Ecological Forecasting for Terrestrial and Aquatic Ecosystems Session

Plant Growth Forms

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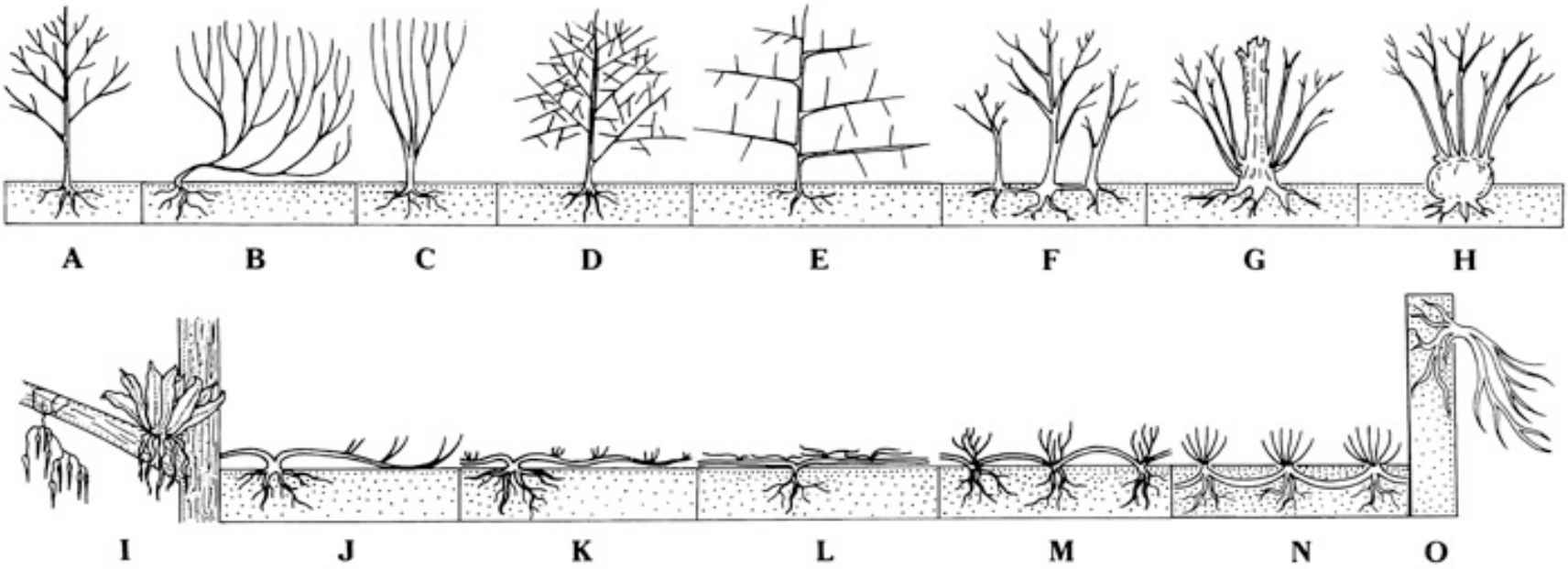

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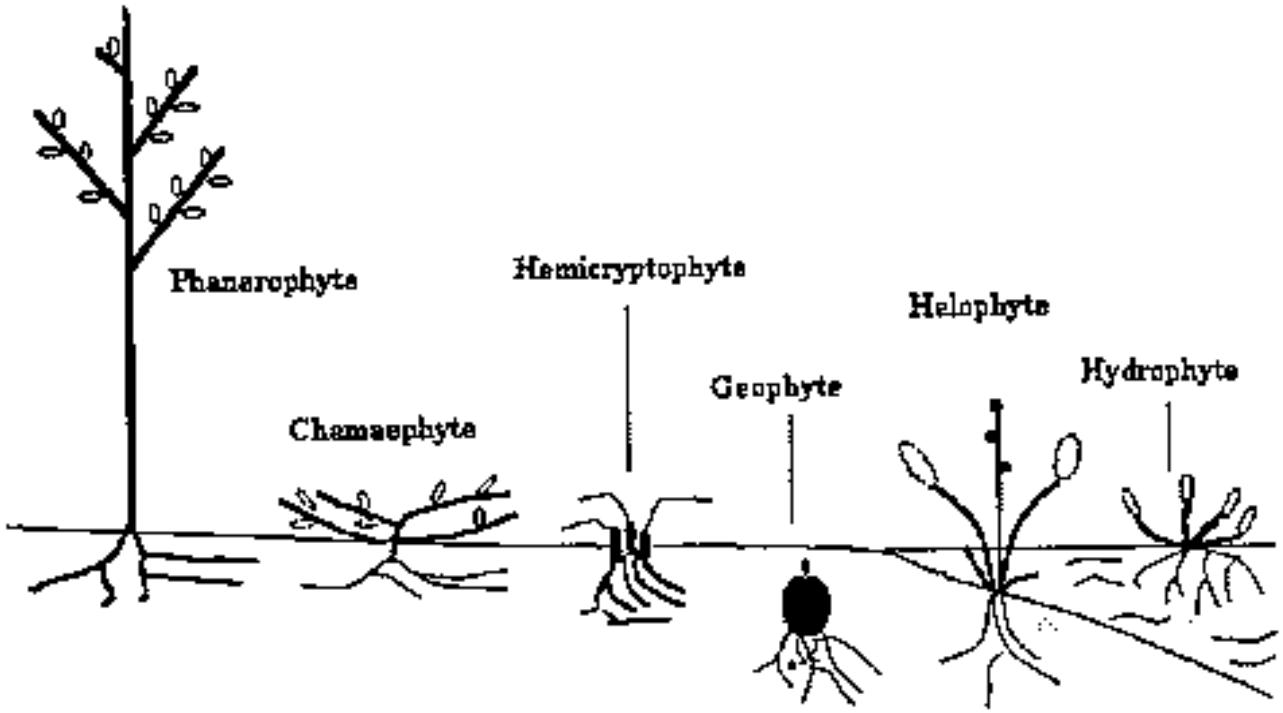
How do Botanists Classify Plants with similar Traits?

Many Definitions of Plant Functional Types

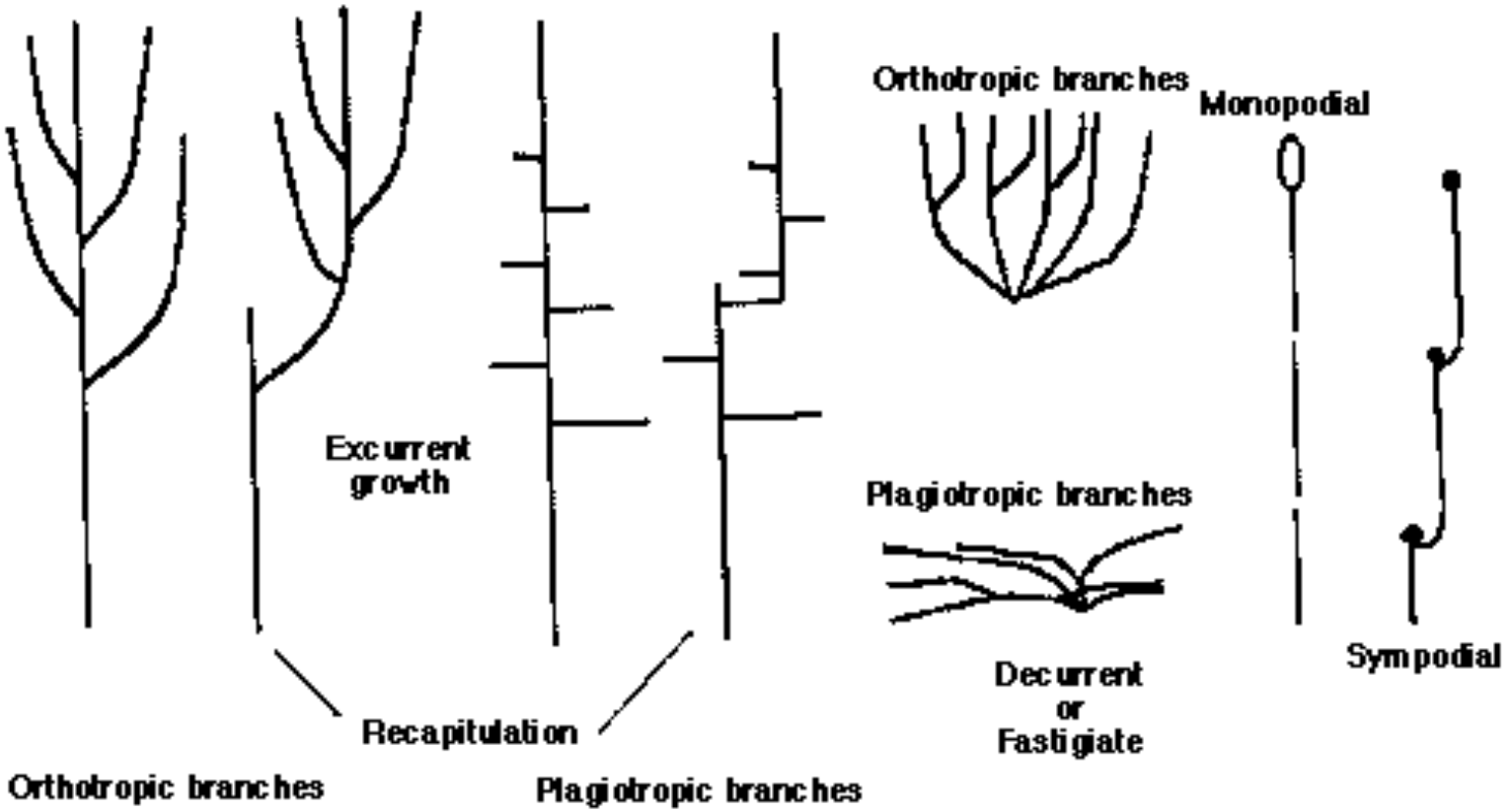
1. Location of pernnating (overwintering) organs



How do Botanists Classify Plants with similar Traits?

Many Definitions of Plant Functional Types

2. Branching architectures



Remote Sensing PFTs Developed from GCM Parameterizations

SiB2	BATS	IGBP DISCover
Broadleaf evergreen tree	Broadleaf evergreen tree	Broadleaf evergreen forest
Broadleaf deciduous tree	Broadleaf deciduous tree	Broadleaf deciduous forest
Broadleaf & needleaf tree	Mixed woodland	Mixed forest
Needleleaf evergreen tree	Needleleaf evergreen tree	Needleleaf evergreen forest
Needleleaf deciduous tree	Needleleaf deciduous tree	Needleleaf deciduous forest
Broadleaf shrub	Evergreen shrub	Closed shrubland
Dwarf trees & shrubs	Deciduous shrub	Open shrubland
Agriculture C3 grassland	Tall grass (savanna)	Woody savanna
Short vegetation C4 grassland	Short grass	Savanna
	tundra	Grassland
	desert	Cropland
	Semidesert	Crop & other vegetation
	Cropland	Barren or Sparse
	Irrigated Crop	Wetland
	Wetland	Snow & Ice
	Glacier	

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	Plant Functional Types
Needleleaf evergreen tree	Temperate Boreal
Needleleaf deciduous tree	Boreal
Broadleaf evergreen tree	Tropical Temperate
Broadleaf deciduous tree	Tropical Temperate Boreal
Shrub	Broadleaf evergreen temperate Broadleaf deciduous temperate Broadleaf deciduous boreal
Grass	C3 C3 arctic C4
Crop	Crop 1 (e.g., corn) Crop 2 (e.g., wheat)

PFT Databases:

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

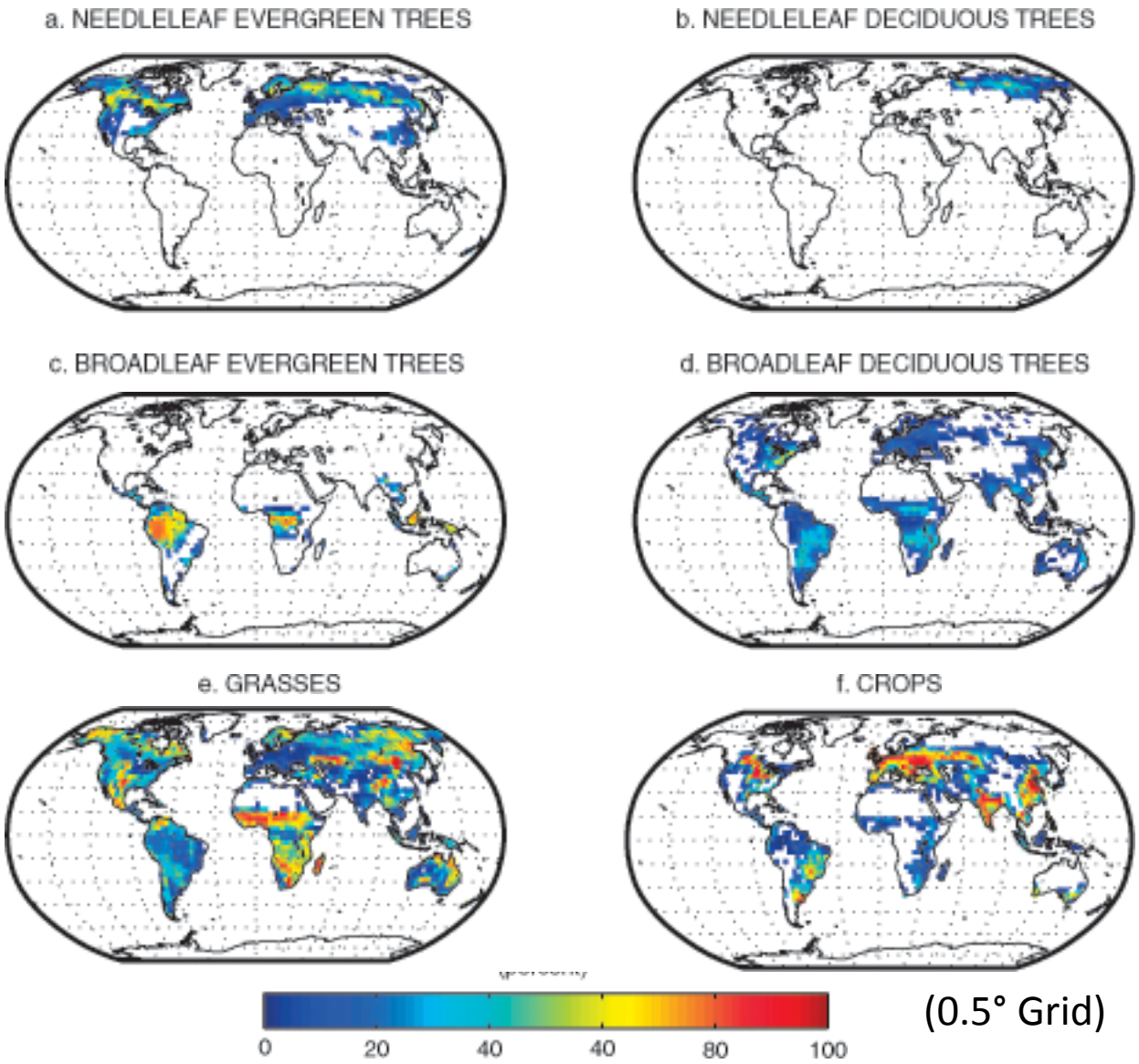
1 km IGBP DISCover
- Shrub, Grass, Crop

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



(0.5° Grid)

Bonan et al. 2002. Global Biogeochemical Cycles

Optical properties for plant functional types

Plant Functional Type	Leaf Angle ❹	Leaf Reflectance VIS ❸	Leaf Reflectance NIR ❸	Stem Reflectance VIS ❷	Stem Reflectance NIR ❷	Leaf Transmittance VIS ❷	Leaf Transmittance NIR ❷	Stem Transmittance VIS ❷	Stem Transmittance NIR ❷
NET temperate	0.01	0.07	0.35	0.16	0.39	0.05	0.10	0.001	0.001
NET boreal	0.01	0.07	0.35	0.16	0.39	0.05	0.10	0.001	0.001
NDT boreal	0.01	0.07	0.35	0.16	0.39	0.05	0.10	0.001	0.001
BET tropical	0.10	0.10	0.45	0.16	0.39	0.05	0.25	0.001	0.001
BET temperate	0.10	0.10	0.45	0.16	0.39	0.05	0.25	0.001	0.001
BDT tropical	0.01	0.10	0.45	0.16	0.39	0.05	0.25	0.001	0.001
BDT temperate	0.25	0.10	0.45	0.16	0.39	0.05	0.25	0.001	0.001
BDT boreal	0.25	0.10	0.45	0.16	0.39	0.05	0.25	0.001	0.001
BES temperate	0.01	0.07	0.35	0.16	0.39	0.05	0.10	0.001	0.001
BDS temperate	0.25	0.10	0.45	0.16	0.39	0.05	0.25	0.001	0.001
BDS boreal	0.25	0.10	0.45	0.16	0.39	0.05	0.25	0.001	0.001
C_3 grass arctic	-0.30	0.11	0.58	0.36	0.58	0.07	0.25	0.220	0.380
C_3 grass	-0.30	0.11	0.58	0.36	0.58	0.07	0.25	0.220	0.380
C_4 grass	-0.30	0.11	0.58	0.36	0.58	0.07	0.25	0.220	0.380
Crop1	-0.30	0.11	0.58	0.36	0.58	0.07	0.25	0.220	0.380
Crop2	-	-	-	-	-	-	-	-	-

different values in database

Morphological Characteristics

Plant Functional Type	Leaf Dimension (m) ❶	Roughness Length ❸	Displacement Height ❷	Root Distribution a ❸	Root Distribution B ❹
NET temperate	0.04	0.055	0.67	7.0	2.0
NET boreal	0.04	0.055	0.67	7.0	2.0
NDT boreal	0.04	0.055	0.67	7.0	2.0
BET tropical	0.04	0.075	0.67	7.0	1.0
BET temperate	0.04	0.075	0.67	7.0	1.0
BDT tropical	0.04	0.055	0.67	6.0	2.0
BDT temperate	0.04	0.055	0.67	6.0	2.0
BDT boreal	0.04	0.055	0.67	6.0	2.0
BES temperate	0.04	0.120	0.68	7.0	1.5
BDS temperate	0.04	0.120	0.68	7.0	1.5
BDS boreal	0.04	0.120	0.68	7.0	1.5
C_3 grass arctic	0.04	0.120	0.68	11.0	2.0
C_3 grass	0.04	0.120	0.68	11.0	2.0
C_4 grass	0.04	0.120	0.68	11.0	2.0
Crop1	0.04	0.120	0.68	6.0	3.0
Crop2	-	-	-	-	-

different values in database

Photosynthetic parameters

Plant Functional Type	Path ❷	V_{max25} ❽	A ❷	m ❸
NET temperate	C_3	51	0.06	6
NET boreal	C_3	43	0.06	6
NDT boreal	C_3	43	0.06	6
BET tropical	C_3	75	0.06	9
BET temperate	C_3	69	0.06	9
BDT tropical	C_3	40	0.06	9
BDT temperate	C_3	51	0.06	9
BDT boreal	C_3	51	0.06	9
BES temperate	C_3	17	0.06	9
BDS temperate	C_3	17	0.06	9
BDS boreal	C_3	33	0.06	9
C_3 grass arctic	C_3	43	0.06	9
C_3 grass	C_3	43	0.06	9
C_4 grass	C_4	24	0.04	5
Crop1	C_3	50	0.06	9
Crop2	-	-	-	-

different values in database

Does classification by growth form categories denote physiological functioning?

Daintree Biosphere Reserve, Queensland, Australia

Tropical Forest in West Sumatra, Indonesia

Growth Form Differences Relate to Adaptations for Resource Conditions

Coast Redwood
Sequoia sempervirens

Sierra "Big Tree"Redwood
Sequoiadendron giganea

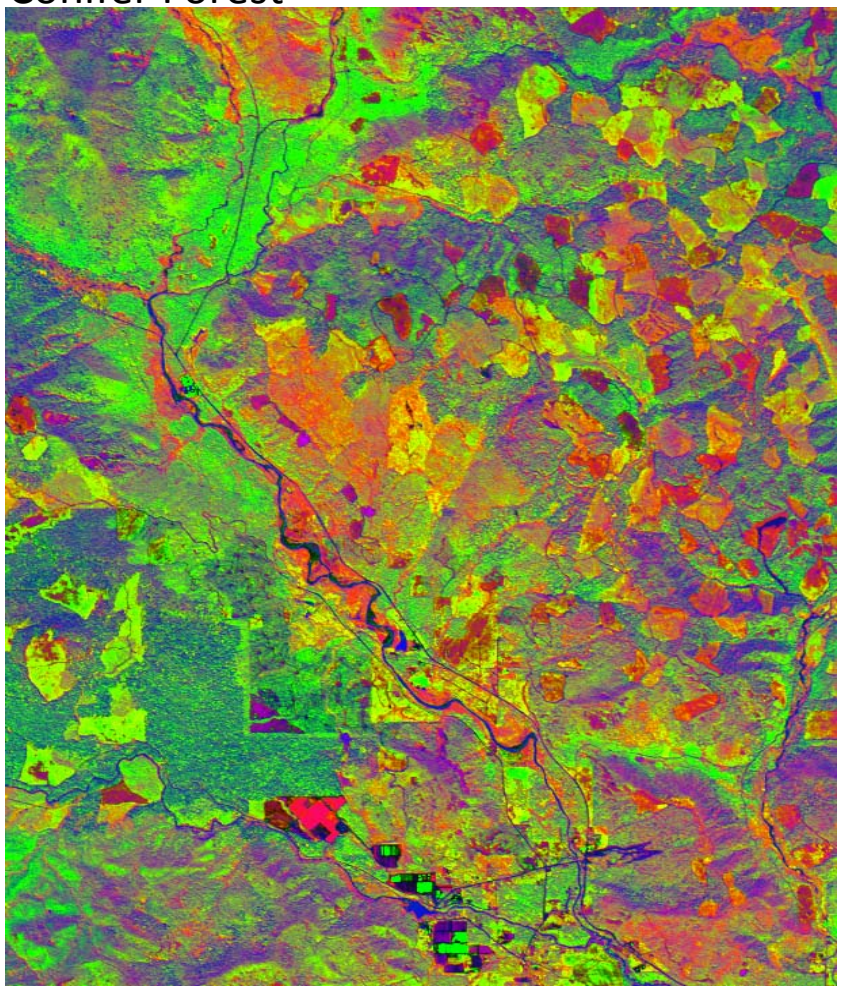
Diffuse Light
Moderate Sum/Win Temperatures
High soil moisture & Relative humidity
Closed canopy forests

Direct Light
Lower winter temperatures
Low summer soil moisture & Relative Humidity
Open canopy forests

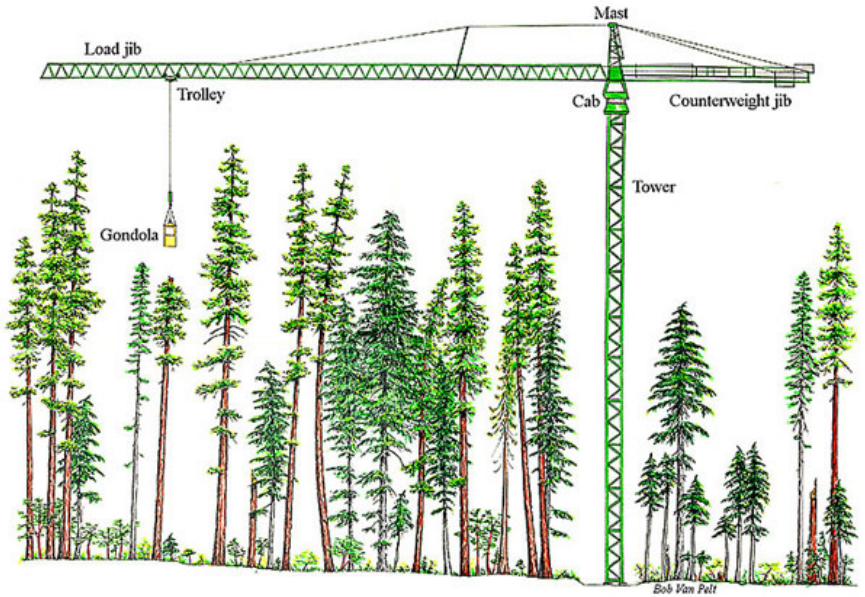
Reflectance Changes with Age Class & Species Mixtures

Wind River Canopy Crane Site, Carson, WA

Age class distributions from newly harvested to 500+ yr “old growth” Conifer Forest

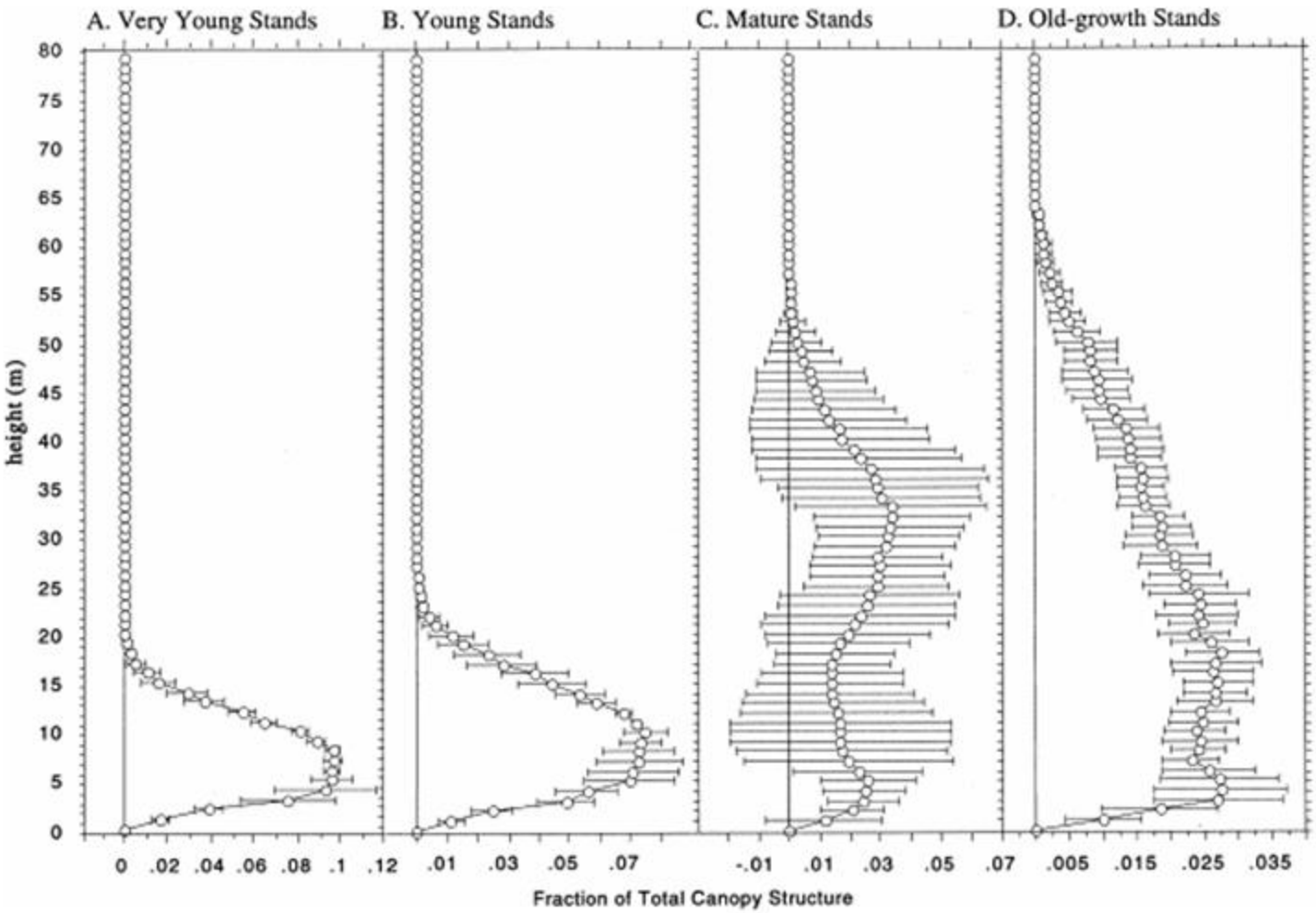


R= soil, G=vegetation, B=shade



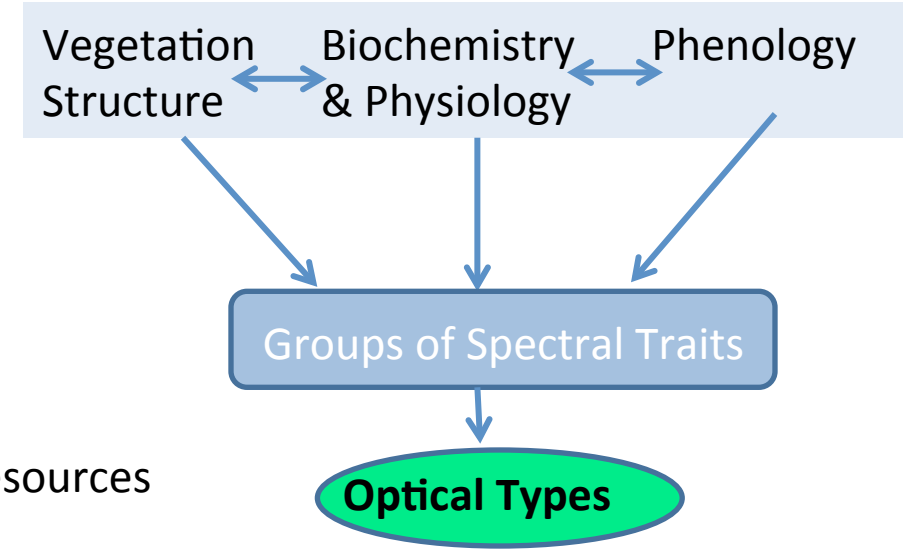
Remnants of the Southern Gondwana Flora in Australia & New Zealand

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



Ustin & Gamon, 2010 New Phytol.

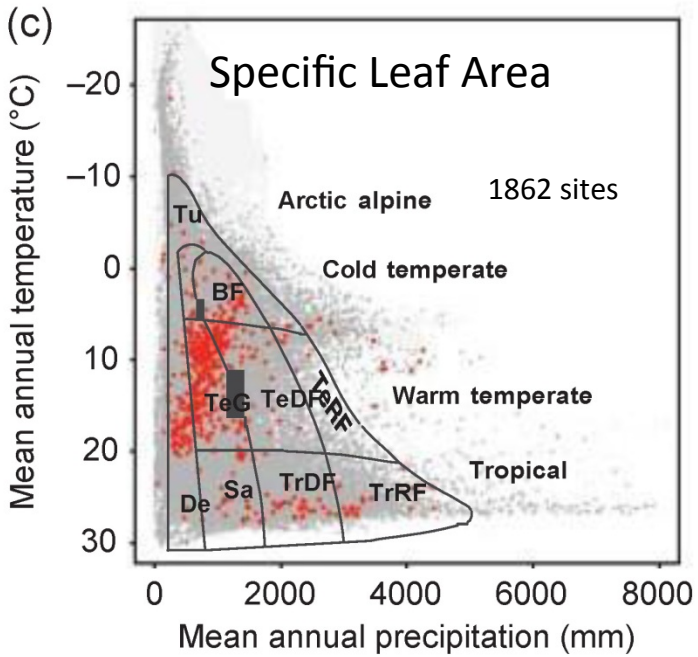
Optimize: Light harvesting, water and nutrient resources for given climate conditions

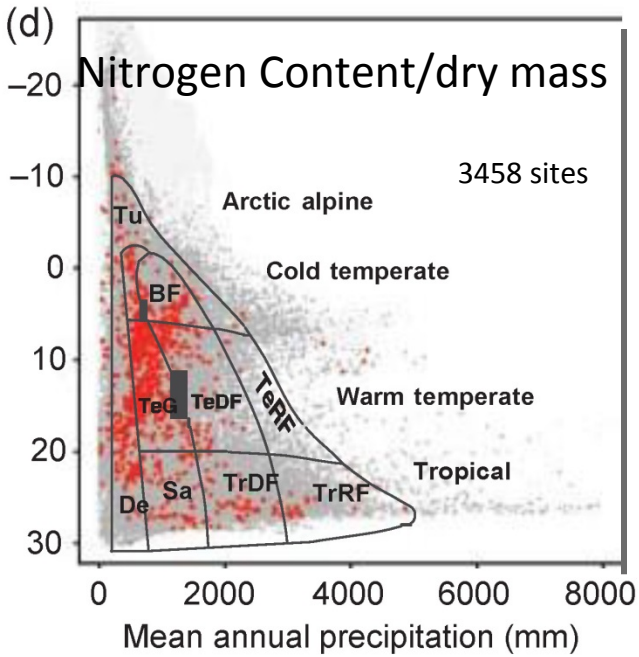
Detectable Optical Properties Using Imaging Spectroscopy

Leaf area index
Leaf Mass Area (=1/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





Whittaker Biome Types:

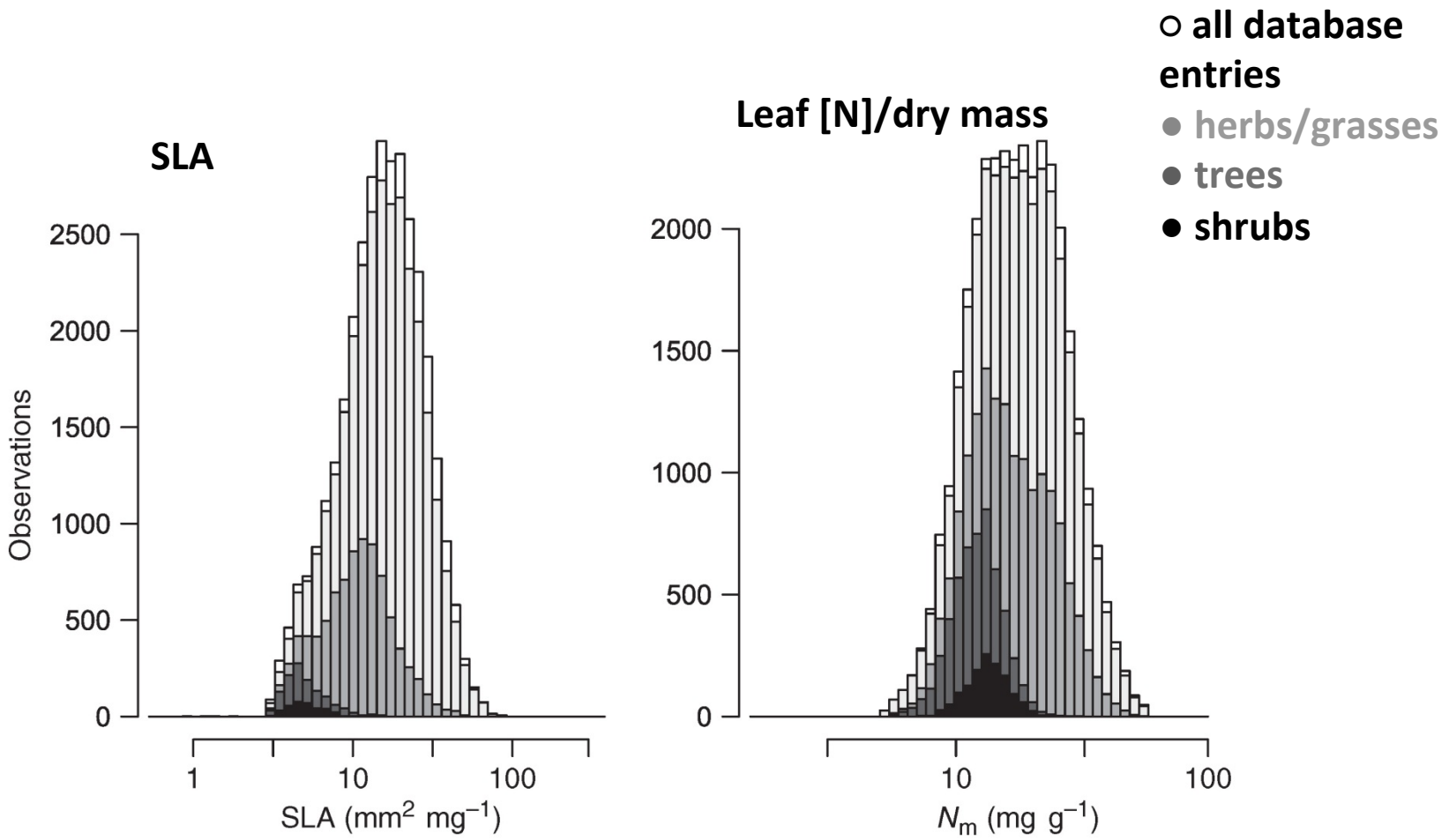
Tu: Tundra
BF: Boreal Forest
TeG: Temperate Grassland
TeDF: Temp. Deciduous Forest
TeRF: Temp. Rain Forest
TrDF: Tropical Deciduous Forest
TrRF: Tropical Rain Forest
Sa: Savanna
De: Desert

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

Note: SLA = 1/LMA

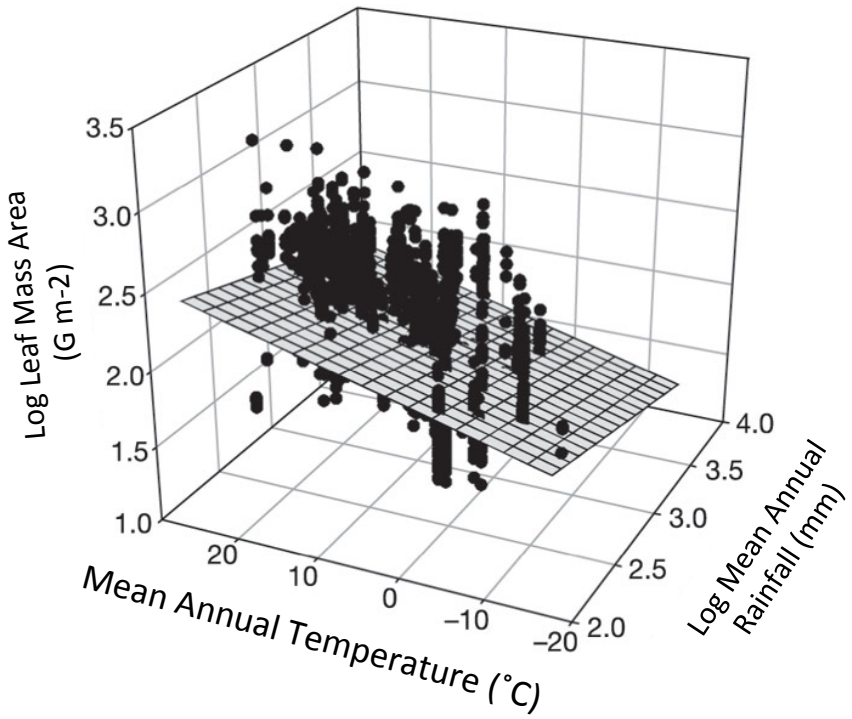
J . KATTGE & 134 others, 2011. TRY – A Global Database of Plant Traits. Global Change Biology (2011) 17, 2905–2935

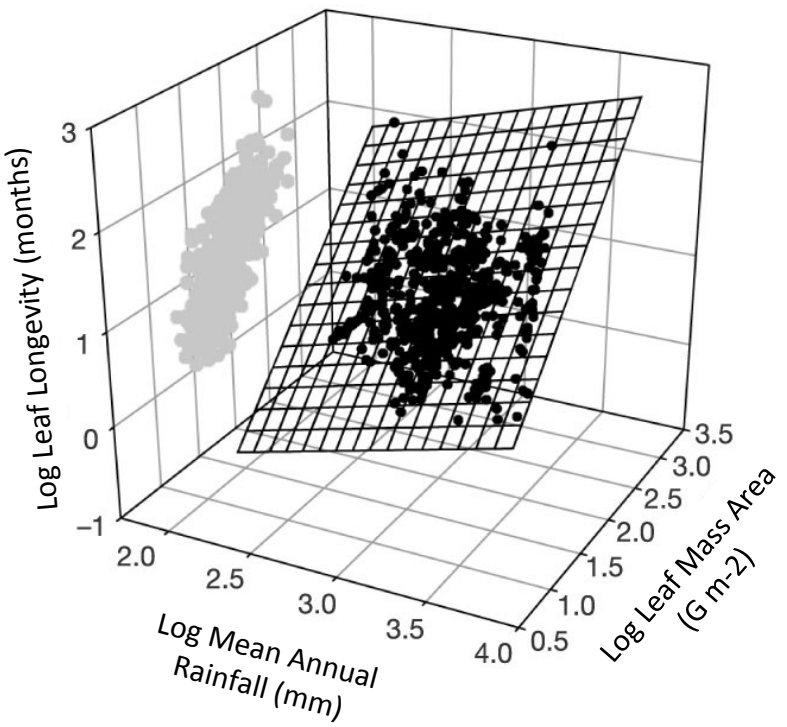
Trait Frequency Distributions for Specific Leaf Area (SLA) and Leaf Nitrogen



J . KATTGE & 134 others, 2011. TRY – A Global Database of Plant Traits. Global Change Biology (2011) 17, 2905–2935

A Global Universal Spectrum of Leaf Economics: Key Co-Varying Structural and Physiological Properties



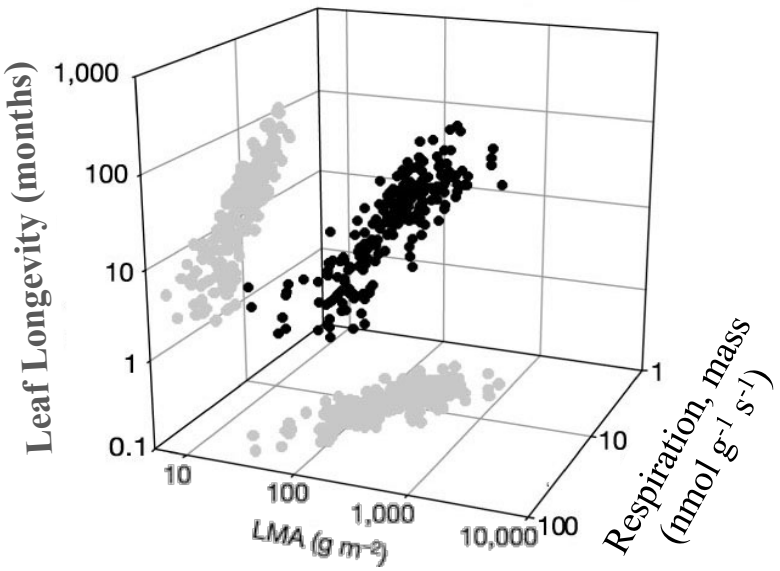


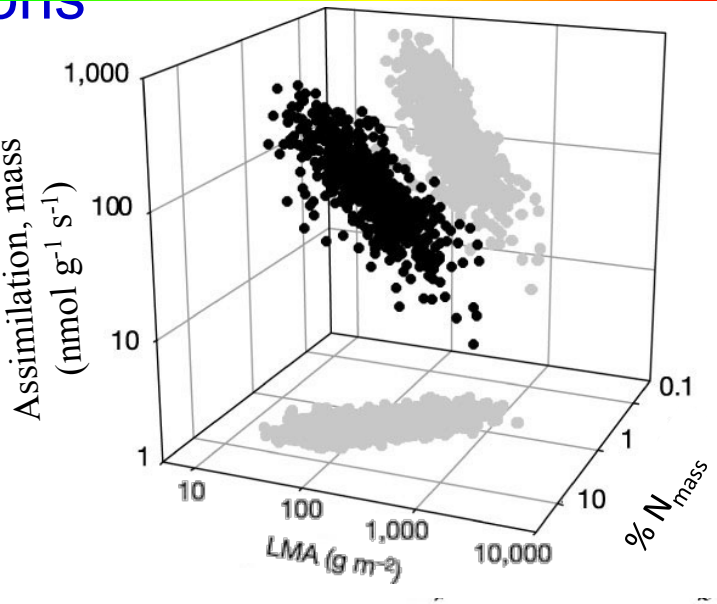
Traits vary from fast to slow return on investments in nutrients and dry mass in leaves, and operate largely independently of growth form, PFT or biome

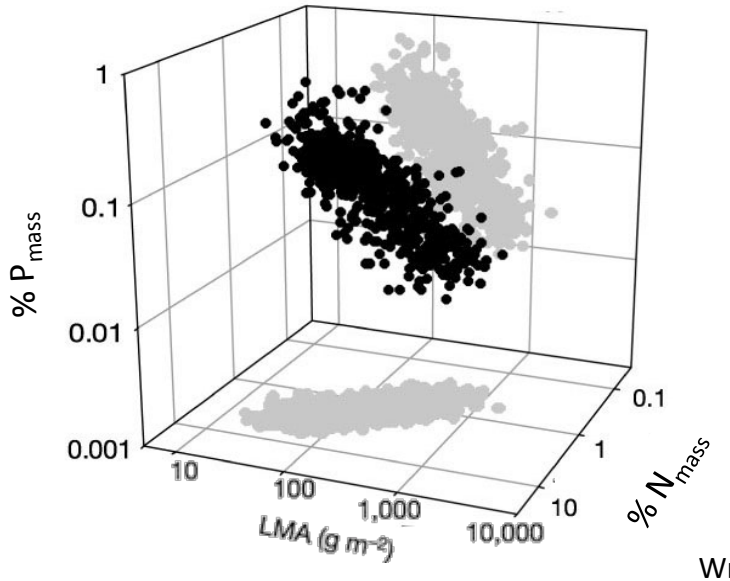
>2500 species from 175 global sites

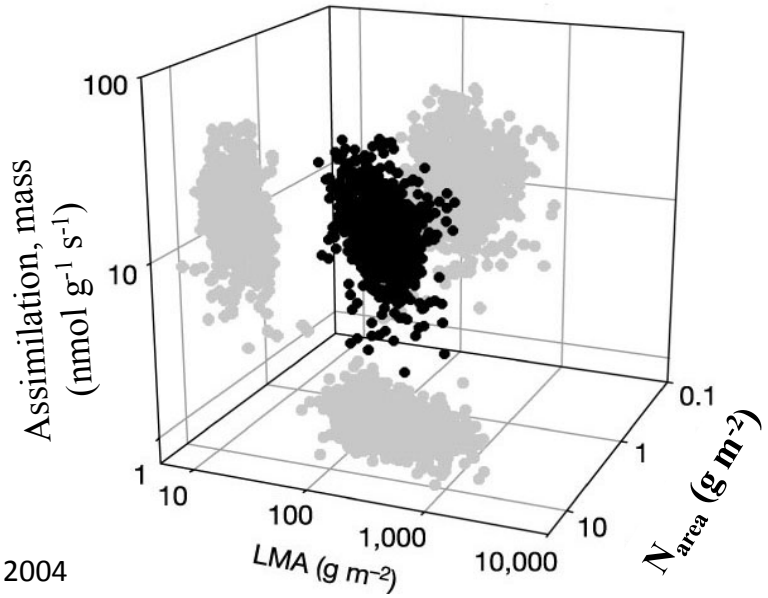
Wright et al. Nature, 2004

Leaf Investment Strategies are Largely Arrayed Along A Single Spectrum, With a Globally Consistent Pattern of Trait Correlations



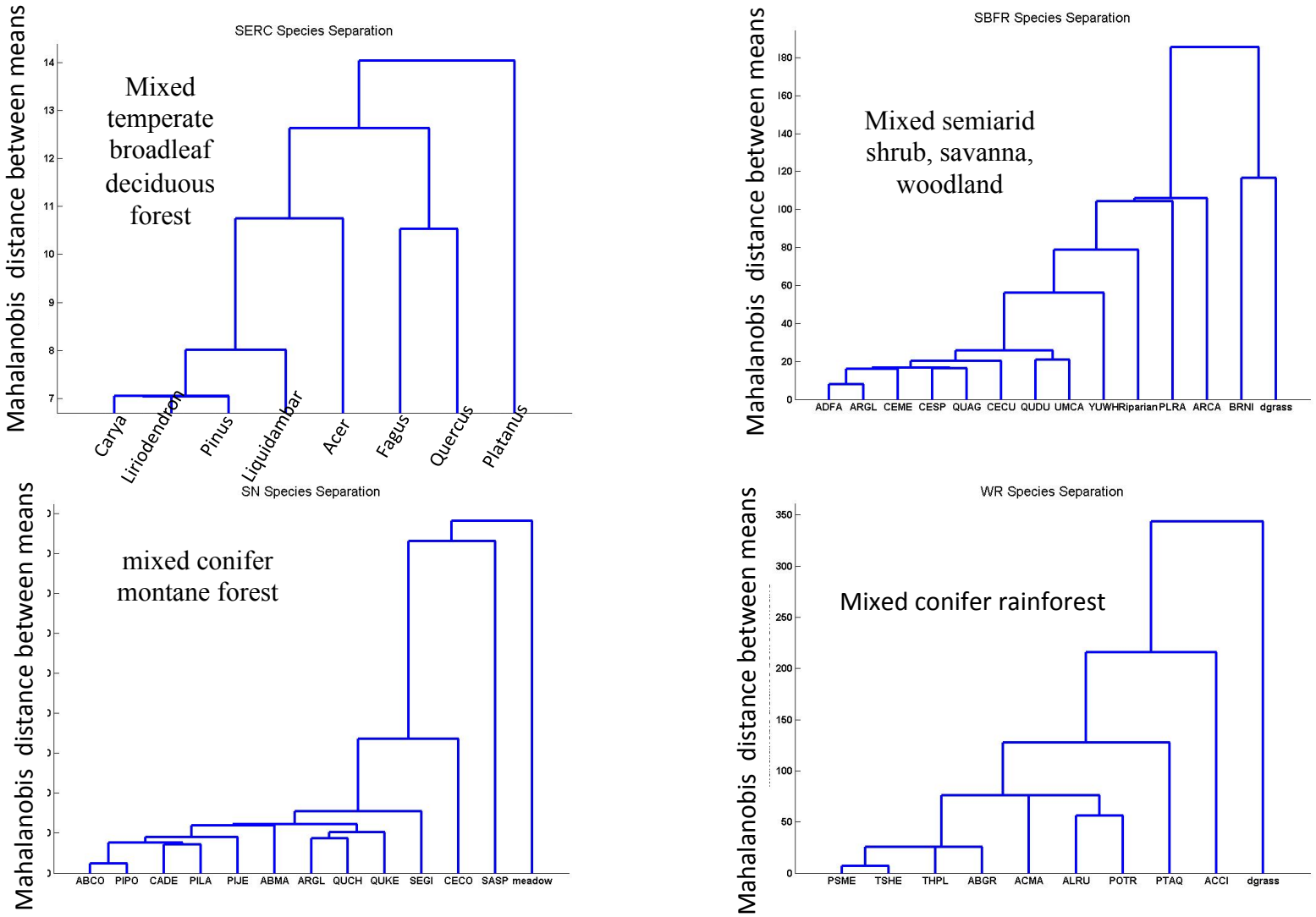






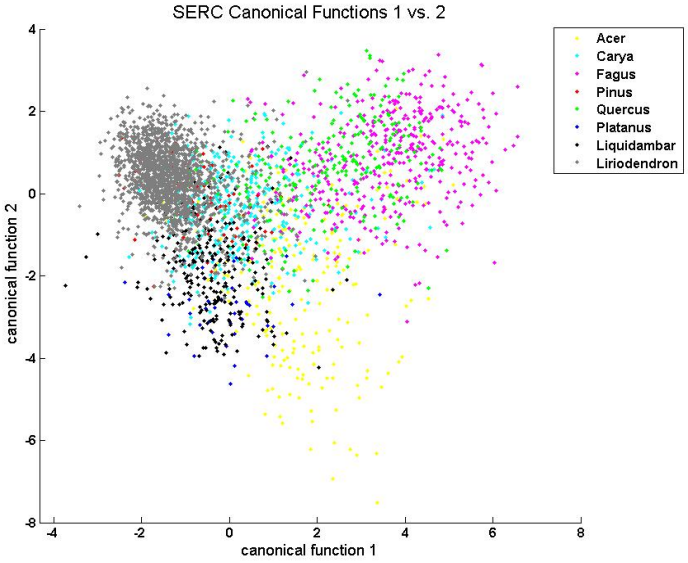
Wright et al. Nature, 2004

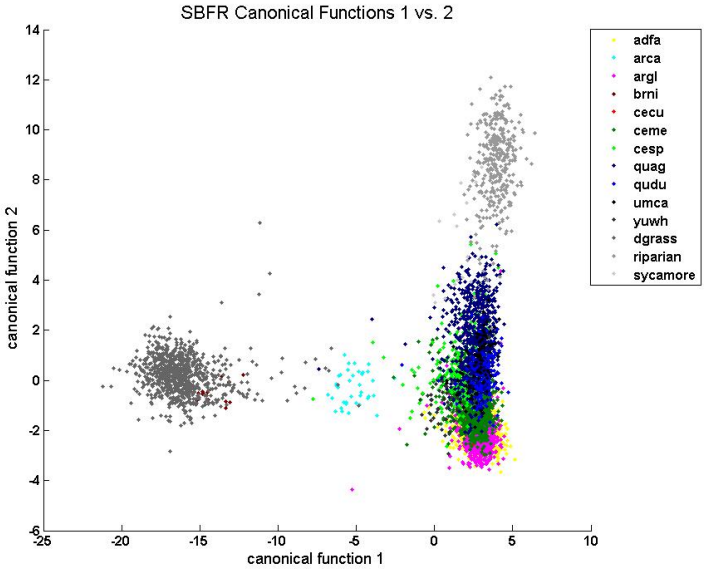
Species Clusters based on Spectral Similarity by Site

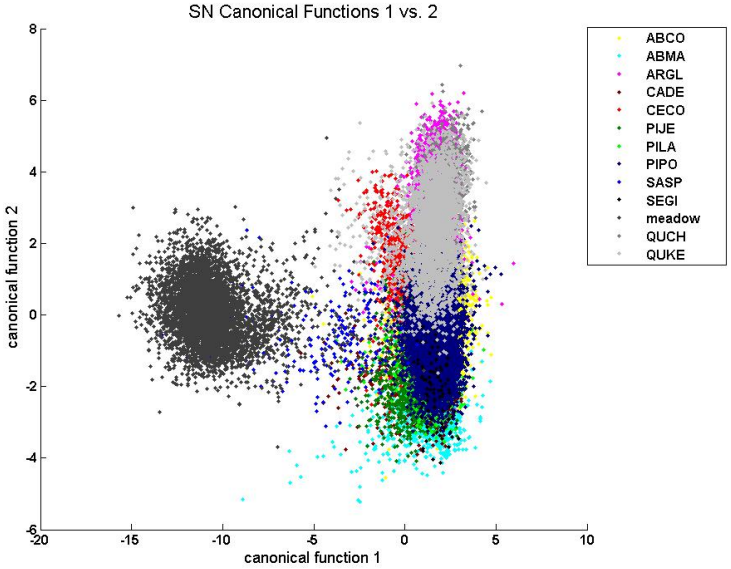


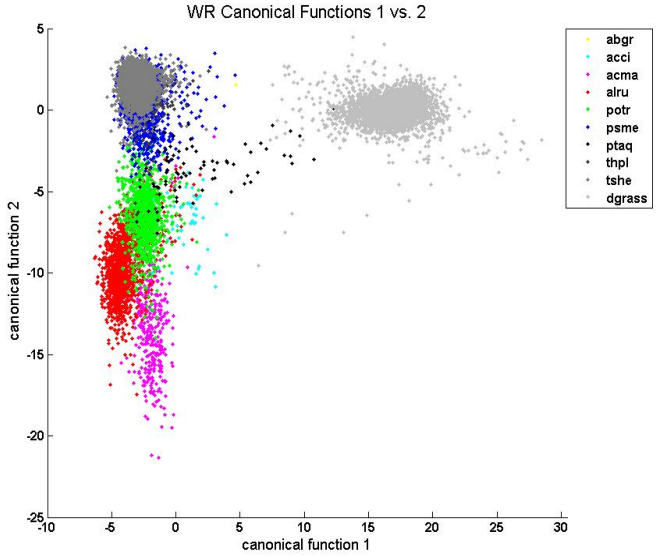
Keely L. Roth, Dar A. Roberts, Philip E. Dennison, and Michael Alonzo, IGARSS 2012

Canonical Discriminant Analysis Results



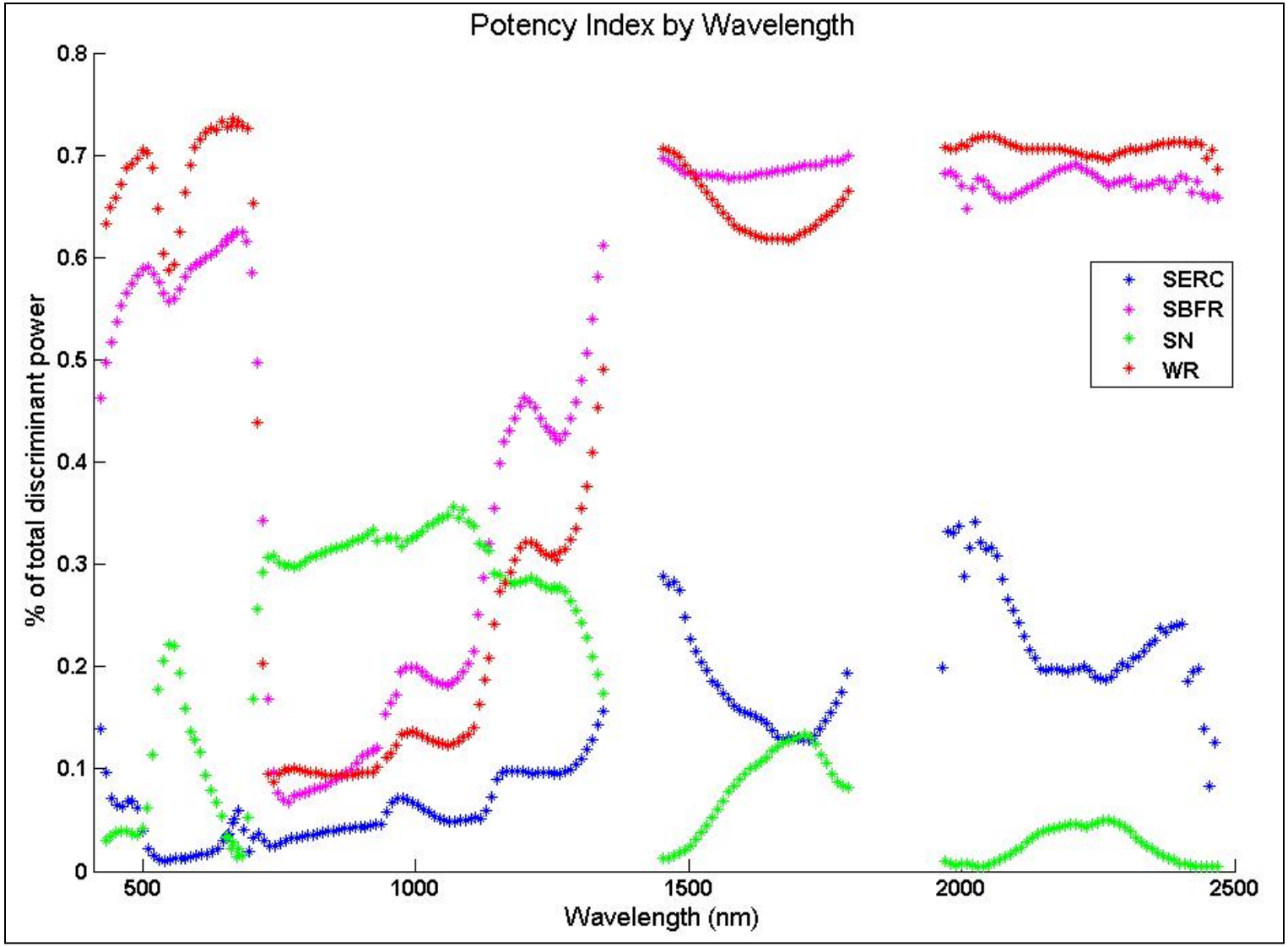






Roth, K.L., Roberts, D.A., Dennison, P.E. and Alonzo, M. (2012, July). *Discriminating plant species across diverse ecosystems with imaging spectroscopy*. Paper presented at the IEEE International Geoscience and Remote Sensing Symposium, Munich, Germany.

Canonical Discriminant Analysis Potency Index



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Questions?

Model of Proposed HyspIRI Satellite