2014-2015 Webinar Series
February 19, 2015

Long-term effects of repeated prescribed burning on tree growth and drought vulnerability in *Pinus resinosa* forests in northern Minnesota

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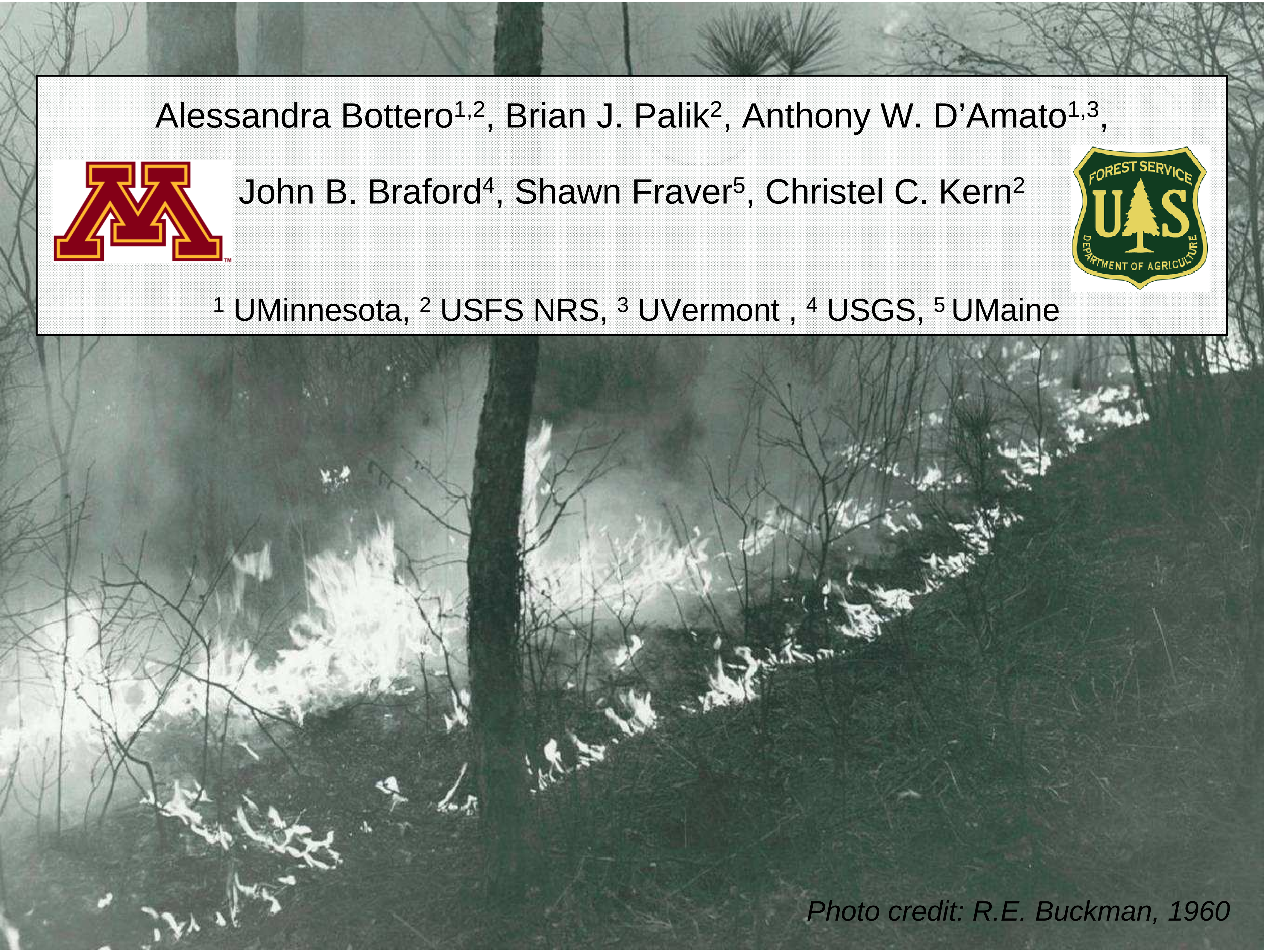


Photo credit: R.E. Buckman, 1960

Outline

- Introduction
  - Prescribed burning in a changing climate
  - Fire-prone forest ecosystems
- Study
  - Red Pine Prescribed Burning Experiment, MN
  - Methods
  - Results
  - Discussion and Conclusions

Prescribed burning

- **What is it & how does it work?**
  - Management tool
  - Application of fire to fuels to achieve specific goals [Fernandes and Botelho 2003]
  - Prescriptions (seasonality, frequency) [Knapp et al. 2009]

Prescribed burning

- **Why?**
  - Fuel reduction, forest regeneration, ecological restoration,…

Stand density reduction

Fuel load reduction

Prescribed burning

- **Impacts?**
  - Forest structure, soil and nutrients, seed banks, understory vegetation, overstory trees [Buckman 1964, Alban 1977, Neumann and Dickmann 2001, Agee and Skinner 2005, Hatten et al. 2012, Keyser et al. 2012]

Pre-burn

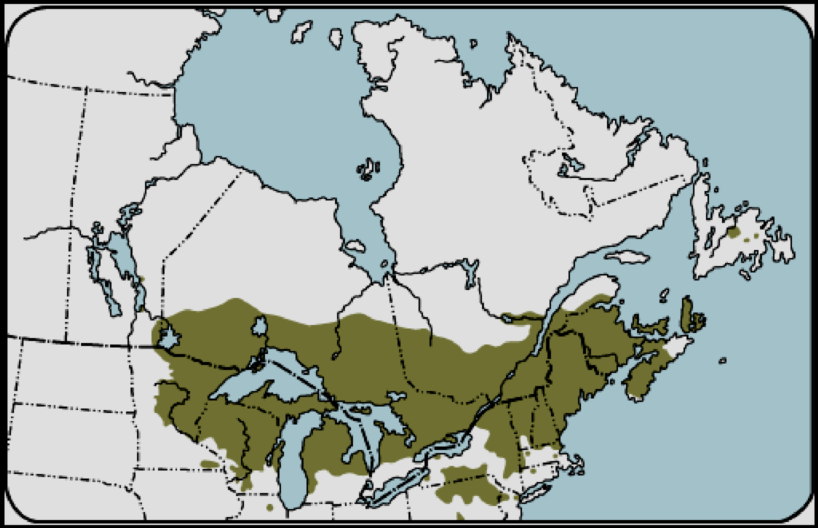
Post-burn

CEF, MN

Photo credit: R.E. Buckman

Fire-prone forest ecosystems
Red pine (*Pinus resinosa* Ait.) forests

CEF, MN



Source: Little 1971

- Wildfire suppression → alterations to forest structure and composition [Aaseng et al. 2003].
- Before: surface fires common (5–50 years), crown fires infrequent (150–250 years) [Heinselman 1996].

Fire-prone forest ecosystems
Red pine (*Pinus resinosa* Ait.) forests

- Suppression of surface fires → increase in live and dead fuels [Sands and Abrams 2011].
- Concerns about severe fires with behavior outside the historical range of behaviors [Scheller et al. 2005].
- More fire-prone climate [Westerling et al. 2006, Fulé 2008].

Fire-prone forest ecosystems

Red pine (*Pinus resinosa* Ait.) forests

Prescribed burning

reduce fuels, reduce competition from shrubs, and prepare seedbeds for pine regeneration, while maintaining a productive overstory.

Fire-prone forest ecosystems
Red pine (*Pinus resinosa* Ait.) forests

Few long-term prescribed burning studies to validate this recommendation → effects of prescribed burning on long-term patterns of tree growth remain poorly understood.

In particular, no or little information on how prescribed fire interacts with drought to affect tree growth.

The study

- Long-term (40 years post-treatment) effects of prescribed burning treatments on tree growth and vulnerability of growth to drought.
- Red pine-dominated forest in N MN, USA.
- Long-term plot measurements and dendrochronological data.

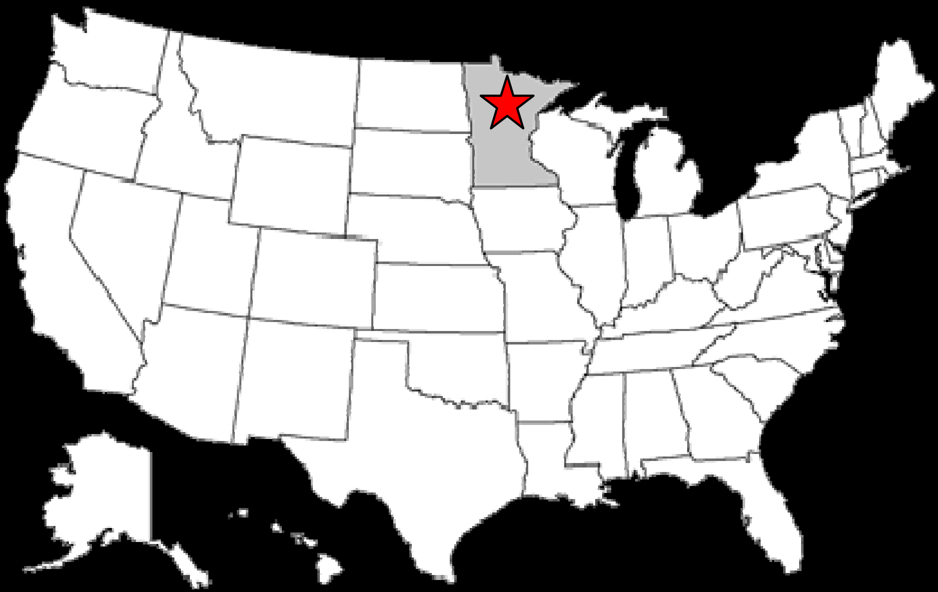
The study

? Tree growth response and drought vulnerability.

? Burning influence on red pine basal area growth.

? Burning influence growth responses of trees during subsequent droughts.

The study site



- MN
- Chippewa National Forest
- Cutfoot Experimental Forest (CEF)

- Red pine prescribed burning experiment, USDA FS 1959

Red pine prescribed burning experiment, CEF

Goal: prescribed burning impacts on regeneration, woody shrub encroachment, fuels reduction, and soil characteristics.

Forest: natural regeneration after fire in the late 1860s.

Experiment:

- Stand density reduction in the winter of 1959-1960 to basal area of 28 m^2/ha for uniform overstory conditions.

- Combinations of frequency (annual, biennial, periodic) and season (dormant and summer) of prescribed burning applied in 1960-1970 [Buckman 1964].

Red pine prescribed burning experiment, CEF

Photo credit: R.E. Buckman, 1960

Prescribed burning treatments analyzed

Periodic burning (PB)
1960, 1970 (2, May)
3 replicate plots

Annual burning (AB)
1960-1970 (11, June-July)
3 replicate plots

Control treatments analyzed

Control thinned (CT) 28 m^2/ha
Thinned in 1959, no burning
2 replicate plots

Control unthinned (CU)
No thinning, no burning
3 replicate plots

Methods

Photo credit: R.E. Buckman

- Trees, diameter at breast height (DBH) > 10 cm
- Species, DBH, height, vigor
- Cores
  - standard dendrochronological procedures
  - Ring width chronologies → annual tree basal area increment (BAI)

Analyses

Growth changes [Nowacki and Abrams 1997]

$$\%GC = [(M2 - M1) / M1] \times 100$$

where %GC = percentage growth change,
M1 = preceding 10 years mean BAI , and
M2 = subsequent 10 years mean BAI.

Analyses

Growth response to drought

[Kohler et al. 2010, D’Amato et al. 2013]

$$\text{Resistance} = BAI_D/BAI_{pre}$$

$$\text{Resilience} = BAI_{post}/BAI_{pre}$$

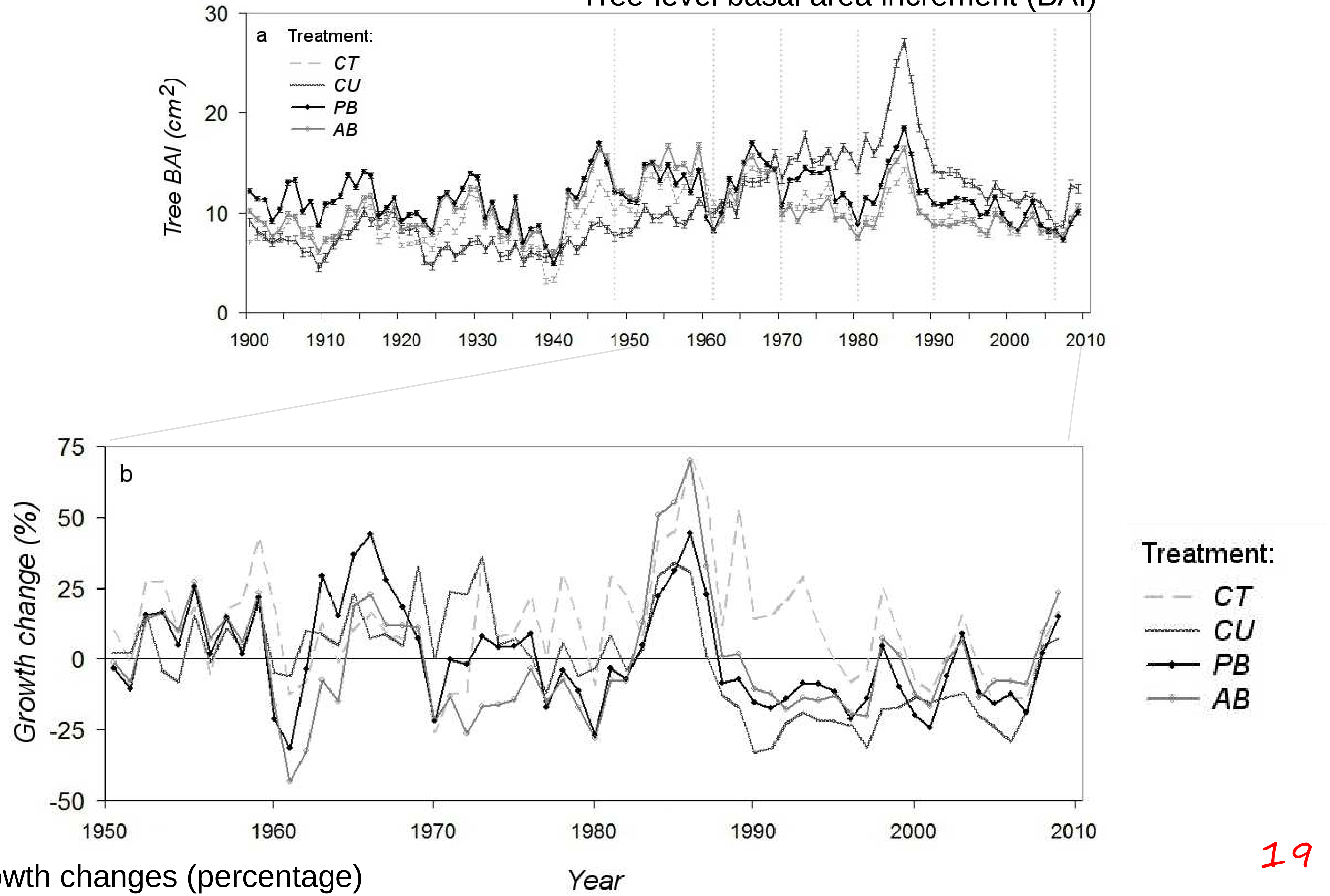
$$\text{Recovery} = BAI_{post}/BAI_D$$

where BAI_D = BAI during drought, BAI_{pre} = BAI in the 1,3,5 years prior to drought, BAI_{post} = BAI in the 1,3,5 years following drought.

Droughts (historical records, SPEI [Vicente-Serrano et al. 2010]):
1948, 1961, 1970, 1980, 1990, 2006

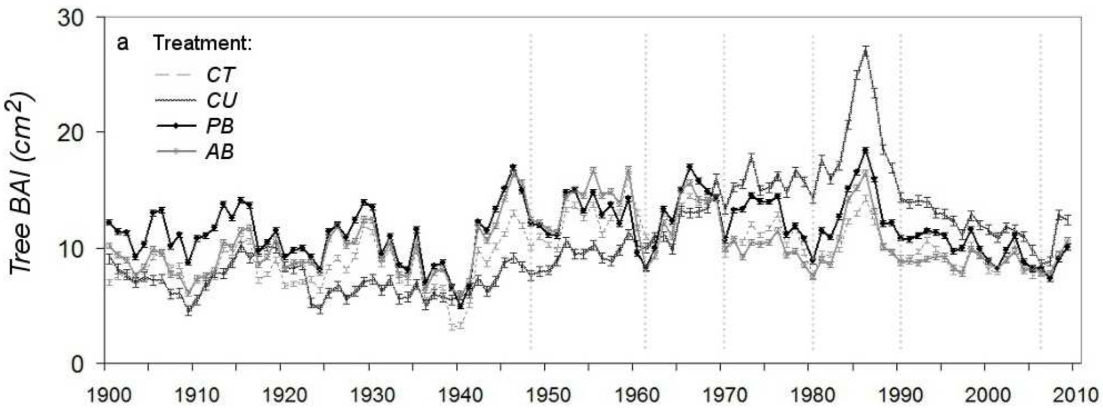
Results – Growth changes

Tree-level basal area increment (BAI)



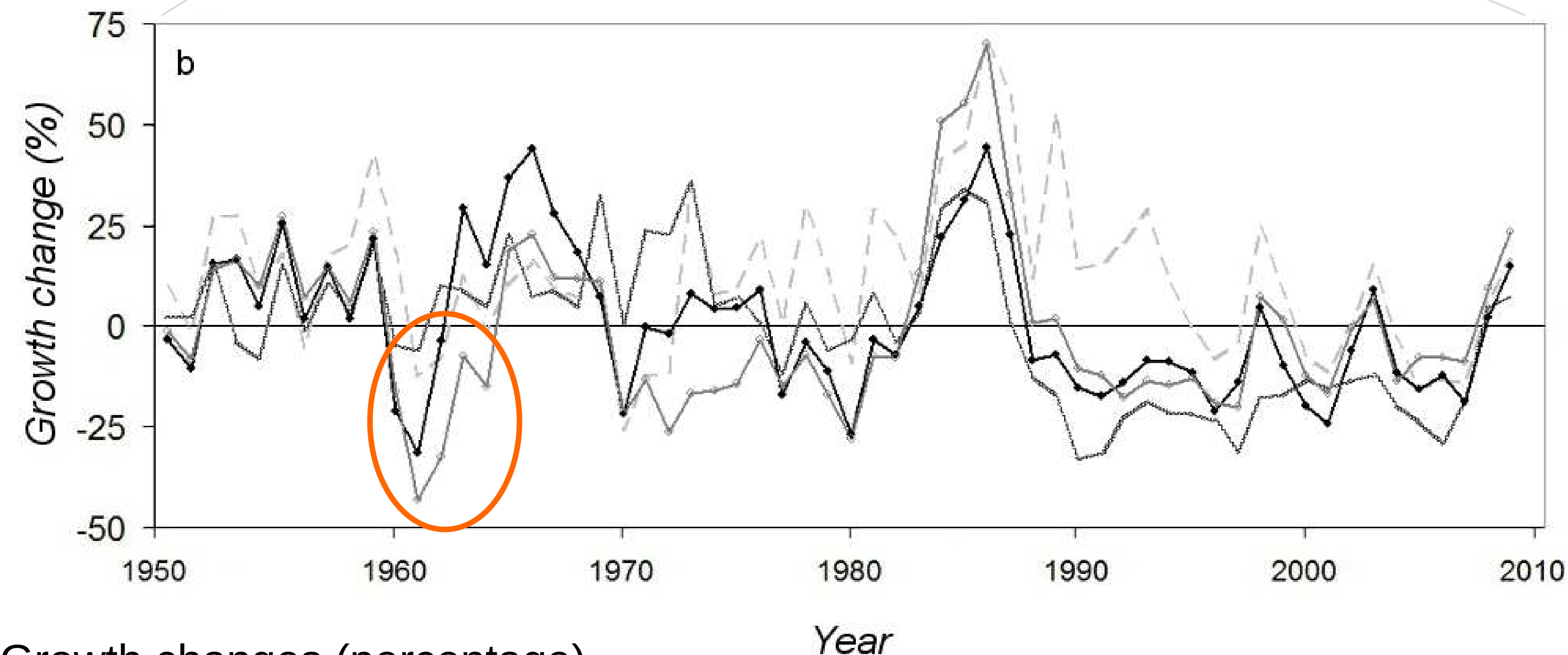
Growth changes (percentage)

Results – Growth changes



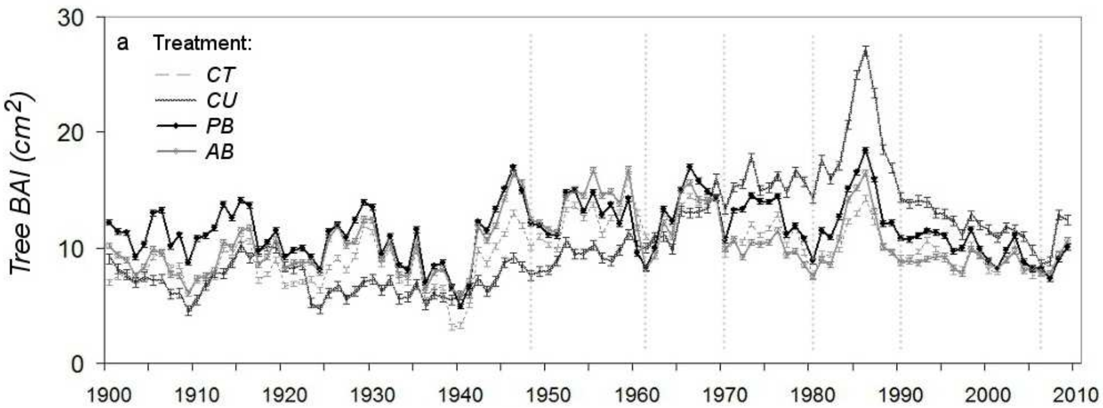
Tree-level basal area increment (BAI)

- *PB*, *AB* - < growth following the beginning of the experiment.
- *AB* - most trees (94%) >25% growth reduction until 1964 (-31% average).



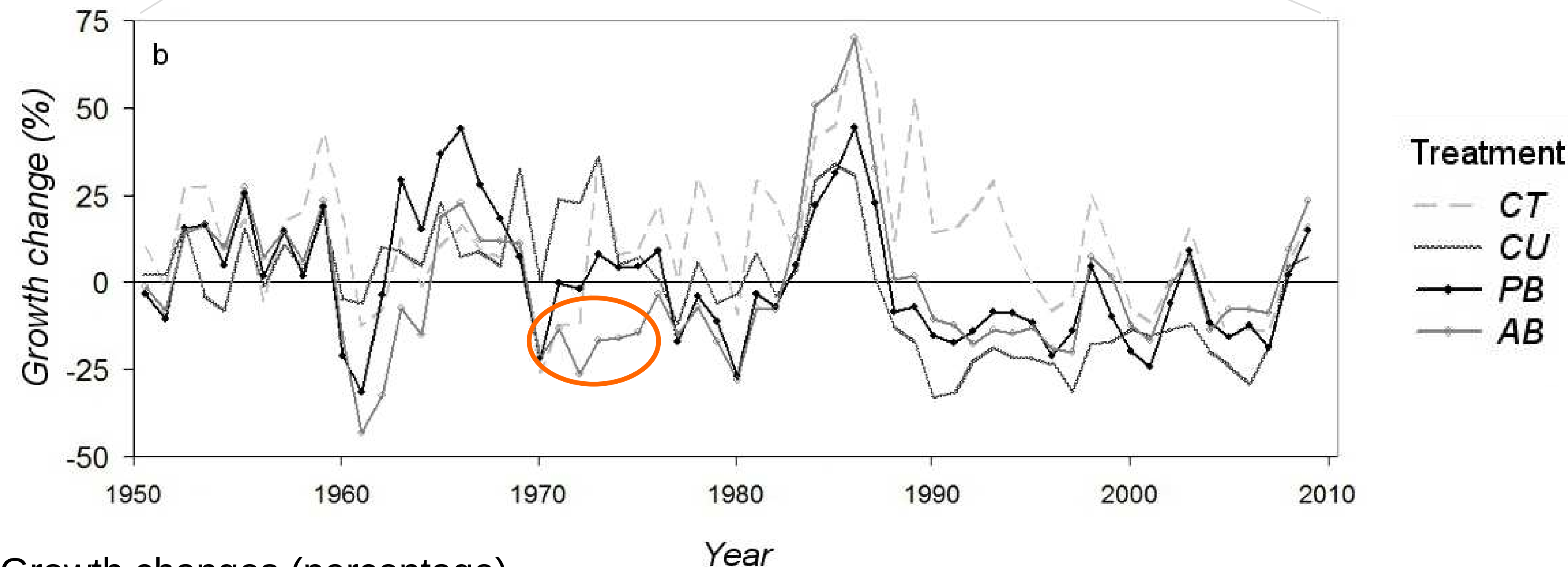
Growth changes (percentage)

Results – Growth changes



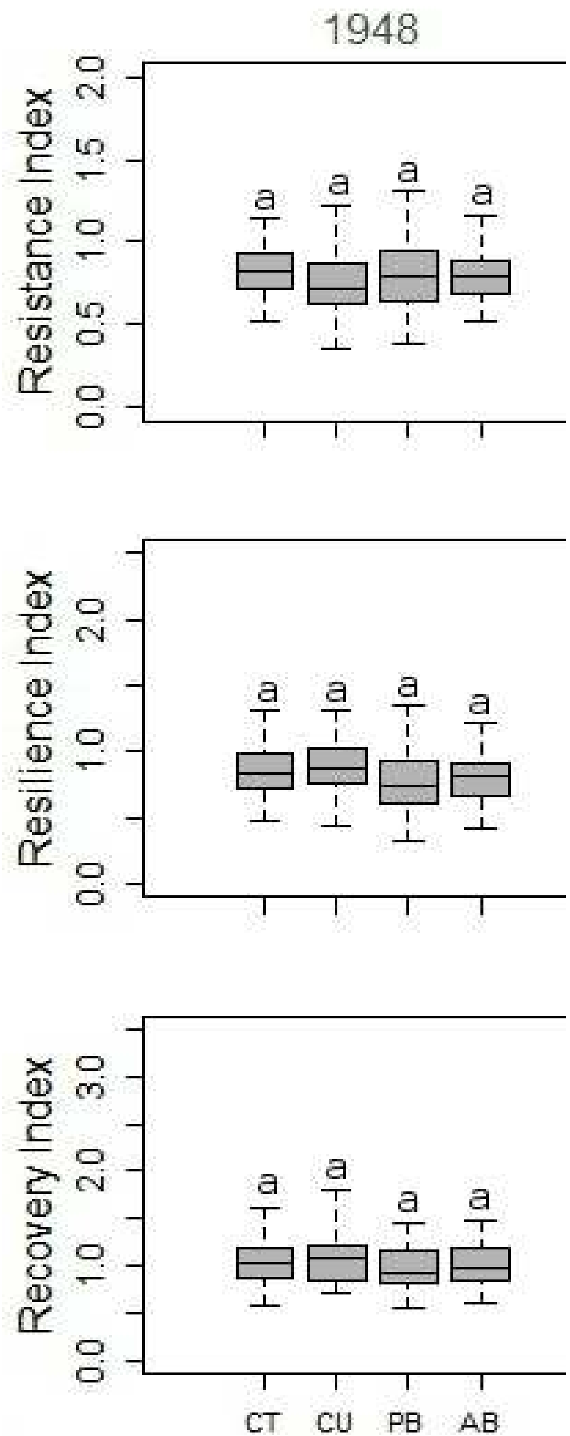
Tree-level basal area increment (BAI)

- *PB*, *AB* - < growth following the beginning of the experiment.
- *AB* - most trees (94%) >25% growth reduction until 1964 (-31% average).
- *AB* - < growth after the end of the burning experiment.



Growth changes (percentage)

Results – Growth response

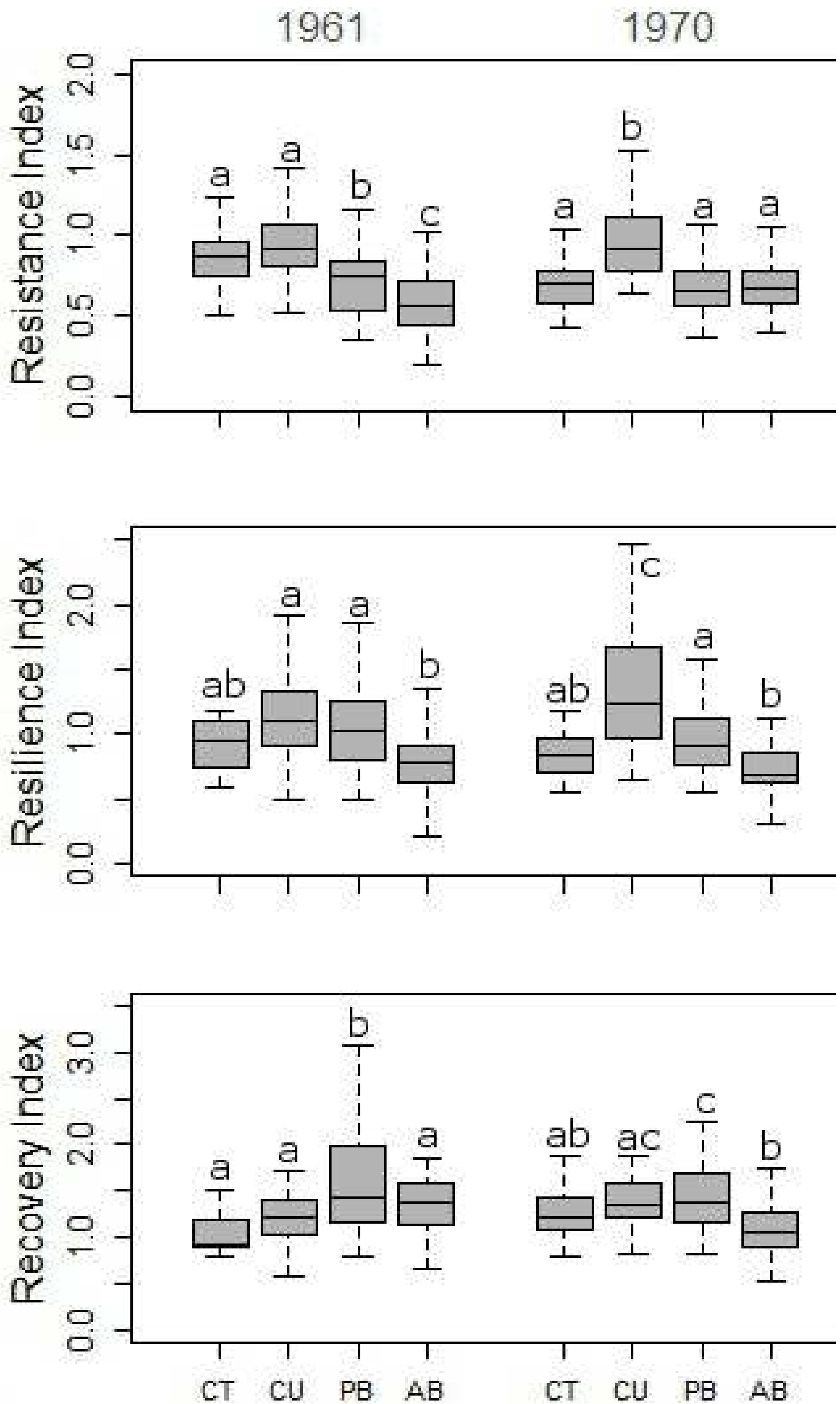


Before the experiment

(drought 1948):

- No significant differences in
  - Resistance
  - Resilience
  - Recovery

Results – Growth response

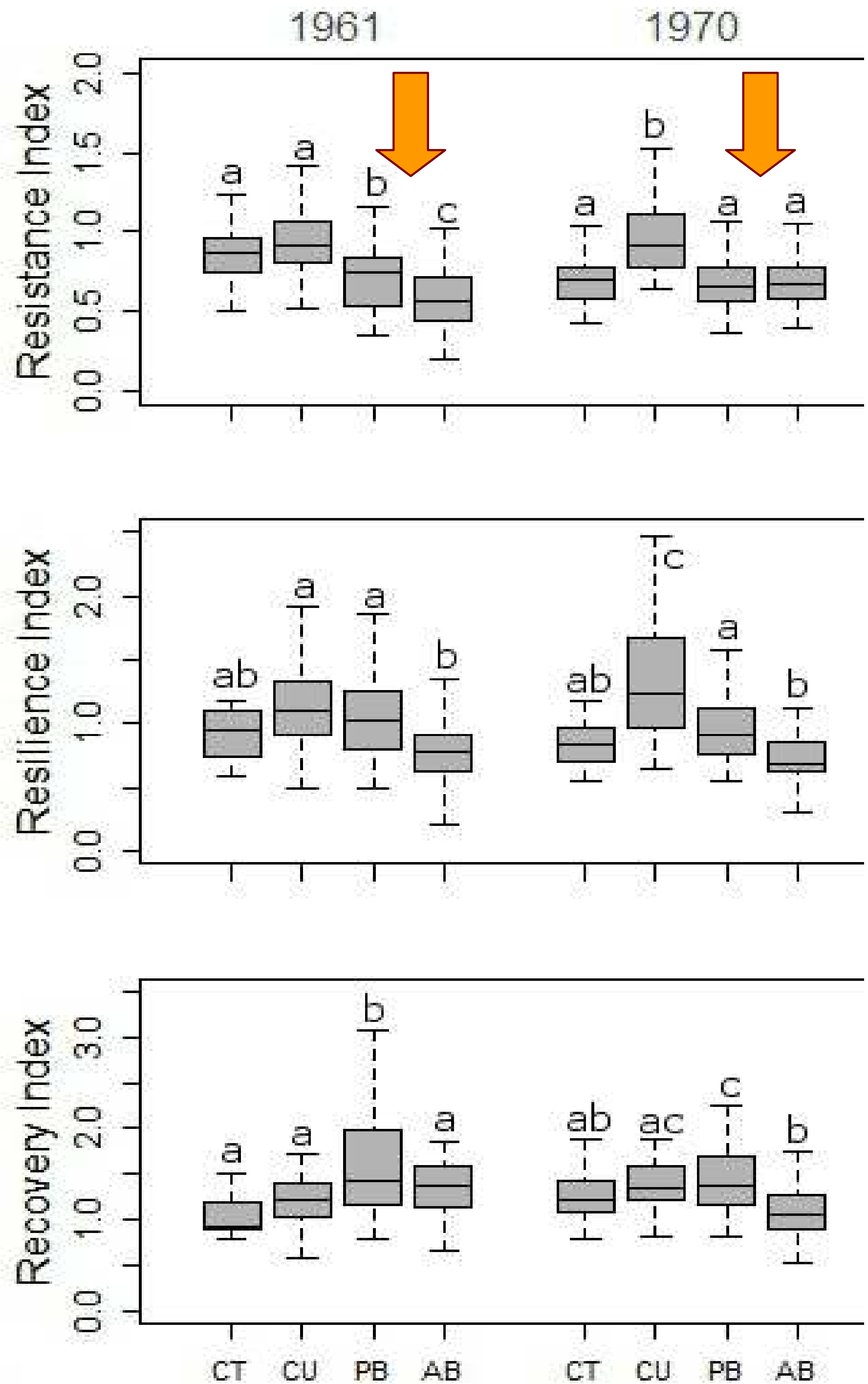


Prescribed burning experiment

(droughts 1961, 1970):

- PB, AB response altered by burnings
- CT, CU no fluctuations in resistance, resilience, or recovery

Results – Growth response



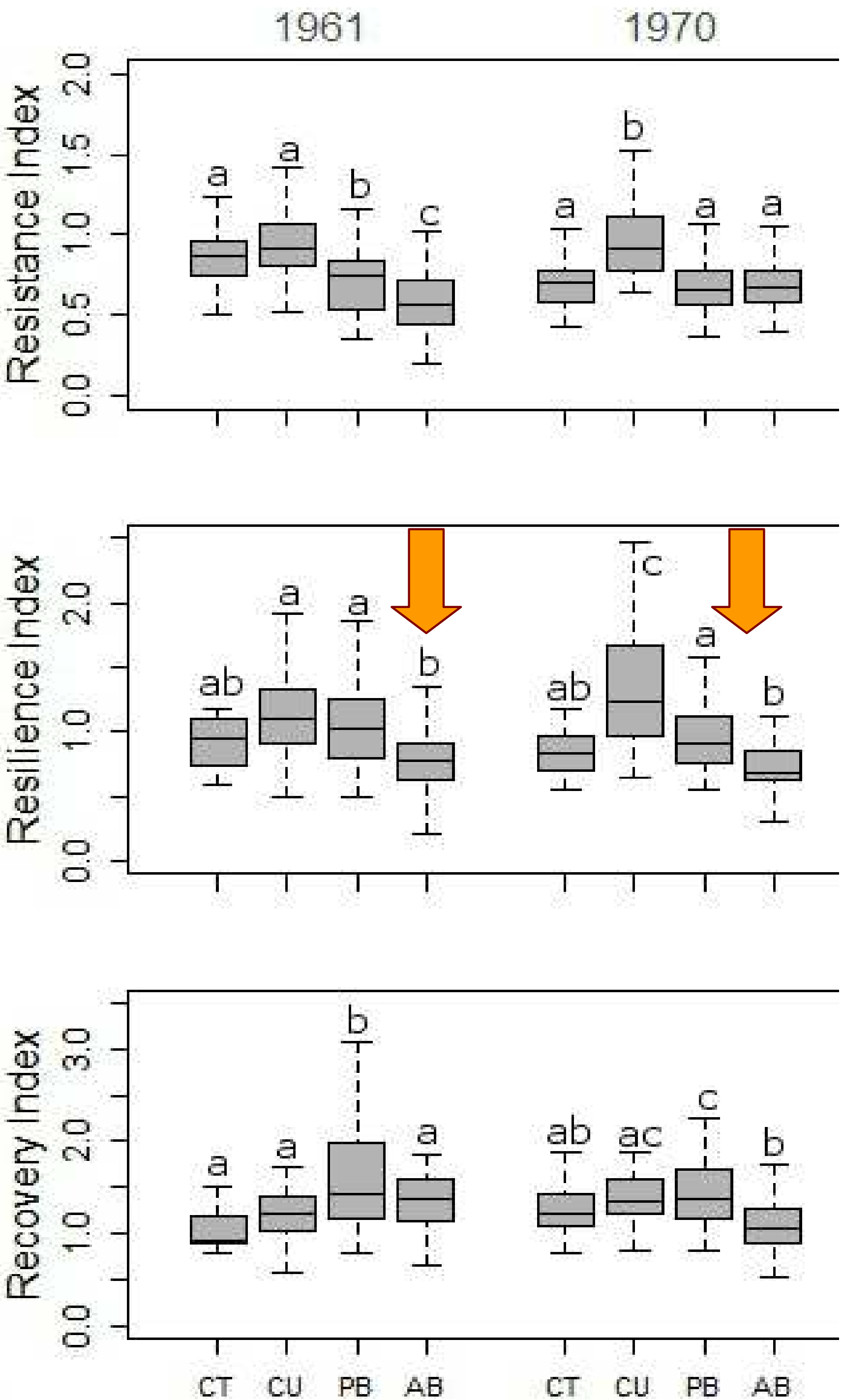
Prescribed burning experiment

(droughts 1961, 1970):

- PB, AB < resistance
- AB lowest resistance (1961)

Resistance = BAI_D/BAI_{pre}

Results – Growth response



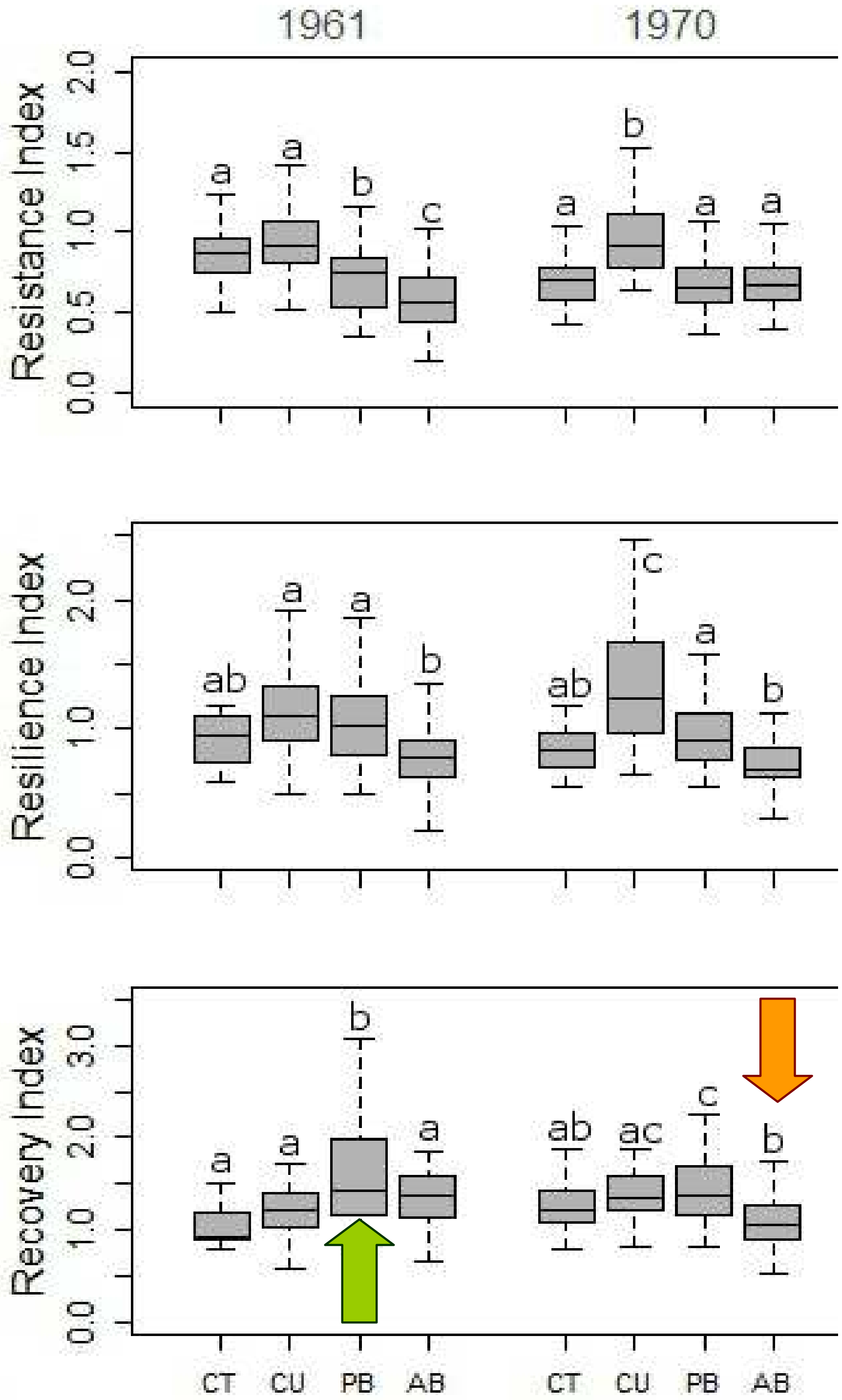
Prescribed burning experiment

(droughts 1961, 1970):

- AB < resilience (1961)
- PB, AB most notable reduction in resilience (1970)

Resilience = BAI_{post}/BAI_{pre}

Results – Growth response



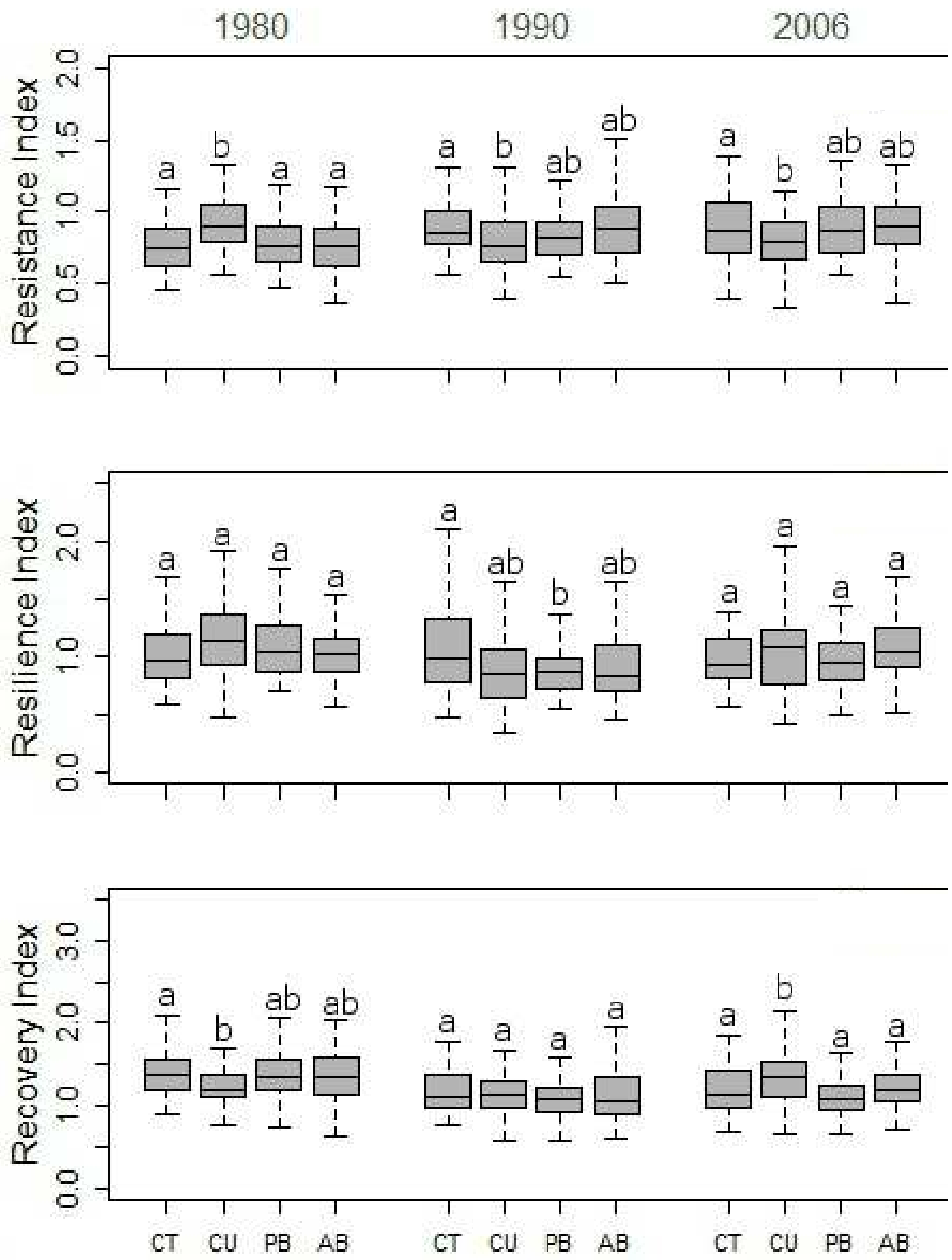
Prescribed burning experiment

(droughts 1961, 1970):

- PB > recovery (1961)
- AB < recovery (1970)

Recovery = BAI_{post}/BAI_{D}

Results – Growth response



Long-term

(droughts 1980, 1990, 2006):

- Little differences among treatments

Discussion & Conclusions

- Repeated prescribed burnings reduced growth in the years immediately following burning, but impacts did not persist after burning treatments were discontinued.
- Growth reduction was more pronounced in the stands burned annually than periodically, but significant only for a few years after burning.

Discussion & Conclusions

- Repeated prescribed burnings reduced growth in the years immediately following burning, but impacts did not persist after burning treatments were discontinued.
- Growth reduction was more pronounced in the stands burned annually than periodically, but significant only for a few years after burning.
- Growth vulnerability to drought was altered by the repeated application of prescribed fire.
- Resistance and resilience to drought were reduced in both burning treatments in the short-term, but not necessarily in the long-term.

Discussion & Conclusions

Based on our results, the use of prescribed burning can increase tree growth vulnerability to drought over the short-term, with no long-term consequences.

Given this susceptibility, the use of prescribed burning as forest management tool needs to be consciously implemented, especially considering predictions of increasing drought frequency, duration and intensity for many fire-prone forest systems.

For drier ecosystems, the application of alternative fuel treatments (e.g., mechanical treatment) may be an option for achieving fuel reduction goals without affecting tree vigor (Collins et al. 2014), or increasing tree growth vulnerability to drought over the short-term.

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Next Webinar:

March 19, 2015 at 2:00 PM Eastern (1:00 PM Central)

Fire Monitoring: Fuels, vegetation, and fire behavior examples from red pine and jack pine burns

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