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

Student Research Symposium
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Wind River Forest Dynamics Plot
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: 2000 - 2100

Projection Period: 2020 - 2100
Results
1. Interactions

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

Deficit (mm H2O)  
Year

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)
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PRISM
<table>
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<th>Min.</th>
<th>Mean</th>
<th>Max.</th>
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<td>250.5</td>
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<td>future.snow</td>
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<td>76.49</td>
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</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

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

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