PREPARING FOR CLIMATE CHANGE IN THE ROGUE RIVER BASIN OF SOUTHWEST OREGON

Stressors, Risks, and Recommendations for Increasing Resilience and Resistance in Human, Built, Economic and Natural Systems

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Executive Summary

The Rogue River Basin, located in southwest Oregon, consists of a diverse array of communities, economies and ecological systems. The Basin's rich history, beautiful setting, and recreational and employment opportunities, attract visitors and residents to the region year-round. Climate change is likely to produce significant new stresses and alterations to water quantity and quality, fish, wildlife, plant life, forests and fire regimes of the Rogue Basin. The Rogue will not be the only region to experience the effects of climate change. Every region of the West, nation, and the world will be affected. These changes will, however, have important consequences for the economy, infrastructure, and human services on which the people and communities within the Rogue Basin rely on for their quality of life.

In the summer of 2008, the University of Oregon Climate Leadership Initiative, in partnership with The National Center for Conservation Science & Policy and the MAPSS Team at the U.S. Forest Service Pacific Northwest Research Station, initiated a project to assess the likely consequences of climate change for the Rogue River Basin. The project began by downscaling three climate models (CSIRO, MIROC, and Hadley) and incorporating a global vegetation change model (MC1) used by the Intergovernmental Panel on Climate Change. A panel of scientists and land managers then assessed the likely risks posed by changing climate conditions to natural systems and made recommendations for increasing the capacity of ecosystems and species to withstand and adapt to those stressors.
In turn, a panel of policy experts used the information provided by the scientists to assess the likely risks to economic, built, and human systems within the Rogue Basin posed by climate change and recommended ways to increase resistance and resiliency of those systems.

The downscaling of the three climate models and the analysis of the vegetation model led to the following future projections for the Rogue Basin :

Temperature

- Annual average temperatures are likely to increase from 1 to 3° F (0.5 to 1.6° C) by around 2040, and 4 to 8° F (2.2 to 4.4° C) by around 2080.
- Summer temperatures may increase dramatically reaching 7 to 15° F (3.8 to 8.3° C) above baseline by 2080, while winter temperatures may increase 3 to 8°F (1.6 to 3.3° C).

Precipitation and Snowpack

- Total precipitation may remain roughly similar to historical levels but increasingly is likely to fall in the mid-winter months rather than in the spring, summer and fall.
- Rising temperatures will cause snow to turn to rain in lower elevations and decrease average January snowpack significantly, with a corresponding decline in runoff and streamflows. According to one model, snowpack will be reduced 75% from the baseline by 2040, and another 75% from 2040 to an insignificant amount by 2080.

Storms, Flooding, and Drought

- The Basin is likely to experience more severe storm events, variable weather, higher and flashier winter and spring runoff events, and increased flooding.
- Both wet and dry cycles are likely to last longer and be more extreme, leading to both periods of deeper drought and those of more extensive flooding.

Wildfire

- Reduced snowpack and soil moisture along with hotter temperatures and longer fire seasons likely will increase significantly the amount of biomass (vegetation) consumed by wildfire.

Based on these projections, the science panel identified the following likely consequences for aquatic and terrestrial systems and species in the Rogue Basin:

Aquatic Systems and Species

- Increased storm and fire frequency will increase sediment and nutrient loads as well as persistent organic pollutants and other contaminants entering the Rogue River and its tributaries. Along with higher water temperatures these factors will reduce water quality, threatening the recruitment and survival of young native fish.
- Shifts in the timing of stream flows could trigger earlier emergences of aquatic insects and shifts in the timing of adult salmon and steelhead spawning migration, egg incubation and hatch, and smolt outmigration. The result is likely to increase the risk of a disconnection between the timing of fish life stages and the availability of primary food resources.
- Warmer water temperatures and extended low summer base flows extending well past the summer months are likely to decrease dissolved oxygen, produce more disease, and create a greater frequency of conditions lethal to native fish.
- More storms and flooding likely will increase streambank erosion and increase channel downcutting resulting in degraded stream habitat and habitat fragmentation precipitating a reduction in biotic carrying capacity, heightened susceptibility to flood and drought, and a contraction of the stream network.

Terrestrial Systems and Species

- Increasingly drought stressed vegetation, due to higher evaporation rates, will lead to increases in insect outbreaks and disease. Stressed and dying vegetation will produce larger and more frequent wildfires.
- Rapid shifts in climate, compounded by habitat fragmentation, will complicate the opportunity for some native vegetation and wildlife to adjust and disperse, leading to shifting populations.
- Changes in the timing of flowering and insect emergence could disrupt historical relationships between migratory species, and especially long-distance avian migrants, and prefered food availability.
- Amphibians may be especially at risk due to the low mobility of some species and increased drying and habitat conversion expected from climate change.
- High elevation wildlife and plant species may not be able to make the shift to new areas due to a lack of available habitat.
- Disease and disease vectors are expected to increase with warmer temperatures. Individuals under stress from climate change and other stressors will also be more susceptible to disease.

Both Aquatic and Terrestrial Systems

- The changes described above mean increased vulnerability of aquatic and terrestrial species should be expected.
- Expansion in invasive species may also be likely as conditions become more favorable for exotics and less favorable for some natives.

Based on the analysis of the risks to natural systems, the policy panel identified the following risks to built, human and economic systems in the Rogue Basin:

Infrastructure

- Increased disruption and direct damage to transportation systems, buildings, and real estate from more flooding and wildfires; possibly even larger indirect costs due to more rapid depreciation.
- Many roads will likely to be impacted by more frequent storm events, flooding and wildfires, impairing the movement of people during emergencies.

Energy Systems

- Electricity from the Bonneville Power Administration (BPA) hydro system is likely to be constrained in summer months because of reduced snowpack and stream flows just as electrical demand rises due to increased need for air conditioning in the summer and increases in population.
- Power lines are likely to face increased stress due to rising fires and temperatures.

Public Health

- Demands for emergency services are likely to increase as storm events, flooding and wildfires increase, but the funding needed to support them may be difficult to obtain.
- Rising summer temperatures will likely increase the incidence and intensity of heat-related illnesses and vector- and water-borne diseases such as Lyme disease and West Nile virus.
- Rising temperatures and increased smoke from wildfires are likely to increase the incidence of asthma.

Agriculture and Forestry

- Forest products may shift to smaller diameter logs if managed by thinning to reduce drought stress and to supply new biomass energy or alternative forest products.
- Agriculture will face increased competition between in-stream and municipal users for available water supplies while rising temperatures are likely to require the use of more water and/or a shift in crop types and farming practices.

Manufacturing, Retail and Service Sectors

- Manufacturing, retail and service sectors are likely to experience higher fuel and electrical costs due to reduced summer output from the BPA hydroelectrical system, disruption in supply chains and the distribution of goods due to increased storm events, flooding, and fires, and increased workforce health concerns.
- Winter recreation activities such as skiing and snowmobiling will be reduced as snowpack decreases.

The science panel made the following recommendations to prepare aquatic and terrestrial systems for climate change by increasing resilience and resistance:

Aquatic Systems

- Restoration and maintenance of stream complexity and connectivity will improve spawning habitat and allow for movement to new areas as other areas become too warm.
- Restoration and maintenance of critical landscapes such as high elevation riparian areas, floodplains, tributary junctions, north-facing streams, and stream reaches with gravels and topographic complexity.
- Management of fisheries to protect genetic and life history diversity of native species.

Terrestrial Systems

- Protection and restoration of ecosystem structure, function and genetic diversity to allow organisms to withstand and adapt to climate stressors.
- The use of strategic fire should be used to reduce the likelihood of severe fire, as should replanting with a diverse array of native species, and ecologically appropriate fuels reduction efforts.
- Remaining intact habitats should be protected, including old growth, roadless areas and corridor connections for wildlife migration. Protected areas should be expanded longitudinally and latitudinally in order to allow species to shift their ranges.
- Land and stream reaches that provide critical support for ecosystem services should be identified, protected and restored. Ecosystem services are benefits that people gain from functioning ecosystems, including clean water, decomposition of waste and toxins, timber harvest, recreational opportunities, etc.
- Translocations may be necessary when the suitable climate changes too quickly for species to adjust their ranges, or when habitat fragementation prevents their movement.

Both Aquatic and Terrestrial Systems

- Reducing existing stressors, such as habitat fragmentation, erosion from resource extraction and roads, air and water pollution and contamination, the loss of keystone species, introduction of invasive species, and conversion of forests, riparian areas and floodplains to urban and suburban development, would result in substantial benefits to both aquatic and terrestrial species and systems.
- Redirect responsibility for emergency services so that private parties that wish to locate in these high risk areas pay for those services, while also providing funding and tools to help low income and vulnerable populations cover these costs.
- Management should shift to encompass climate-induced changes and contribute to the landscape's ability to buffer greater seasonal, annual, and decadal variability in temperature and precipitation as well as more severe storm events.

The policy panel made the following recommendations to prepare human, built, and economic systems for climate change:

Infrastructure

- Permanent structures should be moved out of high risk floodplains, riparian areas and steep forested canyons if and when they are damaged by floods or fires and new development should be constrained in these critical landscape areas.
- Link public transportation systems as much as possible to facilitate movement of people and equipment in emergency situations.
- Expand road upgrading and maintenance such as the installation of larger culverts and regular culvert clean outs to prevent wash outs during major storms and floods.
- Expand conservation and efficiency programs in commercial and residential buildings to dramatically reduce energy and water use.
- Increase the use of distributed energy such as solar and high-efficiency thermal biomass in order to provide backups in times of energy supply problems and to stabilize costs.
- Re-examine the water allocation system and groundwater use to avoid over-appropriation.

Emergency Management

- Concentrate human populations away from high-risk floodplains and steep canyons to less risky portions of the Basin.
- Redirect emergency service responsibilities so that private parties who choose to locate in high-risk areas pay for those services.
- Link climate preparation with economic development such as job creation through fuels reduction in the urban-wildland interface.

Public Health

- Upgrade and adapt vector control programs to better respond to emerging diseases.
- Strengthen and expand water quality protections from runoff and contaminants.
- Enhance strategies to anticipate new climate-induced health service needs and ensure they are provided to the most vulnerable citizens.

Agriculture and Forestry

- Maintain existing crops as long as possible while also researching new crops and sustainable farming practices in advance of climate-induced demands for change.
- Expand agricultural energy and water conservation and efficiency programs.
- Forest management should incorporate future climate conditions by building resistance and resiliency through greater structural and genetic vegetation diversity.
- Forests managed with longer harvest rotations will sequester more carbon and may acquire credits in a cap and trade market.

Manufacturing, Retail and Service Sectors

- Expand the use of on-site renewable energy systems to provide protection against blackouts and provide stability to energy prices.
- Significantly expand water conservation and efficiency programs and policies in manufacturing and other urban and suburban settings.
- Explore ways to expand the tourism season to include spring and winter as summer seasons become hotter.

A consistent theme heard from the panels was the need for new types of information, resource allocations, and decision-making mechanisms. In short, the panels called for new and expanded forms of governance. Specific recommendations include:

- Incorporate climate change preparation into all current and future public and private plans and policies.
- Reorient management plans and policies to focus on the 'Future Range of Climate Variability' rather than the long-held approach of management based on historic patterns.
- Set goals and priorities appropriate for projected future conditions, with alternative plans, goals, and priorities in place for seamless adjustments to changing conditions.
- Utilize 'scenario planning' methods to identify and plan for climate futures.
- Expand planning and decision making to at least the Basin scale rather than planning at the forest, county, city or project levels in isolation of other regions or interests.
- Evaluate how policies, programs and projects may affect climate preparation efforts in other sectors or regions of the Basin and constantly identify ways for one activity or project to provide co-benefits for others.
- Expand participation on planning and decision-making teams to include people representing different stakeholder groups or other regions of the Basin that are likely to be affected by climate change.
- Improve and reorient data gathering and monitoring systems to generate timely information on the speed, trajectory, and consequences of climate change.
- Increase public understanding of the likely consequences of climate change and preparation options as well as efficacy of management action.

Global temperatures are rising in large part due to human activities. No matter how fast human-induced greenhouse gas emissions can be reduced, over the coming decades climate change is likely to significantly stress and transform natural systems in the Rogue Basin. These changes will produce considerable modifications in the way the local economy functions, in infrastructure and buildings, in human health, and in the quality of life of the people who live in and enjoy the Rogue River Basin. Numerous initiatives are already underway within the Rogue Basin that can help people prepare for these effects. Upgrading existing and proactively launching the additional climate preparation steps described in this report in an integrated and co-beneficial manner can build resistance and resilience to climate change and help people and communities adapt and thrive in the future.

Introduction and Background

In 2007, the Intergovernmental Panel on Climate Change (IPCC) declared that the evidence is now "unequivocal" that the earth's atmosphere and oceans are warming (IPCC 2007). The IPCC concluded that human activities, including the emission of carbon dioxide, methane and other greenhouse gasses, along with land clearing and development, are responsible for most of the warming. Left unchecked, rising global temperatures and the changes in climatic patterns they cause will affect ecological health and thus undermine economic and social prosperity and security locally and abroad.

This report describes the likely consequences of climate change on natural, human, built, and economic systems in the Rogue River Basin of southwest Oregon. It also describes a suite of strategies and policies for building resistance and resilience to climate change in the Rogue Basin recommended by a panel of scientists and policy experts. The consequences of climate change will not be restricted to the Rogue Basin. Climate change is a global problem and no region in Oregon or elsewhere in the West or the world will be immune from its impacts.

Photo by Steve Whitney

This report is the product of a larger initiative aimed at establishing a common method for developing integrated climate preparation plans and policies. The project is coordinated by the Climate Leadership Initiative in the Institute for Sustainable Environment at the University of Oregon, in partnership with The National Center for Conservation Science & Policy (NCCSP) and the MAPSS Team at the U.S. Forest Service Pacific Northwest Research Station (PNW). In addition to the Rogue Basin, climate preparation assessments will be developed for the Upper Willamette, Klamath and Umatilla Basins. This work will pave the way for collaborative efforts that will increase the resistance and resilience of natural, built, human, and economic sectors to climate change in Oregon and the West.

What is Climate Change Preparation and Why is it Needed?

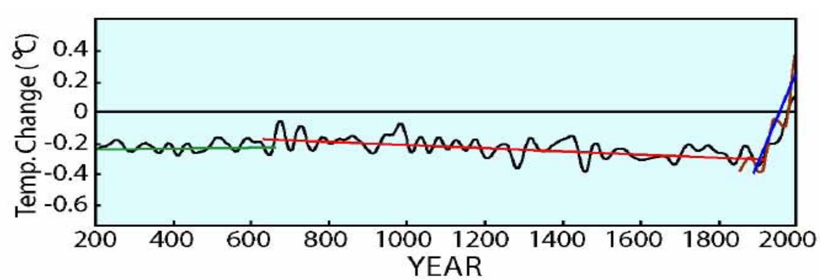

Fig 1. global departures in mean surface temperature over the last two millenia, as compared to 1961-1990 average (adapted from mann and jones 2003).

Global mean surface temperatures have already risen by 1.3º F since the early part of this century (Figure 1). In the Pacific Northwest, average temperatures have risen by 1.5º F. Scientists have spent considerable time teasing out natural from human-related drivers of global warming, and the consensus is that solar variability, volcanic activity and other natural events cannot account for current levels and rates of global warming (IPCC 2007).

Only when the atmospheric concentration of carbon dioxide, which has risen more than 35% since pre-industrial times, methane, which is up 155%, and other greenhouse gasses, are taken into account do climate models replicate observed warming. The bottom line is that global warming is indisputably happening, humans are the primary cause, and this warming will have serious impacts to the world's climate systems.

Although much attention is being appropriately focused on reducing U.S. greenhouse gas emissions by 80% or more to restabilize the climate, it will take fifty years or more for this to occur because of the residence time of emissions already built-up in the atmosphere (IPCC 2007). Efforts to prepare natural, economic, built, and human systems to withstand and adapt to the now unavoidable consequences of climate change therefore must become a priority of government, the private sector, and households. Preparation efforts will, in many cases, complement and enhance actions aimed at reducing greenhouse gas emissions.

This report provides an initial set of guidelines for preparing for climate change in the Rogue Basin. The term "preparation" as used in this context means to proactively build **resistance** and **resilience** within natural, human, built and economic systems to enhance their capacity to withstand and adapt to climate change. Resistance strategies seek to increase the capacity of systems to withstand the negative effects of climate change. Resilience strategies are aimed at building the capacity of systems to recover from the impacts of climate change.

The Rogue Basin Project

This report is intended to provide a starting point for climate preparation efforts in the Rogue Basin. We hope that, over time, all levels of government, the private sector, and households will utilize the information and recommendations as a platform to expand their knowledge and develop continuously improving climate preparation strategies and policies.

The Rogue River Basin of Oregon is a special place. It stretches from the crest of the Cascade Mountains near Crater Lake to the Pacific Ocean in the southwest coast. The Basin incorporates most of Josephine, Jackson and Curry counties, which are home to approximately 302,000 people. Agriculture, forestry, tourism and a diverse array of other commercial sectors support the local economy. Salmon and steelhead fill the rivers, and wildlife is abundant. The Rogue Basin is characterized by its immense natural beauty, which provides spiritual and recreational opportunities for local residents and visitors from around the world.

Climate change is likely to profoundly affect the natural systems of the Rogue Basin. Changes in the structure and function of ecological systems and species will, in turn, affect the economy, communities and quality-of-life of residents. The consequences of climate change in the Rogue Basin were assessed using three models (CSIRO, MIROC, and Hadley) operated under the 'A2' emission scenario assumptions that were developed by the Intergovernmental Panel on Climate Change (IPCC 2007). With assistance from USFS Research Station PNW's MAPSS team, global climate change

Fig 2. Map of Rogue River Basin. Courtesy Richard Nauman

projections were downscaled to the Rogue Basin and mapped for two future time periods, 2035-2045 and 2075-2085. In addition, time series graphs were plotted for some factors, such as wildfire, to show how conditions may change over time.

On the basis of the projections made by downscaling the global climate models (GCMs) and incorporating the vegetation model (MC1), a panel of natural systems experts and other participants (see Appendix A for participant list) assessed the likely impacts of climate change on natural systems (species, ecological communities, and ecosystems). They also identified strategies and policies for increasing ecological resistance and resilience. Finally, they noted better needs for research, data, and monitoring to understand impacts and facilitate ongoing learning and adaptation in rapidly changing conditions over time.

The Emission Scenario and Projected Temperature Increase

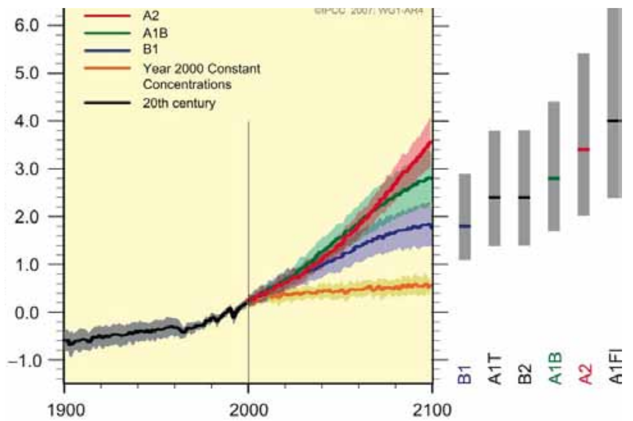

Fig 3. Global surface temperature in the past, and projected 100 years in the future based on multi-model global averages and 6 different emissions scenarios, including A2 (IPCC 2001).

The natural systems assessment served as the basis for a subsequent assessment by a panel of managers and policy experts, (see Appendix B for participant list) who identified the likely risks to human, built, and economic systems posed by the climate and ecological changes. This panel identified strategies and policies for increasing resistance and resilience, as well as information needed to monitor impacts, learn and adjust over time. These workshops form the basis of the recommendations found in this report.

The A2 Intergovernmental Panel on Climate Change (IPCC) scenario used in this project is the "business as usual" emissions path the world is currently following (note that global emissions are now actually higher than the A2 scenario assumes). In this scenario, the IPCC assumes that most countries fail to act individually or collectively to reduce greenhouse gas emissions. Countries preserve self-reliance and national identities, following the lead of the United States, India, and China. The global population continuously increases, reaching a projected 15 billion by the end of the century. The world is much more affluent than today, with a Gross World Product that by 2100 is 26 times the present amount, but economic growth is fragmented and technology change is slow. Emissions caused by land use changes increase, driven by deforestation and converting forests and other lands to agriculture to support population growth, but agricultural productivity gains are low.

On a global scale, surface temperatures increase from just below 1.8º F (1º C) by 2025 to more than 5.4º F (3º C) by 2095 (Figure 3). As ocean waters warm, water expansion from warming alone causes sea levels to rise on average from 0.75 ft (0.23 m) to 1.7 ft (0.51 m); substantial additional rise in sea levels will occur due to polar ice-sheet melting, but ice sheet dynamics are still poorly understood. According to the British Antarctic Survey, sea levels could rise 17-20 ft (5-6m) if the West Antarctic ice sheet collapses (BAS 2004).

To provide a context for the projected increase in global surface temperature, consider Figure 1 (page 1), which shows temperature trends over the last 2000 years. The green line shows global surface temperatures nearly constant for 400 years between 200 AD and 600 AD. The red line shows that global temperatures then declined slowly for 1300 years between 600 AD and 1900 AD. The blue line shows that during the last 100 years, between 1900 AD and 2000 AD, global surface temperatures increased rapidly. This 1.1-1.4º F (0.6-0.8º C) increase in global surface temperature over the past two millenia highlights the novelty of the 1.8-5.4º F (1.0-3.0º C) rise in global temperature anticipated during the coming century.

The Climate Models

The three global climate models used in the Rogue Basin project (CSIRO, MIROC and Hadley) are known as Atmosphere-Ocean General Circulation Models (AOGCM's) and are based on equations describing the atmosphere, land surface, cryosphere (ice and snow), and oceans. Table 1 identifies the factors that are incorporated into the three models.

TABLE 1. MODELING INPUTS FOR EACH OF THE THREE MODELS USED IN THIS PROJECT (IPCC 2007).

Model	CO_2	CH_4	Strat. Ozone	Trop. Ozone	CFCs	Land Use	Aerosols	Solar
CSIRO	Yes	Yes	Yes	Yes	Yes	No	Only SO_4	No
MIROC	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Hadley	Yes	Yes	Yes	Yes	Yes	Yes	Only SO_4, volcanic	Yes

Limitations to the Climate Models

There are several limitations to the climate models that add uncertainty to forecasting future climate. The more refined and region or site specific a global model becomes, the greater the chance of error. Models also have difficulty with modeling the effects of changes in the amount of solar radiation reflected from the earth's surface back to the atmosphere (albedo effect) and the strength of water vapor in warming the planet. The latter issue is especially important because increased water vapor is linked to rising temperatures and water vapor alone may account for 50% of warming. In general, all three models are better at projecting changes in temperature than in precipitation. In addition, the models were created at globally appropriate scales, and "downscaled" to the Rogue Basin. The downscaling permits the examination of local and regional trends, but retains a global level of uncertainty that potentially clouds the results.

> *The global climate models forecast increased precipitation at high latitudes and decreased precipitation at desert latitudes. The Rogue River Basin falls directly in the transition between these two major global bands, rendering future forecasts of precipitation highly uncertain. Most importantly, the models forecast increased severity and variability of precipitation events, particularly in the Rogue Basin transition zone between the wet north and the dry subtropics. More severe and variable weather might mean longer and deeper droughts, as well as longer and more severe floods.*
>
> -- Dr. Ron Neilson, USFS PNW Research Station

Given the limitations, model projections should not be considered absolute; instead, they should both be considered likely possibilities. It is important to note, however, that growing evidence indicates that the climate change projections made by these and many other climate models are, if anything, underestimating the rate and extent of the changes from global warming.