Climate Change: Potential Impacts on Forest Ecosystems

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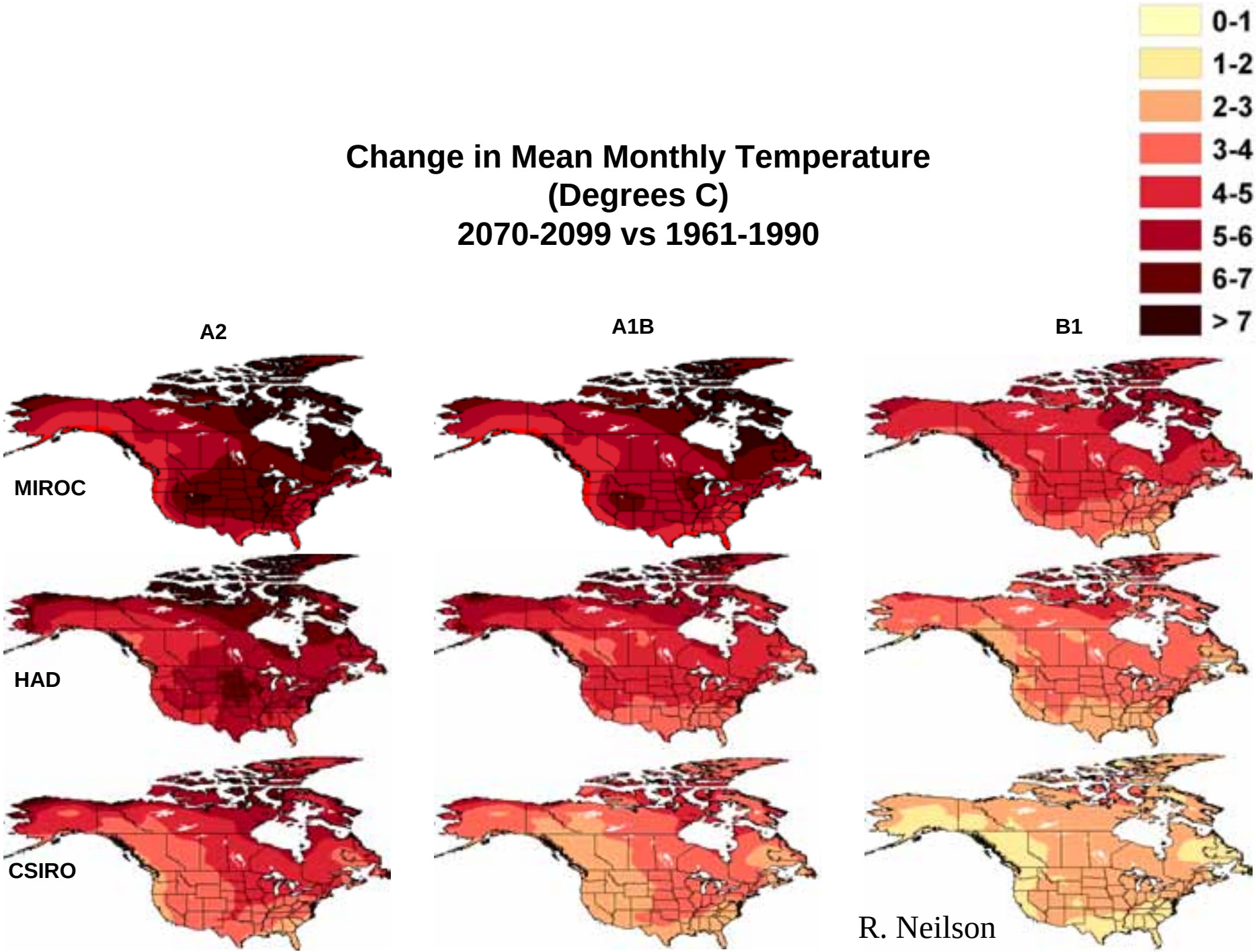
Change in Mean Monthly Temperature
(Degrees C)
2070-2099 vs 1961-1990
0-1
1-2
2-3
3-4
4-5
5-6
6-7
> 7
A2
A1B
B1
MIROC
HAD
CSIRO
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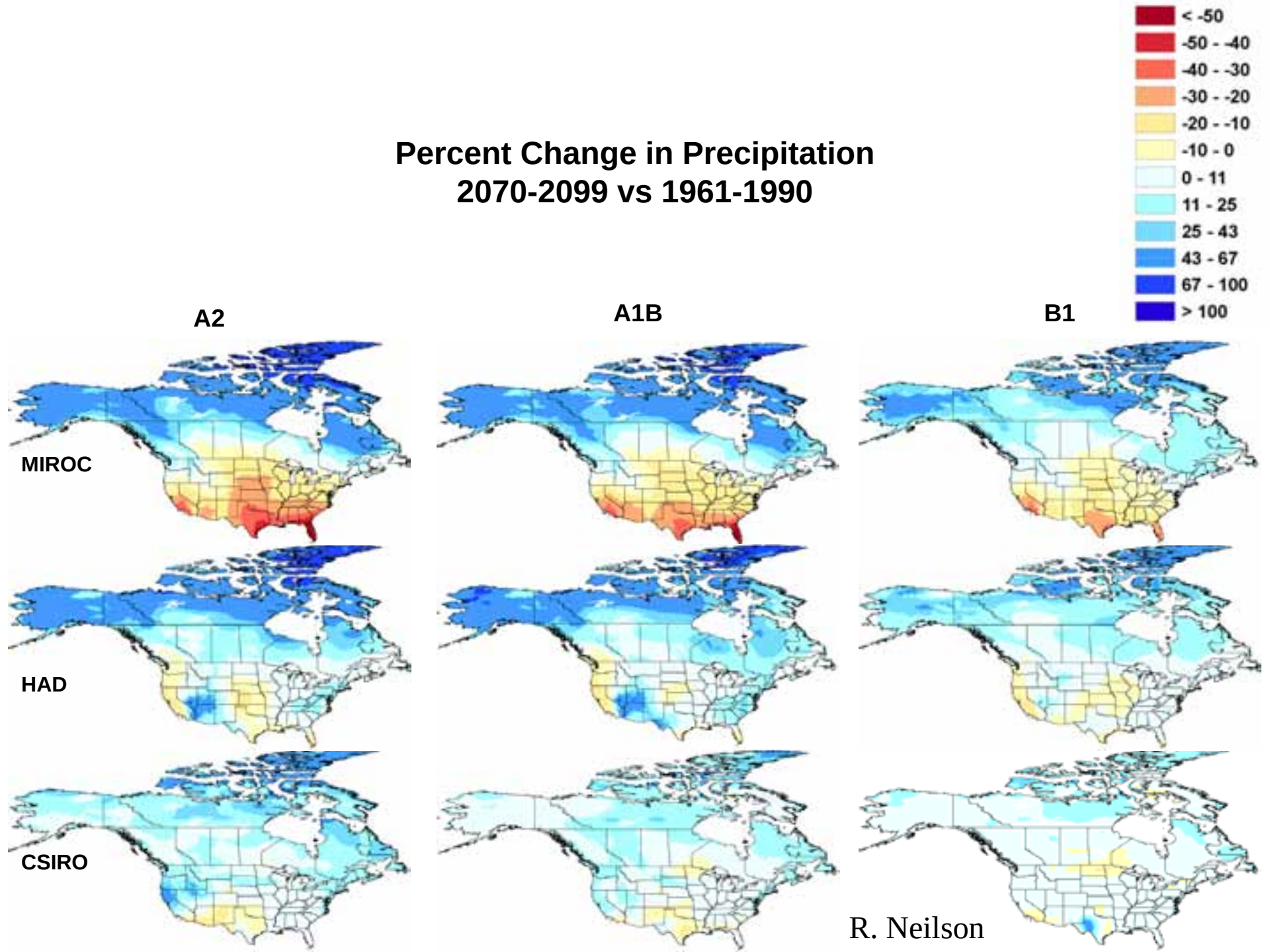
Percent Change in Precipitation
2070-2099 vs 1961-1990



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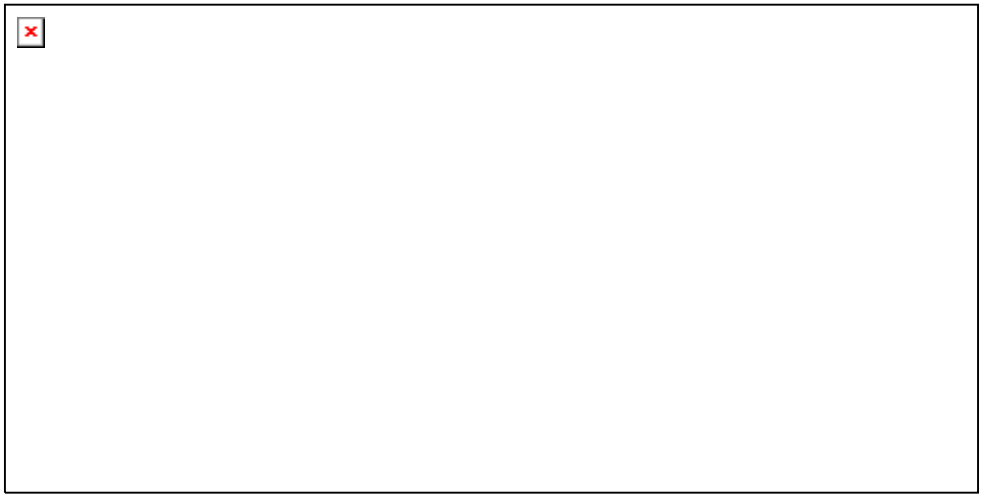
Projections of Dynamic Global Vegetation Models

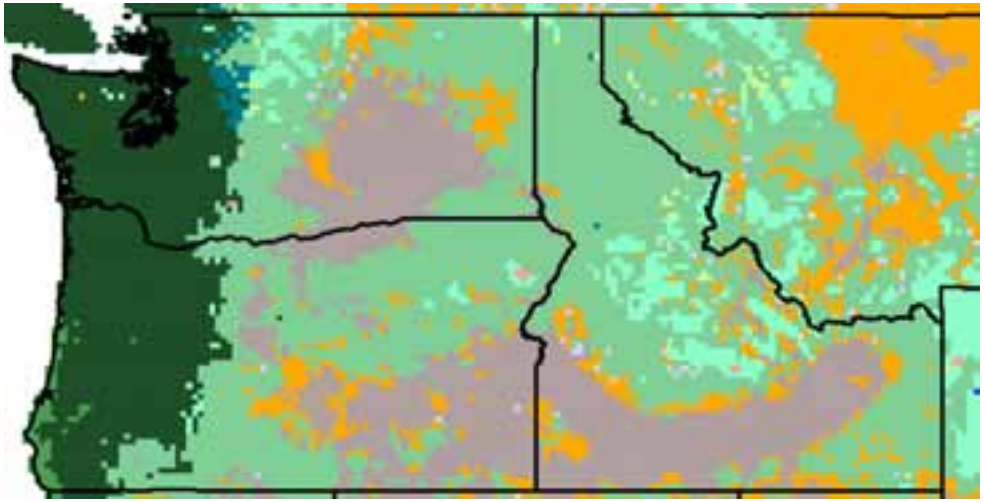
- Tundra
- Boreal Coniferous Forest
- Maritime Temperate Coniferous Forest
- Continental Temperate Coniferous Forest
- Cool Temperate Mixed Forest
- Warm Temperate / Subtropical Mixed Forest
- Temperate Deciduous Forest
- Temperate Deciduous Savanna
- Temperate Conifer Savanna
- C3 Grasslands
- Mediterranean Shrubland
- Temperate Arid Shrubland

Observed



- Tundra
- Subalpine Forest
- Maritime Evergreen Needleleaf Forest
- Temperate Evergreen Needleleaf Forest
- Temperate Deciduous Broadleaf Forest
- Temperate Cool Mixed Forest
- Temperate Evergreen Needleleaf Woodland
- Temperate Shrubland
- Temperate Grassland
- Subtropical Mixed Forest
- Subtropical Grassland

Simulated Historical



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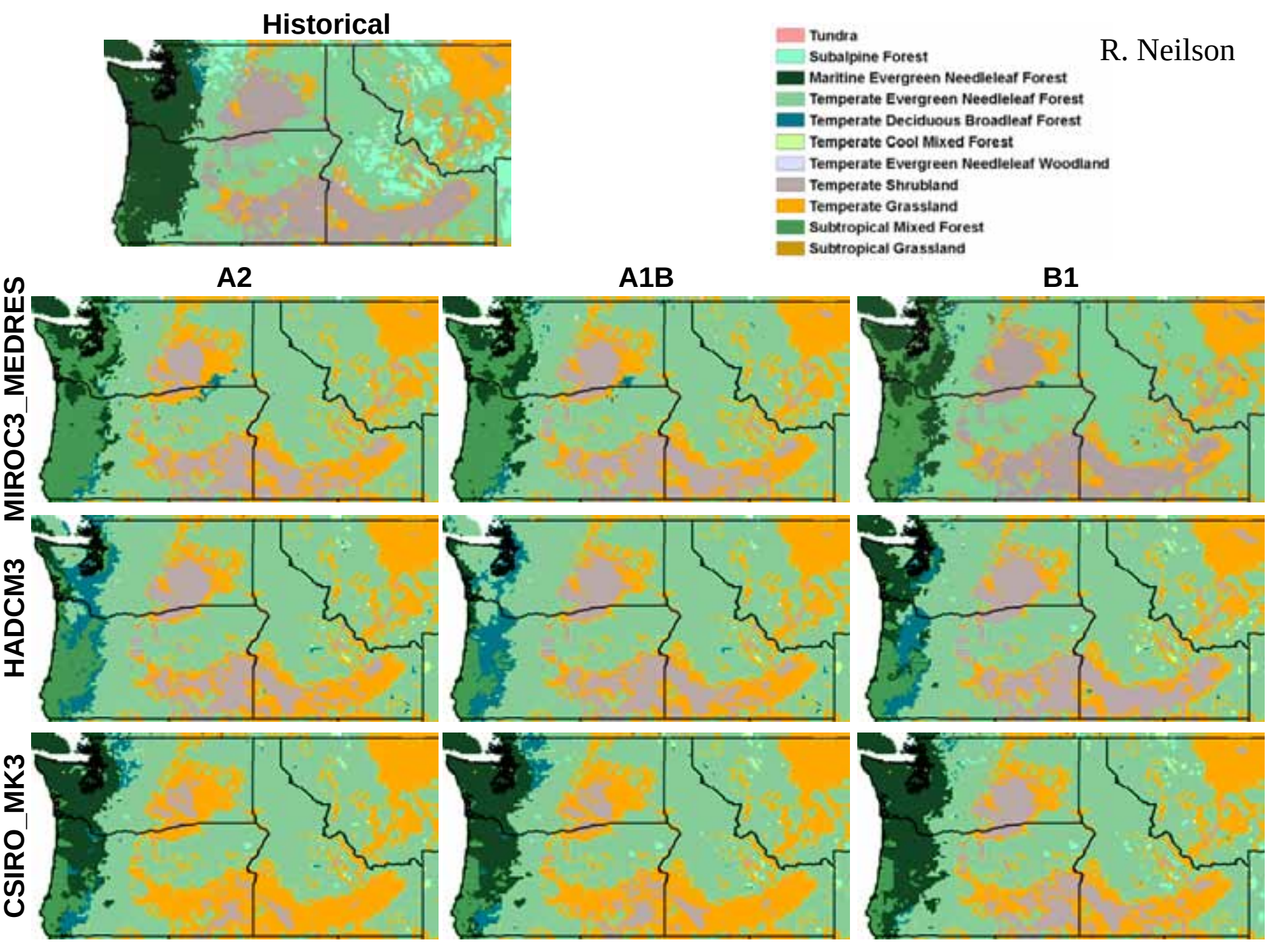
Historical
Tundra
Subalpine Forest
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Temperate Evergreen Needleleaf Woodland
Temperate Shrubland
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Subtropical Mixed Forest
Subtropical Grassland
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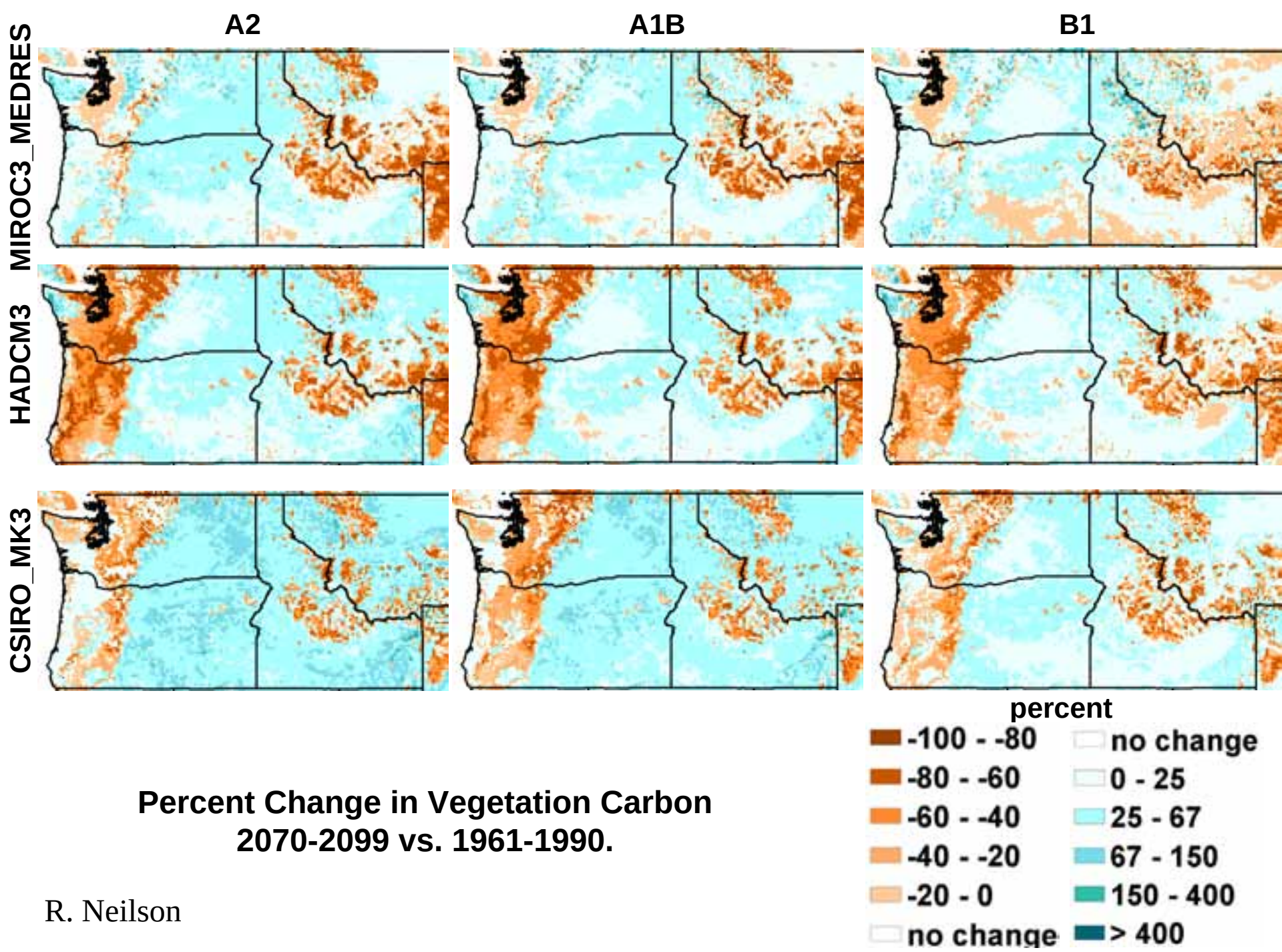
A2
A1B
B1
MIROC3_MEDRES
HADCM3
CSIRO_MK3



Percent Change in Vegetation Carbon
2070-2099 vs. 1961-1990.

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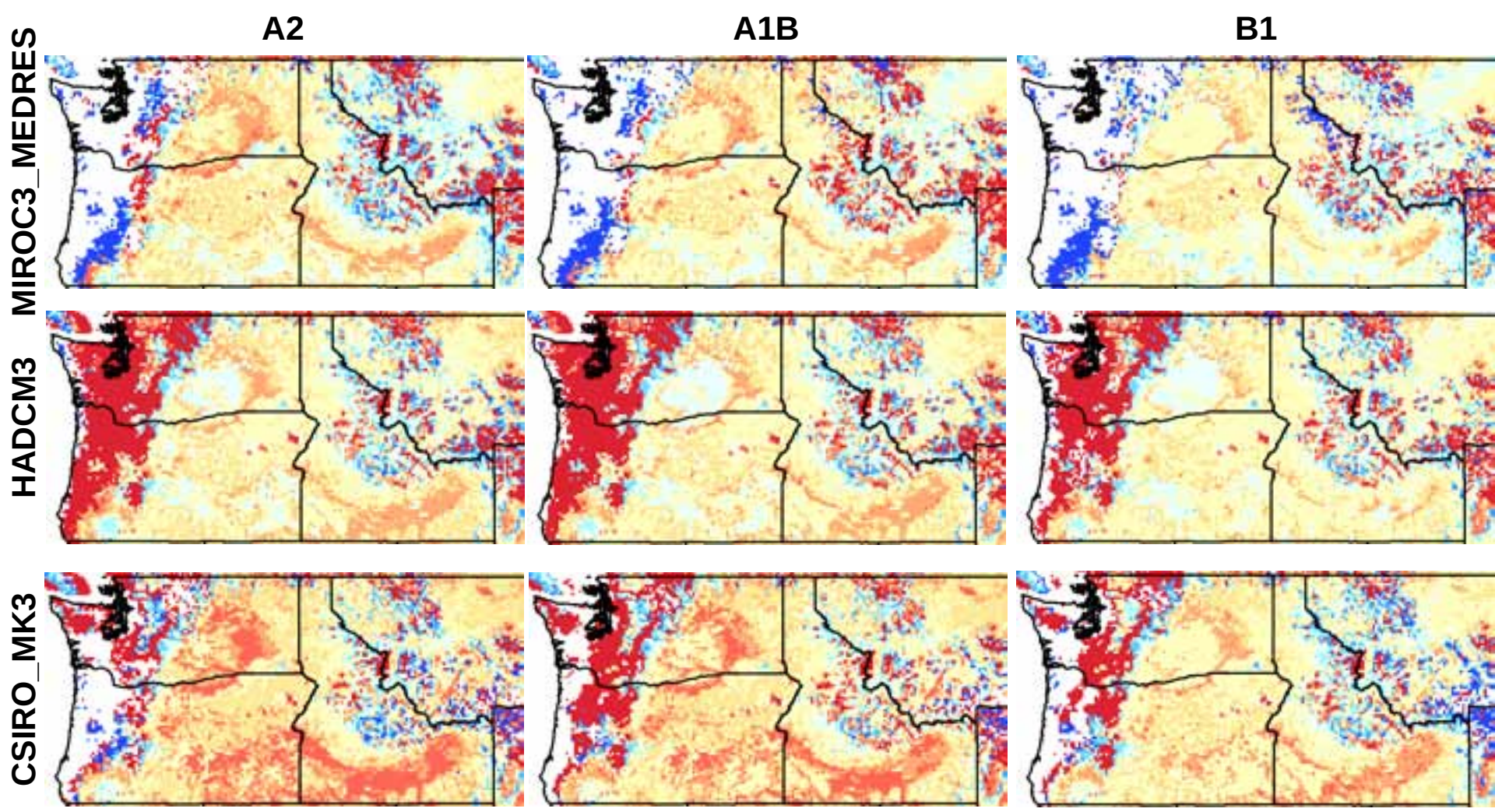

Percent Change Biomass consumed by Fire
2051-2100 vs. 1951-2000.

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Types of Impacts

- Direct
  - Ecosystem productivity
  - Tree growth
  - Establishment
  - Ecotone/range movement
  - Phenology
- Indirect
  - Fire
  - Insects and Disease
  - Human responses (e.g. carbon sequestration)

Major Uncertainty

- Increased CO_2 concentration can promote higher productivity through more efficient photosynthesis

But

- Warmer temperatures increase moisture stress and reduce photosynthesis

But

- But earlier start to growing season can boost growth during time when soil is relatively wet

Limits on vegetation net primary productivity

49 Studies: 37 Pos.; 5 Neg.; 7 no trend or mixed

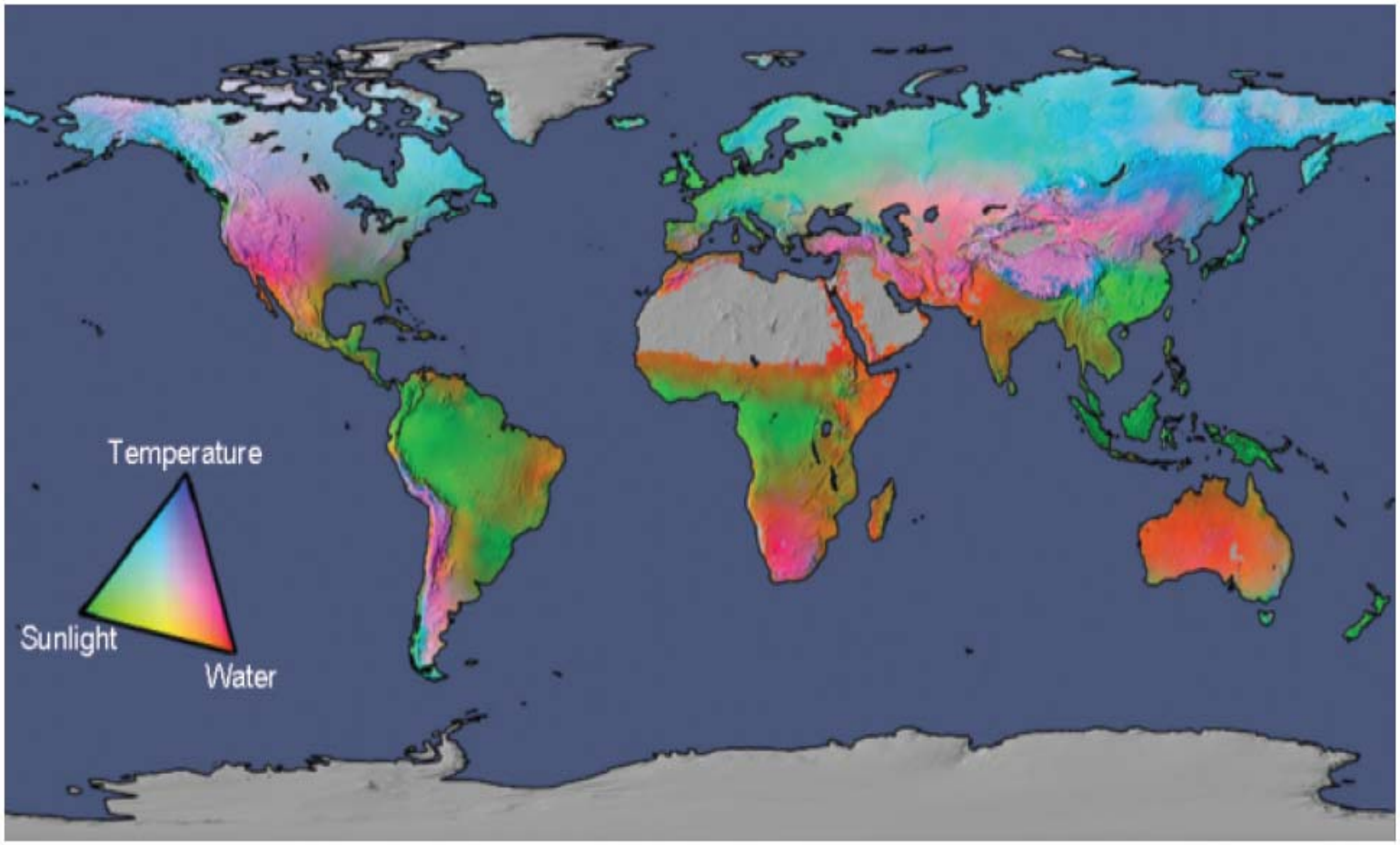
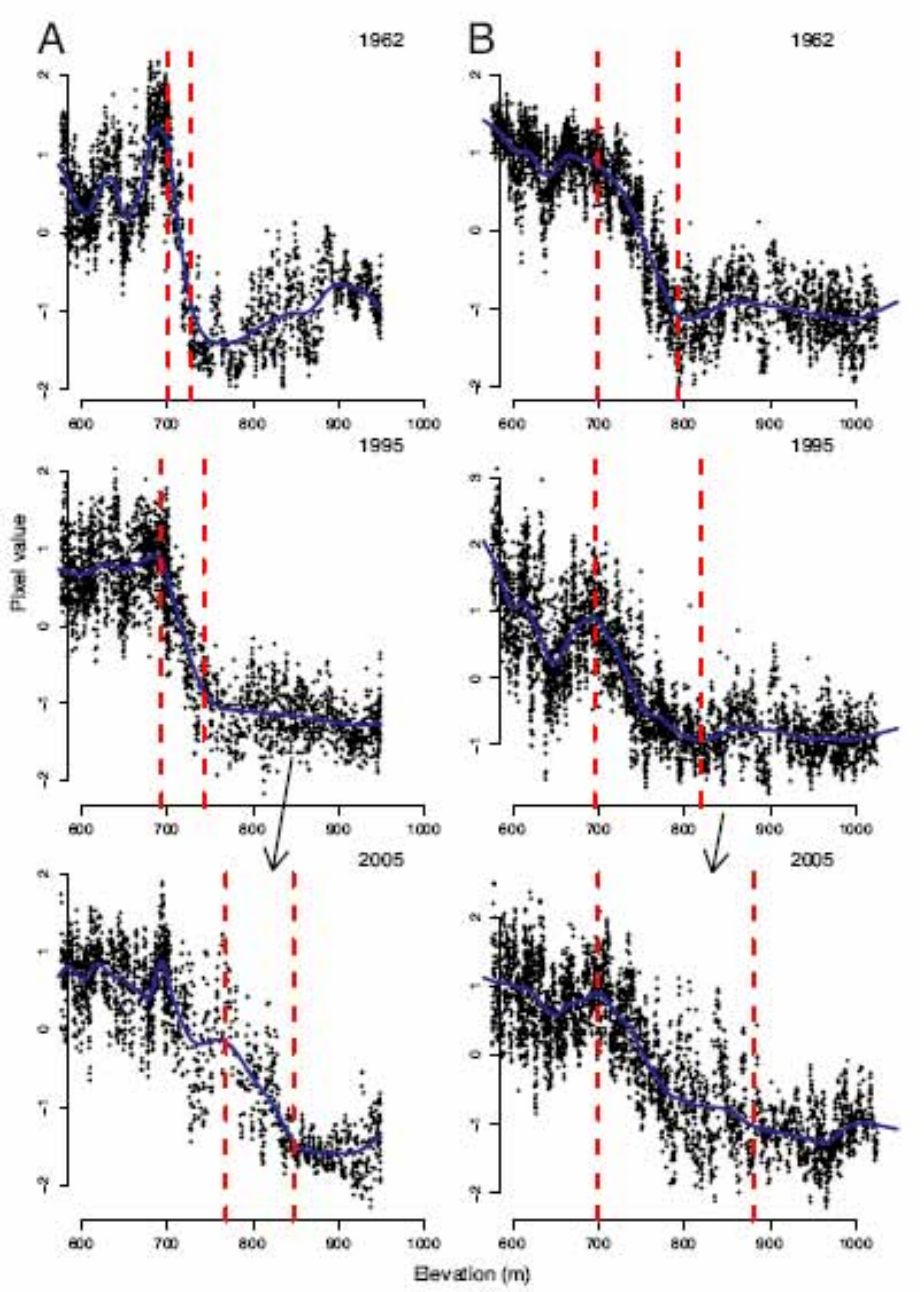


Fig. 1 Potential limits to vegetation net primary production based on fundamental physiological limits by vapor pressure deficit , water balance, and temperature (from Churkina & Running, 1998; Nemani *et al.*, 2003; Running *et al.*, 2004).

From Boisvenue and Running 2006

Examples of Ecological Changes

Upward Movement of Ecotones

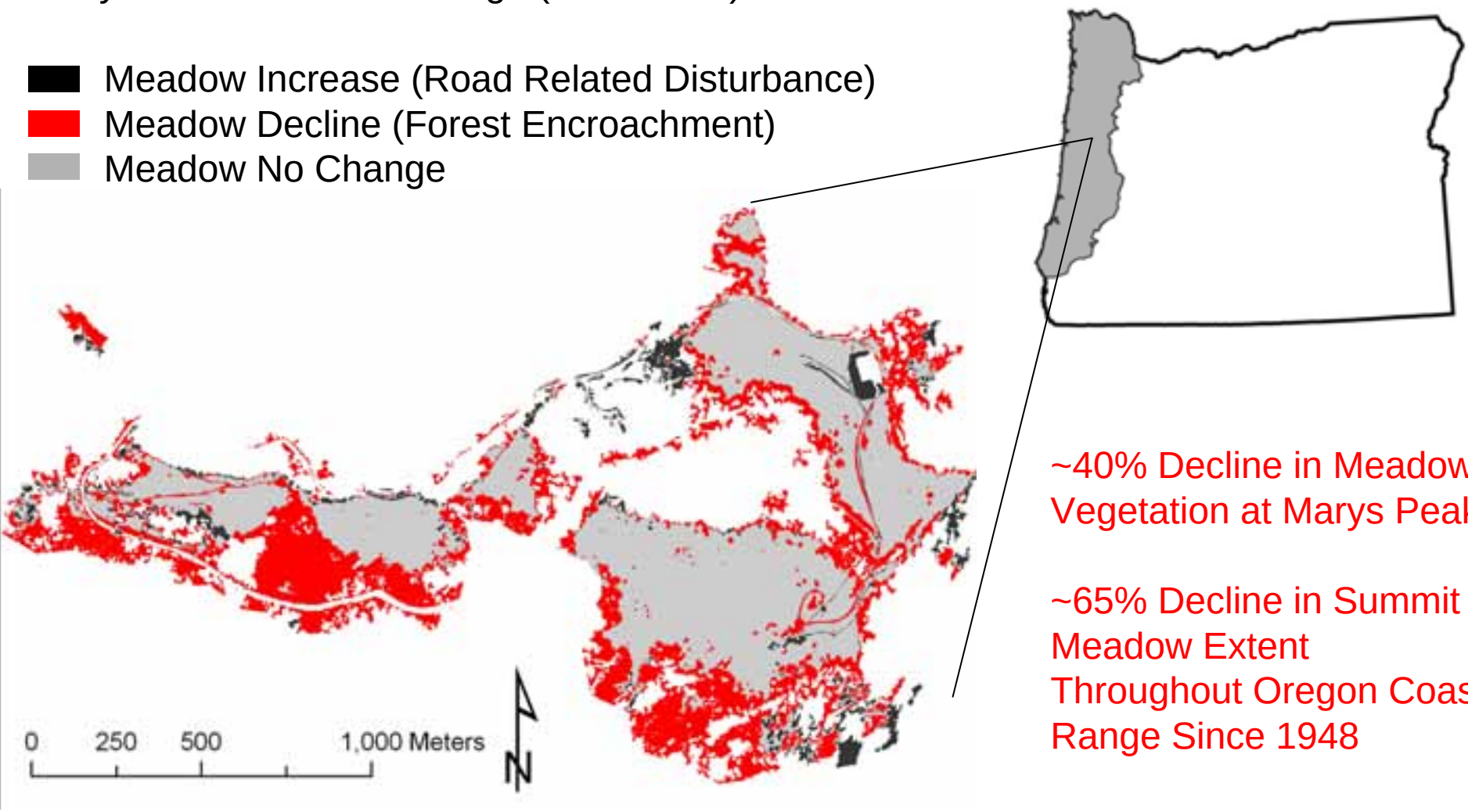


Shifts in Northern Hardwood/Boreal Forest Ecotone in Vermont

Beckage et al. 2008. *PNAS*

Decline of High Elevation Meadows in the Oregon Coast Range

Marys Peak Meadow Change (1948-1994)

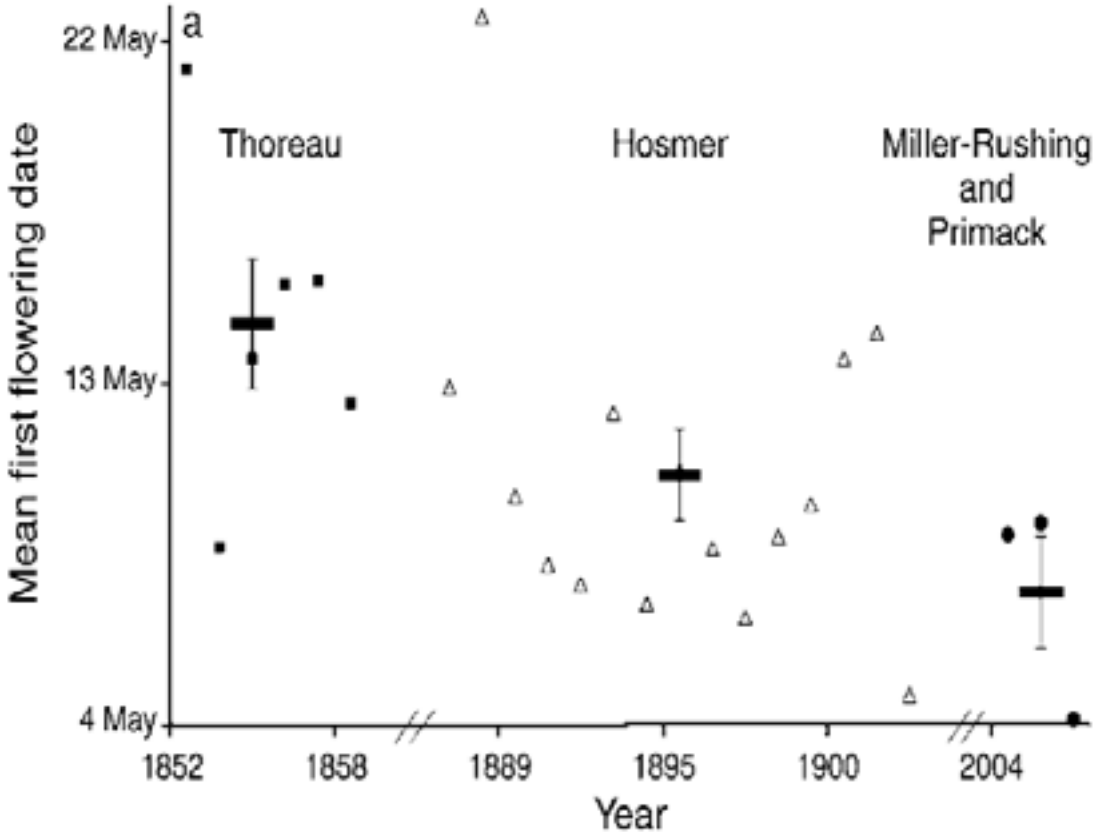


~40% Decline in Meadow Vegetation at Marys Peak

~65% Decline in Summit Meadow Extent Throughout Oregon Coast Range Since 1948

Zald (in revision) *Plant Ecology*

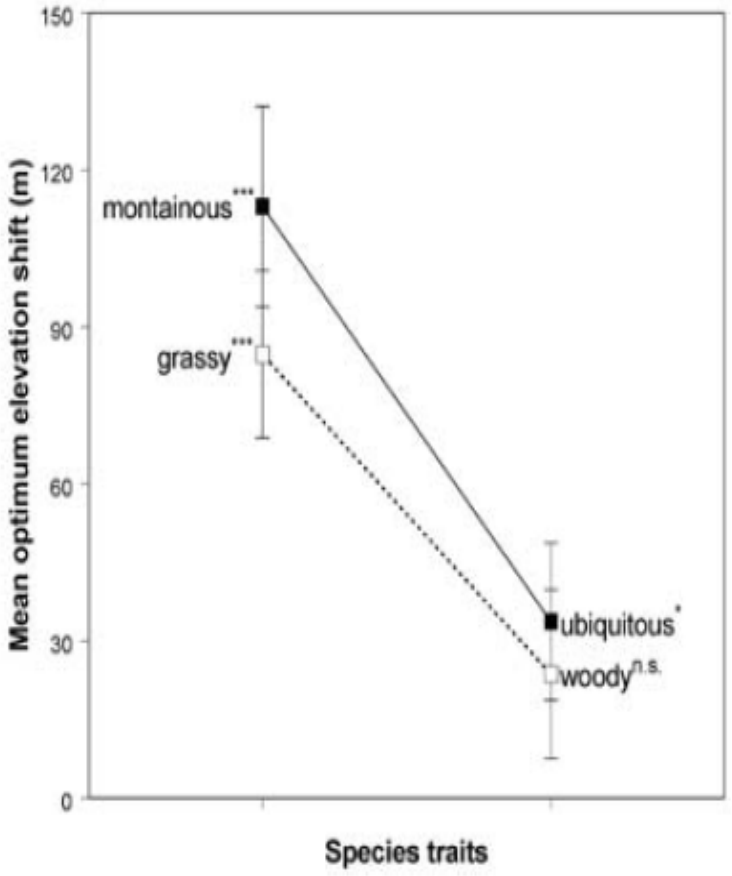
Flowering Times Become Earlier And Species that Don’t Change in Flowering Time may Disappear



Changes in mean first flowering dates for 43 plant species around Thoreau’s Concord, MA

Rushing and Primack 2008

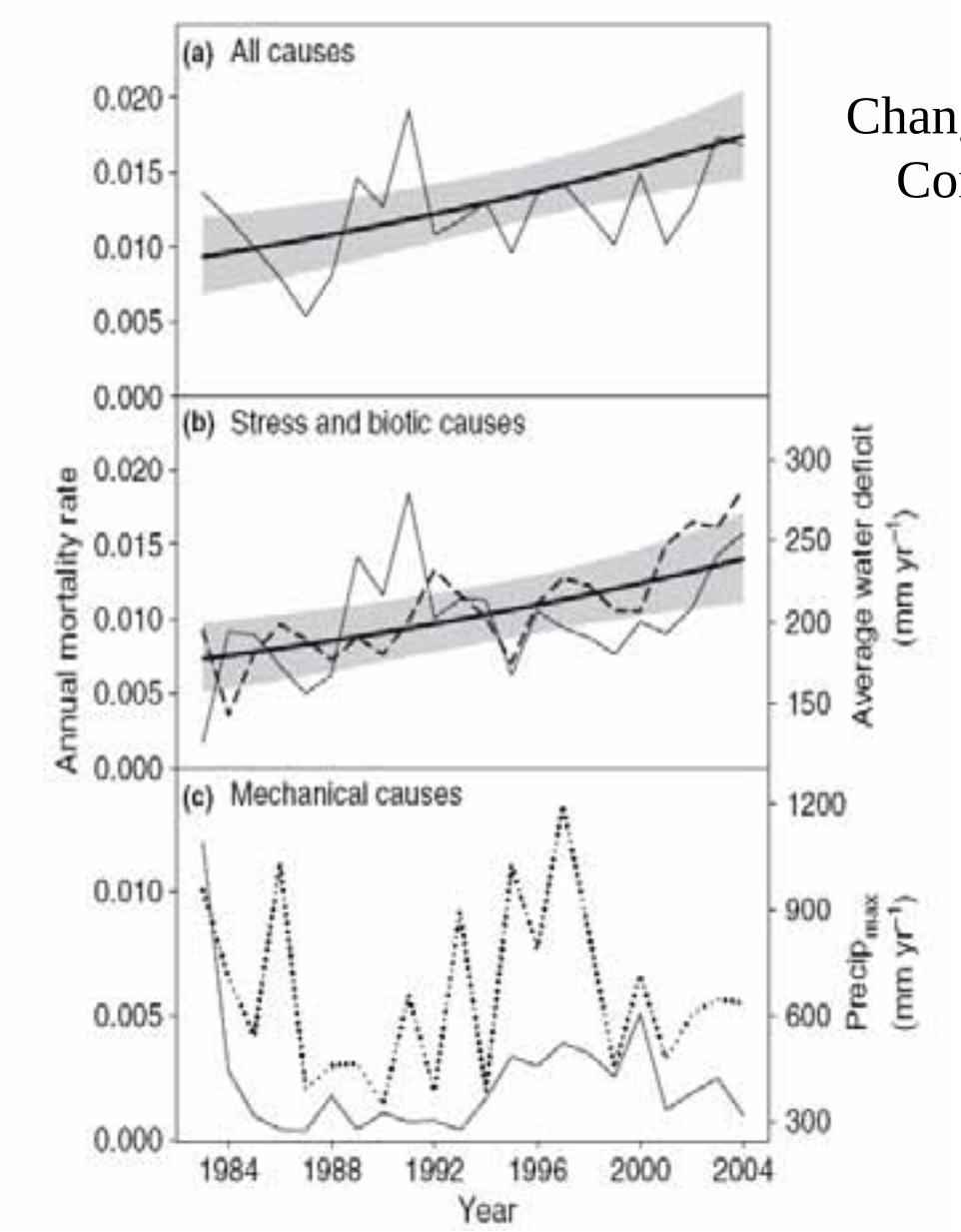
Shifts in Plant Species in Mountains Vary with Life History



Shifts for in Optimum Elevation
For Plant Species of French Alps
in relation to life history: 1905-2005

Lenoir et al. 2008

Increased Mortality Mature Forests from Stress and Biotic Causes



Changes in Tree Mortality in Old-growth Conifer Forests in the Sierra Nevada
From Stephenson et al. 2007

Interactions of Climate and Disturbance: Mountain Pine Beetle Outbreak

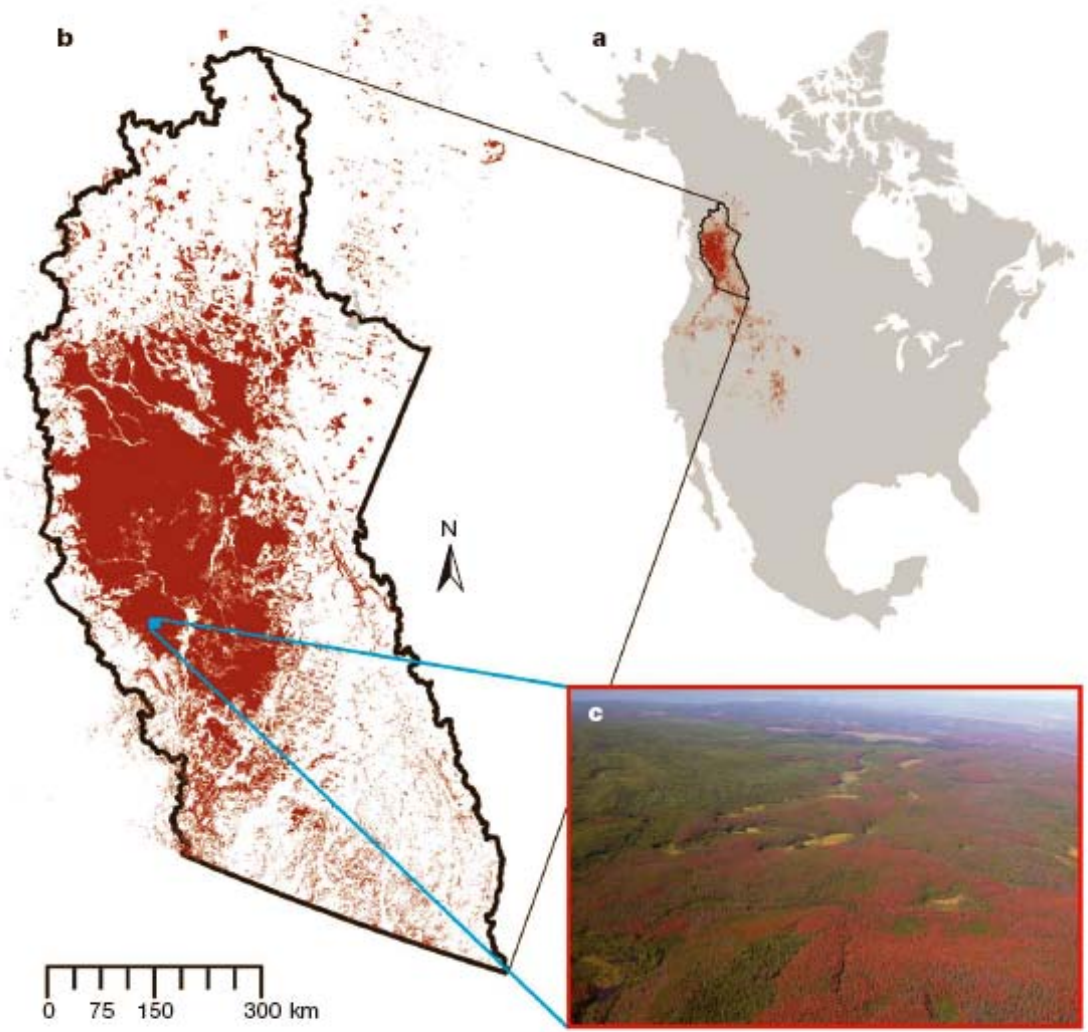
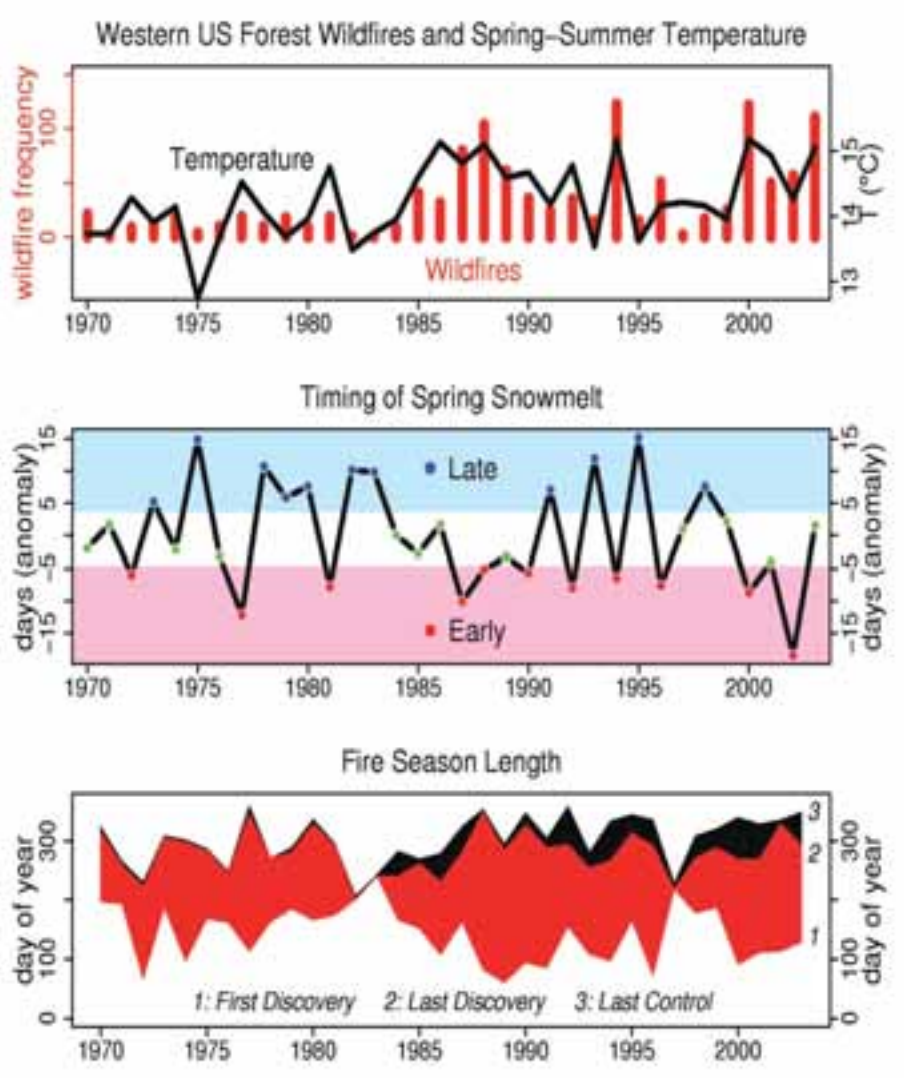


Figure 1| Geographic extent of mountain pine beetle outbreak in North America. **a**, Extent (dark red) of mountain pine beetle. **b**, The study area includes 98% of the current outbreak area. **c**, A photograph taken in 2006 showing an example of recent mortality: pine trees turn red in the first year after beetle kill, and grey in subsequent years. Photo credit: Joan Westfall, Entopath Management Ltd.

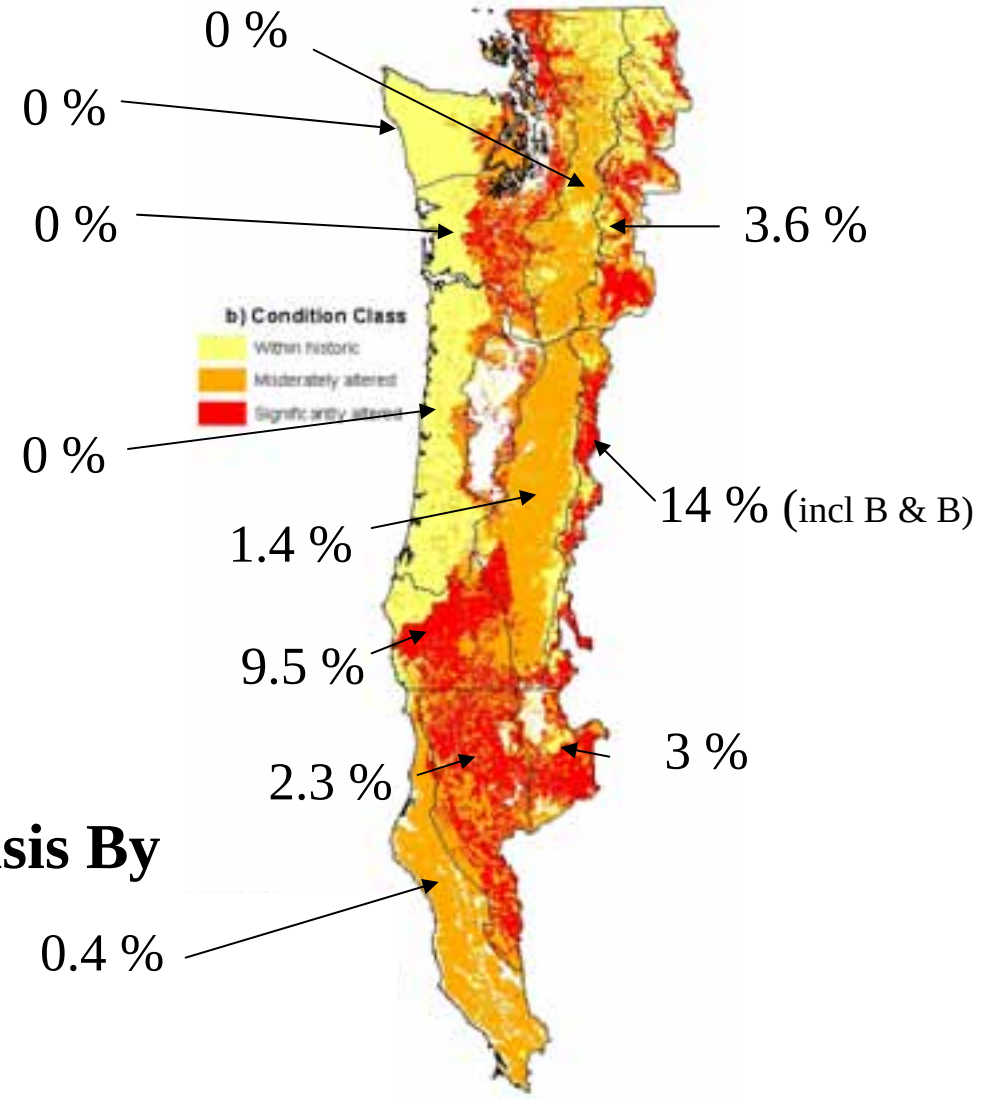
Kurz et al. 2008. *Nature*

Increasing Occurrence of Wildfires in Western US



Westerling et. al. 2006

Monitoring Old Forest Loss to Wildfire 1993-2003



Percent Loss of Older Forest on a Decadal Basis By Province

Moeur and Spies et al. 2005

Potential Changes in Western Oregon

- Tree lines move upward, loss of subalpine meadows
- More fire, especially southern areas and valley margins
- Earlier flowering and leaf out
- Higher stress/mortality on dry sites
- Species range shifts upwards and northwards
- More insect and disease occurrence
- Higher productivity on relatively moist sites

Implications to Conservation

- Change—good or bad?
- Uncertainty—keep options open
- Complexity of responses—holistic/multi-scale perspective

Implications to Conservation

- Potential vegetation types and historical range of variation (coarse filter approaches) less useful
- Monitoring--targeted
- Manage to increase resistance/resilience
  - Density management
  - Assisted colonization
- Integrated approaches are necessary