Wildfire and vegetation responses to climate changes

Rachel Loehman

Missoula Fire Sciences Lab
Rocky Mountain Research Station
USDA Forest Service

Overview

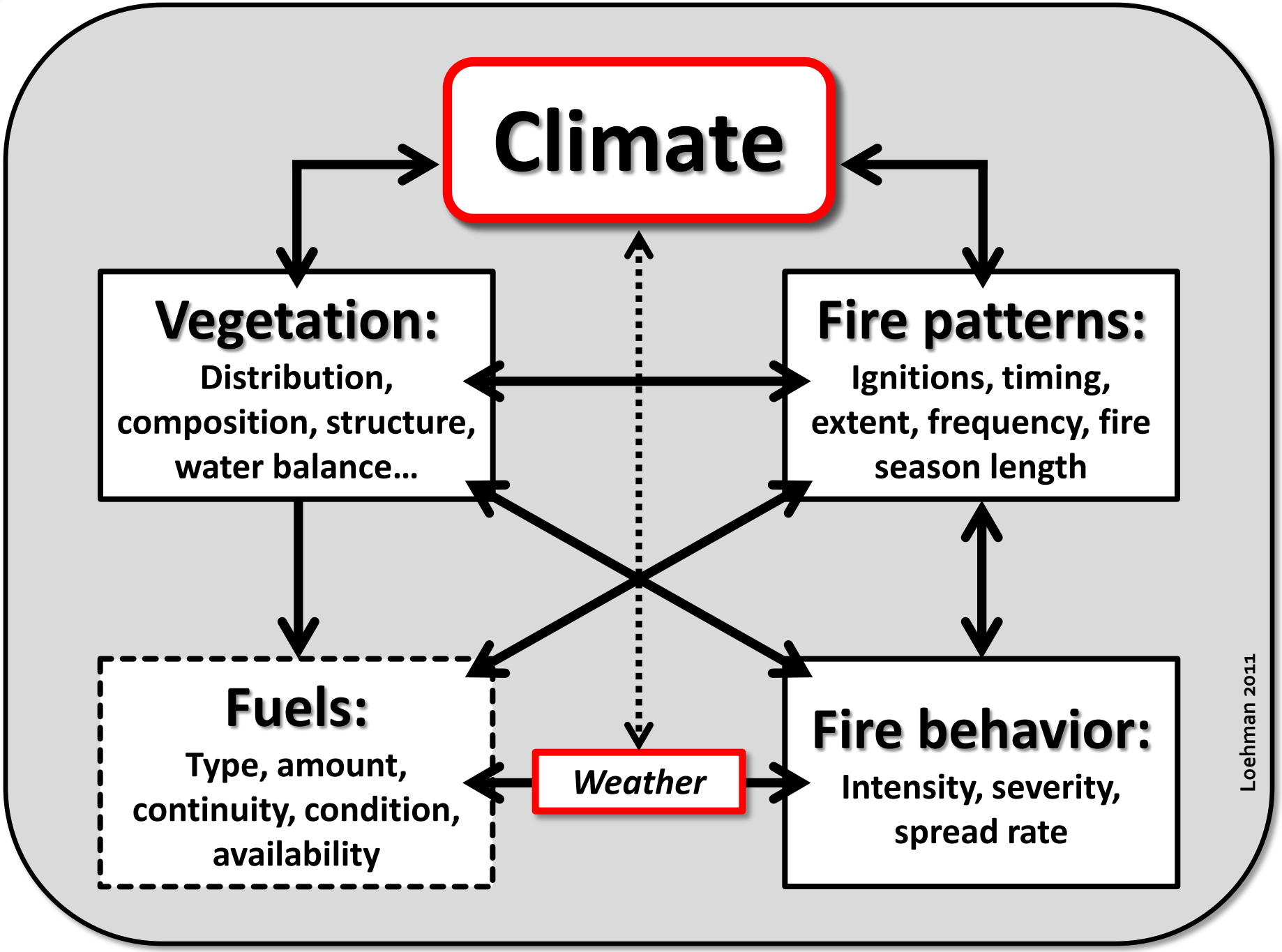
- Climate-fire-vegetation interactions
- Impacts of climate changes on vegetation and wildfires
- 21st century predictions
- Tools and resources

Photo: USFS RMRS

Climate, fire, and vegetation are linked

"Fire is under-appreciated as a global control of vegetation structure…fire-prone formations cover some 40% of the world's land surface ." - Bond et al. 2005

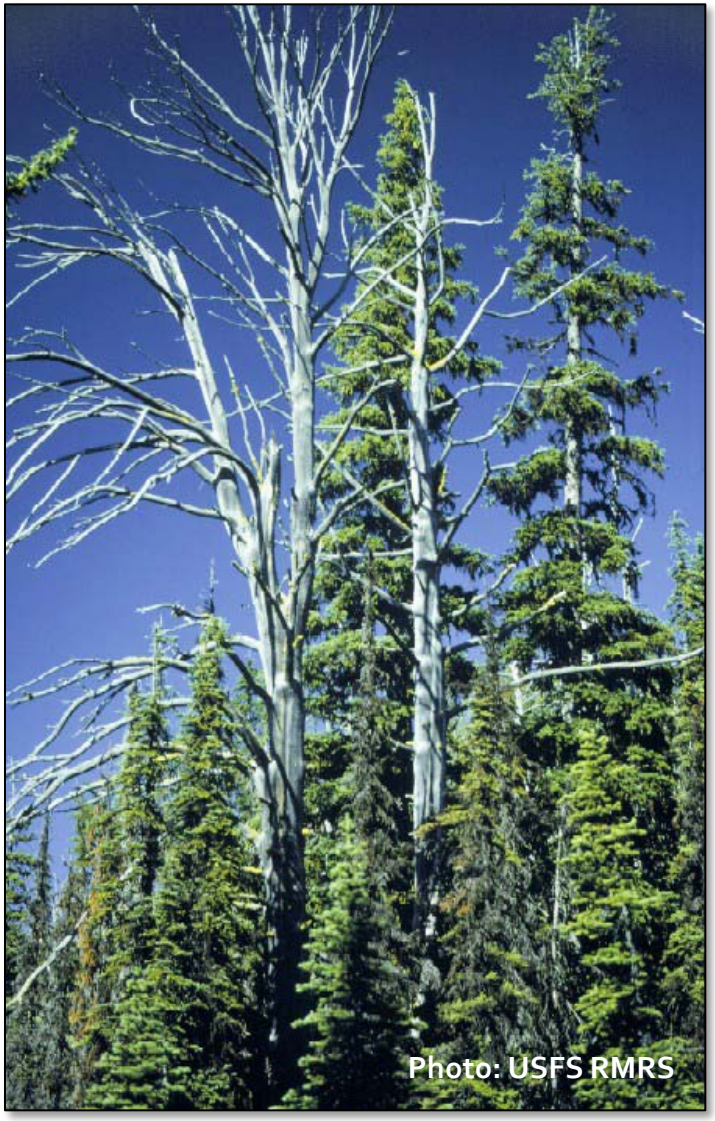
"The almost instantaneous response of the fire regime to changes in climate has the potential to overshadow importance of direct effects of global warming on species distribution, migration, substitution and extinction... fire is a catalyst for vegetation change." - Flanningan et al. 2000


Climate
Vegetation:
Distribution, composition, structure, water balance…
Fire patterns:
Ignitions, timing, extent, frequency, fire season length
Fuels:
Type, amount, continuity, condition, availability
Weather
Fire behavior:
Intensity, severity, spread rate
Loehman 2011

Overview: Climate change impacts on ecosystems

Vegetation

- Phenological shifts
- Altered productivity
- Shifts in species distributions
- Shifts in composition
- Stress-induced mortality
- Extirpations and extinctions
- Susceptibility to pests and pathogens



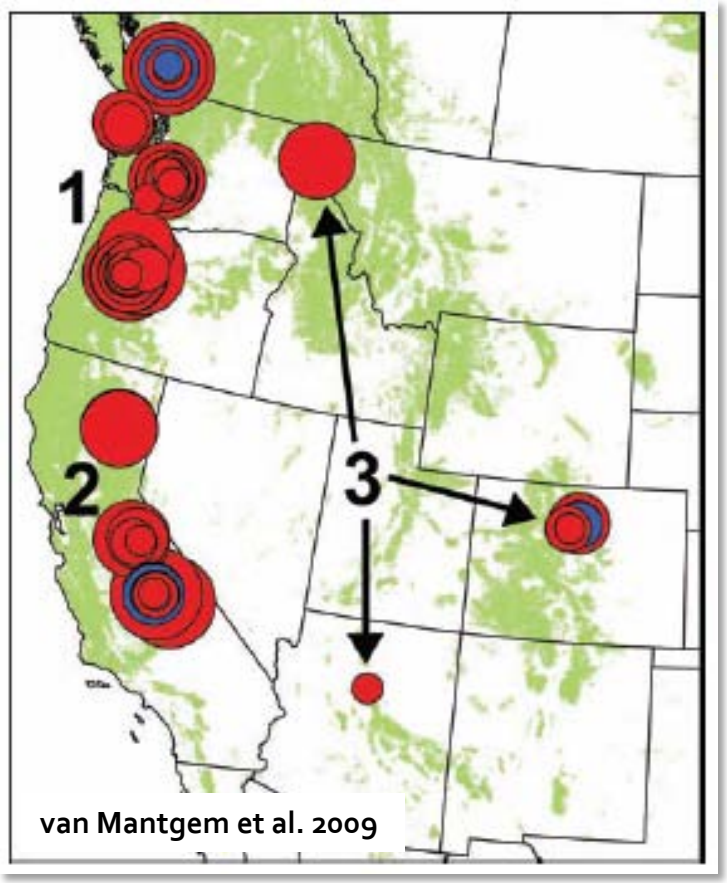
Overview: Climate change impacts on ecosystems

Disturbance

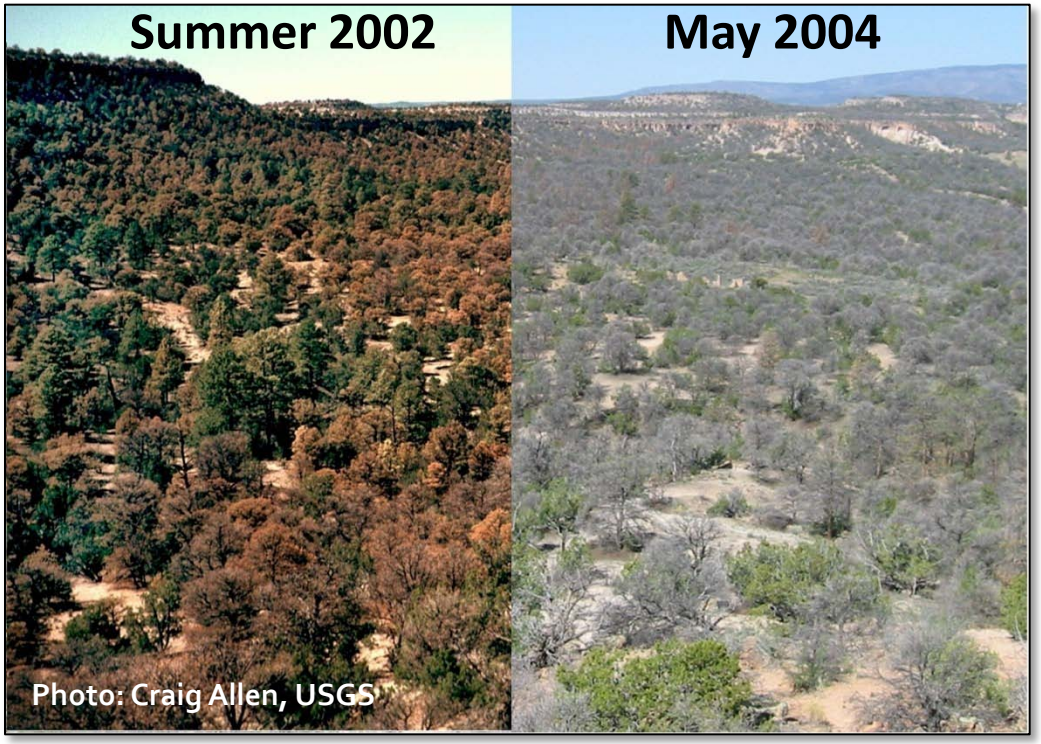
- Longer fire seasons
- Changes in wildfire intensity, severity
- Increased fire frequency, extent
- Increased pest and pathogen activity
- Weather extremes
- **Interacting disturbances**

Observed climate change impacts

Tree mortality



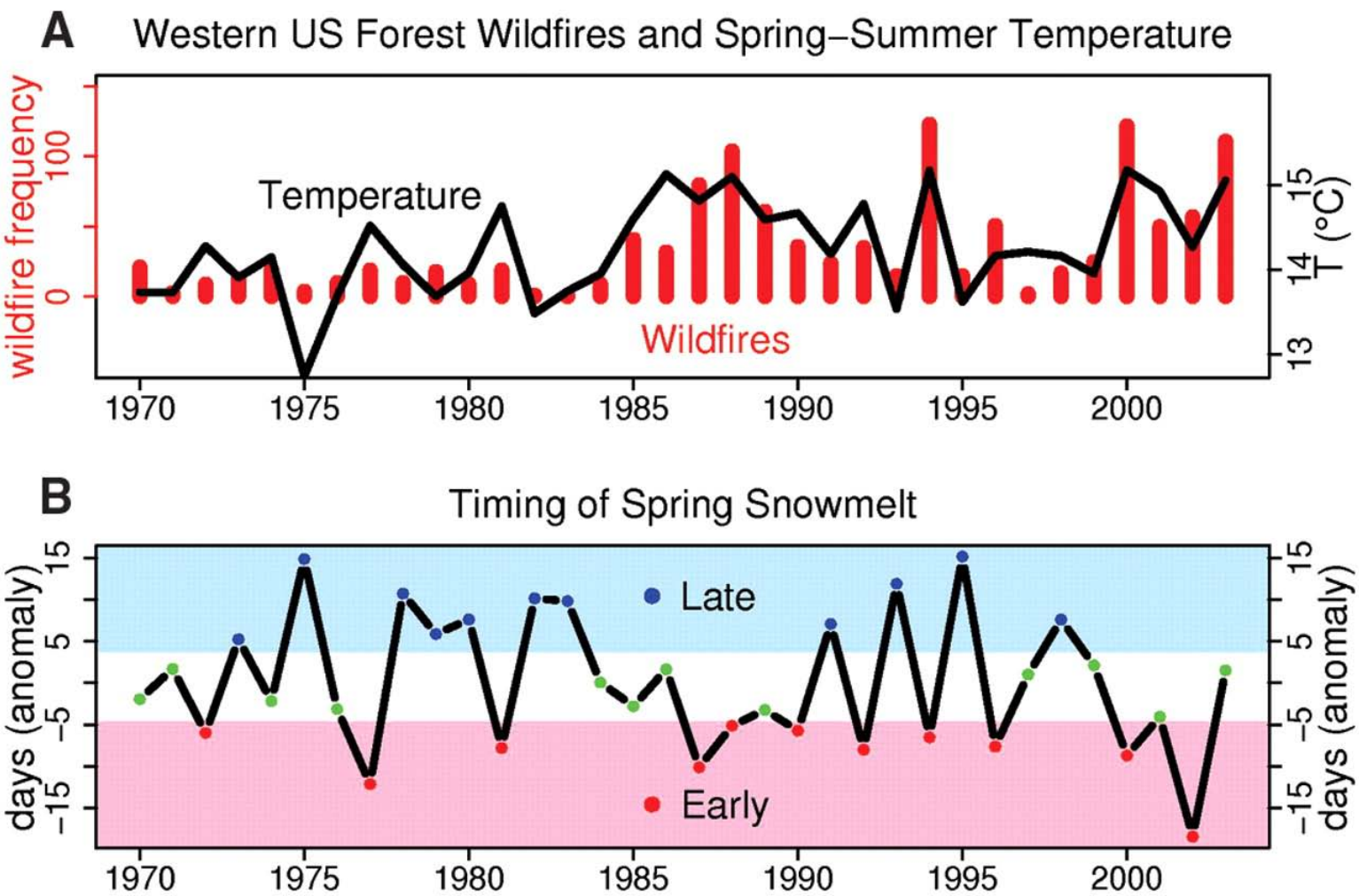
Rapid mortality increase since 1955



Massive die-off of southwestern pines resulting from climate change induced drought stress

Observed climate change impacts

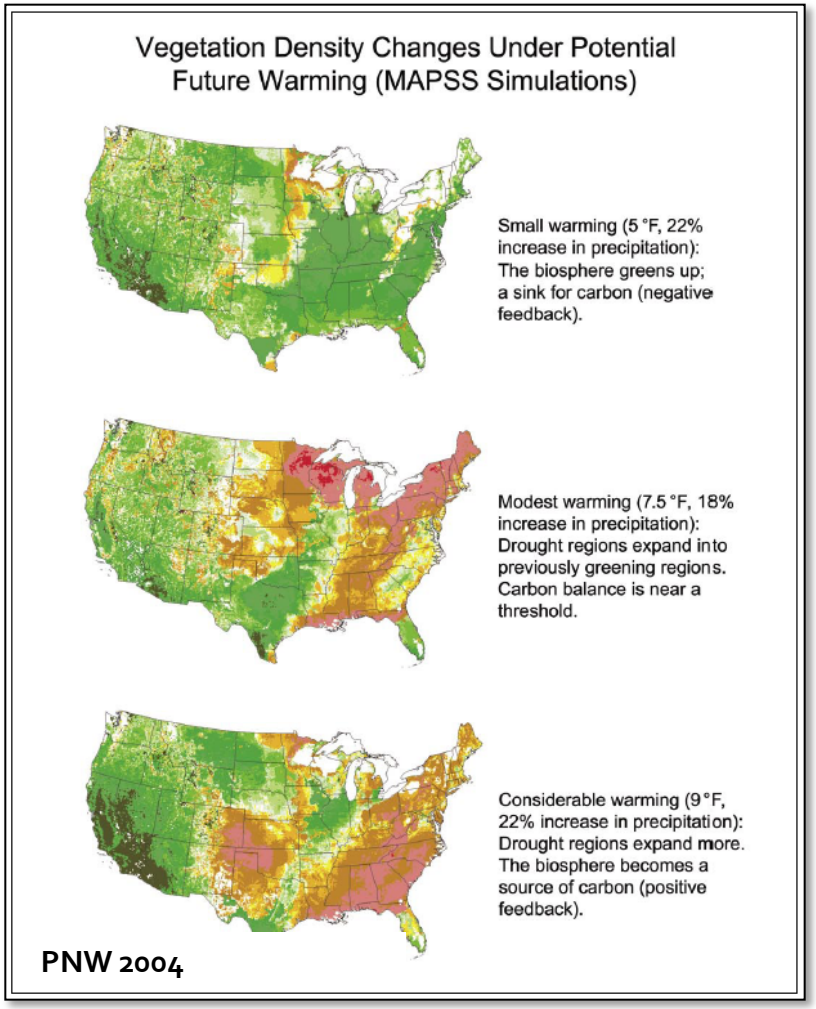
Wildfires



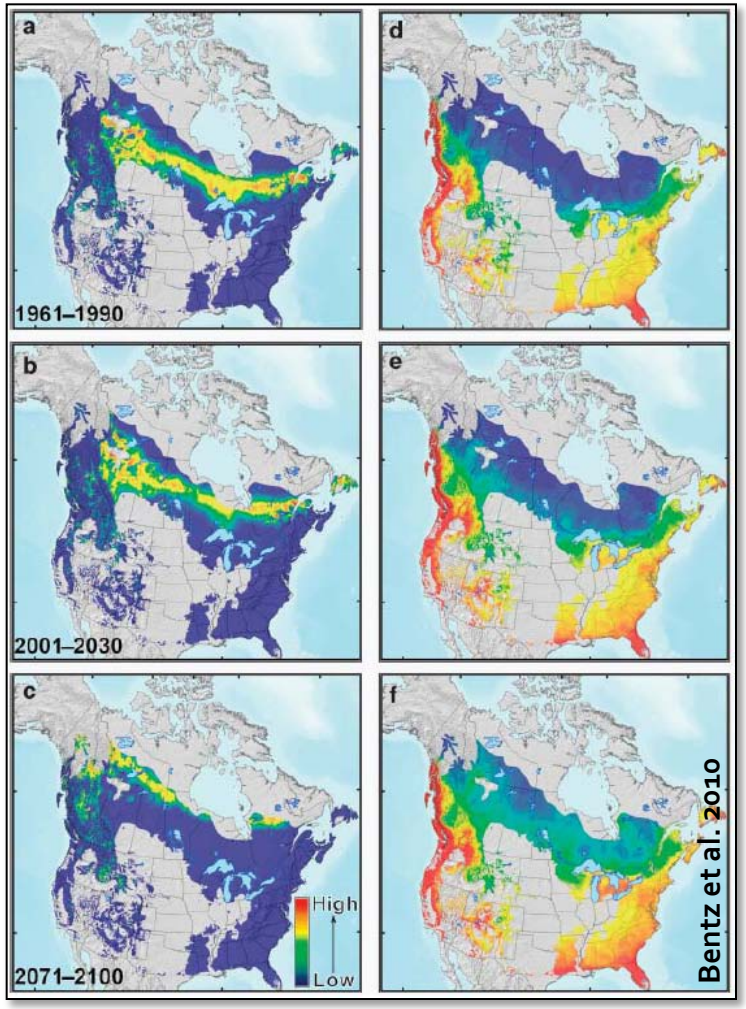
Westerling et al. 2006

Predicted climate change impacts

Shifts in vegetation distribution

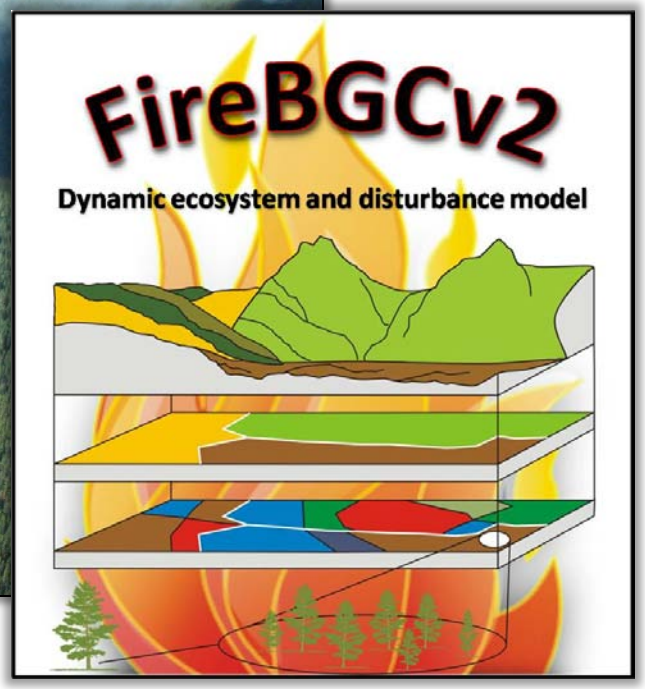


Mountain pine beetle range expansion

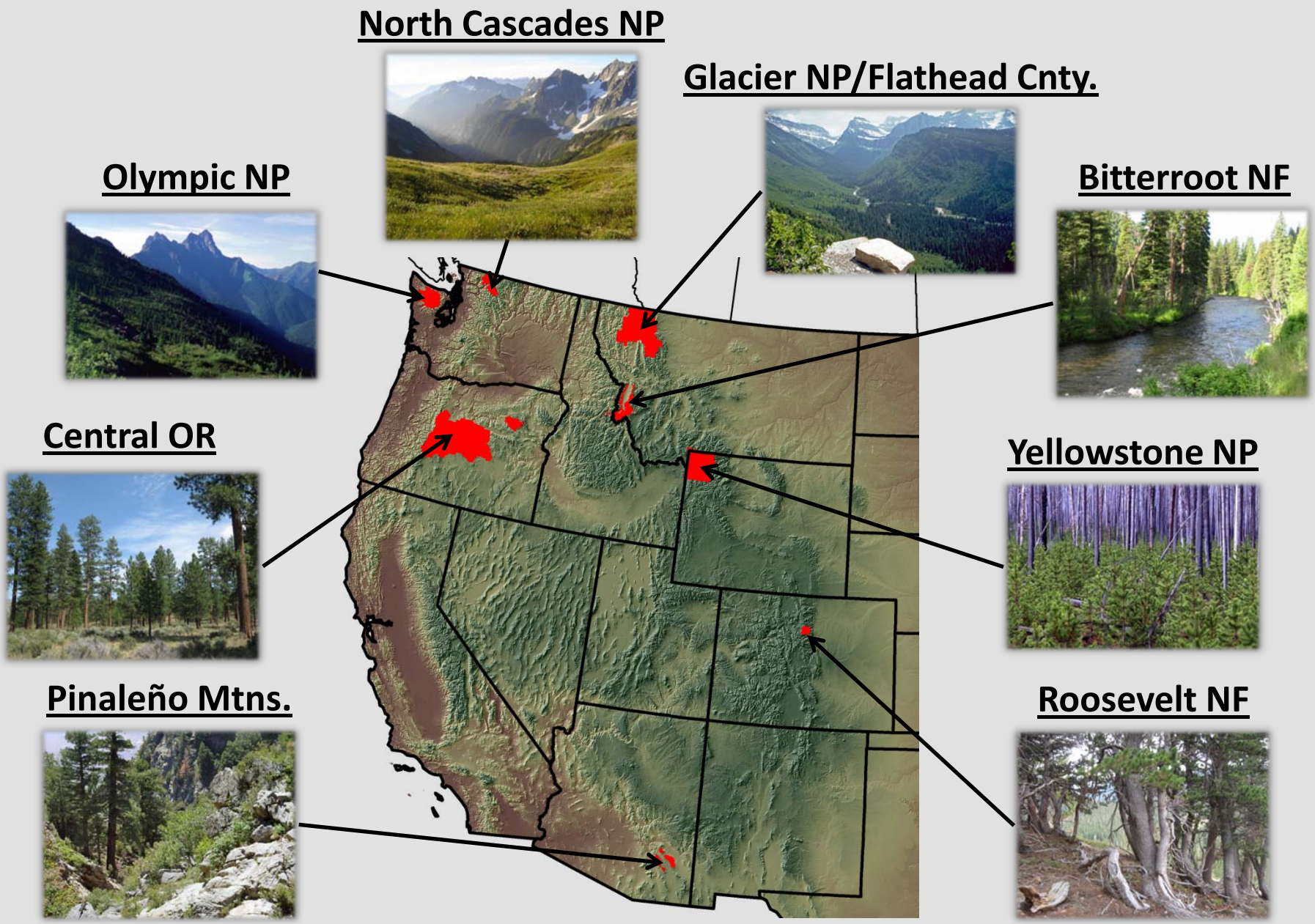


Landscape-scale predictive modeling

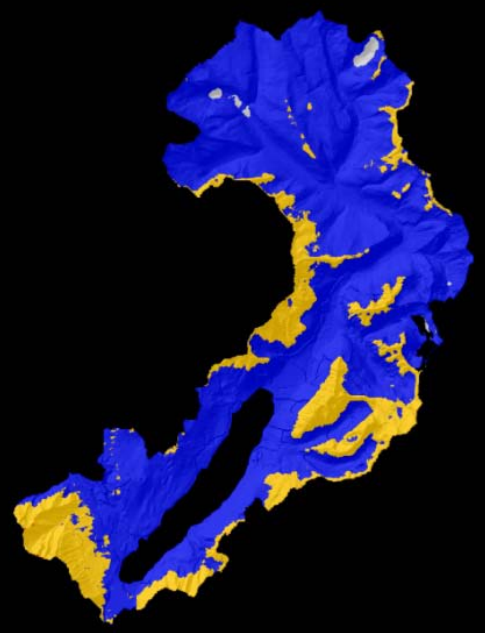
Photo: USFS Bitterroot NF



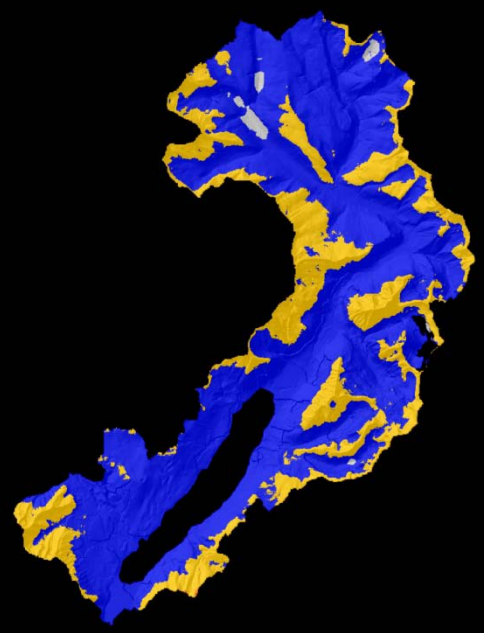
Current study sites



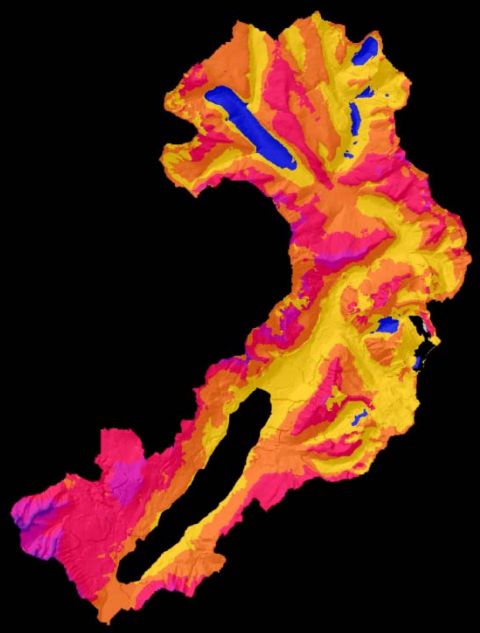
Changes in fire regimes



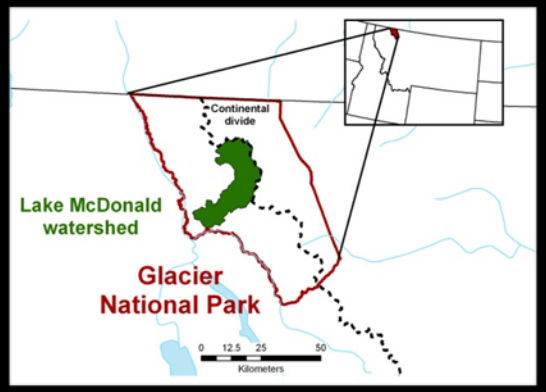
Historical climate - 472 cumulative wildfires



B2 climate scenario (Warmer, Wet) - 511 cumulative wildfires

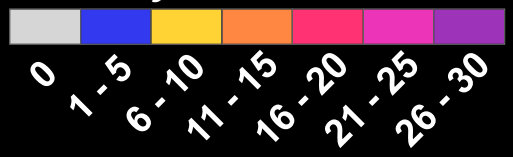


A2 climate scenario (Hot, Dry) - 890 cumulative wildfires



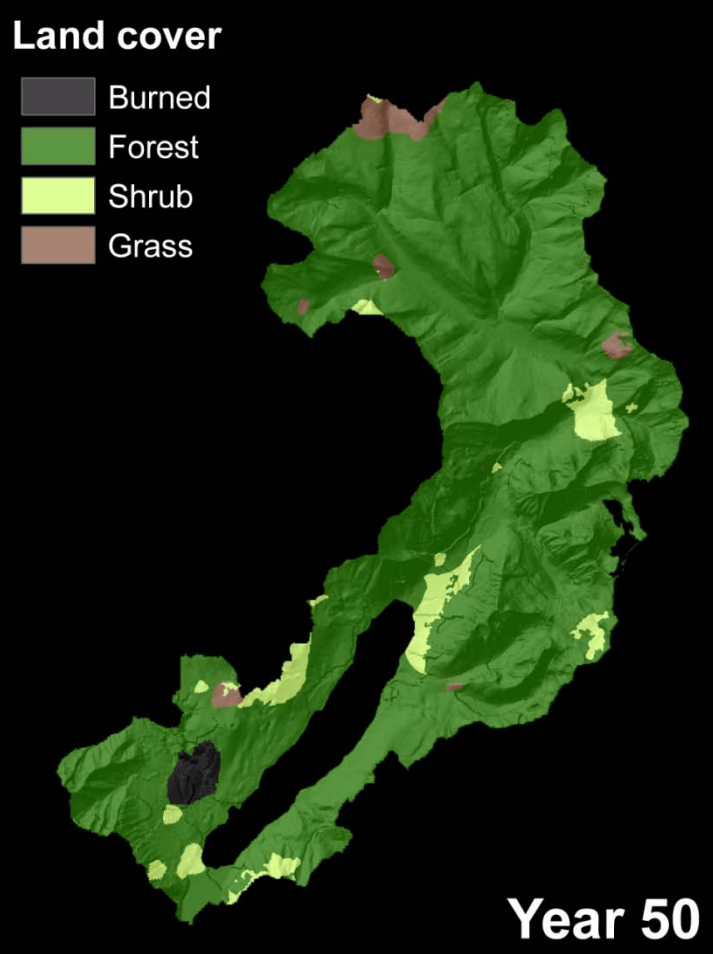
Cumulative # fires

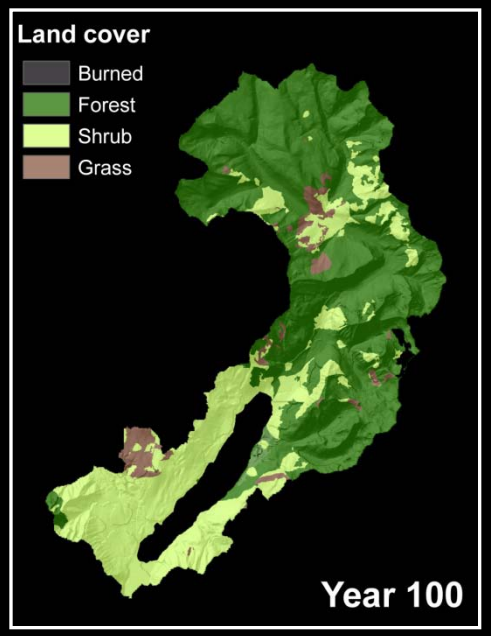
500-year simulation

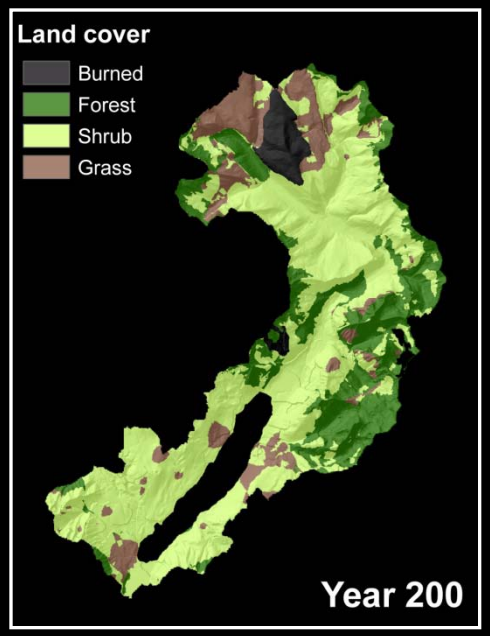


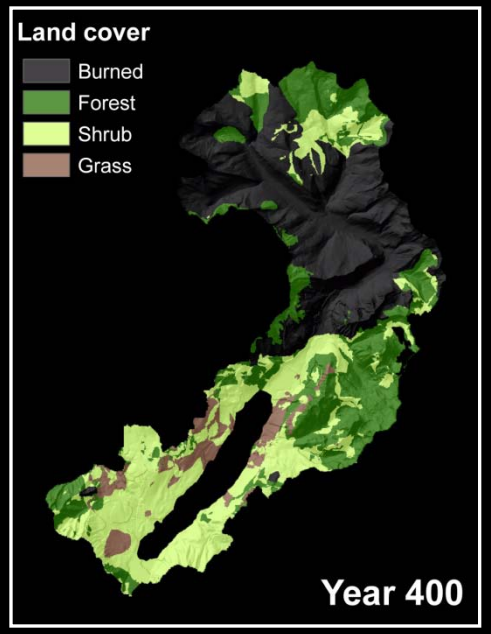
Loehman et al. In preparation

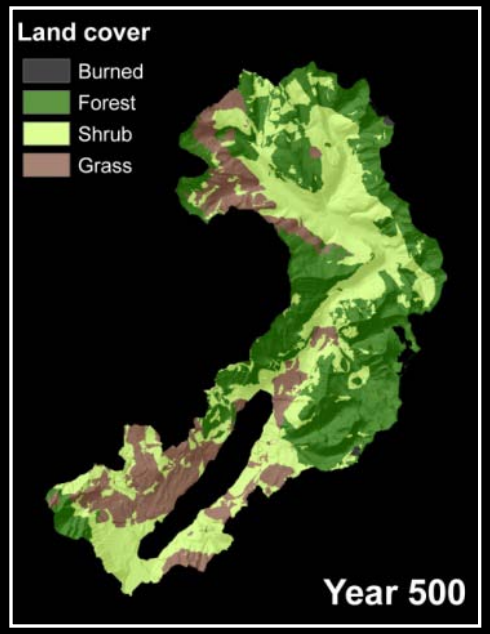
Changes in forest composition





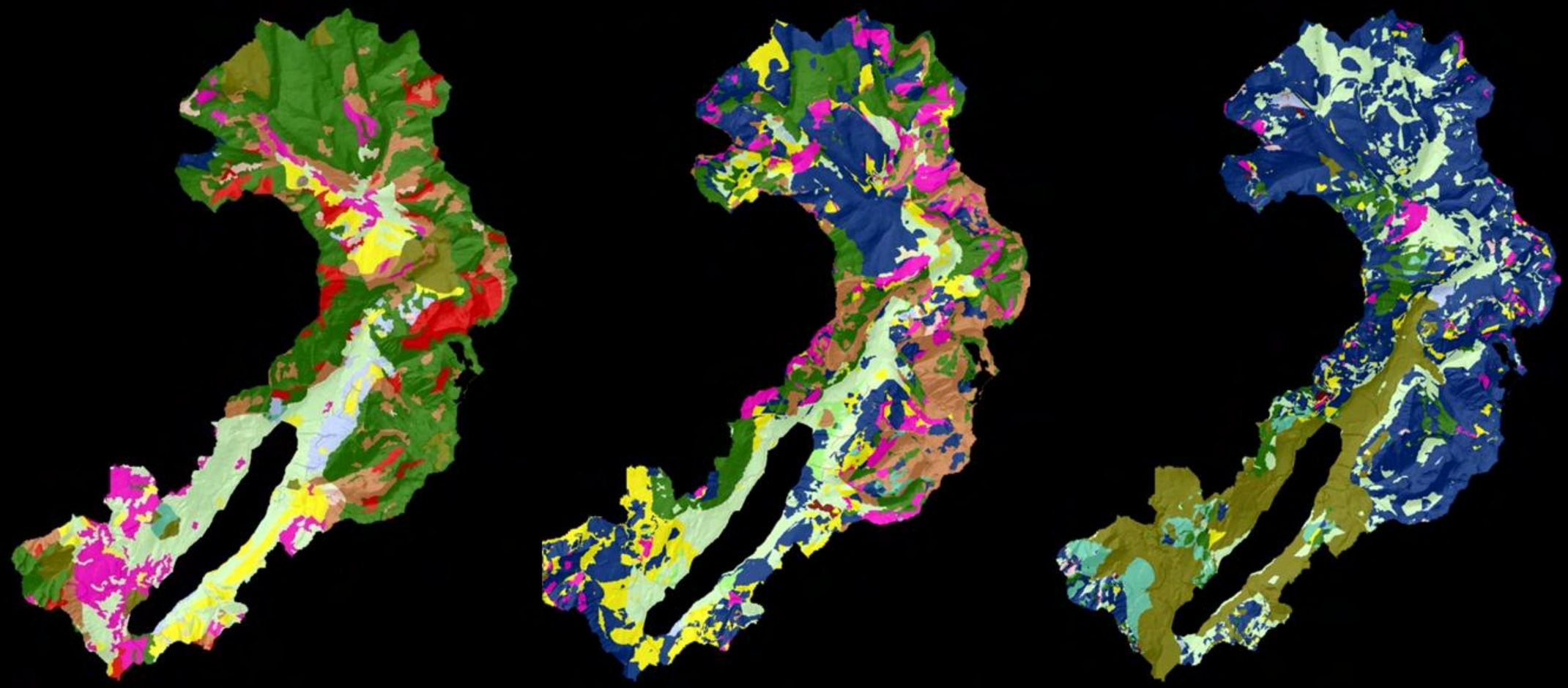






A2 climate scenario – Hot, dry conditions

Changes in species distributions



Historical climate – diverse forest composition

B2 climate scenario (Warmer, Wet) – shift in high elevation spp.

A2 climate scenario (Hot, Dry) – lower elevations dominated by shrubs and grasses

Species

Loehman et al. In preparation

Implications for aquatic ecosystems

Potential changes in:

- Erosion, sedimentation
- Water balance
- Species composition
- Shading, stream temperature
- Productivity
- Invertebrates
- Exotic species

Photo: USFWS, Indian Creek Fire , Alaska, 2004

Photo: USFWS, Kenai NWR , 2001

Uncertainties and unknowns

- Climate futures
- Thresholds
- Non-linear dynamics
- Feedbacks
- Novel interactions
- No-analog conditions
- Abrupt climate changes
- Disturbance synergies

1913

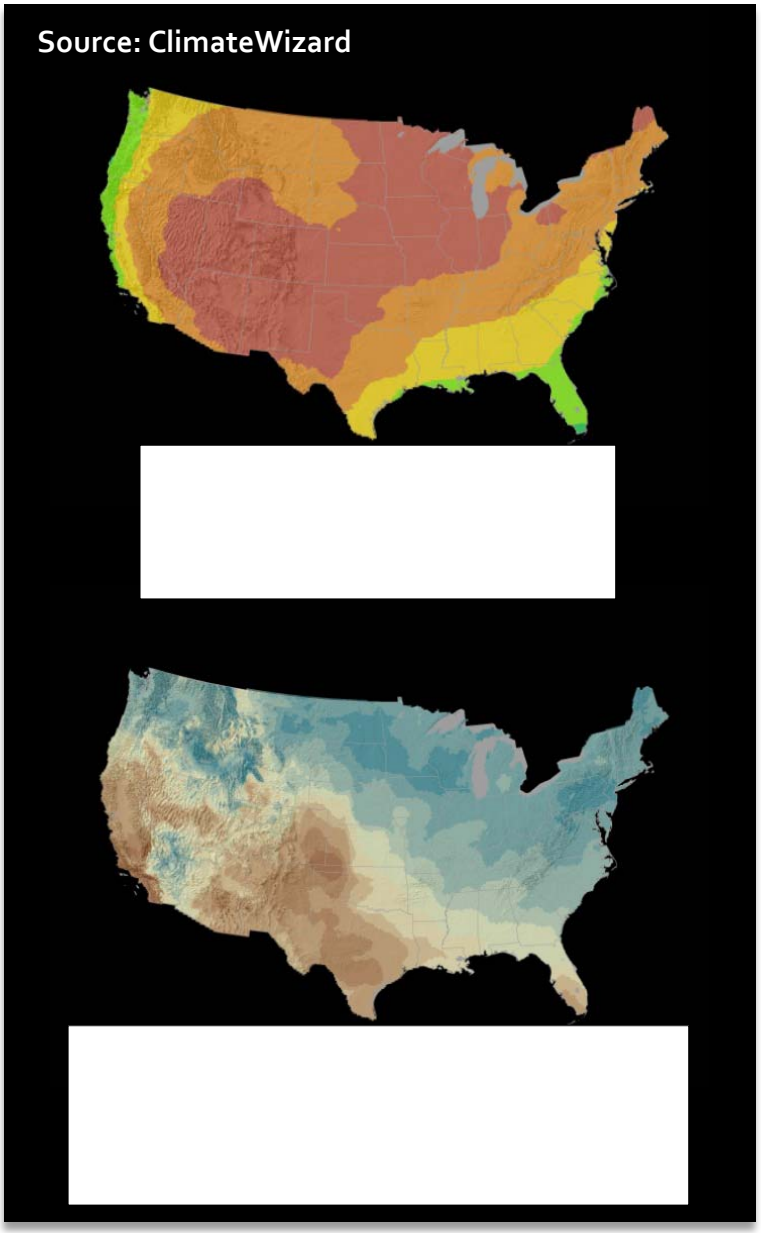
W. C. Alden photo
USGS Photographic Library

2005

Blase Reardon photo
USGS

Tools and resources

- **ClimateWizard**
  http://www.climatewizard.org
- **Climate Impacts Group**
  http://cses.washington.edu/cig/
- **USFS Climate Change Resource Center**
  http://www.fs.fed.us/ccrc
- **US Global Change Research Program**
  http://www.globalchange.gov/
- **Western Wildland Threat Assessment Center (WWETAC)**
  http://www.fs.fed.us/wwetac/
- **RMRS Fire, Fuel, and Smoke Science Program** *http://www.firelab.org*
- **USGS Fort Collins Science Center**
  http://www.fort.usgs.gov/



Rachel Loehman, Ph.D.

Post-doctoral Research Ecologist

Rocky Mountain Research Station
Fire Sciences Laboratory
Missoula, MT
Phone: 406-829-7386
Email: raloehman@fs.fed.us

Climate-Fire Dynamics Group

(www.firelab.org)

Learn from the past…Manage the future

Fire, Fuel, and Smoke
Science Program