Will climate change-disturbance interactions perturb northern Rocky Mountain ecosystems past the point of no return?

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Photo: Craig Allen, USGS
Climate, fire, and vegetation are linked

"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." - Flannigan et al. 2000

"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
Wildland Fire: Pre-European Settlement Period

Fire Was a Dominant Force in the United States Prior to European Settlement

http://www.tnc.org
Incrementally small pushes result in large, abrupt, and persistent changes in landscapes (ecological threshold, critical transition, collapse point, bifurcating trigger...)

Tipping Points

Craig Allen, USGS

Summer 2002

May 2004
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
Climate change impacts on wildfire

- Longer fire seasons
- Increased fire frequency
- Increased fire size, annual area burned
- Potential increased wildfire intensity, severity
- Changes in post-disturbance recovery, biomes
Historic and modeled mean annual area burned with and without fire suppression, MC2 dynamic global vegetation model.
Climate change impacts on mountain pine beetles

- Population size, timing of emergence
- Overwinter survival
- Decreased generation time
- Bivoltinism (2 gens/yr)
- Weakened host trees
- Patterns vary by forest type and elevation: inc. suitability at higher elevations, dec. at lower elevations
Predicted climate change impacts

Shifts in vegetation distribution

Vegetation Density Changes Under Potential Future Warming (MAPSS Simulations)

- Small warming (6 °F, 22% increase in precipitation): The biosphere greens up, a sink for carbon (negative feedback).

- Modest warming (7.6 °F, 18% increase in precipitation): Drought regions expand into previously greening regions. Carbon balance is near a threshold.

- Considerable warming (9 °F, 22% increase in precipitation): Drought regions expand more. The biosphere becomes a source of carbon (positive feedback).

Mountain pine beetle range expansion

Bentz et al. 2010
Climate change impacts on invasive plants

- Adapted to disturbance
- Expansion to higher elevations
- Expansion to currently intact plant communities
- Other stressors exacerbate: grazing, fire, tree mortality, silvicultural treatments

Photo: USFS RMRS

Photo: Montana Weed Control
Conceptual framework of (a) fuels characteristics and (b) fire behavior relative to preoutbreak conditions for red, gray, and old (snagfall and regrowth) phases. Surface fire properties include reaction intensity, rate of spread, and flame length.
Uncertainties and unknowns

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

“...ecosystems are not only more complicated than we think, they are more complicated than we can think.”

– Jack Ward Thomas
Tools and resources

- USGS Climate and Land Use Change
  http://www.usgs.gov/climate_landuse/
- DOI Climate Science Centers
  http://www.doi.gov/csc/
- 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/