

Climate Change and Forests

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Weather is the short-term variation in temperature, precipitation, humidity, wind and cloudiness. The long-term description of weather patterns is climate. Climate influences forest productivity, water runoff, and plant and animal diversity. Seasonal to inter-annual climate fluctuations can affect the abundance and quality of water resources, recreation and the demand for energy.



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Climate and weather vary by geographic location and elevation. In the coastal areas of the Pacific Northwest, climate is characterized by mild winters, relatively cool summers and abundant rainfall that can be markedly reduced in the summer. The western slope of the Cascade Range, the Olympic Mountains and high elevations in the Rocky Mountains are areas

of deep snow accumulation. The eastern slopes of the Cascades, the Blue Mountains and moderate elevations of the Rocky Mountains in Idaho and western Montana are drier and have lower snowpack accumulations.

Climate and weather also vary over a year, decades and centuries. Climate in the Pacific Northwest is strongly influenced by two sources of inter-decadal climate variability: the Pacific Decadal Oscillation (PDO) and the El Niño/Southern Oscillation (ENSO). These oscillations are characterized by changes in the surface temperature of the Pacific Ocean, sea level pressure and wind patterns in the Pacific Ocean. Both oscillations have a warm phase and a cool phase. In their warm phases, winter and spring is likely to be warmer and winter precipitation likely to be average or less than average. In the cool phases, cooler and wetter winters are likely.

Recent and likely future change in the climate

Over the last 100 years, the average temperature of the United States has warmed by one degree Fahrenheit (F) with a similar increase in the Pacific Northwest. Winter and spring temperatures show the strongest trend in warming. Snowpack has shown a declining

trend in the western United States. Spring runoff has occurred one to four weeks earlier in the last 50 years. Alpine glaciers in the west have retreated and lost mass. Alaska has seen the greatest increase in temperatures.

Scientists use historical climate data and large computer models to study global and regional patterns in climate. With these models, they analyze the influence of atmospheric chemistry, land use and land cover, and natural climate variations caused by sunspot activity and the earth's rotational wobble on climate. The chemistry of the air around us is changing from human-caused and natural emissions. Carbon dioxide, methane, nitrous oxides, chlorofluorocarbons and water vapor, collectively known as greenhouse gases, warm the atmosphere by absorbing and reflecting heat energy near the earth's surface. Displacement of forests by other land uses such as agriculture and urban expansion contributes approximately 25 percent of the carbon dioxide emissions; the rest is from fossil-fuel combustion. Scientists generally agree that increases in atmospheric greenhouse gases have resulted from a human influence, and that increases in North American temperatures observed since 1950 are unlikely to be due only to natural climate variations.

These computer models are also used to explore likely future climates.



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Potential temperature increases in the United States at the end of the 21st century range from two to seven degrees F. Projected changes in precipitation have greater uncertainty, particularly in the western United States. These changes may sound small; however, they translate into subtle but significant shifts, such as longer growing seasons, milder winter temperatures, earlier spring frosts and later fall frosts.

Climate influences forest dynamics and productivity

Plants and animals are adapted to local climates. Tree growth and productivity in the Pacific Northwest can be limited by temperature and precipitation. For example, trees at the upper treeline on mountains are limited by cold temperatures and snowpack, whereas trees at the grassland/shrubland edge, such as ponderosa pine, are more likely to be limited by hot and dry conditions. Forests at these tree-lines are likely to show strong direct effects of climate variation and change on tree growth. Scientists have already shown that the warm phase of the PDO is highly correlated with mountain hemlock and subalpine fir growth because snowpack in the warm phase is much less than in the cool phase. Growth rates for ponderosa pine are reduced under the warm phase of the PDO, which is associated with extended drought.

Based on the past, we can say that changes in the climate are likely to alter species composition within forests. These shifts will reflect individual responses by species. The current collection of plant species within forests will reorganize, resulting in new and novel collections. Plants adapted to cooler climates will seek those climates, moving up mountains or north where possible.

In the Pacific Northwest, possible scenarios range from forest dieback to forest expansion. The uncertainty is associated with the variability in the projections of precipitation across the mountainous west. Another uncertainty is the effect of increasing concen-

trations of atmospheric carbon dioxide on plants. Recent research suggests that the positive effect on plant growth will be minimal; however increasing concentrations of carbon dioxide may improve a plant's ability to use water more efficiently during drought.

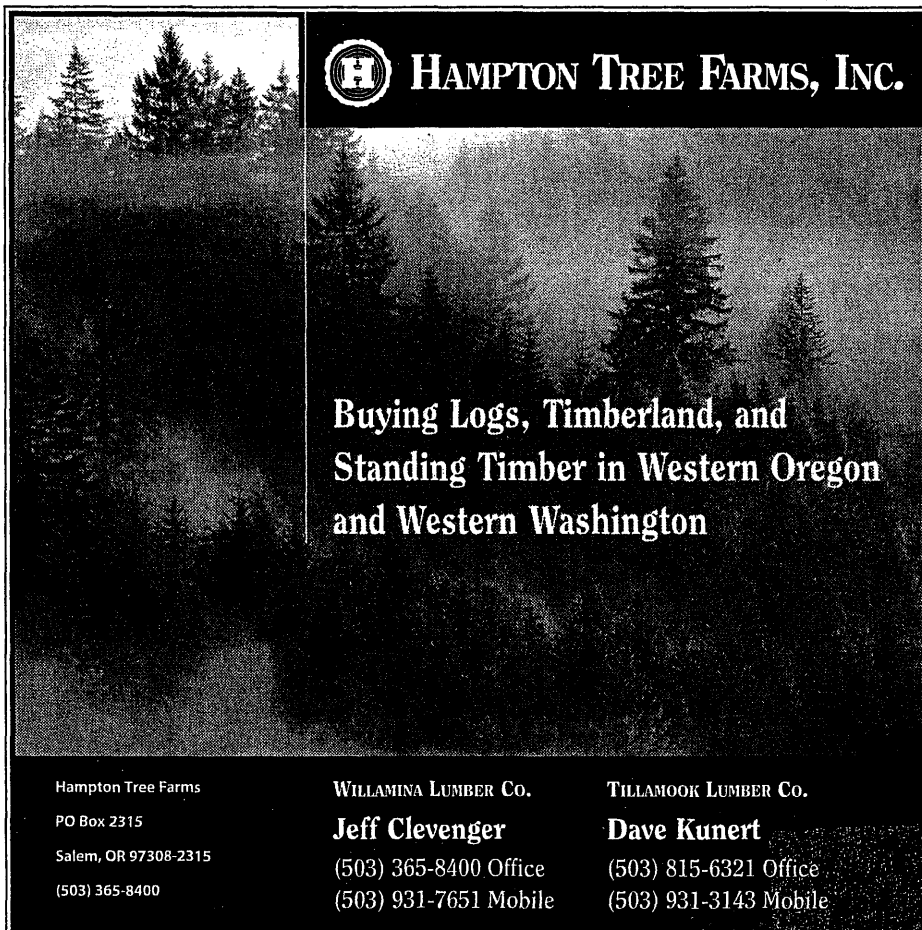
While modeling studies allow a view of what the world might be, scientists are now reporting on observed changes in the climate-sensitive behavior of plants and animals. Analyses of thousands of species and associated climate suggest that observed global and North American changes in plants and animals can be linked to observed climate changes. These behaviors include earlier egg laying by birds, earlier emergence from hibernations in mammals, northern expansion of species ranges, earlier blooming of plants, and changing dominance of warm-water versus cool-water fish species. Further observations of plants and animals in the western United States are needed to definitely conclude that the observed

changes are clearly attributable to climate change.

Climate influences natural disturbances

Natural disturbances such as fire and insect damage are strongly influenced by climate. Analysis of forest fires across the Pacific Northwest suggests that wildfires were more extensive during the 1925-45 PDO warm phase than during the cool phases before and after that period. The amount of area annually burned by fire in drier regions of the Pacific Northwest is expected to be at least twice as high by the end of the 21st century. Recent research has described increasing insect outbreaks associated with warmer temperatures at higher elevations in western mountains.

Ecosystem, plant and animal responses to climate change will be dynamic, influenced by alterations in disturbances (fire, insects), surprises (invasive species, climatic extremes) and adaptation. These changes could be gradual or quite sudden. Climate



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change and increasing atmospheric concentrations of carbon dioxide may encourage the spread of some invasive species. When six invasive weeds—Canada thistle, field bindweed, leafy spurge, perennial sowthistle, spotted knapweed and yellow star thistle—were grown under higher concentrations of carbon dioxide, their average growth increased by 46 percent.

Forest markets and climate

Recent assessments have concluded that nationally, the impact of climate change on aggregate market welfare (consumers' savings plus producer profits) is small. The wood products market is an effective force facilitating forest-sector adaptation to gradual climate change. The market is particularly effective when landowners have options to adapt management to cli-

mate change—options such as altered forest stand management, salvage of dead or dying trees, shifts in the type of planting stock, and changes in fertilization and thinning regimes. With fewer options, regional productivity and sectors will be impacted more.

Managing forests with climate change

A number of responses to managing forests under climate change are possible. Educational resources, national and regional assessments, and local and regional monitoring activities and research provide information on current understanding about climate and forests and are available through federal and state agencies (for example, see www.cses.washington.edu/cig/). Incorporating information about short-term and longer-term climate fluctuations will be critical to activities such as selecting stock and planting. Adaptation may require using nursery stock that are more drought tolerant, mixed species rather than monocultures, and perhaps, lower planting densities (stocking).

In the future, managing for carbon sequestration and increased life cycle of carbon in wood fiber and products will likely become more important, especially if the market value of car-

bon increases. In addition, reduction of greenhouse gas emissions will likely become a stronger regional and national goal. Carbon can be retained for longer periods in the forest by managing with longer rotations and keeping woody debris on-site rather than removing or burning it. The life cycle of carbon can be prolonged by converting material to long-lived forest products. Greenhouse gas emissions can be greatly reduced by substituting wood products for cement and steel in construction.

Flexibility will be increasingly important in managing forests in the future, due to the certainty of a warmer climate, but uncertainty about the rate and magnitude of its effects on the many components of forest ecosystems. Using multiple silvicultural strategies (e.g. variation in species, nursery stock and stocking) on different portions of a given ownership will allow land managers to have a more diversified portfolio, such that most of the landscape will probably be productive and lead to desired outcomes. Managing for high-vigor stands will be the best investment in avoiding potential stresses in a warmer climate, regardless of whether resource objectives emphasize timber, wildlife, water quality or other values. ■

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