Ecological Restoration in a Changing Desert Climate

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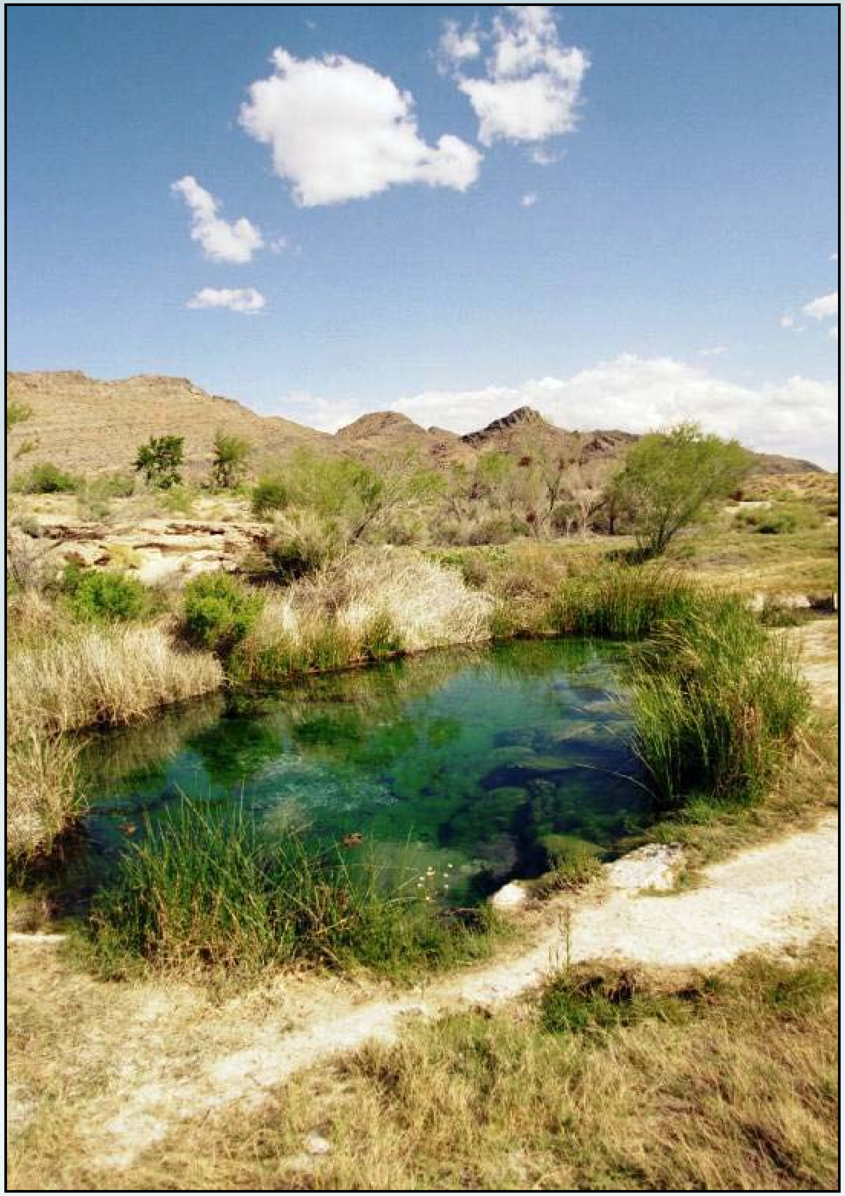


Ash Meadows Natl Wildlife Refuge

Outline

- Other factors important
- Sky island example
- Climate change; effects
- Reference conditions
- Newberry Mtns. study
- Managing for healthy ecosystems

Warming and Earlier Spring Increase Western U.S. Forest Wildfire Activity

A. L. Westerling,[1,2*] H. G. Hidalgo,[1] D. R. Cayan,[1,3] T. W. Swetnam[4]

Western United States forest wildfire activity is widely thought to have increased in recent decades, yet neither the extent of recent changes nor the degree to which climate may be driving regional changes in wildfire has been systematically documented. Much of the public and scientific discussion of changes in western United States wildfire has focused instead on the effects of 19th- and 20th-century land-use history. We compiled a comprehensive database of large wildfires in western United States forests since 1970 and compared it with hydroclimatic and land-surface data. Here, we show that large wildfire activity increased suddenly and markedly in the mid-1980s, with higher large-wildfire frequency, longer wildfire durations, and longer wildfire seasons. The greatest increases occurred in mid-elevation, Northern Rockies forests, where land-use histories have relatively little effect on fire risks and are strongly associated with increased spring and summer temperatures and an earlier spring snowmelt.

Science (2006) 313:940-943.

***But in deserts, effects may result from combined influences of temperature, precip regimes, and CO_2 on exotic grasses as fuel**

Historic and Current Fire Regimes in Ponderosa Pine

Current

Historic

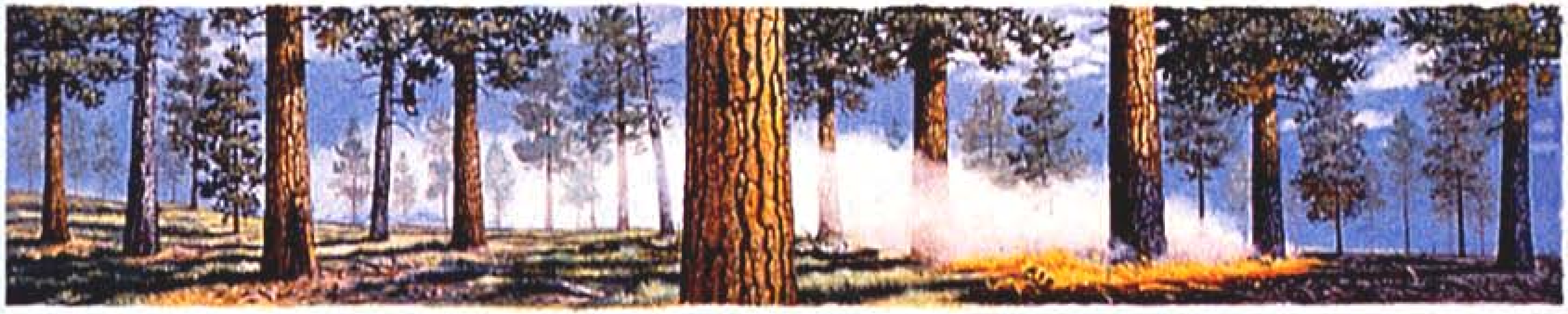
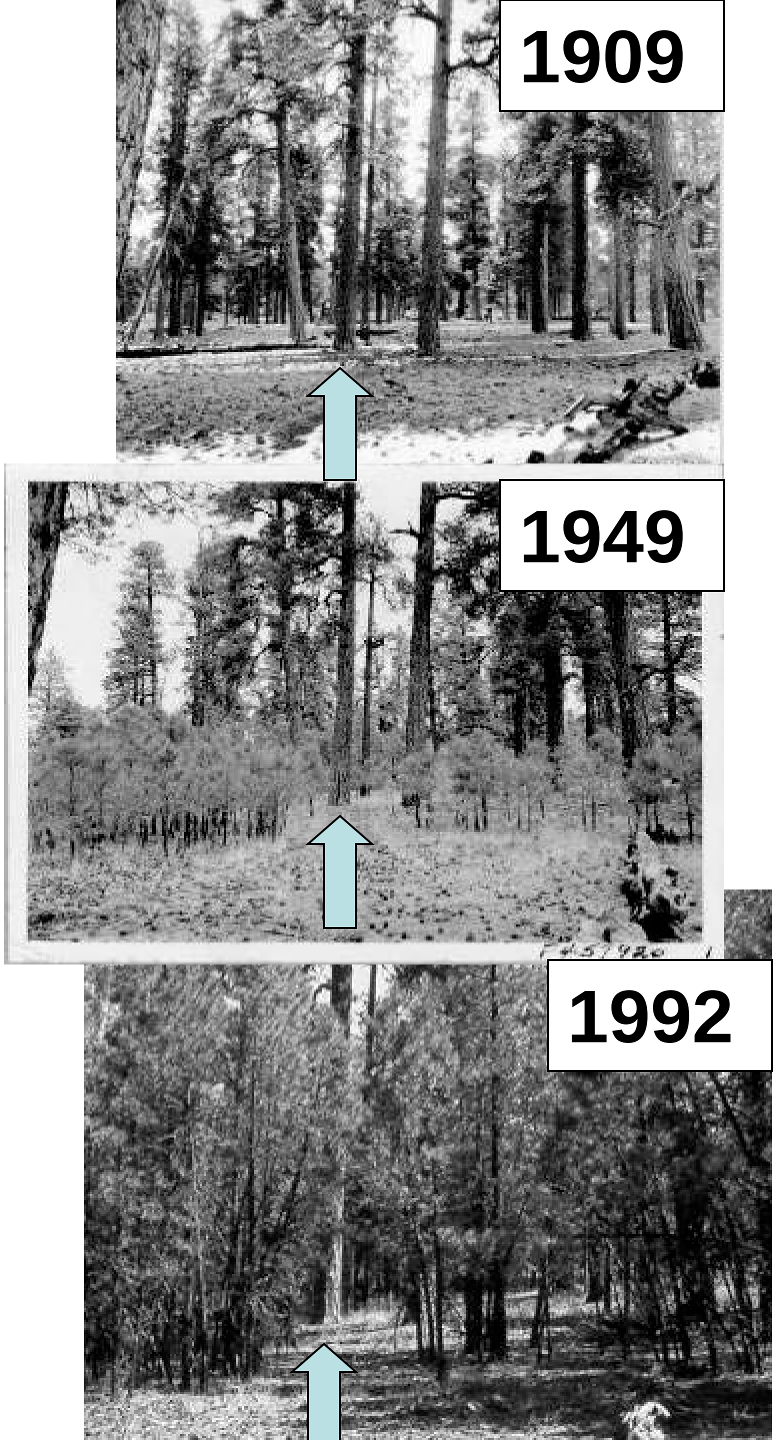


Plate 1

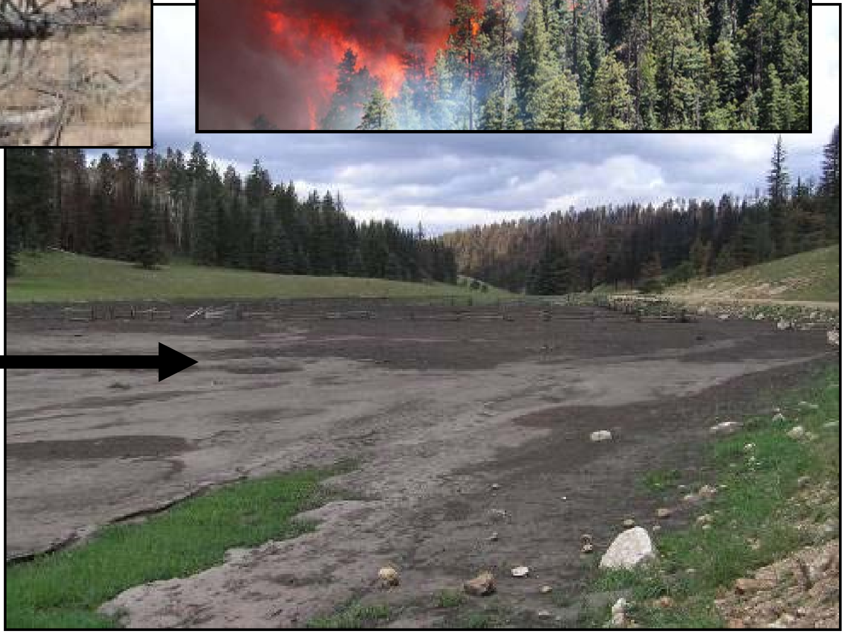
From National Geographic (9/96)



Forest Changes

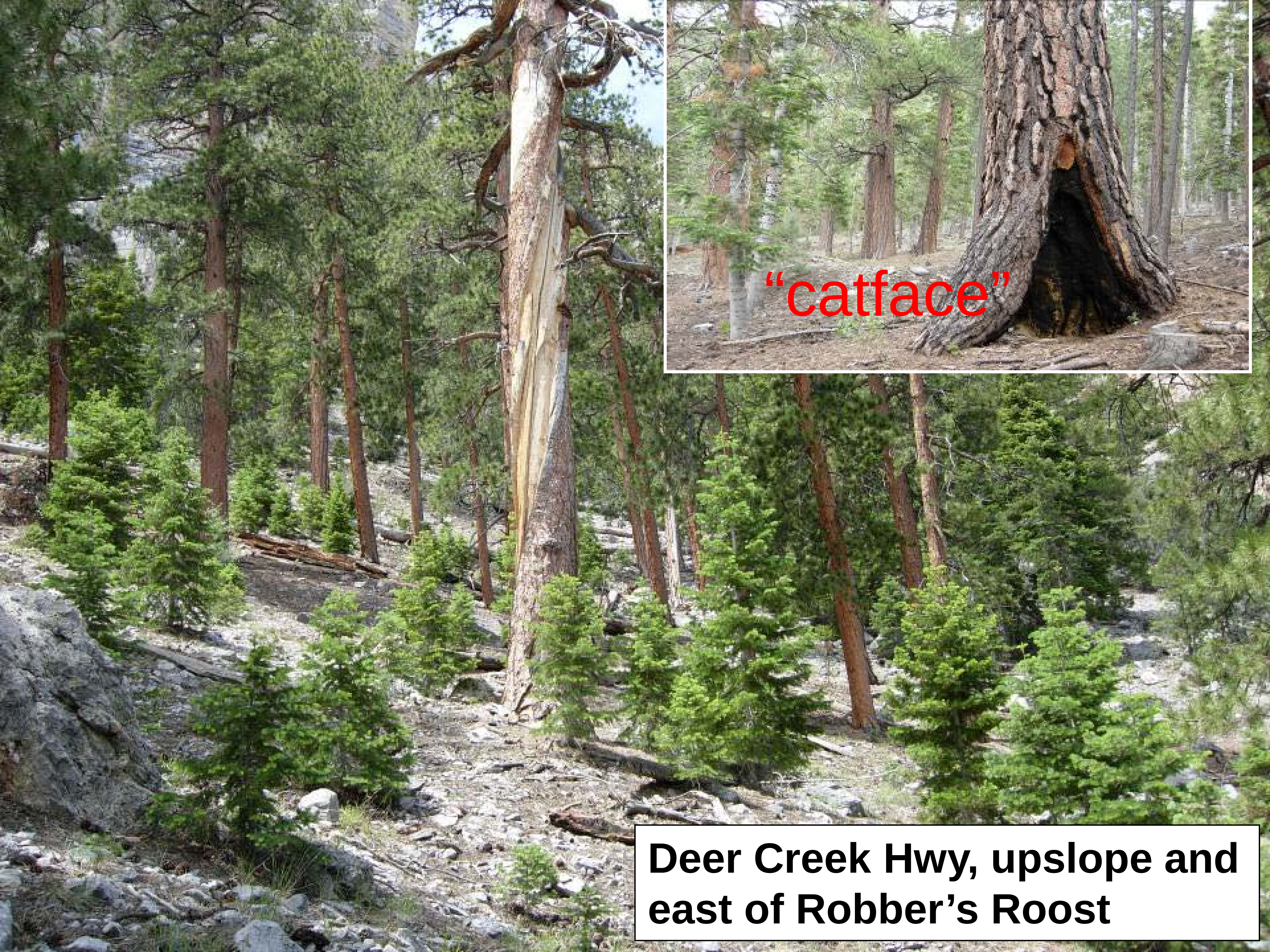
- **Frequent low intensity to infrequent, catastrophic fire**
- **Tree density increases**
- **Disease, old-tree mortality**
- **Species changes**
- **Altered wildlife habitat, human uses/habitation of the forest**

U.S. Forest Service and Northern Arizona University



Epic soil erosion flowing off fire; ashed soils

Wallow Fire photos by J. Coile



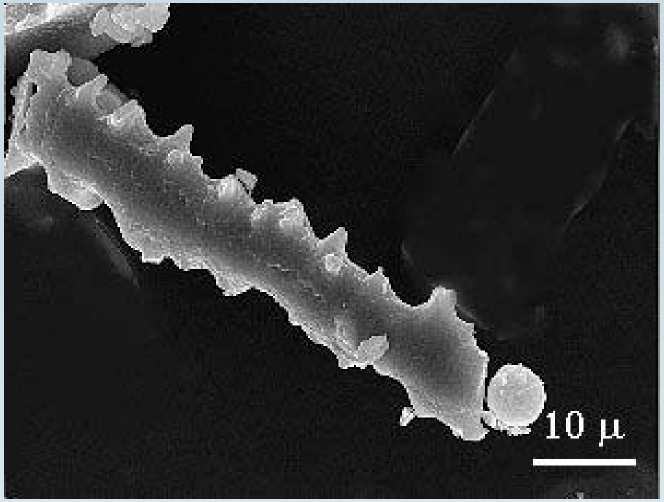
Deer Creek Hwy, upslope and east of Robber's Roost

Before restoration

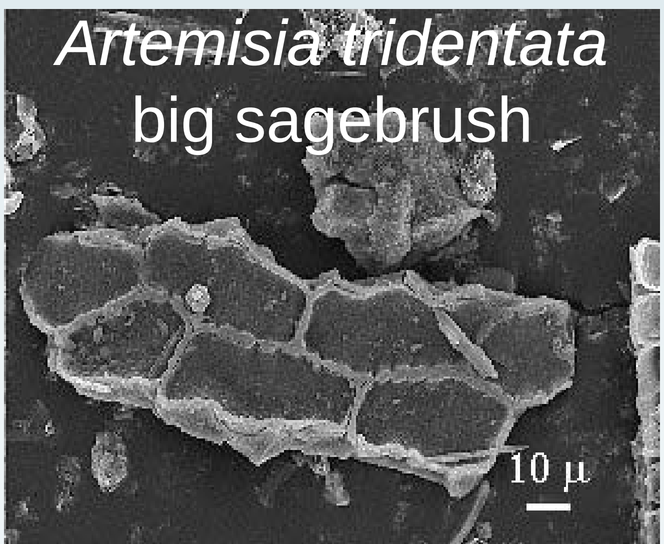
4 years after restoration

www.eri.nau.edu

Plant Phytoliths



Agropyron spicatum
bluebunch wheatgrass



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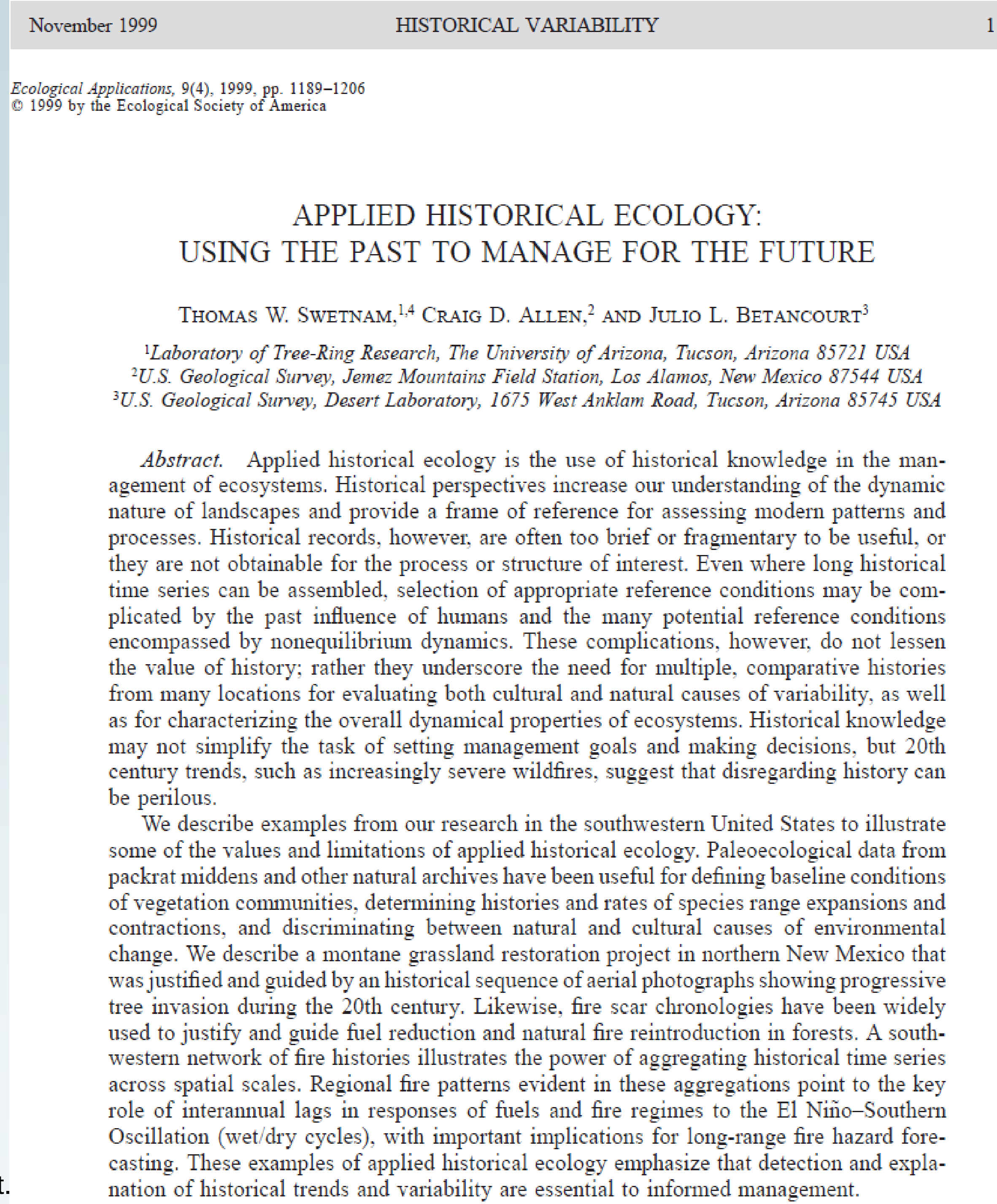

Ecological Applications, 9(4), 1999, pp. 1189–1206

APPLIED HISTORICAL ECOLOGY: USING THE PAST TO MANAGE FOR THE FUTURE

THOMAS W. SWETNAM,[1,4] CRAIG D. ALLEN,[2] AND JULIO L. BETANCOURT[3]

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Abstract. Applied historical ecology is the use of historical knowledge in the management of ecosystems. Historical perspectives increase our understanding of the dynamic nature of landscapes and provide a frame of reference for assessing modern patterns and processes. Historical records, however, are often too brief or fragmentary to be useful, or they are not obtainable for the process or structure of interest. Even where long historical time series can be assembled, selection of appropriate reference conditions may be complicated by the past influence of humans and the many potential reference conditions encompassed by nonequilibrium dynamics. These complications, however, do not lessen the value of history; rather they underscore the need for multiple, comparative histories from many locations for evaluating both cultural and natural causes of variability, as well as for characterizing the overall dynamical properties of ecosystems. Historical knowledge may not simplify the task of setting management goals and making decisions, but 20th century trends, such as increasingly severe wildfires, suggest that disregarding history can be perilous.

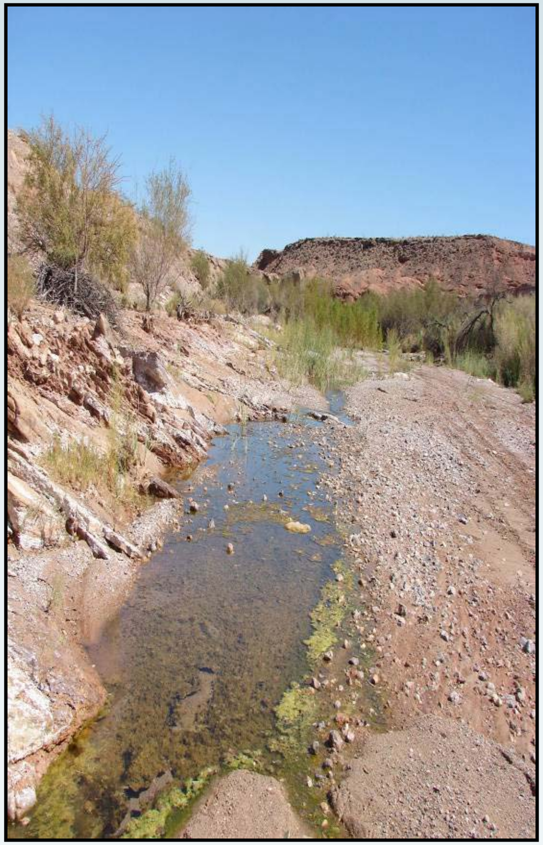
We describe examples from our research in the southwestern United States to illustrate some of the values and limitations of applied historical ecology. Paleoecological data from packrat middens and other natural archives have been useful for defining baseline conditions of vegetation communities, determining histories and rates of species range expansions and contractions, and discriminating between natural and cultural causes of environmental change. We describe a montane grassland restoration project in northern New Mexico that was justified and guided by an historical sequence of aerial photographs showing progressive tree invasion during the 20th century. Likewise, fire scar chronologies have been widely used to justify and guide fuel reduction and natural fire reintroduction in forests. A southwestern network of fire histories illustrates the power of aggregating historical time series across spatial scales. Regional fire patterns evident in these aggregations point to the key role of interannual lags in responses of fuels and fire regimes to the El Niño–Southern Oscillation (wet/dry cycles), with important implications for long-range fire hazard forecasting. These examples of applied historical ecology emphasize that detection and explanation of historical trends and variability are essential to informed management.

Sciencexpress Report

Model Projections of an Imminent Transition to a More Arid Climate in Southwestern North America

Richard Seager,[1] Mingfang Ting,[1] Isaac Held,[2,3] Yochanan Kushnir,[1] Jian Lu,[4] Gabriel Ve
Huang,[1] Nili Harnik,[5] Ants Leetmaa,[2] Ngar-Cheung Lau,[2,3] Cuihua Li,[1] Jennifer Velez,[1] N

How anthropogenic climate change will impact hydroclimate in the arid regions of Southwestern North America has implications for the allocation of water resources and the course of regional development. Here we show that there is a broad consensus amongst climate models that this region will dry significantly in the 21st century and that the transition to a more arid climate should already be underway. If these models are correct, the levels of aridity of the recent multiyear drought, or the Dust Bowl and 1950s droughts, will, within the coming years to decades, become the new climatology of the American Southwest.

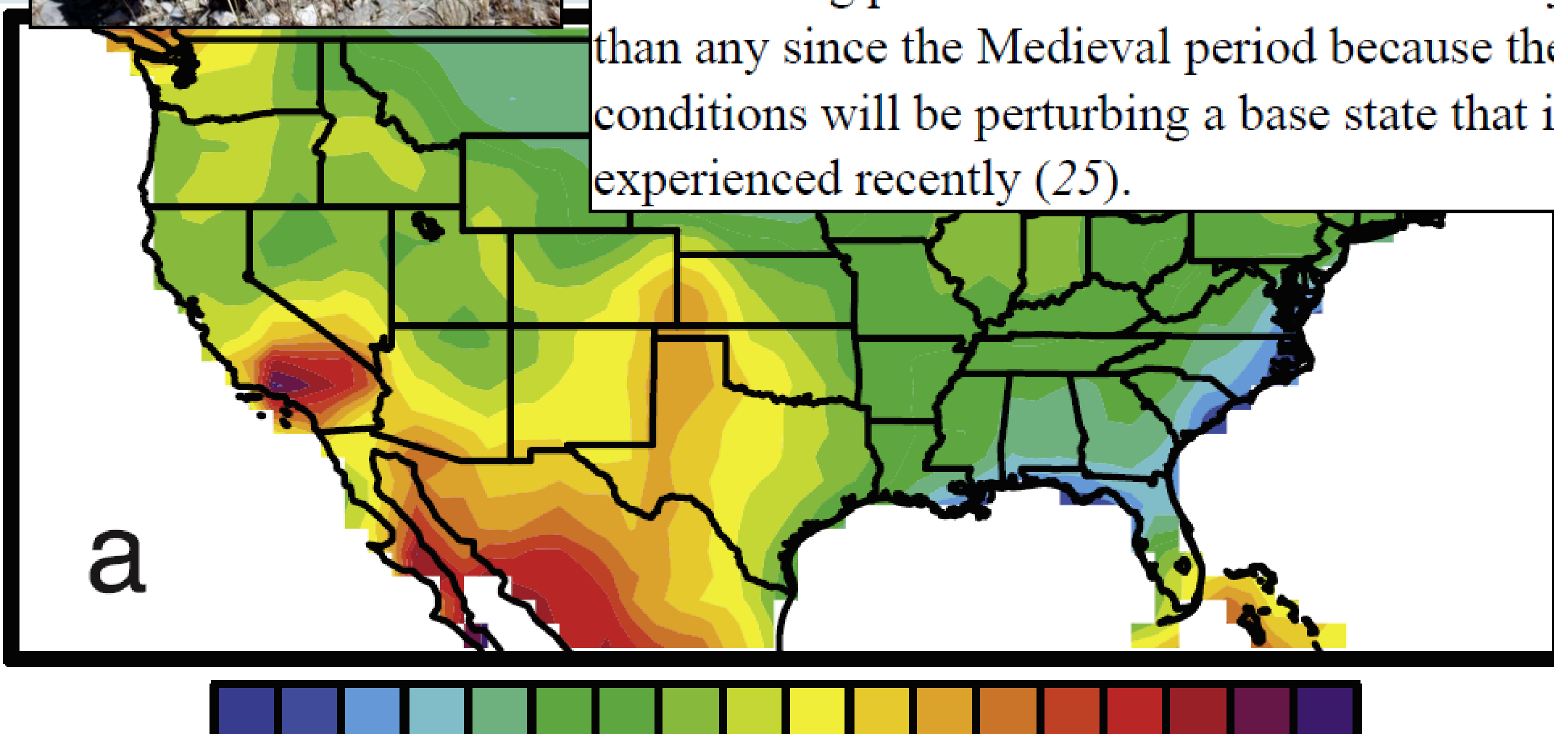


GEOPHYSICAL RESEARCH LETTERS, VOL. 35, L16709, doi:10.1029/2008GL035075, 2008

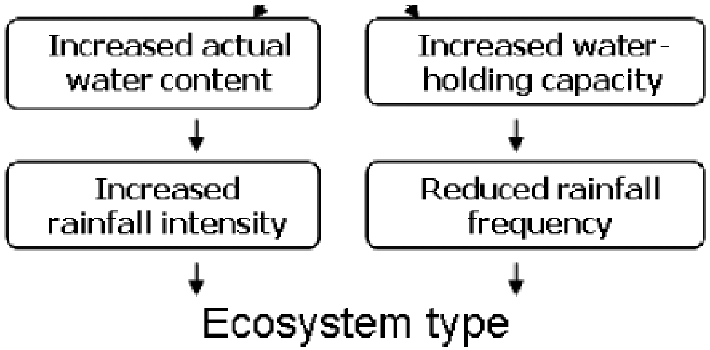
Climate change hotspots in the United States

Noah S. Diffenbaugh,[1]

zones. The drying of subtropical land areas that, according to the models is imminent or already underway, is unlike any climate state we have seen in the instrumental record. It is also distinct from the multidecadal megadroughts that afflicted the American Southwest during Medieval times (*20-22*) which have also been attributed to changes in tropical SSTs (*18*, *23*). The most severe future droughts will still occur during persistent La Niña events but they will be worse than any since the Medieval period because the La Niña conditions will be perturbing a base state that is drier than any experienced recently (*25*).



Consequences of More Extreme Precipitation Regimes for Terrestrial Ecosystems



	Xeric	Mesic	Hydric
Hydrologic processes			
Runoff	⇧	⇧	⇧
Soil evaporation	⇩	⇩	⇩
Interception	⇩	⇩	⇩
Soil storage	⇧	⇩	⇩
Deep drainage	⇨	⇧	⇩
Ecological processes			
Net primary production	⇧	⇩	⇧
Soil respiration	⇩	⇩	⇧
Net ecosystem exchange	⇧	⇩	⇧
Nitrogen mineralization	⇩	⇩	⇧

Knapp et al. (2008) BioScience

Plant phenology and distribution in relation to recent climate change

Robert I. Bertin[1]

Biology Department, College of the Holy Cross, Worcester, MA 01610

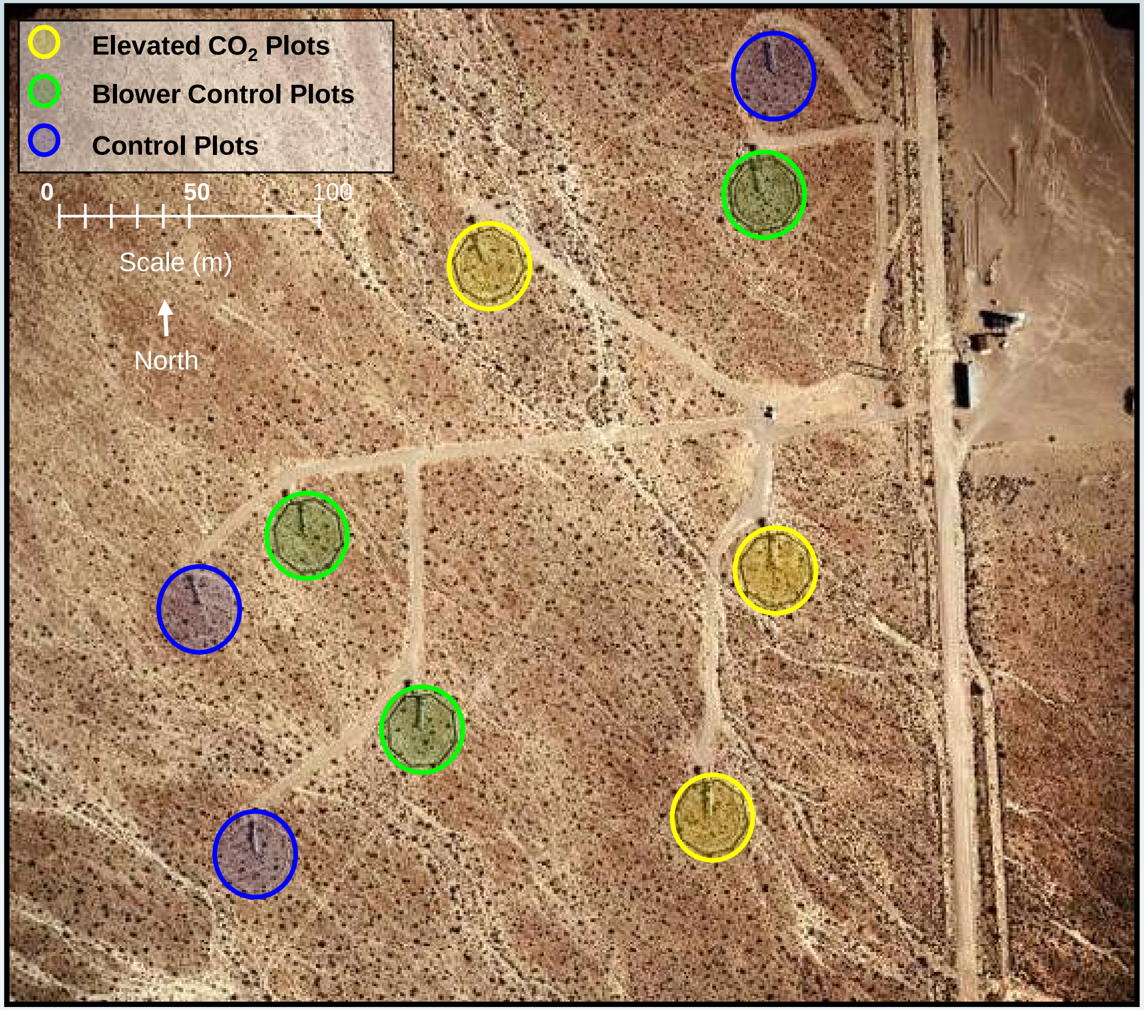
BERTIN, R. I. (Biology Department, College of the Holy Cross, Worcester, MA 01610) Plant phenology and distribution in relation to recent climate change. J. Torrey Bot. Soc. 135: 126–146. 2008.—This paper summarizes a broad range of studies that have examined influences of recent climate change on plant phenology or distribution. Spring events such as leafing and flowering have typically advanced, some by several weeks, with median advances of 4–5 d per degree Celsius. Autumn events, such as leaf coloring or leaf fall, have usually become delayed, though with more variability than spring events. Changes in summer events have been mixed. Phenological changes have varied geographically, as have recent temperature changes. Most studies of at least several decades duration show the initiation of rapid changes in the 1970s or 1980s, paralleling patterns of temperature change. Plants and animals in a given area have often responded at different rates to temperature change, which is likely to change patterns of interaction between plants and their pollinators and herbivores. Altitudinal changes in plant distributions have been demonstrated in several areas, especially in Scandinavia and in Mediterranean Europe, though these changes lag the measured temperature changes. Latitudinal changes in plant distribution have been demonstrated in only a few instances and it has been suggested that precipitation changes may have limited range shifts in response to warming in some areas. The observed and predicted changes in plant distribution and phenology have major implications for various ecological and evolutionary phenomena, including ecosystem productivity, species interactions, community structure, and conservation of biodiversity.

Journal of the Torrey Botanical Society 135(1), 2008,

4-5 days change per 1^{o}C change

Brittlebush

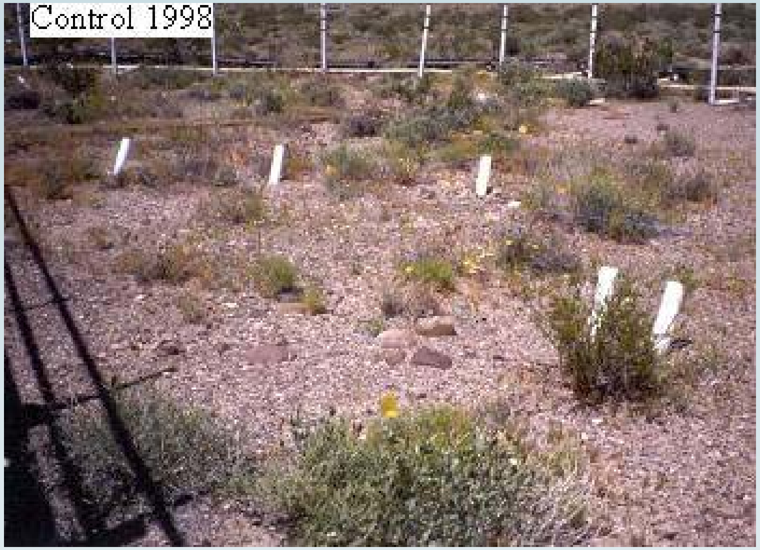
High CO_2 World: Nevada Desert FACE Facility

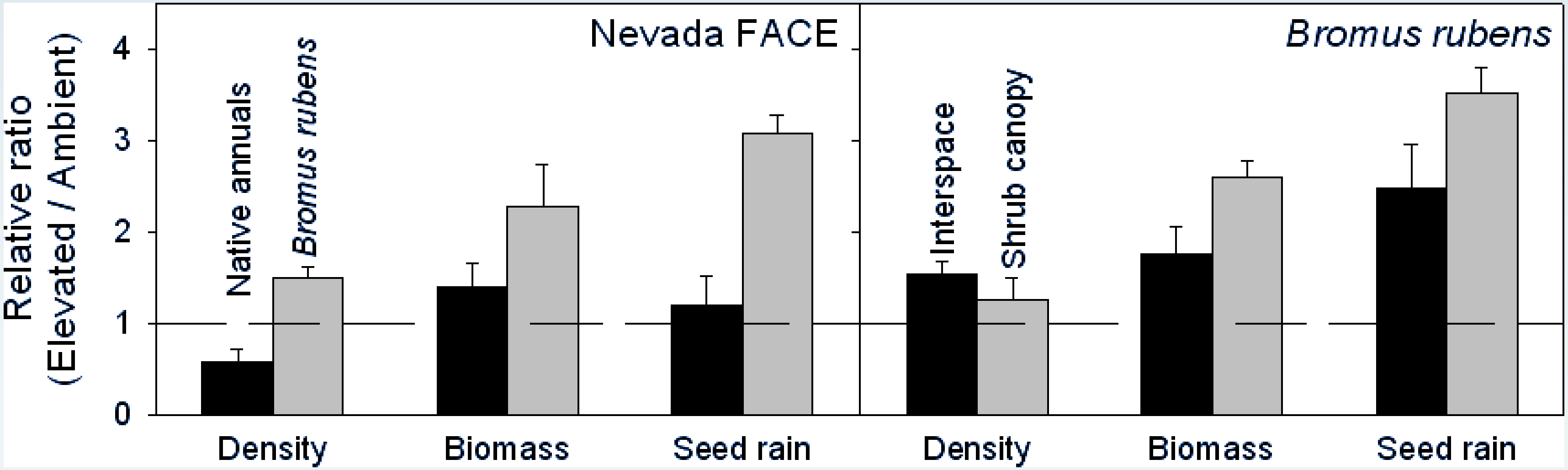


- 9 rings, diameter 82 ft (25 m)
- 3 elevated CO_2 rings, 550 ppm
- 3 blower control rings, ambient CO_2
- 3 non-blower control, ambient CO_2

7
8
12

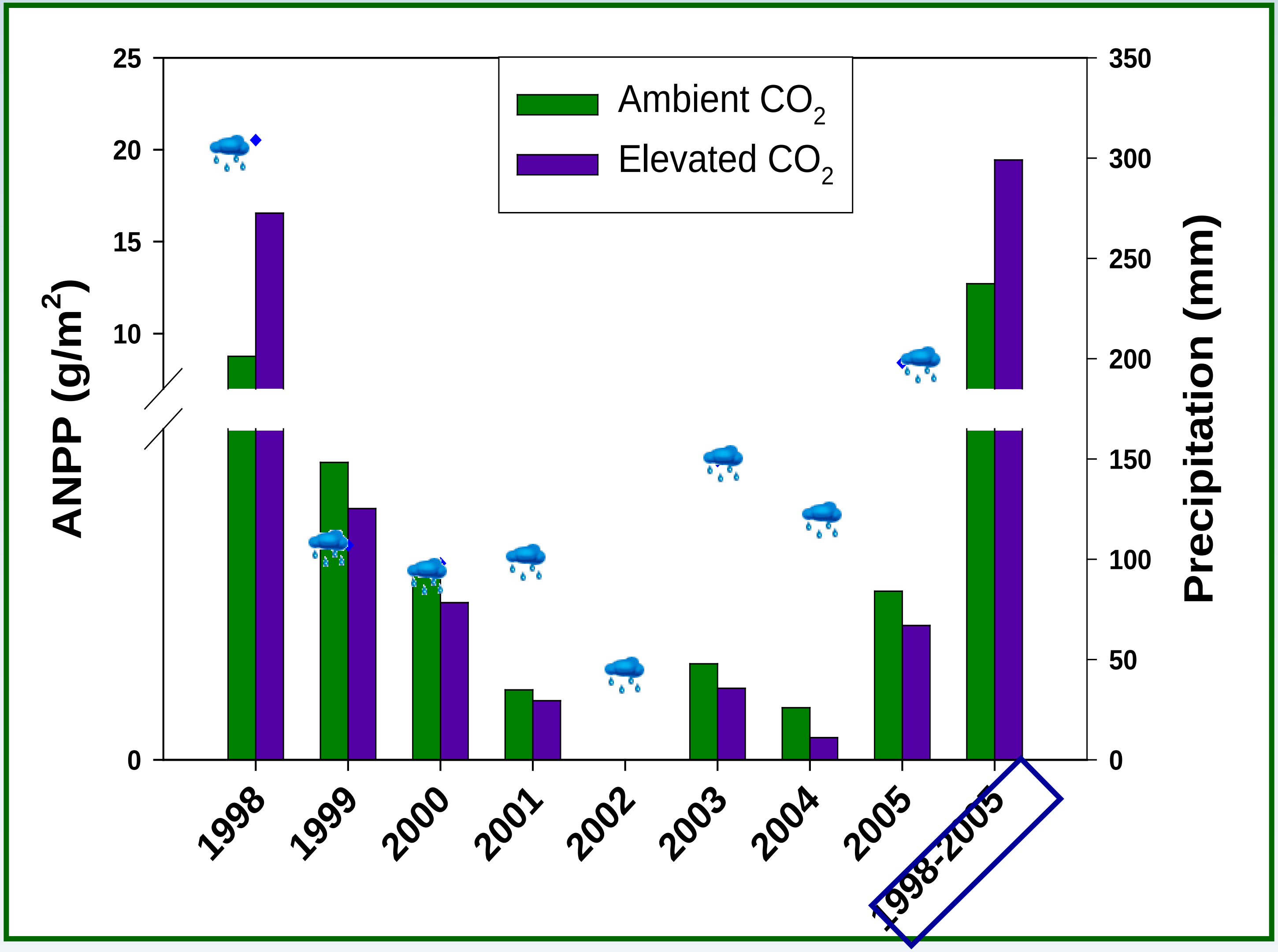
Productivity of Annuals: 1998





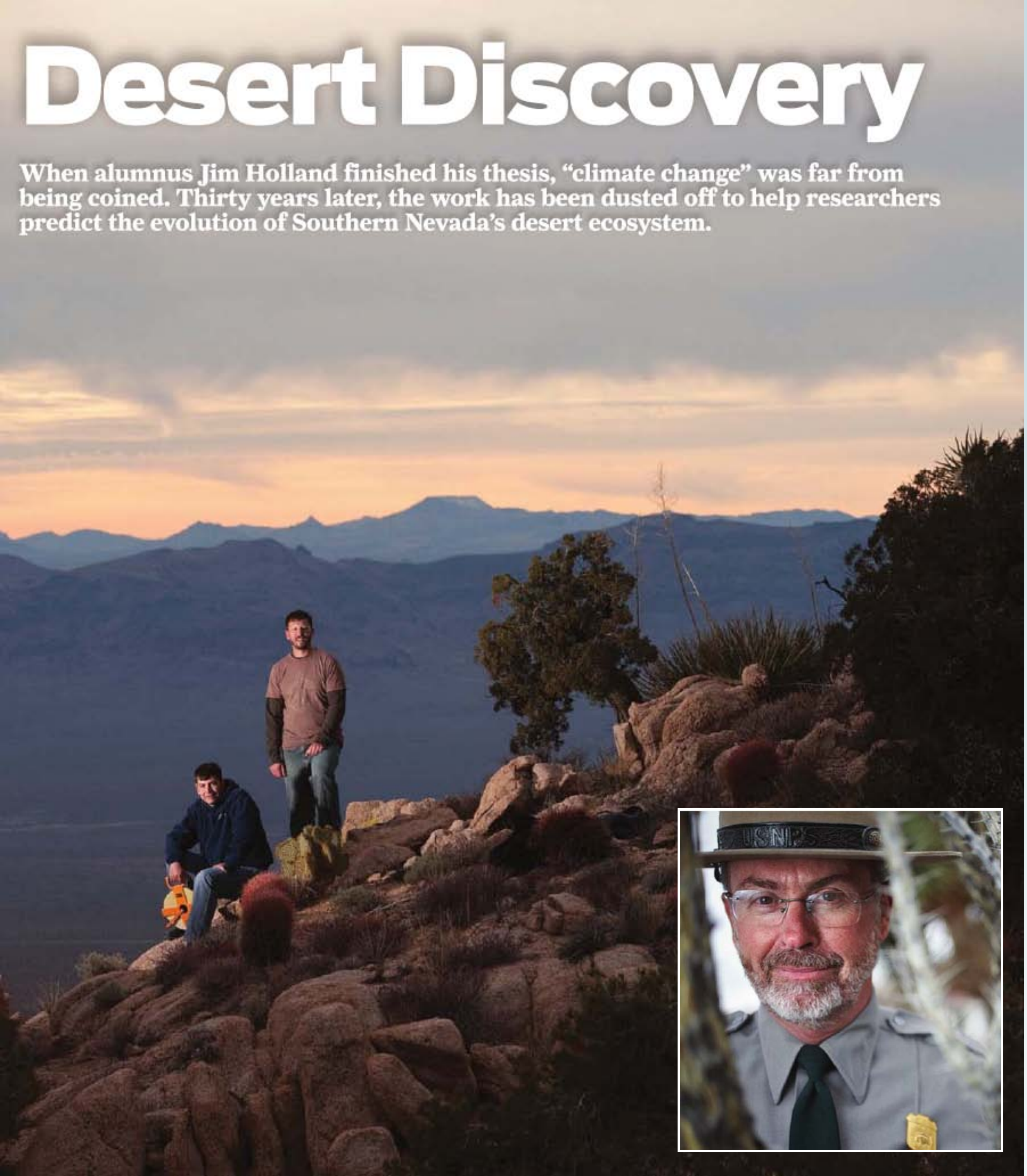
Smith et al. (2000) *Nature* 408:79-82.

Estimated Aboveground ANPP



Desert Discovery

When alumnus Jim Holland finished his thesis, "climate change" was far from being coined. Thirty years later, the work has been dusted off to help researchers predict the evolution of Southern Nevada's desert ecosystem.



BY BRENDAN BUHLER

The thesis had come off a Lied Library shelf, bound in black, covered in dust, 232 pages long, and bearing the scintillating title, "A Floristic and Vegetation Analysis of the Newberry Mountains." No one had looked at it in the last decade. But what it contained was utterly remarkable to Scott Abella.

The Newberries are border country, not merely between Arizona and Nevada but between the inhospitable Sonoran Desert and the almost extraterrestrial Mojave. It's a place where two ecosystems meet and compete, a conflict that could be influenced by climate change and invasive species. The Newberries are also part of one of the world's least studied ecologies. All in all, an ideal spot to expand the boundaries of human knowledge, venomous snakes aside.

So in that thesis Abella first held two years ago, the environmental studies professor saw a baseline record of the past, one that you could compare to the present to puzzle out the changes in Southern Nevada's landscape.

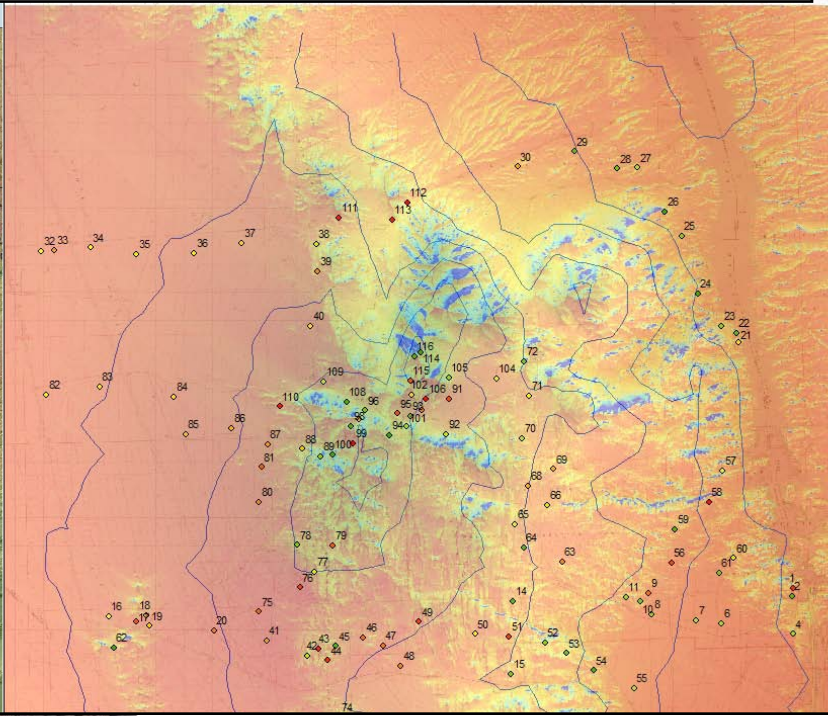
UNLV Magazine 2010

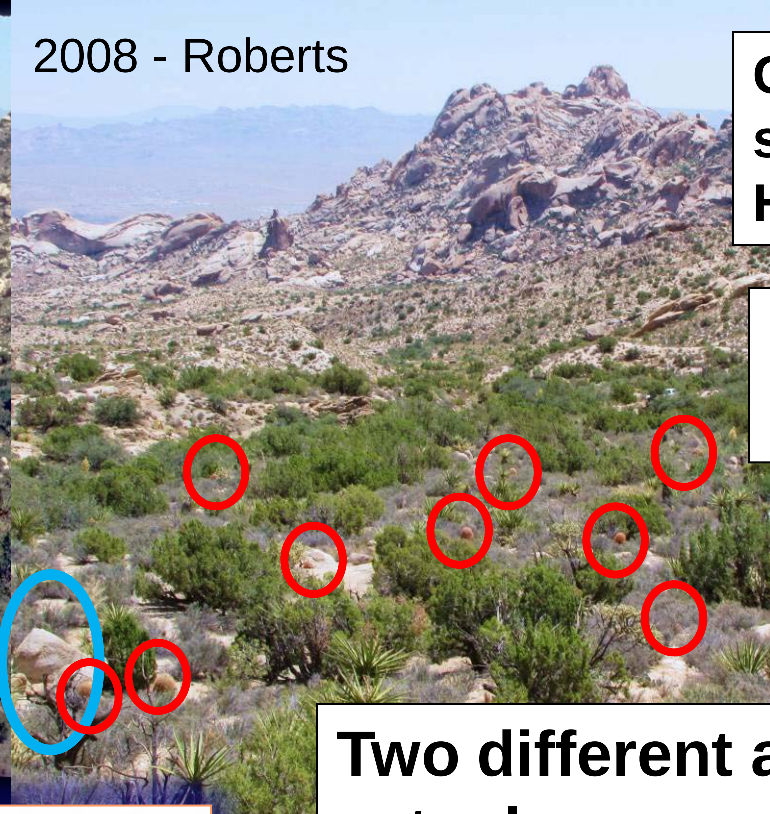

RECREATION
NEWBERRY
MOUNTAINS
LAKE MOHAVE
COLORADO RIVER
NEVADA
CALIFORNIA

Newberry Mountains, Lake Mead NRA, Nevada

Est. 1979 Jim Holland, UNLV

Remeasured 2008 Chris Roberts, UNLV

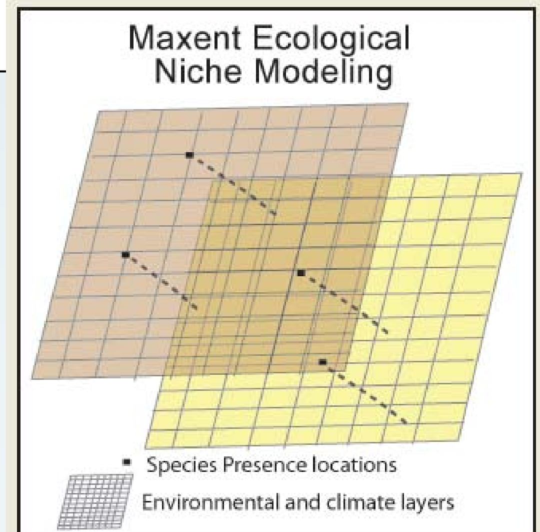




Confidence: same methods, Holland legacy

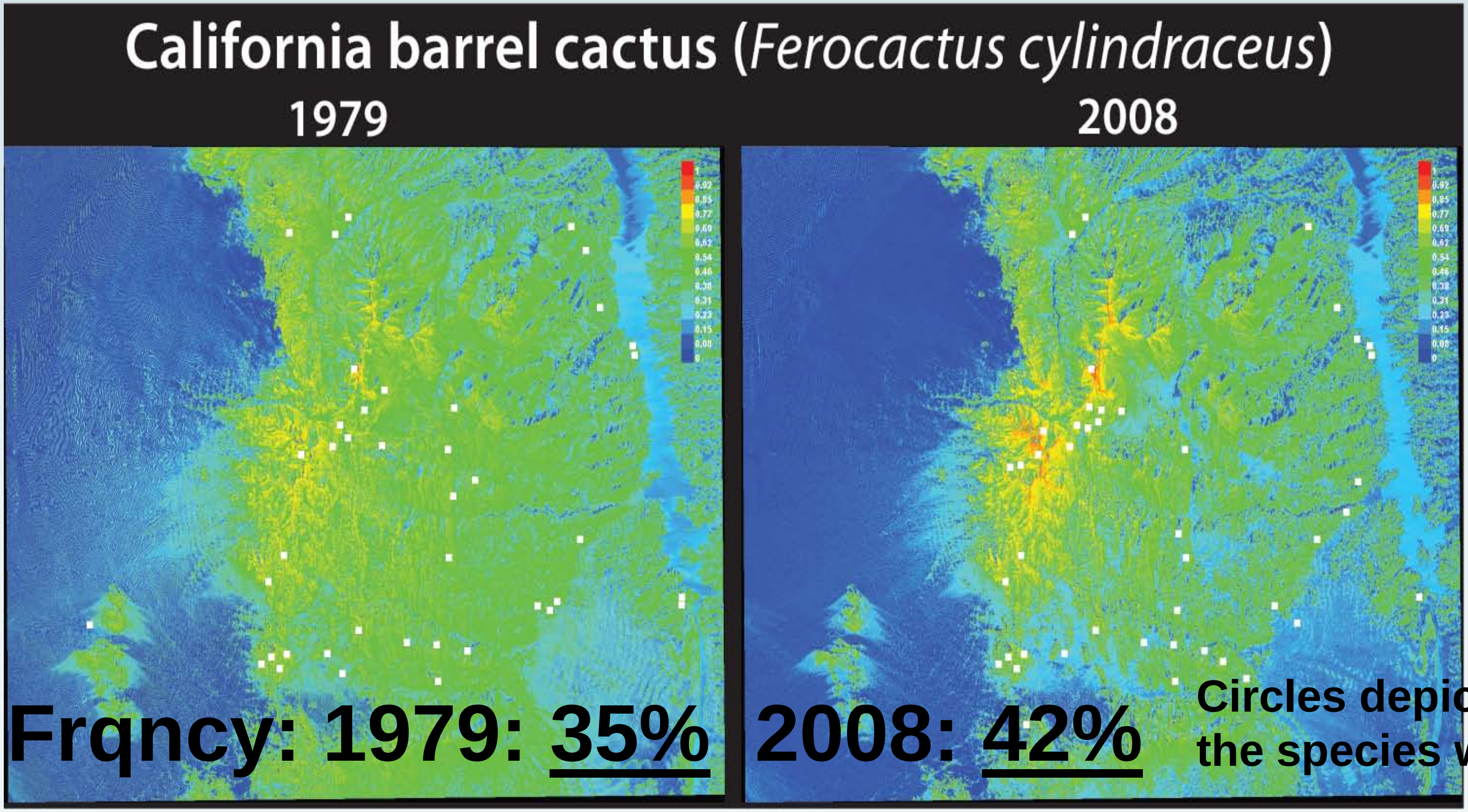
Increasers
Decreasers

Two different approaches: actual measurements modeling



Three general types of species:

- Expanded (e.g., *Encelia farinosa*)
- Remained same (net)
- Decreased in habitat area (high-elev. spp)



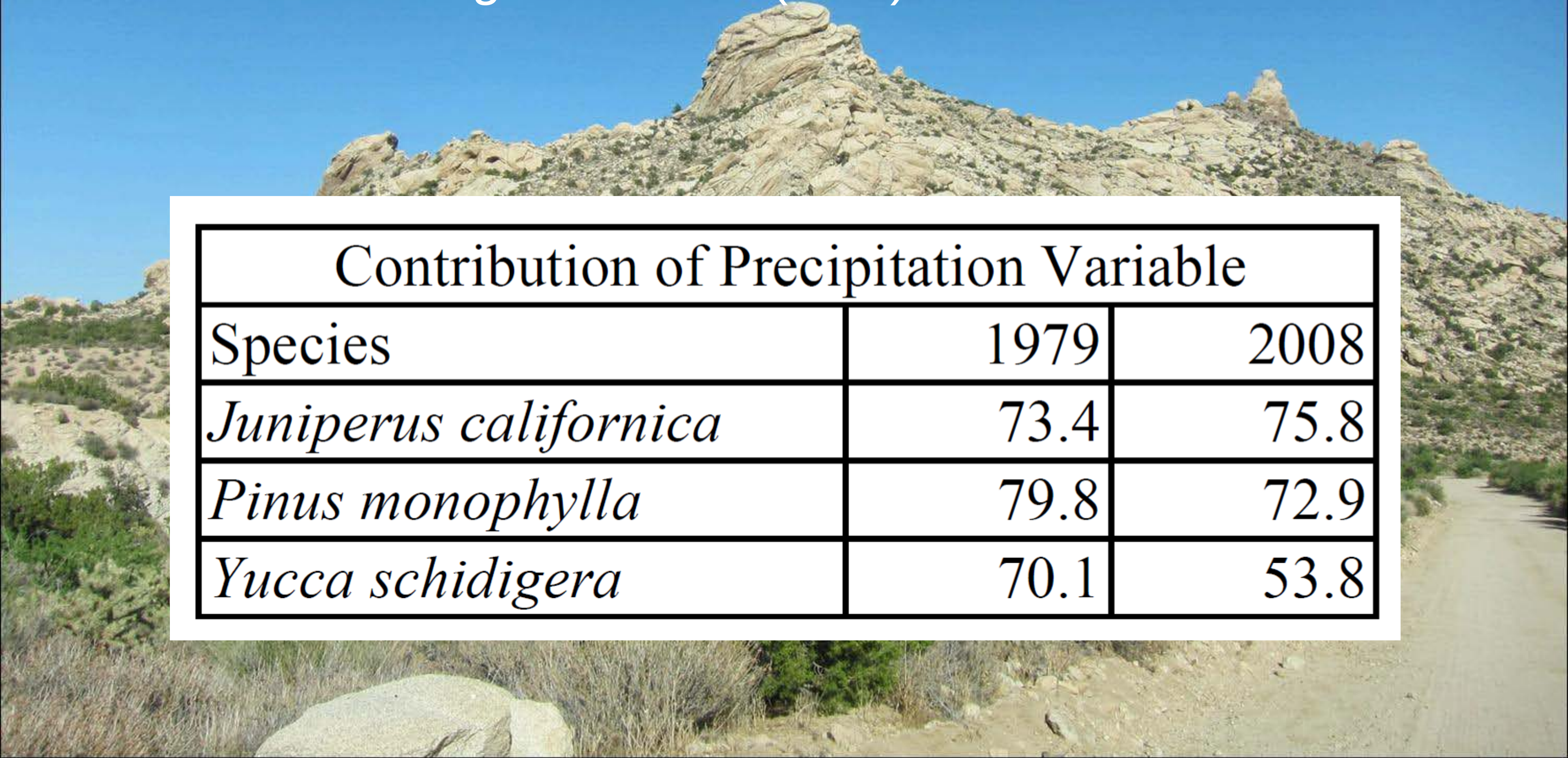
Ross Guida
UNLV thesis

Frqncy: 1979: <u>35%</u> 2008: <u>42%</u>

Circles depict plots where the species was *present*

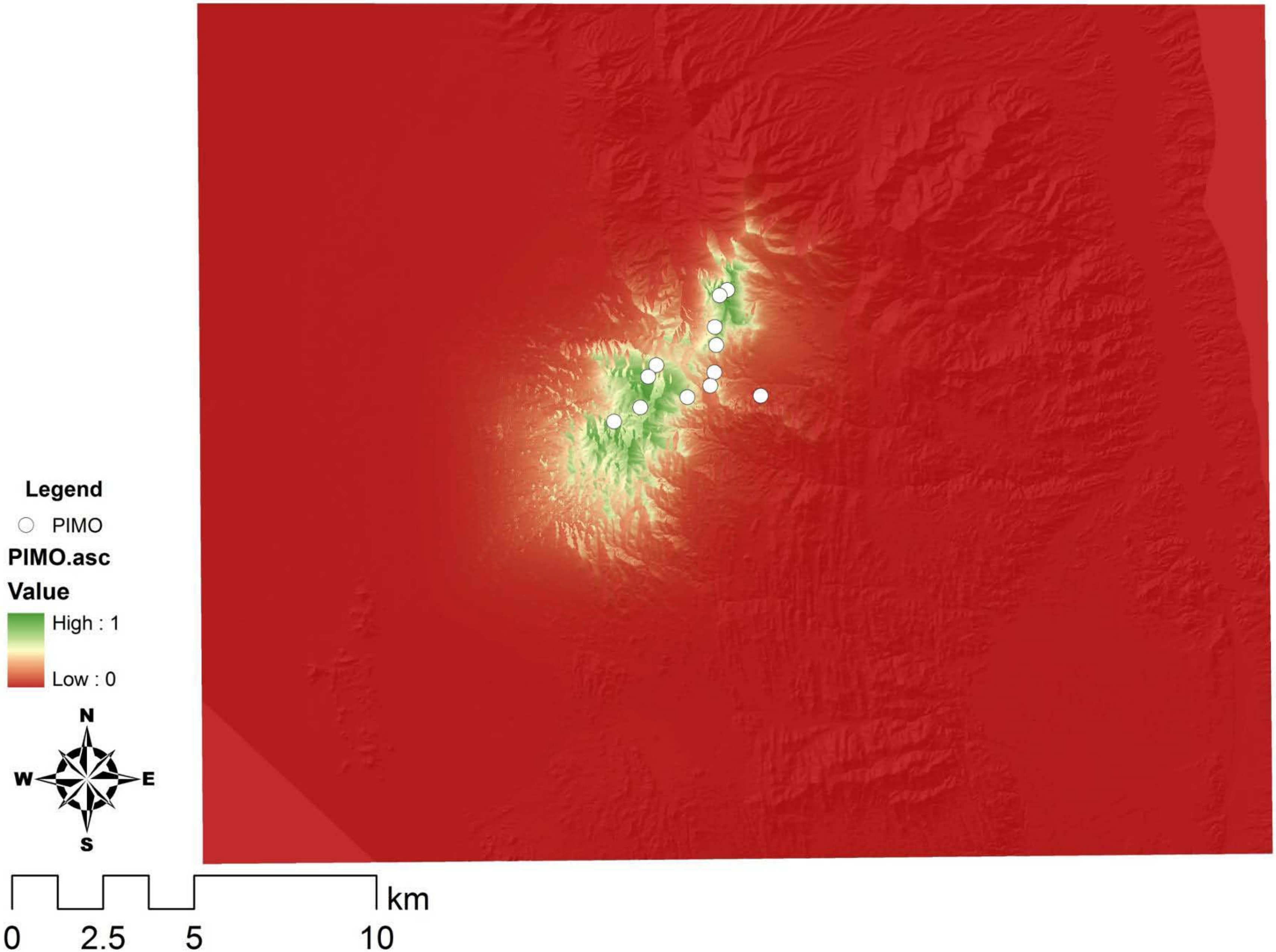
Increasing in Elevation

- Three species with decreasing habitat:
  - *Juniperus californica:* +25 m (82 ft)
  - *Pinus monophylla:* +75 m (246 ft)
  - *Yucca schidigera:* +30 m (98 ft)

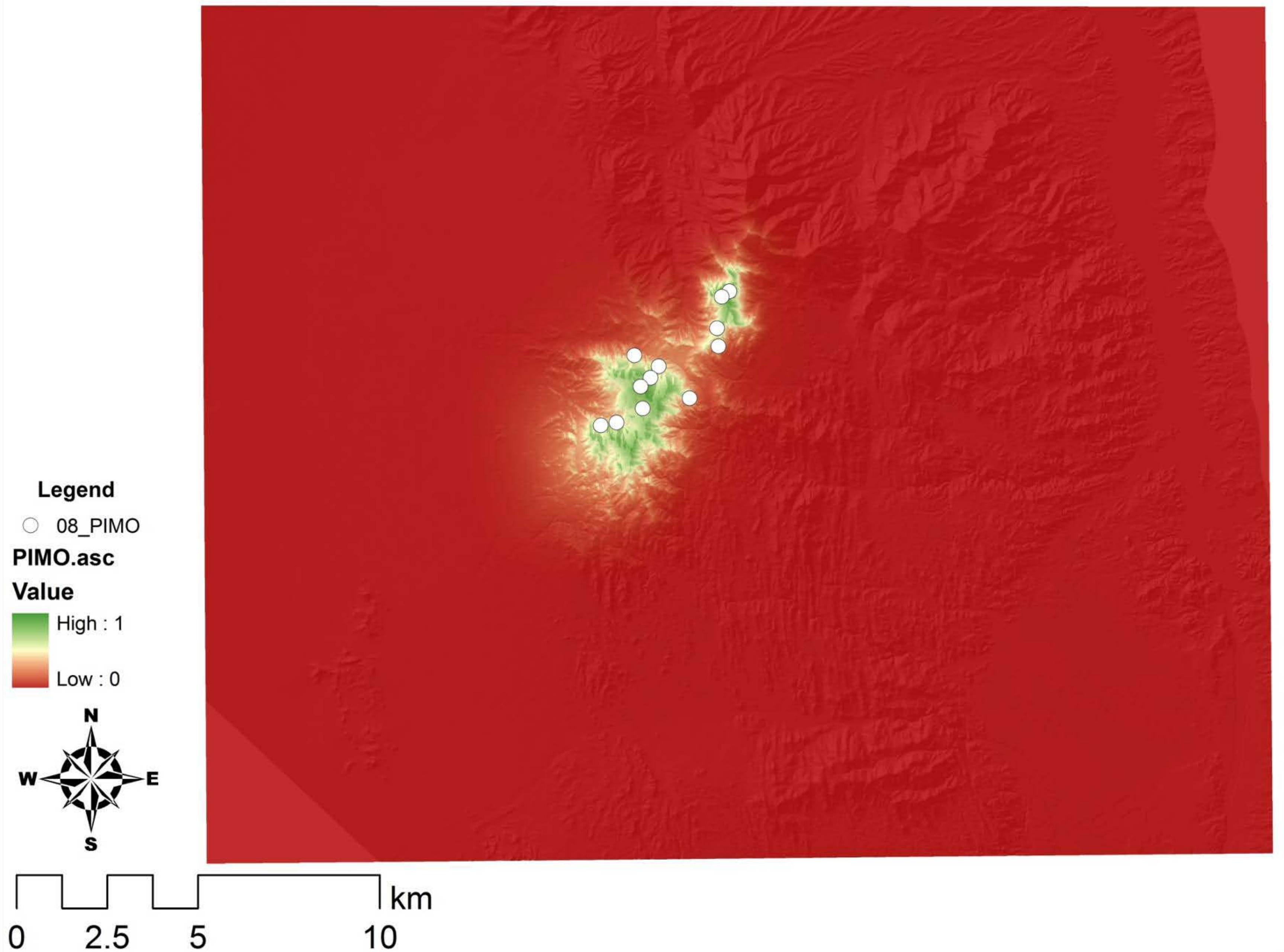


Contribution of Precipitation Variable		
Species	1979	2008
Juniperus californica	73.4	75.8
Pinus monophylla	79.8	72.9
Yucca schidigera	70.1	53.8

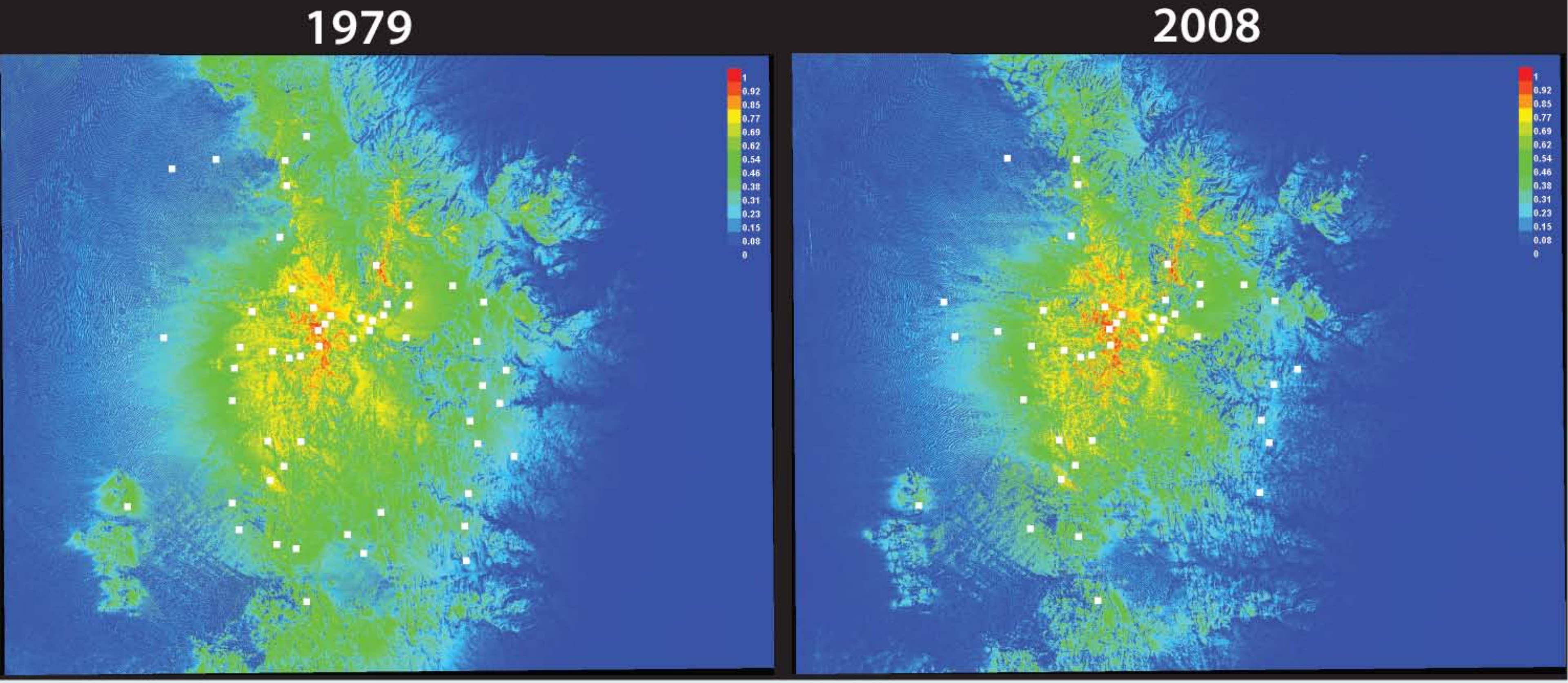
1979 Pinus monophylla



2008 Pinus monophylla

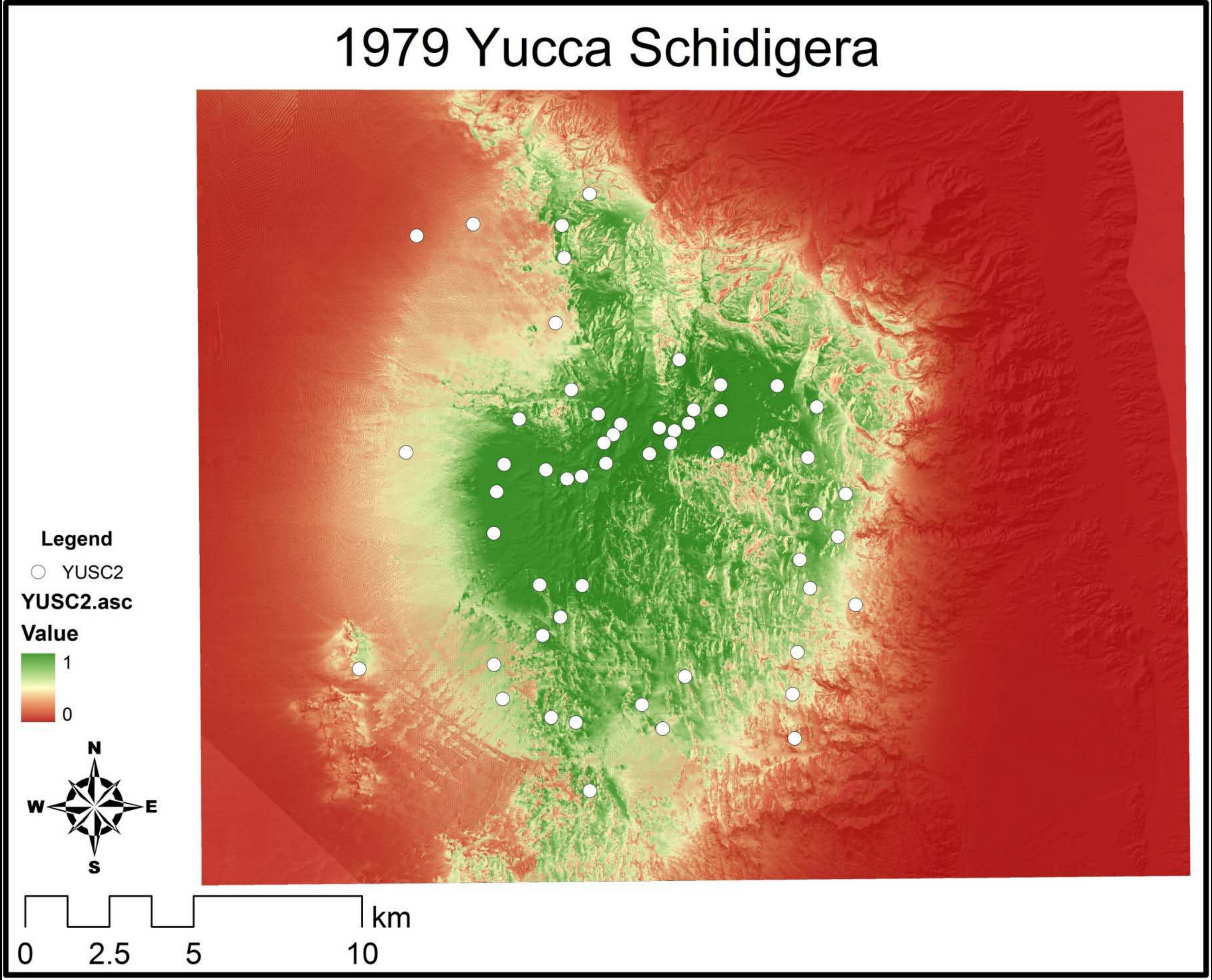


Mojave yucca (*Yucca schidigera*)

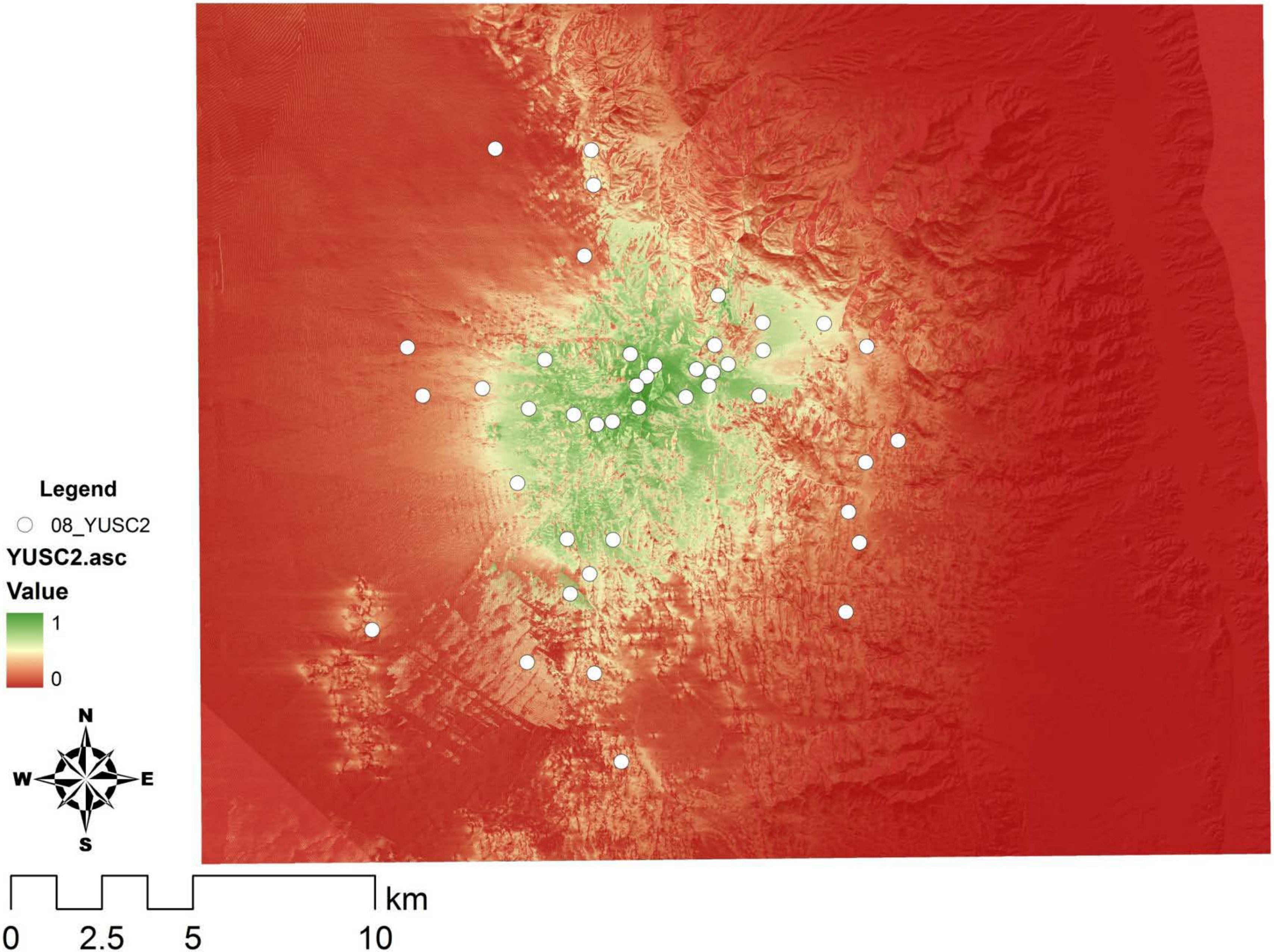


Circles depict plots where the species was *present*

Frequency: 1979: <u>47%</u>　　2008: <u>41%</u>


1979 Yucca Schidigera
Legend
YUSC2
YUSC2.asc
Value
1
0
N
W
E
S
km
0
2.5
5
10

2008 Yucca Schidigera



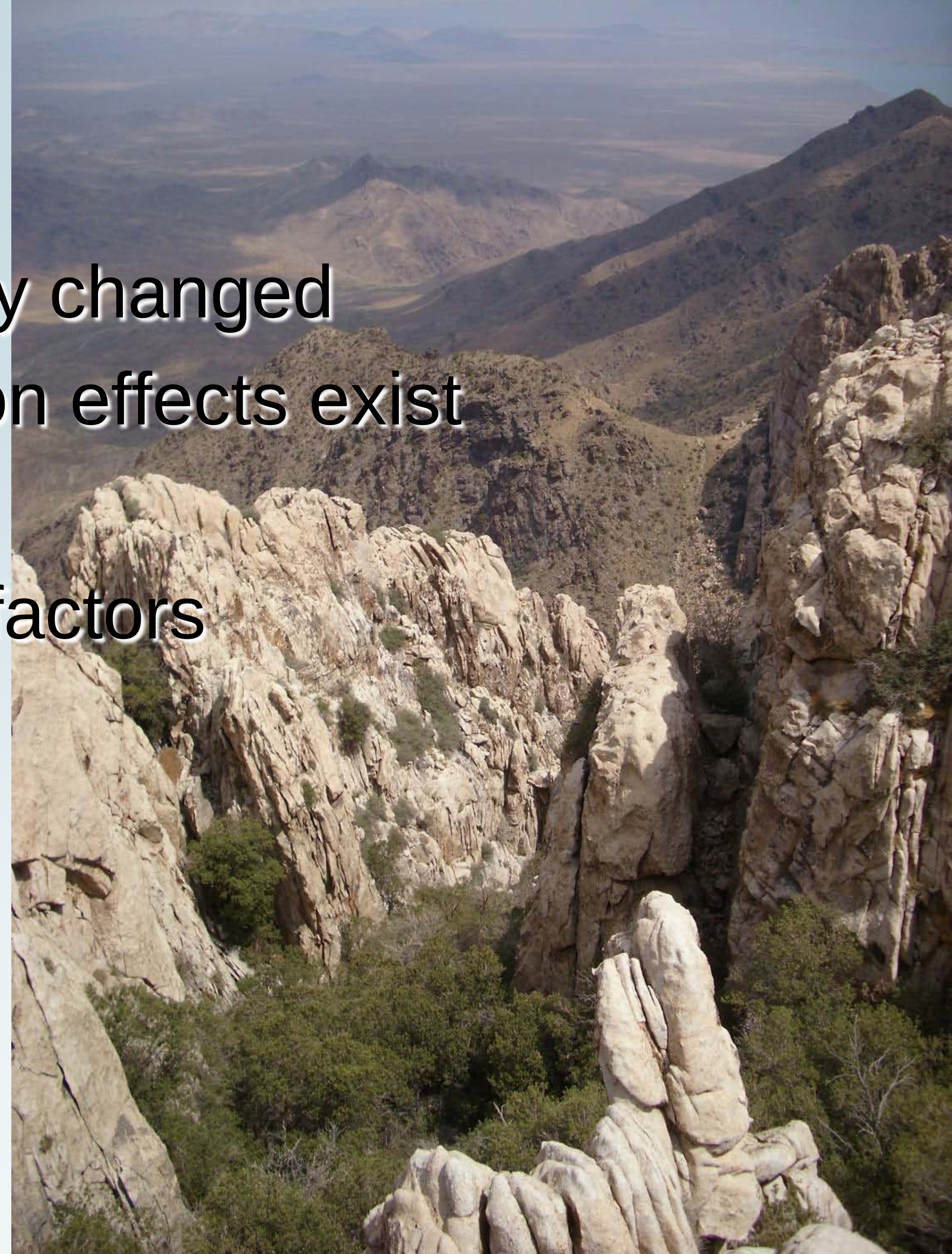
Climate Change

- Warming along with decreased precipitation
  - Supports previous studies (Hereford et al. 2006; U.S. Bureau of Reclamation 2011)
  - Supports Diaz and Bradley (1997) faster higher elevation warming

	Tmin in C (F)	Tmax in C (F)	Precip in cm (in.)
Maximum	3 (5)	2 (3)	0.6 (0.2)
Minimum	-0.5 (-0.9)	-0.6 (-1.1)	-6 (-3)
Mean	1.5 (2.7)	0.6 (1.1)	-3.0 (-1.2)
Standard deviation	0.59 (1.06)	0.46 (0.83)	1.68 (0.66)

Summary

- Climate has already changed
- Some projections on effects exist
- Science in infancy
- Interact with other factors



Lake Pape, Latvia
On 5,700 hectares near Lake Pape, Heck cattle, Konik horses and bison (pictured) roam in a project inspired by the Oostvaardersplassen in the Netherlands. Ecology consultant Joep van de Vlasakker says that the area initially had more promise for growth. But Latvia's entry into the European Union brought subsidies for small farmers, many of whom have now set up shop around the reserve. Van de Vlasakker says the soil is poor and the farmers are unsuccessful. "They mow and plough, but they don't harvest," he says. Meanwhile tourism could benefit from the ecological oddity: "The project could be very influential for local economy."

Reflecting the past

Unsatisfied with merely halting environmental destruction, some conservationists are trying to reconstruct ecosystems of the past. **Emma Marris** travels back in time with the rewilders.

LOST LANDSCAPES

Efforts to rewild from around the world.

Cherskiy, Russia
Near Cherskiy, the 16,000-hectare 'Pleistocene Park' project attempts to recreate the Siberian ecosystem of the later years of a pre-human-domination epoch. In the absence of mammoths and woolly rhinoceroses, Sergey Zimov, director of the Northeast Science Station in Cherskiy, plans to compensate by boosting the density of surviving herbivores, including reindeer, moose and stocky, heavy-maned Yakutian horses (pictured). He plans to reintroduce musk ox, bring in Canadian bison and, eventually, install tigers from the far east of Siberia.

S. ZIMOV

Mahazat as-Sayd, Saudi Arabia
In central Saudi Arabia, the Mahazat as-Sayd is fenced off from grazing livestock. Inside its more than 200,000 hectares, reintroduced houbara bustards, reem gazelle and Arabian oryx (pictured) — a spiral-horned ungulate that went extinct in the wild in the 1970s — mingle with the African red-necked ostrich, a proxy for the extinct Arabian subspecies that once strutted here[3]. Native vegetation and birds largely complete the picture of the Arabian Peninsula as it might have looked 2,000 years ago. But wolf and cheetah predators are absent.

Fenced off from the modern Dutch countryside is a scene that looks more like a diorama in a natural-history museum than a typical central-European park: a plain is dotted with wild herds of large mammals. Empty of humans and haunted by eagles, it is a vision of a distant past on some of the newest land on Earth — the reserve was only reclaimed from the sea in 1968. It's called the Oostvaardersplassen, and the visionary behind it is Frans Vera, a tall, greying government scientist from Staatsbosbeheer, the organization responsible for overseeing Dutch nature reserves.

Vera designed the 6,000-hectare reserve to replicate Europe's prehistoric past. That has meant 'rewilding' the area, populating it with the kinds of creature that lived there many

dot the periphery. It has, however, succeeded as a conservation area; several bird species rare to Western Europe, such as the white-tailed eagle, have moved in. Vera says that it is also a large science experiment, designed to test his theories about how European landscapes used to look. But he has struggled to keep the reserve open and lacks the funding for graduate students. The project generates very little systematic data or scientific papers, adding to its mystique.

Pleistocene parks

Vera's isn't the only rewilding project. Schemes in locales as diverse as New Zealand, Saudi Arabia and the Russian Far East aim to do more than hold the line against further environmental destruction (see 'Lost landscapes'). They are

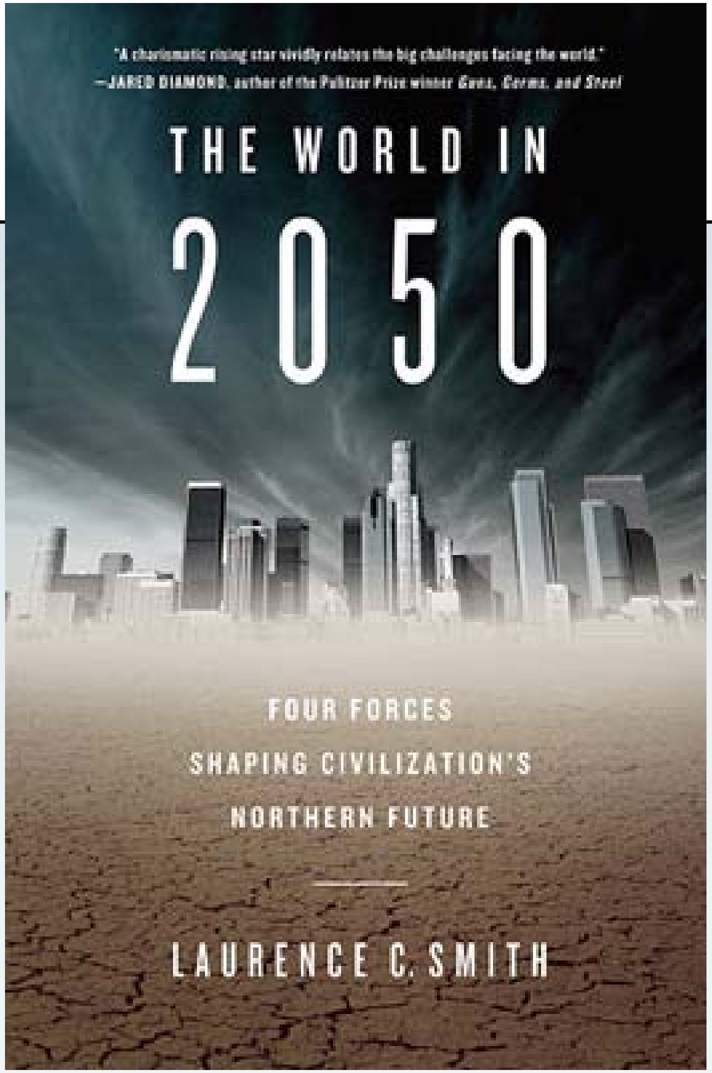
Ecosystem Management

- Place-based land use problems
- Changes exceed speed of ecological and human adaption capabilities
- Assisted migration
- Assisted pollination
- Promote health *in situ*
- Promote adaptive communities

Acknowledgements:

Nevada FACE program; National Science Foundation EPSCoR; funding support from Lake Mead National Recreation Area (NPS), BLM Vegas, Parashant National Monument, Saguaro National Park; Robert Abella for some of the photos; Ross Guida slides

Thanks to Sharon Altman (UNLV) for help preparing the presentation.



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