Climate change effects and adaptation options for forest ecosystems in the west

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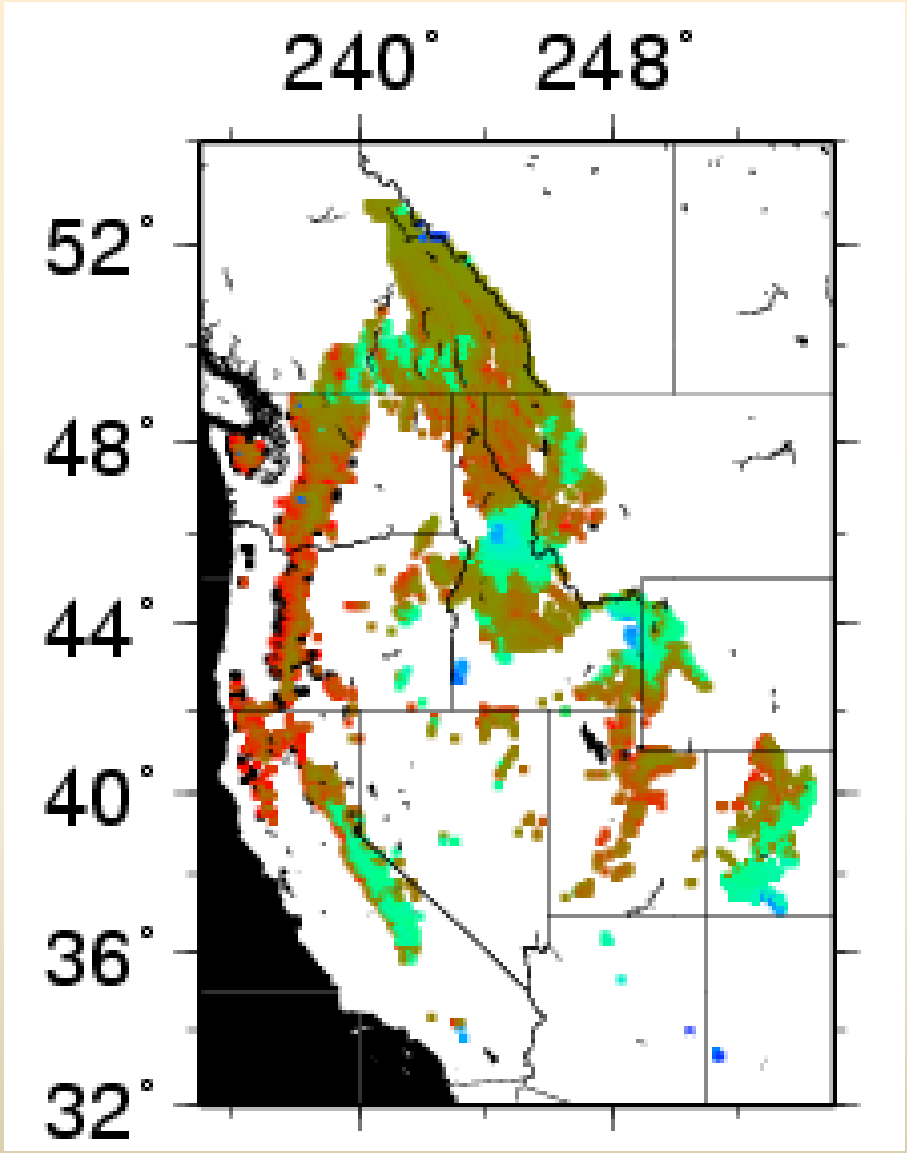
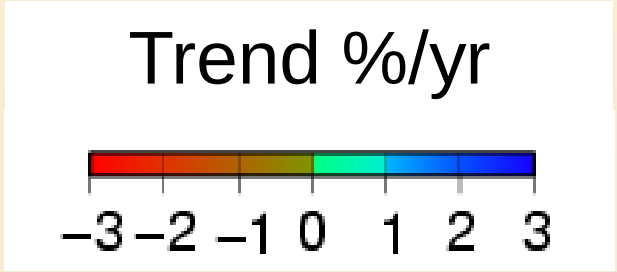
Climate controls ecosystem processes

- The hydrologic cycle
- Plant establishment, growth, and distribution
- Disturbance
  - Drought
  - Fire
  - Flooding
  - Insect outbreaks

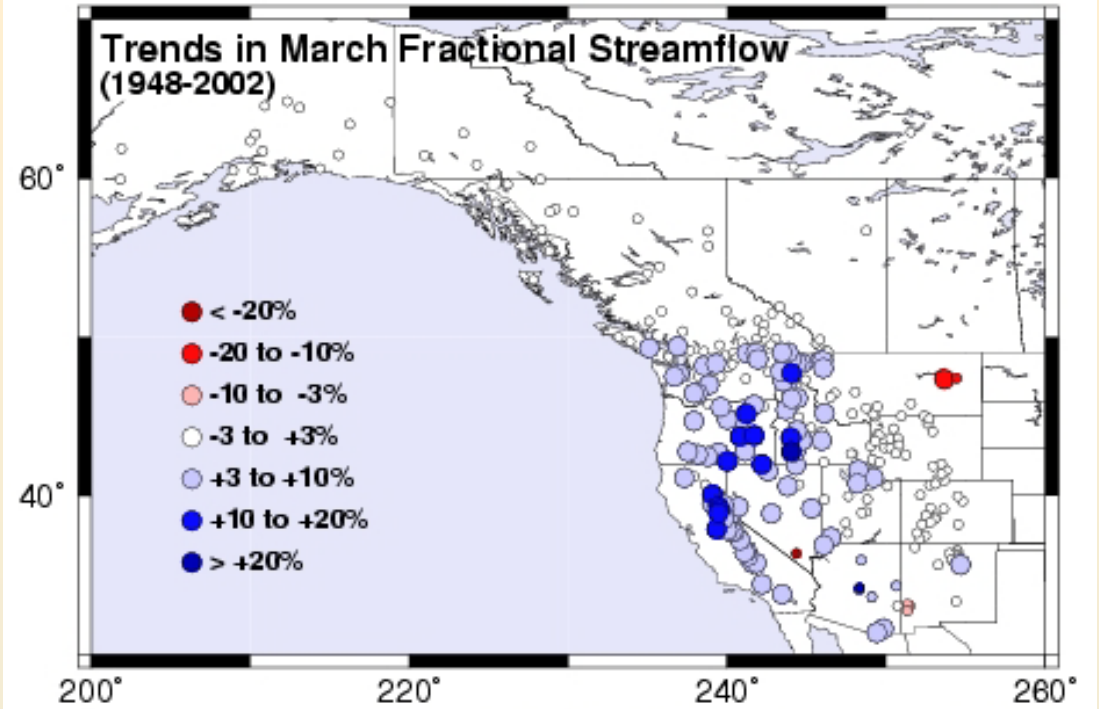
Effects of changing climate on hydrology

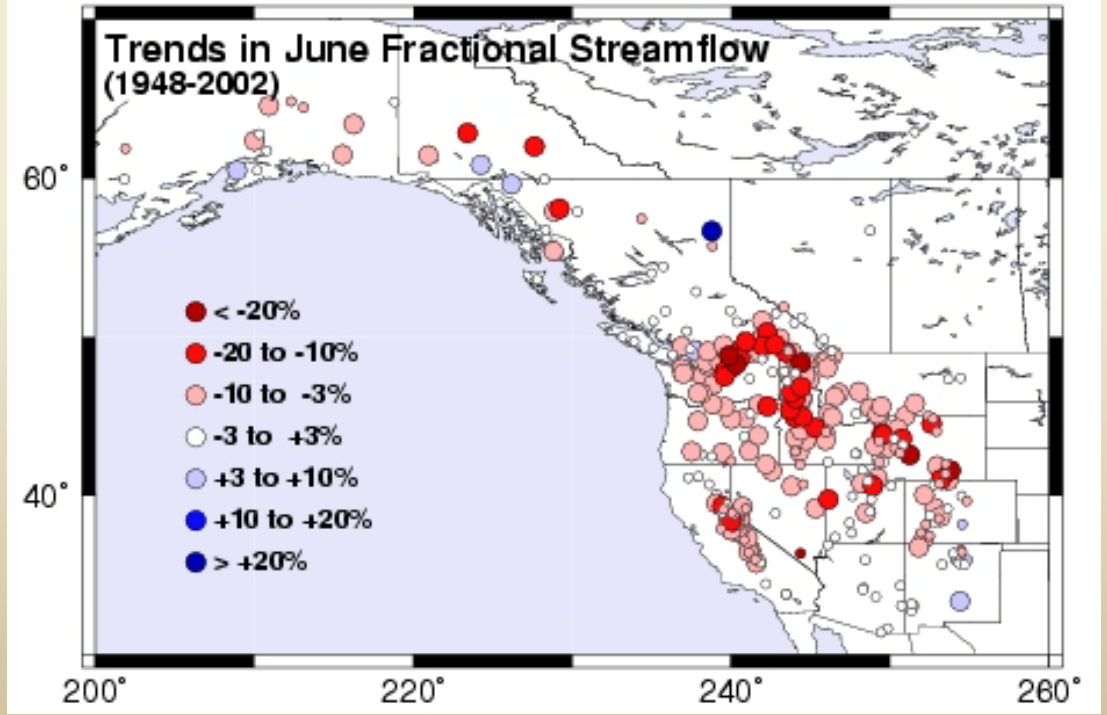
Trends in April 1 SWE from 1947-2003





Hamlet, A.F., Mote, P.W, Clark, M.P., Lettenmaier, D.P., 2005: Effects of temperature and precipitation variability on snowpack trends in the western U.S., J. of Climate, 18 (21): 4545-4561





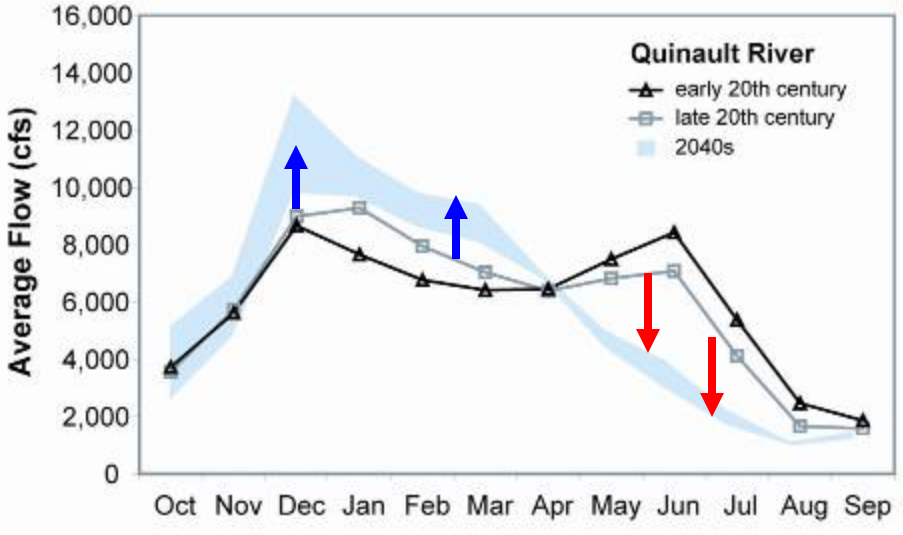
As the West warms, spring flows rise and summer flows drop

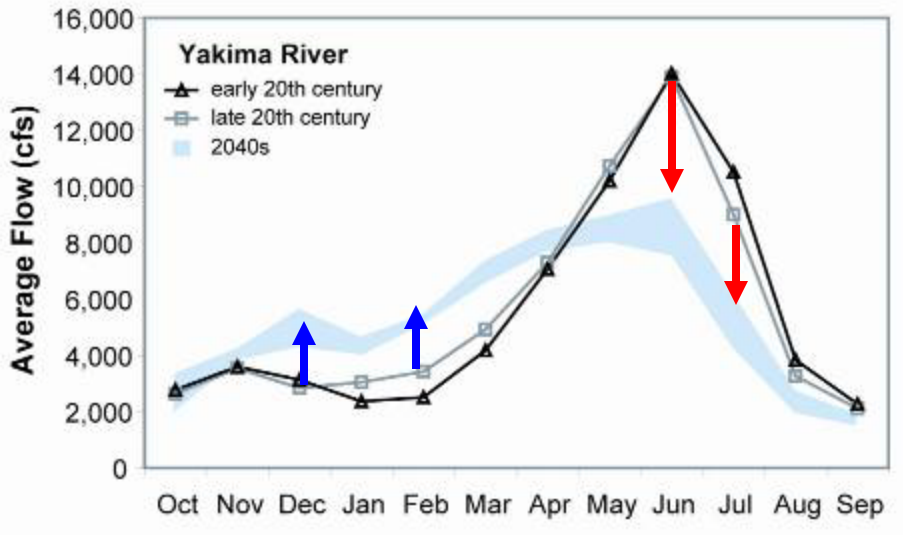
Stewart IT, Cayan DR, Dettinger MD, 2005: Changes toward earlier streamflow timing across western North America, J. Climate, 18 (8): 1136-1155

Climate Change and Streamflow

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

Projected streamflow changes, 2050s





+3.6 to +5.4°F
(+2 to +3°C)

Effects of changing climate on vegetation

Plant species respond to:

- Thermal constraints
- Water constraints
  - ↑ temperatures = ↑ evapotranspiration
  - ↑ CO_2 = ↑ water use efficiency?
- Disturbance regimes

Climatic variability affects tree regeneration

- Regeneration increases when the effects of limiting factors are reduced:
  - Snowpack
  - Length of growing season
  - Soil moisture in summer

Climate change and regeneration

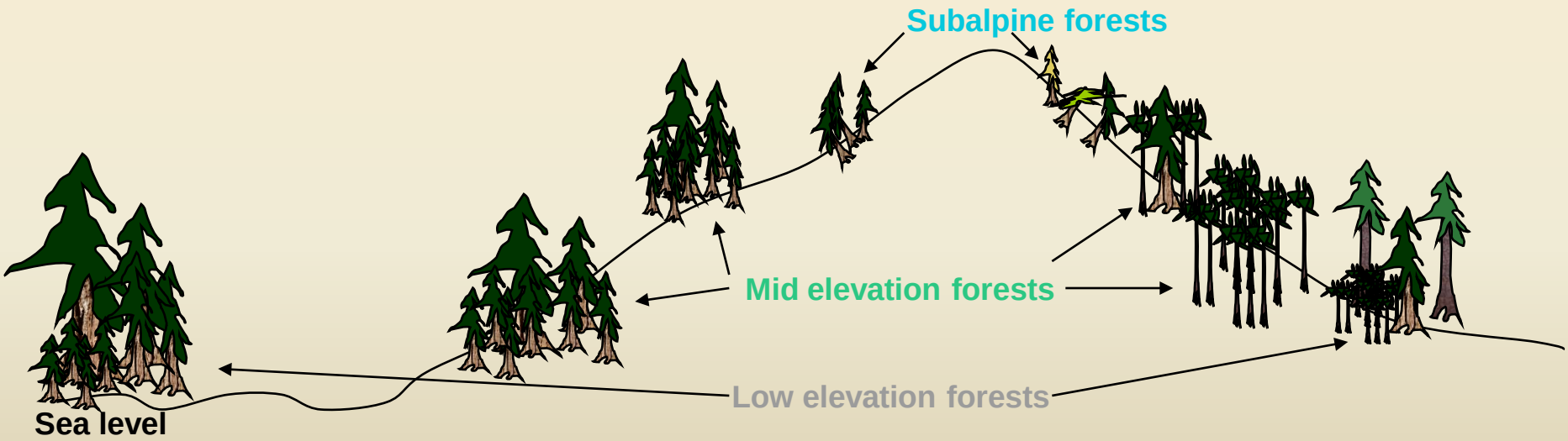
- Effects of a warmer climate will be site specific:
  - In high-snow forests, regeneration will increase
  - In dry forests, regeneration will decrease

Climate change and tree growth

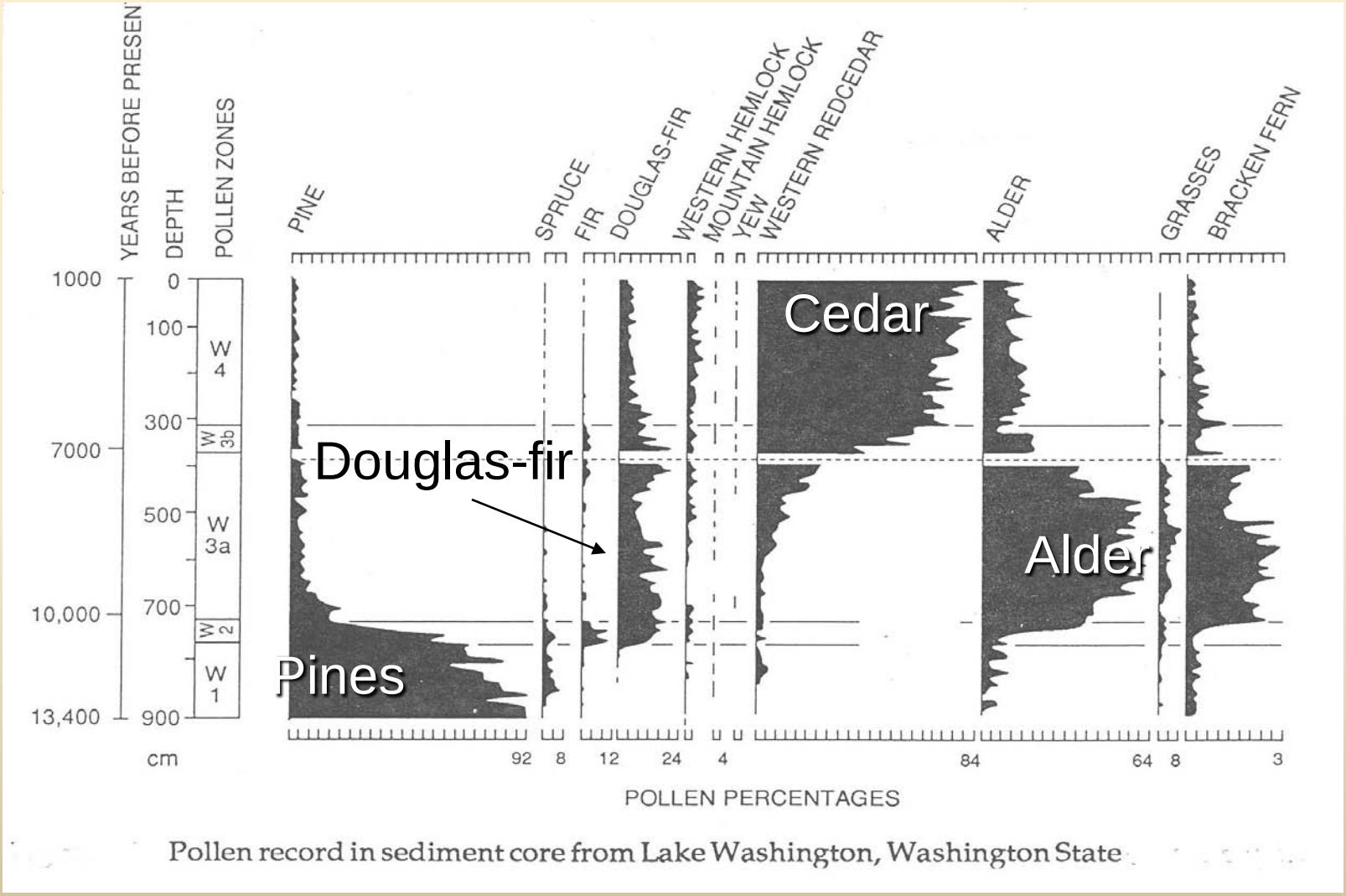
Subalpine forests: less snowpack duration; longer, warmer growing seasons = **growth increase**

Mid elevation forests: warmer summers, less snow pack = **growth depends on precipitation**

Low elevation forests: warmer summers, less snow pack = **large growth decrease**



Plant species respond individualistically to climate change



Pollen record in sediment core from Lake Washington, Washington State

Effects of changing climate on disturbance

Climate Change and Fire

- Warmer and drier spring conditions =
  - early snowmelt
  - lower summer soil and fuel moisture
  - longer fire seasons
  - increased fire frequency and extent
- Fire intensity and severity may also increase

How much will area burned increase with climate change?

Analysis of wildfire data since 1916 for the 11 contiguous Western states shows that *for a 4 F increase* that *annual area burned will be 2-3 times higher*.

McKenzie et al. (2004), *Conservation Biology* 18:890-902

Insect outbreaks may become more frequent with climate change

Extreme weather events will likely increase with climate change

- Wind
- Floods
- Drought

Disturbance drives ecosystem changes

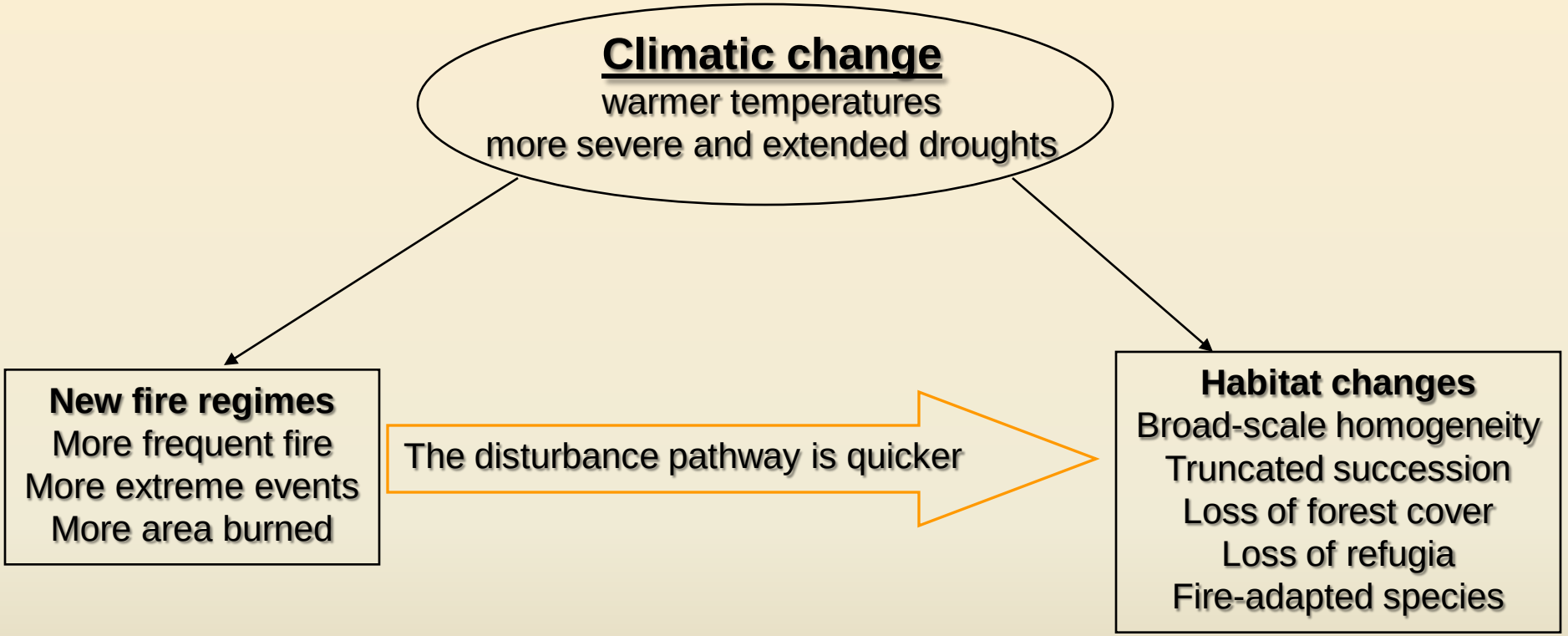
Climatic change
warmer temperatures
more severe and extended droughts

Disturbance drives ecosystem changes

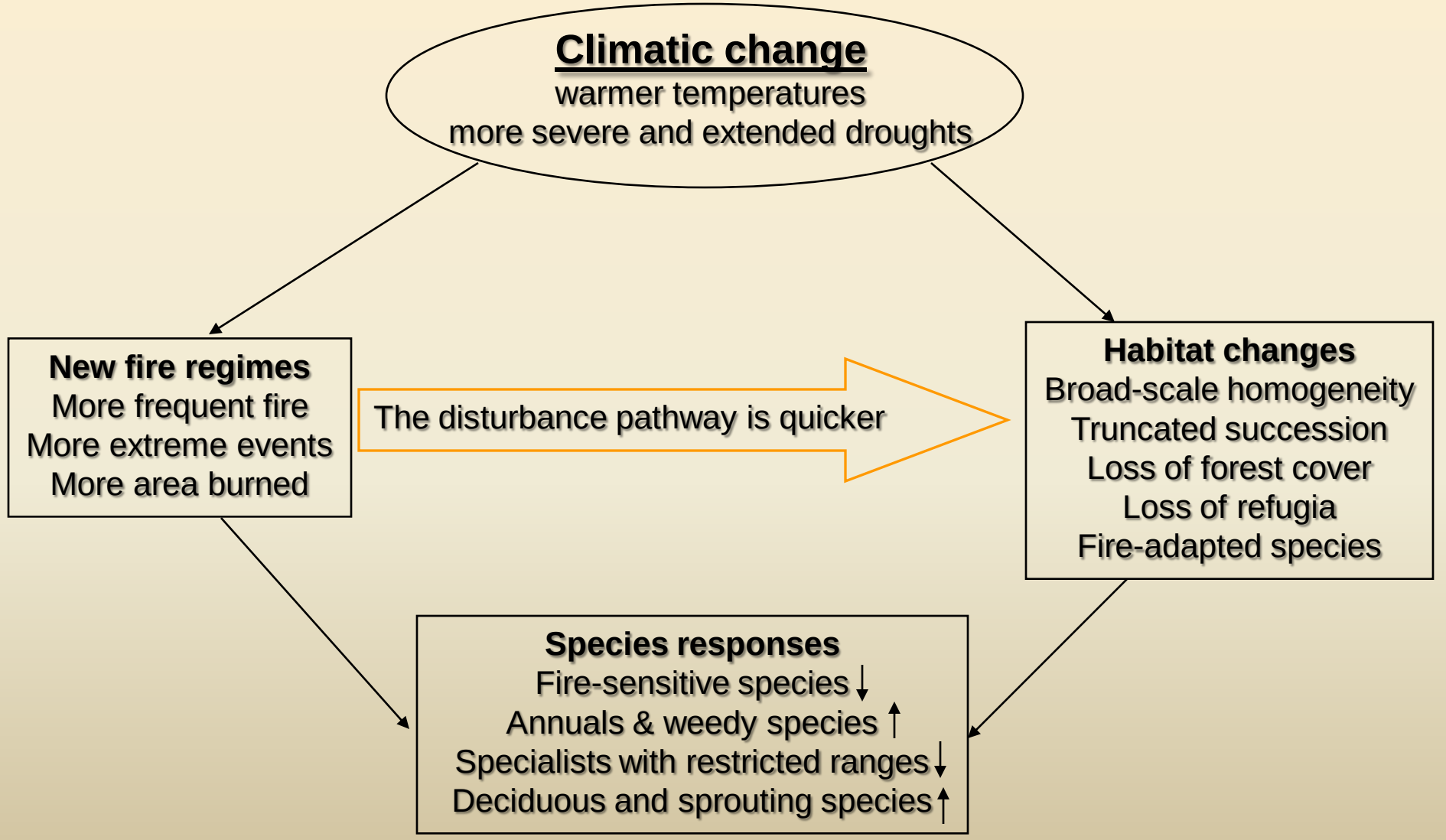
Climatic change
warmer temperatures
more severe and extended droughts

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

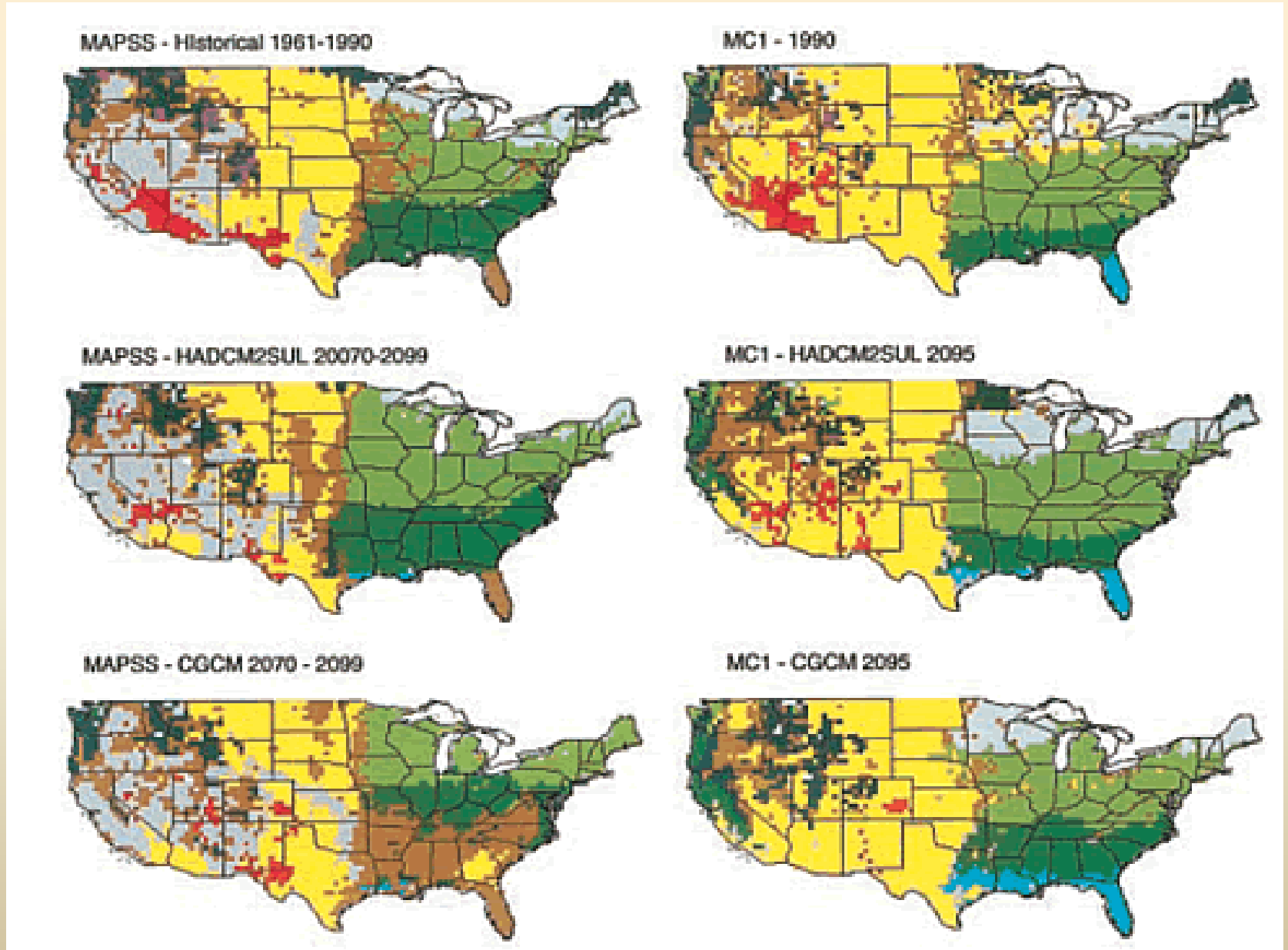
Disturbance drives ecosystem changes



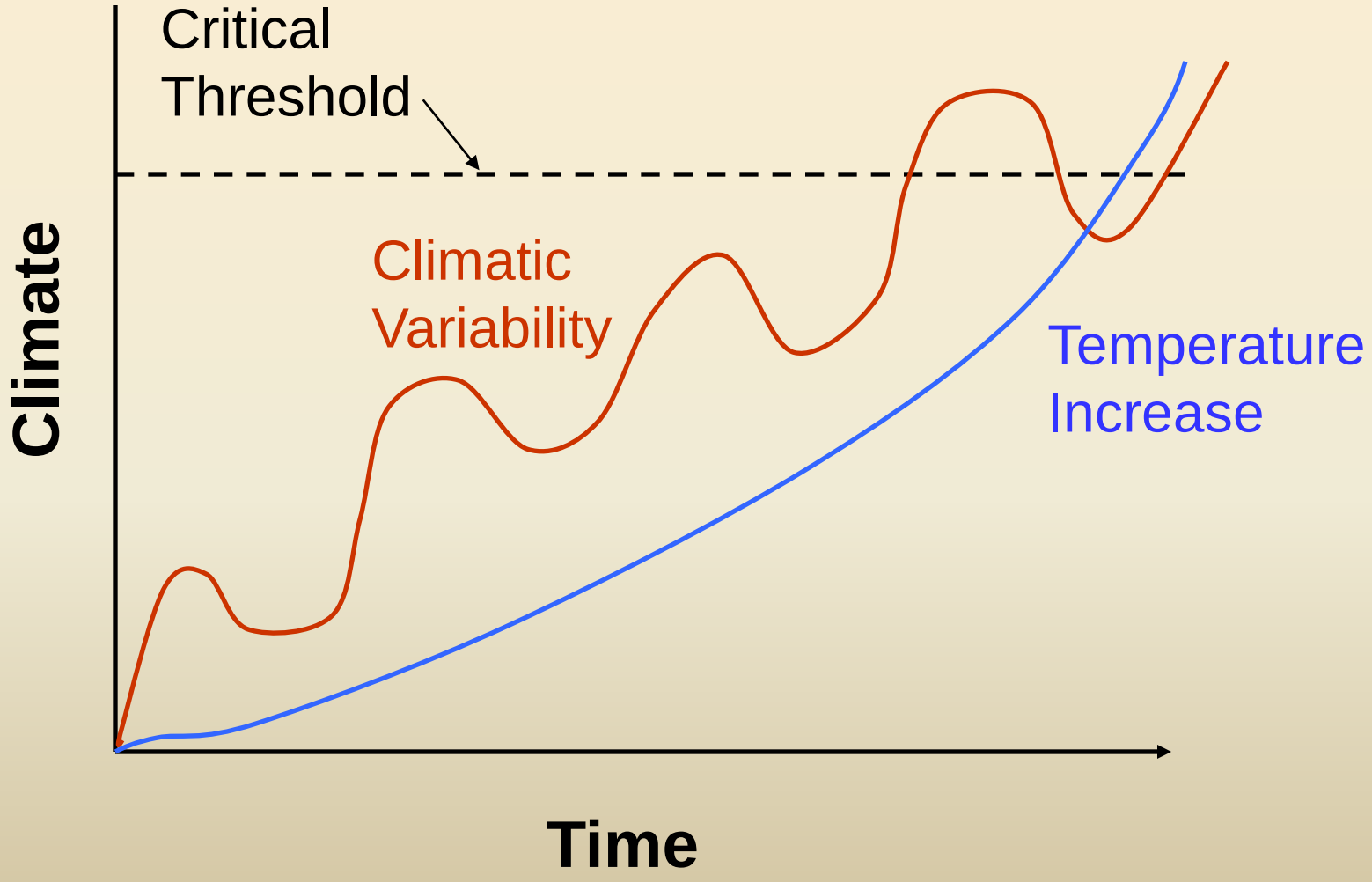
Disturbance drives ecosystem changes



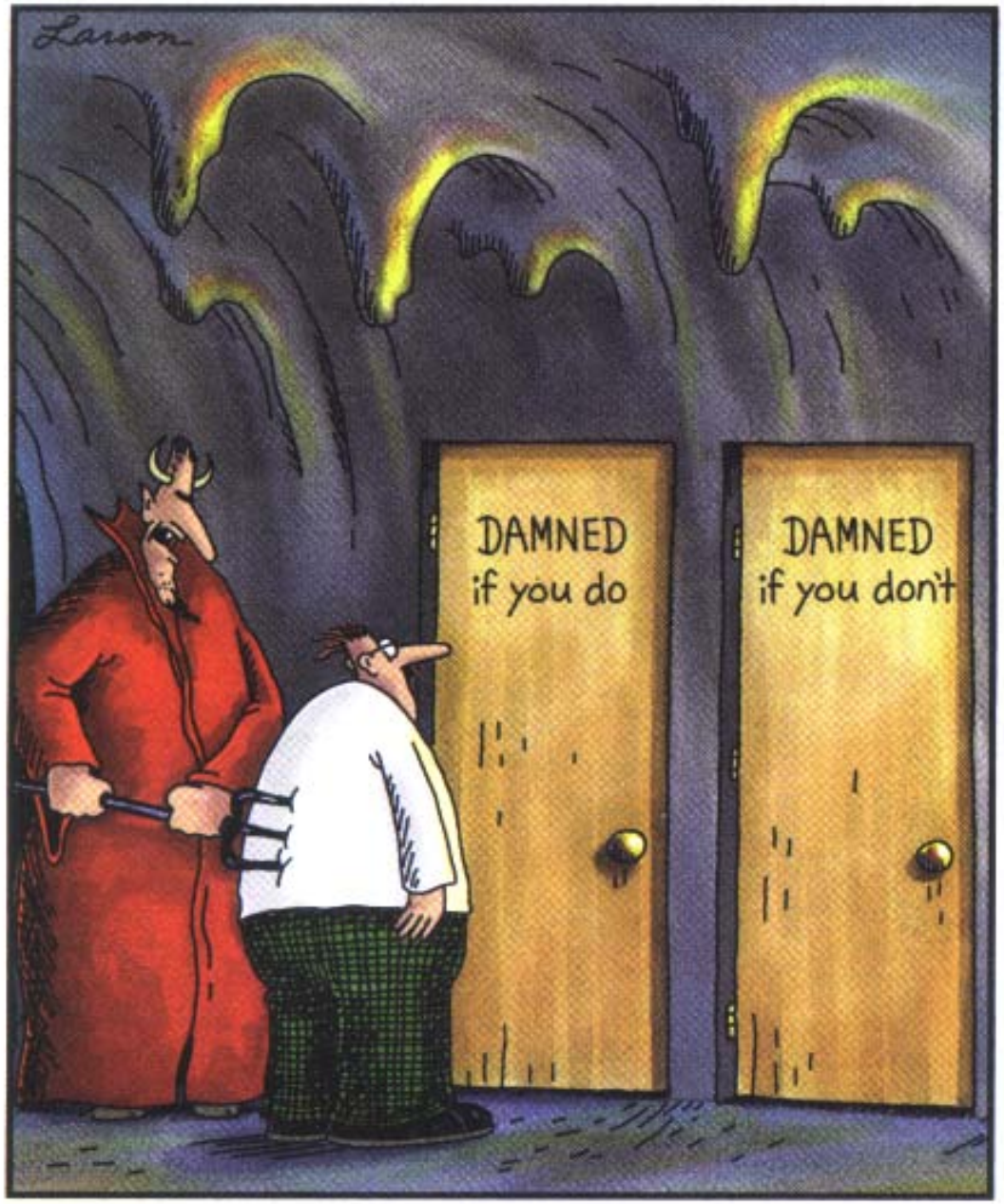
Vegetation Type Changes



Thresholds are Key

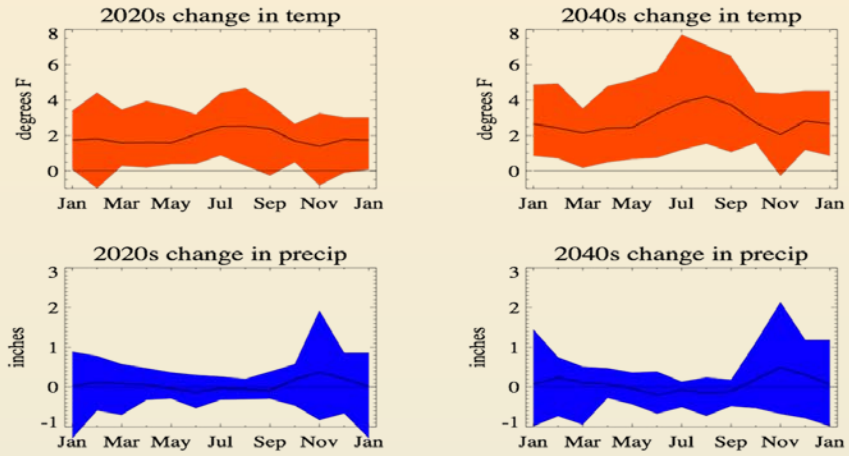


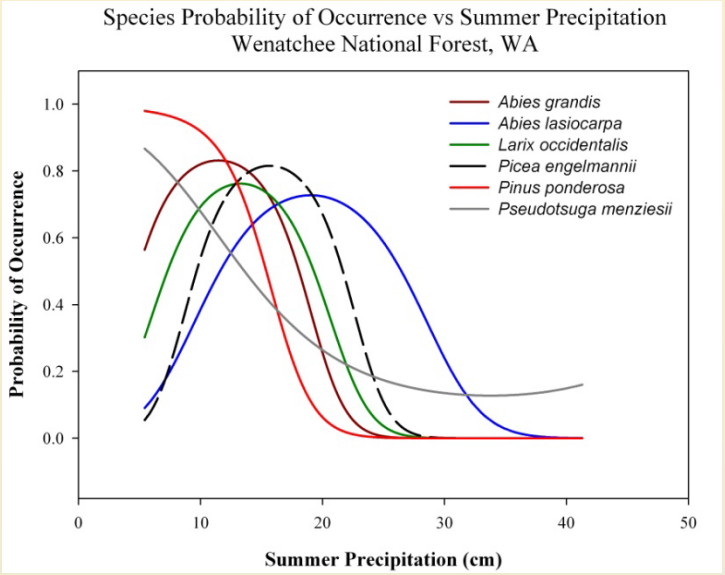
Adaptation strategies for natural resource management?

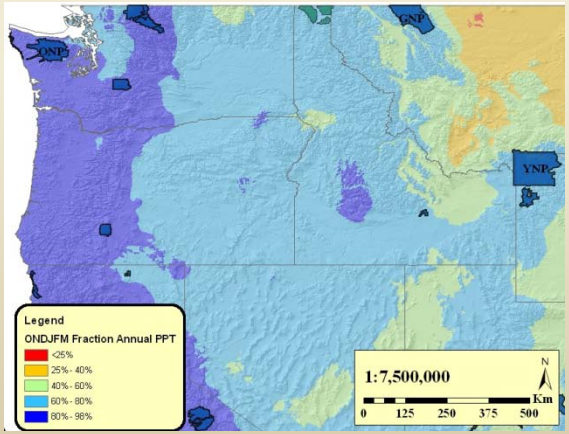


"C'mon, c'mon—it's either one or the other."

Toolkit Approach to Climate Change Adaptation







Adaptation strategy #1

Increase landscape diversity

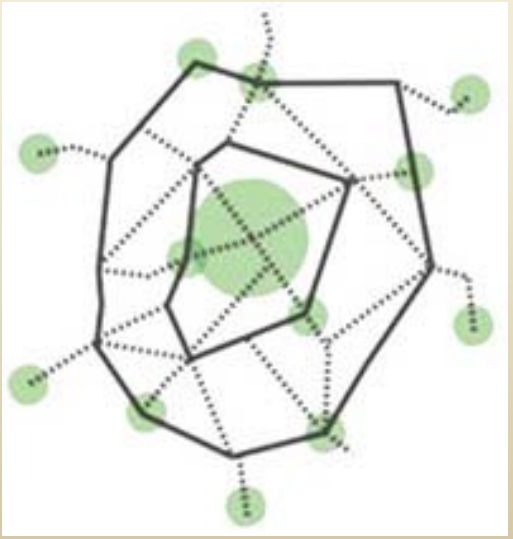
Increase resilience at large spatial scales

--Treatments and spatial configurations that minimize loss of large number of structural and functional groups

Increase size of management units

-- Much larger treatments and age/structural classes

Increase connectivity



Adaptation strategy #2

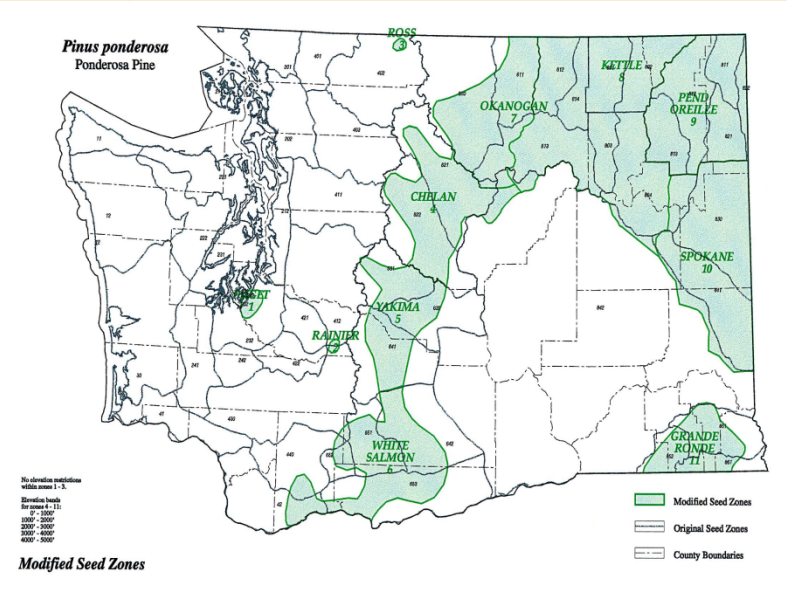
Maintain biological diversity

Modify genetic guidelines

Experiment with mixed species, mixed genotypes

Assist colonization, establish neo-native species

Identify species, populations, and communities that are sensitive to increased disturbance



Adaptation strategy #3

Plan for post-disturbance management

Treat fire and other ecological disturbance as normal, periodic occurrences

Incorporate fire management options directly in general planning process

Adaptation strategy #4

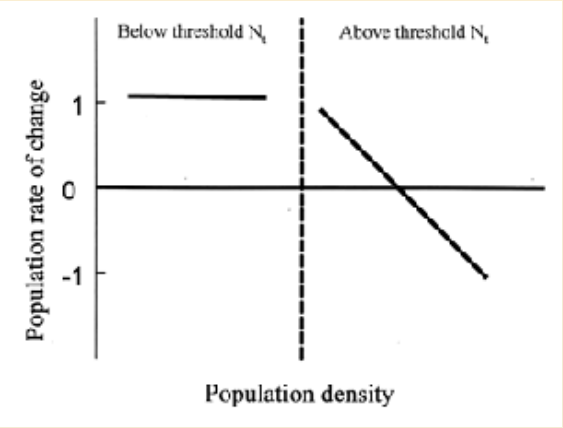
Implement early detection / rapid response

Eliminate or control exotic species

Monitor post-disturbance conditions, reduce fire-enhancing species (e.g., cheatgrass)

Adaptation strategy #5

Manage for realistic outcomes



Identify key thresholds for species and functions

Determine which thresholds will be exceeded (e.g., Pacific salmon)

Prioritize projects with high probability of success; abandon hopeless causes

Identify those species and vegetation structures tolerant of increased disturbance

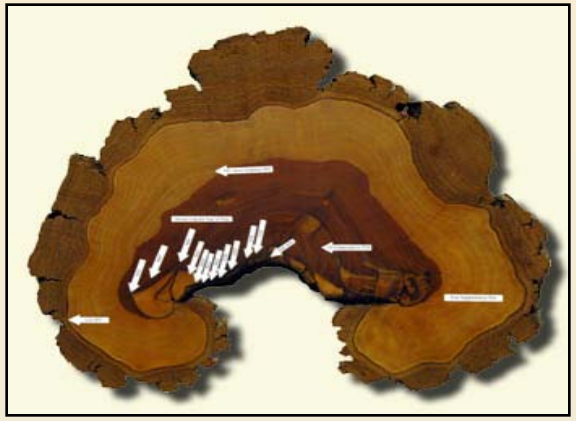
Adaptation strategy #6

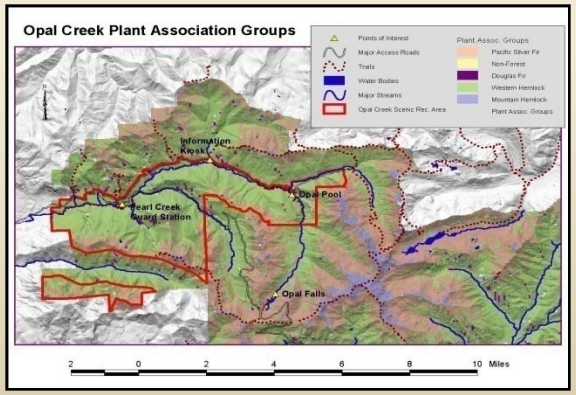
Incorporate climate change in restoration

Reduce emphasis on historical references

Reduce emphasis on guidelines based on static relationships (e.g., plant associations, habitat types)

Develop performance standards appropriate for accomplishing realistic restoration trajectories





Adaptation strategy #7

Develop climate-smart regulations, policies

Address regulatory/policy issues
(e.g. Endangered Species Act)

Address process issues
(e.g., NEPA, public opposition)

Work with legislators and policy makers to revise regulations and policy; work more closely with local stakeholders from onset of projects

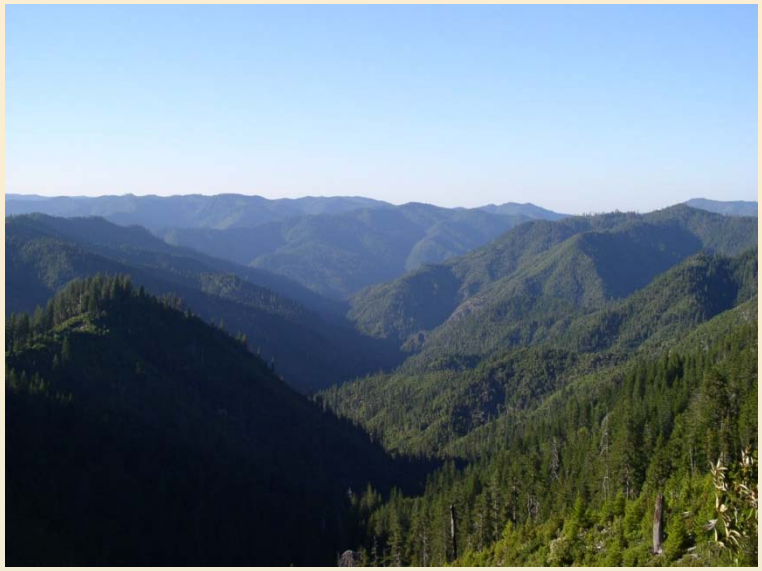
Adaptation strategy #8

Anticipate big surprises

Expect mega droughts, larger fires, system collapses, species extirpations, etc.

Incorporate these phenomena in planning

Thank you!



Other Resources:

Climate Change Resource Center: http://www.fs.fed.us/ccrc

US Climate Change Science Program Synthesis and Assessment Product 4.4 (SAP 4.4), Chapter 3:

http://www.climatescience.gov/Library/sap/sap4-4/final-report/