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FOREST CHANGE

June 2004

UNDERSTANDING CLIMATE HISTORY ALLOWS SCIENTISTS TO BETTER ANTICIPATE FOREST RESPONSE TO FUTURE CLIMATE VARIABILITY AND CHANGE

Summary Points

- Climatic reconstructions indicate that climate changes at a variety of temporal scales.
- Forest species have responded to climate change individually rather than as intact communities.
- In the past, the effects of climate change on forests have been mediated by changes in disturbance regimes, such as fire.

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FOREST ECOSYSTEM CHANGE

Records of forest history indicate that vegetation changes at almost all temporal and spatial scales in response to climate change.

Many forest communities on the present landscape are recent additions, and many communities of the past have no modern-day counterparts.

- Species we see on the landscape today evolved under widely varying climatic conditions.
- Our understanding of species response to climate comes from the narrow range of possible conditions from data collected in the recent past.

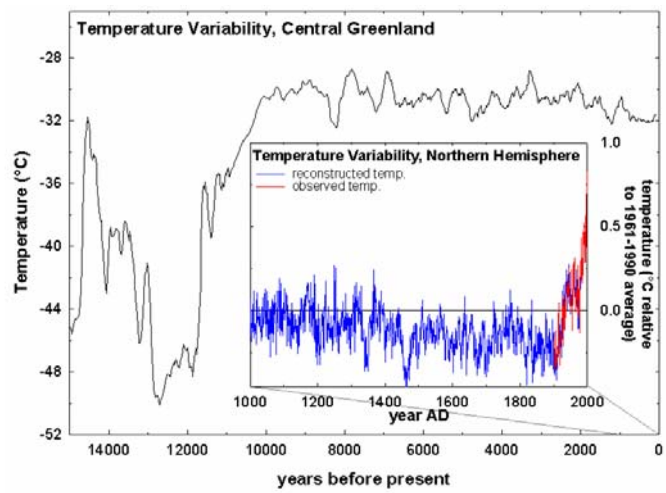


Figure 1. Ice cores, lake-sediments, and tree rings provide continuous records of past environmental change to help place predicted climate change in a historical context. Since the last glaciation, temperatures in central Greenland[1] reconstructed with oxygen isotopes from an ice core indicate temperature variability at a variety of temporal scales. More recently, temperature reconstructions (blue line)[2] indicate that recent warming (red line) is unprecedented within the last 1,000 years.

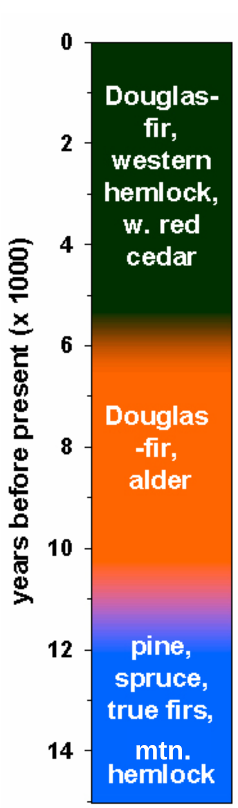
LESSONS FROM THE PAST: VEGETATION

With past climate change, individual species within a community responded uniquely to new climatic conditions.

This implies that future forest communities could be composed of novel species assemblages with little or no precedent.

Douglas-fir/western hemlock old-growth forests developed in the region around 6,000 years ago.

Pacific Northwest Lowland Forest History Timeline:



LESSONS FROM THE PAST: DISTURBANCE

Disturbances such as fire are important components of forest ecosystems, and disturbance regimes have also changed with past climate.

Disturbance regimes respond directly to climate variability, and the ultimate effects on forests depend on interactions between climate, vegetation, and site-specific factors.

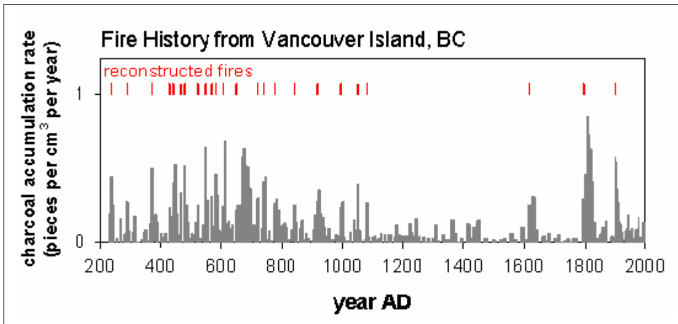


Figure 2. Fire history records from lake sediments, such as this from a coastal temperate rain forest[3], indicate that fire occurrence has varied in the past, partially in response to climate variations. Changes in fire regimes will play an important role in determining how forests respond to future climate change.

FUTURE CHANGE

While environmental change has been a constant in the past, future climate change is of concern because of its predicted *rate.*

Estimates of future temperature increases are for > 2 degrees C in the next 100 years (IPCC, 2001: www.ipcc.ch).

This rate of future climate change may outpace the ability of species to adapt and/or migrate. As a consequence, in some places future forests may have little resemblance to the modern landscape.

Altered species distribution and abundance may affect productivity, carbon cycling, and wildlife habitat.

IMPLICATIONS

1. Forest communities are dynamic and will change at a variety of spatial and temporal scales in response to climate changes.
2. The range of past variations in climate and forests can be used to provide a context in which to view future change and management options.

[1] Alley, R.B. 2004. GISP2 Ice Core Temperature and Accumulation Data. IGBP PAGES/World Data center for Paleoclimatology. Data Contribution Series #2004-013. NOAA/NGDC Paleoclimatology Program, Boulder CO, USA.
[2] Mann, M.E., Bradley, R.S., Hughes, M.K. 1999. Northern Hemisphere Temperature Reconstuction for the Past Millennium, IGBP PAGES/World Data Center-A for Paleoclimatology. Data Contribution Series # 1999-014. NOAA/NGDC Paleoclimatology Program, Boulder CO, USA.
[3] Gavin, D.G., Brubaker, L.B, Lertzman, K. 2003. An 1800-year record of the spatial and temporal distribution of fire from the west coast of Vancouver Island, Canada. Canadian Journal of Forest research. 33: 573-586.

For More Information

For more information on the impacts of climate variability and change on Pacific Northwest forest resources, please contact the Climate Impacts Group. *Photo credits: Linda Brubaker, Chris Earle.*

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FOREST GROWTH AND CLIMATE CHANGE

June 2004

TEMPERATURE AND PRECIPITATION HAVE INCREASED DURING THE LAST CENTURY IN THE PACIFIC NORTHWEST. BECAUSE ATMOSPHERIC CONCENTRATIONS OF GREENHOUSE GASES CONTINUE TO RISE, THIS TREND MAY CONTINUE INTO THE FUTURE. ALTERED TEMPERATURE AND PRECIPITATION CAN AFFECT THE DISTRIBUTION, COMPOSITION, AND GROWTH OF FORESTS, AND IMPACTS WILL VARY ACCORDING TO FOREST TYPE AND SPATIAL AND TEMPORAL SCALES.

Summary Points

Climate change will affect:

- Tree growth
- Species composition
- Forest extent

Which, in turn, will affect the ability to attain management objectives.

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GROWTH

Growth will be among the first forest attributes to be affected by climate change.

Changes in growth will be a result of the interaction of changing climatic variables and growth limiting factors (i.e., growing season length, soil moisture availability, etc.).

Projected climate changes will likely lead to the following:

- Decreased snowpack (except at very high elevations)
- Longer growing season
- Decreased summer soil moisture availability

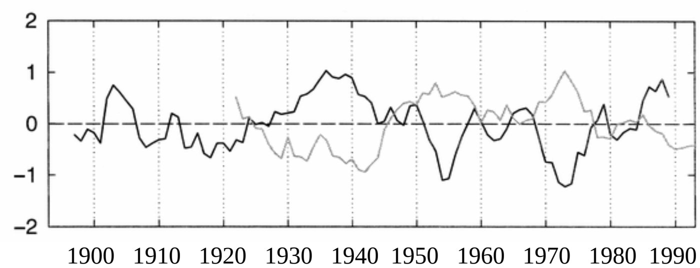

Figure 1. Time series plot comparing 5-year running averages of normalized high-elevation mountain hemlock (*Tsuga mertensiana*) growth variations (black lines) and May 15th snowpack depths (gray lines) at Mount Rainier National Park. Relationship is negative ($r^2 = 0.47$). Figure is adapted from Peterson & Peterson 2001.

As a result, high-elevation species could increase in growth, and species sensitive to moisture availability (i.e., Douglas-fir and ponderosa pine) could decrease in growth at some locations.

COMPOSITION

Changes in tree species distribution and abundance may take place on longer temporal scales:

- Individual species will adapt differently
- Competitive interactions will likely change
- Cover types and biodiversity will be affected
- Invasive and exotic species may increase

Tree encroachment into alpine meadows.

Managers can adapt their practices to decrease overall vulnerability to climate change.

Forest Extent

The extent of forest cover will be affected by growth limiting factors over longer time scales.

There may be a reduction in total PNW forested area as a result of drought stress and the inability of species to adapt to rapid climate change.

Additional possible impacts to forest extent include:

- Increase in the elevation of upper treeline
- Increase in the elevation of lower treeline (due to longer drought season)

Management Implications

Seasonal/annual climate forecasts and long-term climate predictions offer the potential to enhance management practices.

Management objectives that could be impacted by climate change include: growth and productivity, carbon storage, regeneration, biodiversity, and resilience to future disturbances

Potential actions for commercial landowners interested in managing for timber and carbon objectives include:

- Diversify regeneration stock
- Plant more drought tolerant species in soil moisture limited areas
- Prioritize prescribed burns during low fire hazard years
- Consider thinning in densely populated stands to improve vigor and minimize fire risk

Climate projections may help managers assess potential changes in tree growth, species composition, and forest extent, which may be helpful for both commercial and non-commercial landowners.

Future Research

Additional research should consider the following:

- Identify and monitor sensitive forests
- Develop more accurate, local climate models to better predict potential changes in climate

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Forest Fire and Climate

July 2004

Fire, Climate, and Forest Vulnerability to Climate Change

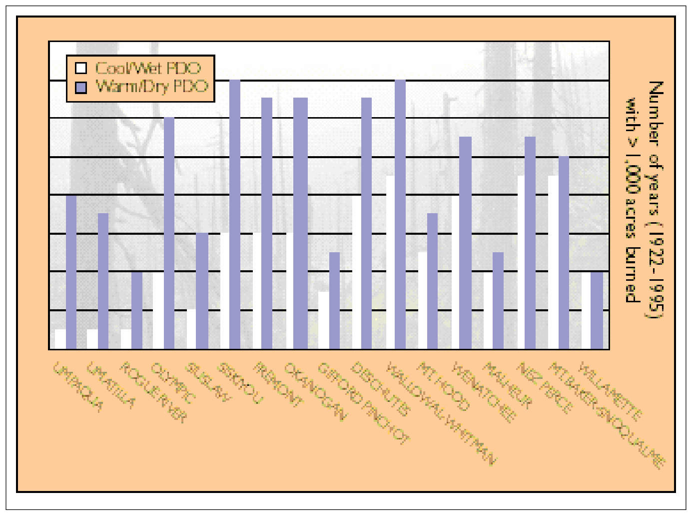
Summary Points

- Different forests have different fire regimes
- Climate has a strong influence on fire regime
- Different forest types have different sensitivities to climate change.
- Adapting or mitigating for fire in the future should consider forest vulnerability on a forest type basis.

Fire Regimes in the Pacific Northwest

Fire regime refers to the characteristic role of fire in an ecosystem, especially the extent, intensity, and frequency of fires. Fire history reconstructions from tree rings and lake sediment indicate fire has been a prominent natural disturbance of PNW forest ecosystems since at least the end of the last glaciation over 12,000 years ago.

A key theme of such research is that different types of fire regimes are associated with different climates and forest types. For example, fire in dry ponderosa pine forests in the interior Columbia Basin typically returned to a site every 7 to 15 years prior to European settlement. In contrast, coastal temperate rainforest ecosystems in British Columbia experienced fire as rarely as once every few millennia .



Relationship between the Pacific Decadal Oscillation and fire area burned for national forests in Oregon, and Washington 1922-1995.

Fire and Climate

Drought increases the likelihood of fire, and over the course of decades or centuries, shifts in climate may shift fire regimes. During the 20th century, the Pacific Decadal Oscillation has had a detectable influence on the area burned by fire in the PNW. In the dry interior northwest forests for the period 1690 to 1995 A.D., larger fires burned in El Niño years. These patterns illustrate the role of climate in PNW fire and provide examples of what climate change impacts might mean for future fire activity. Projected temperature increases during the 21st century could lead to larger and/or more frequent fires in drier climates if trends forecast from climate models occur, especially if precipitation does not increase.

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A low intensity fire

Climate change impacts to forest fire regimes are likely to be highly place dependent.

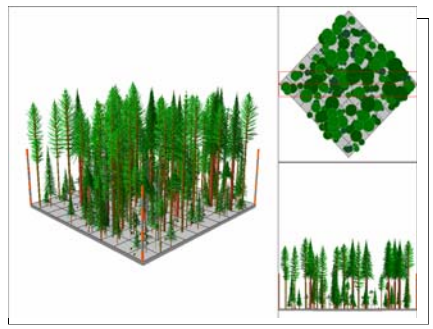
Fire Regimes, Fuel Accumulations, and Climate Change: Regional and Local Effects

Mechanisms of Vulnerability

Climate change is likely to increase temperatures and the length of the snow-free season. At a regional scale, this translates into an increase in the frequency of years in which fires burn substantial areas of forested land. The impact of decadal and inter-decadal climate variability may also produce episodic fires. Indirectly, mortality associated with insects and fire may play a more prominent role in the future as well.

Forest Vulnerability to Climate Change and Fire

Ponderosa pine forests that had shorter fire regimes prior to European settlement and have experienced fire exclusion during the 20th century may be less resilient to future fires because infilling by young trees has the potential to increase fire severity. Forests on the western slope of the Cascades may be more frequently at risk of natural stand-replacing fires. These forest types represent two ends of a spectrum of climate/fire/forest type interactions. The impact of climate change and climate variability on each forest type is thus likely to vary with forest history and physical setting as well as climate.



Fuel modeling may provide strategies for mitigation projects (Envision, USDA)

Mitigate or Adapt?

One large source of uncertainty in our understanding of what future forest changes in response to climate and fire will look like is to what degree forests can be managed for resilience. In drier forest types with lower productivity, fuel is often a limiting factor for fire intensity and severity. In such a case, it may be possible to mitigate fuel loads and attempt to 'buffer' forests to fire and climate change. On the other hand, high productivity forests have plenty of fuel, but are rarely dry enough to burn with high intensity. Drought is much more difficult to mitigate than fuels, and in such forests, socioeconomic, political, and managerial adaptation to the increased risk of fires with climate change may be key.

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FOREST BIODIVERSITY

June 2004

Summary Points

- Most climate scientists believe that a global temperature increases will continue
- While the Pacific Northwest is likely to receive more precipitation in the winter, warmer and drier summers will stress forest communities and species
- The drier summers are likely to enable more frequent and intense fires and insect outbreaks.
- Managers can prepare for these changes by assessing risks, improving the vigor of existing stands, establishing reserves with climate change in mind, and enhancing connectivity across

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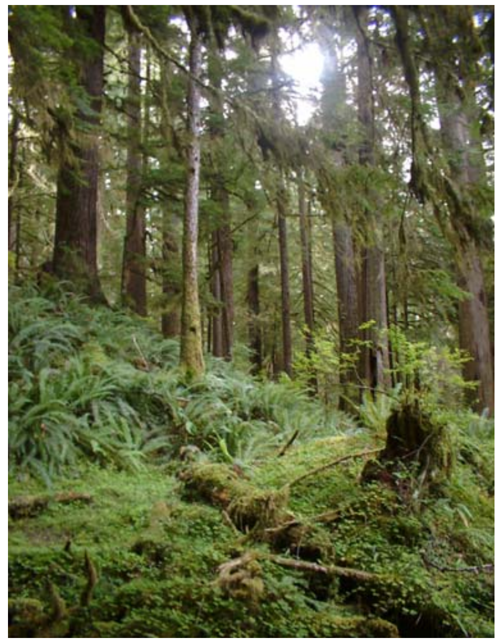
CLIMATE CHANGE AND THE PACIFIC NORTHWEST



The rich forests that cover the Pacific Northwest seem eternal. Yet, they are the product of a climate shift five thousand years ago that brought cooler and wetter weather to this region. In the warmer, drier period that preceded our epoch, grasslands and shrub-steppe covered many areas that are forested today, and many of the forests of that period had a community structure unlike any currently found in the region.

Most climatologists believe that the current trend of increasing temperature will significantly alter climate in the Northwest. Most climate forecasts predict that our region will warm with winters becoming wetter and summers drier than today. If this occurs, the growing season will become longer, but summer water stress will become more intense.

Our region hosts a wide variety of forest communities from rain forests along the coasts, to high subalpine forests, to dry eastside woodlands. Each forest community will have its own reaction to climate change influenced by its unique location. This variety makes it impossible to provide general guidelines for land managers. Instead, land managers can (1) assess the risks for the forests they manage, (2) take steps to minimize the stress caused by climate changes, and (3) protect forest biodiversity.

IMPACTS TO CONSIDER

Ecologists believe that more intense summer drought generally will have a greater impact than the warmer temperatures. Mature trees in intact stands should be able to withstand the increased stress better than younger trees. Seedlings of some species, however, may have trouble surviving the summers.

Mature stands are most likely to be able to withstand the additional stress brought by climate change.

Communities and species currently found near the limits of their climate range generally will be at greatest risk for disruption.

Species that are already rare or at risk may be least likely to withstand a changing climate and should receive special attention in conservation plans.

Possible Impacts (continued)

The distribution of many tree species is primarily determined by the intensity of summer drought and the length of the growing season. If these constraints change, the location at which species can survive is likely to shift. Some species such as mountain hemlock may replace alpine meadows; grasslands and shrub-steppe may replace dry-site forests such as ponderosa pine.

Paleobotany shows that species react individually to climate change; we cannot expect that communities will simply shift to higher elevations or more northern sites. Instead, future communities may consist of entirely new assemblages of species. The greatest impacts are likely to be in areas where communities are currently near their climatic tolerance.

In addition to the stress experienced by individual trees, warmer summers are likely to bring more frequent and more intense disturbances such as fire and insect outbreaks. As trees are lost to these agents, seedlings of the same species may not be able to replace them at those locations. Invasive species may be able to take advantage of these disturbances and replace native species.

Managing to Preserve Biodiversity

Unfortunately, the type, intensity, and duration of the coming climate change cannot be predicted. A precautionary approach can minimize stress and increase the probability of protecting the biodiversity of forests. Potential actions include:

- Work with climatologists and ecologists to model possible climate and vegetation changes to learn which species, communities, and locations may be at greatest risk.
- Provide reserves for communities and species at different latitudes and elevations so that each reserve may be impacted differently. Attempt to locate reserves in areas that are likely to be most buffered from climate change by mature stands, topography, or other factors.
- Allow species to reach new locations by minimizing fragmentation of existing forests.
- Minimize forest fragmentation and retain older age structures where possible, and maintain high-vigor stands.
- Coordinate planning across a broad region because climate's impact on species and communities and their responses will play out over large areas.

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Impacts of Climate Change on PNW Timber Production

June 2004

Focus on ecological, economic, and policy impacts of climate change on PNW Timberlands

Summary Points

- Timber producing forests are distributed among federal, state, and private owners, but most harvesting is on private lands.
- Climate change can affect timber production:

1. Through *ecological* changes in growing conditions and disturbance regimes
2. Through *economic* changes in timber prices
3. Through *policy* changes in regulations and markets

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PNW forests (WA, OR, ID)

- 73.6 million acres (29.7 million hectares)
- 58.8 million acres (80%) considered timberlands (capable of producing timber)
- 36% of timberland is privately owned (18% forest industry, 18% non-industrial private forests)[1]
- 12.1 billion board feet (28.5 million cubic feet) softwood lumber produced in 2001
- 78% harvested timber from private lands
- In 2001, WA and OR maintained 14 direct jobs for every million board feet of timber harvested[2]

Second growth cedar to be manufactured into wood fencing, Olympic Peninsula, Washington, (Steve Jasmer, Tubafor Cedar Company)

Managing impacts due to Ecological Changes

Climate change may affect temperature and precipitation patterns, which in turn will affect snow pack levels, soil moisture, and natural disturbance regimes such as fire, insects, and wind throw.

In the Pacific Northwest both precipitation and temperature may increase, potentially causing reduced winter snow pack and changes in soil moisture levels (drier in summer months but potentially wetter in spring months).

Changing fire and insect disturbance regimes will need to be monitored. Nursery stock should be chosen to withstand changes in soil moisture. Road planners should consider potential future wetter conditions in certain areas.

Effects of Economic Changes

Climate change may affect the price of timber by changing forest

Douglas-fir stand in Oregon
(OSU)

Climate change will impact PNW forests through changes in environment, economics, and policy on local, state, national, and global scales.

productivity around the world. Productivity will vary but is expected to yield a total increase in the harvestable timber supply. This increase may lower average timber prices (unless demand increases more rapidly than supply). Regions with higher costs of timber production may have decreasing economic benefits from timberlands.

In the Pacific Northwest forest productivity may increase in some areas and decrease in others, but higher costs of production will decrease economic benefits from timberlands.[3]

EFFECTS OF POLICY CHANGES

Climate change policies may affect management of timberlands by introducing a new product (carbon) or introducing a new liability (greenhouse gas emissions).

Policies to cap or tax greenhouse gas emissions may increase carbon trading, which can affect forest industry in three ways: by paying landowners to store carbon in forests, by favoring wood products over more energy intensive substitute materials such as steel or concrete, and by increasing the favorability of renewable energy from biomass.

In 1997 Oregon passed the first state law limiting carbon dioxide emissions from new power plants (limit now at .675 lbs per kWh). Similarly, Washington just passed House Bill 3141, which will require fossil fuel powered electric generation facilities to offset 20% of total carbon dioxide emissions through purchasing third party carbon credits or investing in carbon mitigation projects such as cogeneration.

Finally, forest certification standards such as AF&PA's Sustainable Forestry Initiative[4] and Canada's Sustainable Forest Management[5] have included carbon management in their latest standards.

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[1] Warren, Debra D. 2003. Production, Prices, Employment, and Trade in Northwest Forest Industries, All Quarters 2001. Resource Bulletin. PNW-RB-239. USDA Forest Service.
[2] Alig, Ralph J., Andrew J. Plantinga, SoEun Ahn, and Jeffrey D. Kline. 2003. Land Use Changes Involving Forestry in the United States: 1952 to 1997, with Projections to 2050. PNW-GTR-587. USDA Forest Service.
[3] Perez-Garcia, John, Linda A. Joyce, A. David McGuire, and Xiangming Xiao. 2002. Impacts of climate change on the global forest section. *Climatic Change* 54:439-461.
[4] American Forest and Paper Association. 2002. *Sustainable Forestry Initiative Standard 2002-2004.*
[5] Canadian Standards Association. 2002. *Sustainable Forest Management: Requirements and Guidelines.* Z809-02.

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