



Adapting to Climate and Climate Impacts

A Conceptual Framework for Western Public Lands



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Confronting Climate Change

I. Adaptation Strategies

Assist resources & ecosystems to accommodate changes caused by climate



II. Mitigation Strategies

Reduce human effects on climate by sequestering CO₂ & decreasing greenhouse gases



Complementary
↔ Conflicting

USDA Forest Service Strategic Framework for Climate Change, 2008

GOALS

- Sustain ecosystems services
- Assist forests, grasslands, & communities to adapt
- Mitigate climate change through forestry actions
- Develop new scientific tools
- Create new collaborations
- Educate American citizens



USDA Forest Service, Research & Development Global Change Research Strategy, 2009

GOALS

Conduct research to enhance:

- Ecosystem sustainability (adaptation)
- Carbon sequestration (mitigation)
- Decision support
- Collaboration, communication, and education



WestWide Climate Initiative

A Partnership among the
Western US Forest Service Research Stations

Climate Toolkit Project

What Can Resource Managers Do in the Face of Climate Change?

Toolkit Goals

1. Develop Climate- and Climate-Impact Models
2. Conduct Case Studies on National Forests & National Parks
3. Develop Strategic, Tactical, & Reference Tools for Resource Managers

Principal Investigators:

Linda Joyce (RM), Connie Millar (PSW)

Ron Neilson (PNW), Dave Peterson (PNW)



Case Studies on National Forests and Parks

- Olympic NF and NP
 - Dave Peterson
- Tahoe NF
 - Connie Millar
- Inyo NF/Devils Postpile NM
 - Connie Millar
- Shoshone NF
 - Linda Joyce



Lessons Learned

- Basic principles of ecosystem management remain valid
- **Modify current practices using new information**
- Some practices may be inappropriate
- **Manage for desired processes & ecosystem services**
- Foster science-management partnerships

Despite uncertainty, defensible actions can be taken & effective decisions made

TOOLBOX APPROACH

- No single solution fits all situations
- Options differ for short versus long term
- Mix & match tools
- Be flexible, experimental, innovative; take small risks, and be willing to learn & change approaches

Climate Adaptation Tools

“Resource-management practices, educational and reference modules, decision-support aids, and qualitative or quantitative models that address the adaptation of natural and cultural resources to climate change”



Incorporating Climate into Management

Three Strategic Steps

1. Review

Literature, Models, Vulnerabilities

2. Rank

Priorities, Capacities

3. Resolve

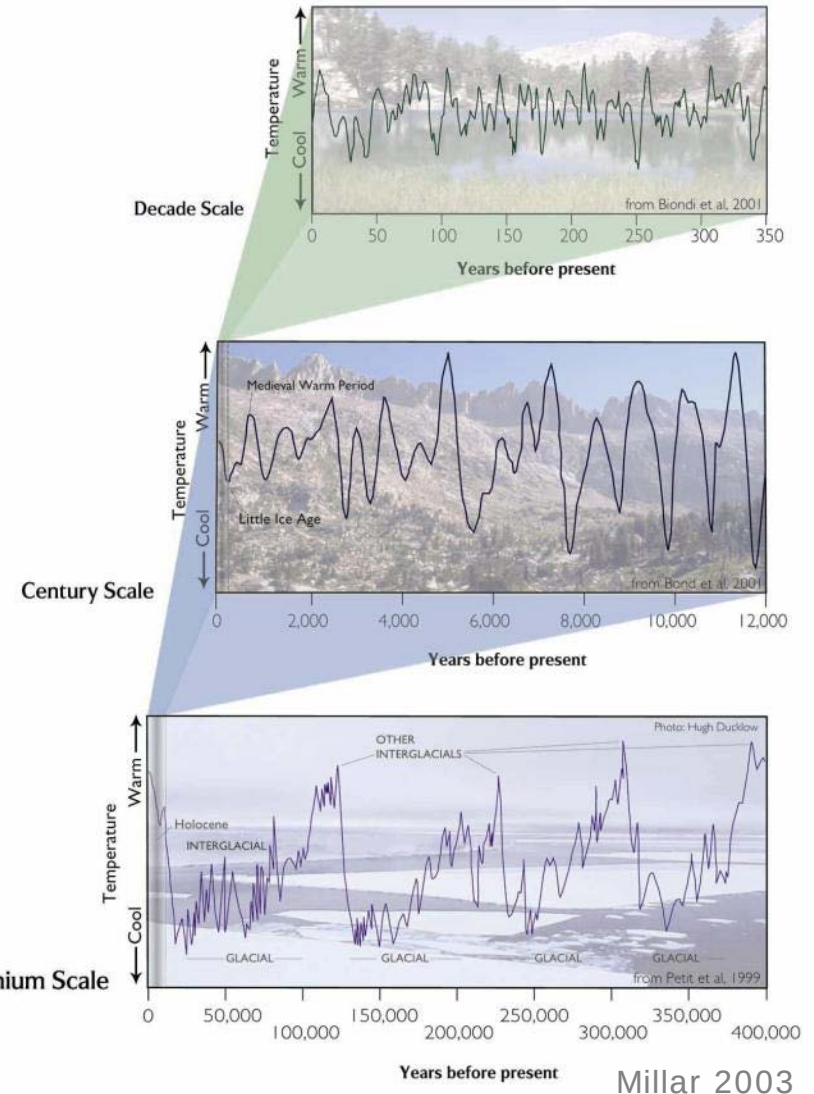
Decisions, Treatments,
Monitoring



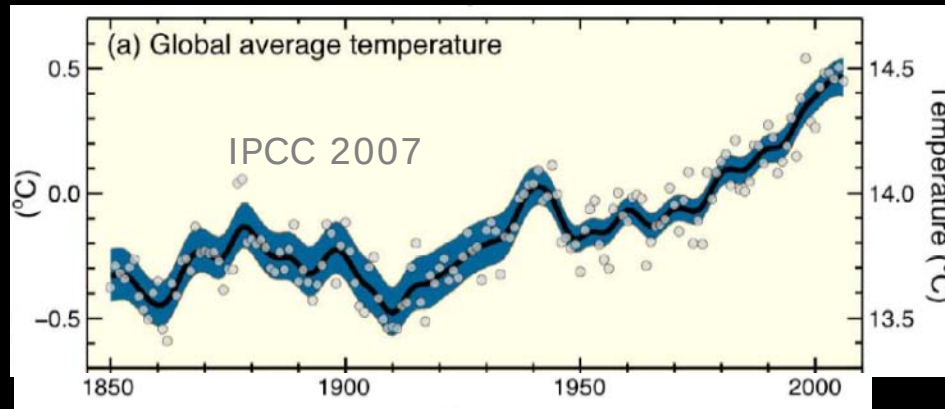
I. REVIEW

Earth's Natural Climate System

- * Continuously Changing; Cyclic
- * Nested Cycles: Annual, Decadal, Century & Millennial Scales
- * Different Physical Causes
- * Changes: Gradual & Directional to Abrupt & Chaotic



CLIMATE: The Current Picture

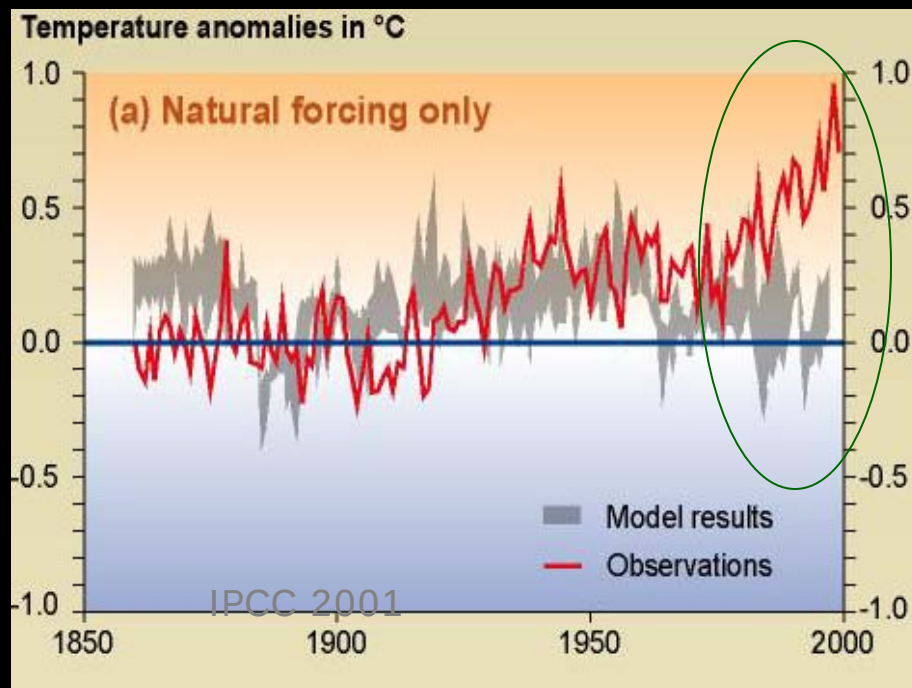


*Intergovernmental Panel
on Climate Change 2007*

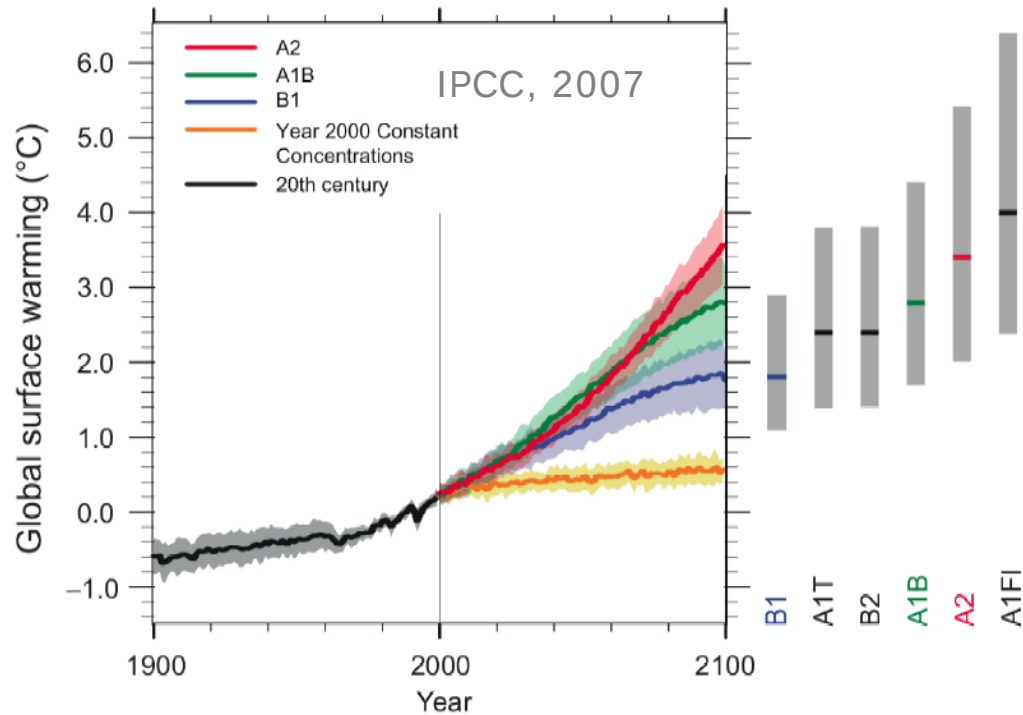
Mean global temperature increase
of 0.76 °C since 1850

Atmospheric [CO₂] exceeds natural
over last 650,000 yrs

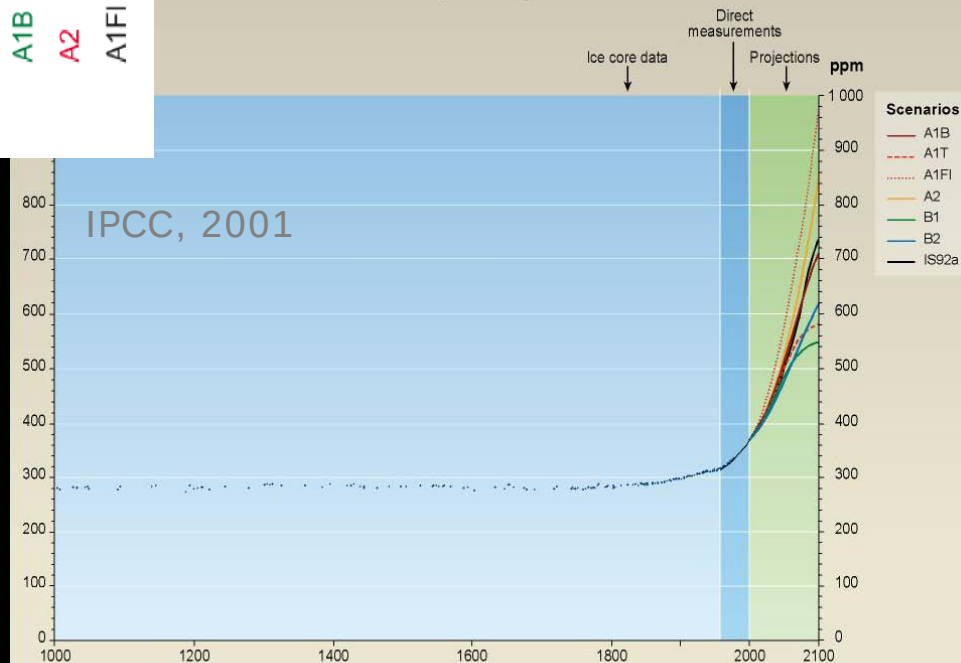
Anthropogenic signal significant
after ~1950



21st Century Projections



Past and future CO₂ atmospheric concentrations

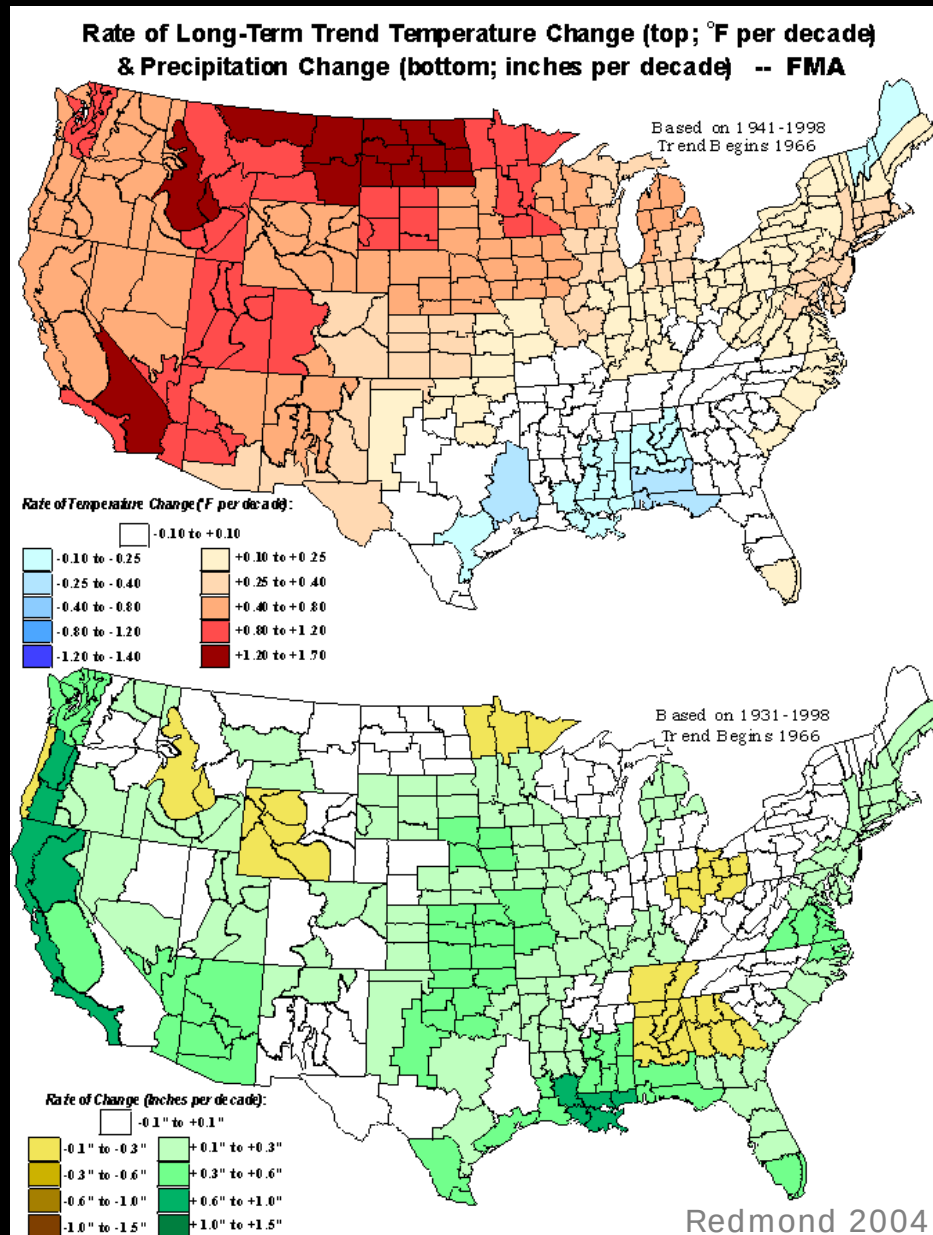


Trends in Western North America

Temperature

Feb-March-April,
1966-2004

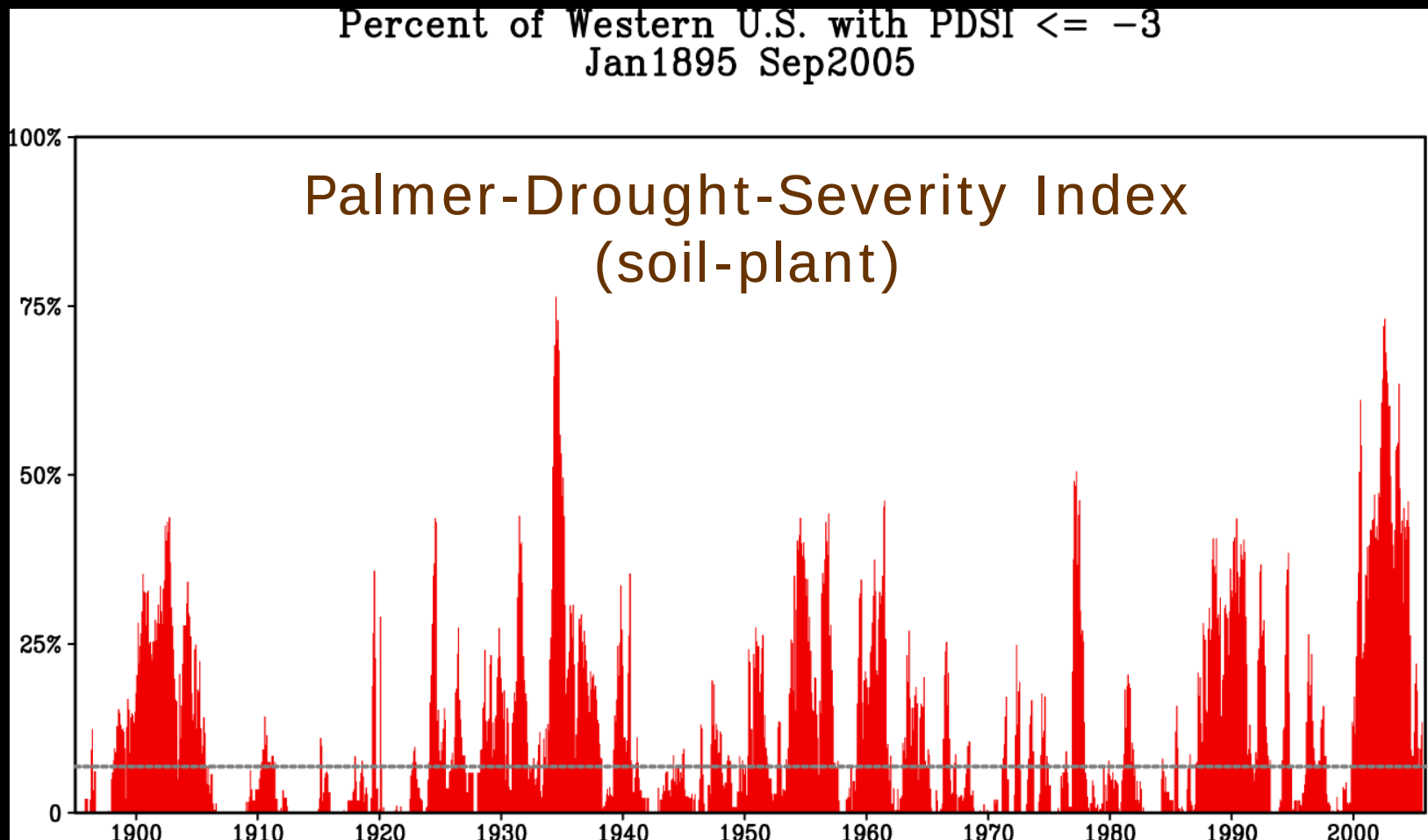
Precipitation



Trends in Western North America

Short-Term Droughts

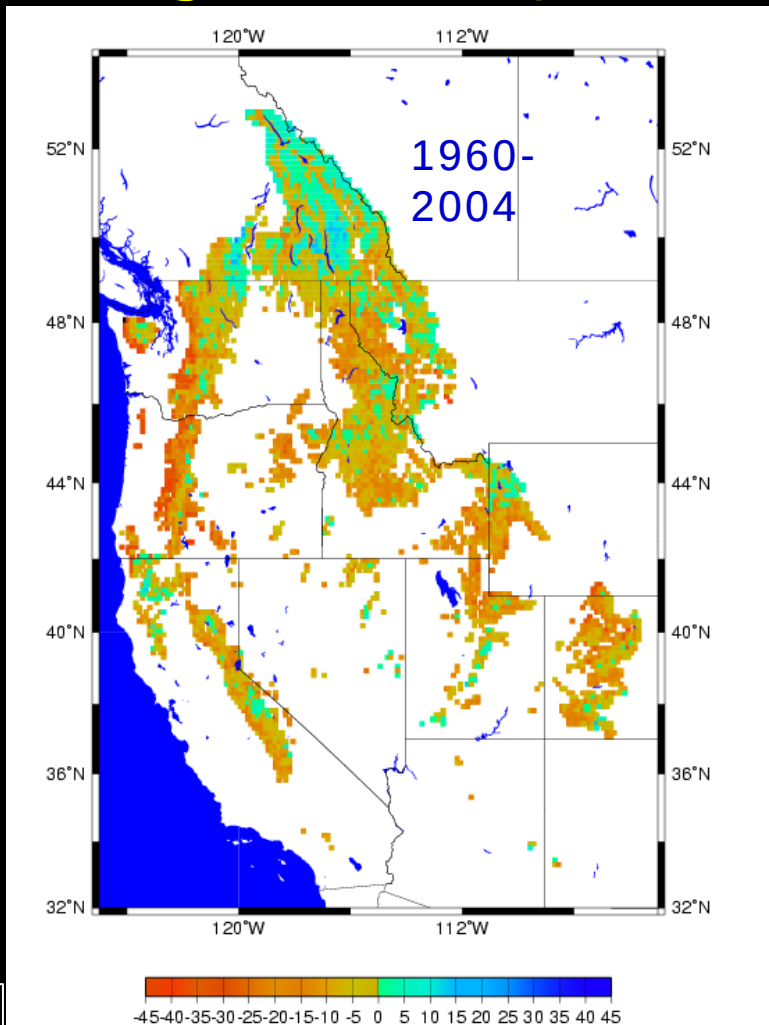
Similar level droughts are harsher when temps higher



Trends in Western North America

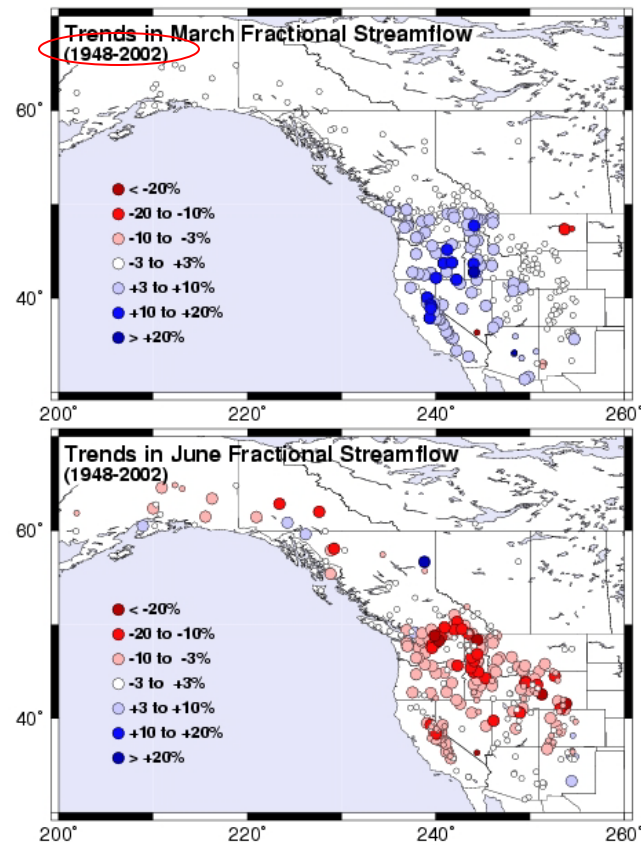
Snowpack and Streamflow

Timing of Peak Snowpack



Hamlet 2004

Changes in Streamflow



from:
Stewart, I.T., D.R. Cayan, and M.D. Dettinger (2004)
Changes toward earlier streamflow timing across western North America
J. Climate, in review

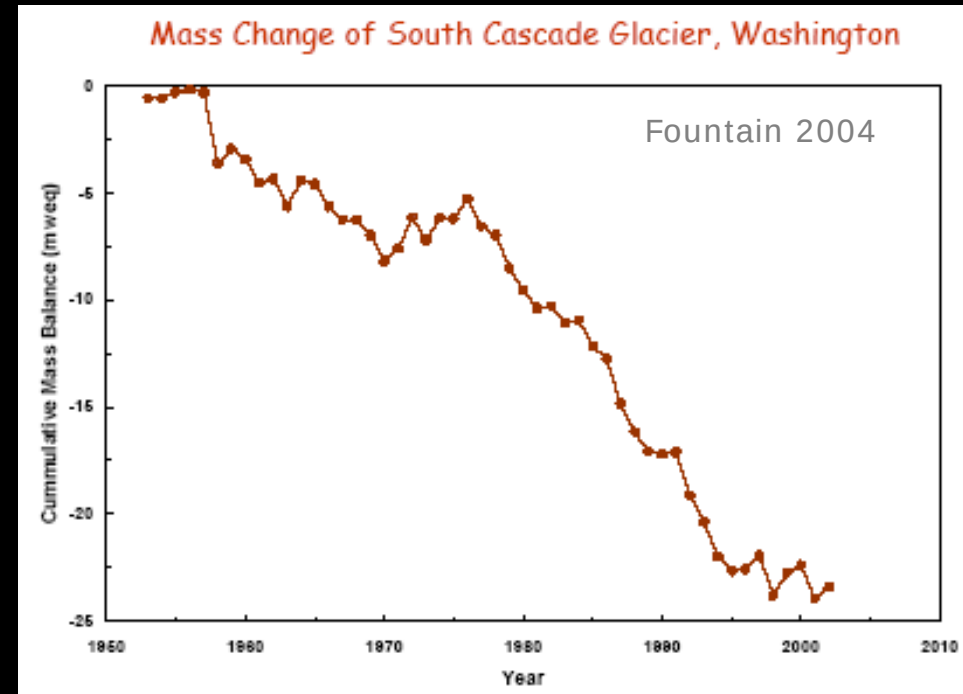
Trends in Western North America

Glaciers



Decreases in Area

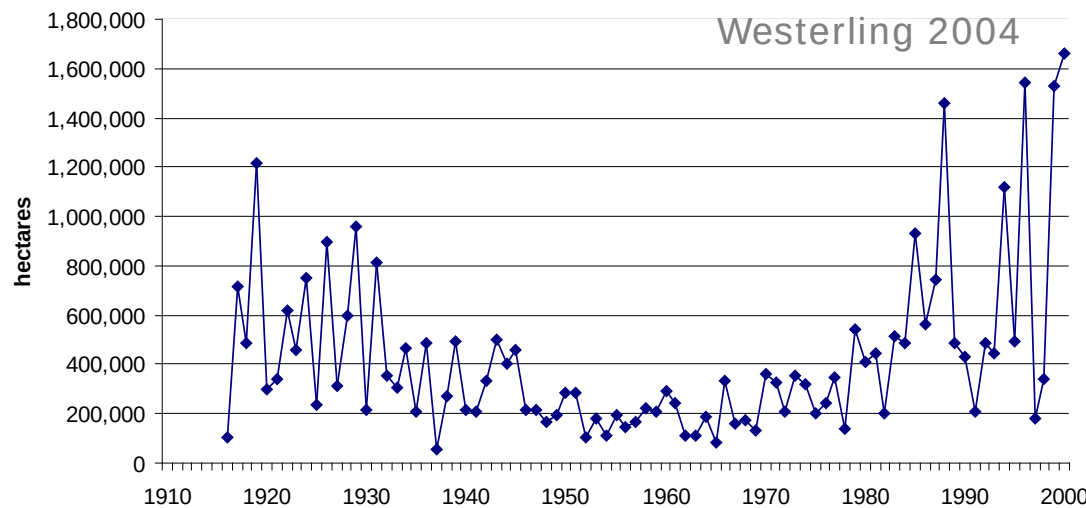
Decreases in Mass



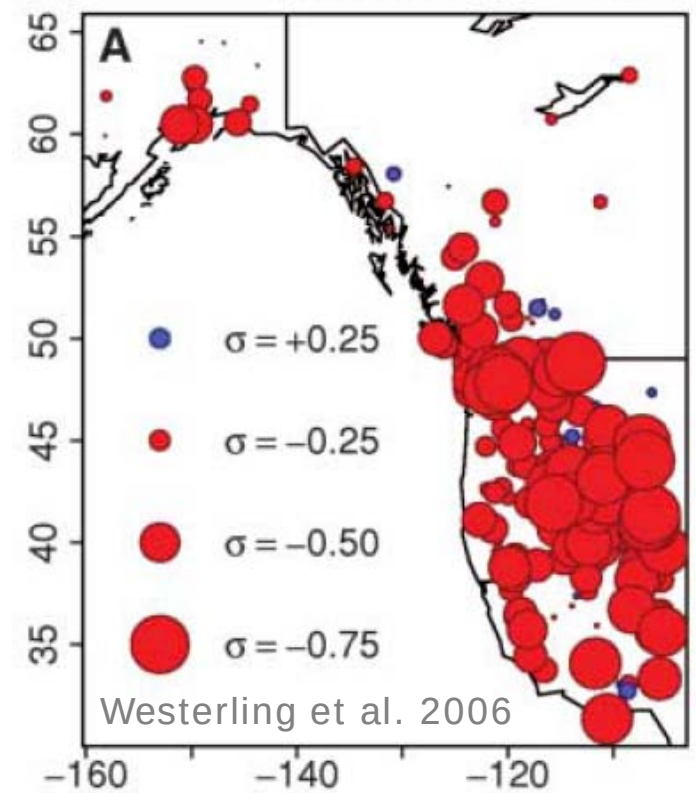
Trends in Western North America

Wildfire & Climate Connection

Annual Western U.S. Area Burned



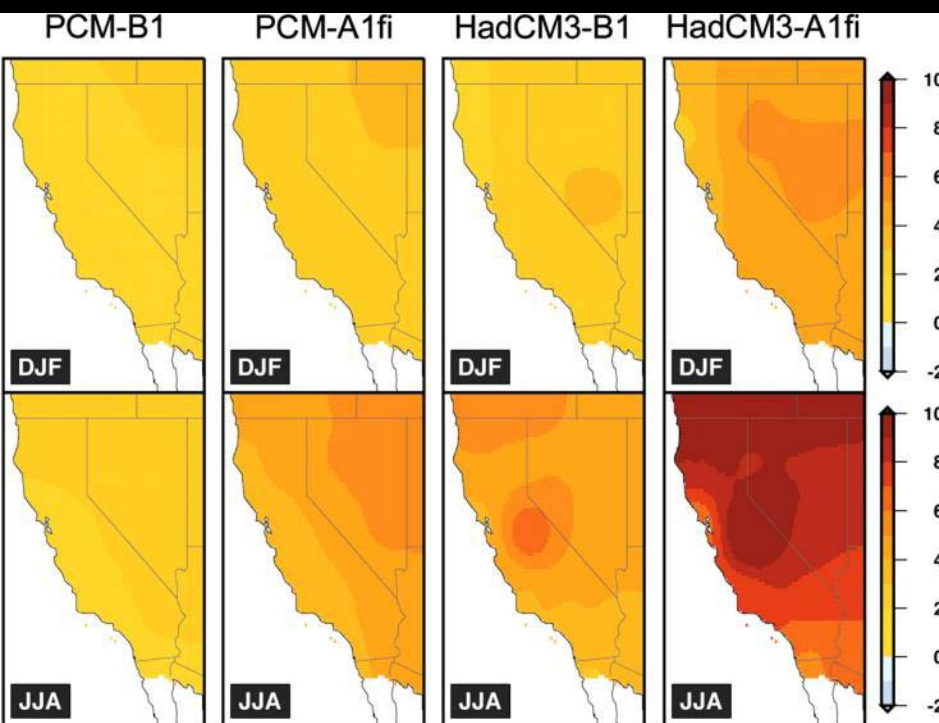
Correlation large fires (>400ha) and timing of spring snowmelt



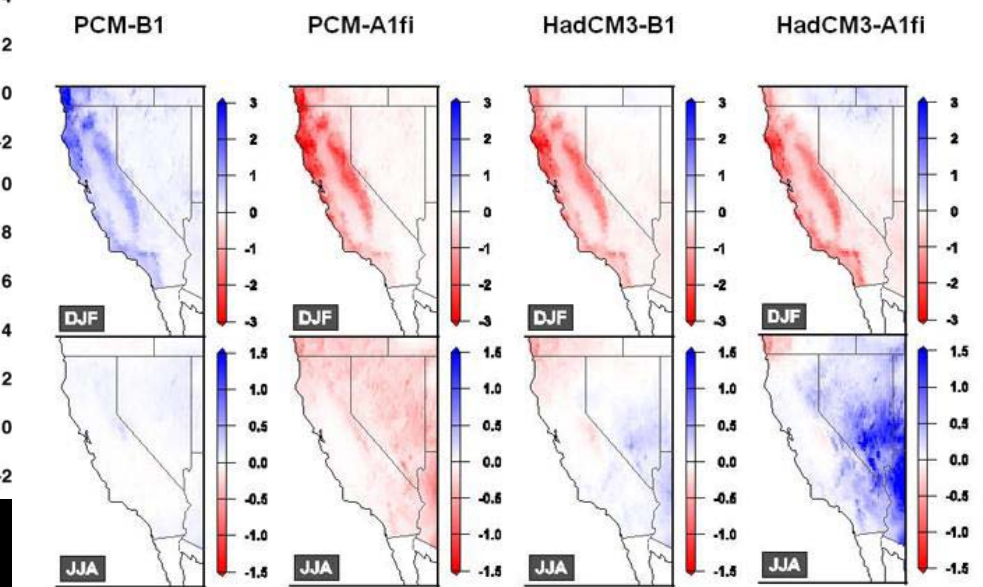
CALIFORNIA PROJECTIONS

Mean Temperature & Precipitation 2100

WARMER

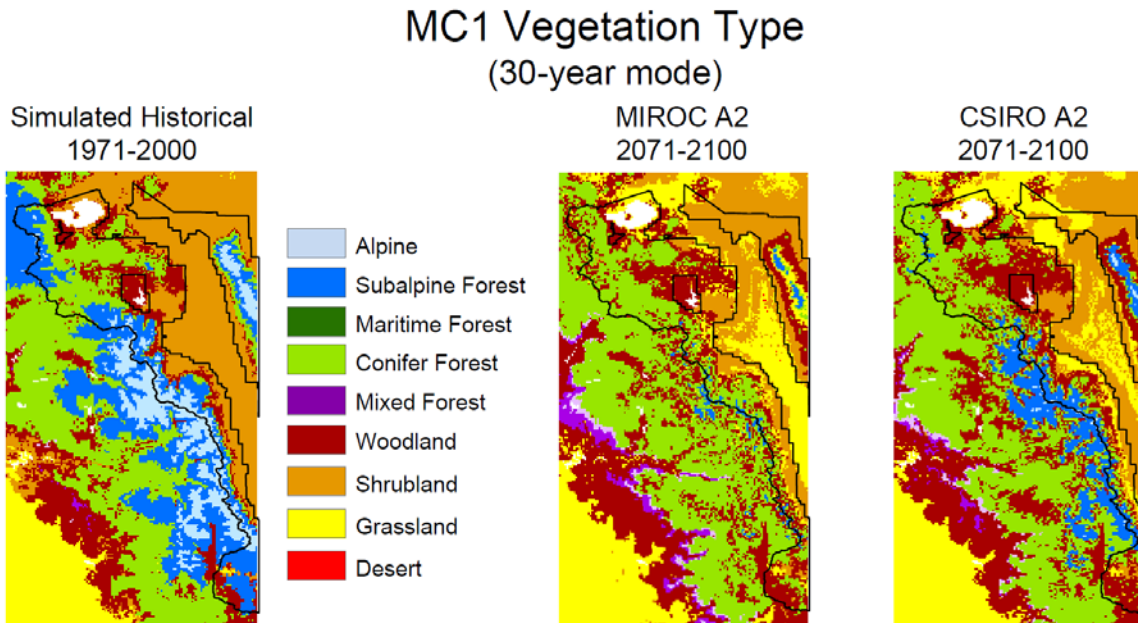


DRIER

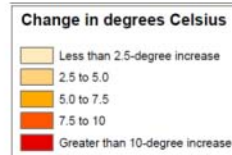
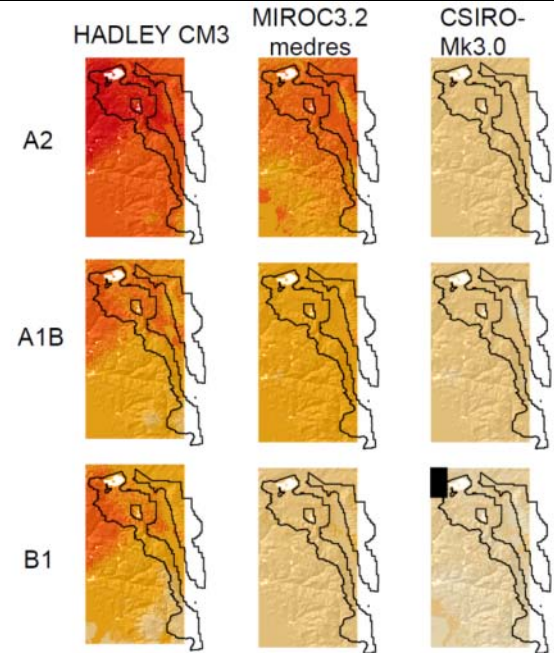


Regional Downscaled Models

e.g., Eastern Sierra, CA

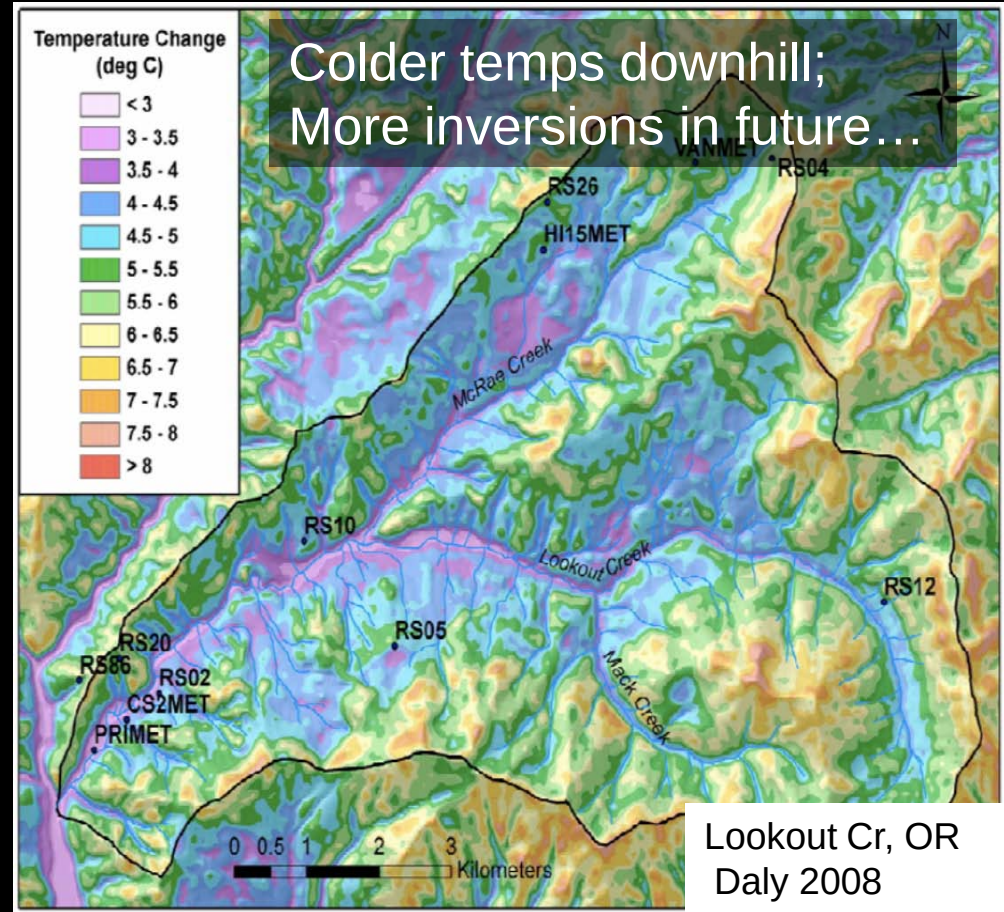


**Change in Maximum
Monthly Temperature**
Comparison of two 30-yr
averages:
1971-2000 versus 2071-2100



Models give a
coarse idea of
trends at land-
scape scale...

But at local scale, climatology is much more complex.
Trends often differ from
global or down-scaled
results



Vulnerabilities are best assessed
by using all info available -- models
and on-the-ground experience

2. Rank

Management Decisions

Do Nothing:
No Advance Action



Be Proactive:
Act in Advance



React after Disturbance
or Extreme Events



Setting Priorities

1. Short Term (<10 yrs)

Project Scale:

Do No Harm

Reconsider Goals



2. Longer Term (>10 yrs)

Planning Scale:

Anticipate Surprises

Ease Transitions

Tools for Project Ranking

Aspen Health Survey



Sudden Aspen Decline (SAD) Survey

CONDUCT THIS SURVEY IN THE CENTER OF THE STAND DURING SPRING OR SUMMER

DATE: _____

_____ ha

slope: _____ %

Fringe ☐ Riparian ☐

7% ☐

1% ☐

Healthy Regenerating Aspen Stand Conifer Succession, General Aspen Decline Aspen Death, No Regeneration

Climate Project Screening Tool

Project Activity	Climate Change Trends and Local Impacts	Key Questions for Managers	Response Narrative (please complete)	Continue with Project?
Aspen restoration by removing encroaching conifers	<p>Trends – Reduced snowpack, longer, drier summers</p> <p>Local Impacts – Reduced plant and animal species diversity; reduced water storage in soils; changed fire regimes with more severe effects</p>	<ul style="list-style-type: none"> ☐ Given the anticipated changes, will this site be capable of retaining aspens over time? ☐ Will aspen occupying this site be able to persist under extreme weather events? ☐ Are there better opportunities for sustaining aspens in other locations that would provide for sustained migration? ☐ Will the proposed project help offset the projected impacts due to climate change? 		<ul style="list-style-type: none"> ☐ Yes ☐ No ☐ Yes, with modification:

Tiered Approaches to Priority Setting

“Win-Win” - Actions that reduce the impacts of climate change while providing other benefits

“No Regrets” - Actions that provide important benefits at relatively little additional cost or risk

“Piggyback” – Priorities determined by other projects



Triage Approach to Priority-Setting

triare (Fr): to sort



TRIAGE Categories:

Red Urgent, treatable:
immediate priority

Yellow Mid urgency; soon
to become red

Green Stable, low priority

Black Urgent, untreatable
with available resources:
→ no action

Re-assess & re-sort

3. Resolve *Develop Treatments*

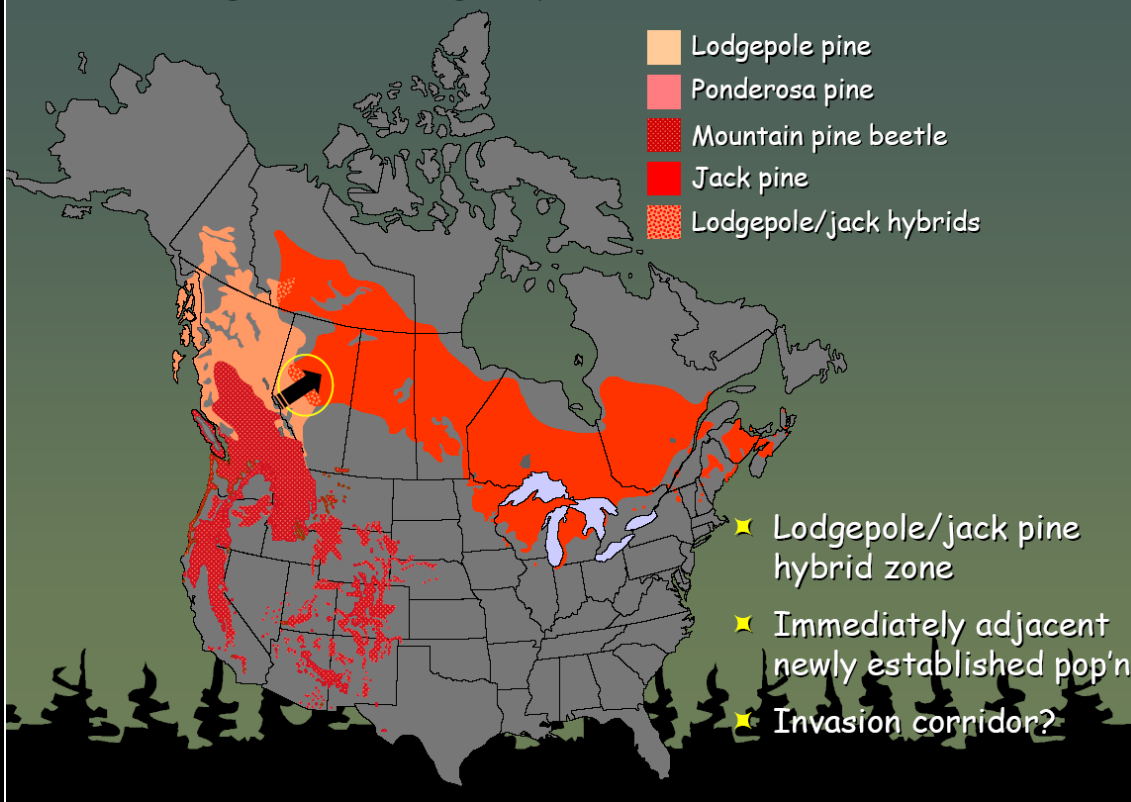
Tactical Approaches (Tools)

- *Develop Resistance*
- *Promote Resilience*
- *Assist Response*
- *Realign Highly Altered Ecosystems*
- *Establish Refugia*

1. Increase *Resistance* to Change

* Defend highest-value resources against change

Climate change induced-range expansion: invasion of the boreal forest?



British Columbia: lodgepole pine & mountain pine beetle
Carroll et al. 2003



Heroic fuel breaks...



and watershed-protection efforts

Resisting the effects of climate change might be possible only in the short term

Meadow invasion



Pinyon/juniper expansion



Salmon restoration



2. Promote *Resilience* to Change

Improve the capacity of ecosystems to return to prior conditions after disturbance

Examples

- Thin Forest Stands
- Prescribe Fires
- Stock Seed Banks
- Make Snow at Ski Areas
- Increase Rare Species Population Numbers



Resilience is also the capacity of a system or species to absorb external challenges without change in state

Forest not Shrubland



Meadow not Forest



Persist not Extirpate



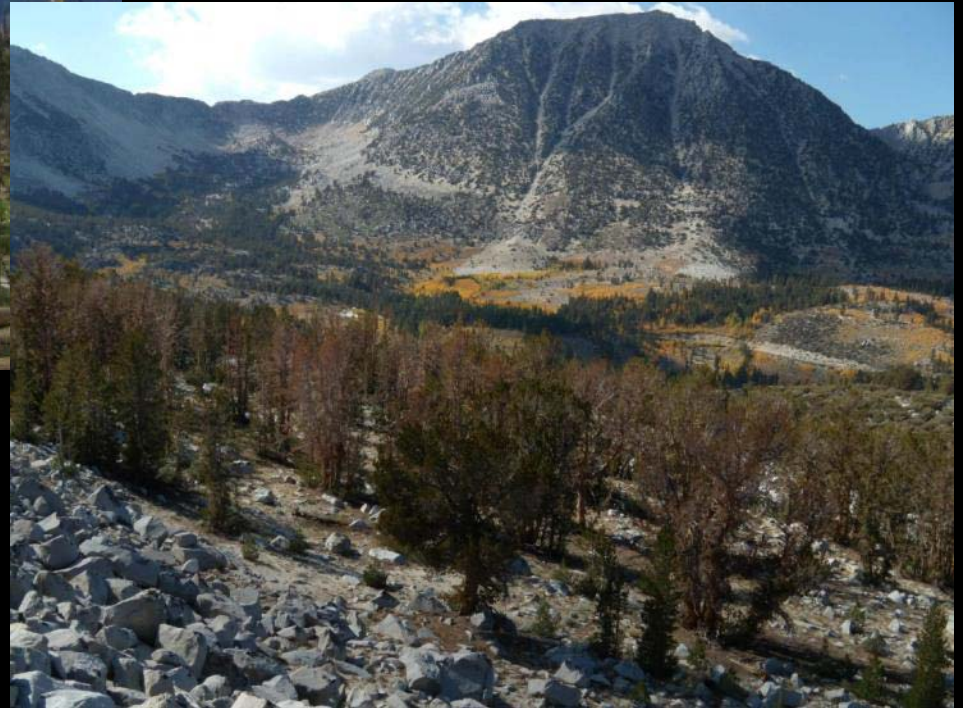
Photo: J. Wehausen

Promoting Resilience

* Work with disturbance processes to...



...increase structural
diversity



...encourage genetic
adaptation

3. Enable Ecosystems to Change Adaptively

Assist transition to new environmental states

Ecological conversions are occurring already



Forest to Grassland

Colorado plateau, *Pinus edulis*
Drought & bark beetles



Grassland to Forest

Great Basin, *Pinus monophylla*
Warming & fire suppression

* *Use Regional Climate & Biotic Effects Projections*

Case Study Domains – MC1 modeling efforts

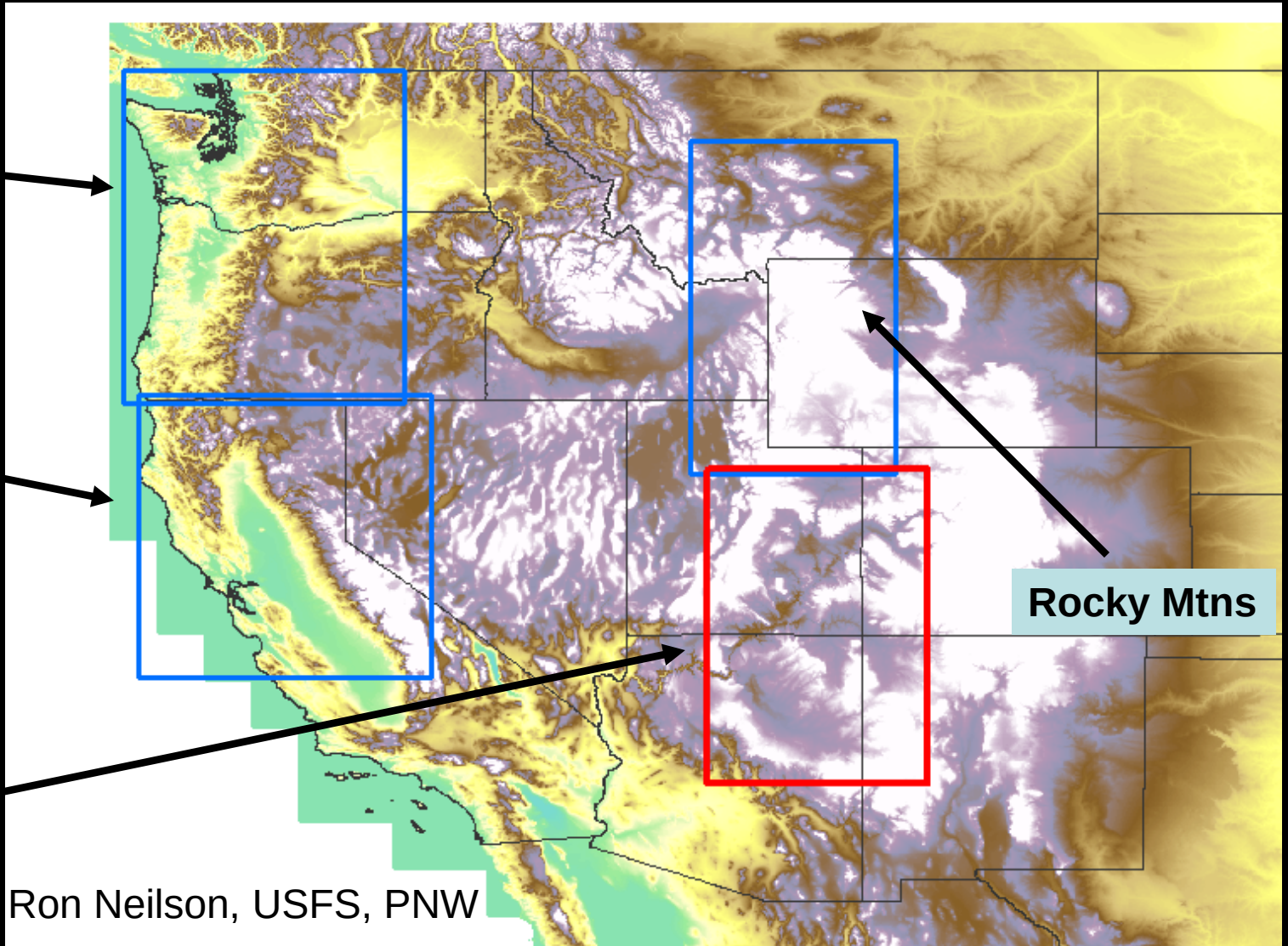
Pacific Northwest

Pacific Southwest

Additional Test Area

Rocky Mtns

Ron Neilson, USFS, PNW



* Anticipate and Plan for Associated Risks

Forest Dieback; Fires in Subalpine Forests; Off-Season & Year-Round Fires; Extreme Wind and Flood Events...



Subalpine Forest Mortality



Sudden Aspen Decline



High-elevation fires



Winter Wildfires

* Consider Alternative Germplasm Options

1. New Species Mixes



*Choose practices that
spread risks*

2. Different Genetic-Management Options



* Assist Migration

Move species to favorable
future locations...

Picea breweriana



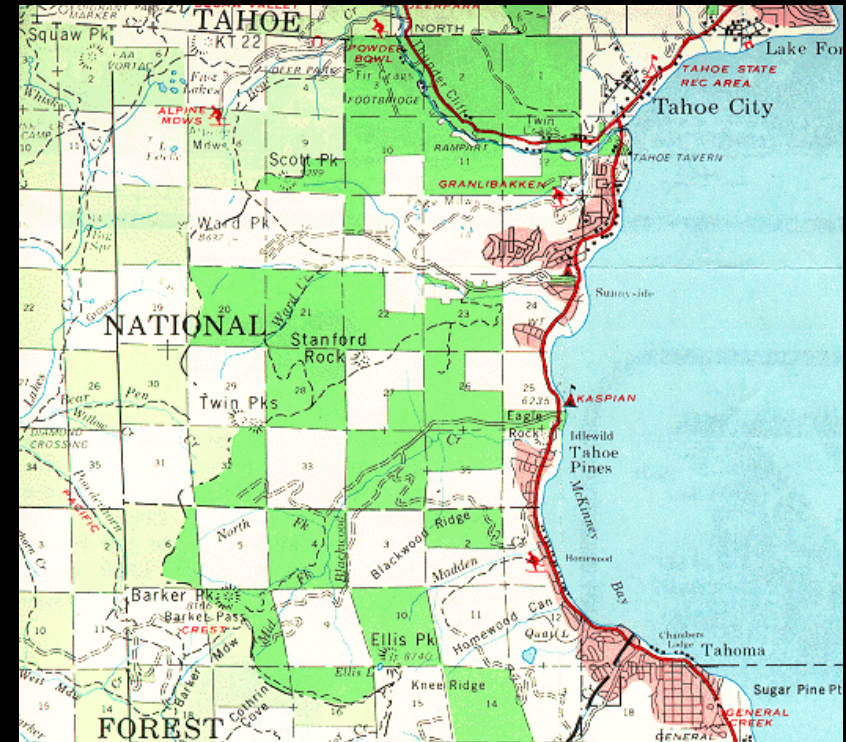
“The climate models indeed show little chance that the climate anywhere in the western US will be suitable for Brewer spruce by 2060. However, all GCMs show suitable climatic niche in south-eastern Alaska and coastal British Columbia. My Canadian colleagues are planning for genetic resource planting sites near Prince Rupert, British Columbia.”

--Tom Ledig, USFS Research Geneticist, Nov 2008

But, Do We Know
Enough?

* Promote Connected Landscapes

- Larger management unit size
- Lower fragmentation
- Continuous riparian zones
- Greater decision flexibility

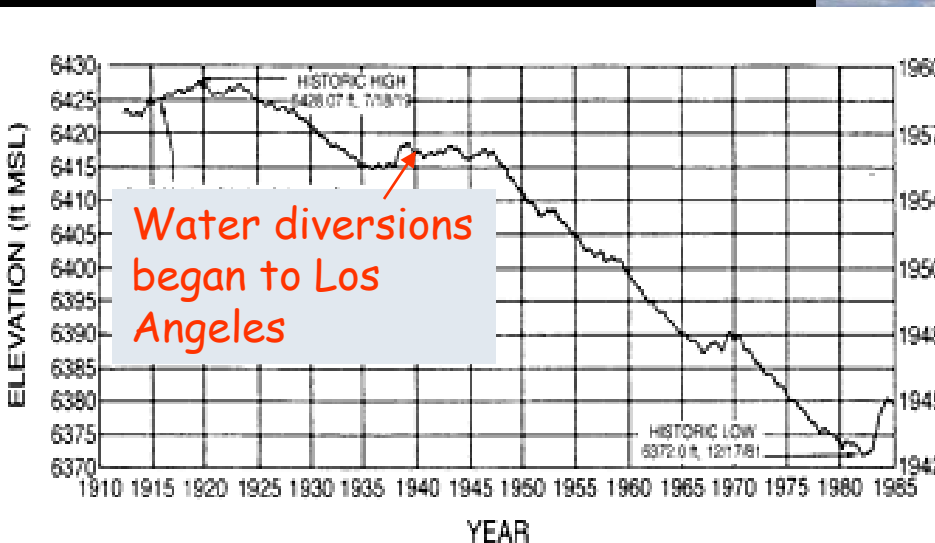


4. *Realign Systems to Current & Future Dynamics*

An option when resources are beyond the range of natural variability

“Historic range of variability”
(*pre-settlement conditions*)
as a management target will
often be inappropriate

Example Mono Lake Basin, California



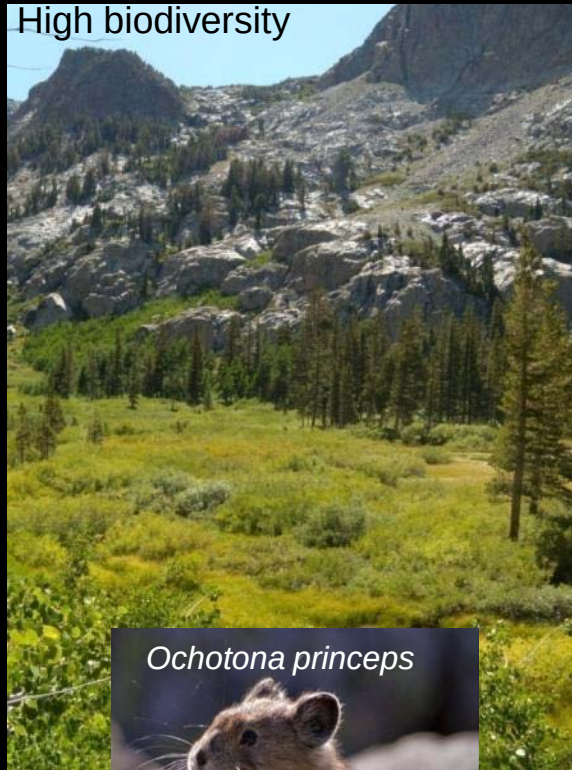
5. Establish Climate Refugia

Locations where species persist during periods of changing regional climates

Climate buffered (riparian)



High biodiversity



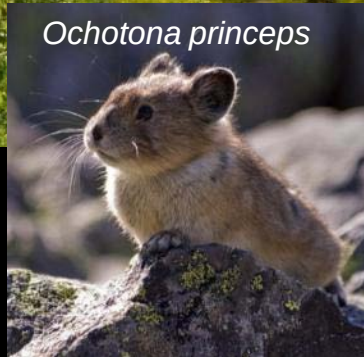
Steep elevational gradients



Substrate (carbonate)



Ochotona princeps

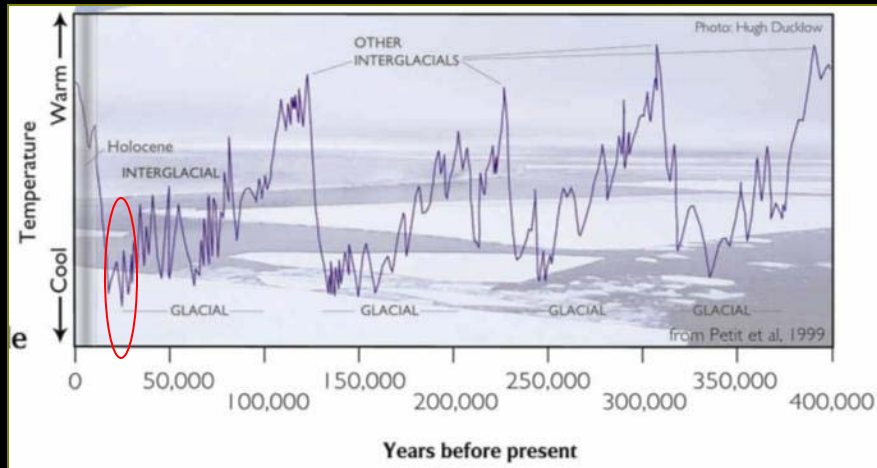


Persistent conditions (RIF wetlands)



Refugia – Quaternary Science

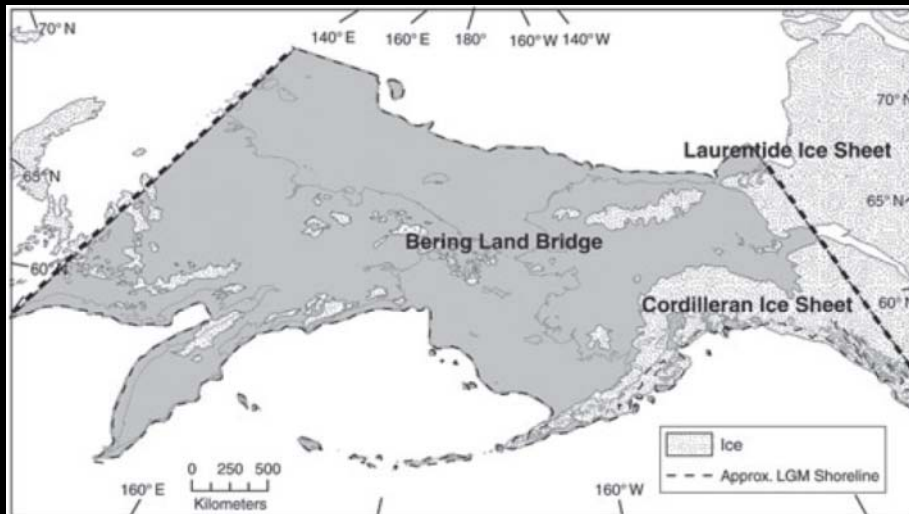
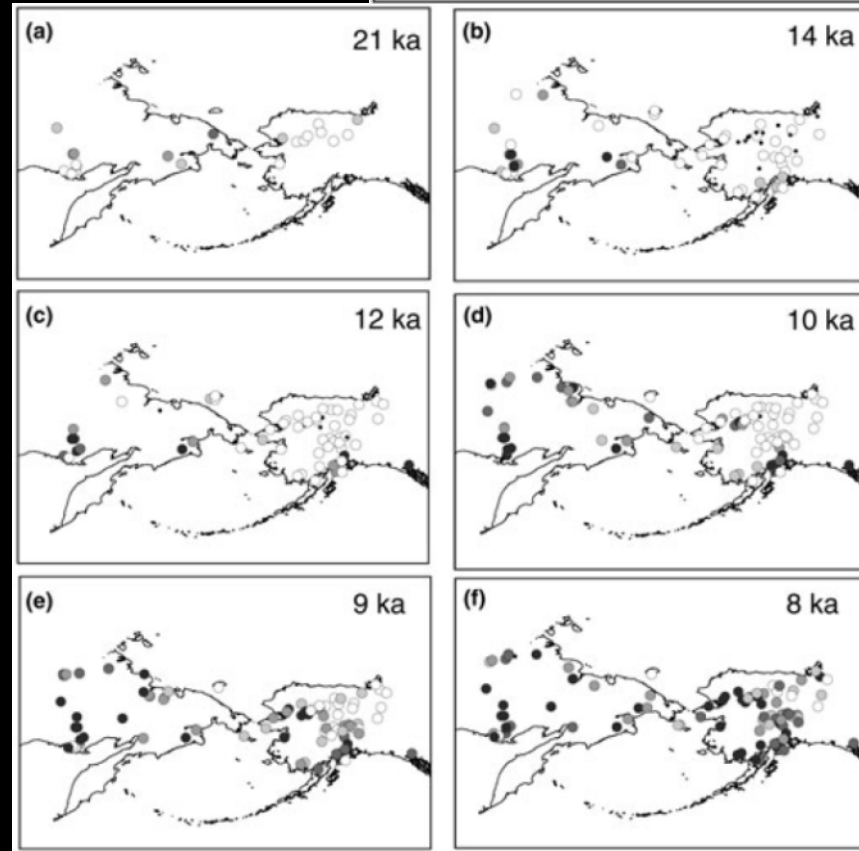
Isolated areas of favorable climate where populations of species survived during Pleistocene glacial periods before migrating outward once again, Huntley & Webb 1988



Ice-Free LGM
Beringia Refugia
Hulten 1937

Percent *Alnus/Duschekia*

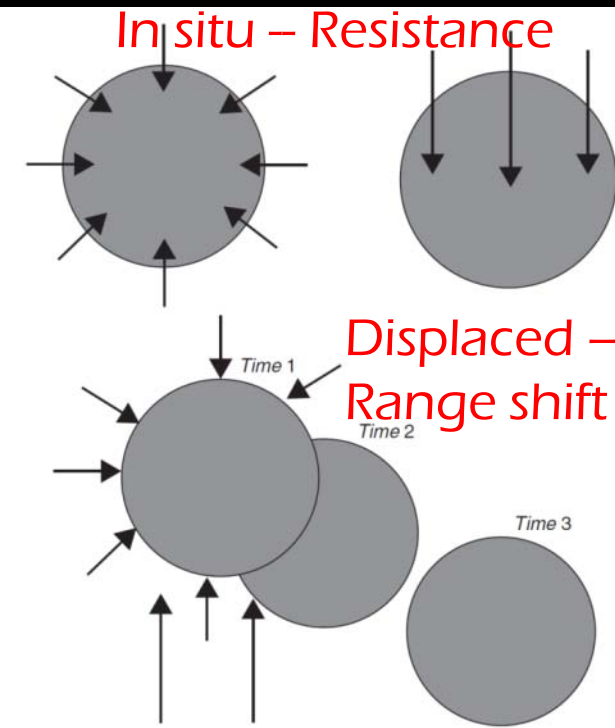
- | | |
|------------|-------------|
| • Absent | ● 10% – 20% |
| ○ < 5% | ● 20% – 30% |
| ● 5% – 10% | ● > 30% |



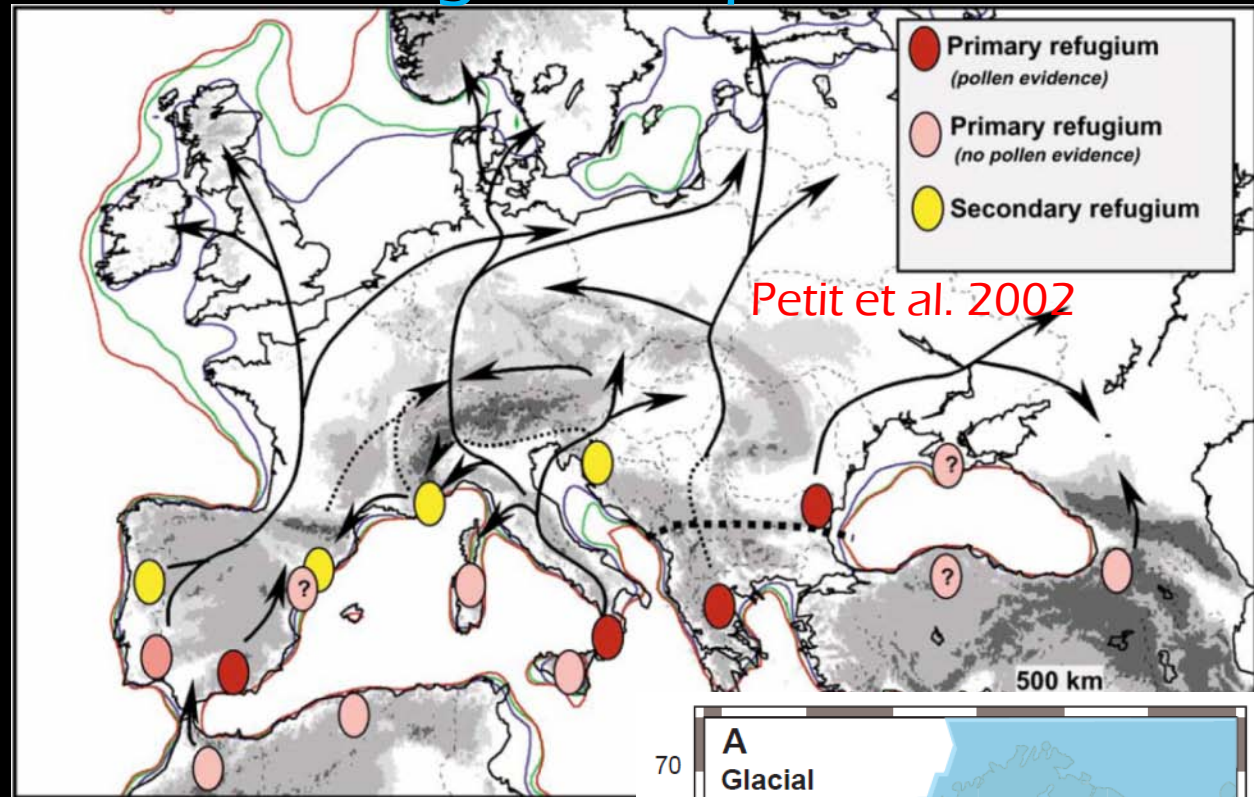
Brubaker et al 2005

LGM Oak Refugia & Dispersal Corridors

Range Contraction



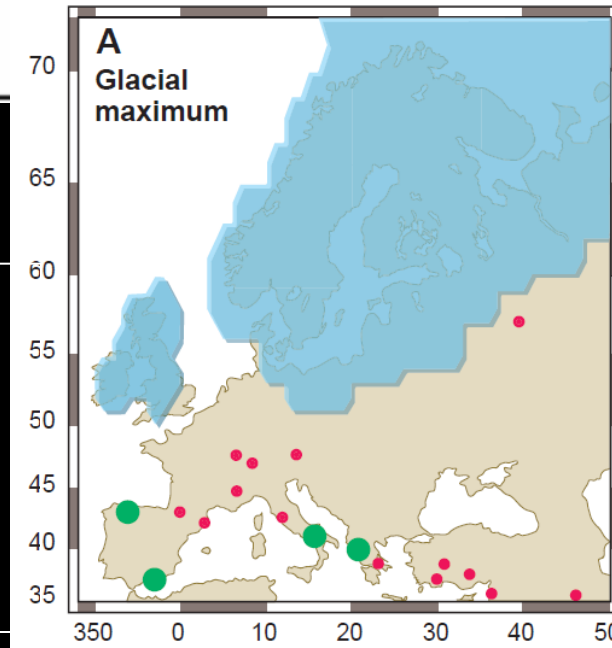
Araujo 2009



“The advantage of long holidays”

Characteristics

- Range contraction
- Favorable, stable climate
- High species diversity
- High genetic diversity
- Source for dispersal & rapid recolonization
- Centers of evolutionary divergence



Refugia For Climate Adaptation

Design & Management Considerations

- Single vs multiple species
- Single vs many refugia
- Combined refugia types
- Dispersal considerations
- Passive or active management

Types of Refugia

1. Climate Buffered; In-situ Contraction
2. Climate Buffered; Displaced Contraction
3. Heterogeneous (Patchy) Environments
4. Unique Substrates
5. Stable Areas, Persistent Resources
6. Favorable Species Characteristics
7. Cultural Refugia
8. Ex-situ Archives

Managing for Climate Change

REVIEW – Literature, Models, Vulnerabilities

RANK – Priorities, Capacities

RESOLVE – Decisions, Treatments

A Toolbox of Planning Options:

- Develop *Resistance*
- Promote *Resilience*
- Assist *Response*
- *Realign* Highly Altered Ecosystems
- Establish *Climate Refugia*

Web Tools for Forest Managers: The USFS "Climate Change Resource Center"


US Forest Service



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- Climate Change Primer
- Management Options

Climate Change and...

- Air Pollution
- Amphibians and Reptiles
- Assessments
- Bark Beetles
- Biodiversity
- Cumulative Effects
- Forests and Carbon Storage
- Genetic Resources
- Invasive Plants
- Landscape Analysis
- Natural Resource Strategies
- Plant Diseases
- Policy Analyses
- Salmon and Trout
- Silviculture
- Vegetation Distribution
- Water
- Wilderness
- Wildland Fire
- Wildlife
- About these pages

Information and Tools for Land Managers

The **Climate Change Resource Center (CCRC)** is a reference Web site for resource managers and decisionmakers who need information and tools to address climate change in planning and project implementation on lands in the West. Changing climates have already catalyzed changes in environments throughout the West, and future effects are expected to be greater. Although future scenarios are daunting, managers can do much to promote adaptation to climate change and encourage reduction of human effects on climate.

The CCRC addresses the manager's question "What can I do about climate change?" by providing information about basic climate sciences and compiling knowledge resources and support for adaptation and mitigation strategies. The site offers educational information, including basic science modules that explain climate and climate impacts, decision-support models, maps, simulations, case studies, and toolkits. The site is a joint project of the three western Forest Service Research Stations **Pacific Northwest Research Station (PNW)**, **Pacific Southwest Research Station (PSW)**, **Rocky Mountain Research Station (RMRS)**, and the **Western Wildland Environmental Threat Assessment Center**.

What's new?

- **State of Wyoming Climate Change Workshop:** Biologists, scientists, policy-makers, sportsmen and members of the media came together in Cheyenne on Monday, June 16 to learn more about climate change and how it could potentially affect Wyoming's resources. Slides and contact information are posted.
- **Analyses of the Effects of Global Change on Human Health and Welfare and Human Systems (SAP 4.6)** This Synthesis and Assessment Product 4.6 (SAP 4.6) focuses on impacts of global climate change, especially impacts on three broad dimensions of the human condition: human health, human settlements, and human welfare.
- **MTNCLIM 2008 Mountain Climate Research Conference.** Talks, Posters, and Webcasts from the conference held June 9-12 in Silverton, CO
- **Bull Trout and Climate Change.** Multimedia production of a 2008 symposium at the Western Division Meeting of the American Fisheries Society. Sponsored by the US Forest Service-Rocky Mountain Research Station, US Fish and Wildlife Service, and the US Geological Survey.
- **Preliminary review of adaptation options for climate-sensitive ecosystems and resources: Final Report, Synthesis and Assessment Product 4.4.** Chapter 3 addresses National Forests
- **Climate Change and Water: In Brief.** A new publication from the Forest Service National Headquarters
- **Woody Biomass Utilization.** New USFS site on using woody biomass for energy and other uses
- **Pacific Southwest Region (R-5) Climate Change site**
- **Climate Change, Water, and Kids.** Comments by Abigail R. Kimbell, Forest Service Chief
- **USFS Climate Research Strategy**
- **Sustainable Forest Resource Management**
- **Sustainable Operations**
- **Carbon Sequestration.** National "Ecosystem Services" site

Toolbox and library

- Video lectures
- Annotated bibliography
- FAQs about climate
- NASA animations
- Resources and documents

Current projects

Research roundup

Case studies

- Olympic National Forest
- Mendocino National Forest
- Tahoe National Forest

Vegetation maps, current and future scenarios

Other Forest Service Web sites

- WD Climate
- National R & D Climate
- PNW Climate
- PSW Climate
- RMRS Climate








The Climate Change Resource Center welcomes your comments and suggestions. ccrc@fs.fed.us
 US Forest Service - Climate Change Resource Center
 Last Modified: Aug 28, 2008 04:32:32 PM

Climate Change Online Short Course

Produced by the WestWide Climate Initiative

Adobe Flash Player 9

File View Control Help



USDA UAS PNW

INTRO CREDITS SUMMARY AGENDA CC QUIZ CCRC WEBSITE ONLINE VERSION

THEMES

PRESENTATIONS

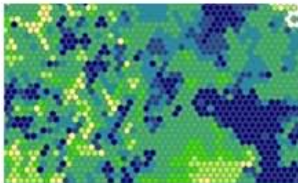
SPEAKERS

ADAPTING TO CLIMATE CHANGE

A Short Course for Land Managers

PNW-GTR-789

Themes



Climate Variability and Projections



Ecological Responses to Climate Variability



Management Responses to Climate Variability

47

Start | Connie Millar - I... | Web Mail Mess... | What's a Scree... | 2 Microsoft Of... | 3 Windows E... | September 200... | Adobe Flash... | Adobe Photosh... | 9:58 AM

For more information, publications, & presentations:

www.fs.fed.us/psw/programs/snrc/staff/millar/

