Ecological Forecasting for Terrestrial and Aquatic Ecosystems Session

Plant Growth Forms

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How do Botanists Classify Plants with similar Traits?

Many Definitions of Plant Functional Types

1. Location of pernnating (overwintering) organs
How do Botanists Classify Plants with similar Traits?

Many Definitions of Plant Functional Types

2. Branching architectures
## Remote Sensing PFTs Developed from GCM Parameterizations

<table>
<thead>
<tr>
<th>SiB2</th>
<th>BATS</th>
<th>IGBP DISCover</th>
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<tbody>
<tr>
<td>Broadleaf evergreen tree</td>
<td>Broadleaf evergreen tree</td>
<td>Broadleaf evergreen forest</td>
</tr>
<tr>
<td>Broadleaf deciduous tree</td>
<td>Broadleaf deciduous tree</td>
<td>Broadleaf deciduous forest</td>
</tr>
<tr>
<td>Broadleaf &amp; needleleaf tree</td>
<td>Mixed woodland</td>
<td>Mixed forest</td>
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<tr>
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<td>Needleleaf evergreen tree</td>
<td>Needleleaf evergreen forest</td>
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<tr>
<td>Needleleaf deciduous tree</td>
<td>Needleleaf deciduous tree</td>
<td>Needleleaf deciduous forest</td>
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<tr>
<td>Broadleaf shrub</td>
<td>Evergreen shrub</td>
<td>Closed shrubland</td>
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<tr>
<td>Dwarf trees &amp; shrubs</td>
<td>Deciduous shrub</td>
<td>Open shrubland</td>
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<tr>
<td>Agriculture C3 grassland</td>
<td>Tall grass (savanna)</td>
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<td>Short vegetation C4 grassland</td>
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<td>Wetland</td>
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<td>Glacier</td>
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*IGBP DISCover, International Geosphere-Biosphere Programme Data and Information System Global 1 km Land Cover Data Set (Loveland et al., 2000)*
## Remote Sensing PFTs Developed from GCM Parameterizations

### Climate Rules

#### Remote Sensing Data Products

<table>
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<th>Remote Sensing Data Products</th>
<th>Plant Functional Types</th>
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<td></td>
<td>C3 arctic</td>
</tr>
<tr>
<td></td>
<td>C4</td>
</tr>
<tr>
<td>Crop</td>
<td>Crop 1 (e.g., corn)</td>
</tr>
<tr>
<td></td>
<td>Crop 2 (e.g., wheat)</td>
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</table>

### PFT Databases:

- 1 km U MD tree cover
  - Needleleaf, Broadleaf
  - Evergreen, Deciduous

- 1 km IGBP DISCover
  - Shrub, Grass, Crop

### Monthly Leaf Area

- 1 km AVHRR R, NIR
- April 1992 to March 1993
- NDVI 200km x 200km grid
- Ave NDVI for 1 km pixel, w/ PFT > 60%

Oleson and Bonan (2000)
Distribution of PFTs Used in CLM model

## Optical properties for plant functional types

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<tr>
<th>Plant Functional Type</th>
<th>Leaf Angle</th>
<th>Leaf Reflectance VIS</th>
<th>Leaf Reflectance NIR</th>
<th>Stem Reflectance VIS</th>
<th>Stem Reflectance NIR</th>
<th>Leaf Transmittance VIS</th>
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<td>0.39</td>
<td>0.05</td>
<td>0.10</td>
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<td>0.36</td>
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# different values in database
## Photosynthetic parameters

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</table>
Does classification by growth form categories denote physiological functioning?
Tropical Forest in West Sumatra, Indonesia

- Emergent trees
- Dense Crown cover
- Epiphytes
- Understory trees
- Epiphytes
- Shrubs
- Herbaceous layer
Growth Form Differences Relate to Adaptations for Resource Conditions

Coast Redwood
*Sequoia sempervirens*

Sierra “Big Tree” Redwood
*Sequoiadendron giganea*

Diffuse Light
Moderate Sum/Win Temperatures
High soil moisture & Relative humidity
Closed canopy forests

Direct Light
Lower winter temperatures
Low summer soil moisture & Relative Humidity
Open canopy forests
Reflectance Changes with Age & Species Mixtures

Wind River Canopy Crane Site, Carson, WA
Age class distributions from newly harvested to 500+ yr “old growth” Conifer Forest

R = soil, G = vegetation, B = shade
Remnants of the Southern Gondwana Flora in Australia & New Zealand

Distribution of Canopy Cover with Height at Canopy Crane Site: Changing Light Conditions
The Concept of Mapping Leaf Optical Types: An Alternative to Mapping Functional Types

- Assumes a Limited Range of Optimizing Strategies to Respond to Environmental Conditions
- Based on Theory of Functional Convergence

Detectable Optical Properties Using Imaging Spectroscopy

- Leaf area index
- Leaf Mass Area \( (=1/\text{SLA})\)
- Chlorophyll and Carotenoid Pigments
- Canopy Water Content
- Xanthophyll pigments
- Leaf Longevity
- Leaf Nitrogen
- Ligno-cellulose

These Optical Properties are consistent with Generalized Leaf Trait Literature developed over the past decade.
Relationships between Climate Space and Specific Leaf Area (SLA) and N Content/dry mass

- Georeferenced in TRY Database (69,296 species; 93 traits)
- Global Biodiversity Information Facility Database

Note: SLA = 1/LMA

Trait Frequency Distributions for Specific Leaf Area (SLA) and Leaf Nitrogen

Global Change Biology (2011) 17, 2905–2935
A Global Universal Spectrum of Leaf Economics: Key Co-Varying Structural and Physiological Properties

Traits vary from fast to slow return on investments in nutrients and dry mass in leaves, and operate largely independently of growth form, PFT or biome

>2500 species from 175 global sites

Wright et al. Nature, 2004
Leaf Investment Strategies are Largely Arrayed Along A Single Spectrum, With a Globally Consistent Pattern of Trait Correlations

Wright et al. Nature, 2004
Species Clusters based on Spectral Similarity by Site

Keely L. Roth, Dar A. Roberts, Philip E. Dennison, and Michael Alonzo, IGARSS 2012
Canonical Discriminant Analysis Results

Keely L. Roth, Dar A. Roberts, Philip E. Dennison, and Michael Alonzo, IGARSS 2012