Perturbations in Fire-Prone Ecosystems Resulting in Exotic Plant Invasions

Jon E. Keeley

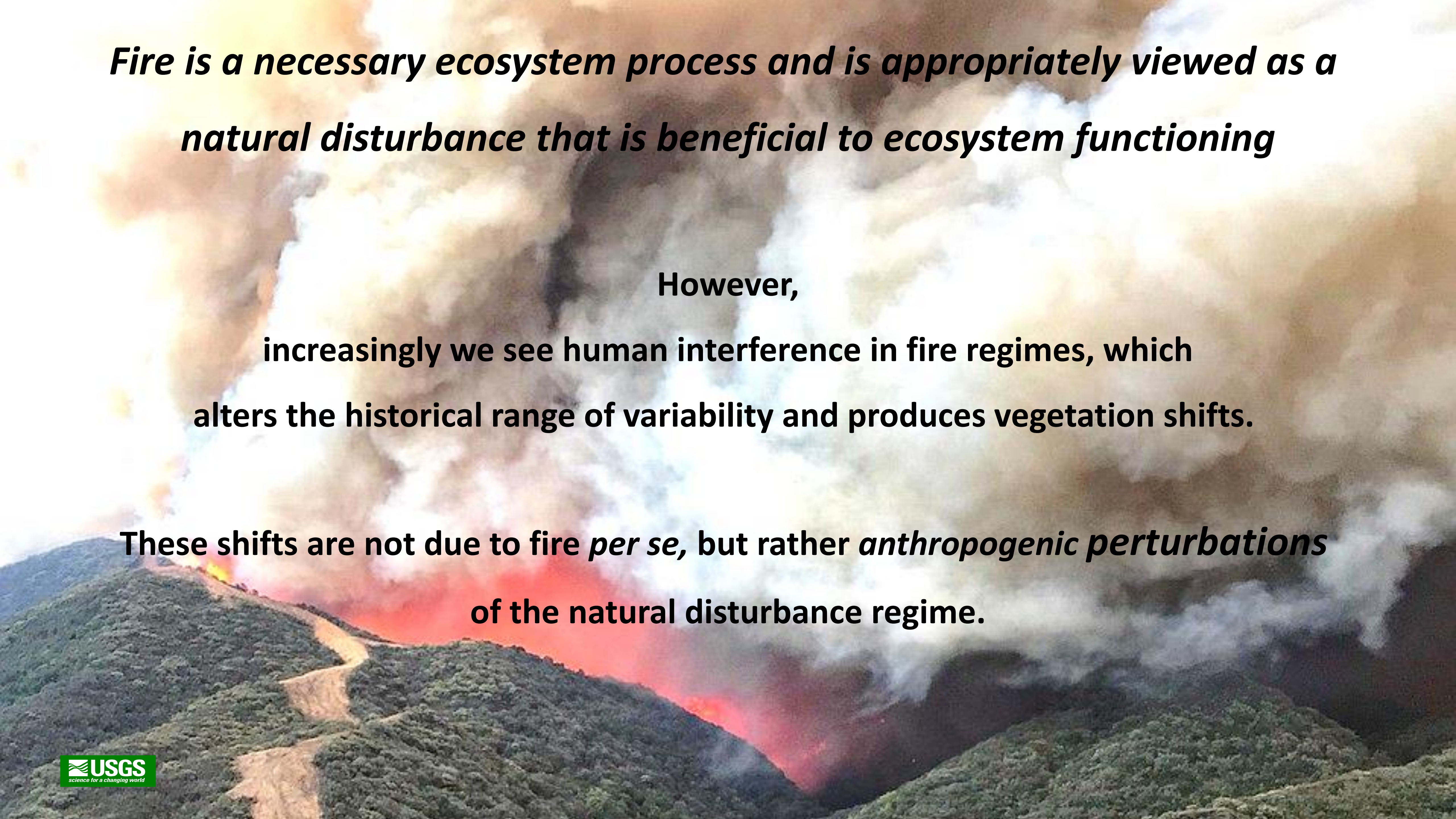
U.S. Geological Survey

UCLA

California Botanic Garden

Cal IPC 28 October 2020

Photo: Jon Keeley

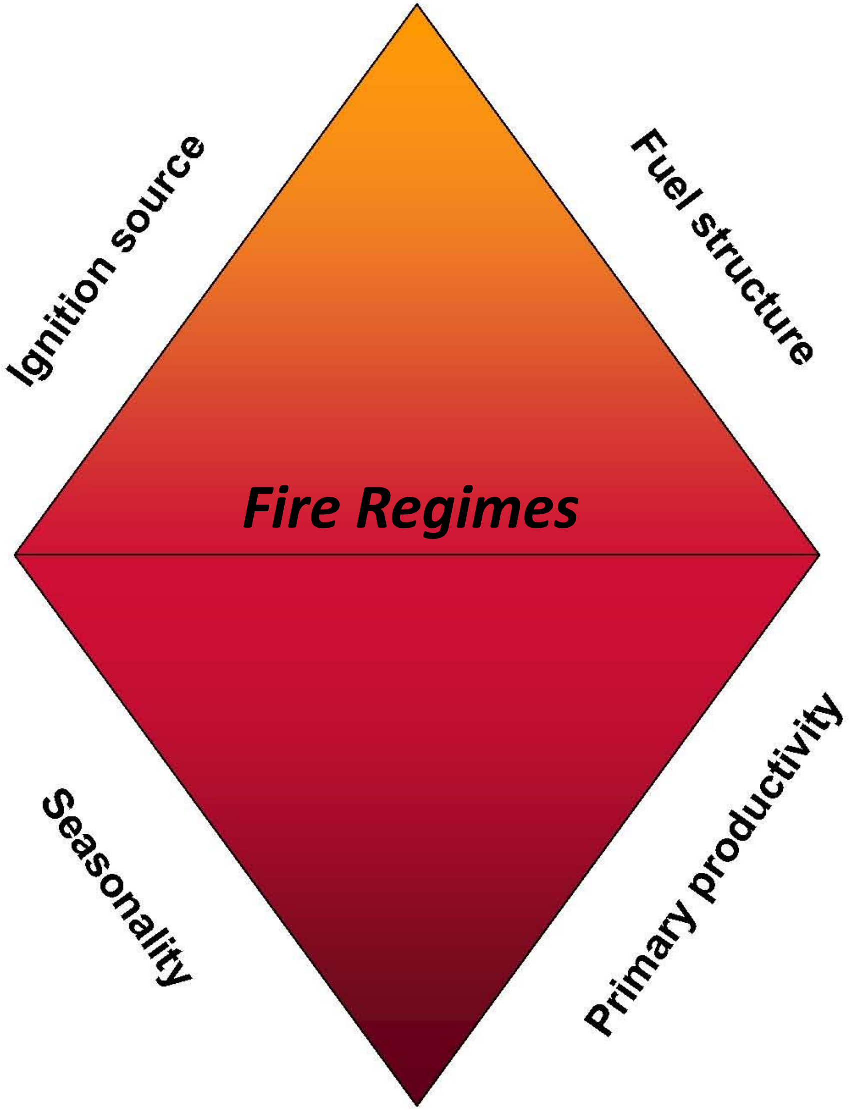


Fire is a necessary ecosystem process and is appropriately viewed as a natural disturbance that is beneficial to ecosystem functioning

However,

increasingly we see human interference in fire regimes, which alters the historical range of variability and produces vegetation shifts.

These shifts are not due to fire *per se,* but rather *anthropogenic* perturbations of the natural disturbance regime.



Fire Regime Parameters

- **Frequency**
- **Severity**
- **Fuels consumed**
- **Landscape pattern**

Keeley et al. 2012. Fire in Mediterranean Ecosystems, Cambridge Press

Fire frequency Historical/'natural' frequencies tied to productivity

e.g. **moderately productive** mixed conifer forests in the West produce sufficient surface fuels to carry fire at ***decadal*** scales and have sufficient lightning ignitions for **high** fire frequency resulting in a **fuel gap** between surface and canopy

→ leading to low intensity **surface fires**

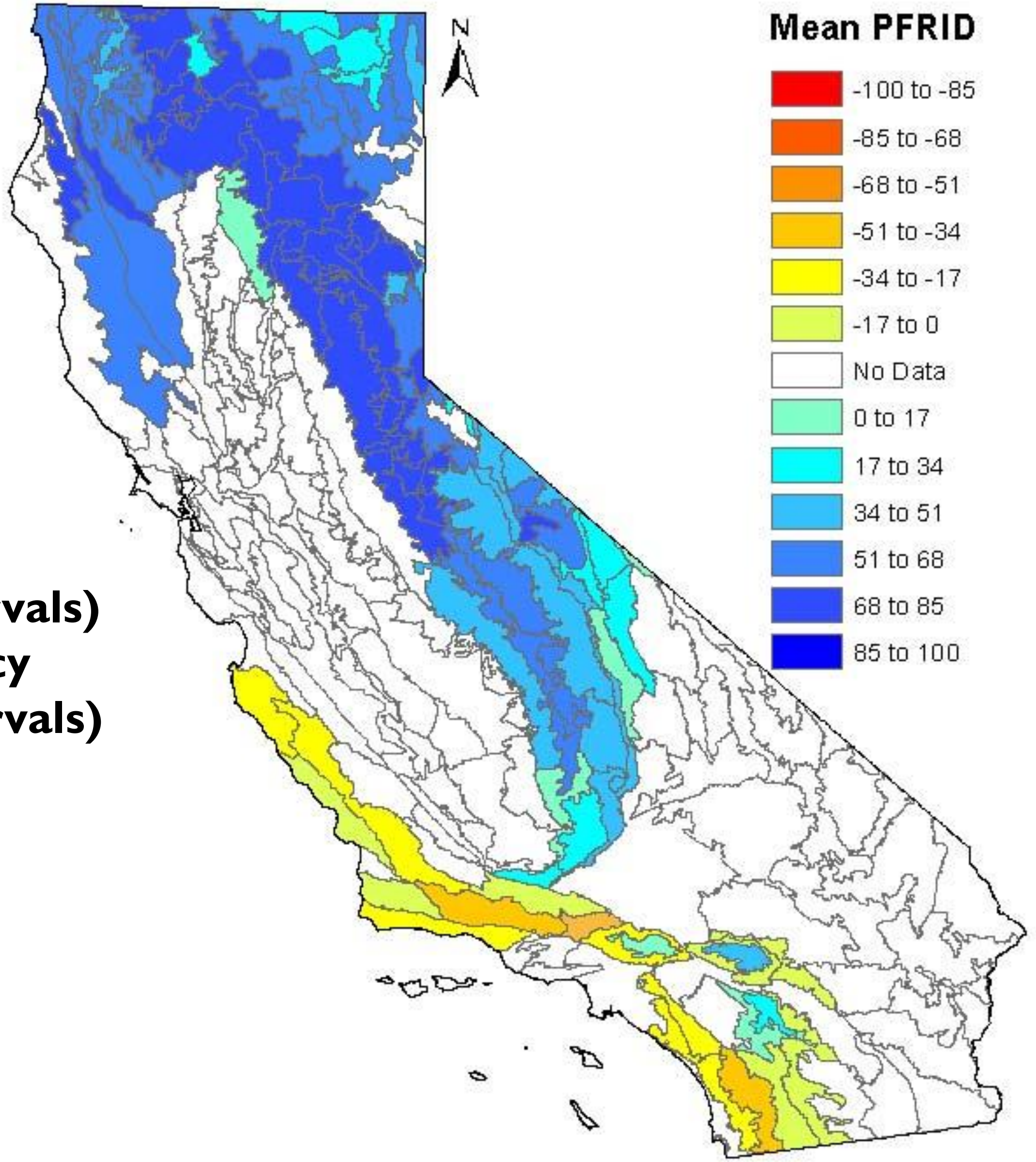
In contrast, lodgepole and jackpine forests at higher latitudes have a shorter growing season, thus **lower productivity** and slower accumulation of fuels leading to longer-interval fire frequencies (***century*** scale), plus tree growth rates are insufficient to outgrow surface fuels

→ contributing to high intensity **crown fires**

USGS science for a changing world

Perturbations

Extent to which 20th & 21st century fires have burned at frequencies similar to pre-Euroamerican settlement



Perturbations

Southern CA (hi frequency shorter intervals)

Northern CA (low frequency longer intervals)

(Safford & van Water 2014)

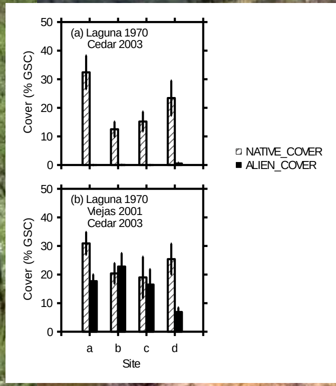
Fire frequency Historical/'natural' frequencies tied to productivity

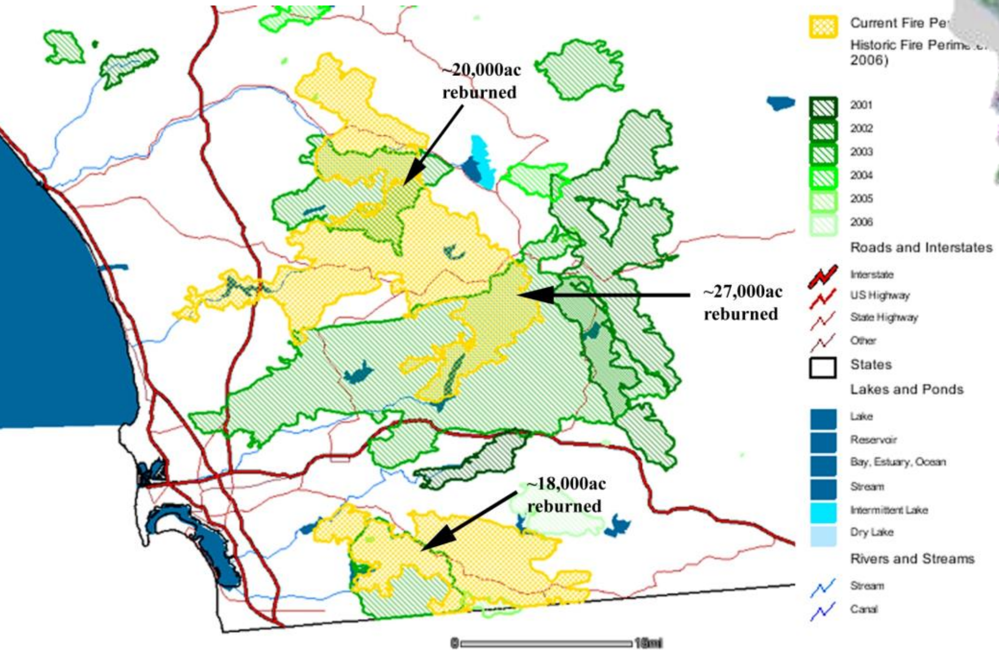
e.g. **moderately productive** mixed conifer forests in the West produce sufficient surface fuels to carry fire at ***decadal*** scales and have sufficient lightning ignitions for **high** fire frequency resulting in a **fuel gap** between surface and canopy
→ leading to low intensity **surface fires**

In contrast, lodgepole and jackpine forests at higher latitudes have a shorter growing season, thus **lower productivity** and growth rates, thus, fuels accumulate more slowly contributing to longer-interval fire frequencies (***century*** scale)
→ leading to high intensity **crown fires**

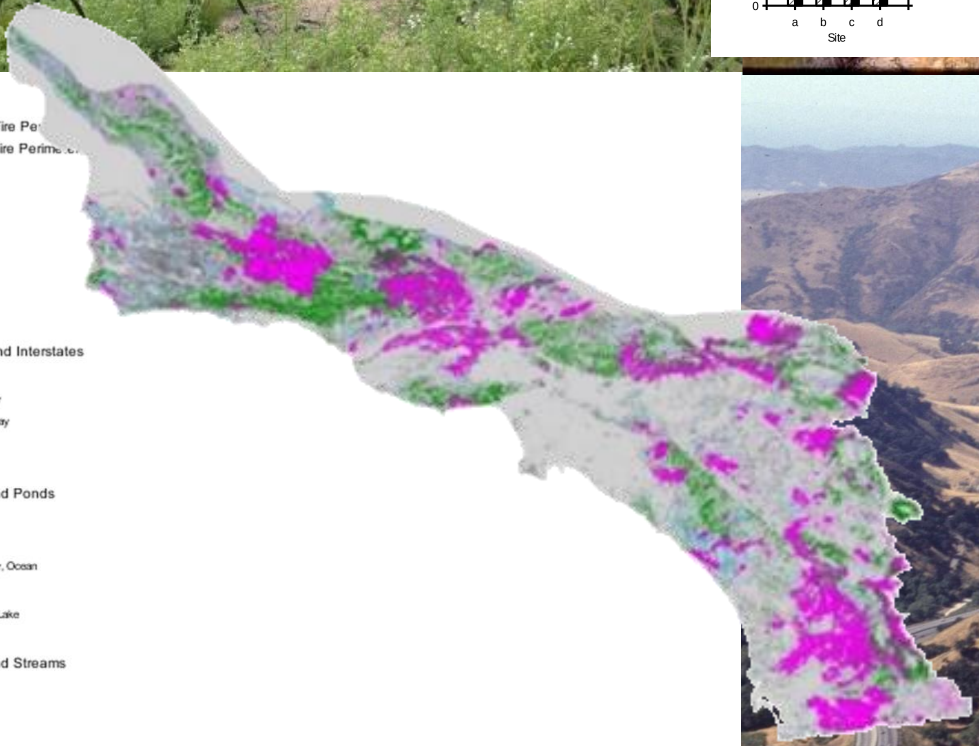
California chaparral
hi severity
crown fires
30 – 130 yr intervals

Recovery from soil stored
seeds and resprouts





Keeley et al. (2007)



Syphard, Brennan & Keeley (2012)

THE BROAD SCLEROPHYLL VEGETATION OF CALIFORNIA

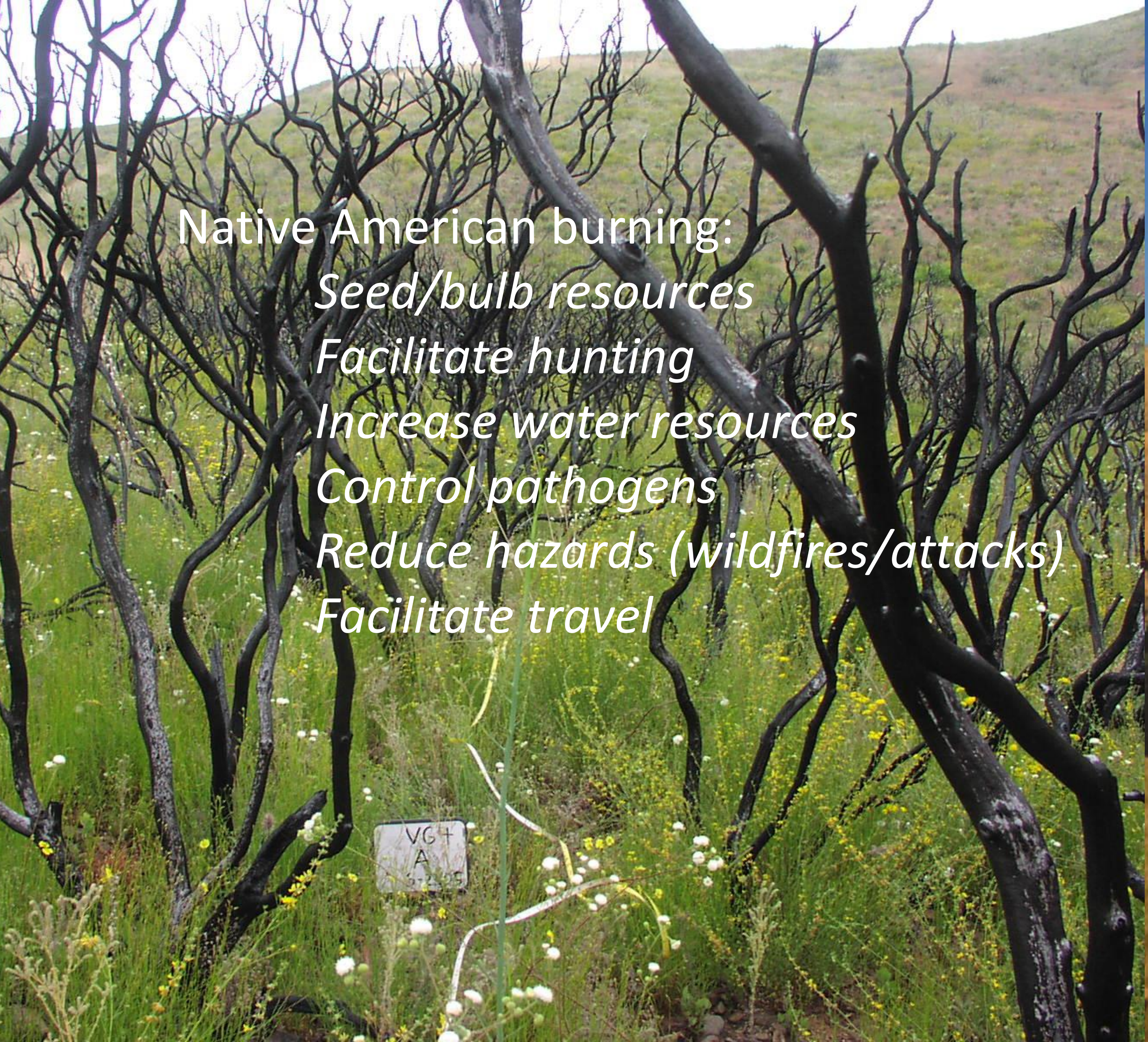
AN ECOLOGICAL STUDY OF THE CHAPARRAL AND ITS RELATED COMMUNITIES

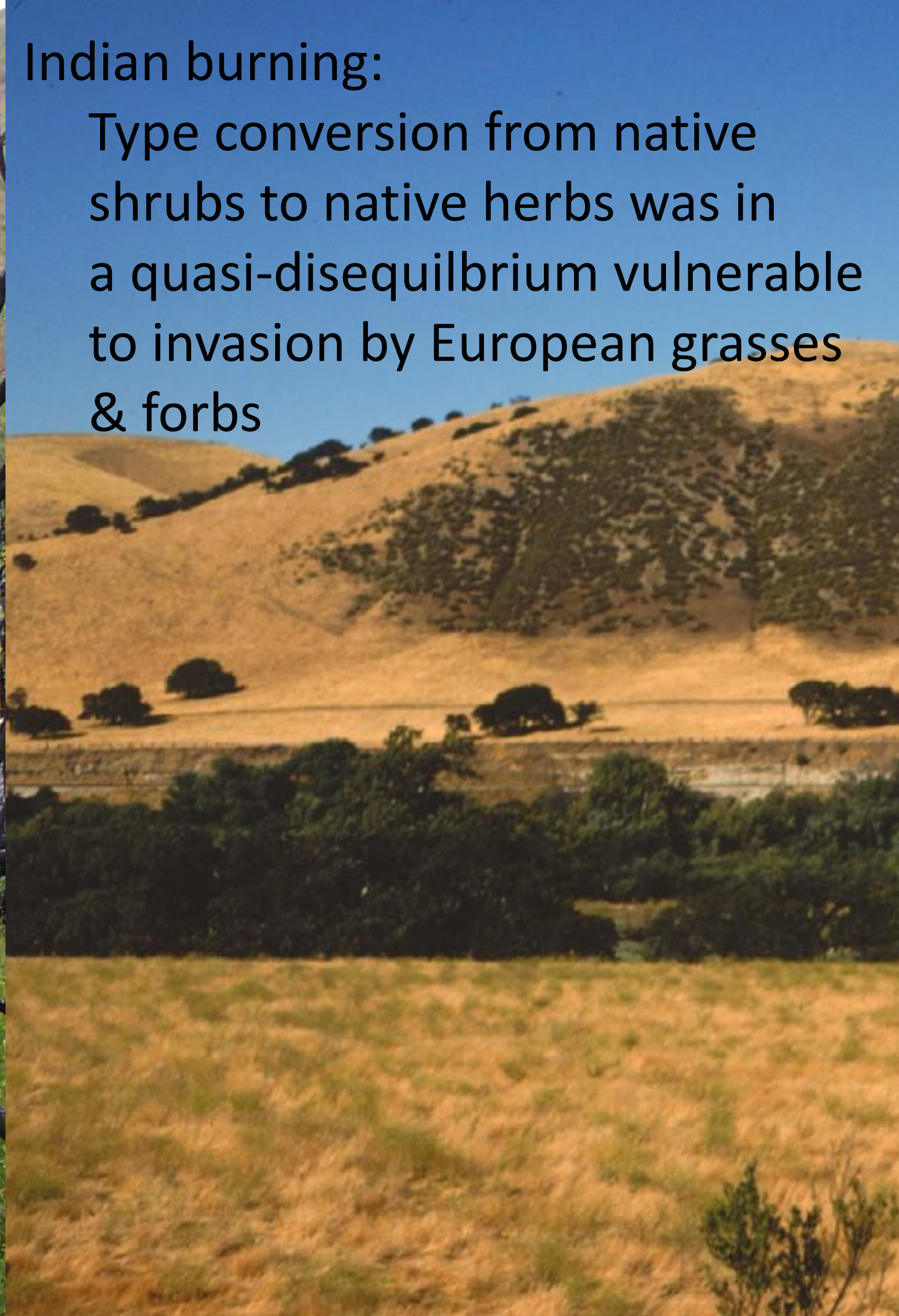
BY

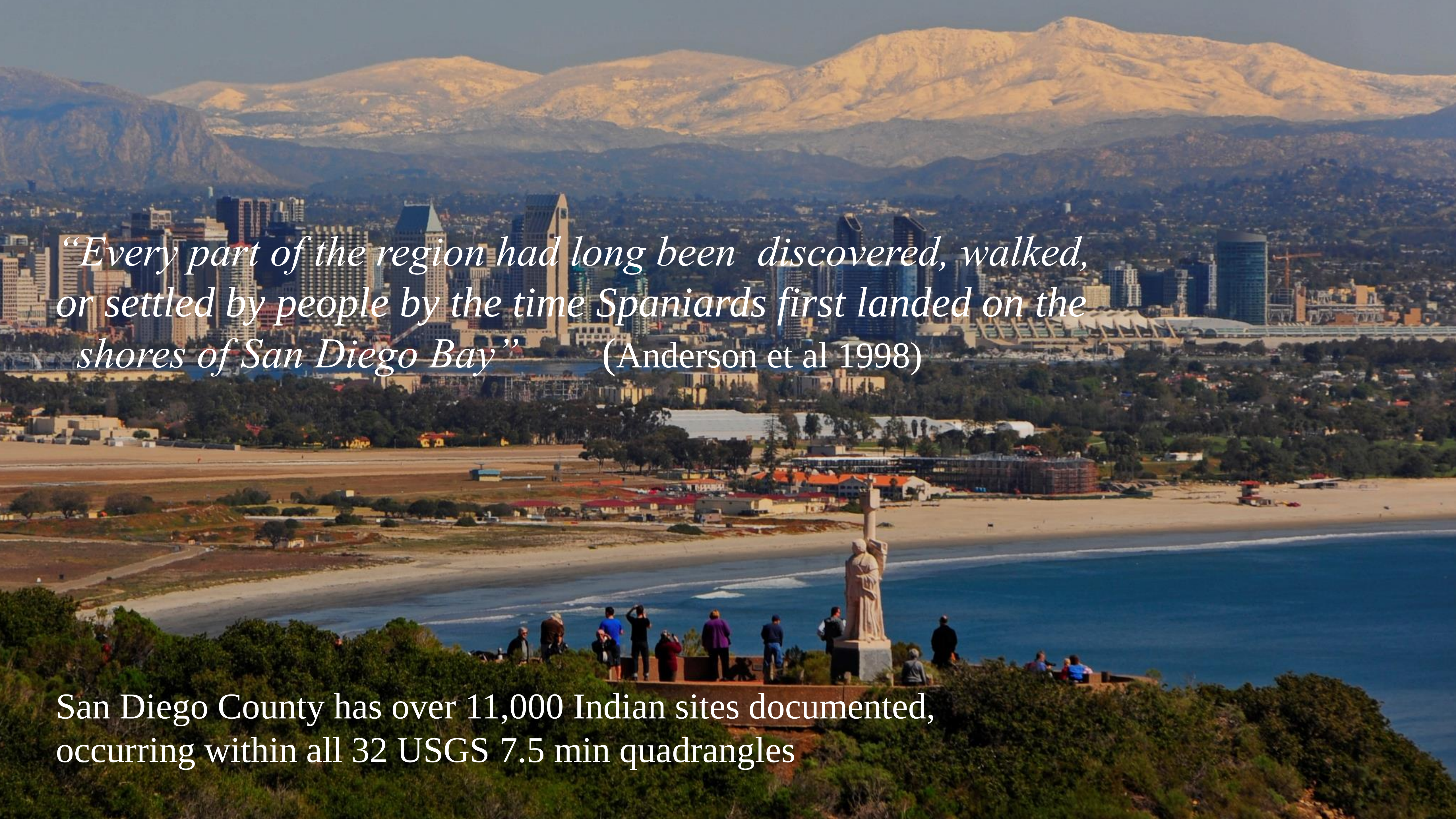
WILLIAM S. COOPER

fire. The patchy transition between grassland and chaparral is also explained, for fires started in the valleys, where most of the Indian population lived, would spread into the surrounding ranges, in various directions and to varying distances. Certain areas would escape, and these would be larger and more numerous toward the interiors of the mountain systems, where paucity of population would reduce the starting of fires to a minimum. The reasons for the burning I have not been able to discover.

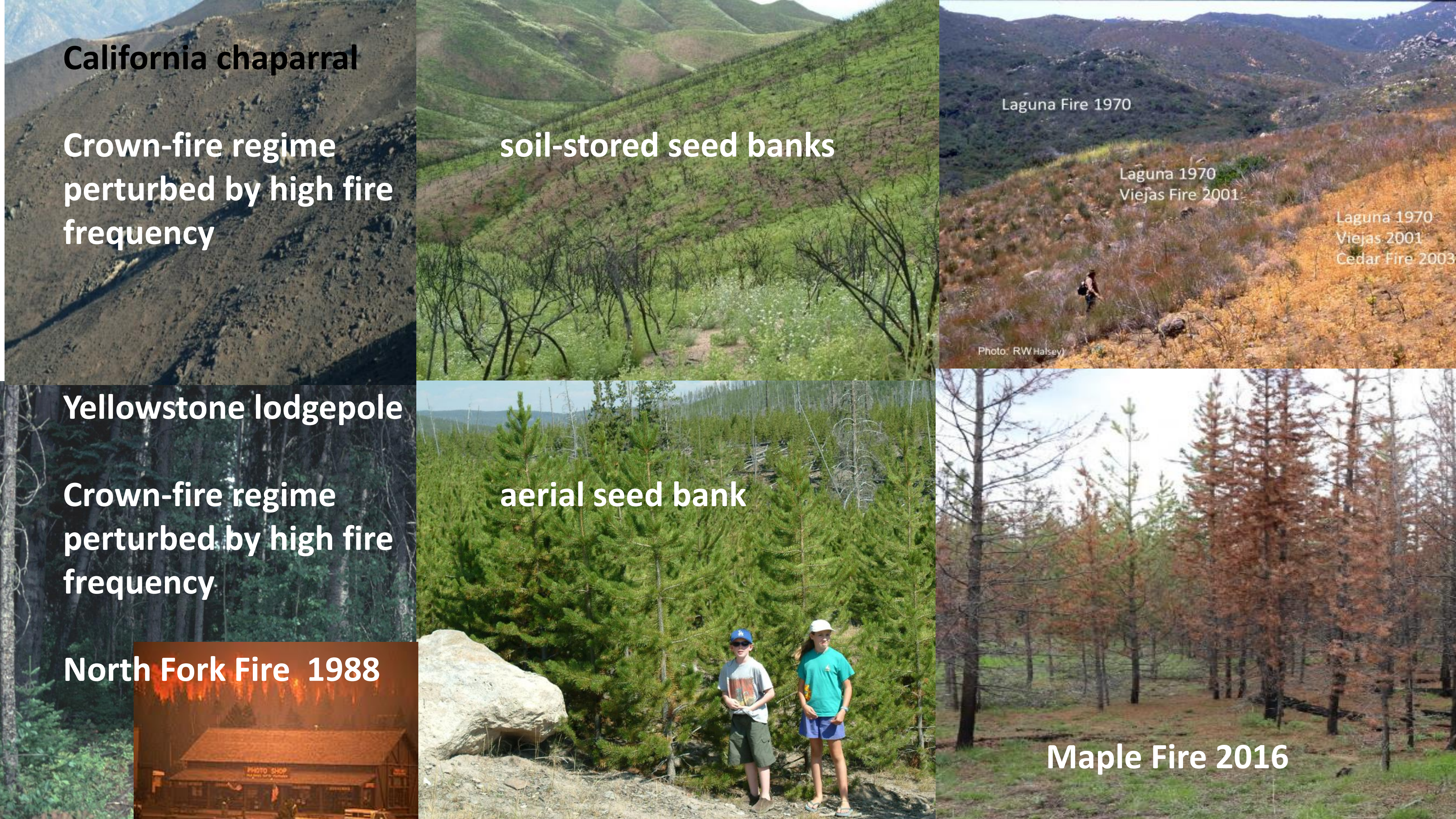
PUBLISHED BY THE CARNEGIE INSTITUTION OF WASHINGTON
WASHINGTON, OCTOBER, 1922


Native American burning:
Seed/bulb resources
Facilitate hunting
Increase water resources
Control pathogens
Reduce hazards (wildfires/attacks)
Facilitate travel


Indian burning:
Type conversion from native shrubs to native herbs was in a quasi-disequilbrium vulnerable to invasion by European grasses & forbs


"Every part of the region had long been discovered, walked, or settled by people by the time Spaniards first landed on the shores of San Diego Bay" (Anderson et al 1998)
San Diego County has over 11,000 Indian sites documented, occurring within all 32 USGS 7.5 min quadrangles

USGS science for a changing world


California chaparral
Crown-fire regime perturbed by high fire frequency
soil-stored seed banks
Laguna Fire 1970
Laguna 1970
Viejas Fire 2001
Laguna 1970
Viejas 2001
Cedar Fire 2003
Photo: RW Halsey
Yellowstone lodgepole
Crown-fire regime perturbed by high fire frequency
North Fork Fire 1988
aerial seed bank
Maple Fire 2016

Fire severity Higher fire intensity leads to more severe impacts that can convert vegetation types

Alaskan spruce forests are fire-adapted

Human perturbation in form of global warming has changed fire intensity/severity

altering substrates

changing forest types

Increasing severity due to fire suppression reduction in fire frequency in conifer forests can change fuels consumed

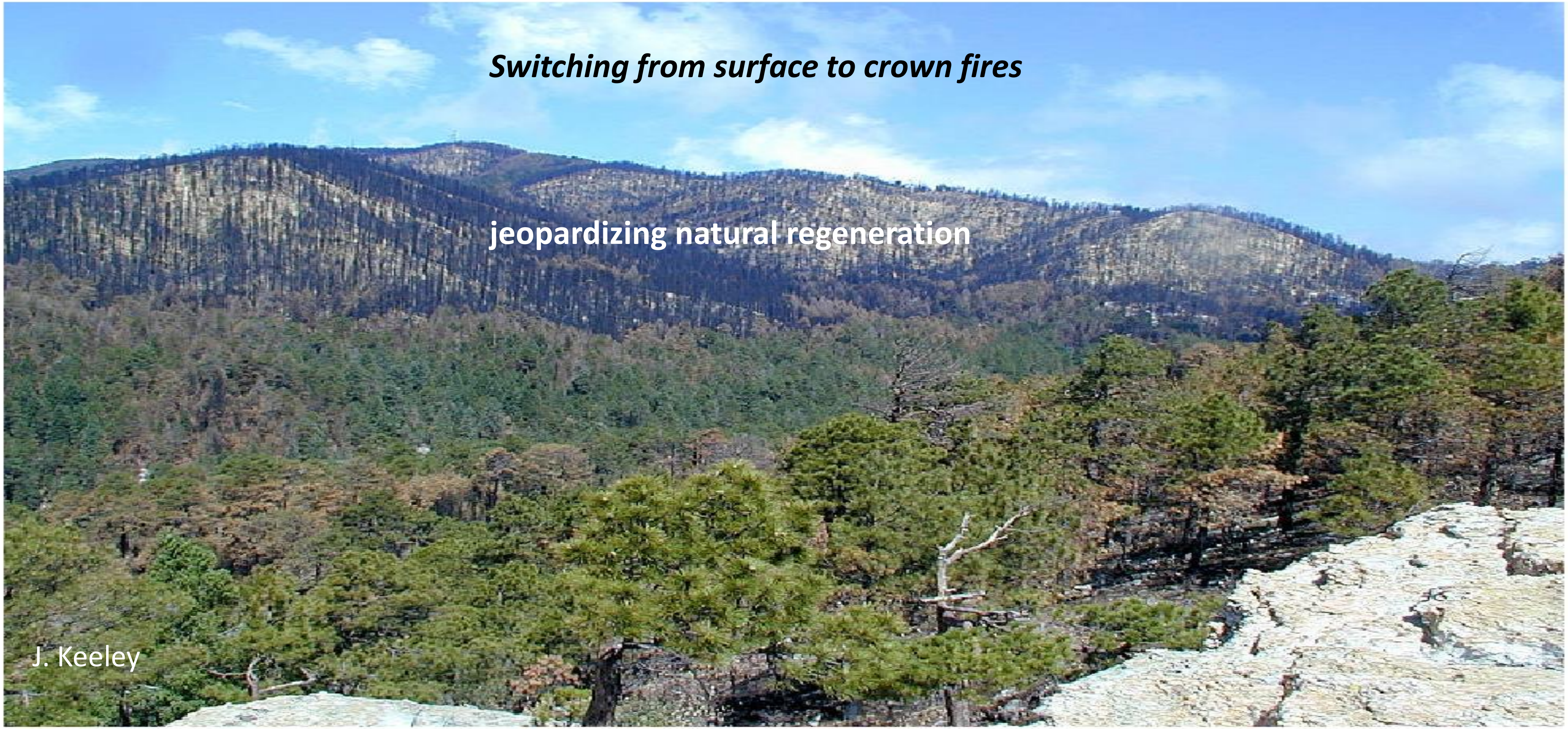
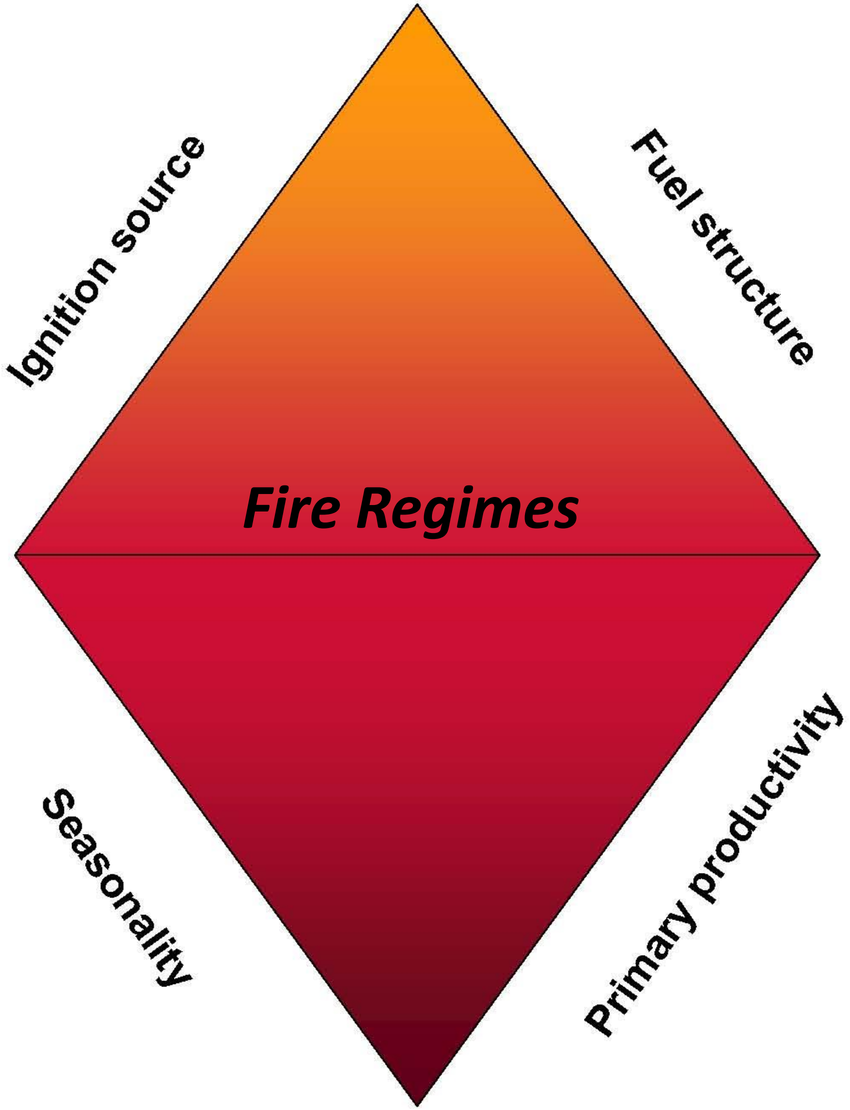



Photo: JE Keeley

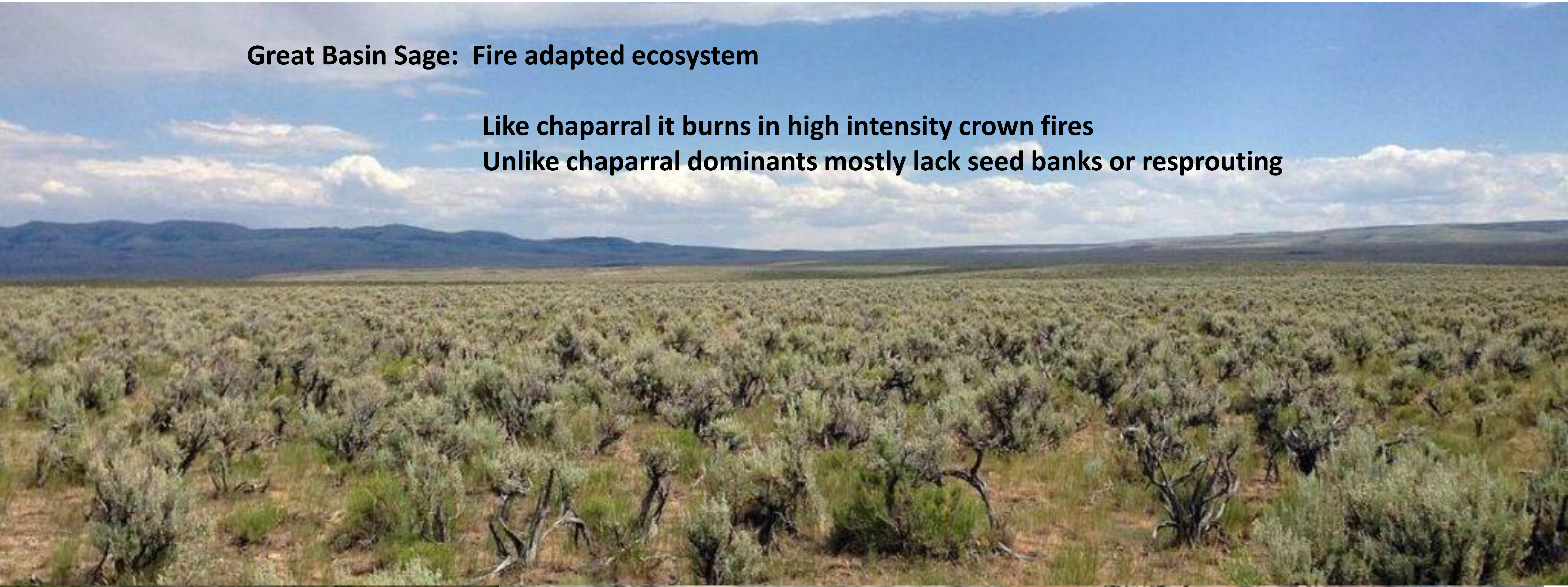


Fire Regime Parameters

Frequency
Severity
Fuels consumed
Landscape pattern

Keeley et al. 2012. Fire in Mediterranean Ecosystems, Cambridge Press

Landscape pattern of burning Patch dynamics can play a critical role



Great Basin Sage: Fire adapted ecosystem

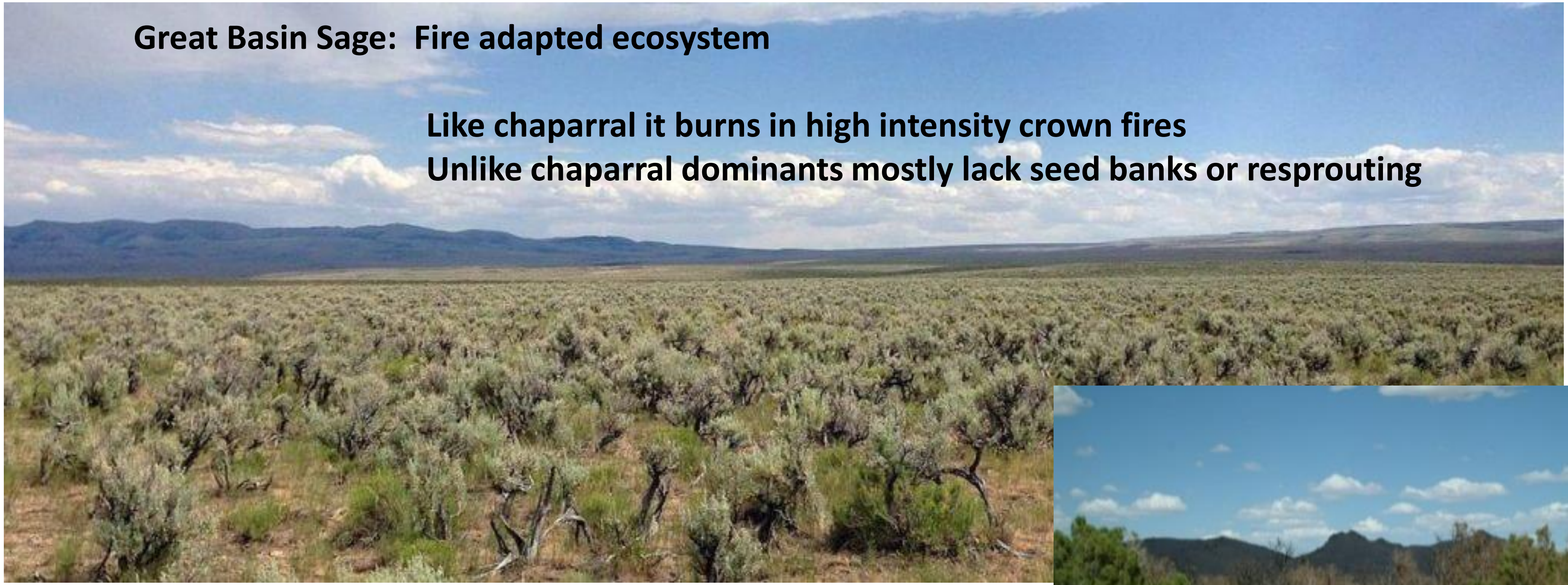
Like chaparral it burns in high intensity crown fires
Unlike chaparral dominants mostly lack seed banks or resprouting

changing fuel continuity

and thus patch size

Landscape pattern of burning

Patch dynamics can play a critical role



Great Basin Sage: Fire adapted ecosystem

Like chaparral it burns in high intensity crown fires
Unlike chaparral dominants mostly lack seed banks or resprouting

Discontinuities in fuels results in patchy burns
Remnant unburned patches are meta populations
that recolonize burned patches

Major perturbation of Great Basin Sage has been a combination of intensive livestock grazing and prescription burning

These perturbations have favored invasion of cheatgrass

Acknowledgments

USGS
science for a changing world

NATIONAL PARK SERVICE

Department of the Interior

Joint Fire Science Program

FOREST SERVICE

U S

DEPARTMENT OF AGRICULTURE

UCLA

CALIFORNIA DEPARTMENT OF FORESTRY & FIRE PROTECTION

CAL FIRE

SINCE 1885

SAN DIEGO STATE UNIVERSITY

Leadership Starts Here

ORANGE COUNTY FIRE AUTHORITY CALIFORNIA

MHDP
USGS Hazards Project

Photo: JE Keeley