Climate modifies competitive interactions in a late-seral Douglas-fir forest

Student Research Symposium
April 12, 2018

Student: Sara Germain
Adviser: Dr. Jim Lutz
BIOTIC

- shading
- crowding
- physical damage
- herbivory
- pathogens

CLIMATIC

- energy
- water
- wind
- mass flow
- runoff

EDAPHIC

- toxicity
- nutrition
- topography

Wind +

Physical damage +

Herbivory +

Crowding +

Pathogens +

Energy -

Nutrition -

Topography -

Mass flow -

Runoff -

Pest success -

Competition -

Balance: + for positive effects, - for negative effects.
Research Objectives

1. Quantify interactive effects
   Does tree mortality depend on biotic, edaphic, climatic contexts?

2. Project into future
   Will population trends change with changing climate?
1. Interactions

**Biotic**
- Hegyi (conspecific)
- Hegyi (heterospecific)
- Species richness

**Edaphic**
- N
- Fe
- Elevation
- P
- Al
- TEB

**Climatic**
- Climatic water deficit
- Snowpack

\[ H_i = \sum \frac{DBH_j}{(1 + Distance_{ij})(DBH_i)} \]
1. Interactions

Cox Regression
- time-invariant predictors
- time-variant predictors

Hazard = instantaneous probability of event at time \((t)\)

\[
h(t) = e^{(\beta_i X_i + \ldots + \beta_k X_k)} \lambda(t)
\]
2. Projections

CCSM4  National Center for Atmospheric Research, USA
GFDL-CM3  National Oceanic and Atmospheric Administration, USA
GFDL-ESM2M  National Oceanic and Atmospheric Administration, USA
GFDL-ESM2G  National Oceanic and Atmospheric Administration, USA
HadGEM2-CC  Hadley Centre for Climate Prediction and Research, UK
HadGEM2-ES  Hadley Centre for Climate Prediction and Research, UK

Study Period  Projection Period
Results
1. Interactions

<table>
<thead>
<tr>
<th>Primary Effects Model</th>
<th>Interactive Effects Model</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Al</strong></td>
<td><strong>Al</strong></td>
</tr>
<tr>
<td><strong>Fe</strong></td>
<td><strong>Fe</strong></td>
</tr>
<tr>
<td><strong>N</strong></td>
<td><strong>N</strong></td>
</tr>
<tr>
<td><strong>P</strong></td>
<td><strong>P</strong></td>
</tr>
<tr>
<td><strong>TEB</strong></td>
<td><strong>TEB</strong></td>
</tr>
<tr>
<td><strong>Elevation</strong></td>
<td><strong>Elevation</strong></td>
</tr>
<tr>
<td><strong>Deficit</strong></td>
<td><strong>Deficit</strong></td>
</tr>
<tr>
<td><strong>Snowpack</strong></td>
<td><strong>Snowpack</strong></td>
</tr>
<tr>
<td><strong>Hegyi (con)</strong></td>
<td><strong>Hegyi (con)</strong></td>
</tr>
<tr>
<td><strong>Hegyi (het)</strong></td>
<td><strong>Hegyi (het)</strong></td>
</tr>
<tr>
<td><strong>Richness</strong></td>
<td><strong>Richness</strong></td>
</tr>
</tbody>
</table>

- Indicates negative effect
+ Indicates positive effect
* Indicates interaction effect
Climatic Water Deficit
2. Projections

Deficit (mm H₂O)

Snowpack (mm H₂O)

Study Period

Projection Period

$+35.9\%$

$R^2 = 0.62$

$P < 0.001$

$-69.7\%$

$R^2 = 0.42$

$P < 0.001$
2. Projections

+ 35.9 %  
- 69.7 %

2061 - 2067
Sparsely heterospecific + drier site

tissues acclimated to low water
low competition for water
Conclusions

• Hypothesis-generating study
  *Unique mechanisms per interaction*

• Interactions must be considered

• Inter-annual climate variability matters
  *Extrapolation to long-term trends uncertain, but in agreement with mortality projections (Das et al. 2013)*
Acknowledgements

Photo Credits:
Sara Germain
Tucker Furniss
Jim Lutz
James Freund
Kaitlyn Schwindt
Marcia Rosenquist
Erika Blomdahl

Advising:
Jim Lutz

Data:
Lutz Lab - USU
PRISM
<table>
<thead>
<tr>
<th></th>
<th>Min.</th>
<th>Mean</th>
<th>Max.</th>
</tr>
</thead>
<tbody>
<tr>
<td>past.def</td>
<td>71.9</td>
<td>144.9</td>
<td>250.5</td>
</tr>
<tr>
<td>future.def</td>
<td>154.9</td>
<td>196.9</td>
<td>236.3</td>
</tr>
<tr>
<td>past.snow</td>
<td>42.67</td>
<td>252.57</td>
<td>494.72</td>
</tr>
<tr>
<td>future.snow</td>
<td>30.62</td>
<td>76.49</td>
<td>104.38</td>
</tr>
</tbody>
</table>
1. Interactions

Cox Regression

- time-invariant predictors
- time-variant predictors

Hazard = instantaneous probability of event at time \((t)\)

\[
h(t) = e^{(\beta_i X_i + \ldots + \beta_k X_k)} \lambda(t)\]

Hazard ratio = predictor effect on hazard

\[
HR_i = e^{n*\beta_i}\]

\[
HR_i = e^{n*[\beta_i + (\beta_{i,k} X_k) + (\beta_{i,j} X_{j}) + (\beta_{i,j,k} X_{j} X_{k})]}\]
\[ P_t = P_0 e^{rt} \]