Climate change and ecological disturbance in the Intermountain Region

Jessica Halofsky
University of Washington, School of Environmental and Forest Sciences
The Intermountain Adaptation Partnership Disturbance Team

- Danielle Malesky (Lead)
- Barbara Bentz
- Gary Brown
- Andrea Brunelle
- Justin DeRose
- John Guyon
- Carl Jorgensen
- Laura Lowrey
- Ann Lynch

- Marek Matyjasik
- Joel McMillin
- Javier Mercado
- Jesse Morris
- Jose Negron
- Wayne Padgett
- Rob Progar
- Carol Randall
- And others
Disturbance agents in the Intermountain Region

- Wildland fire
- Insects
  - Bark beetles
  - Defoliators
  - Invasive insects
- Diseases of forest communities
- Invasive plants
- Geologic hazards
Disturbances will interact
Paleoecological Context

[Map of Emerald Lake and Purple Lake]

[Graphs showing ENSO events and sediment particle count over time for Emerald Lake, Laguna Palcacocha, and Purple Lake]
Fire Behavior Triangle

Fuels

Topography

Weather
Climate Change and Fire

- Warmer and drier spring conditions =
  - *early snowmelt*
  - *lower summer soil and fuel moisture*
  - *longer fire seasons*
  - *increased frequency of large fires*

- Fire intensity and severity may also increase
Correlation between annual western U.S. large forest fire frequency and spring snowmelt

Westerling et al. 2006
Wildfire area burned projections, 2050

From J. Littell
In the western United States, for a 1°C increase, annual area burned will be 2-3 times higher.
Correlations between log(area burned) and summer water-balance deficit

McKenzie & Littell, unpublished data
Map by Robert Norheim
Projections for changes in summer water-balance deficit
Fire Area Burned Projections from MC2

MC2 Mean Fraction Area Burned - Preliminary
Historical PRISM With Fire Supp. for Period 1971-2000

MC2 Mean Fraction Area Burned - Preliminary
RCP 8.5 CCSM4 With Fire Supp. for Period 2040-2069

From D. Bachelet
Future fire regimes will depend on:

- Vegetation changes
- Land use legacies
- Invasives
- Precipitation patterns
Insects

- Bark beetles
- Defoliators
- Invasive Insects
Pathways for climate change effects on insects

Weed et al.
2013
Bark beetle activity (by species)
1968-present

- Mountain pine beetle
- Spruce beetle
- Douglas-fir beetle
- Jeffrey pine beetle
A Destructive Pest

Mountain pine beetles have infested millions of acres of forest in Western states, killing millions of trees. Scientists suspect climate change has contributed to the outbreaks.

Total acres with tree mortality from mountain pine beetle, by year

Area with tree mortality from mountain pine beetle

Mountain pine beetle (actual size)

Source: Forest Health Technology Enterprise Team, USDA Forest Service
Beetle photo: Erich G. Vallery, USDA Forest Service
Graphic by: Ryan Morris
Predicted probability of mountain pine beetle adaptive seasonality (a,c) and cold survival in pine forests
Model projections for spruce beetle presence

DeRose et al. 2013
Defoliator activity

Western spruce budworm

Douglas-fir tussock moth
Diseases of forest communities
2013-2027 National Insect and Disease Composite Risk* Map by Subwatersheds (6th Level HUCs)**

Acres in Hazardous Condition: Approximately 81.3 million

*Risk, or more appropriately termed hazard, is defined as the expectation that, without remediation, at least 25% of standing live basal area greater than one inch in diameter will die over a 15-year time frame (2013 to 2027) due to insects and diseases. These maps depict the percentage of tree area within each watershed classified as being "at risk".

**Overview and History of Hydrologic Units and the Watershed Boundary Dataset (WBD), http://www.ncrca.nrcs.usda.gov/products/datasets/watershed/history.html
Invasive Plants

• Changing species composition and disturbances can make ecosystems more vulnerable to invasion.
• Climate change could result in changes in plant phenology and distribution, resulting in the need to alter control activities.
Geologic hazards that are sensitive to climate change

- Mass-wasting processes (including earthquake-triggered mass wasting)
- Flooding
- Dam failures
- Avalanches
- Problematic soil and rock types (e.g., Karst terrain, sand dunes, collapsible soils, and peat)
Warming affects stress complexes

Global warming

Higher temperatures & more severe and extended droughts

Stand-replacing fire regime

Bark beetles and defoliators

Extensive mature cohorts (70-80 yrs)

Lodgepole pine mortality

Large severe fires

Fuel accumulation

Salvage logging

Changes in species composition (including exotics)

Lodgepole pine
Extremes matter

Frequency, extent, and severity of disturbances may be affected by climate change, altering the mean and variability of disturbance properties. A shift in distribution of disturbance properties has a larger relative effect at the extremes than near the mean. It’s all about the tail!

A shift of 1 standard deviation changes a 1 in 40 yr event to a 1 in 6 yr event.
Disturbance drives ecosystem changes

Disturbance synergy

Fire

Climate

Vegetation

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

Climatic change

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

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

25-100 yr
100-500 yr

McKenzie et al. 2009
Questions?