Species and Biodiversity Responses to Climate Change

Jean Brennan PhD

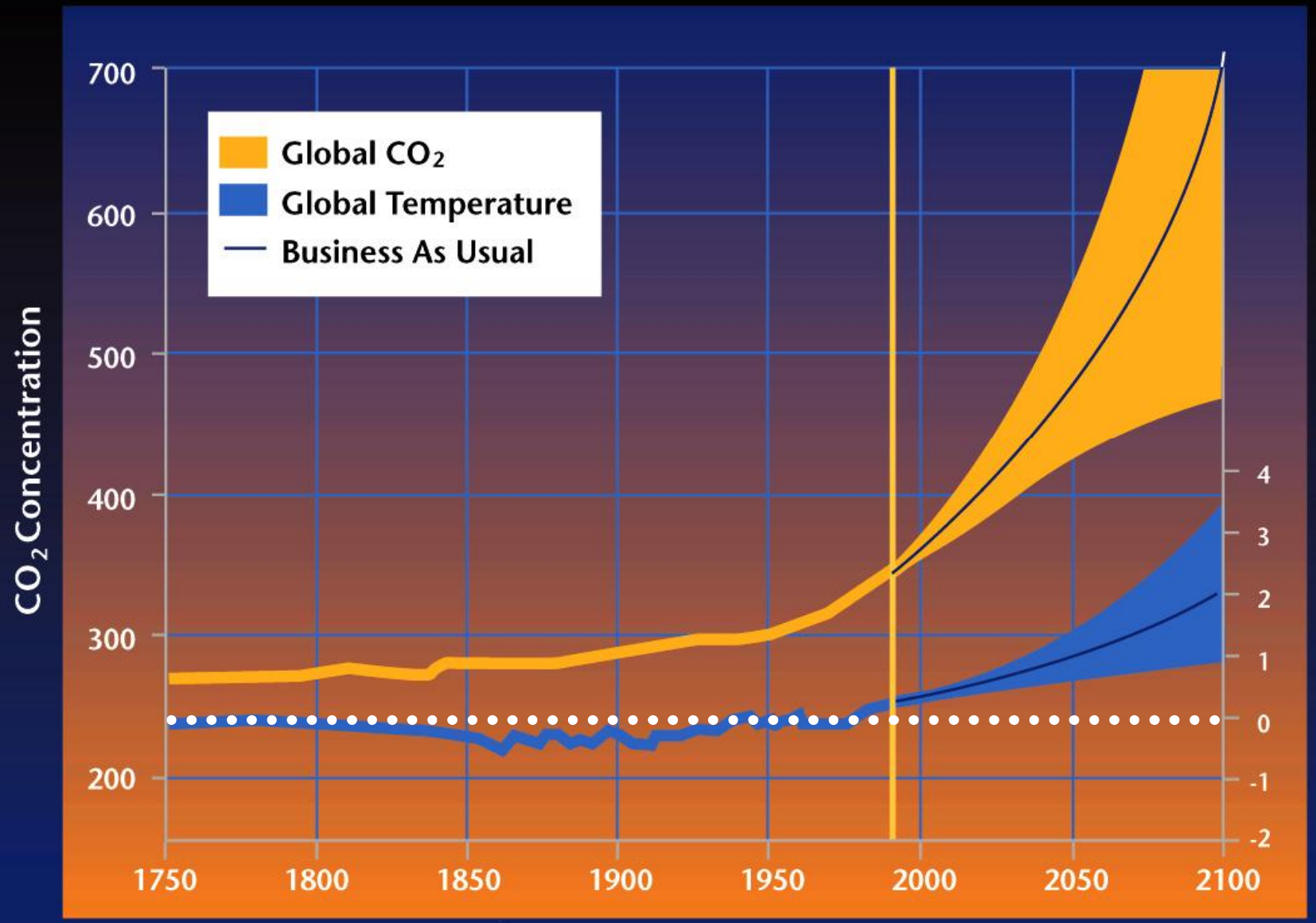
Defenders of Wildlife

Workshop: Climate Change Impacts in the Colombia River Basin. June 24-25, 2008

Outline

- **Physical Changes**
- **Biological Changes**
- **Columbia River**
- **Managing Under Uncertainty -- Assisting Fish and Wildlife Adaptation**

Projection of CO_2 and Temperature to 2100

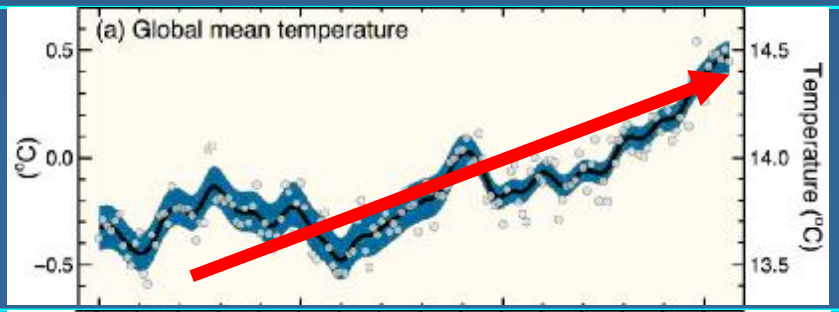


Source: OSTP 1999

"Warming of the climate system is unequivocal

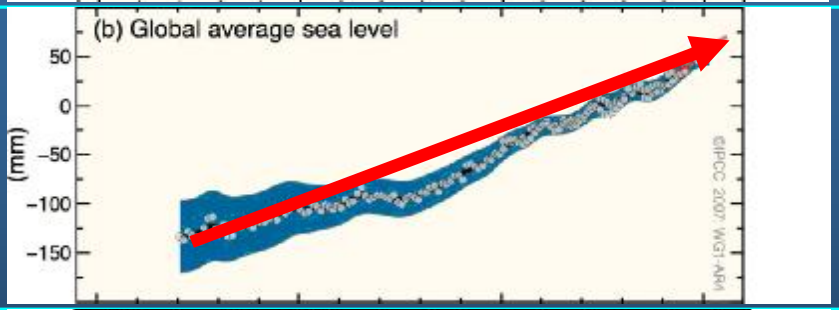
...evident from

– observations ↑ global av. air and ocean T.,



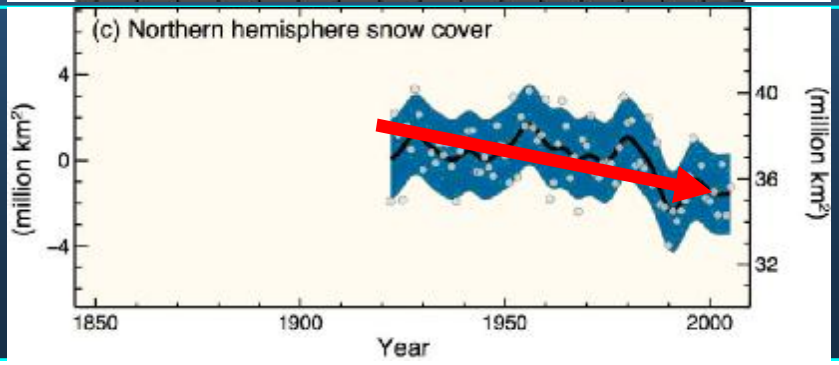
T°

– rising global mean sea level, and



mm

– widespread melting of snow and ice."



area

Regional Impact: No. America

Warming Western Mountains

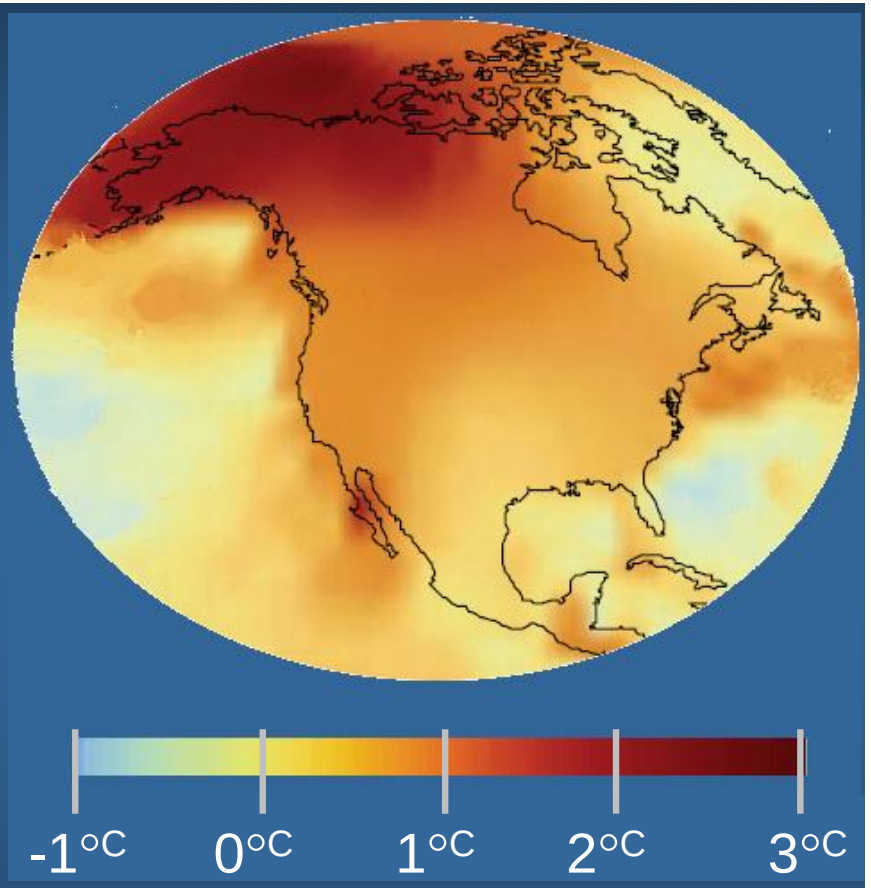
↓ snowpack

↑ winter flooding

↓ summer flows

Impact on forests

↑ pests, diseases, and fires



Change in Ann. Mean T (1995-2005)

Source: IPCC 2007

Coastal areas losses projected to ↑ if storm intensity ↑

Physical Changes

Temperature

- lakes are freezing later
- spring ice break up earlier
- glaciers are retreating
- Arctic ice cap melting
- permafrost is melting

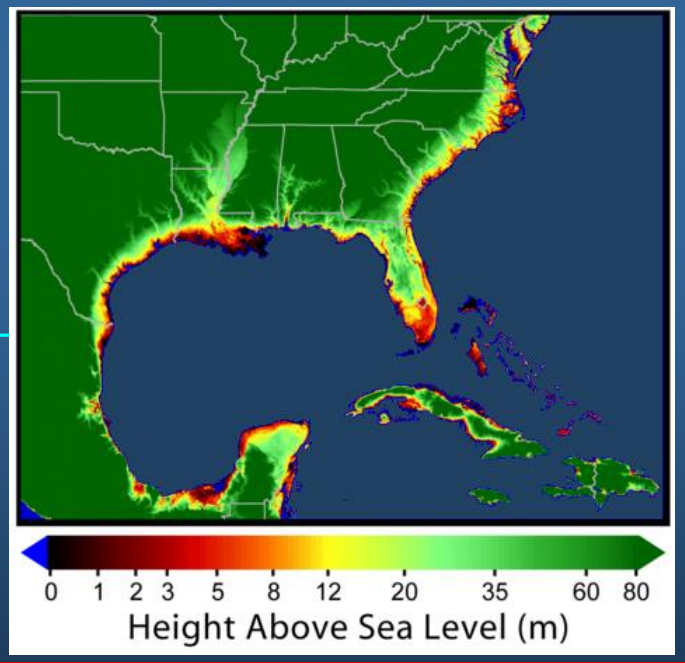




Physical Changes

Sea level

- Arctic => ↑ flow fresh water ocean
  - ↑ surface runoff (melt snow, ice)
  - ↑ global sea level (**diff. rates*)
  - greatest: Atlantic and Gulf coast regions No. America



- ↑ sea level => claiming coastal and sea marsh habitats

Source: USGS

Physical Changes

Precipitation

↑ Frequency and Intensity -- Storms

- extreme weather
  - flooding (*rate* + *force*)
    - coastal erosion

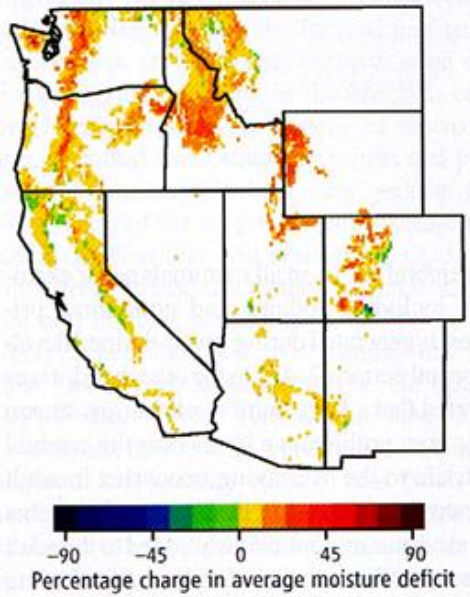
(not directly attributed to CC but correlated w/ ↑ T. and ℕ precip. patterns)

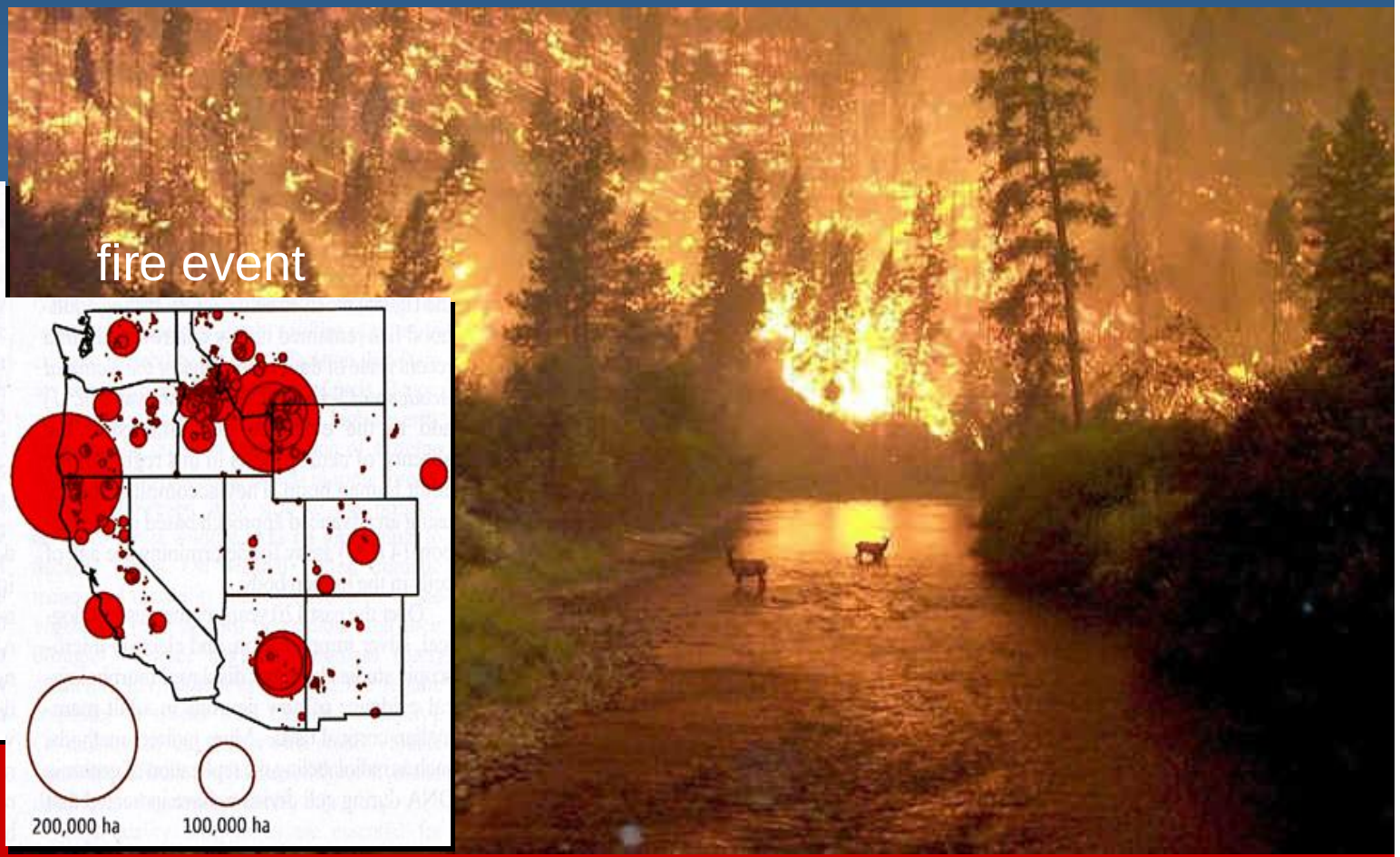
Physical Changes

Precipitation

↑ Frequency and Intensity -- Fires

soil moisture





Source: Running et al. *Science* 2006

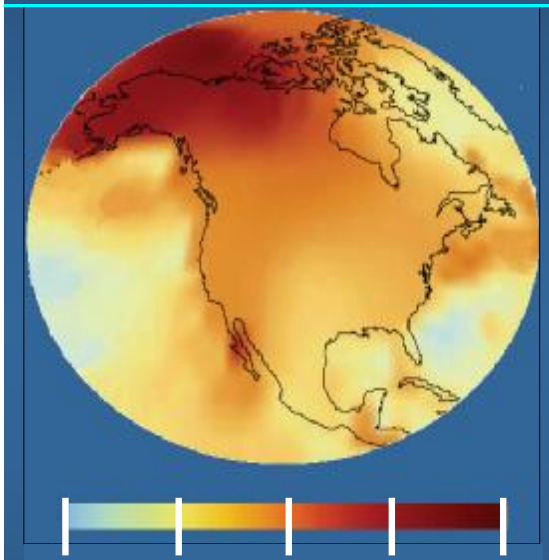
↑ Veg. growth under ↑ CO_2 => ↑ fuel load

Outline

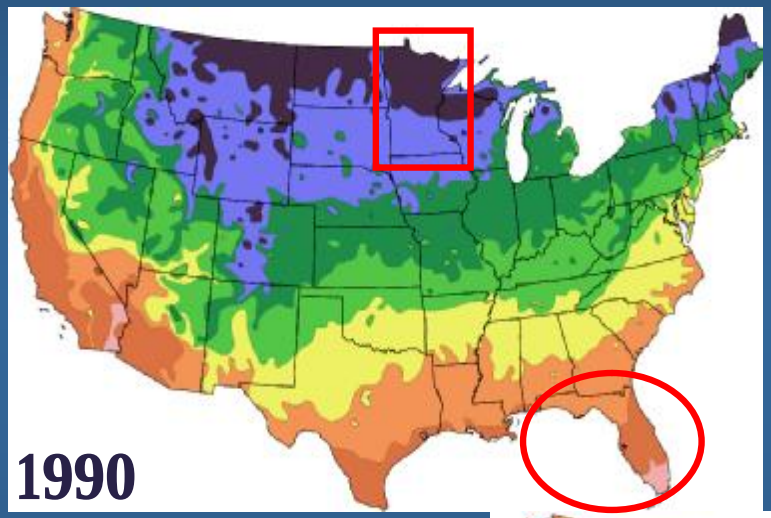
- Physical Changes
- Biological Changes
- Columbia River
- Managing Under Uncertainty --
  Assisting Fish and Wildlife Adaptation

Biological *(spatial)* | latitudinal shifts

- climatic zones shift poleward => plant response

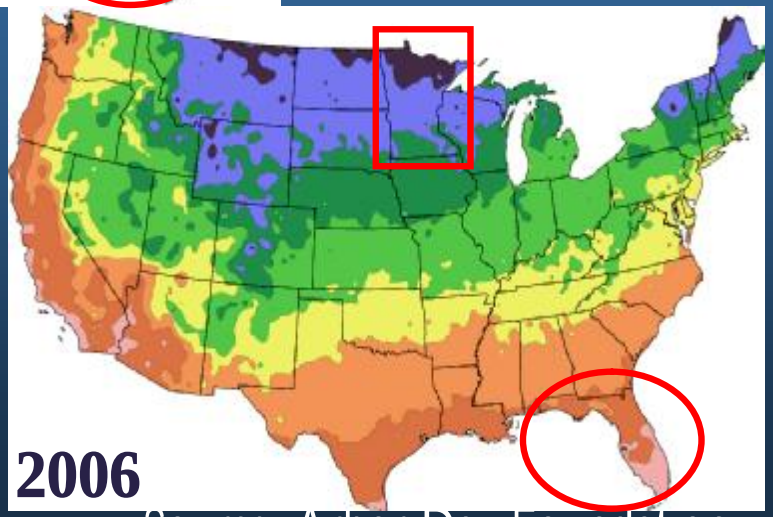


Change Annual Mean Temperature *(1995-2005)*
Source: IPCC 2007



Plant Hardiness Maps

Zone	Avg. Annual Low
2	-40°F through -50°F
3	-30°F through -40°F
4	-20°F through -30°F
5	-10°F through -20°F
6	0°F through -10°F
7	10°F through 0°F
8	20°F through 10°F
9	30°F through 20°F
10	40°F through 30°F



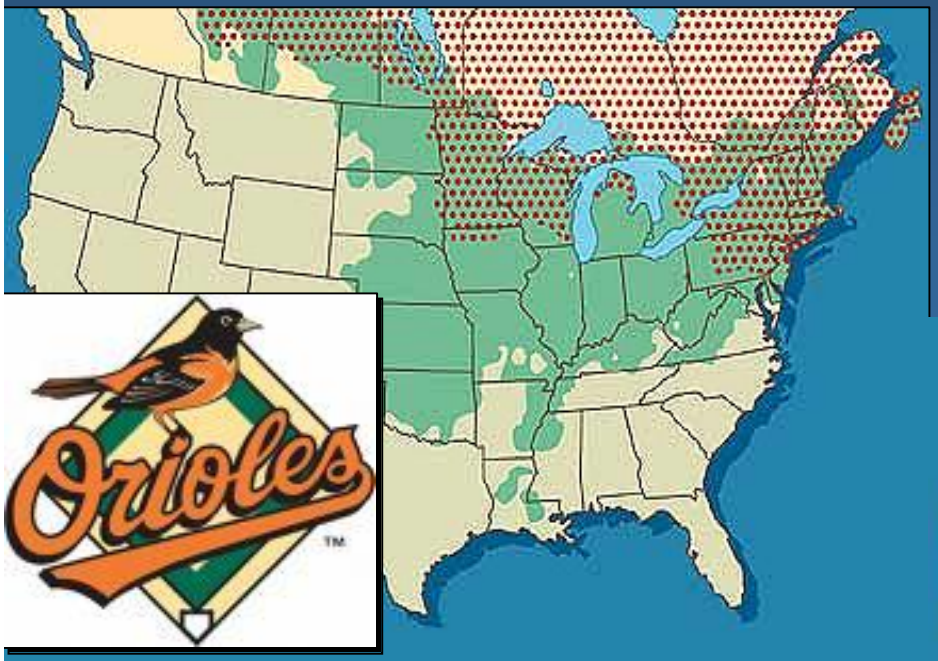
Source: Arbor Day Foundation

Biological *(spatial)* range change

- **species shift range**

Parmesan and Yohe 2003

"significant range shifts - av. 6.1 km per decade towards the poles (or meters per decade upward)"



Current distribution

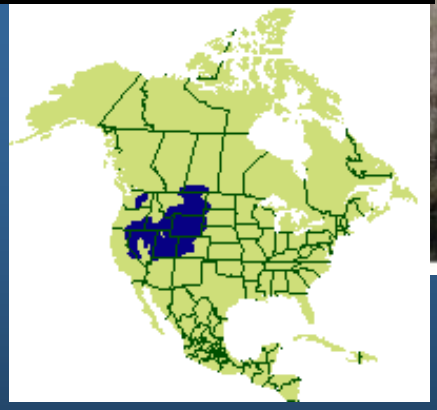
Predicted model under 2x CO_2

Source: J. Price, ABC

Biological *(spatial)* | barrier across landscape

- **fragmentation / land use *(ex. sagebrush habitat)***

Photo: Marc Dantzker



"Effects CC – expected strongly interactive w/ changes in habitat caused by changes in land use"
(e.g., expansion of human populations in West)

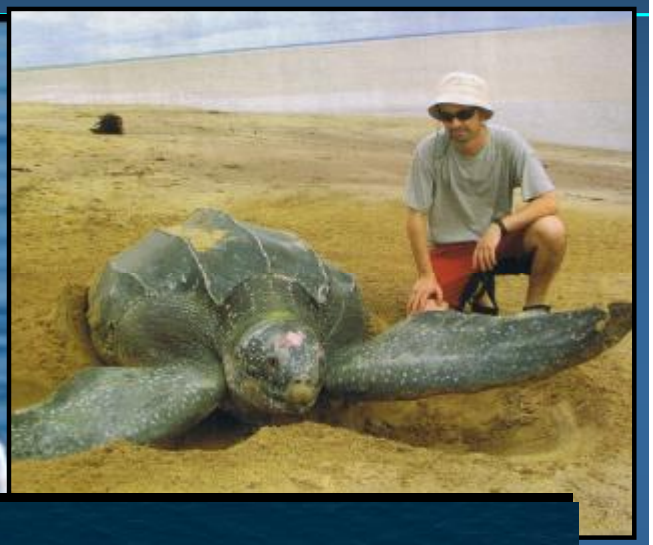
↑ winter precipitation - ↑ plant growth, cover and annual productivity
=> shift shrub and grasslands to woodlands and forests

Source: ISAB 2007

Biological *(spatial)*

loss of critical habitat

- **global impact: arctic, temperate, tropic, marine**



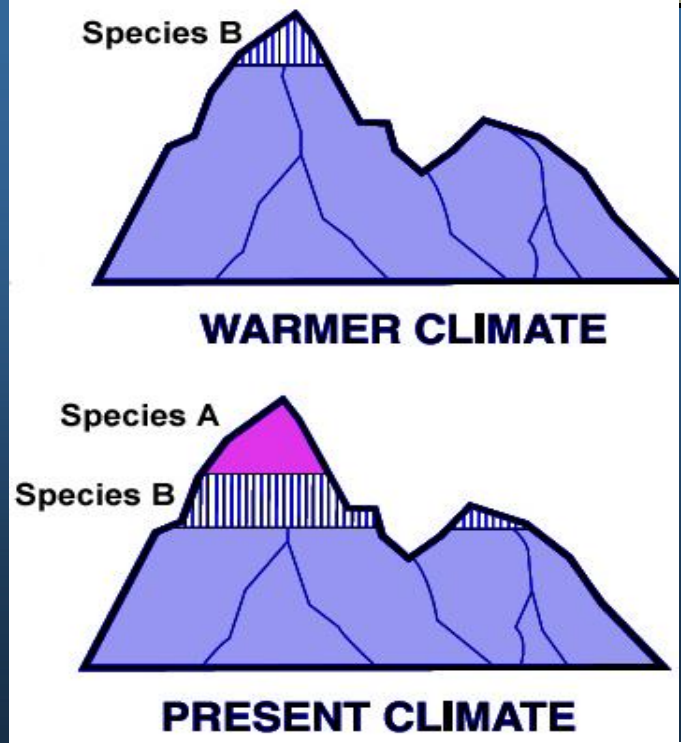
Biological *(spatial)* | altitudinal shifts

- **montane / alpine - move upward**

"Rapid movement of climatic zones is going to be another stress on wildlife

… in effect we are pushing them off the planet."

James Hansen,
NASA. 2006



Biological *(temporal)* | reproductive response

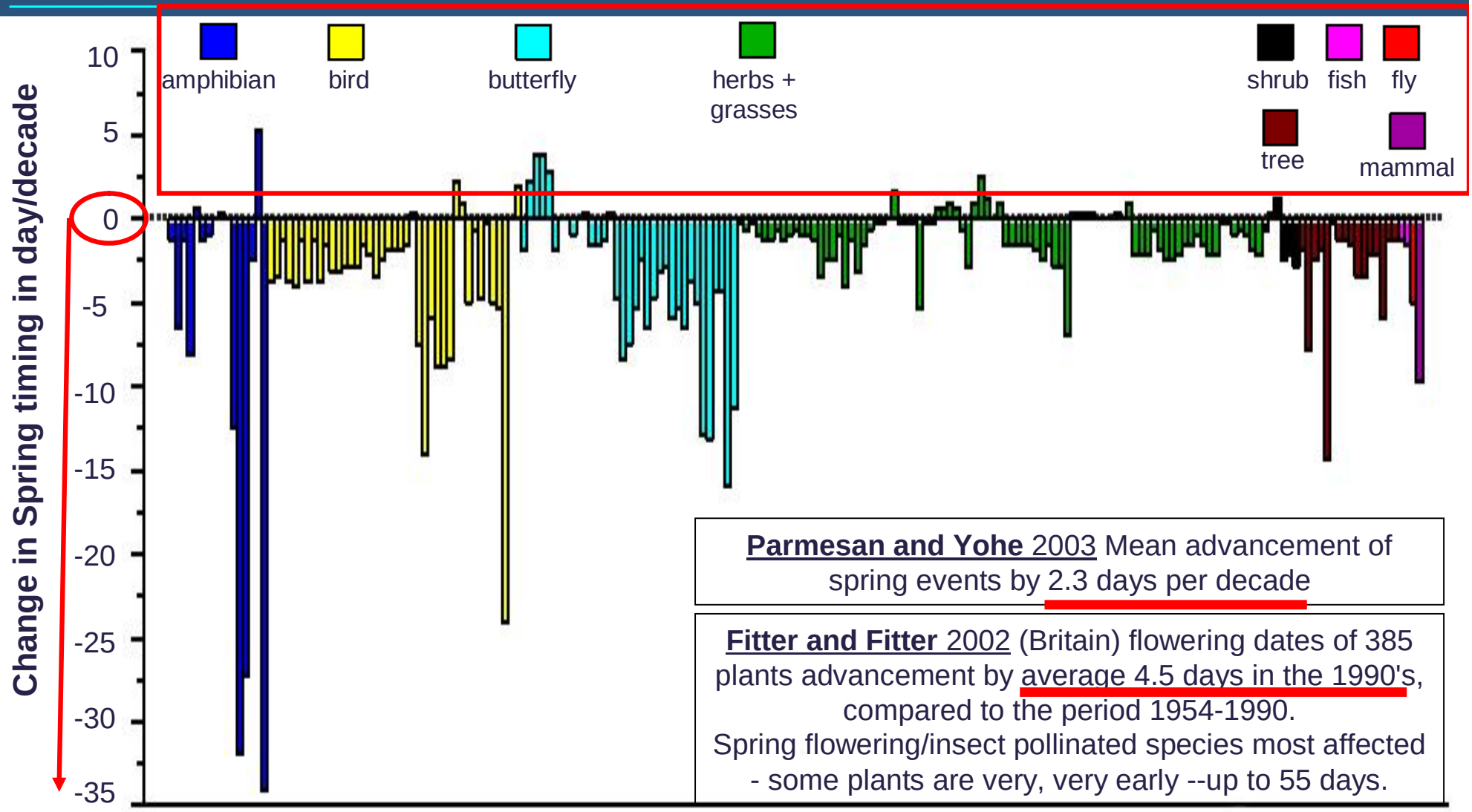
- **decline repro rate – assoc. w/ water availability**

(*rate; volume + form (snowmelt); timing*)

March snowpack

Biological *(temporal)* phenological response

- **timing life history events *(egg laying, flowing, etc.)***



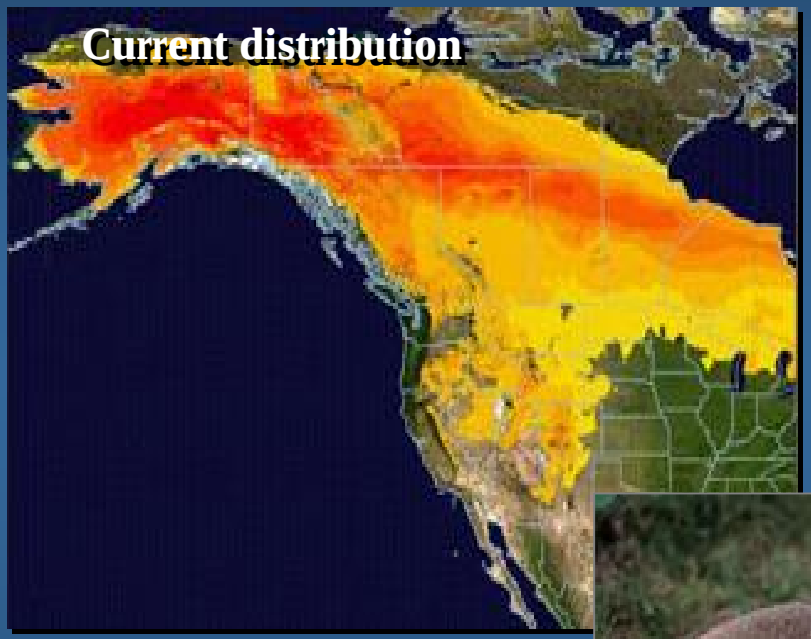
Parmesan and Yohe 2003 Mean advancement of spring events by 2.3 days per decade

Fitter and Fitter 2002 (Britain) flowering dates of 385 plants advancement by average 4.5 days in the 1990's, compared to the period 1954-1990.
Spring flowering/insect pollinated species most affected - some plants are very, very early --up to 55 days.

Biological *(temporal)*

seasonal coloration

- **seasonal molt, pelage change (*asynchronous*)**



Source: Hamilton, CAS

Biological *(temporal)* | trophic mismatch

- **migration out of phase (*summer range*)**

Peak resource demands

Plant growth cue local T.

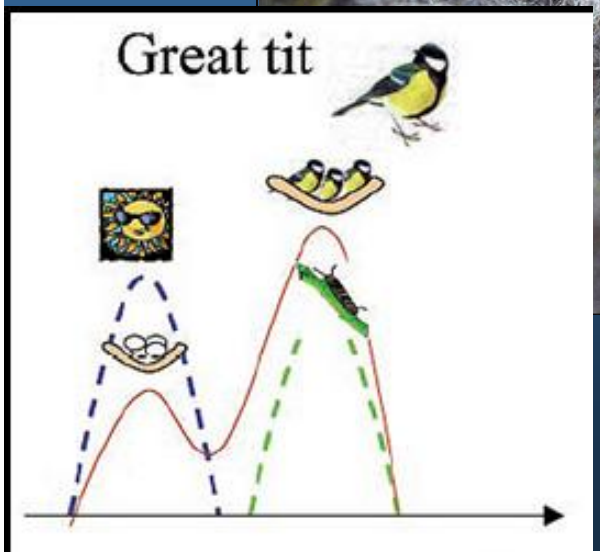
...peak of resource availability

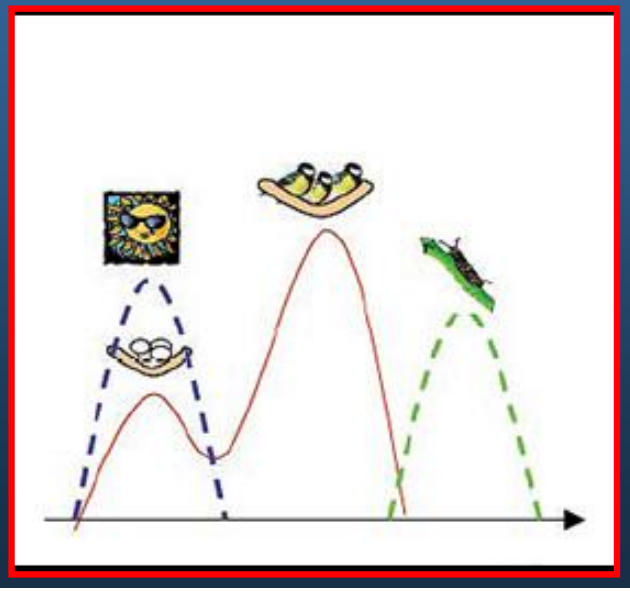
...seasonal migration cue day length

Source: Eric Post, M.C. Forchhammer

Biological *(temporal)* | *biotic interactions*

- **change in biotic interactions (*predator/prey relationships, parasite/host, plant/pollinator, etc.*)**





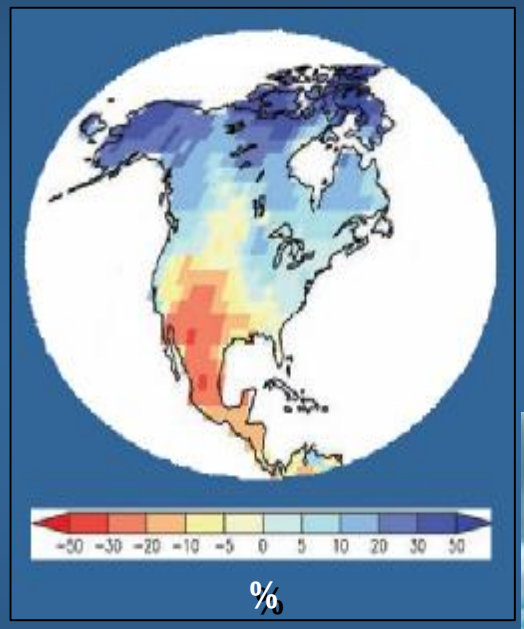
Biological *(physiology)* | *"silent"* response

- **physiological response / energetic demands**
  - **(*heat stress; depletion of fat reserves; nutrient absorption change in plant nutrient/chemistry*)**

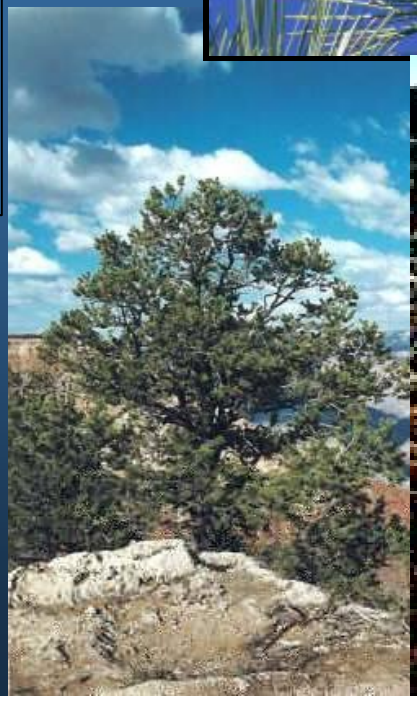
Biological *(physiology)*

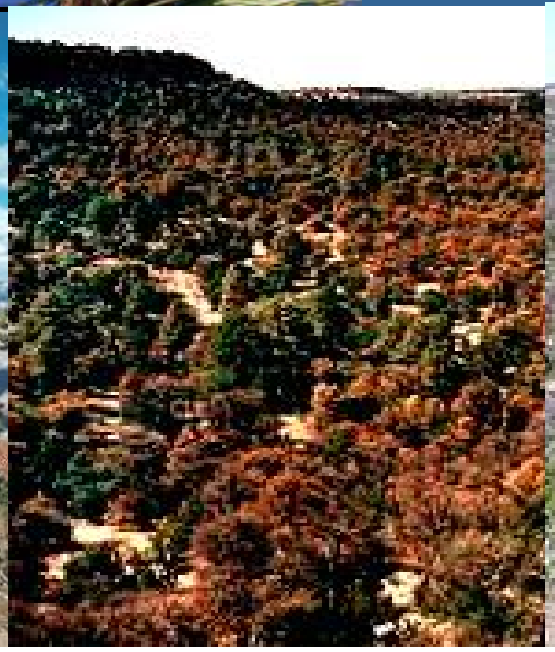
thermal stress

- **temperature / drought + susceptibility to disease**



Change Mean Annual Surface Runoff
(between present and 2081-2100)
Source: IPCC 2007

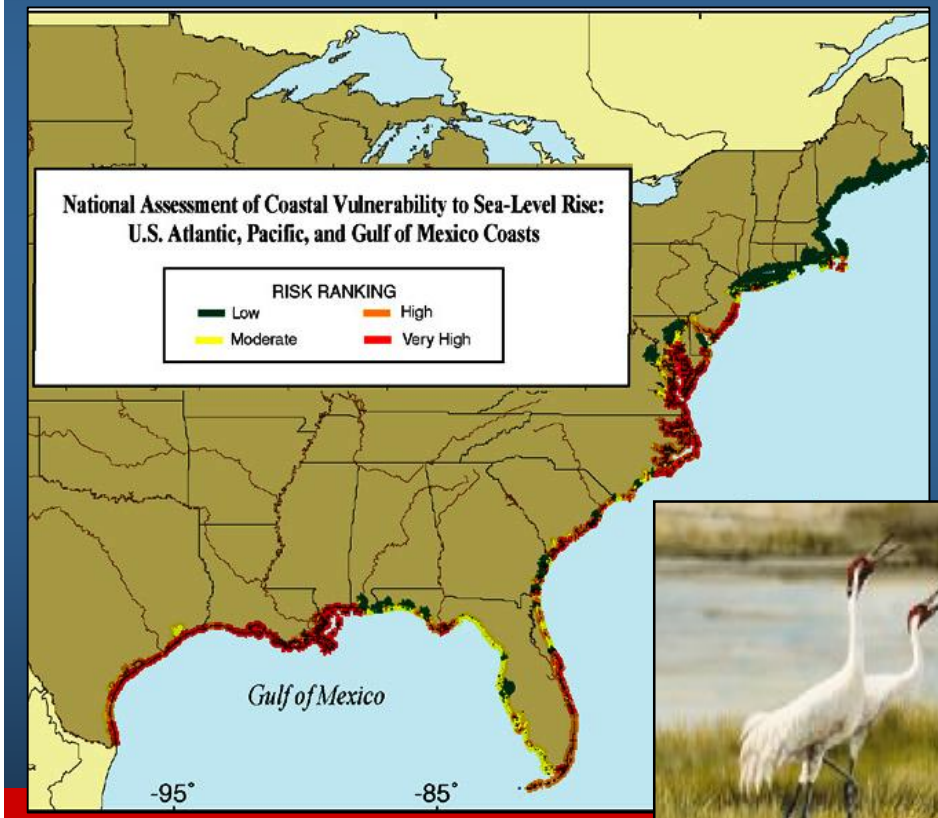




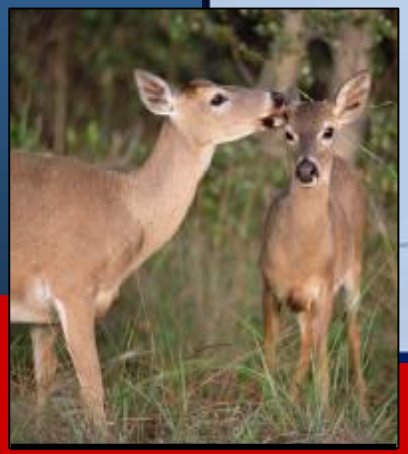
Biological *(threat)*

stochastic events

- **population losses due to extreme weather (*intensity storms; wave surge*)**



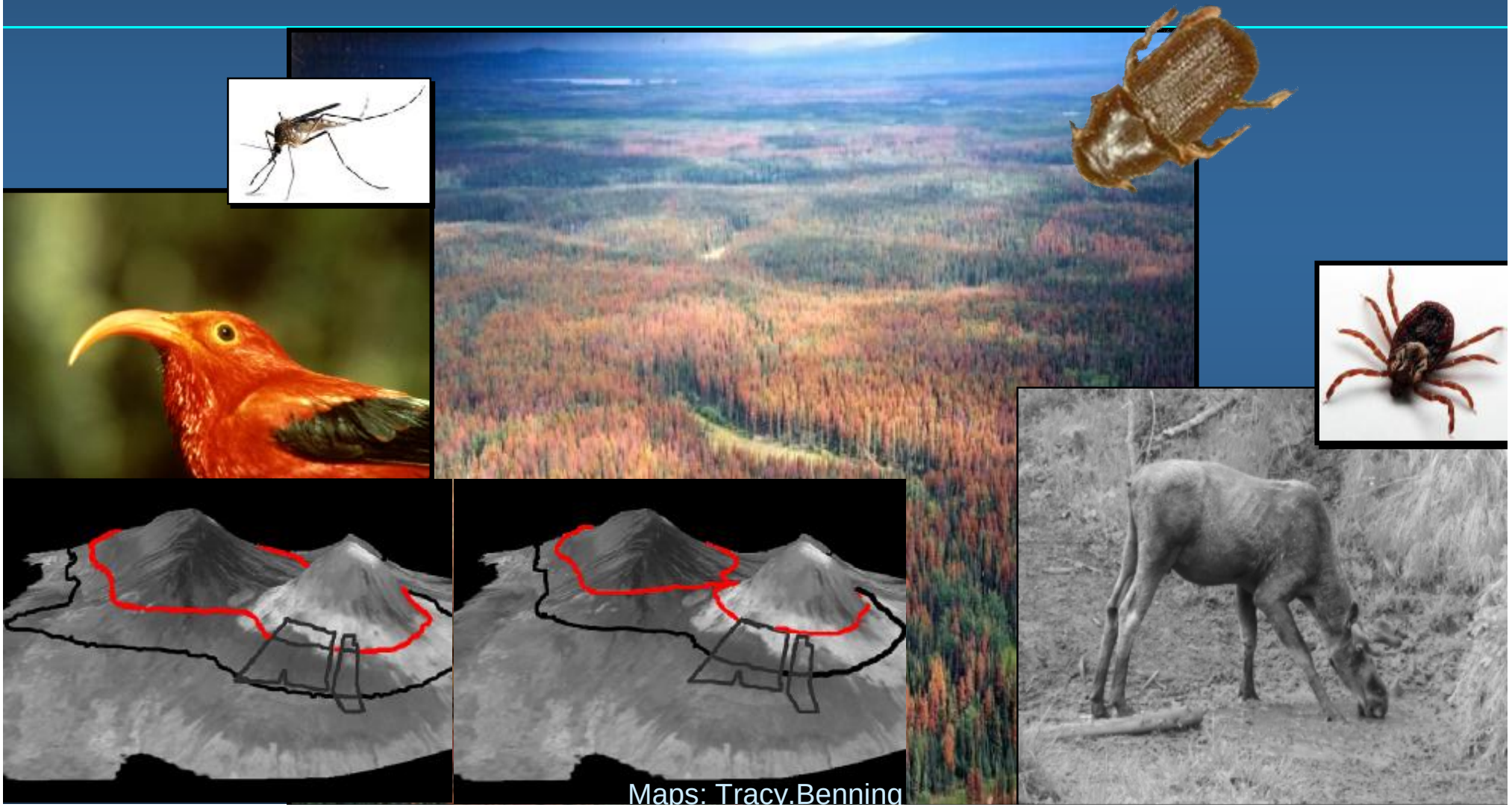
Source: USGS



Source: OSTP

Biological *(threat)* | disease

- **CC exacerbates the impacts of disease *(pest, pathogens, disease vectors)***



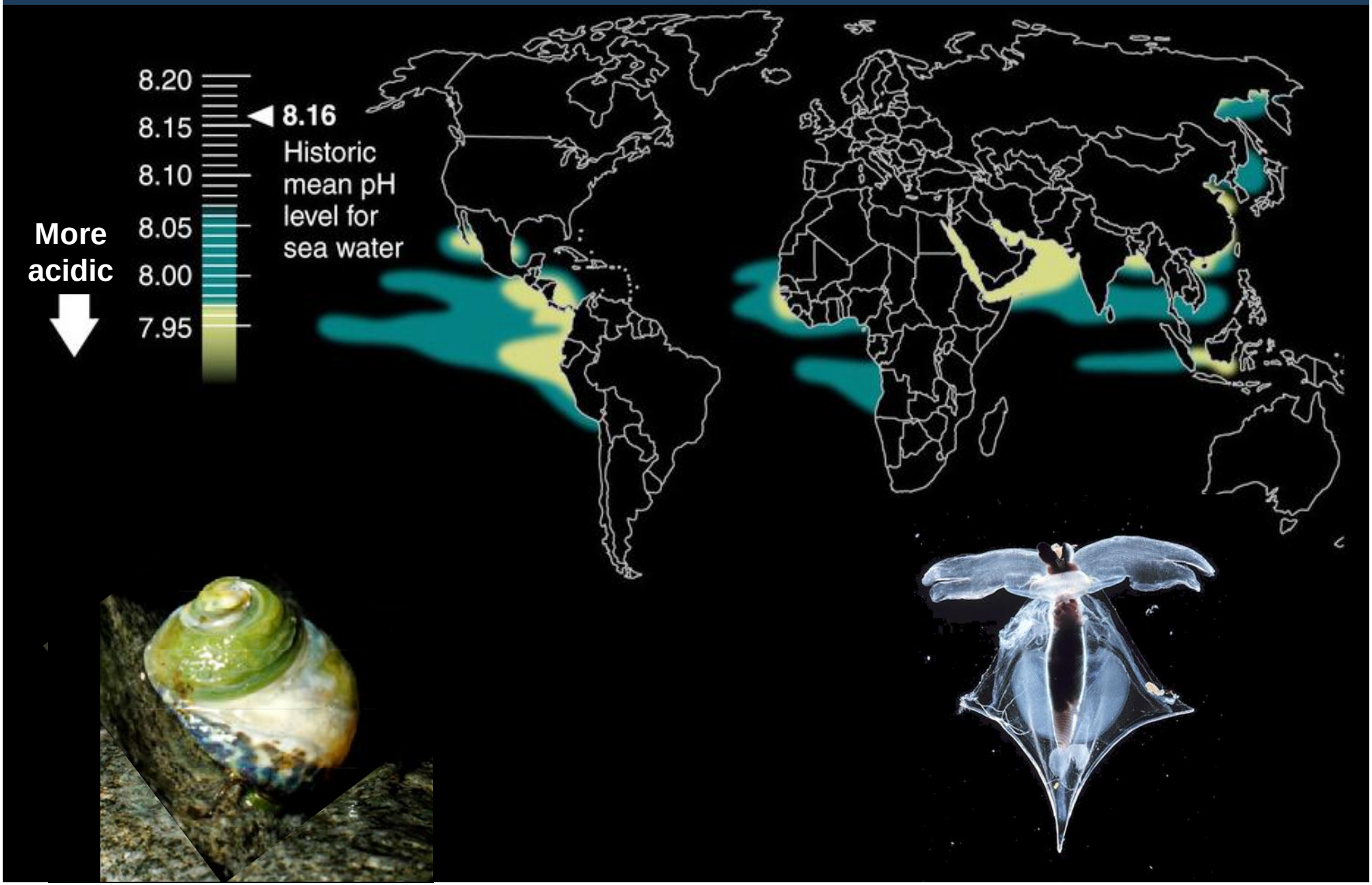
Biological *(threat)*

"tipping point"

- **exceed thresholds**
  - **– (*T. tolerance; change chemistry or toxicity*)**

Biological *(threat)*

ocean acidification



Biological *(threat)*

competitive advantage

- **exacerbate other stressors - invasive**

USGS
science for a changing world

Invasive Species and Climate Change

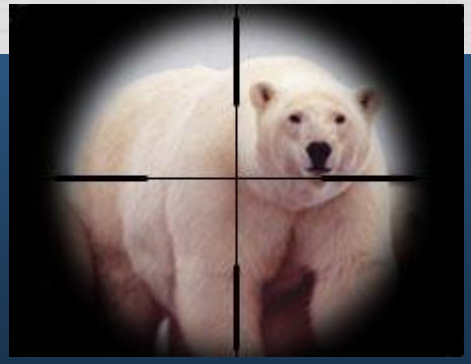
Open-File Report 2006–1153

U.S. Department of the Interior
U.S. Geological Survey

Biological *(threat)*

conflict human-wildlife

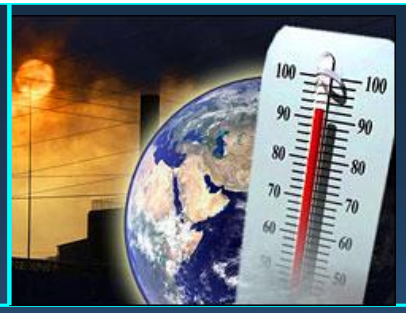
- **increase conflict / competition with humans**



Outline

- Physical Changes
- Biological Changes
- Columbia River
- Managing Under Uncertainty --
  Assisting Fish and Wildlife Adaptation

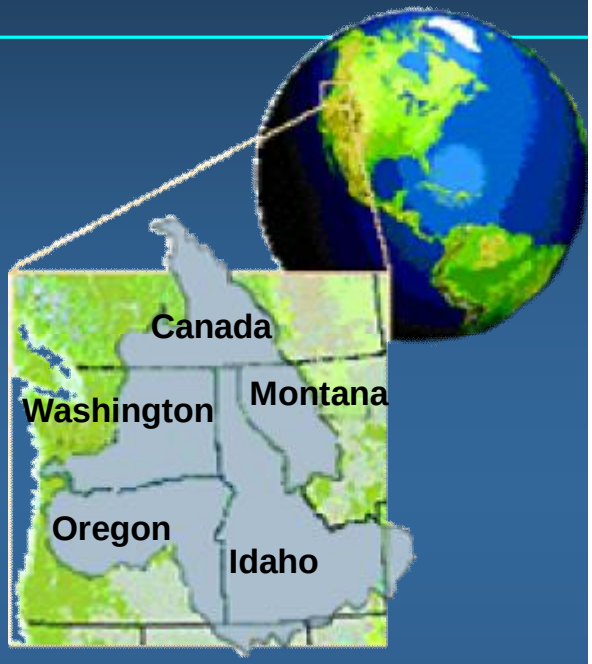
Physical Changes



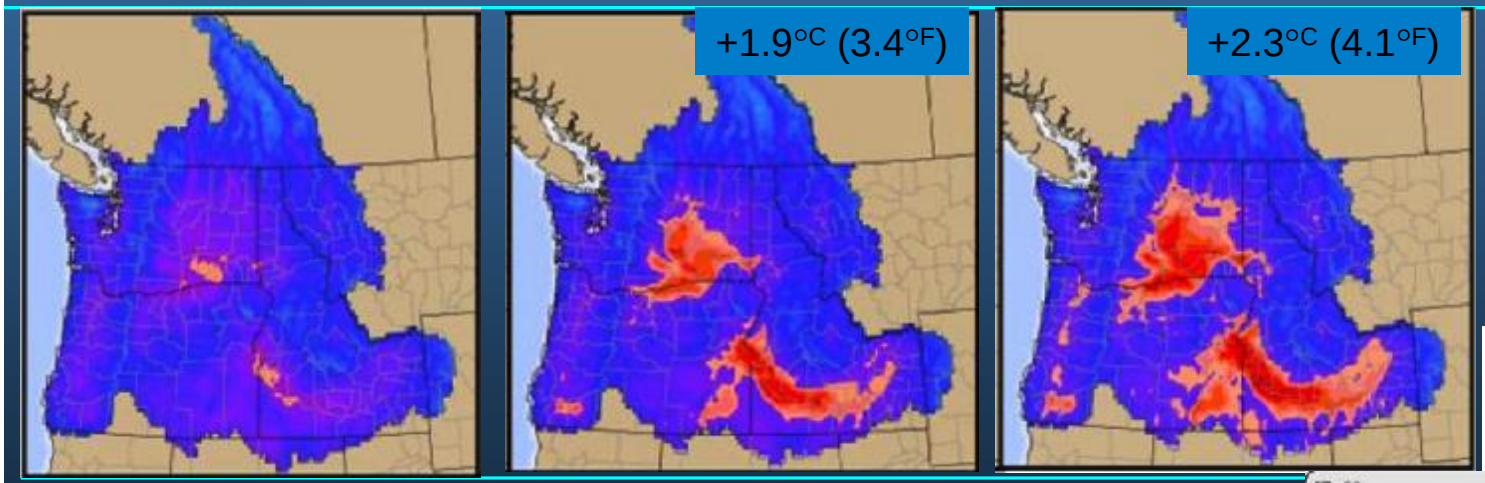
ISAB

Observation PNW *(since 1900)*

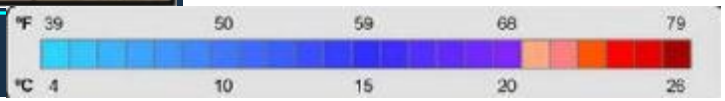
- T. ↑ ~1°C *(~50% >global av.)*
- rate ↑ 0.1-0.6 °C/decade
- precipitation change modest



Colombia River Basin

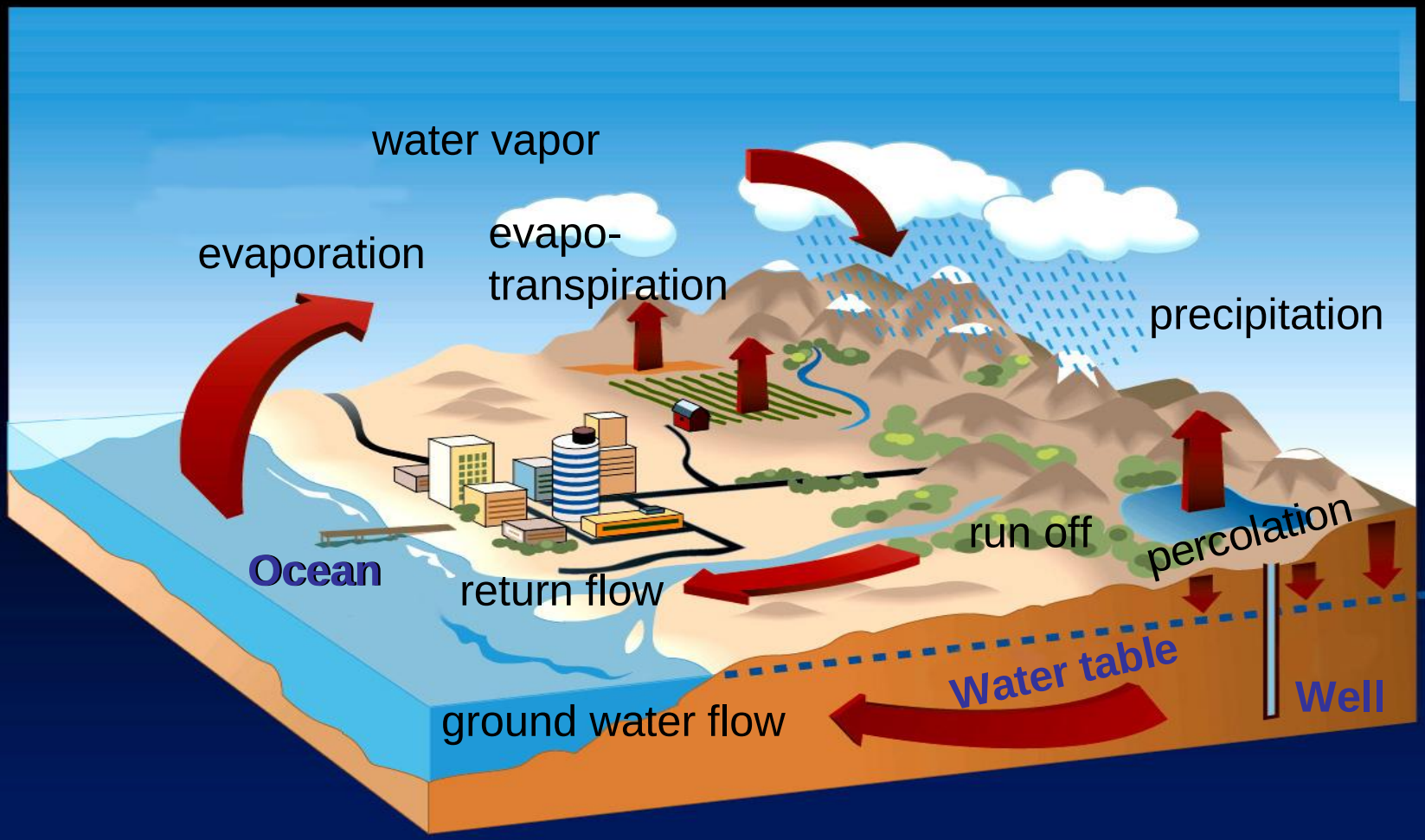


Independent Scientific Advisory Board
for the Northwest Power and Conservation Council, Columbia River Basin Indian Tribes, and National Marine Fisheries Service



Source: ISAB 2007-2 Climate Change Report

PNW – impacts on snow pack, stream flow, water temperature

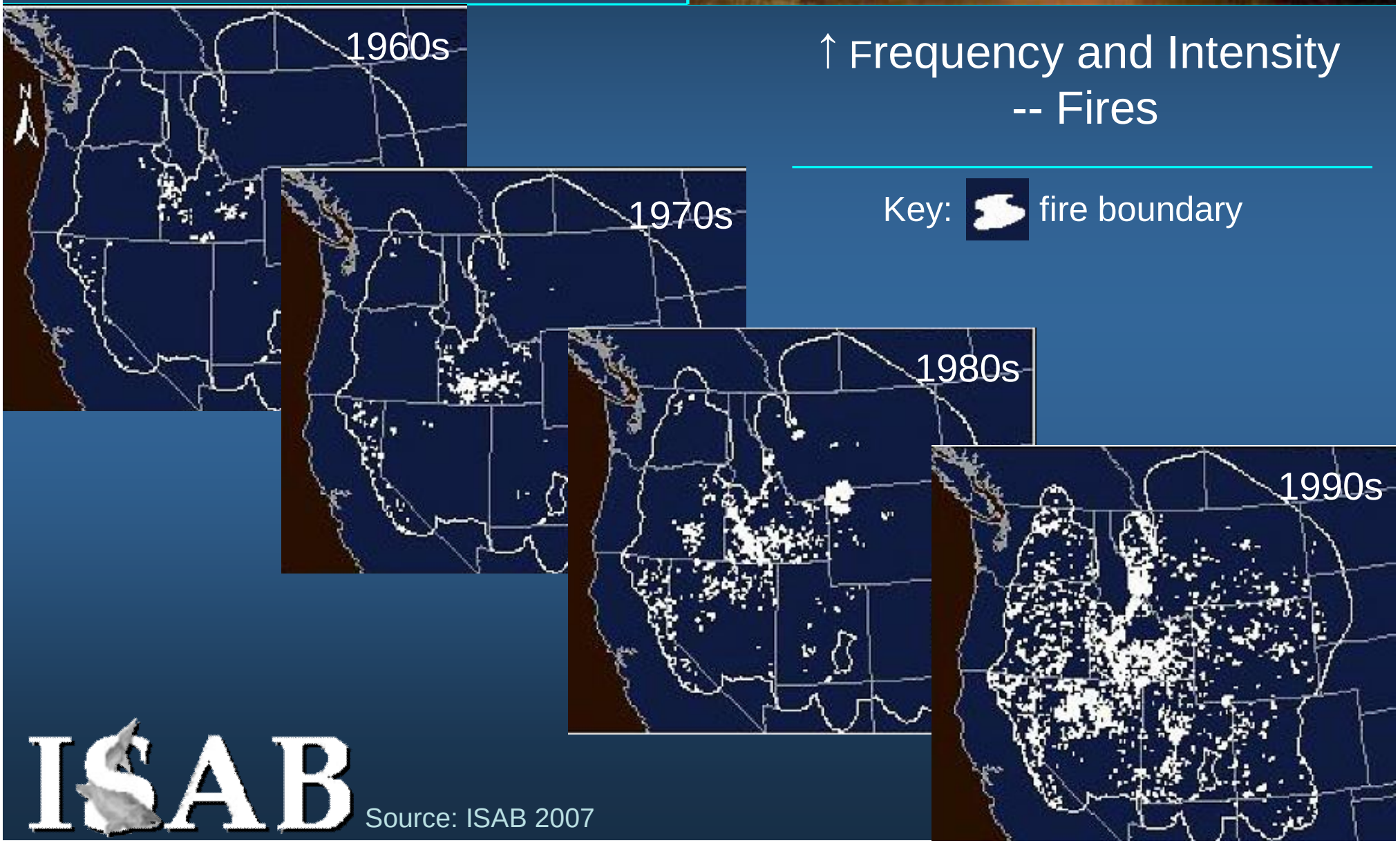


- warmer T. => precipitation rain rather than snow
- snow pack diminish, stream flow timing altered
- peak river flow likely ↑ **+** water T. continue ↑

Graphic: OSTP

Source: ISAB 2007

Physical Changes



↑ Frequency and Intensity
-- Fires

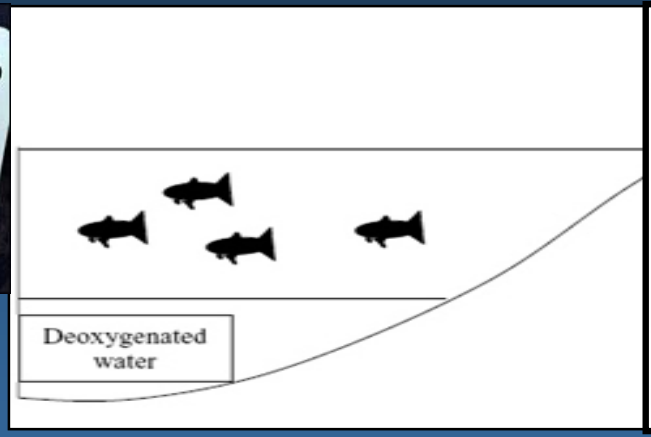
Key: fire boundary

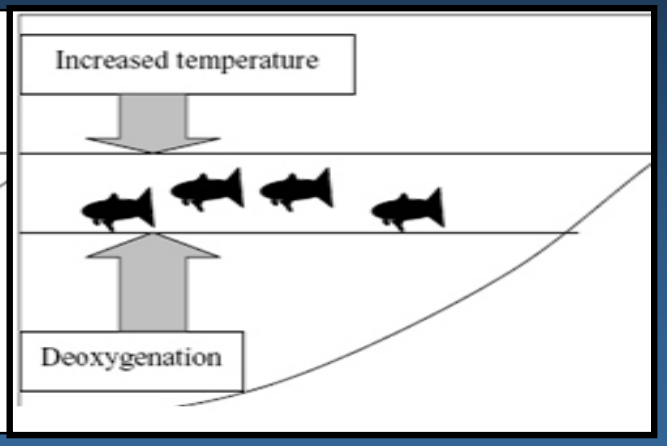
ISAB

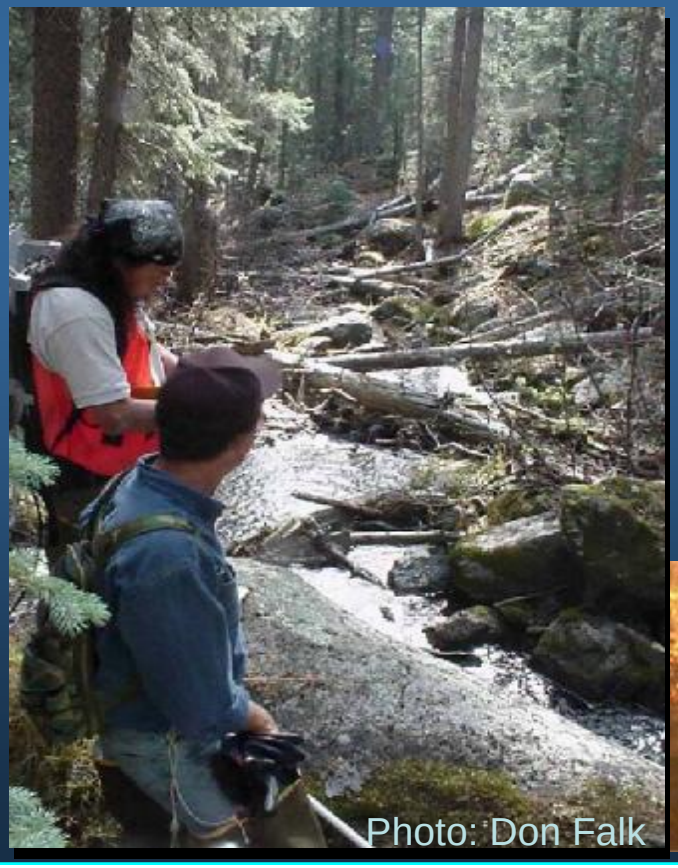
Source: ISAB 2007

Biological *(aquatic)*

cold water fish / salmon



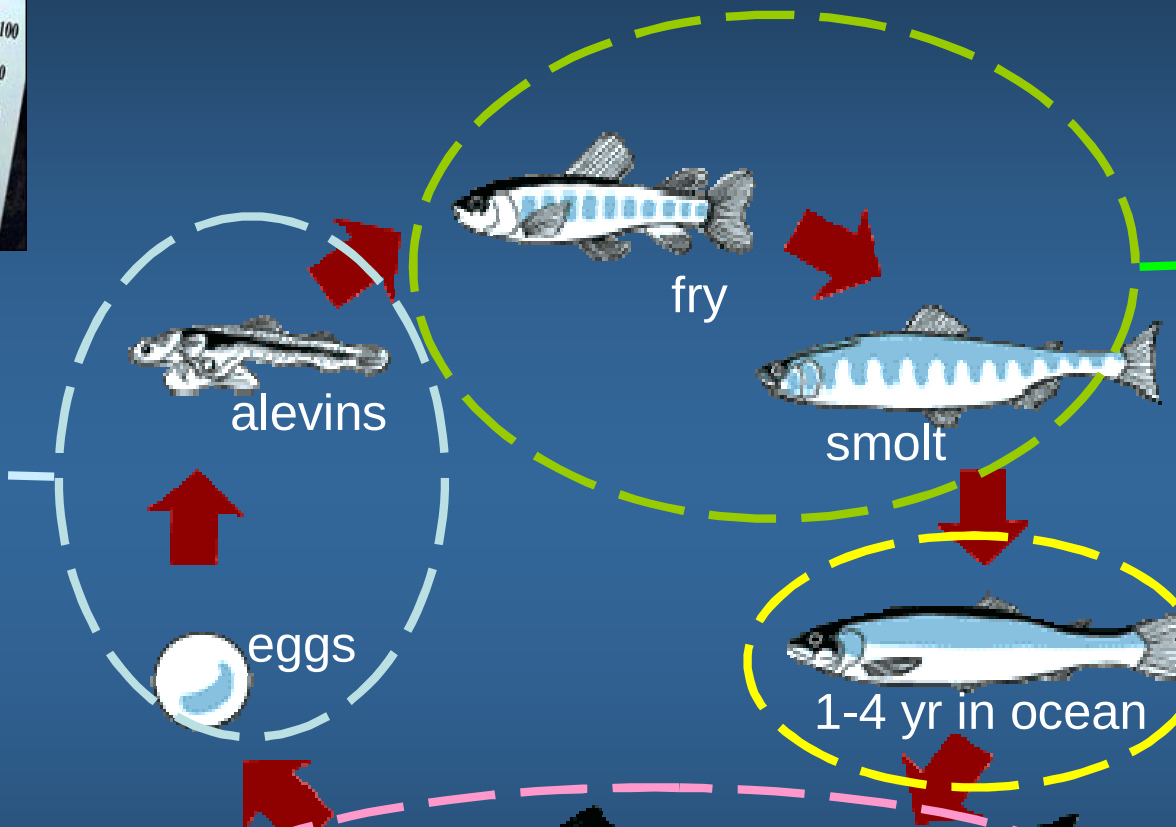




Biological *(aquatic)*

repro, survival, disease

floods, warmer T. (scouring, debris incub. mort.)



early and warmer peak flows (earlier emerge => ↓ food, ↑ predation rates + disease)

warmer, more stratified, upwellings?

warm, low stream flow (delay, isolation channels)

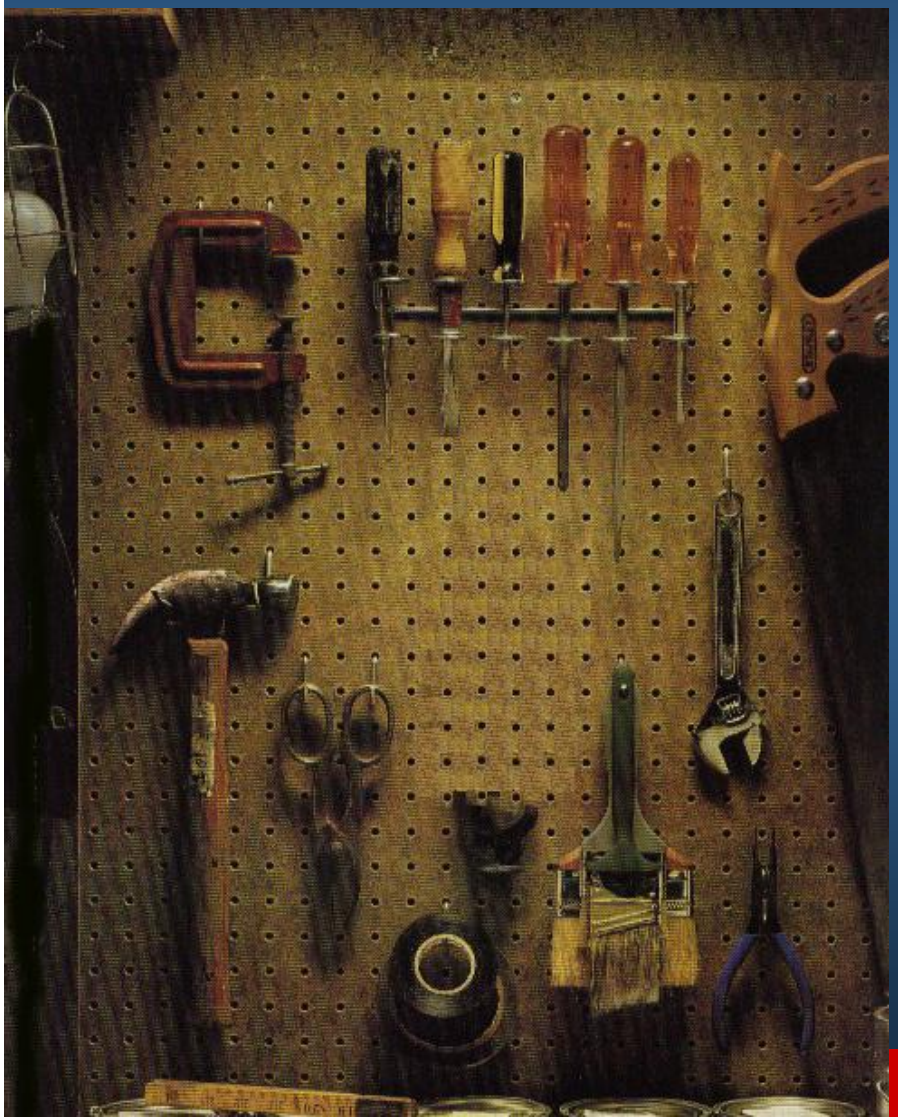
Adopted from: ISAB 2007

Outline

- Physical Changes
- Biological Changes
- Columbia River
- Managing Under Uncertainty -- Assisting Fish and Wildlife Adaptation

Managing under uncertainty | conservation tools

Proven approaches – most cost effective tool



a. Maintain or enhance the resilience of natural systems => prudent and safe standard – can promote immediately

b. Protection and management of adequate and appropriate space (*CC: spatial/temporal*)

c. Creation/maintenance of travel corridors in a conservation network

d. Active adaptive management

Managing under uncertainty | *"buying time"*

a. Maintain resiliency

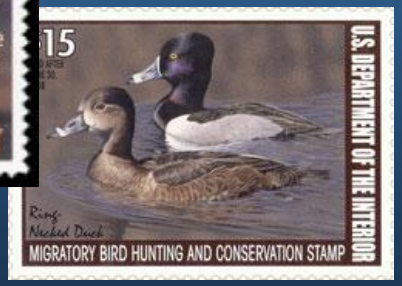
- manage groundwater extraction, augment stream flow
  - translocation, captive propagation & reintroduction
    - improve habitat quality, restoration degraded
      - planning incorporate dynamics outside PAs

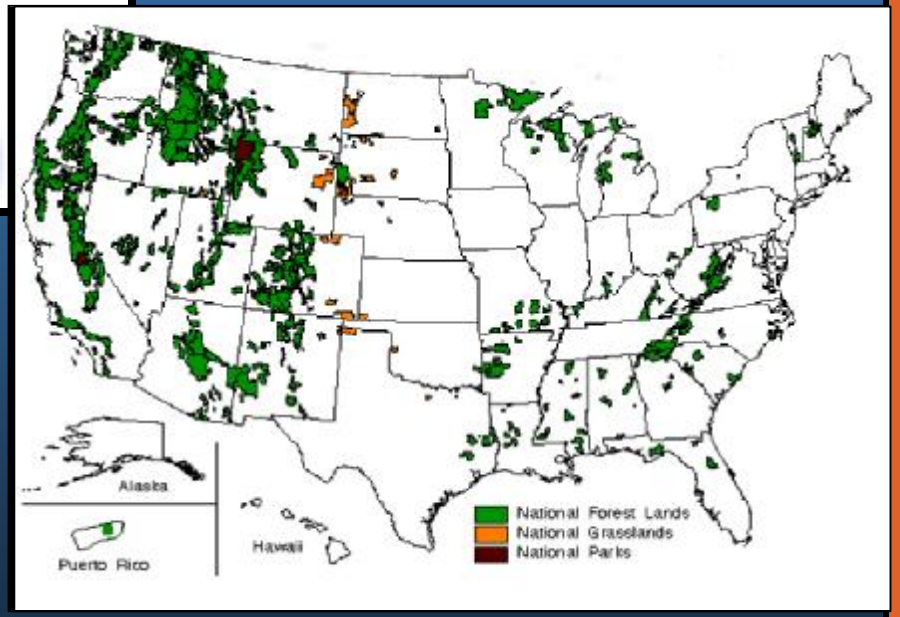




Managing under uncertainty | *"buying time"*

b. Protect adequate and appropriate space





Serious Complication | non-analog condition

- **management objectives – species conservation and protected area management goals**
  (*redefine mgmt objectives, harvest quotas, etc.*)

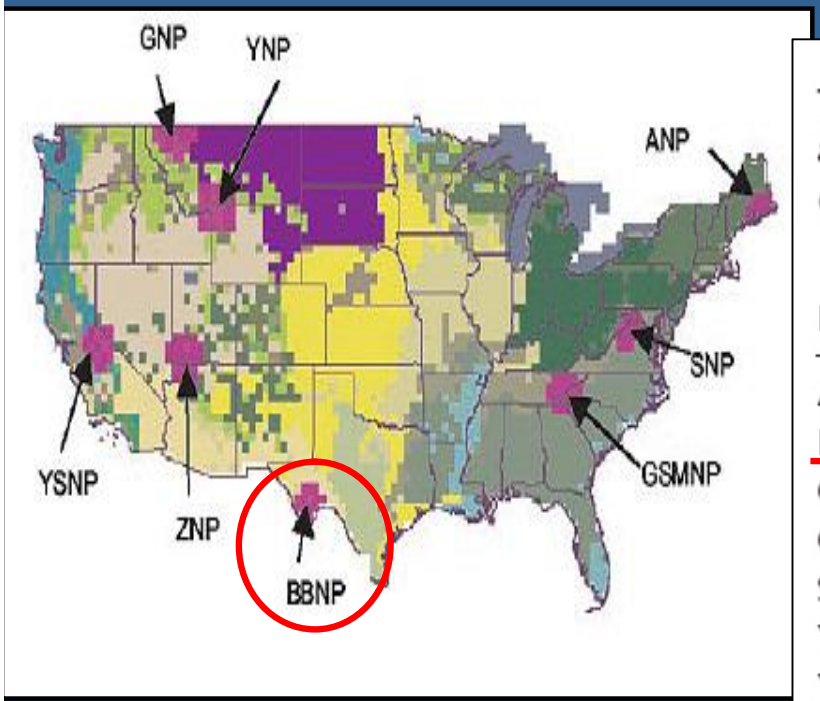


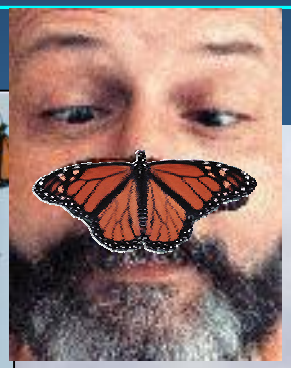
Table 1. Current species found in selected U.S. national parks and predicted species losses, gains, and net turnover under a doubling of atmospheric CO_2

Park	Current species richness*	Species lost	Species gained	Turnover†
Acadia	43	3	8	5
Big Bend	48	10	22	12
Glacier	52	2	45	43
GSM	48	8	29	21
Shenandoah	33	3	11	8
Yellowstone	53	0	49	49
Yosemite	64	6	25	19
Zion	53	1	41	40

*Based on park species lists and Faunmap data for mammal species available.
†Turnover calculated as species gained minus species lost.

Managing under uncertainty | *"buying time"*

c. Maintain travel corridors – conservation network



Serious Complication | human infrastructure

- environmental obstacle course

Managing under uncertainty | *"buying time"*

d. Reduce other stressors

- eradication of injurious invasive species
  - fire and pest management
    - reduce pollution
      - minimize fragmentation
        - prevent genetic hybridization

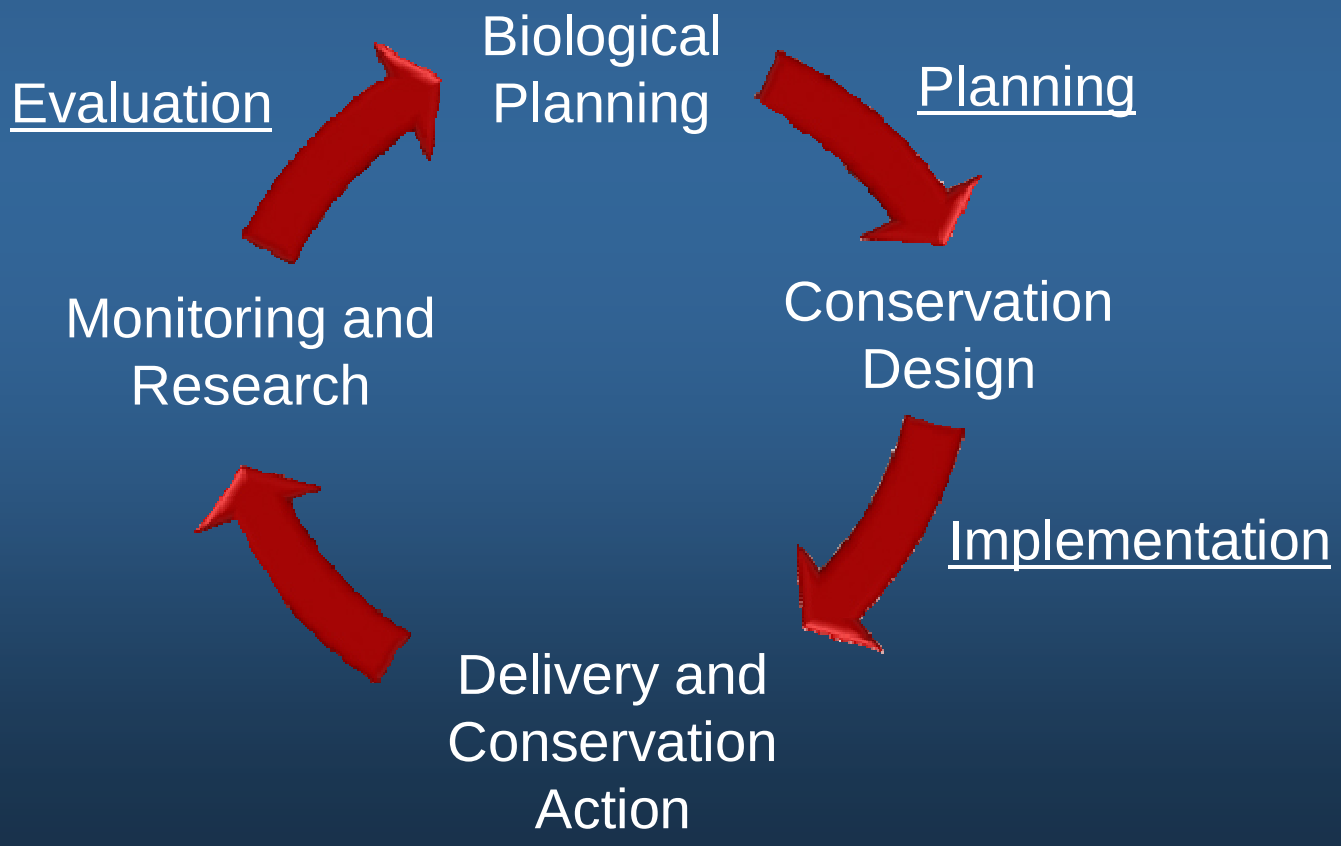




Managing under uncertainty | *"act then study"*

d. Active Adaptive Management

It is experimental (embeds science experimental, proactive management process)

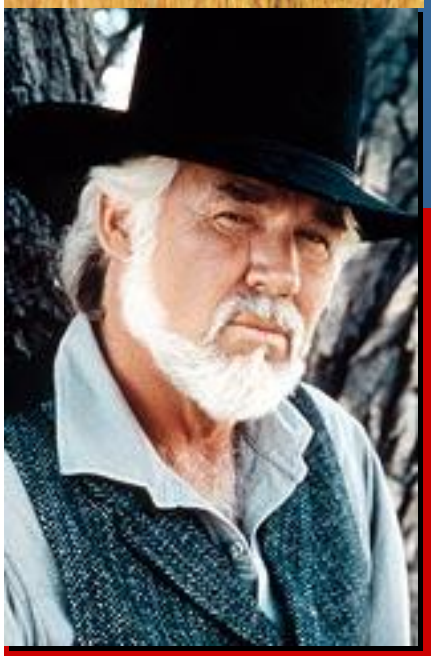


If we wait until we work out the uncertainties, *"climate change would have changed the playing field yet again."*

Lara Hansen, EcoAdapt

Adaptation | define the conservation vision

a. Vision of America's conservation landscape?



- linking human welfare to environmental integrity
- Q. *"How far to go to protect a species?"*
- accept risks

"Future conservation challenges under CC will require action when inaction carries a real risk of extinction."

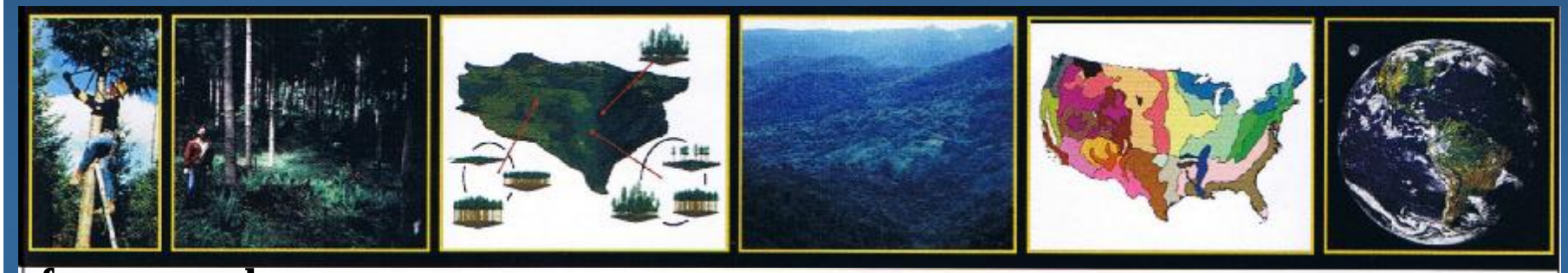
Ron Pulliam, University of Georgia

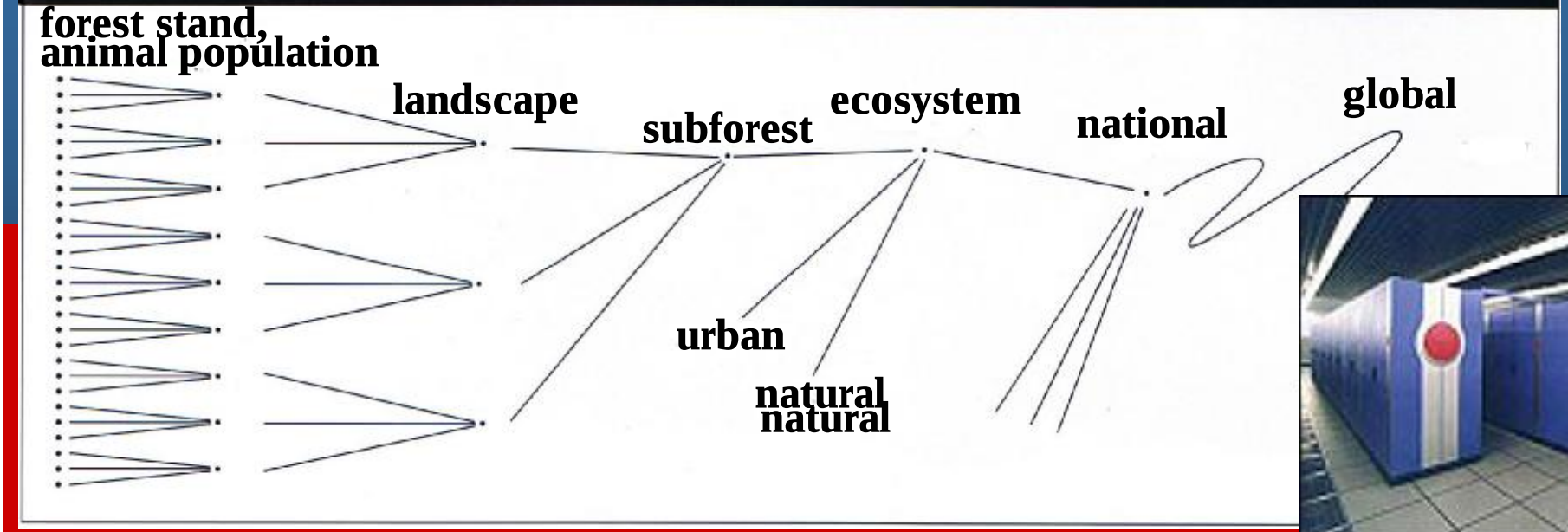
Adaptation

coupled model – bio + CC

b. Predictive modeling as a management tool

- current scale – lack resolution to be useful to managers





based assumption of stability ≠> abrupt change

Adaptation | landscape-level planning

c. Managing across the broader landscape – need

- prioritize response + ID species at highest risk
  - — high altitudes, polar regions, coastal areas, limited geographic range, at boundary of their range on refuges, already threatened or endangered
- global approach – migrating species (*breeding birds*)
- need to adapt –policies to facilitate managers' ability to respond to unanticipated changes (non-analog)

"Our biggest challenge is going to be protecting and reintegrating conservation areas into the American landscape."

Michael Scott, University of Idaho, USGS

Adaptation | landscape-level planning

c. Managing across the broader landscape – need

- maintain connectivity and corridors
  - – part of network of protected areas (*land incentives and multi-stakeholder consultation*)

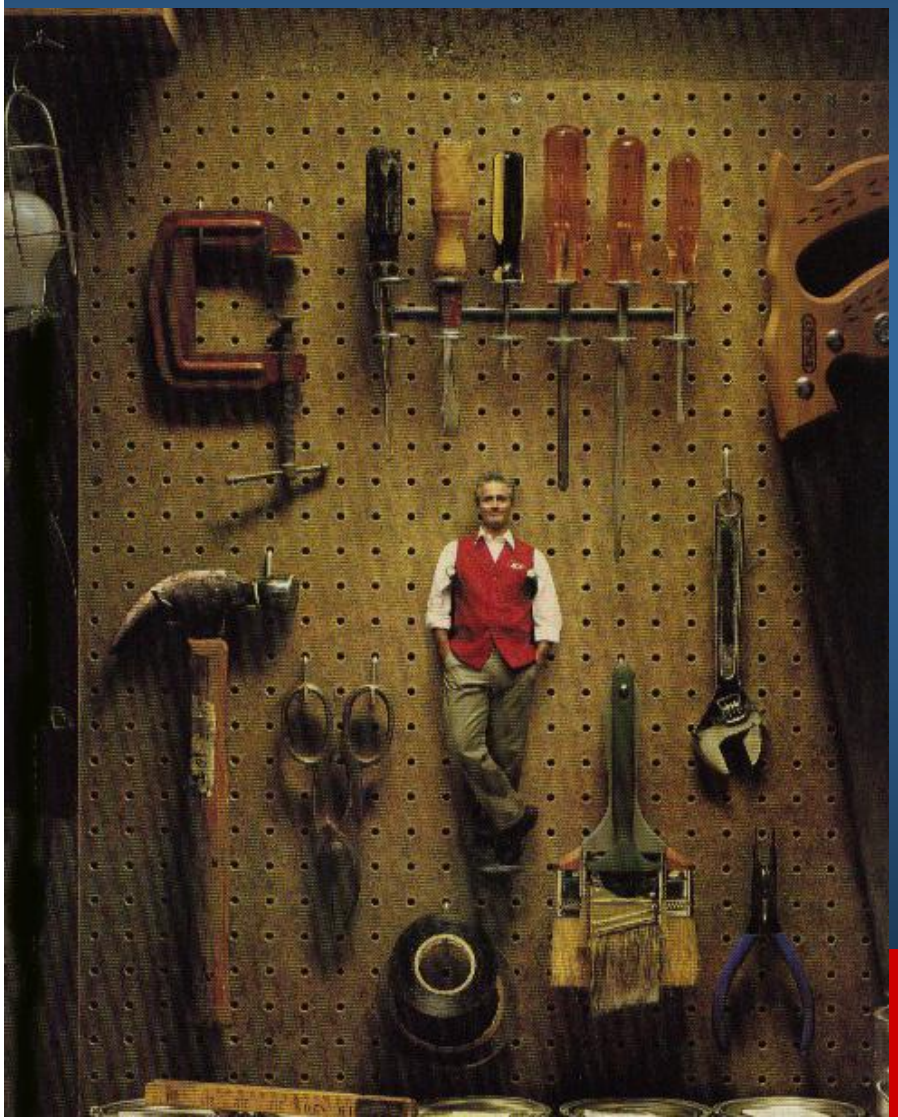
"We have great opportunities, but also great responsibilities to bring (private citizens) more into the process of helping us work on solutions."

Michael Mantell, Resources Law Group

Serious Complication

evolving science

*Adopting a new conservation paradigm



"Anything, any concept founded on assumptions of stability and global-level ecology, must now be questioned."

Dan Ashe, USFWS

Predicted – *Wave of Extinctions*

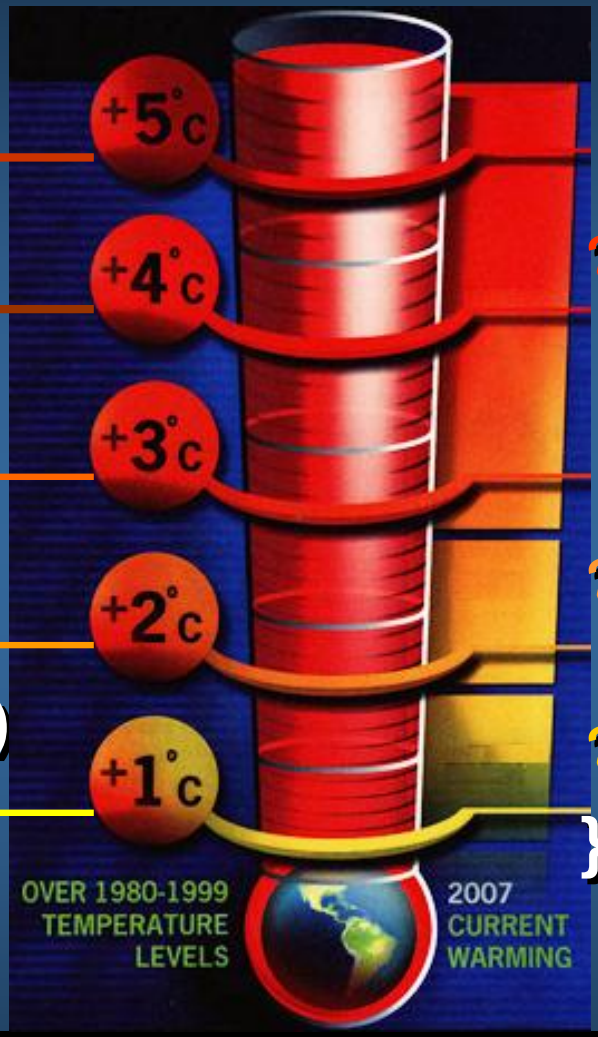
Extinction (>40% known species)

~30% of Global Wetlands lost

Major Changes in Natural Systems =>
Negative Effect on Biodiversity

- risk extinction (20-30% known species)

– water, - drought, - fire risk,
- flood/storm damage



Source: T. Root; Adopted from: www.net.org

Defenders of Wildlife **www.defenders.org**