Perturbations in Fire-Prone Ecosystems Resulting in Exotic Plant Invasions

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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
**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*
Extent to which 20\textsuperscript{th} & 21\textsuperscript{st} century fires have burned at frequencies similar to pre-Euroamerican settlement

**Perturbations**

- **Southern CA** (hi frequency shorter intervals)
- **Northern CA** (low frequency longer intervals)

Mean PFRID:
- -100 to -65
- -65 to -60
- -60 to -51
- -51 to -34
- -34 to -17
- -17 to 0
- 0 to 17
- 17 to 34
- 34 to 61
- 61 to 68
- 68 to 65
- 65 to 100

(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
high severity
crown fires
30 – 130 yr intervals
Recovery from soil stored
seeds and resprouts

Keeley et al. (2007)

Syphard, Brennan & Keeley (2012)
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.
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-disequilibrium 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
The archeological record in San Diego County has over 11,000 Indian sites documented, and the widespread dispersion of human activity is illustrated by the fact that these sites occurred within all 32 USGS 7.5 min quadrangles studied by Christenson (1990) and on all 59 soil types present within the Kumeyaay (= Diegueño) territory.
California chaparral

Crown-fire regime perturbed by high fire frequency

soil-stored seed banks

Yellowstone lodgepole

Crown-fire regime perturbed by high fire frequency

aerial seed bank

North Fork Fire 1988

Laguna Fire 1970

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

Switching from surface to crown fires

jeopardizing natural regeneration
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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
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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.

Cheatgrass has changed fuel continuity affecting patch size of unburned sage scrub thus altering meta-population dynamics leading to type conversion to grassland.

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Photo: JE Keeley