Adapting to Climate Challenges

Putting Ideas into Action

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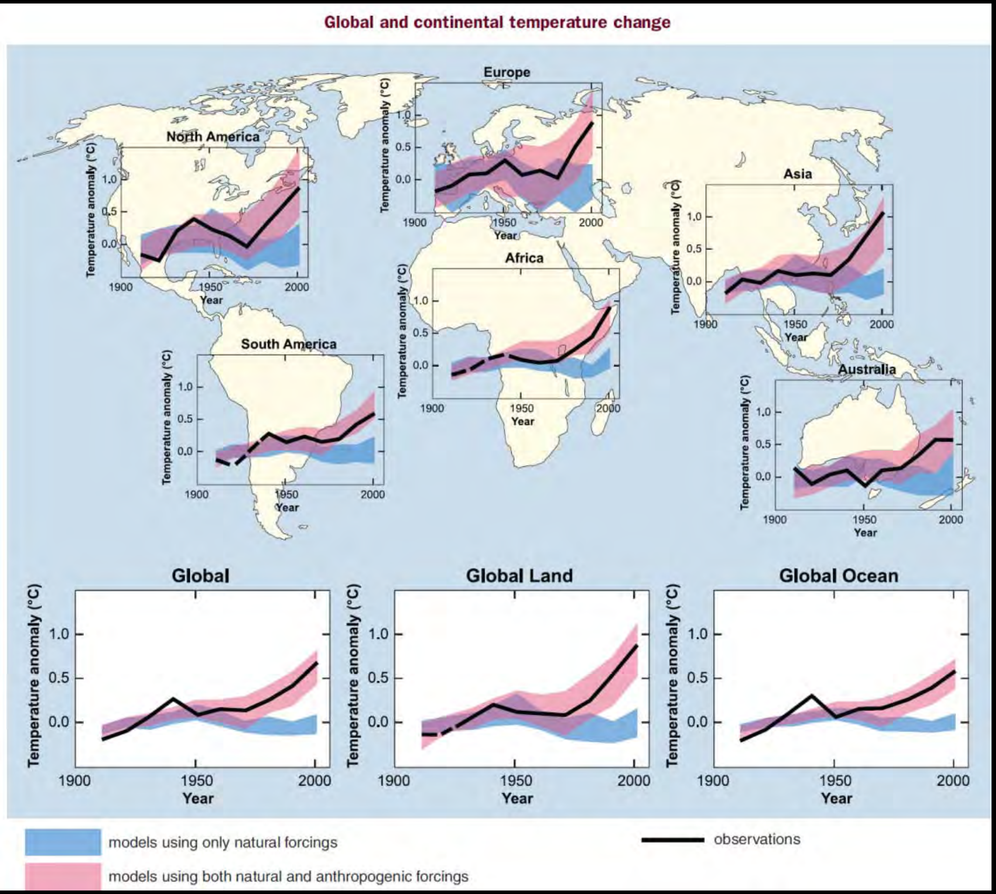
20th-Century "Tipping Points"

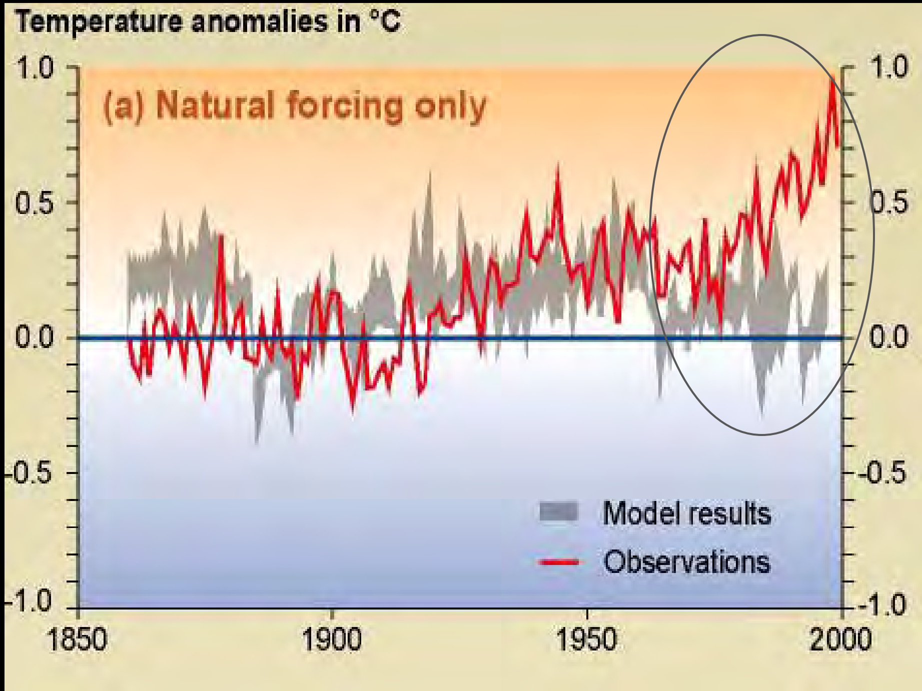
Intergovernmental Panel on Climate Change

4th Assessment Report 2007



Mean global temperature increase of 0.76°C since 1850

Warming trend over the last 50 years is twice the amount during last 100 years



Anthropogenic signal significant after ~1955

Atmospheric [CO_2] exceeds natural levels of past >650,000 years

Climate: The Bigger Picture

Earth's Natural Climate System

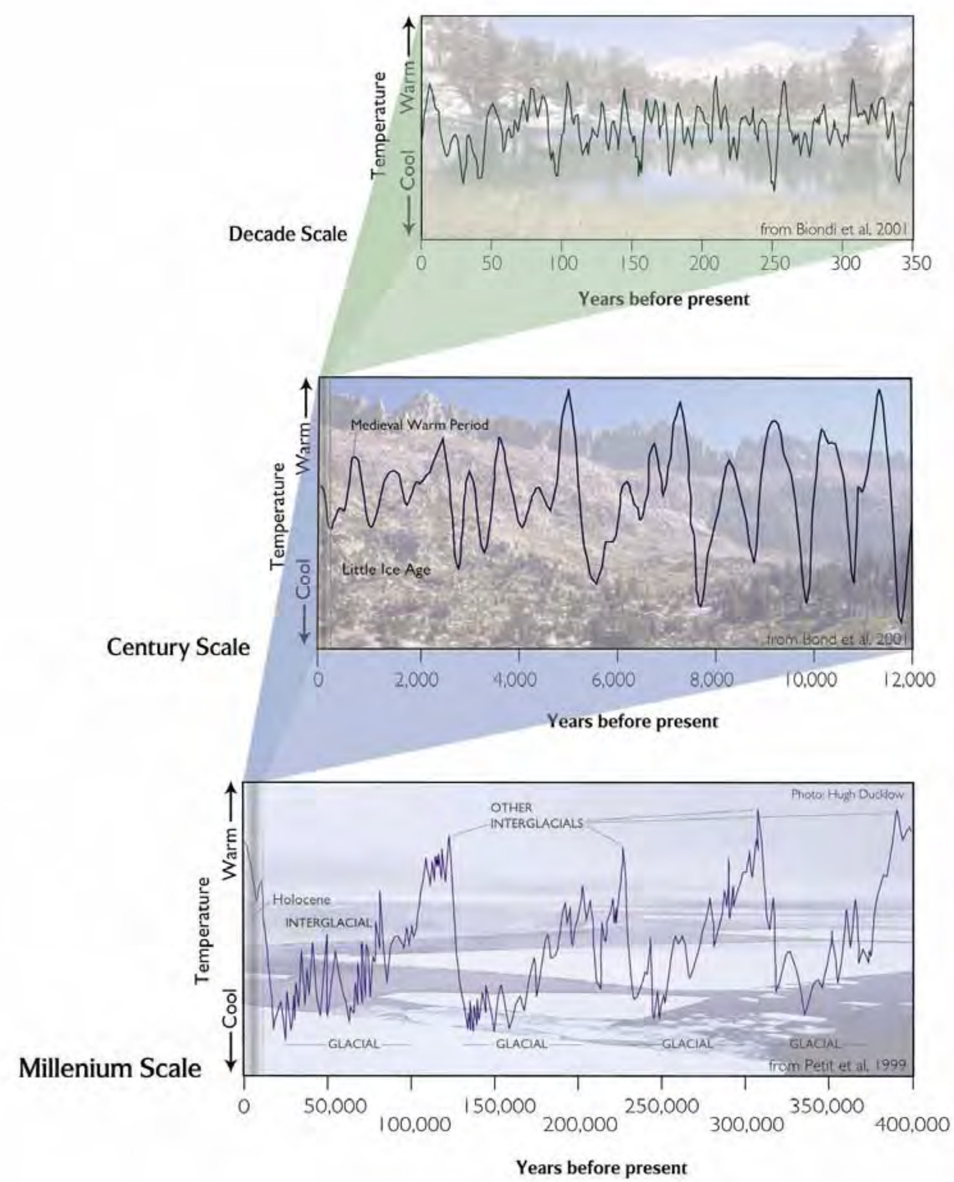
* Continuously Changing; Often Cyclic

* Nested Cycles: Annual, Decadal, Century, & Millennial Scales

* Distinct Physical Mechanisms

* Changes: Gradual & Directional to Abrupt & Chaotic

HOW WILL GHG EMISSIONS AFFECT NATURAL CLIMATE VARIABILITY?



Millar 2003

1. Glacial-Interglacial Cycles

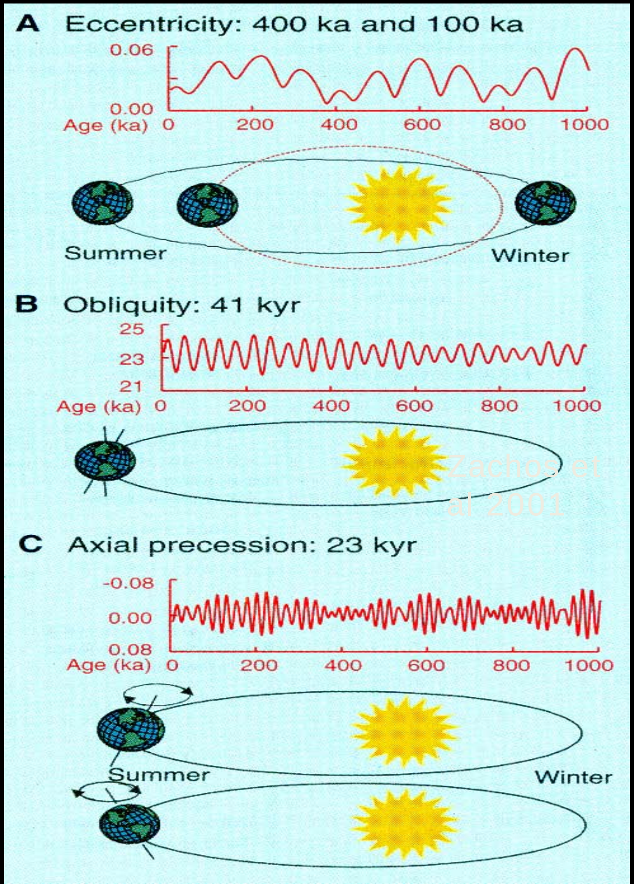
(10,000-100,000 years)

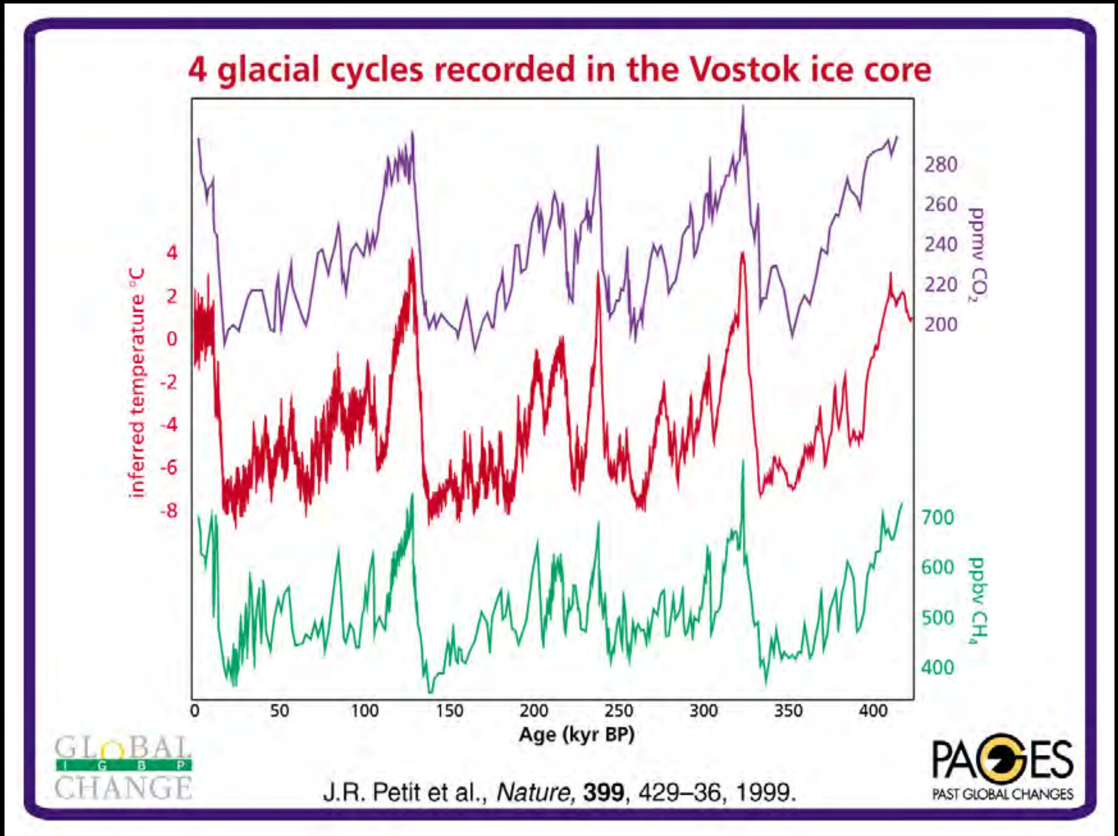
*6°- 8°C mean global differences

*CO_2 & CH_4 cycle as well as temperature

*Changes can be abrupt: >15°C change in 40 years

Earth:Sun Orbital Patterns



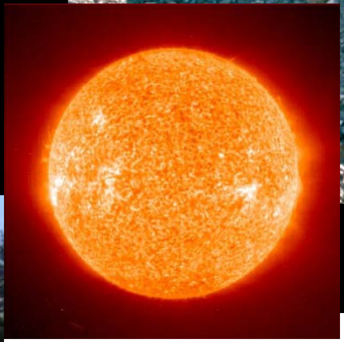


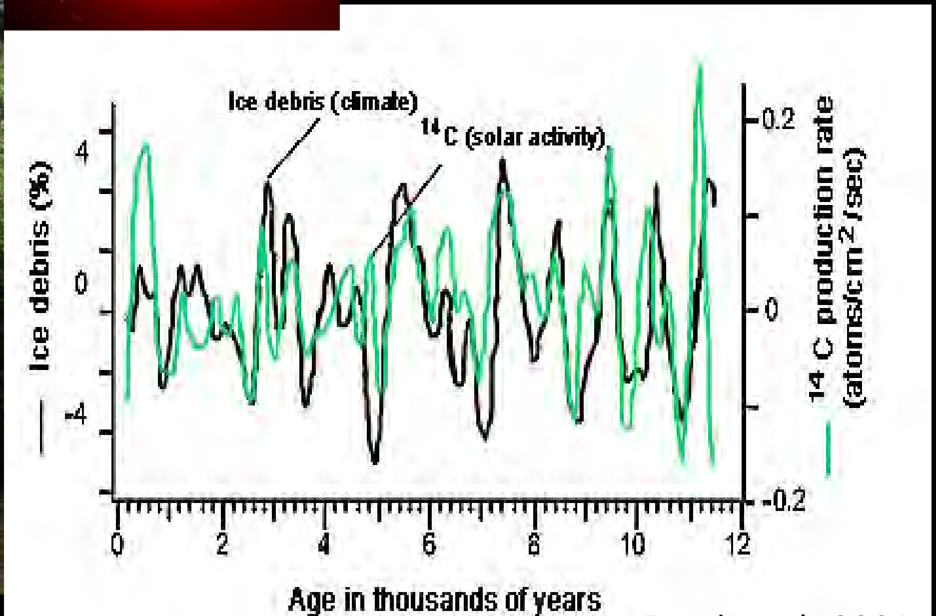
2. Century-Scale Cycles

(200-1000 years)

* 1°-3°C differences during Holocene

Solar activity; volcanic eruptions





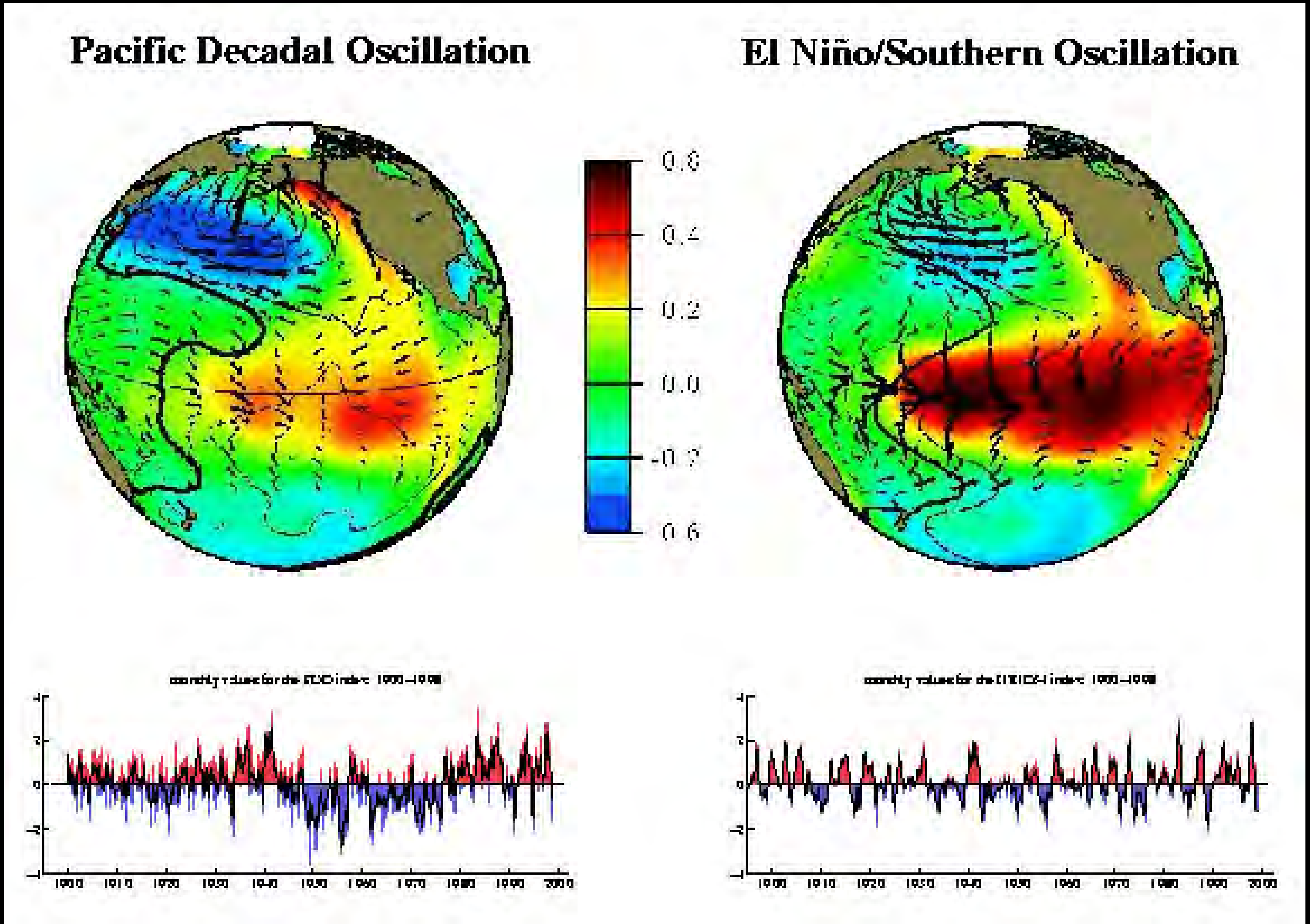
Bond et al. 2001

3. Decadal & Annual-Scale Cycles

*Pacific Decadal Oscillation
25 to 45 year cycle

*El Niño/La Niña
2 to 8 year cycle

Ocean circulation



Plant Species Respond to Climatic Variation at All Scales

Ecological Responses:

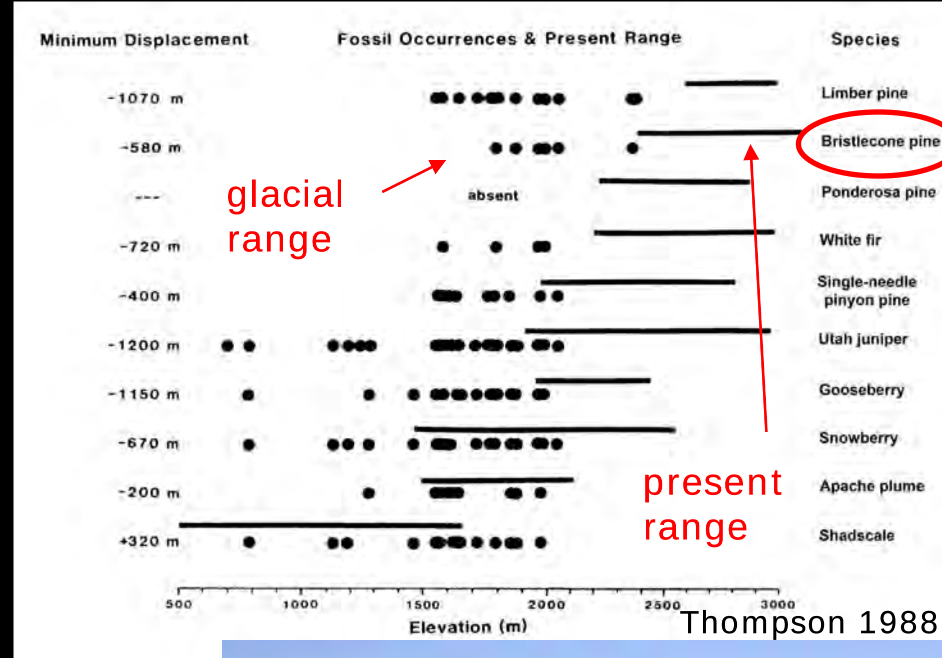
* Move to Favorable Location
* Change Form or Behavior

Genetic Responses:

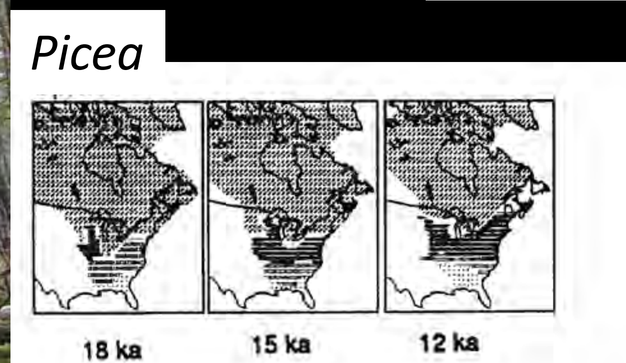
* Gene Flow
* Natural Selection
* Genetic Drift
* Changes in Breeding Behavior

Glacial-Interglacial Scale Responses

Mountain Regions

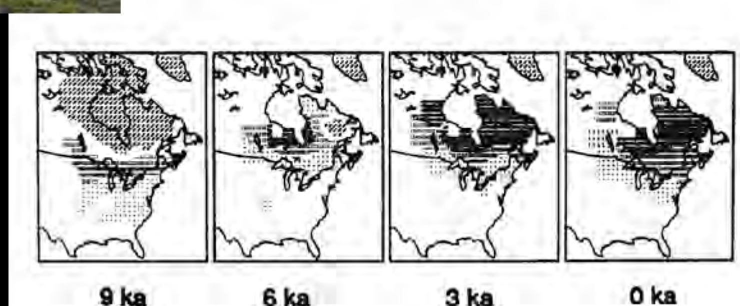


Thompson 1988

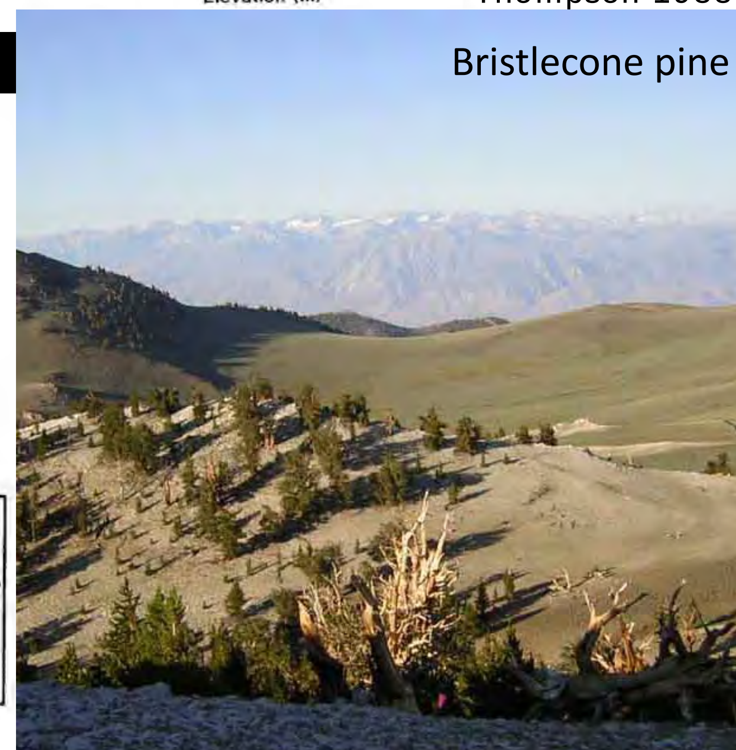


Jacobson et al. 1997

Low Relief Regions



present



Evolutionary Migrants Could be Considered Invasives

The Case of Creosote Bush

Larrea tridentata

South American center of origin

Creosote Bush arrived in North America only in the latest Pleistocene, 12ka -30ka

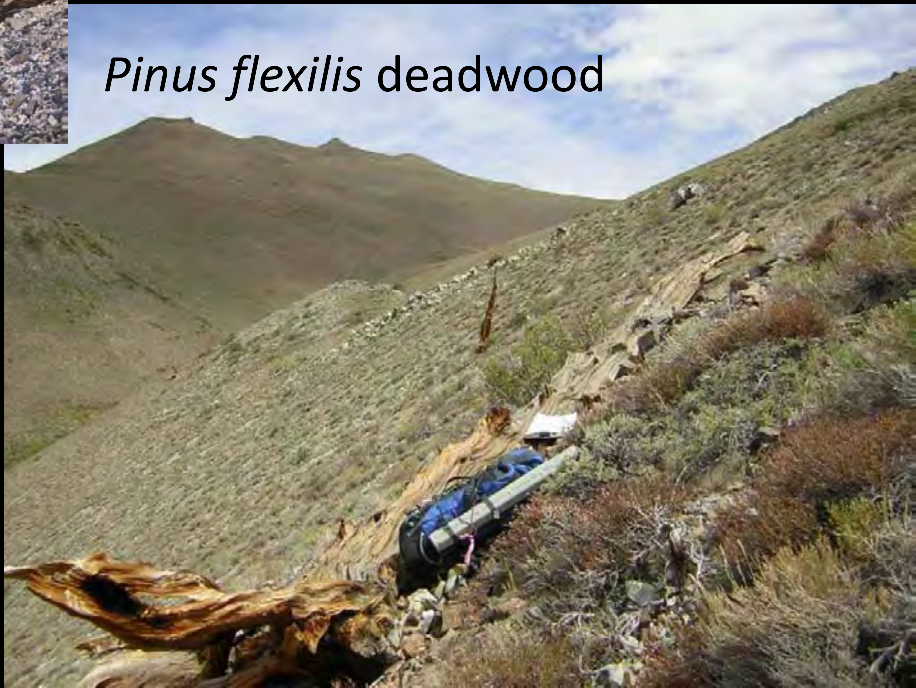
Many desert associates have been in NA for > 2 million years

Century-Scale Responses

Whitewing Mtn

Eastern Sierra Nevada, 3105m
Medieval Deadwood Forest
900-1350 AD Deadwood species:

Pinus albicaulis (50m)
P. contorta (400m)
P. jeffreyi (450m)
P. monticola(300m)
P. lambertiana (600m & western SN)
Tsuga mertensiana (200m)



Pinus flexilis deadwood

Great Basin Ranges

Pinus flexilis forest expansion & contraction relates to century-long drought and wet periods of last 4000 yrs

Millar et al. 2006

Multi-Decadal and Interannual Scale Responses

Changes in demography, stand structure, site conversions, plant form, mortality , fire regimes

Confronting Climate Change

I. Adaptation Assist resources & ecosystems to accommodate changes imposed by climate

II. Mitigation Reduce human effects on climate system by sequestering CO_2 & decreasing greenhouse gas emissions

Complementary…
and sometimes conflicting

Ecosystems of the Future

Embracing Change & Uncertainty

- Basic principles of ecosystem management remain valid
- Modify current practices with new information
- Some traditional practices might be inappropriate – i.e., where future is assumed to be similar to the past
- Manage for processes & ecosystem services

ADAPTATION PRINCIPLES
Toolbox Approach

- No single solution fits all situations
- Mix & match tools
- Options differ for short- versus long-term
- Nimbleness matters: Be flexible, experimental, and innovative
- Take small risks, be willing to learn & change course in midstream
- Prioritize often

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" Peterson et al. *In press*

An Adaptation Framework

Getting from Concept to Practice

Applicable across large areas ⟷ Location & situation specific

Options

—

Foundational adaptation concepts, i.e., resistance, resilience, and response *(after Millar et al. 2007)*

Strategies

—

Broad adaptation responses that consider regionally-specific ecological and managerial conditions

Approaches

—

More detailed adaptation actions that are can be applied to a single ecosystem or forest type

Tactics

—

Prescriptive actions designed for individual site conditions and management objectives

Swanston & Janowiak *In press*

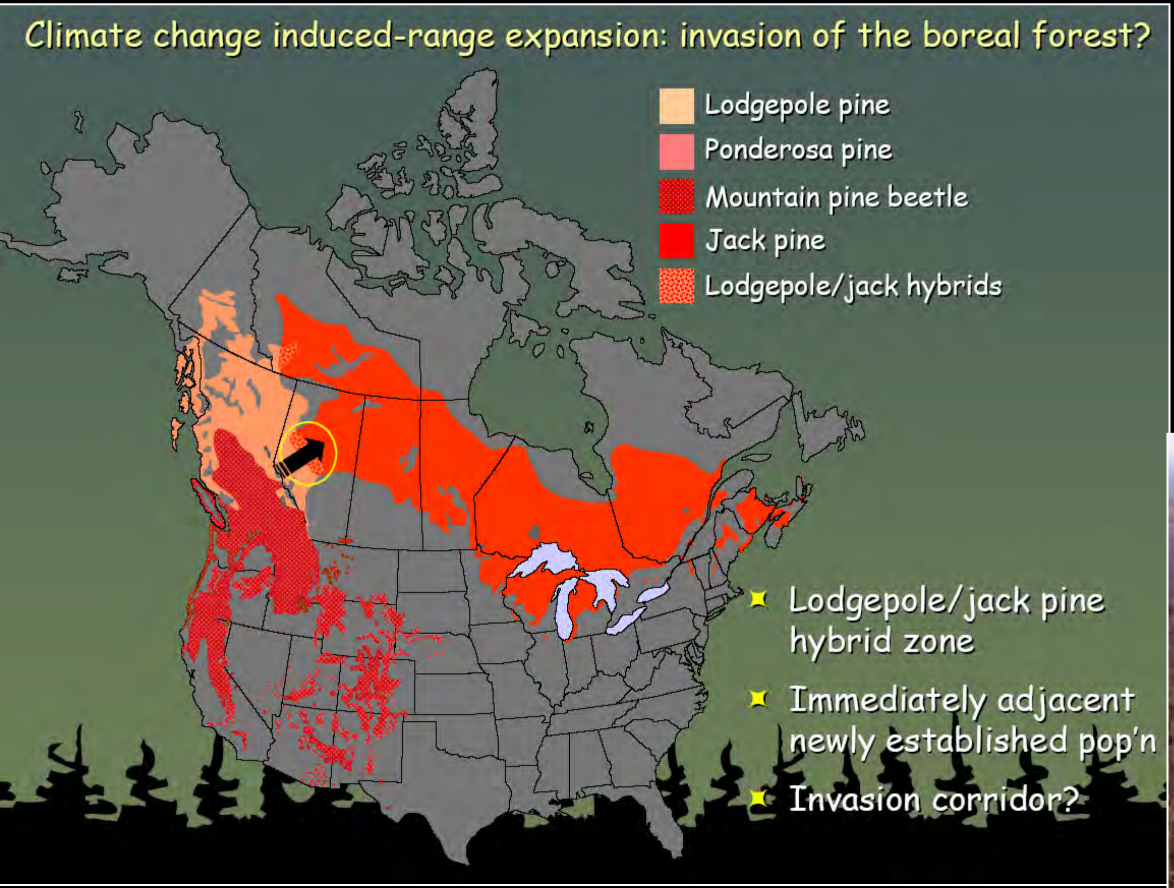
Adaptation Options

* Promote *Resistance*
* Increase *Resilience*
* Enable Ecosystems to *Respond*
* *Realign* Altered Ecosystems

Millar et al. 2007

OPTION 1: Promote *Resistance* to Change

* Defend highest-value resources against change



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

Strategy: Resist movement of beetles into new host species

Tactic: Control beetles at ecotone of *Pinus contorta* and *Pinus banksiana*

RESISTANCE

Strategy: Invasives – Detect early; respond rapidly

Tactic: Aggressively remove all exotic plants from DEPO

Strategy: Defend critical watersheds against extreme storm events

Tactic: Heavily armor ONF stream crossings & oversized culverts

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

★ Be Aware of "Paddling Upstream" Decisions

RESISTANCE

Resist projects that might fail or be inappropriate under future climates

OPTION 2: Increase Resilience

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

Strategy: Minimize stress, improve health, provide buffers and emergency back-ups

Tactics:

- Thin Forest Stands
- Stock Seed Banks
- Prescribe Fires
- Augment Endangered Species Populations

Strategy: Improve the capacity of a system or species to absorb external challenges without change in state

Strategy: Maintain native species not invasives Tactic: Hand cut, no fire use

Strategy: Maintain meadow not forest
Tactic: Vacate grazing allotments

Strategy: Enable species to persist not extirpate   Tactic: Isolate BHS pops from domestic sheep

OPTION 3: **Enable Ecosystems to Respond Adaptively**

* Assist transitions to new ecological conditions or locations

Ecological conversions are occurring already; encourage these how we want them to happen

Forest to Grassland

Colorado plateau, *Pinus edulis*

Drought & bark beetles

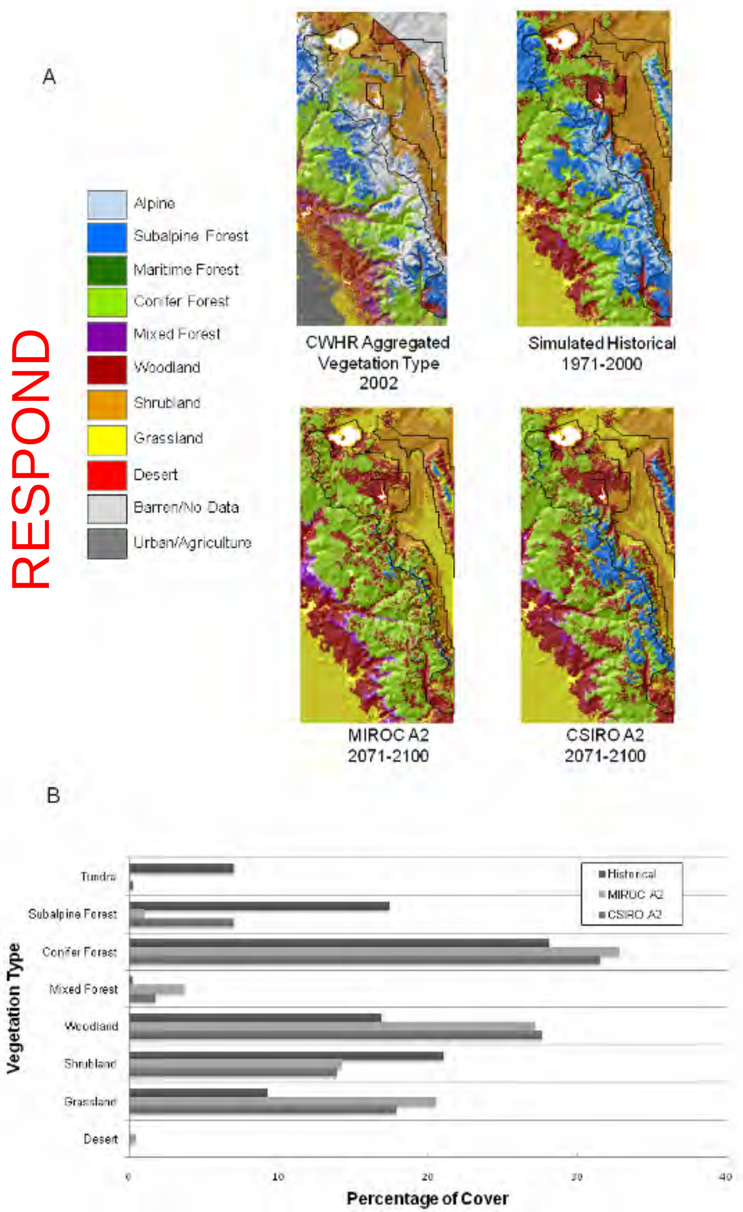
Grassland to Forest

Great Basin, *Pinus monophylla*

Warming & fire suppression

Strategy: Use downscaled climate- and ecological-response models to project future forest trajectories

RESPOND



Tactic: Following fire, plant with new mixes of species, anticipating what the future environment will support, and increasing resistance to invasive spp

★ Beware of "putting all your eggs in one basket"

Strategy: Promote genotypes that will be adapted to conditions of future environments

Tactic 1: Select specific genotypes for explicit climatic conditions

Tactic 2: Select broad genotypic mixes for uncertain future

RESPOND

Strategy: Move plants or animals outside their current native range to anticipated favorable future habitats

Tactic: Establish ex-situ populations of Brewer Spruce 1500 km north of current native range

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

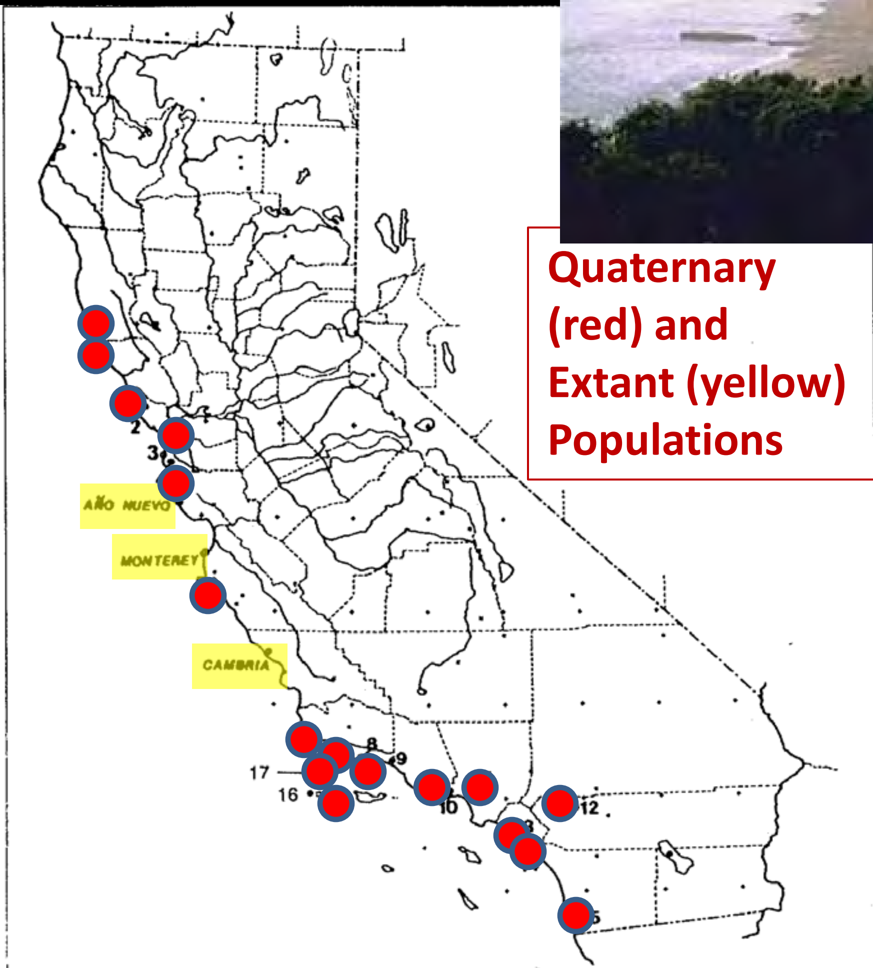
-- USFS Research Geneticist, Nov 2008

"Assisted Migration"

Tactic: Establish "neo-native" populations at paleo-historic locations of similar climatic regime

Pinus radiata

Millar 1999



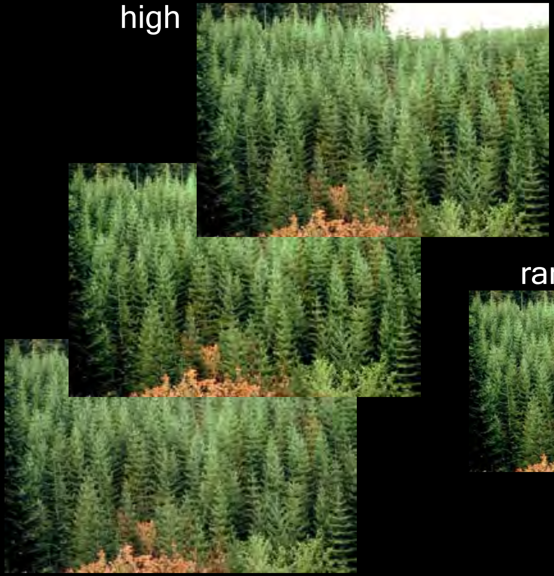
Quaternary (red) and Extant (yellow) Populations

Strategy: Conduct routine work as experiments to learn about ecological responses

Tactic 1: Use redundancy in reforestation

RESPOND

high

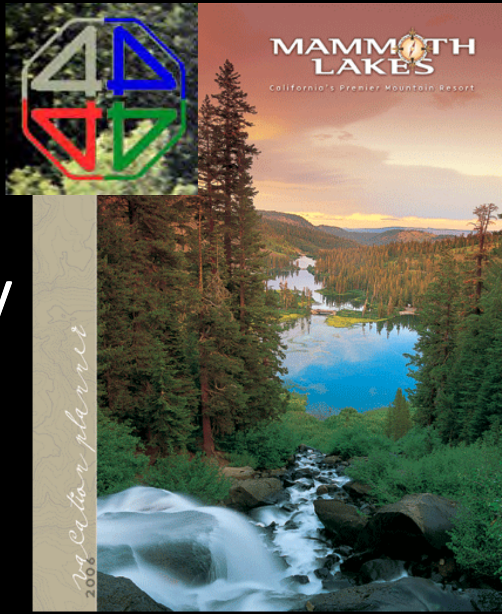


low

range margin

Strategy: Increase Diversity

Tactic: Increase forest structural diversity



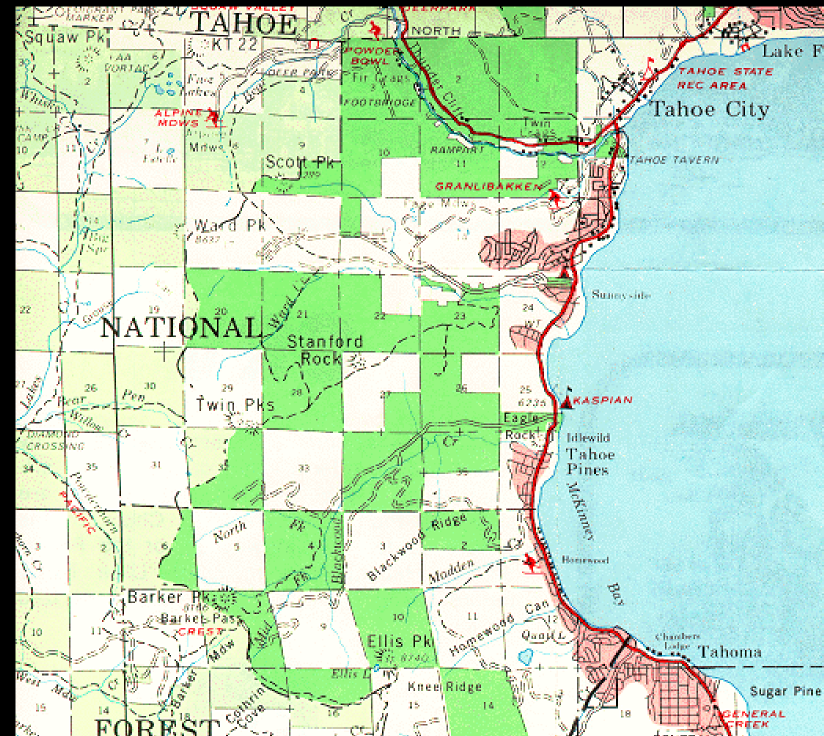
Tactic: Expand from winter- to 4-season resort

Strategy: Promote connected landscapes so that species can move at will to favorable habitat

RESPOND

Tactics:

- Increase management-unit size
- Lower fragmentation
- Maintain robust riparian zones
- Empower decision flexibility



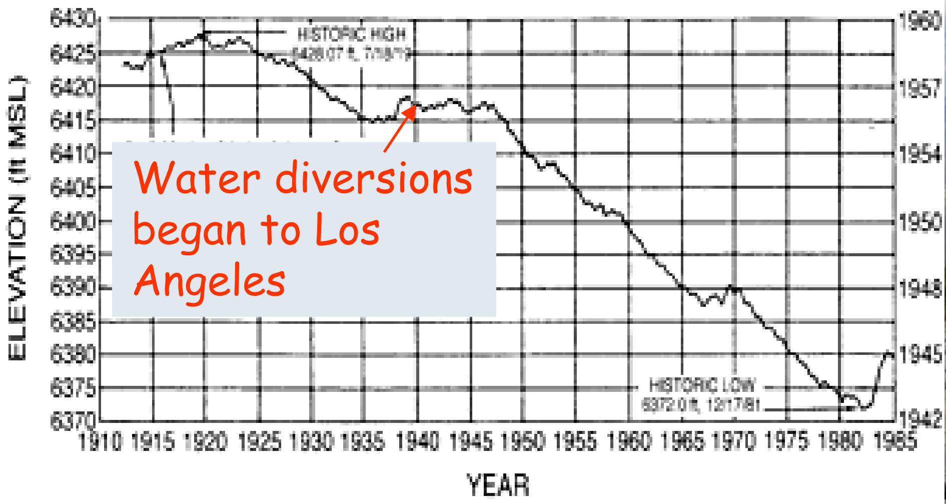
OPTION 4: Realign altered ecosystems to current and future dynamics

Strategy: Use information about future conditions as target for restoration

Tactic: Base target for Mono Lake level on projections of increased drought and lower run-off

"Historic range of variability" (pre-disturbance conditions) as a management target will often be inappropriate

NAS 1987



Adaptation Options

* Promote *Resistance*
* Increase *Resilience*
* Enable Ecosystems to *Respond*
* *Realign* Altered Ecosystems

How to Proceed? A Few Basic Steps

Step 1: Assess Vulnerabilities

Scenario Exercises

1. Spatial
   - Ecoregion (Multi-forest; mountain range)
     - Forest
       - Watershed
         - Project
2. Temporal
   - Current Year
     - Short Term (2-10 yrs)
       - Long Term (> 10 yrs)

Disaster planning crosses scales

Step 2: Set Priorities

1. Short Term (<10 yrs)

   Project Scale:

   Do No Harm

   Reconsider Goals & Targets

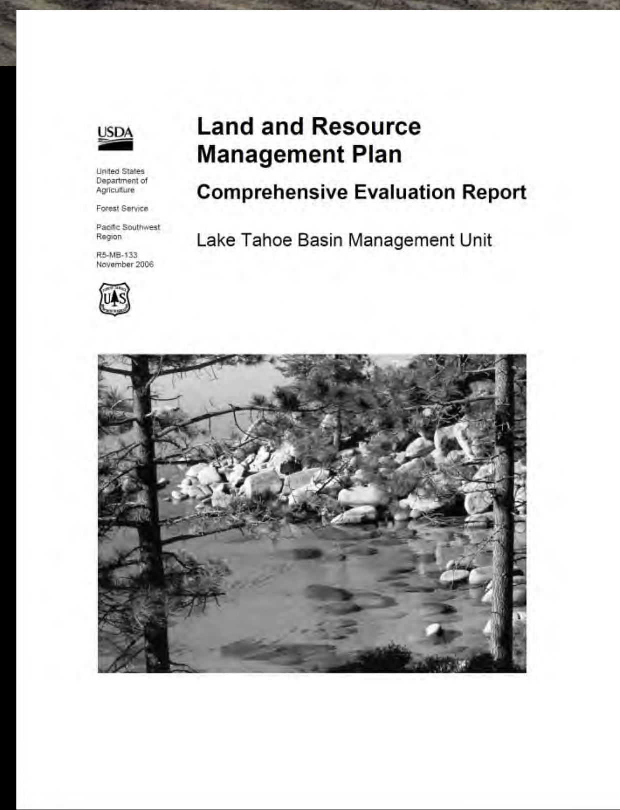
   Modify Existing Practices

2. Longer Term (>10 yrs)

   Planning Scale:

   Anticipate Surprises

   Ease Transitions



USDA

United States Department of Agriculture

Forest Service

Pacific Southwest Region

R5-MB-133
November 2006

Land and Resource Management Plan

Comprehensive Evaluation Report

Lake Tahoe Basin Management Unit

Triage Approach to Priority-Setting

Short term; needs exceed capacity

***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

Tiered Approaches to Priority Setting

Landscape Scale, Longer Term

"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

Step 3: Select Option, Develop Strategies, & Formulate Tactics

Swanston & Janowiak
in review

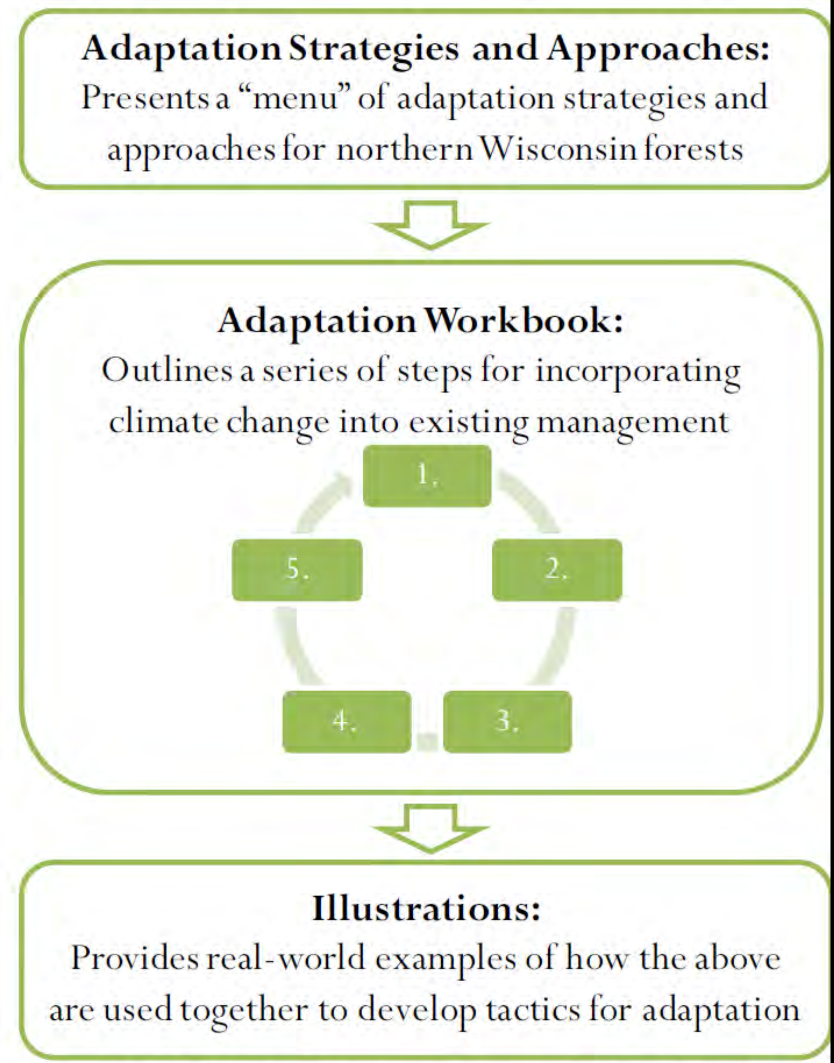
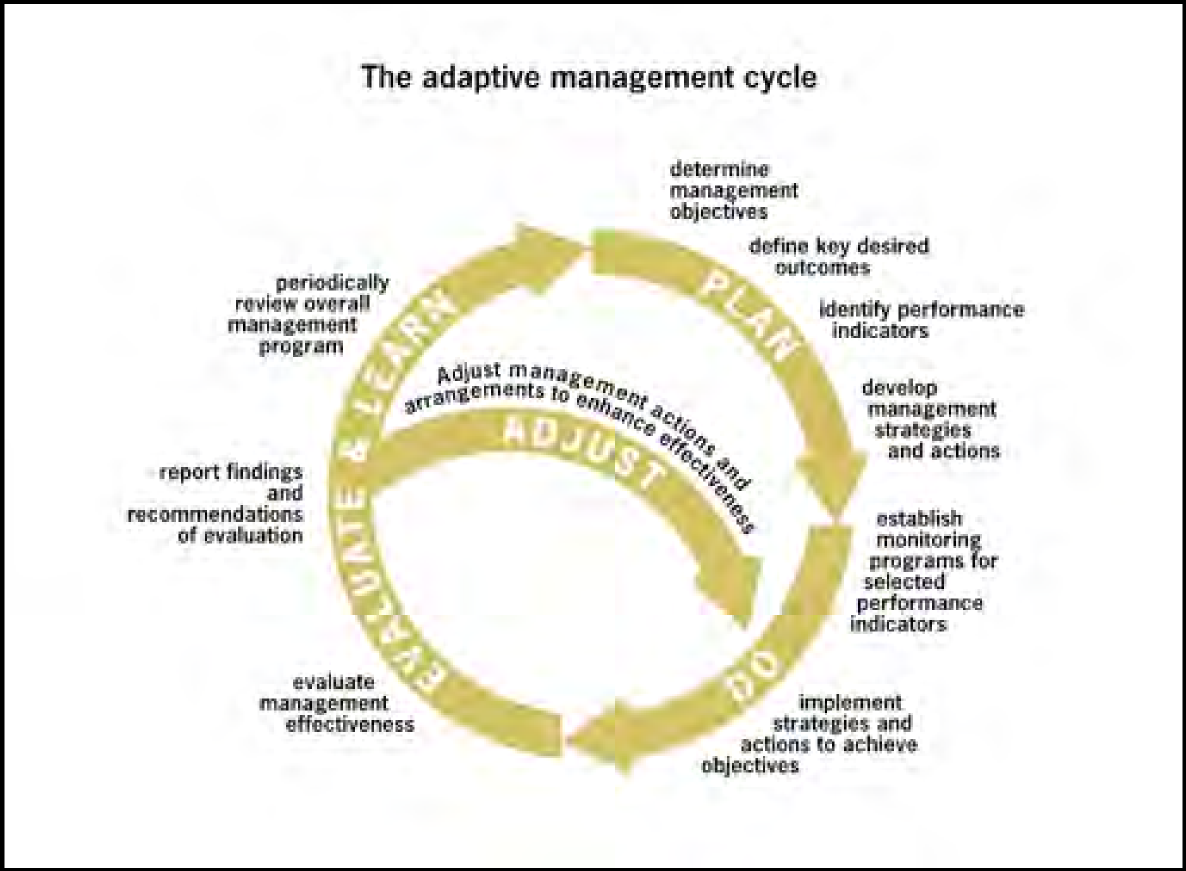


Figure 3. The Adaptation Strategies and Approaches and Adaptation Workbook chapters can be used together to develop management tactics to adapt to the anticipated effects of climate change.

Step 4: Monitor and Adjust

Policy implemented as an experiment

Adaptive management is essential under changing conditions



Simple is ok, but always implement projects so you can learn and adjust

SUMMARY ADAPTATION APPROACH

Step 1: Assess Vulnerabilities

Step 2: Set Priorities

Step 3: Select Option, Strategies, and Tactics

* Promote *Resistance…*
* Increase *Resilience…*
* Enable Ecosystems to *Respond…*
* *Realign* Altered Ecosystems…

Step 4: Monitor and Adjust

Resources:

Swanston, C.W. and Janowiak, M.K. (Eds) In press. *Forest adaptation resources: Climate change tools and approaches for land managers.* Northern Institute of Applied Climate Science.

Peterson, D.L., Millar, C.I., Joyce, L.A., Furniss, M.J. et al. In press. *Responding to climate change on national forests: A guidebook for developing adaptation options*. USDA Forest Service, General Technical Report. PNW/PSW/RMRS.