Effects of Climate Change on Western Forests

Dave Peterson

Climate Change Impacts on Natural Resource Management in the Columbia Basin
June 24, 2008
What can we learn from the past?

Climate is always changing

Abundance and distribution of tree species changes individually in response to climatic variability

Are warm periods of the past an analog for the future?

- 9000 – 5000 years BP
- 900 – 700 years BP
Forest vegetation varies over time

Pollen record in sediment core from Lake Washington, Washington State
Climate change and tree regeneration

Key to regeneration is effects on limiting factors
• Snowpack
• Length of growing season
• Soil moisture in summer

Effects of a warmer climate will be site specific – precipitation patterns critical
• *In high-snow forests*, regeneration will increase
• *In high-rain forests*, regeneration may increase
• *In dry forests*, regeneration will decrease
Climate change and tree growth

Subalpine forests: Less snowpack; longer, warmer growing seasons = **Growth increase**

Mid elevation forests: Warmer summers, less snow pack = **Depends on precipitation**

Low elevation forests: Warmer summers, less snow pack = **Large growth decrease**
“If there is one word that describes the West, it is aridity.”

Wallace Stegner

*Where the Bluebird Sings to the Lemonade Springs*
Dying pinyon pine  
Jemez Mts., October 2002
Droughts were more common prior to 1950

Gedalof et al. (2004)

Streamflow for the Columbia River, reconstructed from tree-ring data
Disturbance drives ecosystem changes

Climate change
- Warmer temperatures
- More severe droughts

Fire resets succession, temporal scale associated with fire rotation.

Mature trees buffer against effects of warmer climate, temporal scale associated with species longevity.

Habitat changes
- Broad-scale homogeneity
- Truncated succession
- Loss of forest cover
- Loss of refugia
- Fire-adapted species

New fire regimes
- More frequent fire
- More extreme events
- More area burned

The disturbance pathway is quicker

Species responses
- Fire-sensitive species
- Annuals & weedy species
- Specialists with restricted ranges
- Deciduous and sprouting species

The diagram illustrates how climate change affects various aspects of ecosystems, leading to changes in species responses and habitat conditions. The disturbance pathway is depicted as quicker due to new fire regimes, which result in broader-scale homogeneity, truncated successions, and loss of forest cover and refugia, further influencing the distribution and resilience of species.
What causes large and severe fires?

Annual Area Burned on Federally-Protected Lands
Western U.S. (no AK)

Published Area Burned
Adjusted Area Burned

Annual Area Burned on Federally-Protected Lands
Western U.S (no AK)

Fire suppression  →  Fire exclusion  →  Fuel accumulation

Annual Area Burned on Federally-Protected Lands
Western U.S (no AK)

- Fire suppression → Fire exclusion → Fuel accumulation

Annual Area Burned on Federally-Protected Lands
Western U.S (no AK)

Fire suppression → Fire exclusion → Fuel accumulation
Lots of fire → Much less fire → Lots of fire
## Years with fire area > 200,000 acres

<table>
<thead>
<tr>
<th></th>
<th>Warm-phase PDO</th>
<th>Cool-phase PDO</th>
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<tbody>
<tr>
<td>Idaho</td>
<td>15</td>
<td>7</td>
</tr>
<tr>
<td>Oregon</td>
<td>14</td>
<td>5</td>
</tr>
<tr>
<td>Washington</td>
<td>11</td>
<td>2</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td><strong>40 (74%)</strong></td>
<td><strong>14 (26%)</strong></td>
</tr>
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Wildfire area burned – $2^\circ C$ increase
Future wildfire?

Analysis of wildfire data since 1916 for the 11 contiguous Western states shows that for a 2°C increase that annual area burned will be 2-3 times higher.

McKenzie et al. (2004), Conservation Biology 18:890-902
Climate, vegetation, and fuels

Fuel moisture (associated with current-year climate) drives extent and severity of fire.

Fuel abundance and continuity (associated with previous-winter climate) drive extent and severity of fire.
Effects of temperature increase on mountain pine beetle

- Population synchronized by temperature (onset of spring)

- Rate of generation turnover increases with temperature increase
Mountain Pine Beetle outbreaks (1959-2002)

Courtesy of Mike Bradley, Canfor Corporation
Managing fuels can be challenging!
Current conditions

Target conditions
Thinning

Surface fuel treatment
Modifying forest structure and fuels: A no-regrets management strategy

Modify potential fire behavior

Reduce crown fire hazard

Increase resilience to increased fire frequency

Increase resistance to insect attack
Silviculture meets fire science

• Increase canopy base height
• Reduce canopy bulk density
• Reduce canopy continuity

AND reduce surface fuels
Increase canopy base height

Dense stand with understory

- Canopy base height < 2 m

Treated stand after thinning from below

- Canopy base height > 6 m
Reduce canopy bulk density

Dense stand with understory

Canopy BD $> 0.30 \text{ kg m}^{-3}$

Canopy BD $< 0.10 \text{ kg m}^{-3}$

Treated stand after thinning from below
Reduce canopy continuity

Dense stand with understory

Treated stand after thinning from below
Surface fuels must be treated following removal of trees
Effective fuel treatment programs must consider large landscapes.
Figure 3. Initial stand conditions for a mixed conifer stand with ponderosa pine overstory on the Deschutes National Forest, Oregon. Stand structure and fuel attributes include quadratic mean diameter = 7.0 in., density = 947 tpa, basal area = 252 ft²/ac, canopy cover = 62%, canopy base height = 3 ft, canopy bulk density = 0.13 kg/m³, surface fuels less than 3 in. = 5 tn/ac, total surface fuels = 17 tn/ac. Different crown shapes represent different tree species.
The only treatment that minimizes crown fire

50-100 trees per acre

+ removal of surface fuels
<table>
<thead>
<tr>
<th>Principle</th>
<th>Effect</th>
<th>Advantage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reduce surface fuels</td>
<td>Reduces flame length</td>
<td>Control easier; less torching</td>
</tr>
<tr>
<td>Increase canopy base height</td>
<td>Requires longer flame length to begin torching</td>
<td>Less torching</td>
</tr>
<tr>
<td>Decrease crown density</td>
<td>Makes tree-to-tree crown fire less probable</td>
<td>Reduces crown fire potential</td>
</tr>
<tr>
<td>Keep big trees of resistant species</td>
<td>Less mortality for same fire intensity</td>
<td>Generally creates open structure with high crowns</td>
</tr>
</tbody>
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Adapted from Agee and Skinner (2005)
A rational approach: Focus on the wildland-urban interface

Benefits

Focus fuel treatment area
Protect high economic value
Reduce fire suppression cost
Respond to political concern
Create defensible zones
Reduce liability
Thank you!

Dave Peterson  
peterson@fs.fed.us  
http://www.fs.fed.us/pnw/fera