

# Quaking aspen and climate change

Dominik Kulakowski

Graduate School of Geography, Clark University, Worcester, MA

This material is based upon work supported by the National Science Foundation and the Joint Fire Science Program.

# Climate change

## Direct Effects

- Altered temperature and precipitation regimes
- Droughts

## Indirect Effects

- Increasing extent, magnitude and/or frequency of various forest disturbances

Effect on forest demography and ecology?

Consequences for dominance and extent of aspen?

# Changes in fire regimes

- Warm and dry conditions result in increased wildfires and bark beetle outbreaks, particularly in coniferous forests.



# Regeneration of aspen

- Regeneration modes can vary even within a relatively restricted area
- But, generally favored by fire.

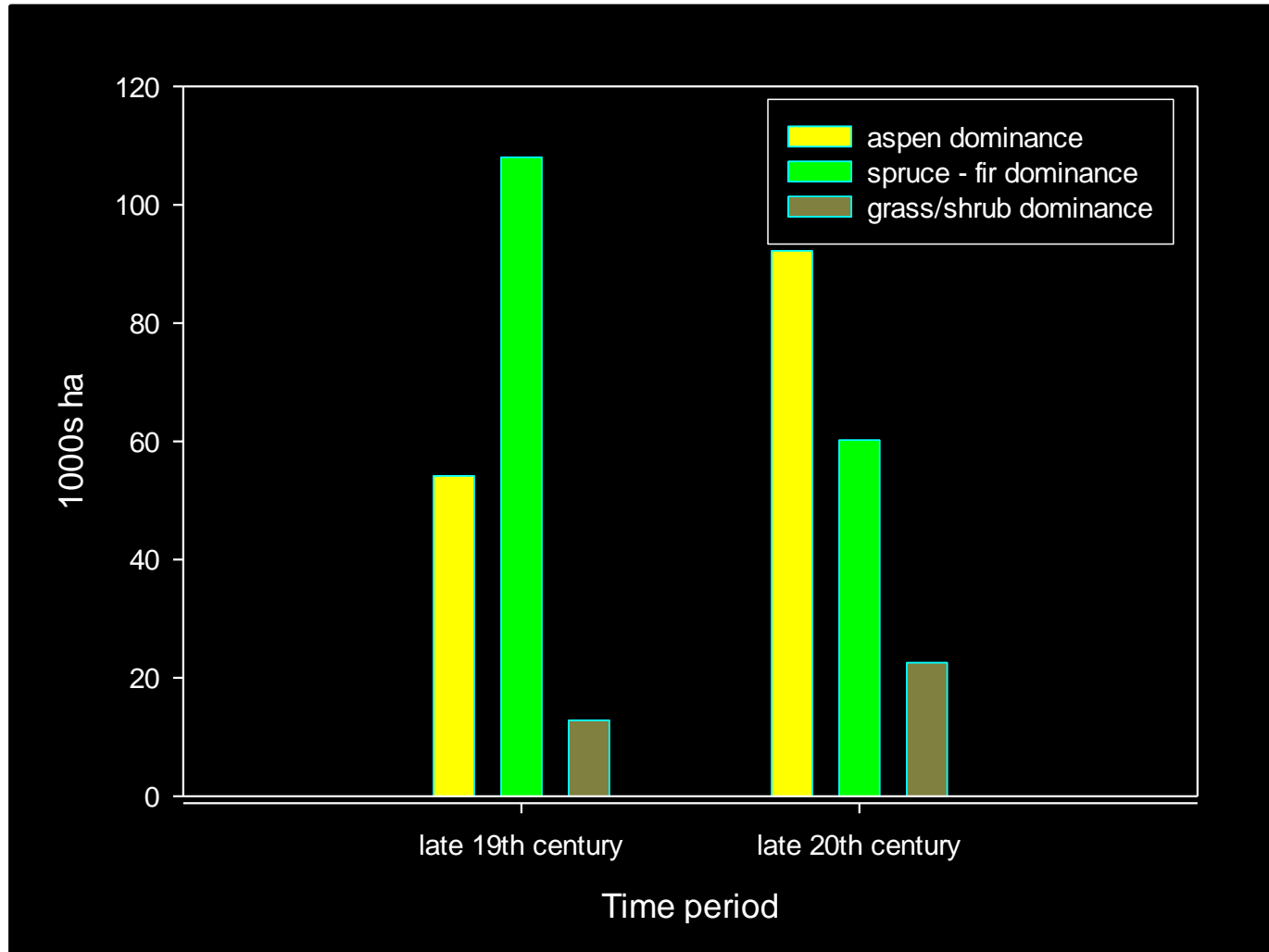


# Regeneration of aspen

- Seed and Vegetative



# Comparison of dominance in Grand Mesa area



# Transition matrix of Grand Mesa

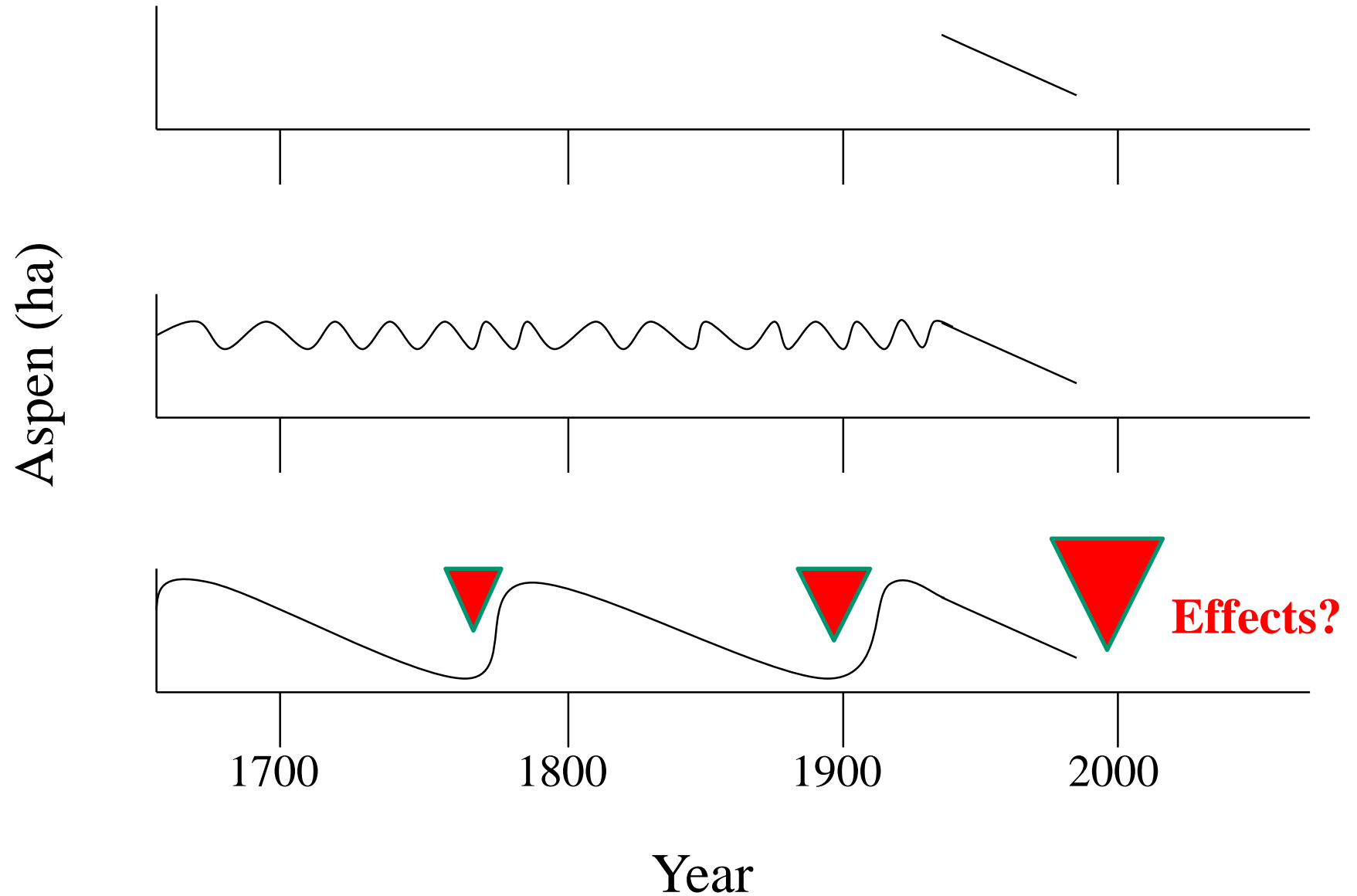
Late 20 <sup>th</sup> century	Late 19 <sup>th</sup> century (ha and percent)		
	Burned		Unburned
	Aspen	Spruce – fir	Aspen
Aspen	9,792 (85%)	17,252 (62%)	33,238 (78%)
Spruce – fir	1,333 (12%)	7,626 (28%)	4,459 (10%)
Grass / shrubland	457 (4%)	2,761 (10%)	4,896 (11%)

# Successional replacement and mortality

- Severe fires during the late 19th century drought increased aspen cover.
- A larger portion of the landscape is presently dominated by aspen than in the 19<sup>th</sup> century.
- Long-lasting effect.



# Amplitude of ecological patterns



# Aspen less flammable than conifers

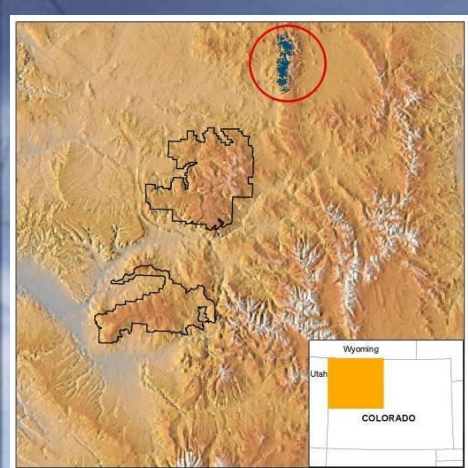
- Fires increase relative amount of aspen, even without considering effects on regeneration



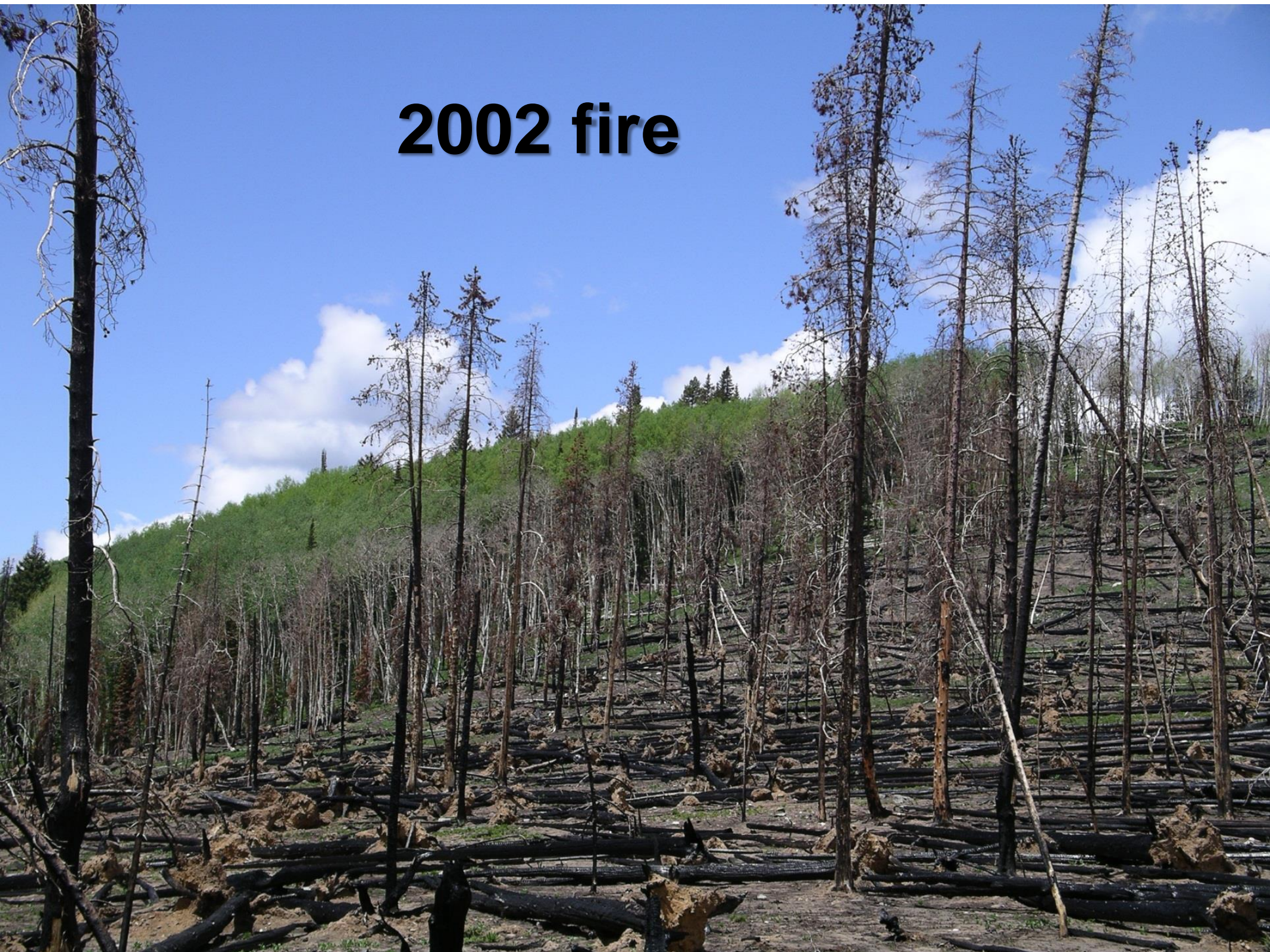
# Compounded disturbances

- Extent, magnitude, and/or frequency of various forest disturbances are increasing.
- Two or more disturbances occurring in short succession.
- Can affect ecosystem development in ways that are not well understood.
- Critical to understand this complexity to better anticipate changes to aspen and other species.

# 1997 wind storm



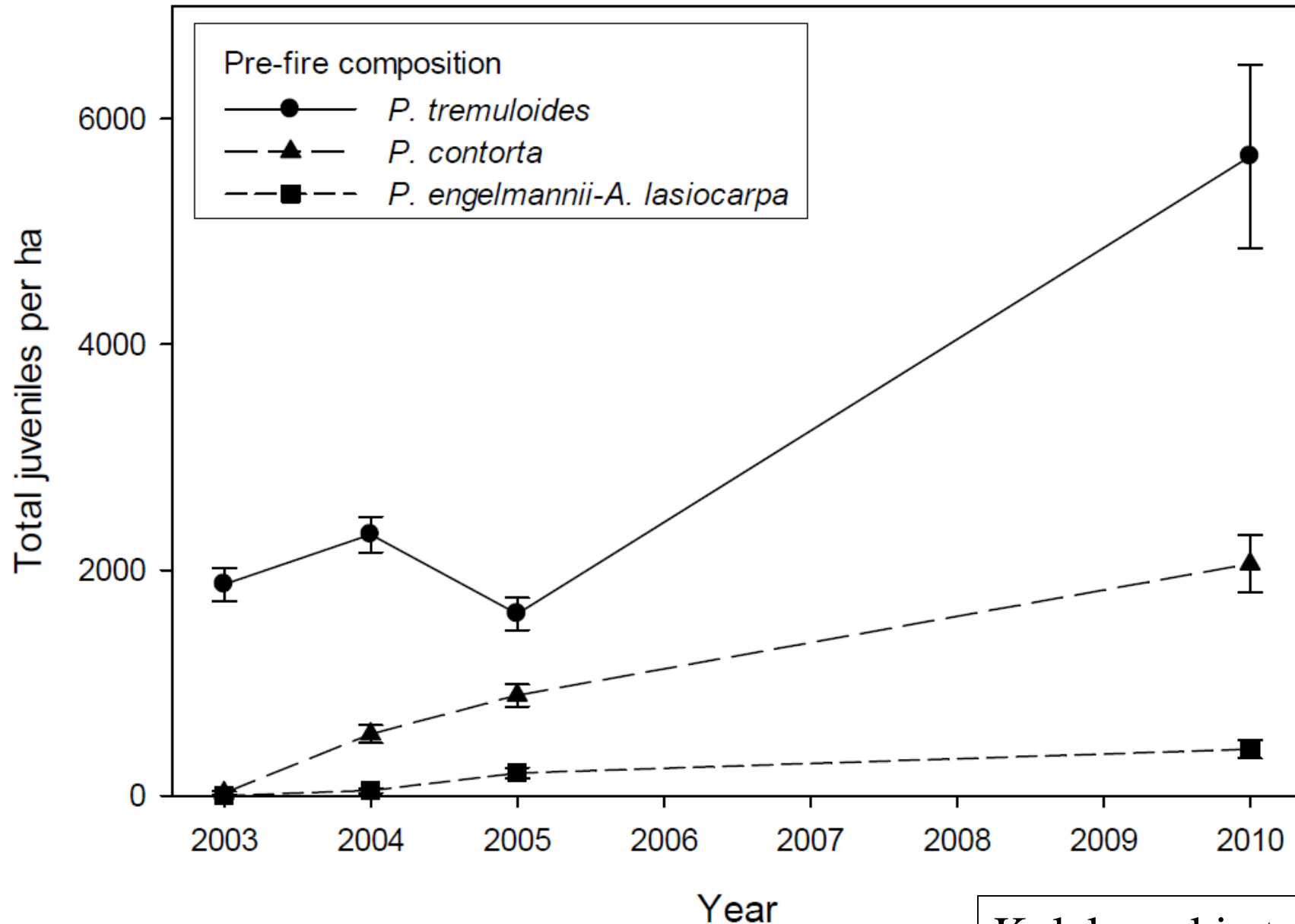
**2002 fire**



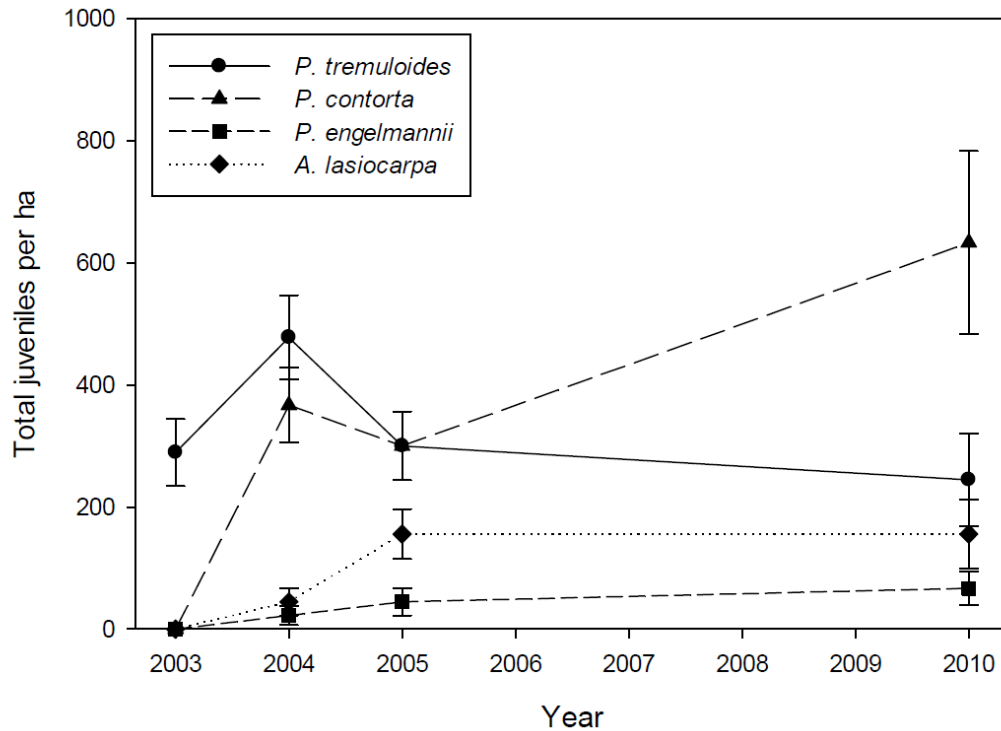
- 1997 windstorm followed by 2002 Fire
- Effect of compounded disturbances on regeneration?



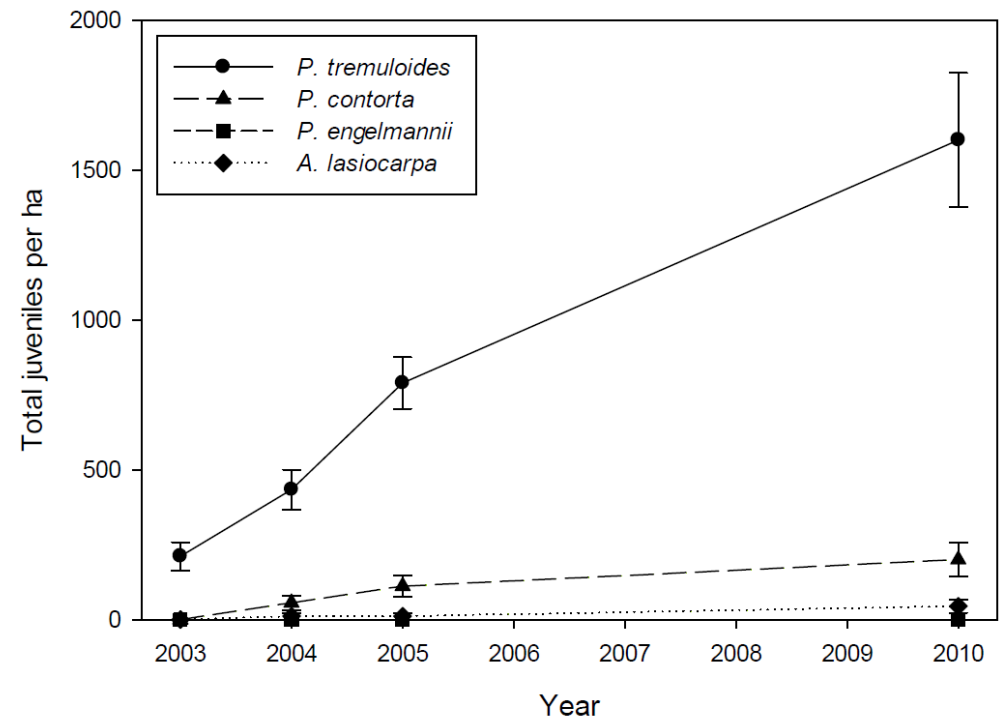
# Total regeneration varies with pre-fire composition



# Compounded disturbances favor initial dominance of aspen



Fire only



Wind then fire

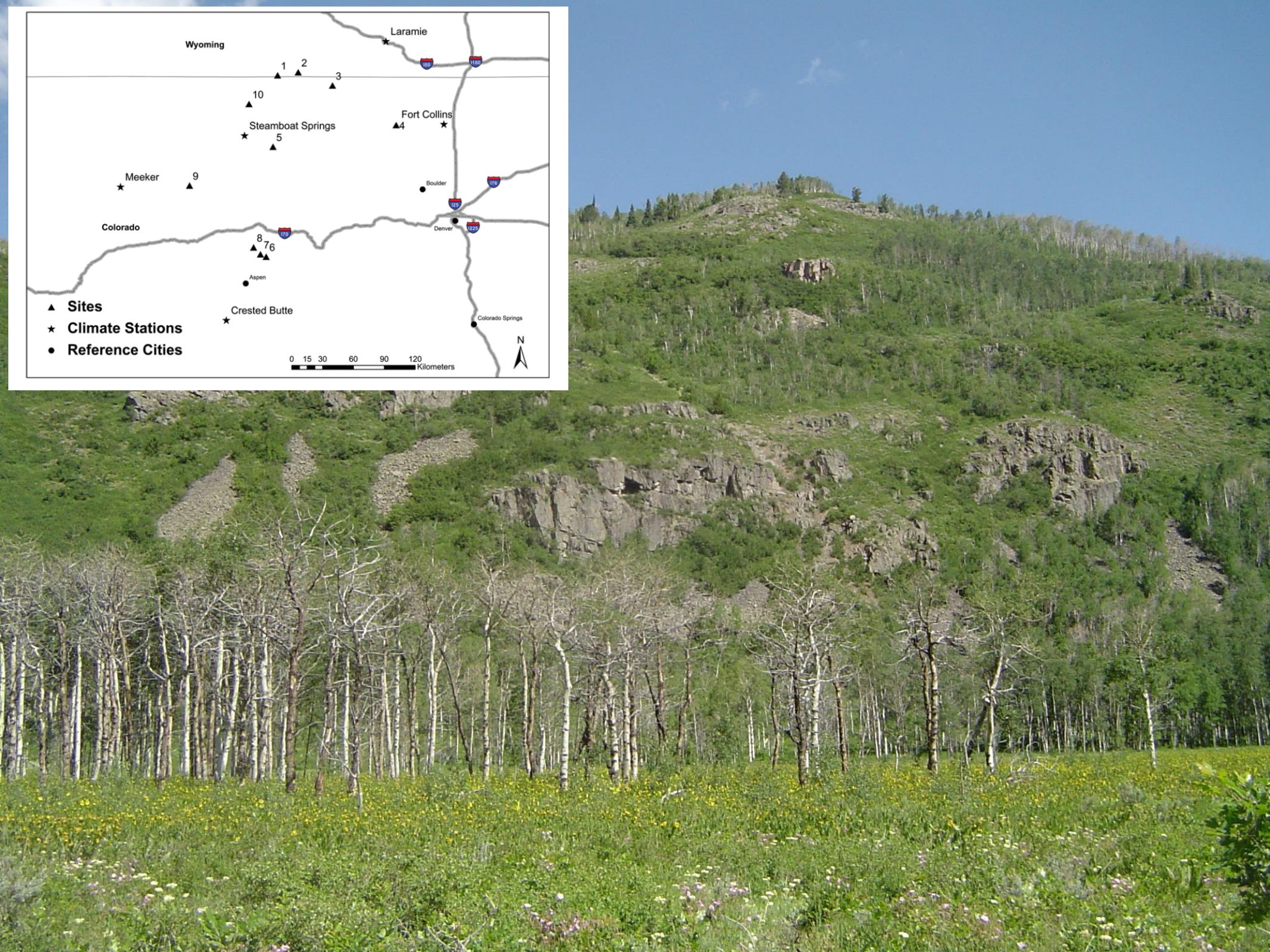
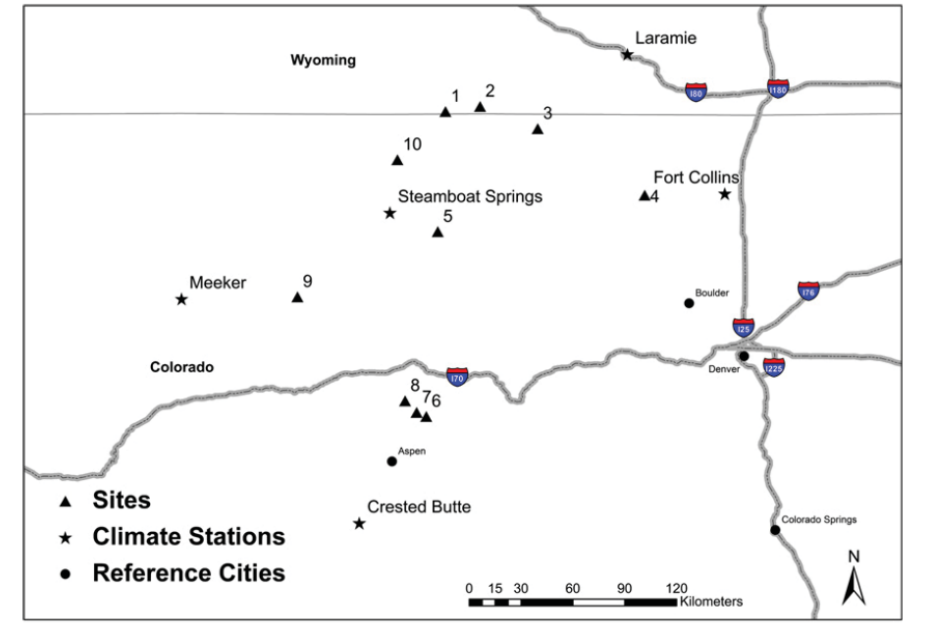


# Compounded disturbances and aspen regeneration

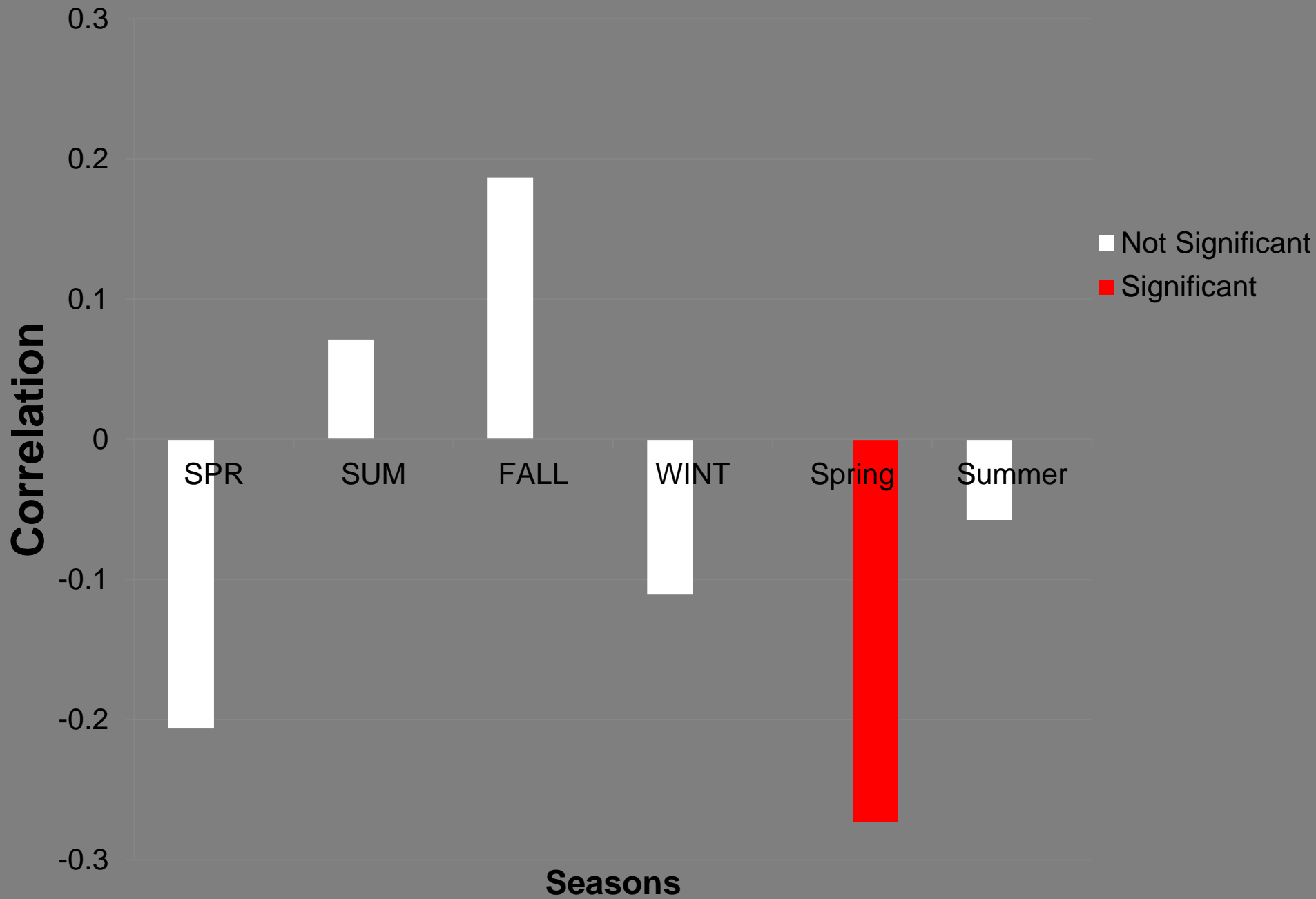
- Pre-fire forest composition and disturbance history affect post-fire regeneration.
- Effect of compounded disturbances on regeneration varies across species.
- Appear to favor aspen regeneration.
- Aspen also less susceptible to many climatically-driven disturbances.

# Direct effects of climate change

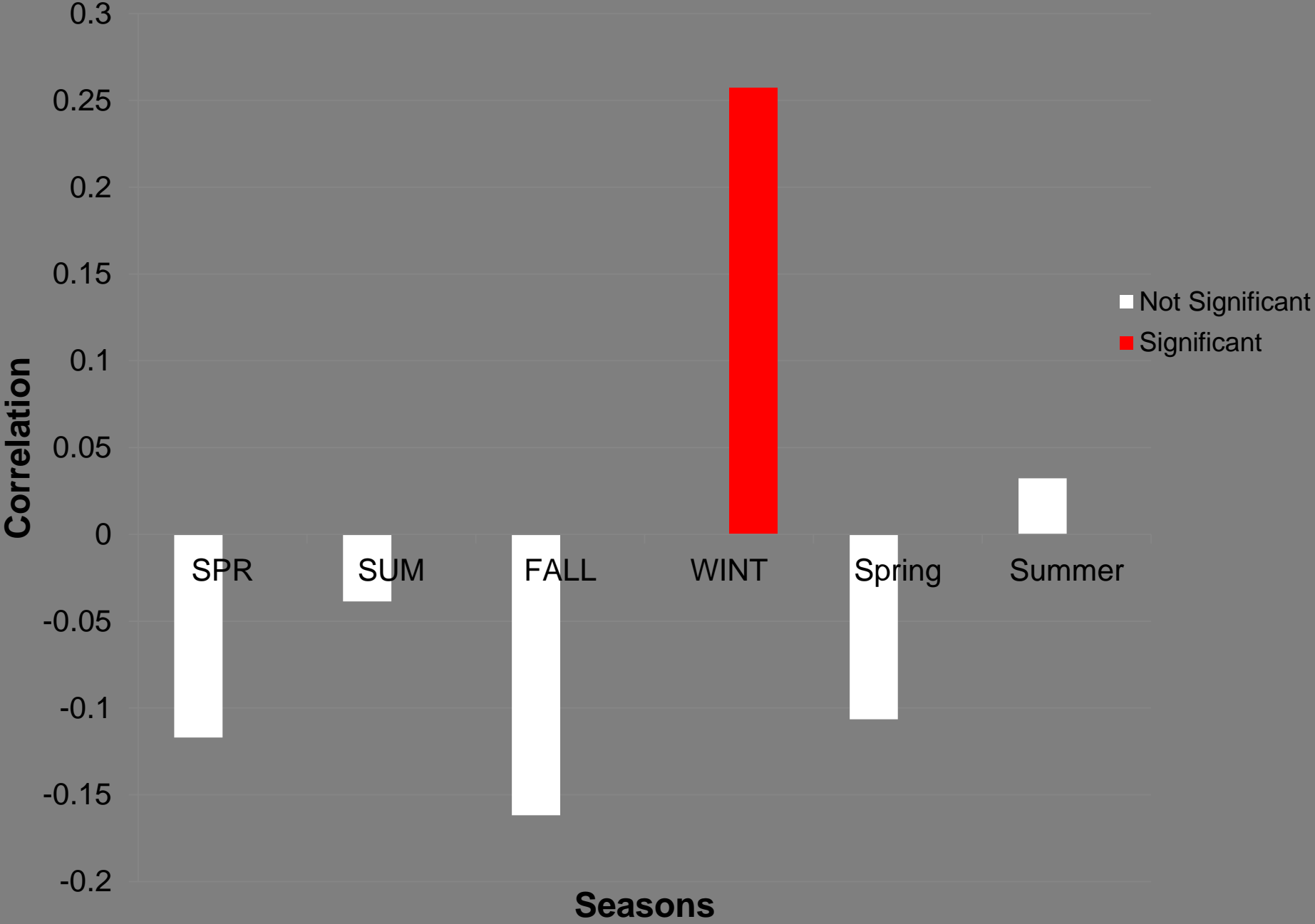
- Aspen demography is contingent on climate
- What is the direct effect of the same climatic conditions that indirectly (via altered disturbance regimes) favor aspen?



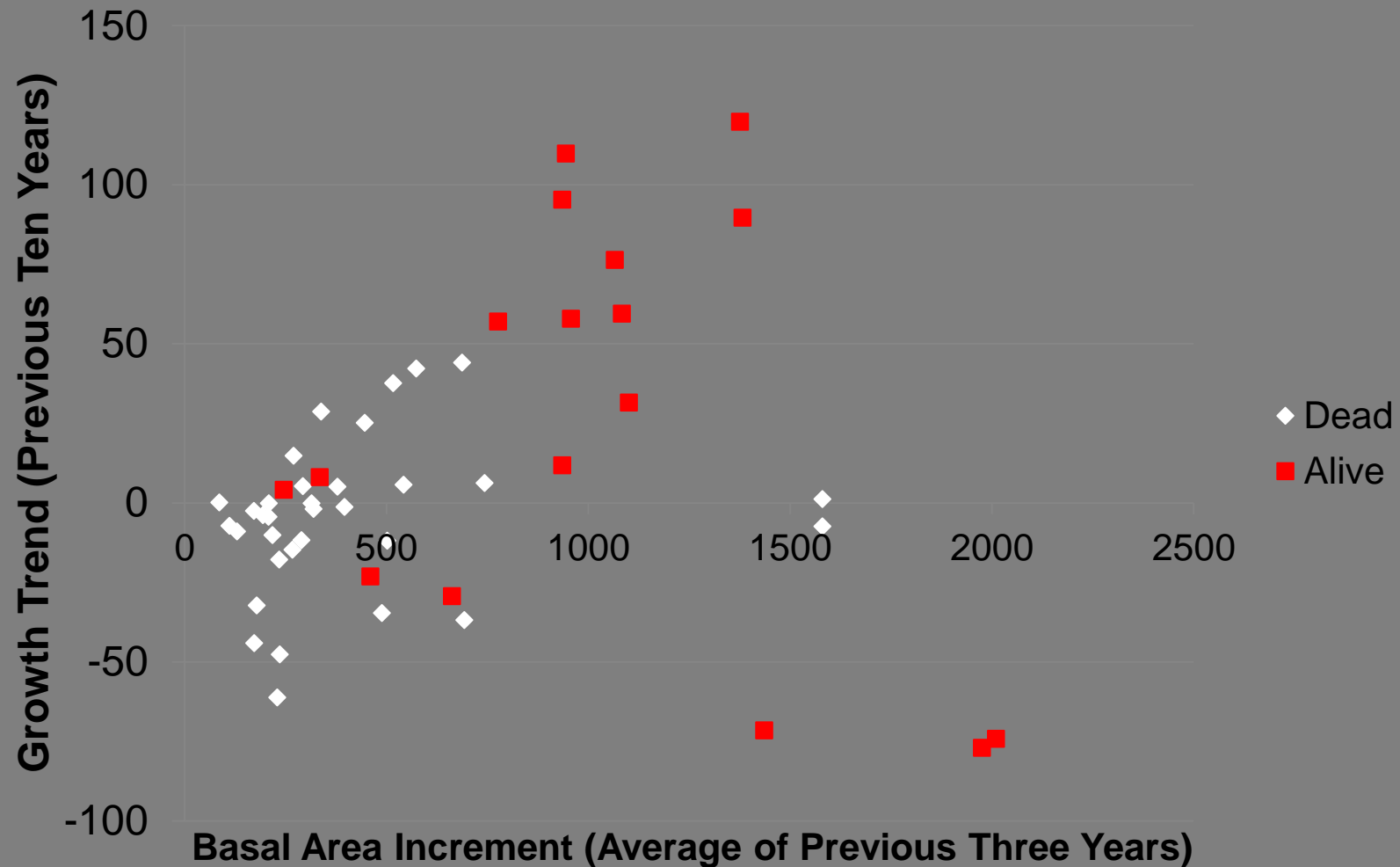
# Temperature



# Precipitation

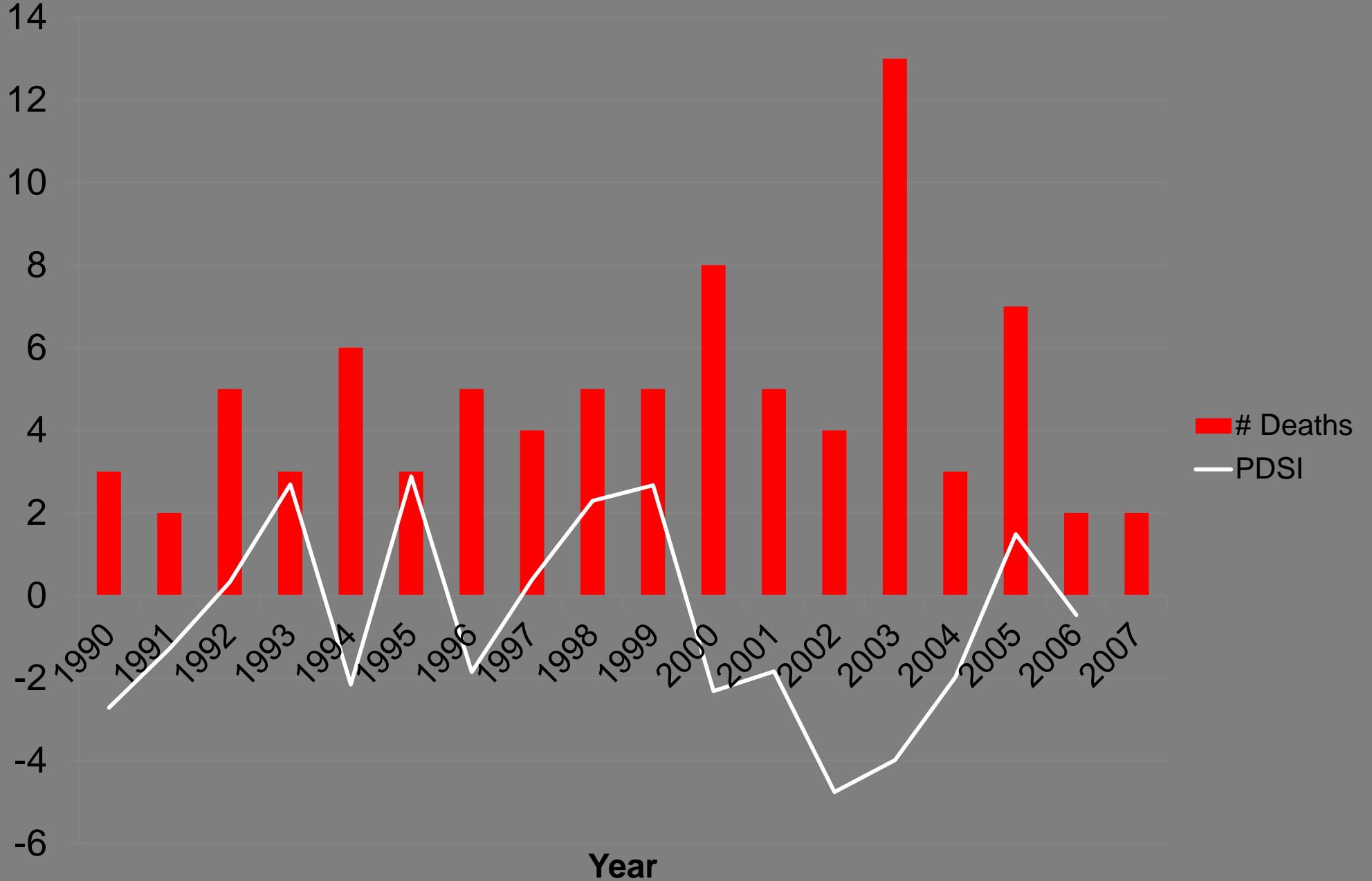


# Recent growth of live vs. dead trees



■ GLM; Model selection used Akaike's Information Criterion; Best model (AIC = 48.22) included variables  $\log(3 \text{ year average BAI})$  [p value < 0.001]; 20 year growth trends [p value < 0.001]

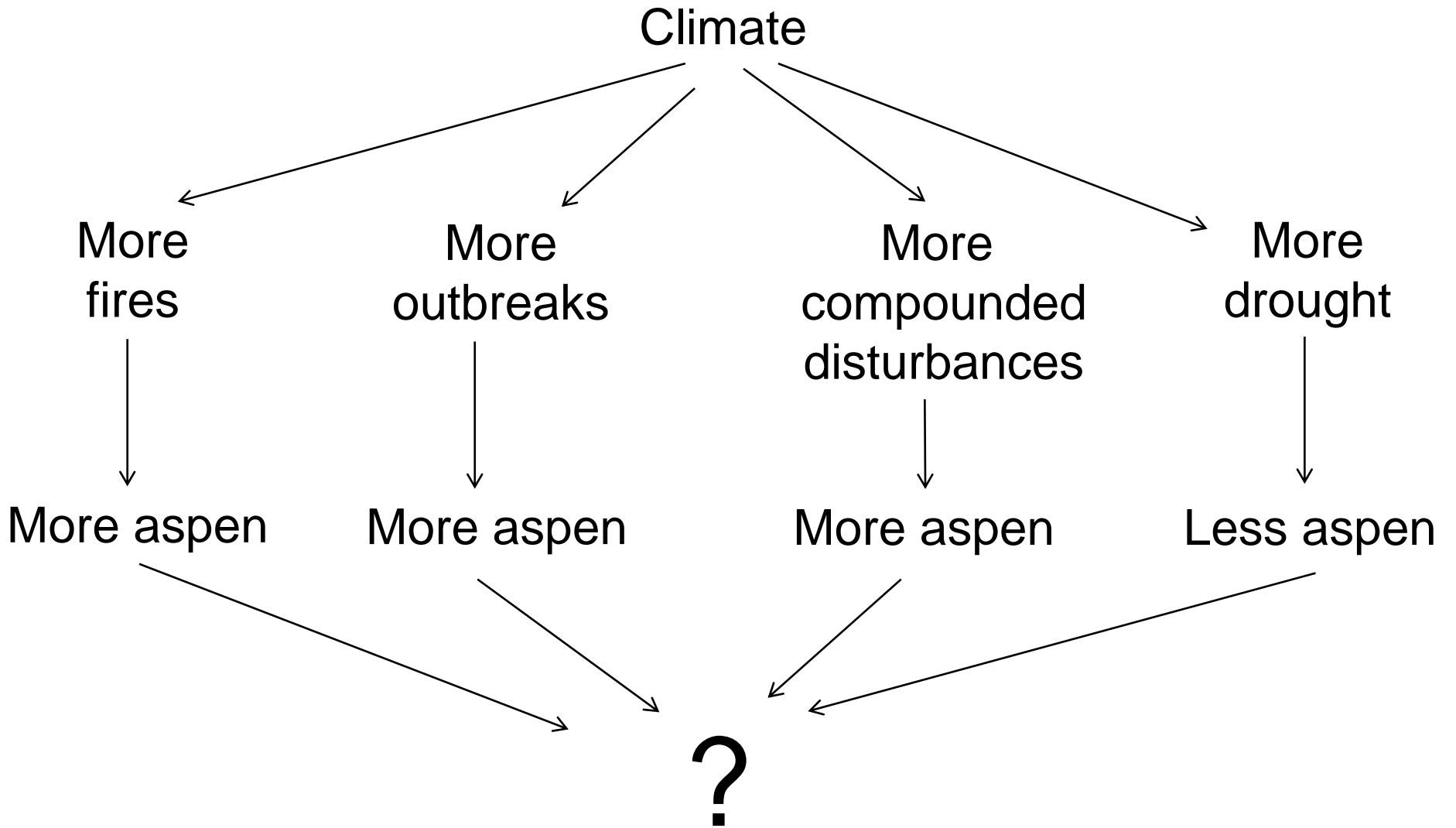
# Aspen Death & Drought

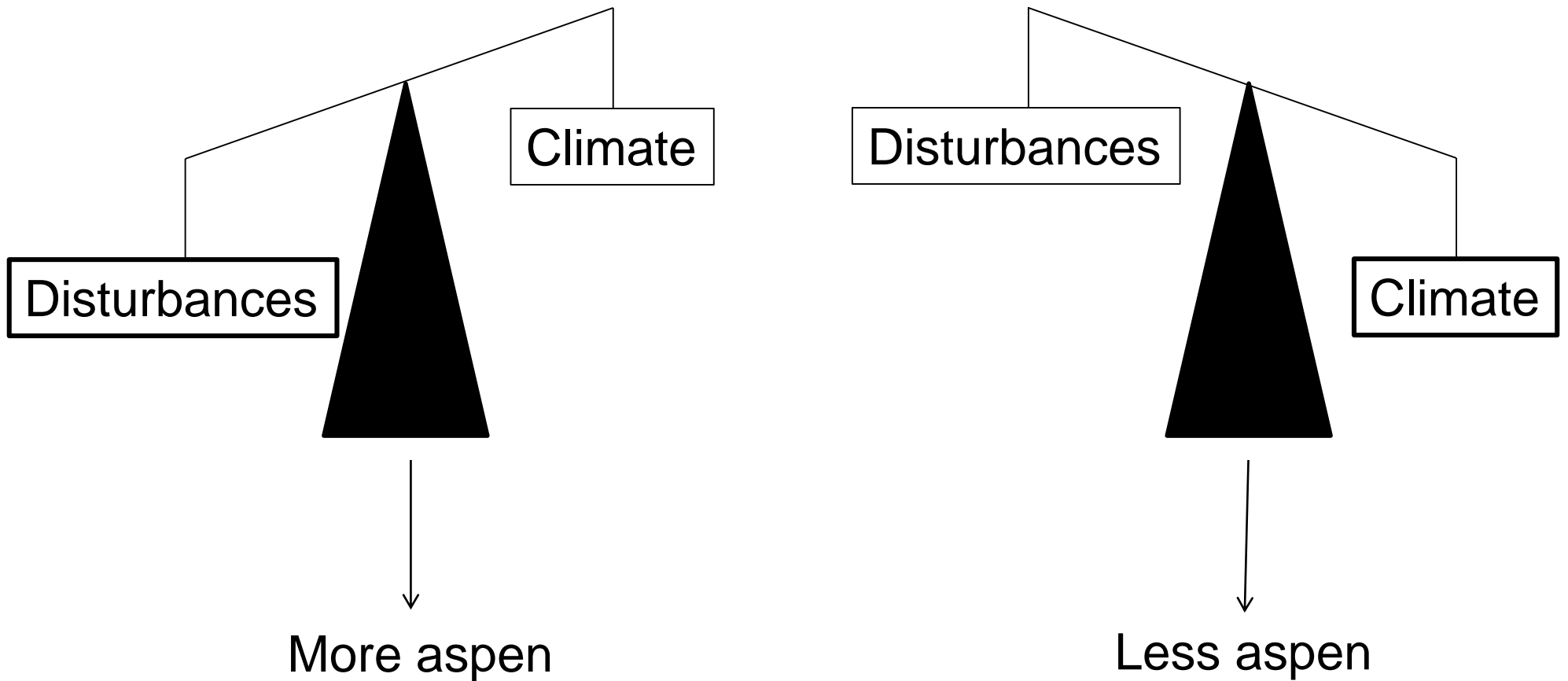


# Climate and mortality

- Growth and mortality of quaking aspen away from transitional zones also strongly associated with climatic variation.
- Specifically:
  - the growth of aspen inhibited by warm temperatures, except at the highest elevations
  - mortality of aspen preceded by multiple years of reduced growth
  - frequency of mortality associated with multiple years of drought

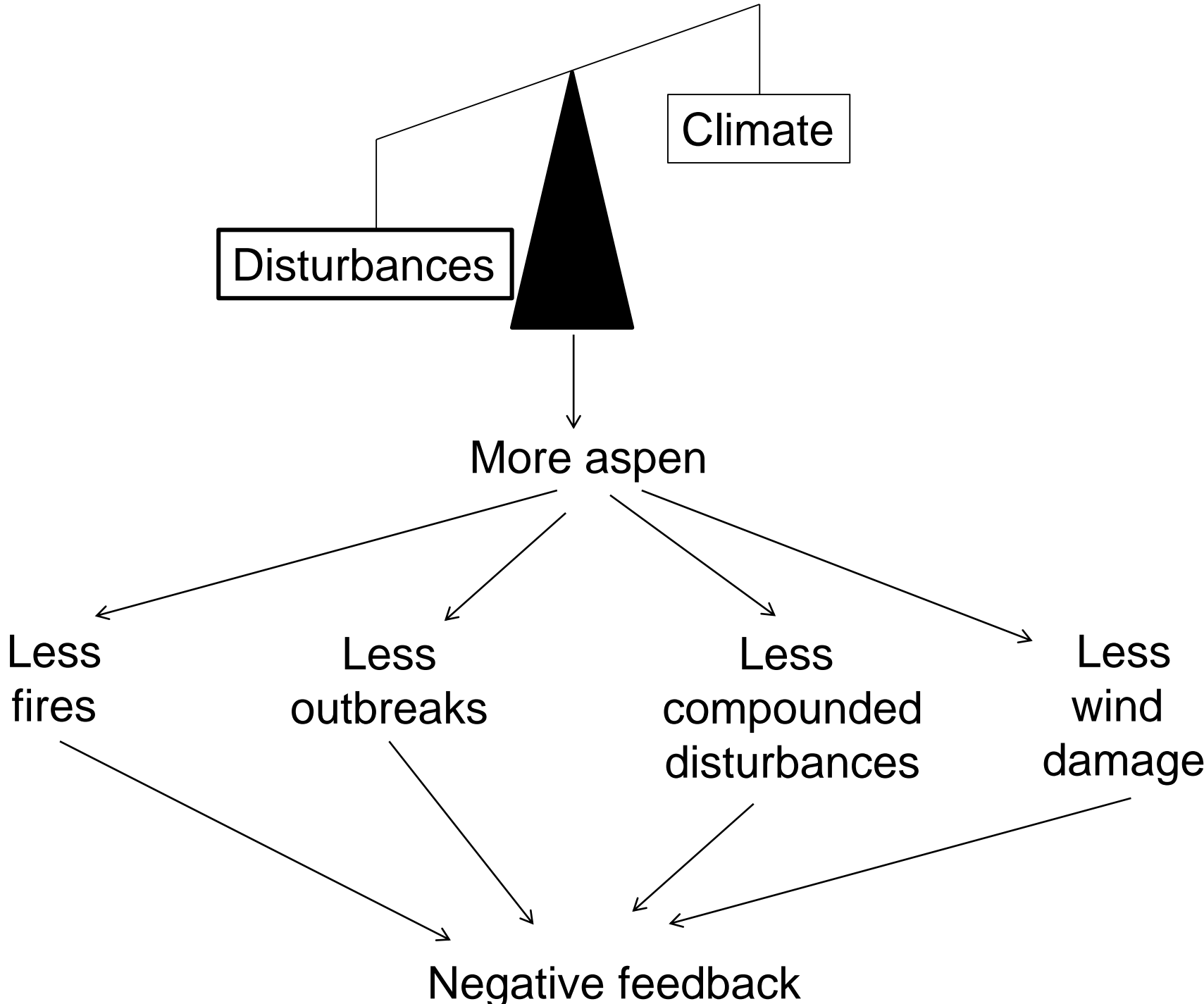




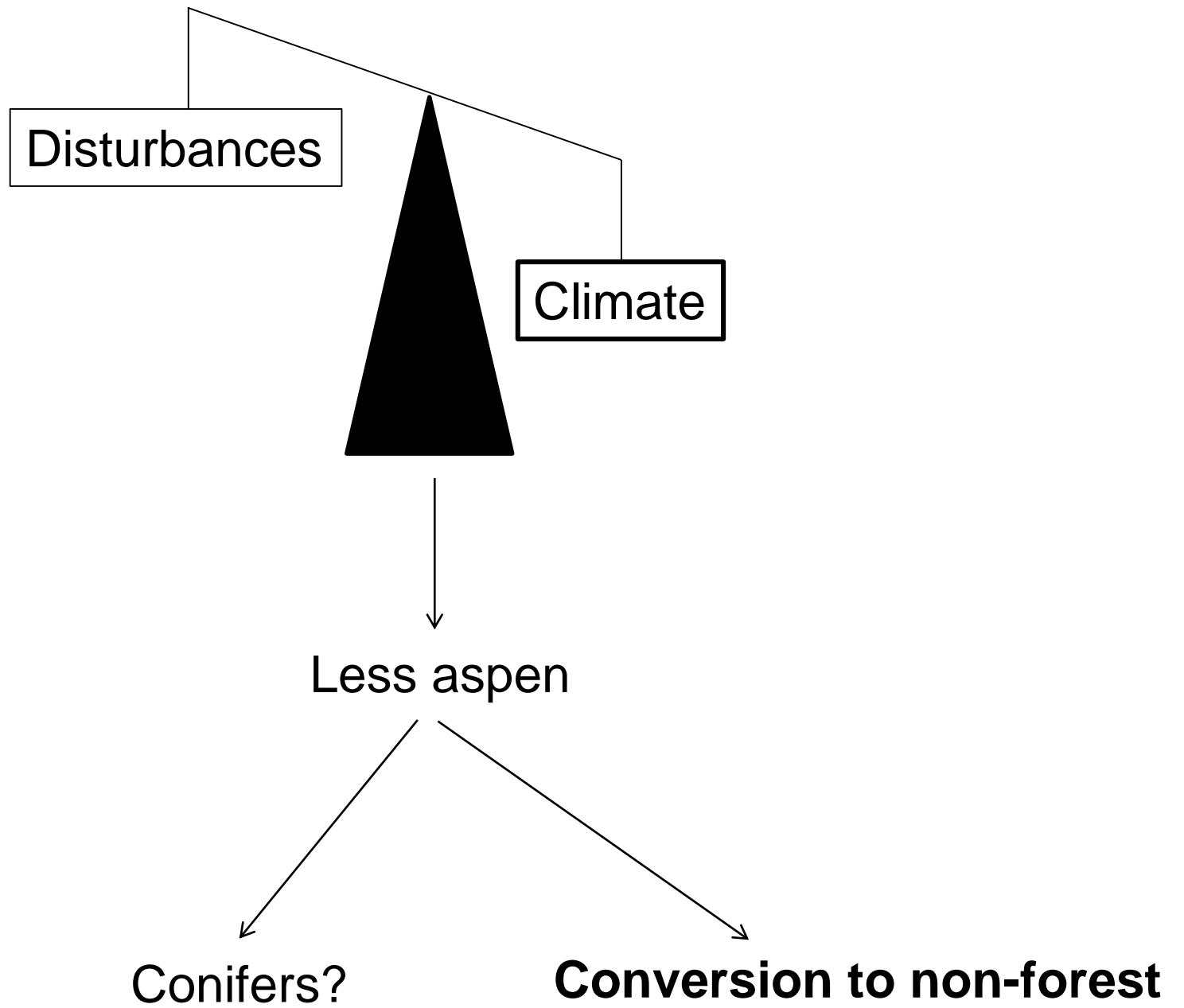


Contingent on aspen's ability to survive  
and regenerate under future climate

# Feedbacks



(Stabilizing factor for disturbance-driven ecological change?)



# Consequences and future scenarios

- Increases in individual and compounded disturbances have potential to promote aspen dominance, but only if post-disturbance climate is suitable for aspen survival and regeneration.
- Continuing drought has potential to hinder aspen dominance.

# The consequences of climate change for quaking aspen

... are likely to be complex and contingent on effects of post-disturbance climate as well as on feedbacks among climate, disturbances, and forest composition.