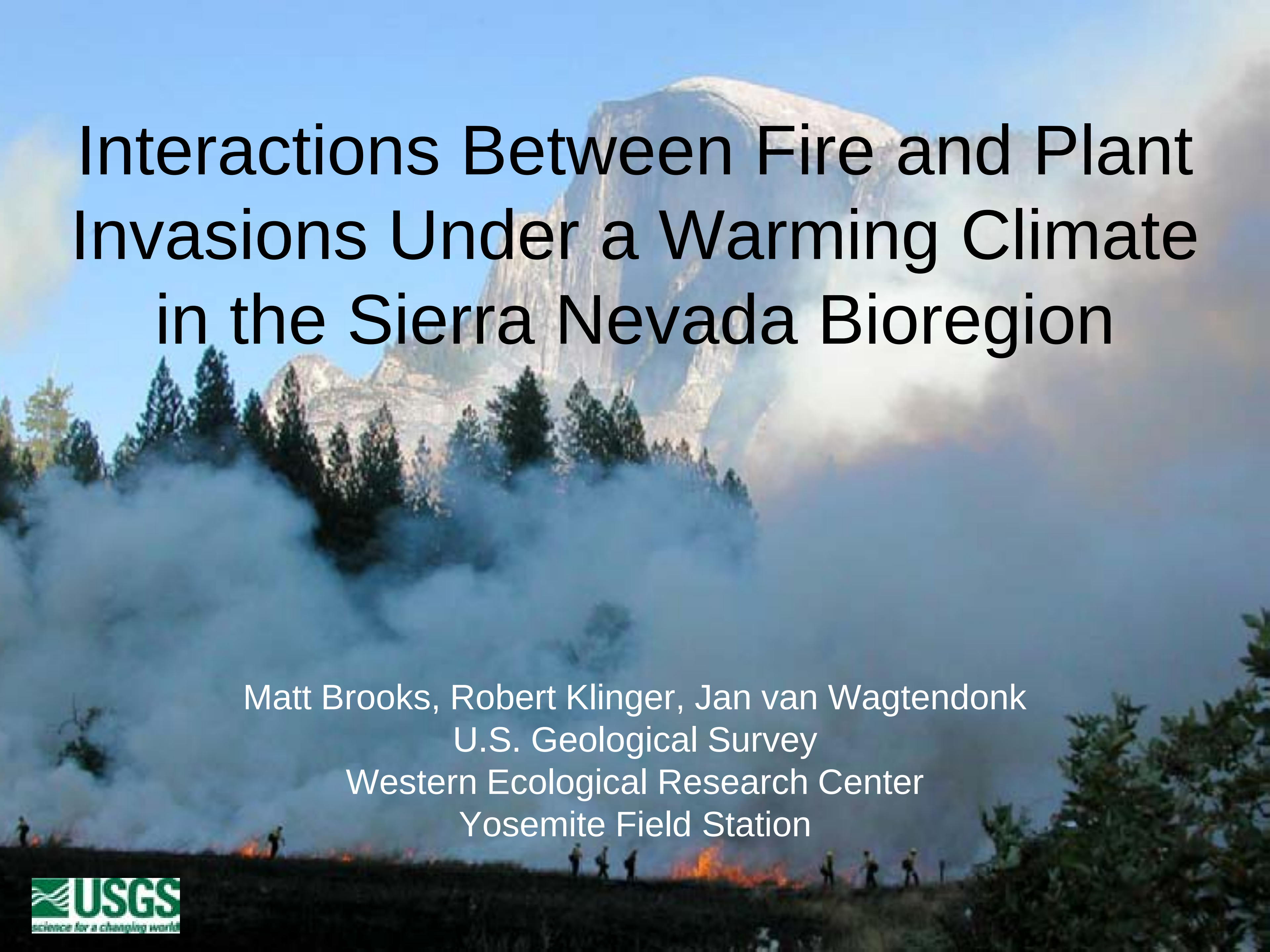

Interactions Between Fire and Plant Invasions Under a Warming Climate in the Sierra Nevada Bioregion

Matt Brooks, Robert Klinger, Jan van Wagtendonk
U.S. Geological Survey
Western Ecological Research Center
Yosemite Field Station

USGS
science for a changing world

Presentation Outline

- Conceptual framework for climate x fire x invasive plant interactions
- Variation among multiple invaders and over time
- Collective implications of a warming climate
- Ways to potentially get ahead of the curve

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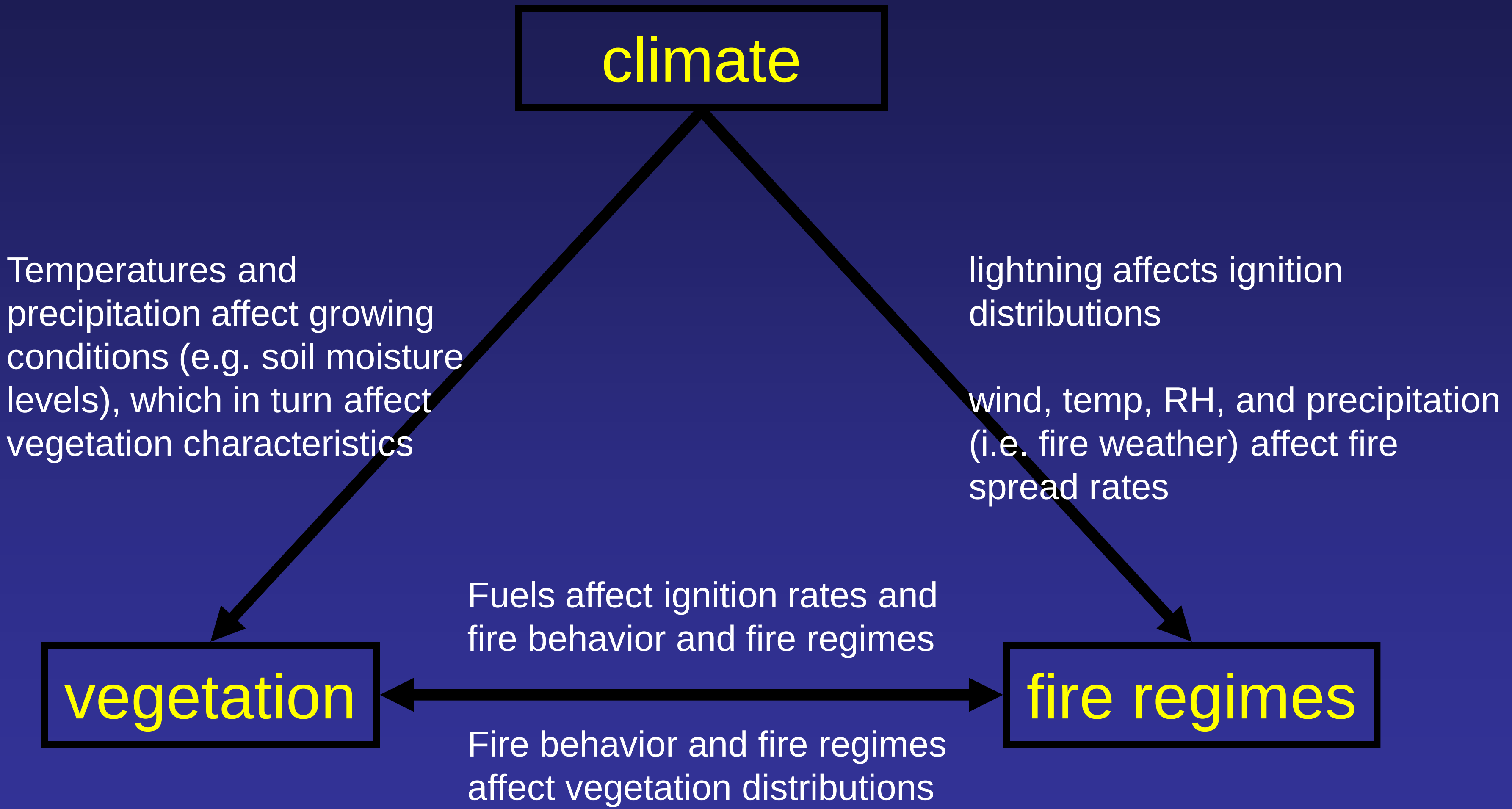
The Fire/Climate Triangle



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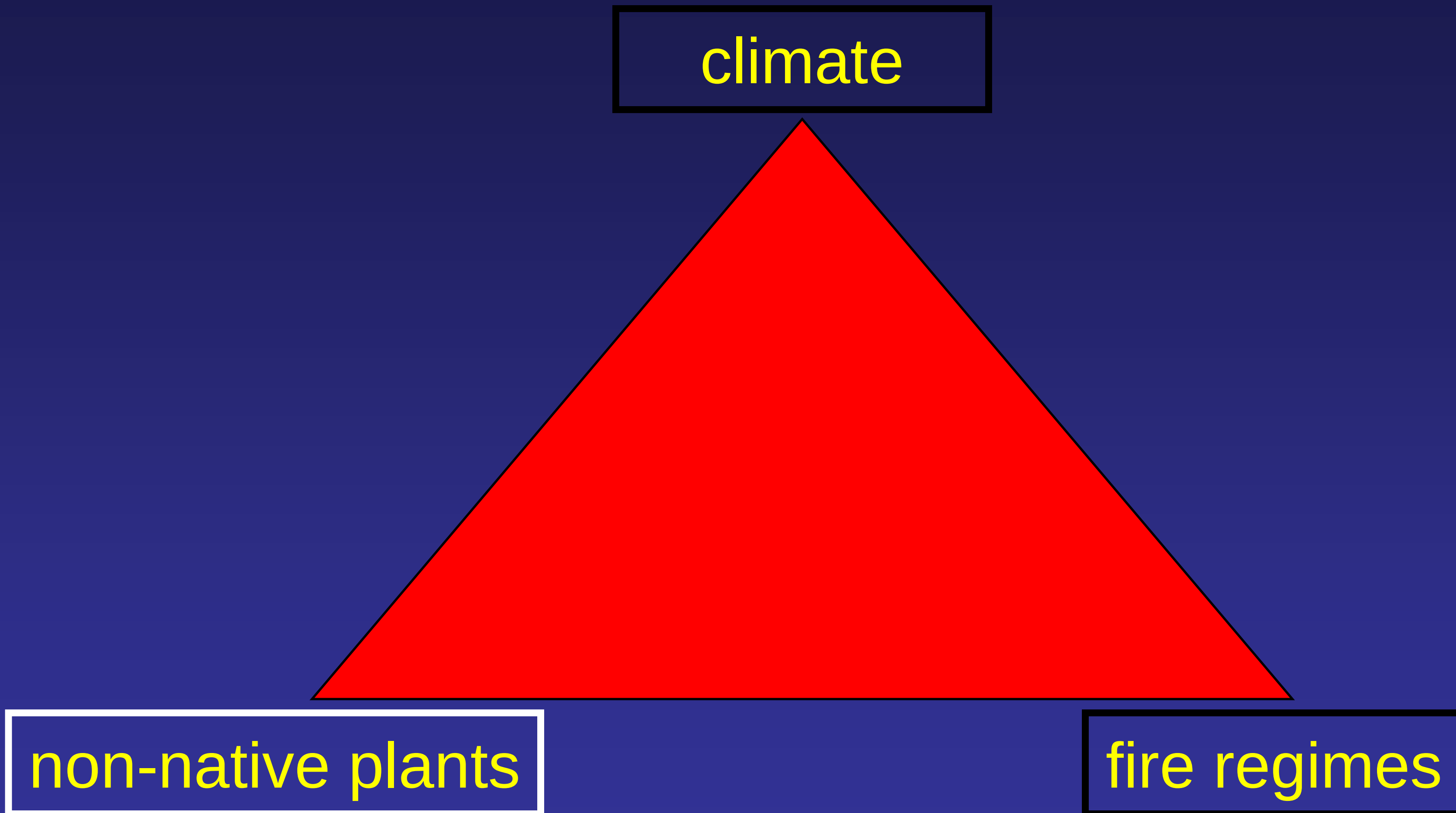
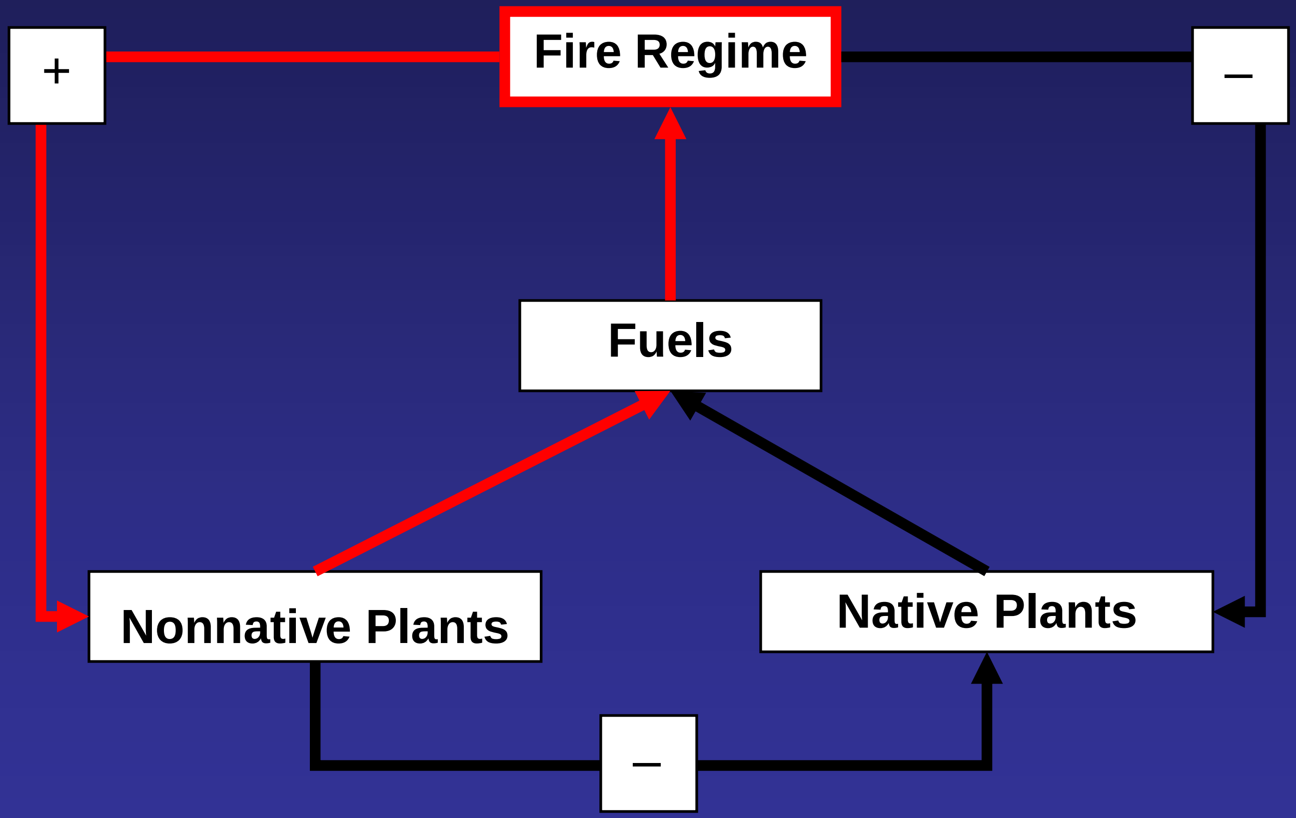
A Fire Triangle For The Modern Era?



Invasive Plant / Fire Regime Cycle



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Brooks et al. 2004

The Invasive Plant / Fire Regime Cycle is Influence by Many Interacting Factors

- Climate
- Vegetation (native and non-native)
- Fire regimes
- Climate x vegetation
- Climate x fire regimes
- Vegetation x fire regimes
- Climate x vegetation x fire regimes

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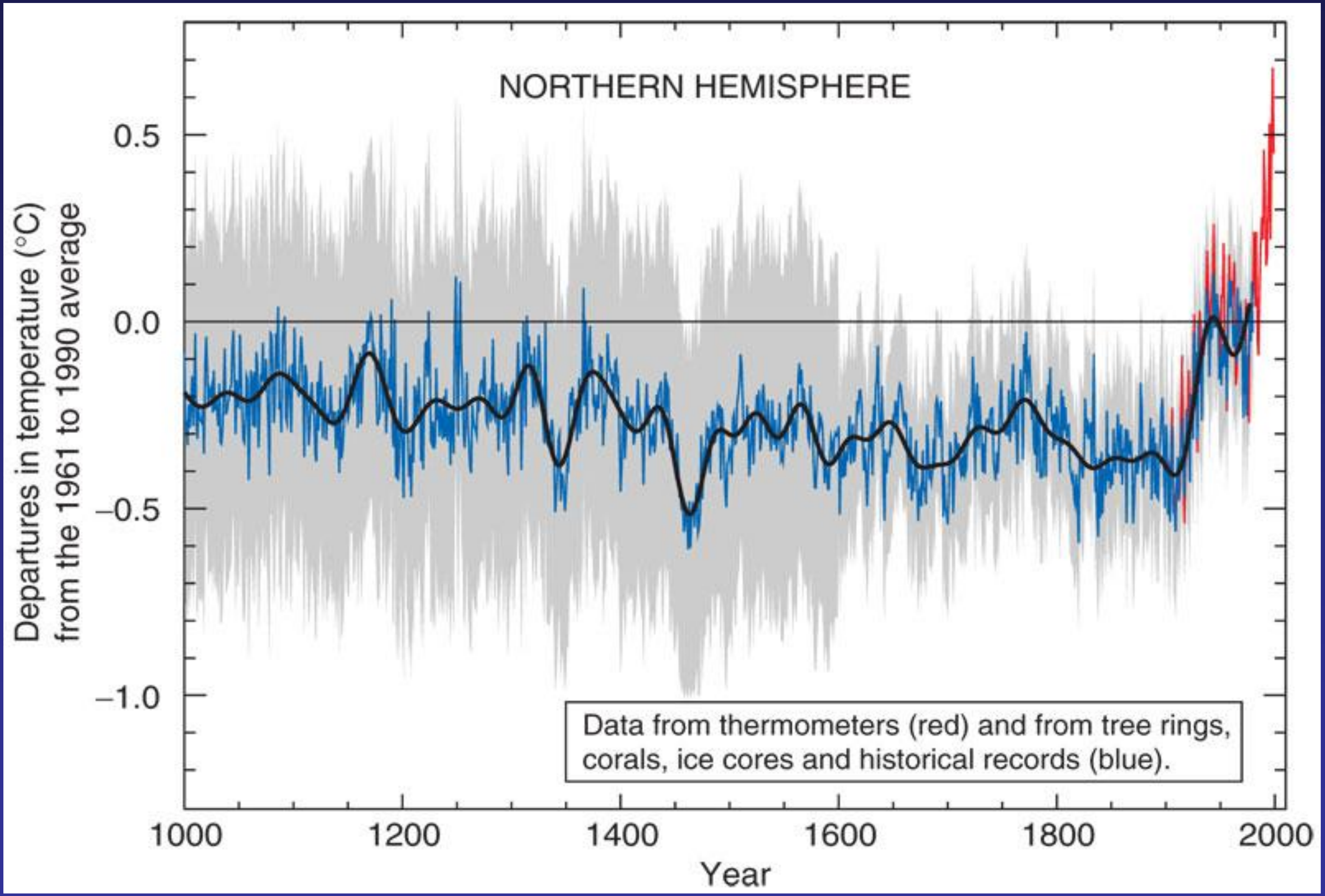
Climate



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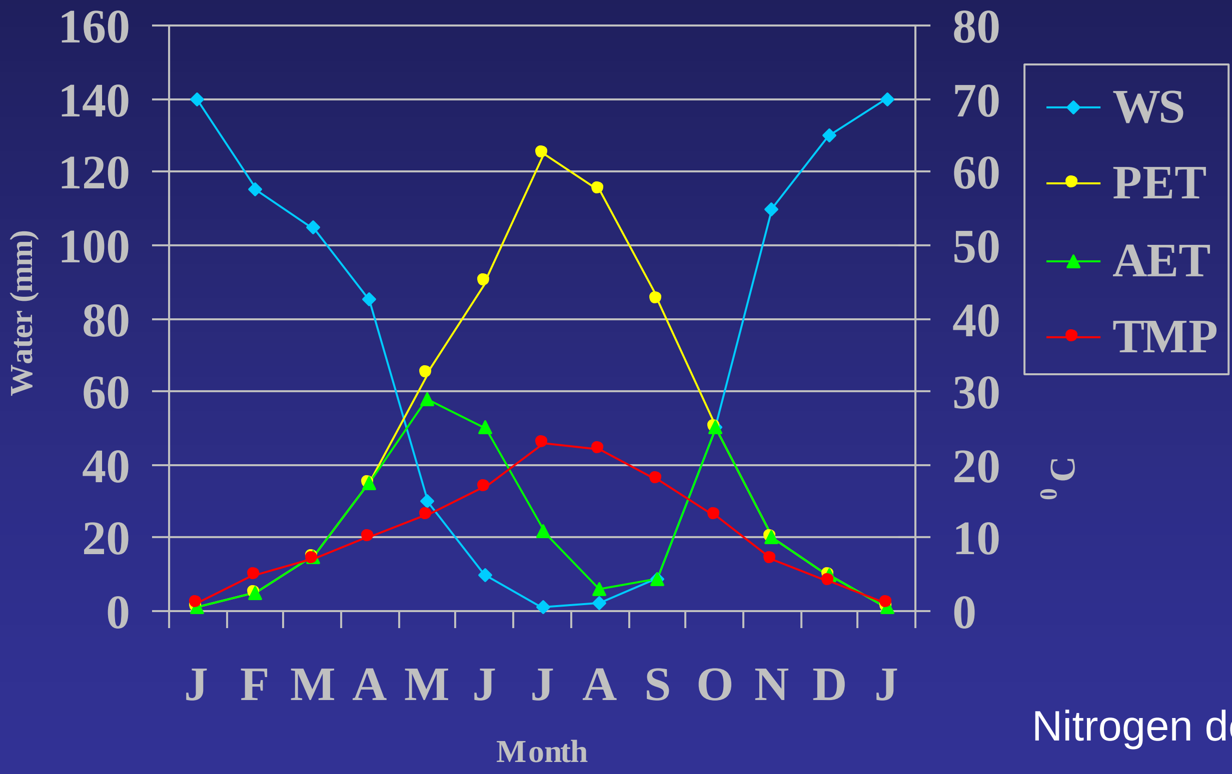
IPCC 2001

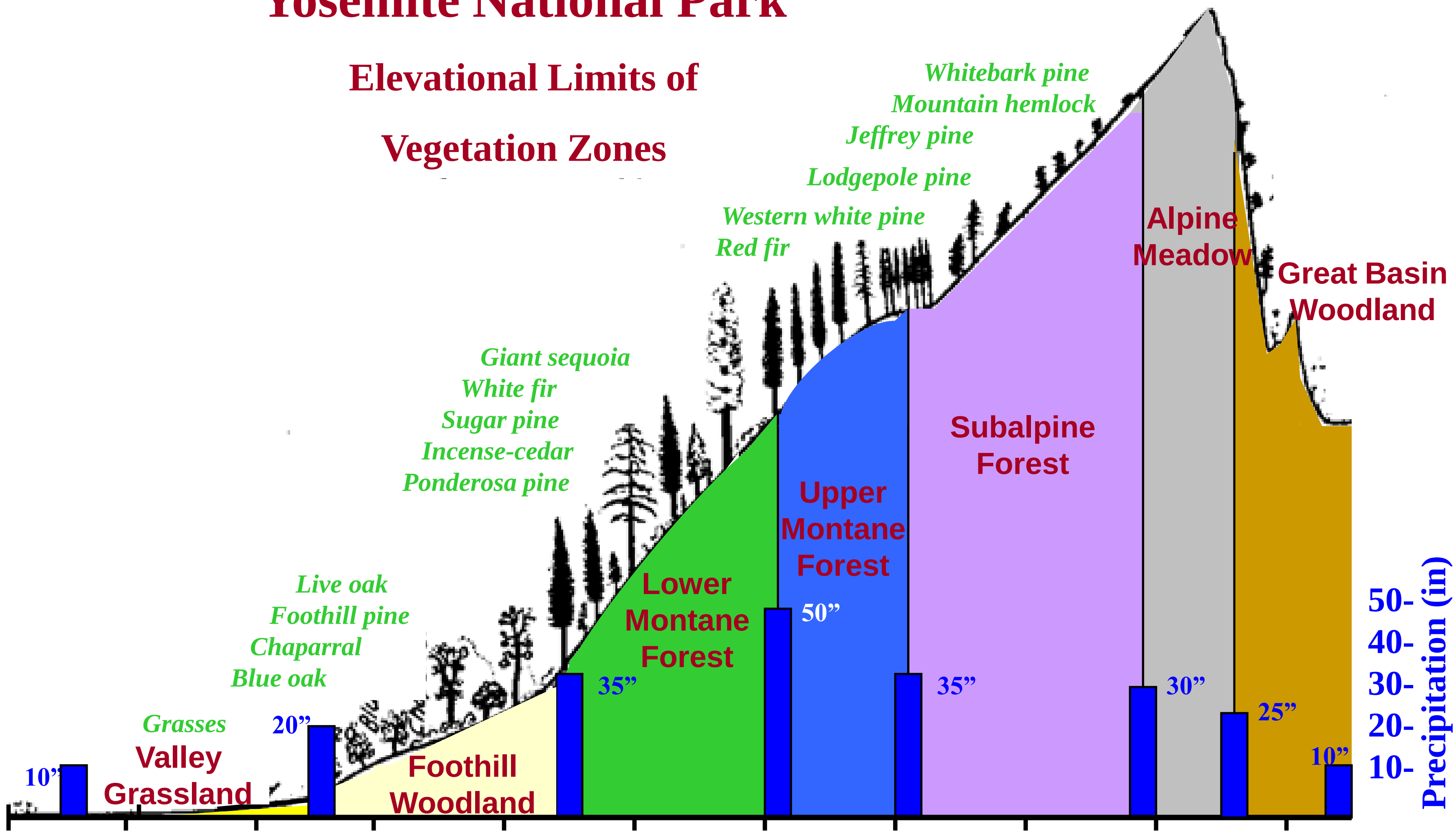
Climate



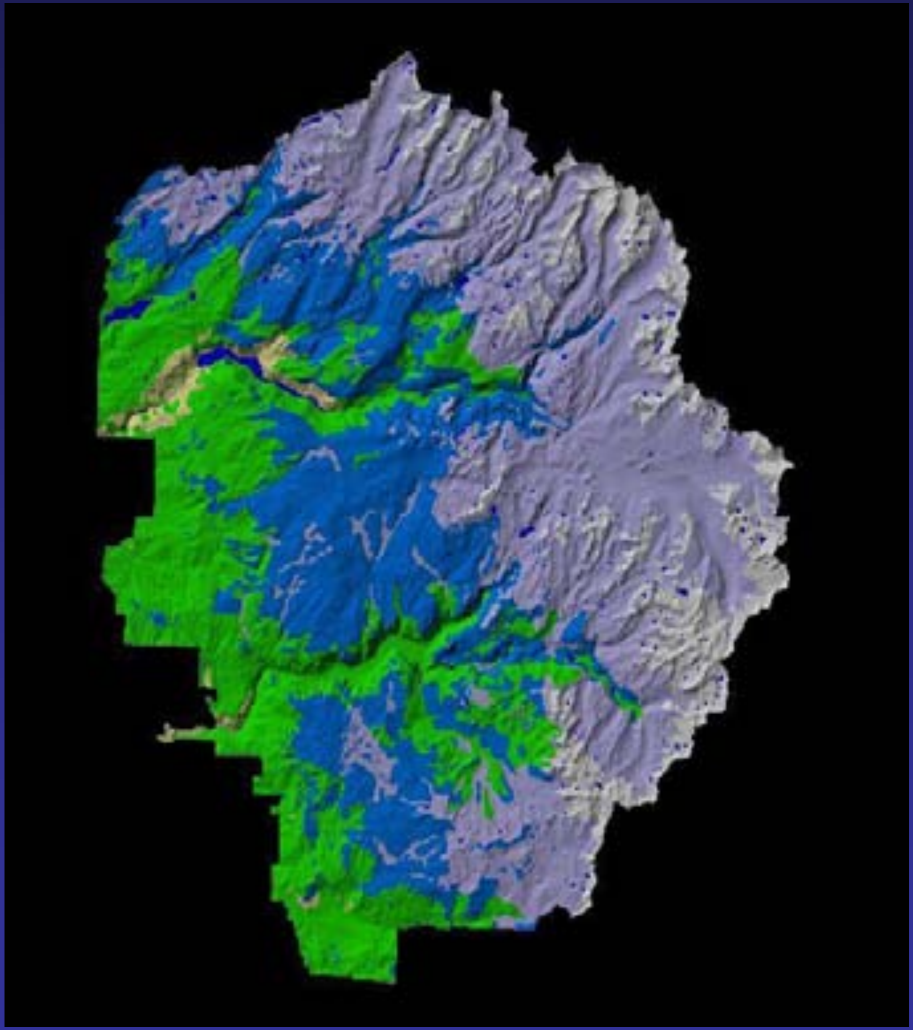
Nitrogen deposition?

Yosemite National Park

Elevational Limits of Vegetation Zones



Vegetation Zones



- Alpine
- Subalpine
- Upper Montane
- Lower Montane
- Foothill

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Patterns of Plant Invasions

- Statewide estimate ≈ 1050
  - ≈ 16%
- Sierra Nevada estimate
  - No comprehensive inventory
  - ≈ 250 -300 species (≈ 24% - 29%)
- Most are herbaceous species (= fine fuels)
- Most concentrated in lower elevations (grasslands, oak woodlands) and areas of anthropogenic use

Sources:

Rejmanek and Randall (1994)

Randall et al. (1998)

Gerlach et al. 2001

Keeley et al. 2003

Klinger et al. 2006

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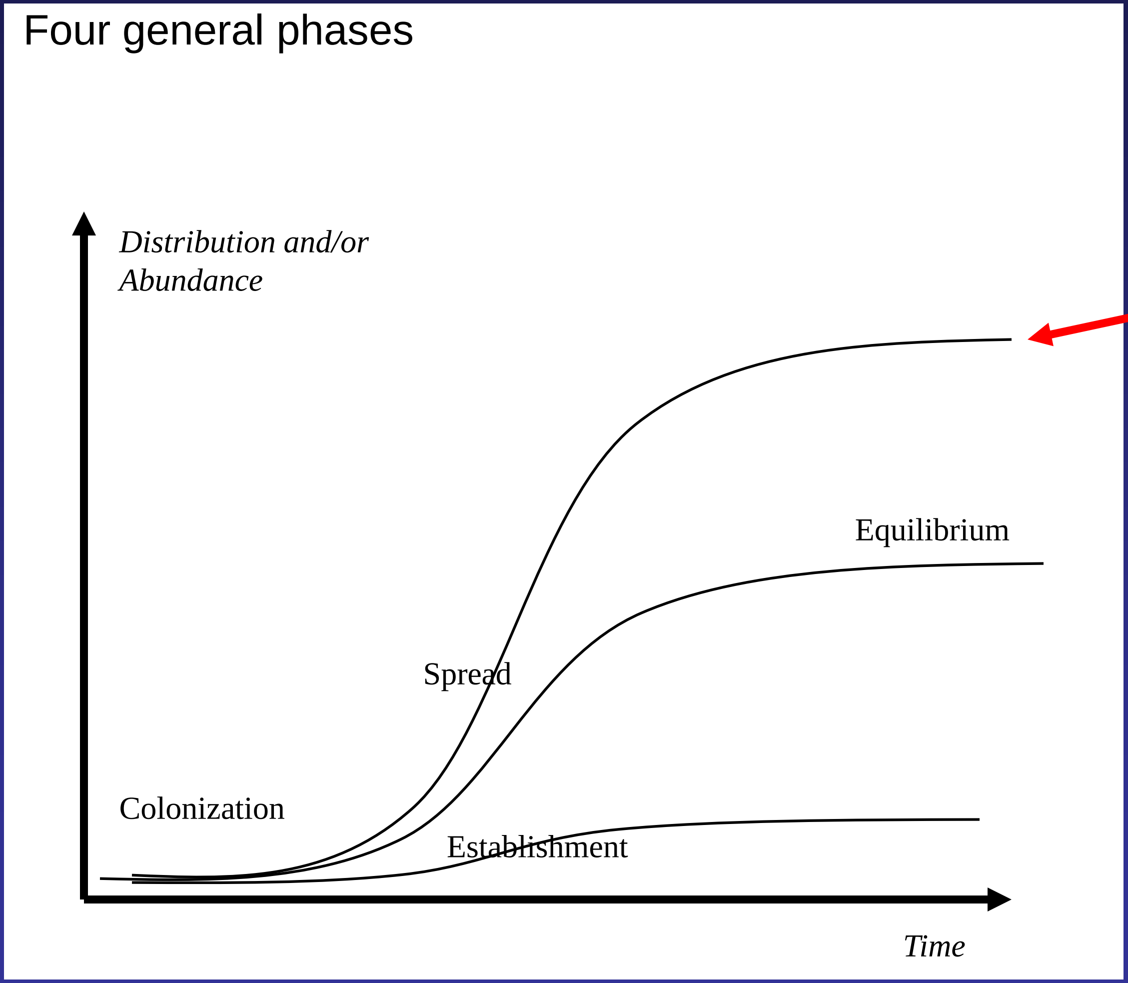
Invasion Process



Transformer species = species that significantly alter ecosystem structure/processes

Fire Regimes

Vegtype	Seasonality	FRI	Area	Complexity	Intensity	Severity	Type
Chaparral	Dry	Moderate	Large	Low	High	High	Crown
Woodland	Dry	Short	Large	Low	Low	Low	Surface
Mix Conifer	Dry	Short	Large	Low	High	Moderate	Surface
White Fir	Dry	Short	Large	Multiple	Moderate	Low	Multiple
Red Fir	Dry	Moderate	Moderate	Multiple	Multiple	Multiple	Multiple
Jeffrey Pine	Dry	Moderate	Small	Low	Low	Low	Surface
Lodge Pine	Dry	Long	Small	Low	Multiple	Multiple	Multiple
WB Pine	Dry	Long	Small	Low	Low	Low	Surface
Meadow	Dry	Moderate	Moderate	High	Multiple	Multiple	Surface
PJ	Dry	Long	Small	Low	Low	Multiple	Surface

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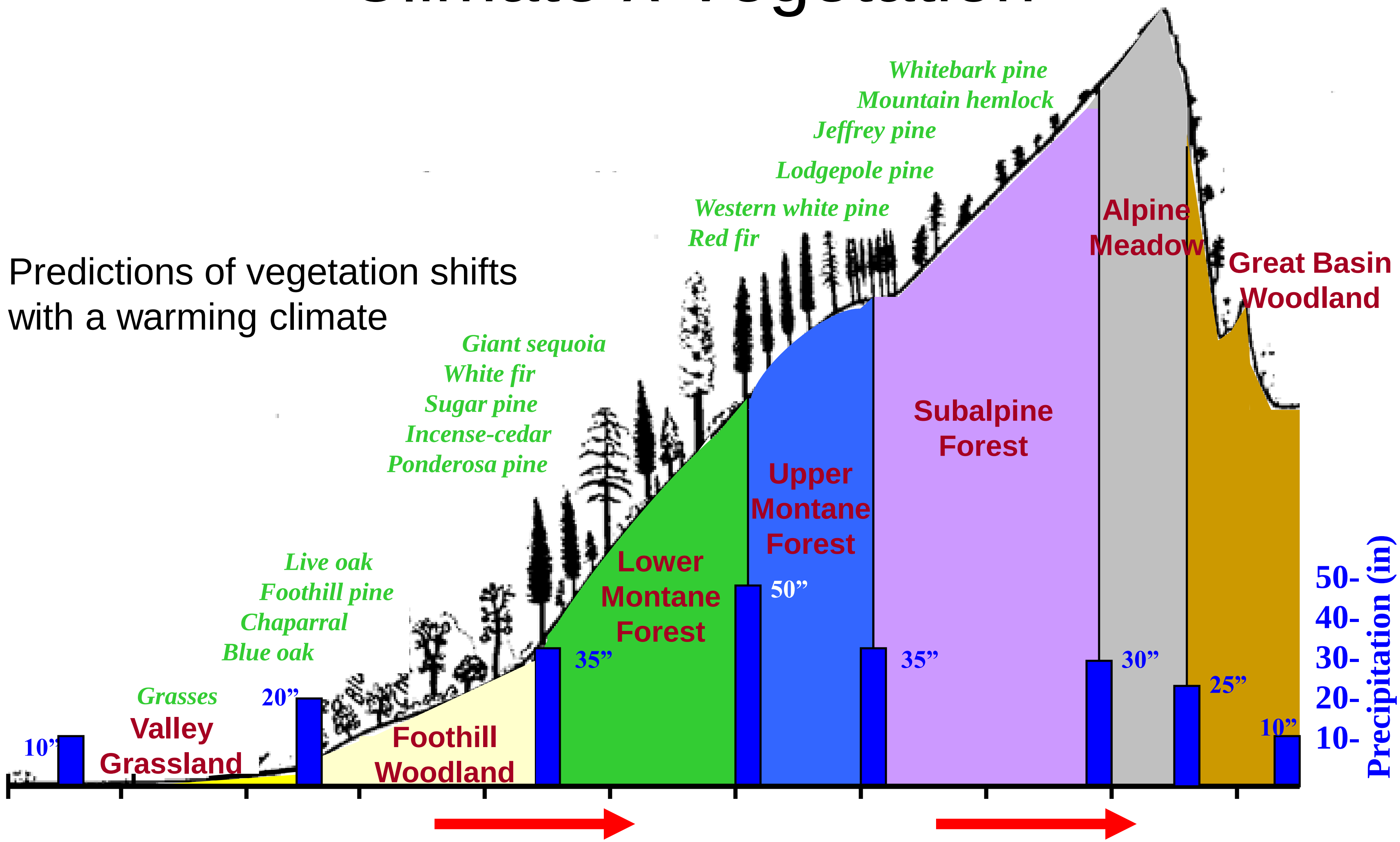
Climate x Vegetation

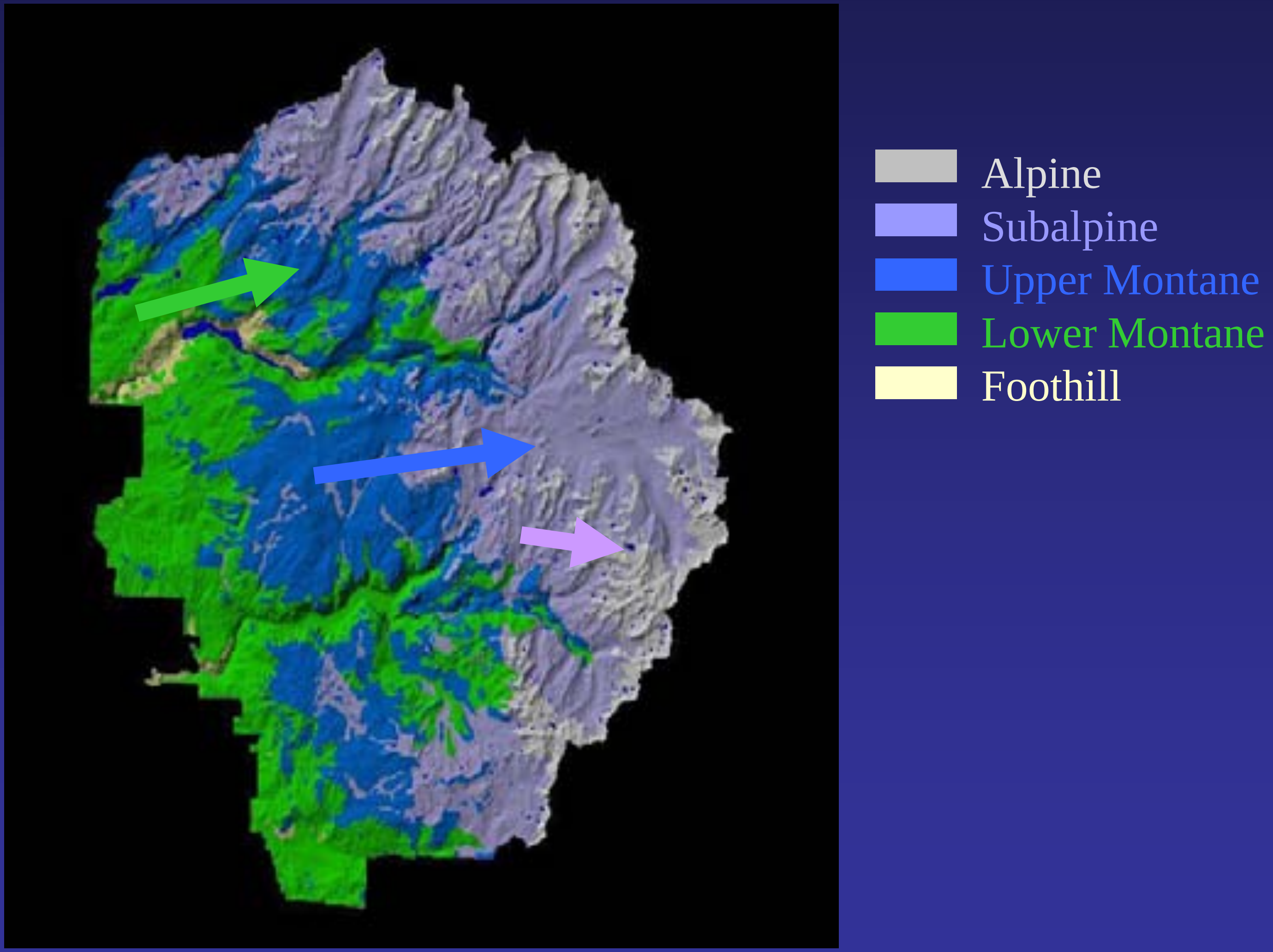
Predictions of vegetation shifts with a warming climate



shrublands and woodlands moving upslope replacing forests

forests moving above current treeline

Climate x Vegetation



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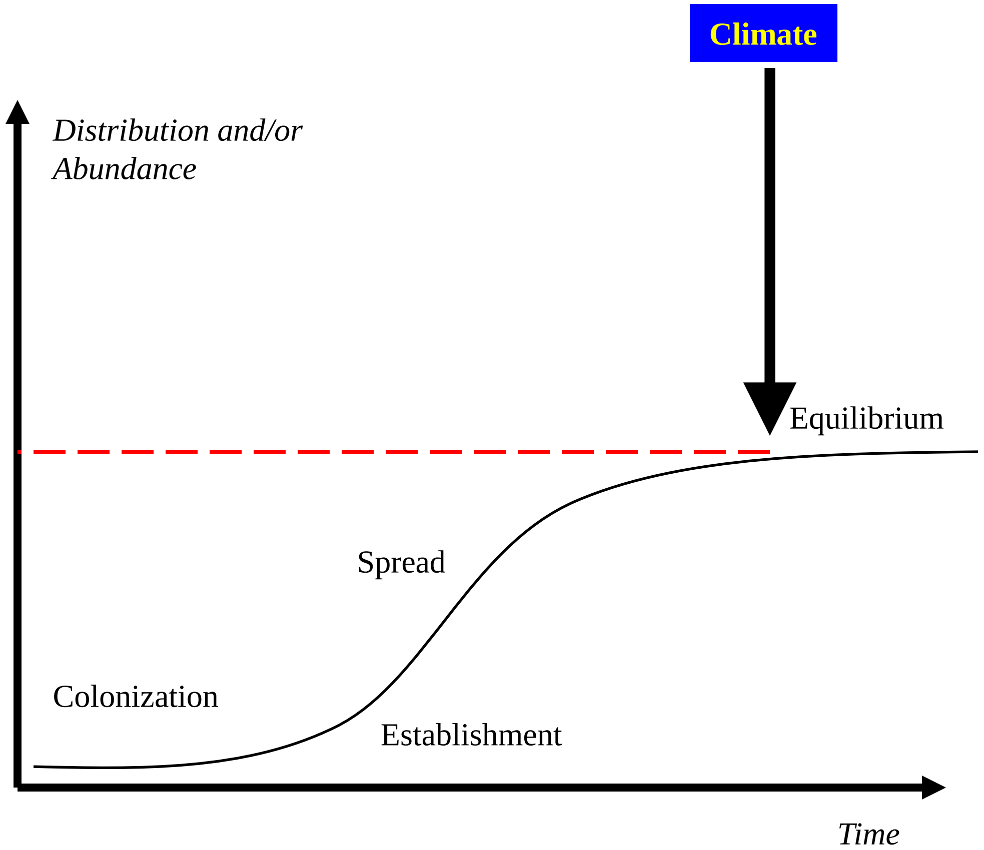
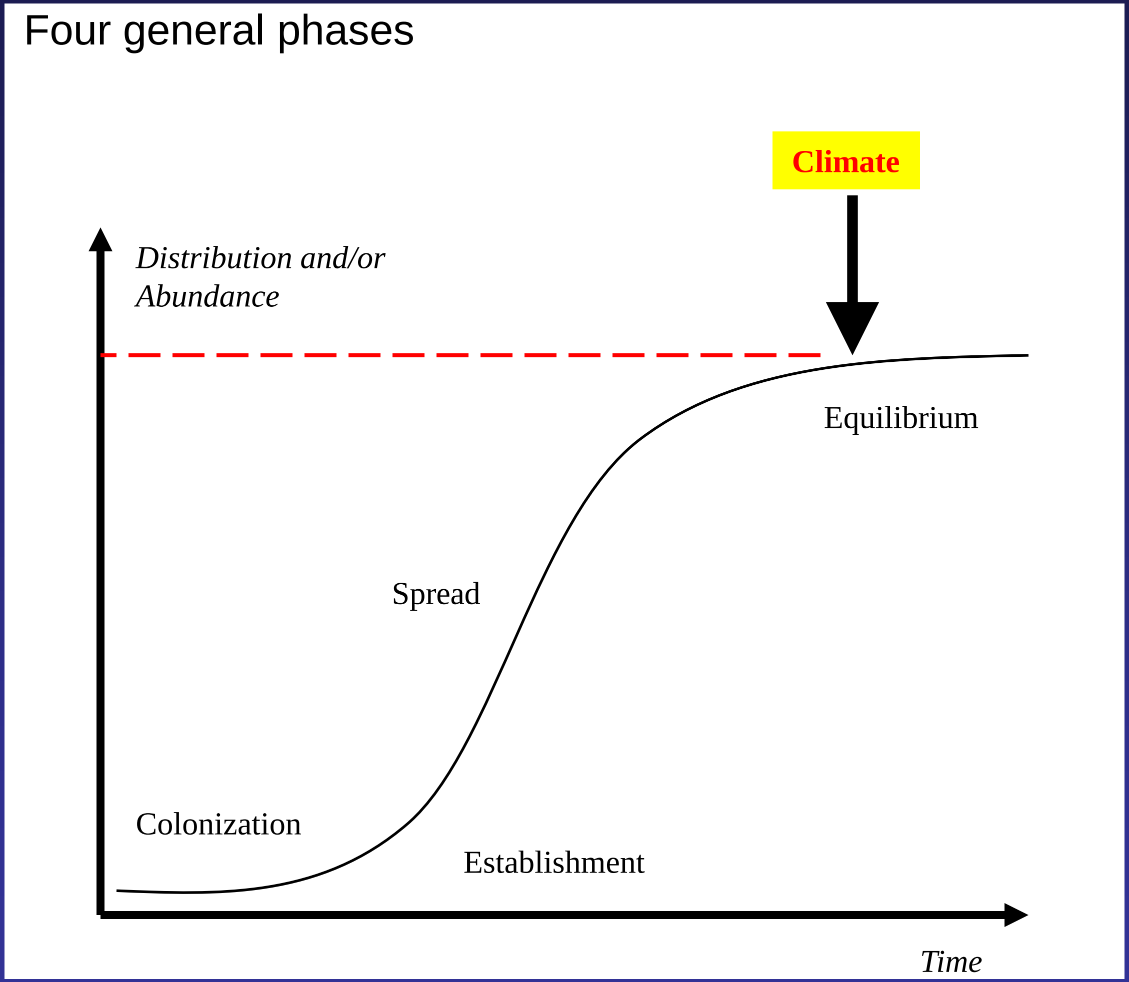
Climate x Invasive Plants: the Contemporary Version

Four general phases

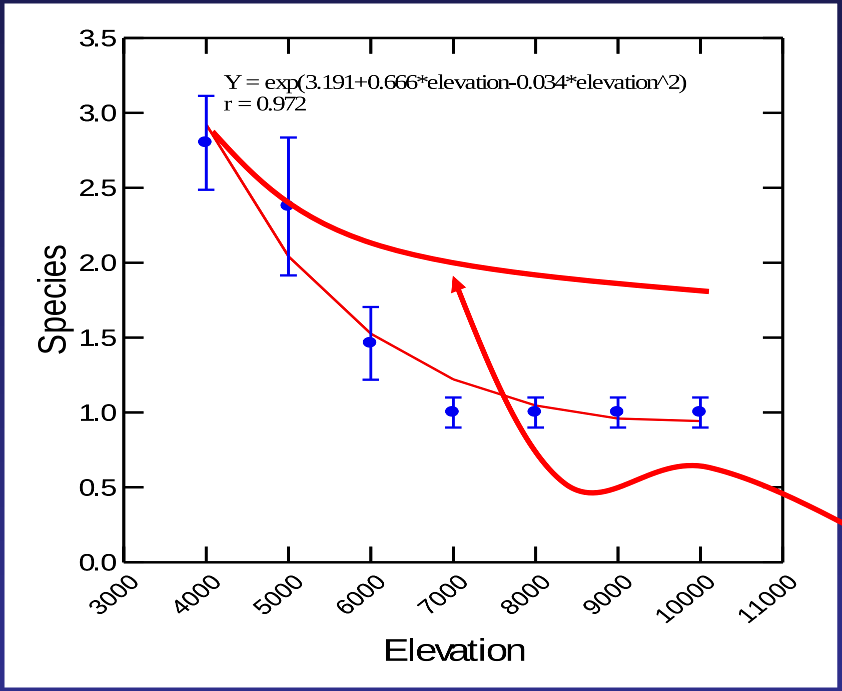


Climate x Invasive Plants: the Warmer Version



- Longer growing season and milder conditions at higher elevations could:
  - Open niches
  - Increase the species pool
  - Increase chances of establishment of transformer species

Invasion x Elevation Relationship



- *Mooney et al. 1986*
- *Schwartz et al. 1996*
- *Keeley et al. 2003*
- *D'Antonio et al. 2004*
- *Klinger et al. 2006*

- Climate has acted as a filter to invasions
- Decreased diversity and abundance of invasive plants with increased elevation

- Climate change could "lower the mountaintop" and improve conditions for invasions at higher elevations

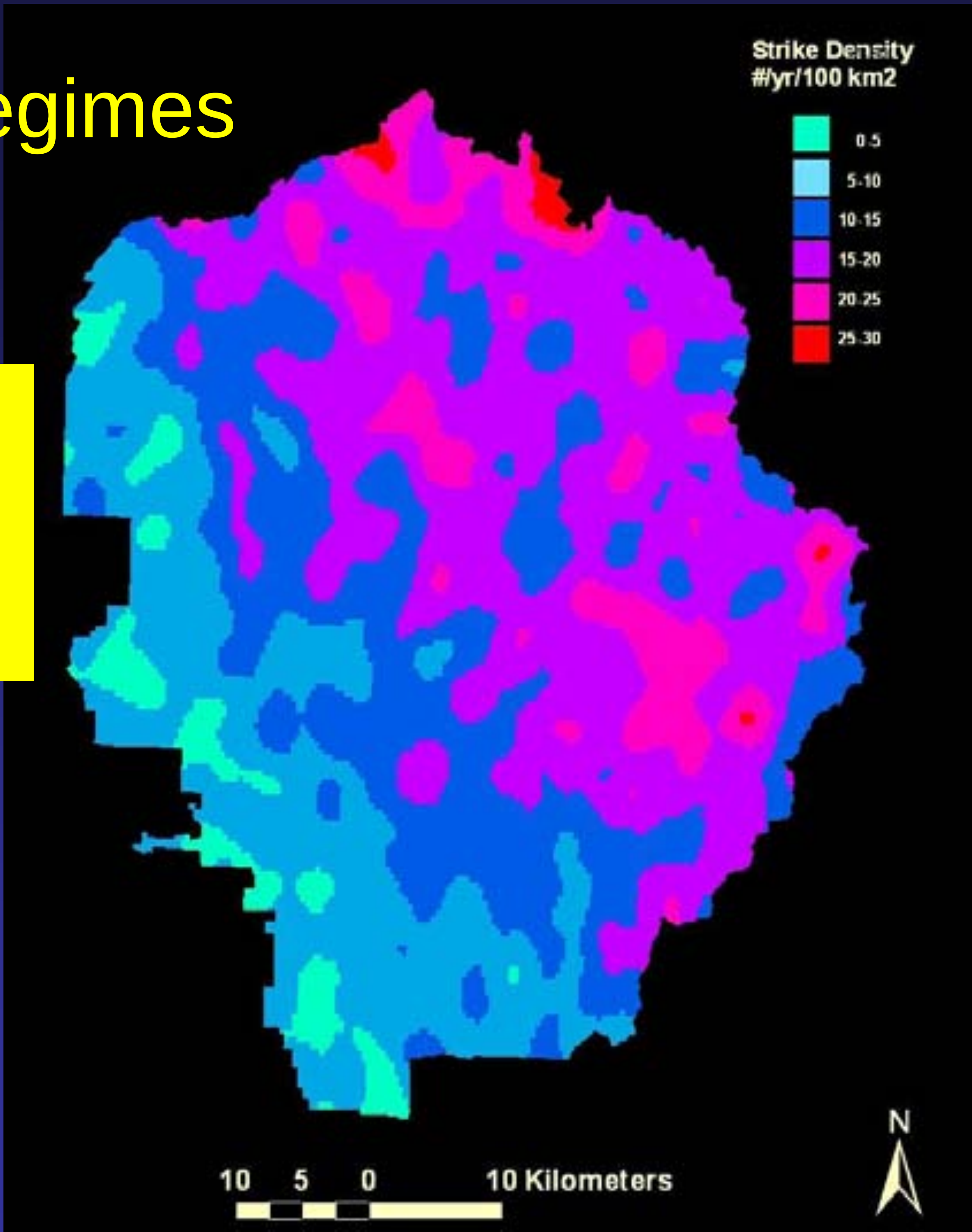
Climate x Fire Regimes

- Temperature
- Precipitation
- RH
- Wind
- Lightning

Warming climate =

- Upslope shift in vegetation
- Drier fuels
- Longer fire season

…increased probability of ignition?



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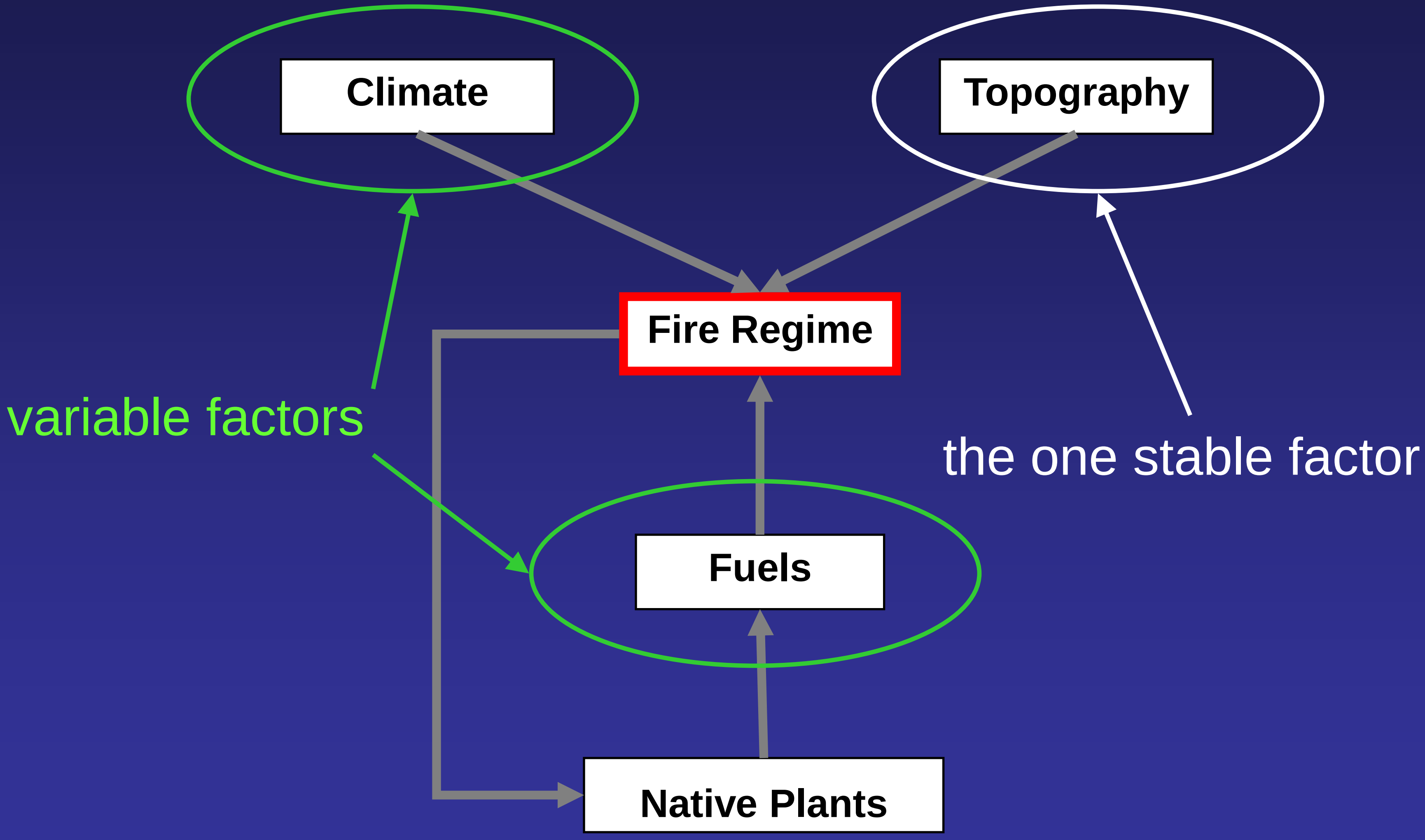
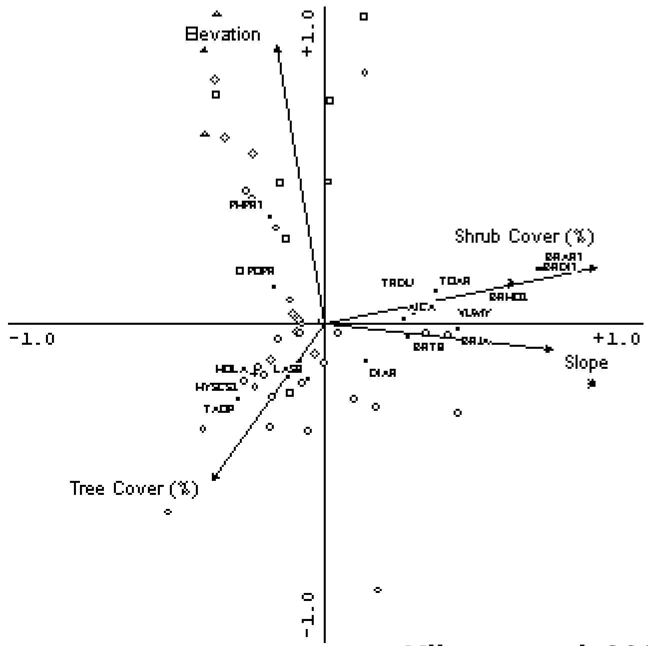
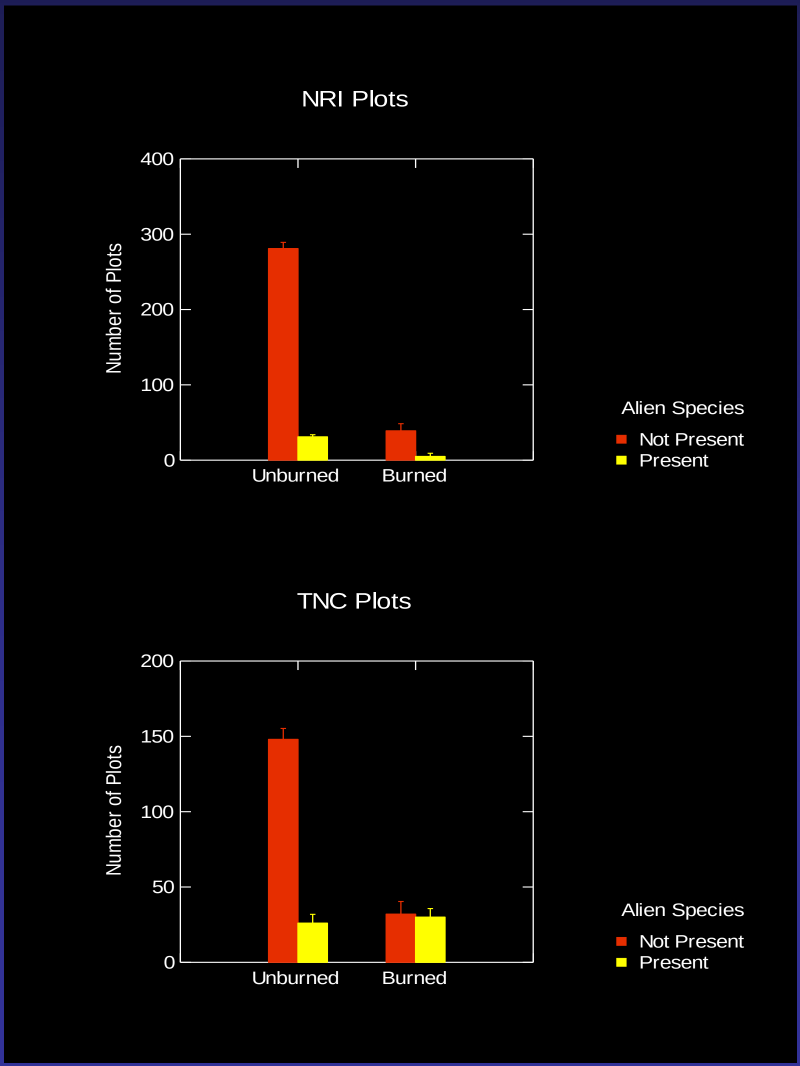
Climate x Vegetation x Fire



Currently, environmental gradients have more influence than fire on presence of non-natives



Klinger et al. 2006



… but this may change as a warming climate reduces environmental limitations, especially at lower elevations

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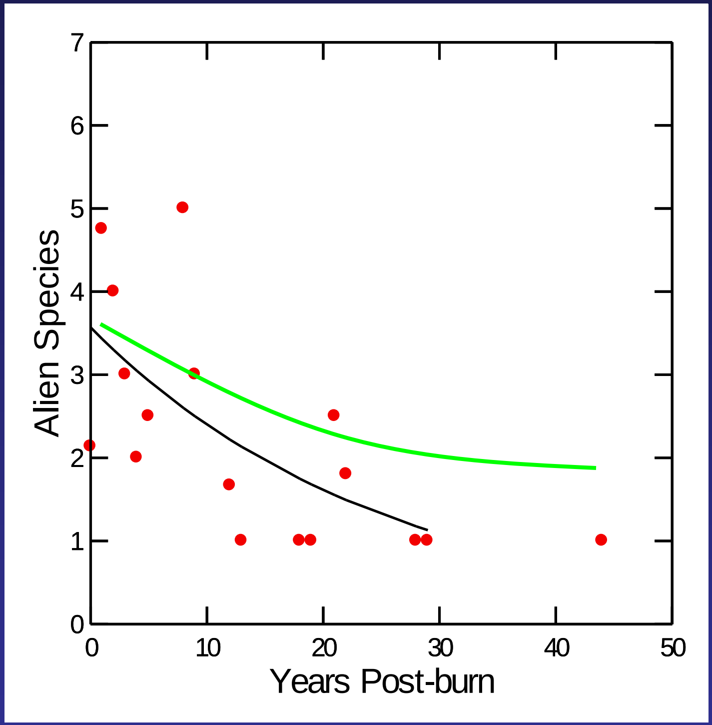
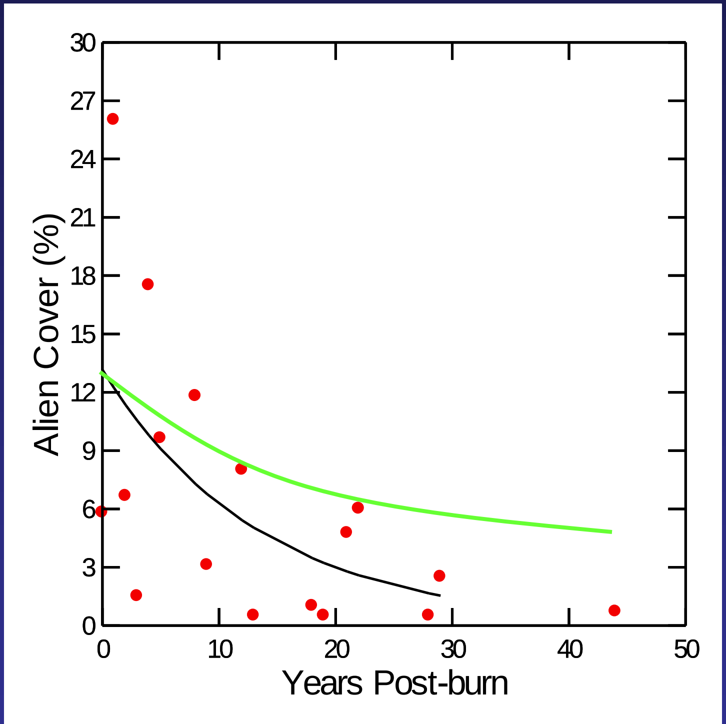
Post-fire succession itself can also suppress non-natives (Klinger et al. 2006)



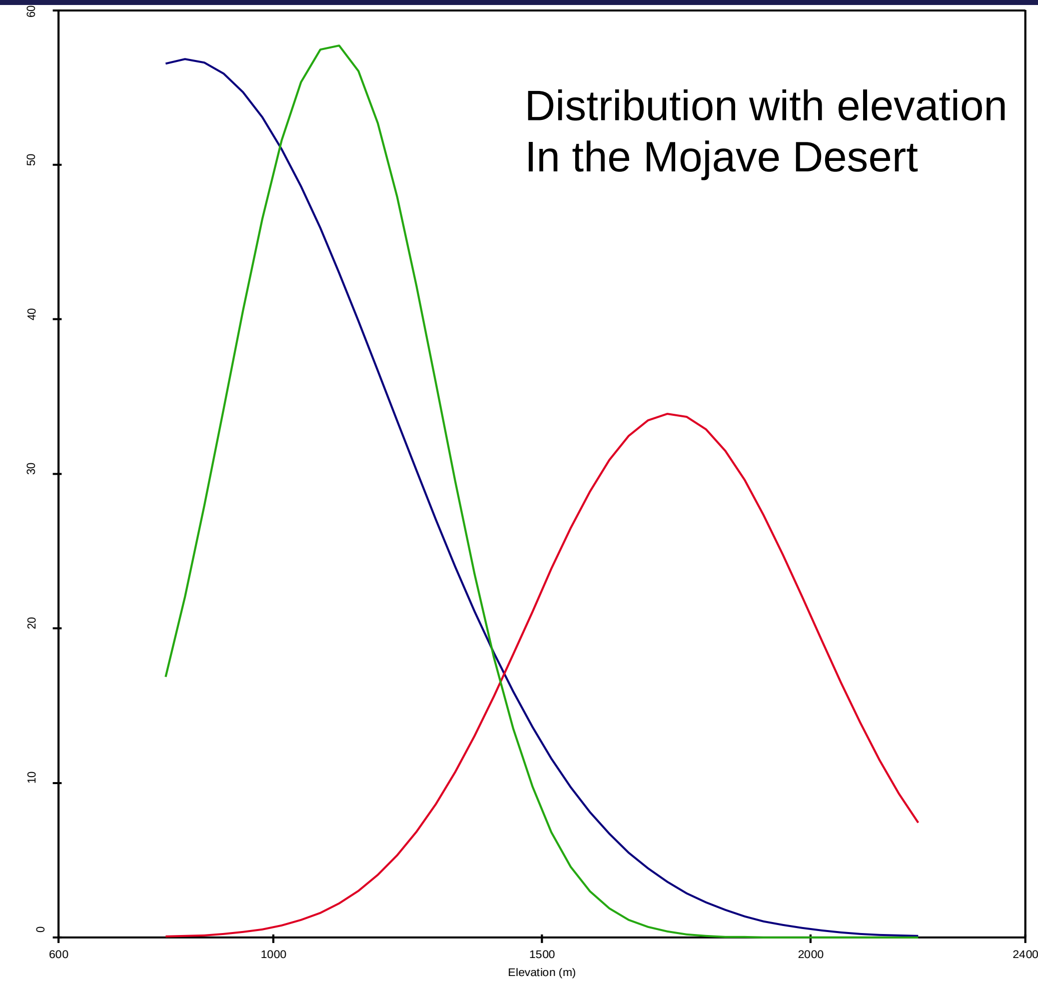


…but this pattern can be affected by initial burn severity, with higher severity associated with longer dominance of non-natives postfire (Keeley et al. 2003)

The Dilemma Of Multiple Invaders

Insights From The 2005 Mojave Fires

- Three species comprise >90% total herbaceous biomass
- Individualistic species responses
- Overlapping but shifting abundance peaks along environmental gradients
- Individual and cumulative effects along gradients



B. rubens *E. cicutarium* *B. tectorum*

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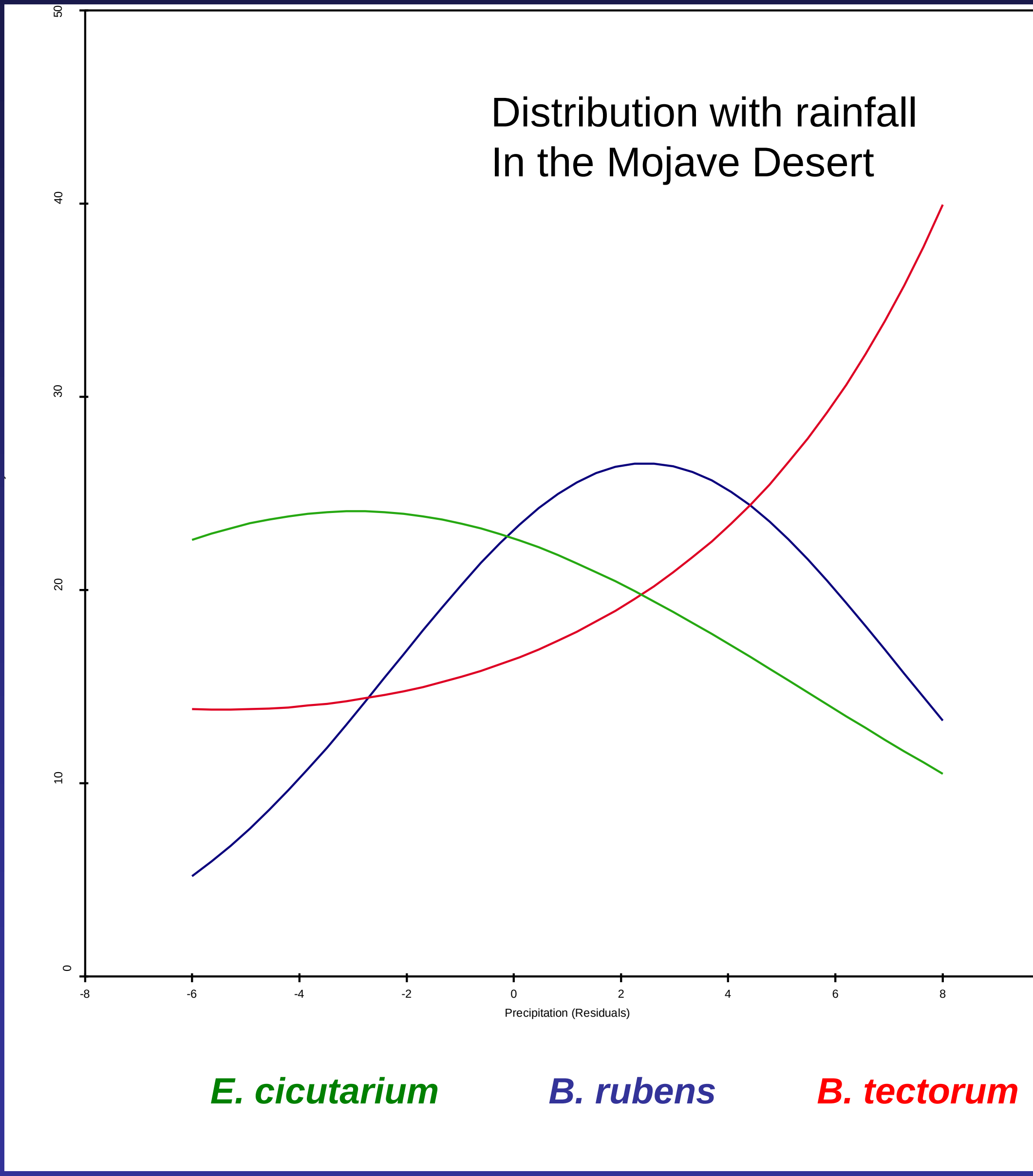
Relationship of Non-natives with Precipitation

- *Erodium cicutarium* peaks at drier end of precipitation gradient
- *Bromus rubens* peaks at intermediate part of precipitation gradient
- *Bromus tectorum* has monotonic increase along precipitation gradient

Transformer species exploiting a broad range of precipitation



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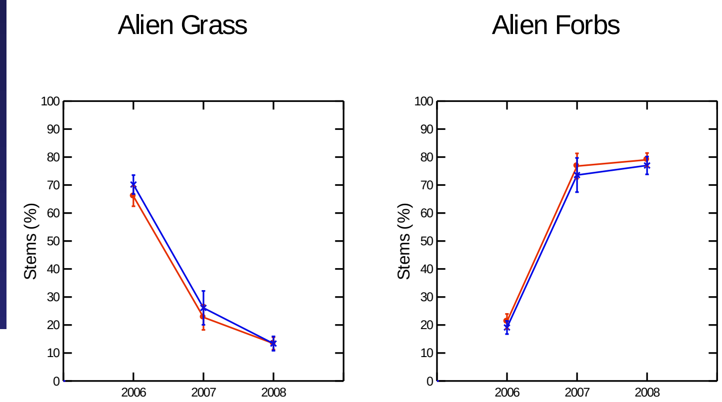
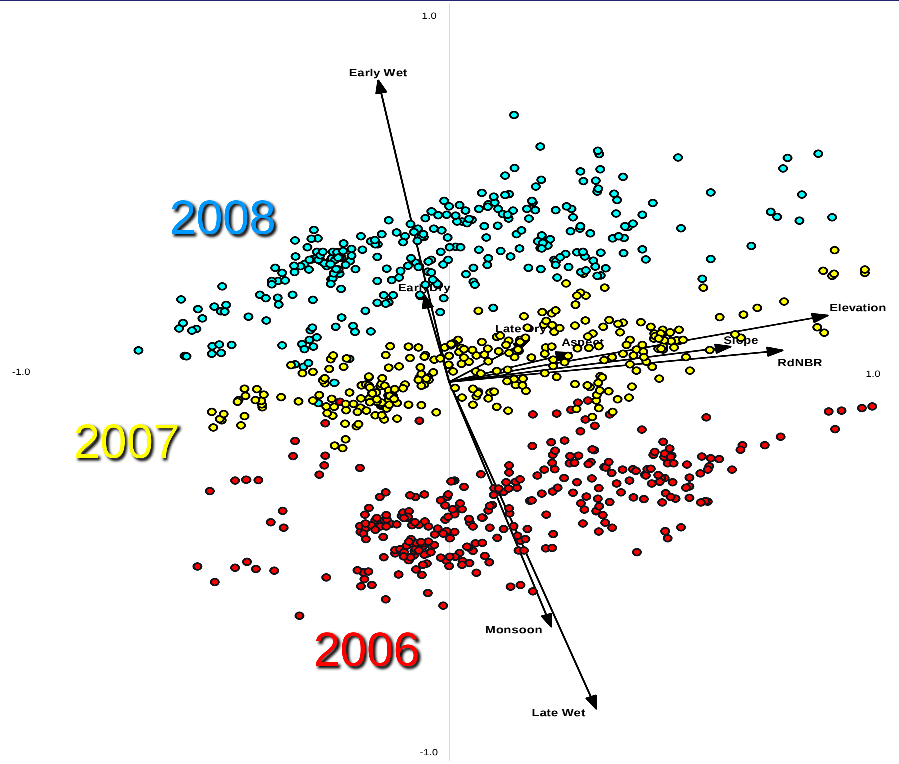
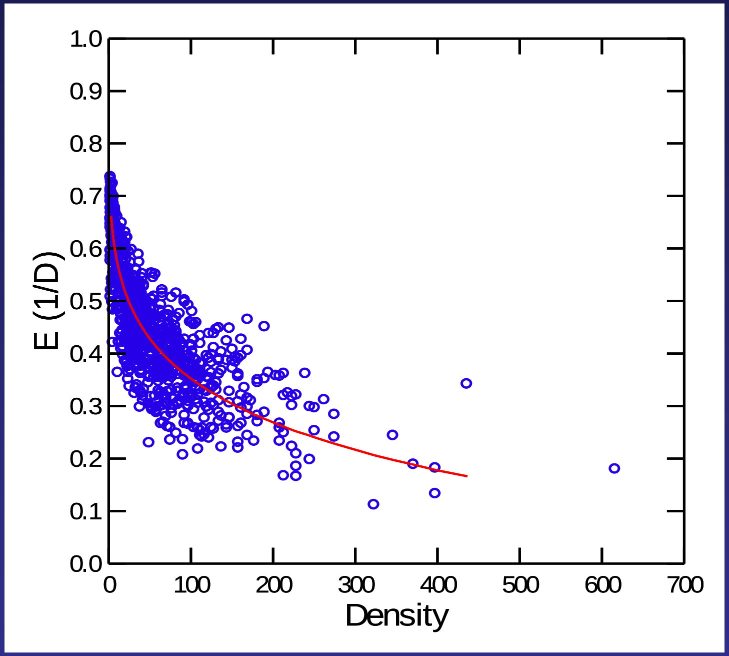
Relative Dominance Varies Over Time Postfire

Shifting patterns of dominance among postfire years is driven by rainfall in the Mojave Desert

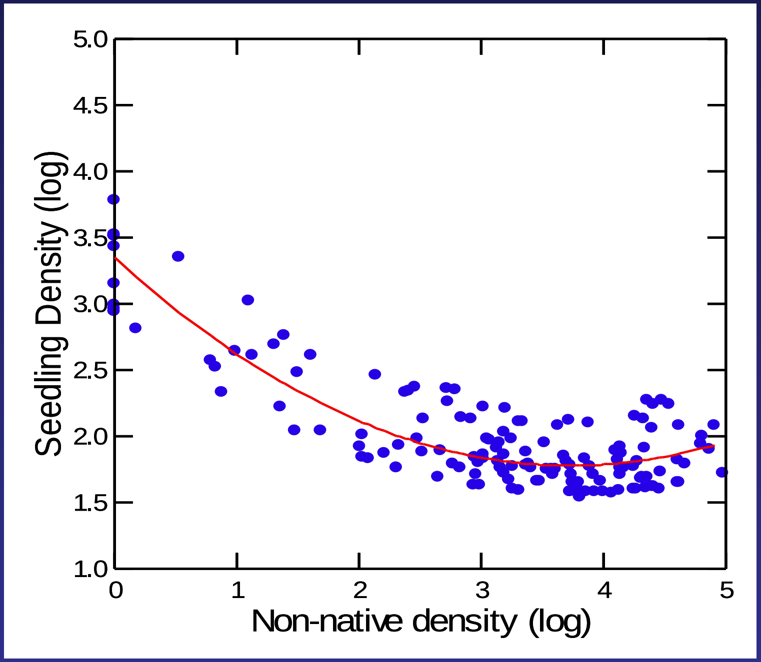




Non-natives May Themselves Alter Succession



Strong negative relationship between native diversity and density of non-natives



Strong negative relationship between native woody seedling density and density of non-natives

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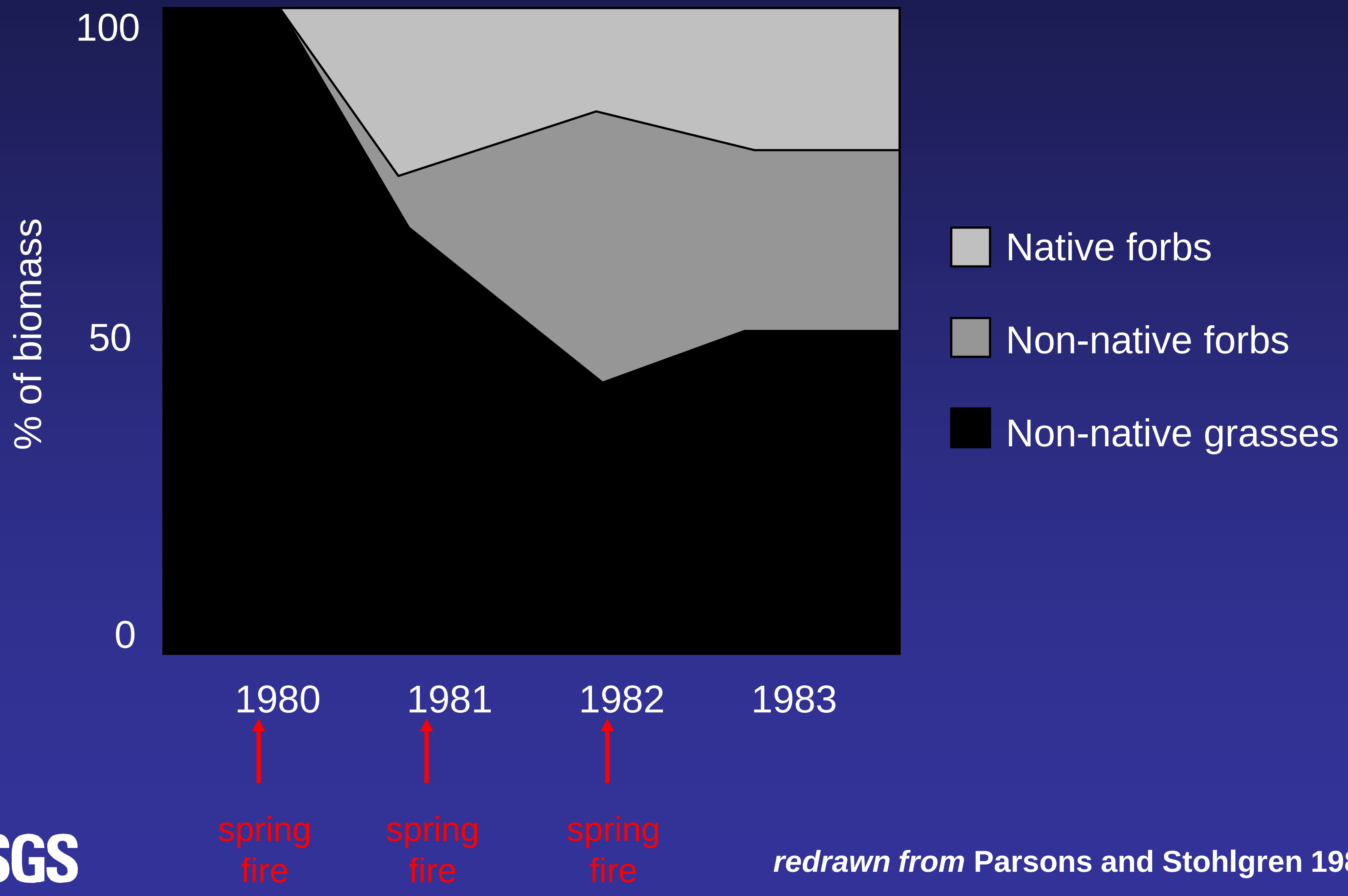
Effects of Repeated Spring Fires in the Sierra Nevada



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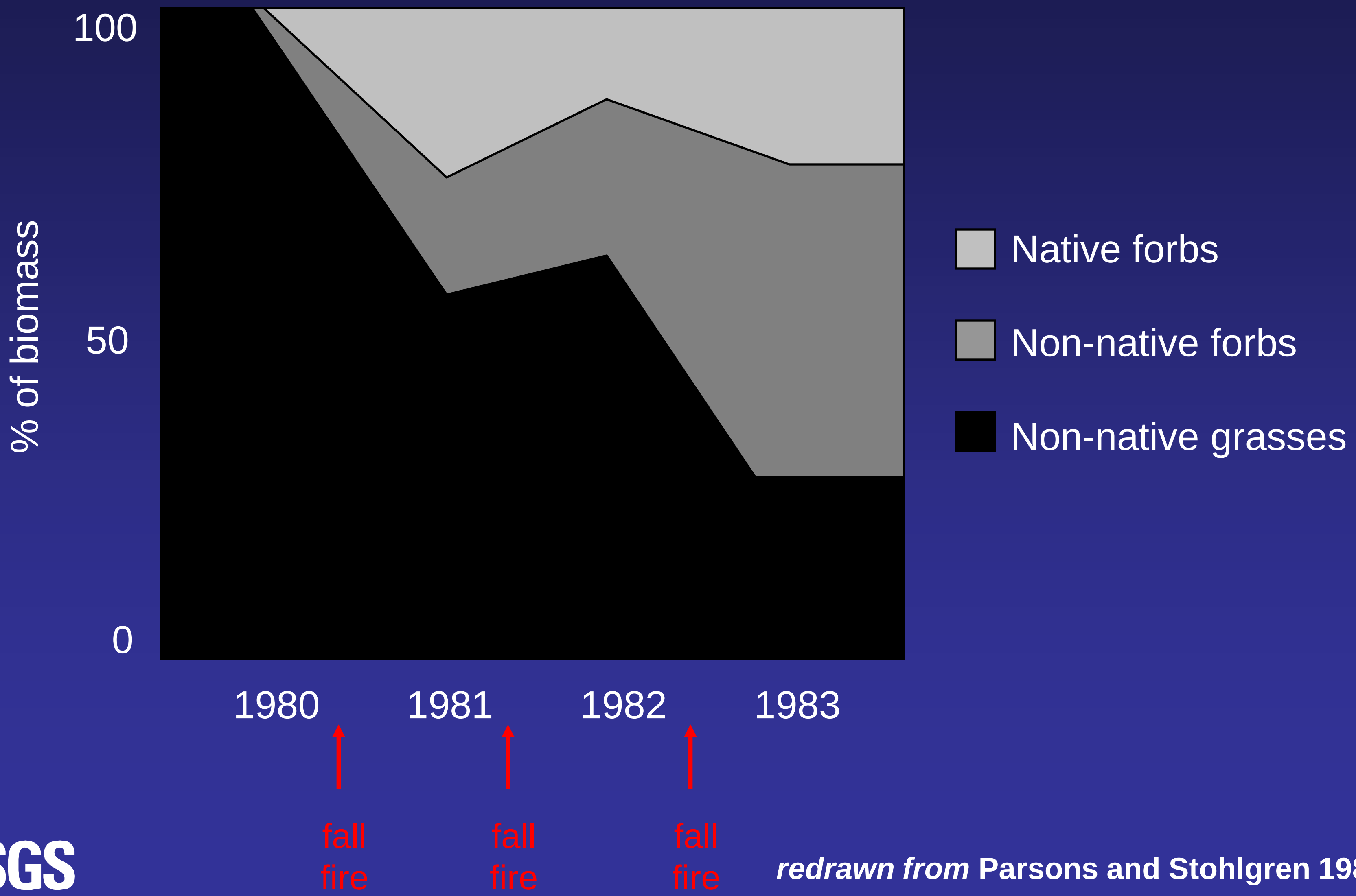
***redrawn from* Parsons and Stohlgren 1989**

Effects of Repeated Fall Fires in the Sierra Nevada



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redrawn from **Parsons and Stohlgren 1989**

Relative Biomass of Herbaceous Species

	1980 pre-burn	1983 3x burned	1983 unburned control		1980 pre-burn	1983 3x burned	1983 unburned control
spring burn increasers				**fall burn increasers**			
Erodium botrys	0	16	0	*Centauria melitensis*	0	46	0.1
*Trifolium microcephalum**	1	11	0.1	*Lotus subpinnatus**	0	11	0
Siline gallica	0	8	0.1	*Siline gallica*	0	5	0.1
*Lotus subpinnatus**	0	7	0	*Hypochoeris glabra*	0	5	0.1
Festuca megalura	0.1	6	0	*Orthocarpus attenuatus**	0	4	0
Centauria melitensis	0	2	0.1				
spring burn decreasers				**fall burn decreasers**			
Avena fatua	77	12	39	*Avena fatua*	90	5	39
Bromus diandrus	13	1	12	*Bromus diandrus*	11	0.2	12

* Native species (all others are non-native species)

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***redrawn from* Parsons and Stohlgren 1989**

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Centauria melitensis							
spring burn decreasers				**fall burn decreasers**			
Avena fatua	77	12	39	*Avena fatua*	90	5	39
Bromus diandrus				*Bromus diandrus*			

Spring burn: *A. fatua* 49%↓ due to year; 84%↓ due to burning

Fall burn: *A. fatua* 57%↓ due to year; 94%↓ due to burning

* Native species (all others are non-native species)

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***redrawn from* Parsons and Stohlgren 1989**

General Patterns In Western Ecosystems

- Fire size has increased in Mojave and Great Basin shrublands
  - Linked to climate and invasive species
- Fire size and severity has increased in western forests
  - Linked to climate and historical factors, ***not*** invasive species (so far)
- Increase severity, coupled with decreased environmental impediments to invasion, may increase the effects of non-natives on forest fire regimes

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Which Species May Emerge at the New Transformer Species?

- *Bromus tectorum* ?
- *Bromus madritensis rubens*?
- *Cirsium vulgare*?
- *Arundo donax*?
- *Genista monspessulana*?
- *Cytisus scoparius*?
- *Tamarix* spp?
- *Ailanthus altissima*?
- *Pinus pinea*?

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Where are New Species Coming From?

- We look most frequently for invaders from the west of the Sierra Nevada
- Species associated with agricultural and urban areas
- Forest cover can impede upward spread of species on the western slope, but this impediment may be moving upslope

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But Many of the Barbarians are at the Eastern Gates

…and a few are already in the castle

- Mojave and Great Basin species
- Forest cover which impedes upward spread on the west slope is relatively low on the east slope
- Elevation gradient is also very steep on the east side, and upslope dispersal distances are much shorter than on the west side

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What Does this all Mean for Land Management in the Sierra Nevada?

- Past experiences may be increasingly insufficient to predict future effects of land management actions (e.g. Rx fire, weed control, native spp. revegetation)

- Thus, well-intended management action may trigger unexpected and potentially undesirable outcomes?

- Example: The bighorn burns project (east side)

- Question: Will an unintended outcome of burning winter range for sheep be increased abundance of cheatgrass as the climate warms?

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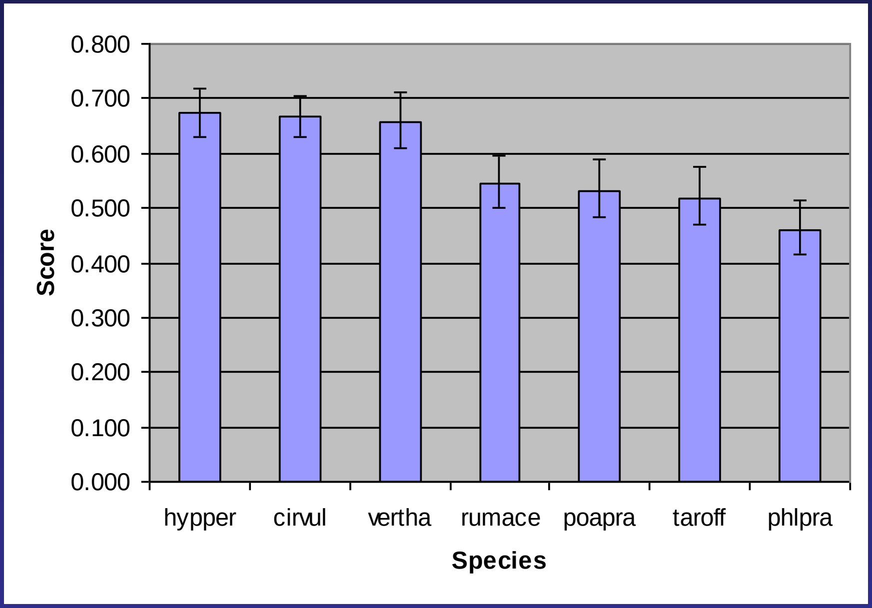
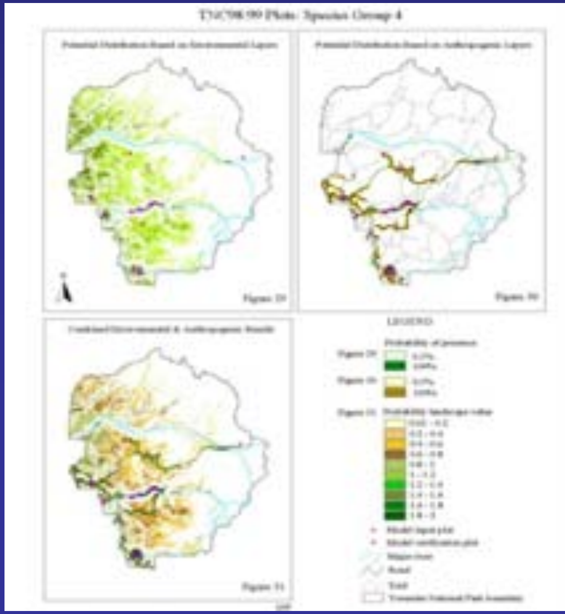
Getting Ahead of the Curve

Integration of prioritization and prediction

- What species will likely become invasive?
- What sites will likely be heavily invaded?



Brooks and Klinger in press



Underwood et al. 2004

Summary

Expect increase in colonizing species from both the west and east

Expect upward elevational spread of non-native species

Fire frequency will likely increase in upper elevations

Combination of prioritization and species distribution models may provide some management options