Recruitment of subalpine tree populations sensitive to warming within and above current altitudinal range

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Photo: J. Mitton
Forest upslope migration
upslope with warming?

(Korner et al., 2004; Harsch et al. 2009)
Hypotheses re: role of seedlings

1. Seedling dynamics are ephemeral and do not affect treeline change
2. Seedlings are ubiquitous and recruitment is stochastic; climate effects minimally important
3. Episodic good years are sufficient to grow or maintain populations of long-lived trees
4. Climatic constraint at treeline predominantly temperature
1. Seedling dynamics are ephemeral and do not affect treeline change

Alternative hypothesis

Seedling recruitment important to population sizes
Meta-population model with field data

Alpine  50 ha
Initially no individuals, relies on dispersal from treeline site

Treeline
Initially few adult trees, mostly large saplings

Forest
Initially many adult trees
Differences in recruitment affect population sizes

- **50 ha**

Generous assumptions for dispersal to alpine

- **Differences in recruitment**

- **Abundance of trees ≥4 cm dbh in 50 ha**
  - **Alpine**
  - **Treeline**
  - **Forest**

Time (years)
2. Seedlings ubiquitous, recruitment stochastic, climate unimportant

Alternative hypothesis

Seedling success is highly sensitive to microclimate factors
First seeds sown in Fall 2009.

Figure: Andrew Moyes, Erin Conlisk
Suboptimal microclimate reduces limber pine carbon uptake

- Treeline
  - Freezing 2%
  - Low or high temperature 14%
  - Low moisture 21%

Realized, 63%

(Moyes et al. in revision)
Heat reduced first-year limber pine survival

Roughly 16,000 seeds were sown from 2009-2013

Germination and First-Year Survival

- Control
- Water
- Heat
- Heat-water

Forest

Alpine

Treeline

9 weeks

1 cm

Photo: Cristina Castanha
Heat, water alter first-year Engelmann spruce survival

Roughly 29,000 seeds were sown from 2009-2013

Germination and First-Year Survival

Control Water Heat Heat-water

Alpine Treeline Forest

Photo: Glenn F. Cowan

Photo: Cristina Castanha

1 cm

9 weeks
3. Episodic good years sufficient to grow or maintain tree populations

Alternative hypothesis

Many good years in a row required; Climate change “loading the dice”
Lodgepole pine expansion into meadows

Best statistical model of 20th c. population growth includes 9 years of favorable climate

(Lubetkin et al. in prep)
Interannual variation in survival and multi-year effects of climate treatments
Heating effect transient; watering effect emerges over time

Alpine

Survival Year 0-1 (+/-SE)
4. Temperature predominant limiting factor at treeline

Alternative hypothesis
Temperature interacts with other factors – soil moisture under-appreciated
Treatments alter spruce population sizes

Abundance of trees ≥4 cm dbh in 50 ha

Alpine
Treeline
Forest

Years

Control
Heated
Watered (2.5 mm/wk)
Heated-Watered

(Conlisk et al. in prep)
Understanding climate effects on seedling dynamics is important to predicting treeline change.

(Smith et al. 2009; Harsch & Bader 2011)
Thank you!

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https://alpine.ucmerced.edu/pub/htdocs/index.html