Effects of Geoclimatic Factors on Soil Nutrients and Site Productivity of Douglas-fir

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Introduction:
- Douglas-fir grows on many different soil types over the coastal Pacific Northwest.
- Soil development has been influenced by parent materials that formed over different geologic time periods.
- Distinct climatic regions have also been identified in the Pacific Northwest due to the proximity of the coast and mountains.
- The combination of climate and soil types affect Douglas-fir productivity throughout the coastal Pacific Northwest.

Hypothesis:
- Boosted regression tree models can describe the relationships between climate, site, and soil variables that determine soil and site productivity.

Objectives:
- Develop models for predicting soil and site productivity.
- Map soil and site productivity across the coastal Pacific Northwest.

Materials and Methods:
- 71 14-28 year-old Douglas-fir installations were established in Oregon, and Washington between 2007 and 2011 (Figure 1).
- Installations are located in Sitka spruce, western hemlock, and mixed conifer-evergreen zones.
- Slope, elevation, and aspect were measured for each installation.
- Average monthly installation temperature and precipitation was calculated using ClimateWNA (1990-2011).
- Soil clay, sand, organic matter, and available water supply were determined from NRCS soil series data.
- Forest floor carbon to nitrogen (N) ratio and total soil N content were determined for each installation.
- Douglas-fir productivity for each installation was measured using King’s site index.
- 76,000 data points were mapped to estimate climate, elevation, and soil data.
- Soil and site productivity were predicted for the data points.

Statistics:
- Boosted regression trees are a combination of regression trees and machine learning.
- 1500 regression trees are produced to explain the deviance in the response variable and are combined to form the final model.
- Partial dependence plots define the effect of the predictor variables on the response variable through a fitted function (Table 1).

Results:
- Soil N contents were greater in the Oregon lowlands and lowest in the Cascade Range due to higher clay and organic matter contents and higher available water (Figure 2).
  - Related to total soil carbon contents.
  - Forest floor C:N ratios were highest in Oregon igneous soils and regions with lower winter temperatures and greater precipitation as snow (Figure 3).
  - Higher mineralization in areas of low forest floor C:N ratios.
- Douglas-fir site index estimations correspond with total soil N and forest floor C:N maps because of the shared predictors between soil and site productivity (Figure 4).

Table 1. Boosted regression tree models of soil and site productivity.

- Total Soil N Content
- Forest Floor C:N Ratio
- Site Index

<table>
<thead>
<tr>
<th>Predictors</th>
<th>Range</th>
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<th>Predictors</th>
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</thead>
<tbody>
<tr>
<td>Clay Content</td>
<td>&gt;2%</td>
<td>30</td>
<td>Regional Parent Material</td>
<td>OR</td>
<td>44</td>
<td>Available Water Supply</td>
<td>&gt;100 mm</td>
<td>39</td>
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<tr>
<td>Available Water Supply</td>
<td>&gt;100 mm</td>
<td>21</td>
<td>Available Water Supply</td>
<td>&gt;150 mm</td>
<td>22</td>
<td>Elevation</td>
<td>&lt;500 m</td>
<td>26</td>
</tr>
<tr>
<td>Sand Content</td>
<td>&lt;40%</td>
<td>16</td>
<td>Precipitation as Snow</td>
<td>&gt;100 mm</td>
<td>17</td>
<td>April Precipitation</td>
<td>&lt;110 mm</td>
<td>15</td>
</tr>
<tr>
<td>Organic Matter</td>
<td>&gt;6%</td>
<td>16</td>
<td>August Precipitation</td>
<td>&gt;20 mm</td>
<td>7</td>
<td>December Temperature</td>
<td>&gt;C</td>
<td>9</td>
</tr>
<tr>
<td>Parent Material and Region</td>
<td>OR</td>
<td>10</td>
<td>Longitude</td>
<td>&lt;123.5°</td>
<td>6</td>
<td>Precipitation as Snow</td>
<td>&lt;100 mm</td>
<td>5</td>
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<tr>
<td>November Temperature</td>
<td>&gt;7° C</td>
<td>6</td>
<td>February Temperature</td>
<td>&lt;5.5° C</td>
<td>3</td>
<td>Clay Content</td>
<td>&gt;30%</td>
<td>5</td>
</tr>
</tbody>
</table>

Figure 1. Study installations in the Pacific Northwest.

Figure 2. Prediction of total soil nitrogen contents.

Figure 3. Forest floor carbon to nitrogen ratio predictions.

Figure 4. Estimations of Douglas-fir site index.