3-PG FOREST GROWTH MODEL

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Lecture 2

Growth Modifiers
Tropical Rainforest: Canopy Stomatal Conductance Relationships

\[ g_s = g_{\text{max}} \cdot f(D) \cdot f(\delta) \cdot f(PAR) \cdot f(N) \cdot f(T) \cdot f(CO_2) \]

Tropical Rainforest: Canopy Stomatal Conductance Relationships

Light-Use and Water-Use Efficiency response to CO₂

Figure 5: modeled relationship light-use efficiency (left) and relative leaf stomatal conductance (gs) (right) with ambient CO₂ concentrations. © The Modeling and Simulation Society of Australia and New Zealand Inc., with permission, taken from Almeida et al. (2009).

Stomatal Conductance and Soil Drought

Soils differ in how they release water

Landsberg & Waring (1997)
Effect of Subfreezing Temperature on Stomata and GPP

### Optimum Temperature

Table 6.2. Optimum Temperature for Photosynthesis Compared with Actual Mid-summer Temperatures for Five Genera of Native New Zealand and North American Tree Species. From Hawkins and Sweet, 1989

<table>
<thead>
<tr>
<th>Species</th>
<th>Optimum Temperature, °C</th>
<th>Mid-Summer Temperature, °C</th>
<th>Difference, °C</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>New Zealand</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Agathis australis</td>
<td>27.0</td>
<td>22.2</td>
<td>4.8</td>
</tr>
<tr>
<td>Dacrycarpus dacrydiodes</td>
<td>27.0</td>
<td>17.9</td>
<td>9.1</td>
</tr>
<tr>
<td>Dacrydium cupressinum</td>
<td>27.0</td>
<td>16.8</td>
<td>10.2</td>
</tr>
<tr>
<td>Nothofagus solandri</td>
<td>27.0</td>
<td>17.0</td>
<td>10.0</td>
</tr>
<tr>
<td>Podocarpus totara</td>
<td>27.0</td>
<td>21.5</td>
<td>5.5</td>
</tr>
<tr>
<td><strong>Mean</strong></td>
<td>27.0</td>
<td>19.1</td>
<td>+7.9</td>
</tr>
<tr>
<td><strong>North America</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Larix decidua</td>
<td>17.0</td>
<td>19.0</td>
<td>-2.0</td>
</tr>
<tr>
<td>Pinus radiata</td>
<td>23.0</td>
<td>21.0</td>
<td>2.0</td>
</tr>
<tr>
<td>Pseudotsuga menziesii</td>
<td>21.0</td>
<td>20.2</td>
<td>0.8</td>
</tr>
<tr>
<td>Sequoia sempervirens</td>
<td>19.0</td>
<td>17.0</td>
<td>2.0</td>
</tr>
<tr>
<td>Tsuga heterophylla</td>
<td>18.0</td>
<td>20.2</td>
<td>-2.2</td>
</tr>
<tr>
<td><strong>Mean</strong></td>
<td>19.6</td>
<td>19.4</td>
<td>+0.2</td>
</tr>
</tbody>
</table>
VPD Response of Northwest Forest Species

Waring and Franklin, 1979. Science
As Trees Grow, They Produce Less Foliage and More Branches


Fig. 4. As tree above-ground biomass increases, the ratio of needle to branch biomass in Douglas-fir decreases exponentially (Bartelin, 1996). Similar plots are presented for three species of southern pines: loblolly (Pinus taeda), longleaf (P. palustris), and slash (P. elliottii). Eucalyptus grandis data were obtained from Almeida (2012). Graph drafted by Carlos Gonzalez-Benecke using some original data (Gonzalez-Benecke et al., 2014, 2015).
As a result of the shift in the partitioning of growth in mass, photosynthesis is constrained by less efficient plumbing as expressed by a drop in total hydraulic conductance (Ga).
All Modifiers Affect Canopy Production and Transpiration
\[
NPP = Q_0^* \left(11 - ee^{-k*\text{LAI}}\right) * \alpha_{cx} * R * f_i
\]

\[
f_i = f_T f_F f_N f_D f_\theta f_{\text{age}} f_{\text{C} \alpha}
\]

Temperature  Frost  Nutrition  VPD  ASW  Age  CO₂

\[
(0 \leq f_i \leq 1)
\]
Gc = Gcmax * $f_j$

\[ f_j = f_D f_\theta f_F f_{Cg} \]

VPD, ASW, Frost, CO₂

(0 ≤ $f_i$ ≤ 1)
General References

