Topic 7: Habitats, Communities, Ecosystems
continued

Climate Change Ecology
Geography 404
Jeff Hicke

Benson Glacier
(courtesy USDA)

Eagle Cap, Wallowa Mountains, OR

1920 (H. Richardson)

1992 (D. Jensen)

Andrew G. Fountain
Portland State University

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Tropical glacier melt

Barnett et al., Nature, 2005

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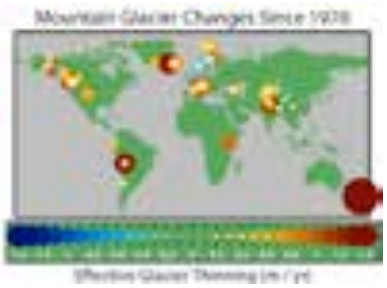
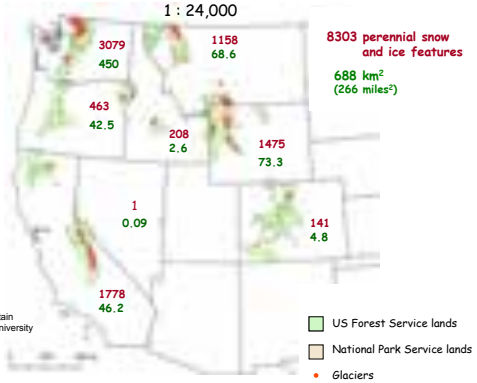
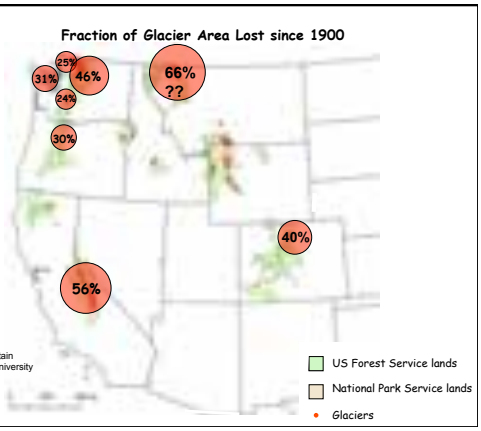


en.wikipedia.org/wiki/File:Glacier_Mass_Balance_Map.png





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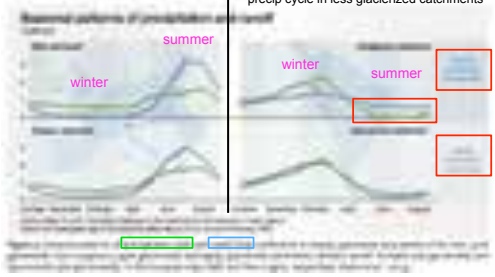
Europe: Glaciers have less effect

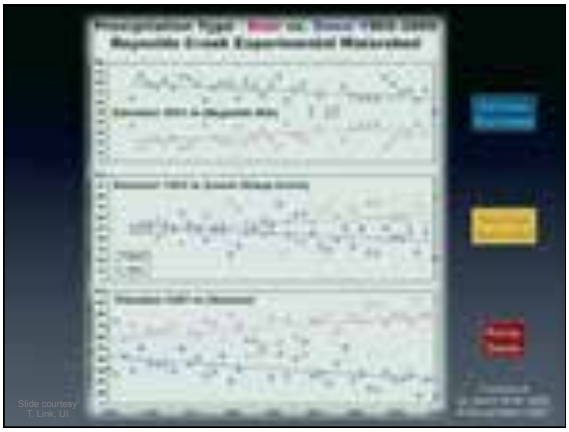
Snow in winter melts in summer

Andes: Glaciers have more effect

Snow melts within days, so runoff follows precip cycle in less glacierized catchments



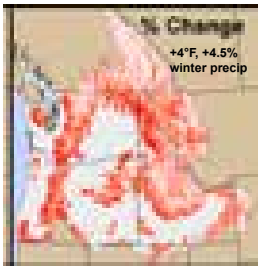
Kaltenborn et al., UNEP Report, 2010



Lower Spring Snowpack

Spring snowpack is projected to decline as more winter precipitation falls as rain rather than snow, *especially in warmer mid-elevation basins*

Snowpack will melt earlier with warmer spring temperatures

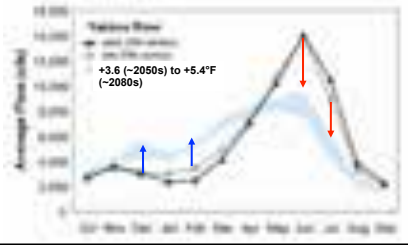


April 1 Snowpack

Source: Climate Impacts Group, University of Washington, www.cses.washington.edu/cig

Shifts in Streamflow

- More winter rain → **higher winter streamflows**
- Warmer temperatures → **earlier snowmelt** and a **shift in the timing** of peak runoff
- Lower winter snowpack → **lower spring and summer flows**



Sensitivity analysis for the Yakima River basin

Source: Climate Impacts Group, University of Washington, www.cses.washington.edu/cig

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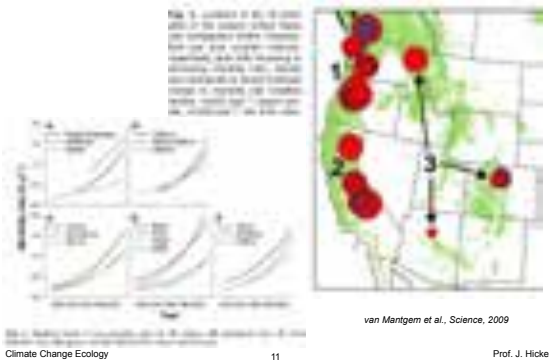
Increase in tree mortality rates in old-growth forests



van Mantgem et al., Science, 2009

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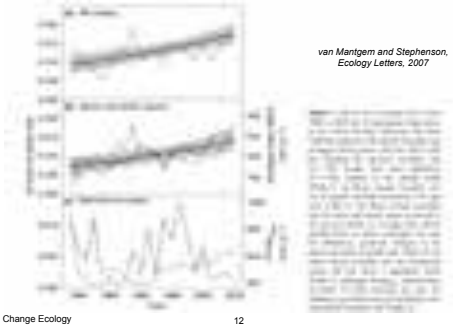
Increase in tree mortality rates in old-growth forests due to warming (stress, biotic causes)



van Mantgem and Stephenson, Ecology Letters, 2007

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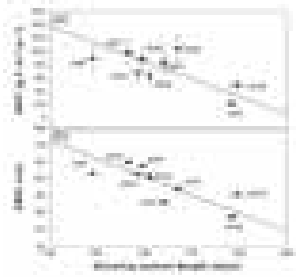
Warming leads to longer growing season but reduced plant growth



Shallower snowpack =>

longer growing season length but less water availability =>

less plant growth (dependence on snow melt water) =>

less carbon storage (lower Net Ecosystem Productivity)

Hu et al., Global Change Biology, 2010

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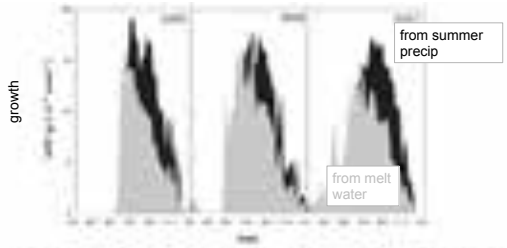
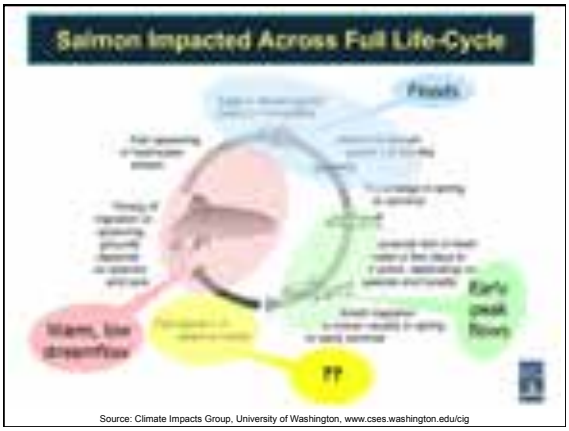
Reliance of trees on snow melt water, not summer precip
Is this typical?



Hu et al., Global Change Biology, 2010



Source: Climate Impacts Group, University of Washington, www.cses.washington.edu/cig

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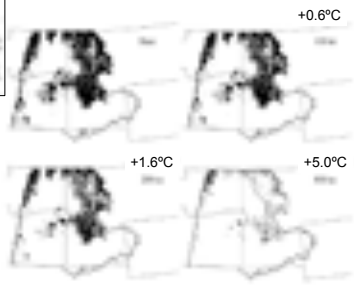
Predicted response of bull trout to warming



Rieman et al. 2007

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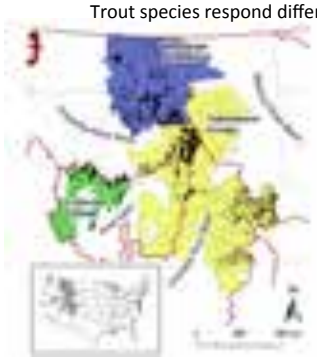
Trout species respond differently to warming



fishandboat.com/trout.htm; fieldguide.mt.gov

Wenger et al. 2011

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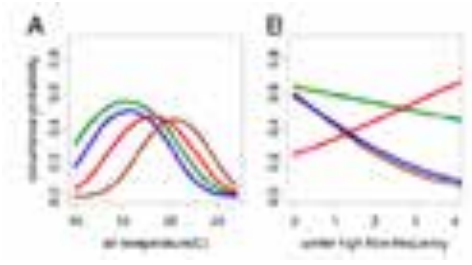
Species responses to air temperature, flow



Brook **Brown** **Rainbow** **Cutthroat**

Wenger et al. 2011

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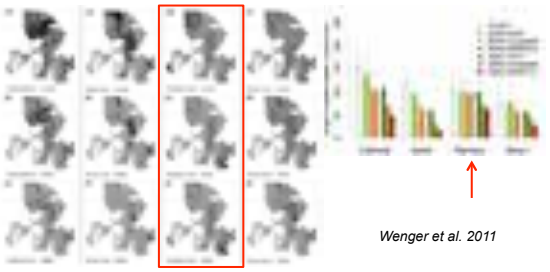
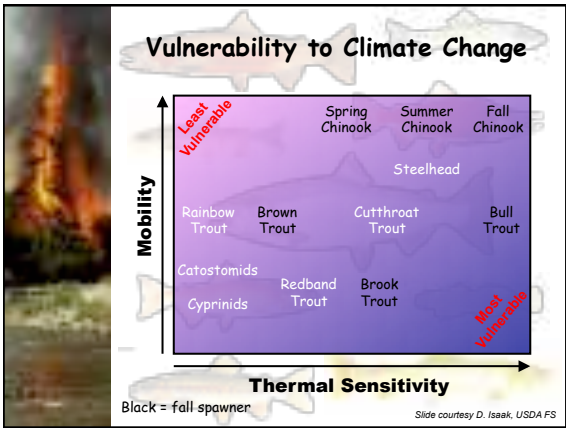
Predictions using future climate projections
Overall: 47% decrease by 2080



Wenger et al. 2011

Rainbow: (less) negative T offset by flow changes that are beneficial (spring, not winter, spawners)



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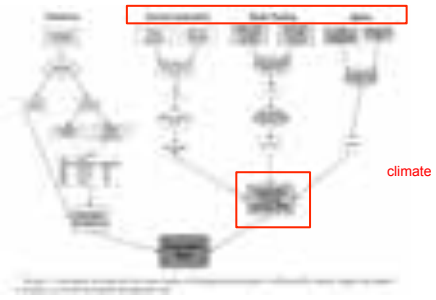
Factors influencing risk of losing cutthroat trout populations:
Adding climate change



Williams et al., NAJ Fish. Manag., 2009

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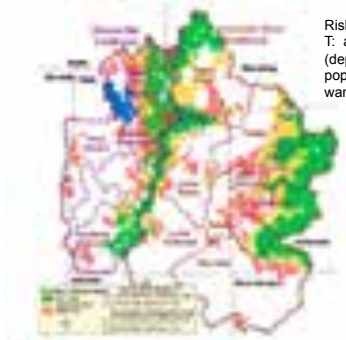
Factor 1: Summer temperature



Risk of higher summer T: above 22º or 24ºC (depending on population) after 3ºC warming

Williams et al., NAJ Fish. Manag., 2009

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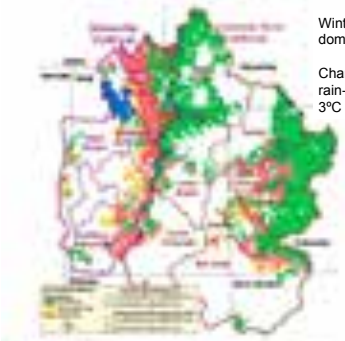
Factor 2: Winter flooding



Winter-precip-dominated watersheds

Change from snow- to rain-dominated with 3ºC winter warming

Williams et al., NAJ Fish. Manag., 2009

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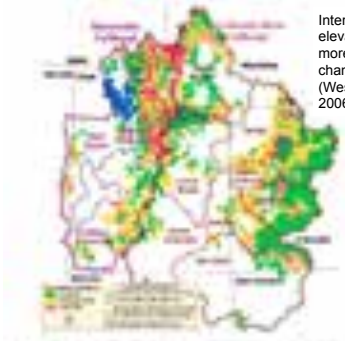
Factor 3: Wildfire impacts



Intermediate elevations may be more susceptible to changes in fire regime (Westerling et al., 2006)

Williams et al., NAJ Fish. Manag., 2009

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Composite risk = max of three climate risks

Bonneville subspecies: 73% in high risk

Colorado subspecies: 29% in high risk

More change from flooding, fire than from summer warming

summer T + winter flooding + wildfire

Williams et al., NAJ Fish. Manag., 2009

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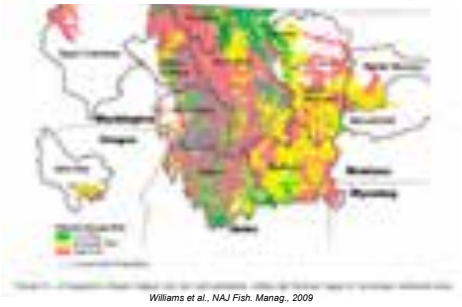
Westslope subspecies: 65% in high risk

More change from flooding, fire than from summer warming



Williams et al., NAJ Fish. Manag., 2009

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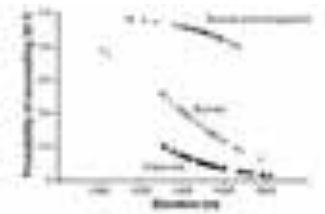
Wildfire effects on stream temperature



"Burned": loss of shading from streamside vegetation

"Reorganized": flooding, debris flows following fires that redistribute sediment and wood

Changes in T lasted for decades

Dunham et al., Ecosystems, 2007

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Projected changes in clouds

Effects of dry periods on animals in cloud forest

Hannah, 2011

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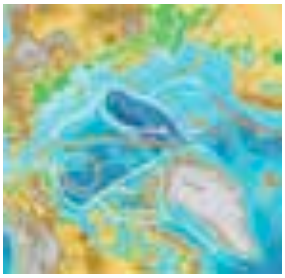
Cascading effects of changes in climate through physical and biological systems

Warm water entering into Arctic -> … -> deflection of low-salinity water to west of Greenland…



…with resulting impacts to marine ecosystems

Greene and Pershing, Science, 2007

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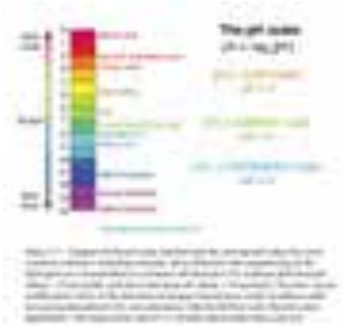
Ocean acidification



NOAA, State of Washington Report on Ocean Acidification, 2012

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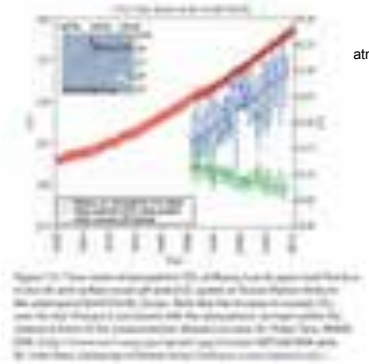

Recent changes in atmospheric CO2, CO2 in seawater, and pH

NOAA, State of Washington Report on Ocean Acidification, 2012

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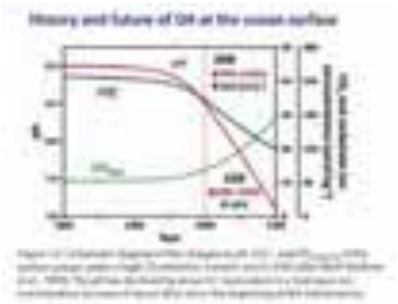
Ocean acidification



NOAA, State of Washington Report on Ocean Acidification, 2012

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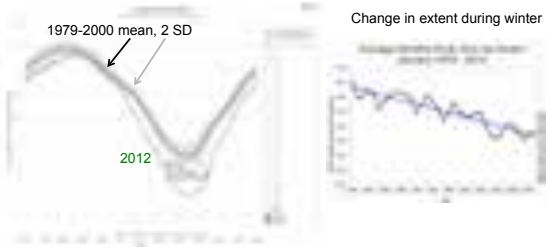
Arctic sea ice retreat



Extent during each year

nsidc.org

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Extent in fall (minimum)

oceantoday.noaa.gov/welcome.html

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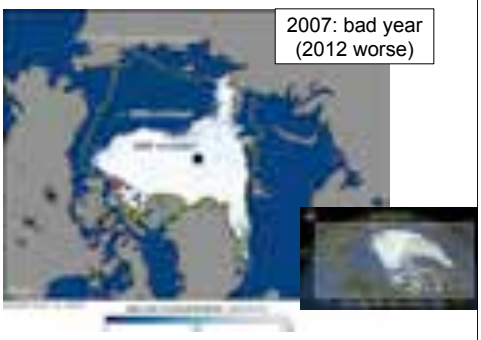

globalwarmingart.com

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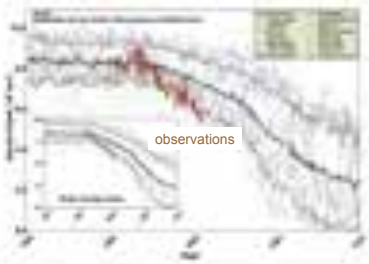
Models do not predict retreat as fast as observed (worrying)



Stroeve et al., GRL, 2007

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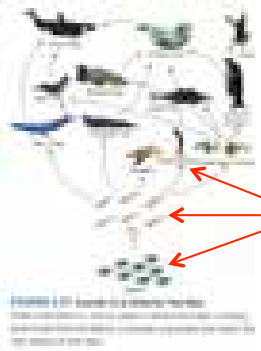

Climate change effects on Antarctic food webs

Hannah, 2011

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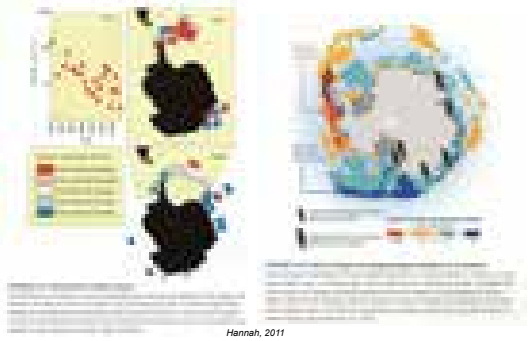
CC -> sea ice -> algae -> krill -> penguins



Hannah, 2011