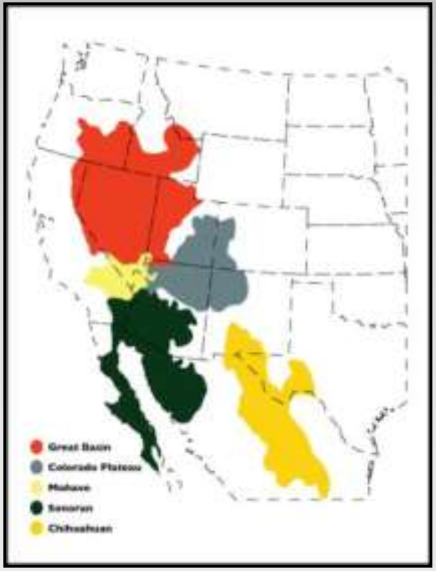
Natural History of Plant Invasions & Altered Fire Regimes in the American Deserts:

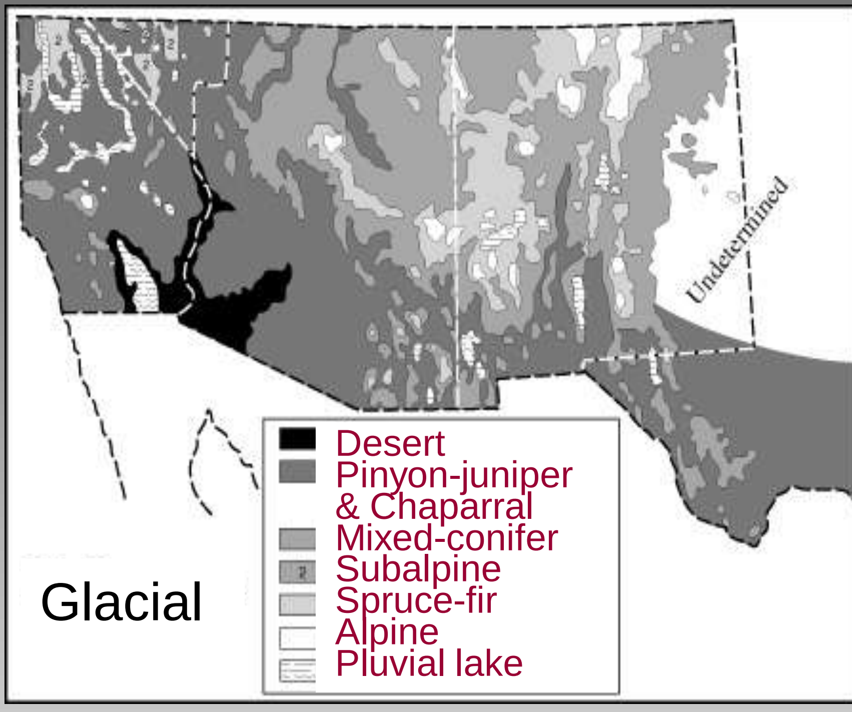
Julio Betancourt

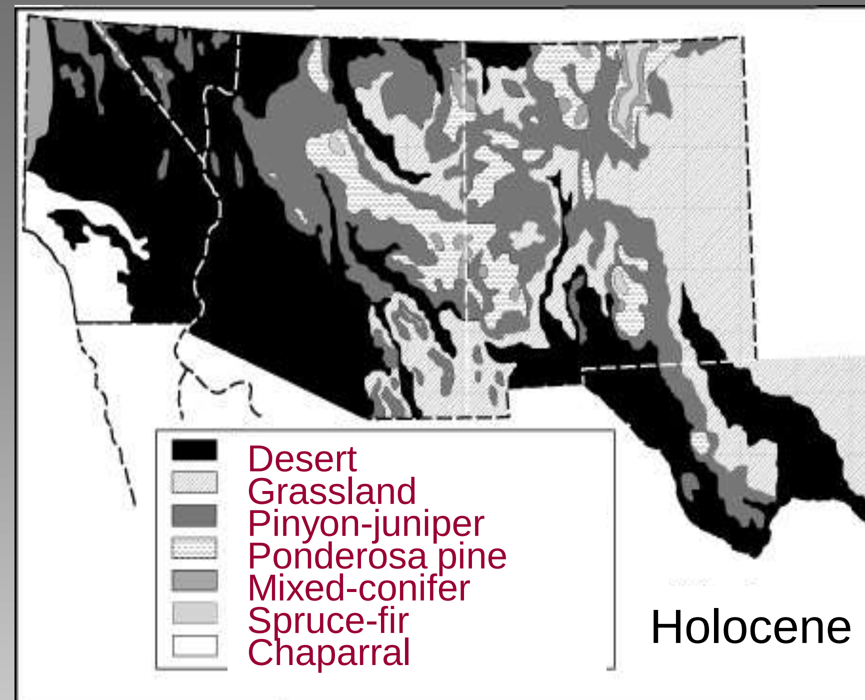


Roadmap

1. Historical Biogeography & “Natural” Invasions
2. Non-Native Grass Invasions & Wildfires
3. Assessment & Call to Action
4. Recent Climatic Trends: Rationale for Regional Initiative

Vegetation History of Southwestern U.S.



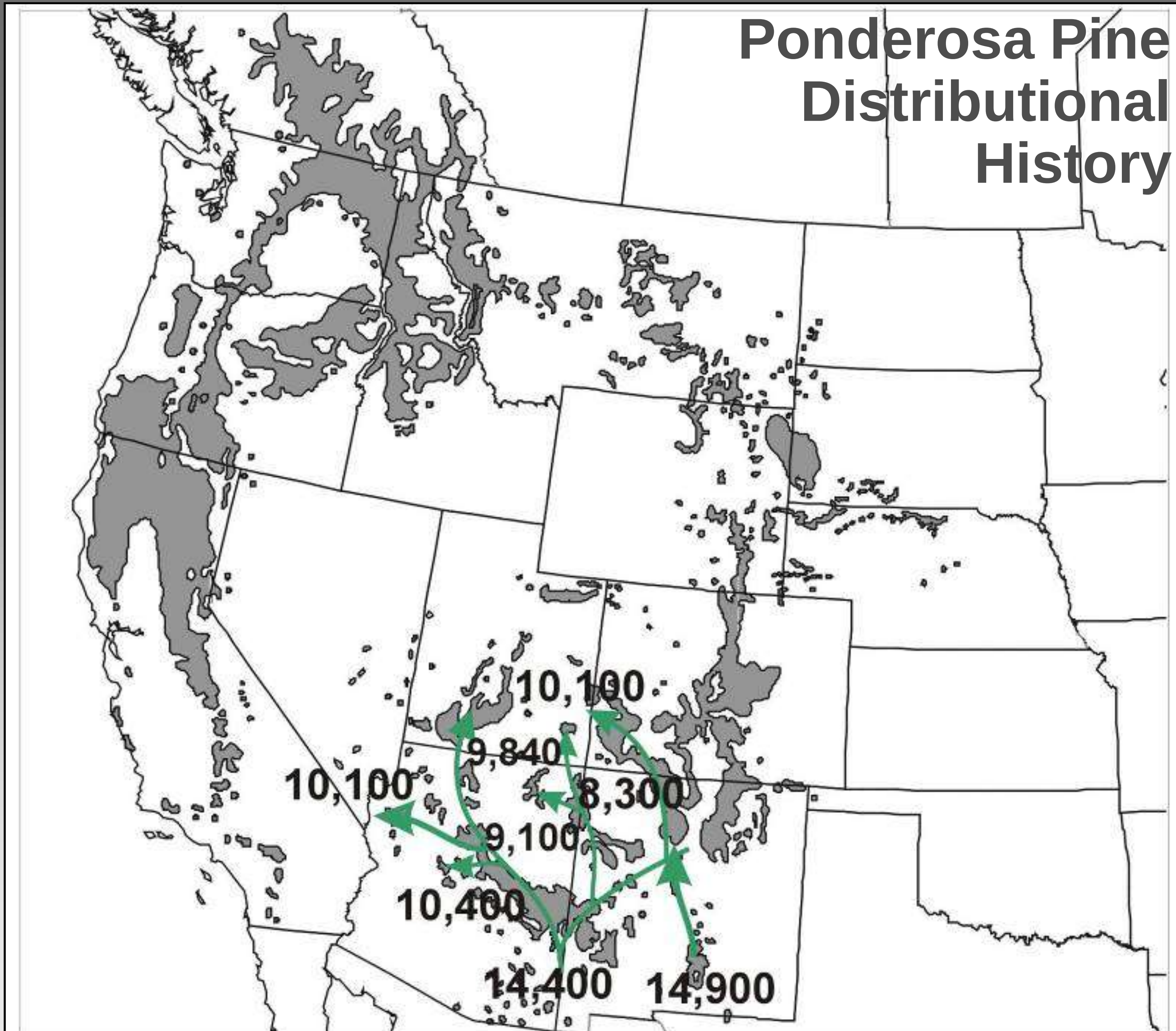


- Deserts <300 m
- Desert grasslands mostly stable
- P-J woodlands 300-1700m
- Ponderosa pine S of 34ºN
- Mixed-conifer woodlands in CP & GB
- Spruce-fir forests >2000 m
- ~5-8ºC cooler summers
- Westerlies displaced from 45 to 35ºN

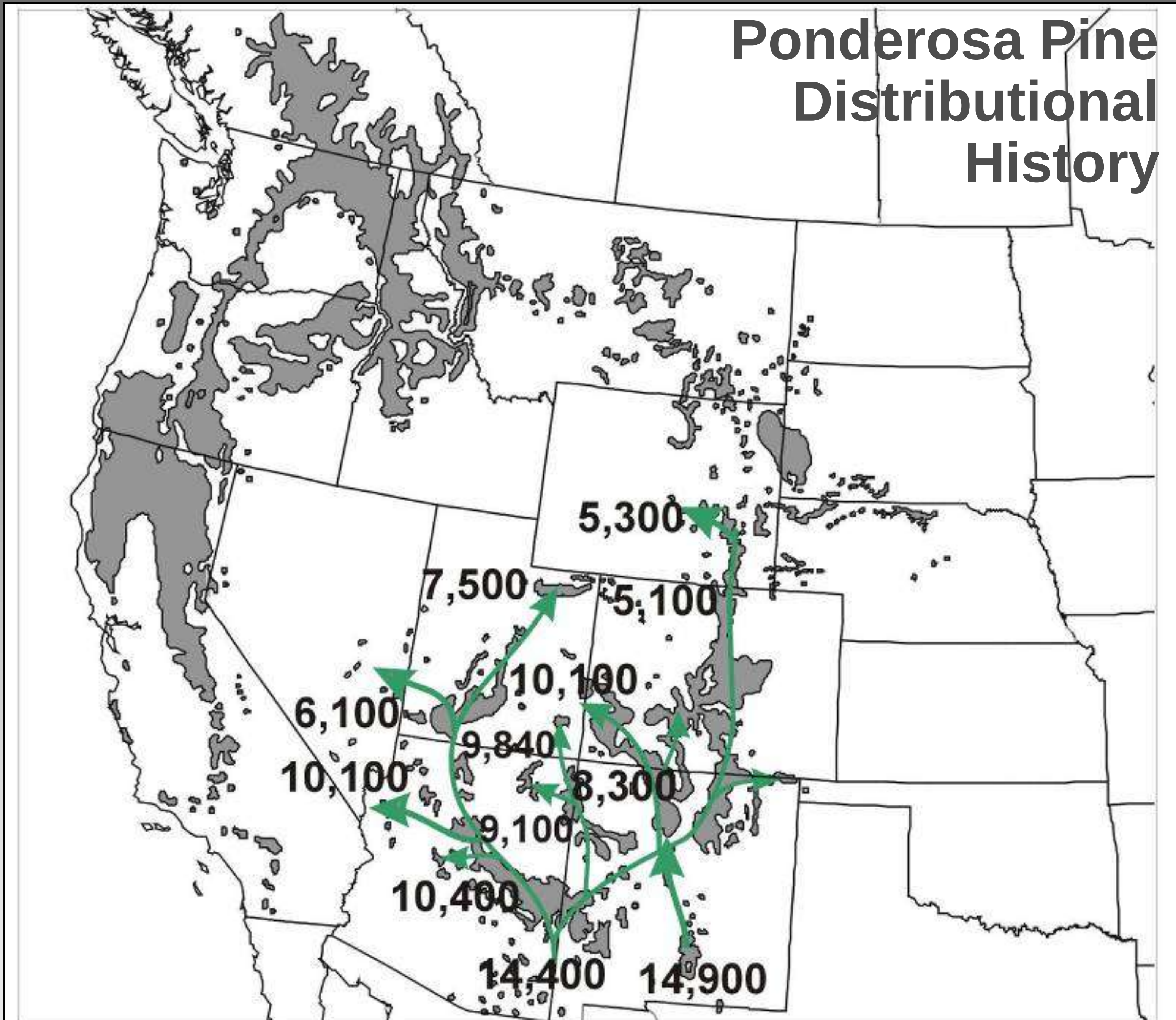
- Dramatic changes 13 ka
- Large herbivore extinctions!
- Pinyon pines vacate low elevations
- P-J & Ponderosa replace mixed-conifer
- Upward migrations quick (10^2 yr)
- Northward migrations slow (10^3 yr)
- Shrubs & Trees considered invasive slow; others surprisingly (saguaros) fast


Karen Carr

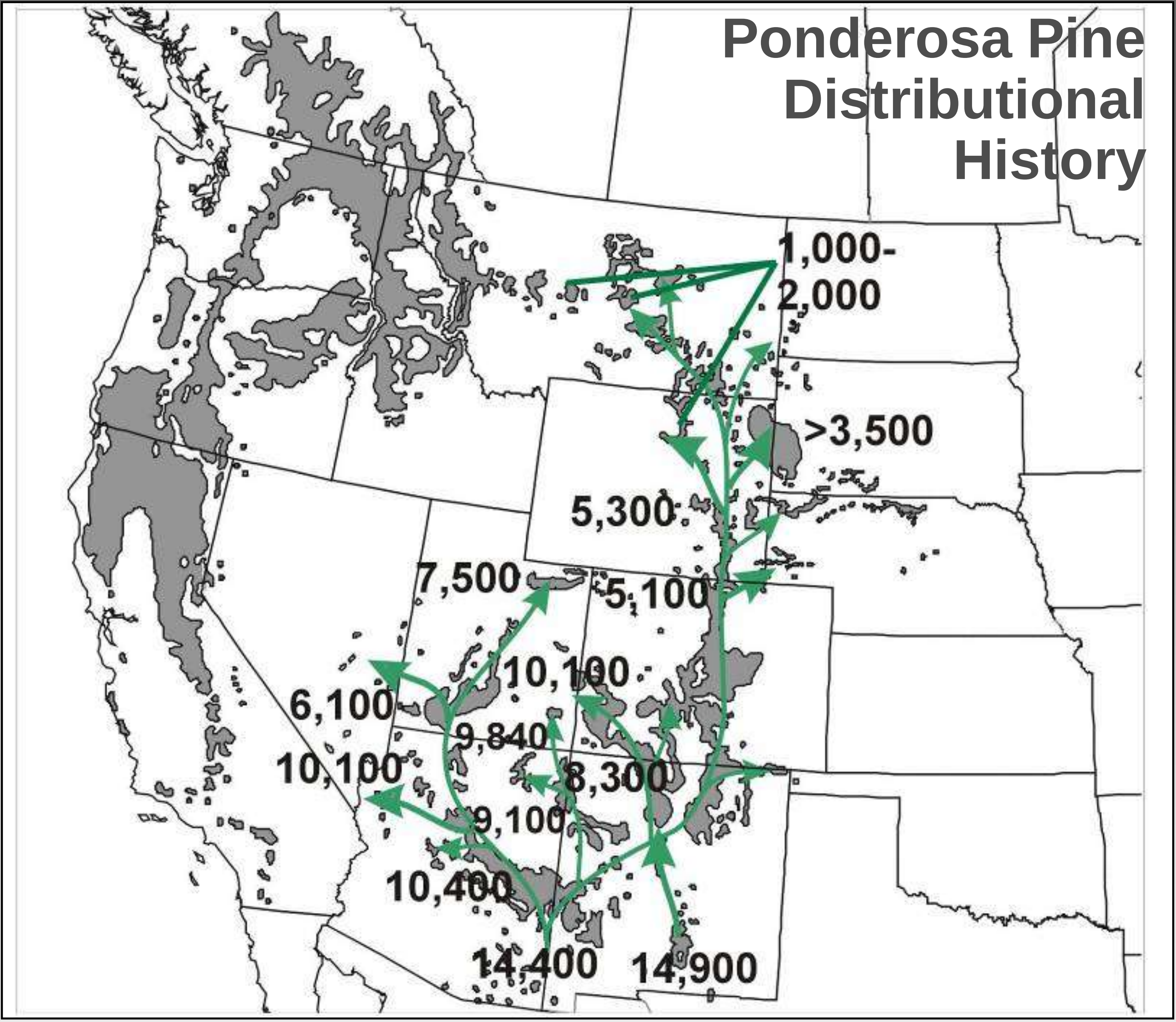
Ponderosa Pine Distributional History



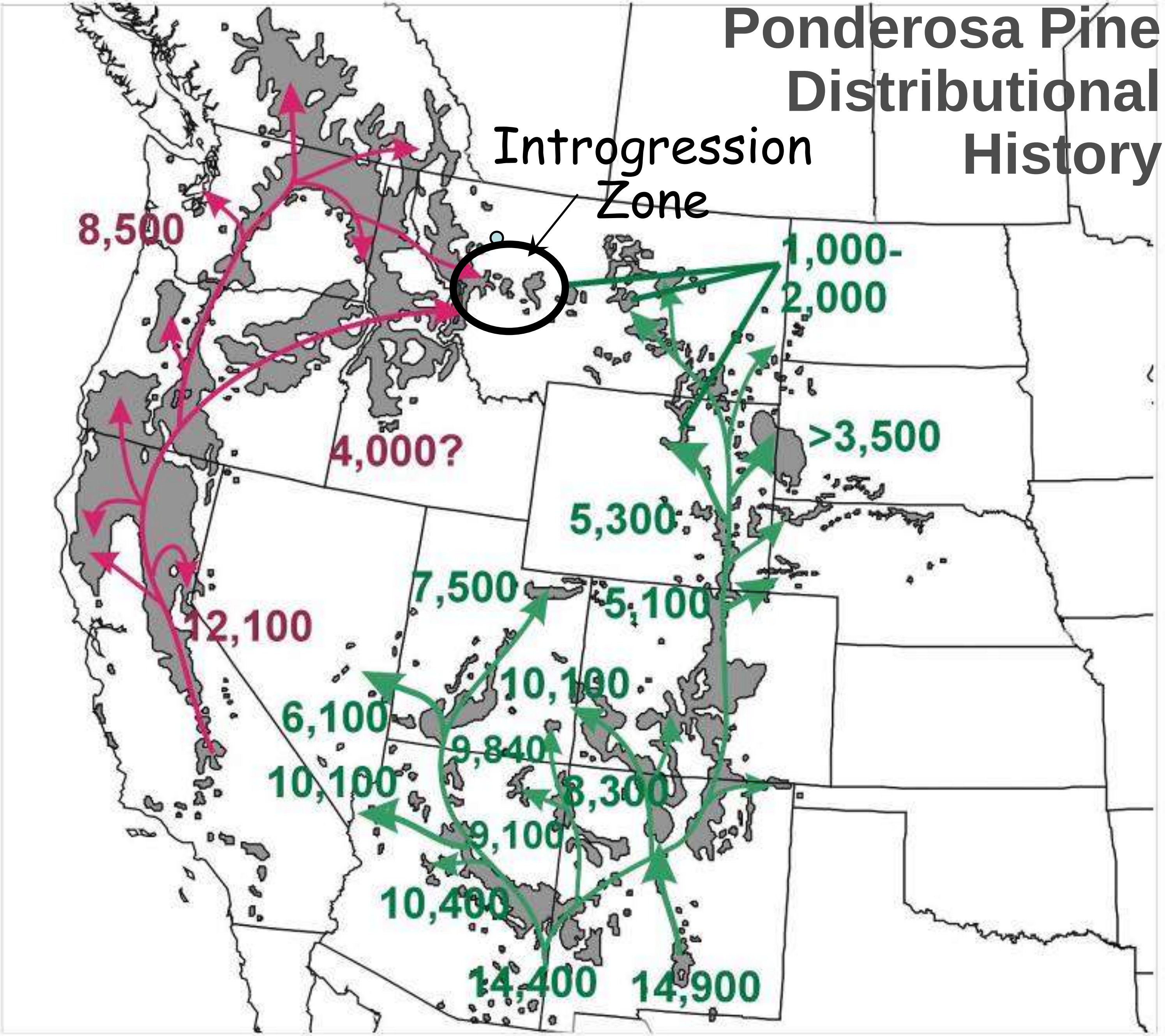
Ponderosa Pine Distributional History

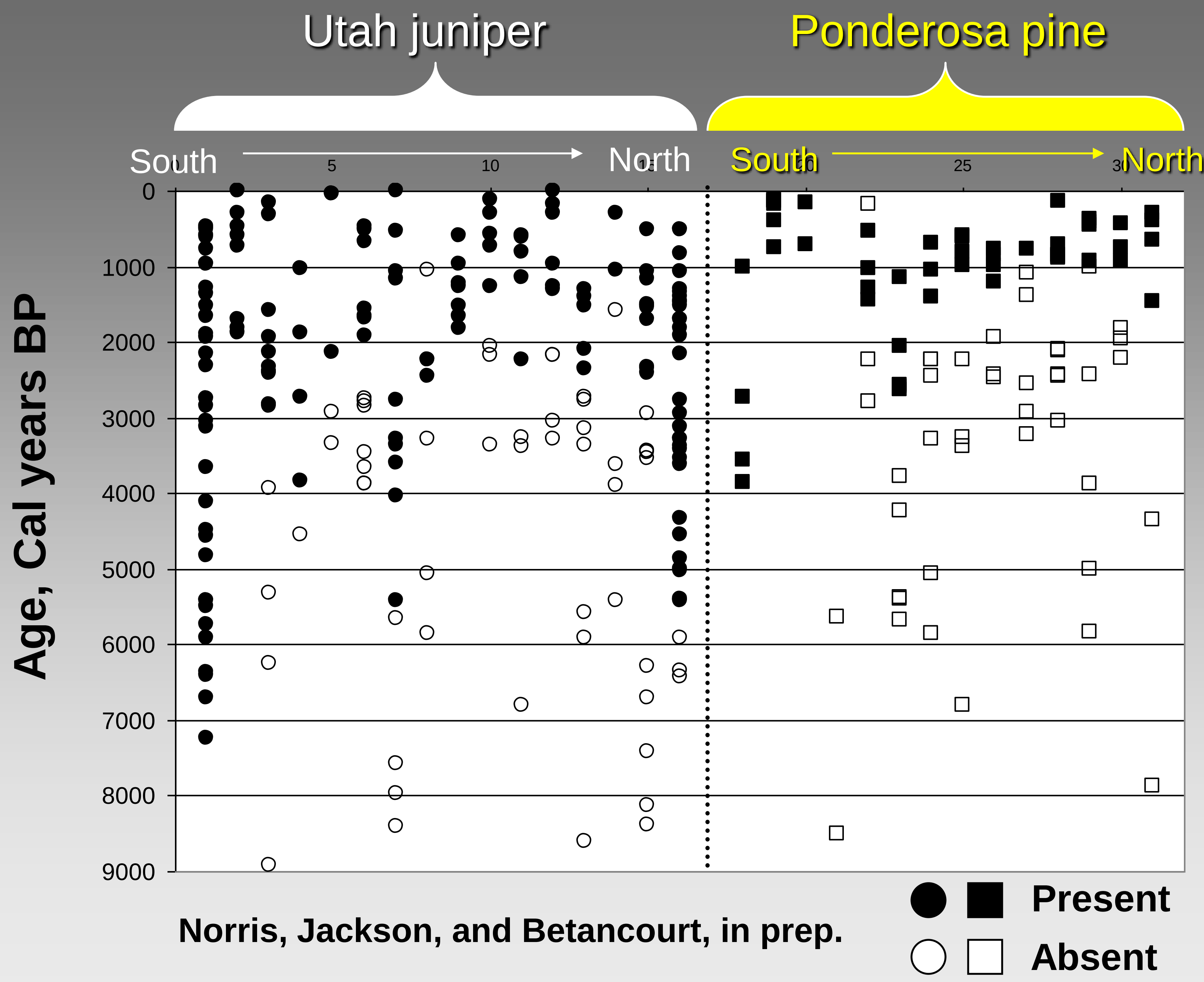


Ponderosa Pine Distributional History

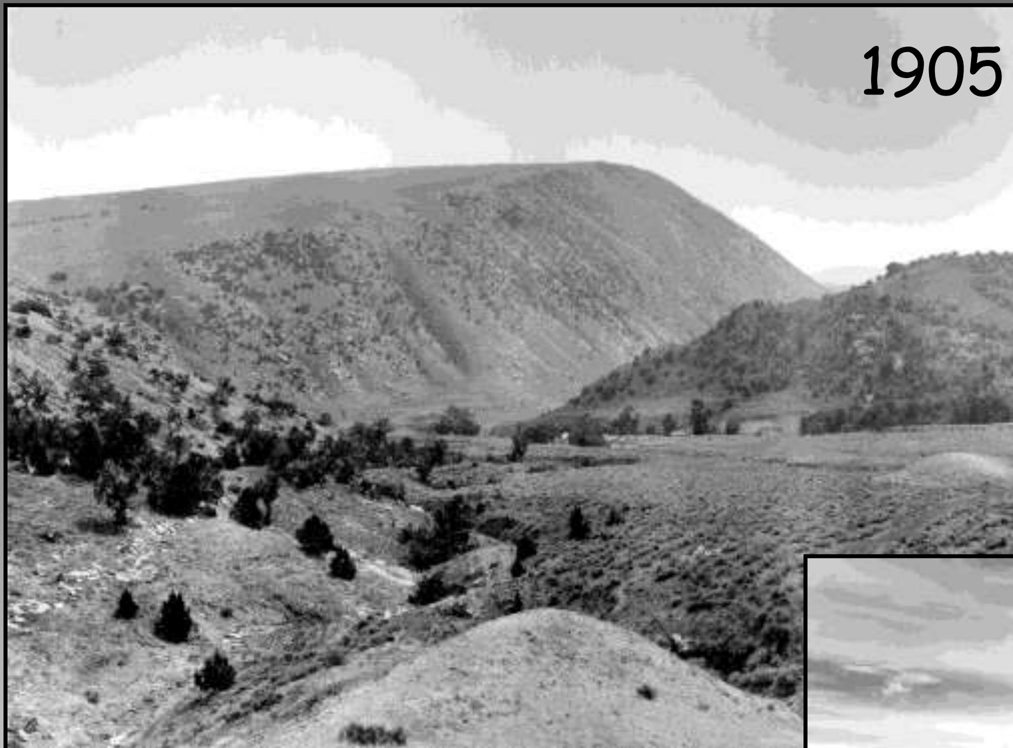


Ponderosa Pine Distributional History





Norris, Jackson, and Betancourt, in prep.



Population infilling associated with ongoing plant migration ?

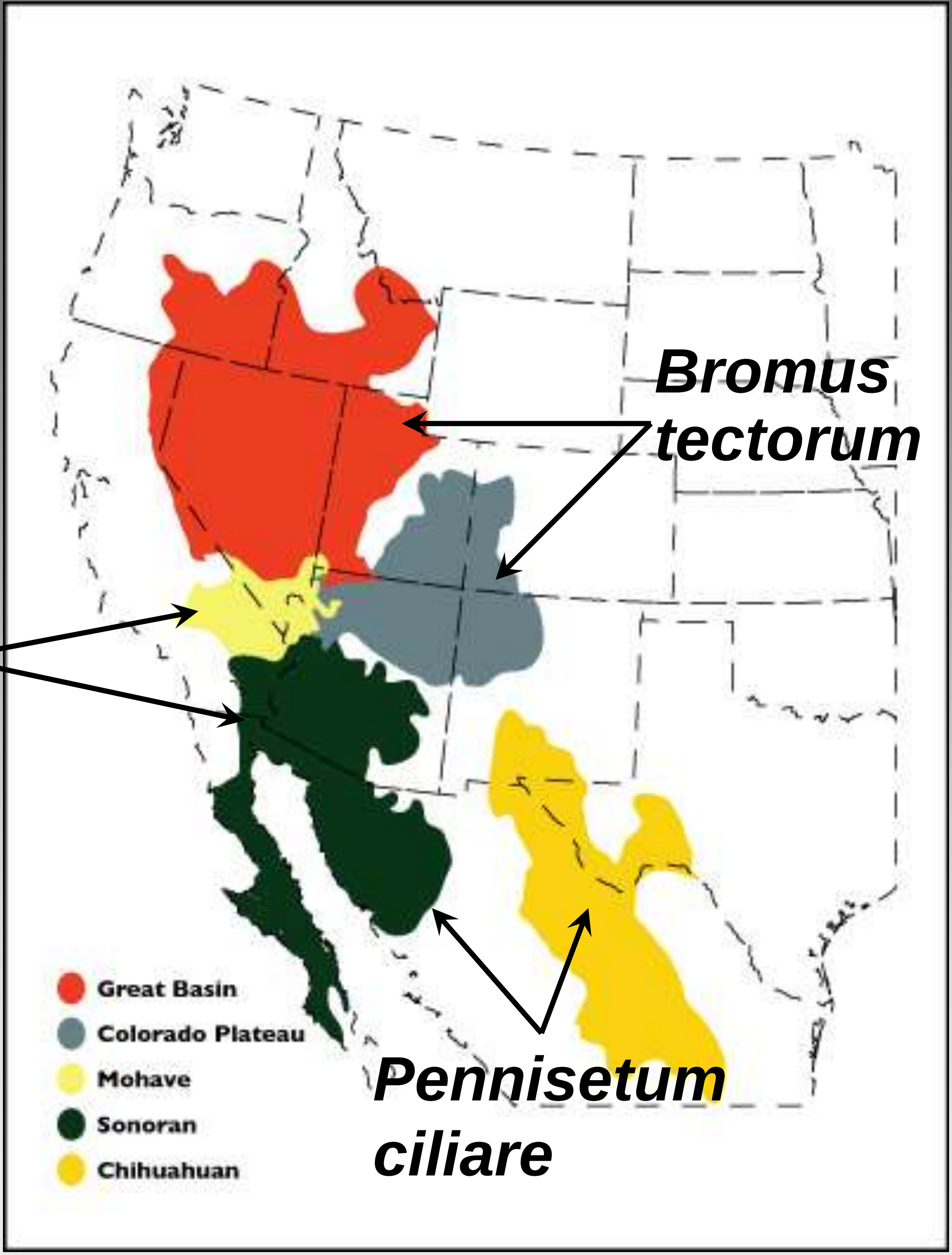
Woody plant encroach-ment of grassland with grazing and fire suppression?

Principal Invasive Grasses Fueling Wildfires in the American Deserts

Schismus arabicus

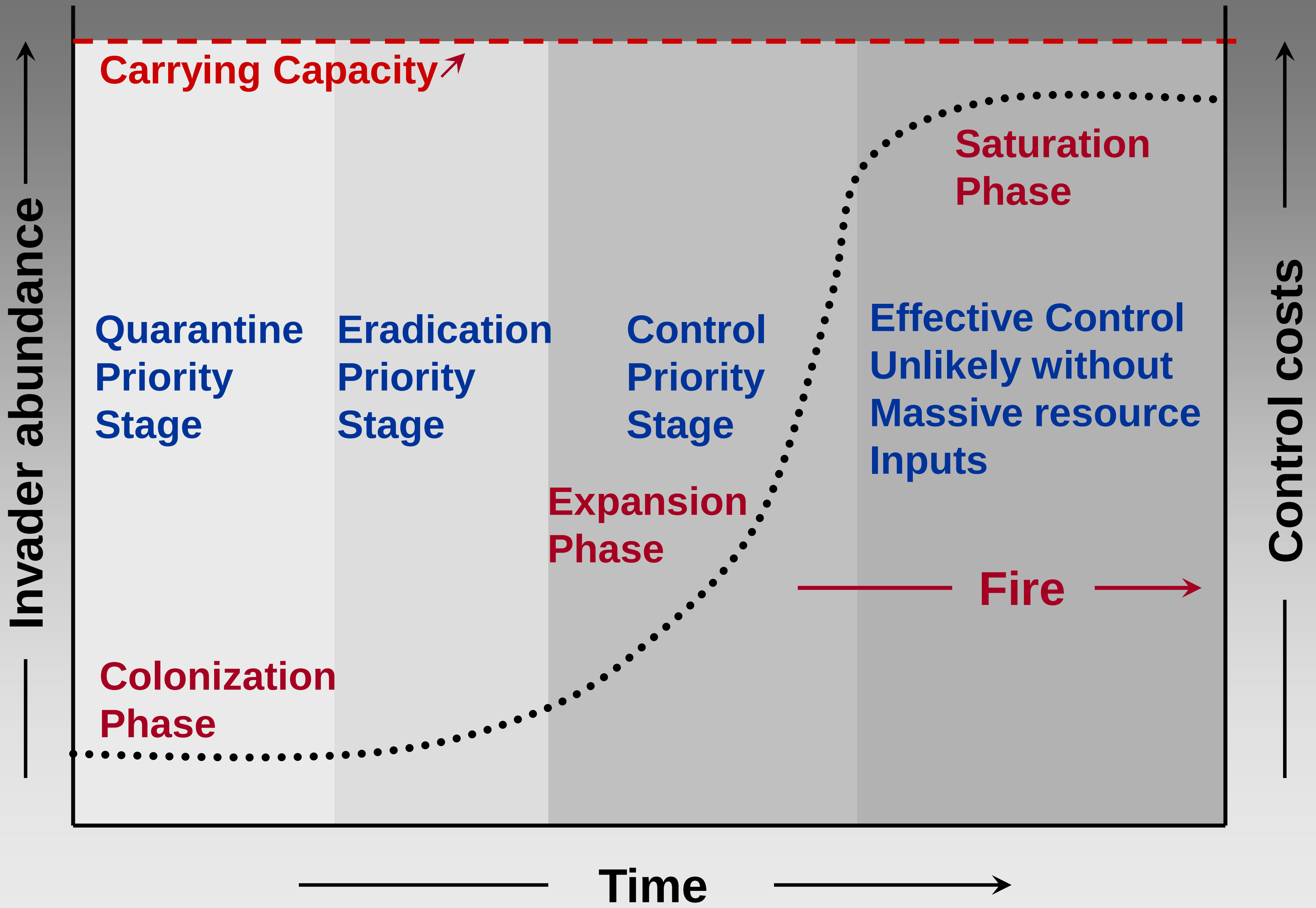
Schismus barbatus

Bromus rubens

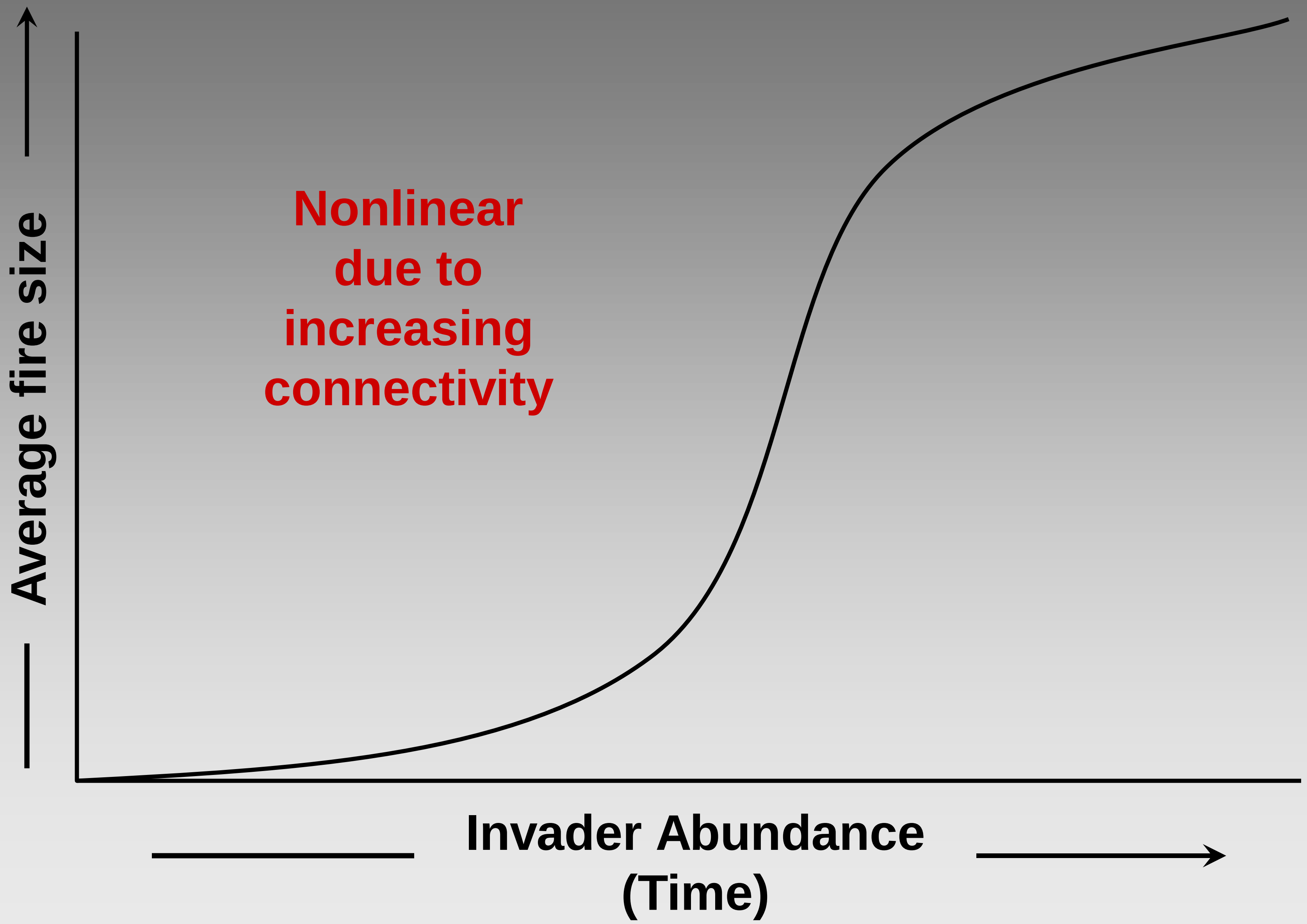


Invasibility and changes in fire regimes vary across deserts

At which threshold is this unmanageable/irreversible?



Invader abundance, Fuel Connectivity & Wildfire Size

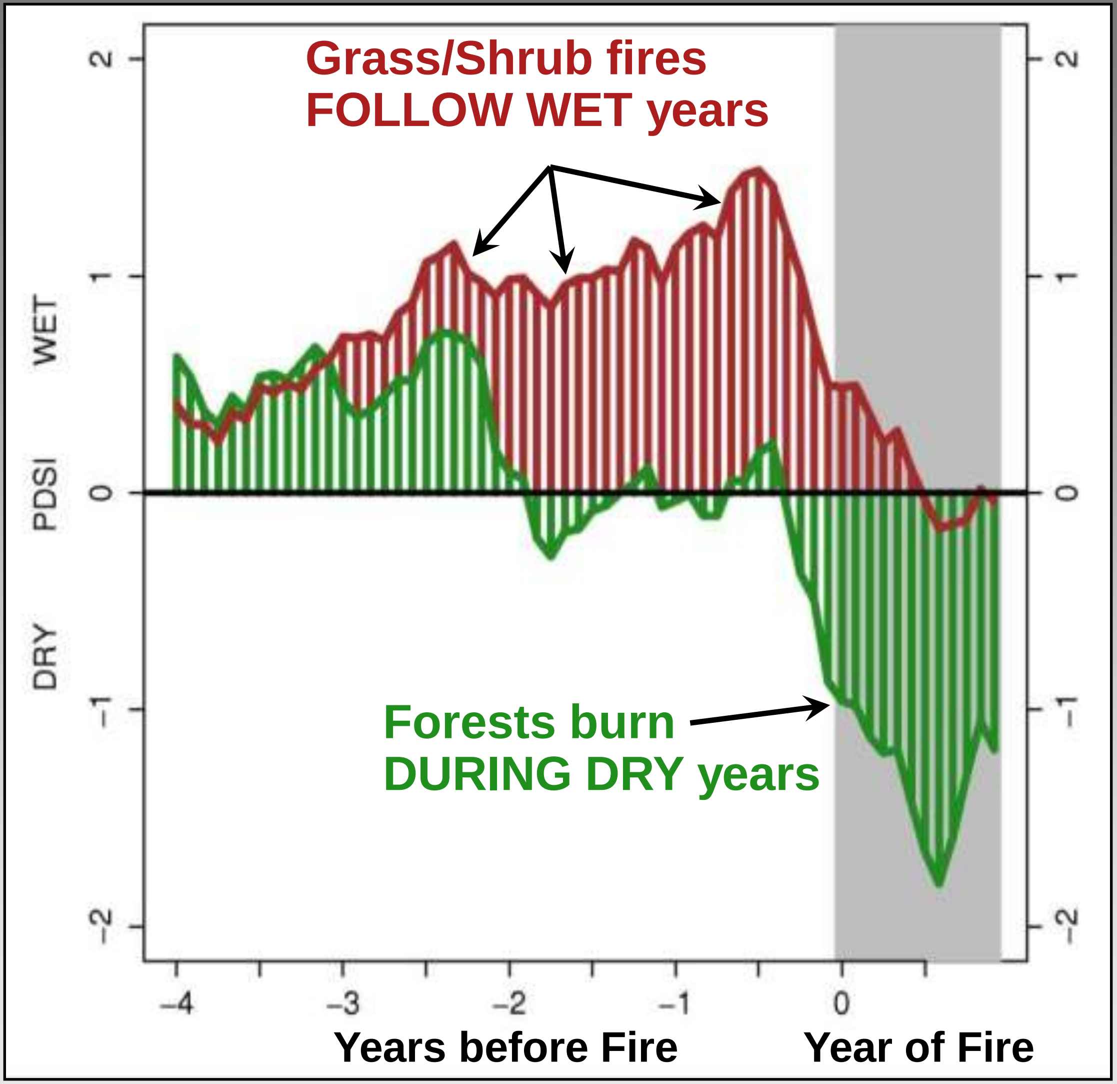


Mustang Fire, Dutch John Mountain, July 1, 2002, 16,000 acres

Sawtooth Complex Fire, July 2006; 61,700 acres

Cave Creek Complex Fire, June 2005, 243,950 acres

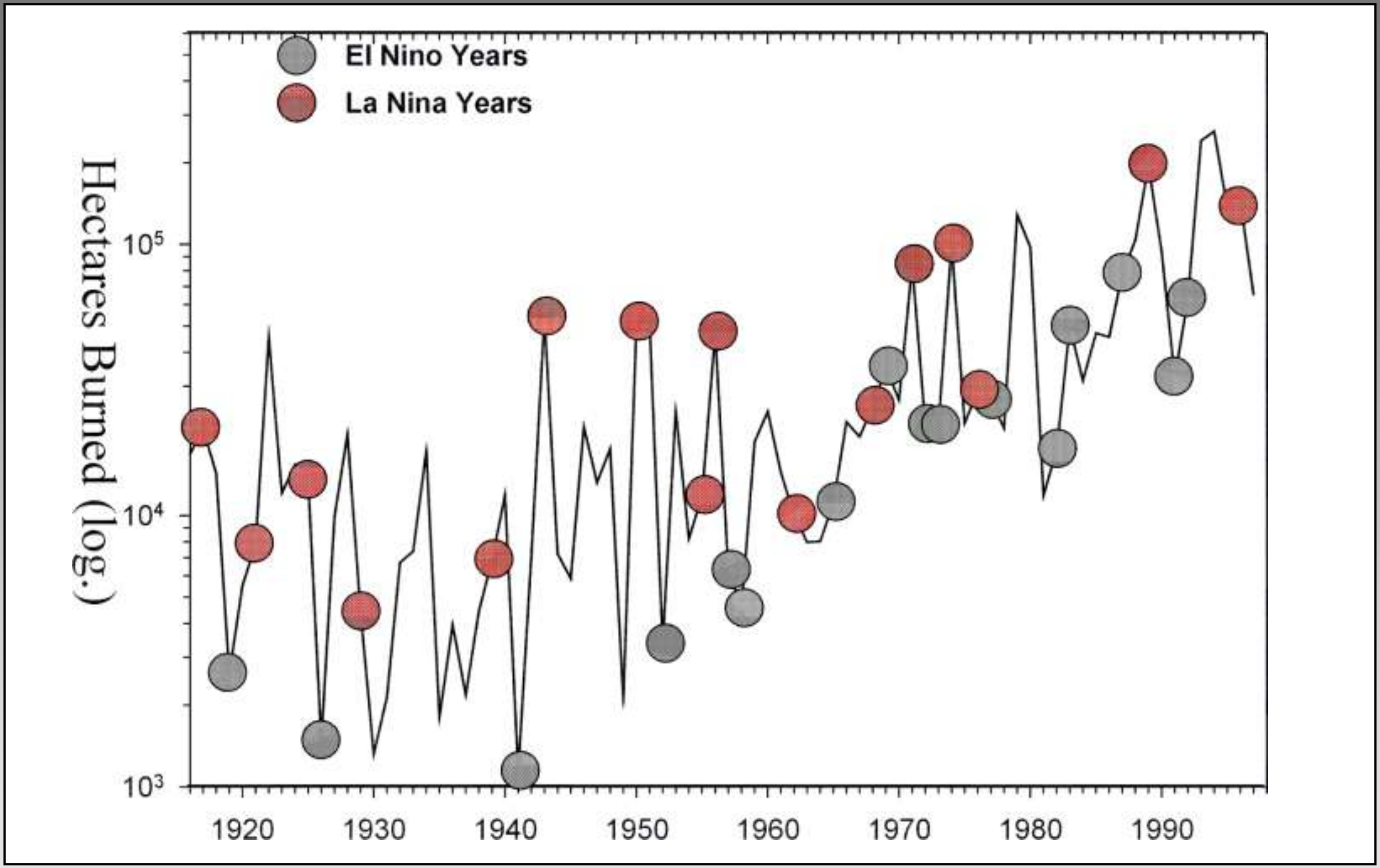
Grassland/shrubland fires have different climatologies than forest fires. With increasing frequency, size and intensity of invasives-driven fires, expect desert fires to become forest fires, and fire climatologies to change.



Courtesy of Tony Westerling, UC-Merced

Ignition front, Beatty Fire 2006

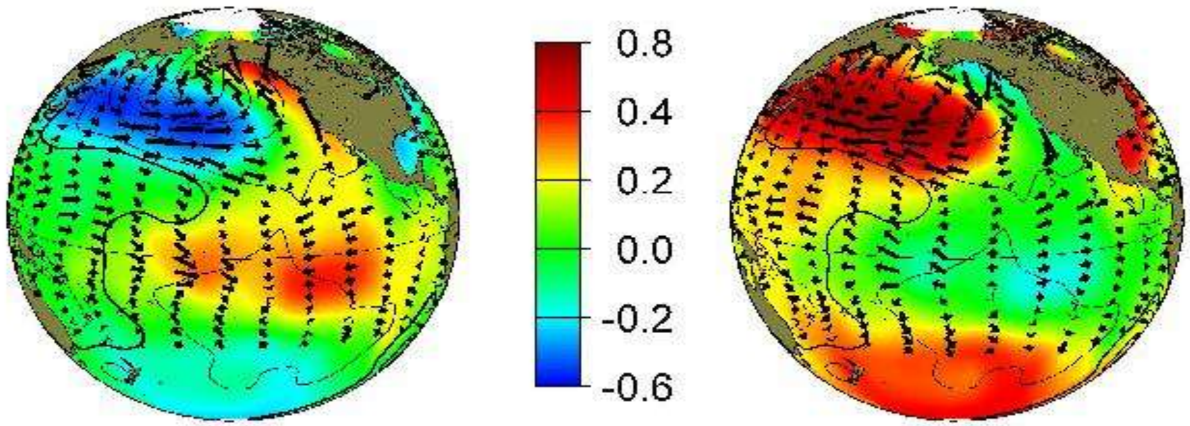
Log of Annual Area Burned in FS Region 3 (AZ + NM) during El Niño vs. La Niña years



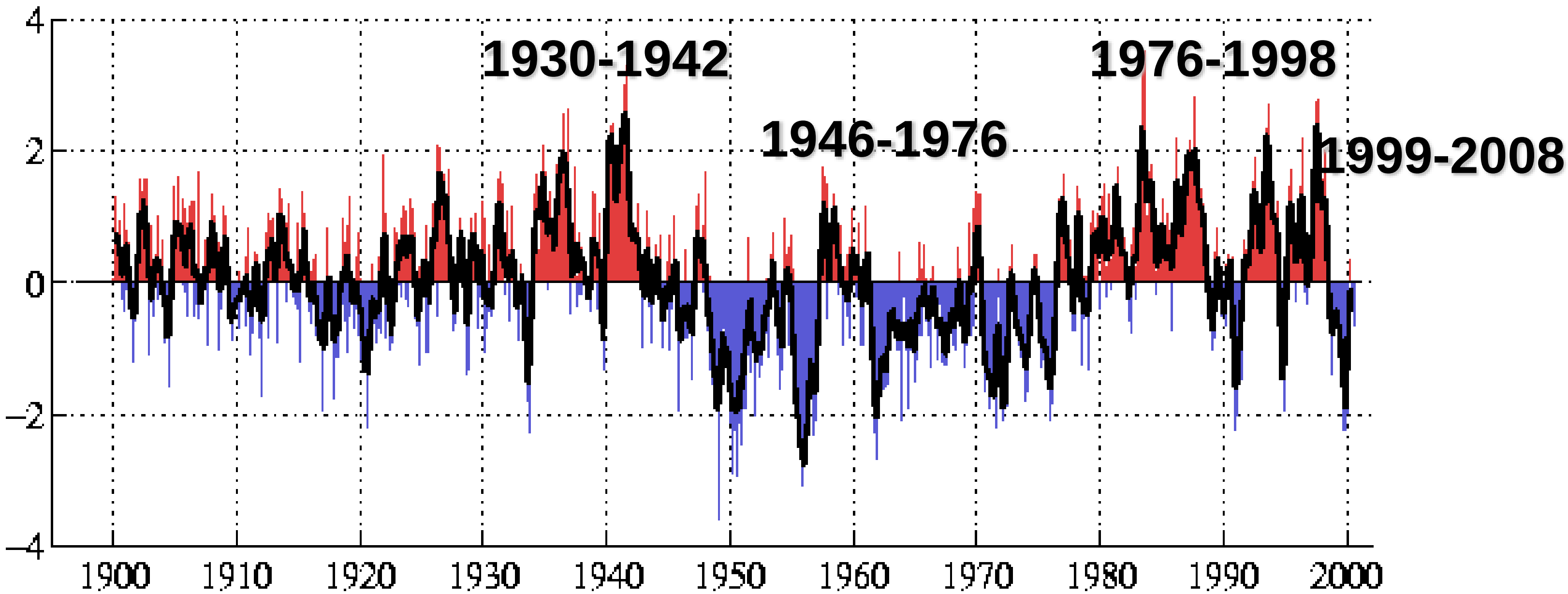
Swetnam, T. W., and J. L. Betancourt. 1990. Fire-Southern Oscillation relations in the southwestern United States. *Science* 249:1017-1020

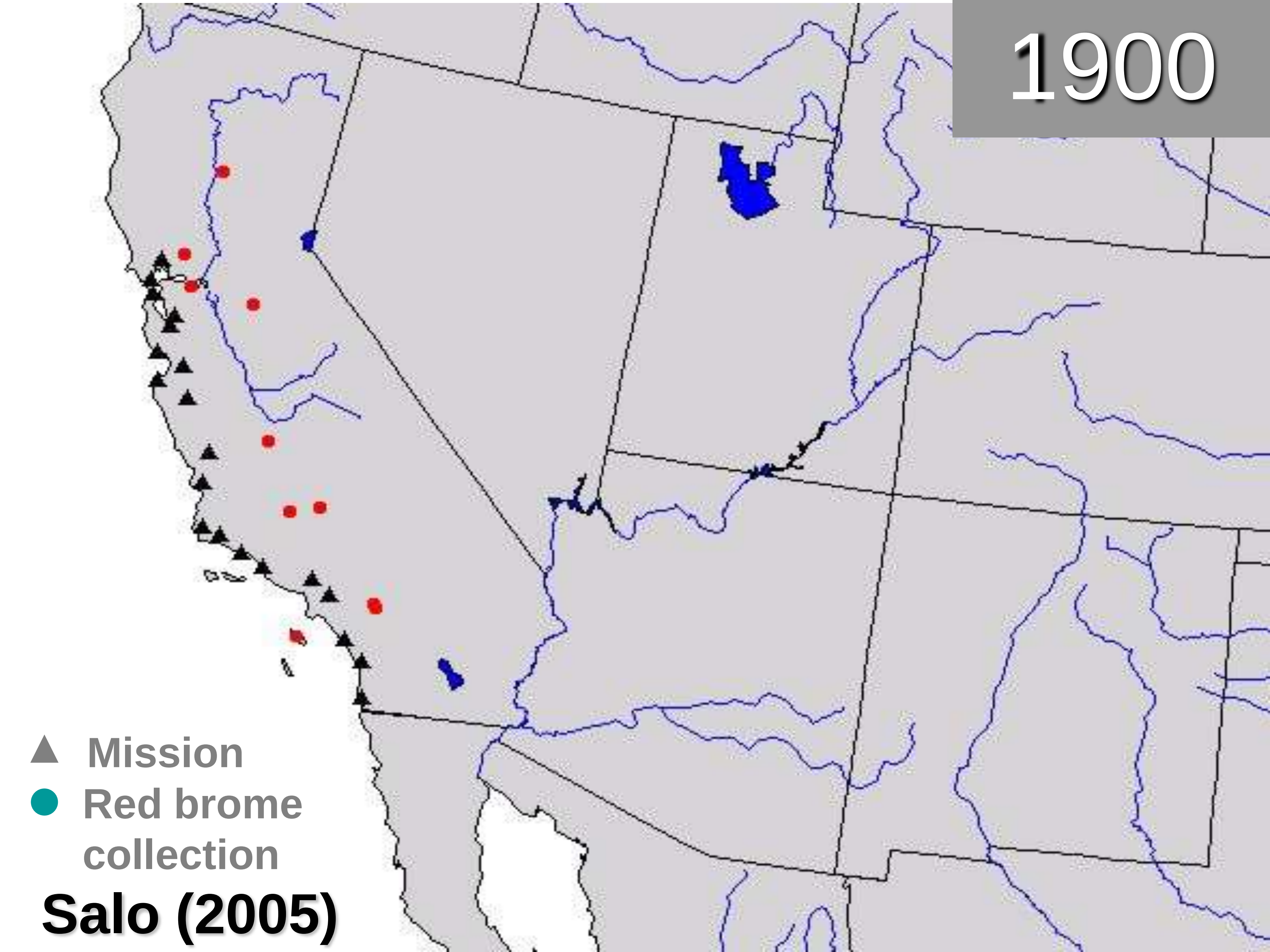
Pacific Decadal Oscillation

+ Phase **- Phase**



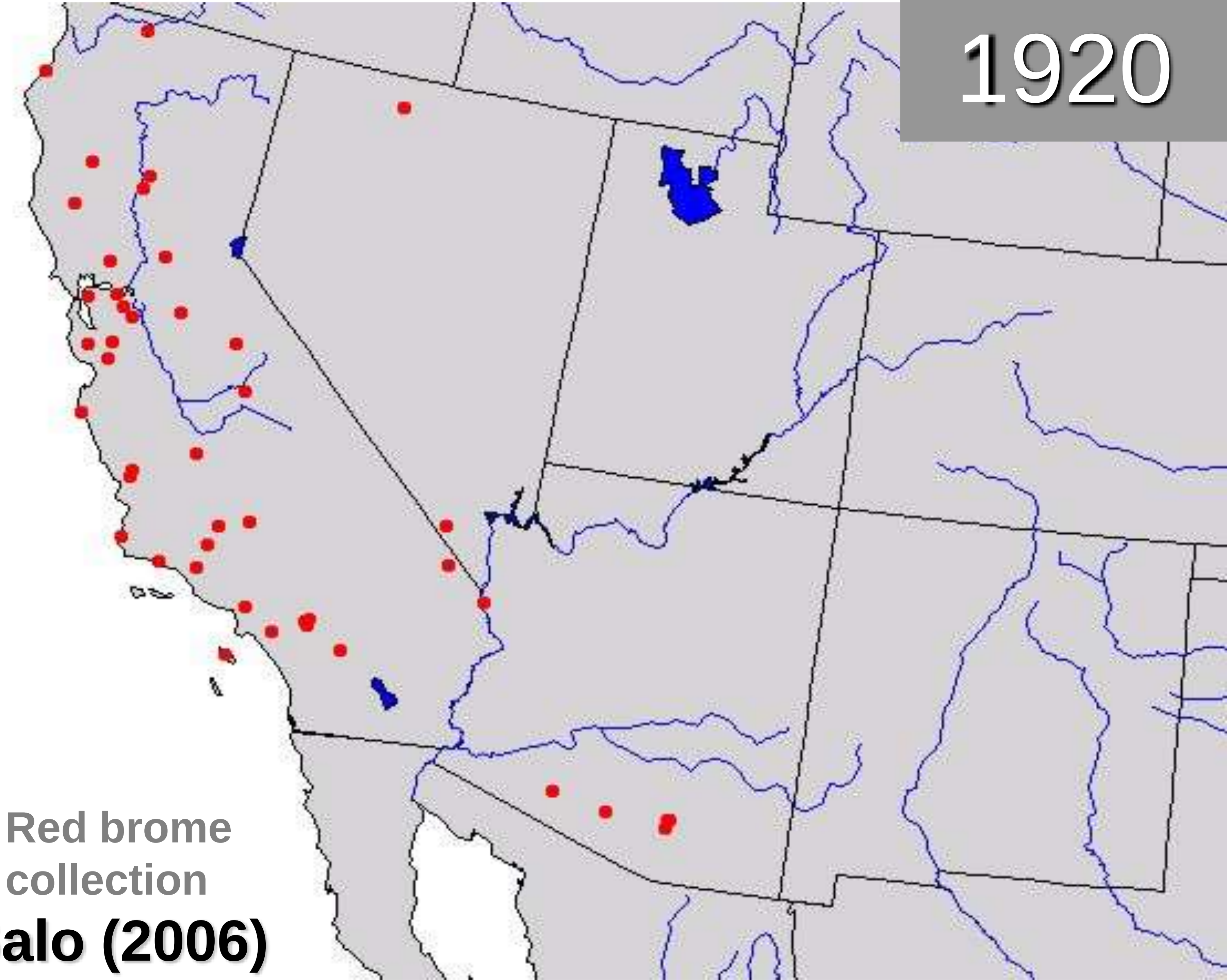
Monthly Values for the PDO Index, 1900-2000





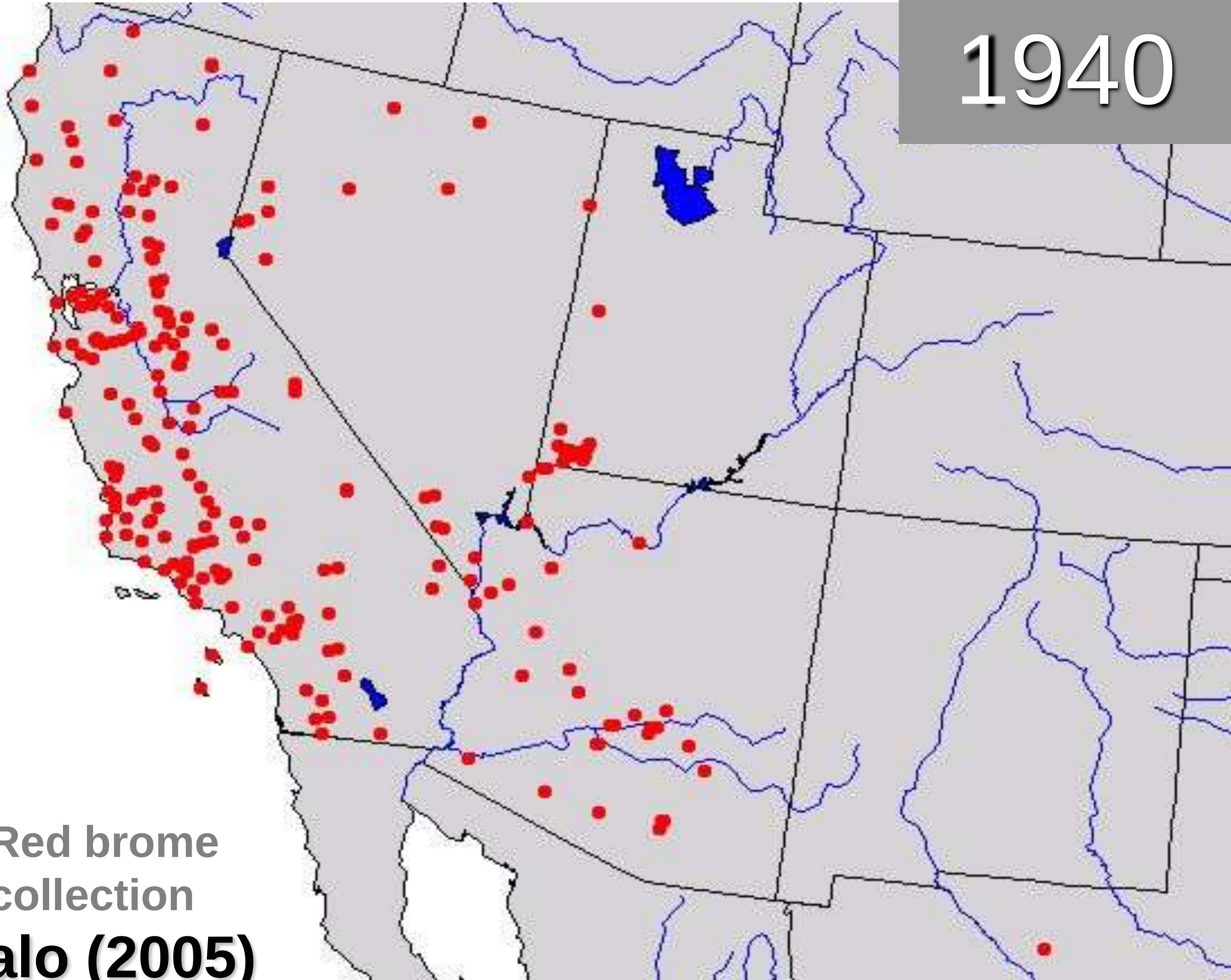
Salo (2005)

1920



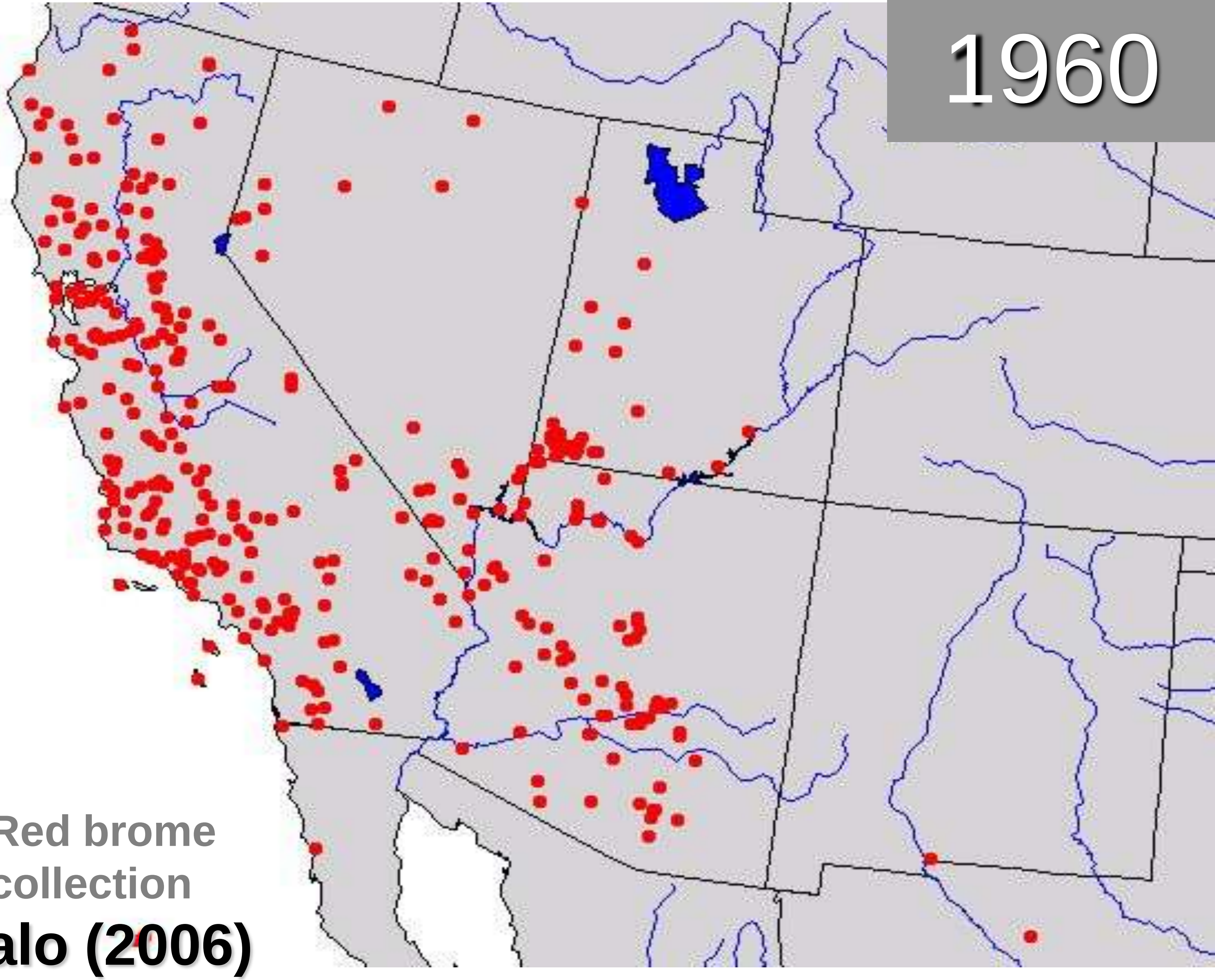
- Red brome collection

Salo (2006)



- Red brome collection

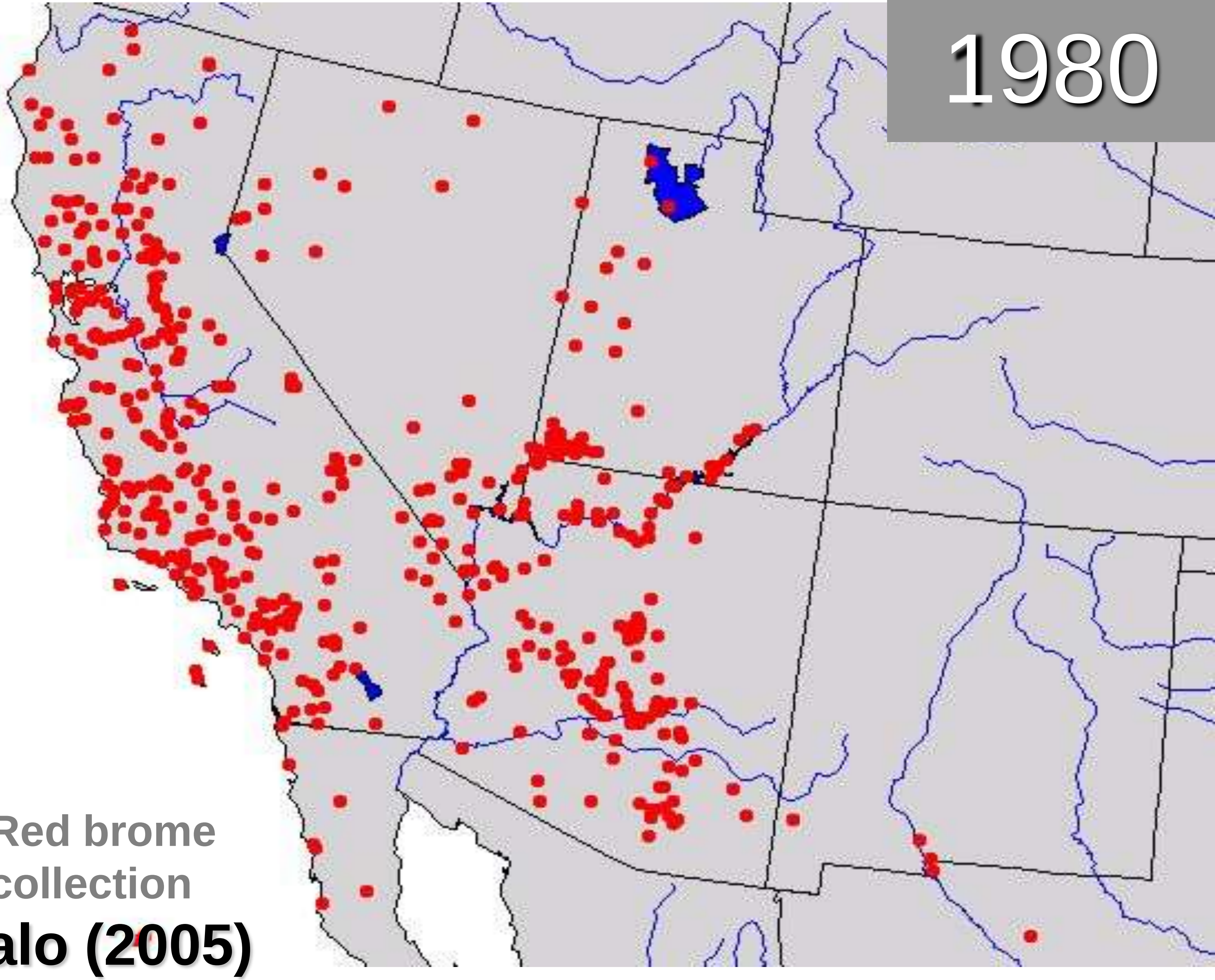
Salo (2005)



● Red brome collection

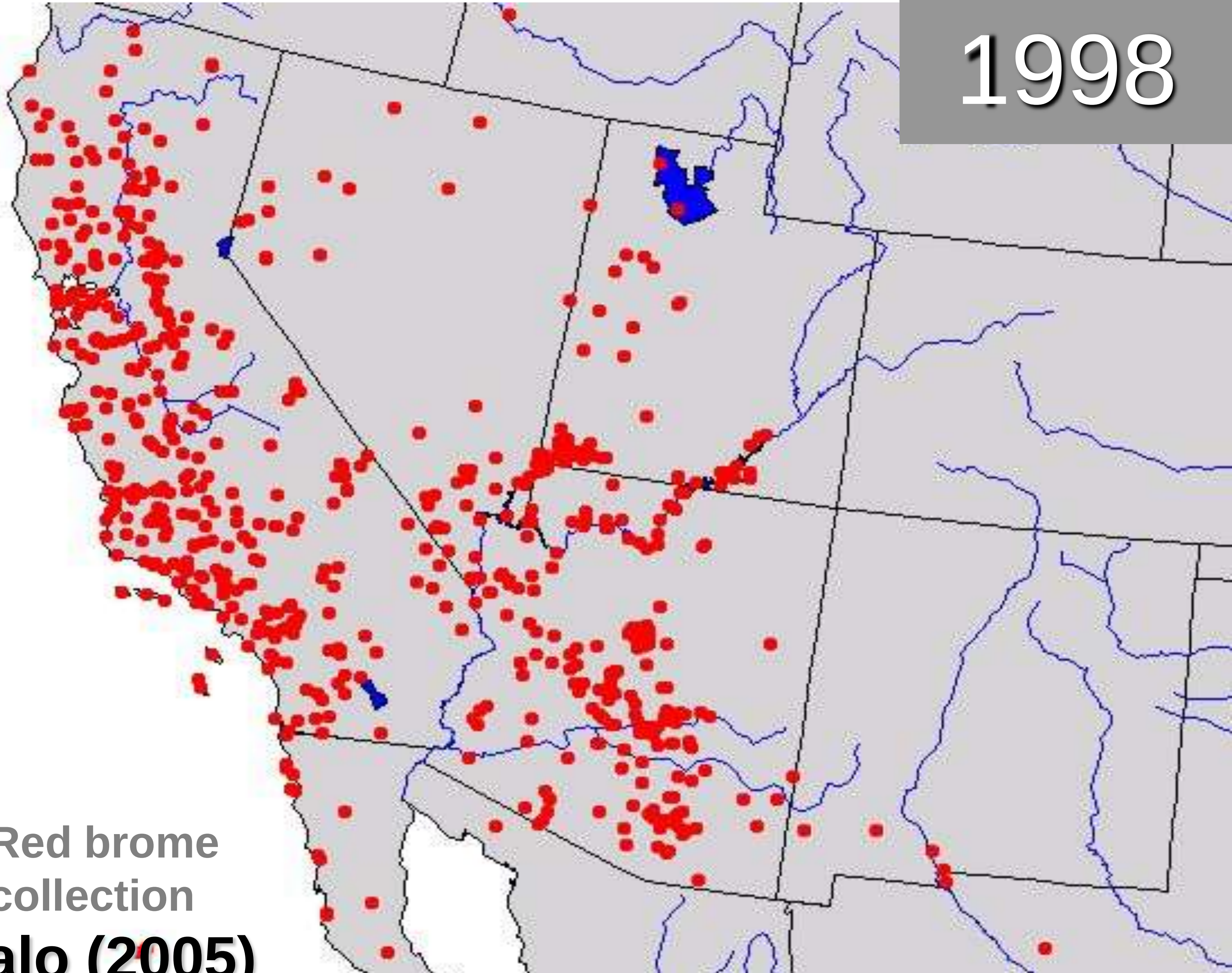
Salo (2006)

1980



- Red brome collection

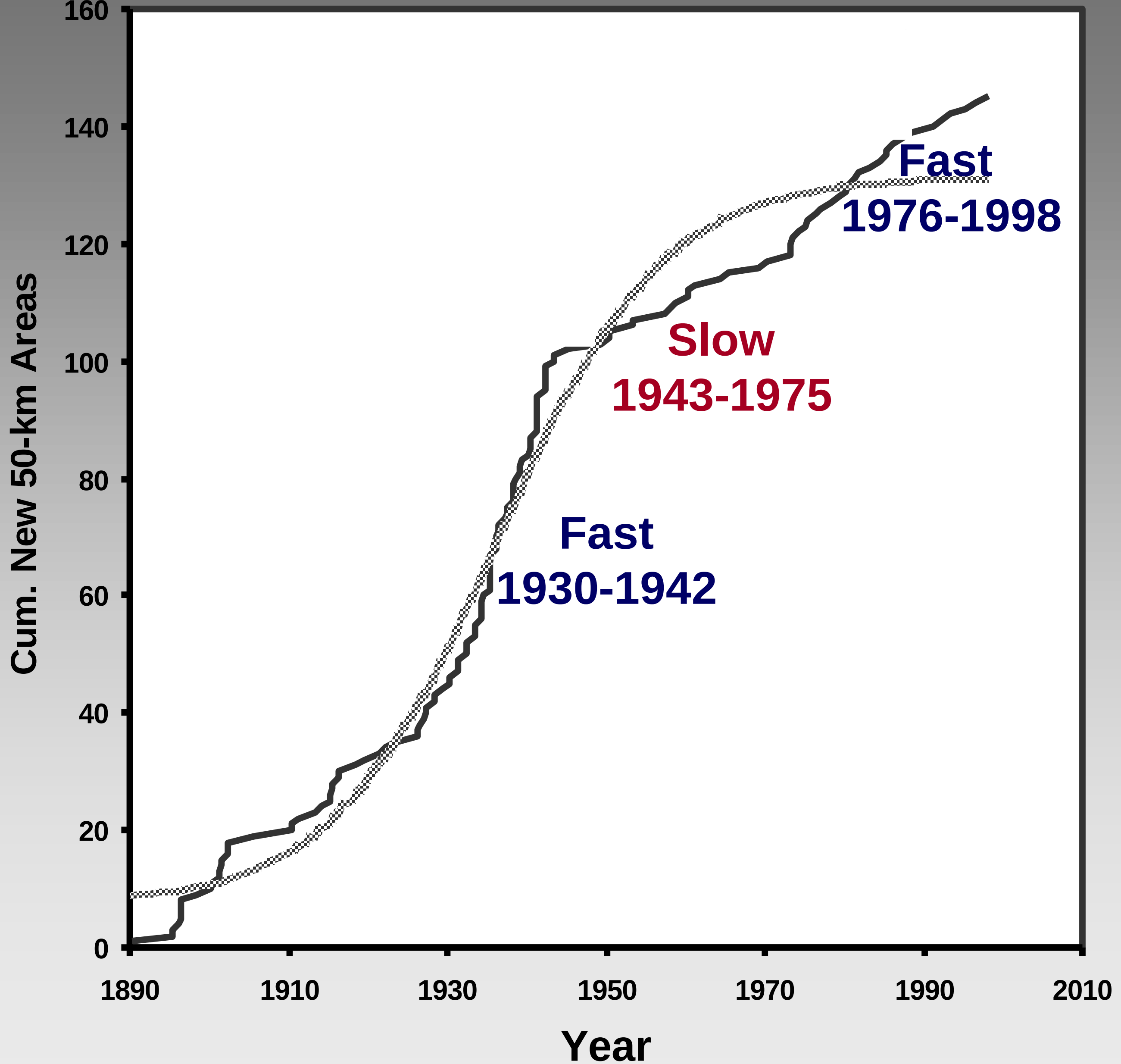
Salo (2005)



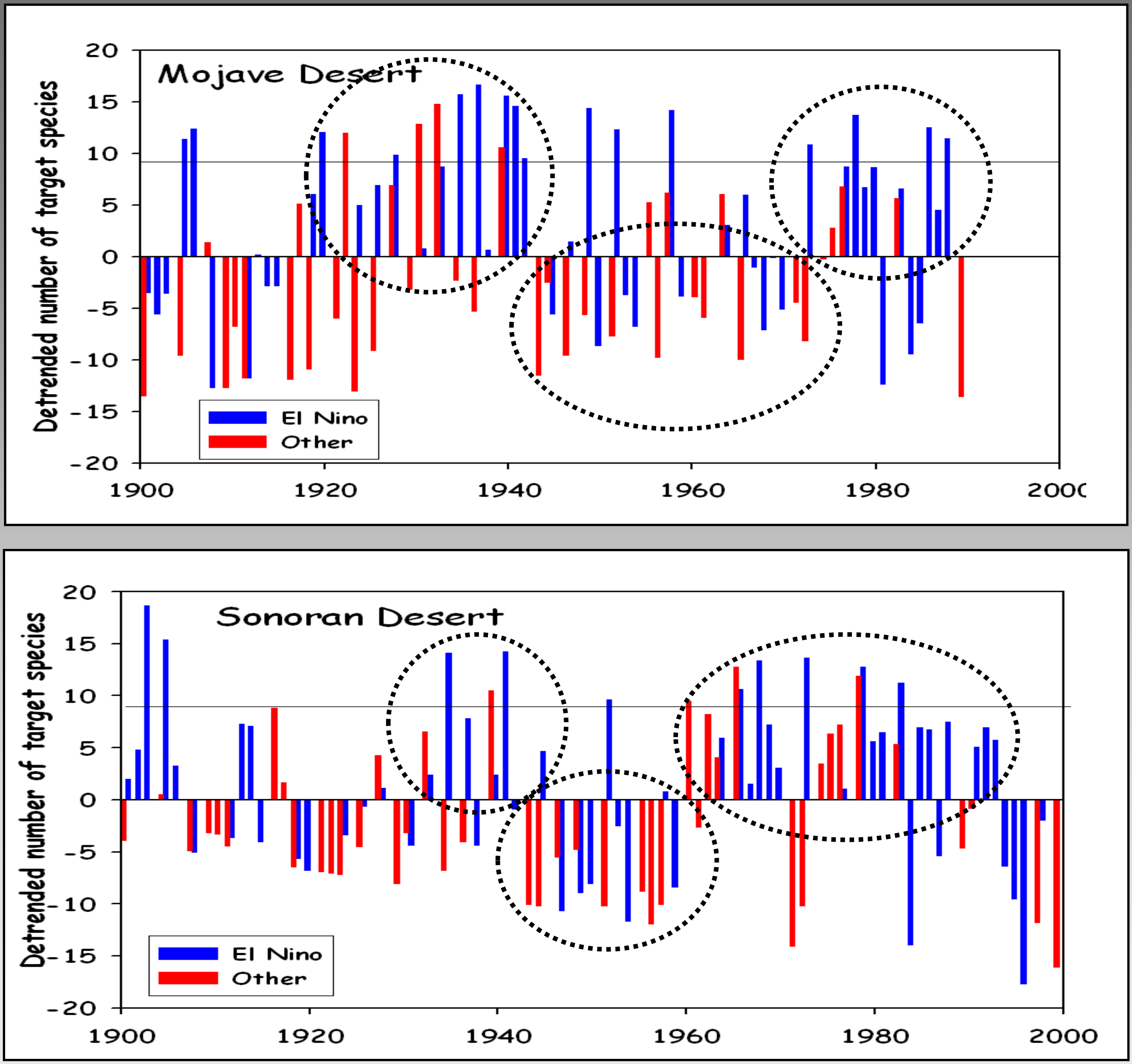
- Red brome collection

Salo (2005)

Expansion and Logistic Growth Curve for Red Brome in western North America (Salo 2005 *Biological Invasions*)

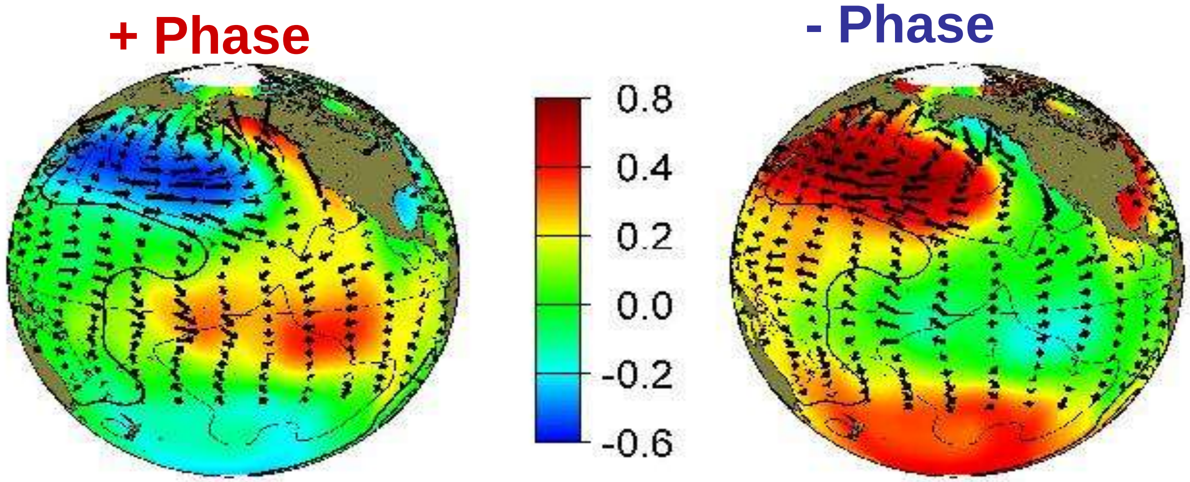


Decadal Variability in Winter Annuals from Herbarium Collections

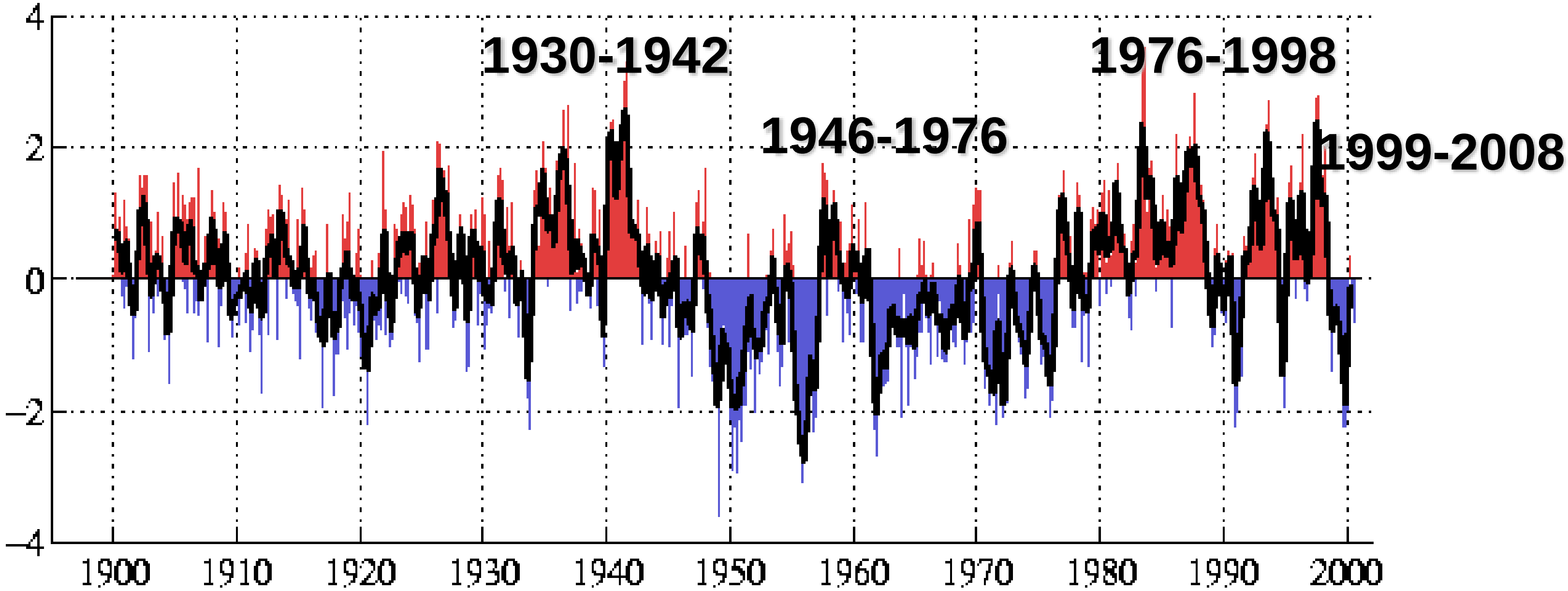


Bowers 2005

Pacific Decadal Oscillation

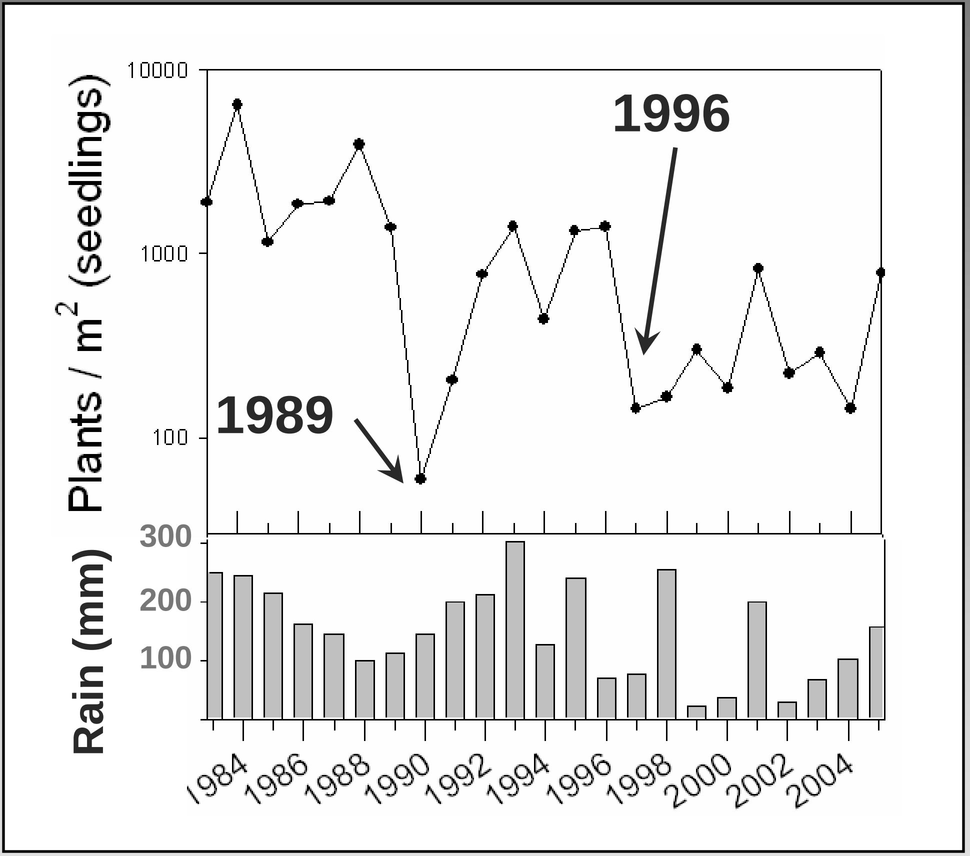


Monthly Values for the PDO Index, 1900-2000



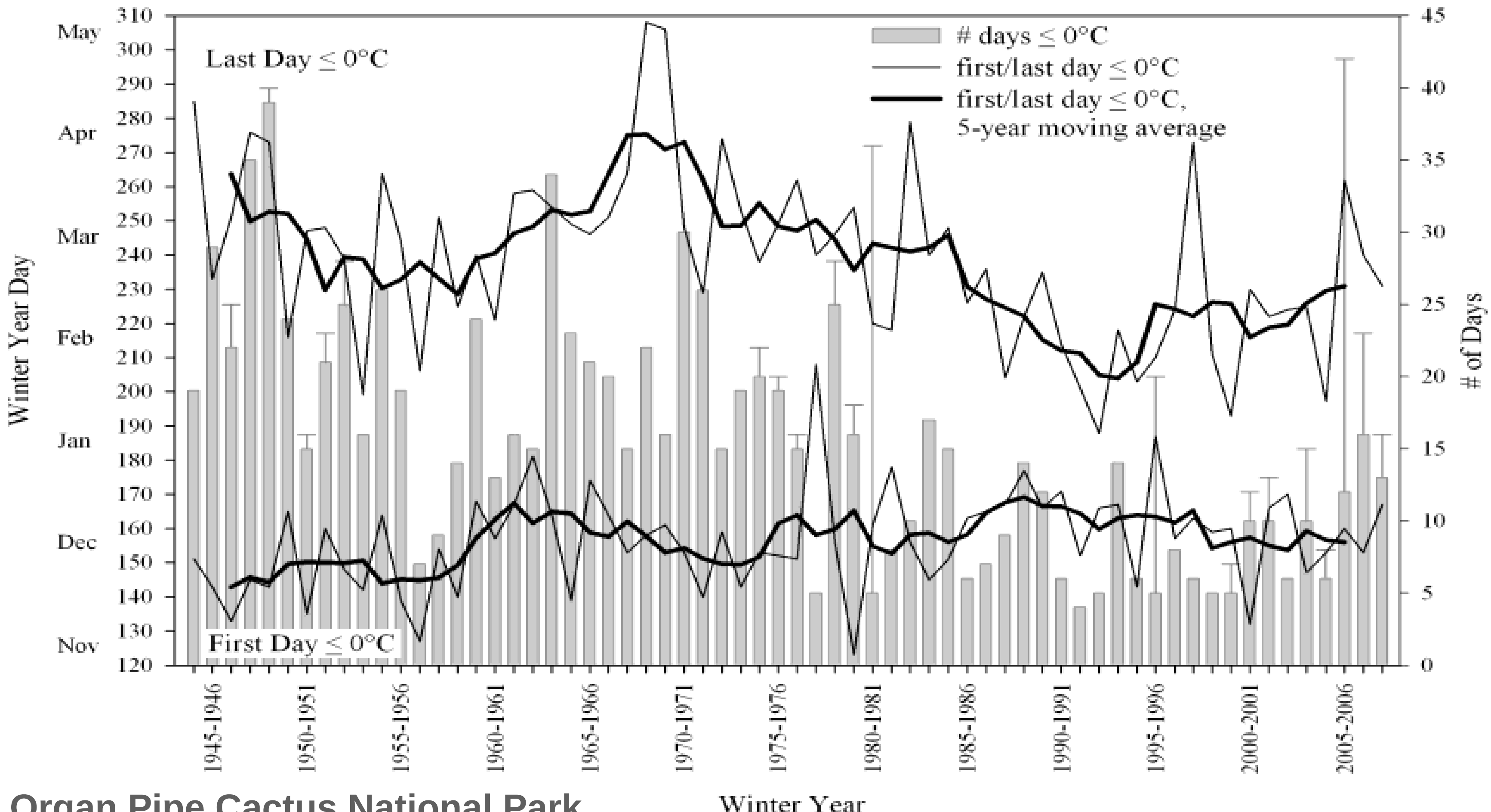
Population Dynamics of Winter Annuals in Permanent Plots on Tumamoc Hill, Tucson

Desert Laboratory on Tumamoc Hill



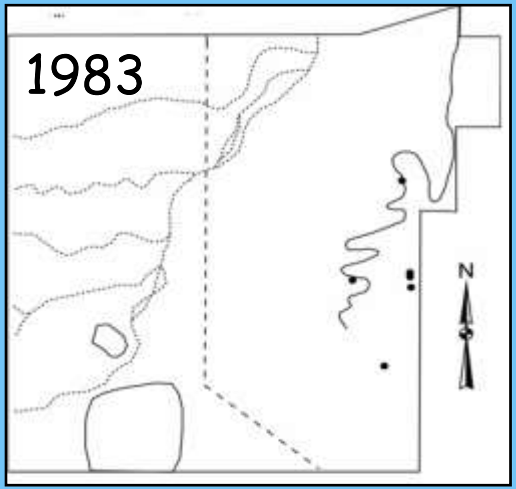
Courtesy of Larry Venable
University of Arizona

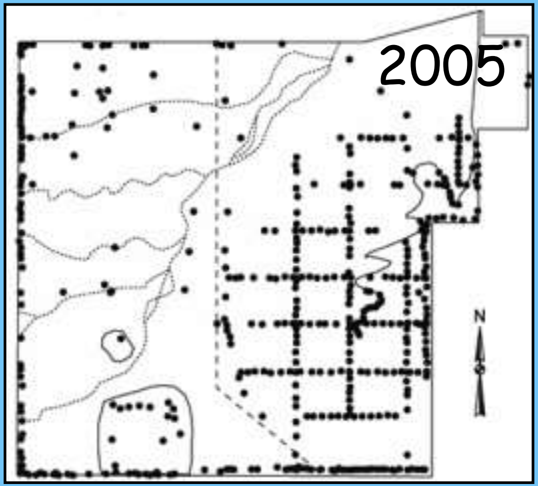
The Sonoran Desert is losing its cool
Weiss & Overpeck (2005) *Global Change Biology*



Organ Pipe Cactus National Park

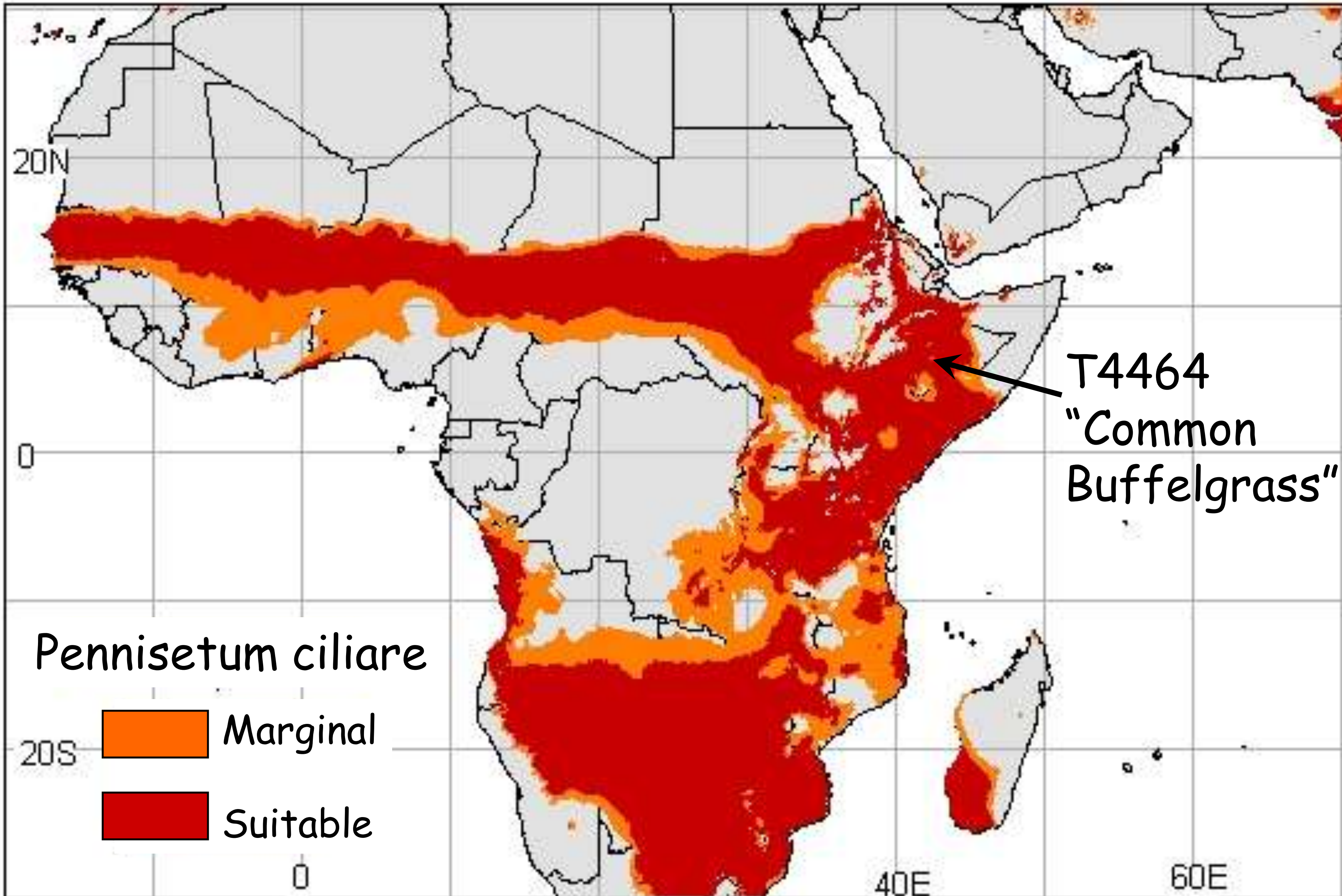
Buffelgrass Outreach & Demonstration Project
Desert Lab, Tumamoc Hill

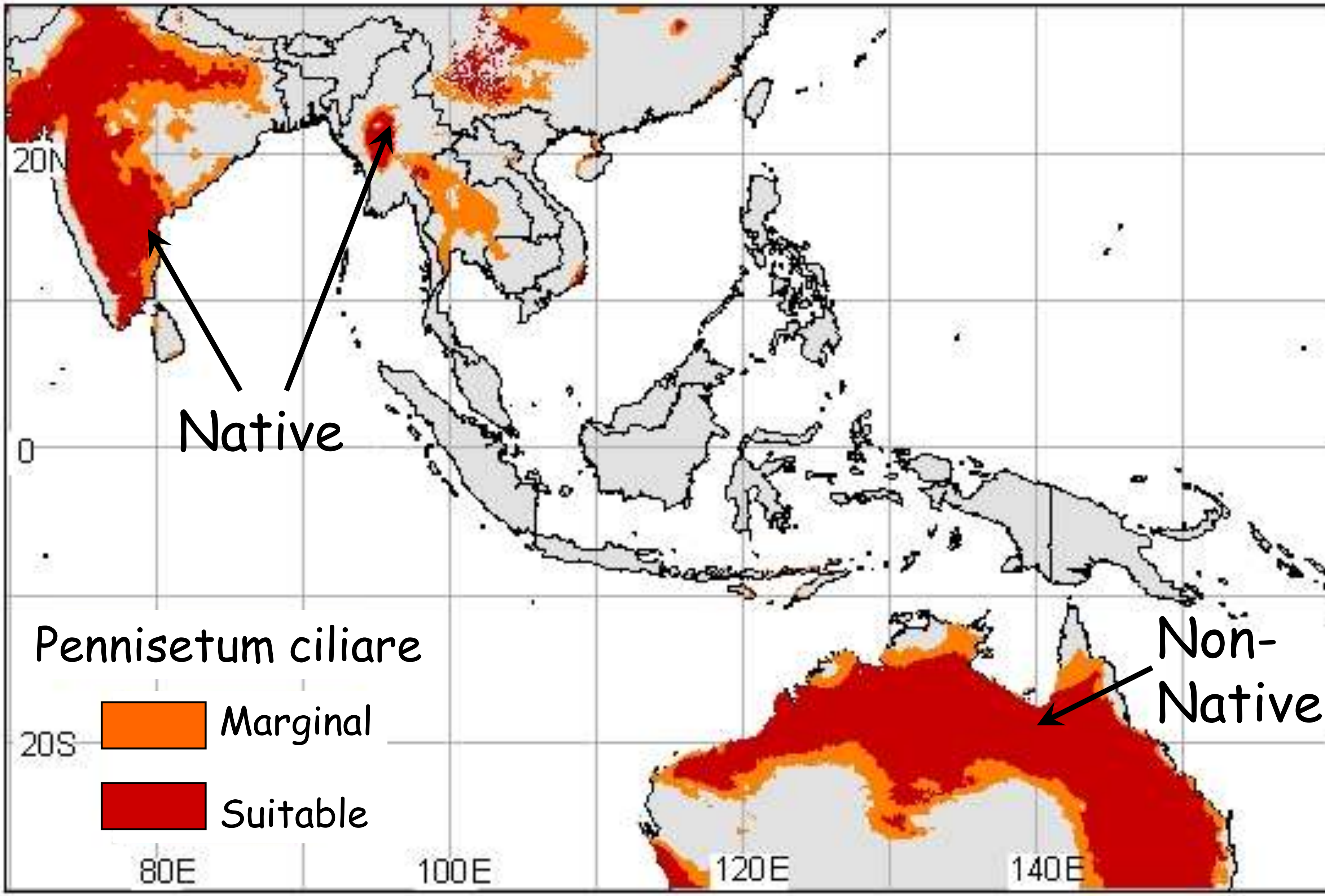




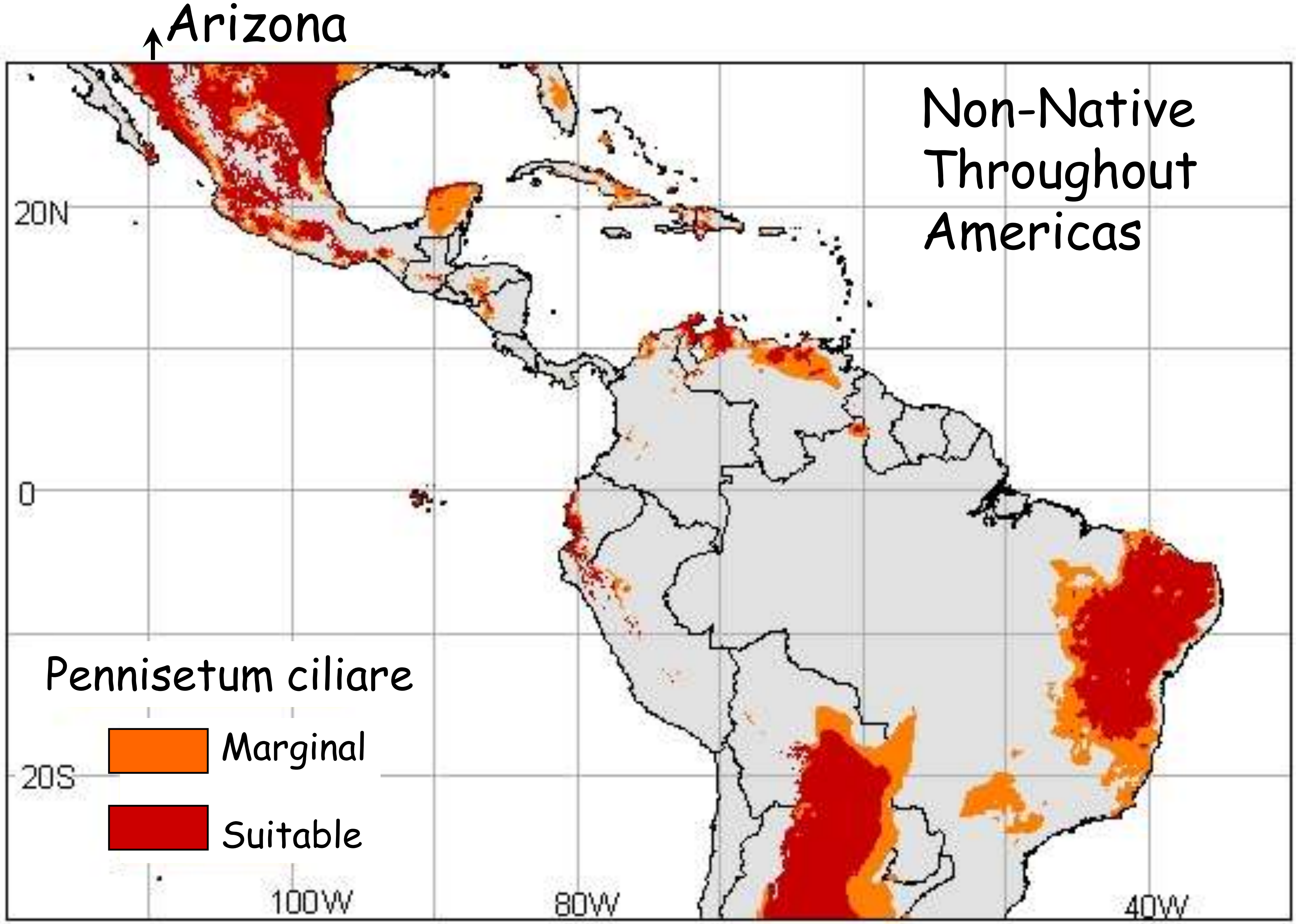
Buffelgrass Attributes

- Perennial C4 bunchgrass from Africa/S. Asia
- Individuals can live 20 yrs
- Swollen stem bases allow it to store carbs & survive grazing, drought & fire
- Apomictic & rhizomatous, seeds viable for up to 4 yrs
- Susceptible to cold
- Introduced throughout subtropics; escapes readily
- Fire temperatures 1400-1800 F, 16-18’ flames


20N
0
20S
0
40E
60E
T4464
"Common
Buffelgrass"
Pennisetum ciliare
Marginal
Suitable



20N
0
20S
80E
100E
120E
140E
Native
Non-
Native
Pennisetum ciliare
Marginal
Suitable

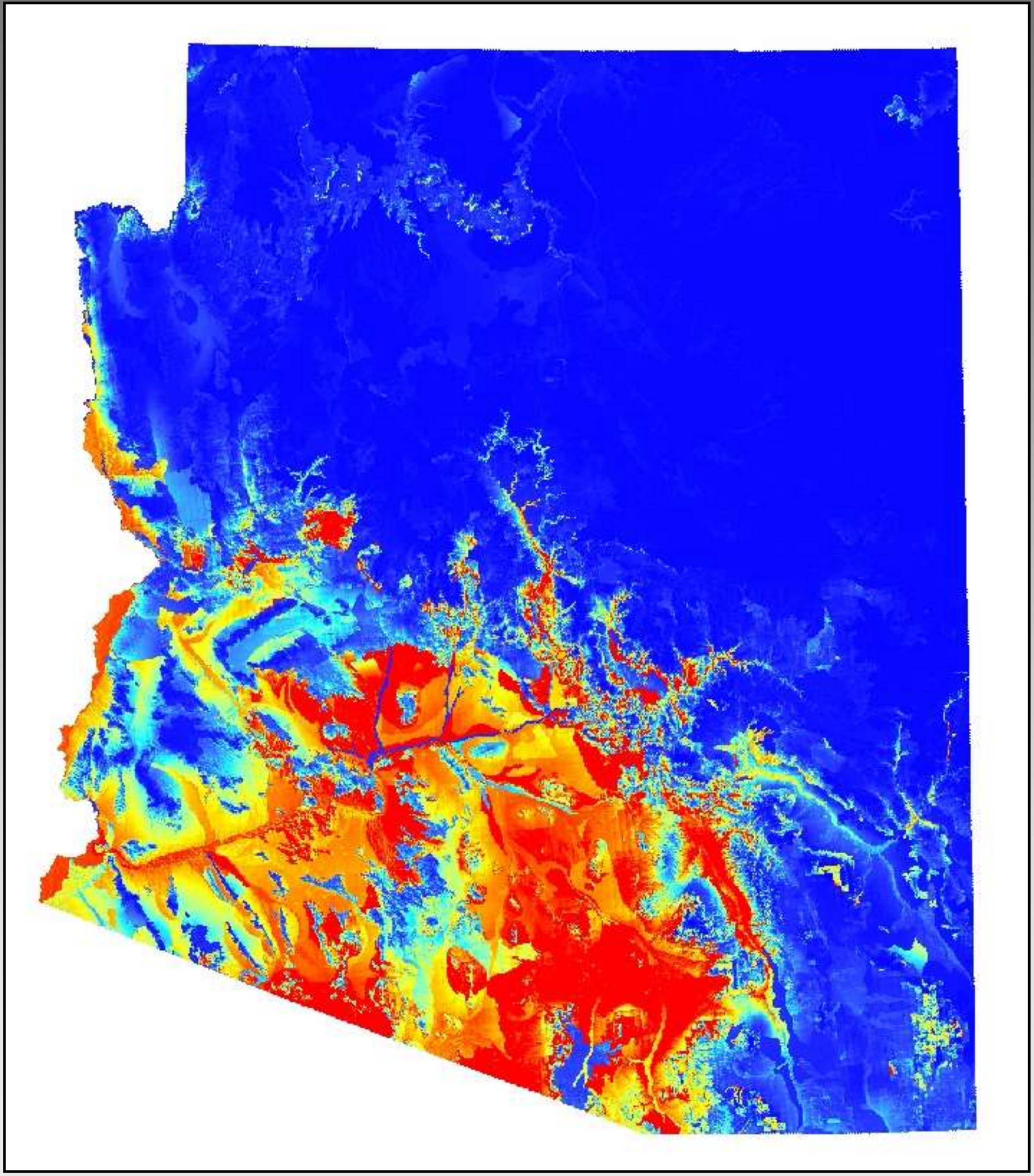

Arizona
Non-Native
Throughout
Americas
20N
0
20S
100W
80W
40W
Pennisetum ciliare
Marginal
Suitable

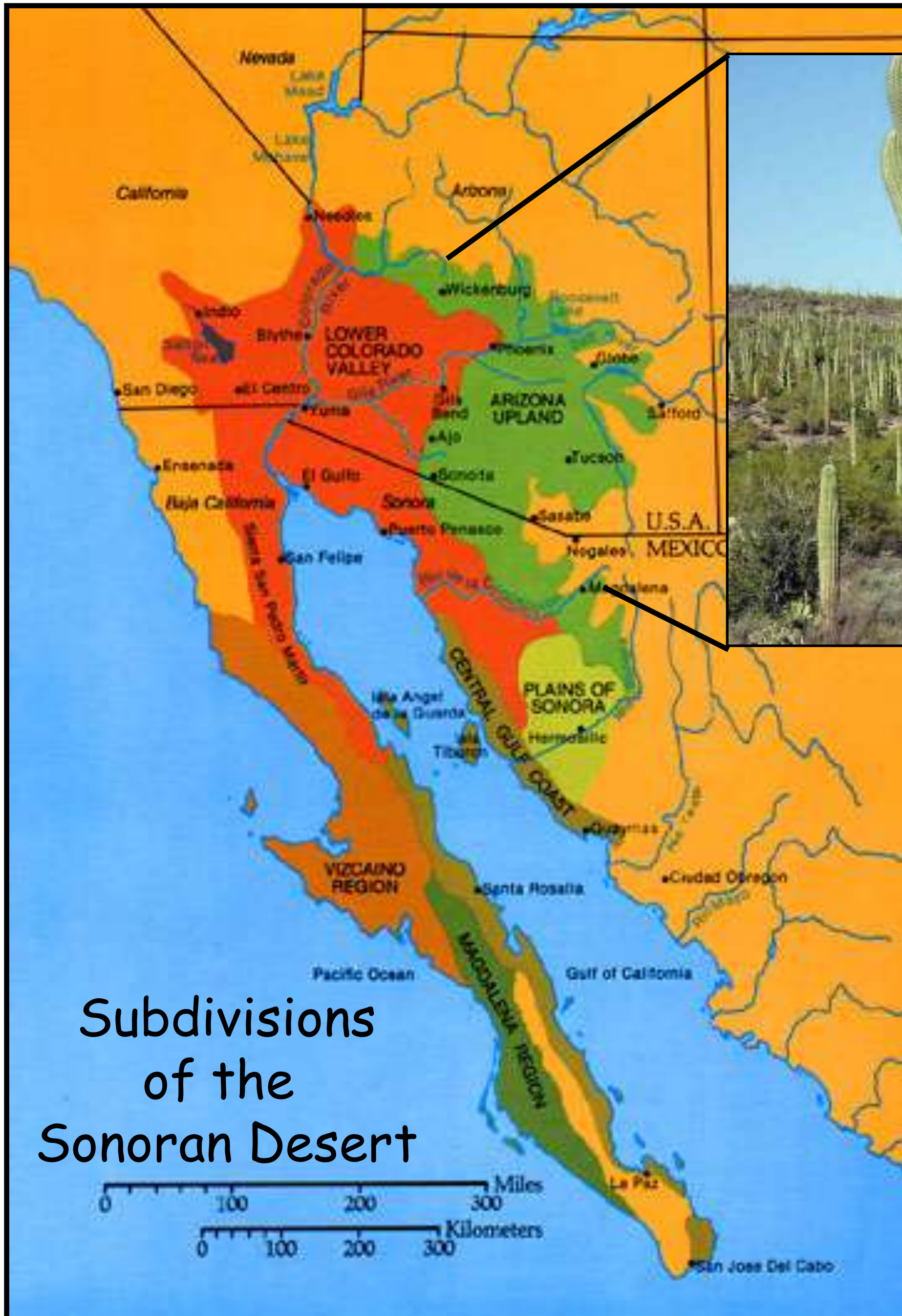
Model Inputs

- **STATSGO soils data: clay, soil depth, AWC, erodibility, permeability)**
- **summer precip (PRISM: 4km interpolated precip, averaged over JJAS from 1989-2005)**
- **topography (elevation, slope, aspect, curvature).**

Aaryn Olsson, U of AZ

Potential Range of Buffelgrass In Arizona





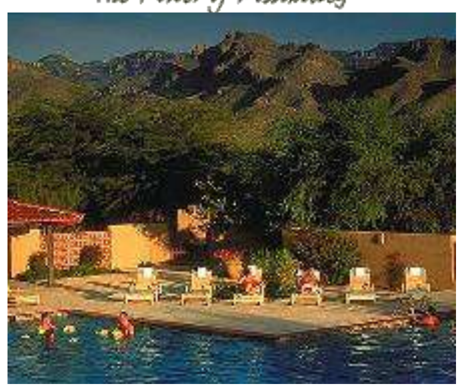
- 4.25 million ha in Arizona
- 1.5 million ha in Sonora
- Leguminous trees
- Open layers of shrubs and perennial succulents in intervening spaces
- Barren ground
- Rich winter annual flora

Sonoran Desert vegetation poorly adapted to fire

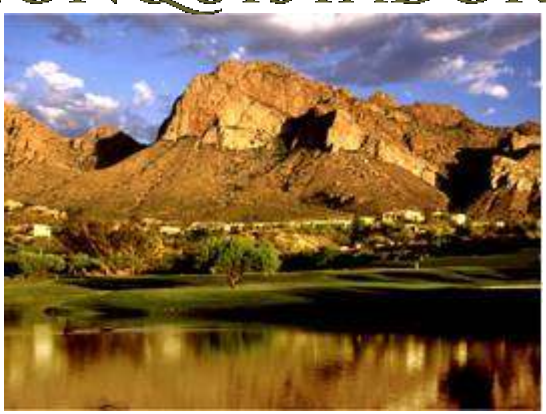

Catalina Mts

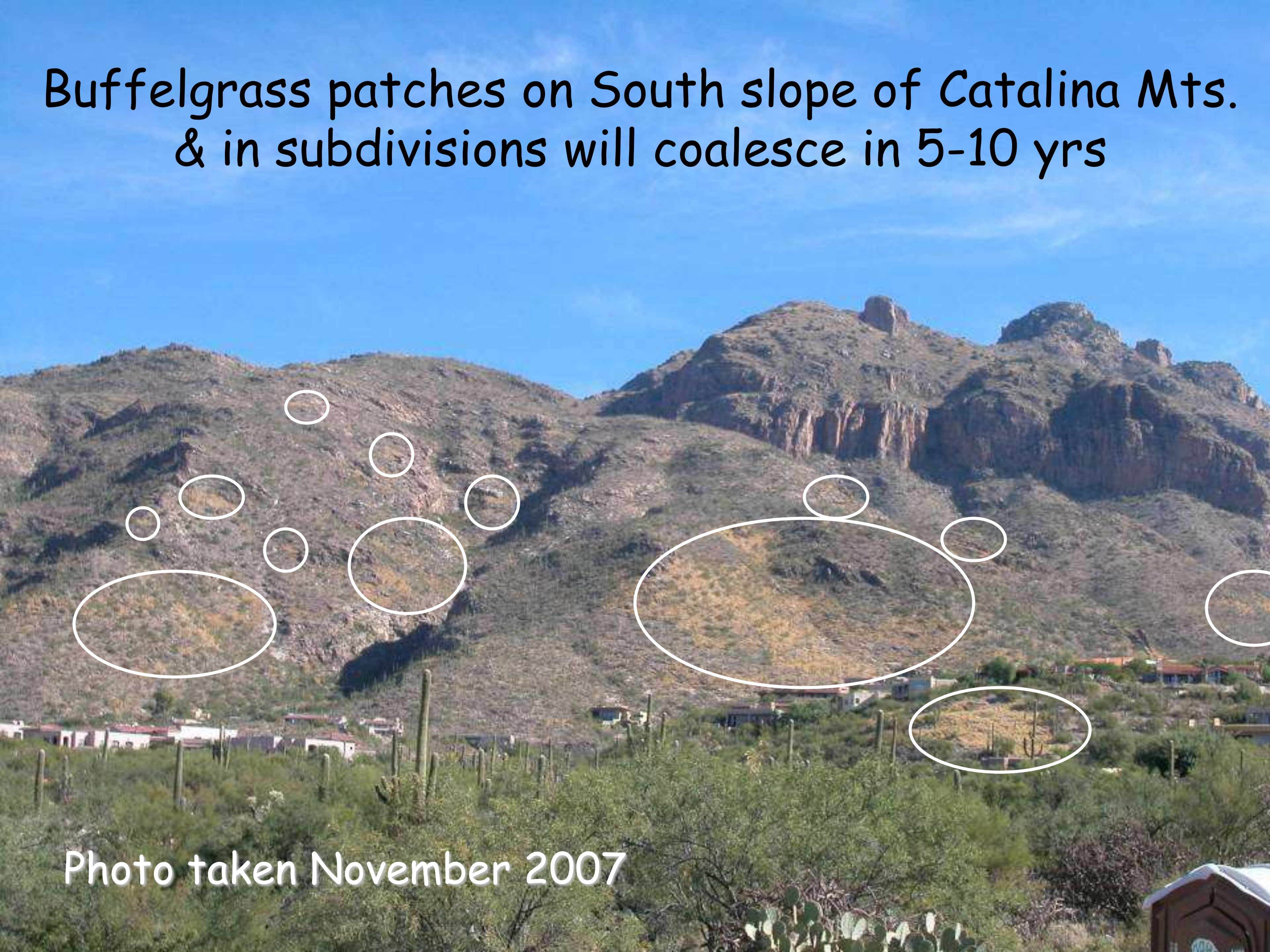
OMNI TUCSON NATIONAL
GOLF RESORT & SPA

CANYONRANCH.
The Power of Possibility™

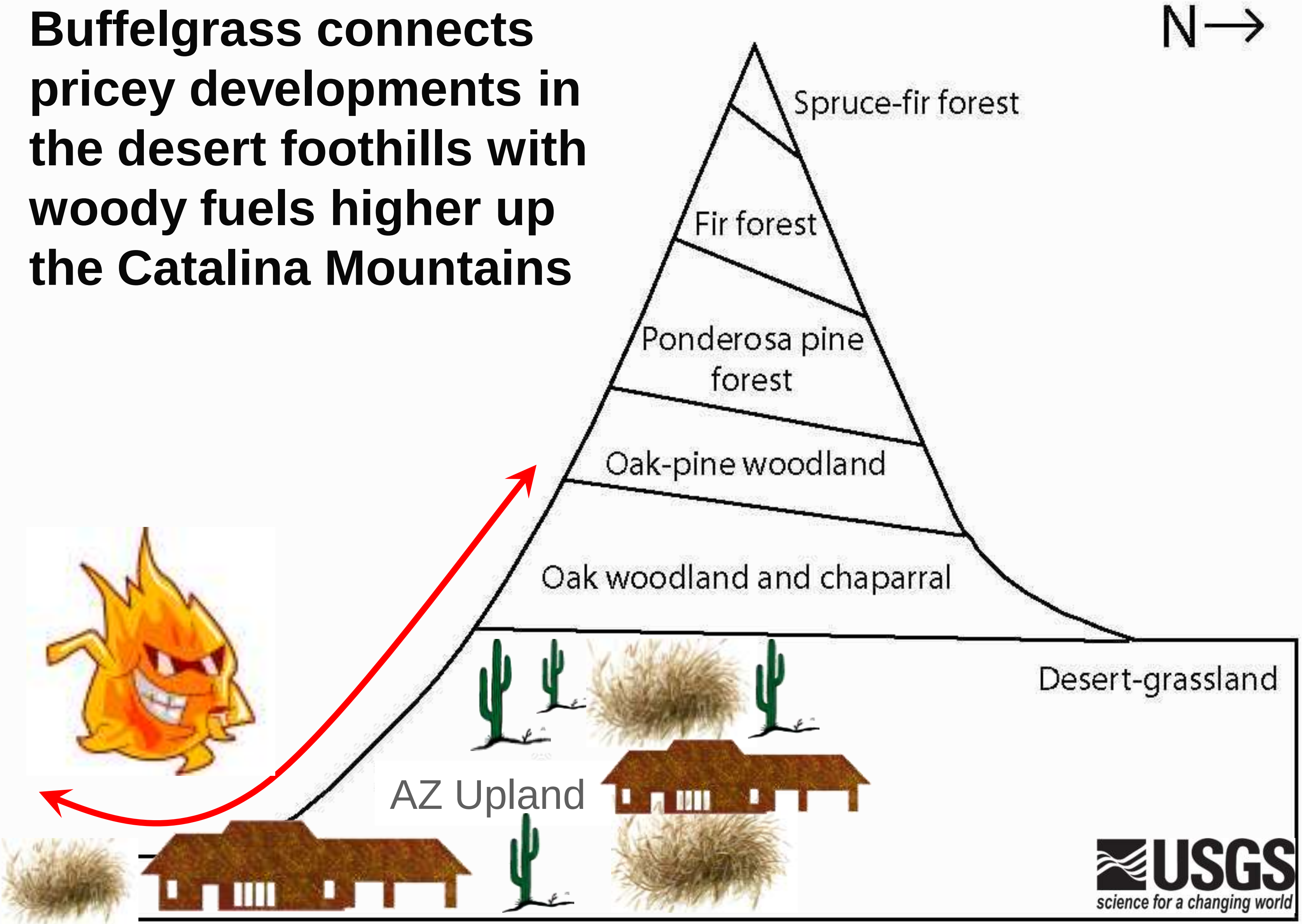


El Conquistador Golf & Tennis Resort—Tucson, Arizona
CONQUISTADOR




Buffelgrass patches on South slope of Catalina Mts.
& in subdivisions will coalesce in 5-10 yrs
Photo taken November 2007

Buffelgrass connects pricey developments in the desert foothills with woody fuels higher up the Catalina Mountains



Sonoran Desert Conservation Plan

$174M Open Space Bond passed in May 2004

Assessment until recently

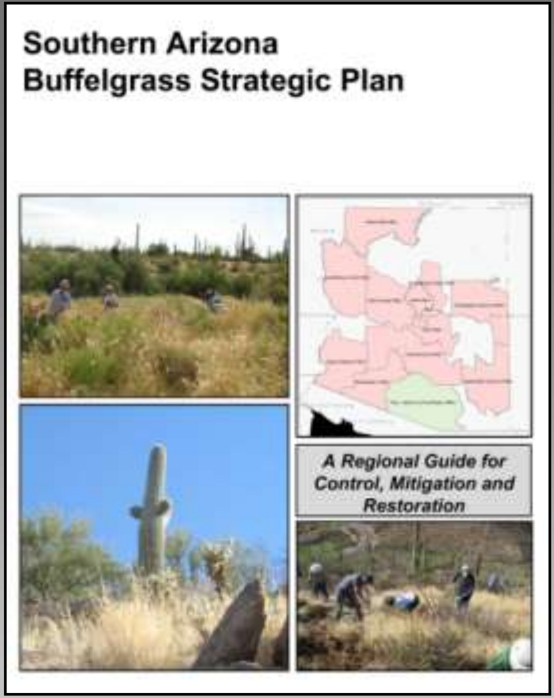
- Little sense of urgency
- Slow incremental approach to an exponential problem
- Research focus on ecological impacts at expense of solutions
- Poor prioritization of science
- No cost-benefit analysis
- Little prioritization of mitigation
- Lack of coordination
- Public unawareness of eventual consequences

www.buffelgrass .org

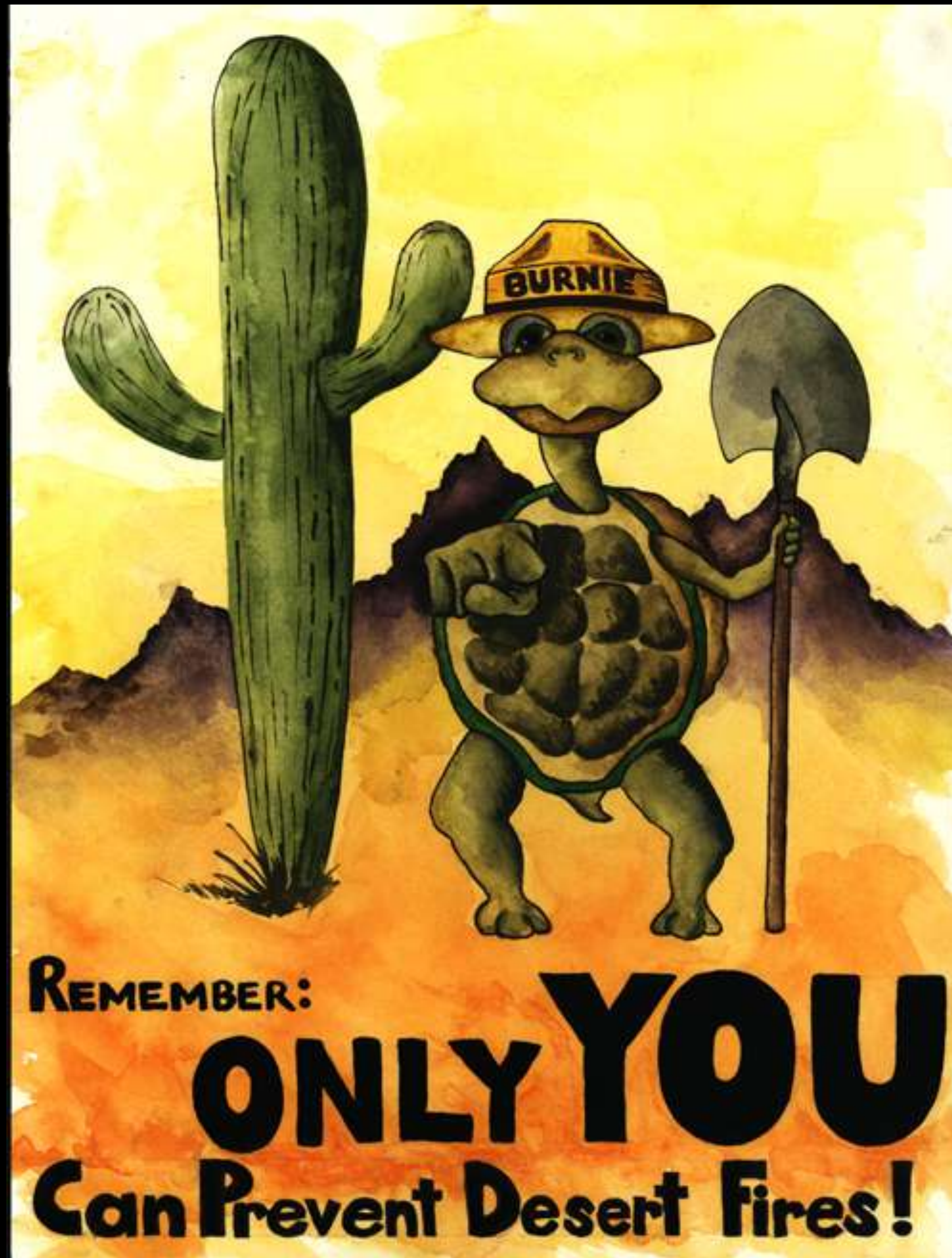
Buffelgrass Summit

Volunteer efforts

Southern Arizona Buffelgrass Coordination Center 11/08/08!


Southern Arizona
Buffelgrass Strategic Plan

A Regional Guide for Control, Mitigation and Restoration


BURNIE
REMEMBER:
ONLY YOU
Can Prevent Desert Fires!

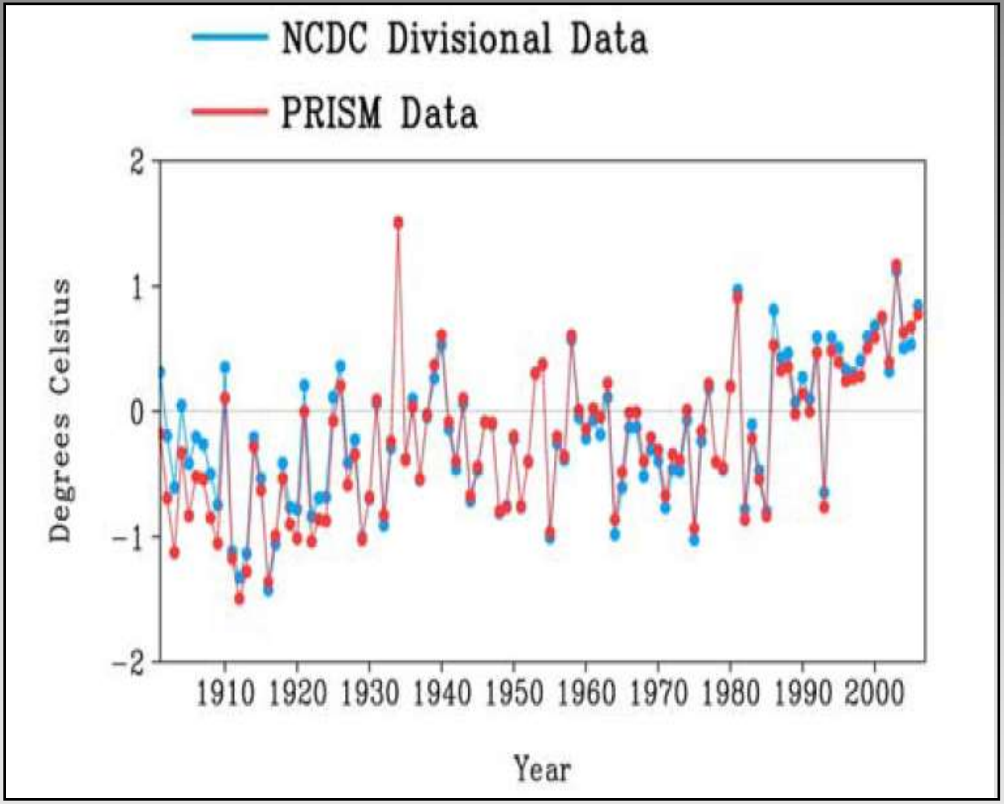
Plan B: Adaptation:

What we should start doing to minimize impacts as deserts become more flammable

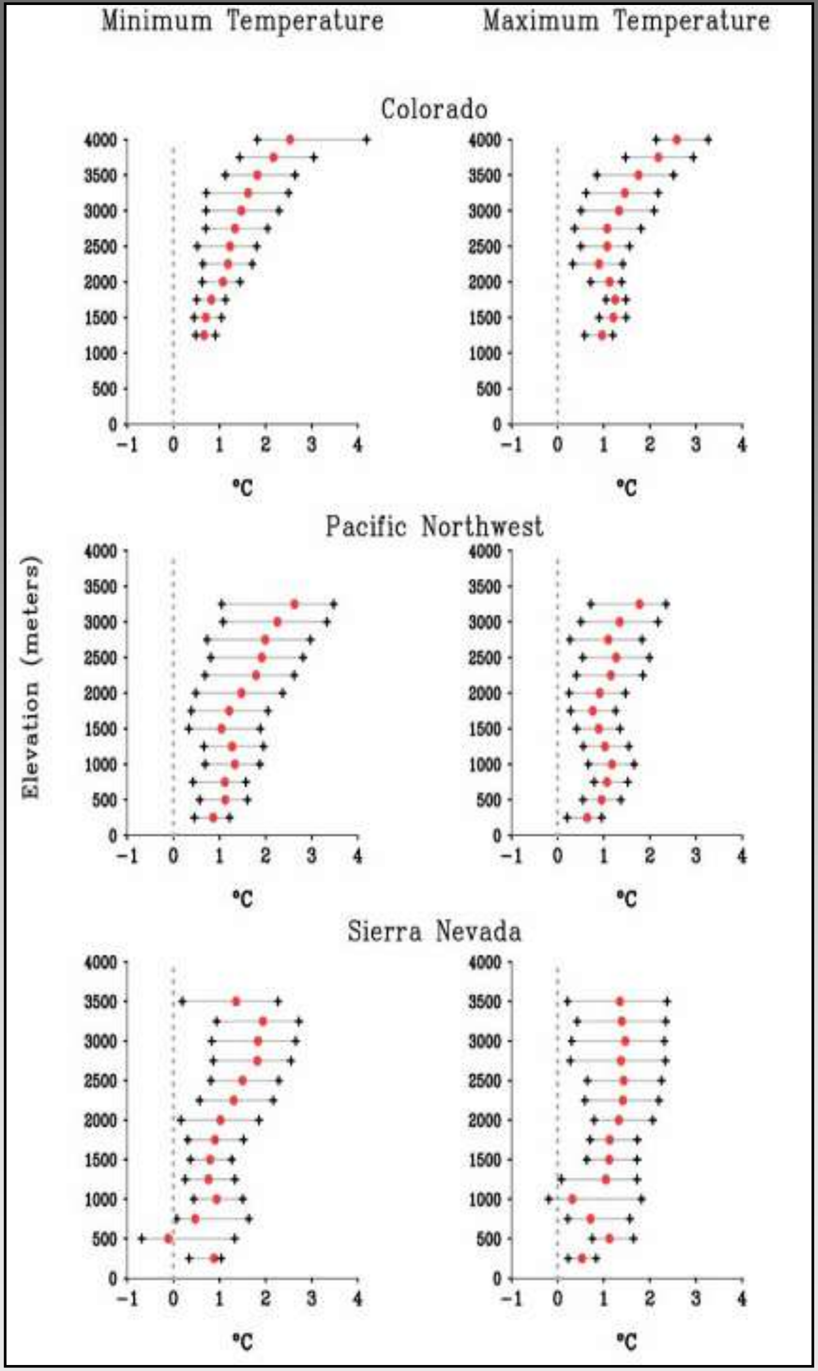
Plan A- Mitigation:

What we must do to prevent deserts from becoming more flammable

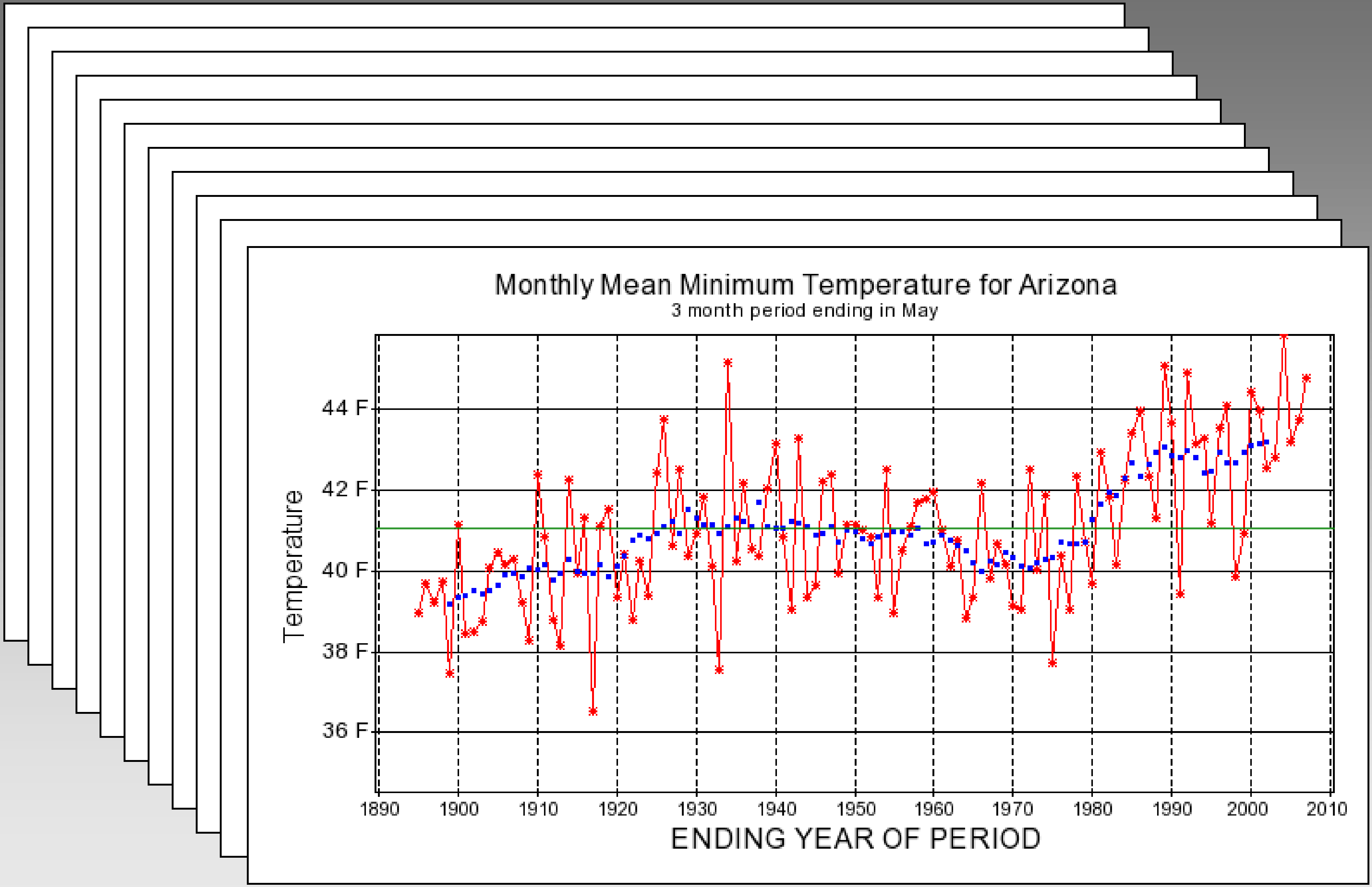
Over past 30 yrs minimum temperatures increased more than maximum temperatures & higher elevations increased more than lower ones



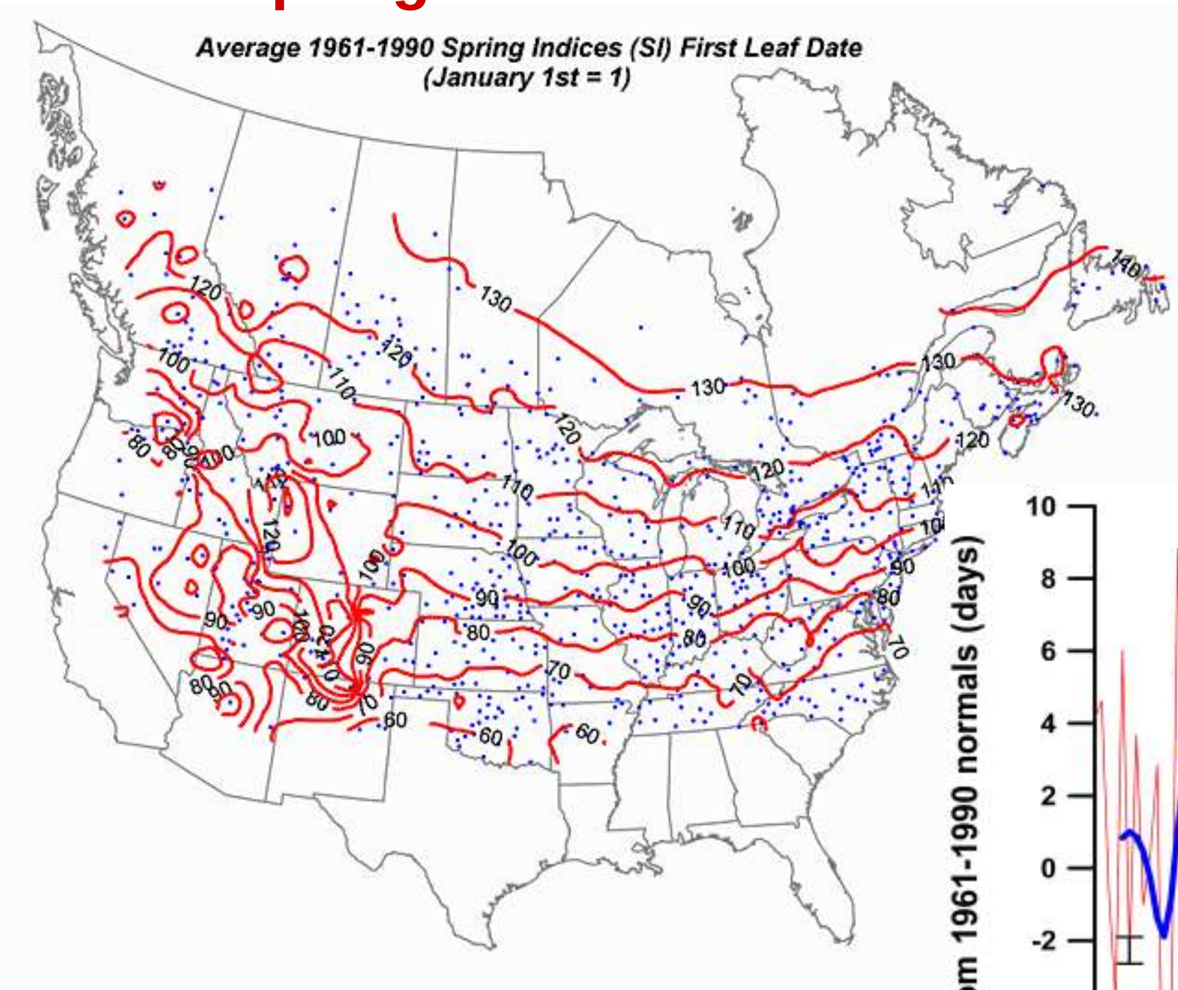
Diaz and Eischeid 2007
Gephysical Research Letters

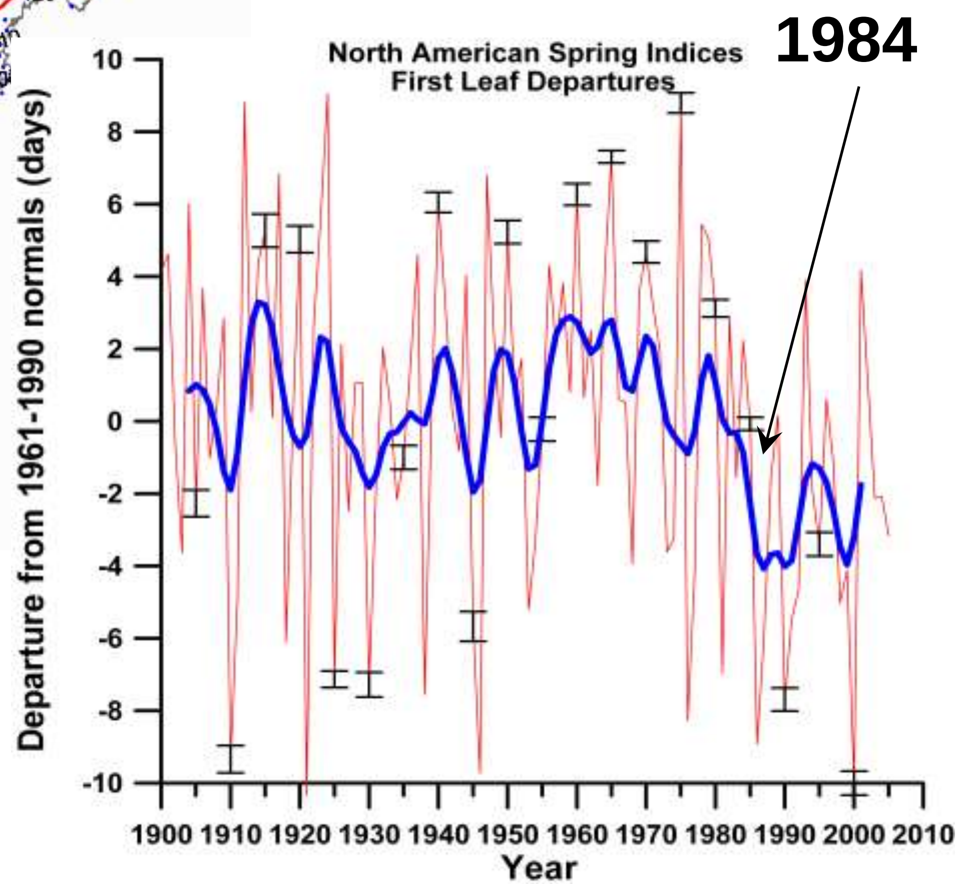


WESTMAP: March-April-May Mean Min Temperature



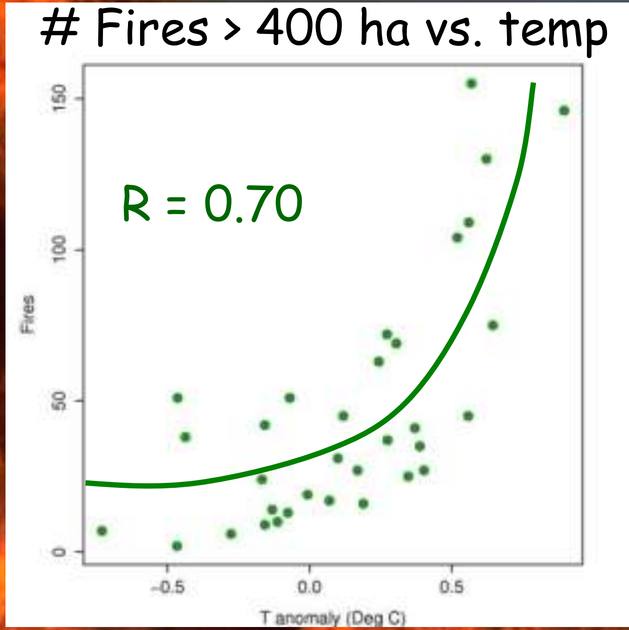
Spring index based on first leaf date for lilacs

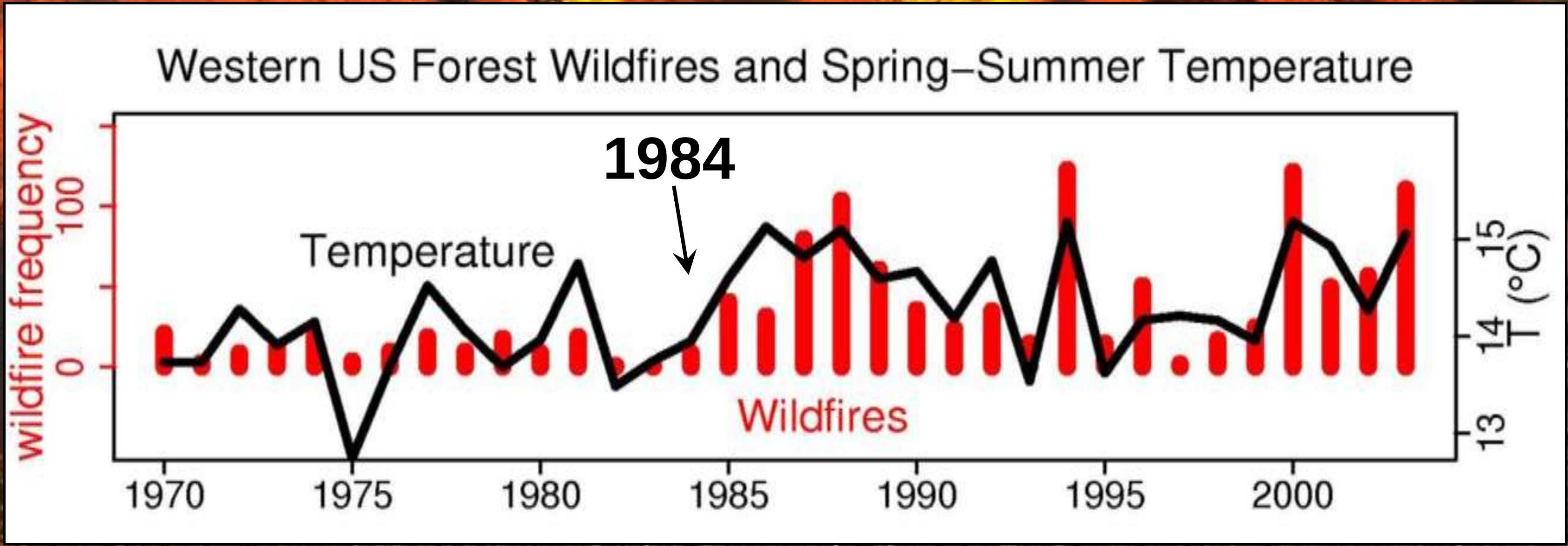




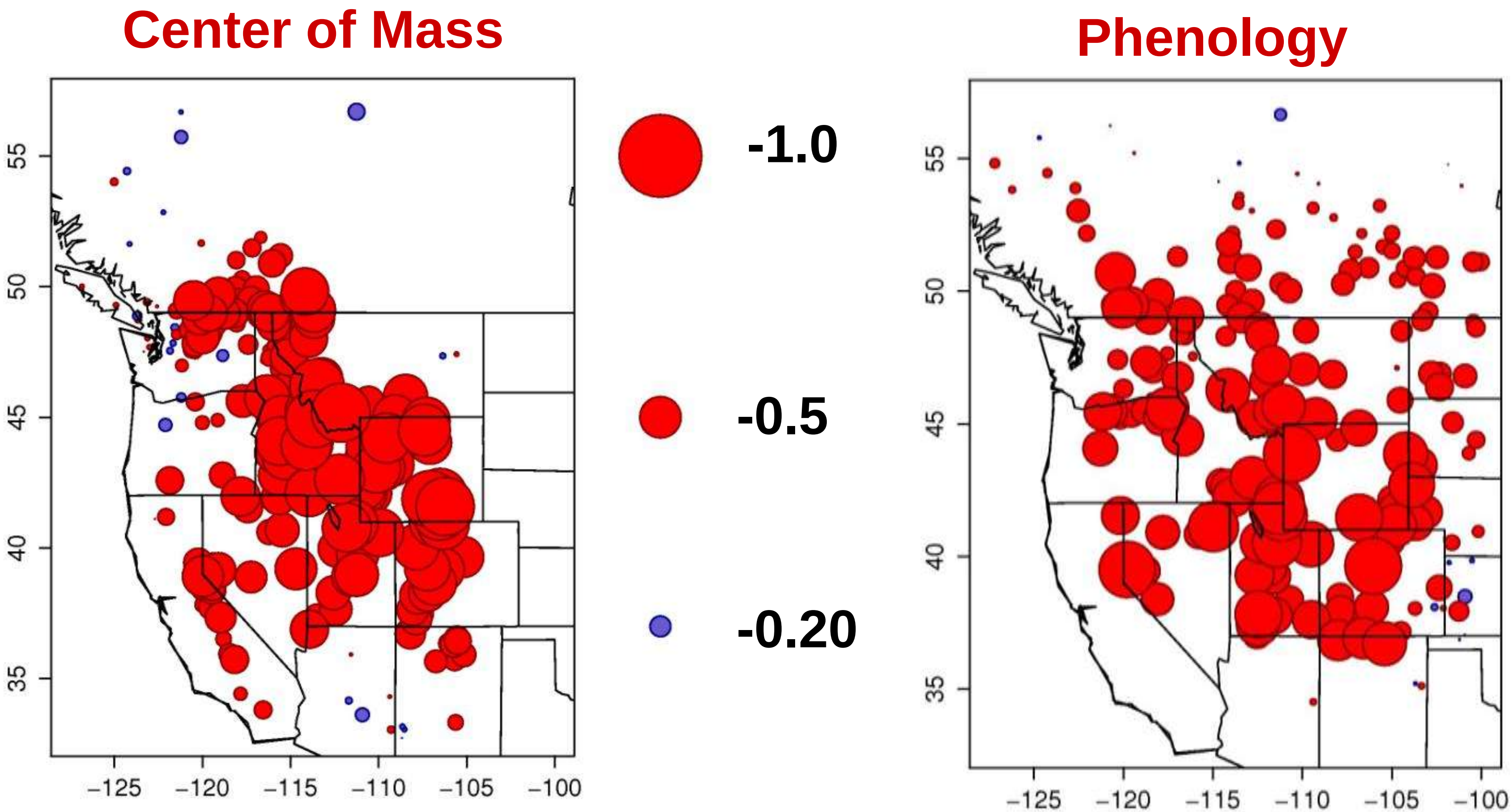
Schwartz and Reiter 2000
International. J. Climatology

Changes in Wildfire and the Timing of Spring in Western US Forests, A.L. Westerling, H.G. Hidalgo, D.R. Cayan, T.W. Swetnam. *Science* (2006)





Correlation between # fires >400 ha for each year between 1970-2003 in the West and spring index at each streamflow (Center of Mass) and weather station (phenology)



Westerling, Betancourt & Schwartz, in preparation

Human-Induced Changes in the Hydrology of the Western United States

Tim P. Barnett,[1*] David W. Pierce,[1] Hugo G. Hidalgo,[1] Celine Bonfils,[2] Benjamin D. Santer,[2] Tapash Das,[1] Govindasamy Bala,[2] Andrew W. Wood,[3] Toru Nozawa,[4] Arthur A. Mirin,[2] Daniel R. Cayan,[1,5] Michael D. Dettinger[1,5]

Observations have shown that the hydrological cycle of the western United States changed significantly over the last half of the 20th century. We present a regional, multivariable climate change detection and attribution study, using a high-resolution hydrologic model forced by global climate models, focusing on the changes that have already affected this primarily arid region with a large and growing population. The results show that up to 60% of the climate-related trends of river flow, winter air temperature, and snow pack between 1950 and 1999 are human-induced. These results are robust to perturbation of study variates and methods. They portend, in conjunction with previous work, a coming crisis in water supply for the western United States.

Trends in warmer winters, less snowpack, earlier streamflow, more large fires in West mostly due to greenhouse gases.

these drier summer conditions (*5*, *8*, *11*).

The west naturally undergoes multidecadal fluctuations between wet and dry periods (*12*). If drying from natural climate variability is the cause of the current changes, a subsequent wet period will likely restore the hydrological cycle to its former state. But global and regional climate models forced by anthropogenic pollutants suggest that human influences could have caused the shifts in hydrology (*2*, *13*–*15*). If so, these changes are highly likely to accelerate, making modifications to the water infrastructure of the western United States a virtual necessity.

Here, we demonstrate statistically that the majority of the observed low-frequency changes in the hydrological cycle (river flow, temperature, and snow pack) over the western United States from 1950 to 1999 are due to human-caused climate changes from greenhouse gases and aerosols. This result is obtained by evaluat-

[1]Scripps Institution of Oceanography, University of California, San Diego, La Jolla, CA 92093, USA. [2]Lawrence Livermore National Laboratory, Livermore, CA 94550, USA. [3]Land Surface Hydrology Research Group, Civil and Environmental Engineering, University of Washington, Seattle, WA 98195, USA. [4]National Institute for Environmental Studies, 16-2, Onogawa, Tsukuba, Ibaraki 305-8506, Japan. [5]U.S. Geological Survey, La Jolla, CA 92093, USA.

*To whom correspondence should be addressed. E-mail: tbarnett-ul@ucsd.edu

We investigated simultaneous changes from 1950 to 1999 (*19*) in snow pack (snow water equivalent or SWE), the timing of runoff of the major western rivers, and average January through March daily minimum temperature (JFM T_{min}) in the mountainous regions of the western United States (*20*). These three variates arguably are among the most important metrics of the western hydrological cycle. By using the multivariable approach, we obtain a greater signal-to-noise (S/N) ratio than from univariate D&A alone (see below).

The SWE data are normalized by October-to-March precipitation (P) to reduce variability from heavy- or light-precipitation years. Observed SWE/P and temperature were averaged over each of nine western mountainous regions (Fig. 1) to reduce small-spatial-scale weather noise. The river flow variate is the center of timing (CT), the day of the year on which one-half of the total water flow for the year has occurred, computed

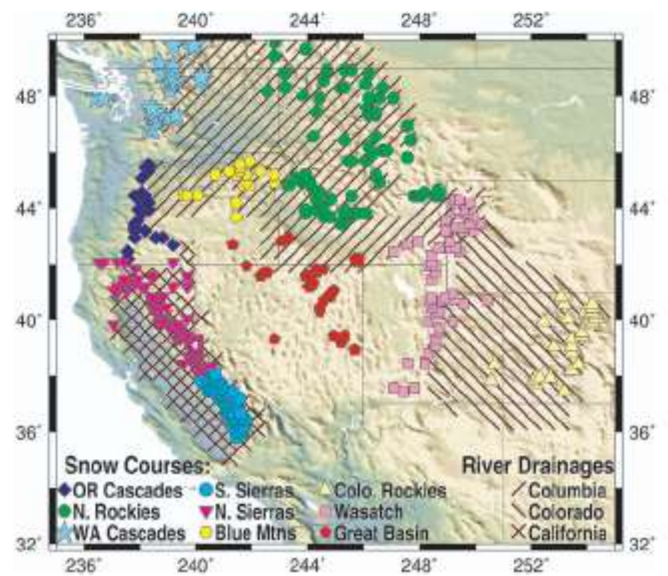


Fig. 1. Map showing averaging regions over which SWE/P and JFM T_{min} were determined. The hatching shows the approximate outline of the three main drainage basins used in this study.

Regional Assessment of Invasive Species and Wildfire Responses to Recent and Projected Climatic Trends in the American Deserts

A Guide For Monitoring, Mitigation, and Adaptation to Plant Invasions and Climate Change