Making fuels management compatible with restoration objectives in an age of global change

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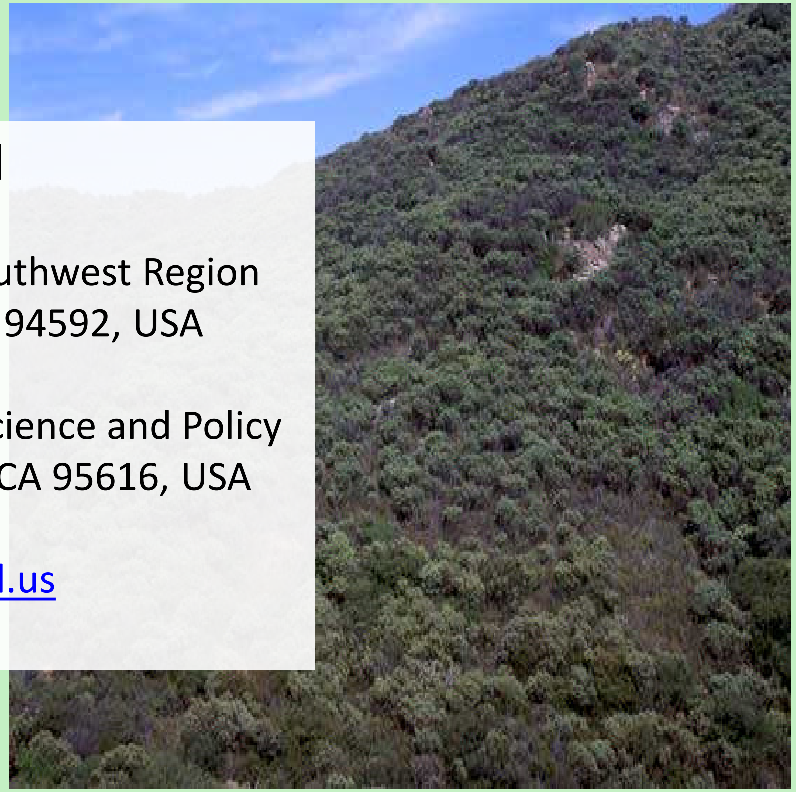


Outline

- Restoration and climate change: the importance of fire
- Fire regimes and ecosystem types
- Current fire restoration situation in California
- A tale of two fire regimes
  - Fire Regime I
    - *Pine and oak forests of frequent, low severity fire; Sierra Nevada*
  - Fire Regime IV
    - *Chaparral and serotinous conifers of infrequent, high severity fire; southern California*
- Conclusions

What is restoration?

Ecological restoration is the process of assisting the recovery of an ecosystem that has been degraded, damaged, or destroyed.

- Society for Ecological Restoration 2005

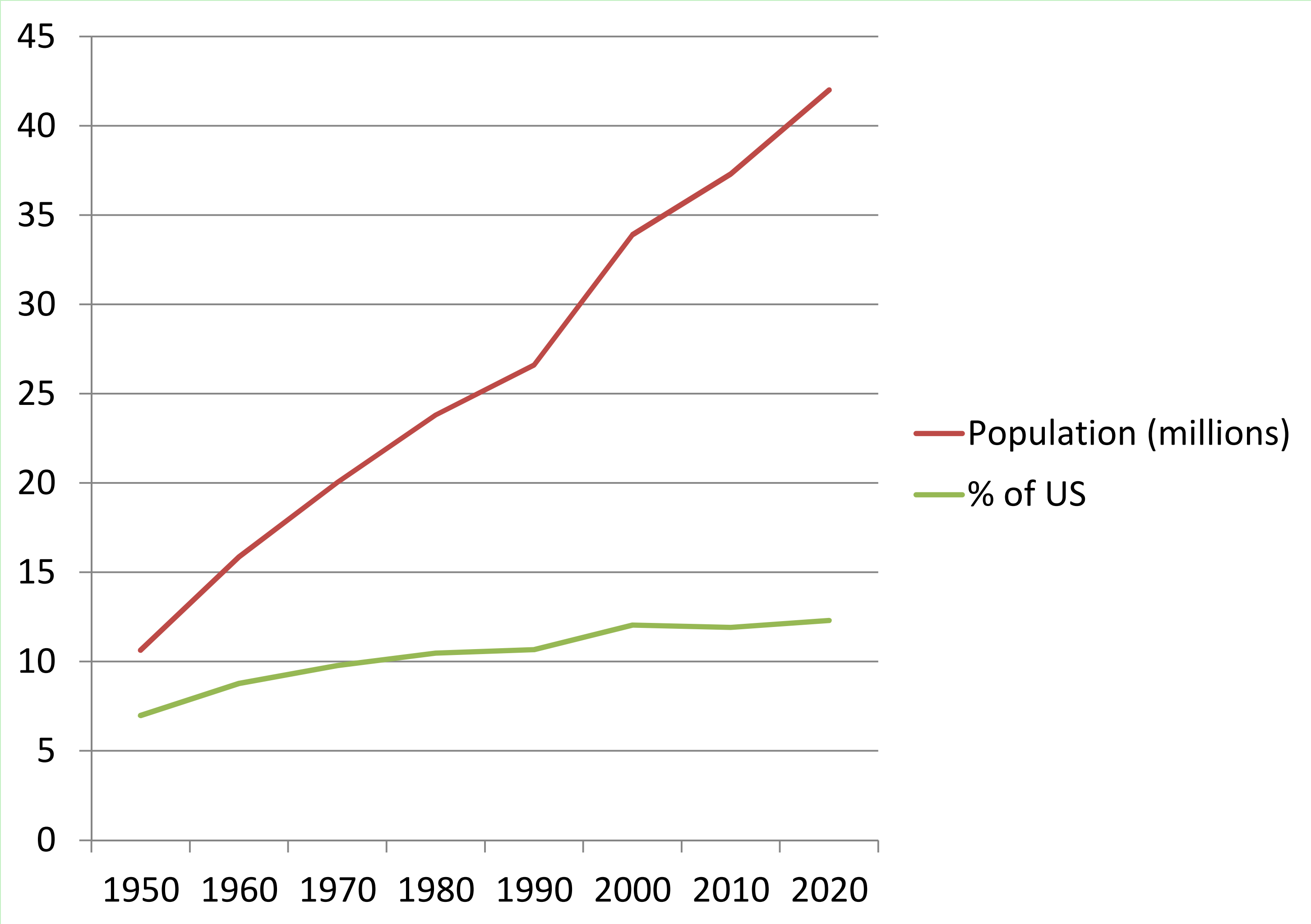
- Ecological restoration is an intentional activity that initiates or speeds the recovery of an ecosystem with respect to its health, integrity and sustainability
- Restoration requires a reference (or "desired") condition. Often, restoration attempts to return an ecosystem to its historic state or trajectory
- A restored ecosystem is self-sustaining, and resilient to ecological processes of disturbance. Key ecological processes have been restored

In many California ecosystems, the keystone ecological process is fire

<u>Key issues</u>:

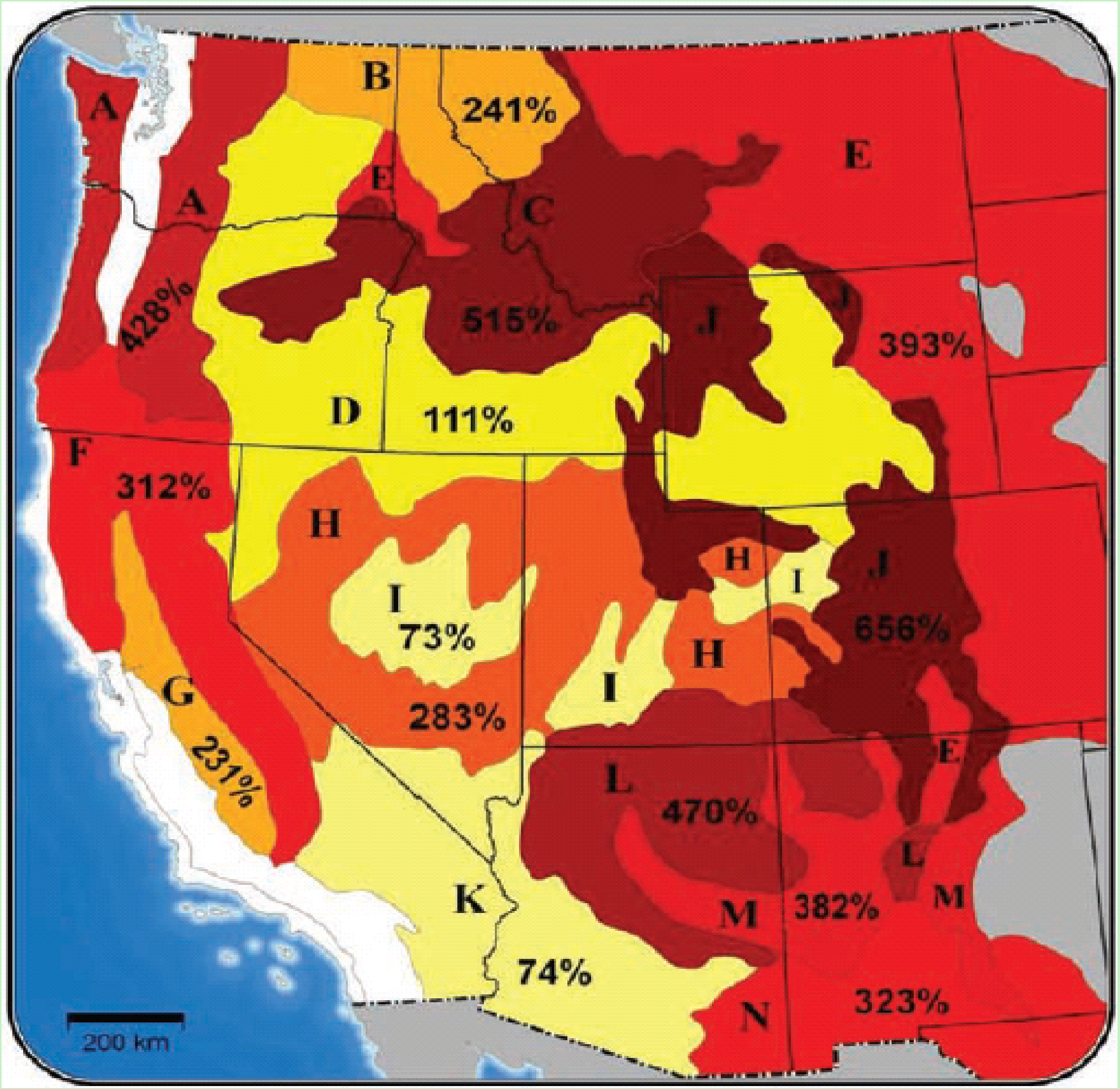
1. Fire has been heavily suppressed in most forests in California for nearly a century, leading to accumulation of forest fuels
2. Human ignitions in areas of high population density have had the reverse effect, and fire frequencies in many areas dominated by chaparral and related shrubland types are excessively high
3. Human population is growing rapidly
4. Warming climates are extending the fire season, augmenting water stress, and increasing the inertia for fire

California population growth, 1950-2020 (projected)



One in every eight Americans lives in California

Modeled increase in median annual area burned under 1°C increase in temperature



National Research Council 2011

By 2100 temperatures in California are expected to rise by 2-5°

Fire regimes: a framework for understanding tradeoffs between fuel reduction and ecological impact

Most common vegetation types on California National Forests

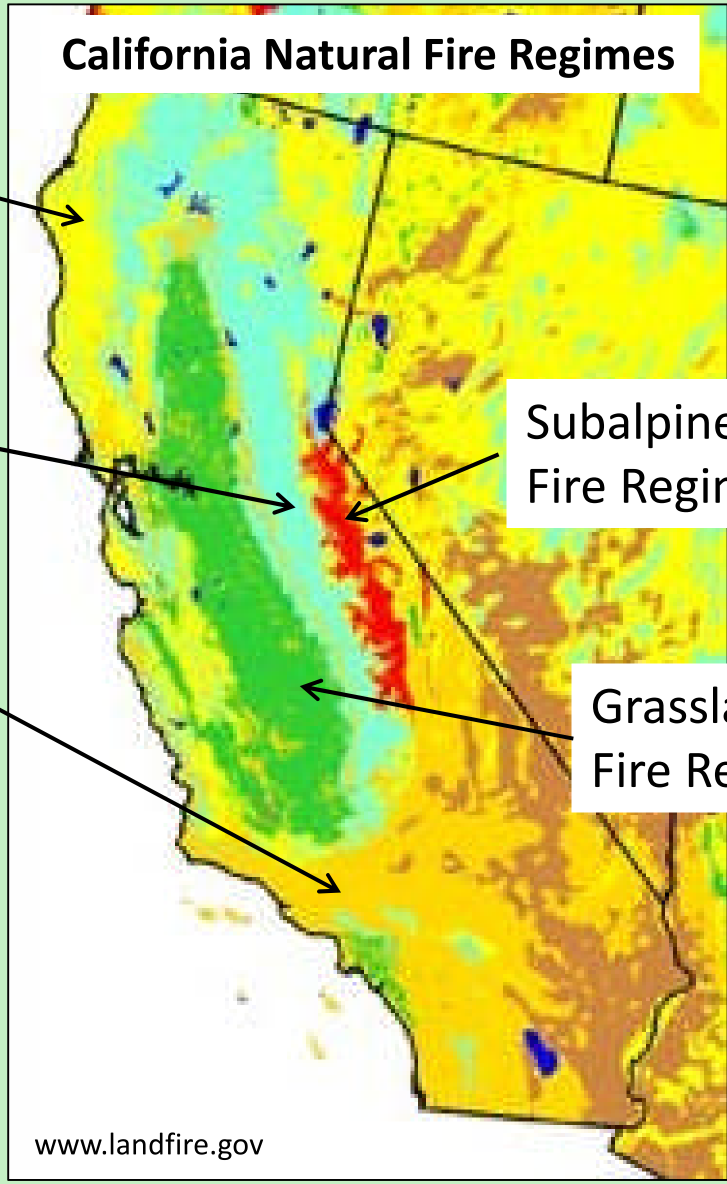
Moist forests:
Fire Regime III

Yellow pine and dry mixed conifer forests, oak woodlands:
Fire Regime I

Chaparral & serotinous conifers:
Fire Regime IV

Subalpine forests:
Fire Regime V

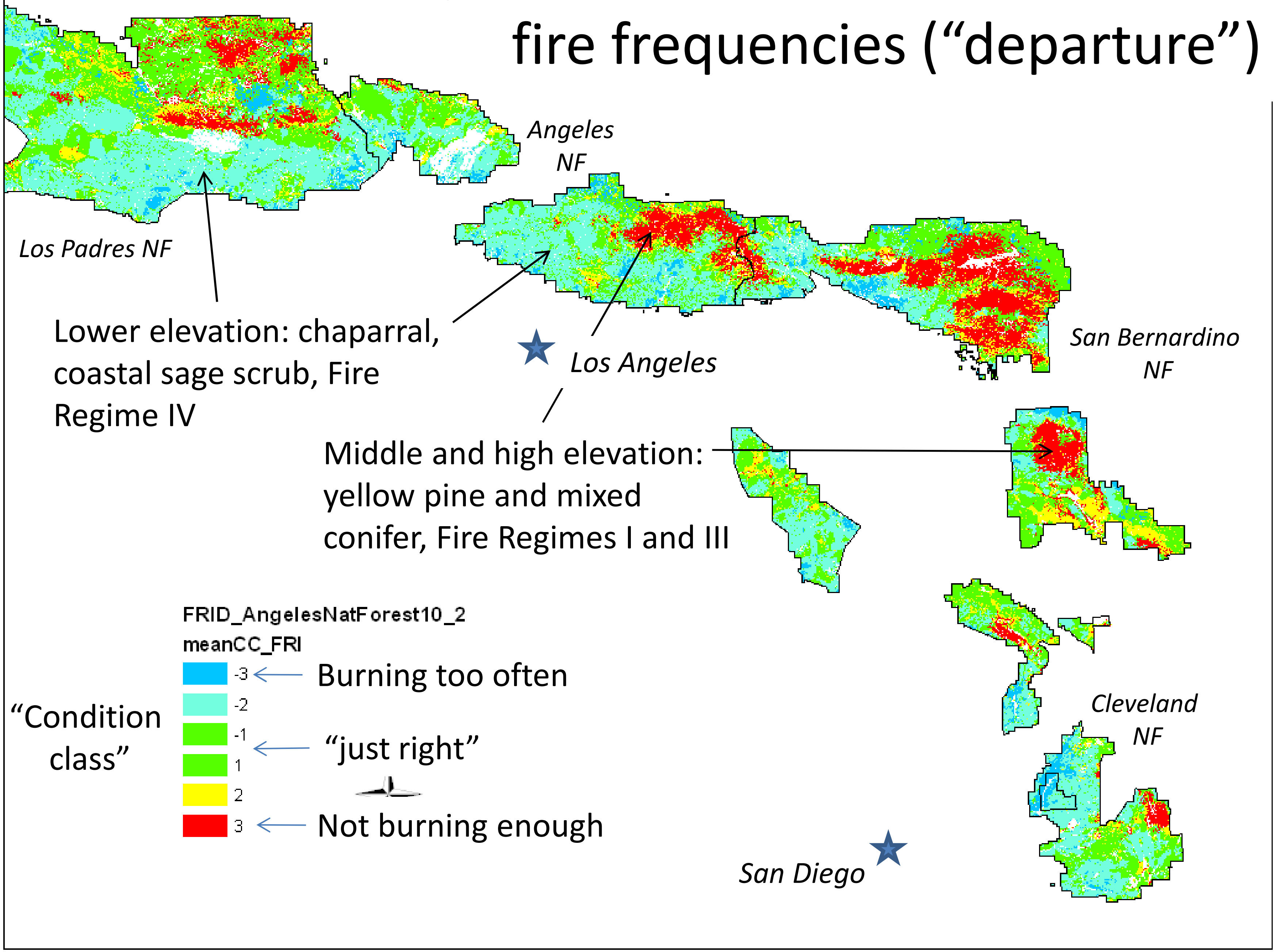
Grasslands:
Fire Regime II

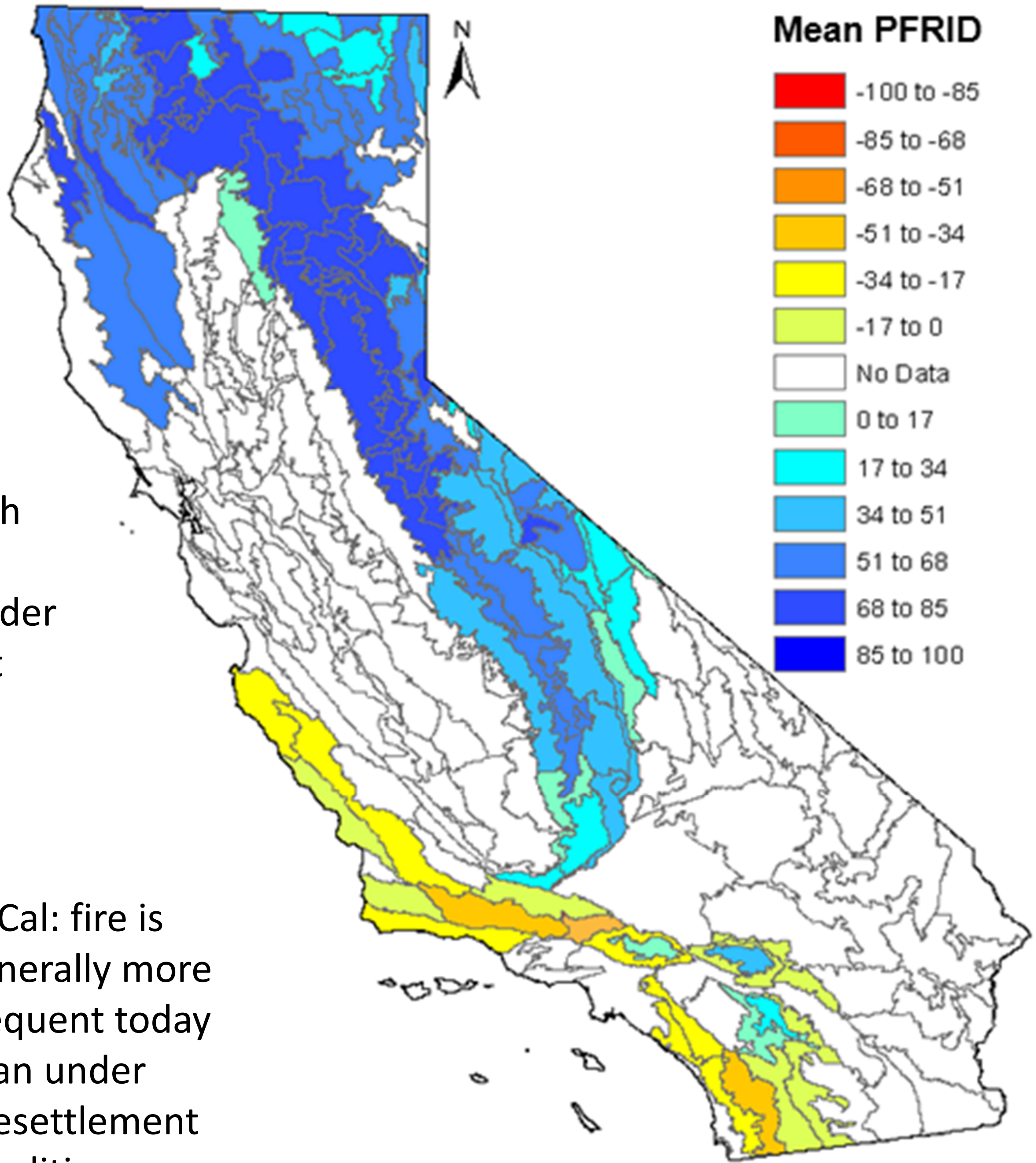


LEGEND

- I: 0 – 35 yr. frequency, Low Severity
- II: 0 – 35 yr. frequency, Stand Replacement Severity
- III: 35 – 100+ yr. frequency, Mixed Severity
- IV: 35 – 100+ yr. frequency, Stand Replacement Severity
- V: 200+ yr. frequency, Stand Replacement Severity
- Barren
- Water

S. California: Comparison of current and reference fire frequencies (“departure”)





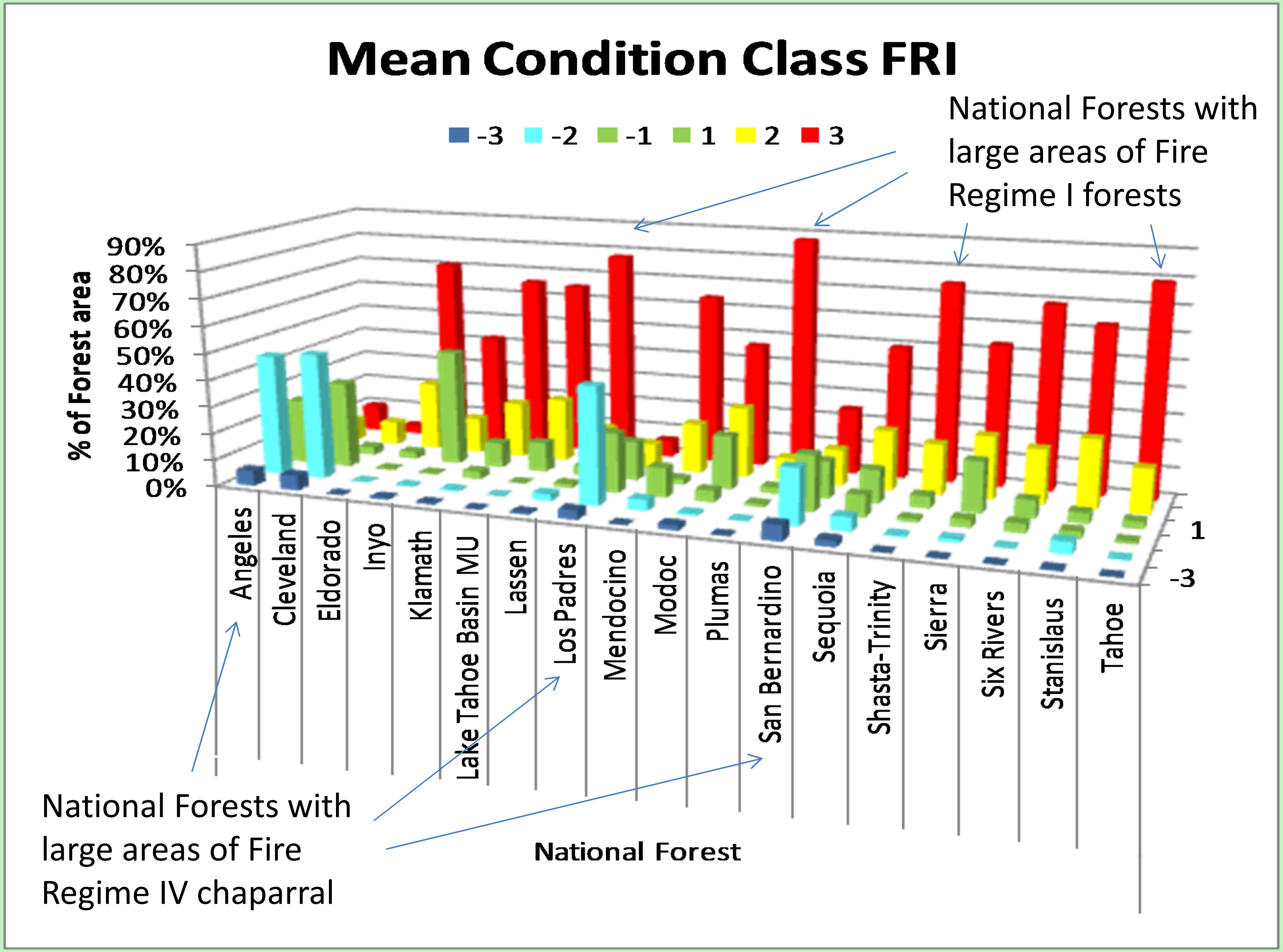
NorCal: fire is generally much less frequent today than under presettlement conditions

SoCal: fire is generally more frequent today than under presettlement conditions

Exceptions are the conifer forests on SoCal mtn tops

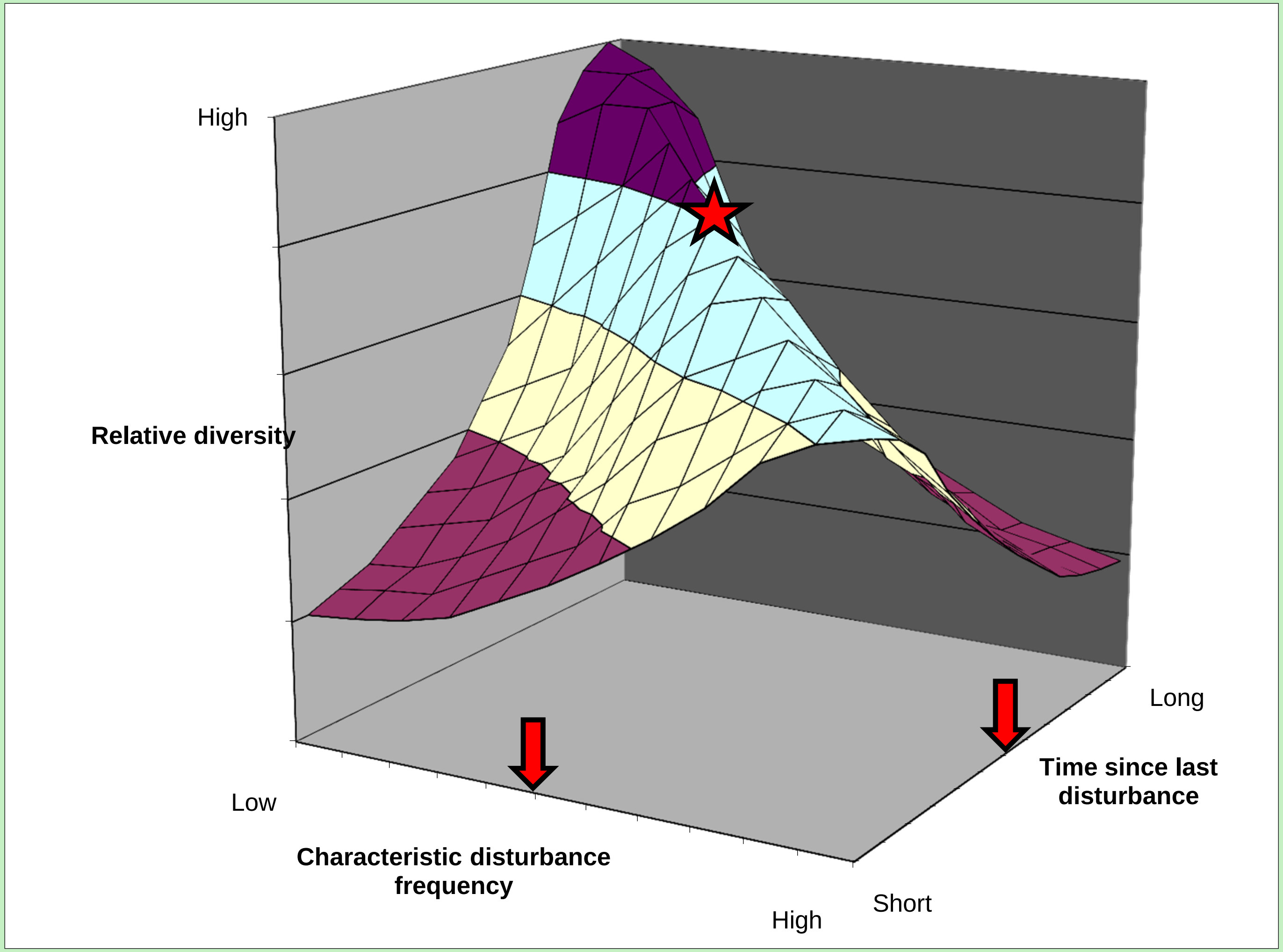
Safford and Van de Water, in press

Fire departure patterns in the California Nat. Forests



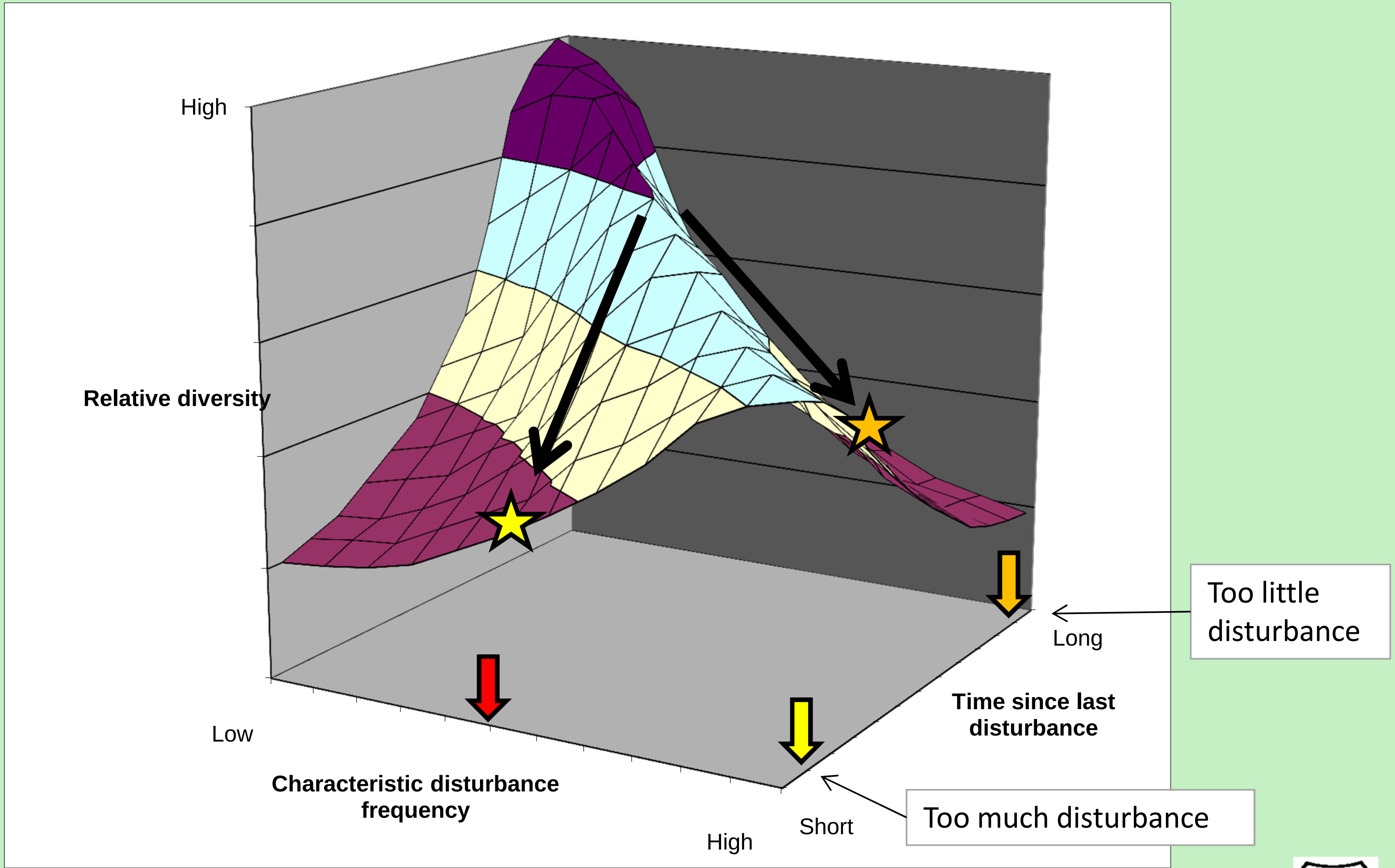
Biodiversity implications of changed fire regimes

Species adapt to fill niches created by an ecosystem's "characteristic" disturbance regime.



Denslow 1985, Milchunas et al. 1988, Huston 1994

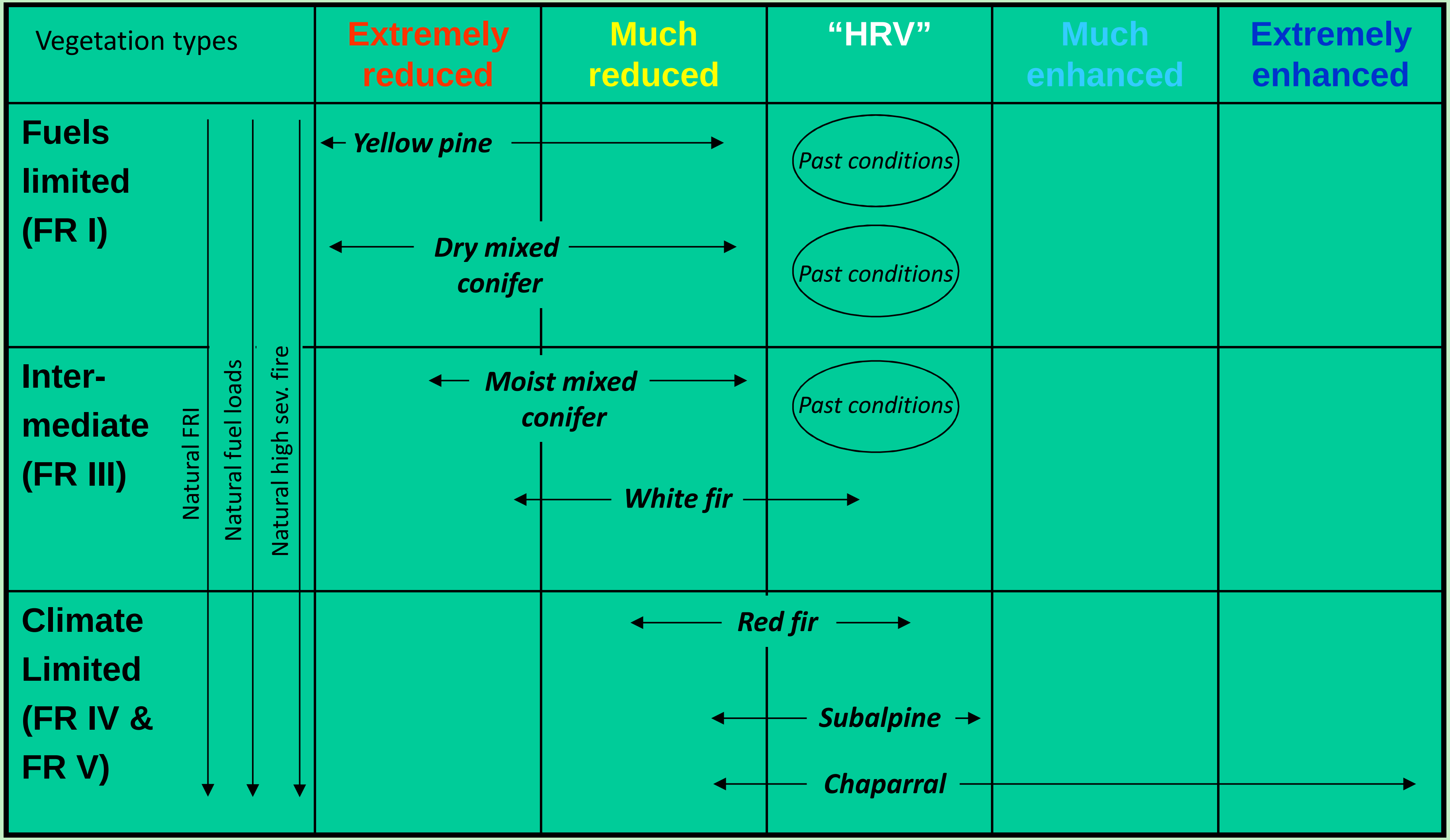
Strong departures from the characteristic regime will negatively impact the diversity of species native to the ecosystem in question



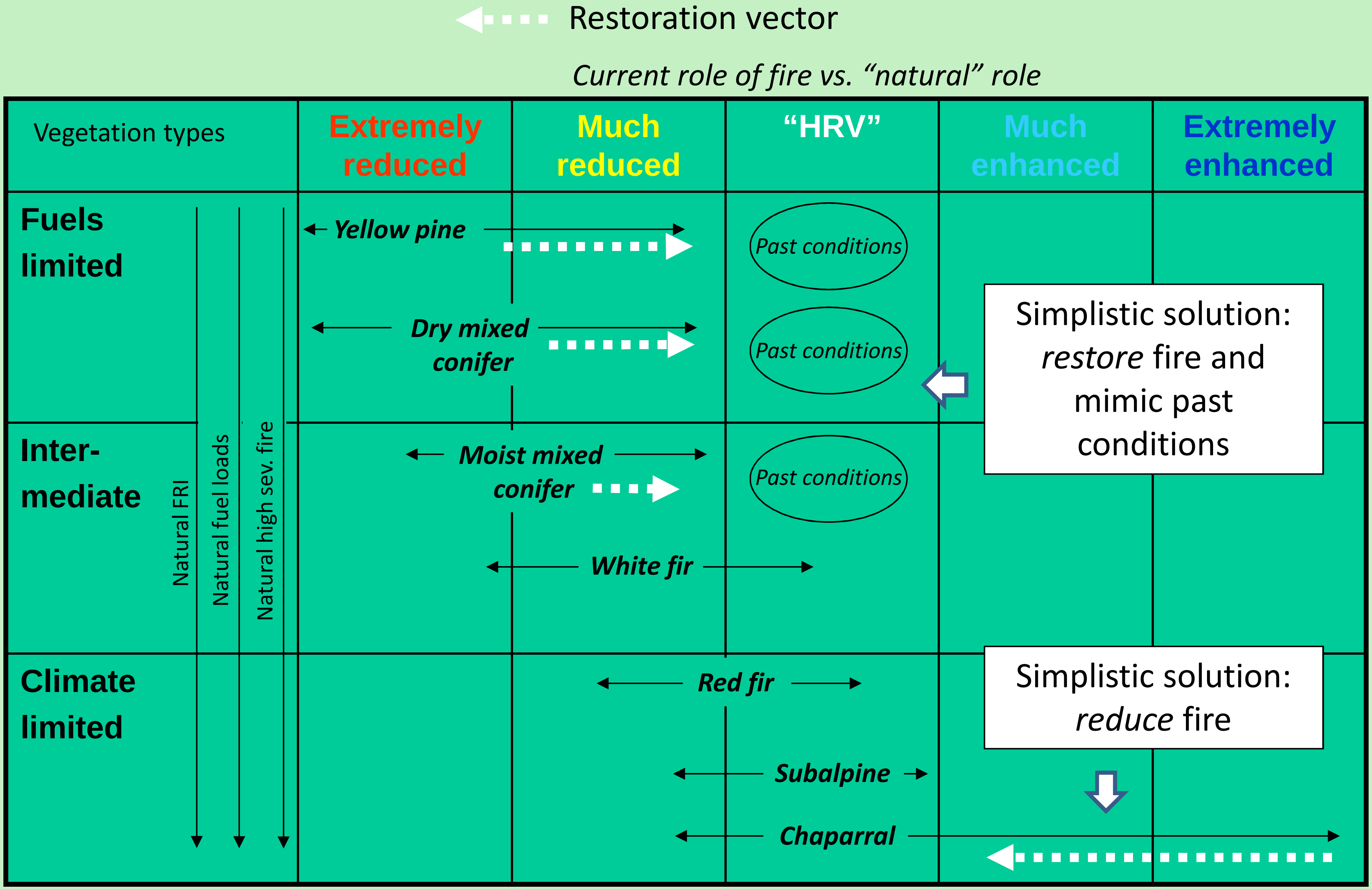
Denslow 1985, Milchunas et al. 1988, Huston 1994

Simplistic portrayal of the “western US fire problem”

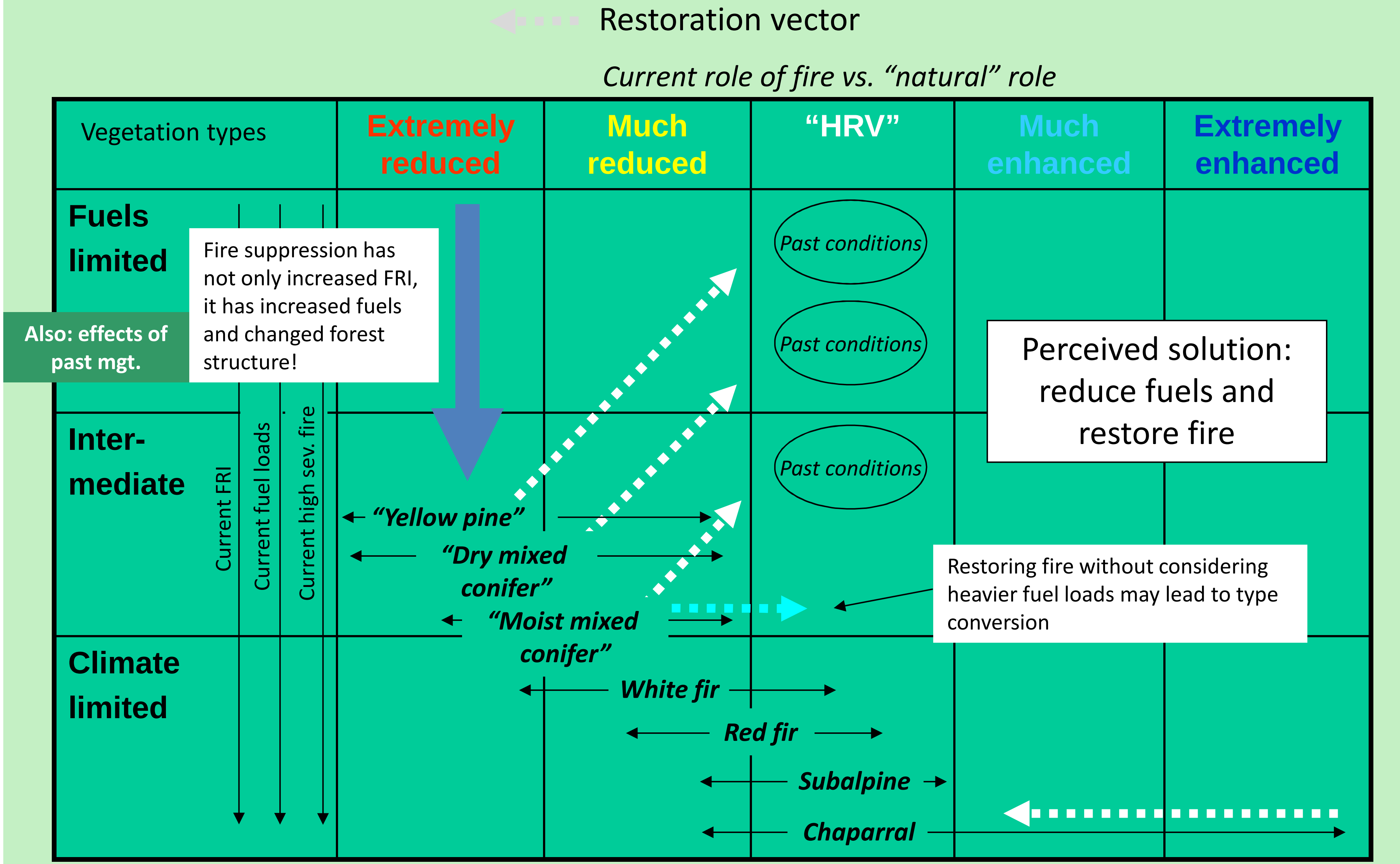
Current role of fire vs. “natural” role



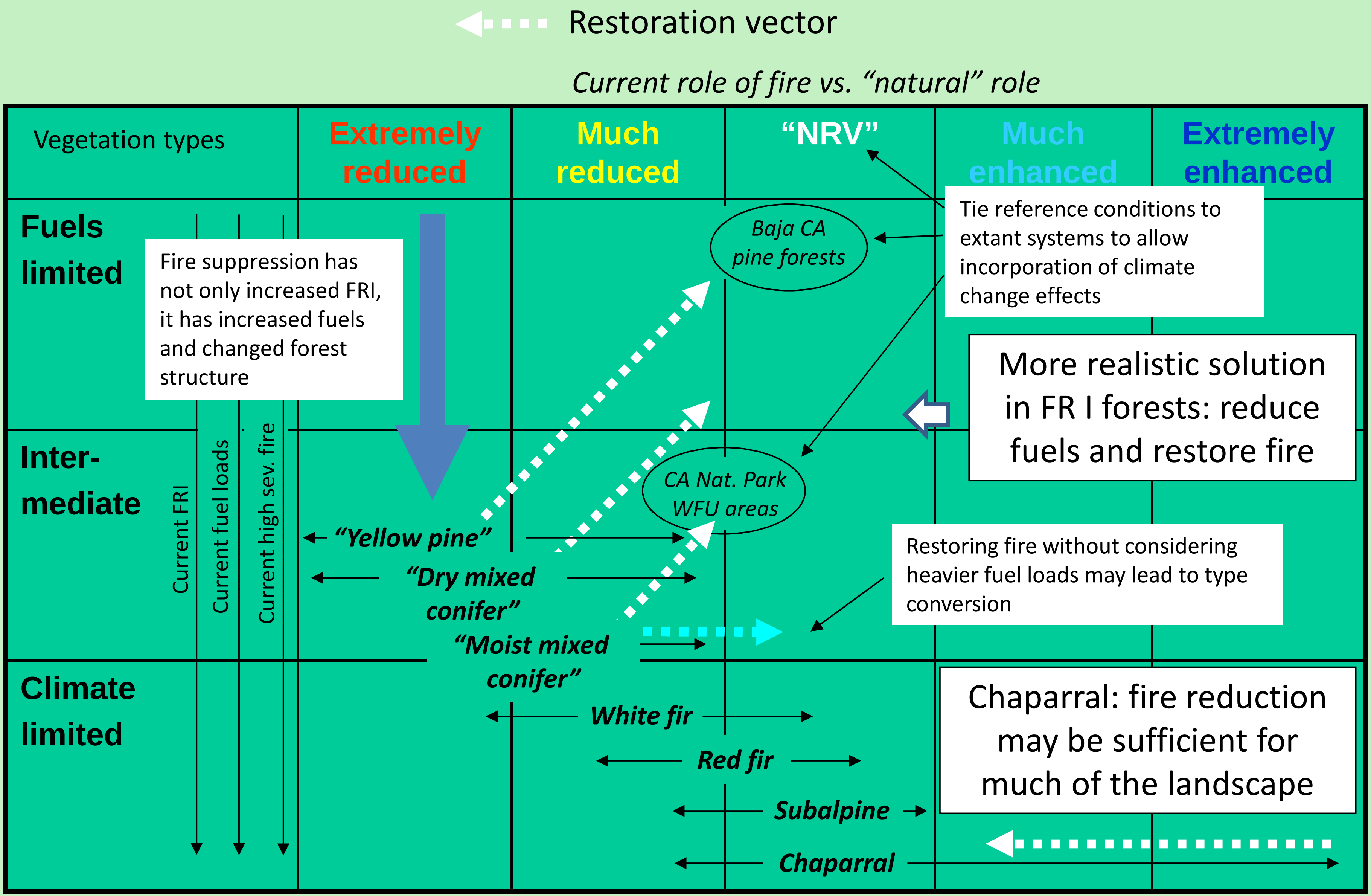
Simplistic portrayal of the "western US fire problem"



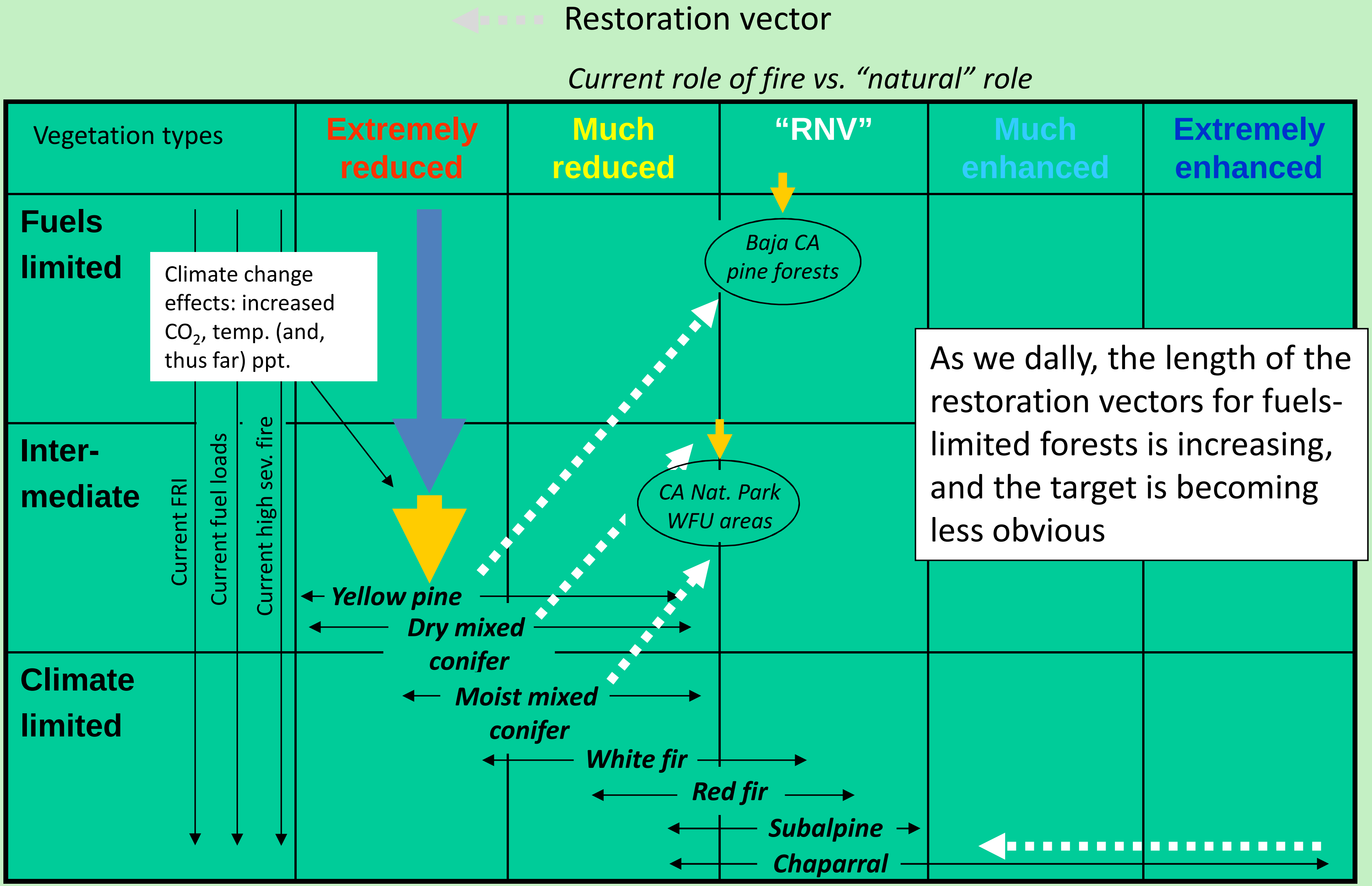
A more realistic portrayal of the "fire problem" #1



A more realistic portrayal of the fire problem #2

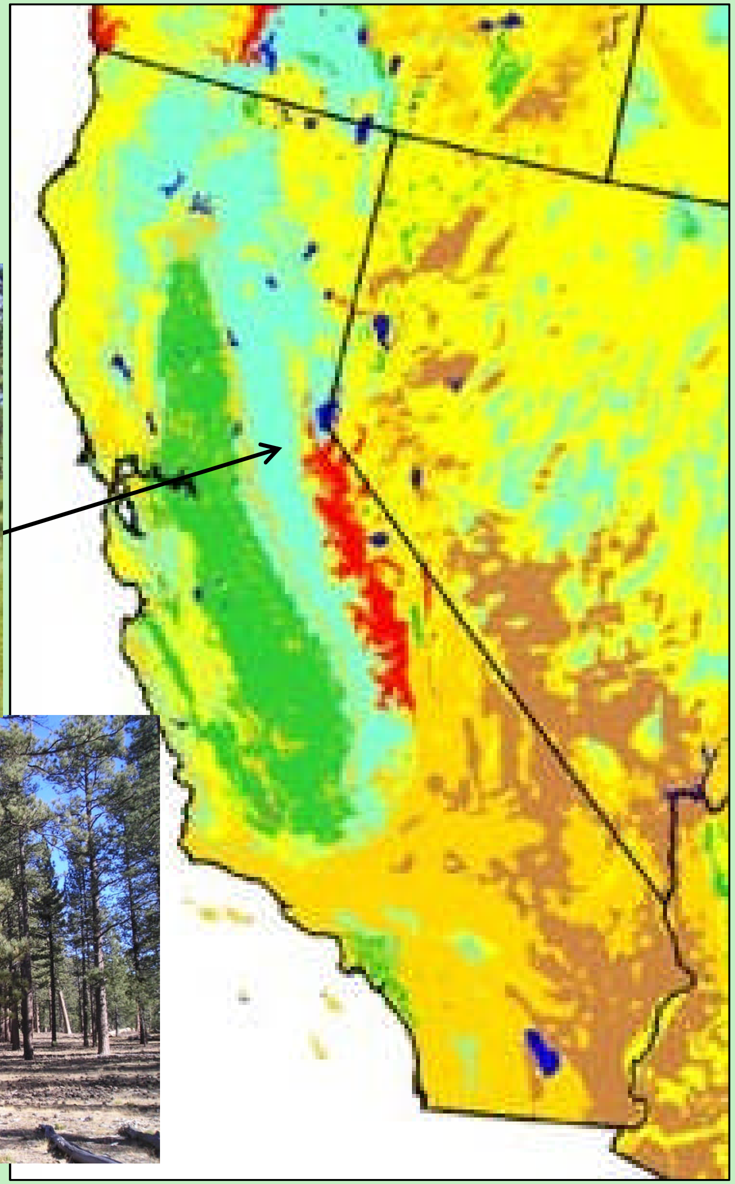


An even more realistic portrayal of the fire problem



Restoration issues in Fire Regime I

Open forests of pine and oak,
oak savanna



Ecosystems of Fire Regime I

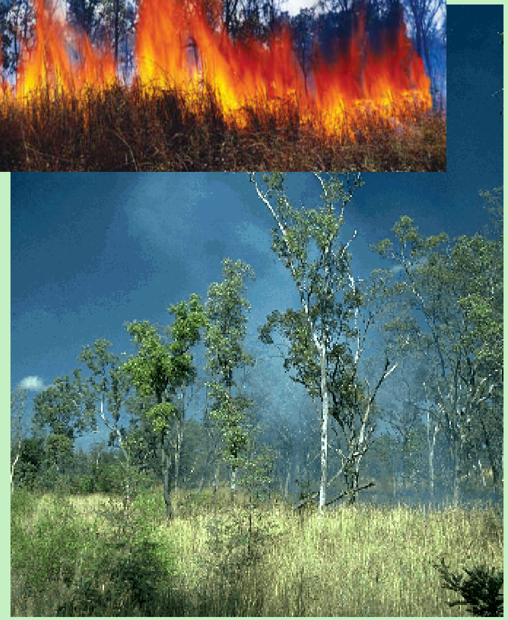
- Where vegetation is dominated by trees that are resistant to fire, but the principle fuel is the herbaceous and litter layers in the understory
- Usually found in areas with a long and/or profound dry season
- The majority of the dominant vegetation (trees) survives fire (< ~25% of the individuals killed)
- Fire does not greatly modify the structure of the dominant vegetation, rather it maintains the structure

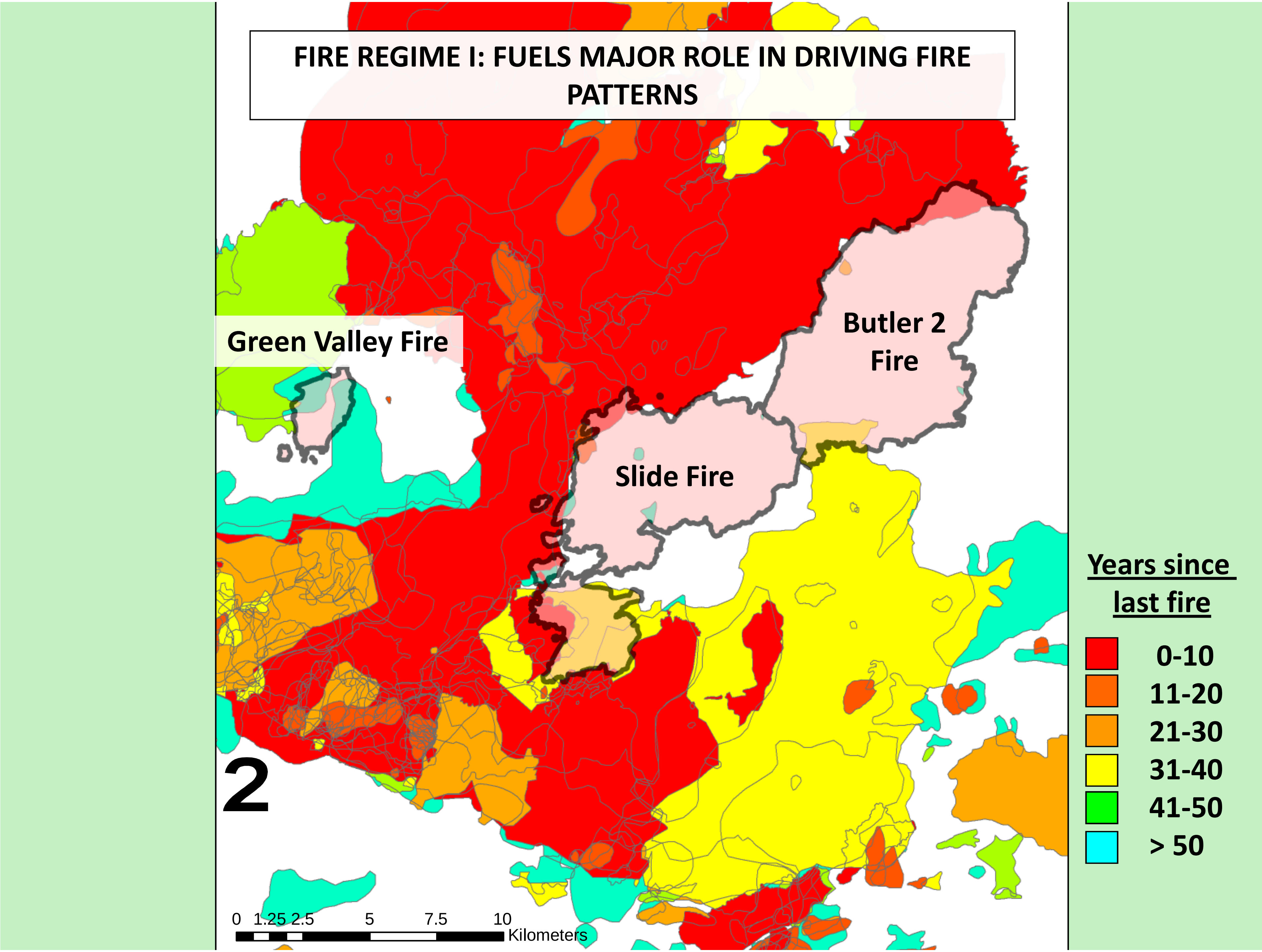
Ecosystems of Fire Regime I

- Fires under normal burning conditions remain relatively small and easy to control, but fires during the late dry season can become large (esp. under windy conditions)
- In tropical latitudes, the natural source of ignition (lightning) occurs primarily during the rainy season, but the herbaceous layer dries rapidly
- The occurrence of fire depends on the coincidence between ignition and the presence of dry fuel

Ecosystems of Fire Regime I

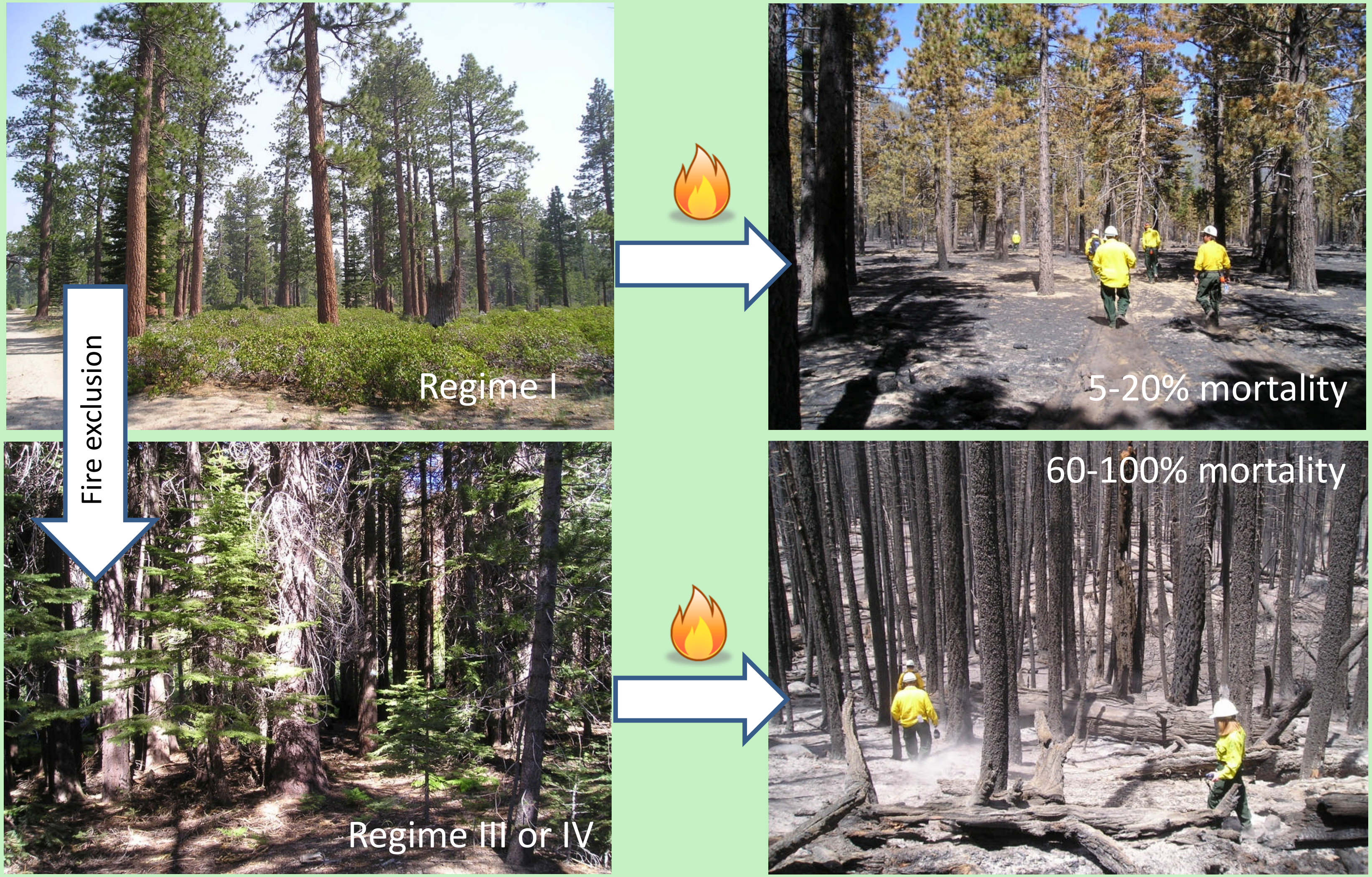
- Fires in ecosystems of Fire Regime I are “fuel limited” and do not require extreme conditions to burn
- The lack of fire over long periods of time leads to an increase in fuel that may notably change the relationship with fire (see Fire Regime III)
- These ecosystems typically require frequent fire to maintain themselves on the landscape





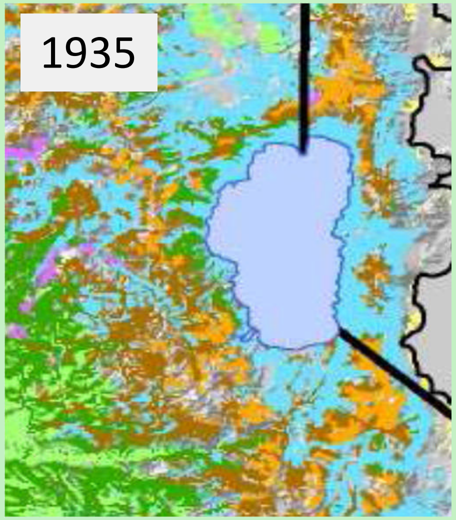
FIRE REGIME I: FUELS MAJOR ROLE IN DRIVING FIRE PATTERNS
Green Valley Fire
Butler 2 Fire
Slide Fire
2
0 1.25 2.5 5 7.5 10
Kilometers
Years since last fire
0-10
11-20
21-30
31-40
41-50
> 50

Fire suppression policies in the US have greatly "changed the equation" in ecosystems of Fire Regime 1



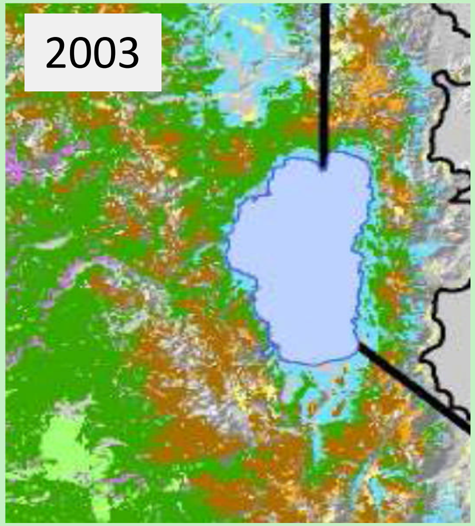
Lake Tahoe Basin

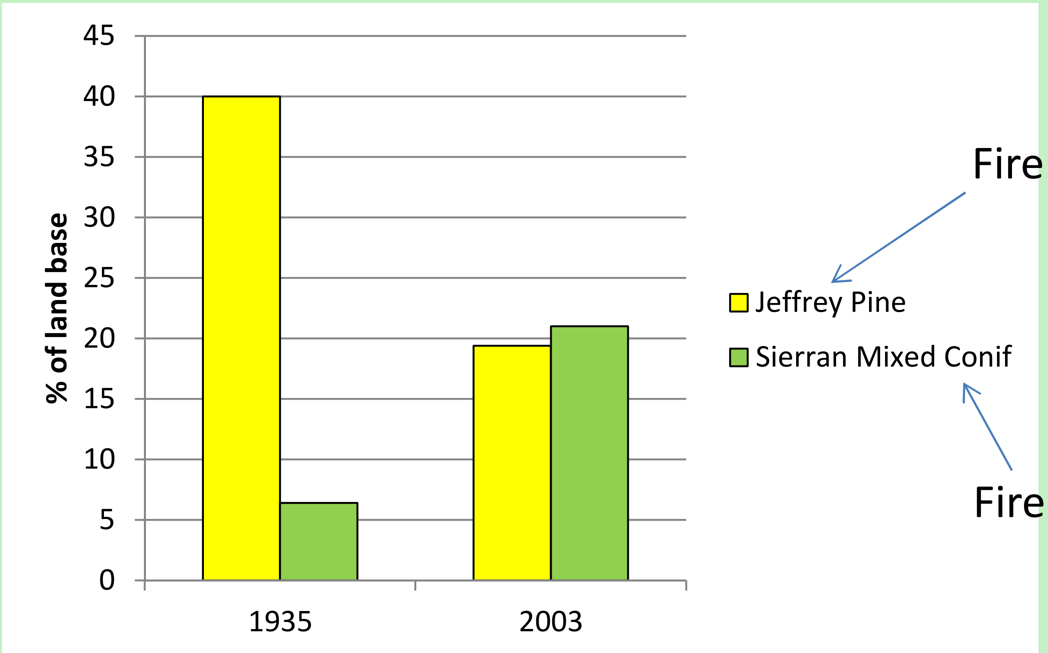
Before Euroamerican settlement, frequent fire maintained a landscape dominated by fire tolerant species



Light blue = Jeffrey pine

Dark green = fir dominated



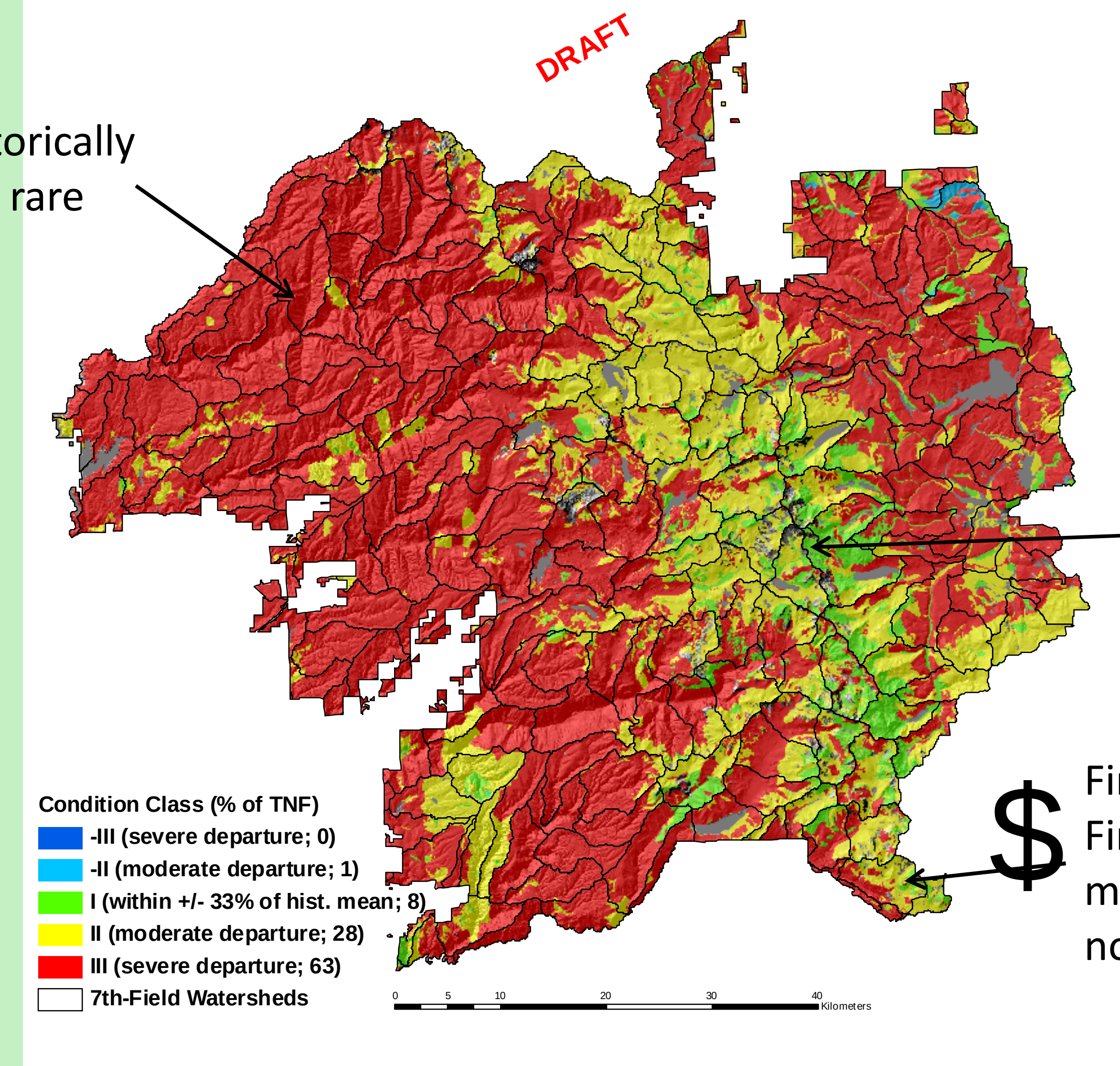


Fire Regime I

Fire Regime III

Tahoe National Forest: the lack of fire is changing the landscape

Fire Regime I:
Fires were historically frequent, now rare



Fire Regime IV/V:
Fires rare historically and today

$

Fire Regime III:
Fires were of inter-mediate frequency, now rare

Lake Tahoe Basin

Slaughterhouse Canyon: 1873

Area was completely cut by 1885

C. E. Watkins

Slaughterhouse Canyon: 1990

P. Goin

Lake Tahoe Basin

Emerald Point: 1880's vs. today

Emerald Point was part of a private estate and was not cut

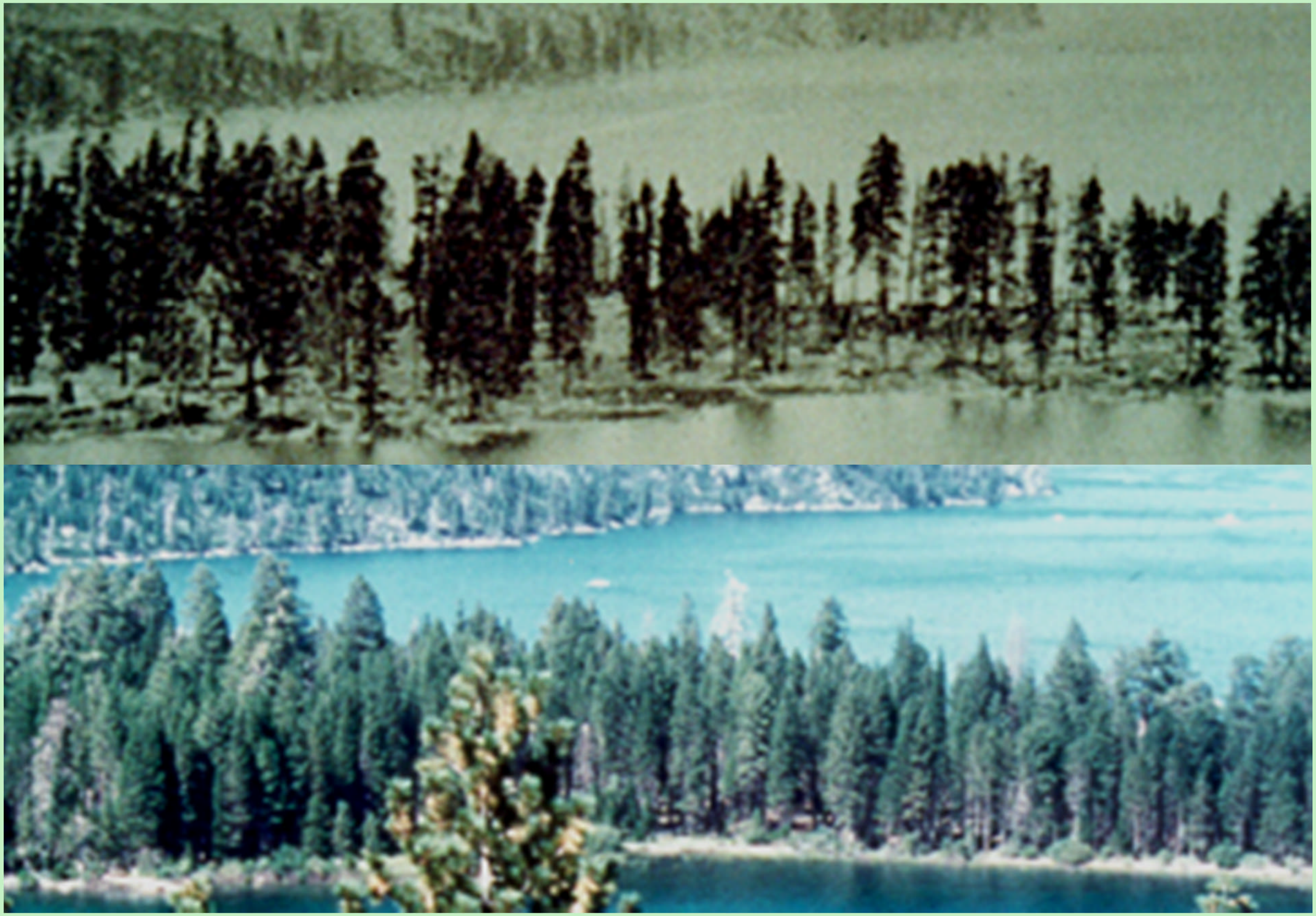
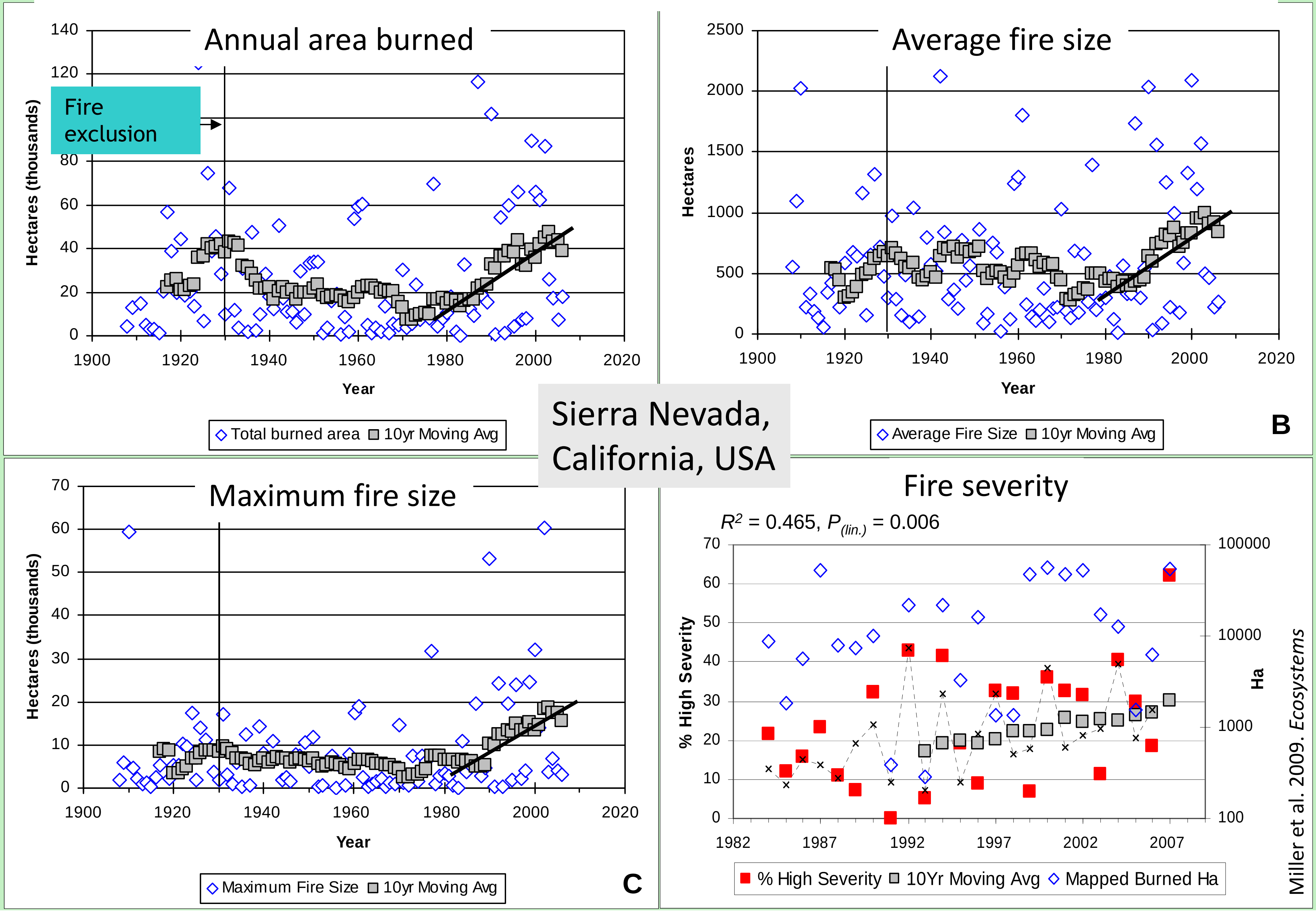


Photo courtesy of Rich Adams

Even with extreme vigilance, increases in forest fuels and air temperatures are leading to increases in area, size, and severity of forest fires



Reference forest: *Pinus* dominated, large canopy trees, open canopy, low stem density, low fuel loading (low litter levels, highly heterogeneous understory, fuel ladders rare), high diversity of understory species; fire frequent, low severity. Fire Regime I

Current forest: *Abies* dominated, mostly small and mid-sized trees, high stem density, closed canopy, high fuel loading (very deep litter, high fuel continuity, fuel ladders common), low diversity of understory species; fire essentially absent, moderate to high severity when it occurs. Fire Regime III

Prefire fuel treatment in Fire Regime I forests is relatively easy to align with ecological restoration goals

- Treatments restricted primarily to surface and ladder fuels, older/larger trees retained
- Prescribed fire utilized where possible
- Periodic re-entry for maintenance (mechanical, hand-treatments, fire)

Fire Regime I: Ecological outcomes of pre-fire treatments

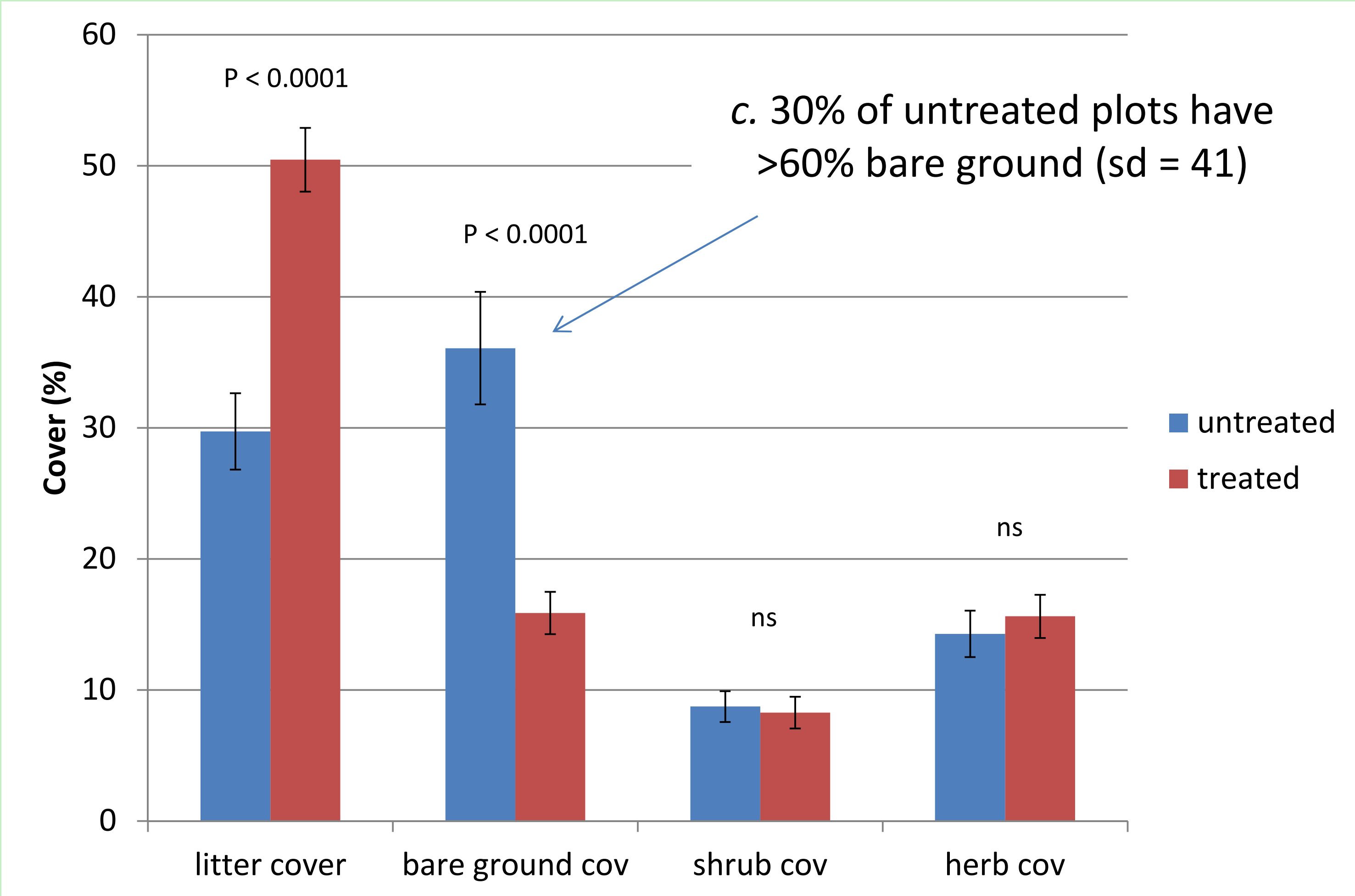
Properly implemented fuel treatments in these forests work very well at slowing fire and ameliorating fire behavior. They also:

- Reintroduce low severity fire to the ecosystem
- Reduce forest density closer to reference conditions
- Restore tree size-class distributions (to dominance by larger trees)
- Increase forest floor light incidence, increasing understory plant diversity and abundance
- Increase heterogeneity in stand structure at multiple scales = positive influence on animal diversity and abundance
- Reduce large tree mortality in subsequent fire = increased carbon retention, ecosystem resilience, aesthetics
- Reduce postfire soil erosion by reducing fire severity and canopy mortality

Lake Tahoe Basin: Angora Fire

Understory

Plots burned by wildfire, one yr postfire



Lake Tahoe Basin: Angora Fire

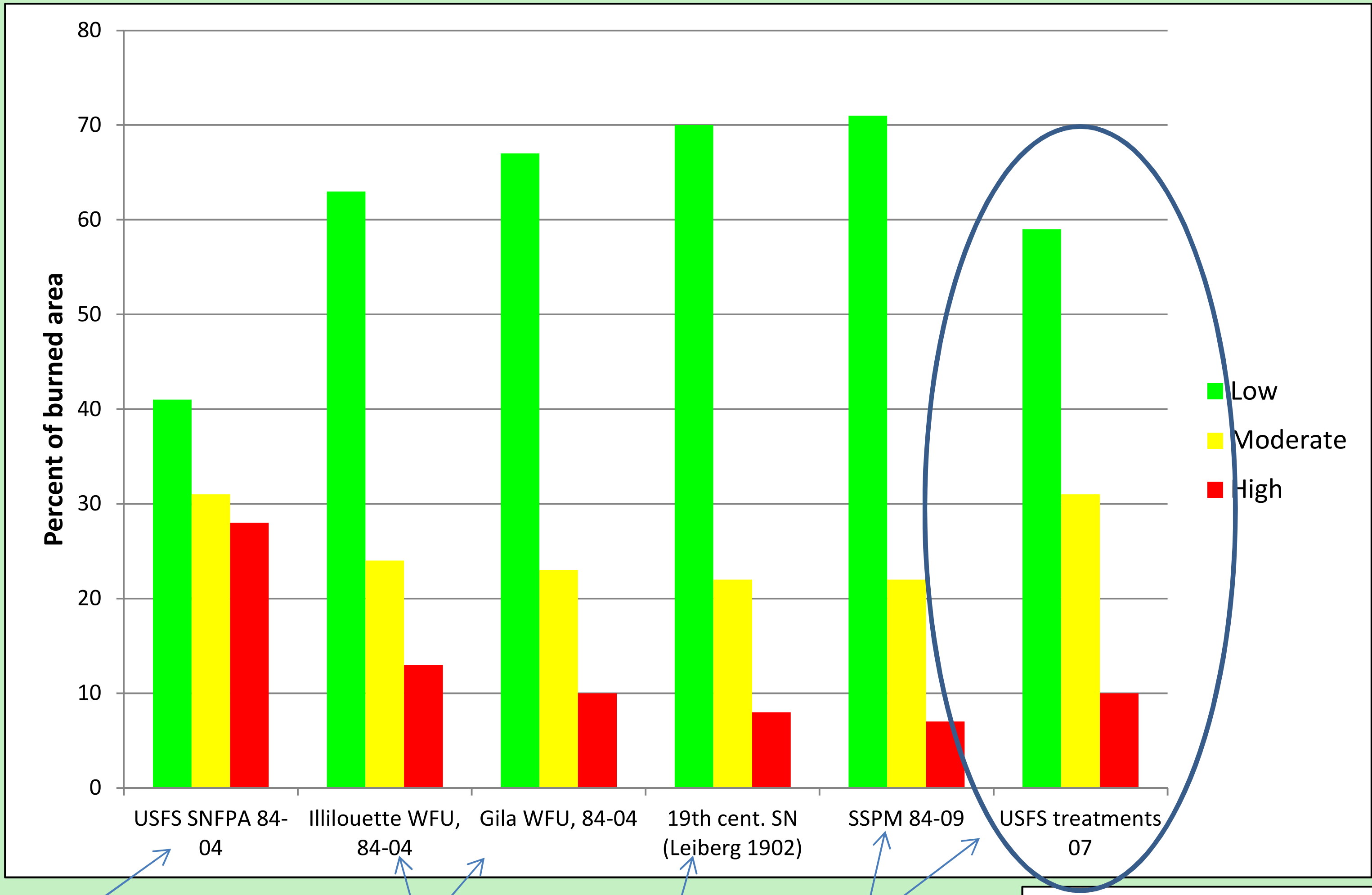
Bare ground and litter

Angora Fire, Transect 5

Treated ← 20 meters → Untreated

Yellow pine forests (Johansen et al. 2001): major erosion threshold reached at >60% bare ground

Fire severity: Sierra Nevada



Current day, under fire suppression, all forests combined (minus blue oak & subalpine)

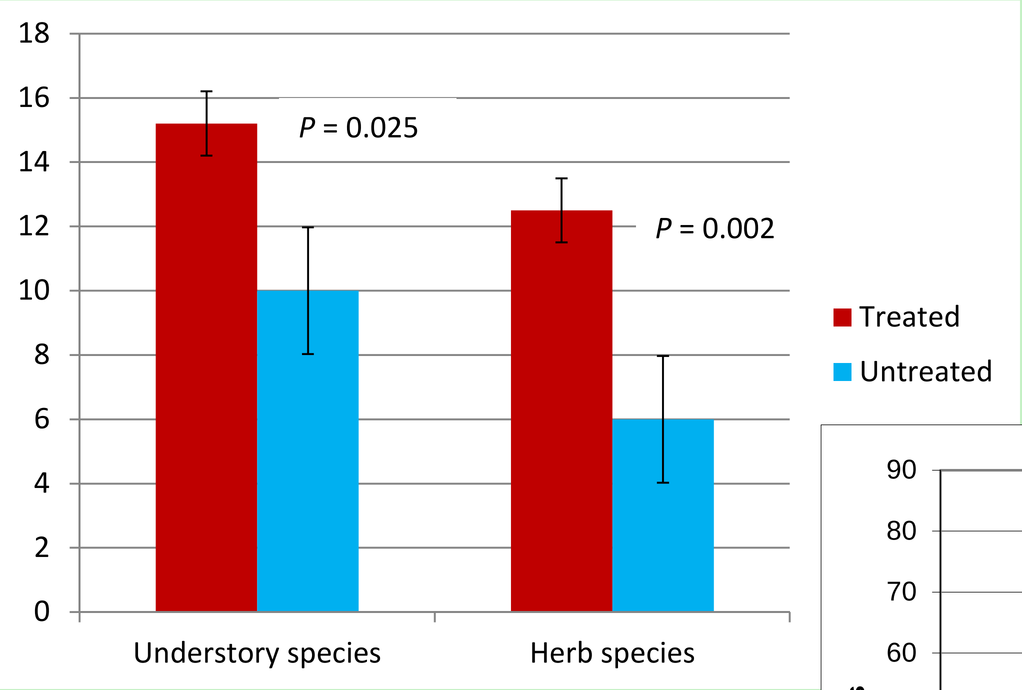
Current day, under Wildland Fire Use

Past reference

Current references

On average, current fires in the SNFPA area burn at much higher severity than either historical or contemporary reference forests

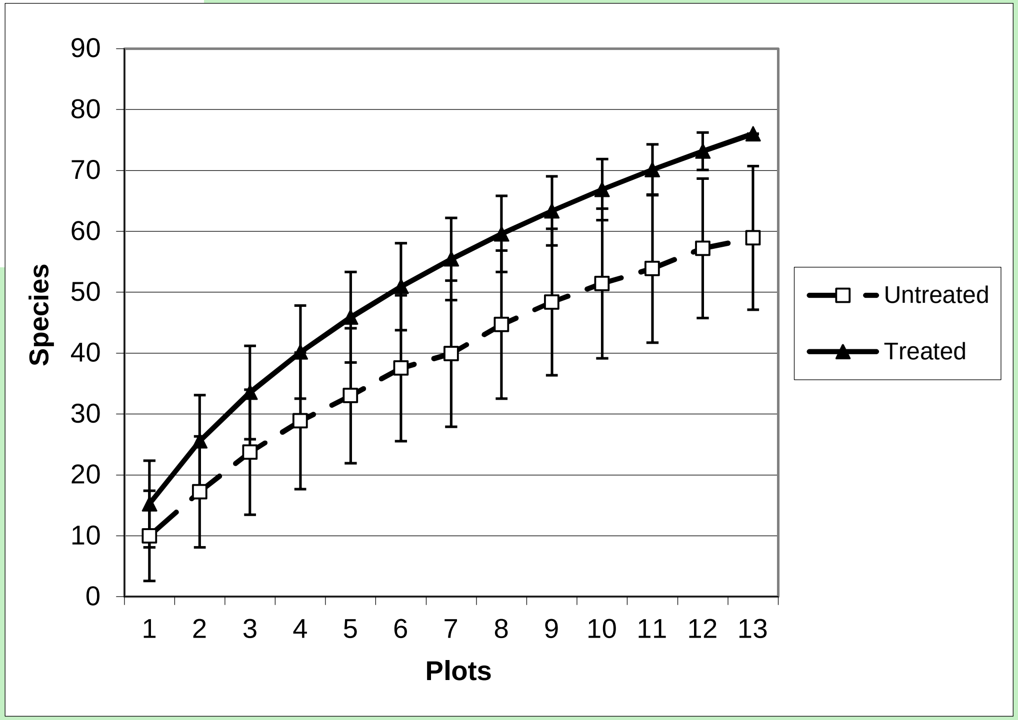
Large contiguous areas of high severity fire in forests of Fire Regime I are uncharacteristic of the ecosystem, and are usually less biodiverse than areas of low and mixed severity



Alpha diversity (810 m^2 plots)

In the Angora Fire (Lake Tahoe, 2007), open-canopied stands in fuel treatments burned at low to moderate severity, untreated forest burned at high severity

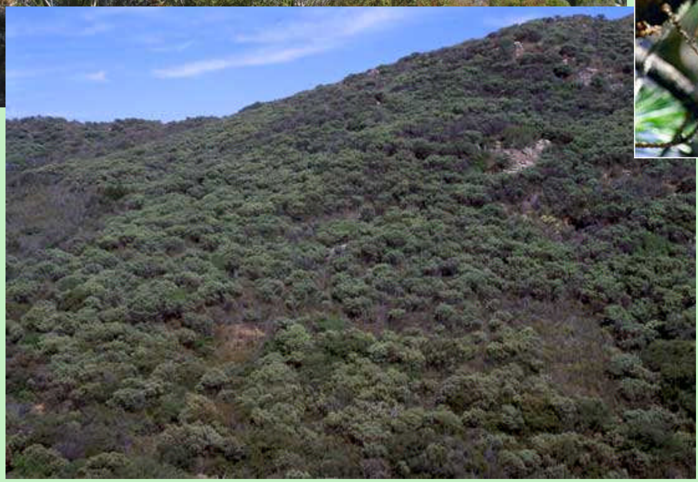
Both graphs from one year postfire

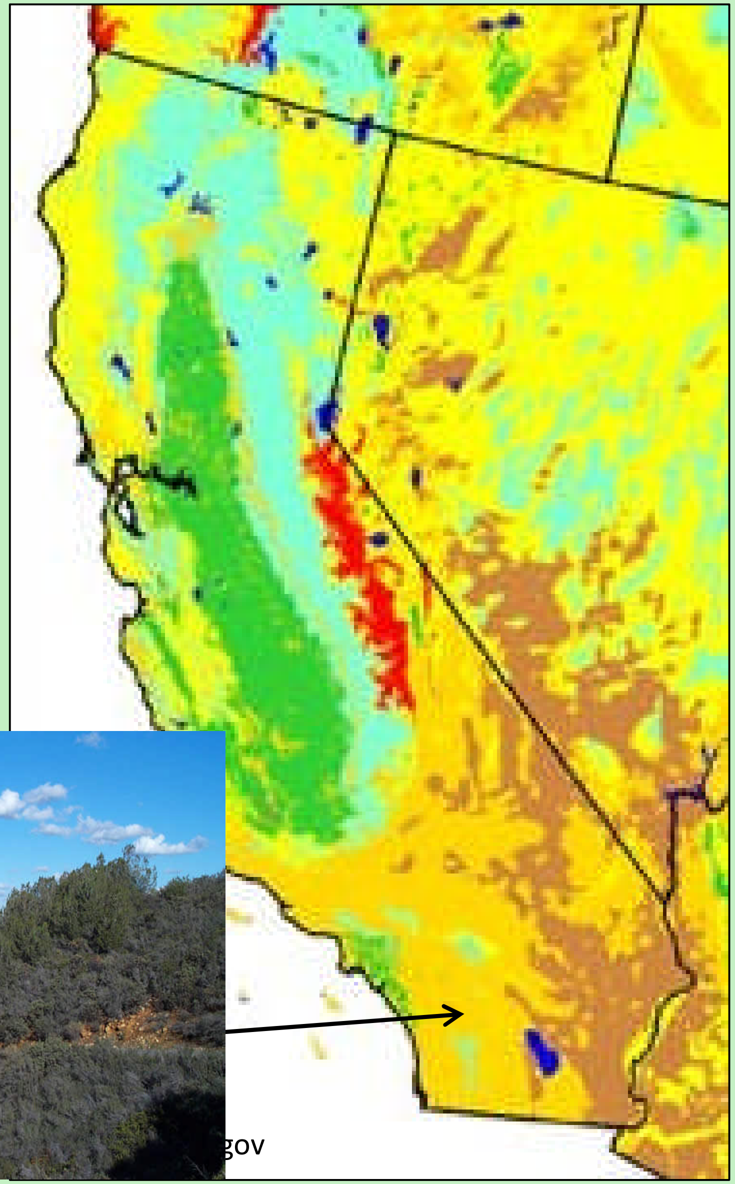


Beta diversity (spp./area curves)

Restoration issues in Fire Regime IV

Sclerophyllous shrublands,
serotinous conifers





Ecosystems of Fire Regime IV

- These are ecosystems where climatic conditions or the lack of an ignition source normally impede the occurrence of fire
- In the years between fires, these ecosystems accumulate much fuel
- Fires in natural ecosystems of Fire Regime IV are “climate limited” (or “ignition limited”), as under most conditions there is plenty of fuel to burn

Ecosystems of Fire Regime IV

- Vegetation is dominated by woody species that possess adaptations to regenerate after the death of the adult plant
- Regeneration can occur by way of seeds stored in the soil, or in “serotinous” structures found on the adult plant

Biodiversity in ecosystems of Fire Regime IV is concentrated in the years immediately after fire

Pinus contorta

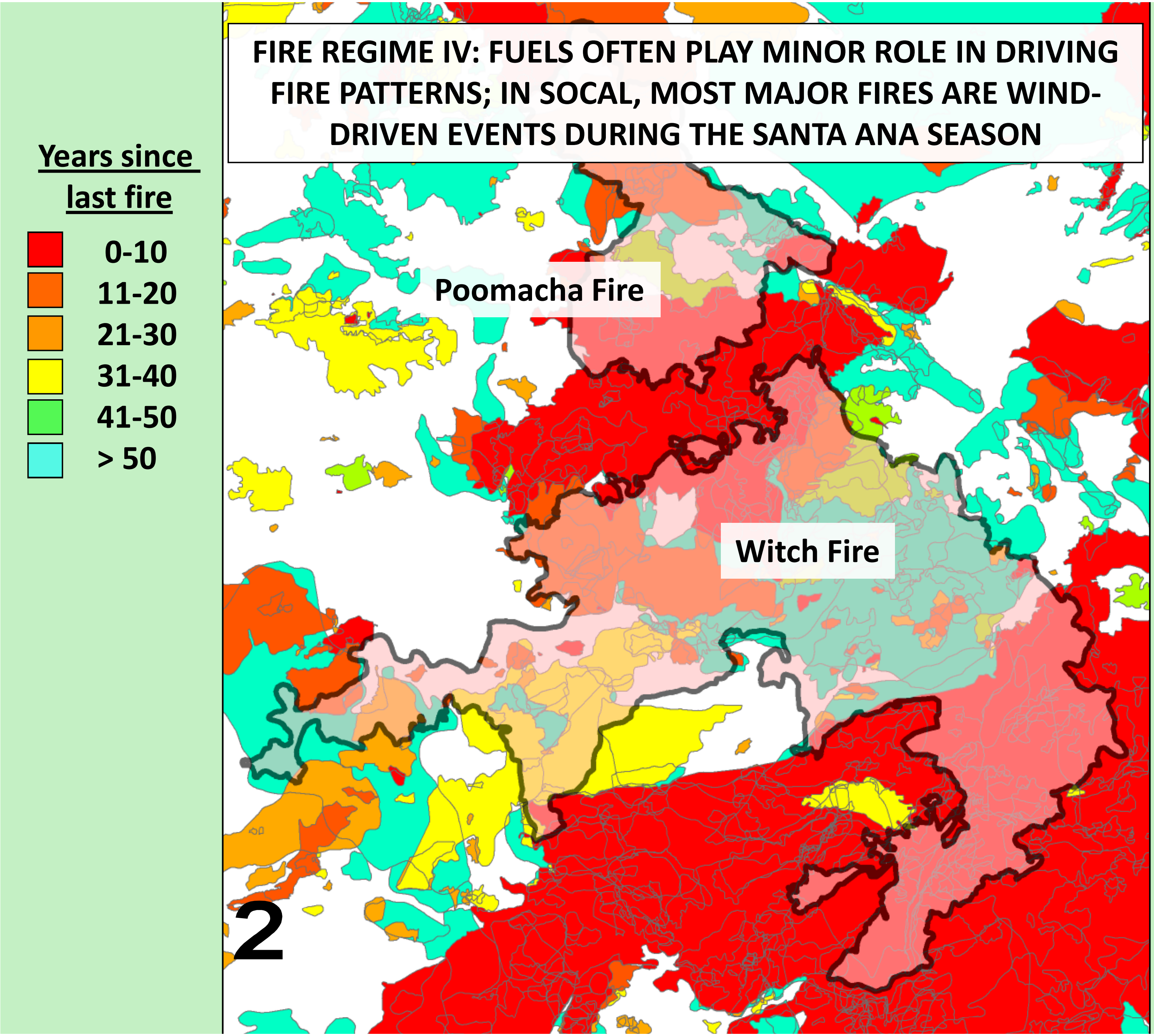
Cupressus macnabiana

Flowering one year after fire, chaparral, California

Ecosystems of Fire Regime IV

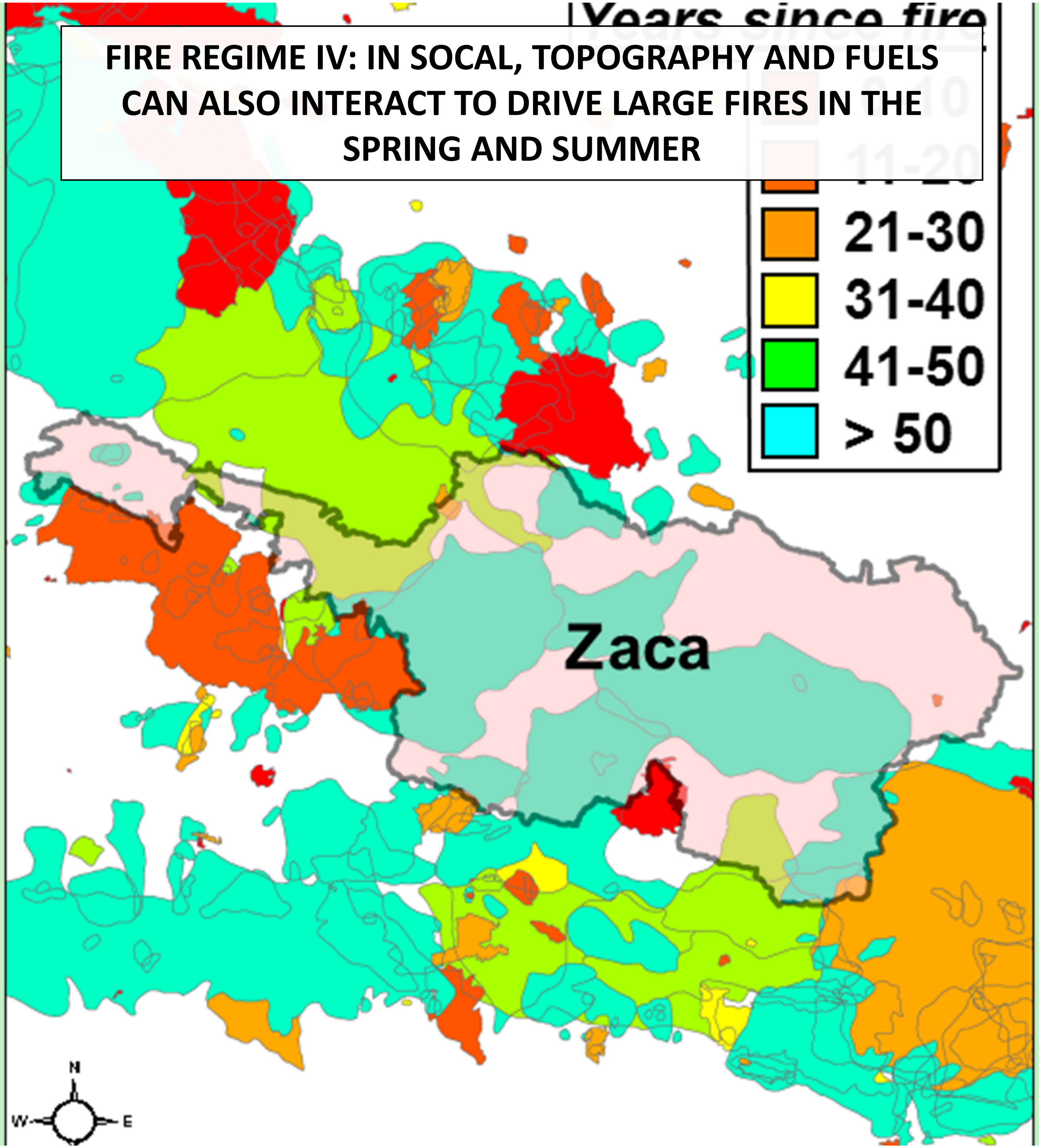
- Fire occurs with the coincidence of ignition and the presence of suitable climatic conditions (wind, drought)
- Exhibit spectacular fire behavior, often incontrollable
- Because they often occur under extreme climatic conditions, fires in ecosystems of Fire Regime IV can become very large
- Homes should not be built in these ecosystems!


SOUTHERN CALIFORNIA,
…1970, 1985, 2003, 2006, 2007, 2009…
But they often are…



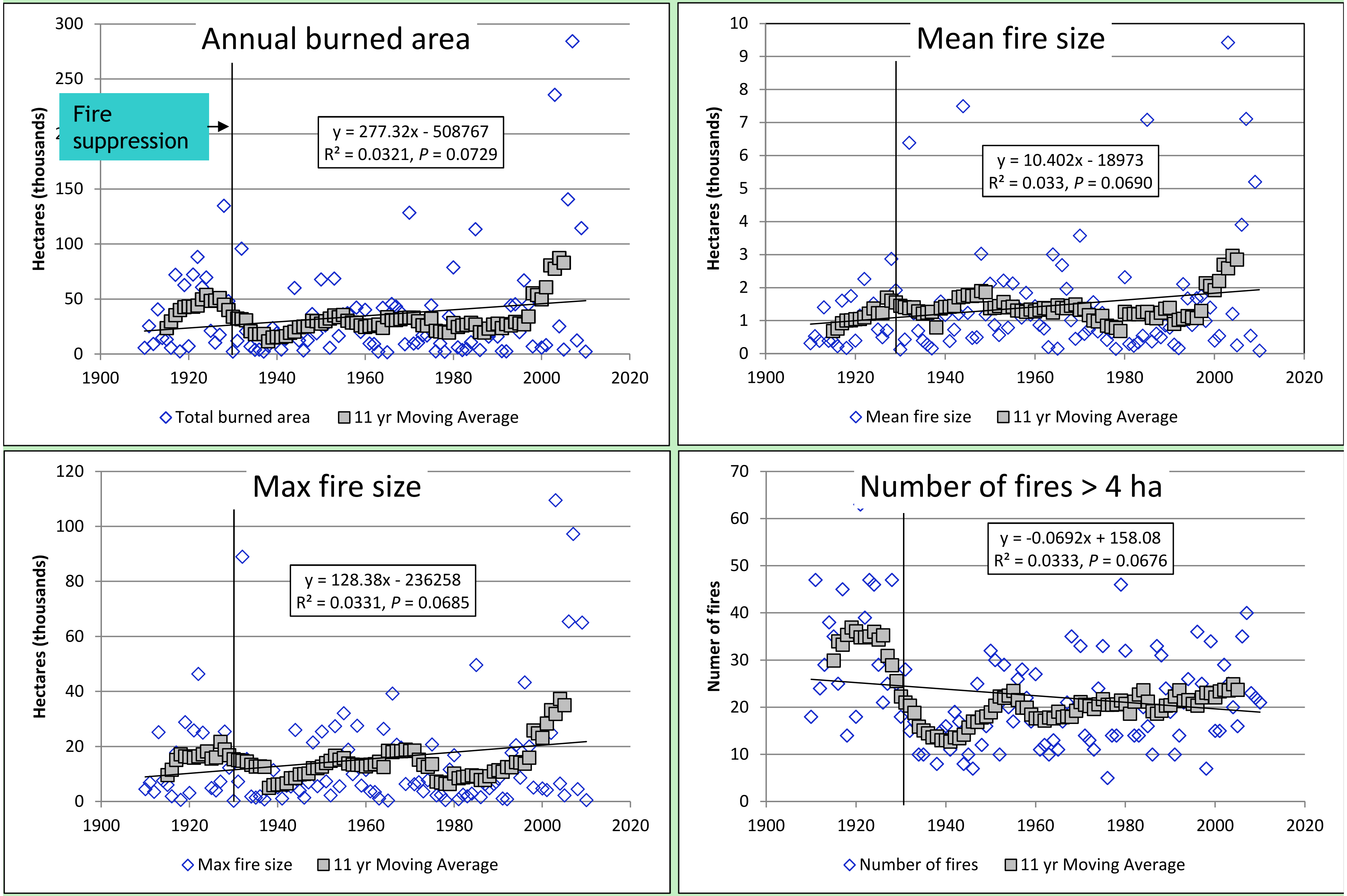
53% of fire area had burned in last 20 yrs

FIRE REGIME IV: IN SOCAL, TOPOGRAPHY AND FUELS CAN ALSO INTERACT TO DRIVE LARGE FIRES IN THE SPRING AND SUMMER

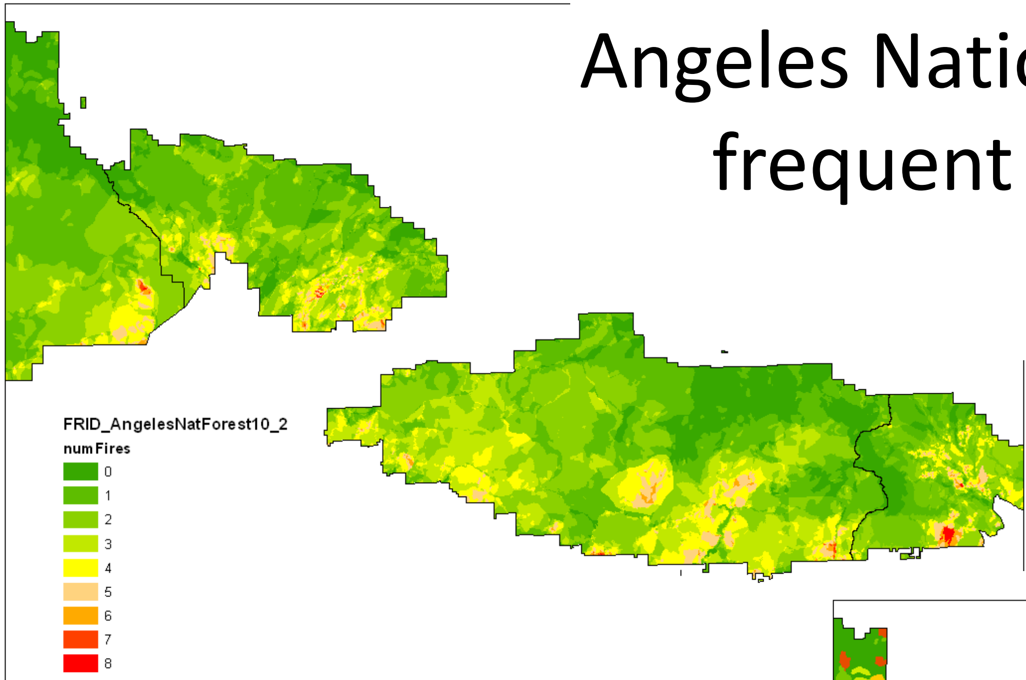


1% of fire area had burned in last 20 yrs

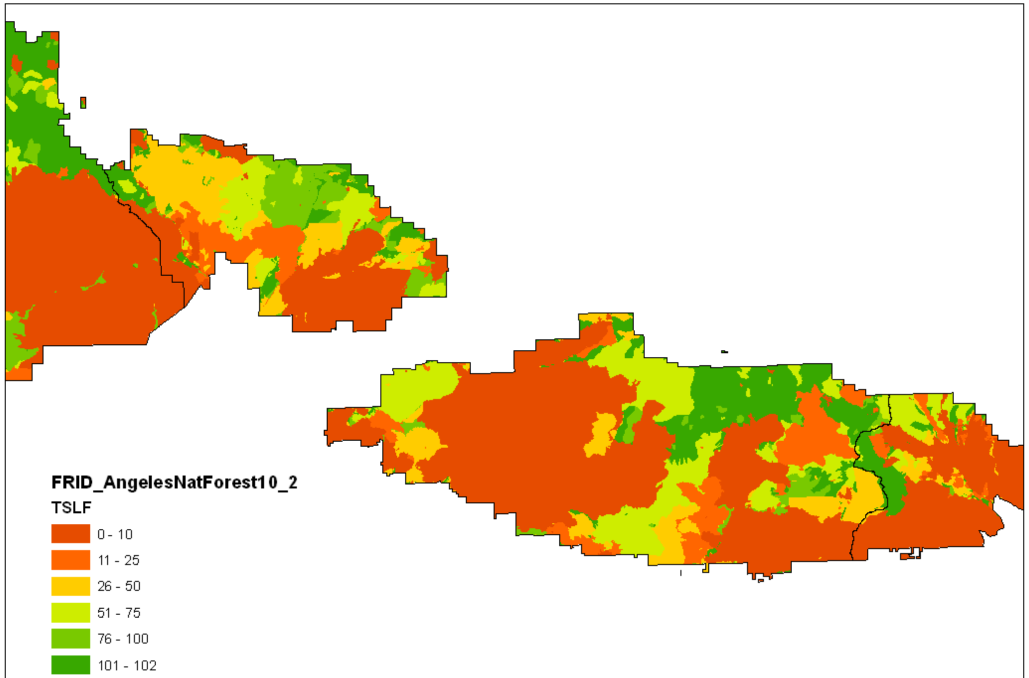
Southern California: trends in fire area and number



Angeles National Forest: excessively frequent fire is changing the landscape



Number of fires since 1908



Time since last fire

Reference ecosystem: dominated by shrubs (plus serotinous conifers); closed canopy, high fuel loading; relatively homogeneous understory; many specialized understory species highly dependent on fire; few to no exotic species; infrequent fire, high severity. Fire Regime IV

Current ecosystem: dominated by shrubs but serotinous conifers threatened by frequent fire, large areas converting to grass/herbs; mix of closed and open canopy, high fuel loading; more heterogeneous understory; under-story species diversity less related to fire; exotic species common; fire relatively frequent, high severity; air pollution (NO_x and ozone). Fire Regime II and IV

Prefire fuel treatment in Fire Regime IV shrublands and forests is not easily aligned with ecological restoration goals

Treatment

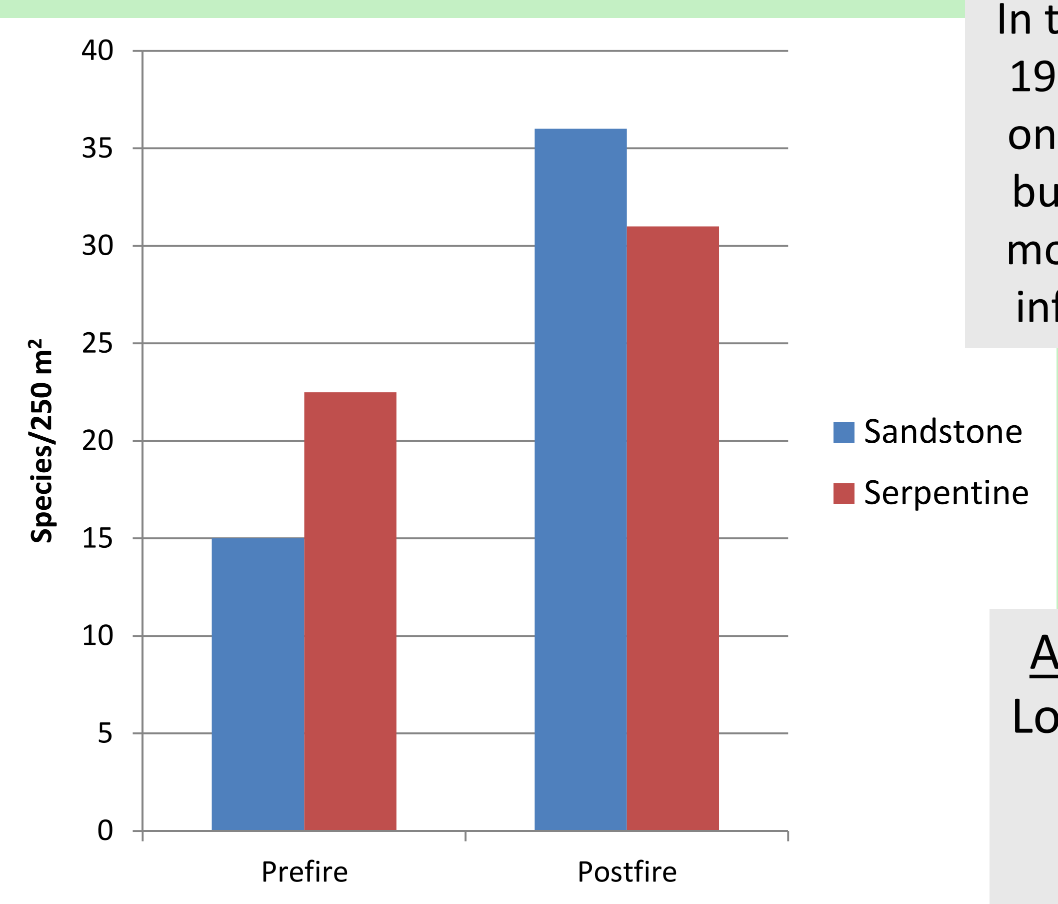
- Treatments remove pretreatment vegetation in linear strips
- Regular re-entry for maintenance (mechanical, herbicides, grazing, etc.)
- More or less permanent conversion of native shrublands to herbaceous, often non-native communities

Fire Regime IV: Ecological outcomes of pre-fire treatments

As long as treatments are easily and safely accessible to fire fighters, they can be effective in stopping or slowing fire under moderate conditions. However, such treatments should not be mistaken for restoration:

- Artificial maintenance of early seral conditions where such habitat is already (overly) sufficiently generated by fire
- Corridors for exotic species invasion
- Sources of erosion
- Playgrounds for unregulated off-highway vehicle use
- Herbaceous vegetation creates layer of flashy fuels that is more flammable than shrubs and expands fire season earlier into the season (drier, herbaceous fuels)

Large contiguous areas of high severity fire in chaparral are characteristic of the ecosystem, and are usually more biodiverse than areas of low and mixed severity



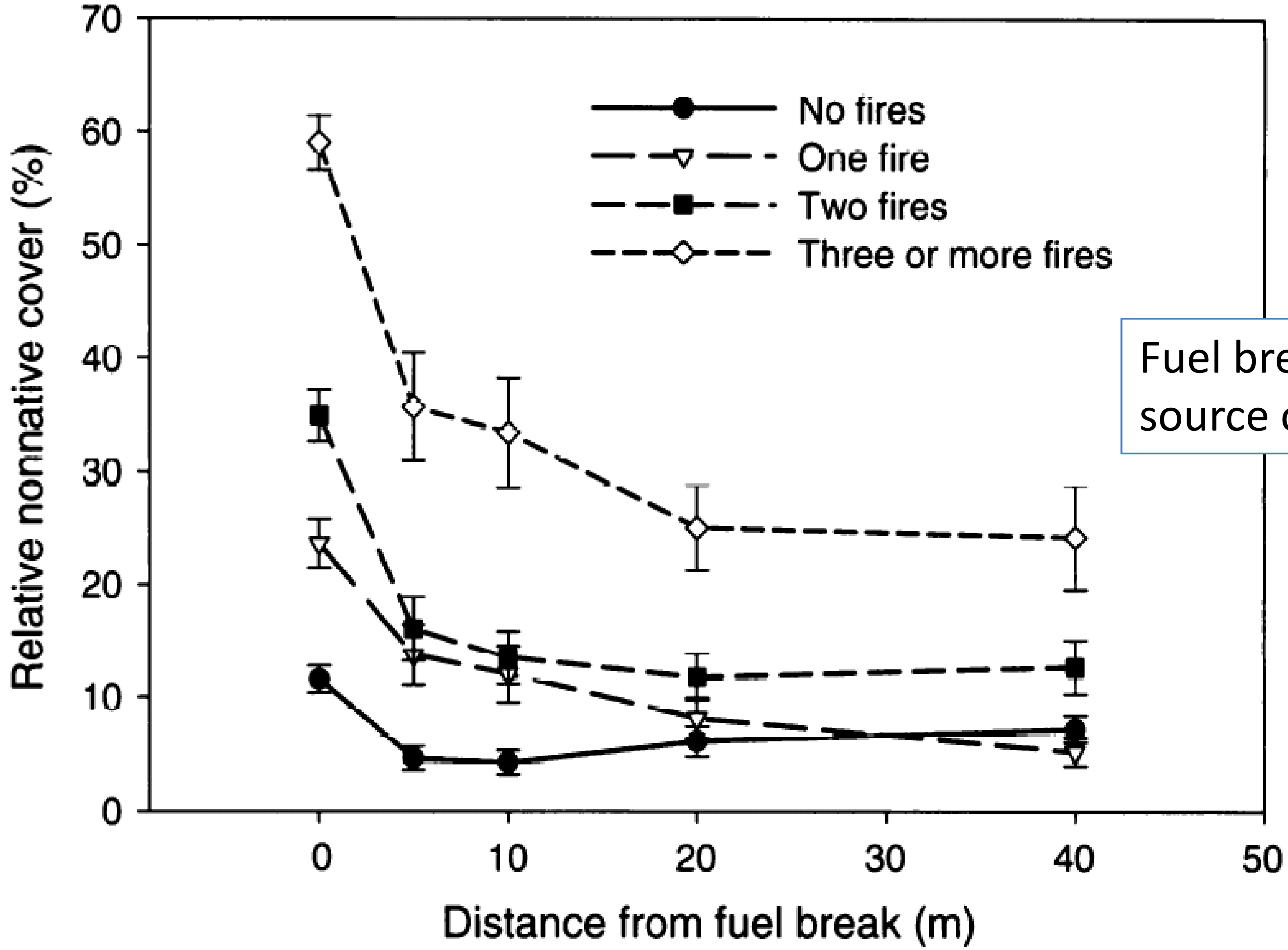
Alpha diversity (250 m^2 plots)

In the Sixteen Fire (Lake County, 1999), dense canopy chaparral on fertile sandstone substrates burned at higher severity than more open canopied stands on infertile serpentine substrates

<u>Application to fuel breaks</u>: Lower canopy cover = lower fire intensity = fewer species stimulated to germinate by fire

Safford and Harrison. 2004. *Ecology*

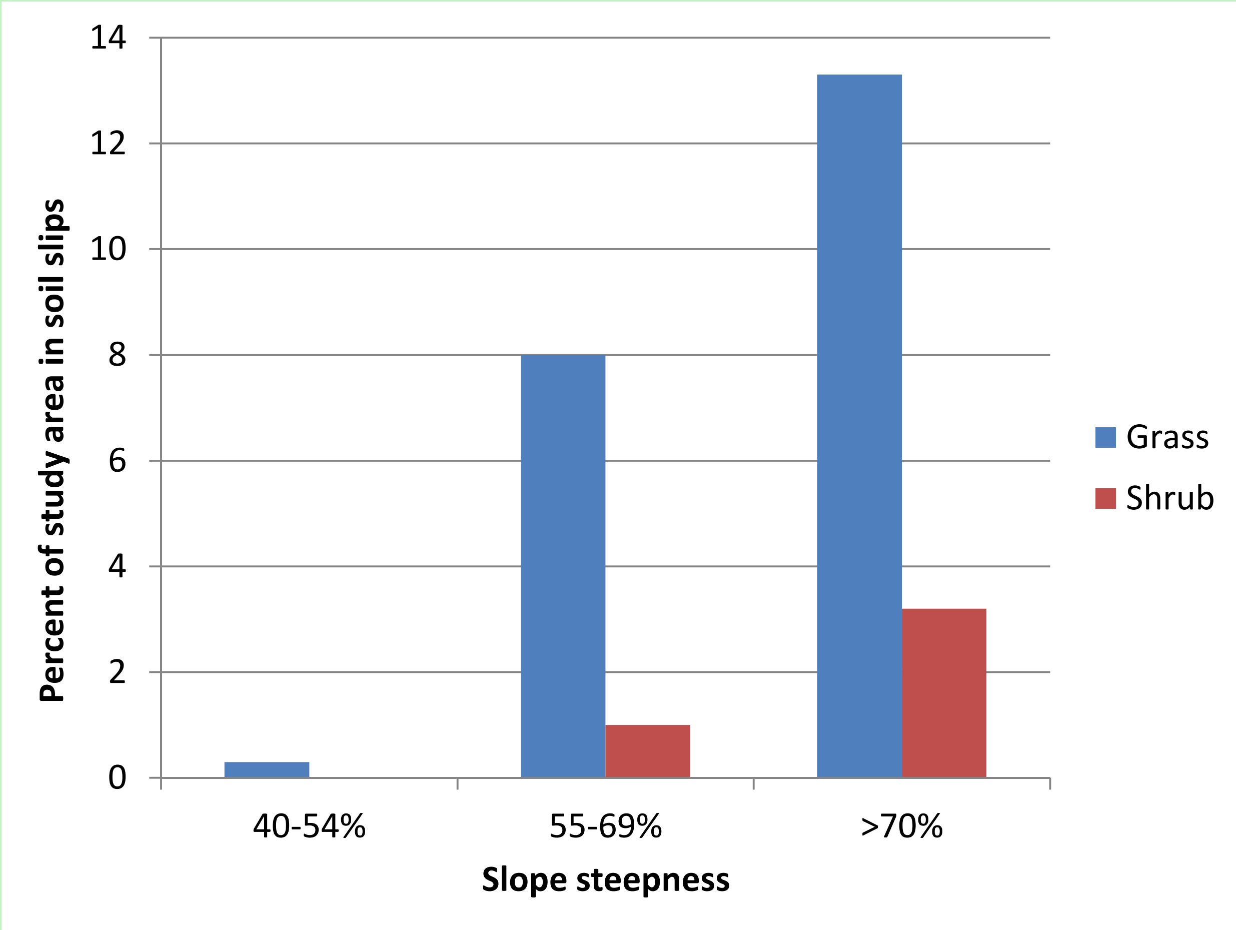
Fuel treatments and exotic species in chaparral



Fuel breaks are a source of invasion

Merriam et al. 2009. *Ecol Apps*

Fuel treatments and erosion in chaparral

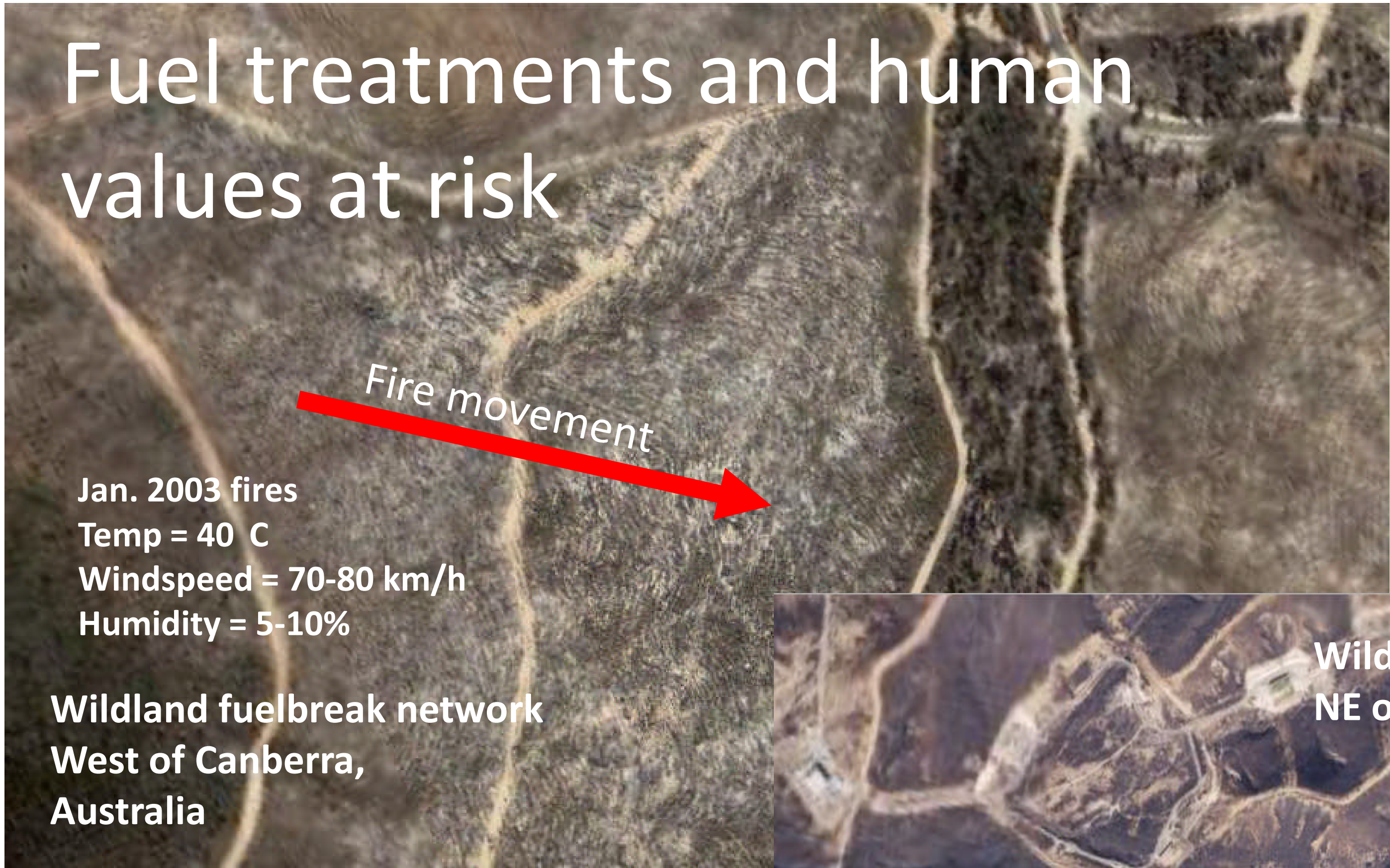


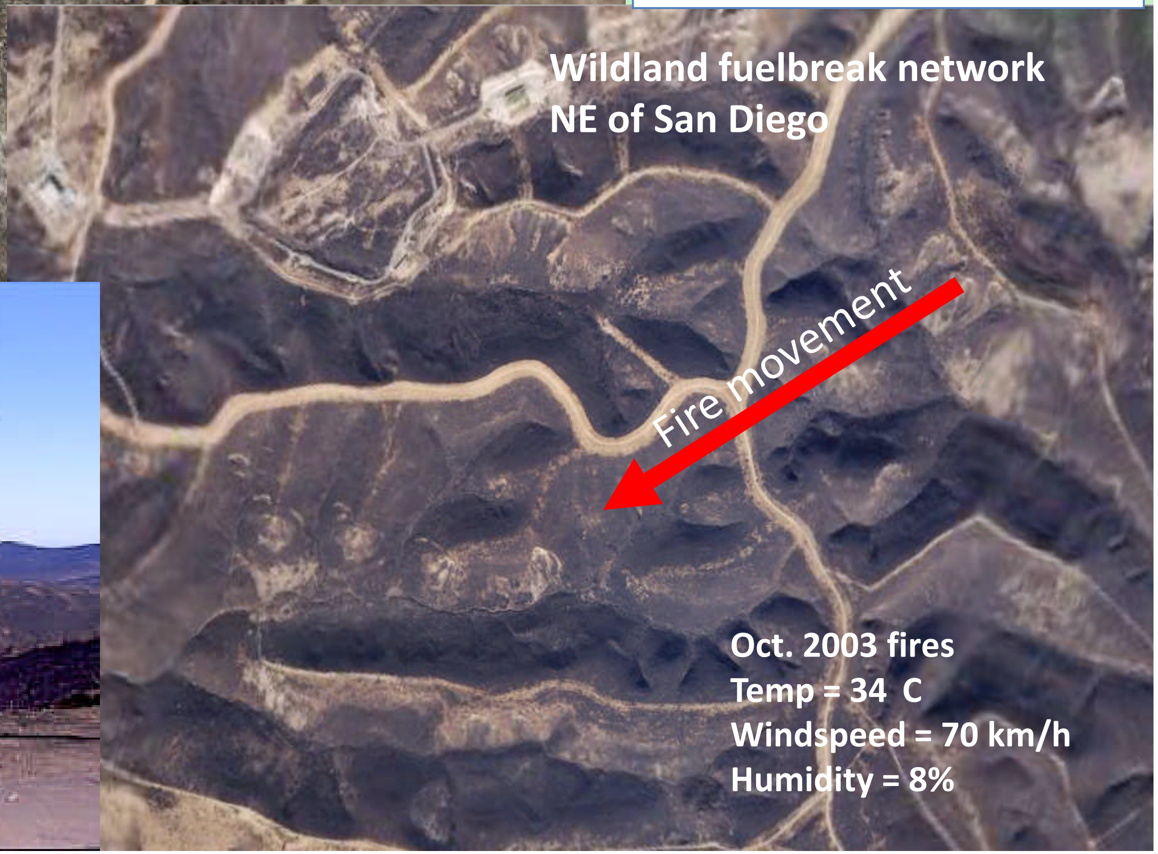
Percent of study area in soil slips after heavy rainfall and soil saturation. “Grass” = area of chaparral converted through fire and herbicide; “shrub” = adjacent chaparral stands six years after fire (~65% cover)

Hill and Rice. 1966. *Jour. Range Mgt.*

Fuel treatments and human values at risk

Under severe conditions in dense fuels, wildland fuel-breaks do not stop or (appreciably) slow fire: must be safely accessible to fire fighters and near values at risk





Fuel treatments and natural values at risk

Strategic fuel reduction sometimes necessary to protect or restore habitat for plants/animals/ ecosystems that are sensitive to frequent fire: Degradation in one place to restore another

Conclusions

- With growing populations and warming climates, strategic fuel reduction is necessary for protection of certain values at risk, both human and natural

- Fuel reduction is relatively easy to align with restoration objectives in Fire Regime I
  - *Outcome leads toward desired ecological conditions*
  - *Spatial expansion of fuel reduction efforts ecologically recommendable*
  - *Successful restoration typically requires reintroduction of fire*

- Fuel reduction difficult to align with restoration objectives in Fire Regime IV (or V)
  - *Outcome leads away from desired ecological conditions*
  - *Fuel reduction efforts should be done carefully and sparingly, in strategically justified locations and conditions*
  - *Successful restoration often requires reduction of fire frequency*

Final slide

- Fire Regime I forests ≠ Fire Regime IV shrublands
    - *Different ecosystems, different relationship with fire, different management tactics are required*
- Biggest ecological issue in southern California wildlands is *too much* fire
    - *There is an overabundance of early seral vegetation on SoCal landscapes*
    - *Large scale prescribed fire use further increases fire frequency and abundance of early seral vegetation*
- S. California is the most biodiverse part of the most biodiverse State in the union
    - *Wholesale type conversion of 1000's of mi^2 could have negative effects on species and ecosystem sustainability*
- Wildland fuel treatments cannot prevent repeats of 2003 and 2007
    - *Recent fuel treatment-climate change report from JFSP, and USFS fuel treatment decision support tool both explicitly recognize this*

Applications to Mt.Carmel

- Maquis and *P. halepensis* are adapted to Fire Regime IV; most oaks can tolerate frequent fire (FRs I and III)
- In ecosystems of FR IV, fuel breaks are unlikely to serve any "restorative" purpose (unless vegetation conversion is a goal): they are there principally to aid fire control
  - *Their contribution to restoration may be through the protection they afford ecosystems that are sensitive to fire*
  - *Breaks could also be used to promote oak woodlands, free of P. halepensis*
- Under conditions of drought and high wind, only safely defensible fuel breaks that are adjacent to values at risk will serve their purpose
  - *Wildland fuel breaks can serve to "compartmentalize" fires, but only under moderate conditions and when they can be accessed safely*
- Fuel break networks can be integrated into trail and park systems, but will need constant maintenance

Thank you