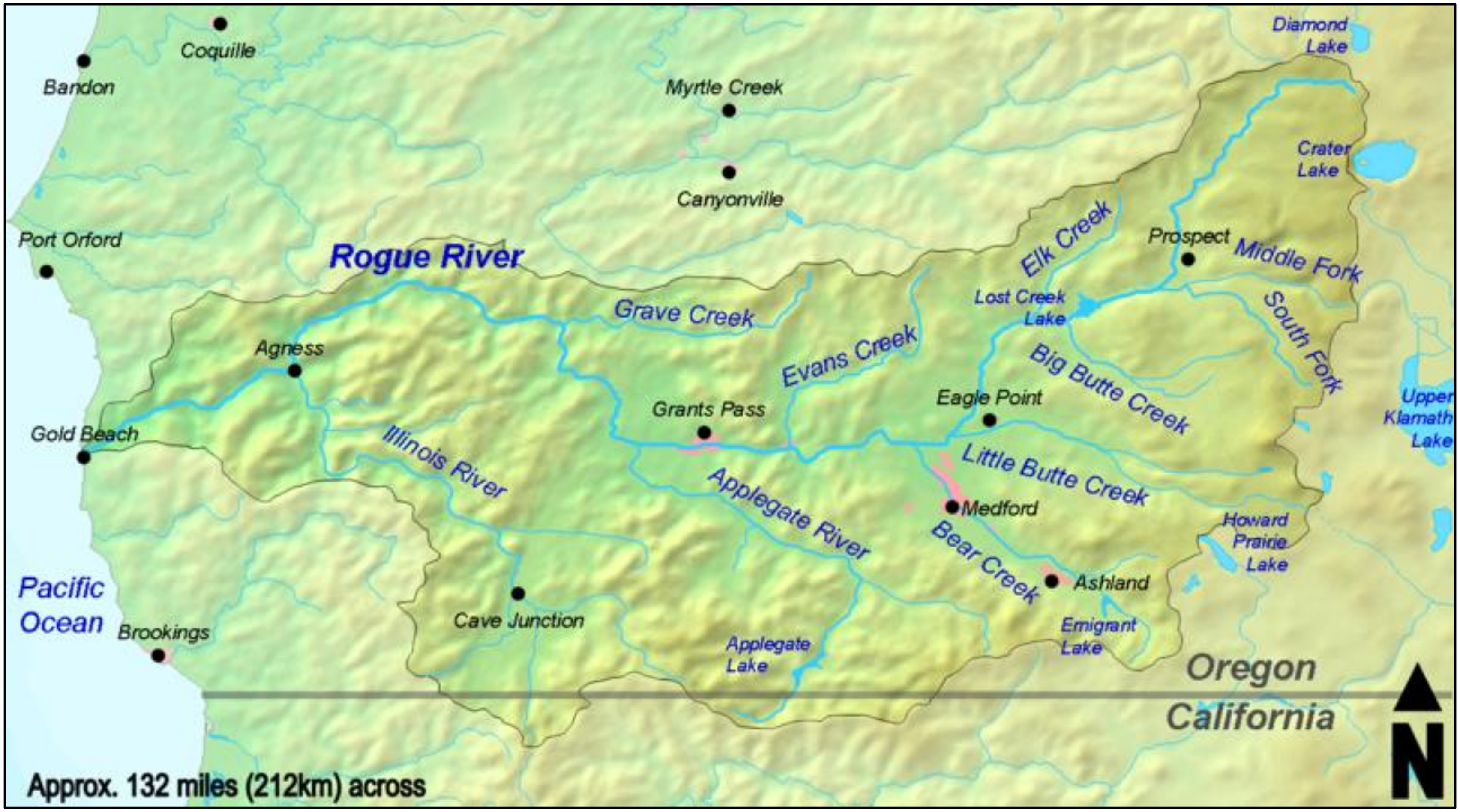


Figure 3. Map of the Rogue Basin. *Source: Map taken from the Demis Map Server [http://www2.demis.nl/mapserver/mapper.asp] and modified by Little Mountain 5, Wikipedia commons, 2013.*

The Climate Action Planning Team

Several members of the Rogue Basin community were involved in this planning process. Those engaged include municipalities and city officials, elected officials, non-profit organizations, timber industry (including TIMOs and REITs), federal and state agencies, community members, and academia. Expertise included: Forest ecologists, forest silviculturists, climate change coordinators, planners (agency, city, and county), wildlife biologists, fire ecologists, social scientists, foresters, water suppliers, fisheries biologists, hydrologists, botanists, economists, public health officials, teachers, and others.

The core team for this endeavor includes:

- Gwyn Myer (project coordinator) and George McKinley (director), Southern Oregon Forest Restoration Collaborative;
- Ken Wearstler (Forest silviculturist and climate change coordinator), Rogue River Siskiyou Forest Service;
- Kerry Metlen (Forest ecologist), The Nature Conservancy; and
- Jim Wolf (county fire plan coordinator).

Others who contributed largely to the planning process include:

- Eugene Weir (Rogue Basin Project Manager), The Freshwater Trust;
- Alan Journet, (retired ecologist and co-facilitator), Southern Oregon Climate Action Now;
- Laura Hodnett, Medford Water Commission;
- Chris Volpe (fisheries biologist), Medford Bureau of Land Management;
- Bill Meyers, Oregon Department of Environmental Quality;
- Amy Patton (hydrologist); and
- Brian Barr (fisheries biologist).

SOFRC and the Planning Team Process

The Southern Oregon Forest Restoration Collaborative (SOFRC) is a non-profit organization that works to build public support and agency capacity to effectively manage federal forests of Southwest Oregon's Rogue Basin. The Collaborative is made up of a diverse group of experts and stakeholders including representation from environmental organizations, academia, watershed councils, fire experts, land management agencies, and elected officials. The mission is to improve forest health and resilience, reduce the risk of uncharacteristic fire to forests and communities, and strengthen regional forest manufacturing and workforce infrastructure. In order to achieve these objectives, SOFRC believes an all lands approach is needed. In other words, land management is needed at a landscape scale that incorporates federal and private lands, upland forested lands and lowland riparian areas, so as to manage holistically across the landscape. Ultimately restoration projects need to start occurring at this scale (i.e., 10-20,000 acres) in order to be economically viable and increase resilience and resistance to climate change risks and vulnerabilities.

Climate adaptation planning at the regional scale tied to existing federal land management boundaries is key to advancing cooperative and coordinated efforts that engage multiple community and agency partners. Such partnerships build capacity to accomplish the goals of ecosystem and economic resilience at a landscape scale. For these reasons, SOFRC took on the leadership role of developing a Climate Plan for the Rogue Basin. SOFRC received a grant through the Model Forest Policy Program (MFPP) for the formation of a community climate adaptation plan. Through the MFPP grant, and generous support from the Rogue River-Siskiyou Forest Service (RRS FS), SOFRC participated in Climate Solutions University (CSU), an 11-month virtual curriculum that takes communities through a four step adaptation planning process: 1) forming a local team and engaging stakeholders (this is an iterative process), 2) preparing forest, water, climate and economic assessments, 3) developing a local action plan with specific recommendations and on-the-ground strategies, and 4) building public support to prepare for implementation.

Other projects SOFRC has been involved in include: coordinating multi-party monitoring efforts on federal projects; the development of an integrated restoration approach to forest management which is and will continue to be used to provide recommendations to federal agencies for an alternative land management that emphasizes ecological, social, and economic resilience and incorporates local values; building upon partnerships and collaborative efforts to both inform management and to engage the public; and partnering and supporting opportunities for outreach and education.

Rogue Basin forests managed by the RRS FS and Medford District Bureau of Land Management (BLM) are some of the most globally diverse, and in many cases, have been subject to land-use decisions, past management and fire suppression efforts that have resulted in uncharacteristically dense stands increasingly vulnerable to insects, disease and uncharacteristically severe wildfire. Conflicting policy directives and public differences in attitude further complicate management planning. SOFRC believes shared understanding promoted through collaborative forest landscape assessment efforts and related implementation projects will achieve forest restoration success.

As climate change will affect our resources, regardless of measures taken, the main goal of this project is to build capacity to engage and adapt to the changing environment, and create a shared vision across federal, local, and private organizations to manage our lands to increase resiliency. This creates an opportunity to work together to overcome weaknesses and to expand upon the strengths of the communities, jurisdictions, and organizations of the Rogue Basin.

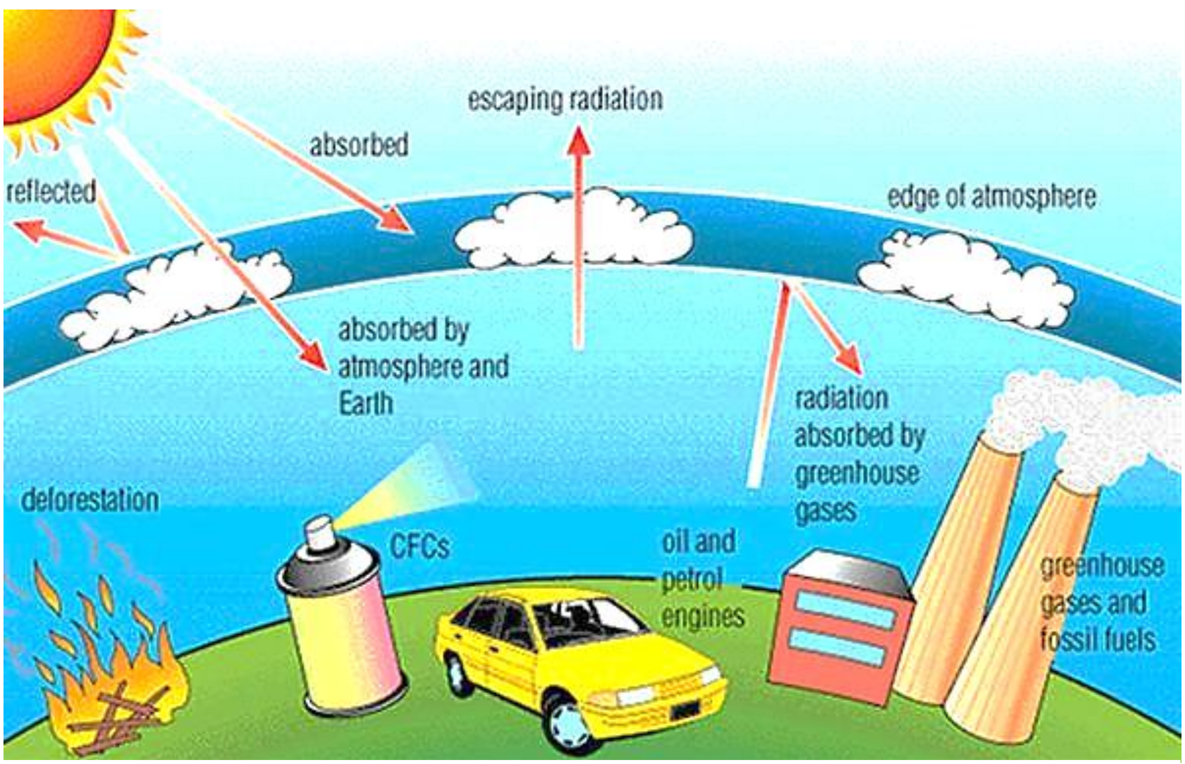


Figure 4. The Greenhouse Effect. *Source: http:// marchantscience.wikispaces.com/enviar, 2013.*

Climate Overview

Greenhouse gases (GHGs) have naturally occurred in the Earth's atmosphere for millions of years. Without GHGs, the Earth would be too cold for humans and other species to survive. The Earth absorbs energy from the sun, and as the Earth cools it gives off heat in the form of infrared radiation (Figure 4). A basic physical principle is that hot objects (the sun) emit short wavelength radiation while cooler objects (the planets) emit longer wavelength radiation. Driving the process of warming is incoming solar radiation in short wavelengths (Gamma rays, UV plus visible light and infra-red). Upon absorption at the earth's surface this incoming energy is transformed into longer wavelength heat radiation that re-radiates back outward. GHGs act as a 'greenhouse,' trapping this outwardly radiating heat in the atmosphere before it reaches outer space, thus keeping the Earth warm enough for us to live. However, humans have been emitting GHGs from the burning of fossil fuels at an accelerated rate (IPCC 2013). As a result of human activities such as land clearing and, especially since the industrial revolution of the 1750s, increased burning of fossil fuels, the concentration of greenhouse gases (notably carbon dioxide) in the atmosphere has increased. In addition, the pace of fossil fuel burning has accelerated particularly since the 1970s. The result is that more of the heat energy radiating out from the Earth's surface is being trapped rather than escaping back out into space. One of the consequences of this energy being trapped is warming of our atmosphere (Figure 5). While local temperature trends can vary, the global average air and ocean temperatures have increased by 0.6 degrees Centigrade compared to historic measures and further increases are projected.

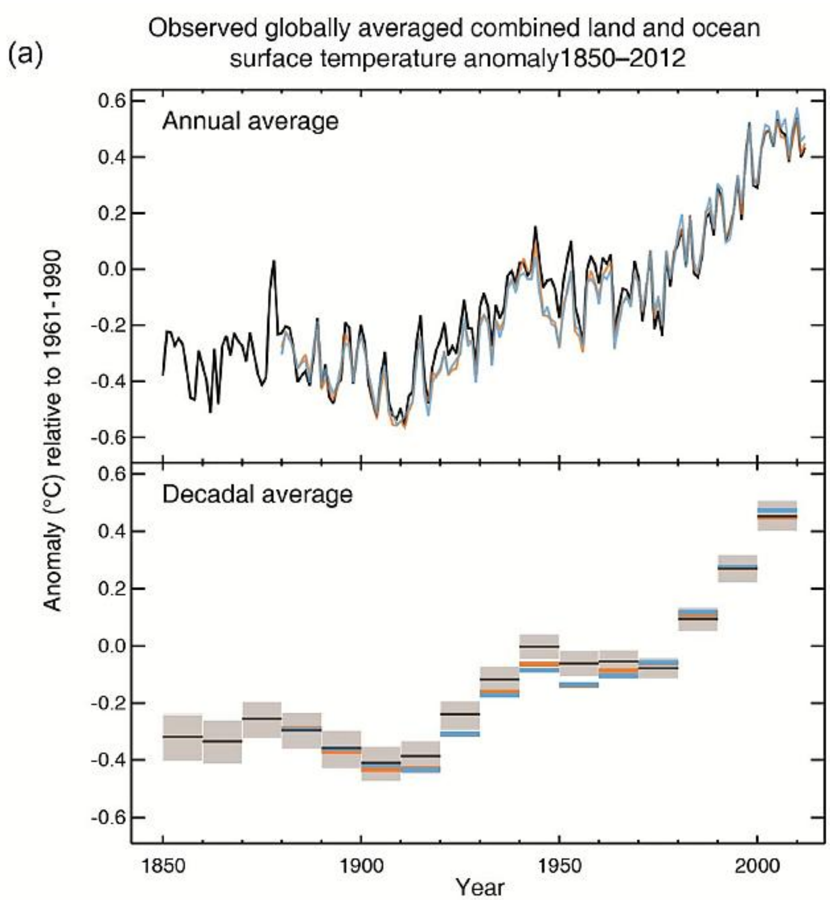


Figure 5. Measured global average temperature curve from several data sets, 1850-2012. *Source: IPCC, 2013.*

The fact that climate is changing is not of concern by itself. Climate always has been, and will continue to be, in a dynamic state of change with recognized patterns that occur over varying time scales from a few years to tens of thousands of years. The concern is the rate of change, and apparent direct link to the global dependence on burning fossil fuels for energy (e.g. transportation, cool/heat buildings, product manufacturing, and production of electricity). There are natural short-term variations in global temperatures as one can see from the above figure, but the long term trend is a notable upward curve. Significant impacts to life on earth could occur as a result of the amount of carbon currently in the atmosphere combined with the additional amounts forecasted to be added from emissions with the increasing rate of burning fossil fuels to meet global energy needs into the foreseeable future.

There are two methods to address the impacts of climate change: adaptation and mitigation. Mitigation is about reducing the concentration of carbon dioxide in the atmosphere by decreasing our combustion of fossil fuel derived energy or removing more carbon from the air. This can be accomplished in several ways: 1) reducing the total amount of energy used in transportation and facilities, 2) selectively purchasing products and services that demonstrate energy efficiencies, 3) reuse and recycling of potential waste products, 4) converting to renewable/sustainable sources of energy, and 5) capturing or sequestering carbon dioxide from the atmosphere, such as reforestation measures. Mitigation is the essence of sustainable operations. Individuals, industries, and organizations can contribute to mitigating climate change by their choices in the use of energy and forest land use practices.

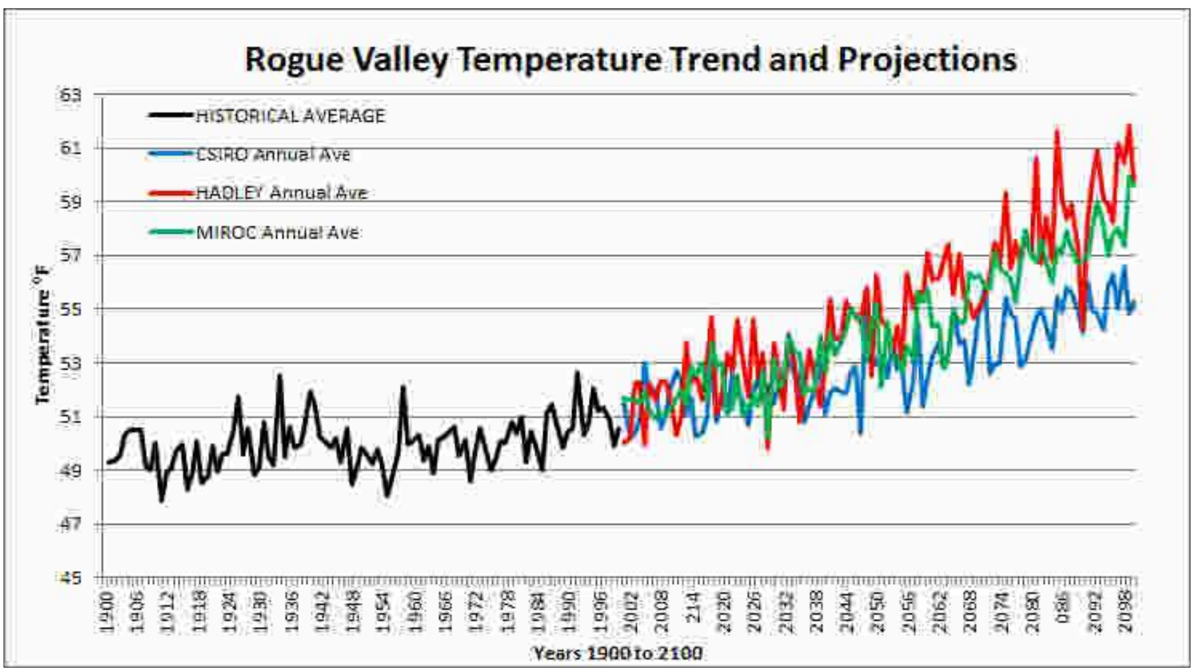


Figure 6. Future temperature projections for the Rogue Basin with highest emissions scenario ('business as usual' approach) (red) and in a scenario with a strong emissions reduction (taking immediate mitigation actions) (blue). *Source: Journet, 2013 using data from Doppelt, 2008.*

In the context of climate change, adaptation means being able to tolerate and survive new conditions. Organisms or communities of organisms facing the effects climate change have few options: 1) persist in spite of change (adaptable), 2) move to a more favorable environment (not adaptable, use avoidance to survive), and 3) become extinct (not adaptable, cannot migrate to a favorable environment, cannot survive). Depending on the species, all are potential and likely outcomes of climate change.

With a business as usual approach, meaning little to no mitigation for climate change, the best science estimates global warming by 2100 to be 4 °C. With aggressive mitigation efforts entailing strong emissions reductions, the warming is projected to be just under 2 °C (IPCC, 2013). The 2010 Oregon Climate Assessment Report indicated that, depending on the extent of human emissions reduction efforts, the Pacific Northwest temperature by 2100 would likely climb to between 2 and 9.5 ^{0}F above historical levels. For the Rogue Basin, projections were developed by the Mapped Atmospheric Plant Soil System team at the USFS Pacific Northwest Research Station employing three General Circulation Models and the 'business as usual' scenario. Data from this analysis suggest that by 2075-2085 annual temperatures in the Rogue Basin will likely increase some 2.3 to 4.5^{0}C (4.2 to 8.3 ^{0}F) above the historical (1961-1990) average. Summers, meanwhile will likely increase 3.1 to nearly 6.7^{0}C (5.6 to nearly 12 ^{0}F) while August alone could reach nearly 9.5^{0}C (17 ^{0}F) above that historical average (Figure 6).

The low end of the range of this warming is unavoidable. The global temperature will remain elevated for centuries after mitigation efforts occur, if they happen at all. This is why the precautionary principle should be applied in the case of climate change. In other words, we should act now rather than wait to see the repercussions before taking action, as the ability to adapt at that point will be much more difficult. Some of the major current impacts and future expectations/predictions of global climate change include, but are not limited to:

- Reducing snowpack accumulation possibly to 20% of historical patterns by late century,
- Shifting precipitation patterns with heavier downpours,
- Shifting precipitation from snow at high elevations to rain,
- Earlier snowmelt, and melting glaciers,
- Earlier peak in stream flow,
- Reducing stream flow in late summer and fall,
- Increasing flooding especially in winter and spring,
- Degrading water quality/quantity (warmer rivers and oceans, water borne illness,)
- Increasing frequency and severity of heat waves and droughts,
- Increasing frequency, severity, extent, and duration of wildfires,
- Increasing extreme weather events (storms, blizzards, etc.),
- Increasing spread of human and crop pathogens, parasites and diseases,
- Changes in forest productivity patterns due to the above,
- Changes in seasonal climate patterns disrupting natural ecosystem function,
- Critical threshold events that will impact wildlife (floral and faunal) species and potentially increase extinction rates.

The potential challenges and impacts of climate change to life on earth have been recognized on a global scale for a number of years. In 1988, the International Panel on Climate Change (IPCC) was established by the United Nations and World Meteorological Organization as an international scientific body tasked with assessing climate change's potential environmental and socio-economic impacts. Within the United States at the national level, there have been Executive Orders (EO 13423 and E0 13514), and Departmental and Agency strategic planning documents identifying the need to respond to climate change. These Executive orders and strategic planning documents emphasize accountability and leadership in responding to climate change. The focus is on mitigation of the source of climate change (reducing carbon dioxide emissions) and adaptation to an expectation of a rapidly changing climate.

Adaptation actions for forest habitat and ecosystems can involve:

1) Buffering the effects of climate change (e.g. maintain/enhance/restore a diversity of habitats and the diversity of species present through a variety of actions, and restore the role of fire in sustaining ecosystems),
2) Facilitating the relocation of organisms to a more favorable environment (e.g. planting, seeding, maintaining corridors for movement, minimizing fragmentation of critical plant associations/vegetation types), and
3) Preserving organisms potentially at risk of becoming extinct with climate change (e.g. collect and store seed, move and establish animals/plants in multiple alternate locations).

Assessment, measurement, and monitoring can help identify and prioritize resources at greatest risk/vulnerability to the changing climate as well as the effectiveness of adaptation actions. The Rogue Basin is already experiencing the following impacts to the forest, hydrologic cycle, and economy:

- Increase in frequency and severity of forest fires
- Reduction in mountain snowpack, affecting water quality and quantity
- Shift in weather patterns and more extreme rainfall and drought events
- Earlier spring snowmelt, also affecting the water supply and native species
- Increasing stream temperatures, affecting water quality and native species such as Salmon
- Threshold effects and extinction risks
- Fewer days with frost, affecting agriculture
- Damage to property and infrastructure (floods, droughts, wildfires, storms),
- Lost productivity (lost work, school days, energy production, tourism, etc.),
- Traffic and travel impacts, and
- Costs to recover from events, especially if unprepared

These impacts are already occurring and are projected to increase in frequency and severity as the global temperature continues to rise. If we desire to be a community of leadership and sustainability, one that protects its values, its residents, its natural resources and economy, then we must act now to increase our resiliency to natural hazards and be prepared for climate change. The longer we wait the more costly and the more difficult it will be to adapt to the changing climate.

Economic Key Points

There is an estimated cost from climate change impacts of $3.3 billion per year to Oregon by 2020 if a business-as-usual approach continues, and that cost is estimated to increase to $9.8 billion per year ($3,500 per household) by 2080.

The Rogue Basin has the most at risk communities along the Wild land Urban Interface in the West. Increases in large wildfires, which are already occurring and projected to continue to increase in severity and size, will prove costly in terms of protecting homes along the WUI, health impacts, impacts to tourism and recreation, impacts to real estate, and threats to the water supply. Wildfire costs are 2-30 times higher than suppression costs.

Rural communities in the Rogue Basin have been shifting from resource extraction to incorporating more tourism and attracting businesses interested in the region's quality of life. Agriculture, timber, travel and tourism have a significantly higher percentage of total jobs in the Rogue Basin than in the U.S., with tourism and recreation making up almost 18% of the local economy. These industries are threatened by the changing climate.

Economics and the Environment

Figure 7. Rafting, kayaking, fishing and hiking are popular tourist and recreation activities in the Rogue Basin. *Photo Credit: Northwest Rafting Company*.

Ecosystem Services and the Economy

Ecosystem Services are services provided to human communities by natural systems that otherwise would require large financial and/or infrastructure investments. Ecosystem services require natural capital, such as forest ecosystems, with processes that support human activities and sustain life. For example, forests and soils are natural capital assets that provide the ecosystem services of filtering water without need of a costly filtration plant (Earth Economics, 2011). There are four categories of ecosystem services:

1) Provisioning services (food, water, oxygen, fuel, clothing, medicine, etc.)
2) Regulating services (climate stability, flood and storm protection, water quality, soil erosion control, disease and pest control; things that contribute to ecosystem functions and economic resilience)
3) Supporting services (habitat, nutrient cycling, soil formation, pollination
4) Cultural Services (spiritual, recreational, scientific, aesthetic, educational values)

The majority of the land in the Rogue Basin is forested; this natural capital, including the ecosystem goods and services it provides, contributes essential input into the economic viability of the region. This natural capital provides benefits such as provision of water (domestic, irrigation, etc.), water filtration, energy production, flood control, recreation, storm water management, biodiversity, and education. Healthy ecosystems are self-maintaining. They have the potential to appreciate in value over time and provide ongoing and sustainable outputs of valuable goods and services. In contrast, built capital depreciates in value over time and requires capital investment and maintenance (Earth Economics, 2009).

An example of the benefits derived from healthy ecosystems is the riparian restoration project of the City of Medford and The Freshwater Trust. The City of Medford conducted a cost-benefit analysis of various ways to cool the temperature in the Rogue River as the water released into the Rogue River from their wastewater treatment plant was too warm. After investigating the costs of chillers ($16 million), cooling ponds, and other gray (engineered) cooling methods, they decided to do a 20-30 mile stream restoration project. The cost of the restoration work is half that of the gray cooling methods ($8 million), and there are co-benefits such as increased habitat for species dependent on healthy riparian zones, including salmon, filtration, and sediment and flood control (The Freshwater Trust, 2011). Thus, the City of Medford saved money, gained a project that requires little to no maintenance, and reaped other benefits as well. The project has successfully brought on board private landowners, including Red Lily Vineyards, located in the Applegate. Red Lily will have invasive blackberries replaced by tall, native trees at no expense; as a matter of fact the City of Medford will pay them about $1,000 a year over 20 years for hosting it, and 8 more private property owners are likely to get on board and will be paid between $100-300 per acre (Freeman, 2013). The sites will be managed by The Freshwater Trust and independently

Figure 8. The Freshwater Trust restoration work in the Rogue Basin.
Source: Skyris Imaging and The Freshwater Trust, 2013.

audited through 2032 to ensure they are indeed offsetting the temperature as expected (Freeman, 2013). Another example is the City of Portland. Instead of purchasing a $200 million filtration treatment system for its water supply, Portland protects 102 square miles of its watershed for water filtration services, which equates to an avoided cost benefit of $3,000 per acre (EcoNorthwest, 2009). Other ecological and social benefits are also reaped from this watershed protection.

Valuing natural capital helps decision makers identify costs and benefits, evaluate alternatives, and make effective and efficient management decisions. Excluding natural capital in asset management can result in significant losses, increased long-term costs, and overall inefficiency (Earth Economics, 2009). By evaluating some of the ecosystem services the Rogue Basin provides, resource managers, planners, political decision makers, and taxpayers can gain greater appreciation and understanding of the real value of healthy ecosystems. For example, a healthy forest provides clean water, flood protection, aesthetic and recreational values, slope stability, biodiversity and other services with minimal maintenance relative to built capital alternatives. Protecting and enhancing ecosystem services increases resiliency. Resistance and resilience are the ability of a system to withstand and recover from disturbances such as pollution or natural disasters. Ecosystems (e.g. forests or wetlands) are self-maintaining and remarkably resilient compared with built capital (Earth Economics, 2009).

Additionally, tourism is a large and growing industry in the Rogue Basin; many local businesses take advantage of the ecosystem services of the basin providing recreational and aesthetic values. These values are threatened by climate change projections. If measures are not taken to restore environmental integrity and resilience, and to adapt to the changing climate, local industries and job markets will be negatively affected.

Figure 9. The people of the Rogue Basin value its natural resources and beauty.
Photo Credit: Gwyn Myer.

The Economy of the Rogue Basin

The Rogue Basin has a growing population, with a change of about 10.4% from 2000-2011, a rate slightly higher than the U.S., and more or less on par with the state. This is being driven primarily by Jackson County, with relatively low population growth in Curry County and average growth in Josephine County. The economy of the region has grown steadily every decade beginning in the 1970s, with a recent slowdown related to the Great Recession (Table 1).

Total Population, Employment, & Real Personal Income Trends, 1970-2011						
	1970	1980	1990	2000	2011	Change 2000-2011
Population	144,778	208,951	229,826	278,759	310,235	31,476
Employment (full and part time jobs)	53,832	87,917	111,274	147,599	156,267	8,668
Personal Income (thousands of 2012 $s)	2,866,035	4,984,538	6,353,138	9,108,148	10,517,265	1,409,117

Table 1. Population, employment, and real personal income trends of the Rogue Basin. *Source: U.S. Department of Commerce. 2012. Bureau of Economic Analysis, Regional Economic Information System.*

100% of the population growth in the last decade has been from in-migration (US Department of Commerce, 2012), which may increase with climate refugees as other regions of the nation are expected to suffer more extensively from climate change than the Pacific Northwest. This could place stress on government services, schools, infrastructure, increase homes in the WUI, and other stressors.

A significant portion of the growth in the economy is related to retirement and investment dollars. Non-labor income represents 50% of total personal income in the region, which is much higher than the national average of 34% non-labor income. In the last decade, non-labor income grew by 27% in the Rogue Basin, compared to less than 6% growth in labor income (US Department of Commerce, 2012). The region has more income from dividends, interest, and rent (DIR) (generally associated with wealthier people), age-related payments (retirees), and income maintenance (poverty) than the US as a whole. This indicates that labor income is relatively low, suggesting that personal income is less tied to the strength of the local economy than elsewhere in the US.

The economic base in Jackson County is varied and growing. The two largest and fastest-growing sectors of the economy, in terms of personal income earned by people employed in these sectors, are health and government services. Health care constitutes the largest single employment group in the private sector, and retail is the second largest, followed by agriculture, manufacturing, and timber. In Josephine County, health care and social assistance, manufacturing, and retail are the largest of twenty major economic sectors. Visitor accommodation and food services, manufacturing, retail, and health care and social assistance are the largest of twenty major sectors in Curry County. Table 2 shows the percent of total employment by industry in the Rogue Basin (Doppelt et al., 2008).

Wages (average earnings per job, in real terms) have remained steady since the early 1980s, at around $35,000, and have risen recently to a little less than $38,000. In contrast, per capita income has risen steadily since the early 1980s, rising from $22,400 in 1982 to $34,000 in 2011. Much of the rise of per capita income can be explained by the rapid rise of non-labor income, which includes retirement and investment earnings, and by the rise of in-migrants (US Department of Commerce, 2012).

Percent of Total Employment by Industry in the Rogue Basin	
Education, health care, & social assistance	21.9%
Retail trade (includes mail orders)	15.4%
Arts, entertain., rec., accommodation, & food	10.2%
Manufacturing	8.7%
Prof., scientific, mgmt., admin., & waste mgmt.	8.5%
Construction	7.0%
Other services, except public administration	6.0%
Finance and insurance, and real estate	5.2%
Transportation, warehousing, and utilities	4.6%
Public administration	4.5%
Agriculture, forestry, fishing & hunting, mining	3.4%
Information	2.4%
Wholesale trade	2.3%

Table 2. Employment by Industry. *Source: US Department of Commerce, 2012.*

The unemployment rate in the region was 6.1% in 2007, rose to 13% in 2010, the midst of the recession, and is beginning to drop again, to 11% by 2011; however it is still much higher than the US and Oregon unemployment rates, which are around 8% (US Bureau of Labor Statistics, 2013). In addition, there are a greater number of individuals and families living below poverty than the national average (Figure 10).

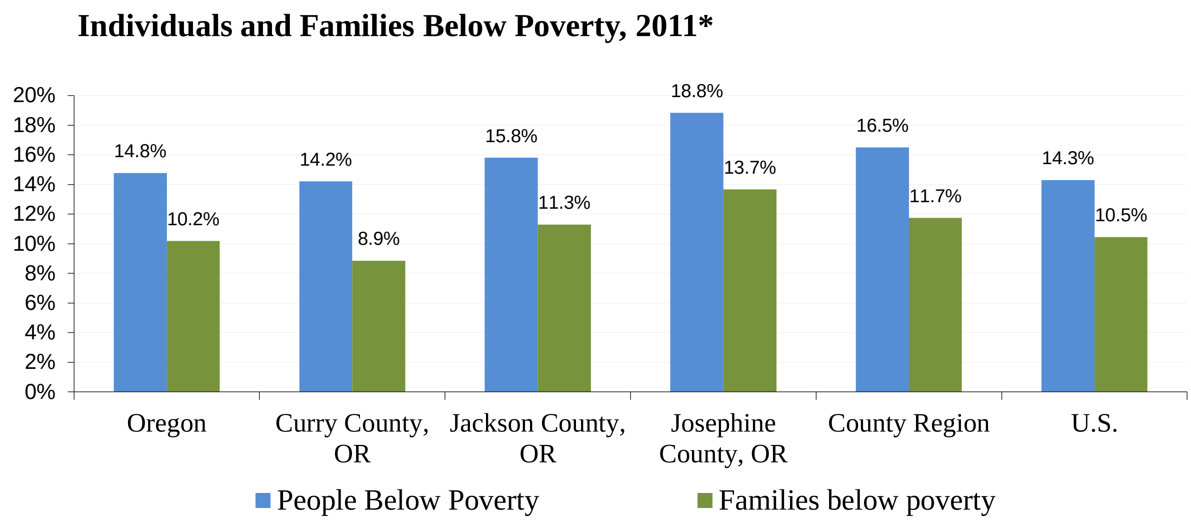


Figure 10. Individuals and Families Below Poverty. *Data Sources: U.S. Department of Commerce. 2012. Census Bureau, American Community Survey, U.S. Department of Commerce. 2000. Census Bureau, Systems Support Division, 2012.*

Another indicator of economic stress is the number of families who receive assistance payments. 14.9% of families in Curry County, 17% in Jackson County, and 18.8% in Josephine County receive food stamp/SNAP payments. By comparison, 14.6% of families in Oregon and 10% in the U.S. receive this form of assistance (US Department of Commerce, 2012).

Educational attainment in the region has an average of 11.4% with no high school degree (on par with the state average, and fewer than the national average of 15%), and 21.5% with a bachelor's degree or higher, a lower attainment compared to 28.6% of the state and 28.2% of the nation having bachelor's degrees or higher (ACS surveys 2007-2011).

The Rogue Basin overall has an older population than the country's average, being predominately middle-aged (median age of ~ 46) whereas the national median age is 37 years old (Figure 11). The age group of 45-64 has also shown the largest growth in the region since 2000, with the 35-44 and under 18 age brackets declining. This suggests that a group called "pre-retirees" are moving to the area. These in-migrants are likely attracted to the area for the quality of life and relatively low cost of living. They are likely responsible for much of the increase in dividends, interest, and rental income so their in-migration is very important to the region's economy.

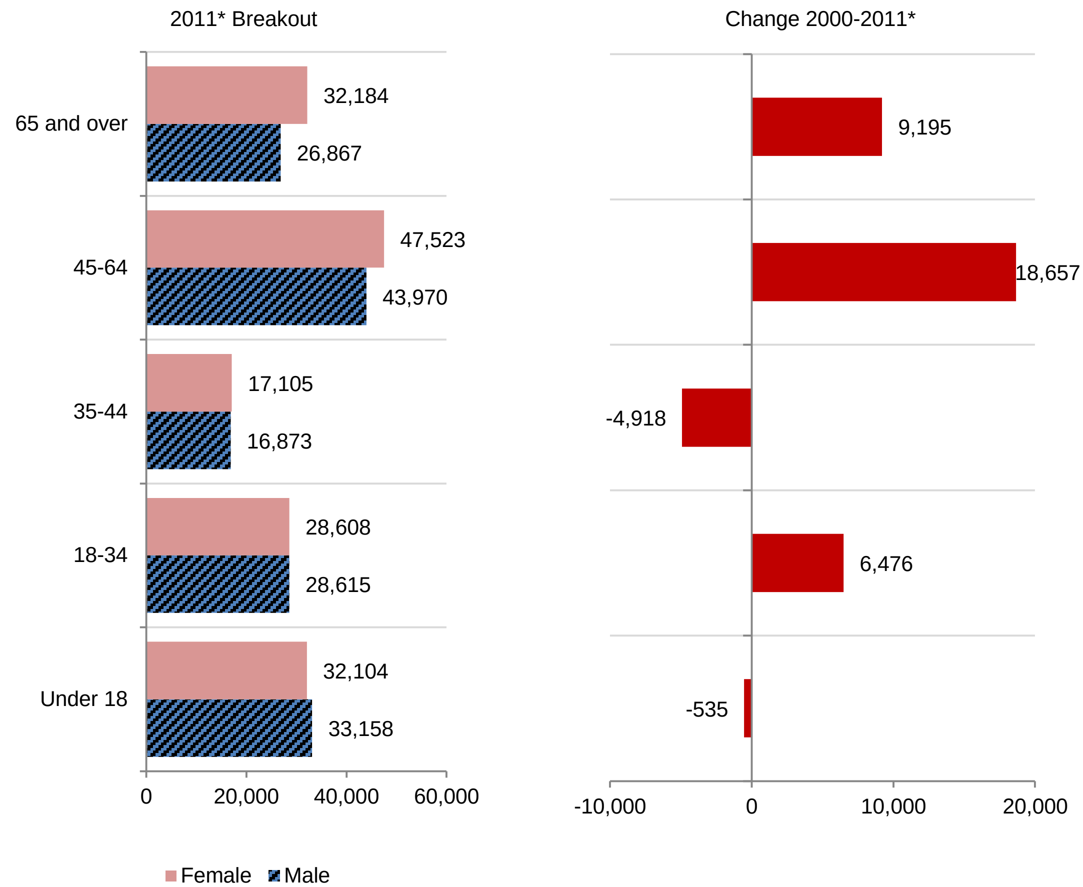


Figure 11. Age Distribution. *Data Sources: U.S. Department of Commerce. 2012. Census Bureau, American Community Survey Office; U.S. Department of Commerce. 2000. Census Bureau, Systems Support Division.*

Note that the largest age bracket is the baby boomers. As they retire, if they stay in the region, retirement and investment dollars (non-labor income), which make up half of the current economy, will increase. Additionally the sector with the largest employment and fastest growth is health care, which will also grow as baby boomers retire.

Agriculture and timber industries have a significantly higher percent of total jobs in the Rogue Basin (as well as travel and tourism) than in the U.S., whereas it is on par with the U.S. in the other use sectors (Figure 12). This demonstrates the region's dependence on natural resources for its economy.

Rural communities in the Rogue Basin have been shifting from the past century's dependence on natural resource extraction to incorporating more tourism and attracting businesses interested in the region's quality of life (Table 3). The public forests are increasing in value for recreation, water production, and fish and wildlife habitat. There has been a loss of jobs in the logging industry due to overharvesting, the growing emphasis on management for biodiversity and threatened and endangered species (e.g. the Northern Spotted Owl) and healthy ecosystems, and global competition in timber markets. This has necessitated shifting of management priorities for natural resources away from timber extraction. Meanwhile, jobs in travel and tourism have been increasing.

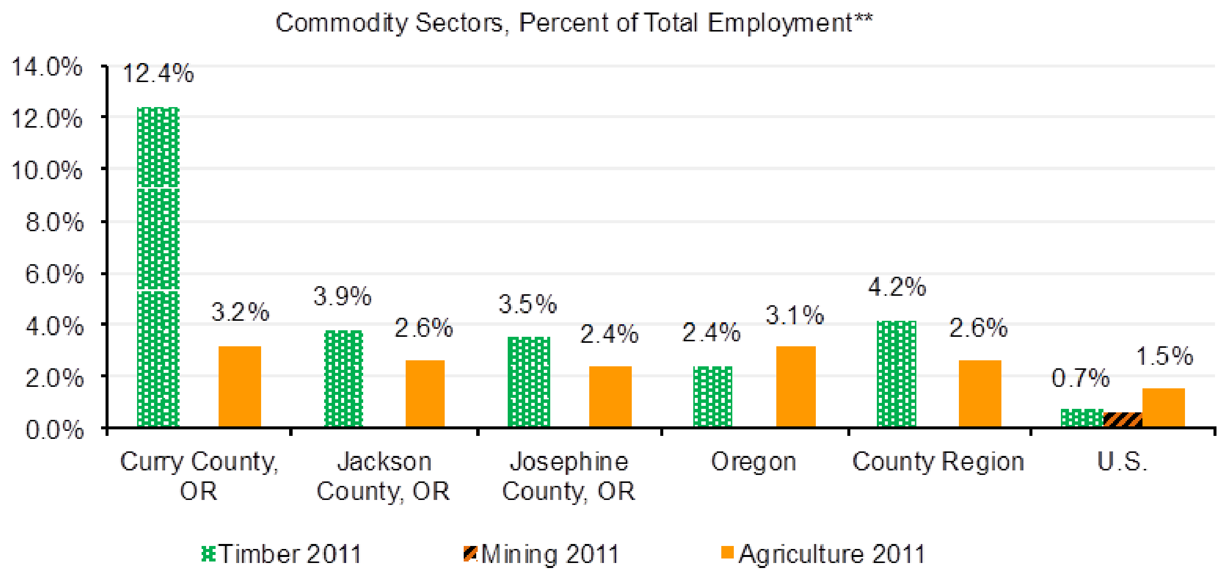


Figure 12. Commodity Sectors. *Source: US Department of Commerce, 2012.*

% Total Private Employment

Use Sectors	Rogue Basin	U.S.
Travel and Tourism	17.8	15.1
Accommodations and Food	10.6	10.1
Timber	4.3	0.7
Retail	2.8	2.8
Agriculture	2.6	1.5
Arts, Entertainment, and Recreation	1.8	1.8
Passenger Transportation	0.4	0.4
Mining	0.1	0.5

Table 3. Employment based on land use sectors. *Sources: U.S. Department of Commerce. 2012. Bureau of Economic Analysis, Regional Economic Information System, Table CA25N; U.S. Department of Commerce. 2012. Census Bureau, County Business Patterns.*

Risks to the Economy

The economy of the Rogue Basin (manufacturing, agriculture, forestry, tourism) is highly dependent on healthy forests and watersheds as aforementioned. While adaptation (preparedness for the climate changes that are inevitable) can allow local natural resources to survive those changes, local contributions to the mitigation efforts are a necessary part of a national and global effort to address the problem of climate change such that worst case catastrophic scenarios do not transpire. If we do not undertake this effort, natural resources and ecosystem services will be compromised not just of the Rogue Basin but for the nation and planet as a whole. If Oregon continues on a 'business as usual' approach, and does not take measures to mitigate and adapt to climate change, the impacts to the natural resources of the region will in turn impact the local economy. EcoNorthwest (2009) conducted an economic study on the projected impacts of climate change to Oregon's economy. For a summary of the costs to the economy, see Table 4, which predicts an estimated cost of $3.3 billion ($1,930 per household) per year to Oregon by 2020 if a business-as-usual approach continues, and that cost is estimated to increase to $9.8 billion per year ($3,500 per household) by 2080. Among regions throughout the western states, the Rogue Basin is one of the most severely at risk regions for disruption and damage to infrastructure and energy from flooding and wildfires (Oregon Environmental Council, 2013).

Rising average summer temperatures are strongly associated with an increase in the number of wildfires (Gude et al., 2012). The fire season has extended in the west two and a half months since 1970. Projections suggest that in Southern Oregon fire area burned may increase 300-400% during the century (i.e., burn 4-5 times as many acres). A ranking of all 417 counties in the 11 western states in 2008 showed that Josephine and Jackson Counties were ranked #1 and #2, respectively, in risk to existing development in fire-prone areas adjacent to public lands, also known as the Wildland Urban Interface, or WUI (Gude et al., 2012). The costs of managing large wildfires in southwest Oregon are climbing dramatically, and their true costs extend far beyond what it takes to extinguish the flames.

- The 1987 Silver Complex in 1987 burned 99,310 acres and cost $19 million to suppress;
- The 2002 Biscuit Fire burned 499,945 acres at a cost of $150 million;
- The 27,111 acre Timbered Rock Fire, also in 2002, burned on BLM and private forestlands and cost $14 million dollars of Oregon Forest Land Protection Funds to suppress.

All of these fires were lightning-caused and started on federal lands. Overgrown forest fuels, limited access, and low priority ranking for limited suppression forces were all factors in these fires becoming large.

There are more than 27,000 homes in the WUI in the Rogue Basin; these are threatened by large wildfires (Western Leadership Forestry Coalition, 2010). Watersheds, air quality, timber and recreational resources on public and private forestlands, tourism, and habitat important for the recovery of several threatened and endangered species, and real estate are all at risk from increasing fire severity. During the Biscuit Fire, for example, real estate sales plummeted in the Illinois River valley for several weeks. Fifty-seven percent of the southwest Oregon landscape is now prone to crown fires during hot, dry summers (such as the summer of 2013) and climate change elevates the urgency to promote more fire-resilient forests (Gude et al., 2012).

Potential Cost	2020	2040	2080
Costs of Climate Change			
Increased Energy-Related Costs	$119 million	$328 million	$815 million
Reduced Salmon Populations	$632 million	$1.0 billion	$1.9 billion
Increased Flood and Storm Damage	$64 million	$132 million	$309 million
Reduced Food Production	$13 million	$35 million	$153 million
Increased Wildland Fire Costs	$206 million	$423 million	$941 million
Increased Health-Related Costs	$764 million	$1.3 billion	$2.6 billion
Lost Recreation Opportunities	$167 million	$390 million	$1.1 billion
Subtotal for Costs of Climate Change	*$2.0 billion*	*$3.6 billion*	*$7.8 billion*
Additional Costs from Business-as-Usual (BAU) Activities that Contribute to Climate Change			
Inefficient Consumption of Energy	$1.3 billion	$1.5 billion	$2.0 billion
Increased Health Costs from Coal-Fired Emissions	$33 million	$38 million	$52 million
Subtotal for Costs from BAU Activities	*$1.3 billion*	*$1.5 billion*	*$2.0 billion*
TOTAL	**$3.3 billion**	**$5.1 billion**	**$9.8 billion**
Average Cost per Household per Year	$1,930	$2,400	$3,500

Source: ECONorthwest.

Notes: These numbers illustrate different types of annual costs Oregonians potentially would incur if society were to continue with a business-as-usual approach to climate change. There may be overlap between the values for some of the different types of costs. Nonetheless, adding the different types of costs probably seriously understates the total potential cost of climate change because the table excludes many additional types of climate-related costs that Oregonians would incur under a business-as-usual approach. The numbers do not indicate the net effect of climate change, as they do not represent a forecast of how the economy will respond to the different effects of climate change, or account for potential economic benefits that might materialize from moderate warming and other changes in climate.

Table 4. Potential economic costs in Oregon under a business-as-usual approach to climate change (dollars per year). *Source: EcoNorthwest, 2009***.**

Agriculture

Agriculture has always played an important role in the economy of the Rogue Basin. Climate change projections demonstrate a need for the agricultural sector to be adaptable and prepared in order to be resilient. Carbon dioxide is an important component of photosynthesis in all plants, and increased carbon dioxide has been demonstrated to enhance growth under controlled conditions when other nutrients are not limiting. However, in the real world, carbon dioxide is rarely a limiting factor. In fact, limitations on plant growth are generally imposed by shortages of water, nitrogen, phosphorous, and potassium (hence N-P-K fertilizers). In reality, studies suggest that while plant growth might, in some cases, increase with increased temperature – up to an optimum beyond which depression and death ensue – the critical component of crop yield (soybeans and corn, for example) is actually depressed by increasing temperature. Additionally, weeds and invasive species tend to thrive better with enhanced carbon dioxide than do crops species (Journet, personal communication, 2013).

Shifts in temperature and increased severity of natural events may threaten some local crops (the majority of agricultural profit comes from high value fruits, including wine grapes). While the grape varietals currently grown in the region may allow vintners to continue producing wine through much of the century, if the higher range of growing season temperatures arrive, grape varieties may be limited to table grapes and raisins. Additionally, fruit crops need to undergo a winter chill period. Although current winter chill hours are more than adequate to provide conditions for successful pear development, the trend in winter chill days is downward (though non-significantly so). While the Rogue Basin may be able to escape this problem for many years, areas such as the San Juaquin Valley are already suffering a shortage of winter chill and are adapting crops accordingly.

The key for the agricultural industry to adapt to climate change is to be prepared for the changes to come and modify accordingly. However, climate change will still likely impact the industry. The industry employs about 2500 people directly and 9000 indirectly. Josephine, Jackson and Curry counties produce about $121 million in farm and ranch sales (Oregon Department of Agriculture/National Agriculture Statistics Service, 2013).

Some impacts to local agriculture include (Doppelt et al., 2008):

- Disruptions in the timing and quantity of water flows, which will reduce already over-appropriated surface water
- Drought, which will affect ground water, soil health, and water demands
- Limited water supplies
- Limited use of hydro cooling due to lack of available water
- Warmer and wetter spring months may lead to conditions for pear blight
- Modification of the style of wine that a region can produce
- Warmer temperatures will change plant disease and pest timing and severity
- Reduction in soil fertility and erosion
- High temperatures could reduce viability of pears and wine grapes, particularly Jackson County’s pinot noir vineyards

- Viable zones for wine grape production in southwest Oregon will likely shift toward the coast, northward, and upward in elevation, likely disappearing from the region by 2100 except in a narrow zone along the coast
- Pollinators may be affected by climate change induced disease
- Higher numbers of insects may lead to increases in pesticide use and reduced water quality
- Monocultures will be more susceptible to disease
- Growers that rely on single crops are likely to be more at risk financially than growers with a diverse array of crops
- Horse farms are likely to face reduced pasturage options and higher feed costs due to rising costs for water

Risks to Public Health and Emergency Services

Figure 13. Smoke in the air during wildfires in the summer of 2013.
Photo Credit: Gwyn Myer.

Increased storm intensity, flooding, wildfire, and rising temperatures (particularly in the summer) will likely increase demands for emergency services (Oregon Environmental Council, 2013). The projected increase in frequency and severity of forest fires poses public safety hazards due to both risk from fire and smoke degrading the air quality (Figure 13 and Figure 14).

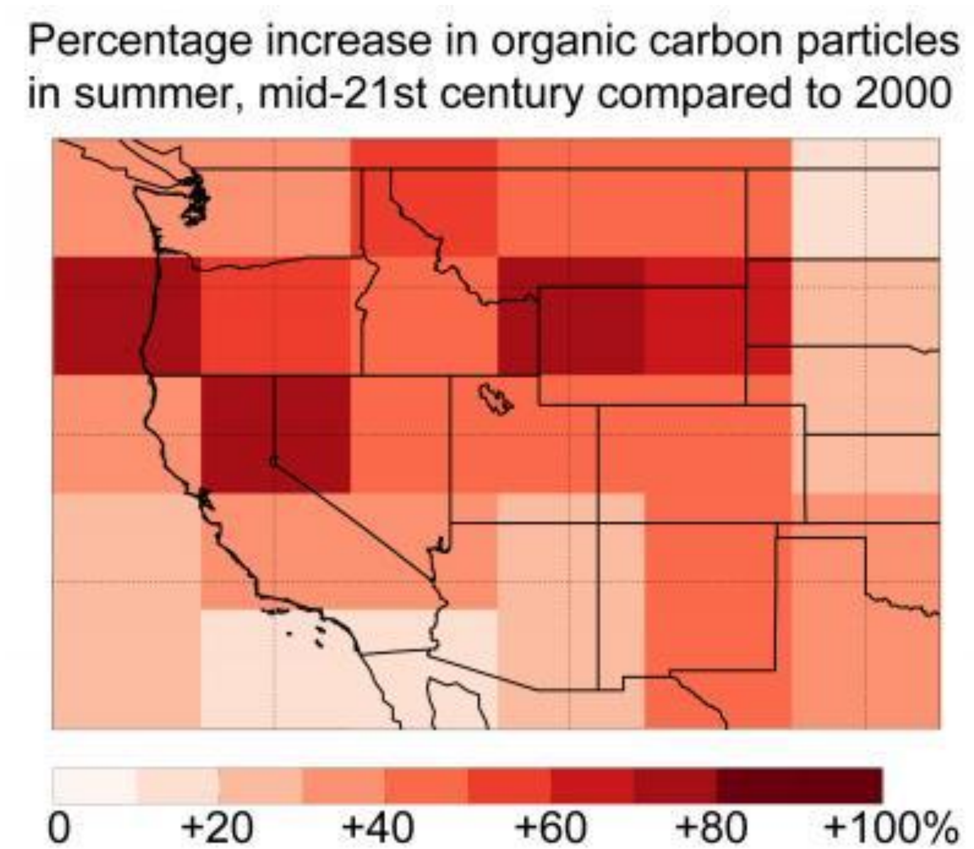


Figure 14. Organic carbon is one component of smoke from wildfires. Overall, wildfires in 2050 are expected to be up to twice as smoky, threatening visibility and public health. *Source: Xu Yue, Harvard University, 2013.*

With rising temperatures, there will likely be higher incidences of heat-related illnesses such as heat stroke and exhaustion. Additionally, a substantial number of homes lack air conditioning in the Rogue Basin, which could place more people at risk of heat-related illness. The elderly, infirm, and poor are likely to be most at risk due to lack of funds for healthcare and air conditioning, and greater vulnerability to warming and pollution (Doppelt et al., 2008). Around 20% of the population of the Rogue Basin is uninsured for health care (County Health Rankings, 2013). Increased temperatures will also lead to more respiratory illnesses from higher ozone levels and increased pollens and allergens. The occurrence of asthma is also likely to grow. Asthma is already considerably more prevalent in Oregon than the US average. The estimated percentage of the adult population affected by asthma between 2004 and 2007 was 8.8 - 9.3% in Jackson County; in Josephine County 10.5 - 17.2%; and in Curry County 9.4-10.4%, an increase from previous years (Oregon Health Authority, 2010).

Hotter summer temperatures, increased allergens, and poor air quality (due to rising temperatures and smoke from wildfire) could also adversely affect the local workforce. The retired population, whose income from retirement and Social Security Income payments are an important part of the economy, could leave the area due to these cumulative effects. They also provide significant support for the health care industry, which is an increasingly important part of the economy. Greenhouse gas reduction measures, however, that lead to cleaner vehicles, more mass transit, and the use of renewable energy could have positive impacts on public health in the Rogue Basin (Doppelt et al., 2008). Flooding and drought will degrade water quality for municipal water supplies and ground water, affecting water quality for human consumption (Doppelt et al., 2008). Additionally, vector-borne diseases are likely to increase, such as Lyme disease and West Nile Virus (EcoNorthwest, 2009). The Jackson County Health and Human Service's Climate and Health Action Plan (2013) provides more information on the local impacts of climate change to health in the Rogue Basin. Table 5 summarizes their findings.

Climate Change Risks to Human Health				
Injury/Morbidity/ Mortality	Water and Vector-borne Diseases	Respiratory Diseases	Malnutrition and Food Security	Mental Health
Extreme Weather and Storm Events (floods and tsunamis); Rising Temperatures.	Insect and pest outbreaks; Higher precipitation levels and flood events; Increased algal blooms due to warming waters; Changes in habitat and species.	Degraded air quality; Rising temperatures; Increased pollen counts; Increased mold exposure; Increases in wildfires.	Rising sea levels; Rising temperatures and drought events; Threatened food supplies.	Extreme weather threats and displacement; Economic stress; Environmental degradation.

Table 5. Summary of Climate Change Risks to Human Health in Oregon. *Adapted from: Bizeau, 2013.*

Manufacturing, Retail and Service Sectors

In the past decades Jackson and Josephine counties have diversified their economies. The principle industries today include the manufacturing of durable goods, retail trade, and health services (Doppelt et al., 2008). These sectors are likely to experience disruption in supply chains and distribution of goods and services due to increased dramatic weather events. Reduced summer output from the BPA hydro system could cause higher fuel and electrical costs as well (Oregon Environmental Council, 2013). Balancing the municipal and agriculture water demands will become more challenging: as the late summer and fall stream and river flow is reduced due to lower snowpack and earlier snowmelt, irrigation demand will increase, electricity demand for cooling will increase, and hydro-power's ability to meet the need will drop. Municipalities that sell water will be more greatly affected (Doppelt et al., 2008). In addition, the climate impacts on transportation are likely to affect these sectors.

Tourism and Recreation

Tourism is a large and growing industry in the Rogue Basin, and locals enjoy many of the ecosystem services of the basin for recreation and aesthetic values. These values are threatened by climate change projections and if measures are not taken to increase resiliency and prepare for the changing climate, the entire recreational service sector, which makes up almost 18% of the Basin's economy could be impacted. Tourist seasons may shift due to extreme summer temperatures and changes in timing of stream flows and water quantity and quality. Low water levels in streams may reduce recreation opportunities, such as river rafting and kayaking. As peak flows shift earlier in the season due to earlier snowmelt, they may no longer overlap with the summer season in which many people enjoy river recreation (EcoNorthwest, 2009). Reduced snow pack will also impact winter recreation such as skiing and snowboarding. Increased fire, smoke, and stream sediment may reduce the ability to fish recreationally and cause camping to be less appealing. Tourism, hunting, and other recreational activities may all be impacted by declines in wildlife and intact habitats (Doppelt et al., 2008).

The increased risk of fire could cause forest closure events, and dry, high-risk fire seasons might limit areas for activities such as mountain biking, hiking, wildlife viewing, and scenic drives. Recreational uses of the Wild & Scenic Section of the Rogue River was prohibited for public safety during the Biscuit Fire, the 2005 Blossom Complex fires and the 2013 Big Windy Complex fires, an action that cost the river rafting and support industries millions of dollars in losses. Post-fire landscapes may not attract tourism and may have limited capacity for recreational uses. These current and projected shifts in the natural system of the Rogue Basin can significantly impact the tourism and recreation industry.

Summary

The consequences of climate change for the Rogue Basin are likely to be substantial: if no action is taken, damages could amount to billions of dollars in costs (EcoNorthwest, 2009). Preparation is needed to lessen the severity of the impacts from climate change that are an inevitable consequence of the greenhouse gases already emitted and those that will be emitted, and increase the resistance and resilience of natural and human systems to these changes. Additionally, ecosystem services need to be integrated into decision making and planning. If we do not consider the various values and benefits, avoided costs, efficiency, and resilience ecosystem services provide in our decision making, land management, and economic analyses, we may lose those benefits at a much greater cost. On the other hand, proactive decision making now can lead to ongoing benefits across the economy of the region.

Now let's look deeper into the specific risks and opportunities associated with climate change for the forest and water resources of the Rogue Basin.

Forest Key Points

Fire suppression, widespread even-aged stand management, land use, and other stressors have dramatically reduced and degraded critical wildlife habitat (including habitat for the endangered Northern Spotted Owl) and promoted dense overcrowded stands, elevating tree stress and placing the oldest trees at risk of uncharacteristic wildfire. Forest diversity has been reduced at both the landscape and stand scale.

Younger stands are threatened by density-related wildfire risk and competitive stress; without active management their development into mature stands dominated by large trees is slowed.

Climate change impacts are exacerbating these forest stressors and threatens to cause profound shifts in species composition and habitat abundance while increasing risk of species extinctions. Other climate risks include an increase in insects, pathogens, and disease and an increase in invasive species.

Logging has strong roots in the region, but has declined, while tourism and recreation are increasingly important. There is no consensus on appropriate management in the Rogue Basin and current federal management is often stalemated.

Forest management must reduce fire risk and protect drinking water while promoting critical habitat, species diversity, and carbon sequestration. The SOFRC integrated assessment is a management alternative incorporating social, economic, and ecological values to increase forest resistance and resilience to a changing climate. Resilient forests will require landscape planning and collaborative approaches that incorporate both federal and private lands.

Forest Assessment

Figure 15. View of the Rogue Basin from Wagner Butte.
Photo Credit: Gwyn Myer.

Assessment Process

The Forest assessment was authored by Gwyneth Myer, Kerry Metlen, and Ken Wearstler, but its preparation includes major collaboration by a variety of experts. Other contributors included: Alan Journet, Retired Ecologist, Southeast Missouri State university, co-facilitator, Southern Oregon Climate Action Now; Alicia Fitzgerald, Ashland Forest Resiliency project assistant; Jackson County Planning Department, Industrial and non-industrial land owners/managers, Southern Oregon Timber Industries Association, U.S. Bureau of Land Management (BLM) fire and fuels specialist, the Southern Oregon Forest Restoration Collaborative, the Coordinator for the Jackson and Josephine County Fire plans, and the Medford Water Commission. Resources used are listed in the references and include: a landscape assessment of the Rogue Basin completed by the Southern Oregon Forest Restoration Collaborative; a wide variety of scholarly articles on historic and present forest conditions, fire history and management, vegetation types and conditions historically and present; climate effects and assessments on the region; economic assessments; city, county, and agency plans; data on regional resource management (present and historically);

Oregon Department of Environmental Quality (ODEQ) data; Headwaters Economics data; The Geos Institute data; BLM data; and U.S. Forest Service data.

Current Conditions and Trends

The Rogue Basin is created by converging mountain ranges resulting in rich geological diversity which, acted upon by a frequent fire regime and relatively little glaciation, has resulted in rich biological diversity (Agee 1991, Taylor and Skinner 1998, Whittaker 1960), with the greatest alpha and gamma-scale diversity in Oregon (Ohmann and Spies 1998). Vegetation in the region follows complex gradients from a continental climate in the eastern portion of the subregion to a maritime climate with low seasonal temperature variability, high winter precipitation, and high seasonal variability in precipitation along the coast and ultramafic soils are more important for explaining vegetation patterns than elsewhere in Oregon (Ohmann and Spies 1998). The region can be roughly divided into seven vegetation zones, all but the Alpine Zone containing substantial forested components (Figure 16; Franklin and Dyrness 1988; Waring 1969). The Interior Valley Zone includes the Oak Woodland zone which occurs up to 800 m in elevation and common forest species include white oak (*Quercus garryana*), black oak (*Q. kelloggii*), pacific madrone (*Arbutus menziesii*) and scattered but important pockets of forest dominated by Douglas-fir (*Pseudotsuga menziesii*), Jeffery pine (*Pinus jeffreyi*), or ponderosa pine (*Pinus ponderosa*) with associated sugar pine (*Pinus lambertiana*), and incense cedar *Calocedrus decurrens.* Grassland, riparian, manzanita, and chaparral communities are common in this zone.

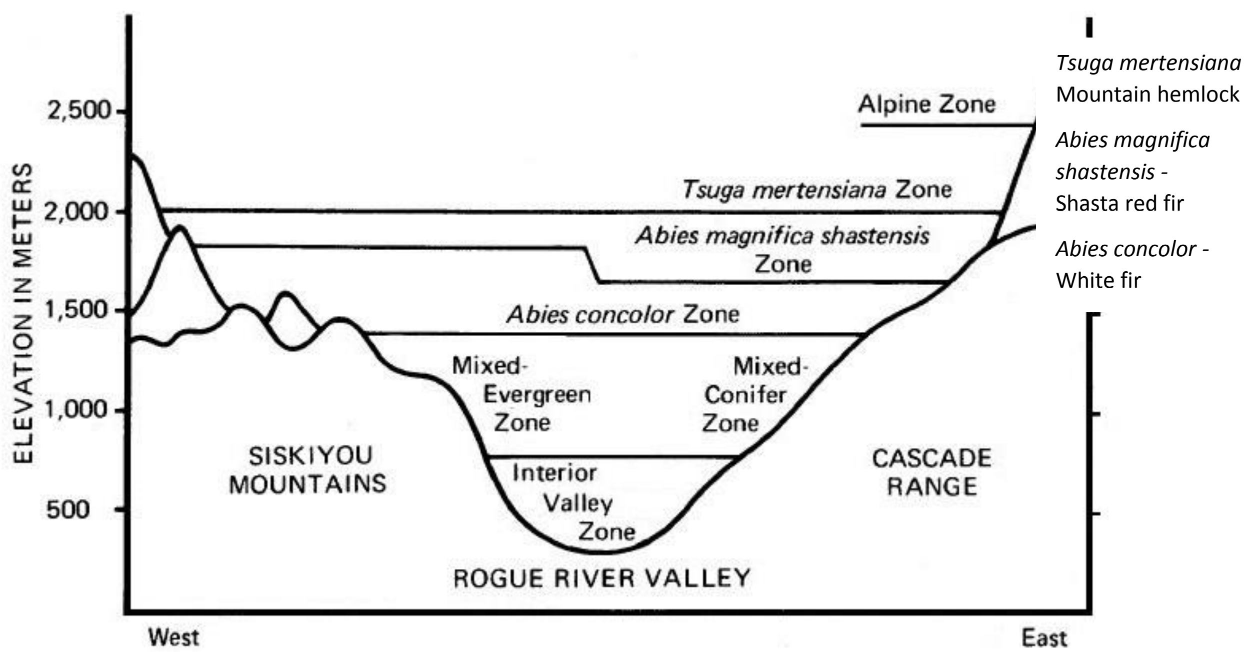


Figure 16. Vegetation zones of the Rogue Basin are driven by geology, topography, glacial history, volcanism, and fire. Mixed-Evergreen and Mixed Conifer Zones are found on both the Siskiyou Mountains and the Cascade Range, but Mixed-Evergreen forests are more common in the Siskiyou and Mixed-Conifer forests are more common in the Cascade Range. The Interior Valley Zone may more aptly be called the Oak Woodland Zone. *Figure adapted from Franklin and Dyrness (1988).*

The Mixed-evergreen Zone tends to be more prevalent on the Siskiyou side of the Rogue Basin and is dominated by Douglas-fir and tan-oak (particularly in the west) but includes substantial components of canyon live oak, sugar pine, ponderosa pine, incense cedar, and pacific madrone. The Mixed Conifer Zone is more abundant in the Cascade Range and at higher elevations where conifers in general, particularly white fir and Douglas-fir become even more dominant. The *Abies concolor* zone occurs in stands generally between 1400 and 1600 meters in the Cascade range and between 1650 and 1800 meters in the Siskiyou Mountains (Waring 1969, Whittaker 1960) and while white fir is the major tree species, it commonly associates with Douglas-fir, sugar pine, ponderosa pine, and western white pine and on moister sites incense cedar. Shasta red fir becomes increasingly common with elevation, becoming dominant in the *Abies magnifica shastensis* Zone with associates of white fir, western white pine, lodgepole, and mountain hemlock. The *Tsuga mertensiana* Zone is dominated by mountain hemlock, Shasta red fir, or lodgepole (primarily in the Cascades), but white fir and Douglas-fir can act as seral species and there is a minor component of western white pine and Engelmann spruce. Tree species distributions correspond with vegetation zones, as illustrated for the Siskiyou Mountains in Figure 17; these distribution patterns are similar for the Cascade Mountain side of the Rogue Basin.

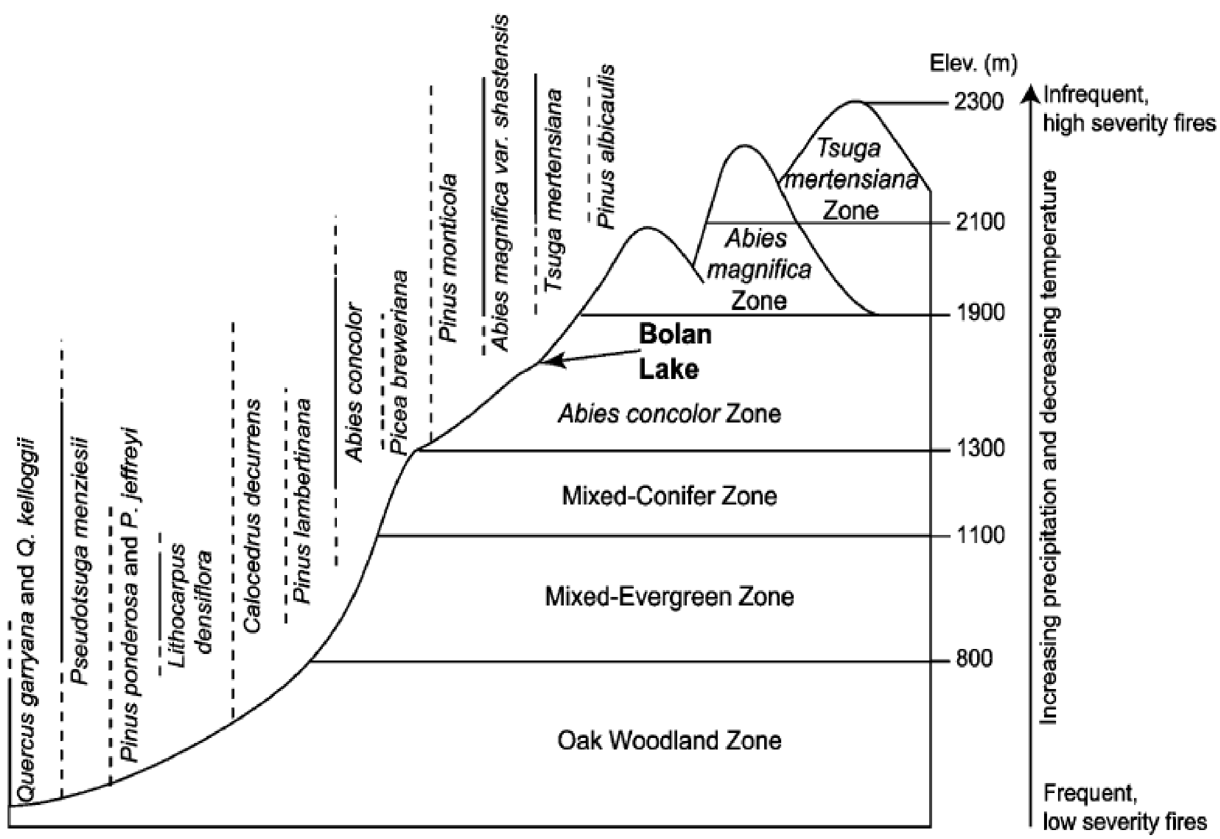


Figure 17. Modern vegetation zones of the Siskiyou Range are correlated with precipitation, temperature, and fire frequency. Briles et al. (2005) redrew a portion of Franklin and Dyrness (1988), with information from Agee (1993) and Taylor and Skinner (1998). Solid vertical lines indicate the altitudinal range of a species' dominance while vertical dashed lines indicate species' presence. Note that Bolan Lake, the source for much of the data on vegetation dynamics since the Holocene, lies at 1600 meters, in the current *Abies concolor* Zone. *Source: Briles et al., 2005.*

Plant Subseries	Acres	Percent
Douglas-fir - Dry	944,419	29%
White fir - Intermediate	584,398	18%
Not Modeled	347,049	11%
Tan oak - Douglas-fir - Dry	333,166	10%
Tan oak - Douglas-fir - Moist	194,405	6%
Oregon white oak	154,869	5%
White fir - Cool	149,339	5%
Ultramafic	147,452	4%
Mountain hemlock - Cold Dry	119,240	4%
Western hemlock - Hyperdry	47,303	1%
Douglas-fir - Moist	46,133	1%
Ponderosa pine - Dry	43,324	1%
Shasta red fir - Moist	36,713	1%
Western hemlock - Coastal	35,130	1%
White fir - Moist	29,191	1%
Ultramafic	19,046	1%
Western hemlock - Intermediate	13,777	0.4%
Subalpine parkland	10,732	0.3%
Water	9,339	0.3%
Wetland	9,282	0.3%
Lodgepole pine cold	5,432	0.2%
Barren	5,370	0.2%
Pacific silver fir - Intermediate	3,808	0.1%
Sitka spruce	3,791	0.1%
Western hemlock - Moist	323	0.0%
Sum	**3,293,023**	**100%**

Table 6. Plant subseries as mapped by the Integrated Landscape Assessment Project (ILAP) with acres and percent of total for each subseries. Each subseries is composed of many plant associations but is broadly representative of site productivity. *Source: ilap, 2013.*

Across the 3.3 million acres of the Rogue Basin the most abundant subseries is moist Douglas-fir (26%) followed by White fir intermediate, dry Tan oak-Douglas-fir (19%) , dry Douglas-fir (13%), and Oregon white oak (5%).

While plant subseries is representative of what species will grow on a site in absence of disturbance, the Mediterranean climate of this region drives a fire regime that rarely allows succession to proceed unchecked. Thus, old growth forests, particularly in the drier subseries, are many-aged forests dominated by the large, older members of the seral species. The species that characterize the subseries tend to be very sensitive to drought induced mortality while increased densities of host species is tied to elevated distribution and abundance of insects and disease. Forest densities in excess of those found historically, driven by reduced fire frequency, corresponded with elevated risk of high severity fire in a landscape that would have burned at low to mixed severity under a more frequent fire regime. Increased density (everywhere) and shifts to shade-tolerant species (in most settings and in the understory) are documented across a range of habitats including shrublands, oak savannas, and forests dominated by everything from pines to true firs.

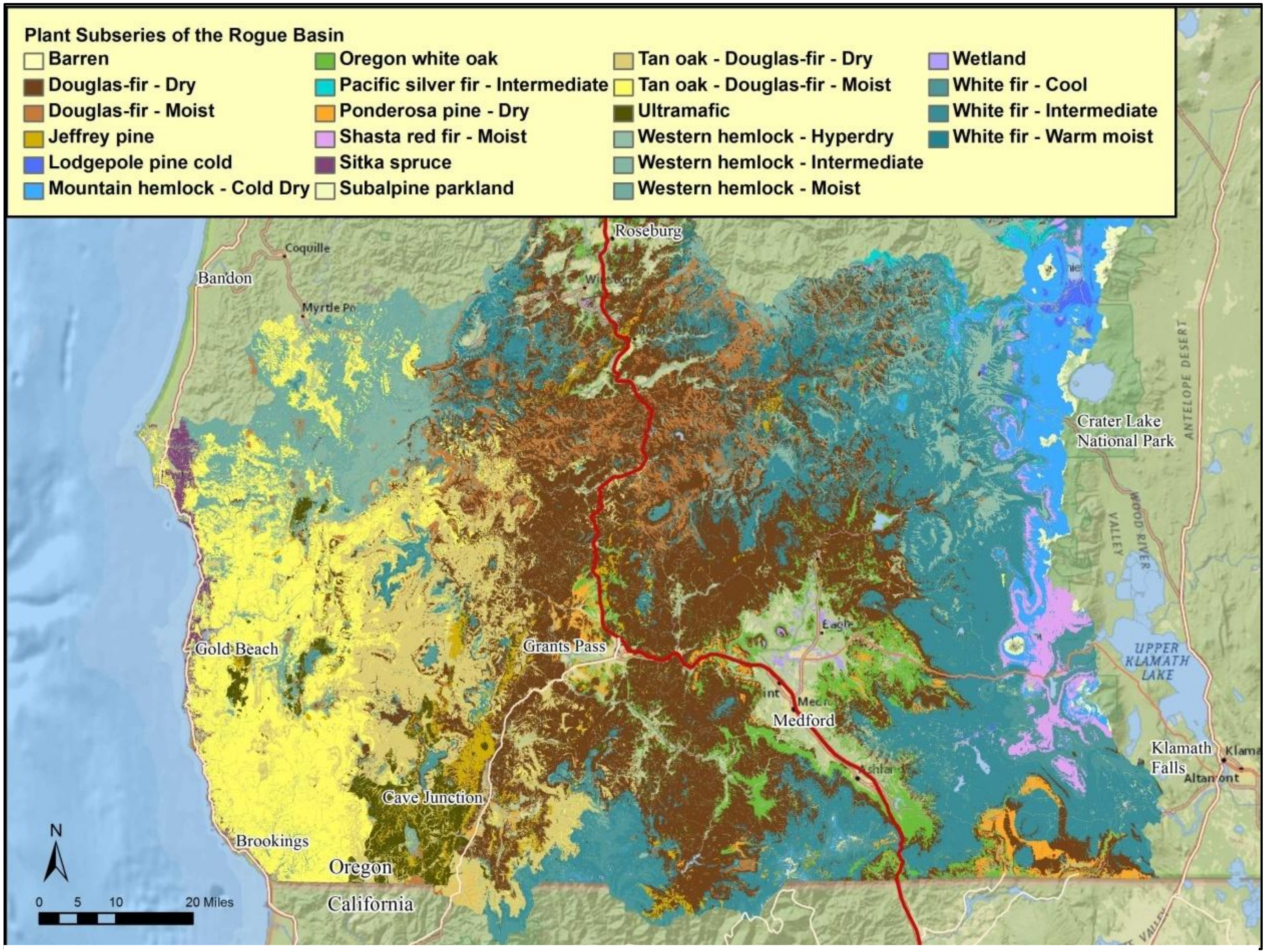


Figure 18. Rogue Basin Plant Subseries: Vegetation of the Rogue Basin can be classified by plant series, the most shade tolerant tree regenerating in the understory, and productivity. *Source: The Nature Conservancy, 2013.*

Forest History

The Holocene epoch is interesting from a future range of variability standpoint because climate of the early Holocene approximates likely future climate scenarios (Whitlock et al. 2003). In early sedimentation work, Hansen (1947) found yellow pine (ponderosa, sugar, and/or Jeffery pine), white fir, and Douglas-fir to all be particularly well represented in sediment columns collected from the Upper Rogue River Valley, relative to sediment cores taken throughout the Pacific Northwest. This work found yellow pine particularly well represented following the warm, dry stage following the Mount Mazama volcanic eruptions (~5,700 BP) with increasing Douglas-fir pollen found in later time periods associated with recent cooling climate and increased moisture. Lack of a thick pumice mantle may explain high proportions of fir and lower proportions of lodgepole pine pollen than in similar climates east of the Cascades.

Charcoal, pollen, and plant macrofossils have more recently been evaluated in sediment cores from high elevation lakes to cast inference to disturbance patterns and vegetation types of the Holocene of the Klamath and Siskiyou mountains. Bolan Lake, the most relevant source of data for the Siskiyous, is located in contemporary white fir Zone at 1638 m elevation (Figure 19; Briles et al. 2005).
In general, fire frequency on submillennial time scales have been closely tied to the pollen record, with infrequent fires tied to fire-sensitive fir, spruce, and hemlock and periods of more frequent fire coincident with abundance of Douglas-fir, juniper, and alder (Figure 19; Briles et al. 2005). Charcoal in the Bolan Lake sediment core suggest that fire activity over the last 14,500 years BP varied between 4 and 10 episodes per 100 years (Briles et al. 2005). Fire frequency fluctuated with climatically driven changes in fuel availability and seasonal dryness but increased to 9 episodes per 1000 years toward the present. From a regional perspective, the Klamath-Siskiyou experienced frequent fire throughout the Holocene, even though sediment cores from Bolan Lake recorded surprising periods of relatively low fire frequency for a summer-dry lake (Whitlock et al. 2008).

Prior to 14,500 BP, pollen suggests an open parkland of vegetation similar to modern subalpine environments, consisting largely of sage and grasses with relatively low percentages of conifer pollen, primarily Haploxylon-type pine (probably *Pinus monticola*), spruce (likely *P. engelmannii* or *P. breweriana*), mountain hemlock, and juniper (probably *Juniperous occidentalis*). After 15,000 BP a mixed conifer forest developed with little pollen of sage or herbaceous species but diverse assemblages of conifer pollen: true fir (*A. concolor* and *A. magnifica* var. *shastensis*; 5–10%), mountain hemlock (5–10%), Douglas-fir (5–10%; northern sites only – Rogue Basin), and Haploxylon-type *Pinus* 60–80%). The pollen record suggests that modern vegetation established around 4,000 BP (Briles et al. 2005, 2011).

A much shorter record (2000 years) was sampled at Upper Squaw Lake (Colombaroli and Gavin 2010) and the sediments record pollen and charcoal from contemporary Mixed Evergreen and Mixed Conifer Zones at 930 m elevation. Throughout this entire record, pine pollen (likely ponderosa and sugar pine) was more abundant than the pollen of Douglas-fir or other, more shade tolerant tree species. Charcoal free periods (such as 2000 years BP) are associated with increased pollen counts of fire sensitive species, such as pacific yew. Subsequent frequent fire periods (such as 1100 years BP) recorded less pacific yew and more incense cedar pollen, indicative of more open habitats.

Sediment records do not cover all environments, notably arid environments because they rely on pooling water to collect and stratify sediments (Minckley et al. 2008). Holocene-era forests of the lower elevations have been less well characterized for the Rogue Basin, but broad scale vegetation patterns could mirror those observed for the Willamette Valley, even though contemporary vegetation tends to be much more mesic than that in the Rogue Basin. Figure 20 (Sea and Whitlock 1995) illustrates the movement of plant communities up and down the slopes of the west Cascades since 14000 BP with xerophytic vegetation (pines, oaks, and Douglas-fir) more widely distributed under drier, warmer climates and a shift toward firs and hemlocks with more mesic, contemporary climates. At the lower elevation sample sites of the Willamette Valley a relatively short sediment record (1200 years) found that periods of more frequent fire shifted plant communities from forests dominated by Douglas-fir, cedar and alder to more open habitats that produced more pollen of herbaceous taxa, even when fire frequency was not necessarily tied to climate (Walsh et al. 2010).

To summarize, for the last 15,000+ years drier, warmer climates and more frequent fire, regardless of the source, have favored more drought and fire tolerant vegetation and these trends have been shown in sediment records of the Rogue Basin for the Cascades (Hansen 1947), at individual sites in the Klamath and Siskiyou Mountains (Briles et al. 2005, Briles et al. 2011, Whitlock et al. 2008), and for the further removed, but more completely sampled Cascade mountains and Willamette Valley (Sea and Whitlock 1995, Walsh et al. 2010).

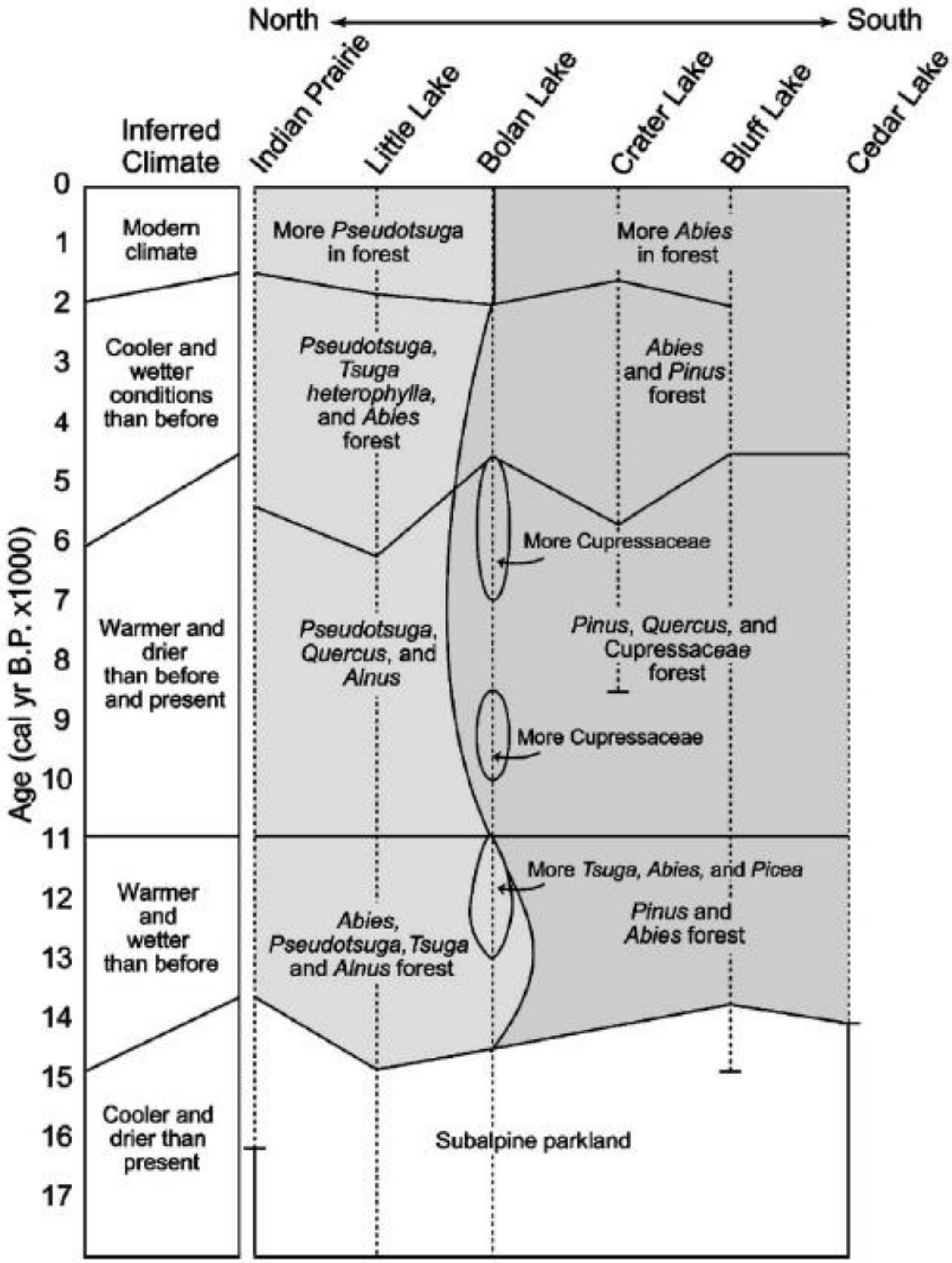


Figure 19. Vegetation reconstruction based on pollen data from sites in western Oregon and northern California. A dashed line represents an individual site with a (8) signifying the end of the record (only Little Lake and Bolan Lake extend back to 17,000 cal yr B.P.). The solid vertical line represents the hypothesized spatial displacement of the biogeographic transition zone between the more xerophytic vegetation of the Klamath Mountains (dark gray) and the more mesophytic vegetation of the PNW (light gray) (note: the distance between sites is not to scale). *Abies* (true fir); *Psuedotsuga* (douglas-fir); *Quercus* (Oak); *Alnus* (alder); *Pinus* (pine). *Source: Briles et. al, 2005.*

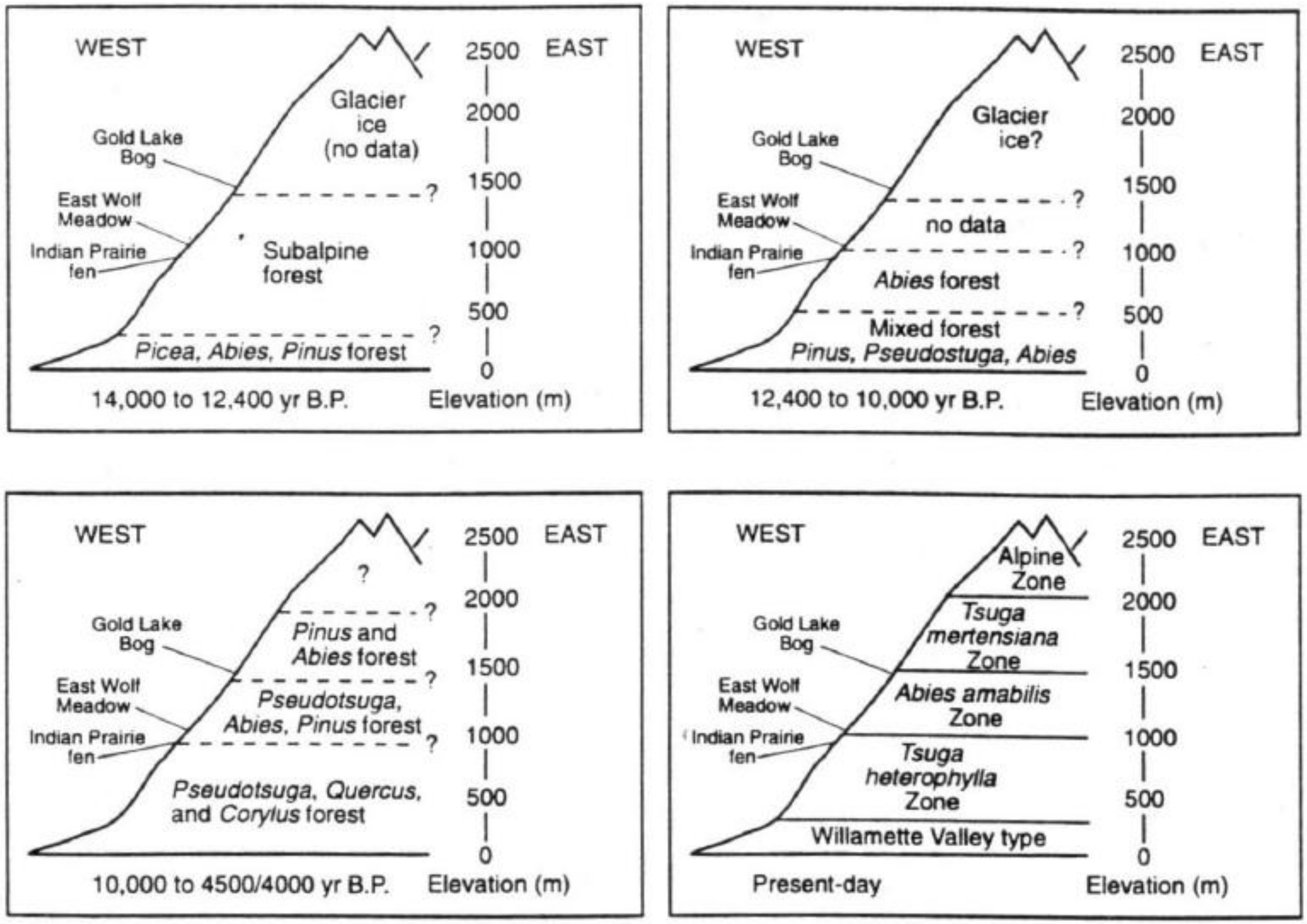


Figure 20. Vegetation of the west slope of the cascades has moved up and down in elevation with climate trends over the past 14,000 years.
Source: Sea and Whitlock, 1995.

In the last 100 years dry forests of the American West that historically were dominated by widespread large trees and diverse and productive understories have subsequently become densely crowded with regeneration of small, often shade tolerant trees species. This pattern has been well described in the Southwest (Cooper 1960, Fulé et al. 1997), northern Sierra (Collins et al. 2011) portions of the Klamath Mountains in California (Taylor and Skinner 1998), and east of the Cascades (Harrod et al. 1999, Everett et al. 2000; Youngblood et al. 2004; Taylor 2010, Hagmann et al. 2013). Increased densities of small trees and shifts toward shade-tolerant, fire sensitive vegetation have been directly tied to fire exclusion in Arizona (Cooper 1960), the San Bernadino mountains (Minnich et al. 1995), the Sierra Nevadas (Collins et al. 2011), Mt. Rushmore (Brown et al. 2008), and the eastern Cascades (Everett et al. 2007, Taylor 2010). In 1978, Vankat and Major documented increased density and shifts to shade-tolerant species across a range of habitats including shrublands, oak savanna, and forests dominated by everything from pines to true firs in Sequoia National Park and attributed those changes to the combined effects of grazing and fire exclusion. Forests adjacent to riparian systems have also been shown to historically have experienced frequent fire in the California Sierra, with a mean fire return interval of 17 years, which were indistinguishable from the nearby upland sites, with dramatic fire exclusion effects in both habitats (Van De Water and North 2010).

In the Northwest, frequent fire-adapted forests are at high risk of uncharacteristically large, severe fires that can be destructive to habitats, species, and people (Hessburg and Agee 2003; Spies et al. 2006). Across the west large old trees are dying at accelerating rates, a trend exacerbated by a warming and drying climate (Van Mantgem et al. 2009). In Yosemite National Park the absence of fire is converting stands once dominated by large diameter shade intolerant species, in particular ponderosa pine, Jeffery pine, and sugar pine to closed-canopied forests dominated by small-diameter trees (Lutz et al. 2009). Climate change, combined with other stressors including fire exclusion, logging, and grazing, increase the risk of frequent, uncharacteristically severe wildfire (Whitlock et al. 2003; Westerling et al. 2006).

Increased forest densities and altered fire regimes observed throughout the West are evident in forest communities of the Rogue Basin. Fire exclusion has also been demonstrated more regionally with a recent 100 year period of relatively infrequent fire preceded by a significant period of historically frequent fire at return intervals of <20 years in warmer settings and less frequent fire in the more moist settings (Agee 1991, McNeil and Zobel 1980, Colombaroli and Gavin 2010, Sensenig et al. 2013) and Klamath Mountains (Taylor and Skinner 1998, Taylor and Skinner 2003, Fry and Stephens 2006, Taylor 2010). Fires were historically more frequent on warmer slopes than on cooler slopes (Agee 1991, Taylor and Skinner 1998). As an example, at Crater National Park McNeil and Zobel 1980 found historic fire return intervals of 9 years in ponderosa pine forests and 41 years in cooler, moister white fir forests. Longer fire return intervals have also been documented in moist white fir forests of the western Klamath, with pre-suppression median return intervals of 27 to 74 years (Stuart and Salazar 2000).

Frequent fires regimes with mixed severity effects historically maintained very diverse uneven-aged forests. However, lack of fire has driven a dramatic increase in the density of shade tolerant species, primarily Douglas-fir and white fir; and a shift away from fire resistant, shade intolerant ponderosa pine and sugar pine in mixed conifer forests of the Klamath Mountains (Taylor and Skinner 1998, Taylor and Skinner 2003). Across the Rogue Basin Sensenig et al. (2013) have also found widespread evidence for old growth stands that established under very open conditions where trees that survived frequent fire were capable of rapid growth, while contemporary stands are dramatically denser and slow growing. Messier et al. (2012) sampled lowland and mixed conifer riparian forests across the Rogue Basin and found dramatic declines in growth rates that are correlated with fire exclusion and increasing establishment of many white fir and Douglas-fir (Figure 21; Messier et al. 2012). Increased forest densities have also resulted in less forest area in openings than found historically, (Skinner 1995) decreasing spatial heterogeneity which is critical for numerous forest processes. These studies provide strong evidence that increasing forest density and competitive stress observed across the west is also happening in the Rogue Basin.

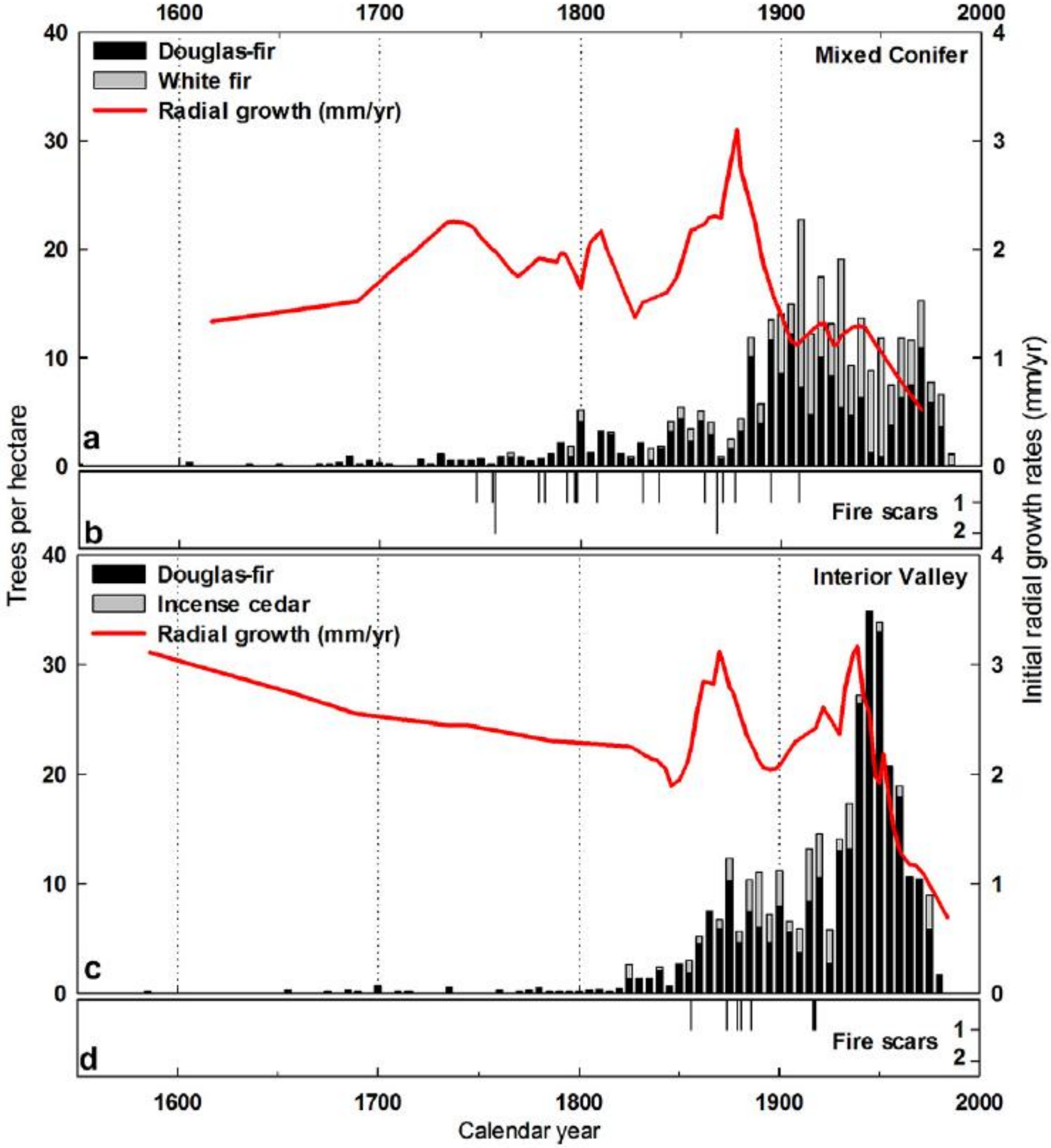


Figure 21. (a) Average age distribution (left axis) of Douglas-fir and white fir on Mixed Conifer riparian sites in the Rogue River Basin, Oregon, with the smoothed initial growth rates (right axis, average of first 20 years) for a subsample of Douglas-fir. (b) Fire scars recorded at five Mixed Conifer riparian sites. (c) Average age distribution (left axis) of Douglas-fir and incense cedar on 12 Interior Valley riparian sites in the Rogue River Basin, Oregon, with the smoothed initial growth rates (right axis, average of first 20 years) for a subsample of Douglas-fir. (d) Fire scars recorded at three Interior Valley riparian sites. *Source: Messier et al. 2012.*

Forests and Carbon Flux

Forests are net carbon sinks and yet climate change and natural disturbances alone threaten forests of the Northwest and could cause widespread forest mortality while turning forests into net sources of carbon (Dore et al. 2010, Van Mantgem et al. 2009, Boisvenue & Running 2010, Littell et al. 2010, Vose et al. 2012). Climate change is going to increase the likelihood of fire (Whitlock et al. 2003, Westerling et al. 2006, Littell et al. 2009), fire severity (Brown et al. 2004, Van Mantgem et al. 2013), and suppression difficulty (Fried et al. 2004).

A key adaptive strategy to climate change is to reduce forest loss (Cathcart et al. 2007, Amiro et al. 2010, McKinley et al. 2011, Vose et al. 2012) and the degree to which forests burned by wildfire become carbon sources scales to the severity of wildfire (Meigs et al. 2009). For example, carbon emissions of the 2002 Biscuit fire increased with increasing burn severity and the total released carbon equated to one third of the fossil fuel carbon emissions for Oregon in that year (Campbell et al 2007). Fuel reduction treatments can effectively mitigate wildfire effects (Fulé et al. 2012, Safford et al. 2012, Martinson and Omi 2013). Increasing rotation length, the age at which forest stands are harvested for commercial reasons, could also significantly increase carbon sequestration (Hudiburg et al. 2009).

Carbon emissions for mechanical treatments and controlled fire are significant and some argue that these carbon costs are not offset by reduced carbon emissions in the event of subsequent wildfire (Harmon et al. 1990, Harmon et al. 2009, Finkral & Evans 2008, Hudiburg et al. 2011). Other researchers have shown that fuels treatments are justified by reduced carbon emissions due to wildfire (Dore et al. 2010, Hurteau & North 2008, Finkral & Evans 2008, Wiedinmyer & Hurteau 2010, North & Hurteau 2011, Stephens et al. 2012). In part, this dichotomy exists because likelihood of wildfire must be considered when determining the effectiveness of fuel reduction treatments at mitigating carbon release (Mitchell et al. 2009, Ager et al. 2010, Campbell et al. 2011). In dry, frequent fire forests of the west many authors make the case that with 100 years of fire exclusion and a lengthening fire season due to climate change these forests are so flammable the majority of the landscape will receive wildfire, thereby justifying the assumption that fuel treatments will be a net carbon benefit (e.g. Dore et al. 2010, Hurteau & North 2008, Finkral & Evans 2008, North et al. 2009, Wiedinmyer & Hurteau 2010, Stephens et al. 2012). Further, targeting treatments to remove small diameter trees and tree species that are sensitive to fire – actively promoting large, fire tolerant trees – may over the long run increase stable carbon stocks as found in historically open frequent fire forests (North et al. 2009) .

Even in absence of future fire some authors have found increased carbon sequestration in thinned forests, particularly in regard to future climate (e.g. Cathcart et al. 2007, North et al. 2009, Dore et al. 2010), others find thinning forests simply releases carbon with no long-term carbon storage benefit (e.g. Campbell et al. 2009, Hudiburg et al. 2009, Amiro et al. 2010, Hudiburg et al. 2011, Law et al.). Fortunately, fuels treatments and forest restoration are justified for non-carbon reasons as well, further justifying use of mechanical treatments and fire to promote natural processes and resilience to facilitate forest adaptation to a changing climate while minimizing undesirable state changes (McKinley et al. 2011, Peterson et al. 2011, Vose et al. 2012)

Relative to other forests of the West potential for forests to sequester carbon is moderate for this region but varies by forest type (Hudiburg et al. 2009, Hudiburg et al. 2011, Law et al. 2012). Much of the forested area on the hillsides and mountainsides of southern Oregon comprises Douglas-fir and/or ponderosa pine associations, with a tanoak/laurel association notably occurring on the coastal SW corner. These forests are relatively productive compared to lower elevation oak woodlands where precipitation is relatively low for the region. Comparing the USFS Inventory map (http://databasin.org/maps/new#datasets=e0cd62ede7874743b4063f87c44bc574) with the Hudiburg et al (2009) map on aboveground forest biomass carbon (mapped at http://databasin.org/datasets/ 00cfef5252c64f578fcd453ef253aaed) it is evident that the Douglas-fir association (at app. 200 Mg / ha) exhibits far greater carbon sequestration potential than the ponderosa pine association (app. 100 Mg / ha). The tanoak / laurel association, meanwhile, appears comparable with the Douglas-fir association.

Forest Impact Findings

Climate impacts are already occurring in the Rogue Basin. Southwestern Oregon is one of the key regions where fire frequency is expected to increase with climate change (Westerling et al. 2006). There has been a six-fold spike in the area of forest burned since 1986 in the Pacific Northwest as compared with the 1970-1986 period (CIER 2007). Figure 22 shows the number of fires and acres burned from 1960-2013 in the Oregon Department of Forestry's Southwest district. One can see a notable shift to larger fires in terms of acres burned starting around 1985, with the fires of 2013 (Figure 23) bringing a record number of acres burned for the region in the past 50 years. While these increases in fire severity and frequency are

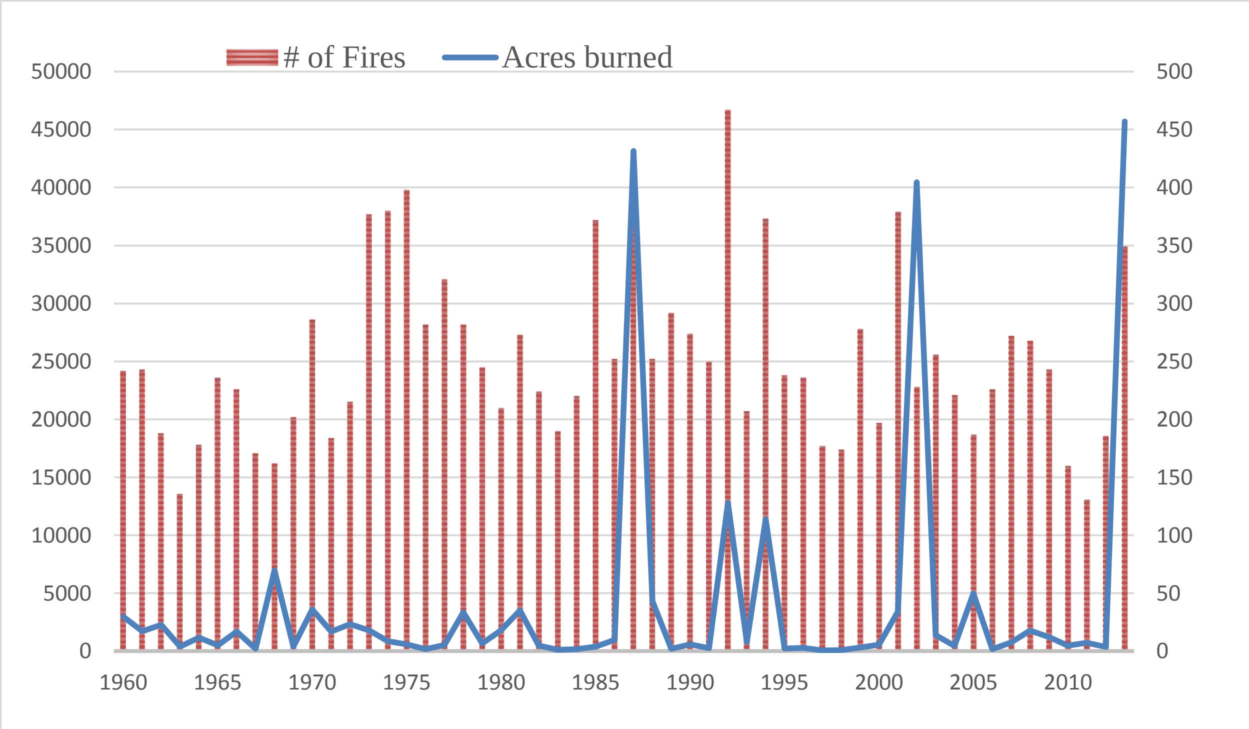


Figure 22. ODF Southwest District number of fires and acres burned, 1960-2013.
Source: Myer, 2013. Using data from Oregon Department of Forestry, 2013.

linked to fire suppression and overcrowded stands, climate change effects such as increases in temperatures in the spring and summer, drier soils, and earlier snowmelt have played a part in this fire frequency. Forests are expected to continue to have large impacts from increased incidence of fire (CIER 2007). Duration of fires has also increased from 7.5 to 37.1 days since 1986 (CIER 2007). This affects forest, water quality for human use, human health, soil quality, forest productivity, and habitat for a variety of species.

Figure 23. Wildfires in Southern Oregon, August 2013. *Photo Credit: Marvin Vetter, ODF.*

In addition to increases in frequency, severity, and duration of fires, endemic species of the forests are also at risk. The Klamath-Siskiyou region is of global importance for biodiversity as it has served as a refuge for species during past climate change events and has unique geology and geography contributing to its biodiversity (Olson et al. 2012), an IUCN Area of Global Botanical Significance (1 of 7 in North America), and is proposed as a World Heritage Site and UNESCO Biosphere Reserve (Vance-Borland et al. 1995). There are many unique and endemic species in the region. Habitat ranges of many North American species are moving northward in latitude and upward in elevation. For some this means an expansion in range, for others this results in a reduction in range and/or less hospitable habitat and an increase in competition. Some species are already at the northernmost or uppermost limit of their habitat and thus have nowhere to go (EPA 2013). The American Pika lives in the Western U.S., including Oregon, in cold areas near mountain tops. Due to the warming temperatures snowfall is declining in higher elevations, causing the Pika to die off below elevations of 7,000 ft. (Figure 24). More than one third of their population has already disappeared. These individual species being pushed toward extinction also serve as an indicator that the ecosystem as a whole is at risk. Interestingly, serpentine soils of the Siskiyou Mountains have hosted unusual and diverse vegetation for millennia and this vegetation has not been responsive to changing climate (Briles et al. 2011). However, the relative stability of this vegetation could be due to dispersal limitations, suggesting a possible vulnerability in the face of anthropogenically driven climate change (e.g. Olson et al. 2012). In-fact, dramatic changes in endemic serpentine herb communities since 1960 suggest this may be the case (Damschen et al. 2010).

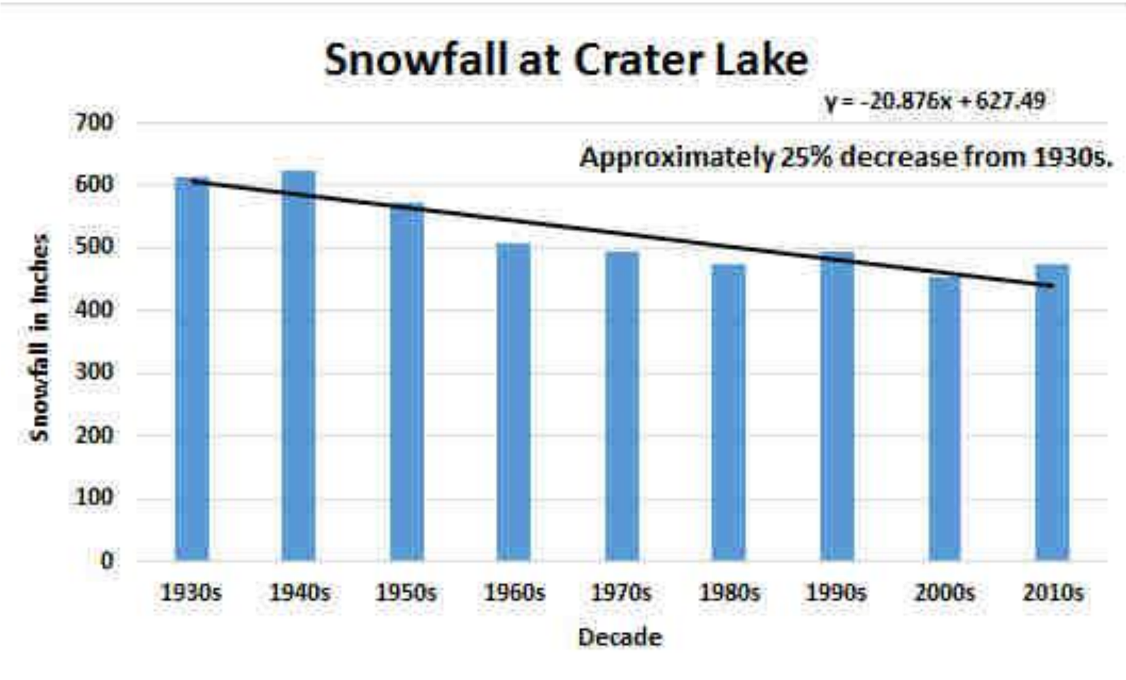


Figure 24. Declining High Elevation Snowfall.
Source: Journet, 2013 using data provided by Crater Lake National Park.

A primary effect of climatic change in water-limited environments, such as the dry forests of Southwest Oregon, is to exacerbate drought stress. Harrison et. al (2010) conducted a study on the effects of climate warming on forest herb communities in the Klamath-Siskiyou region, and found that "Siskiyou low-elevation forest herb (non woody, non tree) communities have shifted toward a greater prevalence of species with small, thick leaves…that are better adapted to dry conditions than species with large, thin leaves. Undisturbed lower montane herb communities at low elevations also shifted toward lower percentage of cover by species of north temperate biogeographic origin, which are characteristic of cool and moist macro- and microenvironments. Finally, both undisturbed and second-growth lower montane herb communities shifted to resemble more closely communities on warm southerly slopes, as we previously found for herb communities on serpentine soils in the study region." Projections show significant declines in conditions for maritime evergreens, and two models show an increase in conditions for maritime needleleaf and temperate deciduous broadleafs (Figure 25). Since the most profound influences determining the distribution of natural communities are temperature (average, seasonality, and extremes) and precipitation (water availability) serious changes in these parameters are likely to impact the ability of regional areas to support natural communities currently present. The dimensions of the changes that projections suggest might occur have the potential of devastating effects on many terrestrial communities. In particular by late century, it is possible that: high elevation spruce/fir/hemlock associations will be eliminated, Douglas-fir associations will be reduced, ponderosa pine associations will expand, Oak-chapparral association will expand, and shrubland/grassland will expand. As species shift, the structure and function of the ecosystems in the Rogue Basin will be impacted.

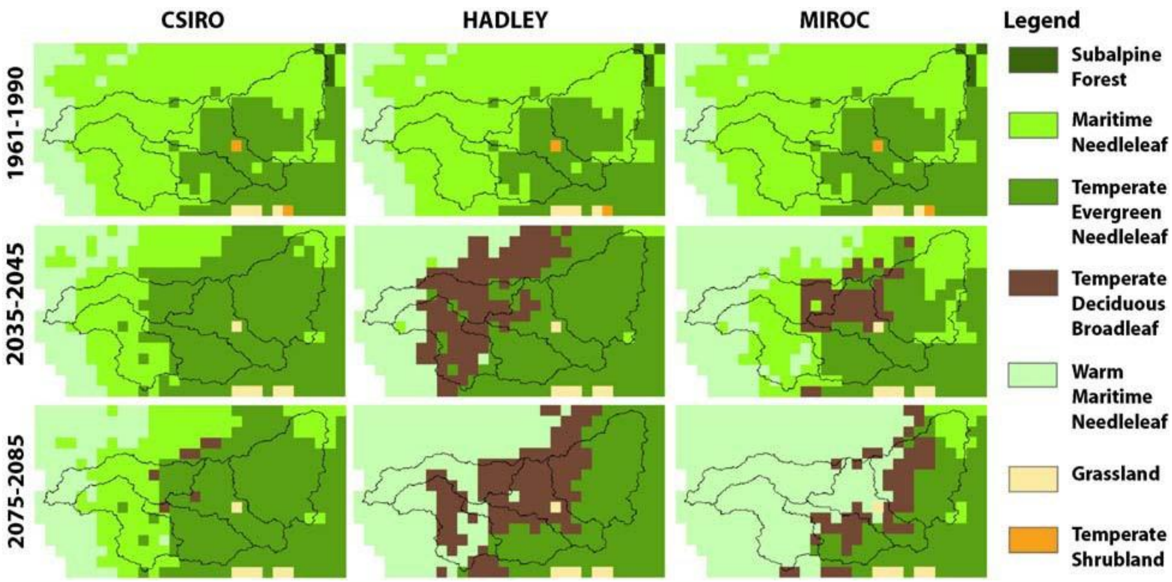


Figure 25. Current and future projected conditions for vegetation distribution across the Rogue Basin, as estimated with the MC1 vegetation model and 3 Global Climate Models. *Source: Doppelt et al., 2008.*

Ecological

The above information is based on events that are already occurring. In terms of projections of climate change for the Rogue Valley, there are many. Table 7 summarizes the likely trends and consequences for the Rogue Valley: in short, temperatures will increase, precipitation will have greater fluctuations and extremes, snowfall will be limited to higher elevations, there will be more instances of severe weather and fires, and native vegetation and terrestrial and aquatic species will be impacted.

TEMPERATURE[1] 	**Summer = June to Aug; Winter = Dec to Feb**	***Projections for 2035 - 2045***	***Projections for 2075-2085***
	Average Annual Increase	1.5 to 4^{0}F	4.3 to 8.2^{0}F
	Average Summer Increase	1 to 6^{0}F	5.6 to 11.8^{0}F
	August Increase	1 to 7.5^{0}F	6.7 to 16.8^{0}F
	Average Winter Increase	1 to 3.5^{0}F	3.4 to 6.3^{0}F
PRECIPITATION[1] 	**Summer = June to Aug; Winter = Dec to Feb**	***Projections for 2035 - 2045***	***Projections for 2075-2085***
	Average annual change	-4.46 to +0.04 inches	-5.56 to +11.81 inches
	Average summer change	-0.65 to -0.34 inches	-0.75 to -0.12 inches
	Average winter change	+0.33 to +1.83 inches	-0.40 to + 5.67 inches

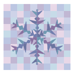
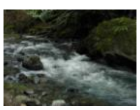
SNOWFALL[2] 	Rising temperatures will likely cause precipitation to fall as rain at lower elevations rather than as snow on peaks so average January snowpack will decrease; by 2035 – 2045 snowpack may be reduced 60 – 65% and by 2075 – 2085 as much as 90%. This will likely reduce run-off during late summer / fall and substantially reduce available irrigation and drinking water.
SEVERE  **WEATHER**[2]	Weather variability is likely to increase as both wet and dry cycles are likely to increase in length and severity. Many more days are likely to exceed 90^{0}F and 100^{0}F while more heavy rainfall days are likely. More precipitation falling as rain at low elevations rather than snow at high elevations is likely to increased flash flood frequency in Winter and Spring.
WILDFIRES[2] 	Longer droughts and higher temperatures with more intense heat waves will likely increase substantially the amount of (vegetation) forest lost to wildfire.
VEGETATION[2] 	With warming and drying, climatic conditions will likely become more appropriate for deciduous forest communities such as oaks and other hardwoods while conditions for higher elevation spruce/fir/hemlock communities will be severely compromised and those for Douglas-fir will likely be reduced in area. Grassland and scrubland conditions are likely to expand as forest conditions diminish.
NATIVE AQUATIC SYSTEMS[2] 	With increases in storms and fires, enhanced soil erosion will likely cause greater stream sediment and mineral build-up. Increased summer air temperatures will elevate water temperatures reducing critical dissolved oxygen concentrations and potentially enhancing bacterial and disease conditions. Reduced snowpack and earlier snowmelt will likely modify current stream flow patterns. With warmer water temperatures earlier aquatic insect emergence is probable, compromising historic food availability pulses for migratory fish. Reduction in conditions for many native fish species may be accompanied by range expansion of non-native species.
NATIVE TERRESTRIAL SYSTEMS[2] 	Probable increase in wildfires and lengthened fire seasons may induce dramatic shifts in vegetation communities towards more fire-adapted associations. Both invasive and non-native species abundances may be enhanced as natives are reduced. Particularly at risk are mature forests and the wildlife species they support as well as amphibians which will have limited dispersal capacity conditions become dryer. Disruption of synchronicity is likely between insect development and nesting / hatching particularly of migrant bird species. Bark beetle conditions will be enhanced, increasing the threat to native forests.

Table 7. Likely Climate Trends and Consequences for the Rogue Valley.
Source: Journet, 2013, unpublished data.

Additionally, several studies indicate that climate change is likely to exacerbate forest damages resulting from disease and pests such as the mountain pine beetle. Mountain pine beetle populations are typically held in check by cold winters (EcoNorthwest, 2009). As the frequency of cold winters decreases, the mountain pine beetle's population will no longer be constrained. This could lead to rapid and widespread tree mortality. Furthermore, the mountain pine beetle is now beginning to show a potential to jump to non-pine species if pine is no longer available (EcoNorthwest, 2009). Mountain pine beetles potentially could impact the majority of remaining forest in Oregon. Adding to the problem, stressed trees increase the concentration of amino acids in their tissues, making them more nutritious for herbivorous insects (that are generally nitrogen limited) (Hsiao, 1973). Stress from insects and pathogens coupled with other local stressors such as increased temperatures and decreased soil moisture, will hasten tree mortality. There has already been a drastic increase in bark beetles, as one can see from Figure 26. This is a graph from region 6 of the US Forest Service, which covers the Rogue Basin.

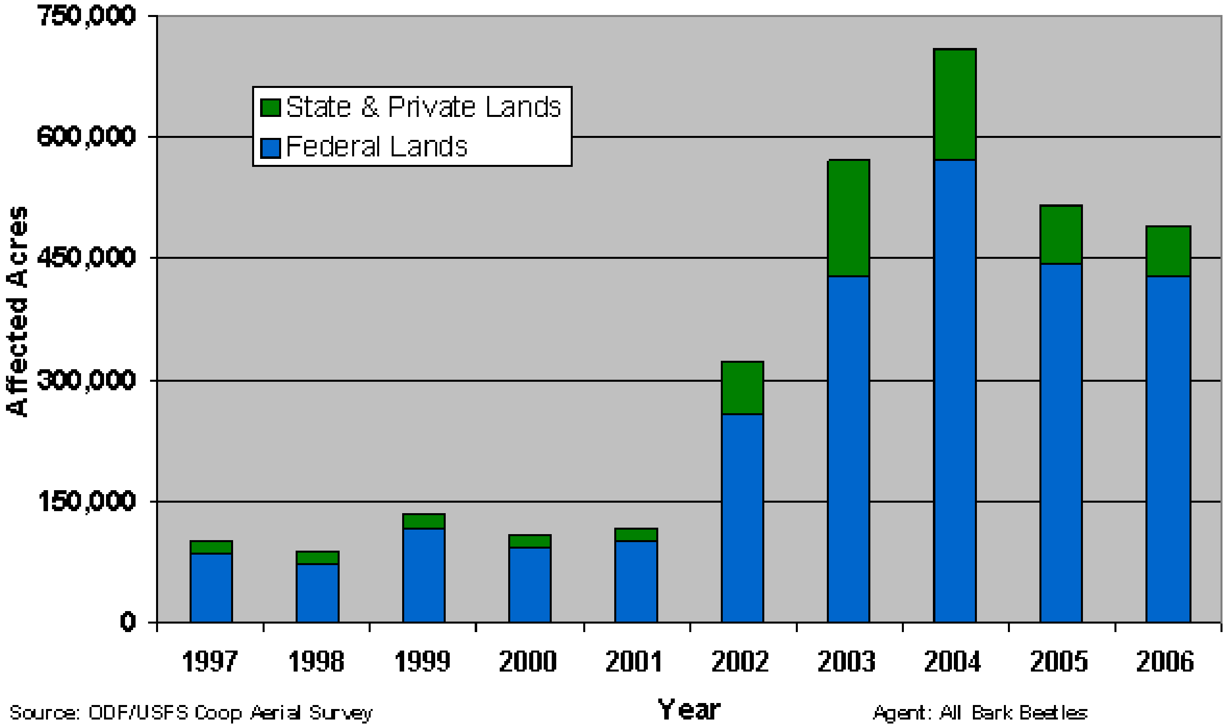


Figure 26. Bark beetle affected areas in region 6 of the US Forest Service.
Source: http://www.fs.usda.gov/detail/r6/forest-grasslandhealth/insects-diseases/?cid=fsbdev2_027213.

Analyses of the impact of climate projections on the forests of southern Oregon (e.g. Doppelt et al. 2008) indicate that the Douglas-fir association is likely to diminish but that the ponderosa pine and oak chaparral associations are likely to expand. By way of contrast, the climate envelope analyses of Rehfeldt et al. (2006) that identify where future conditions are likely to be suitable for the success of western tree species indicate that both the Douglas-fir and ponderosa pine are at risk. Maps are available at http://forest.moscowfsl.wsu.edu/climate/species/. The conflicting projections for ponderosa pine between these studies suggest that our confidence in knowing what will happen to these species and associations during the next century is not high. Uncertainty underlines the need for caution in forest management and the need for an adaptive management framework for management to maintain forest health in the face of climate change (Lawler et al. 2010).

Policy and Practices

Land Ownership

Over half of the Rogue Basin is federal land, with the Forest Service managing the majority of publicly owned lands (1.63 million acres), then the BLM (.87 million acres), and at a much smaller scale the National Park Service and others. There are over 1 million acres of private land, with 218,231 of those acres under small woodlands ownership, and ~ 315,000 acres to industrial and non-industrial owners, with John Hancock, a Timber Investment Management Organization (TIMO) managing the largest of that sector (~138,000 acres), followed by Plum Creek (a Real Estate Investment Trust (REIT)) (~75,000 acres), Lone Rock Timber (36,000 acres), Indian Hills Timber (~25,000-30,000 acres), Perpetua Forests (26,520 acres), and the Fruit Growers Supply company (~5,000 acres) (Figure 27 and Figure 30).

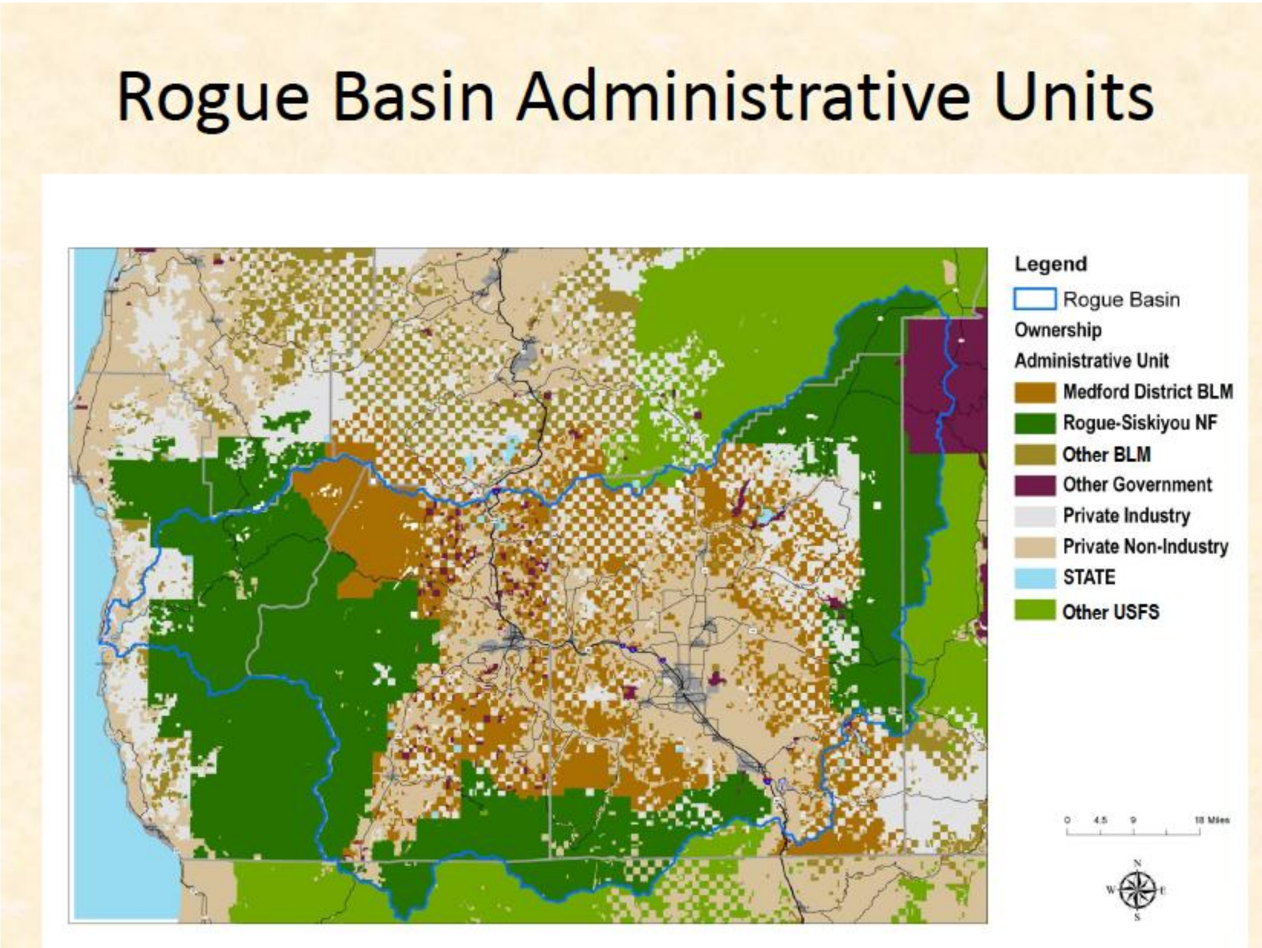


Figure 27. Land Ownership by Administrative Units of the Rogue Basin.
Source: Southern Oregon Forest Restoration Collaborative, 2013.

Of the 11 western states, Oregon has the largest area of homes in the WUI (Gude et al., 2012). The Rogue Basin in particular contains several of the most severely at-risk counties among western states, in terms of both existing risk of wildfire (number of square miles of the WUI with homes now), and potential future risk (number of square miles of WUI that remains undeveloped) (Headwaters Economics, 2013). Figure 28 is a map demonstrating WUI, residential, and public lands.

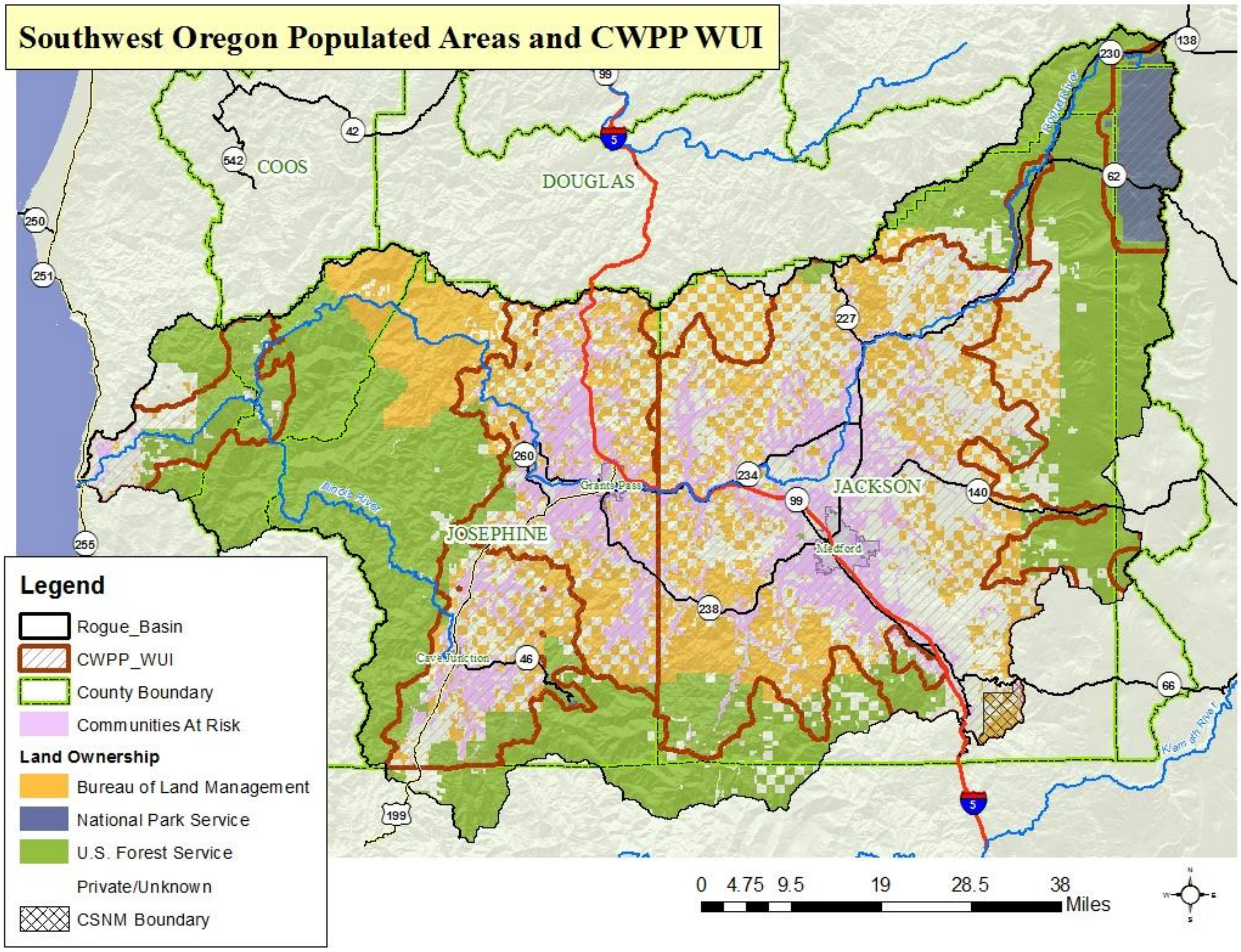


Figure 28. Homes in the Wildland Urban Interface.
Source: Jena DeJuilio, Medford Bureau of Land Management, 2013.

Land Use

The Rogue Basin comprises 3.3 million acres, most of which is forested. The primary uses are forest, followed by grasslands and shrubs, and to a smaller scale, agricultural, urban, and other uses (Figure 29). Land use patterns reflect ownership (Figure 30), however while 63% of the Rogue Basin is under federal ownership, and Oregon, similarly, is comprised of around 60% federal land, the majority of timber harvest comes from private forestlands (about 75% with 19% of land ownership, whereas federal harvest makes up about 15% of total Oregon harvest (Figure 31) (Oregon Forest Resources Institute, 2013).

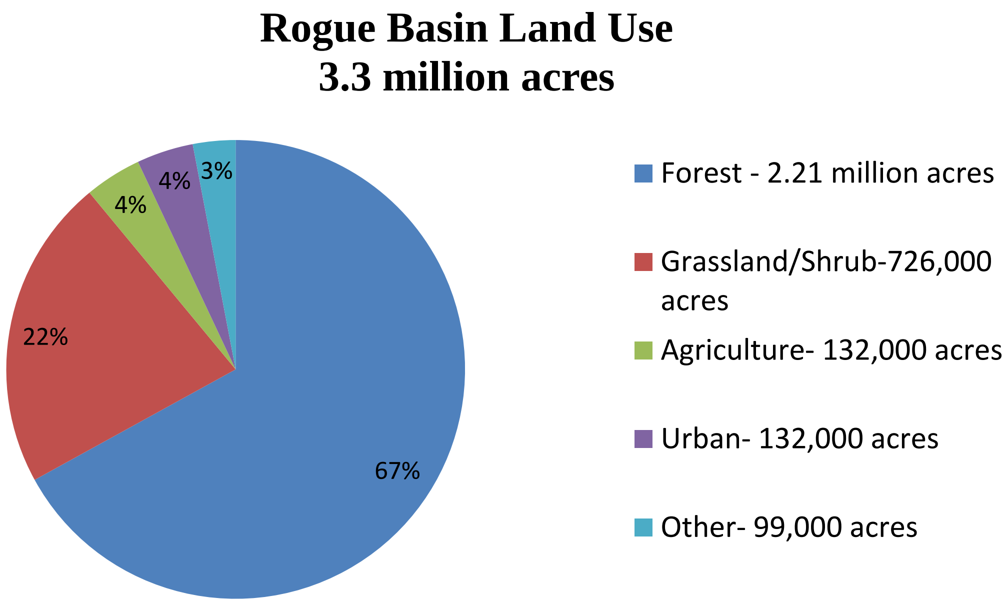


Figure 29. Land Use in Rogue Basin.
Adapted from the Oregon Department of Environmental Quality, 2012.

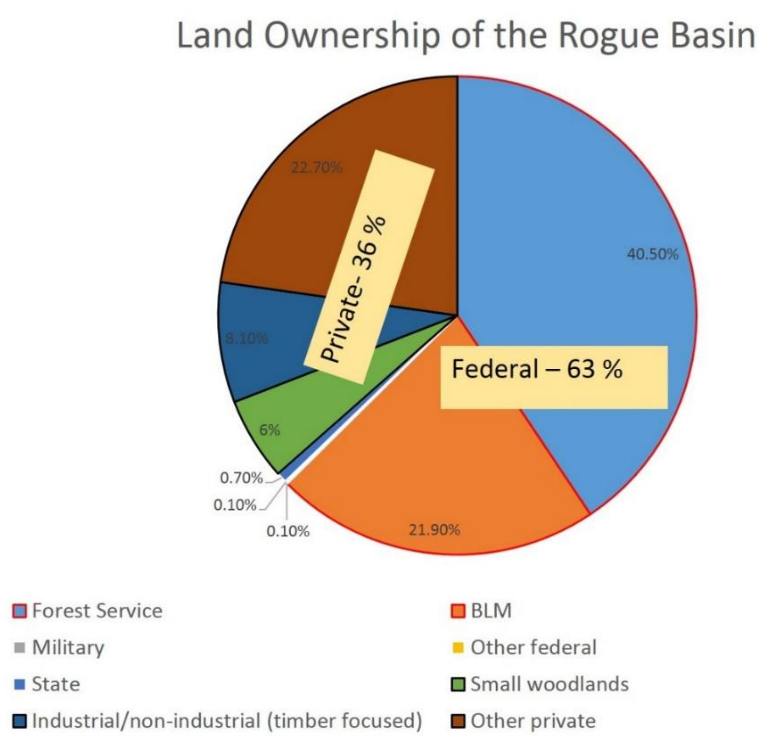


Figure 30. Land Ownership of the Rogue Basin. *Source: Myer, 2013 using data from US Geological Survey, Gap analysis Program. 2012. Protected Areas Database of the United States (PADUS). Version 1.3.*

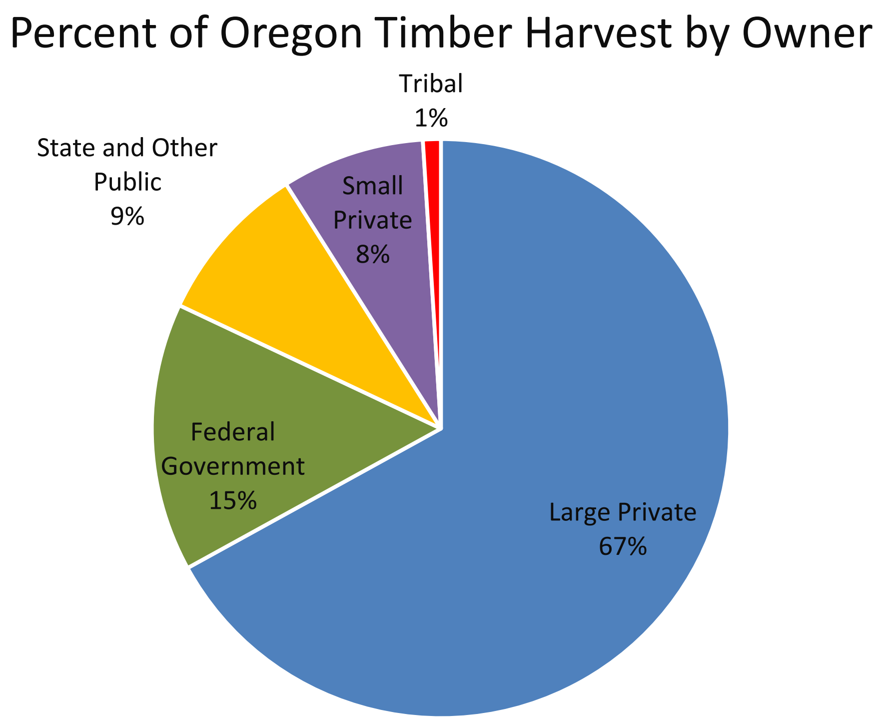


Figure 31. Oregon Timber Harvest by Ownership.
Source: Gwyn Myer, 2013. Using data from Oregon Department of Forestry, 2013.

Resource Governance

One of the largest threats to forest resilience is our ability to make choices and decisions that are truly for the greatest good considering all of the resources, ecosystem functions and processes. Fire suppression was a conscious choice and decision with huge impacts to ecosystems. The dramatic reduction in public timber harvesting (vegetation treatments) in the 1980s in response to concern over loss of habitat required by the Northern Spotted Owl was a socio-political consensus, choice, and decision. The intent was the protection of natural resources, but the consequences were huge and included potentially negative impacts to forest ecosystems. Governance of public forest land both in the past and present has homogenized forest structure. For an overview of existing governance and policy and who it affects or who administers it see Table 8. This is important when considering opportunities and threats for managing the forests.

Governance/ Policy	What it does/requires	Who it affects/who administers
O&C Lands Act 1937	Directs timberlands be managed for permanent forest production with the principal of sustained yield for the purpose of providing a permanent source of timber supply, protecting watersheds, regulating stream flow, and contributing to the economic stability of local communities and industries, and providing recreational facilities. - "Sustained Yield" – Requires that harvested areas be reforested; - Requires 50% of revenue generated from mgt of the land be returned to the 18 counties that contained revested lands. The revenues are divided annually by the percent of the assessed value of the lands in each county as they were in 1915.	BLM (USDI lands) (Must abide by.)
Payment in Lieu of Taxes Act (1976)	Under PILT, O&C counties receive payments per acre of land managed by the BLM or USFS to reimburse them for revenues lost from tax-exempt federal lands.	USFS/BLM
Secure Rural Schools and Community Self-Determination Act of 2000 (SRS Act)	This law was created to ensure counties that are dependent on FTPs could continue to count on "stable and transition payments that provide funding for schools and roads, make additional investments in projects that enhance forest ecosystems, and improve cooperative relationships." The law was set to end in 2008, providing counties 8 years to develop alternative ways of generating economic revenue from timber receipts. However in 2008, counties were still unprepared to generate enough revenue to cover county costs outside of the SRS Act, thus it was reauthorized from 2008-2011, and recently reauthorized for another year, however with declining amounts of money distributed (SRS Act).	
Northwest Forest Plan (1994)	- Protect critical habitat for Northern Spotted Owl. - Decreased timber yields. 5 Key Principles: 1. Never forget human and economics dimensions of issues 2. Protect long term health of forests, wildlife, waterways 3. Focus on scientifically sound, ecologically credible, and legally responsible strategies and implementation 4. Produce a predictable and sustainable level of timber sales and non-timber resources 5. Ensure federal agencies work together - Produce timber products while protecting impacted species. - Aquatic Conservation Strategy (restore and maintain ecological process for aquatic and riparian area conservation on fed lands in NW).	National Forests (FS), BLM, National Parks, National Wildlife Refuges, Military Bases (Must abide by.)

ESA (1973)	- Protect critically imperiled species from extinction as a consequence of economic growth and development. - Protect species and the ecosystems on which they depend. - If the timber harvest could impact a listed species, a biological assessment is prepared by the Forest Service and reviewed by the FWS or NMFS or both.	USFWS, NOAA (administers)—Any and all land mgt must abide by it.
CWA (1972)	Water quality standards consist of four basic elements: 1. Designated uses (Public water supply quantity/quality, protection of fish, wildlife, recreational waters, agricultural, industrial, and navigational. "Fishable/swimmable") 2. Water quality criteria 3. Antidegradation policy 4. General policies	EPA. DEQ, ODA. For: Streams, oceans, rivers, lakes of US. Everyone is supposed to abide by it
NEPA	To assure that all branches of government give proper consideration to the environment prior to undertaking any major federal action that significantly affects the environment.	EPA administers, any federal agencies must abide by it.
USFS Climate Score Card	- Create a balanced approach to climate change that includes managing forests and grasslands to adapt to changing conditions, mitigating climate change, building partnerships across boundaries, and preparing our employees to understand and apply emerging science. - Expected to do 7 of the following by 2015: employee education; designated climate change coordinators; program guidance; science and mgt partnerships; other partnerships; assessing vulnerability; adaptation actions; monitoring; carbon assessment and stewardship; sustainable operations).	FS must abide by it.
Multiple Use Sustained Yield Act 1960 (MUSYA)	To ensure that all possible uses and benefits of the national forests and grasslands would be treated equally. The "multiple uses" include outdoor recreation, range, timber, watershed, and wildlife and fish in such combinations that they would best meet and serve human needs.	FS must abide by.
Knutson Vandenburg (KV) Act (1930)	Portion of timber receipts goes directly back to forest, for 'reforestation'.	FS can utilize.
Healthy Forests Restoration Act	- Streamlines salvage sales and thinning projects. - Fire Control. - Removal of NEPA and other requirements (categorical exclusions).	Federal Forests must abide by.

Wilderness Act	- Protect lands as wilderness areas ('an area where the earth and community of life are untrammeled by man, where man himself is a visitor who does not remain'). - Can have multiple uses but the 'wilderness character' of area must be maintained. Specifically, mining, grazing, water uses, or any other uses that don't significantly impact the majority of the area, can remain in some degree.	NPS, FS, FWS, BLM all have wilderness areas.
Oregon Groundwater Protection Act 1989 (ORS 468B.150-190) and Groundwater Rules (OAR 340-040, 044, 045, 071, 073)	Establishes anti-degradation policy for groundwater resources. Establishes mandatory minimum groundwater quality protection standards relating to impacts from permitted sources or nonpoint sources such as agriculture and stormwater. Establishes statewide groundwater monitoring program. Requires private well testing for nitrate, e-coli and arsenic at property transfer. The goal of the Oregon Groundwater Quality Protection Act is to prevent contamination of groundwater and to conserve, restore, and maintain Oregon's groundwater resource for present and future uses.	DEQ, ODA
Safe Drinking Water Act 1974/1984	Sets national drinking water standards, develops programs to protect public water supplies. Designates method for establishment of source water protection areas around community water supplies.	DEQ, OHA
Governance/Policy mainly affecting/administered by city, county, and state		
Jackson County Fire Plan	- Reduce the risk of wildfire to life, property and natural resources in Jackson County by coordinating public agencies, community organizations, private landowners, and the public to increase their awareness of and responsibility for fire issues.	County
Josephine County Fire Plan	- Promote wildfire and public safety. - Build citizen awareness of wildfire. - Support the roles and functions of each the County's Fire Districts and Fire Service Providers. - Instill a sense of responsibility for taking preventative actions. - Communicate to residents, visitors and businesses what it means to live in a region with high wildfire risk. - Focus on collaborative decision-making, citizen participation, and landscape-scale fuels treatment projects. - Improve survivability to people, homes, and the environment when wildfire occurs.	County

Wildland Urban Interface (WUI) Property Regulations	Increase fire safety, defensible space, fire prevention surrounding homes near forested lands.	WUI property owners, county and state regulations (http://www.rvfpc.com/Preparedness/WUI_Regs/statewide_wui_regs.html).
Oregon Forest Practices Act	- Protection of water, air, wildlife, while still encouraging forest uses. Applies to: timber harvesting (soils, wildlife habitat, water quality must be protected), road construction/maintenance (soils and water must be protected), slash treatment (allows burning if soil, air, water protected), reforestation (tree stocking rule standards post-harvest), pesticide and fertilizer use (soil, air, water must be protected). - Requires tree retention along many streams/wetlands, lakes, scenic highways, wildlife areas. - ORS 527.722(4) allows counties to prohibit, but in no other manner regulate, forest practices in specific areas outside UGBs if an acknowledged exception to an agricultural or forestland goal has been taken. The intent of this allowance is to provide a way for counties to protect outstanding natural features if harvesting or their forest practices might damage them.	ODF implements.
Oregon Plan for Salmon and Watersheds (1997)	- Voluntary restoration activities by private landowners (especially forest landowners), supported by local citizens, students, businesses, and government. - Coordinated tribal, state, and federal agency actions. - Continued monitoring of watersheds health, water quality, and salmon recovery. - Rigorous scientific oversight by independent scientists.	State, private landowners
Jackson Co. Comprehensive Forest Plan and Land Development Ordinance	- Similar to the Oregon Forest Practices Act but more specifics for the county level. - Covers different designations and what they can/can't be---need to review this further.	Jackson Co.

Table 8. Forest Policy and Governance Chart outlining the policy and practices that influence forest land use, conversions, fire prevention and fighting, water resources and timber harvest practices

Economics and Forestry

Forestry has strong roots in southern Oregon and has historically been an important component to the local economy. The forestry industry in the Rogue Basin employs 30% of all of the forest sector workers for Oregon (Oregon Employment Department, 2013).

Reduced snowpack and stream flows, rising temperatures and the occurrence of drought will likely decrease soil moisture, weaken trees and increase disease. This will make forests more susceptible to wildfires, which will likely cause forest production to decline. A longer wildfire season may further narrow the window for harvesting trees (Doppelt et al., 2008). The current shift to small diameter logs requires markets, mills, and transportation and other infrastructure. These features are already limited and may be further restricted by climate change impacts (Doppelt et al., 2008).

During the boom of the timber industry the Rogue Basin was thriving economically and the counties were more than capable of handling expenses through the federal timber payments (FTPs) they received. FTPs are paid to counties because the majority of the land base is publicly owned, and therefore untaxed. As counties in states with large bases of federal land do not receive enough income from property taxes to cover county expenses, they receive federal timber payments as designated under the Payment in Lieu of Taxes Act (PILT). Under PILT, O&C counties receive payments per acre of land managed by the BLM or USFS to reimburse them for revenues lost from tax-exempt federal lands (Blumm and Wigington, 2011).

Figure 32. Timber has strong roots in Oregon. *Source: Oregonstate.edu.*

Of the timber harvest in Jackson and Josephine county industrial timber land accounts for the majority, followed by public lands, and then non-industrial private forest land owners (Table 9), with a trend of overall decreasing timber harvest regionally and statewide (Figure 33). From 1945-1989, timber harvests in Oregon average 7-9 million board feet (mbf) annually. Since 1989, due to changes in management emphasis and environmental litigation regarding old growth habitat, the timber harvests on federal lands fell by 90 percent (Oregon Forest Resources Institute 2013).

2011 Oregon Timber Harvest

	Industry	Other Private	Native American	State	BLM	FS	County and Municipal	Total
Jackson County	58,942	2,319	0	46	4,323	13,098	0	78,728
Josephine County	8,622	3,058	0	0	509	6,253	458	18,900
TOTAL	67,564	5,377	0	46	4,832	19,351	458	97,628

Table 9. 2011 Oregon Timber Harvest (in million board feet). *Sources: Forest industry, Other Private and Other Public harvests were compiled by the Department of Revenue and are subject to revision. Native American harvests were compiled from five Confederated Native American tribes by ODF.BLM harvests were compiled by the U.S. Bureau of land management. USFS harvests were compiled by the United States Forest Service.*

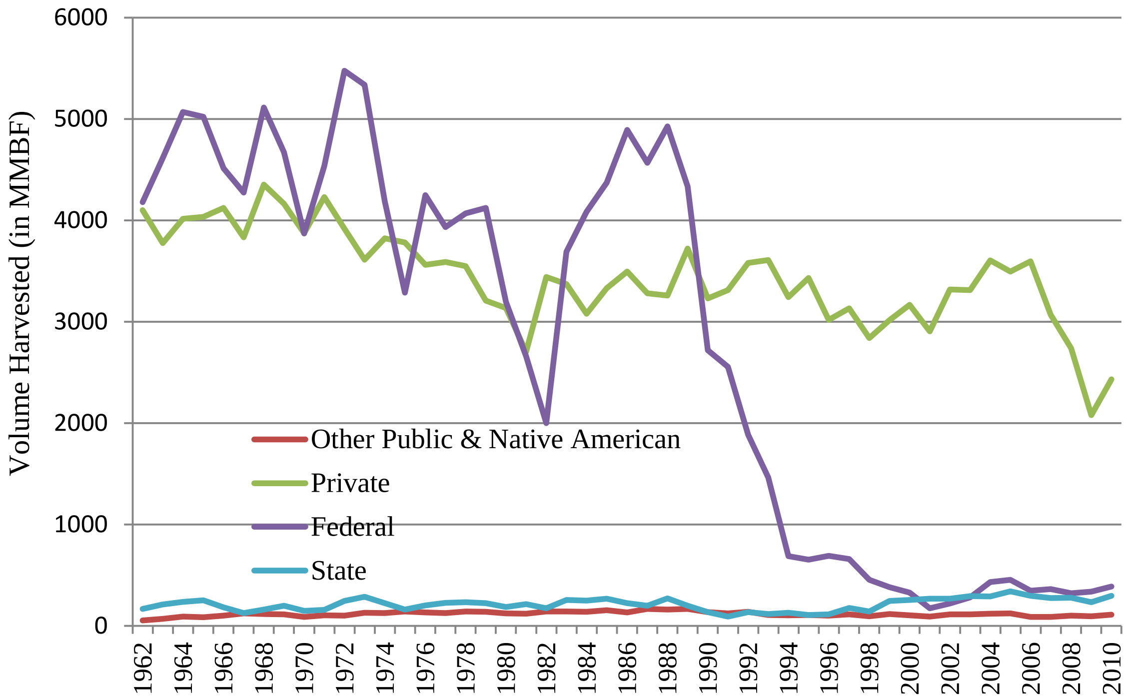


Figure 33. Decreasing timber harvest in Oregon. *Source: Oregon Department of Forestry, 2013.*

Since the timber industry's decline the region's economy has never fully recovered. Private employment in the timber industry has been decreasing and the trend continues. In 1998, timber represented 6.64% of total employment. By 2010, timber represented 4.28% of total employment. While timber still creates thousands of jobs in the region (Table 10), timber employment decreased by 28.6% from 1998-2010 (5,264 to 3,761) and non-timber employment increased by 13.6% (73,999 to 82,028) (Figure 34) (US Department of Commerce, 2012).

	Curry County	**Jackson County**	**Josephine County**	**County Region**
Total Private Employment	**4,638**	**63,965**	**19,186**	**87,789**
Timber	~587	~2,545	~629	~3,761
Growing and Harvesting	~96	1,111	~294	~1,501
Sawmills and Paper Mills	~488	~1,056	~171	~1,715
Wood Products Manufacturing	~3	~378	~164	~545
Non-Timber	~4,051	~61,420	~18,557	~84,028

Table 10. Private Employment in Rogue Basin Counties, 2010. *Source: U.S. Department of Commerce. 2012. Bureau of Economic Analysis, Regional Economic Information System, Table CA25N; U.S. Department of Commerce. 2013. Census Bureau, County Business Patterns.*

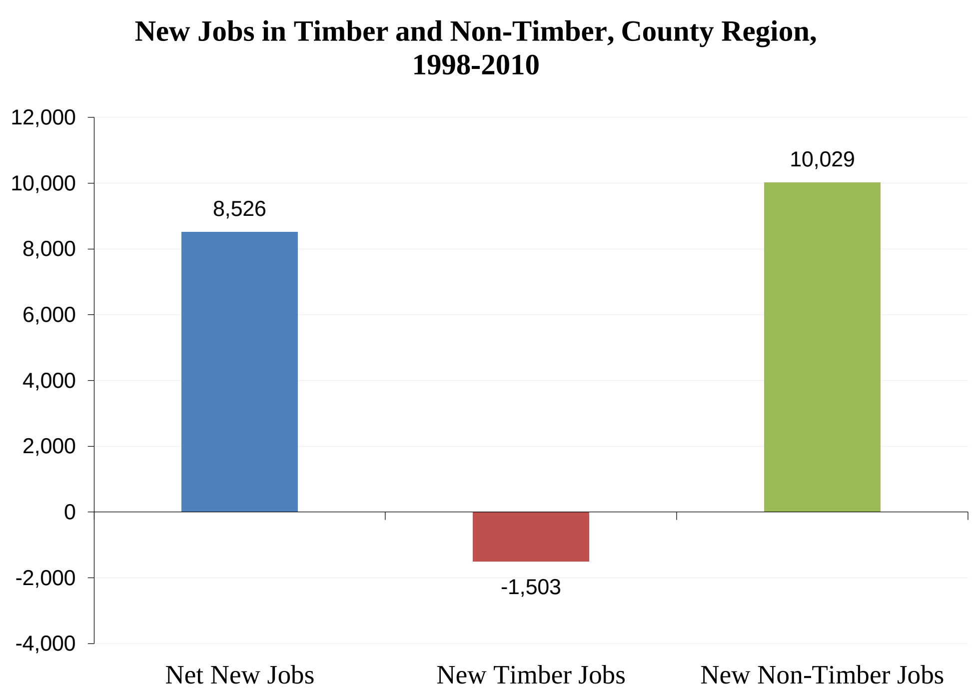


Figure 34. Jobs in Timber and Non-Timber 1998-2010. *Source: U.S. Department of Commerce. 2012. Bureau of Economic Analysis, Regional Economic Information System, Washington, D.C. Table CA25N; U.S. Department of Commerce. 2013. Census Bureau, County Business Patterns.*

In conjunction with a decrease in jobs in the timber market, there has been a state-wide decrease in cut volume, a decrease in cut value, and a decrease in cut price (Figure 35) (Headwaters Economics, 2013). This has resulted in the closure of several mills, leaving only 2 mills presently operating in the Rogue Valley.

When timber harvesting decreased drastically in the late 80s, the counties dependent on federal timber payments were hard hit. They are still receiving FTPs, but due to the decline in harvesting, the money provided to the counties is minimal compared to what it was during the timber boom. As a result of the Northwest Forest Plan and other measures that shifted the regional economy away from timber, the Secure Rural Schools and Community Self-Determination Act of 2000 (SRS Act) was created to ensure counties dependent on FTPs could continue to count on "stable and transition payments that provide funding for schools and roads, make additional investments in projects that enhance forest ecosystems, and improve cooperative relationships" (Secure Rural Schools Overview, 2009). The law was set to end in 2008, providing counties 8 years to develop alternative ways of generating economic revenue from timber receipts. However in 2008, counties were still unprepared to generate enough revenue to cover county costs outside of the SRS Act, thus it was reauthorized from 2008-2011, and reauthorized for 2012 and 2013, however with declining amounts of money distributed (SRS Act). A recent 2012 assessment of Oregon county dependence on FTPs demonstrates the importance of these payments to the counties (see *the Secretary of State's Audit Report: Oregon's Counties: 2012 Financial Condition Review* for more information). Counties would be severely impacted if SRS funds were to cease, and the counties of the Rogue Basin (Jackson, Josephine, and Curry) are among the most dependent on timber receipts in the state (Figure 36). This leaves the counties in a vulnerable state as the Act has been set to expire for years, and it is uncertain how long or if it will continue to be reauthorized (Secretary of State, 2012).

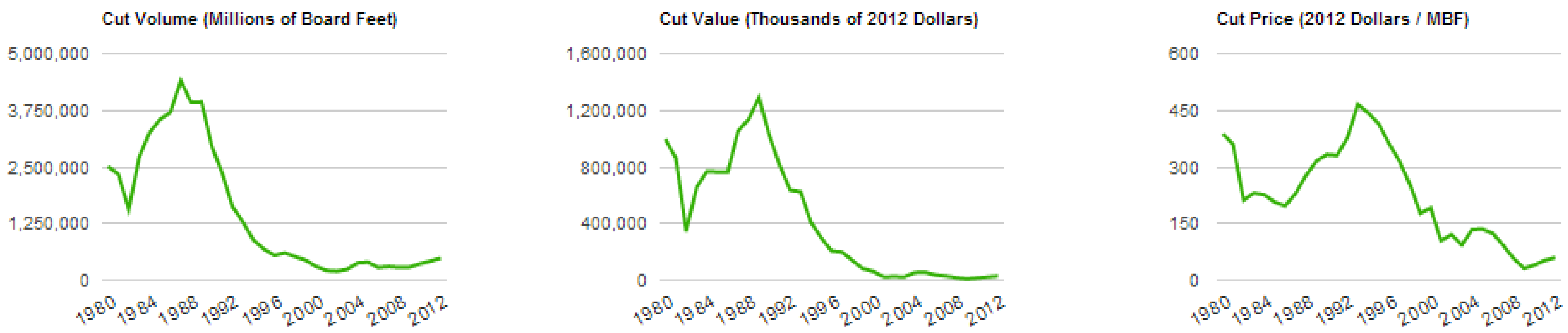


Figure 35. Cut Volume, Value, and Price 1980-2012. *Source: Headwaters Economics, 2013.*

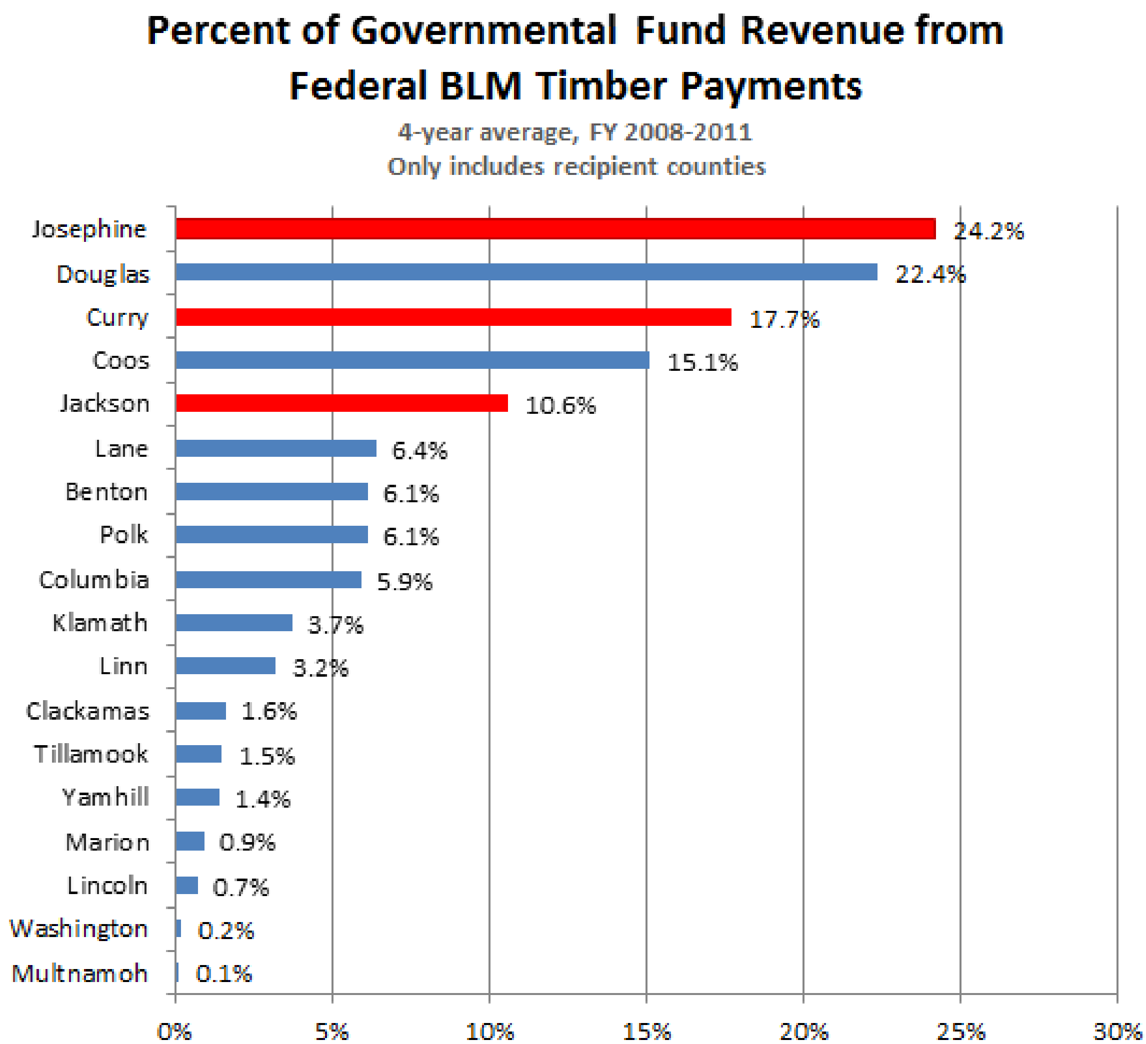


Figure 36. Percent Government Fund Revenue from Timber Payments to Counties.
Adapted from: Secretary of State Audit Report: Oregon's Counties: 2012 Financial Condition Review.

Currently federal land management in Southern Oregon has largely been in a stalemate. Due to conflicting resources and mandates under the O&C Act, the Northwest Forest Plan, and Resource Management Plans, the BLM is hard pressed to move forward with active land management and avoid litigation. The requirements of the O&C Act constrain alternative forms of management, such as restoration ecology or stewardship contracting as they do not meet the required timber output and do not provide the payments to counties in receipts. There are several proposed solutions to this predicament, but the outcomes are uncertain.

Oregon representatives DeFazio, Schrader, and Walden, propose splitting the O&C lands into a timber zone managed by a private trust, and a conservation zone managed by the USFS. Another solution entails a new county payments program and an extension of PILT for five more years (Blumm and Wigington, 2011). Blumm and Wigington (2011) suggest these solutions are inadequate: the former for not adequately protecting the environment, undermining the integrity of the Northwest Forest Plan (NWFP), and basing economic recovery on outdated industrial forestry assumptions; and the latter for not fully understanding the Northwest forest economy, lack of a viable long-term solution to the O&C county funding issues, and lack of incorporating stakeholder values. Other congressional proposals address federal forest management at a broader scale, encompassing resolution of O&C land issues within a national framework.

In 2012, Oregon Governor Kitzhaber put together a special interest task force to propose solutions for the O&C counties and federal forest management in those regions. A February 2013 "O&C Lands Report" was prepared by the governor's staff to highlight the range of issues and series of proposed solutions to the situation. While the task force failed to reach consensus or come to shared understanding on key issues, the report provides key background information and a series of alternatives to address ways to solve the O&C situation. Within this report, the sale of public forest land to set up an interest bearing account is assessed for economic viability.

Oregon's Senator Ron Wyden is a linchpin for resolution of the O&C issue due to his position as chair of the Senate Energy and Natural Resources Committee. In a recent (May 2013) "O&C Legislative Framework" release, Wyden proposes to advance legislation that will divide O&C lands into sustainable harvest units and conservation areas, promote public/private land exchanges to consolidate management, and generate funds for counties through revised timber receipt sharing and additional federal legislation to support fiscally challenged counties. The legislation will also modernize existing laws to ensure a reliable, predictable and sustainable flow of timber from federal land.

Blumm and Wigington (2011) propose a solution involving a combination of payments for ecosystem services (i.e., watershed protection and recreation); local sales tax initiatives; higher state taxation of log exports; increased county property tax rates; and possible federal management consolidation of the O&C lands.

The above are proposed solutions to the current state of the local economy and the difficulties of active federal land management. However it is critical to have community engagement in any proposed solution to create healthy, working communities and forests, and to collaboratively develop a process to get the communities out of economic dependence on FTPs and have a more stable county income over time. O&C counties estimate they need $110 million annually to sustain county services (Blumm and Wigington, 2011).

Potential Forest Solutions and Strategies for Climate Resilience

Primary strategies to adapt forests to future threats include reducing competition and promoting drought and fire tolerant species (Millar et al 2007; Joyce et al. 2009; Allen et al. 2010, Lawler et al. 2010, Spies et al. 2010, Peterson et al. 2011, Franklin and Johnson 2012). Specifically that means reducing numbers of shade tolerant tree species (e.g. white fir) and regenerating tree species like ponderosa pine that are shade intolerant but resistant to drought and fire (North et al. 2012). Resource dynamics driven by within-stand spatial patterning, such as light availability, are critical for determining long-term vegetation trajectories (Larson and Churchill 2012). Forest restoration treatments have additional benefits, protecting habitat, water, and other critical values threatened by severe fire (Millar et al. 2007, McKinley et al. 2011, Safford et al. 2012). Since major fire events can devastate forests and release vast amounts of carbon, managing our forests to reduce the likelihood of such events constitutes a sound policy in support of carbon sequestration, particularly when such activities are conducted conservatively, in an adaptive management framework (Millar et al. 2007, Lawler et al 2010, Spies et al. 2010, Peterson et al. 2011) and scaled to historical and likely future fire return intervals (Hurteau & Brooks 2011).

Our greatest challenge is our capacity to effectively create change that will minimize the negative impacts and risk of landscape-scale, stand-replacing fires. Fire will continue to be the dominant process influencing vegetation of southwestern Oregon into the future. The questions are: When will fires burn through the forest? Under what environmental conditions will fires burn? And what are the likely outcomes of fire events when they occur? Fire is the primary disturbance/stressor that has created the incredible diversity and inherent resilience of forest ecosystems in southwestern Oregon. They will continue to be a part of the ecosystem, but how we choose to manage the forests can influence the impacts of fire positively or negatively.

Critical elements of change are: 1) awareness of the issues, 2) getting the socio-political consensus and license to manage vegetation at a large enough scale in a reasonable period of time, and 3) adequate funding. Resilient forest ecosystems are capable of adapting to change and stress. Threats to the forest ecosystems of southwestern Oregon directly attributable to a changing climate are amplified by current fire suppression policies and governance related to vegetation treatments on public forest lands. Ecologically speaking, forest density, species conversion to shade tolerant trees, degraded aquatic habitat, and increased fuel loads are the primary stressors on forested lands. Primary solutions are landscape planning, forest density reductions, and the reintroduction of large-scale fire (both prescribed and from natural ignitions). Appendix A provides more information on local forest stressors and potential solutions, with governance, responsible parties, and additional comments

Under the current and expected funding framework it is very unlikely that sufficient funds for restoration treatments will be available through government appropriations/taxes or non-profit organizations at a scale, and in a time frame, to successfully minimize potential for large, landscape-scale, stand-replacing fires. Harvesting trees and converting them into products has the potential to generate the value to achieve restoration at scale, but stewardship contracting is necessary for this and is politically difficult. Stewardship contracts with the BLM do not include payments to counties, and often need subsidized as they are not done at large scales. This can make support for such practices difficult. However there are mechanisms to use stewardship contracting and receive economic benefits, as demonstrated in the SOFRC integrated restoration assessment. Stewardship contracting is likely to have many direct and indirect benefits to counties as well, but without timber receipts explicitly demonstrating the benefits, it can be politically difficult to gain support for such an approach.

Another potential constraint is the infrastructural capacity to utilize the amount of wood generated from the vegetation treatments and convert it into value-added products. Much of the wood processing capacity in southwestern Oregon, and the entire West, has been lost with the dramatic reductions in public timber harvesting since 1980. Investment to increase processing capacity and new economic development opportunities will require community consensus and assurances of wood supplies.

Providing tangible information (such as demonstration sites) on how different management strategies affect those items which the public values or utilizes from the land (water, recreational values, forest products, old growth, etc.) is important to engage citizen participation. Engaging the public in a context where discussion is fostered and encouraged can increase community participation and understanding. This in turn increases public engagement in management decisions and increases the likelihood of the public to provide ideas for alternative management strategies. These approaches have been demonstrated to be more effective at increasing knowledge and support for alternative forms of management than traditional, one way communication such as brochures or public meetings (Toman et al., 2008; Toman et al., 2006; Parkinson et al., 2003). Guided field trips and demonstration sites have also been shown to increase understanding and support, reduce uncertainties, and enhance goodwill and relationships among stakeholders and agency personnel (Toman et al., 2008).

Preparing for climate change doesn't necessarily require rewriting management plans or creating something new: it's finding the vulnerable places and deciding on which techniques to use to manage for the resources and ecosystem services people value.

The Southern Oregon Forest Restoration Collaborative and partners have been working to develop a common sense strategy and analytical framework to identify forest restoration need and opportunity in the Rogue Basin. Broad goals for the strategy include: restore a diverse mosaic of healthy, resilient forests; conserve habitat with special attention to species and risk; and support regional forest products and associated workforce capacity (SOFRC, 2013). In contrast to emphasis in the past on timber production as the primary goal of forest management, this strategy generates forest products and associated economic outputs through treatments specifically designed to achieve a broad range of ecological outcomes and services, as well as a broad range of social benefits, such as fuels reduction prioritized by a local fire plan. Goals and outputs for individual projects and planning landscapes will vary. However, the overall goal is a balance of social, ecological, and economic objectives. Central to the strategy are landscape emphasis areas designed to guide prescription development based on identified conditions and need. These emphasis areas include: complex forest habitat, fuels management, riparian systems, and ecosystem resilience and forest productivity. This is a strategy SOFRC would like to see applied at landscape scale, incorporating private lands as well. Sustainable harvesting mechanisms are critical to forest and watershed health; for clean water and reduced fire risk while protecting critical habitats and resources. These need to be implemented on federal and private lands. Many private landowners feel their lands is threatened by fire because of adjacent federal lands that have not been actively managed. Collaborating with private land owners on management strategies can help to create more resilient forests at a larger scale, and develop implementation strategies that can be mutually beneficial and supported.

The ultimate goal of collaborative actions (including adaptation to climate change) in southwestern Oregon should be to promote diverse, resilient forests that support clean water, abundant wildlife, and local economies. A critical strategy to accomplishing these goals is to restore fire's role in maintaining resilient, healthy forest ecosystems capable of adapting to environmental disturbances. This will involve thinning the forest in identified priority areas, promoting shade-intolerant species and returning spatial heterogeneity through gap creation, and appropriate fire use. A second strategy is to identify those forest communities most at-risk, buffer them from the more direct impacts of climate change (i.e., severe fire), and ensure that corridors are open for species migration and community adaptation to future climate.

Restoration and thinning activities will additionally increase revenues to counties. Payments for ecosystem services can provide an alternative source of revenue to counties, as can local sales tax initiatives, higher state taxation of log exports, and increased county property tax rates. Collaborative management of the O&C lands can make it possible to approach ecosystem restoration at a landscape level approach, which is necessary to create truly resilient watersheds, forests, and counties.

Water Key Points

Streamflows in the Rogue Basin are heavily dependent on snow. The majority of surface water use is through the irrigation sector. Over 70% of the Rogue Basin depends on ground water for its supply. In drought years and during the late summer months, water supplies can dwindle and streams can have insufficient water. Climate change stressors will lead to even lower flows during this period.

Climate risks currently happening to the supply and quality of surface water in the Rogue Basin include: decreased snow pack; more precipitation falling as rain instead of snow; more extreme precipitation events leading to floods and erosion; longer base flow (drought) periods; increasing stream temperatures; earlier peak stream flows; and wildfires which can cause erosion, sediment, debris, and ash to enter the water supply system.

These risks impact aquatic species, limiting the habitat for cold water species such as Salmon. In turn, recreation and tourism industries suffer from threats to aquatic habitat (fishing); decreased snow pack (skiing); wildfires closing recreational areas; and earlier peak flows (rafting).

The largest surface water stressors identified by ODEQ include temperature, channel and habitat modification (over simplification of channels), and altered hydrology.

There are several adaptive and mitigation strategies that can be implemented, with restoration of riparian areas and fire risk management addressing a multitude of these stressors. Restoration work is also proven to be an economic benefit to the local communities.

Water Assessment

Figure 37. Soda Springs. *Photo Credit: Gwyn Myer.*

Assessment Process

To plan for effective stewardship of the water resources of the Rogue Basin, a careful water resource assessment was included in the planning process. The water assessment was collaboratively researched by a variety of experts. These included: Chris Volpe, Fisheries Biologist at BLM; Laura Hodnett, Medford Water Commission; Bill Meyers, Oregon Department of Environmental Quality; Sam Whitridge, Rogue Basin Coordinating Council; Eugene Weir, The Freshwater Trust; and Brian Barr, The Geos Institute. Other outside expertise that contributed information included: City of Ashland, Ashland's Water Treatment Plant, and Medford's Water treatment plant.

Resources used are listed in the references and include: Oregon DEQ's Rogue Basin Water Assessment (2012), Water Quality Status and Action Plan for the Rogue Basin (2011) and TMDL report (2008); Medford and Ashland's Water Conservation Plans; Gold Hill, Gold Beach, and Grants Pass's websites for water information; and the Rogue Valley Irrigation District.

Introduction

All land is part of a watershed. A healthy watershed provides food, fiber, clean water, and habitat for native plants and animals. It moves sediment, cycles nutrients, stores and purifies water, reduces flooding and erosion, and even affects air quality through absorption of pollutants and greenhouse gases (marinwatersheds.org). Collectively these benefits of a healthy watershed are often referred to as ecosystem services to describe what they provide to human communities. Healthy watersheds are more resilient to disturbances such as climate change, fire, and anthropogenic stressors, than highly-impacted watersheds. A healthy watershed has the following characteristics (marinwatersheds.org):

- High water quality that can support native aquatic species
- Streams and floodplains that can accommodate flood flows without regular, destructive erosion
- Seasonal streamflow patterns that are close to historic conditions
- Streams that have complex habitat features (pools, gravel bars, large woody debris) to support aquatic species
- Native keystone species that sustain stable populations. Examples of keystone species in Oregon include the Chinook and Coho salmon and beaver
- Non-depleted, high-quality, groundwater resources that cool surface water bodies in summer and warm them in winter, support habitat, provide for year-round stream flow, and provide irrigation and water supply

Climate change will impact the water cycle and characteristics that comprise a healthy watershed. With the projected increases in air temperature from climate change, the distribution, volume, timing, and type of precipitation will change. Water needs by native plants and animals will also change. Human demand for water is likely to increase as well, especially during dry periods. Figure 38 summarizes projected changes in the water cycle due to climate change impacts.

While different predictive models may not generate the same outputs, there are general patterns emerging from the various models. On a national scale, some areas are likely to receive more precipitation, while others will receive less. Overall, warming temperatures will result in less precipitation falling as snow resulting in smaller snow packs; earlier snowmelt; increased incidence of rain-on-snow flooding; reduced dry season stream flows; greater moisture stress on vegetation; and increased stress on aquatic ecosystems. Droughts and floods are likely to increase, both in frequency and severity, which is already occurring in many areas across the country. Insect outbreaks may be more severe, and increases in frequency and size of large wildfires will impact water quality through increased erosion (fs.fed.us/ccrc/topics/water.shtml). Clean water supplies and water-related ecosystem services will be at greater risk. This water assessment is aimed at identifying the specific water impacts in the Rogue Basin that are already occurring and projected to intensify in order to prioritize the risks and develop appropriate local adaptation solutions.

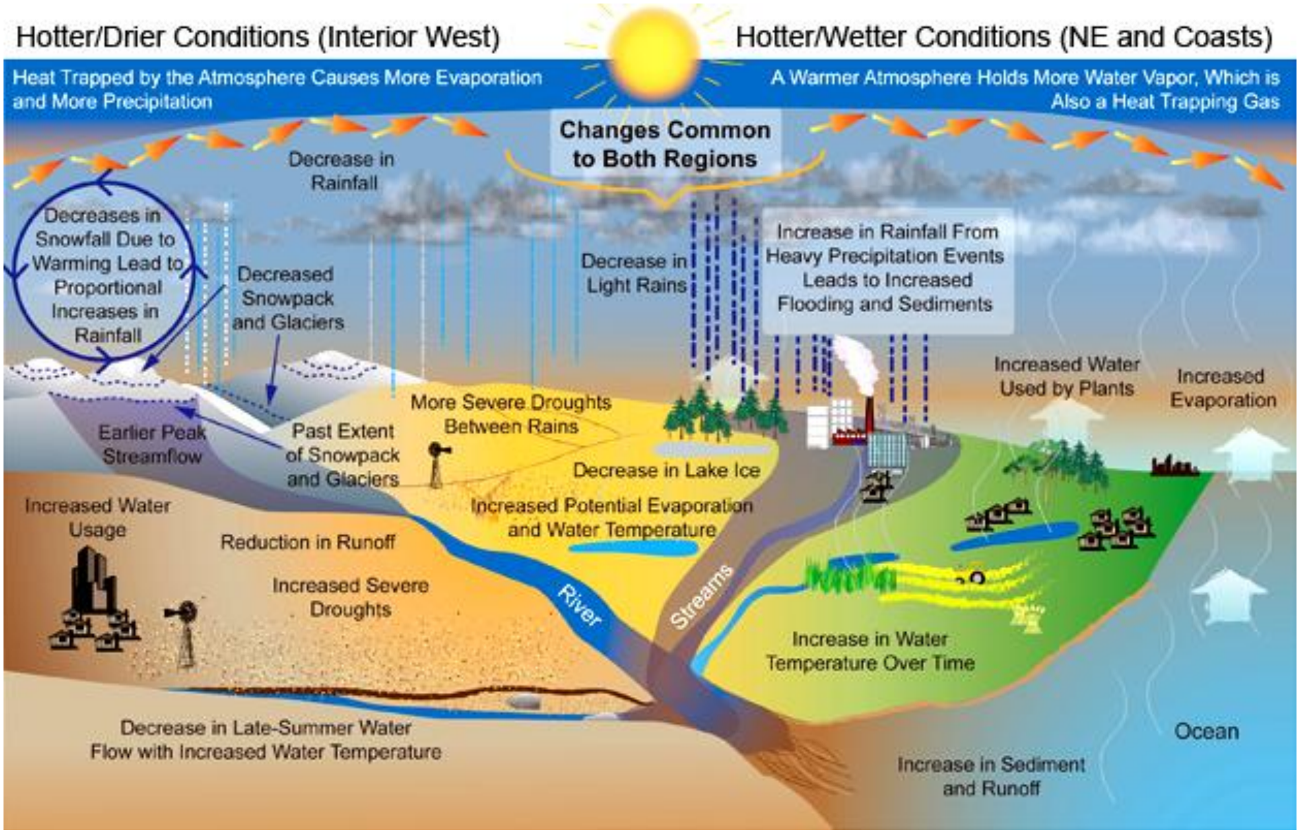


Figure 38. Key changes to the hydrological cycle associated with climate change.
Source: US Global Change Research Program http://nca2009.globalchange.gov/projected-changes-water-cycle.

Watershed History, Current Conditions and Trends

The Rogue Basin is located in a transitional area with four different climate zones: Pacific Maritime on the coast, Oregon High Desert in the East, California Mediterranean in the South, and Northern Temperate in the north (ODEQ, 2011). This results in highly unpredictable weather and large annual fluctuations in precipitation and temperature within longer climatic cycles (ODEQ, 2011). Significant snowfall occurs at higher elevations, and rainfall ranges from 20 inches in the interior valleys to 120 inches on the coast (Figure39).

Throughout the Rogue Basin, most of the precipitation falls during the late fall, winter, and early spring months. At higher elevations in the interior valley, precipitation falls predominantly as snowfall and leads to higher flows in May as the snow melts. However, in the coastal range most of the precipitation falls as rain. This can result in rapid runoff and high flows during winter storms, and low flows during the summer drought periods (ODEQ, 2011).

There are five sub basins that drain to the Pacific Ocean: Lower Rogue River, Middle Rogue River, Upper Rogue River, Illinois River, and the Applegate River (ODEQ, 2012). Draining 5,156 square miles, the sub basins run from the northeastern flanks of the Siskiyou Mountains to the western flanks of the Cascade Mountains, with elevations varying from 0 feet to 9,485 feet. The Rogue Basin totals 3.3 million acres. Land cover is 67% forest, 22% grassland/shrub, 4% agriculture, and 4% urban (3% other) (USGS 2001 National Land Cover Database) (Figure 40). Approximately 60% of the Rogue Basin is publicly owned, and is managed for multiple uses including water quality, timber production, livestock management, and wildlife and recreation (ODEQ, 2011).

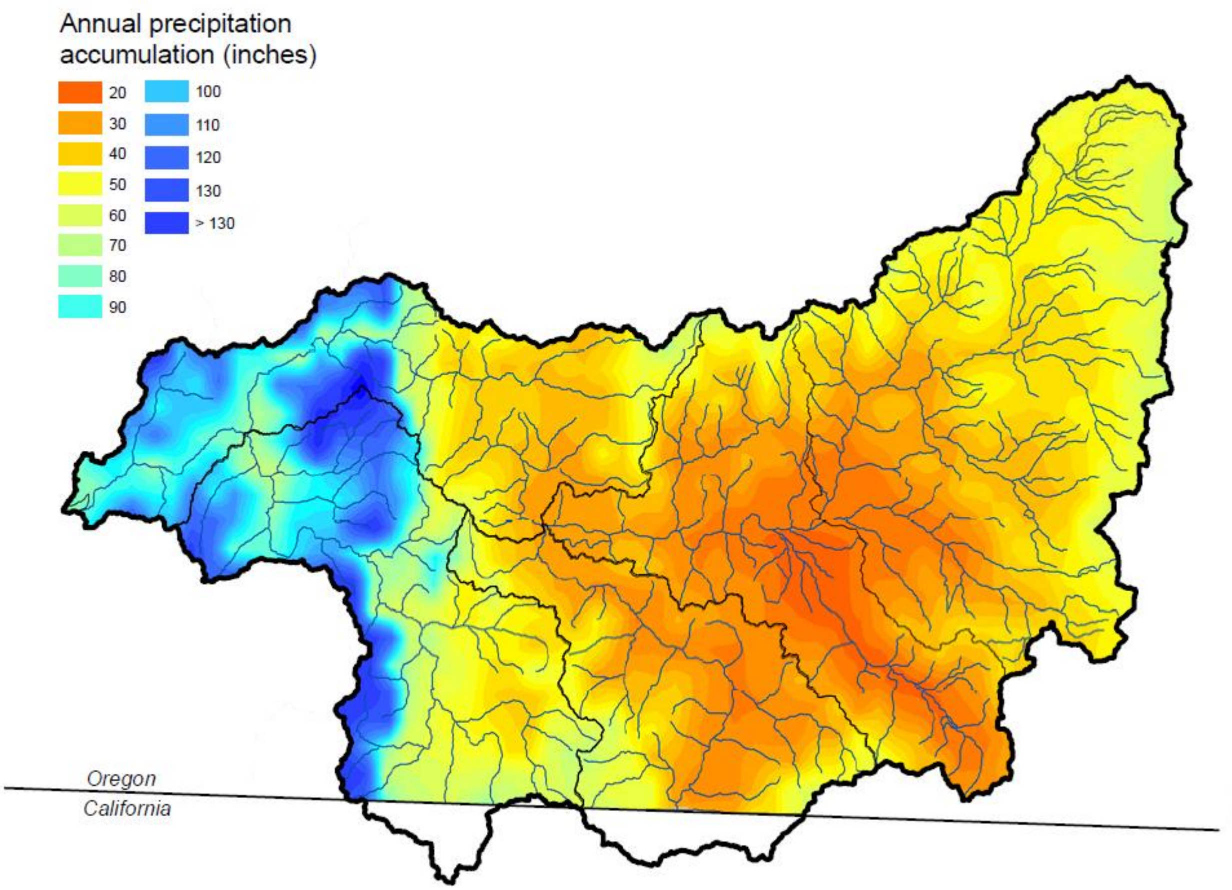


Figure 39. Annual precipitation accumulation in the Rogue Basin.
Source: Oregon Department of Environmental Quality, 2008.

The Rogue Basin provides drinking water to nearly 260,000 people, with the majority of that population concentrated around Bear Creek, primarily in the Medford area, which is the 4th largest metro area in the state of Oregon. The population of the cities in the Bear Creek region are: Medford (75,501), Ashland (20,322), Central Point (17,308), Talent (6,115), Phoenix (4,575), and Jacksonville (2,807). Half of the population in the basin lives along Bear Creek, (US Census Bureau, 2011). Outside of the Bear Creek valley but still in Jackson County are Eagle Point (8,537), Shady Cove (2,298), Rogue River (2,148), and Butte Falls (427). The Rogue Basin covers parts of Jackson, Josephine, Curry, Klamath and Douglas Counties in Oregon with portions located in Siskiyou and Del Norte County California. Jackson County has the largest population (204,822). Josephine County has the second largest population (82,897), and includes the cities of Grants Pass (34,646), and Cave Junction (1,890). Curry County only has one city within the Rogue Basin, Gold Beach (2,260) (US Census Bureau, 2011). Small, relatively uninhabited portions of the Rogue Basin are in Klamath and Douglas counties (ODEQ, 2011).

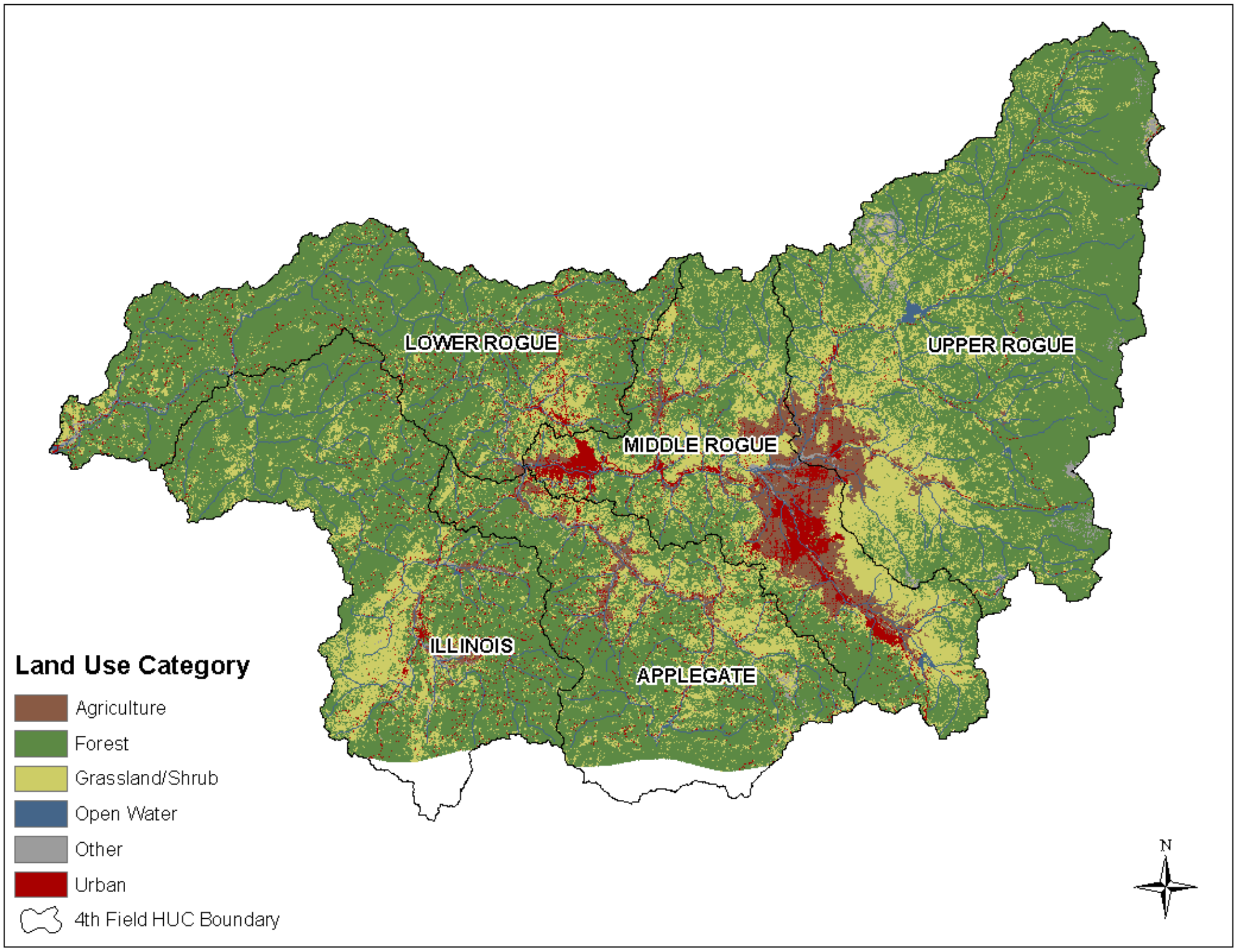


Figure 40. Land use in the Rogue Basin. *Source: ODEQ Rogue Basin Water Analysis, 2012.*

Water Supply

As the climate changes, projections show an increase in demand for water due to hotter temperatures and longer drought periods. Climate change has compromised, and will continue to impact, water security by reducing summer stream flows. In the Pacific Northwest, declines are especially acute as demonstrated from observed and predicted shifts in precipitation phase from snow to rain, earlier onset and faster rates of snowmelt, increased summer evapotranspiration, and increased frequency of rain on snow events (Mote et al., 2009; Das et al., 2011).This is already occurring in the Rogue Basin and is projected to worsen (Figure 41).

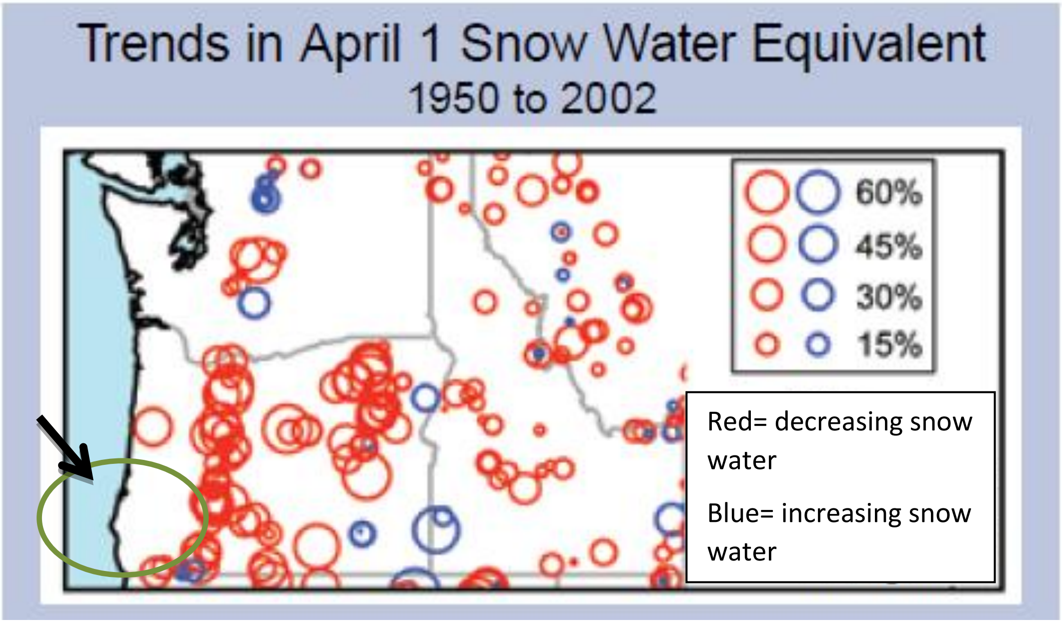


Figure 41. Declining snow water in the Rogue Basin.
Source: U.S. Global Change Research Program, 2009.

Stream flows in the Rogue Basin are allocated for irrigation, mining, and domestic use. The Rogue Basin has 6,898 approved surface water rights, many of which pre-date statehood. In the 1950s, it was determined that natural flow amounts were not adequate to supply all water rights and most of the basin closed further appropriation. Senior water right holders can continue using water in low flow years, as long as water is available to meet demand. Three irrigation districts (Talent, Medford, and Rogue River Valley) supply irrigation, municipal and industrial water to over 35,000 acres in the Rogue Basin. Some of this water comes from interbasin transfer and is at risk from competing claims (Rogue Valley Irrigation District, 2012). The Irrigation districts provide a yearly report to Oregon Water Resources Department of total water used. Boating, fishing, and other recreational activities are popular on the reservoirs created by dams constructed by the districts, which are accessible to the public. All of the reservoirs are also widely used by wildlife (Rogue Valley Irrigation District, 2012).

Water use in the Rogue Basin is dominated by irrigation, with 52% of water use in Jackson County and 75% in Josephine County serving this sector. Below is a chart of estimated water use by sector, with Jackson and Josephine counties representative of the Rogue Basin (Figure 42).

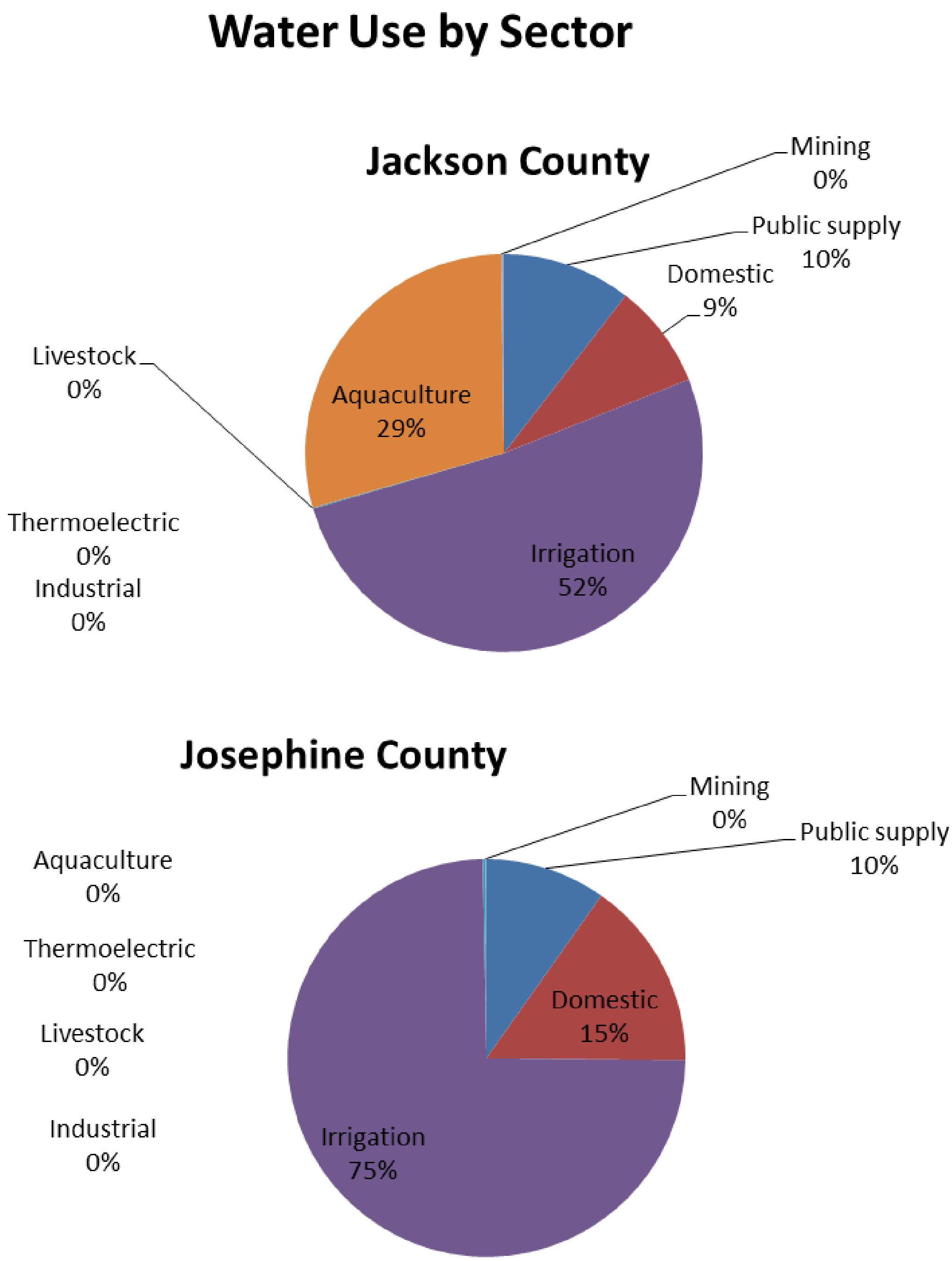


Figure 42. Surface Water Use by Sector. *Source: Myer, 2013 using data from USGS estimated use of water in the US county-level data for 2005.*

Irrigation and water withdrawals affect water quantity and quality (temperature, dissolved oxygen, pH) which affects aquatic habitat (Table 11) (ODEQ, 2011).

Waterbody	Flow at mouth (cfs)* Current	Flow at mouth (cfs)* Without withdrawals	Predicted temperature increase due to decreased flow (°C)**
Little Butte Creek	17.5	56.2	5.7
North Fork Little Butte Creek	13.7	36.1	3.2
Antelope Creek	6.4	8.9	1.4
Elk Creek	3.2	7.2	1.6
Rogue River Mainstem	1957	2370	0.9
Evans Creek	3.0	8.7	0.5
South Fork Little Butte Creek	9.2	12.8	0.5

*Flows are from August 1 of the applicable model year and temperatures based on average changes to the portion of the stream modeled (i.e. not predicted change at the mouth).
**Impact of water withdrawals on maximum 7-DADM temperatures for various waterbodies as predicted by water quality modeling.

Table 11. Modeled impact of water withdrawals on temperature.
Source: Oregon Department of Environmental Quality, 2011.

In the Rogue Basin there are 22 public water systems using surface water and 251 public water systems relying on ground water (in whole or in part) (ODEQ, 2011). The Medford Water Commission (MWC) is the largest supplier of potable water. MWC directly serves customers within Medford, White City (unincorporated) and 3 small water districts that border the city. The cities of Central Point, Eagle Point, Jacksonville, Phoenix and Talent are also served on a wholesale basis (the cities purchase treated water from MWC and in turn distribute it to their customers). Phoenix, Talent, and Jacksonville have acquired water rights to water stored in Lost Creek Reservoir, which MWC treats and transports for their use during the summer season. Part of the water supply contract with MWC requires these cities to obtain water rights to meet their summertime demands. Quantities sufficient to meet their 2020 summertime demands must be secured by 2015. The total population served by MWC is estimated at 125,000 - 130,000. The other municipal suppliers in the Rogue Basin are owned and operated by their respective cities: Ashland, Grants Pass, Cave Junction, Gold Hill, Rogue River, and Gold Beach. In addition, there are a large number of small public water suppliers and thousands of private well owners dependent on groundwater supplies.

On an annual basis, about 80% of the MWC's water is supplied from Big Butte Springs, which is a groundwater supply. Big Butte springs capacity ranges from 25-35 million gallons per day (mgd) depending on rainfall, snow pack, and groundwater conditions, but the transmission facility capacity limits withdrawal to a maximum of 26.4 mgd. During the summer months (typically May - October), water from the Rogue River is utilized as a supplemental supply. Water is withdrawn at the Robert A. Duff Water Treatment Plant on Table Rock Road, which has a capacity of 45 mgd (Medford Water

Commission, 2009). During those summer months, Rogue River water may comprise more than half of the supply. Water usage varies, particularly as temperature changes (use increases with increasing temperatures), and the amount of Rogue water used fluctuates accordingly. The remainder of the municipal water suppliers use Rogue River water year round, except Gold Beach which draws water from a shallow ground infiltration gallery 5 miles up the Rogue River, which is then treated by a filtration plant (City of Gold Beach website, 2013).

Ashland's primary supply is the West and East Forks of Ashland Creek (all surface water), which is collected in Reeder Reservoir before it is treated at the plant. Ashland also uses Talent Irrigation District (TID) water during the summer. The City of Ashland buys water rights from the Talent Irrigation District. They then sell the water to customers for irrigation purposes that live along the irrigation ditch. In curtailment years, or when running short on supply in summer, TID water is added into Ashland Creek, then routed to the water treatment plant where it is treated for drinking water if need be.

MWC has historically had an excess of water from its groundwater and surface water sources, and for now is able to meet water supply demands into the near future. However with projections of climate change, it is not likely to continue to have a surplus into the longer term future. MWC trends mirror those nationwide with winter (indoor) usage declining, reflecting plumbing code changes (mandating efficient fixtures) that became effective in 1994 and other water efficiency measures. MWC has also seen declines in industrial usage over the last 30-40 years, and overall per capita usage has declined. The last five years have shown little to no growth in population of areas served by the MWC. Maximum Day Demands (MDDs) have been relatively stable the past five years, however it is important to consider that there are normal fluctuations in MDD. MDDs fluctuate from year to year because they are strongly influenced by weather patterns such as the following (MWC 2009):

- Maximum temperatures
- The number of consecutive days at high temperatures
- When high temperatures occur during the summer (For example, if high temperatures occur early in the summer, the demand may be higher because residents are more consistent in their outdoor irrigation. Later in the summer customers may not be as inclined to maintain green landscapes)
- Rainfall levels during the summer
- The number of consecutive days without rainfall
- Number of new homes with new landscapes

For more details about MWC's water supplies, see Page 2-29 + from the Water Management & Conservation Plan http://www.medfordwater.org/Files/MWC%20WMCP%202009.pdf.

Water use and demands are projected to increase with population growth and climate change projections. According to a population trend analysis incorporating climate change projections (A2 scenarios), Jackson County is projected to increase in population by over 9%, while Josephine County is projected to decrease in population by 25% by 2050 (EPA 2009). However, given the region is at a lower risk for catastrophic natural disasters and climate change impacts than most other parts of the country, these estimates may be low as climate refugees seek haven in areas projected to have less impacts (i.e., the Pacific Northwest) (Figure 43 and Figure 44).

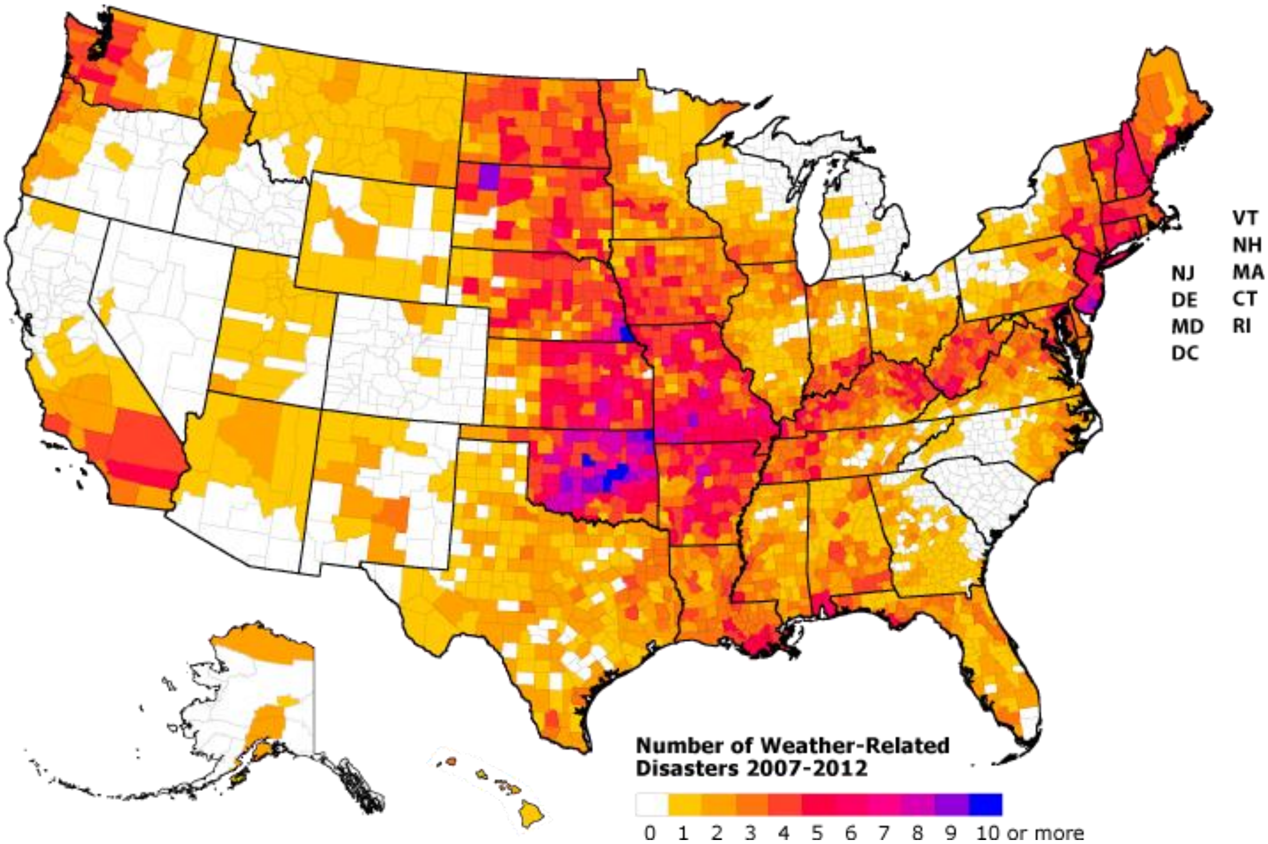
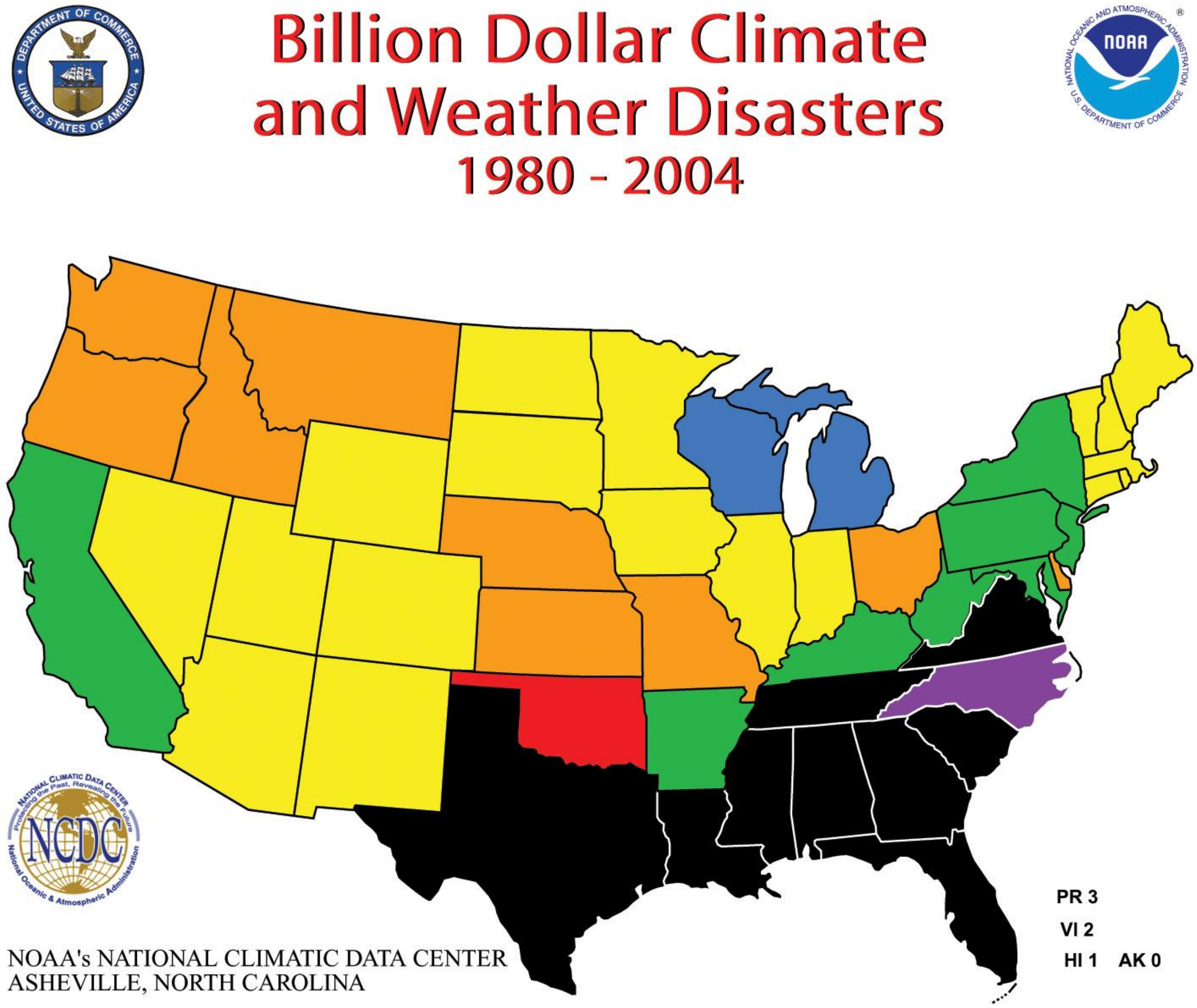
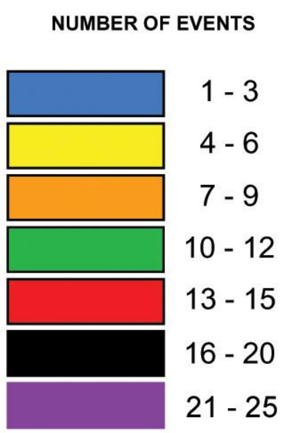


Figure 43. Number of weather related disasters 2007-2012. *Source: Environmentamerica.org, 2013.*

The state of Oregon requires municipal water suppliers to prepare Water Management & Conservation Plans (WMCP) and submit them to the Oregon Water Resources Department. Certain actions start the clock ticking for submittal, including filing for new water rights. Currently, Jacksonville is working on updates to their plan, and Phoenix & Talent have existing plans. Central Point and Eagle Point haven't completed their plans yet, the MWC completed their plan in 2009, and Ashland completed a comprehensive water master plan adopted in 2012 (http://www.ashland.or.us/SIB/files/2012%20CWMP-Carollo%281%29.pdf). The Oregon Administrative Rules for WMCPs require that all water suppliers establish five-year benchmarks for: annual water audits, system-wide metering, meter testing and maintenance, unit-based billing programs, leak detection and repair, and public education. However, having a plan is just a step in the process. MWC has operated conservation programs for several years. Most of the smaller utilities have done very little in terms of conservation actions thus far. Ashland is the exception and like Medford, has had a conservation program for more than 20 years. Ashland has experienced supply shortages at times, and perhaps as a result they have pursued the most conservation actions within the Rogue Basin.





DISASTER TYPE	NUMBER OF EVENTS	PERCENT FREQUENCY	NORMALIZED DAMAGES (Billions of Dollars)	PERCENT DAMAGE
Tropical Storms/Hurricanes	20	32.3%	144	36.8%
Non-Tropical Floods	12	19.4%	55	14.1%
Heatwaves/Droughts	10	16.2%	144	36.8%
Severe Weather	7	11.3%	13	3.3%
Fires	6	9.6%	13	3.3%
Freezes	2	3.2%	6	1.6%
Blizzards	2	3.2%	9	2.3%
Ice Storms	2	3.2%	5	1.3%
Noreaster	1	1.6%	2	0.5%
	62		391	

Please note that the national map color-coded by state reflects a summation of billion dollar events, for each state affected--ie, it does not mean that each state shown suffered at least $1 billion in losses for each event.

Figure 44. Billion Dollar Climate Disasters from 1980-2004. *Source: NOAA, 2005.*

Groundwater supplies the needs for 70% of Oregon via private, public, and industrial water wells. Groundwater is a critical natural resource providing domestic, industrial and agricultural water supply, base flow for rivers, lakes, streams and wetlands, and other beneficial uses. In areas where groundwater supply wells are hydraulically connected to surface water bodies, groundwater extraction can impact surface water resources (ODEQ, 2011). In the Pacific Northwest, deep groundwater aquifers serve an important role in mediating stream flow response to climate variability and warming (Safeeq et al., 2013). Summer stream flows in watersheds that drain slowly from deep groundwater and receive the majority of precipitation as snow are most sensitive to climate warming (Safeeq et al., 2013). The Rogue Basin is an area dominated with deep groundwater systems (Figure 45). However, more information and research is needed to better understand the impacts of climate change on groundwater, and the impacts of groundwater to streams and water supply and quality.

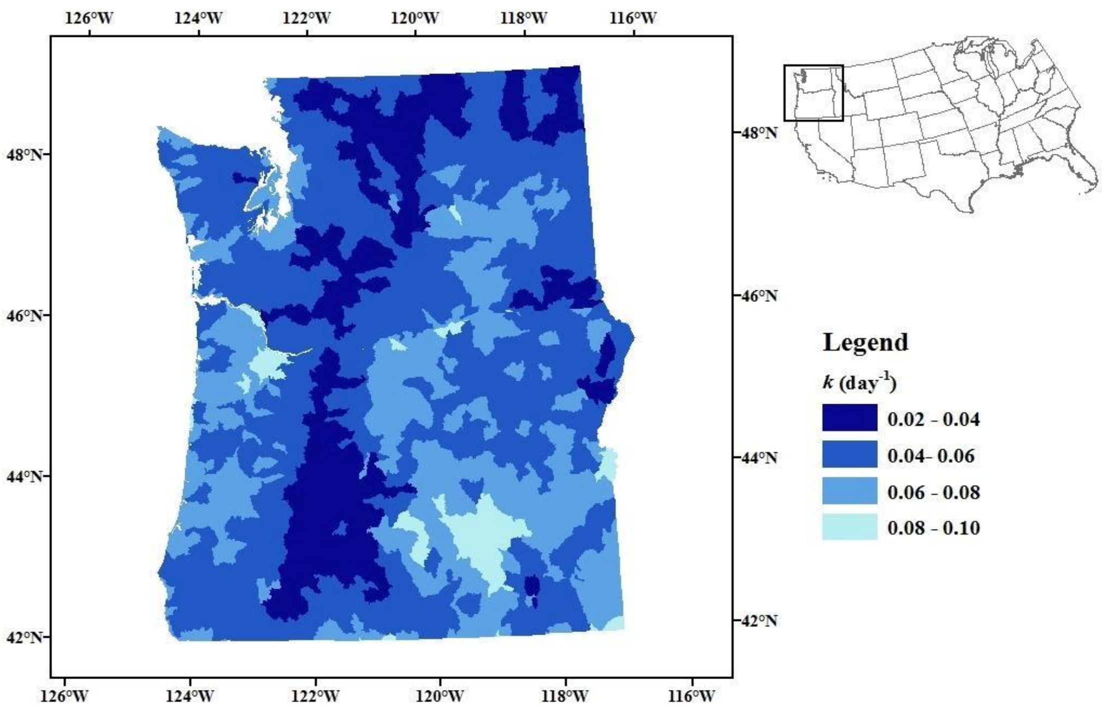


Figure 45. Spatial distribution of recession constant *k*. Lower *k* values represent deep groundwater-dominated systems; higher *k* values represent surface flow-dominated systems.
Source: Safeeq et al., in press.

Luce and Holden (2009) found large and widespread declines in the lowest annual stream flows from 1948-2006. Stream flows appear to be getting lower even in natural systems, but there is not a general consensus of the cause; speculation ranges from overly dense forested stands, to changes in precipitation regime due to climate change, to natural climatic cycles (Chris Volpe, personal communication). This is an information gap that needs to be filled. Surface water quantity is a major issue of concern in the Applegate, Middle, and Upper Rogue sub basins. Watershed analyses (examples include Rogue River, Gold Hill, Little Butte Creek, Bear Creek) conducted in these sub basins have identified several streams that are over allocated (surface water rights). Summer stream flows are commonly reduced to nothing in many of the smaller tributary streams to the Applegate River and middle and upper Rogue sub basins (i.e., Foots, Galls, Kane, Star Gulch, Thompson Creek). These changes impact consumptive water use, hydropower, and aquatic biota, particularly recreationally and commercially important species like salmon, steelhead, and trout.

Water Quality

Just as climate change is projected to affect water quantity, it in turn is projected to impact water quality. Higher temperatures, lower summer stream flows and shifts in the hydrologic cycle will impact water quality and habitat for cold water aquatic species. Algae blooms are likely to increase while dissolved oxygen levels decrease. There are many existing stressors to water quality, and climate change impacts will exacerbate those existing vulnerabilities. Wildfires can also severely impact water quality by reducing the forest's ability to filter and store water and through increased erosion in the years immediately after the fire. As stream flows become reduced, more pressure will be placed on groundwater supplies; as groundwater supplies decline, stream recharge, temperature moderation, and water quality will all likely be affected. The following paragraphs provide an overview the current water quality in the Rogue Basin.

Water quality in the mainstem reaches of most sub basins (Applegate, Illinois, Upper and Lower Rogue) can be characterized as generally being good, though there are concerns such as temperature and channel modification. The mainstem Rogue River in the Middle Rogue Sub-Basin suffers periodically (in particular during low flow-summer periods) from high levels of nutrients. The reaches especially affected include the portion between the mouths of Little Butte and Bear Creeks (area includes the Medford sewage treatment plant), and reaches below the old Gold Ray Dam site. These sites are currently being impacted by excessive sedimentation as decades of deposited fine sediment are working their way down the system. The summary of surface water quality concerns (Figure 46) reveals that 100% of the surface streams are impaired for temperature, altered hydrology and habitat modification.

Excessive summer water temperatures are a common Water Quality Limited listing parameter for urban, rural, and even some forested streams (Figure 47), however there is a plan in place by ODEQ that should result in water temperature improvements. These high summer temperatures put habitat for Chinook and Coho salmon, Steelhead and resident Rainbow trout at risk. The likely causes of high water temperatures in the Rogue Basin include urban and rural residential development near streams and rivers, reservoir management, irrigation water return flows, past forest management within riparian areas, NPDES regulated point sources, agricultural land use within the riparian area, water withdrawals, and road construction and maintenance. Climate change impacts with rising ambient air temperatures are likely to contribute this problem.

Surface Water	Bacteria	Biological Stressors, Harmful Algae Blooms	Temperature	Dissolved Oxygen	Nutrients, pH ,Chlorophyll a	Altered Hydrology	Habitat Modification	Sediment / Turbidity	Toxics: Emerging Contaminants, Pharmaceuticals, PCPs	Toxics: Metals	Toxics: Arsenic	Toxics: Mercury	Toxics: Pesticides
Upper Rogue	Red	Red	Red	Yellow	Yellow	Red	Red	Red				Green	
Middle Rogue	Red	Yellow	Red	Red	Red	Red	Red	Red	Yellow	Yellow		Red	
Lower Rogue	Green		Red	Green	Green	Red	Red	Yellow					
Applegate Subbasin	Green		Red	Red	Yellow	Red	Red	Yellow				Yellow	
Illinois Subbasin	Green	Yellow	Red	Green	Yellow	Red	Red	Yellow					

Red	Generally poor condition, **substantial** concern for water quality.
Yellow	Deteriorating condition, **moderate** concern for water quality.
Green	Generally good condition, **low** concern for water quality.
	Unknown condition or lack of data.

Figure 46. Summary of surface water quality concerns in the Rogue Basin.
Source: ODEQ Water Quality Assessment Report, 2012.

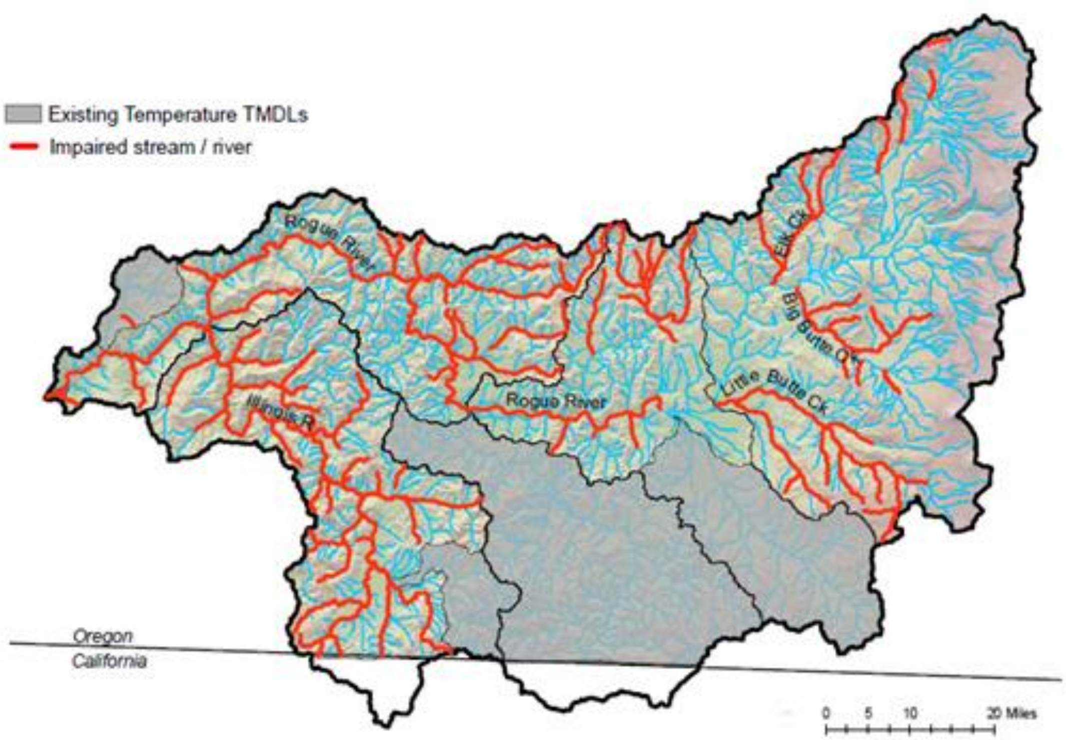


Figure 47. Temperature impaired streams in the Rogue Basin.
Source: Oregon DEQ Rogue River Basin TMDL, 2008.

Habitat modification and altered hydrology of streams can have a variety of negative impacts, including a decrease in resiliency to floods and drought (in other words, the impacts of floods and drought will be greater), interrupted surface flow, and a loss of floodplain connectivity. Somewhat unique to the forested streams in the Rogue Basin, in particular those streams draining the Siskiyous, is that many are subject to various levels of (mostly) gold mining, ranging from recreational operations to large-scale, channel-altering, and highly disturbing plan of operation scale gold mining. The legacy of historic mining includes miles of stream reaches which have been straightened, channelized, and armored by worked tailings; to this day, stream segments subjected to this type of mining disturbance still have an increased likelihood of interrupted surface flow during low flow periods. Current mining practices, even at a recreational scale, have localized impacts to aquatic and riparian habitat and aquatic organisms. Turbidity increases resulting from mining may often be above ODEQ standards (Christopher Volpe, personal communication, June 3, 2013).

Impervious surfaces also contribute to degradation in water quality. Natural environments filter water, slow drainage, and recharge groundwater supplies, whereas urban environments have fast, eroding runoff, with pollutants often flowing directly to streams (Figure 48). Acreage around most of the major and many of the small streams in the Bear Creek Valley have been developed with homes, roads, farms, etc., resulting in the loss of trees and shrubs in riparian corridors. This correlates with increases in stream temperatures, the simplifying of channels, and resulting reduction in quality and quantity of aquatic habitat. That combined with the withdrawals of water results in diminished stream flows. Lack of water and stream temperature are some of greatest concerns to aquatic organisms in this area) (Christopher Volpe, personal communication, June 3, 2013).

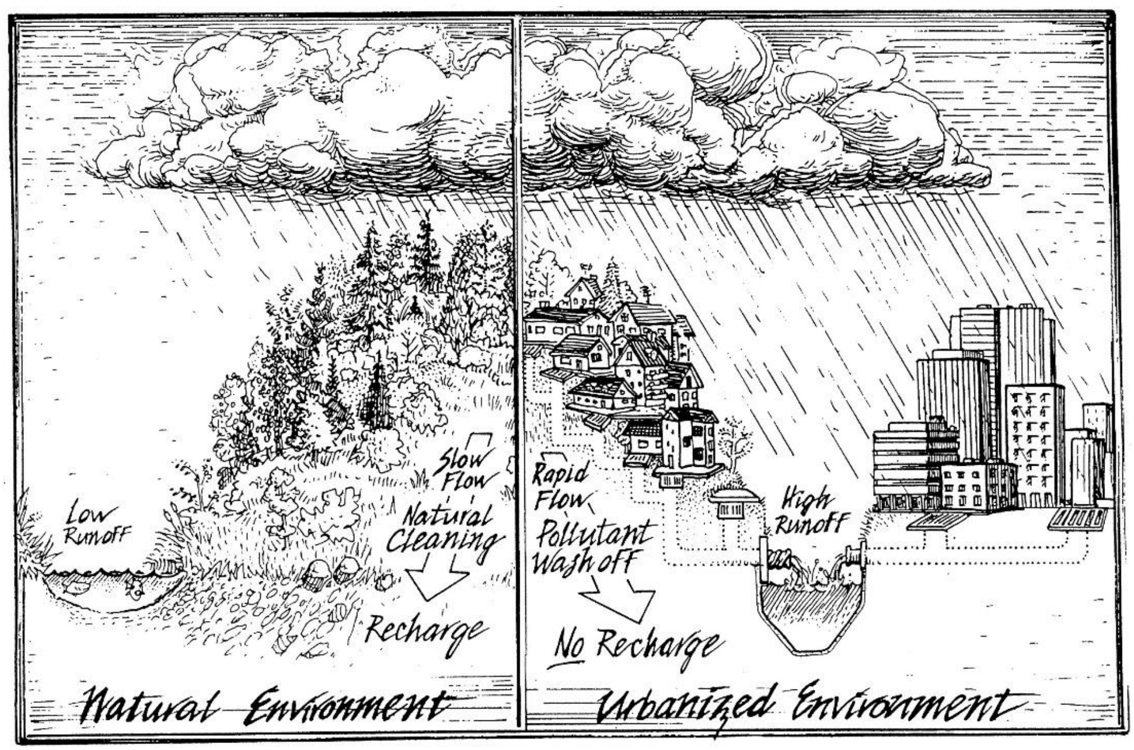


Figure 48. Natural vs. Urban Environment Stormwater Runoff.
Source: http://rvcog.org/MN.asp?pg=NR_Stormwater_General.

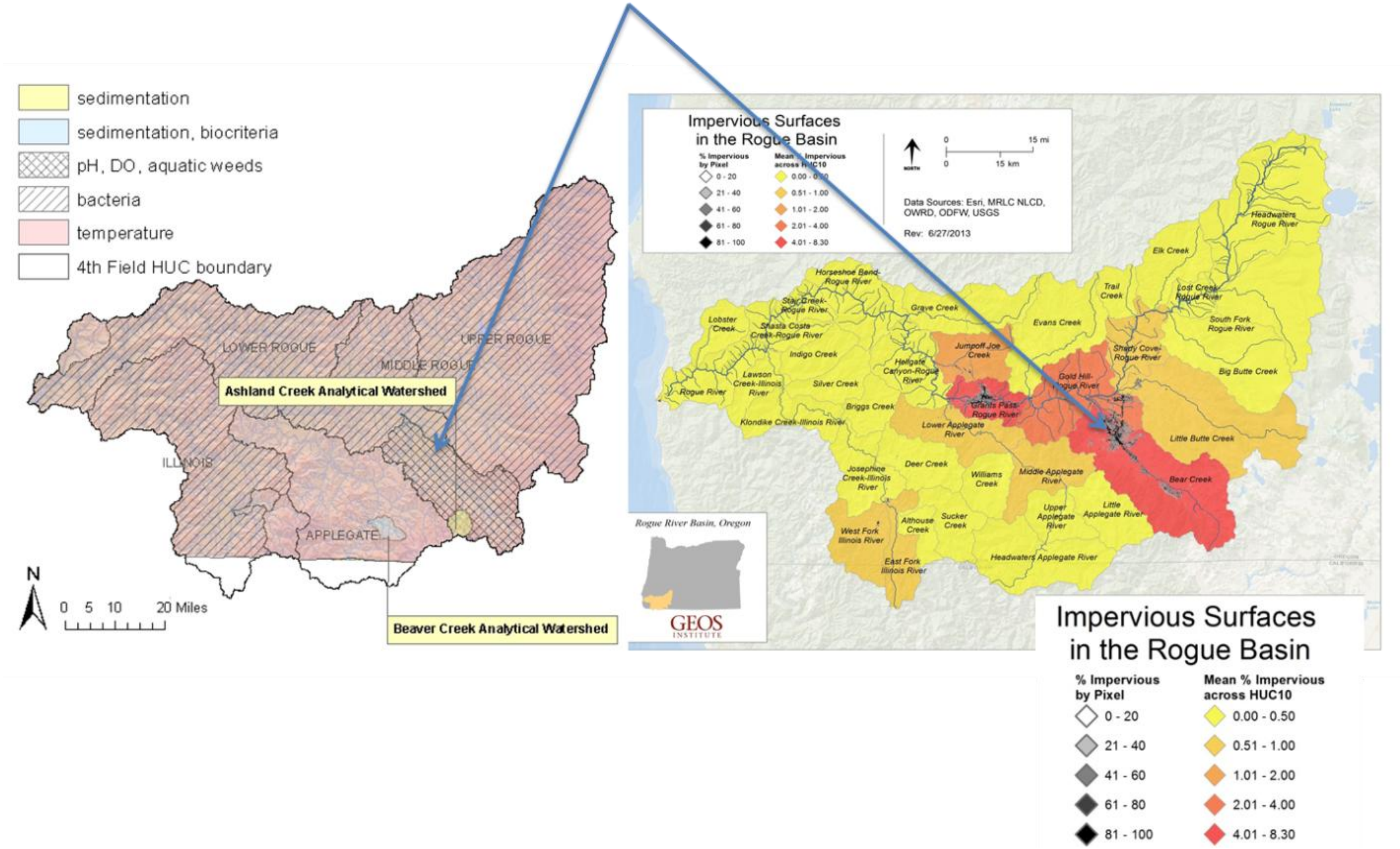


Figure 49. Impervious Surfaces and Pollutants. *Adapted from: ODEQ Water Analysis, 2012 and The Geos Institute, 2013.*

Even a slight increase in impervious surface can greatly affect water quality. Looking at Figure 49, above, one can see how impervious surface coverage and higher population is correlated with water quality issues, as the area with the greatest percentage of impervious surface coverage and the highest population density also has the greatest number of pollutants.

Groundwater quality is potentially impaired in many areas of the basin based on results from the Oregon Health Authority real estate transaction testing results (Figure 50) (ODEQ, 2013). The primary groundwater quality concerns in the basin are: nitrate and bacteria in the valley and lowlands; arsenic, salts and minerals, and fluoride and boron in the hills and mountain areas. ODEQ analysis indicates 98% of the bacteria in Bear Creek and 96% of the bacteria in the Rogue River are due to nonpoint sources of pollution including: runoff from streets, lawns, agricultural lands, and others (ODEQ 2012). Arsenic, salts and minerals, fluoride and boron are most likely present in groundwater due to naturally occurring sources in the bedrock.

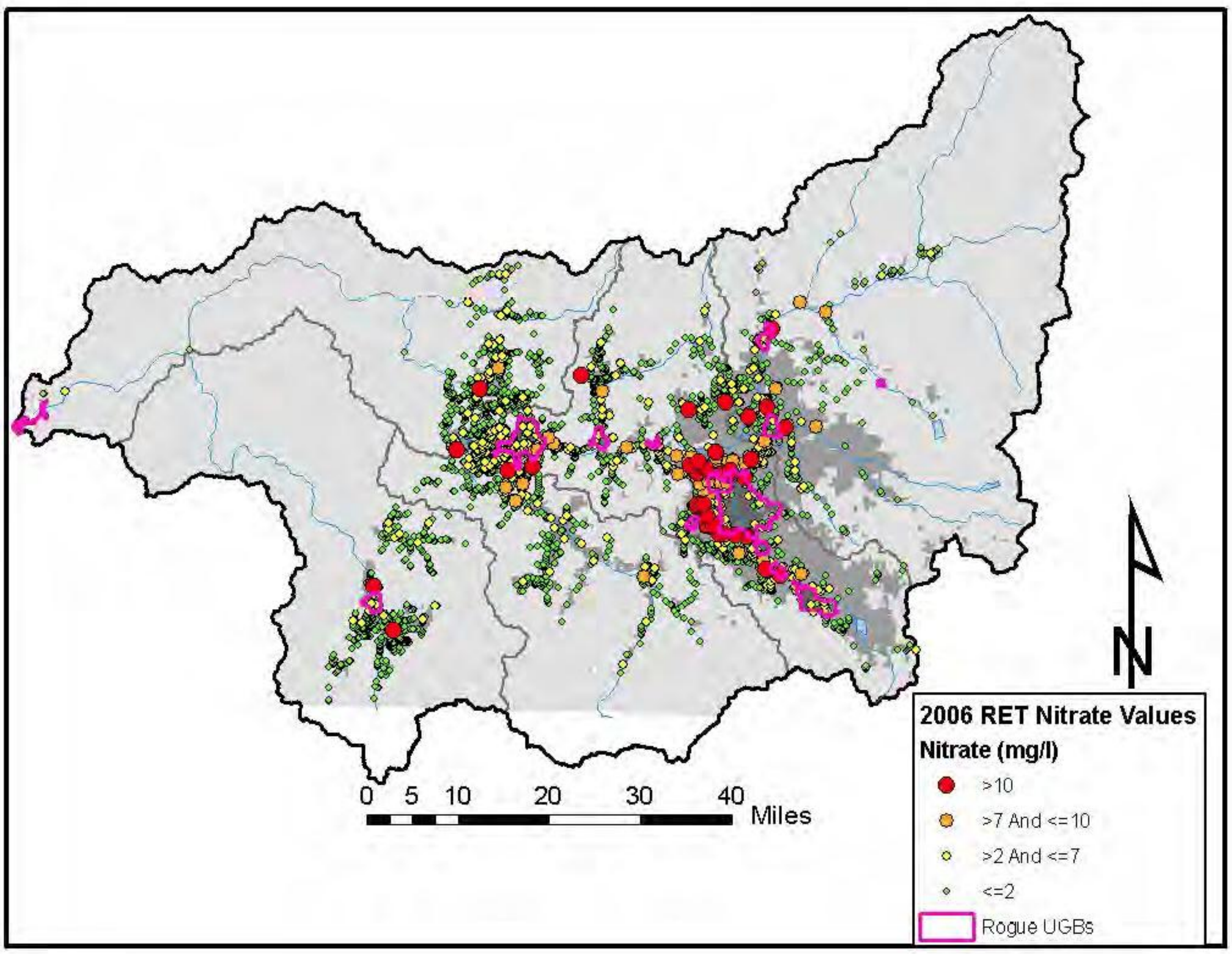


Figure 50. Groundwater quality data from Real Estate Transaction Program, Rogue Basin 1989 to 2006.
Source: Oregon Department of Environmental Quality, 2013.

The Rogue Basin may meet the requirements for declaring it a Groundwater Management Area (GWMA), as the documented number and levels of nitrate contamination of private wells compares or exceeds areas that already have Groundwater Management Area (GWMA) designation. More information is available at: http://www.deq.state.or.us/lab/lasar.htm and http://www.deq.state.or.us/wq/sisdata/sisdata.asp. See Figure 51 for a summary of groundwater concerns in the Rogue Basin.

Ground Water	General Quality	Quantity	Nitrate	Bacteria	Pesticides	Volatile and Synthetic Organic Compounds	Arsenic	Nickel	Lead	Fluoride
Upper Rogue	[yellow]	[yellow]	[red]	[red]						
Middle Rogue	[yellow]	[yellow]	[red]	[red]			[red]			[red]
Lower Rogue										
Applegate Subbasin	[yellow]	[yellow]	[red]	[red]			[red]			[red]
Illinois Subbasin	[yellow]	[yellow]	[yellow]	[yellow]			[yellow]	[yellow]		
[red]	Generally poor condition, **substantial** concern for water quality.									
[yellow]	Deteriorating condition, **moderate** concern for water quality.									
[green]	Generally good condition, **low** concern for water quality.									
	Unknown condition or lack of data.									

Figure 51. Summary of Groundwater Quality Concerns in the Rogue Basin.
Source: ODEQ Water Quality Assessment Report, 2012.

Twenty-two conservation and management plans have been developed in the Rogue Basin to date. These Designated Management Areas are actively implementing their plans which describe when and what actions will be undertaken to address a jurisdiction’s water quality impairments. Beginning in 2004, four large dams have been removed in the Rogue Basin providing salmon and steelhead with unobstructed access to an additional 333 miles of high-quality spawning habitat and improving water quality. None of these dams stored water for water use in the basin (ODEQ, 2011). In 2002 the City of Ashland upgraded its waste water treatment plant by adding a tertiary treatment phosphorus removal system resulting in water quality improvements in Ashland and Bear Creeks (City of Ashland, 2013). Monitoring within the basin will be examining treatment plant effluent, water column and fish tissue as part of SB737 and the toxics program. ODEQ and OWRD are working collaboratively to develop an integrated water resources strategy to address the impacts of water withdrawals and usage across the state (ODEQ, 2011). The Freshwater Trust and the City of Medford, with funding from ODEQ, are also working on a restoration project of up to 30 miles along the Rogue River and its tributaries. This began in late 2011 and is part of a mitigation effort by the City of Medford to meet its thermal load limits. Another conservation and water quality project is the Ashland Forest Resiliency Project (AFR). AFR is a stewardship agreement between the U.S. Forest Service, the city of Ashland, The Nature Conservancy, and Lomakatsi Restoration Project, which entails a ten year stewardship project designated to reduce the risk of severe wildfire in the watershed and protect water quality, older forests, wildlife, people, property, and quality of life. AFR began implementation work in 2010 and there is increasing public support for the project (Ashland Forest Resiliency Stewardship Project, 2013). For more information on the AFR project see: http://ashland.or.us/Page.asp?NavID=12907.

Figure 52. Field Trip of Ashland Forest Resiliency Project, explaining purpose and need to stakeholders. *Source: The Nature Conservancy.*

ODEQ is also helping to fund the Rogue River restoration work being implemented by The Freshwater Trust, and has also outlined the following implementation strategies to address water quality concerns in their Water Quality Status and Action Plan (2012):

Urban Areas	**Forest Lands**
• Onsite infiltration, treatment, or retention of storm water • Limit fertilizer use on lawns to eliminate nutrient run-off • Improvement to storm sewer infrastructure • Protection of sensitive areas from future development	• Restore and maintain riparian buffers • Improve harvest management practices • Stabilize and decommission roads • Calculate fertilizer and pesticide application rates • Protection of sensitive riparian and steep slope areas
Agricultural Areas	Other Areas as Applicable
• Implement voluntary farm management plans • Restore riparian buffers with plantings and fencing • Control livestock access to streams • Manure application and storage management projects • Calculated fertilizer and pesticide application • Seek conservation easements • Support projects that conserve irrigation water including the installation of sprinklers and pressure systems as an alternative to flood irrigation	• Implement culvert removal/upgrades • Ensure on-site septic systems to ensure proper function with no discharge to surface • Develop ordinances to protect resources of riparian, wetland, and in-stream habitat • Education and outreach to landowners to address TMDL parameters • Investigate and manage bacteria sources • Purchase riparian easements

Table 12. ODEQ's implementation strategies from their water and quality action plan, 2012.

Risks in a Changing Climate

Ecological Vulnerabilities

Changes in timing and volume of snowpack, run off, snow melt, and soil moisture will affect water quantity and quality for both ground and surface water supply. Stream flows in this region are also projected to be impacted by climate change in both timing and amount of water (Figure 53 and Figure 54).

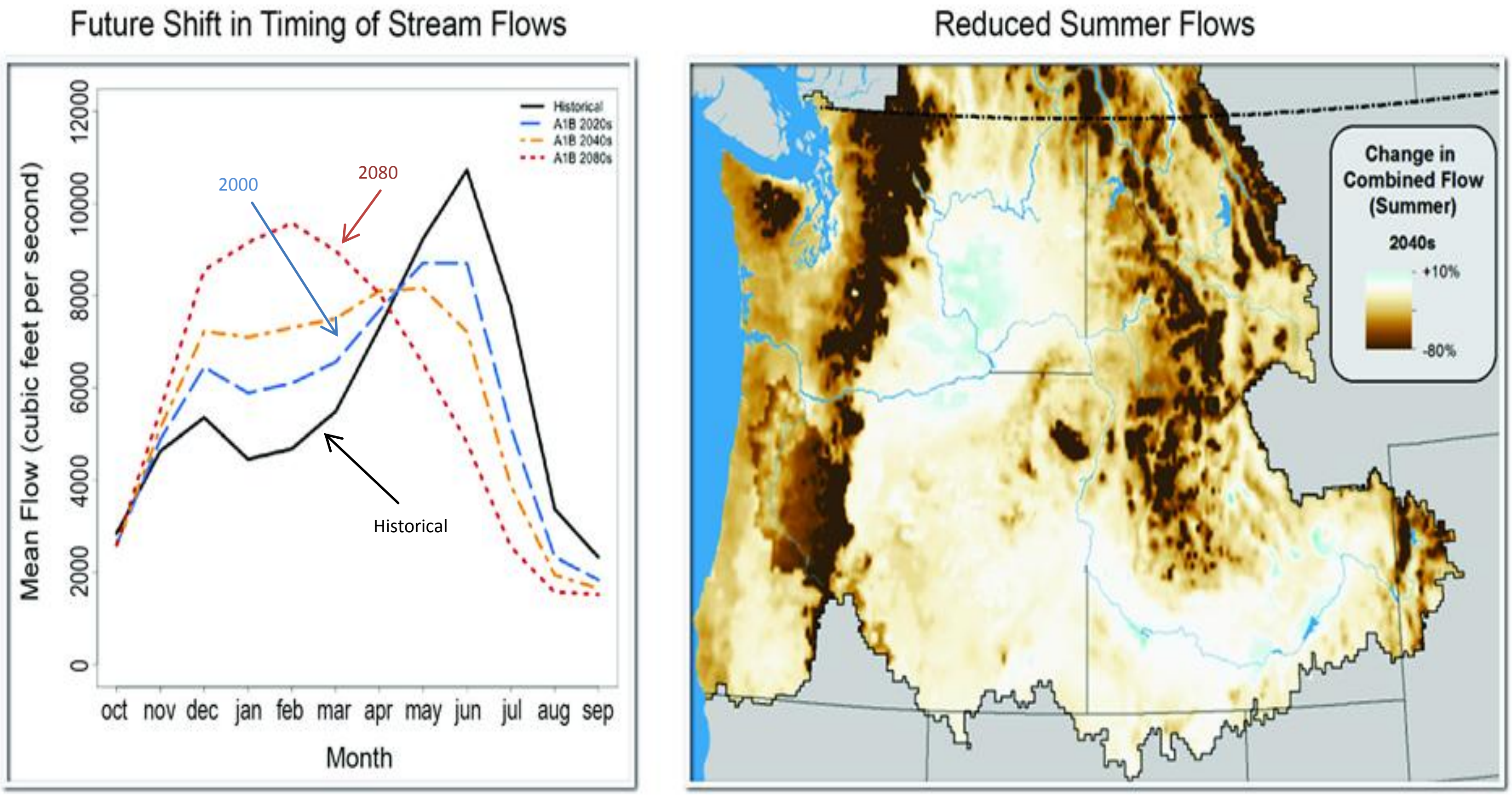


Figure 53. Projected changes in stream and summer flows for the Pacific Northwest.
Source: National Climate Assessment Development Advisory Committee, http://ncadac.globalchange.gov/.

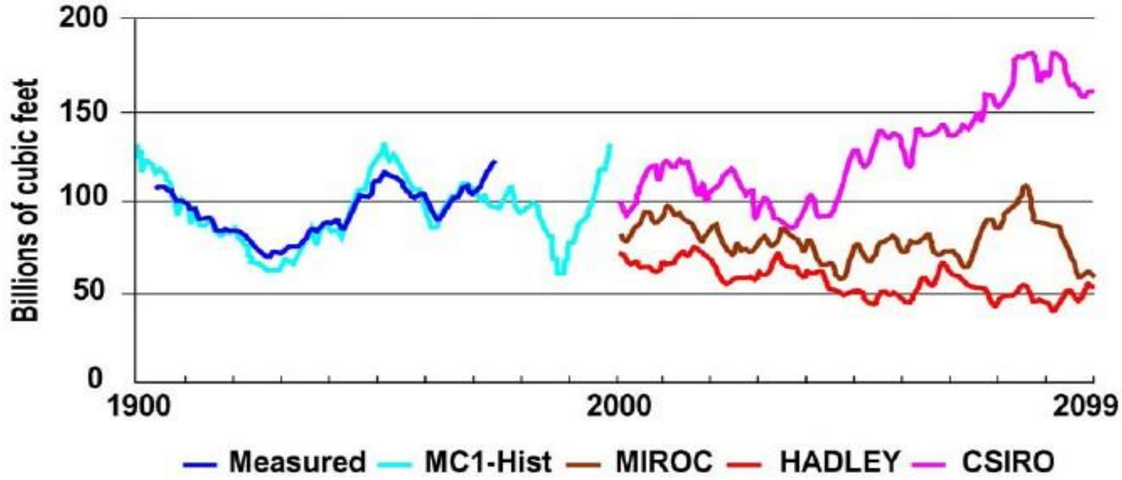


Figure 54. Annual stream flow at a single stream gauge (gold ray) in the rogue basin, with an 11 year filter. historical stream flow is shown based on historical data (dark blue) and modeled (light blue). Projected stream flow is given based on three downscaled global climate models. *Source: Doppelt, 2008.*

Increasing temperatures and reduced snowpack are causing earlier spring snowmelt, and the changing climate will continue this trend. The increased temperatures and earlier spring snowmelt can be linked to increases in wildfires as demonstrated by Figure 55.

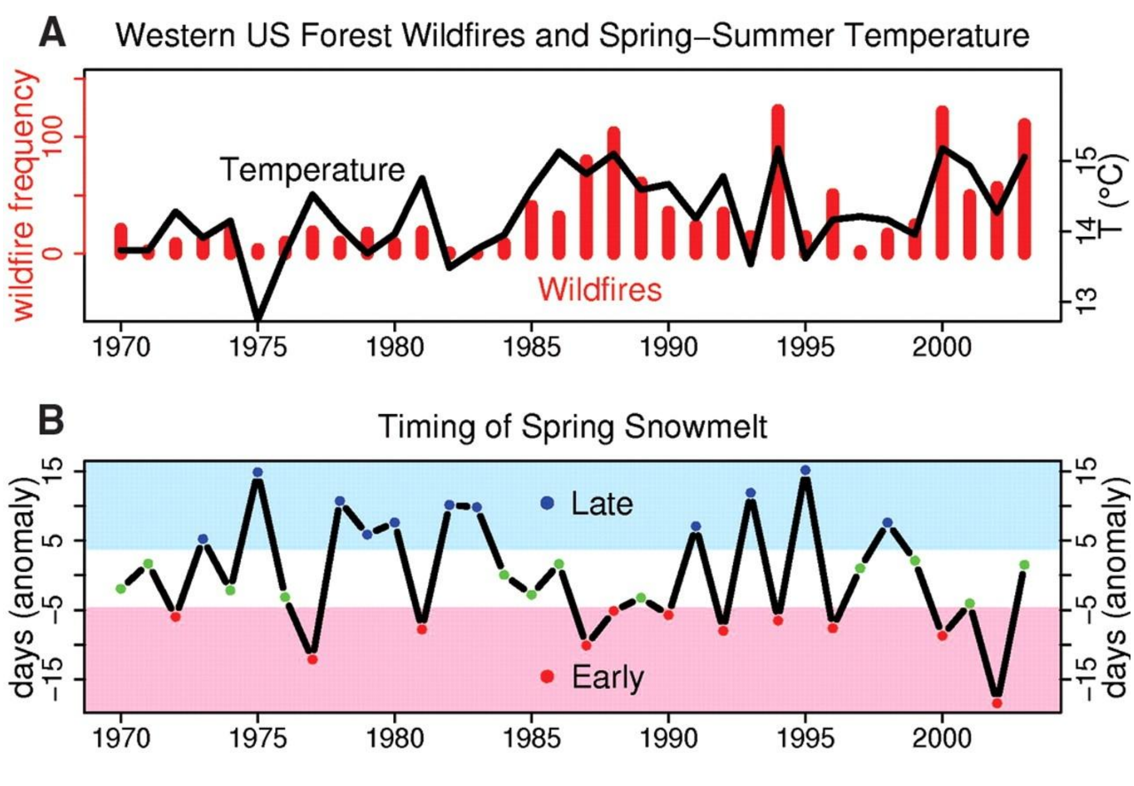


Figure 55. Increasing temperatures and the relation to earlier spring snowmelt and increases in wildfires. *Source: Westerling et al., 2006.*

Rising temperatures will likely cause precipitation to fall as rain at lower elevations rather than as snow on peaks so average January snowpack will decrease; by 2035 – 2045 snowpack may be reduced 60 – 65% and by 2075 – 2085 as much as 90% (Journet, unpublished). This will likely reduce run-off during late summer / fall and substantially reduce available irrigation and drinking water.

Potential ecological implications of these hydrological changes, especially in conjunction with increases in air temperature, earlier snowmelt, and changes in precipitation, could result in shifts in native fish assemblages. Streams in the Rogue Basin provide habitat for many cold-water species including Coho salmon, spring Chinook salmon, fall Chinook salmon, summer and winter steelhead, many species of trout, amphibians, and other fish such as the Pacific lamprey, green sturgeon, white sturgeon, Klamath smallscale sucker, speckled dace, prickly sculpin, and others (ODEQ 2012). As temperatures increase, salmon populations will be at greater risk of thermal stress from warm water temperatures (Heyn 2008; Mantua 2010). High water temperatures can limit distribution, migration, health, and performance of salmonids (Mantua 2010). Projected temperatures in the Pacific Northwest suggest a decrease in habitat for cold water aquatic species (Figure 56). In the Rogue Basin salmon runs are relatively strong, but it must be protected and resilient to climate change for these runs to be able continue. Many salmon runs in the Northwest endangered or threatened (EcoNorthwest 2009). The health of the Rogue River is necessary for anadromous fish to be able to spawn, rear, and migrate.

Decreasing Habitat for Coldwater Fish

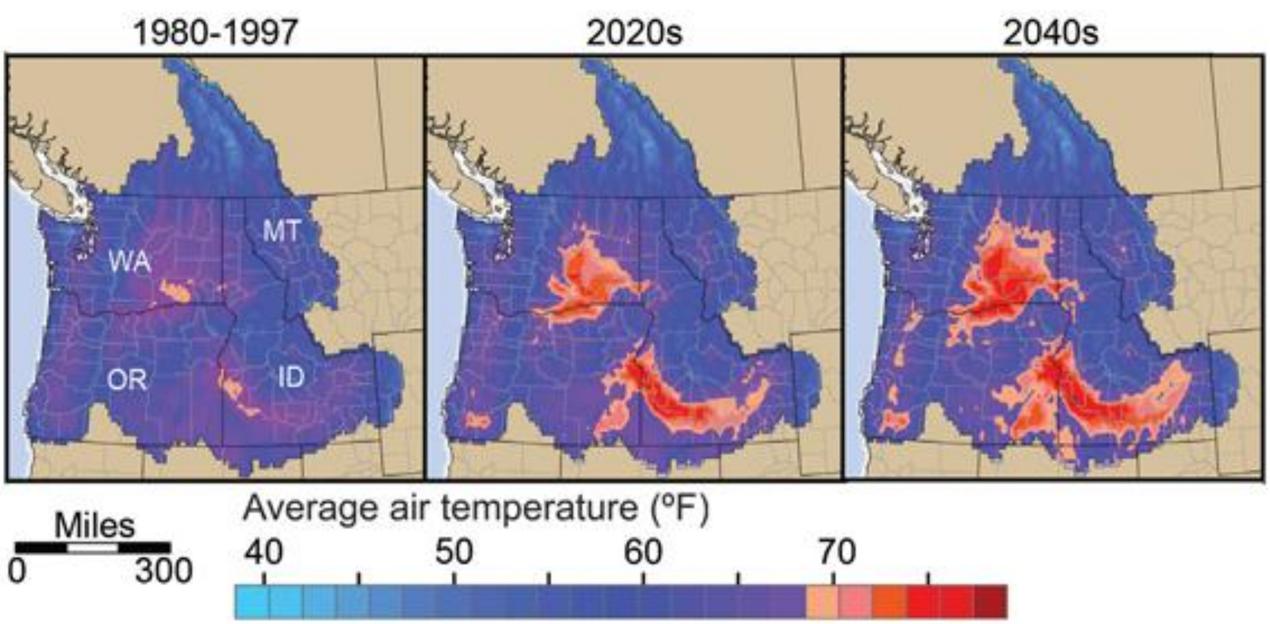


Figure 56. Increasing air temperatures lead to rising water temperatures, which increase stress on cold water fish. Projected temperatures for the 2020s and 2040s under a higher emissions scenario suggest a dramatic decrease in habitat for cold water fish. *Source: University of Washington.*

Invasive species, also a large concern in the Rogue Basin with Himalayan Blackberry overrunning several riparian areas, are also likely to increase as native vegetation is stressed by changes in precipitation and temperatures.

As temperatures rise, water use will also rise while aquifers continue to decline. In the future, snowpack, will melt earlier in the year, leading to less aquifer recharge, more rapid runoff, reduced late season runoff, and lower base flow (or can call it late summer flows), . This will result in lower supplies of water from both surface and groundwater sources, despite growing demand.

Policy and Practice Vulnerabilities

MWC and Ashland have worked on their Conservation Plans to encourage and incorporate green infrastructure (e.g. riparian planting to prevent stream temperature warming) and reduced water consumption, but the urgency and resolve to enact conservation measures could be improved, and is difficult due to red tape and the bureaucratic process. Implementation of conservation strategies can be challenging and slow. MWC recently was able to pass certain zoning ordinances and incentives for green infrastructure and planting of vegetation. It took a two year process and persistence of the MWC to get these ordinances passed. The largest vulnerability in policies is not so much inadequate protection as it is inefficiency in passing policies that create such protections, inefficiency in implementing protections due to the slow bureaucratic process, and a lack of climate change projections incorporated into planning and conservation measures. Management practices to increase resilience and resistance to climate change and improve the current state of the Rogue Basin's watersheds needs to happen in a timely manner, in order to adapt to future climatic conditions.

Economic Vulnerabilities of Water Resources to Climate Change

The ecosystem services provided to people by a healthy watershed and forest greatly benefit the local economy, as well as other downstream resource users. Ecosystem services help to offset costs from gray infrastructure and create jobs, income, and fiscal benefits. As the natural environment is restored or enhanced, so are the ecosystem services. Climate change projections threaten such services and cost-savings rendered from ecosystem services, particularly if the Rogue Basin does not work to build capacity to adapt and prepare for the projected impacts.

One of the risks to the watersheds of the Rogue Basin is severe wildfire. After wildfires, sediment, debris and ash can flow into streams and rivers, damaging water quality. It can cost millions of dollars to repair damage to habitat, reservoirs, and facilities (Moriarty and Cheng, 2012). Several wildfires in recent decades exemplify the magnitude of direct costs wildfires can have on water users (USDOI, 2013):

- The 1997 Buffalo Creek and 2002 Hayman Fires cost Denver Water more than $26 million on dredging Strontia Springs Reservoir, treating water and reseeding the forests in the watershed

- The 2000 Cerro Grande Fire cost the Los Alamos Water Utility more than $9 million and generated about $72.4 million in emergency rehabilitation, restoration and flood mitigation cost

- The 2009 Station Fire and ensuing storms in 2010 cost the Los Angeles County Department of Public Works $30 million to remove sediment from debris basins. LA County Public Works plans to spend an additional $190 million dredging four reservoirs that are no longer able to reliably meet the county's needs for flood control and water storage capacity
- The 2011 Las Conchas Fire prompted the cities of Santa Fe and Albuquerque to shut down their water supply intake systems in affected rivers and reservoirs due to ash accumulation.

Wildfires can also impact tourism and recreation use. The Wild and Scenic section of the Rogue has closed during and post fire events (during the Blossom Complex fire, 2005 and more recently in July and August, 2013 from several wildfires), costing the tourism industry millions of dollars. The estimated cost to outfitting businesses on the Rogue during the 2013 closure was $100,000 per day (DuBois, 2013).

Water withdrawals coupled with declining base flows are also a large risk to the Rogue Basin. Low stream flows could also negatively impact the tourism industry. Decrease in snow pack will also impact recreational uses such as skiing. Increased risks of flooding can damage infrastructure and properties, proving costly. As availability of water declines, and cost for water is likely to rise, the cost for food is also likely to increase as costs will increase for the agricultural industry.

Additionally declining base flows and increasing stream temperatures will significantly impact fisheries and aquatic species. In a report by EcoNorthwest (2009), they found that Rogue River salmon and steelheads runs account for $1.5 billion in economic benefit, and from a number of surveys found overwhelming support for salmon protection and habitat enhancement, including a willingness to pay more than $70 million dollars per year to improve salmon habitat in Oregon. Climate change impacts could significantly impact the economic revenue from fisheries as well as the intrinsic values locals hold for salmon.

Potential Water Solutions for Climate Resilience

Despite the many serious existing and new climate related water stressors, there are cost effective strategies available to help protect water resources to meet economic, environmental and social needs. A combination of education and behavior change, enhanced public policy, and on-the-ground restoration projects can go a long way to solving problems today and building resilience for future decades.

If the Rogue Basin does take measures to prepare, even more benefits from ecosystem services could be reaped. For example, the city of Medford undertook a cost-benefit analysis on different methods to cooling the Rogue River due to their non-compliance of effluent water temperatures. They discovered that restoring riparian areas along the Rogue Basin would cost nearly half the amount of other methods of cooling water temperatures, and would have the highest benefits. They are using a water quality trading program with The Freshwater Trust (and ODEQ's approval) to conduct restoration work and mitigate the temperature impacts. The goal of the trading program is to plant almost 30 miles of riparian shade in the Rogue Basin over the next 20 years to obtain 400 million kilocalories of thermal credit in late fall (DEQ Approves Medford's Thermal Trading Program, 2011). The program has multiple benefits: approximately $10 million in reduced compliance costs over the first 20 years when compared to other options (i.e., chillers or holding ponds); enhancement of wildlife habitat; landowner and community engagement;

streamside improvements effective throughout the year; and prevention of greenhouse gas emissions – approximately 25 to 150 metric tons of carbon dioxide per year (DEQ Approves Medford's Thermal Trading Program, 2011). This is the first water quality trading program in the Rogue Basin, and is just one example of ecosystem services provided by a healthy (or restored) riparian area.

Beechie at al. (2012) conducted a literature review to determine strategies most likely to ameliorate stream flow and temperature changes and increase habitat for salmon. They determined the most effective measures to be: restoring floodplain connectivity, restoring stream flow regimes, and restoring channels. The restoration of stream complexity and connectivity will improve salmon spawning habitat and allow for aquatic animal movement to new areas if needed, and the restoration of riparian corridors will provide a safe migratory route for land animals as well (Beechie et al. 2012). Restoration of floodplain functions allow aquifer recharge (Mantua 2010; Beechie et al. 2012). Restoration should include identifying and protecting thermal refugia provided by ground-water and tributary inflows, improving or decommissioning roads to reduce temperature impacts and soil erosion, and restoring vegetation in riparian zones that provide shade and complex habitat (Mantua 2010). Zoning ordinances to discourage development and/or agriculture within (and immediately adjacent to) riparian areas should also be developed and incorporated into local land use planning. Such restoration and protection efforts will reduce impervious surfaces, disconnecting them from streams and storm drains. The use of native plants in riparian restoration will reduce chemical and pesticide use as the vegetation is low maintenance and adapted to the region.

Reducing out-of-stream withdrawals during periods of low streamflow and high temperature can help mitigate stream temperature increases (Mantua 2010). Protection of vegetation and undergrowth from excessive removal by fire or harvest in snow pack and snow melt areas will slow runoff and allow more aquifer recharge in spring months. Restoration and maintenance of riparian corridors, stream complexity and connectivity to floodplains can address many of the stressors both present and projected in the Rogue Basin. Planting native shade trees and restoring riparian buffers help to protect against higher water temperatures, filter pollutants from entering the stream, increase aquifer storage capacity, reduce erosion, increase stream bank stability, mitigate storm flows and nutrient loading downstream, restore natural floodplains for both flood and drought mitigation, and can reduce risks to salmon habitat by providing refuge from high flow events. Reducing wildfire risk through restoration work (thinning/prescribed burning) and planting native fire tolerant species can also help mitigate higher temperatures and erosion. This is one of many areas where forest and water protections work synergistically for greater climate resilience.

Protection of groundwater quality from surface activities such as spills and leaks of hazardous materials, improperly operated or sited septic systems, permitted discharges, and over-fertilization or over-irrigation will preserve this large resource for future uses as will likely be needed. Hazardous material containment structures and spill containment mechanisms are available and cost effective to install. Technical assistance, grants and loans are available through the DEQ and OHA Drinking Water Protection Program (www.deq.state.or.us/wq/dwp/dwp.htm). (Amy Patton, Personal Communication, Nov.1 2013). Current monitoring of the groundwater resource in the Rogue Basin is inadequate to determine the volume of high quality water available at present, and there is a lack of information on how reduced snowpack and earlier peak stream flows may affect groundwater resources. This is an information gap that needs to be filled.

Appendix B provides more detailed information on solutions to water stressors.

An important component to any of these projects is collaboration with the public, non-profits, conservation districts, federal land managers, private land owners, watershed councils, and water suppliers such as MWC. Incentives should be created to encourage support, implementation, and compliance. Tax credits for green infrastructure implementation, reduced storm water fees to reward greater permeability at new developments (or re-developments), and rebates for downspout disconnection are an example of incentives that can be used. Incentives should also encourage the use of porous alternatives to impervious surfaces such as gravel or pervious pavement for driveways and paths. The planting of native trees/shrubs instead of ornamental grasses and other high maintenance vegetation that require mowing and chemicals/pesticides should also be encouraged. Other measures such as collecting roof runoff and slowing its release through rain barrels, rain gardens, and bioswales mitigate pollutants from entering streams and decrease water demands. Best management practices for businesses (to protect groundwater from spills and leaks) and for agriculture to reduce non-point source contamination of ground and surface water should be encouraged through public education and incentives and even regulated in high risk or high (water) value areas or for high risk industries These measures need to be encouraged through tiered payment systems for water use and for stormwater generated; planning policies and guidelines; zoning ordinances; tax credits; and other methods. Incorporation of climate change risks and adaptive strategies into water suppliers' Water Conservation and Management plans is important for prevention of associated costs due to lack of preparation for the changing climate. Climate change risks and adaptive strategies should also be incorporated into risk management and hazard mitigation plans.

Partnering with groups such as the Jackson County Soil and Water Conservation District and the OSU Extension Office can help bring education and outreach around these issues. Organizations such as The Freshwater Trust have developed innovative ways to encourage land owners to restore riparian areas with low risk and high benefits, and can be critical in establishing solutions on privately owned lands, moving restoration forward at an appropriate pace and at a landscape scale. The use of mechanisms such as the Water Quality Trading Program can help avoid red tape, allow for a faster and more efficient process, and give those paying for services (i.e., City of Medford) greater assurance as they are paying for a finished product. For more information on the Water Quality Trading Program see: http://www.thefreshwatertrust.org/conservation/water-quality-trading/the-water-quality-trading-solution.

Additionally, restoration work helps the local economy. In a report by the National Forest Health Restoration, it was found that every $1 million spent on forest and watershed restoration will generate $5.7 million in economic returns (National Forest Health Restoration, 2012), and typically creates 15-20 local jobs (The Freshwater Trust, 2011). A University of Oregon study found that over 80 cents of every project dollar spent on ecological restoration stays in the county where the project is located, and over 90 cents of every dollar stays in the state (Hibbard and Lune, 2006). Additional research found that every dollar spent on restoration work indirectly generates an average of $2.10-$2.40 in spending within the county (Nielsen-Pincus and Moseley, 2010) (Figure57).

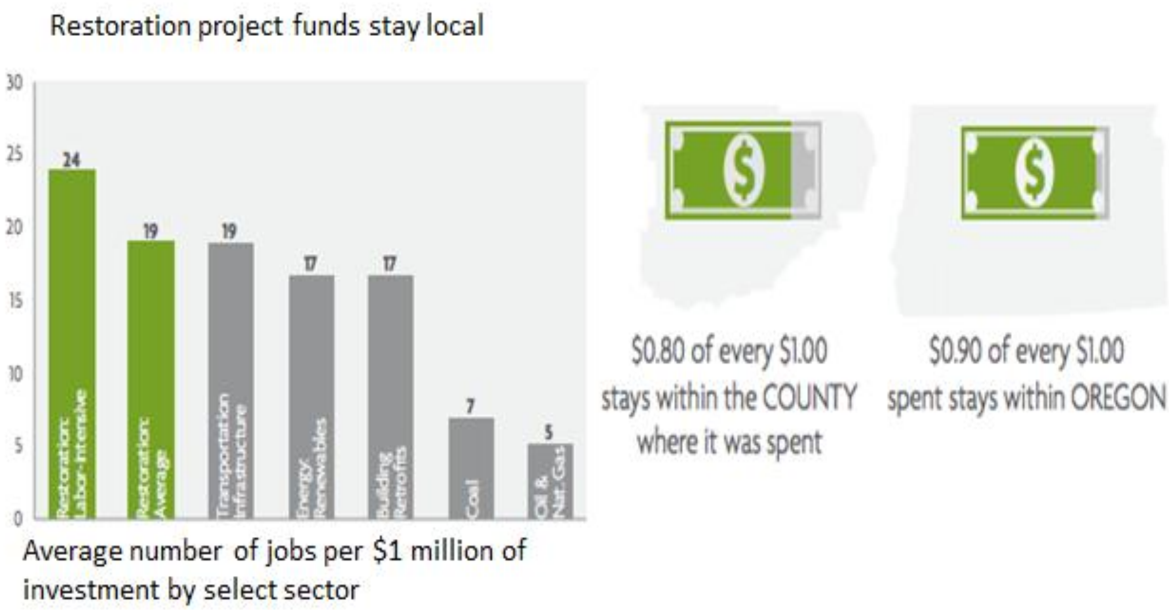


Figure 57. Restoration projects help the local economy. *Adapted from EcoTrust, 2009.*

Analysis and Recommendations

The community of the Rogue Basin is one which greatly appreciates its natural resources, both for economic and intrinsic values. Citizens are engaged in policies and land management, and natural resource expertise abounds. While the Rogue Basin has faced many challenges with land management activities, there is an opportunity to bring together the drive of the community and the expertise of agencies, non-profits, and academia to be a leader in preparation and adaptation for climate change, and in the development of land management practices that can be supported by the community while meeting federal mandates.

A business as usual approach will put the many values derived from the Rogue Basin at risk. Rather than waiting for impacts and responding, the precautionary principle should be applied so that potential impacts can be assessed and specific adaptation strategies implemented. Climate change is happening and the impacts can be seen already, and they are going to compound. However, there are many opportunities in the Rogue Basin to implement measures for adapting to climate change. These measures can also provide a framework for addressing land management across private, federal, and local lands, which is needed for resiliency of the forests and watersheds. Incorporating the values derived from the environment by the local community is important to informing land management decisions. Climate change will affect our natural resources, but there are many opportunities to increase ecosystem and community resiliency. By implementing projects to increase resiliency that can be supported by the public and tie to federal land management boundaries, the Rogue Basin can prepare for climate change. Community engagement is key. Outreach and education are needed through groups like the Southern Oregon Climate Action Now. Monitoring is necessary to continually update adaptation strategies as needed, and for accountability and trust.

This plan is one step toward preparing for climate change and increasing resiliency in the Rogue Basin. This is an iterative process, and this plan will need to be continually updated and modified as conditions change and monitoring informs. This is a step toward bringing the community together to develop the agility and capacity to adapt to climate change, increase resiliency, and serve as a model for other regions. As a part of the planning process, potential impacts of climate change on the forest, water, and economy of the Rogue Basin were identified. The risk matrix on the following pages, which will need to be continually updated, provides information on the risks identified, including a risk score, the adaptive capacity to respond, and the priority ranking based on probability, risk, and capacity. This information was put together through collaborative efforts and stakeholder meetings, with literature and data informing the decision making. From that process, goals, objectives, and strategies were formulated that would reduce risks, which are listed in the Climate Action Plan section.

1) **Economic Risks**

The major economic risks identified largely stem from wildfire risks. Wildfires are a high risk as demonstrated throughout the plan in the Rogue Basin, and can be costly to fight, suppress, and recover from. They can cost millions of dollars to water users post fire; and cost millions of dollars to suppress and protect homes during the event; and can accrue thousands of dollars in costs for health impacts and emergency services from smoke and to mental health. Fires prove much more costly when homes are threatened and need to be protected, and as the Rogue Basin is the most at risk area in the West for WUI, this proves to be a high priority threat. Additionally, the economic viability of the region is low compared to the nation. There are high unemployment rates and rural communities once dependent on timber harvests are suffering. The stalemate in federal management only exacerbates the lack of funds to counties. Forest and riparian restoration strategies can bring money to the local economy, provide jobs, and reduce fire risk.

2) Forest Risks

Fire risk ranked as a high priority and risk for the region's forests. The forests are overly dense and homogenized due to past management activities, suppression efforts, and current lack of active management on federal lands. Fire puts communities, species, and water quality at risk. The density of the forests, coupled with lack of fire and stressors from climate change are causing an increase in insects, pathogens, and diseases in the forests. Over-harvesting on private lands is a greater issue in the region, as they are not subject to the laws federal lands are and comprise a much greater amount of timber harvest in Oregon (75% with 19% land ownership versus federal harvest of about 15% with 60% ownership) (Oregon Forest Resources Institute 2013). Lack of active management on federal lands is a greater concern due to the fire risks associated with lack of management- risks to both federal lands and adjoining private lands. Identifying priority areas for fire management and restoration treatments can address many of the identified high priority risks.

3) Water Risks

One of the greatest current and future risks to the water system is stream temperatures. All of the sub basins of the Rogue Basin are over the recommended stream temperatures by ODEQ, and these are projected to increase further in stream temperature. The Rogue Basin is home to several threatened and endangered aquatic species such as salmon. Salmon are important to the economy and recreational values of the Rogue Basin. Many enjoy fishing the Rogue, and as cold water species decline from high temperatures this recreational use will be threatened. Additionally, over 137 species depend on salmon directly for survival. Salmon are a keystone species and an indicator species: if salmon disappear, there will be a domino effect, threatening the ecological and economic vitality of the region. Salmon are even important to the health of forests. Their decomposing bodies provide nutrients important for tree growth. When salmon are abundant, trees grow up to three times as fast as when salmon are scarce (Helfield, 2001 and Reimchen, 2003). Salmon are also important for providing streams and lakes with carbon, nitrogen, phosphorus, and micronutrients (Helfield, 2001 and Reimchen, 2003). Culturally salmon are valued strongly among local native tribes as well as local communities. Thus, increasing stream temperatures are a major threat for a variety of reasons.
Loss of intact riparian corridors also ranked high. Lack of healthy riparian corridors threatens the quality and quantity of our drinking water, aquatic species and other species dependent on riparian areas (80% of species depend on the riparian area; and over half of endangered species depend on the riparian area). Healthy riparian areas are integral for water filtration and storage, and can greatly mitigate impacts from flood and drought events, which are also ranked high on the priority list. When looking at solutions, restoring riparian areas can help mitigate the impacts from floods and droughts; can help increase shade and reduce stream temperatures; help replenish aquifers, and can bring money to the local economy.

Economic Risks	Risk Score	Adaptive Capacity	Priority
Current and increase in WUI risk (including structural damage/loss of homes from wildfires)	High	Low-Medium	Medium-High
Increase in costs for fighting fires	High	Medium	Medium-High
Rural communities once dependent on timber harvest are high in poverty	Medium-High	Low-Medium	Medium-High
Health impacts	Medium	Medium	Medium
High unemployment rates	Medium	Medium	Medium
Shifts in agriculture grow seasons and variety, stress on crops, impacts on viability of pears/wine grapes	Medium	Medium	Low-Medium
Increasing costs for health impacts	Medium	Medium	Low-Medium
Shifts in tourist seasons	Medium	Low-Medium	Low-Medium
Emergency service and public health providers may face increasing demand with decreasing budgets	Medium	Low-Medium	Low
Outflux of retired population	Low	Low	Low

Table 13. Economic risks, risk value, capacity to adapt, and priority ranking.

Forest Risks	Risk Score	Adaptive Capacity	Priority
Fire risk (severity, duration, and frequency) and Increased Fuel Loads	High	Medium	High
Lack of active management	High	Medium	High
Insects/pathogens/diseases	Medium-High	Low-Medium	High
Threats to endangered species	High	Low-Medium	High
Over harvesting Public	Medium-High	High	High
Loss of forest land to development	Medium	Medium	Medium
Recreational uses	High	High	Medium
Over harvesting Private	High	Low	Medium
Disruption in synchronicity of food web	Low-Medium	Low	Medium
Invasives/non-natives	High	Low-Medium	Low
Shifts in species composition	High	Low	Low
Grazing	Medium	Medium	Low

Table 14. Forest risks, risk value, capacity to adapt, and priority ranking.

Water Risks	Risk Score	Adaptive Capacity	Priority
Flooding	High	Low-Medium	High
Drought	High	Low-Medium	High
Summer temperature exceedance; increasing stream temperatures	High	Medium	High
Loss of intact riparian corridors	Medium-High	Medium	High
Water withdrawals	High	Medium	High
Declining aquifers	High	Low	High
Increase in water demand with decreasing water supply	High	Medium	Medium
Changes in soil moisture	Medium-High	Low	Medium
Soil erosion, sediment into streams	Medium	Low-Medium	Medium
Decreases in dissolved oxygen	Medium	Low	Medium
Shifts in native/non-native fish populations	Medium	Low	Medium
Biological stressors/algae blooms	Medium-High	Low	Low-Medium
Nutrients, pH, Chlorophyll a	Medium-High	Low	Low-Medium
Less snow, more rain/Less snowpack/Earlier Snowmelt/Shift in timing and reduction of stream flows	High	Low	Low-Medium
Bacteria/Nitrate/Arsenic/Fluoride	Medium	Low	Low

Table 15. Water risks, risk value, capacity to adapt, and priority ranking.

Climate Adaptation Action Plan

The climate planning process identified these primary goals to bring climate resilience to the people and forested watersheds of the Rogue River Basin:

Goal 1: Manage risk and reduce the potential for uncharacteristic wildfire within forest ecosystems and restore forest structure and function by implementing projects with an integrated restoration approach focusing on ecological principles at a landscape scale.

Goal 2: Manage risk and reduce impacts of uncharacteristic wildfire to communities by implementing treatments in SOFRC fuels emphasis areas (e.g. public lands within ½ mile of occupied private lands) as well as identified strategic locations outside of these fuel emphasis areas designed to promote ecosystem resilience.

Goal 3: Manage and implement practices that ensure high water quantity and quality with an emphasis on domestic water and salmonid streams.

Goal 4: Provide quantifiable ecological restoration and economic support for practices by incorporating an Ecosystem Services model to identify and focus on priority areas.

The following outlines the detailed climate adaptation action plan designed to implement these important broad goals in coming years.

Goal 1: *Manage risk and reduce the potential for uncharacteristic wildfire within forest ecosystems and restore forest structure and function by implementing projects with an integrated restoration approach focusing on ecological principles at a landscape scale.*

Objective 1.1. *Develop treatment prioritization at meaningful landscape scales.*

Strategy 1.1a. Complete SOFRC analysis identifying need and opportunity for 150,000 acres of the Fuels Emphasis Area (1/2 boundary of private/federal). Use in conjunction with the Land Fire Departure Analysis (Chris Zanger) to corroborate the ecological underpinnings of management approaches.						
Action Step	**Deliverable**	**Timing**	**Responsible Parties**	**Resources**	**Success Indicators**	**Notes**
Contact Chris Zanger for Land Fire Departure Analysis comparison/ corroboration.	Validation of areas identified for treatment. Maps.	Short.. December-February 2014.	Chris Zanger, Kerry Metlen, Gwyn Myer	Model developed by Collaborative; Land Fire Departure Analysis Risk maps associated with county fire plans;	Call completed. Maps with validated areas identified.	Use this information for implementation strategies and objectives.

Hold a GIS session to determine actual tangible target acres.	GIS mapped areas demonstratin g tangible target acres.	Short. Feb-April 2014.	Kerry Metlen	GIS data and maps; Risk maps associated with county fire plans.	See deliverable.	Check with Kerry for timeline.
Conduct Fire and Vegetation Modeling under future climate scenarios to determine where more frequent fires may occur and where to leave more dense forests.	Fire and veg models incorporating future climate scenarios.	Short. September 2014.	Kerry Metlen will determine who can be responsible to carry this out.	Existing fire and vegetation modeling.	See deliverable.	Partner with GEOS? Other local groups incorporating climate modeling?
Strategy 1.1b. Inform agency planning/management.						
Action Step	**Deliverable**	**Timing**	**Responsible Parties**	**Resources**	**Success Indicators**	**Notes**
Provide recommendations and share collaboratively developed tools for land management (i.e., SOFRC analysis).	SOFRC analysis, 2 pager with brief summary of SOFRC strategy, recommend-ations provided during comment period for FS/BLM plan updates/ revisions.	Short. October 2013; Medium-Long (continual-ly provide recom-mendations for any plan updates.	George McKinley and SOFRC technical team	Model developed by SOFRC.	Adoption of SOFRC principles and approaches into BLM resource management plan and future NEPA.	

Strategy 1.1c. Incorporate stakeholder input/values in landscape treatment prioritization.						
Action Step	**Deliverable**	**Timing**	**Responsible Parties**	**Resources**	**Success Indicators**	**Note**
Hold workshops to incorporate stakeholder values.	Workshops held and stakeholder values identified and prioritized.	Short. 2014.	The Nature Conservan-cy (Darren Borgias) and SOFRC (George McKinley)	TNC funding for workshops, facilitator.	1-3 work-shops held in 2014.	Contact Darren to ensure is on board.

Objective 1.2 *Develop economic rationale for uneven-aged (diversity in structure and age/multi-canopy vegetation) management .*

Strategy 1.2a. Provide stand specific feasibility to identify cost effective acres based upon access, volume and need.						
Action Step	**Deliverable**	**Timing**	**Responsible Parties**	**Resources**	**Success Indicators**	**Note**
Kerry and Terry work to develop this.	Cost effective acres identified.	Short. June 2014.	Kerry Metlen, Terry Fairbanks		Cost effective acres identified.	Kerry will fill this in better.

Objective 1.3. *Develop a strong rationale for where upland vegetation restoration is needed within the Northwest Forest Plan Interim Riparian Buffers to protect all riparian/aquatic values.*

Strategy 1.3a. Gather relevant information and create partnerships to collaboratively achieve objective.						
Action Step	**Deliverable**	**Timing**	**Responsible Parties**	**Resources**	**Success Indicators**	**Note**
Contact Dan VanDyke (ODFW).	More information about Dan's prioritization approach.	Short. January 2014.	Gwyn Myer		Phone call made, information exchanged.	Contact made, need to follow up.

Contact Chris Park .	Information about program that can generate where 'upland' begins in a riparian reserve.	Short. February 2014.	Gwyn Myer		Chris allows us to use this information to inform planning for upland vegetation restoration.	
Use SOFRC strategy to explicitly identify where riparian ends and forest begins for fish bearing and no fish bearing streams.	Identification of areas described in action step.	Short. March-May 2014.	SOFRC technical team (Kerry, Ed, George, Max)	SOFRC analysis/ strategy.	Deliverable is used to support rationale for where upland vegetation restoration is needed.	
Form subcommittee to aggregate information about buffers as treated after site specific analysis (2013) and literature regarding appropriate management approaches.	Information on buffers.	Short. March-May 2014.	SOFRC technical team (Kerry, Ed, George, Max)	Information obtained from steps 1-2.	Subcom- mittee formed.	
Present synthesis of information to Collaborative to develop and identify collaborative approach to riparian reserves.	Presentation of information.	Short. June 2014	SOFRC technical team (Kerry, Ed, George, Max)	Information obtained from steps 1-4.	Presentation occurred.	
Work with National Marine Fisheries Service to vet, refine, and gain support for collaborative approach.	NMFS letter of support for collaborative approach.	Short. June 2014.	George McKinley	SOFRC analysis.	Contact with NMFS made.	

Objective 1-4. *Collaboratively promote use of fire as a management tool for NSO habitat.*

Strategy 1.4a. Engage with USFWS, ODFW to obtain maps of existing and suitable NSO habitat.						
Action Step	**Deliverable**	**Timing**	**Responsible Parties**	**Resources**	**Success Indicators**	**Notes**
Contact USFWS (Cindy Donegan) and ODFW.	Maps of NSO habitat.	Completed Fall 2013.	SOFRC		See Deliverable.	Need to determine who to contact with ODFW.
Strategy 1.4b. Apply landscape fire probability models to identify the most effective treatment placement and incorporate into landscape assessment of treatment priorities of existing and suitable NSO habitat.						
Action Step	**Deliverable**	**Timing**	**Responsible Parties**	**Resources**	**Success Indicators**	**Notes**
Run models applying landscape fire probability.	Models identifying priority areas.	Short. June 2014.	SOFRC technical team	SOFRC assessment, Jena DeJuilio.	Models incorporated into landscape assessment.	
Strategy 1.4c. Demonstrate reduced risk of fire to NSO habitat across the 3,000 acre Pilot Joe project..						
Action Step	**Deliverable**	**Timing**	**Responsible Parties**	**Resources**	**Success Indicators**	**Notes**
SOFRC technical team will determine who will run the models demonstrating reduced risk.	Fire and fuels modeling to demonstrate reduced risk.	Short. August 2014.	SOFRC technical team; ODFW; Cindy Donegan	Maps of NSO habitat.	Fire and fuels modeling demonstrating reduced risk post treatment.	Check with Cindy on this.

Objective 1-5. *Schedule implementation and subsequent maintenance treatments.*

Strategy 1.5a. Calculate an appropriate cycle for treatment returns to stands after they have been treated at an interval that tiers to their historical fire return interval and productivity.						
Action Step	**Deliverable**	**Timing**	**Responsible Parties**	**Resources**	**Success Indicators**	**Notes**
Use LANDFIRE data to inform this.	LANDFIRE data and forest ecology knowledge used to inform the treatment intervals.	Short-medium. November 2014.	Kerry Metlen	LANDFIRE data.	Determination of appropriate cycle for treatment returns.	
Continue to engage partners and agencies to work toward implementation efforts.	Meetings, correspondence, steps being taken toward Implementa-tion.	Short, medium, long-continual.	SOFRC	Use pilots, AFR, etc. as examples to demonstrate successful restoration projects in the region.		

Goal 2: *Manage Risk and Reduce Impacts of uncharacteristic wildfire to communities by implementing treatments in SOFRC fuels emphasis areas (e.g. public lands within ½ mile of occupied private lands) as well as identified strategic locations outside of these fuel emphasis areas designed to promote ecosystem resilience.*

Objective 2.1. *Promote Fire Adapted Communities.*

Strategy 2.1a. Engage with FIREWISE, CWPPs, and partner with other efforts (i.e., fire plans).						
Action Step	**Deliverable**	**Timing**	**Responsible Parties**	**Resources**	**Success Indicators**	**Notes**
Meet with the 2 oversight committees for the county CWPPs (Josephine County Emergency Management Board and the Jackson county Integrated Executive Committee to determine if they are willing to be the leads for this strategy.	Leads for this engagement.	Short. June 2014.	Jim Wolf, Gwyn Myer, George McKinley		Oversight committees agree to be leads.	
Work with SOFRC Fire Adapted Communities Learning network to better integrate resilient forests, community risk reduction and emergency response by sharing expected regional impacts of climate change.	Collaboration with SOFRC FAC network.	Short. June 2014 and medium-long term.	Jim Wolf, Gwyn Myer, George McKinley	Existing CWPPs, existing FIREWISE projects in area, county plans will be updated summer 2014.	Information exchanged with SOFRC FAC learning network.	Creating and maintaining FACs will be an ongoing process of implementation, continual interaction, education and outreach.

Objective 2-2. *Increase use of fire as a management tool through SW OR Prescribed Fire Council and demonstration of successful projects.*

Strategy 2.2a. Treat 80k acres/double use of prescribed fire over the next ten years in the Rogue Basin.						
Action Step	**Deliverable**	**Timing**	**Responsible Parties**	**Resources**	**Success Indicators**	**Notes**
(See above action steps for strategies 2.1 and 2.2.)						These strategies provide the science and public support needed.
Implement projects with prescribed fire used as a management tool.	Projects occur with greater use of prescribed fire.	Short-long: a continual process. Start at a smaller scale in the short term (FY 2014/5) and move to a larger scale as the science and public support improves in the long term.	Agencies (FS- Rob Mac-Whorter; BLM-Dane Barron) to implement; SOFRC (George McKinley); SOPFC (Rich Fairbanks); TNC (Darren Borgias) to provide recommenda-tions to agencies for implementation, help with public support and science.		Projects using prescribed fire are planned FY 2014. The amount of projects using prescribed fire is doubled by 2024.	Lomakatsi has national recognition for their restoration ecology work and use of prescribed fire.

Prioritize maintenance of existing treated areas with landscape-scale prescribed fire in order to reduce maintenance costs (e.g. more cost effective).	Prioritization of maintenance and implementa-tion of prescribed fire.	Continual (Short, med, long).	Agencies- Fire and Fuels planners; SOPFC, SOFRC; county fire plan coor-dinators; Rich Fairbanks		Partner with Southern Oregon Prescribed Fire Council.	

Objective 2-3. *Incorporate community values into landscape scale assessment.*

Strategy 2.3a. Prioritize treatment areas in the Rogue Basin.						
Action Step	**Deliverable**	**Timing**	**Responsible Parties**	**Resources**	**Success Indicators**	**Notes**
Complete valuation assessment of restoration need for the Basin to prioritize treatment areas.	Valuation outlining priority areas.	Short. April 2014.	SOFRC technical team (Ed Reilly, Max Bennett, Kerry Metlen, George McKinley)	SOFRC integrated assessment tool.	Valuation completed.	
Embed results of valuation assessment into the 2013-14 county fire plan update process.	Country fire plans with valuation results.	Short. May 2014.	Jim Wolf, Neil Benson		Valuation results embedded into county plans.	

Objective 2-4. *Optimize where treatments would be most effective to protect homes/communities*.

Strategy 2.4a. Complete fire modeling across the Rogue Basin to optimize where treatments would be most effective.						
Action Step	**Deliverable**	**Timing**	**Responsible Parties**	**Resources**	**Success Indicators**	**Notes**
Contact those already conducting fire modeling (Jena Dejuilio, BLM; Ed Reilly; ODF, FS).	Contact made.	Short. Feb- March 2014.	SOFRC technical team (Ed Reilly, Max Bennett, Kerry Metlen, George McKinley); Gwyn Myer; Jim Wolf	Fire modeling already being done.	Contact made.	
Use data completed and conduct further analysis if needed to complete fire modeling across Rogue Basin.	Fire modeling completed demonstratin g most effective treatment areas.	Short. June- Sept 2014; and long.	SOFRC technical team, Jena DeJuilio, Jim Wolf		Fire modeling completed for Rogue Basin.	This will need to happen every five-ten years to determine where is most effective to treat given changing circumstances.

Goal 3: *Manage and implement practices that ensure high water quantity and quality with an emphasis on domestic water and salmonid streams.*

Objective 3-1. *Improve water transport and use efficiencies for both ground and surface water.*

Strategy 3.1a. Collaborate with ongoing efforts to increase efficiencies with water						
Action Step	**Deliverable**	**Timing**	**Responsible Parties**	**Resources**	**Success Indicators**	**Notes**
Contact the WISE project.	Information shared from WISE project for improving efficiencies.	Short. August 2014.	Gwyn Myer, Eugene Weir, Laura Hodnett		WISE project contacted, information exchanged.	Use information from this to inform methods for increasing efficiencies, share with cities municipalities. This ties in to objective 3-2 also.
Contact ODEQ.	Partnership on efforts for water conservation.	Short. August 2014.	Gwyn Myer		ODEQ contacted, partnership opportunities identified.	Also for objective 3-2.
Contact municipal water conservation departments.	Information on ongoing and future conservation efforts.	Short. August 2014.	Gwyn Myer		Knowledge of ongoing/ future efforts; information exchange.	Also for objective 3-2.

Objective 3-2. *Improve water transport and use efficiencies for irrigation systems.*

Strategy 3.2a. Education/outreach to agriculture industry.						
Action Step	**Deliverable**	**Timing**	**Responsible Parties**	**Resources**	**Success Indicators**	**Notes**
Contact Soil and Water Conservation districts and OSU extension.	These organizations contacted.	Short. September 2014.	Gwyn Myer		Organizations contacted, SOFRC and other climate plan partners demonstrate support for their education and outreach efforts.	SOFRC/other climate partners should sign on/demonstrate support for these org's for funding opportunities as well to maintain their education and outreach.

Objective 3-3. *Reduce road system impacts to surface water and salmonid fisheries.*

Strategy 3.3a. Analyze transportation systems.						
Action Step	**Deliverable**	**Timing**	**Responsible Parties**	**Resources**	**Success Indicators**	**Notes**
Determine who can accomplish this task.	Responsible party identified	Short. September 2014.	SOFRC technical team	ODOT, NOAA?	Party agrees to this task.	
Strategy 3.3b. Prioritize road restoration and decommissioning.						
Action Step	**Deliverable**	**Timing**	**Responsible Parties**	**Resources**	**Success Indicators**	**Notes**
Determine who can accomplish this task.	Responsible parties identified.	Short. September 2014.	SOFRC technical team	ODOT, NOAA, agencies all responsible?	Parties agree to this task.	

Objective 3-4. *Develop rationale and social support for restoration of riparian reserve vegetation in conjunction with upland vegetation treatments.*

Strategy 3.4a. Collaborate with organizations already doing this type of work.						
Action Step	**Deliverable**	**Timing**	**Responsible Parties**	**Resources**	**Success Indicators**	**Notes**
Develop partnership with The Freshwater Trust.	Contact made.	Completed.	Gwyn Myer		Partnership sustained.	Continual contact is needed to ensure partnership continues. Make sure to include them in planning processes.
Investigate potential to work with USDA and Dept of Interior's partnership to protect America's water supply from increased wildfire risk.	More information obtained.	Short. June 2014.	Gwyn Myer, George McKinley		Project supported by partnership.	Continual contact is needed to ensure partnership continues. Make sure to include them in planning processes.
Obtain information from The Willamette Partnership studies.	Contact made.	Completed.	Gwyn Myer			

Strategy 3.4b. Fill information gap of upland restoration effects on Riparian Reserves.						
Action Step	**Deliverable**	**Timing**	**Responsible Parties**	**Resources**	**Success Indicators**	**Notes**
Identify who can fill this info gap.	Responsible party established.	Short. July 2014.	SOFRC technical team/ Climate core team		Info gap filled.	PhD Candidate? Agencies/non-profit partnership?

Objective 3-5. *Identify priority areas for watershed restoration work.*

Strategy 3.5a. Collaborate with ongoing efforts.						
Action Step	**Deliverable**	**Timing**	**Responsible Parties**	**Resources**	**Success Indicators**	**Notes**
Contact Ian Reid (FS) regarding his work in this.	Ian Reid contacted.	Short. January 2014.	Gwyn Myer		Ian contacted, information exchanged.	
Contact Brian Barr (GEOS).	Brian Barr contacted.	Completed	Gwyn Myer	FS study on watershed prioritization .	Communica-tion maintained.	Continual contact/ engagement needed to ensure information exchange.
Identify areas with high quality/high volume and low quality/low volume groundwater supplies in valley.	Areas identified.	Short. Summer 2013.	USGS, WRD, DEQ, can assist with this.	USGS has matching funds.	Areas identified.	Need to identify someone locally to work on this with USGS, DEQ, WRD.
ID areas/watersheds supplying groundwater to large numbers of private wells and/or to public wells in valley. Determine the need for protection of those watersheds from contamination and overdraft.	Areas identified.	Short. Summer 2013.	Need to identify someone/org that could take this on. Ask OWEB? Perhaps a graduate student?	Grants may be available through OHA drinking water protection program, EPA section 319, OWEB.	Data collected, maps created.	This is a huge area of no information. This project would significantly help to identify our critical valley groundwater resource.

Objective 3-6. *Restore Riparian Areas Protect All Riparian/Aquatic Values.*

Strategy 3.6a. Identify areas for floodplain connectivity.						
Action Step	**Deliverable**	**Timing**	**Responsible Parties**	**Resources**	**Success Indicators**	**Notes**
Contact Bonneville Environmental Foundation about their ongoing effort with this.	BEF contacted.	Short. July 2014	Gwyn Myer		BEF contacted, info exchanged	

Strategy 3.6b. Identify grubstake reaches and prioritize them for restoration.						
Action Step	**Deliverable**	**Timing**	**Responsible Parties**	**Resources**	**Success Indicators**	**Notes**
Contact Bonneville Environmental Foundation about their ongoing effort with this.	BEF contacted.	Short. July 2014	Gwyn Myer	The Freshwater Trust (Eugene Weir) has info on this as well.	BEF contacted, info exchanged.	

Strategy 3.6c. Fill information gap on the effect of water withdrawals on streamflow as well as vegetation treatment effects on snowpack.						
Action Step	**Deliverable**	**Timing**	**Responsible Parties**	**Resources**	**Success Indicators**	**Notes**
Identify who can fill this info gap.	Responsible party identified.	Short. August 2014	Climate Plan Team		Info gap filled.	Eugene Weir, BEF, Brian Barr, ODEQ (Bill Meyers) may have ideas on who can do this.

Goal 4: *Provide quantifiable ecological restoration and economic support for practices by incorporating an Ecosystem Services model to identify and focus on priority areas.*

Objective 4-1. *Develop an ecosystem services model to quantify and describe actions/benefits and to provide a framework for transaction of services (Spring 2014).*

Strategy 4.1a. Provide recommendations to agencies/landowners for using ecosystem services.						
Action Step	**Deliverable**	**Timing**	**Responsible Parties**	**Resources**	**Success Indicators**	**Notes**
Collaborate with Sara Vickerman (Defenders of Wildlife).	Contact made with Sara Vickerman.	Completed, ongoing.	Gwyn Myer	Ecosystem services guide/framework Sara has been working on.	Collabora-tive efforts in imple-mentation.	Met with Sara Nov 1 in Portland, follow up meeting scheduled.
Collaborate with The Freshwater Trust, who has ongoing work with water quality trading in the Rogue Basin.	Contact made with Eugene Weir.	Completed, ongoing.	Gwyn Myer	Willamette Partnership, water quality trading program.	Collabora-tive efforts in imple-mentation.	Met with Alex from TFT Nov 1, follow up meetings scheduled.
Work with Nikola Smith and Bob Deal (USFS PNW Research Station).	Contact made with Nikola and Bob.	Completed, ongoing.	Gwyn Myer		Collabora-tive efforts in imple-mentation.	Met with Nikola Nov 1, follow up meetings scheduled.
Strategy 4.1b. Schedule and attend meeting with PNW FS research station (Nikola Smith and Bob Deal), Defenders of Wildlife (Sara Vickerman), Institute for Sustainable Solutions (Fletcher Beaudoin), and The Freshwater Trust (Eugene Weir/Nick Southall) to develop the model.						
Action Step	**Deliverable**	**Timing**	**Responsible Parties**	**Resources**	**Success Indicators**	**Notes**
Schedule and attend meetings.	Meetings occur.	Short-long, continual process.	Gwyn Myer, Nikola Smith	Framework Sara has been working on.	Meetings occurring consistently.	Met Nov 1, more to be scheduled.

Strategy 4.1c. Convene a process to establish a demonstration project in partnership with USFS and other partners.						
Action Step	**Deliverable**	**Timing**	**Responsible Parties**	**Resources**	**Success Indicators**	**Notes**
(See action for strategy 4.1b.)						
1. Continued contact with Rob Macwhorter and Tracy Tophooven.	Contact continued.	Completed, ongoing.	George McKinley, Nikola Smith		Contact maintained/ continued.	
2. Continue communication with Ken Wearstler on this project.	Continued communica-tion.	Completed, ongoing	Gwyn Myer		Contact maintained/ continued.	Ken has attended some ecosystem services meetings to date
3. Maintain Jack Shipley's participation.	Jack Shipley is kept in the loop.	Completed, ongoing.	George McKinley, Gwyn Myer		Contact maintained/ continued.	Jack is aware of this endeavor and supports it.

Objective 4-2. *Use ecosystem services as tool to fund climate adaptation work.*

Strategy 4.2a. Take model to funders, municipalities, private landowners after the model is developed						
Action Step	**Deliverable**	**Timing**	**Responsible Parties**	**Resources**	**Success Indicators**	**Notes**
Take the model to funders, municipalities, private landowners.	Model shared.	Short-long, continual process. Begin as soon as model is developed.	Ecosystem Services team (Gwyn, Sara, Nikola, Bob, George, Kerry, TFT)	Model once completed.	Model shared.	

Objective 4-3. *Articulate ecosystem services to gain public support/engagement.*

Strategy 4.3a. Create a report/survey to give to the public						
Action Step	**Deliverable**	**Timing**	**Responsible Parties**	**Resources**	**Success Indicators**	**Notes**
Create a report/survey articulating ecosystem services.	Report/ Survey.	Short- Summer 2014.	Ecosystem Services team (Gwyn, Sara, Nikola, Bob, George, Kerry)		Report/ Survey distributed.	

Objective 4-4. *Incorporate metrics for ecosystem services into the climate adaptation plan and the Rogue Basin treatment prioritization (2014).*

Strategy 4.4a. Conduct a coarse-level assessment of ecological integrity in the Basin to determine where the areas are that might be prioritized for biodiversity conservation.						
Action Step	**Deliverable**	**Timing**	**Responsible Parties**	**Resources**	**Success Indicators**	**Notes**
Collaborate with Sara Vickerman (Defenders of Wildlife) and Jimmy Kagan who are taking on such an assessment.	Map or set of electronic products that will be available to anyone who wants to use them on the Oregon Explorer (OSU).	Short. Summer 2014.	Jimmy Kagan, Oregon Biodiversity Information Center at PSU		Maps/produ cts produced and incorporate-ed into planning efforts regionally.	
Strategy 4.4b. Incorporate Forest Products into the Climate Implementation/Rogue Basin Treatment prioritization.						
Action Step	**Deliverable**	**Timing**	**Responsible Parties**	**Resources**	**Success Indicators**	**Notes**
Meet with SOFRC technical team and ecosystem services team to determine how to incorporate forest products.	Meeting held.	Short. Spring 2014.	SOFRC technical team and ecosystem services team	SOFRC assessment.	Forest products incorporated.	Bring someone from SOTIA in on this conversation?

Strategy 4.4c. Conduct a coarse scale 'valuation' of a limited set of ecosystem services in the basin, e.g., water, carbon, fire and biodiversity to address both market and non-market values, and to use economic, quantitative but not monetized, and qualitative methods to assess these "values".						
Action Step	**Deliverable**	**Timing**	**Responsible Parties**	**Resources**	**Success Indicators**	**Notes**
Find funding to partner with Defenders of Wildlife, who are conducting this valuation.	Funding found.	Short. Summer 2014.	Ecosystem services team		Funding established, valuation completed.	Economists, social scientists, ecologists, and stakeholders should be brought together for valuation.
Strategy 4.4d. Incorporate health benefits into decision making and identify health benefits in outcomes received from management approach.						
Collaborate with Jackson County Health Dept/Susan Bizeau.	Coordination and support from JCHD.	Short. July 2014.	Gwyn Myer, Susan Bizeau	Jackson County Climate and Health Action Plan.	Health benefits from management outlined.	PSU Institute for Sustainability and OHA both are interested in this type of work as well.

Objective 4-5. *Schedule implementation of a project with an ecosystem services approach that has a focus on climate adaptation.*

Strategy 4.5a. Tie into existing projects (tiered approach).						
Action Step	**Deliverable**	**Timing**	**Responsible Parties**	**Resources**	**Success Indicators**	**Notes**
1. Tie ecosystem services and climate adaptation into Ashland Forest Resiliency Project.	Ecosystem services and climate adaptation mechanisms clearly defined with AFR work.	Short. March-May 2014.	Ecosystem services team		See deliverable.	TNC (Es partner) is involved with AFR and can likely help with the lead on this.

2. Identify other existing projects that could be tiered to climate adaptation and ecosystem services.	Projects identified.	Short. March-April 2014.	Ecosystem services team		Projects ID'd and ES /Climate adaptation tied in.	Friese Camp? Pilots? Tie into identified AMA project by end of 2014.
Strategy 4.5b. Increase stakeholder base in order to garner more support and resources.						
Action Step	**Deliverable**	**Timing**	**Responsible Parties**	**Resources**	**Success Indicators**	**Notes**
Create and build upon partnerships and synergy with existing projects.	See 4.5c #2 and action steps under 4.5a.	Short, med, long (continual).	Ecosystem services team			
Provide/coordinate with SOCAN to provide materials at outreach events.	Material info shared at public outreach events.	Short, medium (ongoing).	Ecosystem services team and SOCAN (Alan Journet, Cara Cruikshank)		Material/info shared at events.	Need to develop a brochure/ pamphlet for this.
Hold workshops on ecosystem services and climate adaptation.	Workshop held incorporating land managers and other stakeholders.	Short. By May 2014.	Ecosystem services team	TNC might have funding for such a workshop, could partner with SOFRC.	Workshop held.	Be sure to include/contact Becky Gravenmeier and Louis Evers (FS and BLM climate change coordinators for the region.

Strategy 4.5c. Create implementation project with focus on climate adaptation and ecosystem services by 2016.						
Action Step	**Deliverable**	**Timing**	**Responsible Parties**	**Resources**	**Success Indicators**	**Notes**
1. (see above actions for objective 4.5).						These will help prep for this project, learn and improve from current successes.
2. Partner with others currently engaged in developing ecosystem services (TFT, Willamette Partnership, Defenders of Wildlife, Klamath Basin Rangeland Trust, TNC, GEOS).	Partnerships formed/ contact made.	Short. April 2014.	Ecosystem services team		Partnerships formed.	Already have contacted/have support from TFT, TNC, GEOS, Defenders, and Willamette. Still need to contact Klamath Basin Rangeland Trust.

Plan Implementation

While components of this plan require further planning and funding, implementation of this plan should begin immediately. There are several synergistic opportunities for partnerships and engagement that can enable objectives to be met and the creation of mutually beneficial projects or endeavors. Thus, building upon engagement and partnerships, outreach about the plan, and moving forward on synergistic opportunities are the first steps that should occur. This will increase the local capacity to be adaptive and resilient.

A partnership that is already forming is with SOFRC, the USFS Pacific Northwest Research Station, RRS FS, Defenders of Wildlife, and The Freshwater Trust. Meetings began in August 2013 to begin formulating a plan for an implementation project in the Rogue-River Siskiyou Forest Service lands that would focus on climate adaptation using an ecosystem services approach. There have been follow up meetings, and more are scheduled as well as a workshop among experts and land managers to be held in Spring 2014 to identify knowledge gaps and how to best move forward with an implementation project. The RRS FS has expressed support for such a project.

Additionally, SOFRC has conducted an initial social assessment and timber assessment for implementation of their integrated restoration approach in the Illinois Valley, which was presented to Governor Kitzhaber in November, 2013. Overall public support of this type of restoration approach seems strong and timber outputs economically viable.

Several partnerships were created throughout this process, as well as synergistic opportunities identified. Continued contact and information sharing is important to keep momentum going forward and to identify funding opportunities. SOFRC's funding of a project coordinator will help ensure this happens through meetings, email updates, and coordinated efforts to inform management planning, find funding, and work toward implementation.

One of the best methods to ensure adaptation measures are considered and implemented is to integrate this plan's findings into existing planning and decision making processes. There are several existing opportunities for the findings to be incorporated. Gaining stakeholder engagement and input, and updating of the plan based on such input and 'lessons learned' is critical to its success.

Anticipated Outcomes

An anticipated outcome that we are currently working toward is the implementation of a project focused on climate adaptation with an ecosystem services approach that incorporates the SOFRC integrated forest restoration strategy. This would be a demonstration project to start, working to gain public support and scientific backing for such an endeavor. The next step is to apply it on a larger, landscape scale. As the projects move forward, recommendations to agencies of how to incorporate climate change and ecosystem services into federal landscape planning and implementation will be made. Agencies are mandated to incorporate these into their management beginning FY 2014. Through the partnerships formed and collaborative efforts ongoing, we are poised to provide recommendations to the agencies on these new mandates, and furthermore we've been asked to do such by the agencies.

As the aforementioned strategies are implemented, the ecological and economic resilience of the region will increase. Watersheds will become healthier with reduced fire risk to both the watershed and homes in the WUI identified as communities at risk through local fire plan efforts. Additionally, methods to quantitatively assess the valuation of ecosystem services in the Rogue Basin will be established. This will assist in future decision making that incorporates local values, avoided costs and non-market values, and explicitly considers the values and benefits derived from healthy watersheds. Current stressors, climate and non-climate related, will be reduced.

Economic benefits of active restoration management include timber receipts for county government, employment and tax revenues associated with harvest, production and forestry support, and less quantifiable benefits related to home values, quality of life, and others. For example, treatments restore more fire resistant and drought resistant forests, resulting in reduced fire suppression and rehabilitation costs as well as reduced loss of critical wildlife habitat, forest, property and economic opportunity (tourism, hunting, recreation, etc.) to wildfire and increased resilience to climate change.

The cost of climate change, which is anticipated to be more than $1 billion dollars by 2040 if we do nothing to address it, can also be mitigated substantially. Reducing wildfire risk and threats to water quality and quantity will not only save money by avoiding emergency situations, but it will also aid in reduction of health impacts. The Rogue Basin will be better able to anticipate and prepare for natural events such as strong storms, drought, flooding, and fire.

Significant progress has been made in the Rogue Basin to meet two of the three National Wildfire Cohesive Strategy goals: fire response and creating fire adapted communities. The third goal, restoring fire-resilient forests, can be achieved through the recommendations in this plan. The integration of fire resilient forests into regional goals as part of the Western Regional Cohesive Strategy is currently a project of the SOFRC through the Fire Adapted Communities Network.

Additionally, the partnerships created throughout the process and the stakeholder engagement will increase capacity to respond swiftly. Knowledge of other ongoing efforts and collaborative approaches will also increase flexibility to adapt as needed. These efforts will strengthen relationships and incorporate diverse interests. The quality of life will increase, and economic activities will expand. The Rogue Basin will be recognized as a leader in climate change adaptation, and economic and ecological resilience.

Appendix A. Forest Stressors and Solutions

Stressor	Solutions	Responsible Parties	Comments	Policy/Governance
Forest Management Practices (over harvesting; crowded stands; mining; dredging; chemical use, water diversion, etc.)	Increase collaborative project development Incentives for ecologically based land management (education -workshops, scenario planning; funding/recognition) Modifying forest permits for local conditions Reform OFPA, forest plans Increase use of Stewardship Authority Integrated Resource Restoration (Forest Service)	Regulatory agencies (NOAA, FWS, ODFW) BLM, FS, County, City	Limitations of capacity for regulatory and government agencies; streamlining not ideal; Stewardship Authority resisted by the O&C counties	HFRA, OFPA, NWFP, ESA, CWA, CFLRA, P.L. 108-7 (16 USC 2104 Note)
Increased fire severity and frequency overcrowded stands (= threats to native terrestrial systems) (drought)	Forest thinning/fuels reduction Fire management/controlled burns Landscape forest restoration planning to integrate and protect multiple values and allow large-scale prescribed fire use Use of wildland fire under appropriate conditions to reduce fuels and accomplish restoration	BLM, FS, County, city	Politically difficult (both for burning and thinning), O&C lands make it hard to do a landscape scale mgt to truly lower risk; Stewardship Contracting politically difficult	CWA, OFPA, NWFP, county fire plans, HFRA, ESA, CFLRA, P.L. 108-7 (16 USC 2104 Note)

	Reduce likelihood of megafires with large-scale restoration projects that include prescribed fire that will reduce wildfire severity Burn under conditions of our choosing, rather than when nature overwhelms our fire suppression Increase use of Stewardship Authority Integrated Resource Restoration (Forest Service)			
Current species conversion to shade tolerant, drought sensitive species (not likely to be resilient to climate change) and longer-term threat of loss of conifer dominated forests	Forest management/controlled burns Forest thinning Promote conifer species that are likely to be resilient to climate change across the landscape (pines at low elevations, Douglas-fir at higher elevations) Identify where on the landscape dense, multilayered conifer forests are most likely to persist (as in the NSO habitat suitability layer) and protect those areas Ensure connectivity that will allow species migration to more favorable climates	FS, BLM, county	Politically difficult	ESA

Degraded aquatic habitat	Riparian buffers Watershed clearing limitations Road management plan Stream crossing requirements Stormwater rules Increase shade ORV regulations Mining regulations Increased use of Stewardship Authority, timber receipts restore streams Integrated Resource Restoration (Forest Service)	County, F.S./BLM on federal land, private land owners, City	Buffers politically difficult except on government land Clearing limitations, same Road plans, expensive. Mining regulations have issues with grandfather laws, ORV hard to enforce regulations Stewardship Authority resisted by the O&C counties	ACL guidelines (NWFP), CWA, OFPA, county plans, P.L. 108-7 (16 USC 2104 Note)
Increased fire-Wildland Urban Interface issues (WUI)	Land use regulation to prohibit or control housing in WUI Reduce economic incentives for housing in WUI, such as by reducing subsidization of fire protection Realtor education Private landowner education Fire management / controlled burns Forest thinning programs	County, state fire agency, F.S., BLM, private land owners, city	Need good economic analysis to help “sell” the idea to landowners and county; Reducing incentives might require change in state law. There is FIREWISE in Ashland. Could be good to bring them on board	Zoning ordinances, cty comprehensive plans, O&C Act (creates lots of borders to public land), Cty fire plans

	Firewise programs CWPPs			
Insects/Disease/ Pathogens (drought)	Forest management/Prescribed burns Forest thinning Promote non-host tree species Promote diverse forests-manage for all species	County, city, BLM, FS	Again, using fire and/or thinning are politically challenging	NWFP, OFPA, HFRA, ESA
Invasive Species	Preventative regulatory actions Controlled burns Biological control	BLM, FS, City, County, private land owners OR statute 569 Regulatory agencies: USDA/ODA	Difficult to do on landscape scale due to O&C lands; lack in agreement in solutions	ESA, Noxious weed control districts, limits on interstate commerce, homeowners associations, county programs
Loss of forest land to development	Land use/zoning; Urban growth boundary Land acquisition; Development restrictions (subdivision codes), Riparian zone requirements Inheritance programs to keep large tracts intact Ecosystem service valuations for business case for conservation	County; easement purchase	Politically difficult and/or expensive; use ecosystem services to make case and possibly find ways to pay or make politically tenable	City plans, zoning ordinances, CWA, ACL guidelines, conservation easements

Rangeland Use	Monitoring impacts to determine practice sustainability Prescribed fire to annual grass thatch Control invasive exotic species Frequent grazing rotations Reclaim historical meadows and opening from encroaching conifers	BLM, FS, City, County, private land owners	Politically challenging; grandfather laws	CWA, see above
Recreational Uses	Collaboration with user groups Education Oversight/regulations	Tourism industry, FS, BLM, City, County	Requires policing and regulatory action because people don't follow rules; lack of agreement in who enforces	CWA, ESA, OFPA

Appendix B. Water Stressors and Solutions

Water Stressor/ Impact	Solutions	Responsible Parties/ Parties to include
Stream temperature increasing, Dissolved oxygen decreasing	Plant shade trees and riparian buffers Restore riparian corridors Retrofit existing surface storage (flow curtains, flow outlets) Reduce wildfire risk through thinning/prescribed burning and planting of fire resistant species (fires= less shade) Improve/decommission roads Maintain conditions for groundwater recharge in uplands (uncompacted soils, undergrowth, woody debris, road BMPs to reduce overland flow) Maintain aquifer levels and reduce contamination of groundwater supplies to continue quality surface water recharge Identify gaining reaches of streams and seek to protect groundwater quality and quantity supplies to those reaches	Respective waste water management facilities; ODEQ and maybe ODF(funding); Freshwater Trust and other such agencies (implementation); Private land owners; Federal agencies (BLM/FS) (same as above) Respective source water providers and water treatment plants Watershed councils ODF, BLM, FS ODEQ, Dept of Ag, WRD USGS and WRD, DEQ
Droughts	Identify critical drought areas Assess vulnerability of groundwater and surface water resources Update/develop climate change drought management plans Require local water use restriction ordinances/conservation measures during water shortages Increase authority to implement water restrictions	Water suppliers (cities); ODEQ, ODF?, Emergency Management, Planning commissions, JCSWD, RVCOG For planting: the above, agencies, etc. will likely need to hire organizations such as the Freshwater Trust to do the plantings and restoration work Watershed councils WRD

	Develop automated gauging/formal reporting network for rivers, public water supply reservoirs and aquifers Plant native drought and fire tolerant/resistant species	
Floods	Conserve and restore Riparian zones, wetlands, and floodplains Inventory past flood conditions Assess future flooding risks and impacts on infrastructure Develop/update floodplain mapping Integrate climate change into land use planning. Enhance filtration in headwater areas and near watershed divides, and protect/recharge infiltration buffers from overland flow and runoff Provide tax credits for green infrastructure implementation, reduced storm water fees to reward greater site permeability and rebates for downspout disconnection Involve insurance providers to encourage development outside vulnerable floodplains, reflect risk rates, and protect lands at risk Improve/decommission roads	Emergency Management (OR; counties) Cities Counties Planning commissions Jackson County Soil and Water Conservation District ODEQ ODF Agencies (BLM, FS, USFWS, NOAA) Freshwater Trust KS Wild and other non-profit and environmental groups Private Landowners Watershed Councils
Sediment/Erosion, Pollutant Runoff (arsenic, nitrate, bacteria, salts/minerals, radon, pesticides), and associated biological imbalance (algae blooms, PH, chlorophyll),	Restore or enhance riparian buffers and wetlands Decrease runoff and increase infiltration in uplands Increase pesticide and nitrate monitoring efforts in groundwater to	Agriculture industry and farmers Cities, counties, federal, and private lands NGOs and non-profits, orgs such as extension office, JCSWD, Freshwater trust to promote outreach, education, and

Turbidity	identify priority areas Employ conservation tillage and cover crops Retrofit filtration devices to existing drainage systems to reduce water quality impacts Promote education for farming BMPs to reduce fertilizer volume and timing, irrigation volume and timing, and reduce pesticide use, including land-use techniques Promote green infrastructure Use non-toxic household and garden products Promote planting of native plants Reduce wildfire risk Improve or decommission roads	help with restoration and mitigation projects; and applying updates/conservation techniques/tools Watershed Councils Public
Altered hydrology	Require enhanced performance-based retention standards Monitor biophysical impacts to hydrology and water resources Conduct longterm basin hydrology assessment	ODOT ODEQ Water suppliers (cities) Non-profits interested in such work to perform monitoring and analysis (SOFRC, TNC, GEOS, Freshwater Trust, SOCAN?, others?)
Habitat Modification, Simplification of stream channels, Loss of intact riparian corridors	Restore and maintain critical landscapes (see above solutions)	All landowners, agencies, counties, cities, watershed councils, non-profits, environmental orgs
Water Quantity-depleting aquifers	(see above solutions) – Possible restrictions on new private wells where public supplies are available	(same as above)

	Conservation practices and incentives with water use; restoration of habitat and riparian areas; reduce impervious surfaces and increase vegetation; improve recharge opportunities in uplands	
Water quantity- shifts in stream flows, Earlier snowmelt, Less snowpack, more precipitation instead, soil moisture	Plant/retain native trees Update flood storage/mountain reservoir capacity for changing climate forecasts (same solutions as listed above)- conservation measures; planning incentives/disincentives; preparation for and mapping/monitoring; increase vegetation/decrease impervious cover; restoration work Additional protections for existing wetlands, possible creation of new wetlands where feasible to slow flows Maintain and restore necessary environmental flows	Mt. Ashland, FS/BLM, private landowners, water suppliers (cities), planners, JCSWD, watershed councils
Mining Practices	Improve monitoring of mining practices Educate on proper mining practices Increase regulations	ODEQ? Permitting entities? (agencies?)
Faulty/aging septic systems	Monitor septic systems Provide incentives for updated septic systems	ODEQ? Conservation districts
Cattle grazing	Increase oversight of cattle grazing Increase riparian areas/wetlands regulations Educate and outreach to cattle owners re BMPs, options for cattle watering	JCSWD, OSU extension (education/outreach) Cattle owners Permitting agencies (BLM/FS)

Agricultural Practices	Use soil conservation techniques Use cover crops and water-holding crops Develop incentives/promote dry farming opportunities (see above items in relation to agricultural practices under erosion/sediment/pollution and cattle grazing; also under irrigation (below)	OSU extension (outreach/education), planning commissions, counties (zoning) ODA, SWCD
Irrigation/outdoor water usage (over use due to lack of attention or education)	Maintain and repair existing irrigation systems Education re appropriate use for various crops, optimal distribution Harvest and store rainwater for agricultural use Capture runoff Provide incentives for increasing storage capacity Use efficient irrigation technology (drip/pulse irrigation) Continue to provide incentives for reduction in water use (tiered system) Change/continue development ordinances to address water usage to reduce irrigation demands	Agriculture OSU extension, JCSWD, Freshwater Trust, conservation districts, water suppliers (cities; MWC)
Impervious surfaces	Reduce impervious surfaces Restore riparian buffers and corridors Encourage planting of climatically appropriate vegetation	All land owners and water managing agencies, land use planning agencies, ODOT
Aquatic Species threats	Restore and maintain stream complexity and connectivity Improve fisheries management for native species	All land owners, counties, cities, agencies; Non-profits and restoration groups; fisheries; planning agencies, watershed councils

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