Fire, Water, and Nitrogen

Growth constraints in a New Mexico ponderosa pine forest

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100 years of fire suppression

• Change in forest structure
  – Grazing removes understory fuels
  – Active fire suppression

Flagstaff, AZ early 1900’s.

Dense area of field site, 2006.
Problem

• Fire suppression: more competition
• Climate change: warmer, drier southwest
• How will forest respond?
  – Reduced growth
  – Higher mortality
Objective

Examine competition and drought impacts on growth, survival, and canopy physiology.

Winter fieldwork in MCN.
Methods

• Site selection
  – Monument Canyon Research Natural Area (MCN)
• No cutting, no fire =
Jemez Mountains

Los Alamos

MCN

open

dense

N
Methods

• Basal area: measure of competition
  – Amount of wood surrounding target tree
Methods

- Test period selection: 1897-1907, 1971-1980
  - Climatically similar
    - Range of wet/dry years, close average PDSI
    - PDSI: Palmer Drought Severity Index, +cool, wet –hot, dry

![Graph showing PDSI values for pre-fire and post-fire exclusion periods](chart.png)
Methods

• Basal area increment
  – ‘Doughnut’ of new growth each year
  – Measured ring widths, converted to BAI

• Mortality
  – Annual census of tree condition and survival
Methods

• Discrimination (\(\Delta\)): measure of water stress
  – With \textbf{unchanging} site fertility

  When water stressed, plants close stomata.
  Drought => less water per tree => water stress, lower \(\Delta\)

\[\begin{align*}
\text{Wet} & \quad \text{stomata open} \\
\text{CO}_2 \text{ intake high} & \quad \Delta = \text{high} \\
\text{Dry} & \quad \text{stomata closed} \\
\text{CO}_2 \text{ intake low} & \quad \Delta = \text{low}
\end{align*}\]
Hypothesis

Water stress in dense stands is cause of increased mortality.

Dense area of MCN.
Results

• Growth: not a big response to competition
  – Ring widths => BAI (Basal area increment)
  – Higher mortality in dense sites

![Graph showing BAI (Basal area increment) over time for pre-fire and post-fire exclusion periods. The graph compares open and dense sites with error bars indicating variability. The x-axis represents the year, ranging from 1897 to 1980, and the y-axis represents the average BAI in m².]
Results

- Discrimination: measure of water stress
- Response opposite of water stress prediction
Results

- Discrimination: measure of water stress
- Response opposite of water stress prediction
Nitrogen!

Less N
⇒ Less rubisco
⇒ Decreased photosynthesis per unit leaf area
⇒ Higher ∆

Suggests mortality results from nitrogen starvation, *Not water stress.*
Conclusion

• Relative to open stands, dense stands have:
  – Higher mortality
  – Higher discrimination
  – Lower % leaf nitrogen

Dense stands in MCN appear nitrogen limited, not water limited.
Thanks!

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LDRD-Laboratory Directed Research and Development
Questions?

Thinning of dense sites in ongoing restoration study.