Climate Change Primer – What Is Climate Change and How Should We Think About It?

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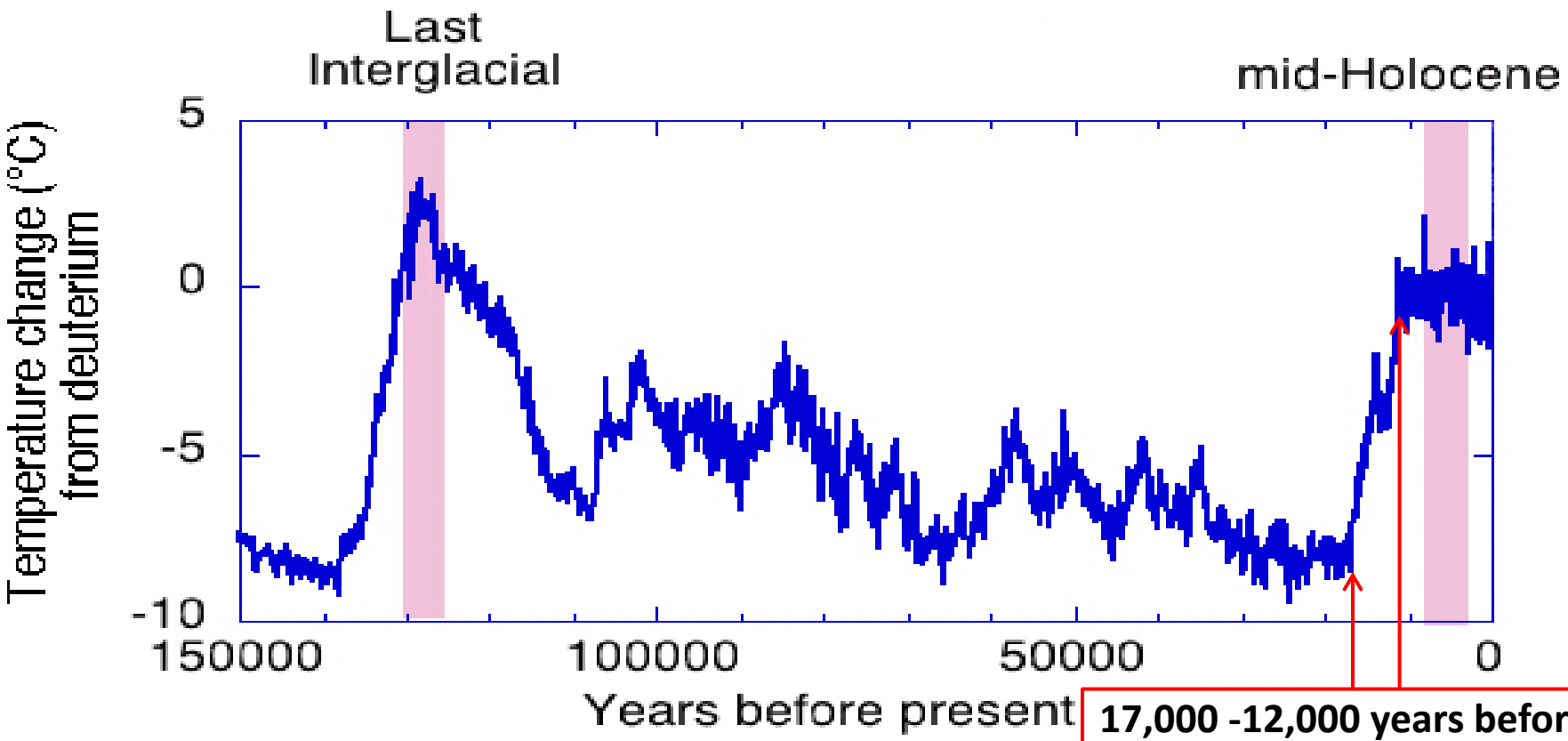
Inferences about the effects of climate change in the 21st Century and beyond are informed by the identified effects of climate change at the Pleistocene/Holocene transition.

What lessons does science offer about the effects of this past climate change?

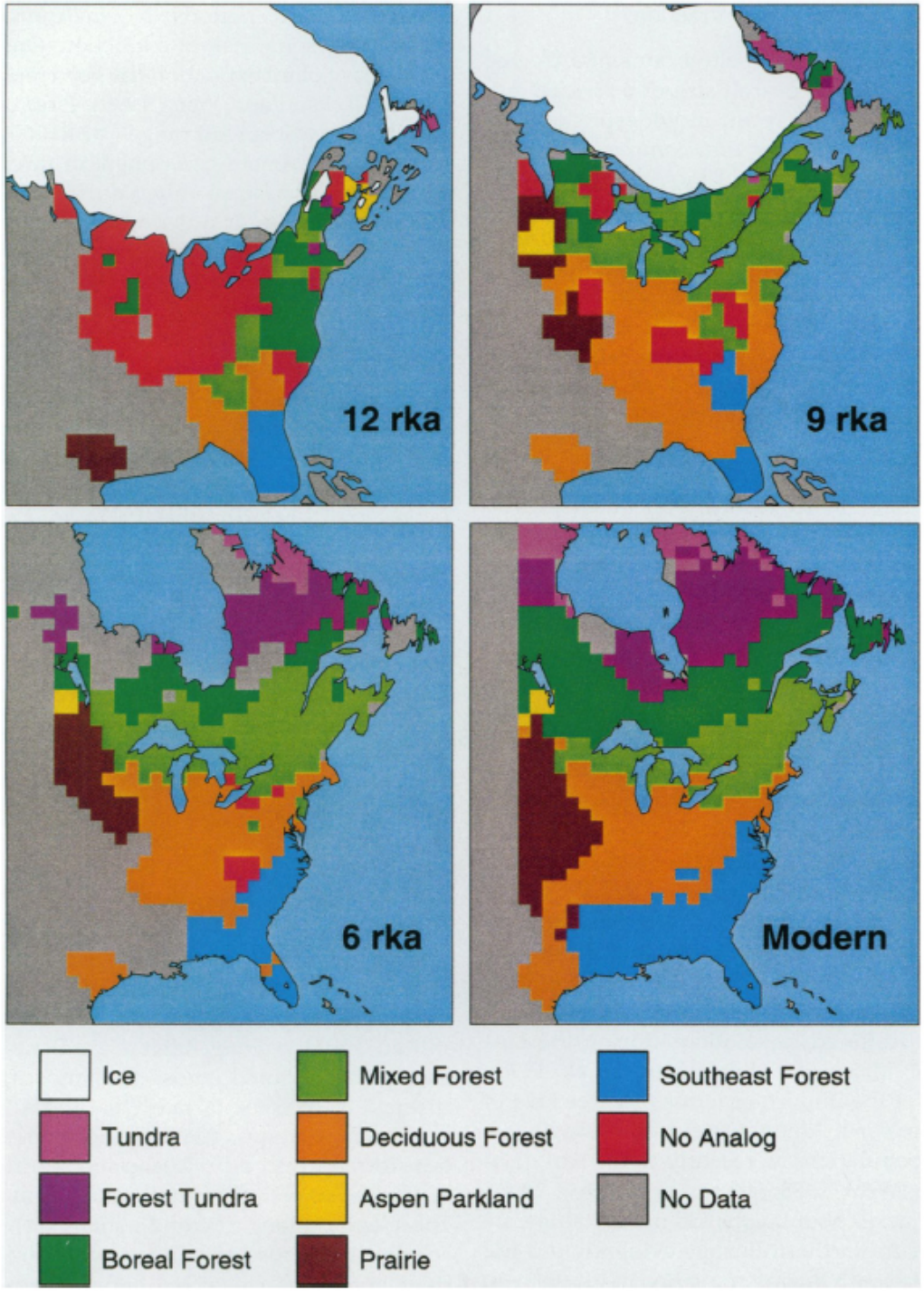
Global Temperatures During Late Pleistocene and Holocene

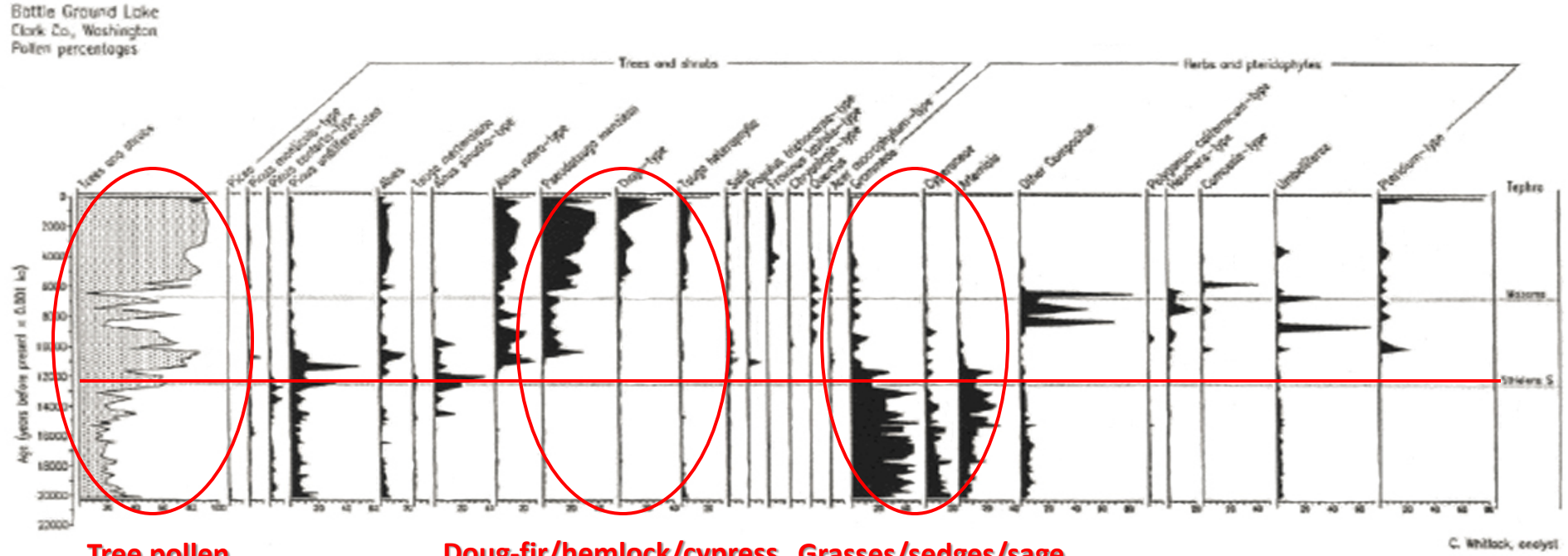
A geologically rapid temperature increase began ca 17,000 years bp. Global average temperature increased ca 8° C over approximately the next 5000 years. Global mean temperature has remained relatively stable for the past 12,000 years.



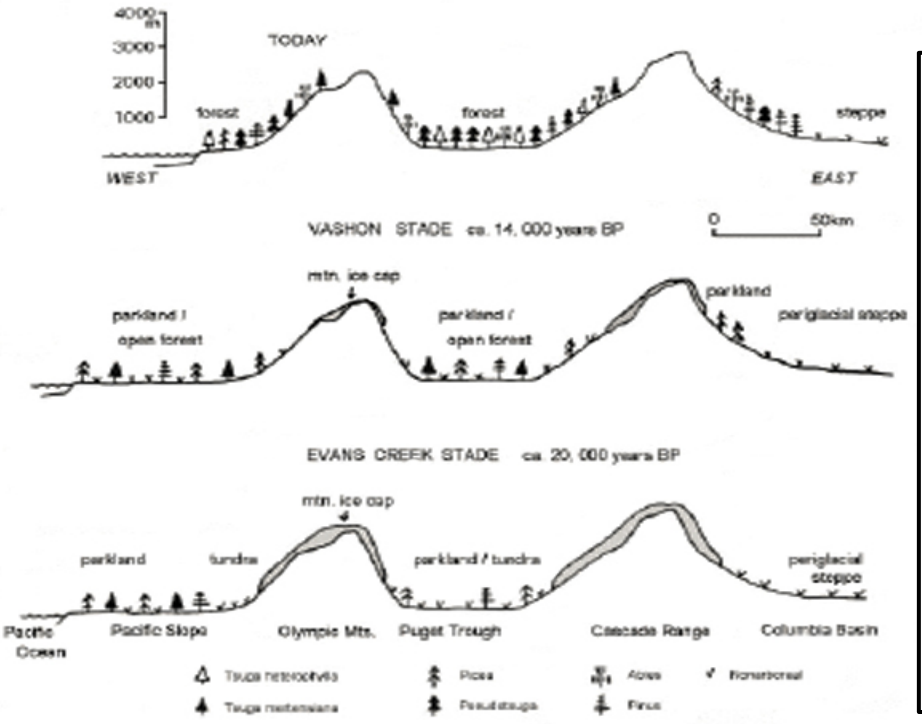
Reorganization of Biotic Communities in the Eastern US by Climate Change During the Holocene

- 12,000 (radiocarbon) years ago Canada was covered by ice. Ecosystems were compressed into the North American landscape south of the ice sheet.
- While most plant communities of that period can be broadly identified by dominant vegetation types, about 40% of early-Holocene plant alliances, by areal distribution, were “no-analog communities” not represented in 20th Century North American vegetation.
- From Jackson and Overpeck 2000.
- (Note: coastlines vary; 12,000 ybp sea level was 120 meters lower than today.)





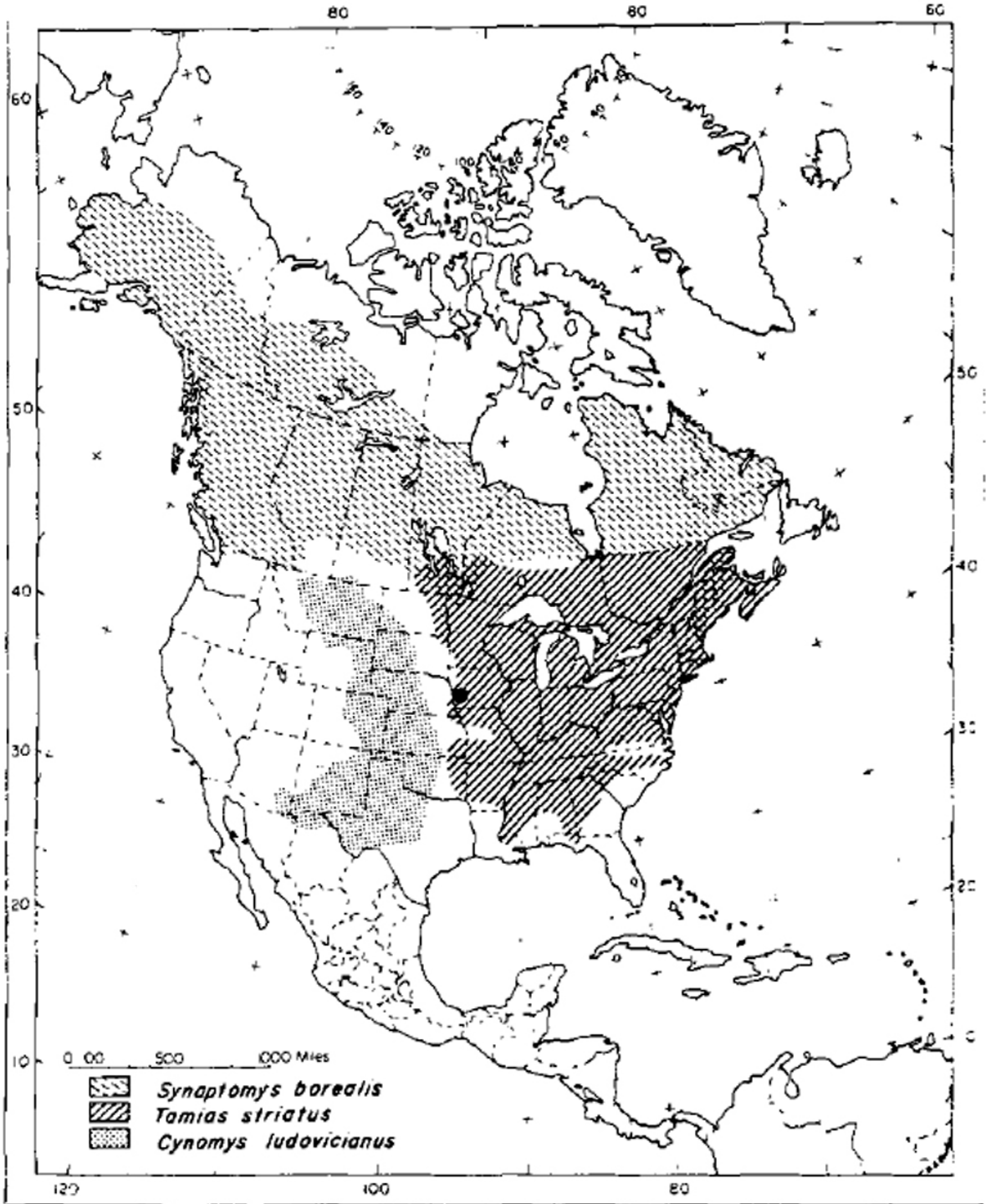
Tree pollen **Doug-fir/hemlock/cypress** **Grasses/sedges/sage**



- Pleistocene and Holocene vegetation in the PNW are well documented by pollen from lake sediments.
- In NW Washington the Pleistocene-Holocene transition resulted in the replacement of periglacial steppe and open parkland dominated by grasses, sedges, and sage by conifer forests in which Douglas-fir, western hemlock, and cypresses (e.g., *Thuja*) were dominants.
- - from Whitlock 1992.

Example: disruption of wildlife community by climate change during the Holocene

- Three small mammal species were found together (fossil co-occurrences) in western Iowa (dot) at the end of the Pleistocene.
- Eastern chipmunk (*Tamias striatus*) is now isolated in the eastern US and Canada.
- Northern bog lemming (*Synaptomys borealis*) is now isolated in northern Canada and Alaska.
- Black-tailed prairie dog (*Cynomys ludovicianus*) is now isolated in western US.
- From Graham 1988.

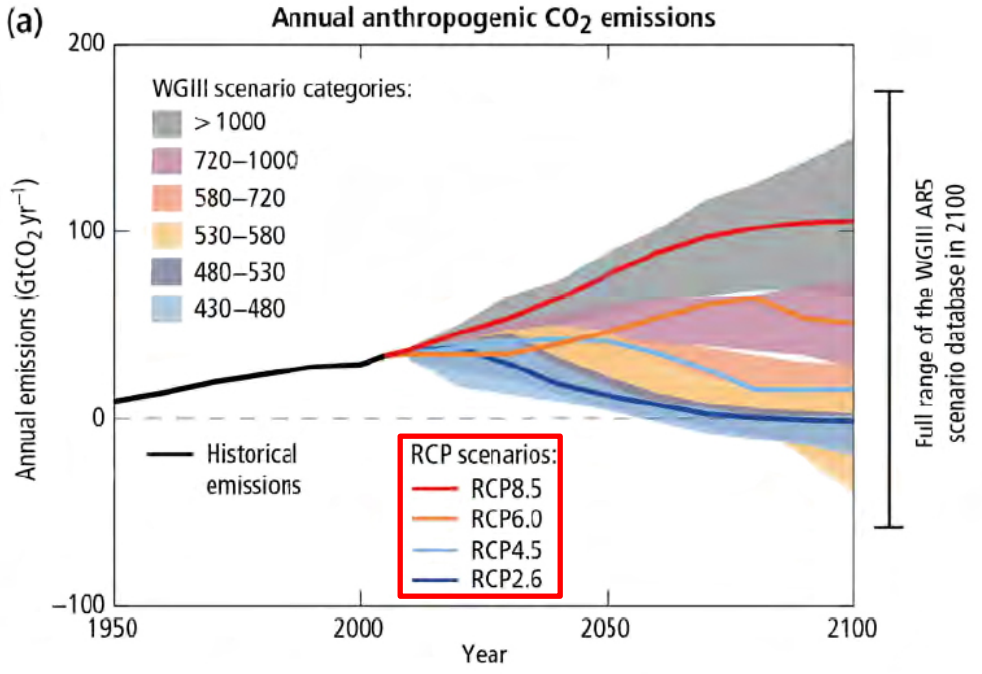


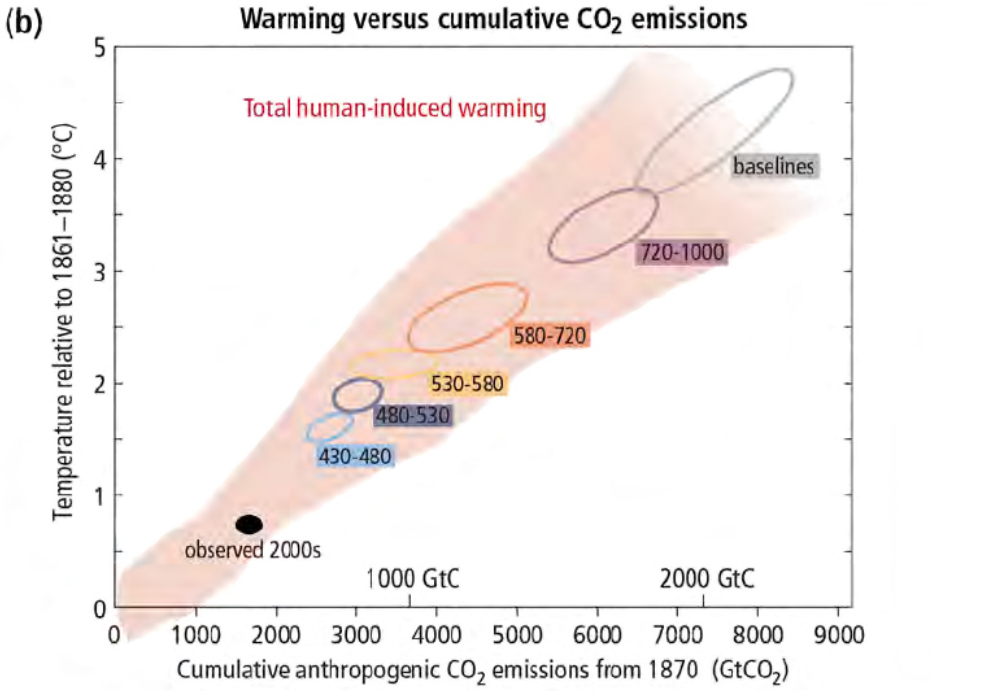
Potential effects of future climate change have been identified primarily on the basis of *climate modeling*. The most detailed and widely accepted modeling is conducted by the International Panel on Climate Change (IPCC).

What are the essential results of the IPCC modeling?

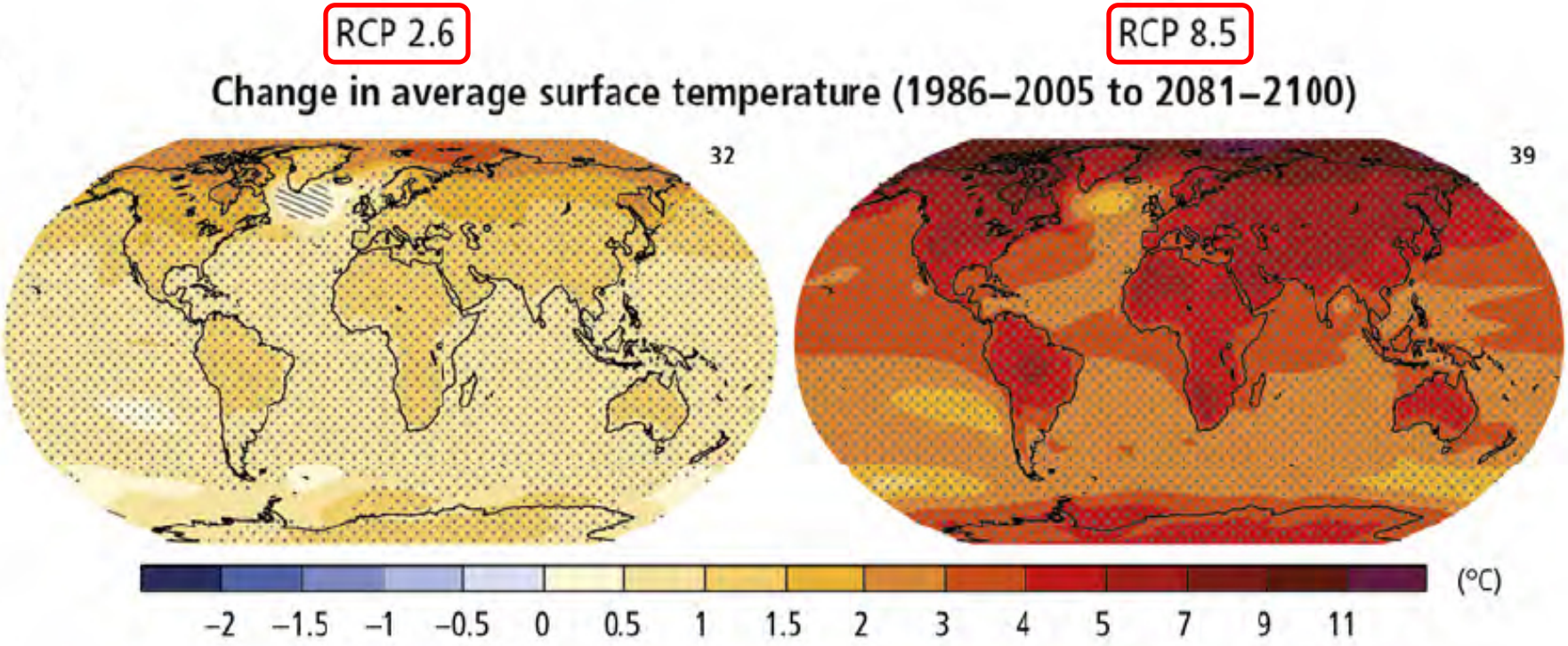
IPCC 5th Assessment Projections Use New Methodology Which Includes Mitigation Scenarios

"**Representative Concentration Pathways**" (**RCPs**) are used for making projections to describe four different 21st century pathways of greenhouse gas emissions and atmospheric concentrations, air pollutant emissions and land-use. The RCPs include a *stringent mitigation scenario* (*RCP2.6*), two intermediate scenarios (RCP4.5 and RCP6.0), and one scenario with *very high greenhouse gas emissions* (*RCP8.5*). … The RCPs are consistent with the wide range of scenarios in the literature as assessed by WGIII.



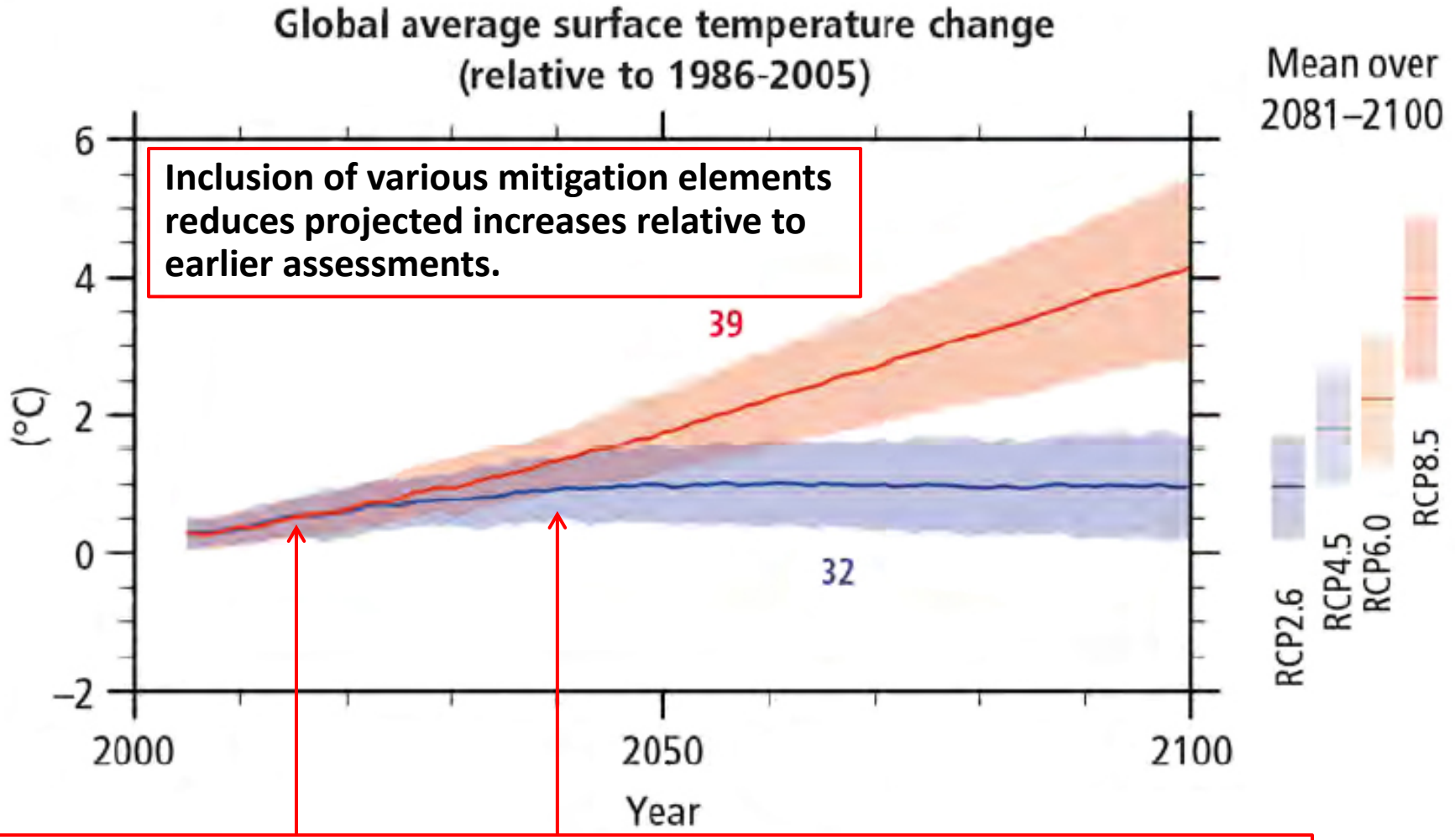


IPCC 5th Assessment Projects Global Temperature Increases by 2100 which Vary by Region and by RCP



Projecting future temperatures to specific locations is problematical for global climate models (GCMs), which typically have grid-cell resolutions of ca 100 km (60 mi) width. Thus GCM projections are typically imprecise at local scales.

IPCC 5th Assessment Focuses on Consensus Among Results from Multiple Climate Models



Projections among model results do not diverge significantly prior to ca 2040.

DATA: 20th Century MNF Temperature Data Support Model Predictions

- Trends are shown for annual average (green), mean maximum (red), and mean minimum (blue) temperatures in Round Valley (left, 1936-2008) and East Park Reservoir (right, 1911-1999).
- Average and maximum temperatures show no statistically significant trends; minimum temperatures demonstrate significant increases.
- From Butz and Safford (MS), Draft report for climate trends, Mendocino National Forest.

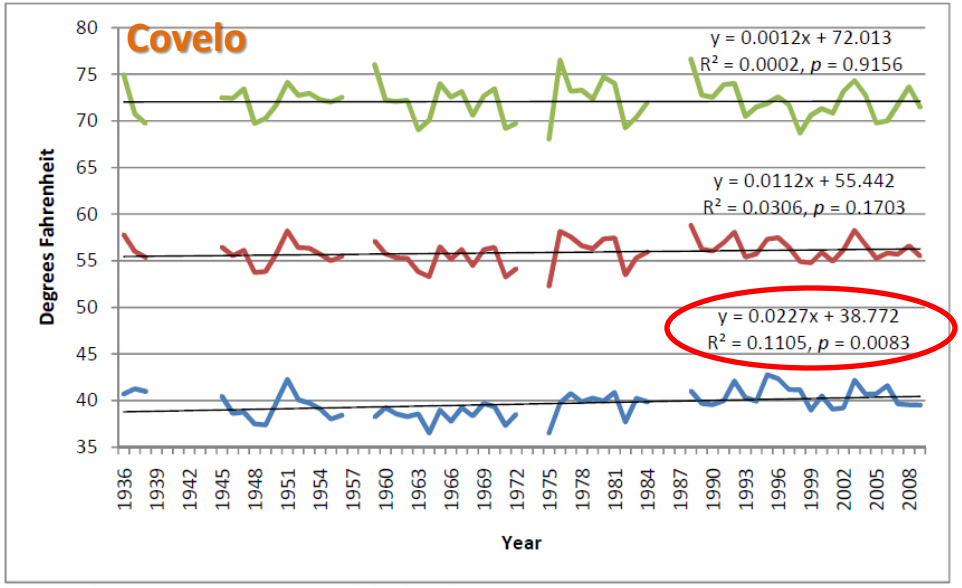


Figure 2. Annual mean, mean maximum, and mean minimum temperatures at Covelo, California, 1936-2009. Trend lines fit with simple linear regression, no transformations employed. Data from WRCC (2010).

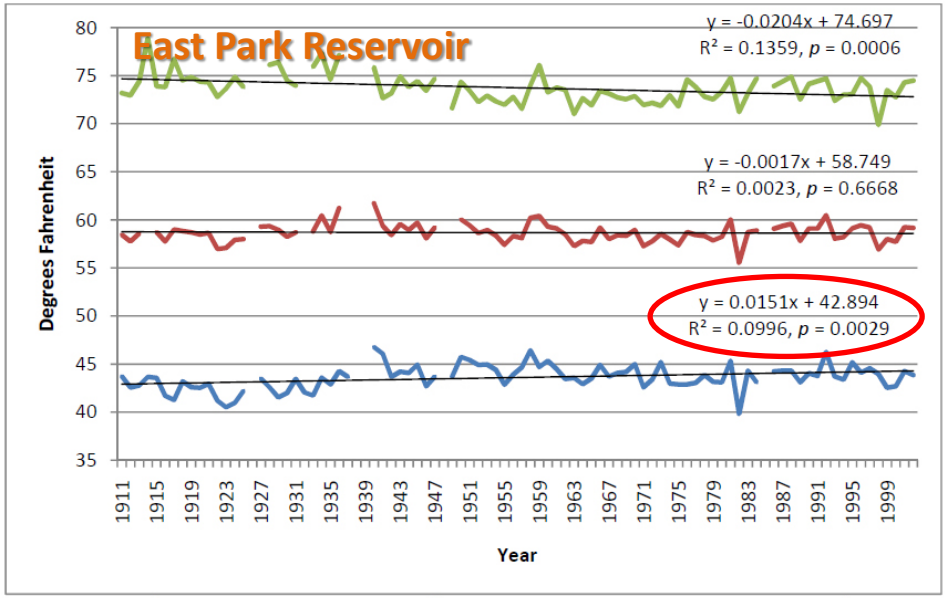
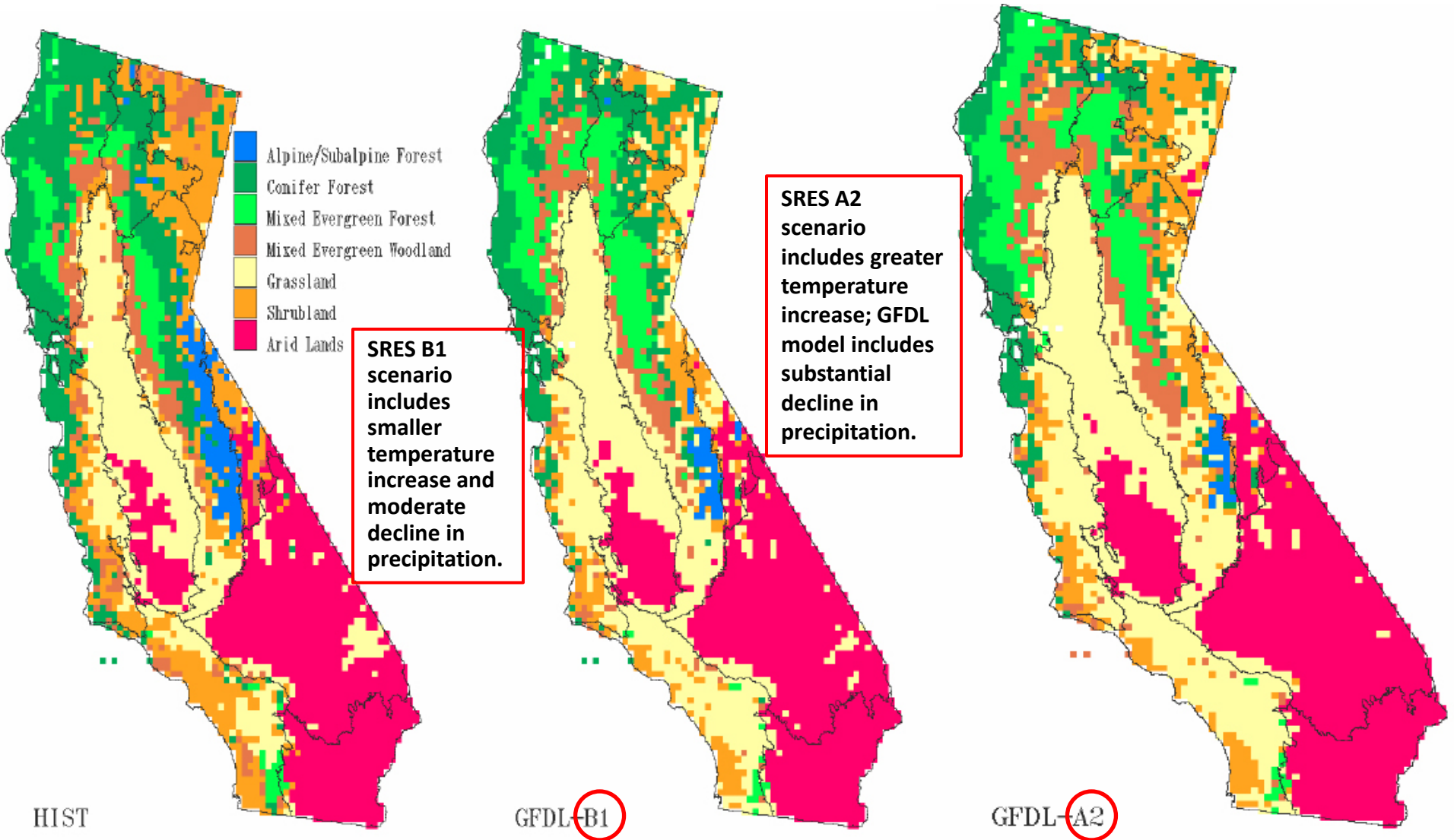


Figure 4. Annual mean, mean maximum, and mean minimum temperatures at East Park Reservoir, California, 1911-2002. Trend lines fit with simple linear regression, no transformations employed. Data from WRCC (2010).

Modeling has been used to investigate a variety of potential climate-change effects, from changes in vegetation distribution to impacts on fire frequency and intensity. The modeling results are not predictions, but they help to identify management concerns.

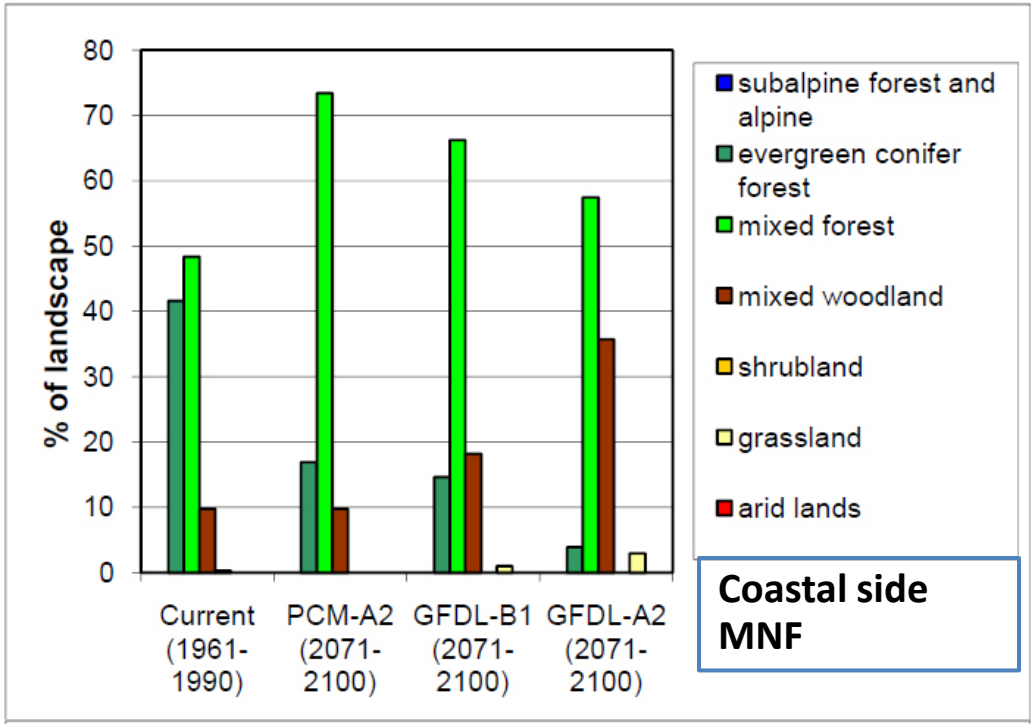
What are some of these results?

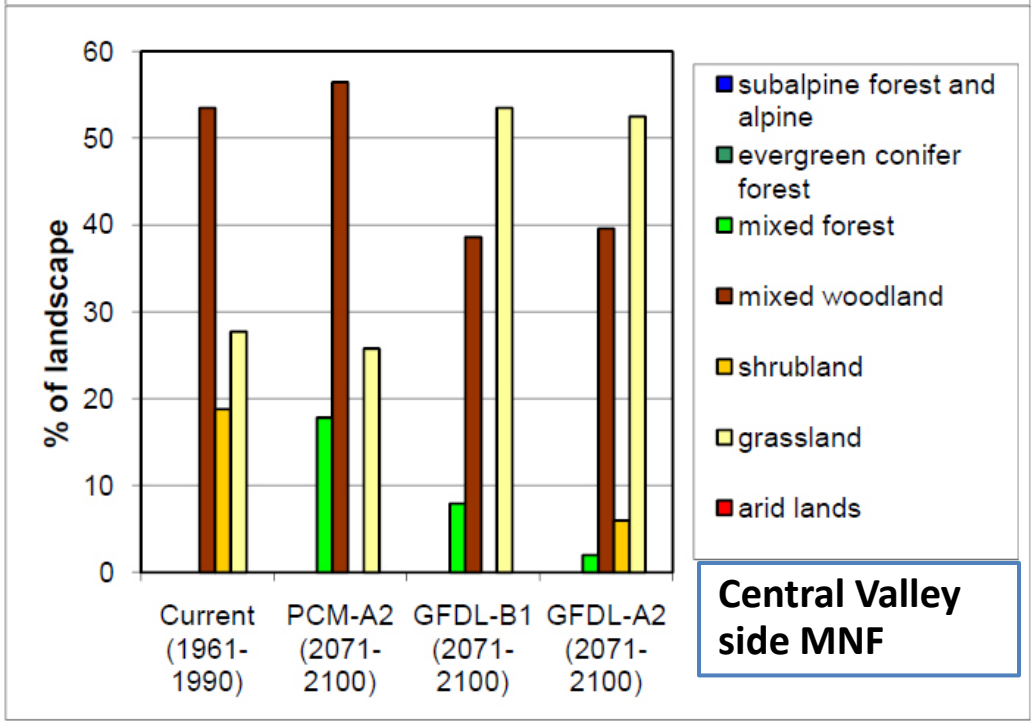
Projections for vegetation patterns in most scenarios suggest that by the late 21st Century NW California will have less "conifer forest," that the extent of "mixed" forest with hardwoods and conifers will increase, and that there will be increased areas of grassland. - from Lenihan et al 2006.



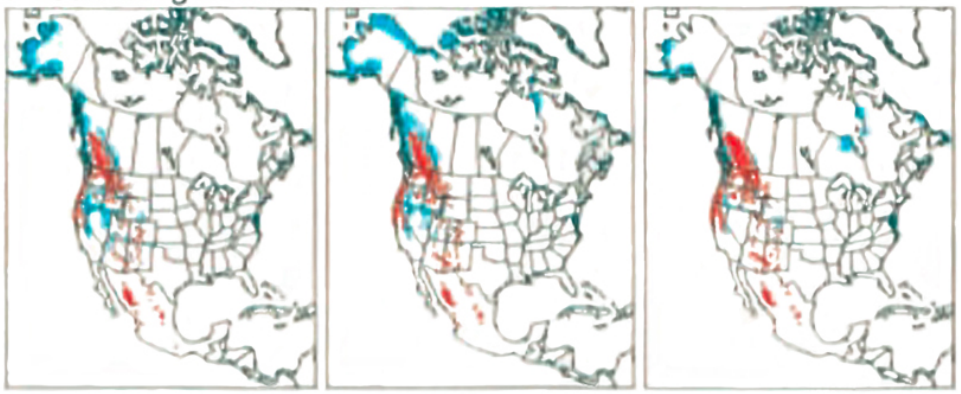
Vegetation Change Projections, Mendocino National Forest, 1961-1990 to 2071-2100

- Figure illustrates projected changes in vegetation for Mendocino National Forest between conditions in 1990 and 2100 (- from Lenihan et al 2008).
- SRES B1 scenario includes smaller temperature increase and moderate decline in precipitation.
- SRES A2 scenario includes greater temperature increase. PCM model does not include substantial decline in precipitation; GFDL model includes substantial decline in precipitation.
- Source: Butz and Safford (MS) – Draft report for climate trends Mendocino National Forest.

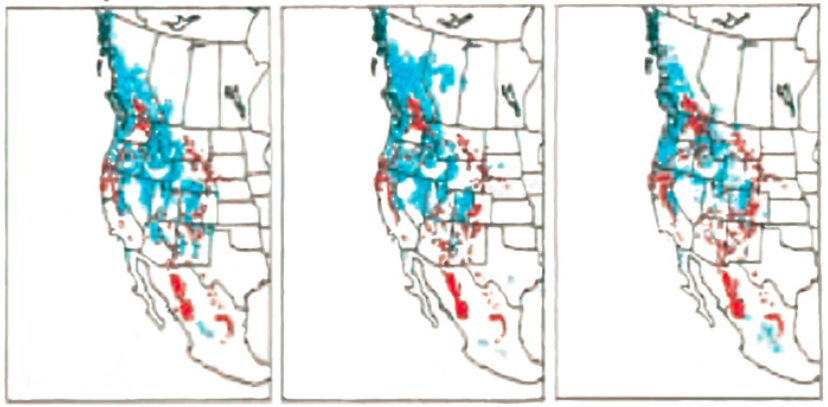




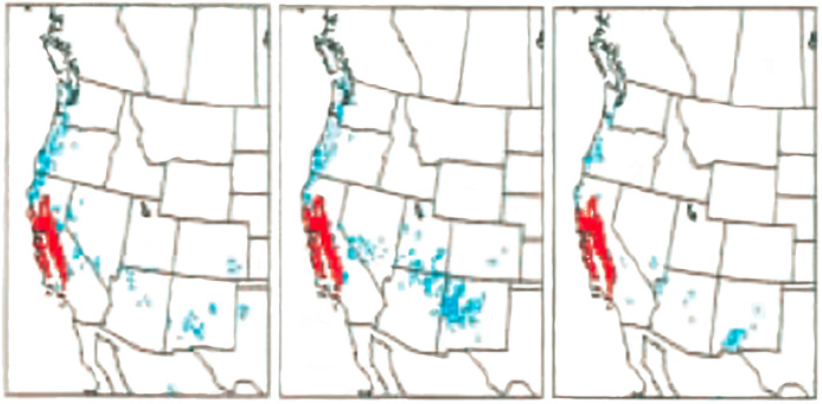
Pseudotsuga menziesii



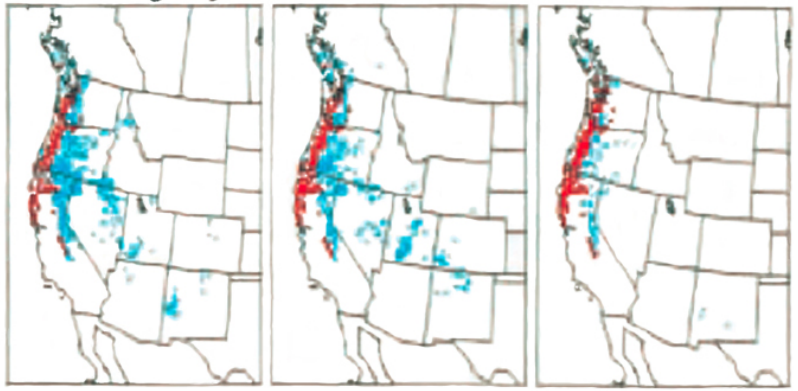
Pinus ponderosa



Quercus lobata



Quercus garryana



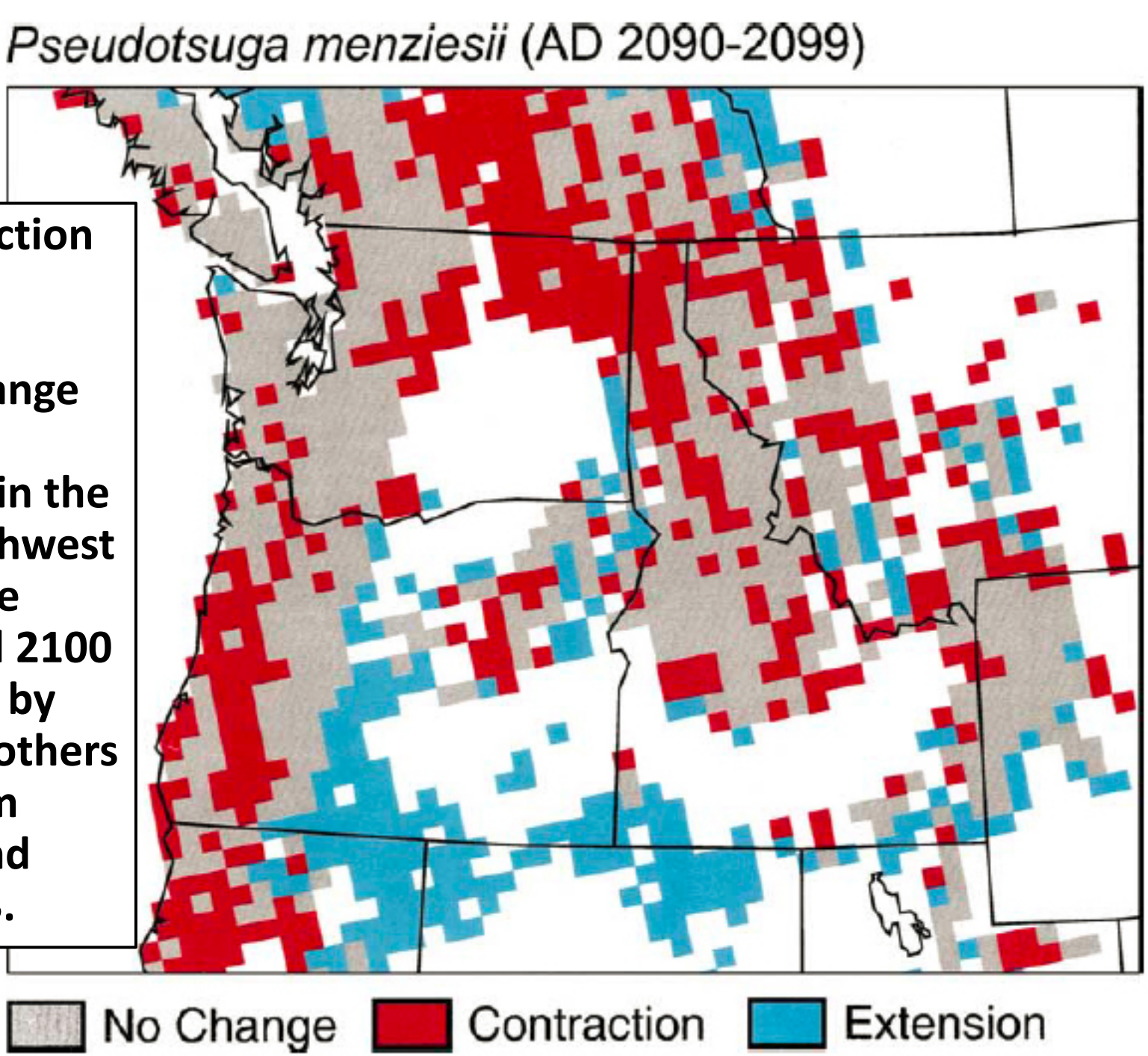
HADCM2 (2090-99) CGCM1 (2090-99) CSIRO (2090-99)

No Change
Contraction
Extension

This model included three factors:

- *Mean temperature of the coldest month.*
- *Growing degree days.*
- *Moisture index.*

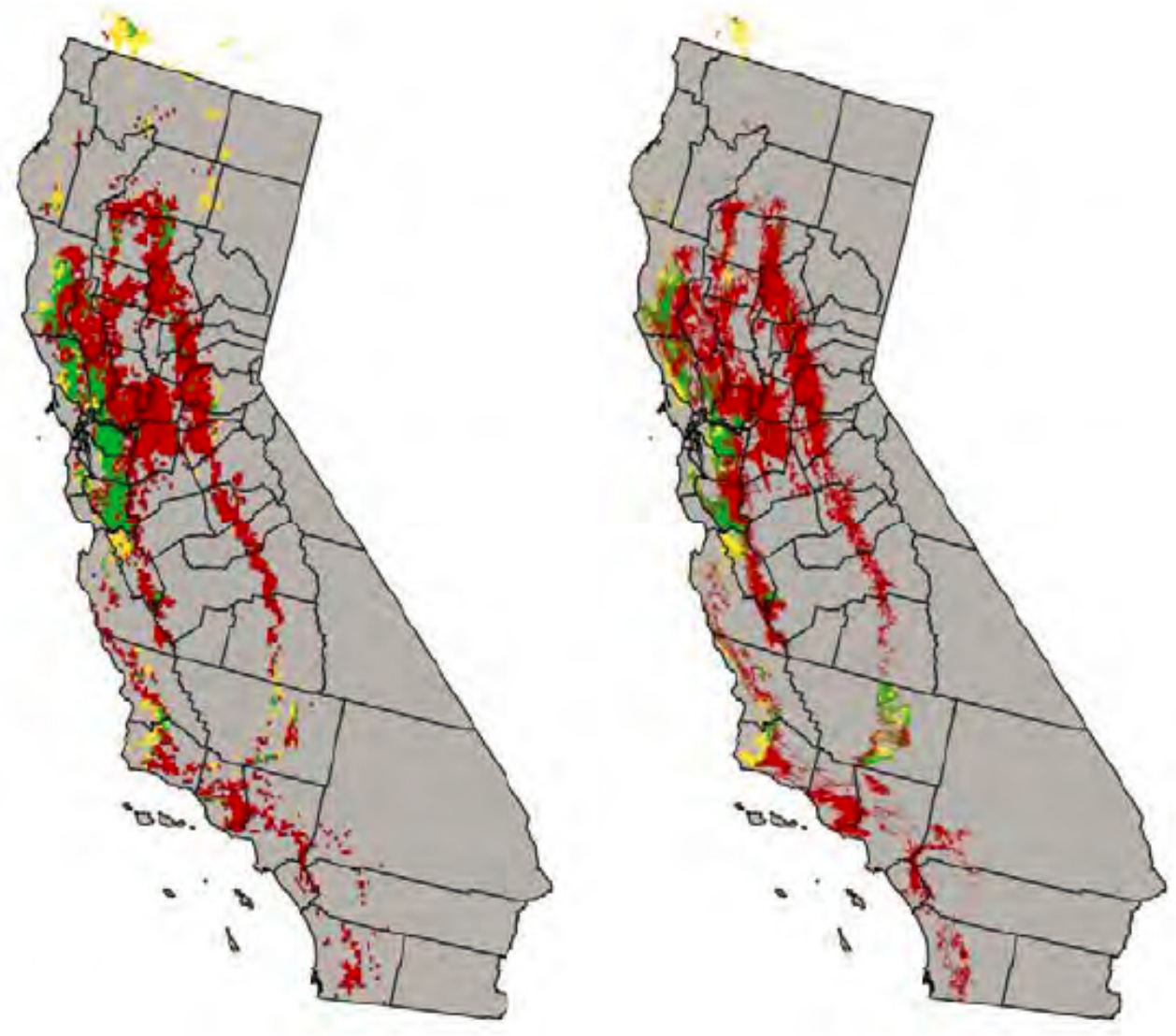
Modeled changes in range in the western United States between the present and 2100 for Douglas-fir, ponderosa pine, garry oak, and valley oak. Red shading = range contraction, blue shading = range expansion. – from Shafer and others 2001.



Enlarged section of diagram showing projected range changes for Douglas-fir in the Pacific Northwest between the present and 2100 as modeled by Shafer and others 2001. – from Whitlock and others 2003.

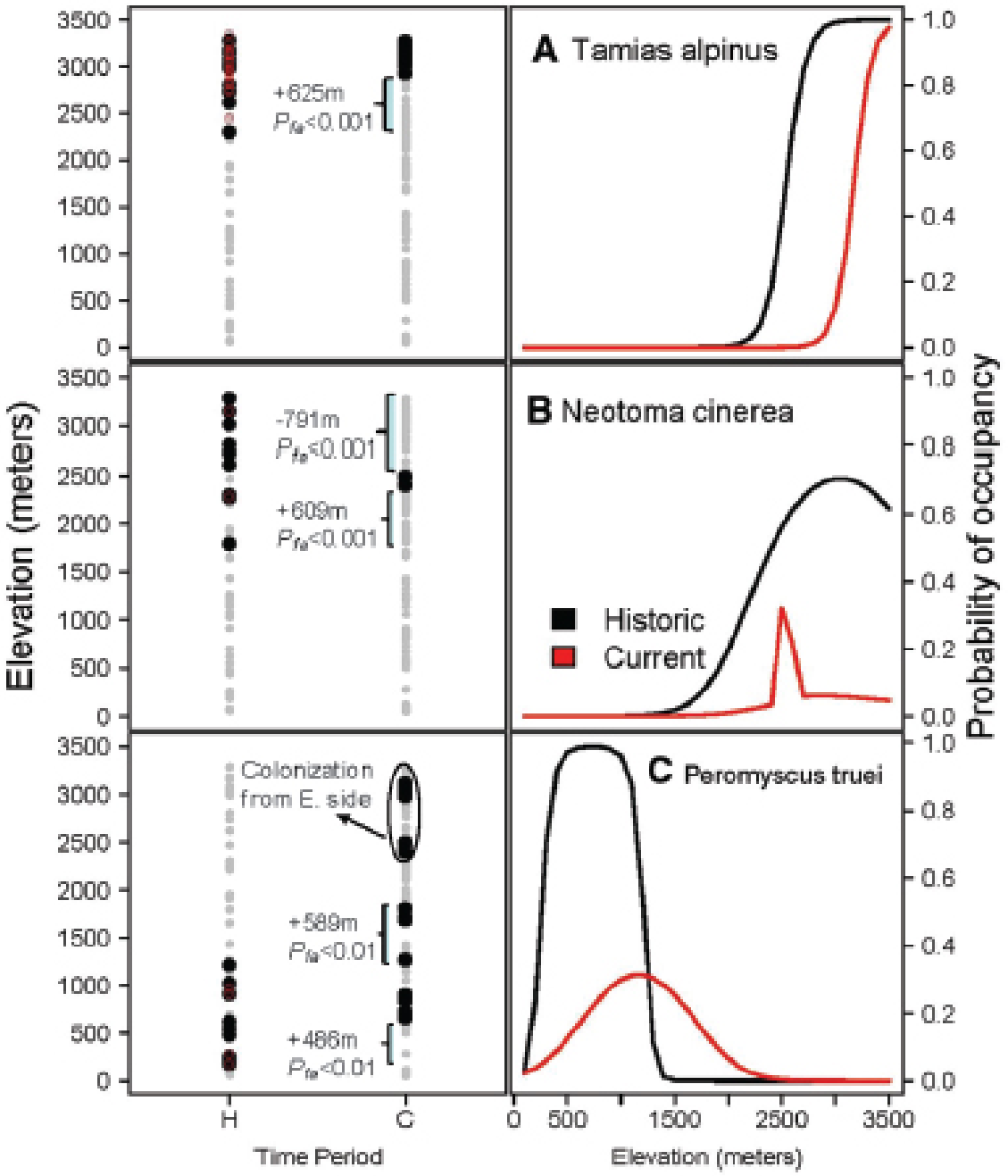
Simulated Changes in Suitable Habitat Conditions for Valley Oak by Mid-21st Century

- Simulated habitat conditions for SRES A2 under two climate models are shown for *Quercus lobata*, based on the species' bioclimate envelope.
- Red shading represents loss of suitable habitat by mid-21st Century.
- Green shading represents retained habitat by mid-21st Century.
- Yellow shading is anticipated newly suitable habitat by mid-21st Century.
- - from Hannah et al 2012.

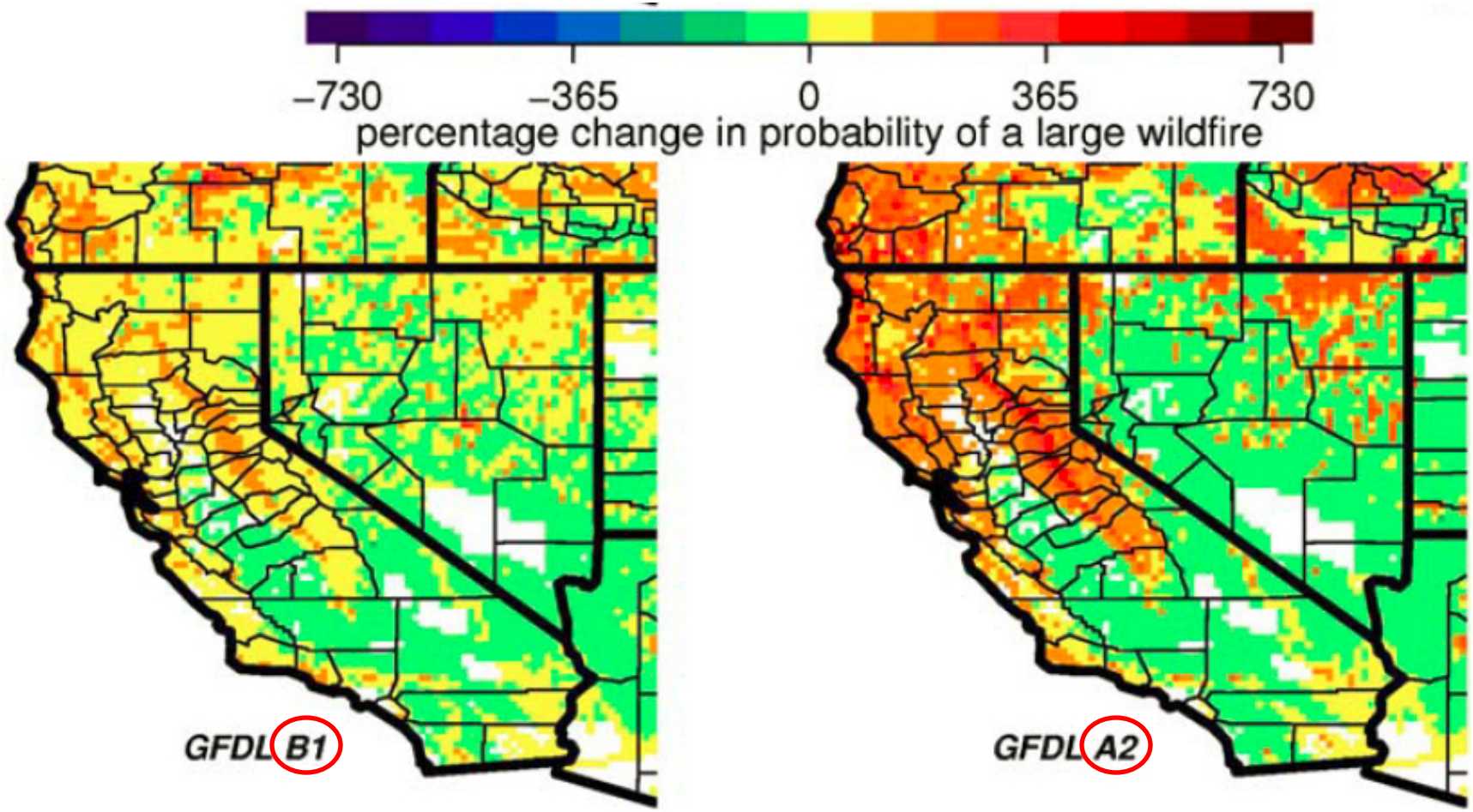


DATA: Climate Change Effects Have Already Been Demonstrated - Small Mammals in the Sierra Nevada

- Plots from a west slope transect resampling early 20th Century studies show upward range expansion (*Tamias alpinus* and *Peromyscus truei*) (A and C), and range collapse (*Neotoma cinerea*) (B).
- Shown are occupied (black) and unoccupied (gray) sites and model-averaged occupancy-elevation profiles.
- *P. truei* colonized high elevations west of the Sierra crest from the eastern slope.
- From Moritz et al 2008.



Climate-Change Projections Include Increased Fire Potential in Western US



Percentage change in probability of a large (>200 ha) wildfire by 2070-2099 relative to the 1960-1991 reference period. - from Westerling and Bryant 2008.

Climate change will be associated with changes in American society, some of which are difficult to quantify:

- Altered recreational use patterns
- Shifted settlement
- Changes in agriculture
- Demands to increase water yield from wildlands
- Stresses on landscapes important for species conservation

How will these changes affect Mendocino NF and FireScape?

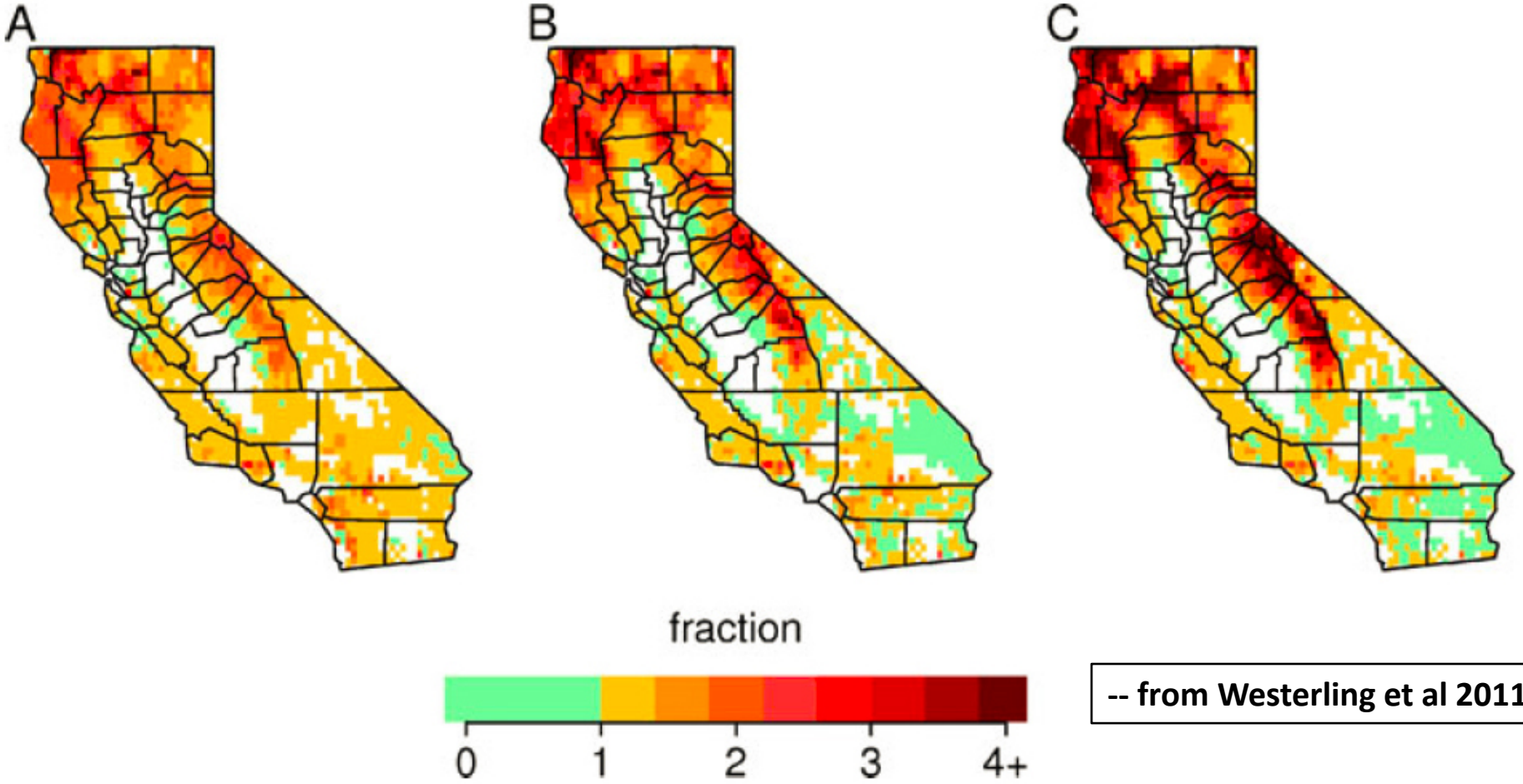
EXERCISE: Climate-Change Planning for MNF-Region Forestry

What direct implications do climate changes have for local concerns? Consider the following question/scenario: *How will changed climate affect forestry in the Mendocino National Forest region?*

1. Currently California has experienced approximately 0.8° C of increased temperature since 1975 (1.4° F).
2. Climate models project an additional half-degree to 1.5° C (about 0.8° to 2.7° F) increase by 2040, for an overall increase of about 1.3° to 2.3° C, or about 2.3° to 4.1° F.
3. The *lapse rate* for temperature in dry air (i.e., summer) is about 10° C per 1000 meters, or *5.4° F per 1000 feet*.
4. Therefore we're looking at an elevation increase of 2.3/5.4 to 4.1/5.4 x 1000 feet, or about 426 to 760 feet to enable plant species (e.g., Doug-fir) to maintain the same local climate conditions in 2040 that were experienced in 1975.

Rural Development and Wildland Urban Interface Expansion Increase Fire Impacts by End of 21st Century

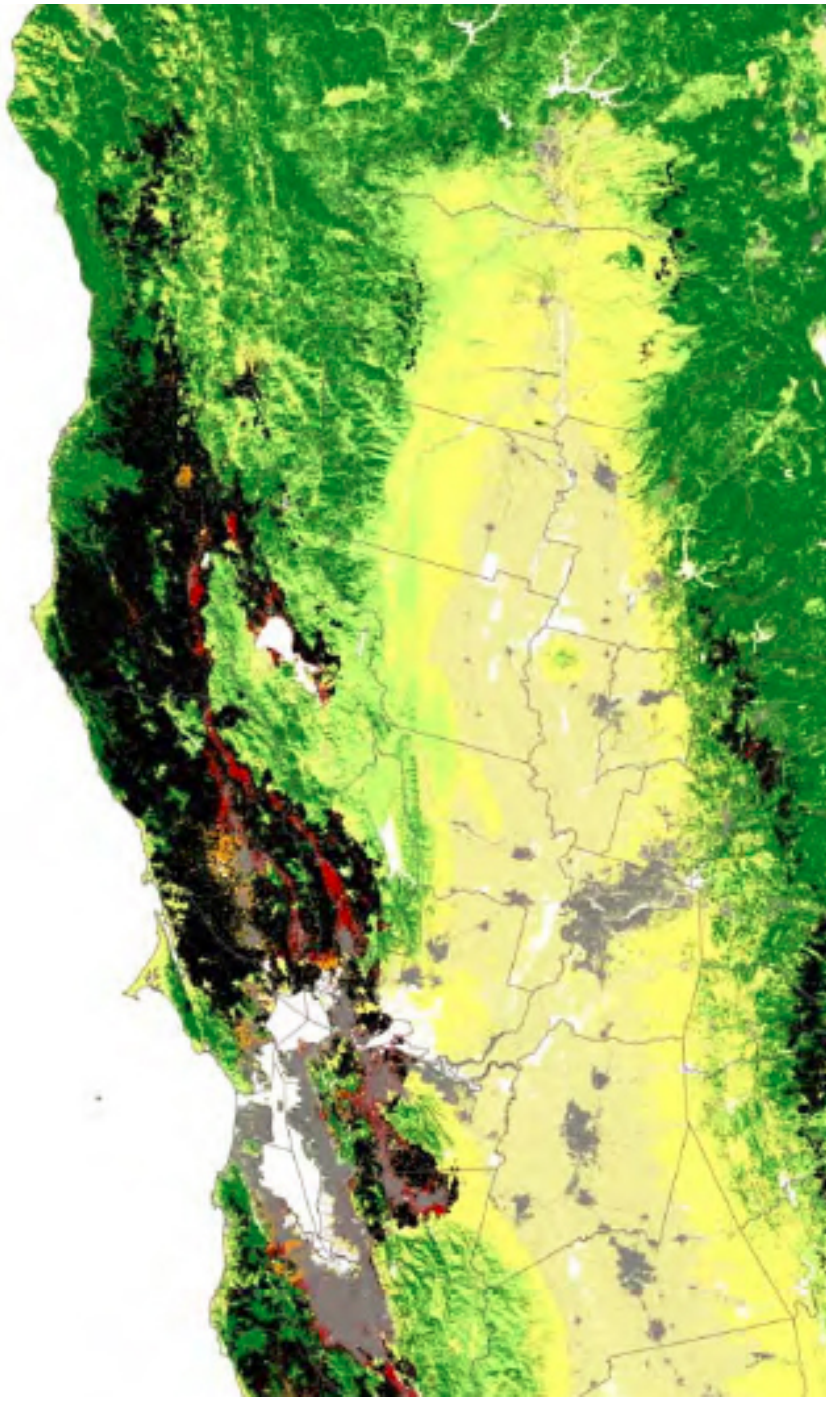
Predicted burned area in 2085, three SRES A2-scenario climate models, with high population growth, high sprawl, and a high threshold housing density. Unchanged burned area is "1;" 4+ indicates that burned area is 400% of the reference period (300% increase).

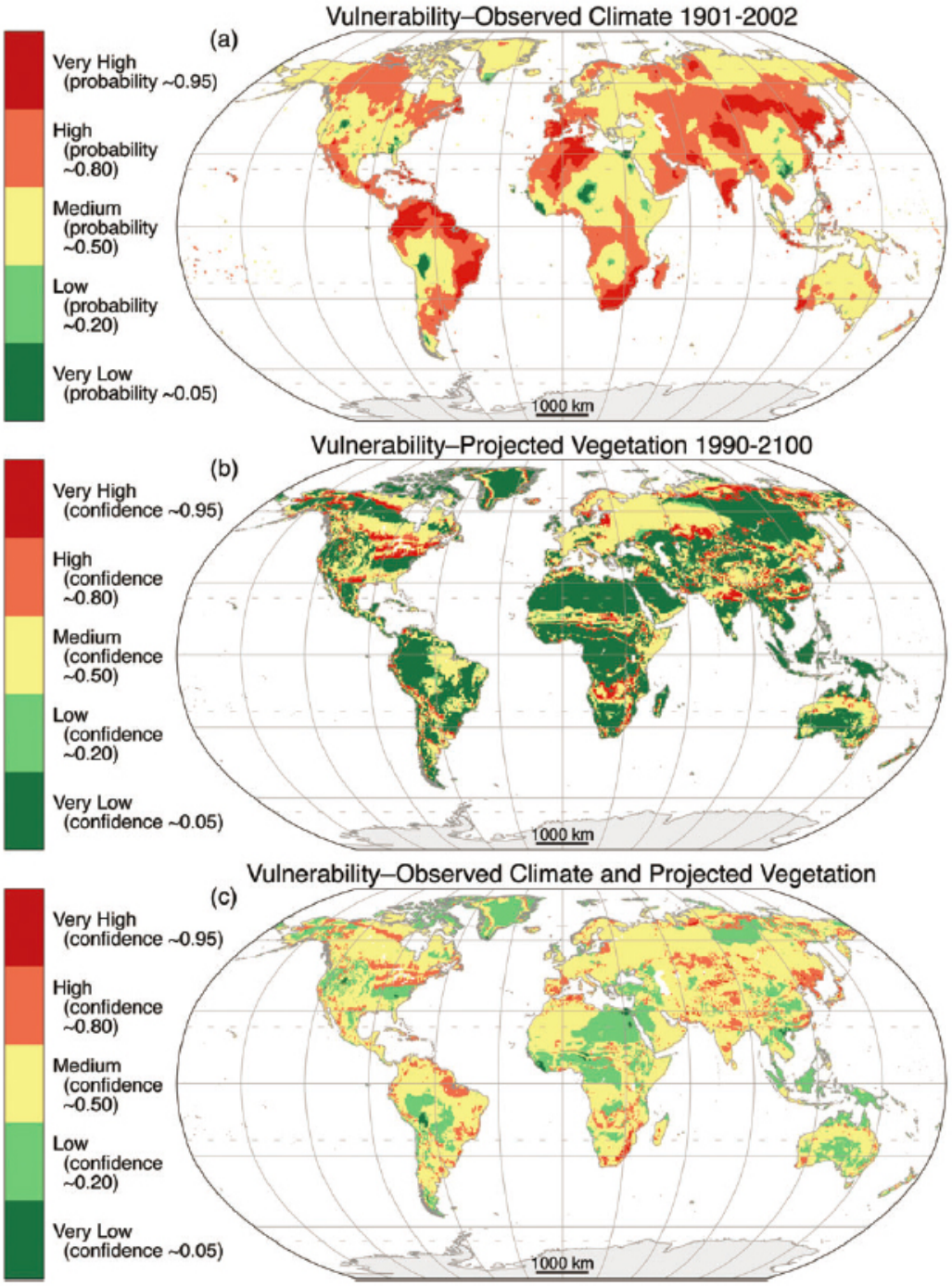


-- from Westerling et al 2011.

Increased Potential Conflict Between Vineyards and Natural Vegetation Areas, Northwestern California, 2070-2100

- Areas with projected enhanced climate suitability for winegrape vineyards by the end of the 21st Century that are currently mapped in National Land Cover Dataset (NLCD) as *natural landscape areas* are shown in black shading.
- Red, orange, and blue shadings represent areas currently suitable for vineyards that are projected to remain suitable by 2100 and which do not conflict with *natural landscape areas*.
- Other map colors represent areas not projected to provide suitable climate conditions for vineyards by 2100.
- From Hannah et al 2012.

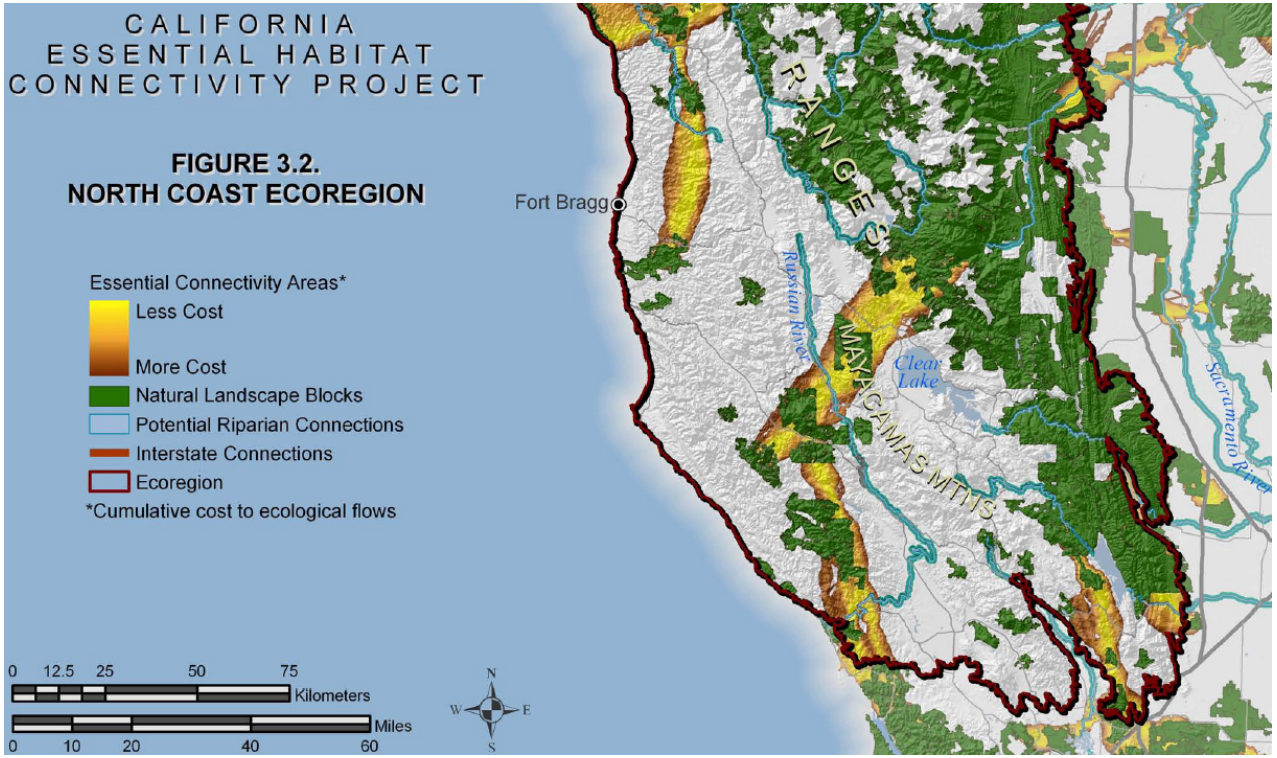




Climate Change Will Alter the Biological Environment and Could Adversely Affect Conservation Practices

- Conservation is fundamentally dependent on the extent and distribution of the habitat types that support species of concern.
- Climate change will alter habitat suitability in many parts of North America by re-sorting biological communities or “biomes”.
- Western coniferous forests are less vulnerable to climate-driven “biome shifts,” although species mix will likely be altered; oak-containing habitats and shrublands are more vulnerable.
- -from Gonzalez et al 2010.

Mendocino NF Is an Essential Element in Conservation Planning for NW California and the Pacific Northwest



The California Essential Habitat Connectivity Project (Spencer et al 2010), prepared for the California Department of Fish and Wildlife, identifies the National Forests in the northern inner Coast Range as essential in providing habitat connectivity to counteract habitat fragmentation resulting from climate change.

- The effects of climate change on habitat elements such as large trees and multilayered stands are unpredictable, and maintaining such elements may not be possible.
- Conservation in this new era necessitates additional measures, such as *landscape connectivity* that maintains migration, colonization of new habitats, “rescue” from local extirpation, and metapopulation maintenance, which may represent a departure from existing conservation approaches.

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