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

Student Research Symposium
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Adviser: Dr. Jim Lutz
BIOTIC
- shading
- crowding
- physical damage
- herbivory
- pathogens

CLIMATIC
- energy
- water
- wind
- mass flow
- runoff

EDAPHIC
- toxicity
- nutrition
- topography

The diagram illustrates the interactions between biotic, climatic, and edaphic factors.
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

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>
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<tr>
<td><strong>N</strong></td>
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<tr>
<td><strong>P</strong></td>
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<tr>
<td>TEB</td>
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<tr>
<td>Elevation</td>
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<tr>
<td>Deficit</td>
<td>Deficit</td>
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<tr>
<td>Snowpack</td>
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<tr>
<td>Hegyi (con)</td>
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</tr>
<tr>
<td>Hegyi (het)</td>
<td>Hegyi (het)</td>
</tr>
<tr>
<td>Richness</td>
<td>Richness</td>
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</tbody>
</table>

- **Primary Effects Model**
  - Al: \(-\)
  - Fe: \(+\)
  - N: \(+\)
  - P: \(-\)
  - TEB: \(-\)
  - Elevation: \(-\)
  - Deficit: \(-\)
  - Snowpack: \(-\)
  - Hegyi (con): \(-\)
  - Hegyi (het): \(+\)
  - Richness: \(-\)

- **Interactive Effects Model**
  - Al: \(-\)
  - Fe: \(+\)
  - N: \(+\) \(\ast\)
  - P: \(-\) \(\ast\)
  - TEB: \(-\) \(\ast\)
  - Elevation: \(-\) \(\ast\)
  - Deficit: \(+\) \(\ast\)
  - Snowpack: \(-\) \(\ast\)
  - Hegyi (con): \(-\)
  - Hegyi (het): \(+\) \(\ast\)
  - Richness: \(-\) \(\ast\)
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)
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PRISM
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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

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

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