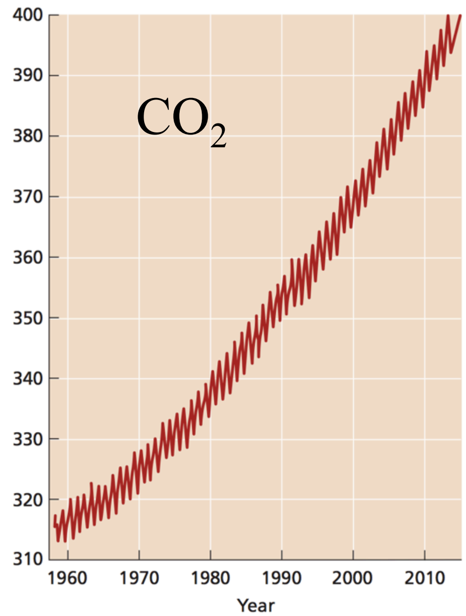


Climate warming today and tomorrow: fire ecology, phenology, drought stress, and changes in species distribution

Plant Ecology in a Changing World

Jim Ehleringer, University of Utah
http://plantecology.net

2015 Likely to Be Hottest Year Ever Recorded

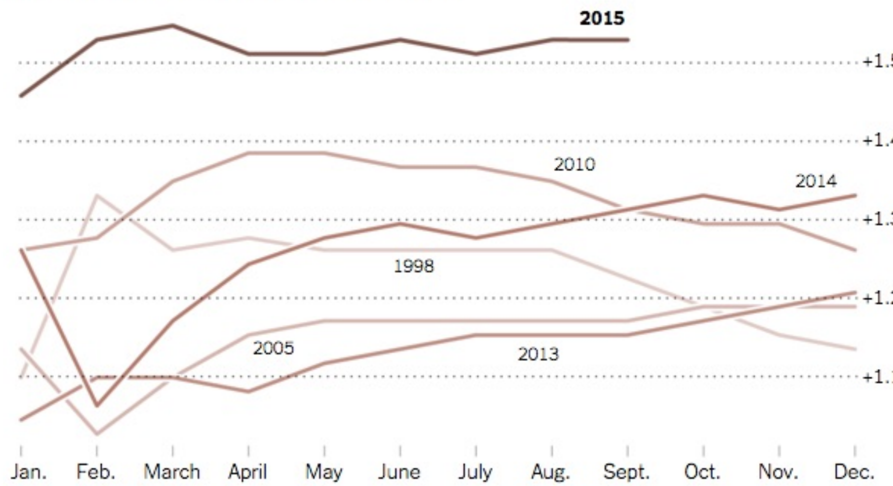
By JUSTIN GILLIS   OCT. 21, 2015

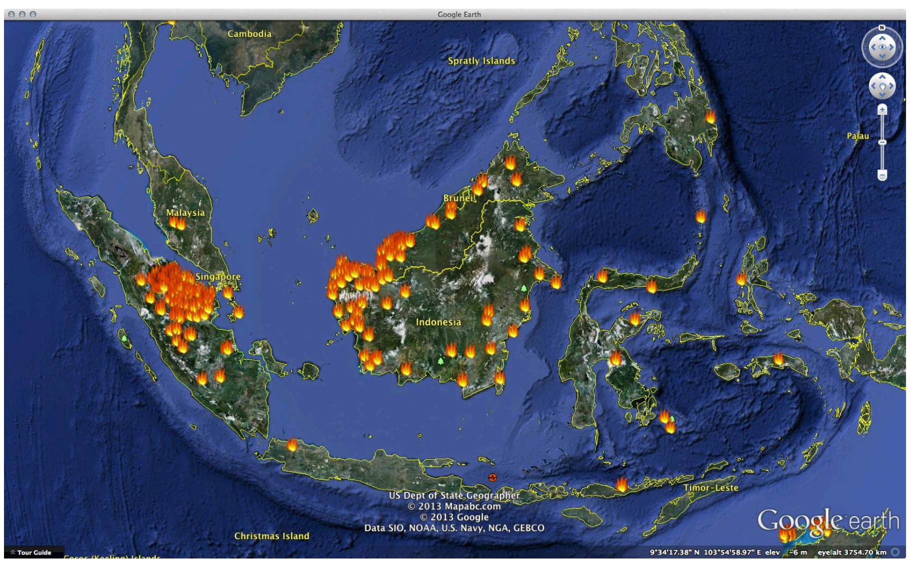
The first nine months of 2015 were the hottest since 1880. Clockwise from top left: a water spring north of Jerusalem; the boardwalk at Coney Island in New York City; a graveyard in Karachi, Pakistan; and a fountain in Madrid.
Clockwise from top left: Abir Sultan/European Pressphoto Agency; Spencer Platt, via Getty Images; Akhtar Soomro, via Reuters; Emilio Naranjo, via European Pressphoto Agency

Tracking Temperature

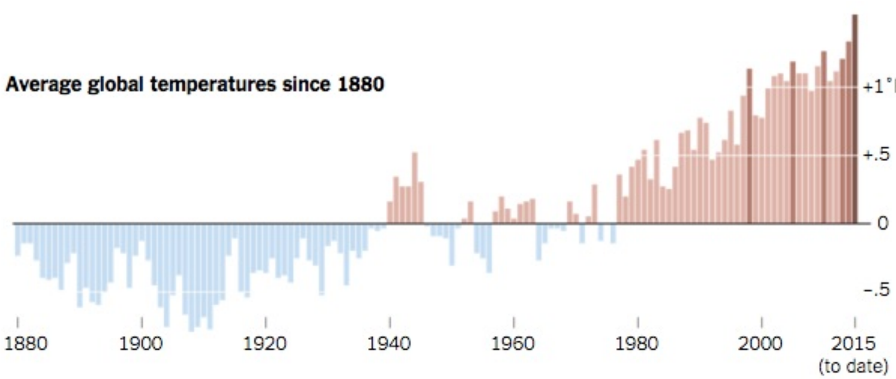
This year will almost certainly be the warmest year in recorded history.

How 2015 compares to five of the hottest years





Average global temperatures since 1880



Temperatures relative to the 20th century average.

Source: National Oceanic and Atmospheric Administration

By The New York Times


Part 1:
Plants in many biomes have features to ensure persistence following natural fire cycle events

Fire – lightning ignition as a natural landscape feature

Fire as a natural factor on the landscape (<u>understory</u> versus <u>replacement</u> fires)

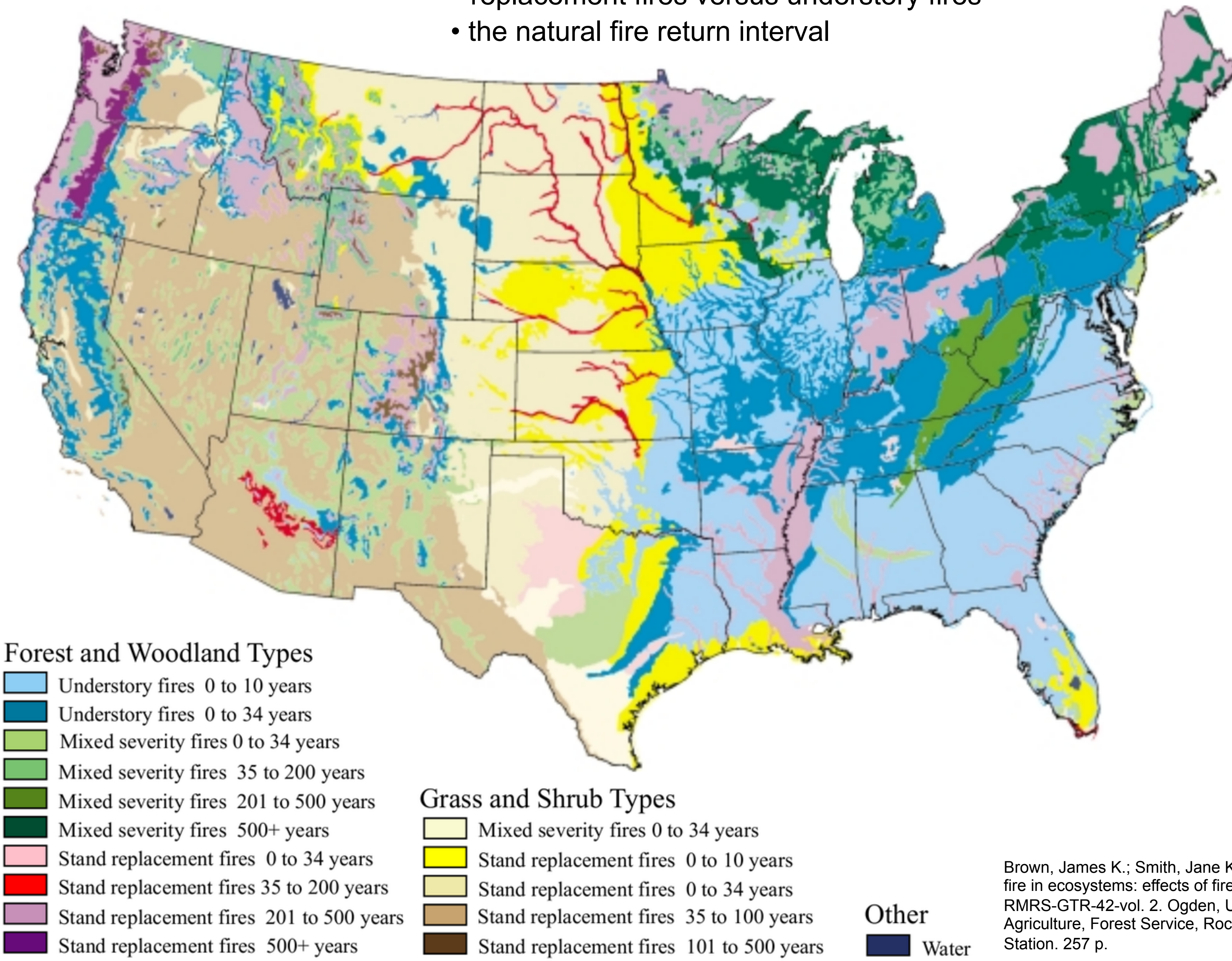
- Chaparral and Mediterranean climates
  - stump sprouting
- Interior North American coniferous forests and other arid woodlands (e.g., *Banksia*)
  - serotinous cones
  - thick bark (e.g., redwoods, sequoia, ponderosa pine)
- Savannahs
  - thick bark
- Prairies across North America

Some of the new ways in which fire is altering the landscape

- Invasive species (e.g., cheatgrass)
- Urban-wildland interfaces
- Forest fire prevention policies
  - understory buildup
  - conversion of sagebrush shrubland to juniper woodland

Key concepts:

- replacement fires versus understory fires
- the natural fire return interval



Brown, James K.; Smith, Jane Kapler, eds. 2000. Wildla
fire in ecosystems: effects of fire on flora. Gen. Tech. Re
RMRS-GTR-42-vol. 2. Ogden, UT: U.S. Department of
Agriculture, Forest Service, Rocky Mountain Research
Station. 257 p.

Basal resprouting following chaparral fires (stump sprouters, carbon reserves in burls)

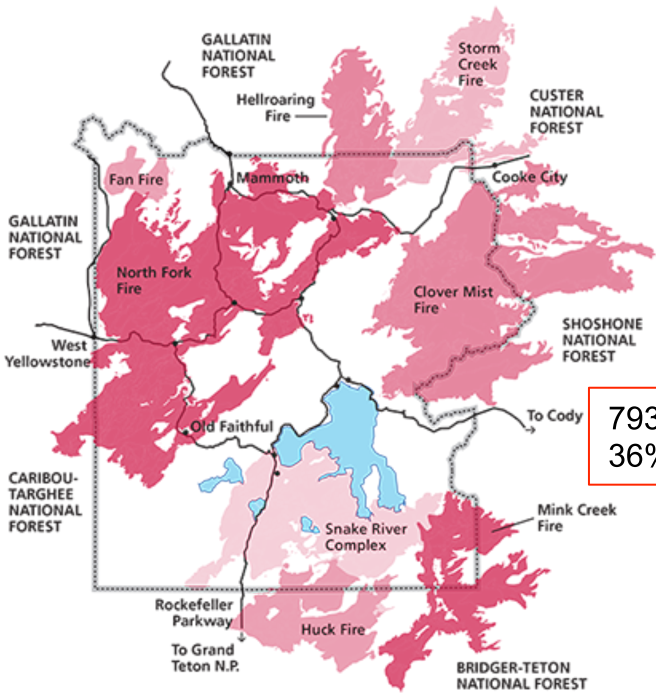
https://en.wikipedia.org/wiki/California_chaparral_and_woodlands#/media/File:Chaparral1.jpg

http://www.geolobo.com/?p=464

http://home.sandiego.edu/~pkemp/Bio112-Chaparral.html

Pinus contorta (lodgepole pine) and the Yellowstone fire of 1988

NPS Photo



793,880 acres
36% of the park

http://www.nps.gov/yell/learn/nature/images/1988FireMap_1.png

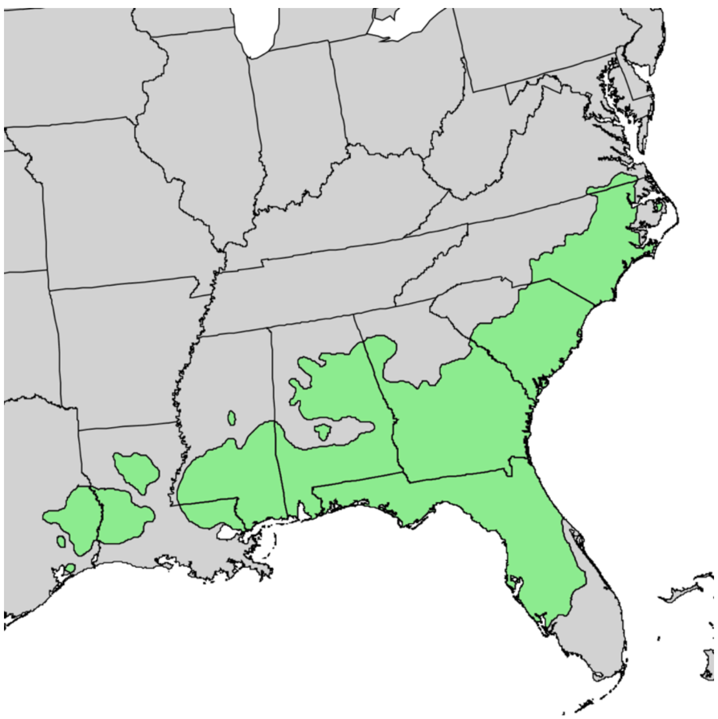
http://www.greater-yellowstone.com/graphics/Yellowstone-Fire/fire-old-faithul.jpg

serotinous cones

seedling establishment following 1988 fire

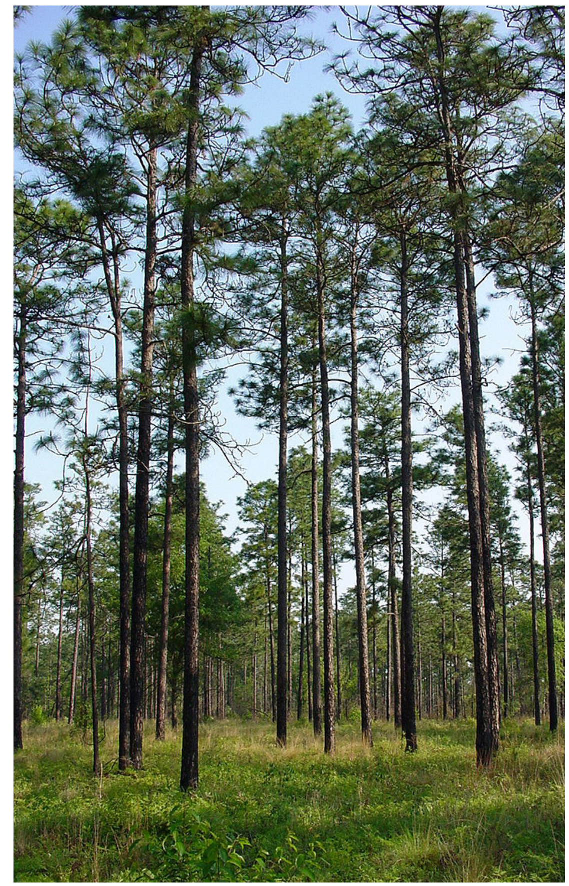
https://en.wikipedia.org/wiki/Pinus_contorta

Longleaf pine savannahs of the southeastern United States burn naturally at decadal intervals



sensitive juvenile stage

mature adult stage



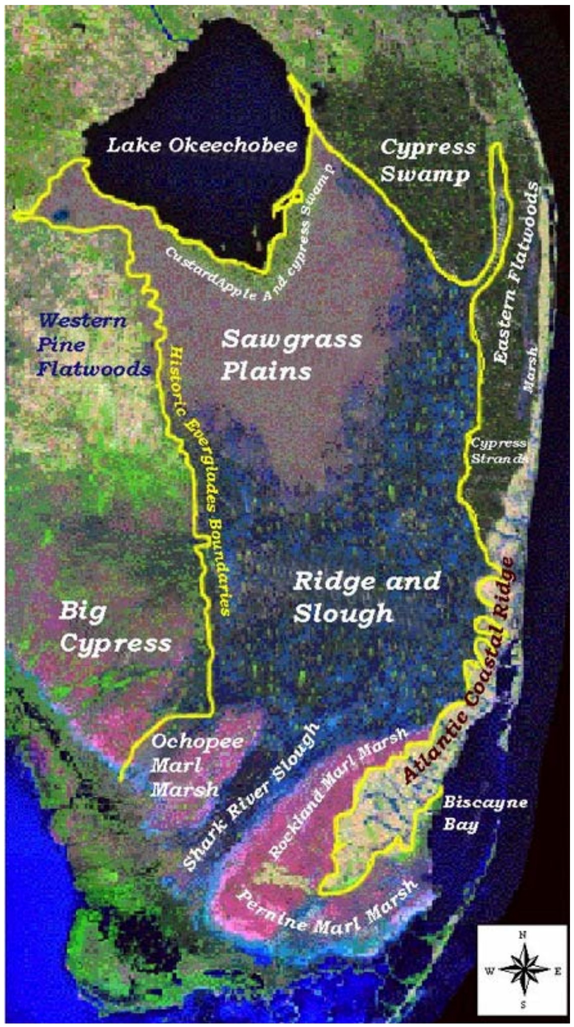
With fire prevention, shrub densities become high enough to cause crown fires

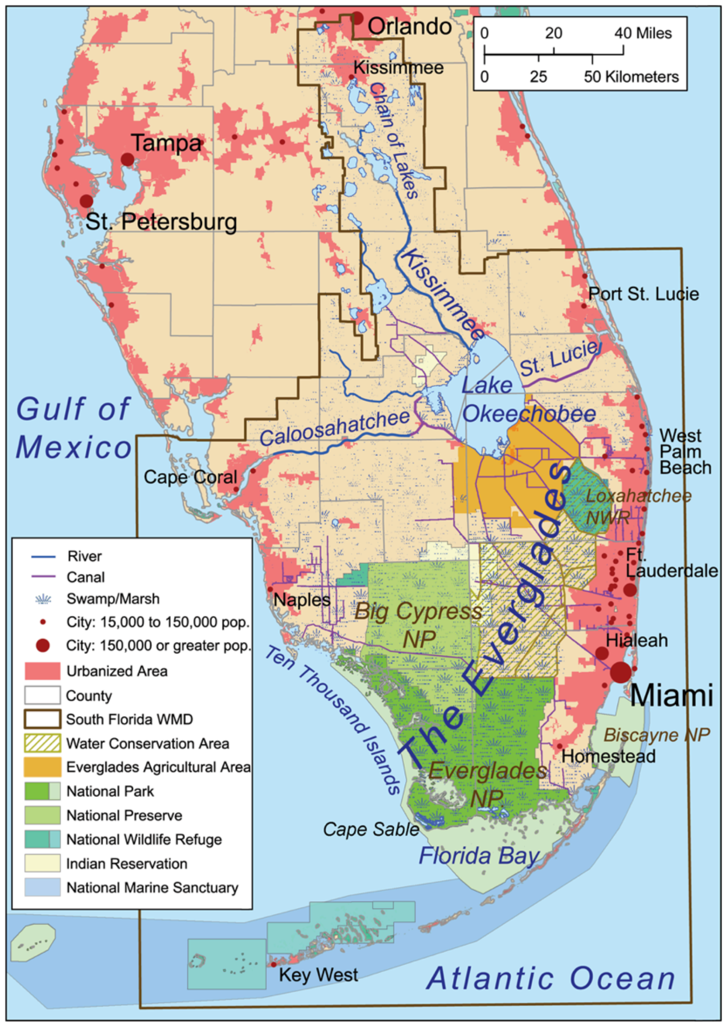

Naturally regenerating longleaf pines in DeSoto National Forest, Mississippi

Florida everglades

Succession without fire

sawgrass prairie → pine woodland → hardwood hammock





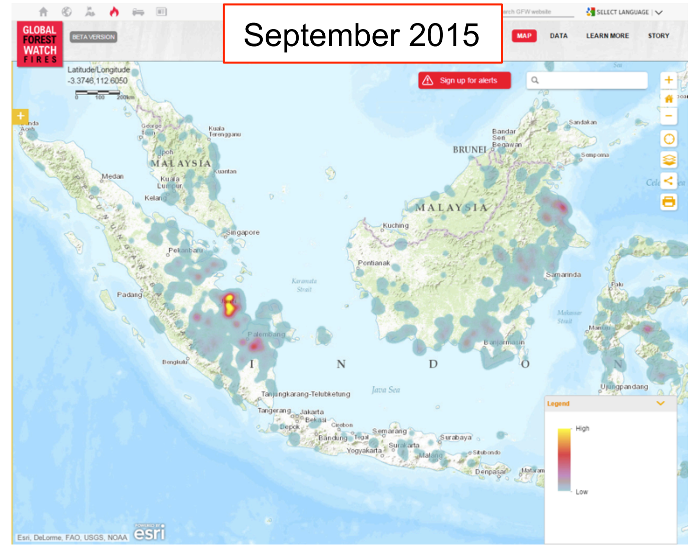
Everglades prairies

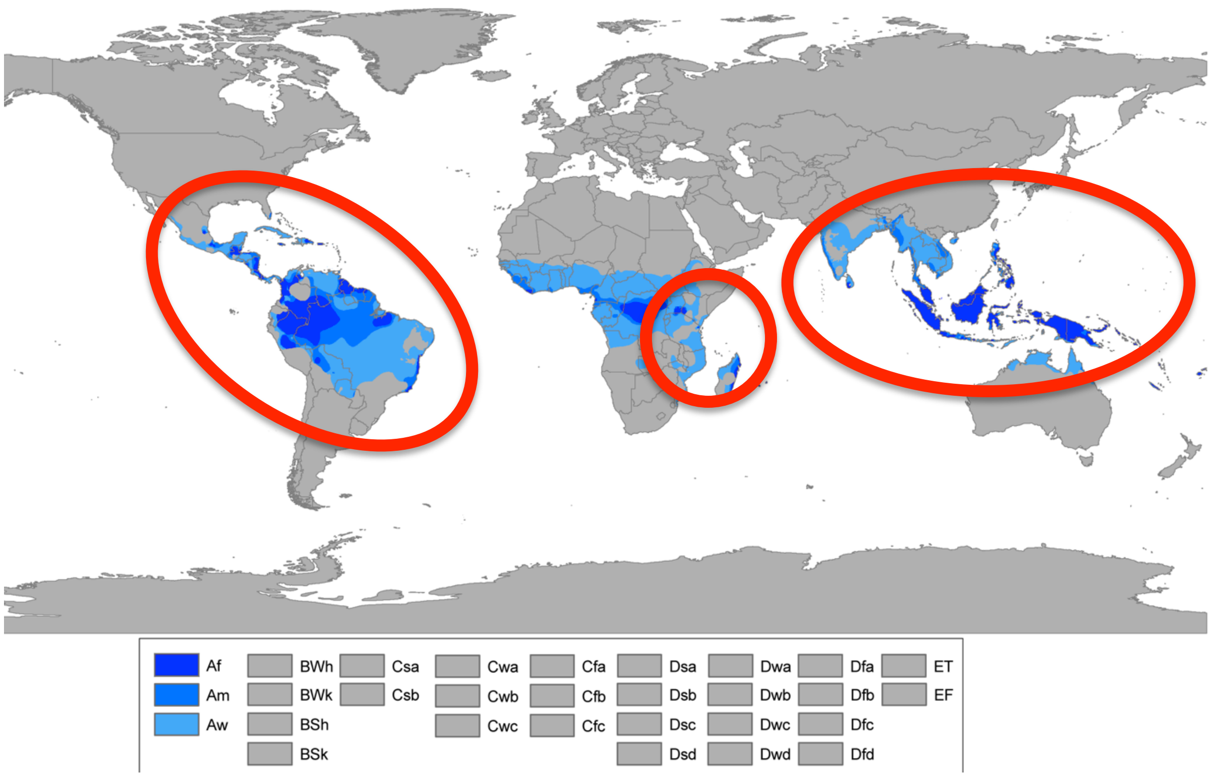
both prairie and pine woodlands
naturally burn frequently,
especially during La Niña

Cladium (sawgrass) wet prairie

Sabal (palmetto) dry prairie

El Niño events increase the probability of fires in the tropics



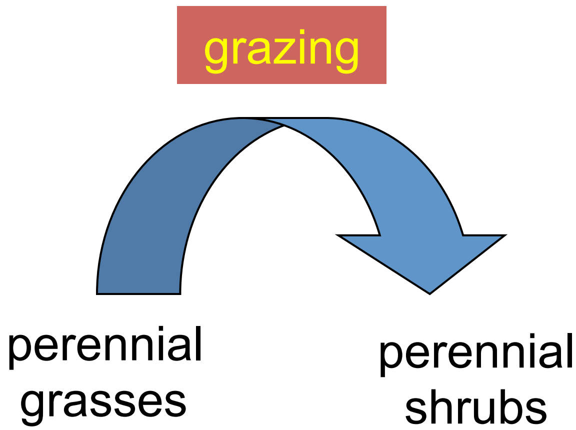



Part 2:
Human have impacted natural fire cycles through fire-prevention management and introduction of invasive species

Many of the aridland ecosystems, especially west of Salt Lake Valley, experienced a transition from shrubland to annual grassland with the invasion of *Bromus tectorum* (cheatgrass)

The introduction of cows and sheep into Utah’s arid ecosystems resulted in

- shifts in species composition
- increases in fire frequency



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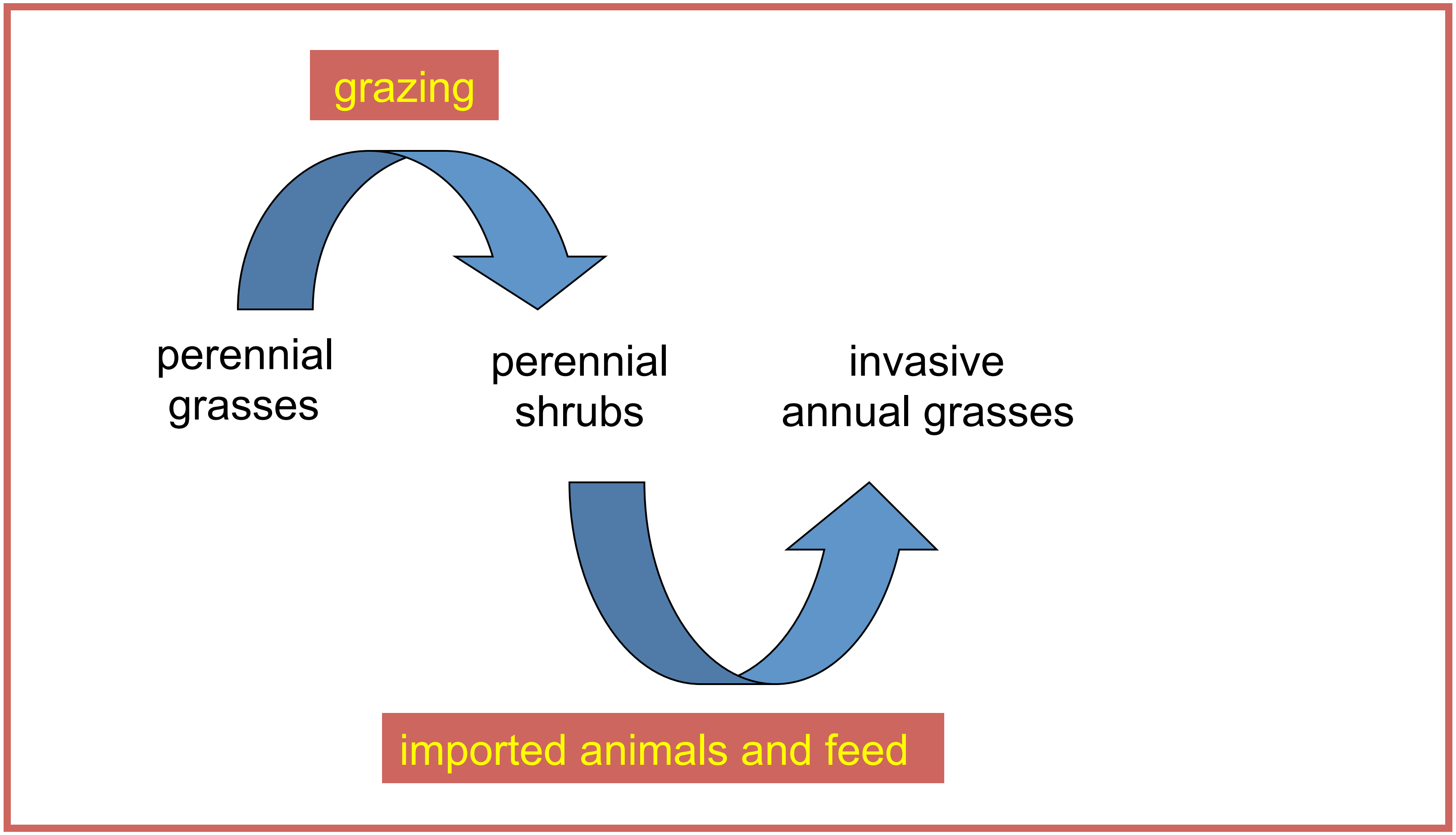

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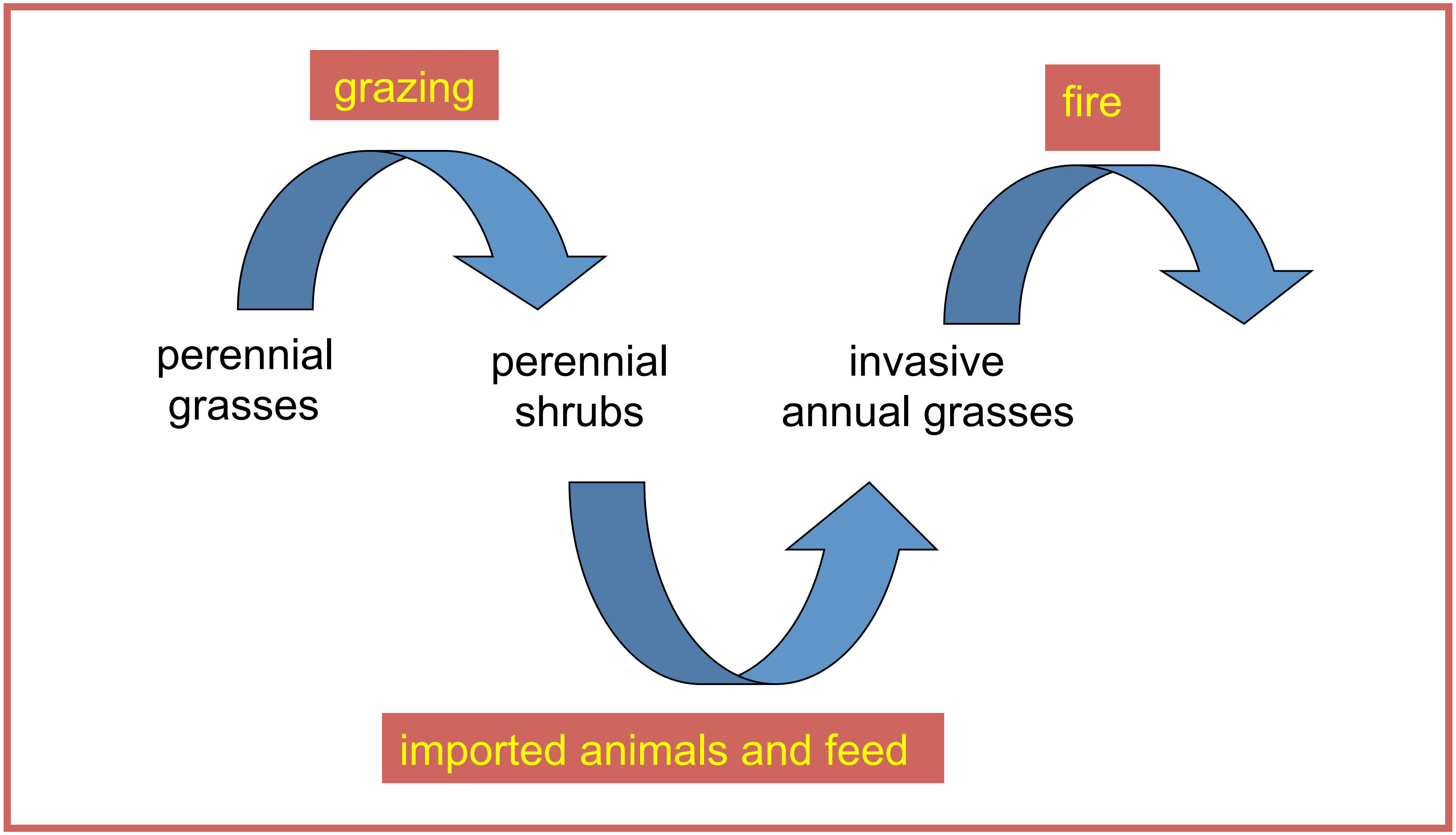

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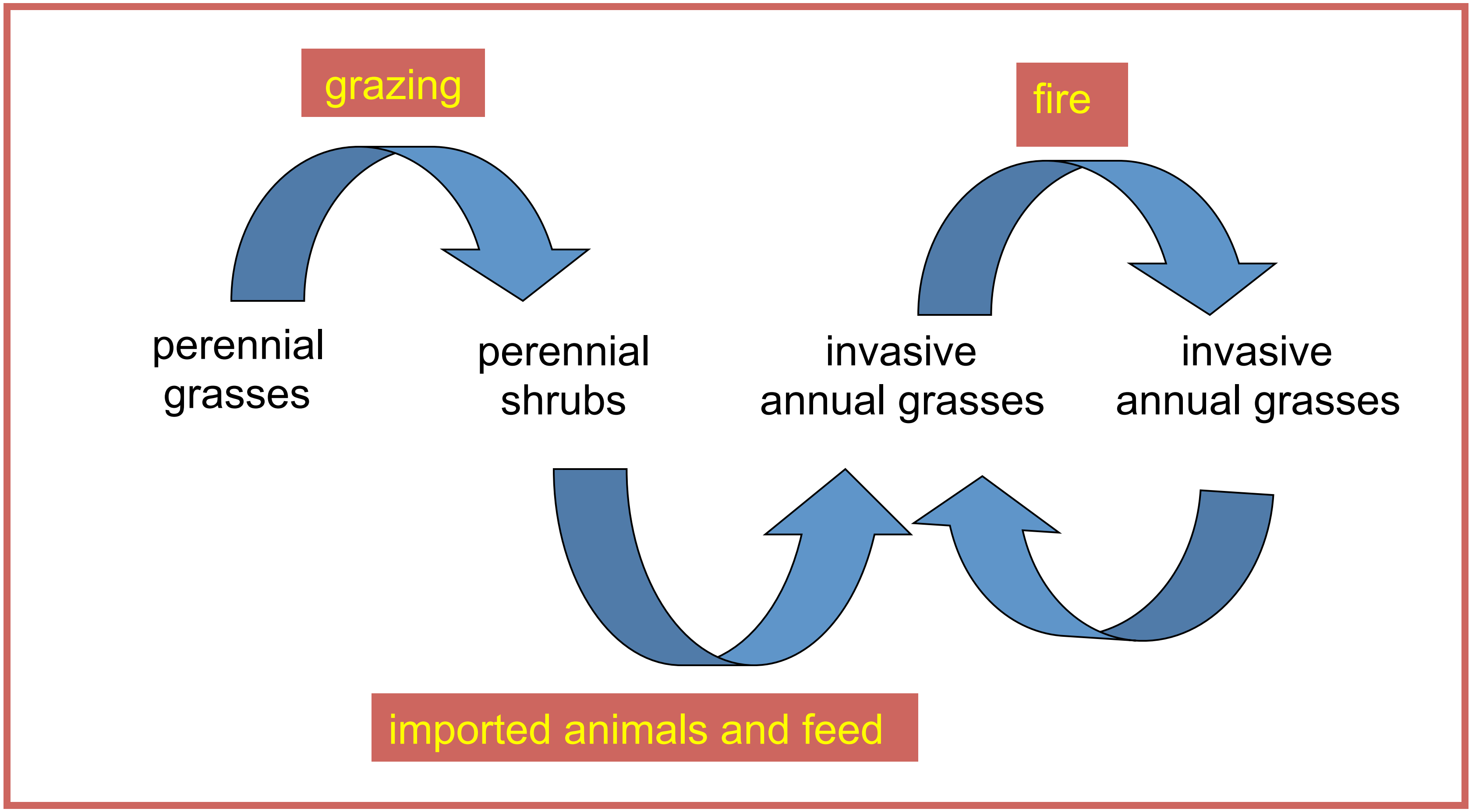
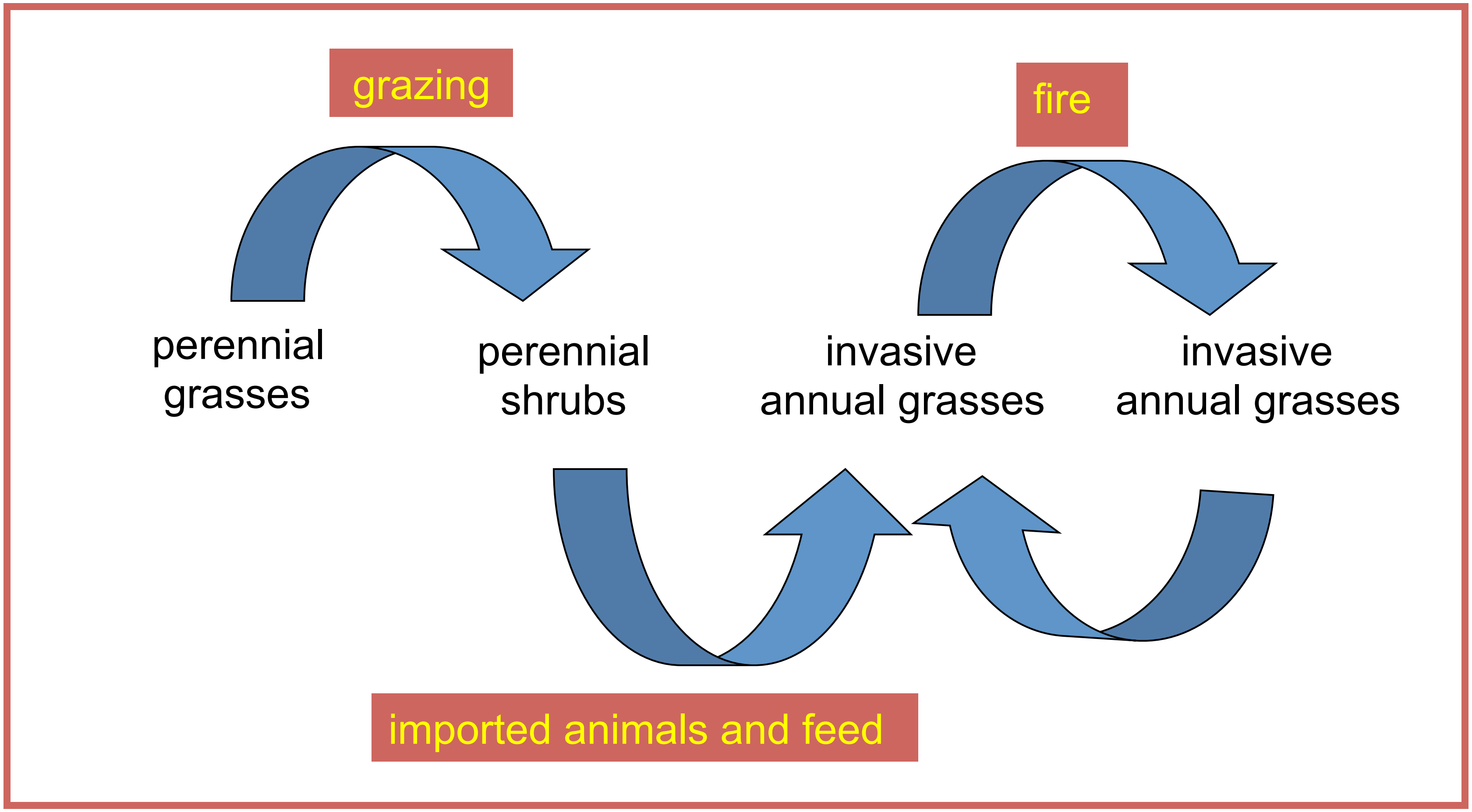


. . . but not all ecosystems have yet undergone the transition from shrubland into annual grassland

. . . this is what you or your children will likely see



Western US fires are becoming more frequent and larger

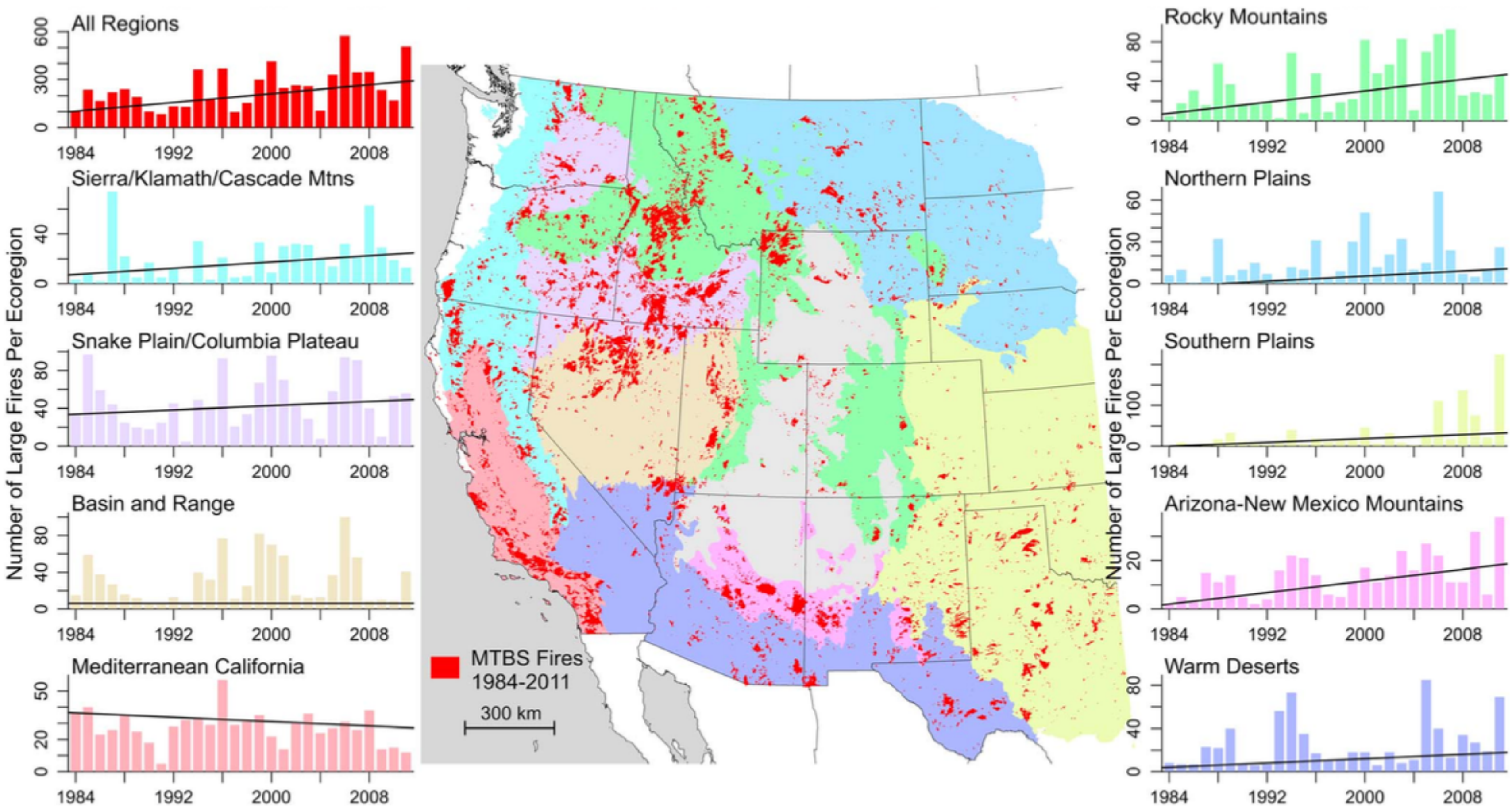
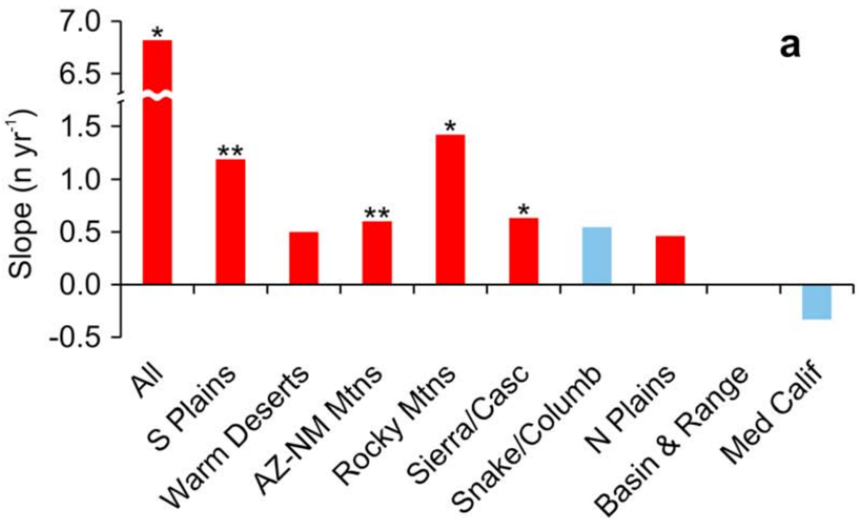


Figure 1. Western U.S. trends for number of large fires in each ecoregion per year. The center map illustrates ecoregions based on Levels II and III of the Omernik ecoregion system. The Wyoming Basin and Colorado Plateau ecoregions had too few large fires for trend analysis at the ecoregion level, and are shown in gray. MTBS-mapped fires are shown in red. The surrounding bar plots display the number of large fires in each ecoregion over the 1984–2011 study period. The black line on each plot indicates the Theil-Sen estimated slope for each ecoregion, with slope values and significance shown in Figure 2a.

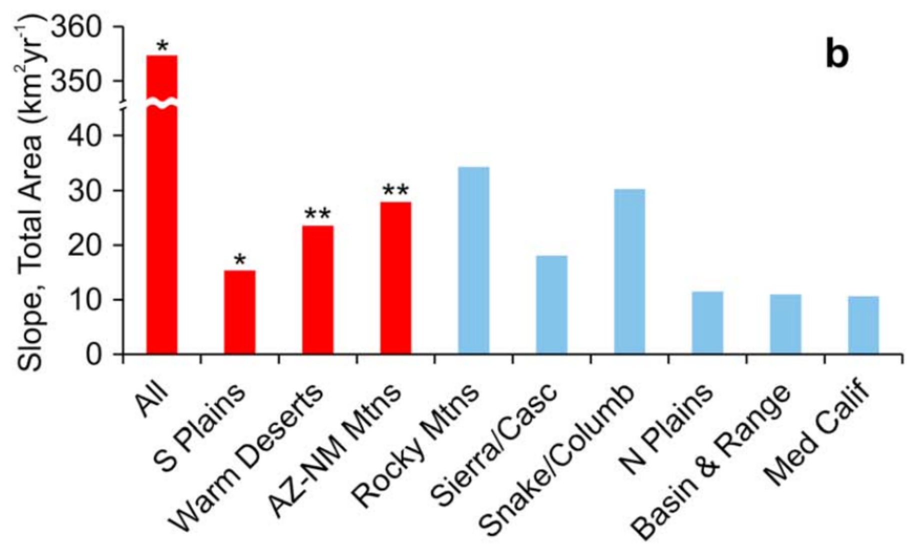
Dennison et al (2014)

Western US fires are becoming more frequent and larger

Fires are becoming more frequent
in all but Mediterranean climate regions



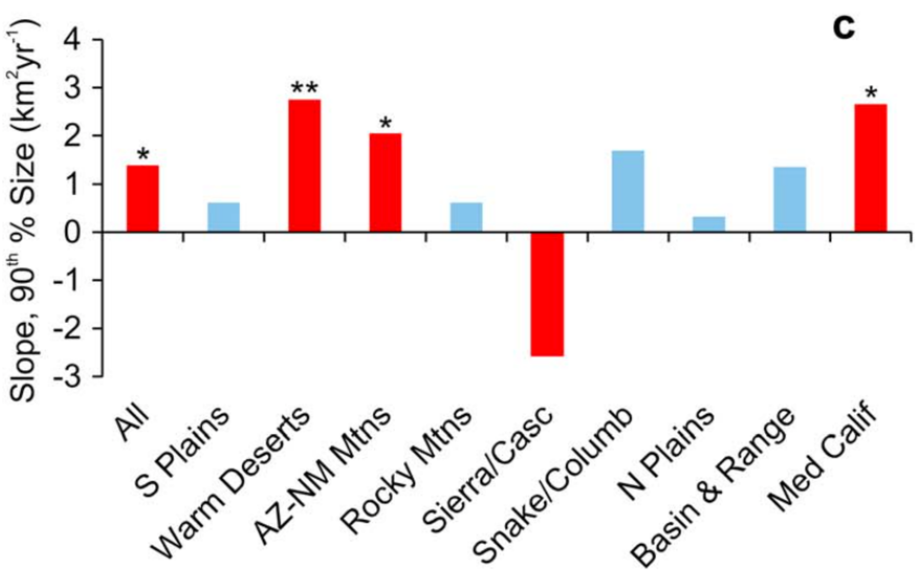
Fires are consuming more land area
per year in all regions



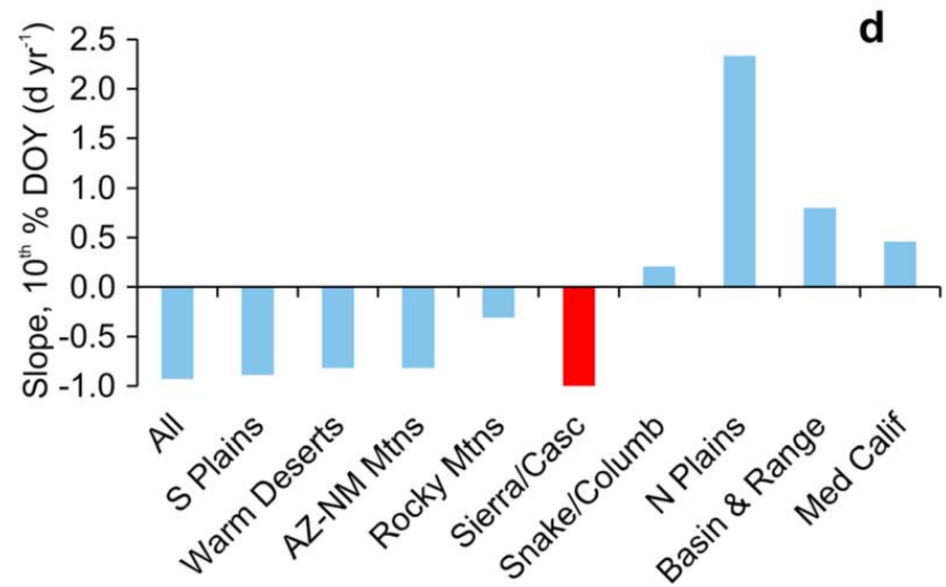
Dennison et al (2014)

Western US fires are becoming more frequent and larger

Fires are becoming more larger in 9 of 10 climate regions

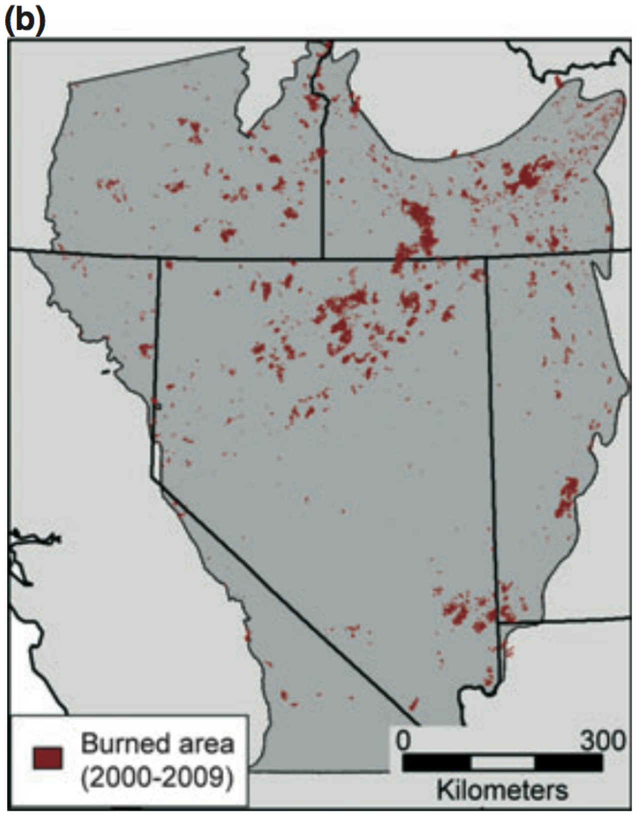


Fires are starting earlier and earlier in 6 of 10 climate regions



Dennison et al (2014)

Great Basin fires 2000-2009



Burned area from 2000 to 2009 recorded by MODIS.

Cheatgrass plant communities are more likely to burn than other intermountain plant communities. The probability of a fire occurring in any plant community appears to be increasing.

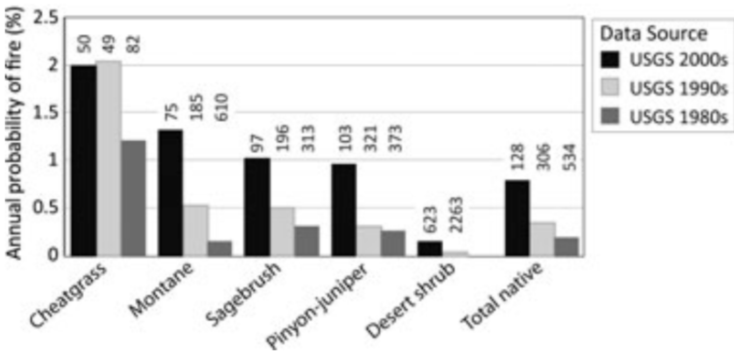


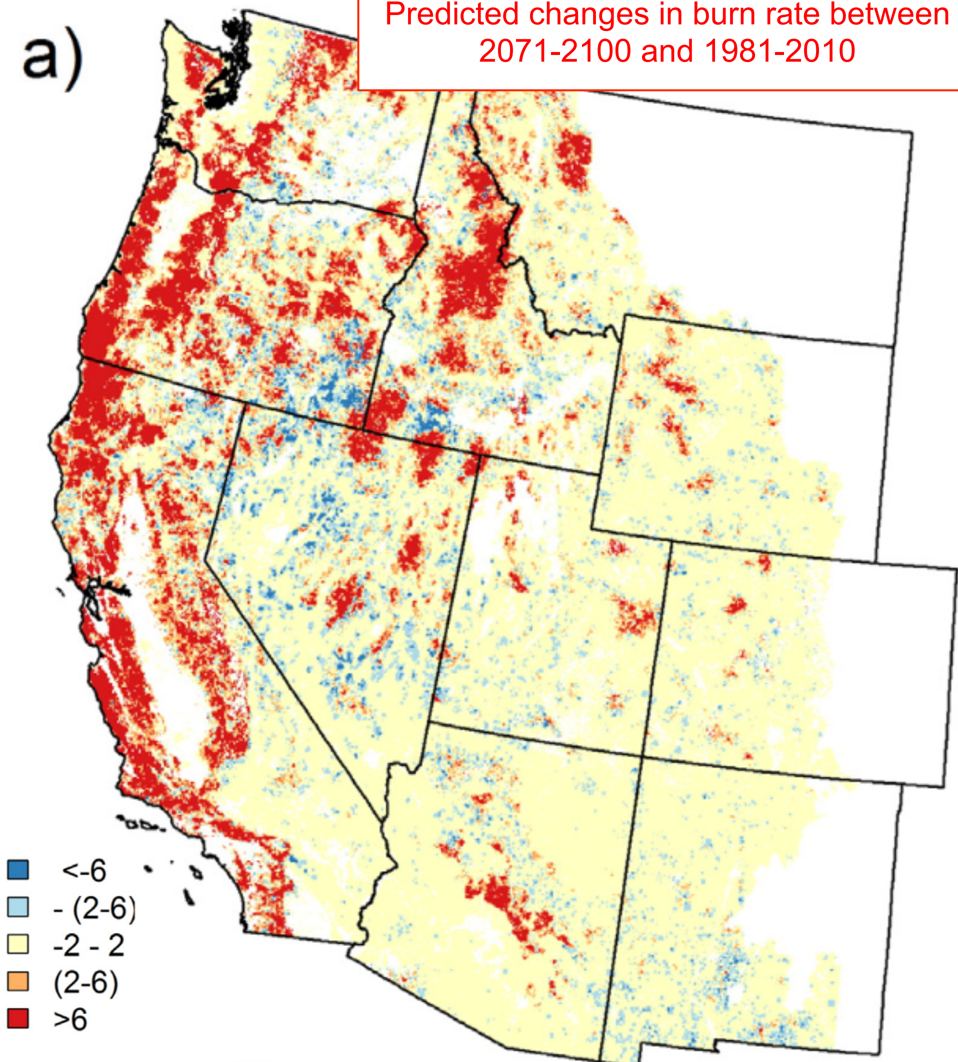
Fig. 3 Annual probability of fire by vegetation type, based on the USGS record 1980–2007. Corresponding FRI values are indicated above each bar.

Balch et al (2013)


Part 3:
Climate change is predicted to make western US ecosystems more fire sensitive

Increased future fire sensitivities are expected in the western United States

Predicted changes in burn rate between 2071-2100 and 1981-2010



Burn rate – defined as the expected number of firs in a 500-year interval.

Which vegetation types are projected to be the most sensitive to future fire changes in the western United States?

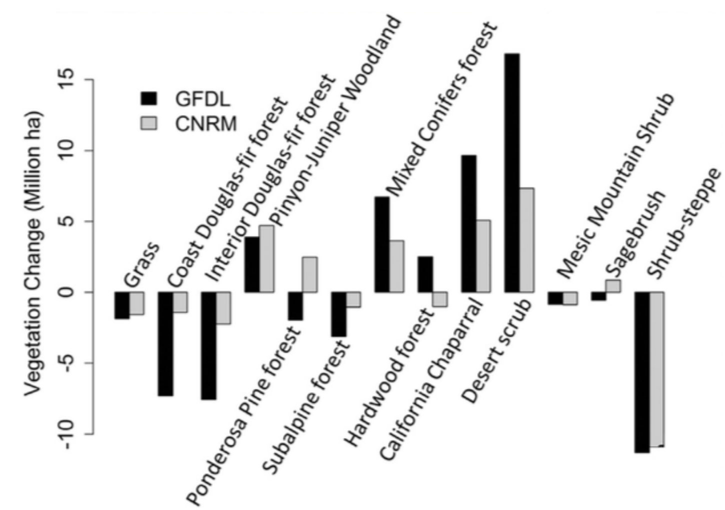


Fig. 4. Projected vegetation type change from historical (1981–2010) to future (2071–2100) time periods under Geophysical Fluid Dynamics Laboratory (GFDL) CM 2.1 and Centre National de Recherches Météorologiques (CNRM) CM 3.0 climate models.

Z. Liu, M.C. Wimberly / Science of the Total Environment 542 (2016) 65–75


Part 4:
Climate change will have temperature related impacts beyond the fire cycle
• increased fire frequencies andintensities
• accelerated phenology
• changes in plant distributions (upper and lower elevation/drought limits)

Global warming will have predictable impacts

Altering a plant's **thermal** regime (higher temperatures)
- Shifts in a plant's geographical range
- Shifts in plant phenology (e.g., earlier spring, developmental duration)
- Shifts in biotic interactions (e.g., herbivore, pollinator, pathogen)

Altering a plant's **hydrologic** regime
- Longer and more damaging fire seasons in arid regions
- Increased forest beetle impacts (winter kill)
- Drought-induced mortality in arid regions
- Increased precipitation in humid regions

Climate impacts
- Increased interannual variability (e.g., ENSO events)
- Intensification of weather events (e.g., flooding, droughts)