



Climate Change, Uncertainty and Forecasts of Global to Landscape Ecosystem Dynamics



Ronald P. Neilson

USDA Forest Service

Pacific Northwest Research Station

Corvallis, OR, USA



Climate Change, Uncertainty and Forecasts of Global to Landscape Ecosystem Dynamics



Contributions From:

Geoff Blate, U.S. EPA

Linda Joyce, RMRS, USFS

Connie Millar, PSW, USFS

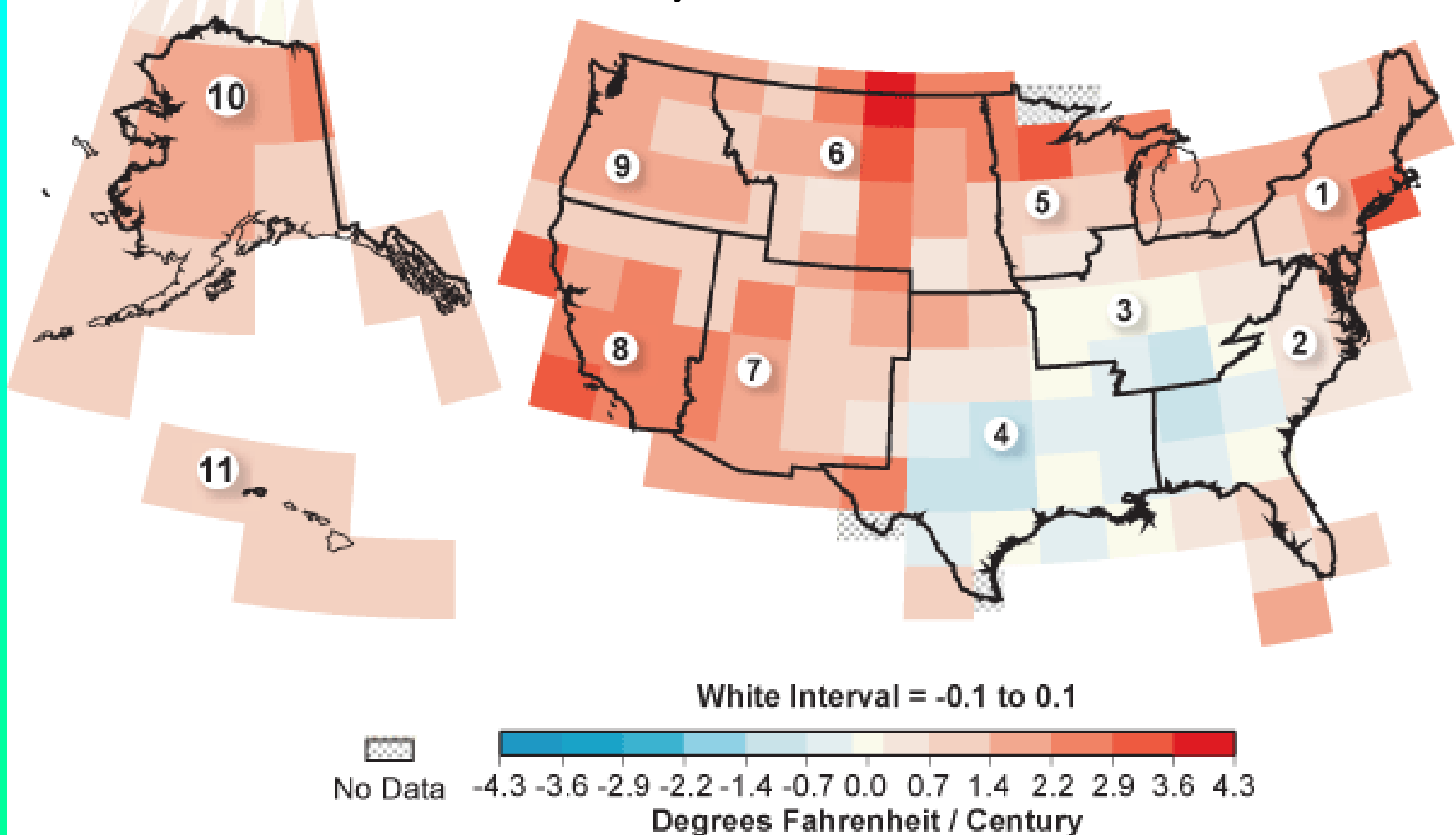
Future Climate

Managing for Change with Uncertainty

- Hierarchical Assessment
 - Global to Local Scales
 - Near to Long Term Scales
 - Natural Climate Variability – Near term Variability vs. Long term trends
 - Historical Management Legacy – e.g., Fire Suppression
- Natural Resources and Issues of Concern
 - Biodiversity – Vegetation Type and Species Distribution
 - Global Carbon Balance – Sources and Sinks, Forest Productivity
 - Catastrophic Disturbance, e.g. Fire and Infestation
- Management *Of* Change, per se
 - Perpetual Uncertainty
 - Toolbox for Managers

Warming Trend Observed in Most of US

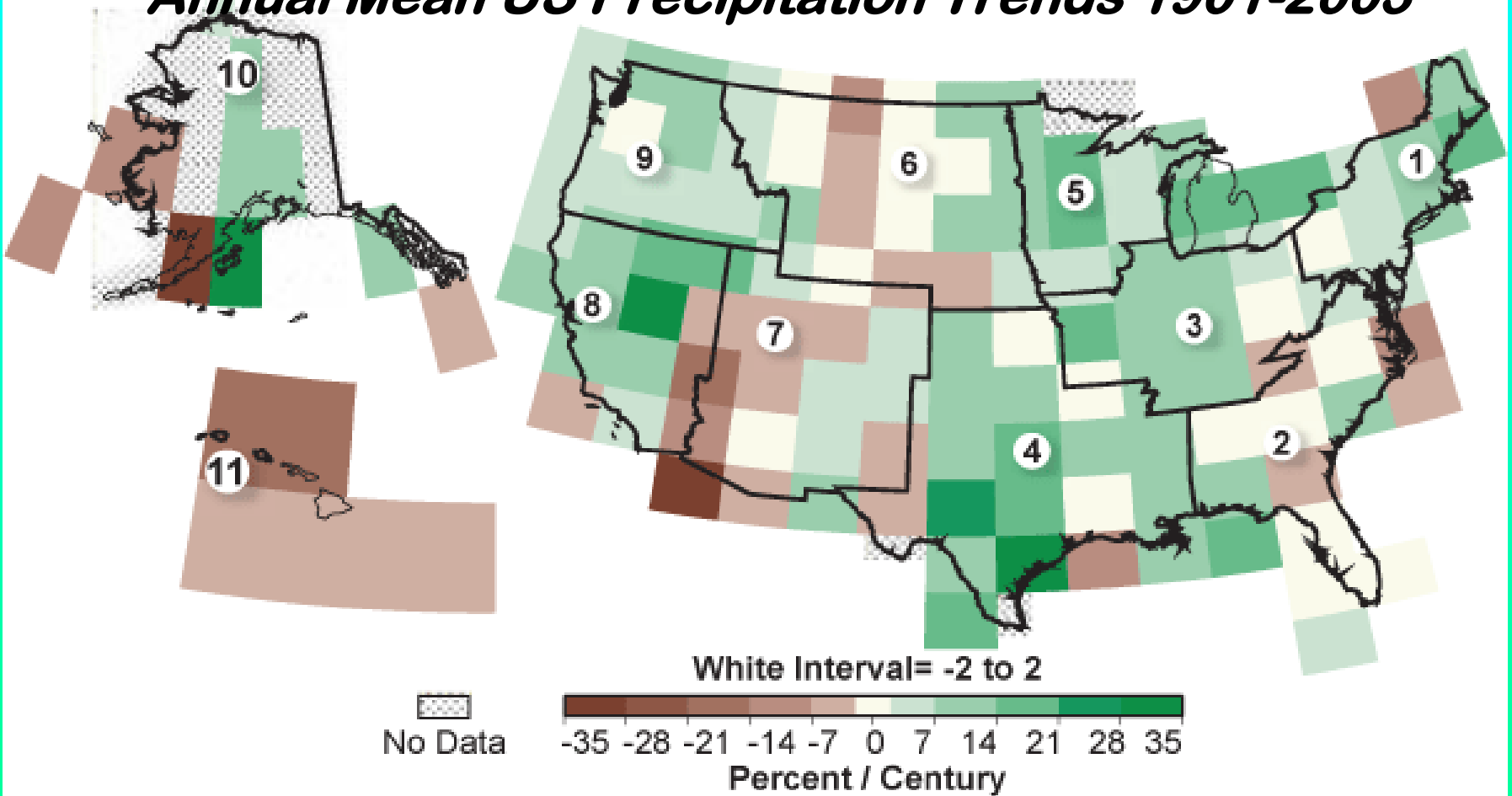
Annual Mean US Temperature Trends 1901-2003



Data from NOAA/NCDC; See: <http://www.epa.gov/climatechange/science/recenttc.html>

Precipitation Increases & Decreases depending on Region

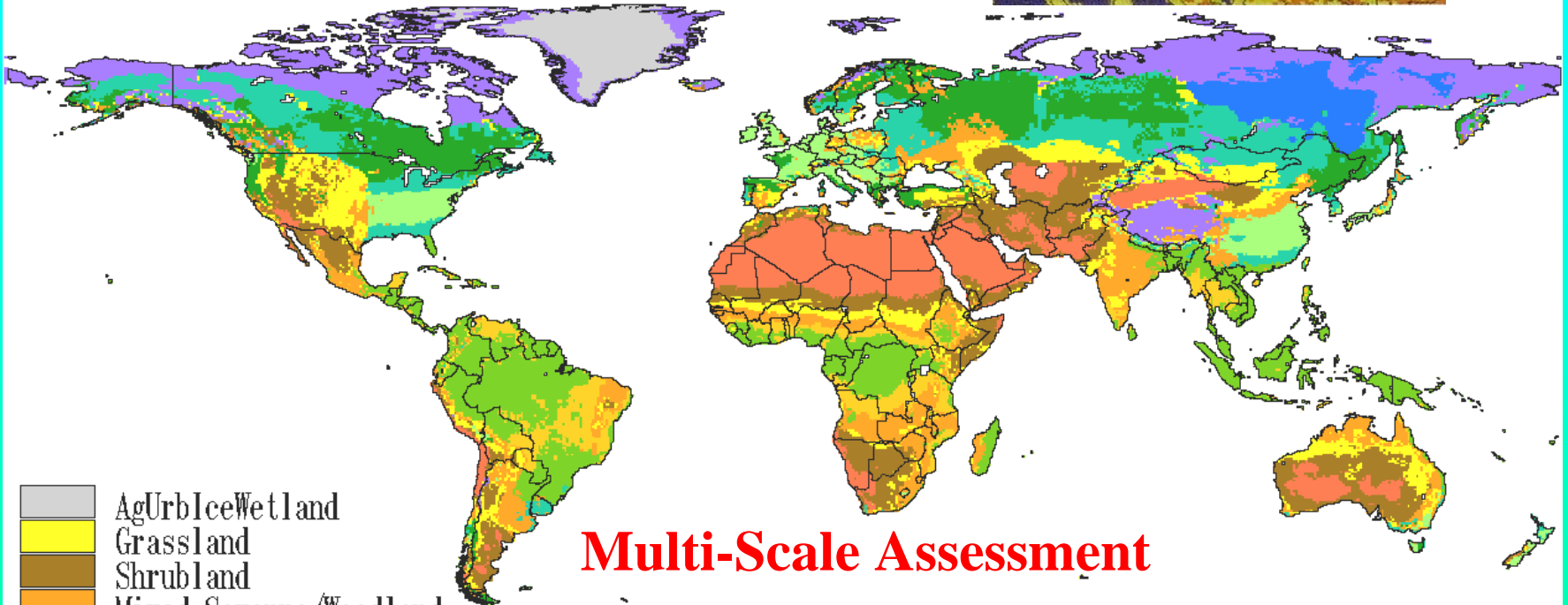
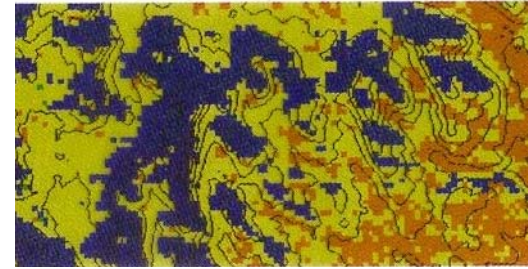
Annual Mean US Precipitation Trends 1901-2003



Simulated Historical Vegetation MC1 (MAPSS-CENTURY, v.1)

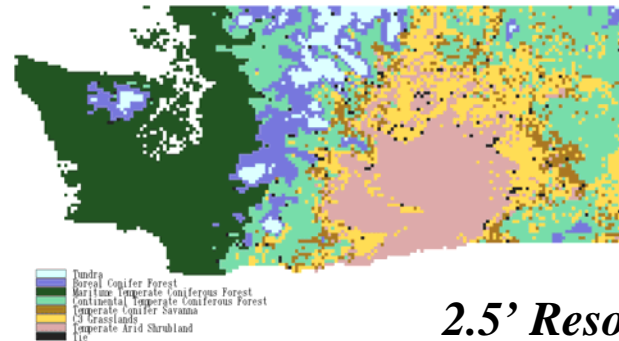
0.5° Resolution

50m Resolution



- AgUrbIceWetland
- Grassland
- Shrubland
- Mixed Savanna/Woodland
- Drought-Deciduous Woodland/Savanna
- Deciduous Broadleaf Forest
- Deciduous Needleleaf Forest
- Evergreen Broadleaf Forest
- Evergreen Needleleaf Forest
- Mixed Forest
- Desert
- Tundra

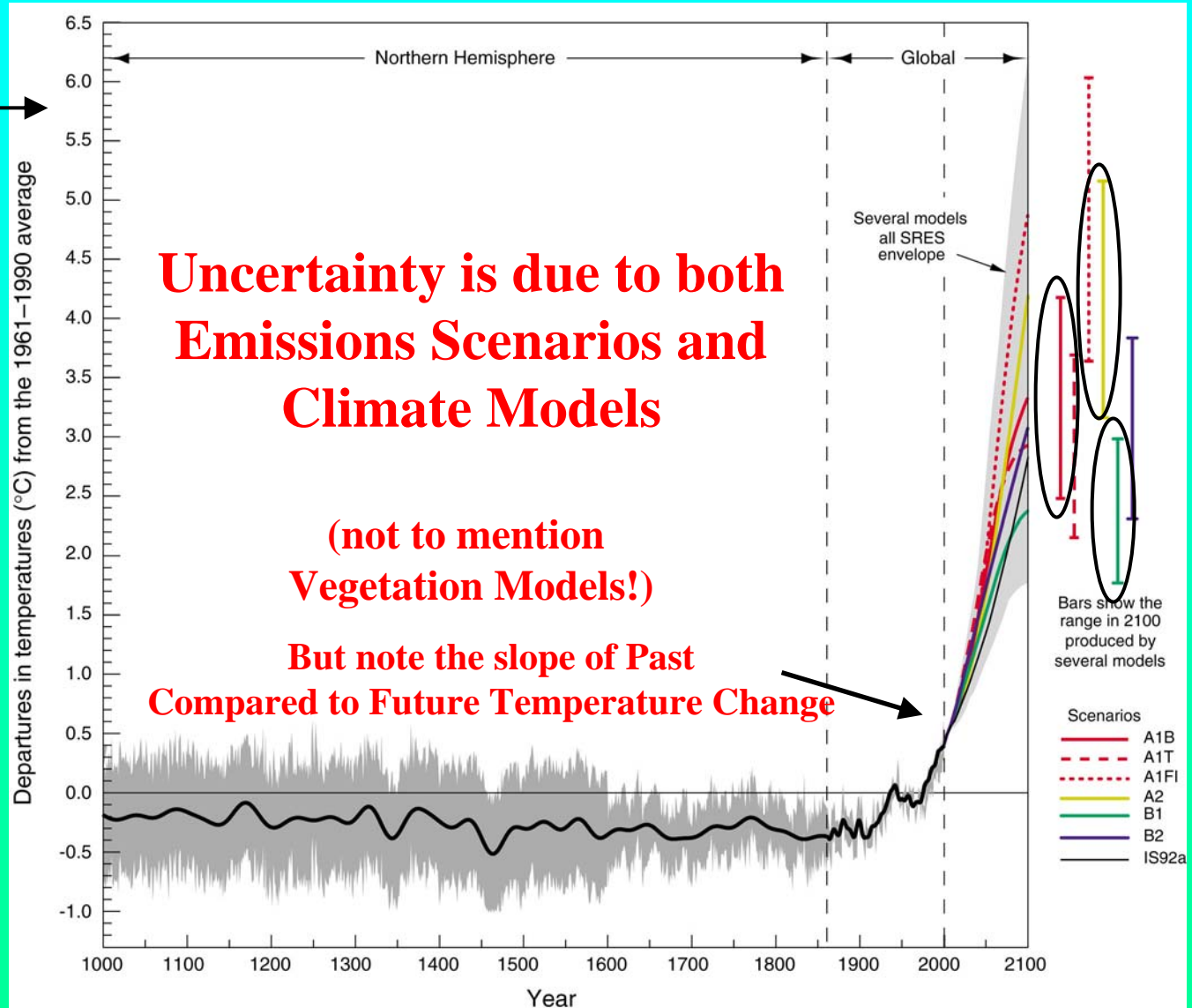
Multi-Scale Assessment



2.5' Resolution

Variations of the Earth's Surface Temperature: 1000 to 2100

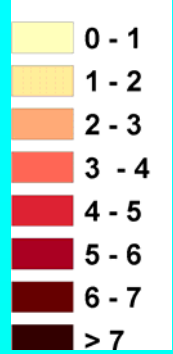
Similar to Glacial –
Interglacial
Temperature Change



- 1000 to 1861, N. Hemisphere, proxy data;
- 1861 to 2000 Global, Instrumental;
- 2000 to 2100, SRES projections

The Low End of Some Models Is as High as The High End of Other Models

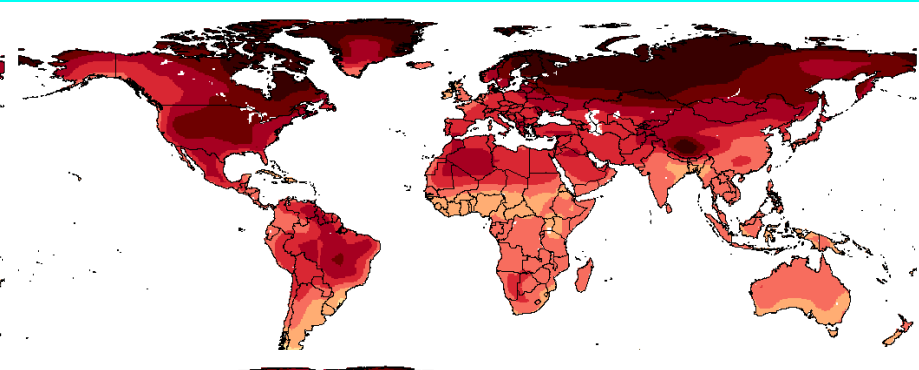
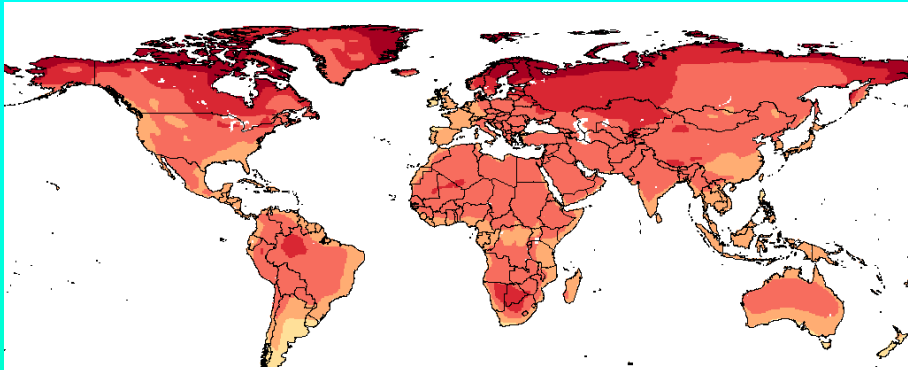
Temperature difference:
2070-2099 vs. 1961-1990



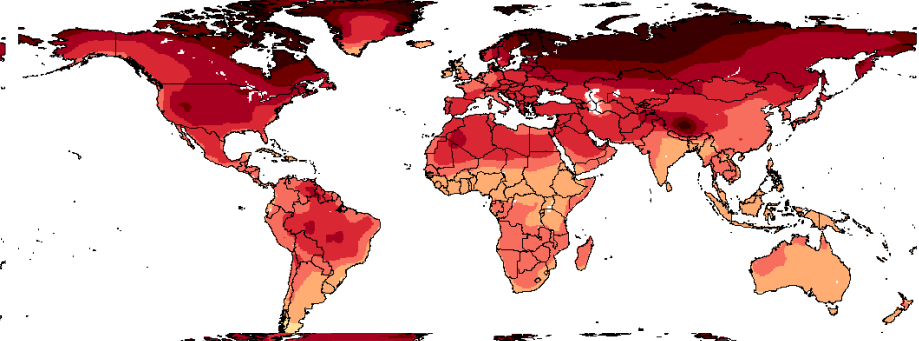
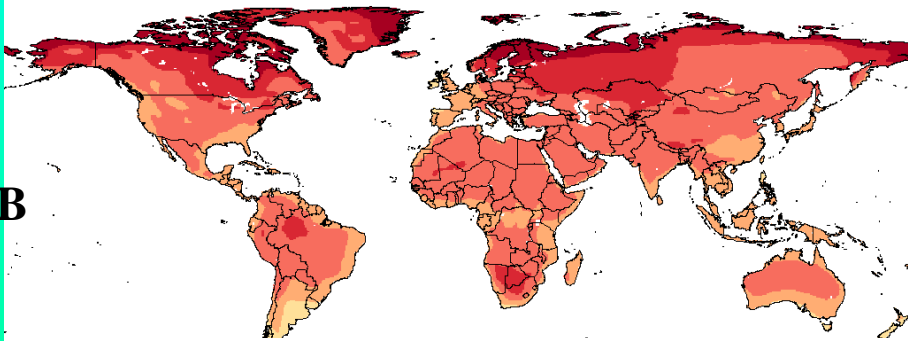
CSIRO MK3

MIROC MEDRES

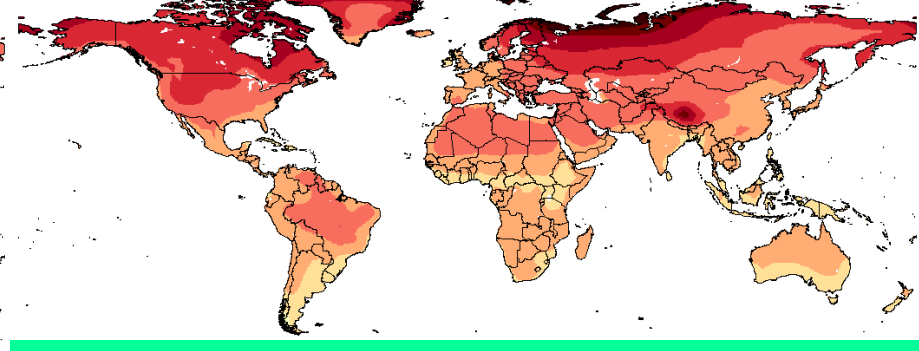
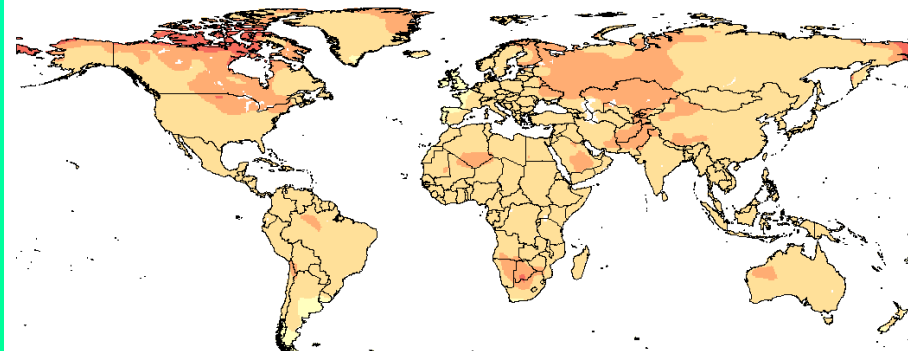
A2



A1B



B1



The Uncertainties are Often Greater Between Climate Models Than between Emissions Scenarios!

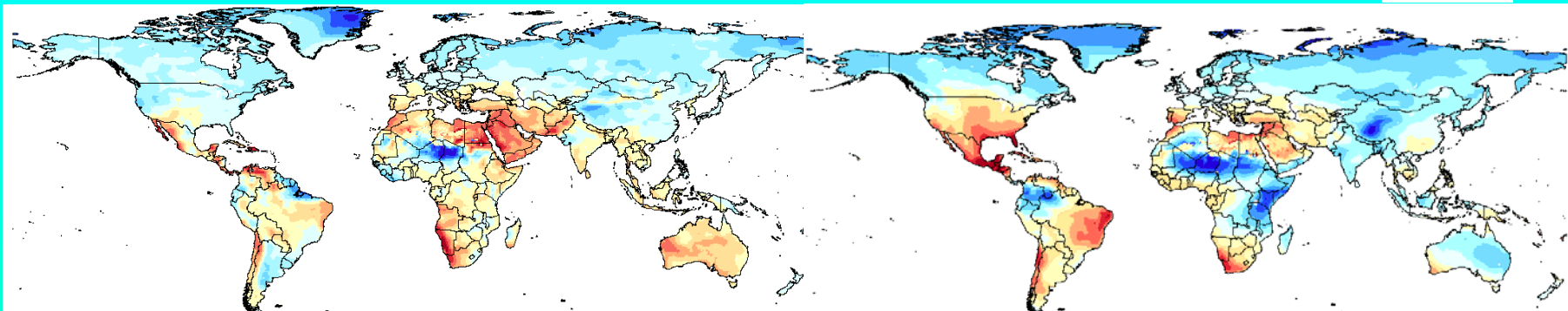
Percent Change Precipitation:
2070-2099 vs. 1961-1990



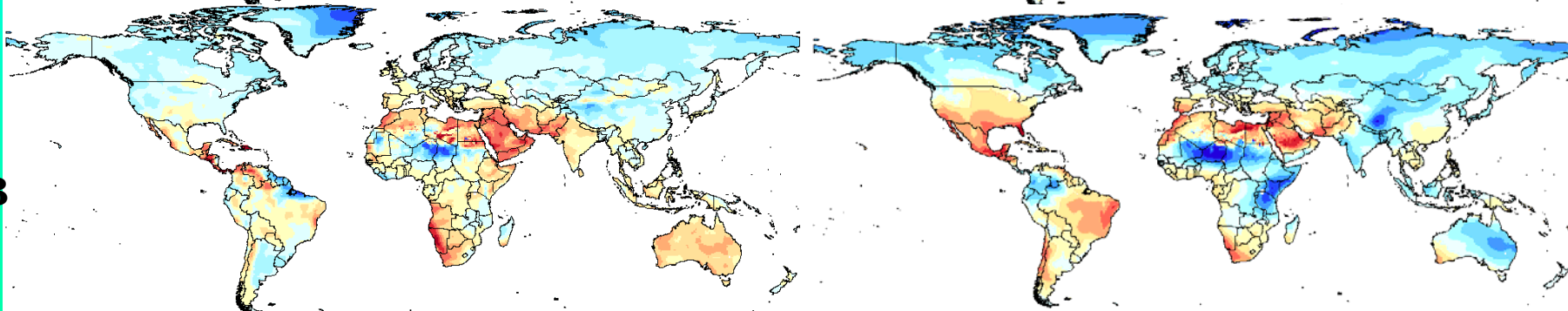
CSIRO MK3

MIROC MEDRES

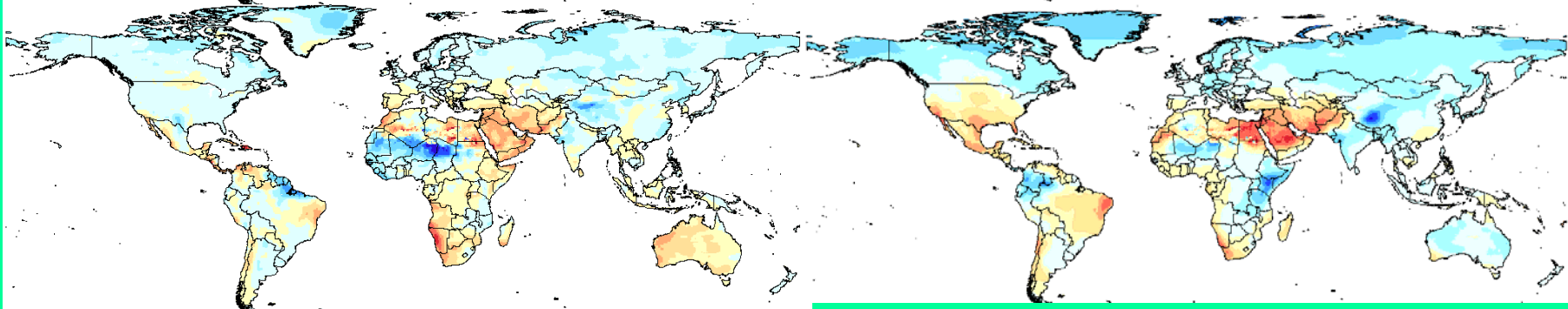
A2



A1B



B1

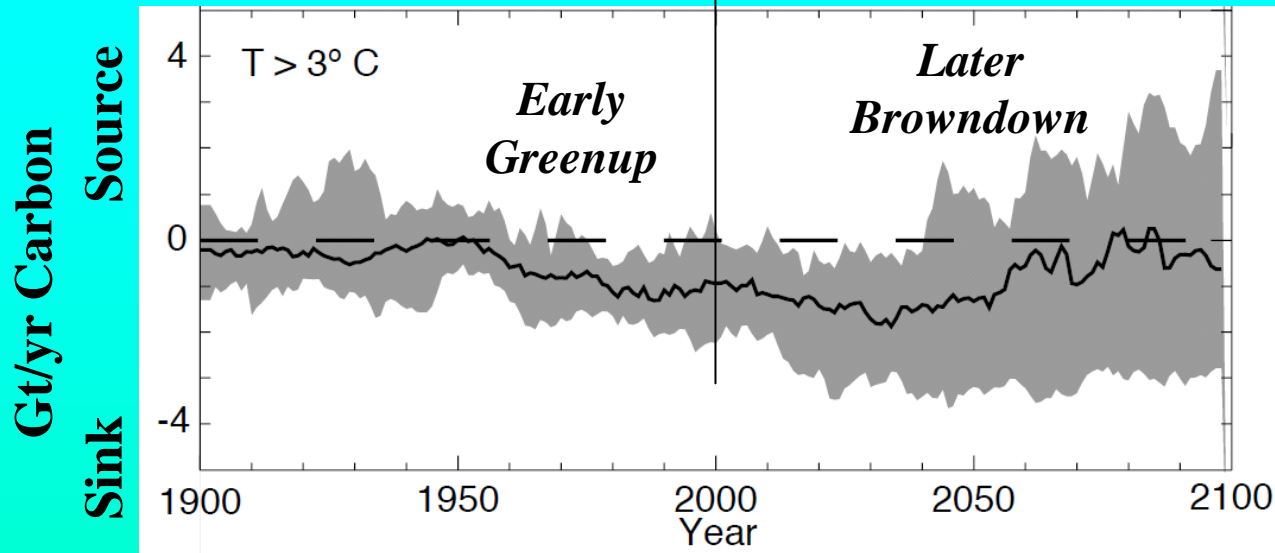


Future Climate Managing for Change with Uncertainty

Global Assessments

A climate change risk analysis for world ecosystems

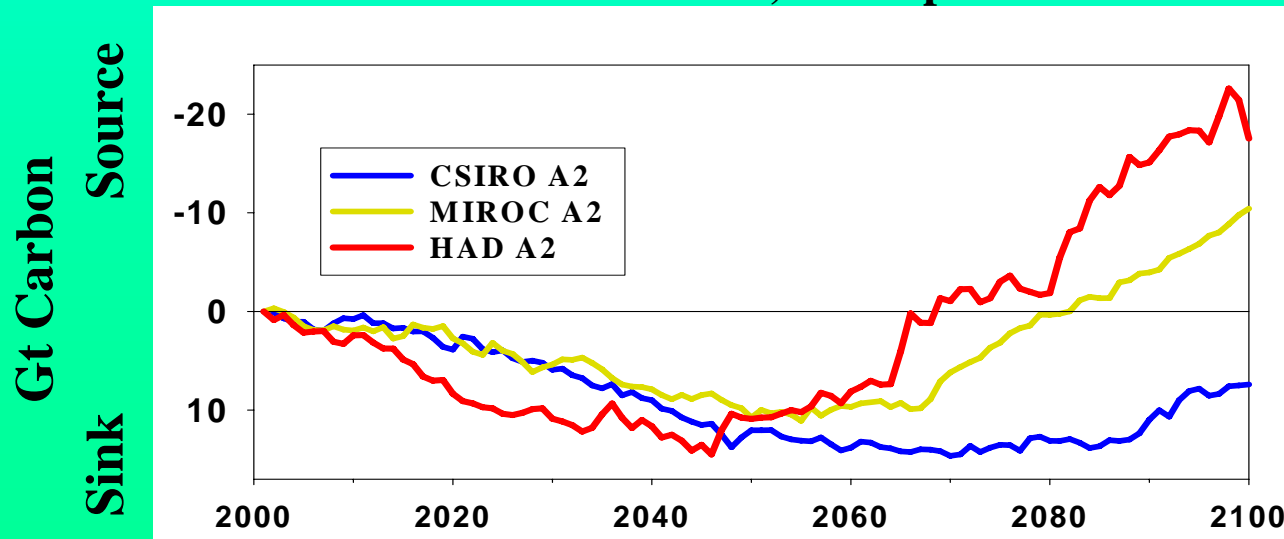
Scholze et al. 2006. Proc. Natl. Acad. Sci.



LPJ DGVM
16 Climate
Scenarios

Global Simulated Ecosystem Carbon Change (Pg)

MAPSS Team, In Prep.

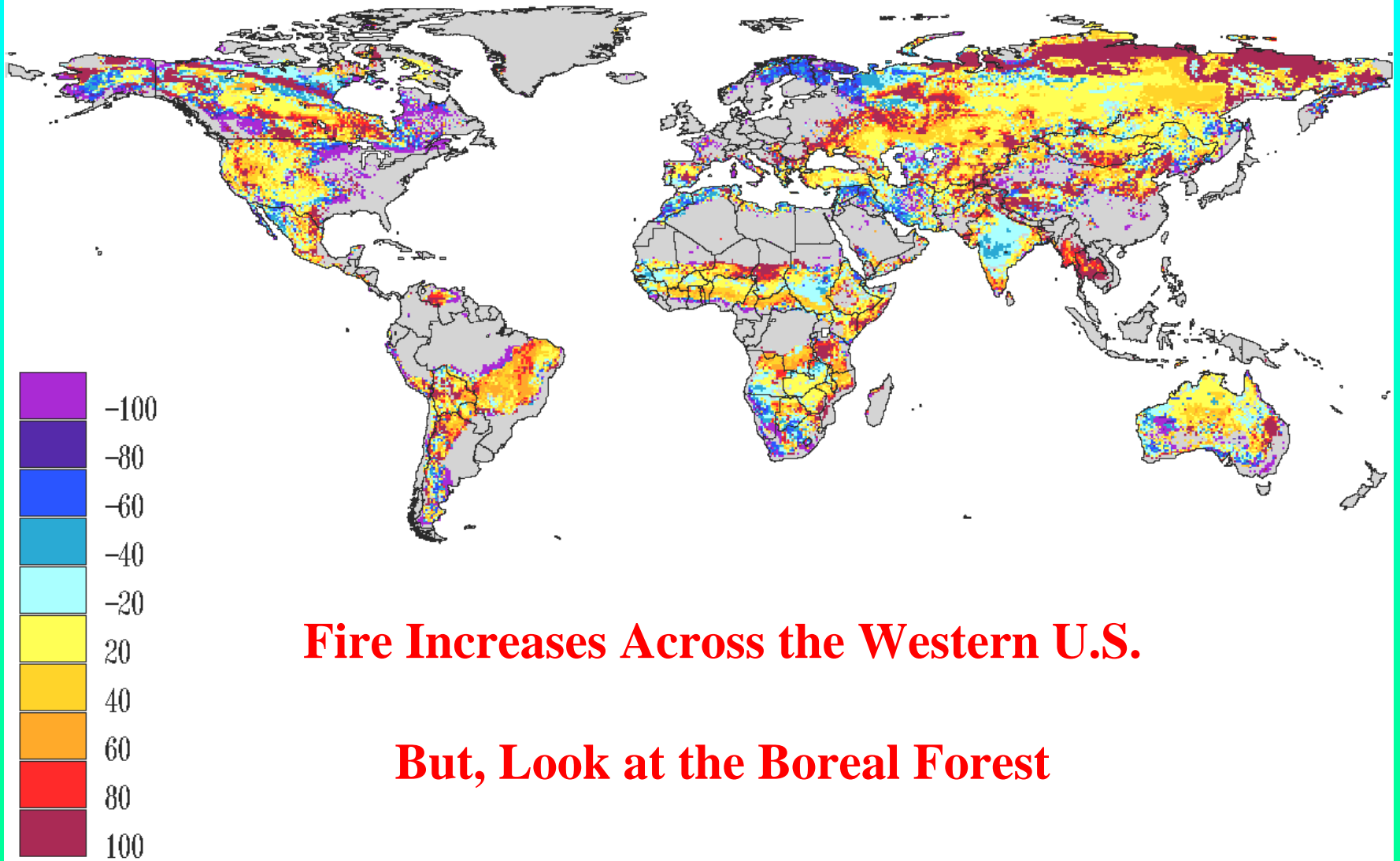


MC1 DGVM
3 Climate
Scenarios

Percent Change in Biomass Burned

MAPSS Team, In Prep.

CSIRO_MK3 A2



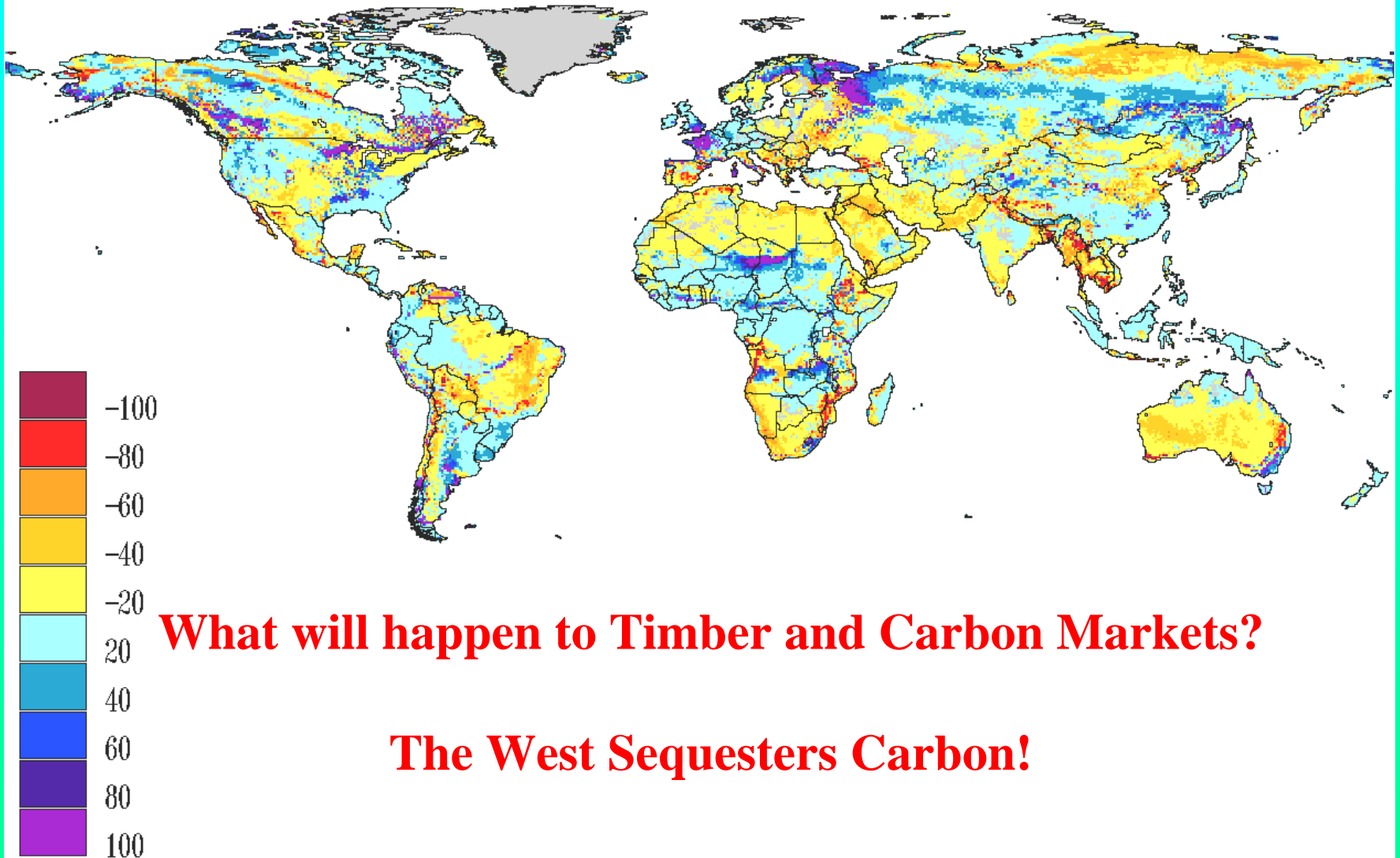
Fire Increases Across the Western U.S.

But, Look at the Boreal Forest

Percent Change in Total Ecosystem Carbon

MAPSS Team, In Prep.

CSIRO_MK3 A2



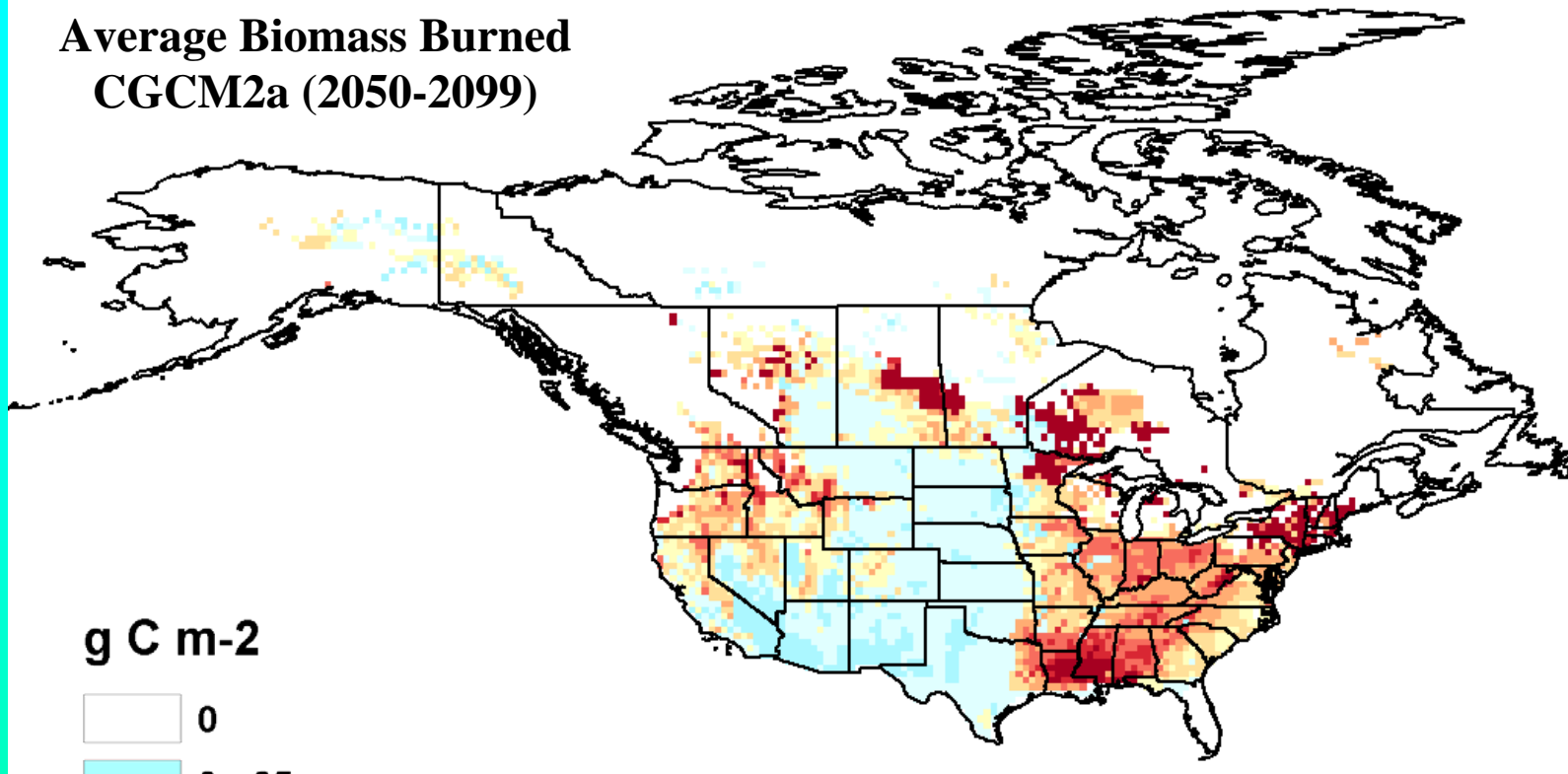
What will happen to Timber and Carbon Markets?

The West Sequesters Carbon!

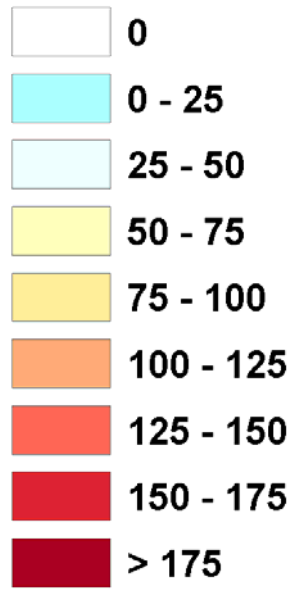
Future Climate Managing for Change with Uncertainty

Regional Assessments

**Average Biomass Burned
CGCM2a (2050-2099)**



g C m⁻²



**In the Future
The West gets Woodier, and
It burns a lot more!...
But, look at the East!**

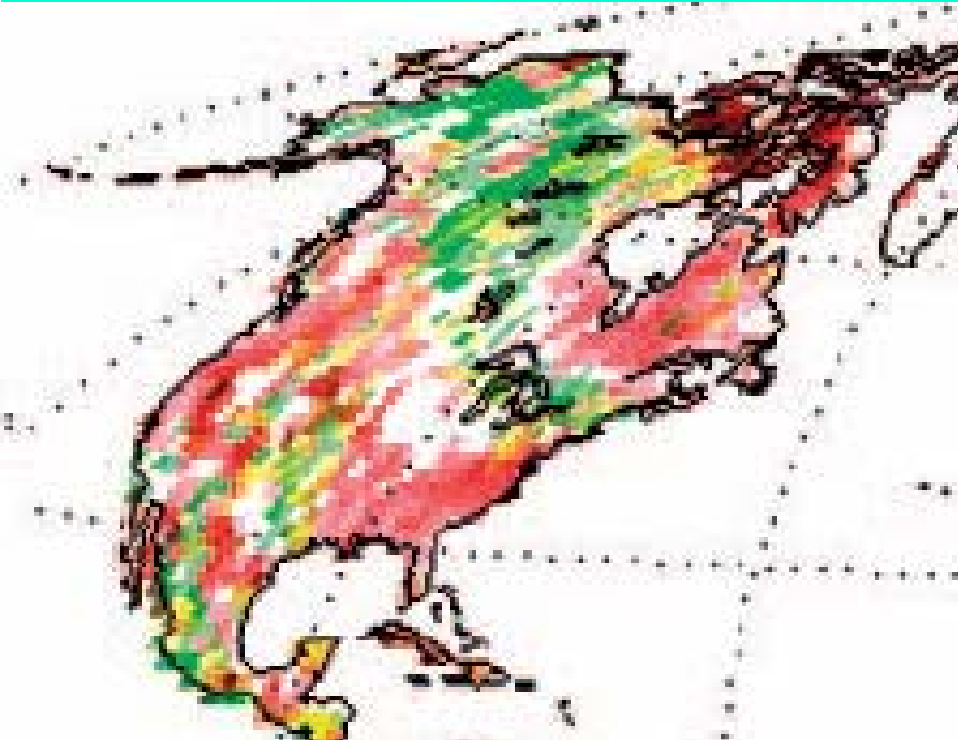
LPJ DGVM 16 Climate Scenarios

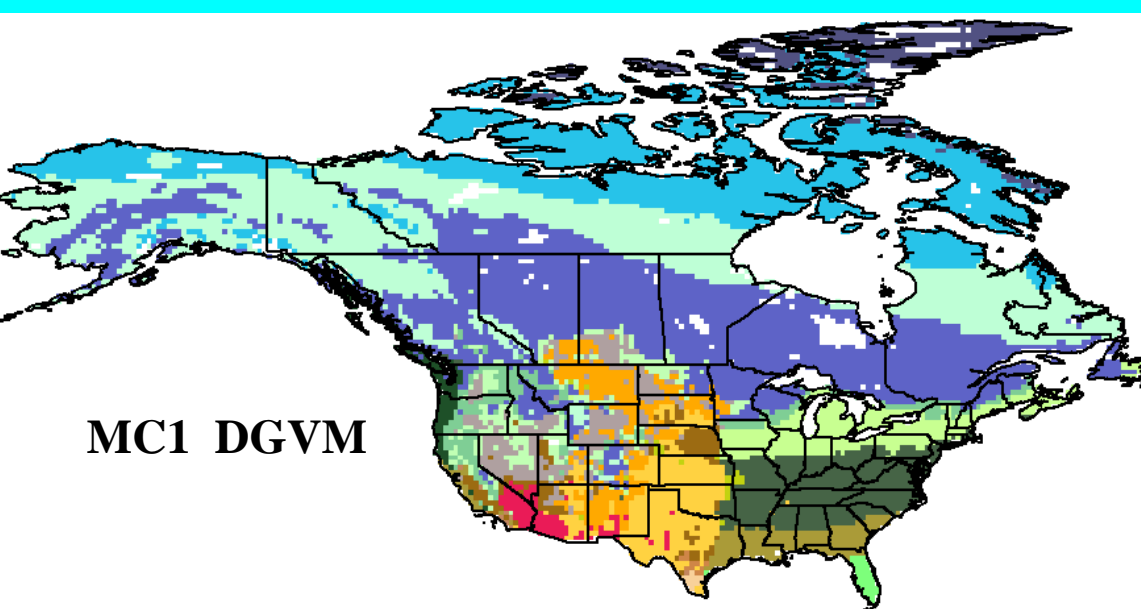
Areas that Exceed One
Standard Deviation
of 1961 – 1990

Red = - Runoff
Green = + Runoff

Red = + Fire
Green = - Fire

Scholze et al. 2006.
Proc. Natl. Acad. Sci.



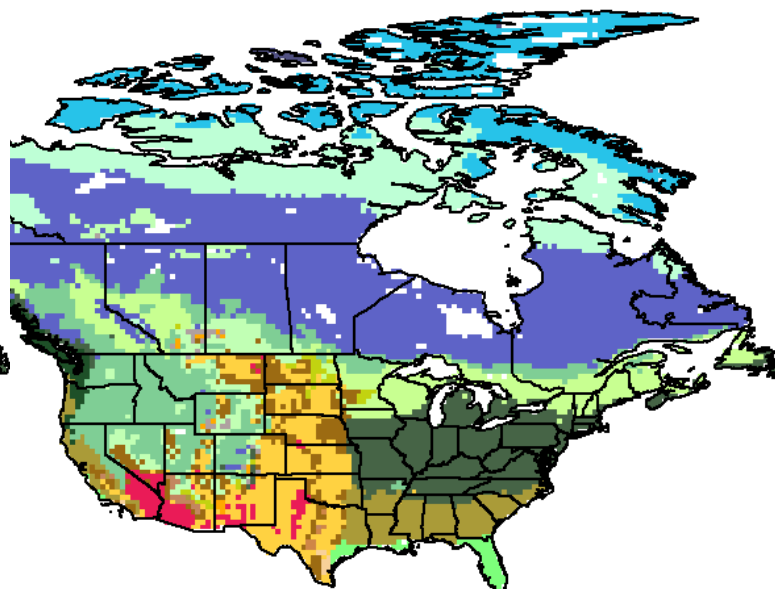
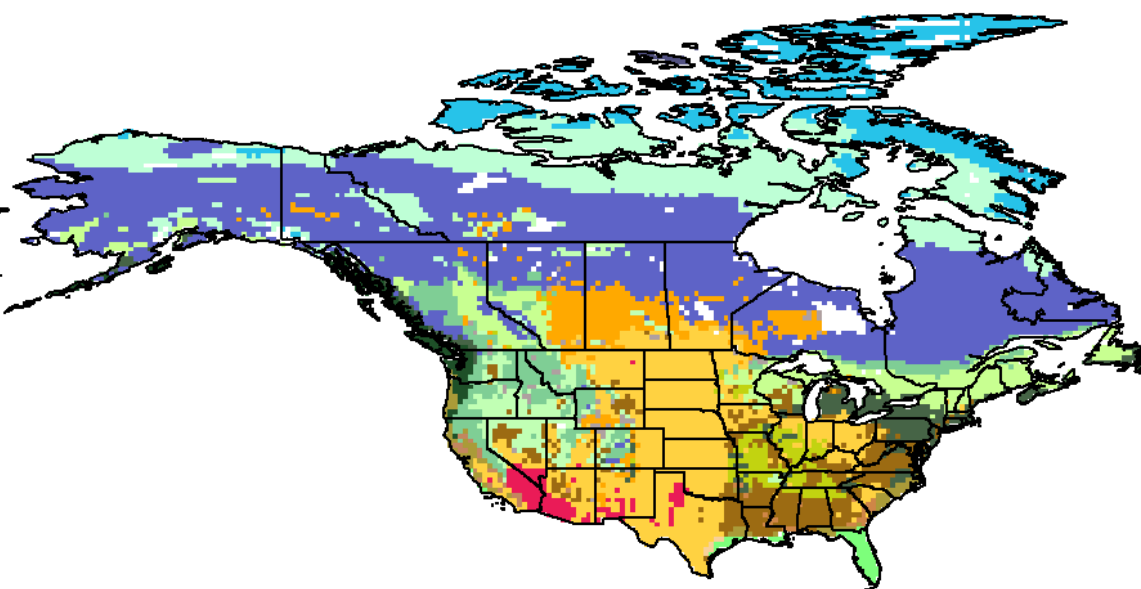


MC1 DGVM

**Current Vegetation (1961-1990)
Suppressed Fire**

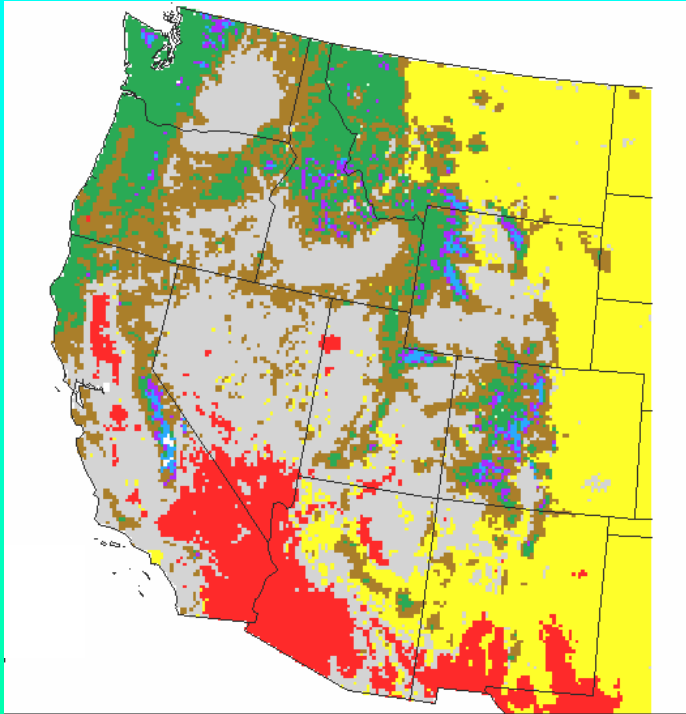
MAPSS Team, In Prep.

With Fire **CGCM2-A2 Scenario** **Suppressed Fire**

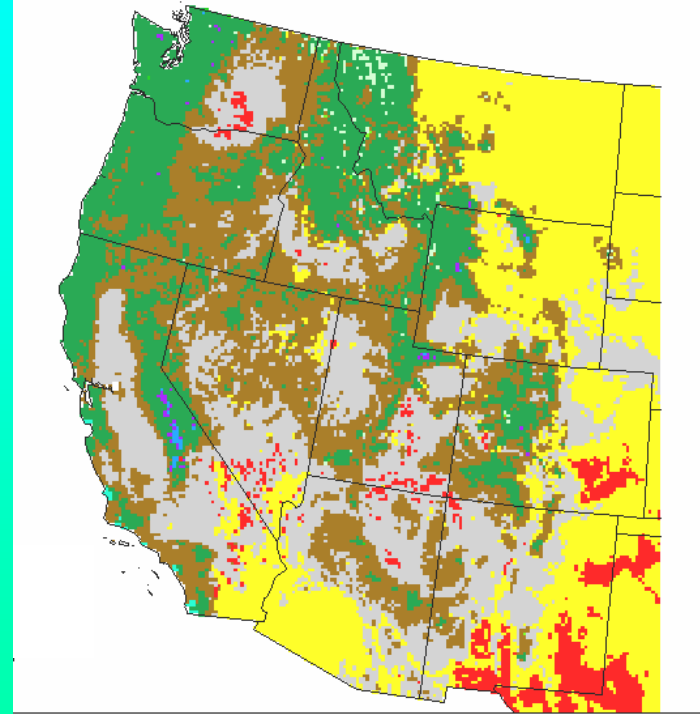


MAPSS Simulated Vegetation Distribution

Current Climate



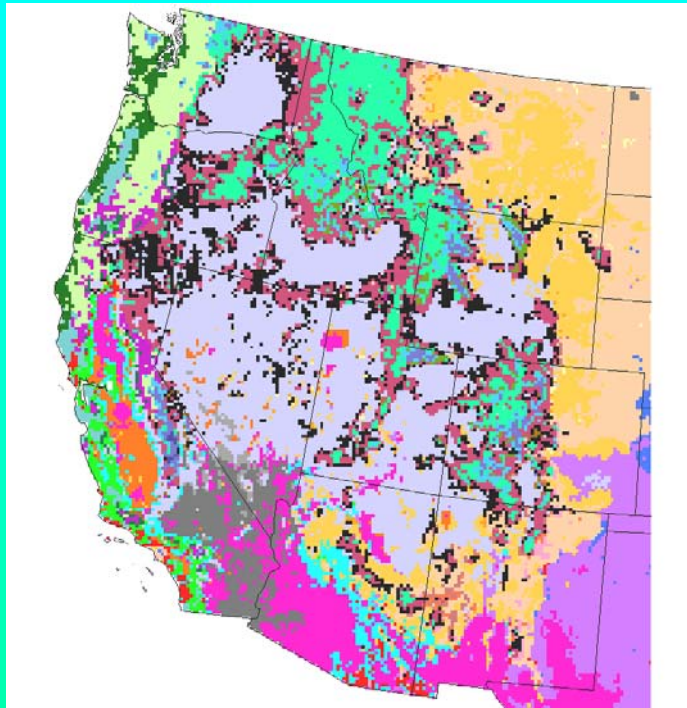
Future Climate
(CGCM1)



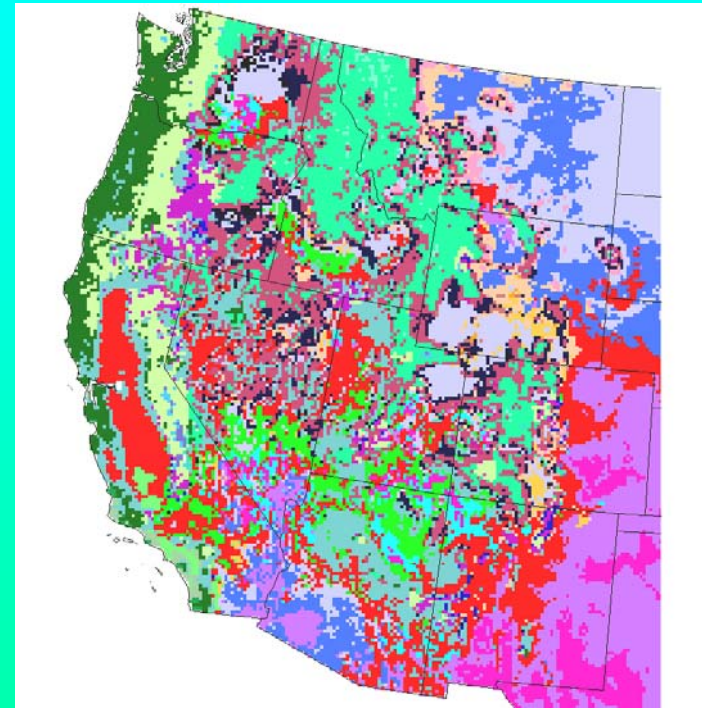
**Future Woody and Grass Expansion in the West
Enhance Carbon Storage, and
Catastrophic Wildfire, But...**

Changing Vegetation Community Diversity

Current Climate



Future Climate
(CGCM1)



Threshold Change – Migration Lags

Future Climate Managing for Change with Uncertainty

Local Assessments

THE RESPONSE OF VEGETATION
DISTRIBUTION, ECOSYSTEM
PRODUCTIVITY, AND FIRE IN CALIFORNIA
TO FUTURE CLIMATE SCENARIOS
SIMULATED BY THE MC1 DYNAMIC
VEGETATION MODEL

**A California Assessment
Requested by the Governor**

A Report From:
California Climate Change Center

Prepared By:
James M. Lenihan, Dominique Bachelet,
Raymond Drapek, and Ronald P. Neilson

DISCLAIMER

This report was prepared as the result of work sponsored by the California Energy Commission (Energy Commission) and the California Environmental Protection Agency (CalEPA). It does not necessarily represent the views of the Energy Commission, CalEPA, their employees, or the State of California. The Energy Commission, CalEPA, the State of California, their employees, contractors, and subcontractors make no warrant, express or implied, and assume no legal liability for the information in this report; nor does any party represent that the uses of this information will not infringe upon privately owned rights. This report has not been approved or disapproved by the California Energy Commission or CalEPA, nor has the California Energy Commission or CalEPA passed upon the accuracy or adequacy of the information in this report.

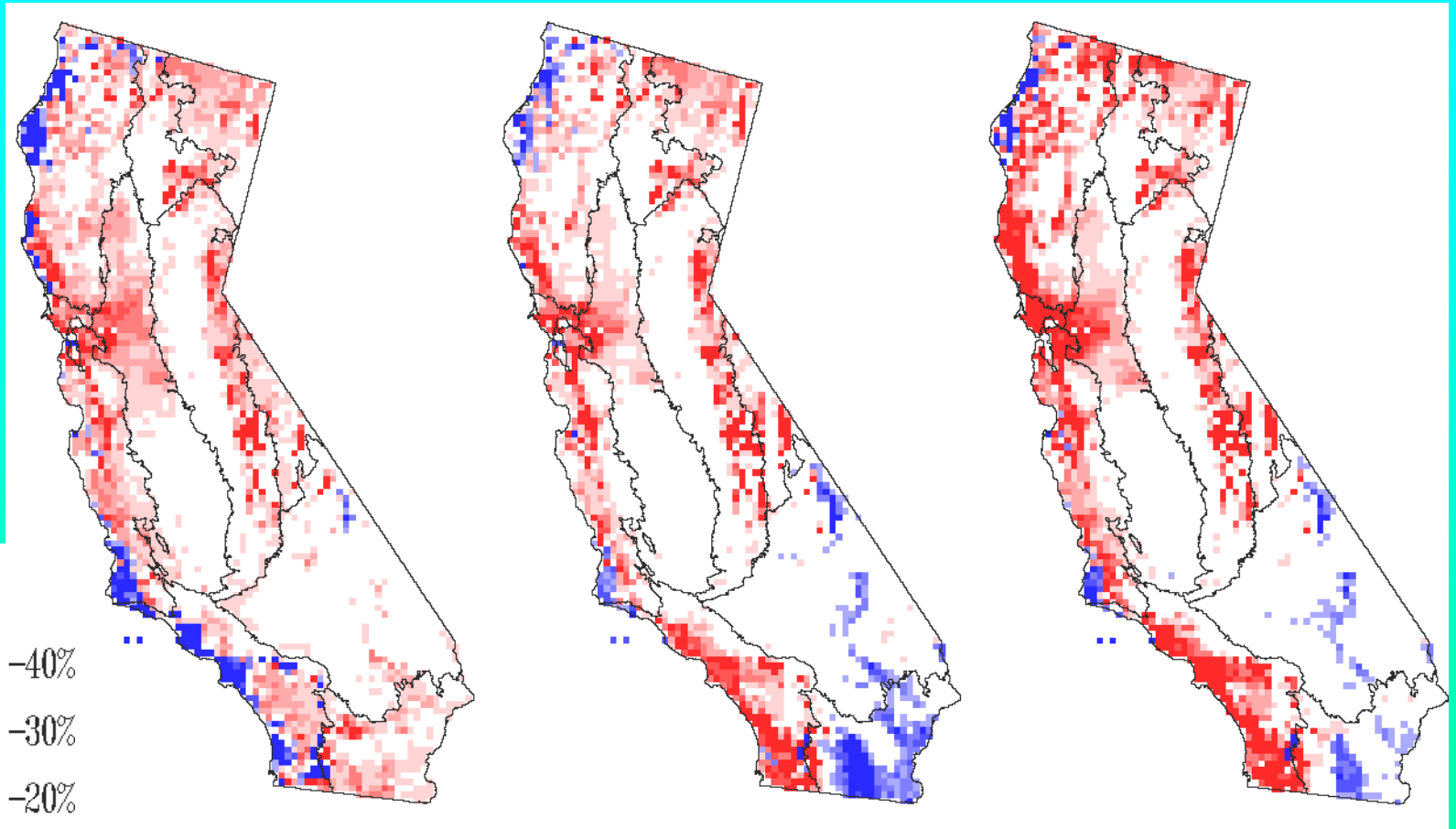


Arnold Schwarzenegger, Governor

WHITE PAPER

February 2008
CEC-500-2005-191-SF

Percent Change In Annual Area Burned (2050-2099), Compared To The 20th Century



PCM-A2

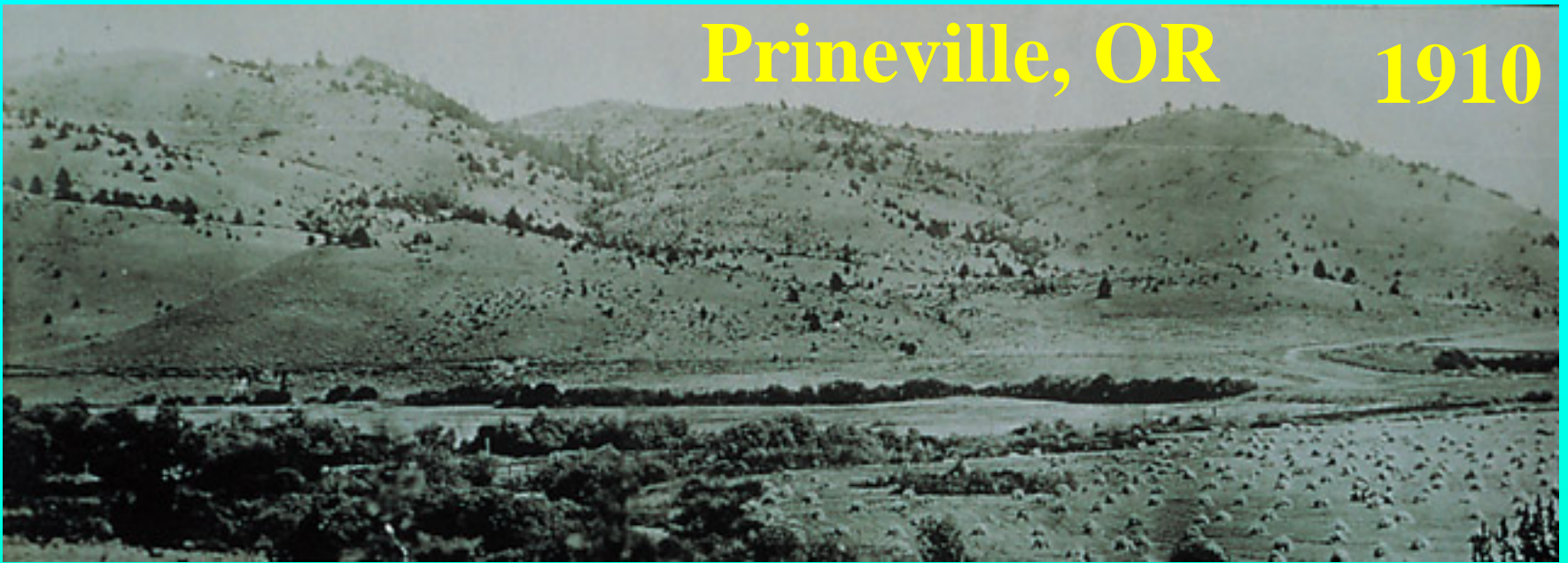
GFDL-B1

GFDL-A2

**Even Across Models, there Appear to be
Intrinsic Regional Sensitivities**

Prineville, OR

1910



**Have ecosystems reached their Water-limited Carrying Capacity
Under Fire Suppression/Exclusion → Drought Stress, Infestation**

1991



San Francisco Peaks, AZ – May 17, 2003

(courtesy of Neil Cobb)



San Francisco Peaks, AZ – 4 Months Later

(courtesy of Neil Cobb)



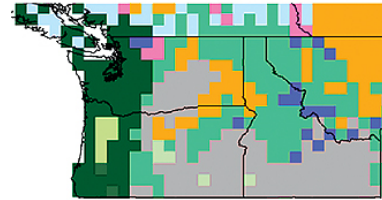
Threshold Change – Drought → Infestation → Dieback

Vegetation Distribution Change

Figure 12

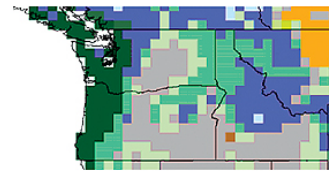
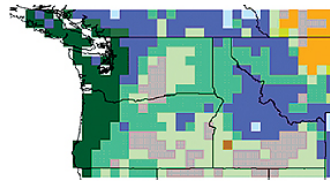
- Tundra
- Boreal Conifer Forest
- Maritime Temperate Coniferous Forest
- Continental Temperate Coniferous Forest
- Cool Temperate Forest
- Warm Temperate/Subtropical Mixed Forest
- Temperate Deciduous Forest
- Temperate Conifer Xeromorphic Woodland
- Temperate Deciduous Savanna
- Temperate Conifer Savanna
- C3 Grasslands
- C4 Grasslands
- Temperate Arid Shrubland
- Taiga-Tundra

Observed



Simulated, Suppressed Fire

Simulated, Full Fire



Historical Climate

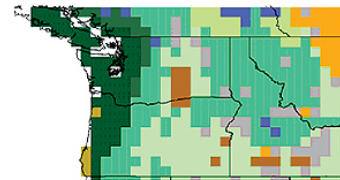
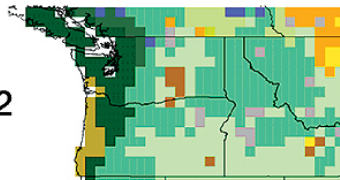
Historical Climate

Future Vegetation Distribution (2070-2099)

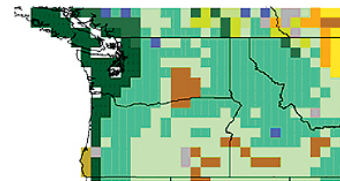
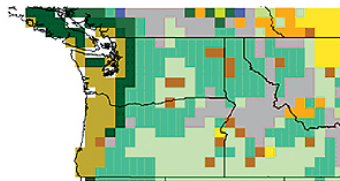
A2

B2

CGCM2



CSIRO



HADCM3

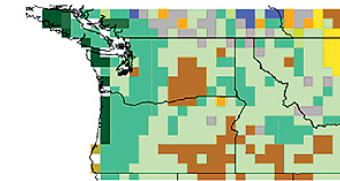
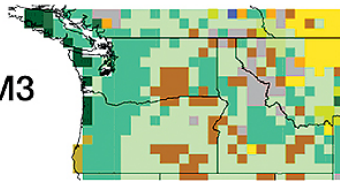


Figure 15

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

Ecosystem Carbon Change

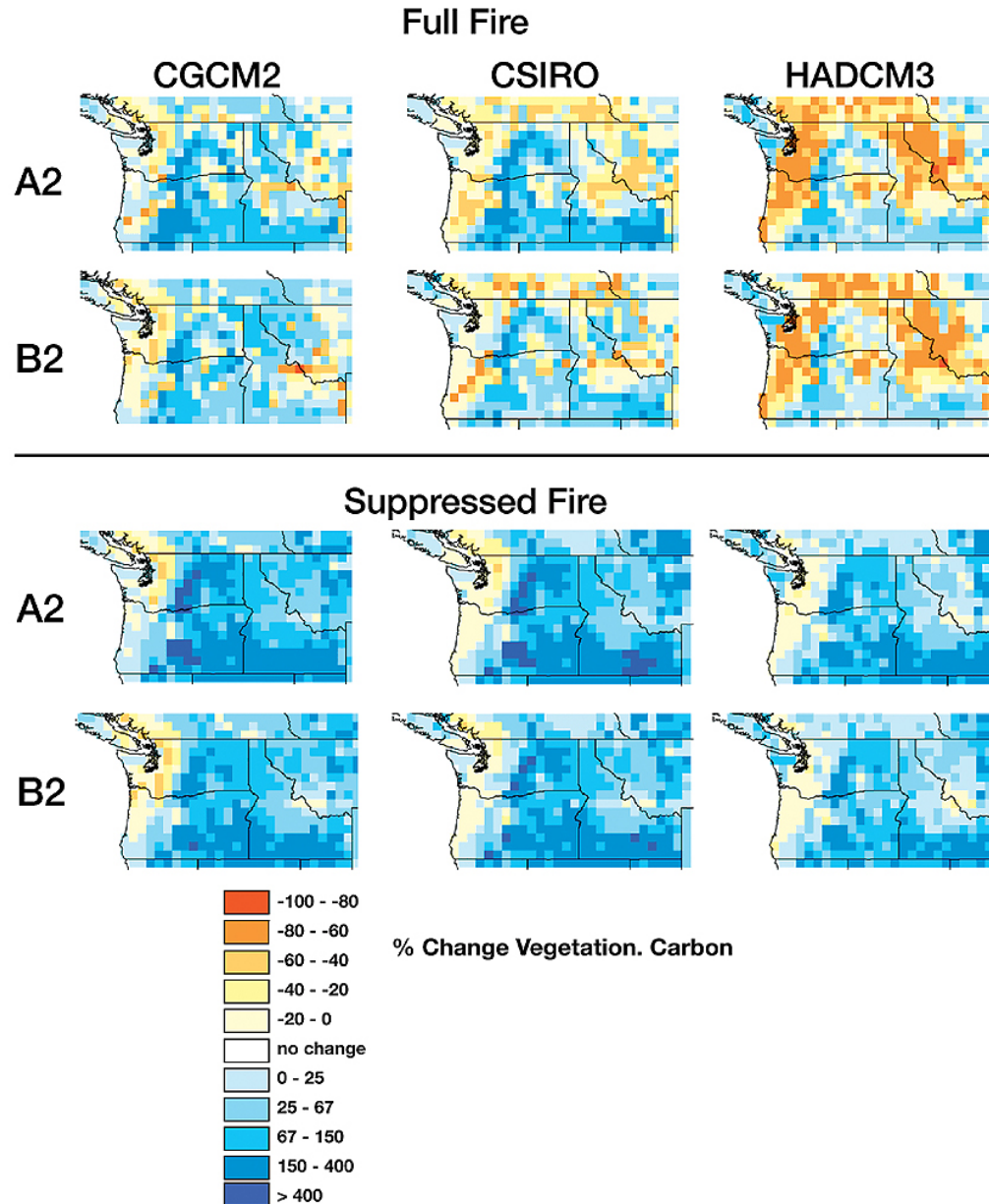
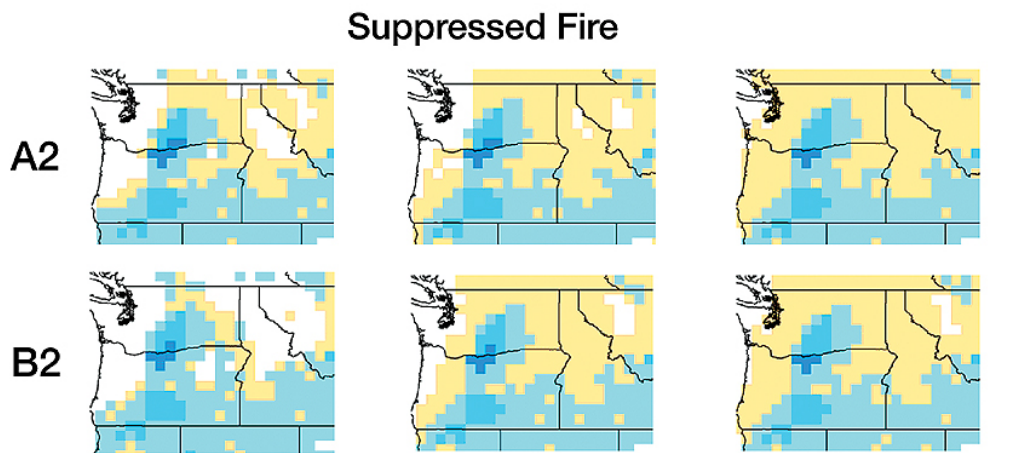
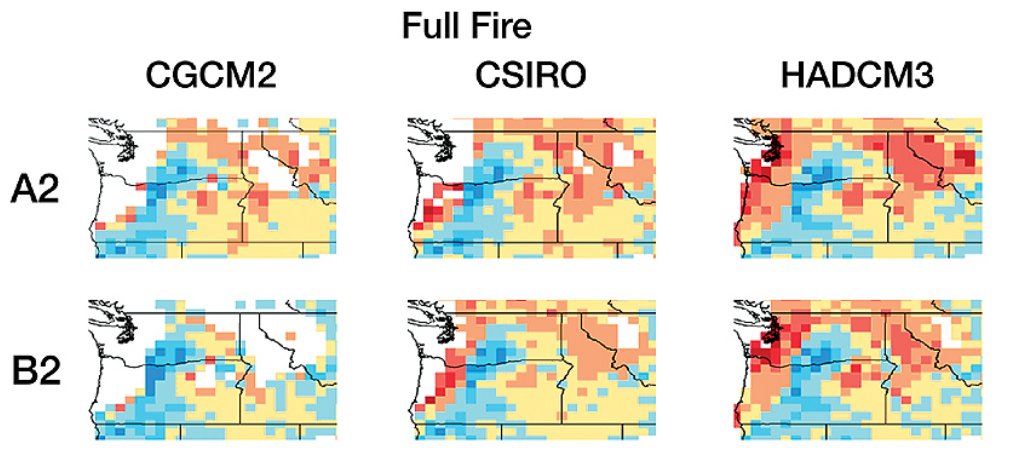


Figure 14

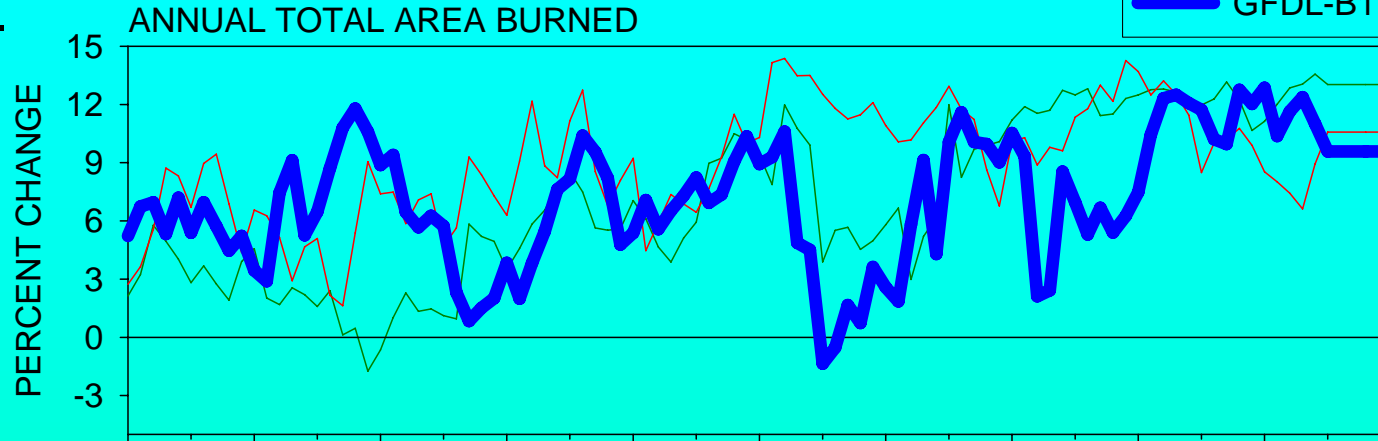
Difference in Biomass Consumed by Fire 2070-2099 vs. 1961-1990, (Carbon g/m²)

Biomass Burned Change

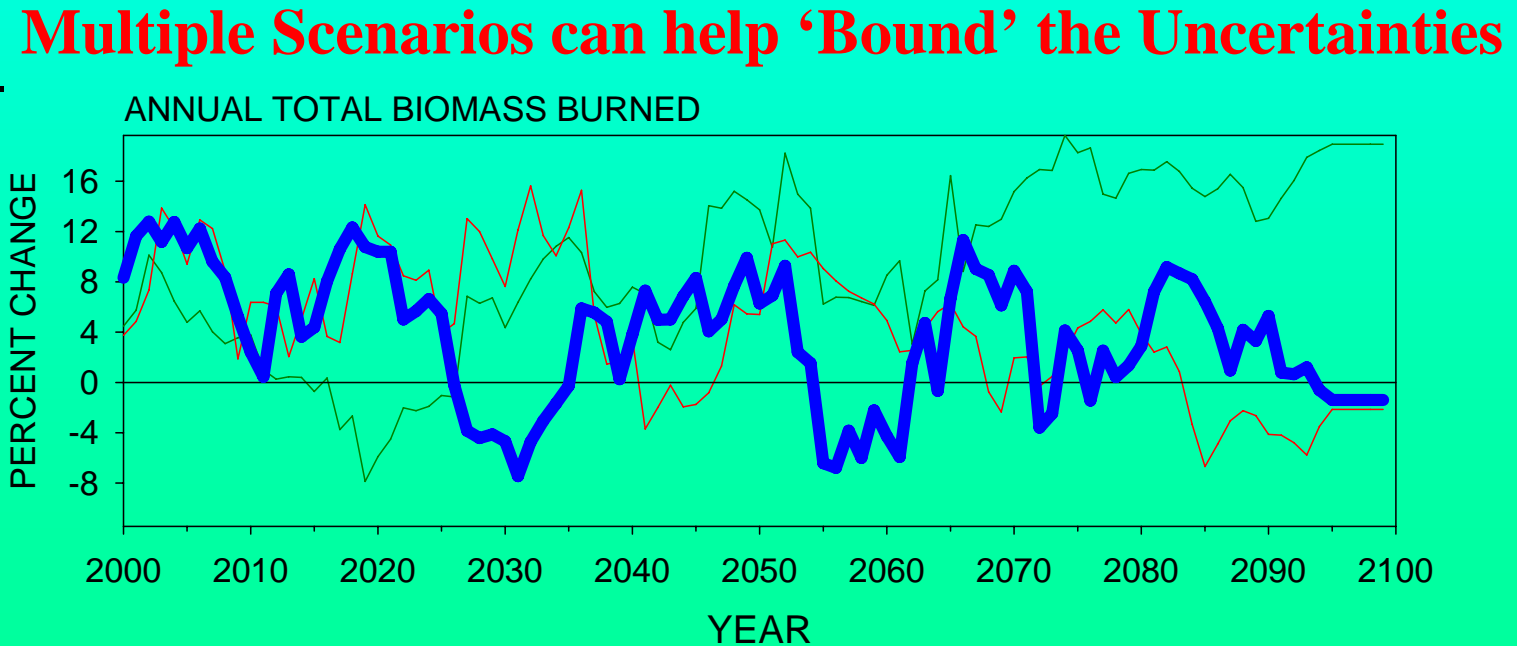


Interdecadal Climate Variability Can Obscure the Long Term Change

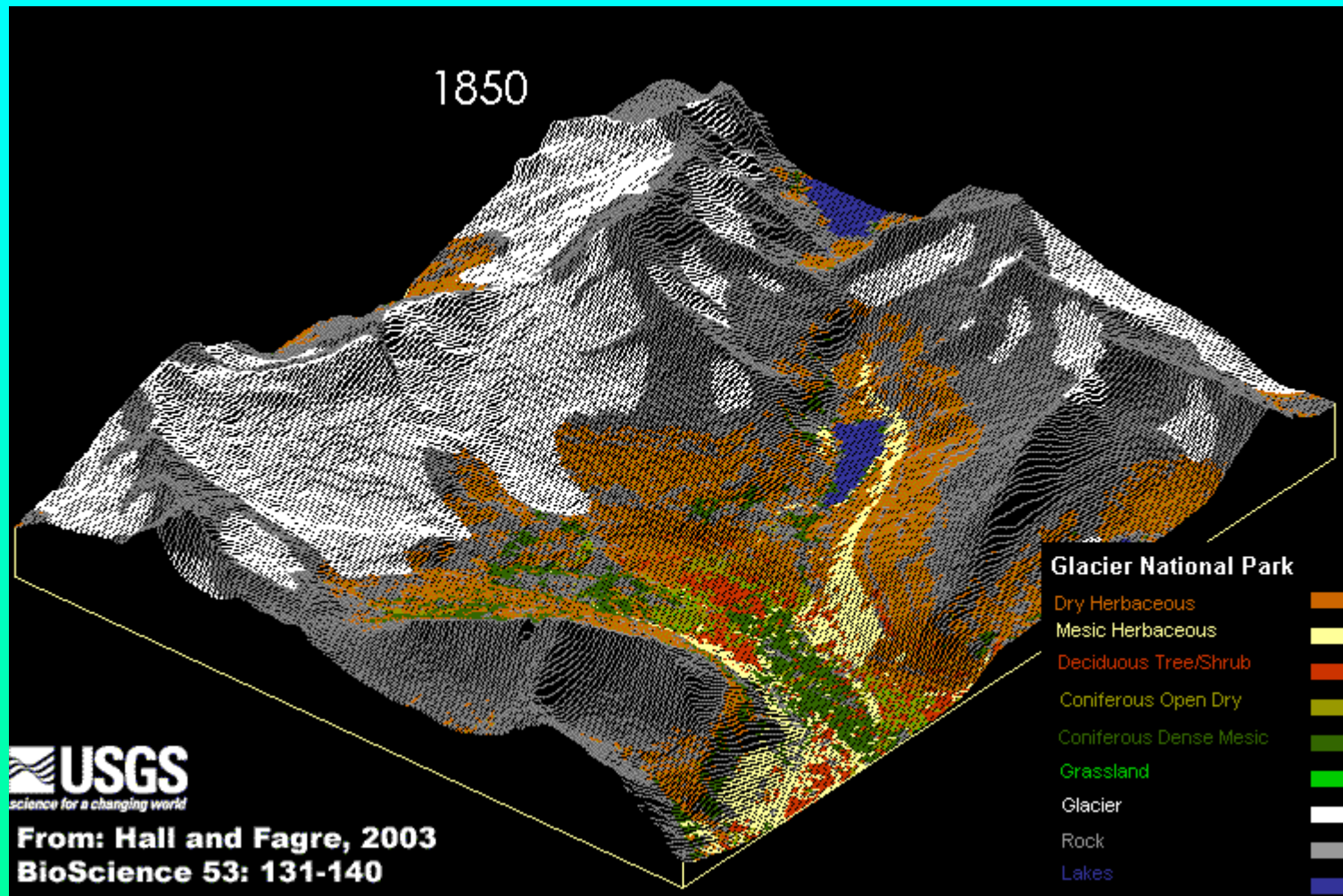
A.



B.



Glacier National Park



USFS Strengths

- **Observers of the Natural World – Data!**
- **Management Activities**
 - Discussions, education, monitoring, assessments, management, mitigation, policy and planning, research
- **Climate Change Assessments**
 - Synthesis of Knowledge
 - Future changes
- **Options for Adaptation to a Changing Climate**
 - Unplanned
 - Respond to Disturbances
 - Proactive

Management Options

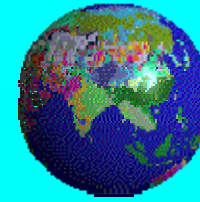
- Adaptation options
 - *Resist* change (paddling upstream)
 - Promote *Resilience* (reduce stresses, minimize catastrophic transitions)
 - *Respond* to change (consider “bet-hedging” approaches)
 - *Realign* to conditions that are far out of NRV
- Mitigation options
 - *Reduce* GHG emissions (e.g. carbon sequestration)
 - Carbon **Pump** vs. Carbon **Bank**

Management Toolbox

- Most planning tools, such as FVS, TELSA and VDDT, cannot use climate.
- Re-build tools to be ‘climate smart’, yet to retain their ‘look and feel’.
- Workshops between scientists and managers to design and refine these tools.
- Socio-economic factors must be included.

Management Implications

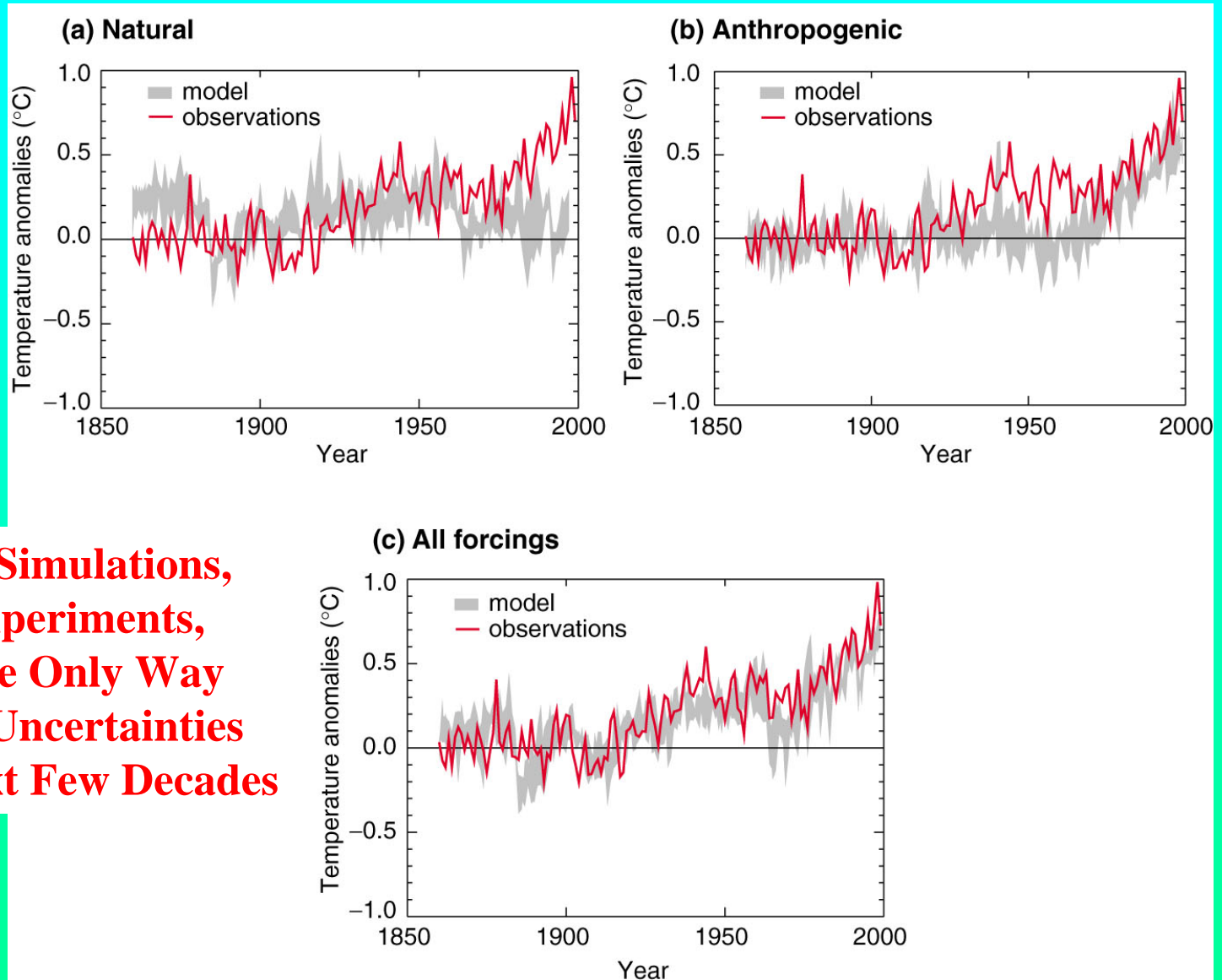
(personal musings)



- Management Goals face an *uncertain* Future
 - The Future will NOT echo the Past
- Instead,... Manage *Change, per se*
 - Desired *function* may supercede ‘Desired future *condition*’
- Improve resilience of ecosystems to rapid change, e.g.
 - Keep forest density below water-limited carrying capacity
 - Plant diversity rather than homogeneous monocultures
- Fire, Carbon and other policies may be at cross-purposes demanding creative management of change



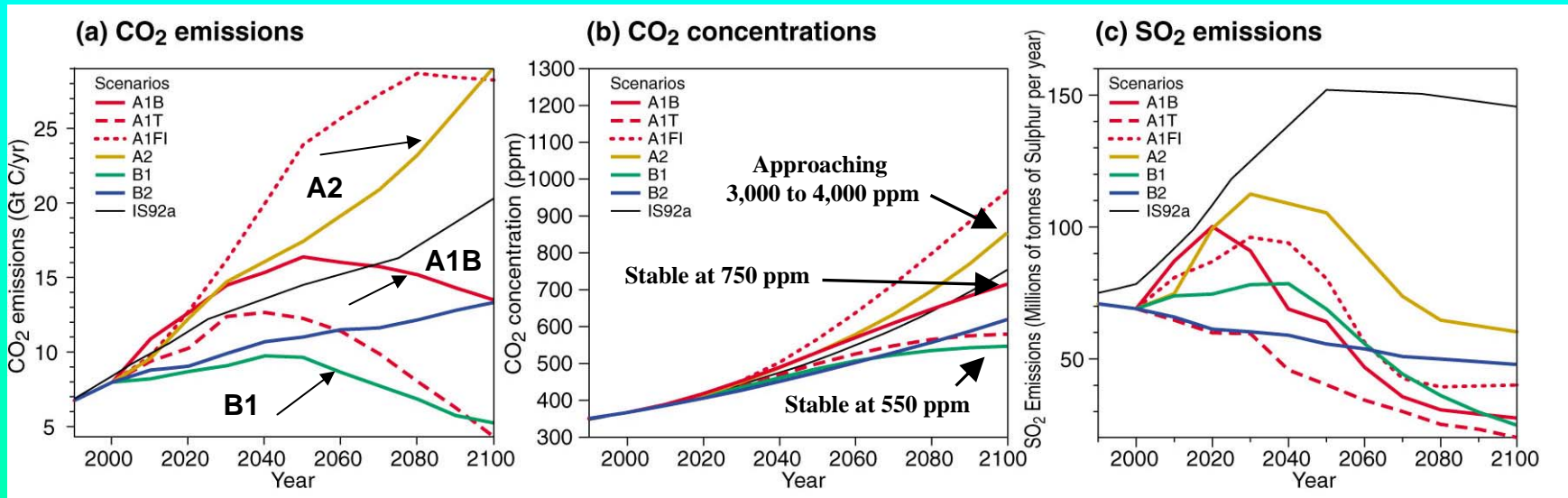
Simulated Annual Global Mean Surface Temperatures



**Ensemble Simulations,
Doing Experiments,
May be the Only Way
To Bound Uncertainties
Over the Next Few Decades**

Assessments of Future Climate Change Begin with Uncertainty

CO₂ and SO₂ in the 21st Century

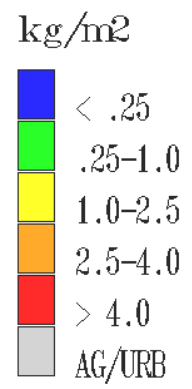
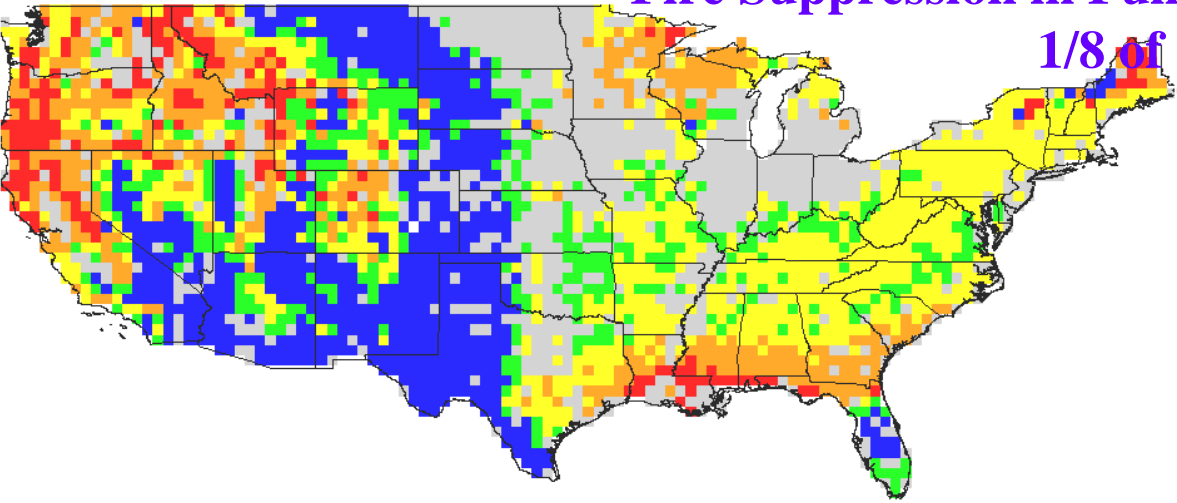


Future Scenarios are Based on Socio-Economic ‘Storylines’

**This Presents a Paradigm for
All Future Management Considerations**

Fire Suppression in Full Force from 1950 to the Present

1/8 of Potential Area Allowed to Burn



Absolute Change
(Kg/m²)

Where is all the Excess Wood

From Fire Suppression / Exclusion?

Percent Change

MC1 Simulation of
Fire Suppression

