Retrieval of Quantitative and Qualitative Information about Plant Pigment Systems from High Resolution Spectroscopy

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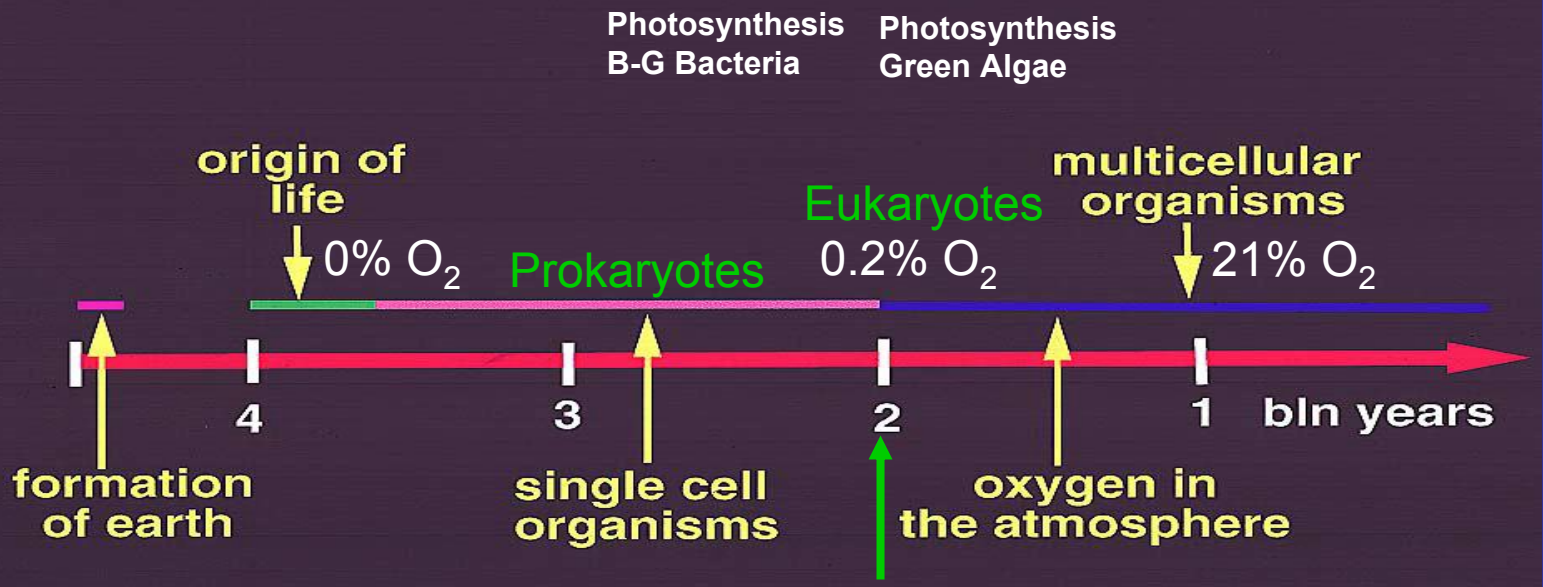
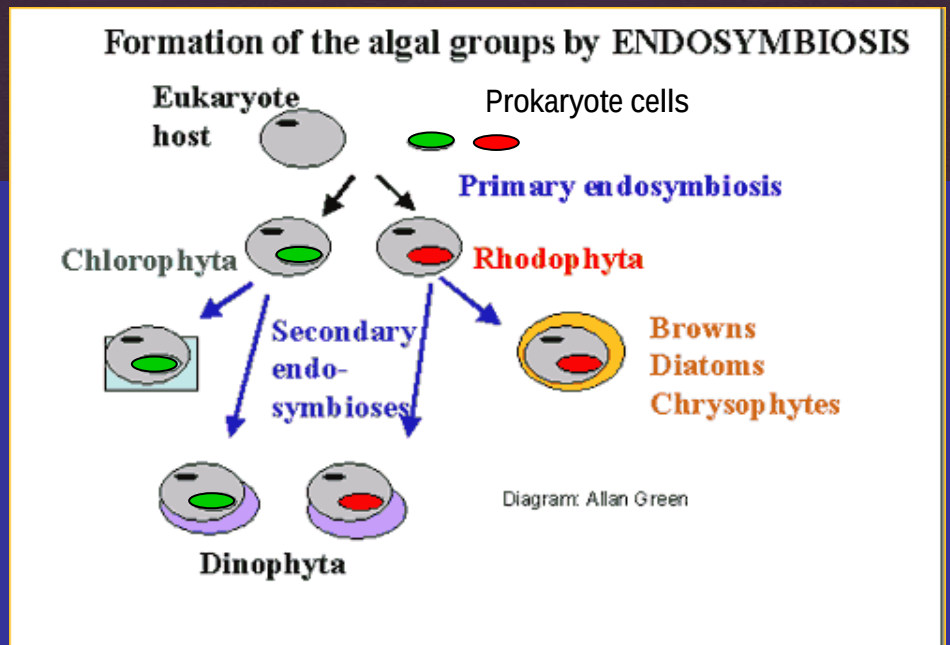
A BRIEF HISTORY OF EARTH

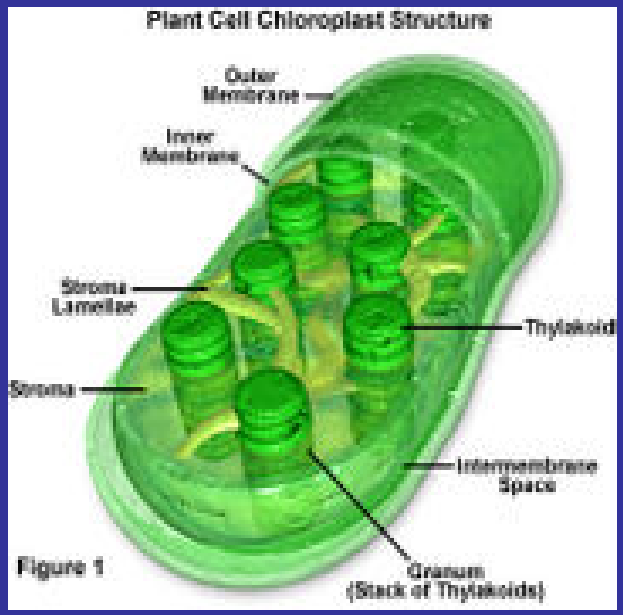


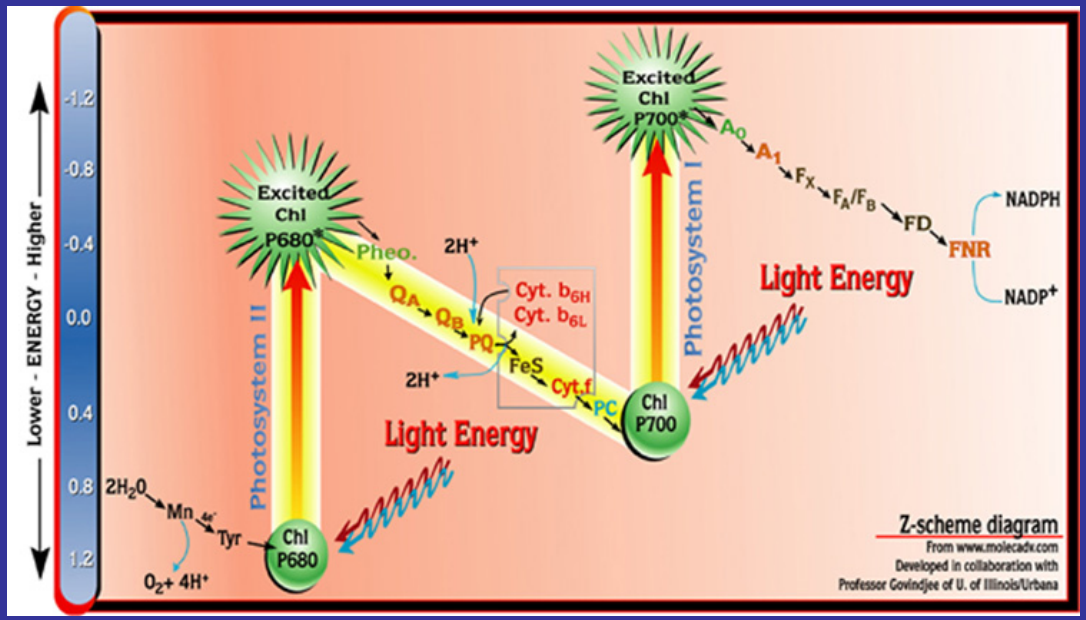


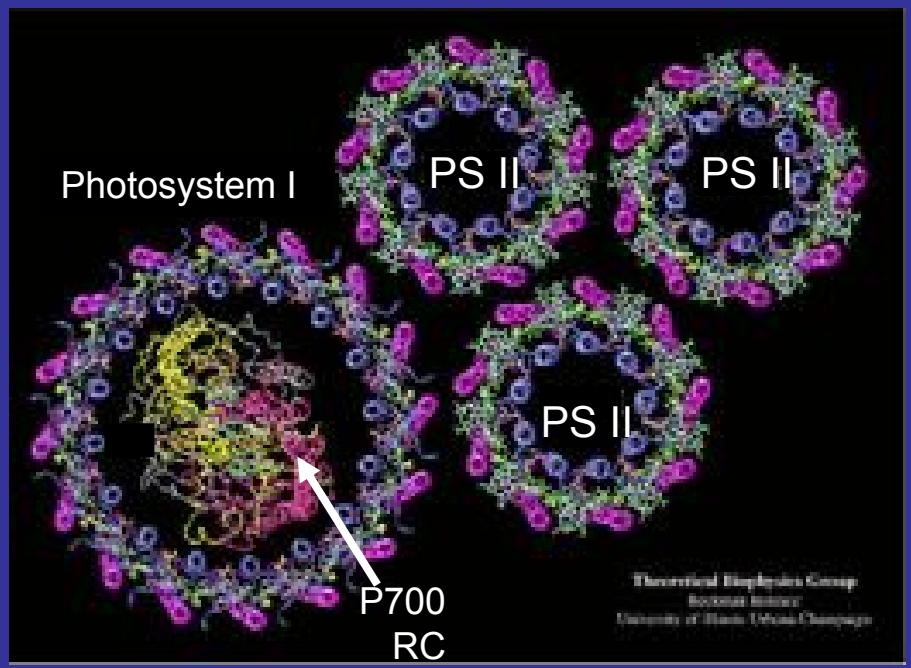
Green algal symbiont

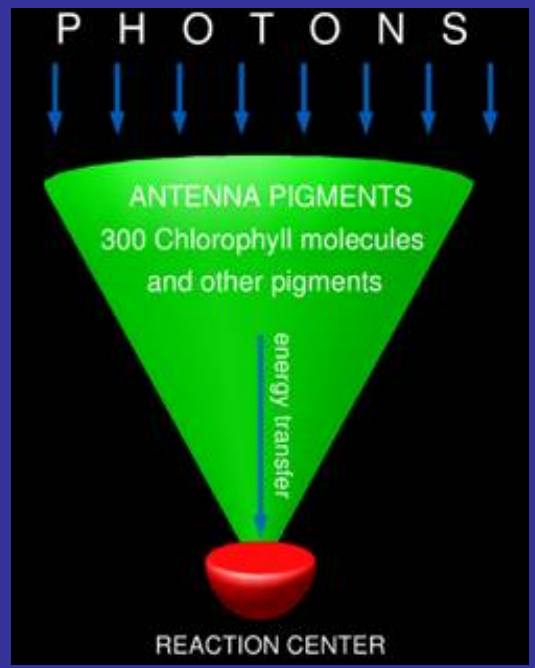
Red algal symbiont

Light Harvesting Complexes (Photosystems I, II)

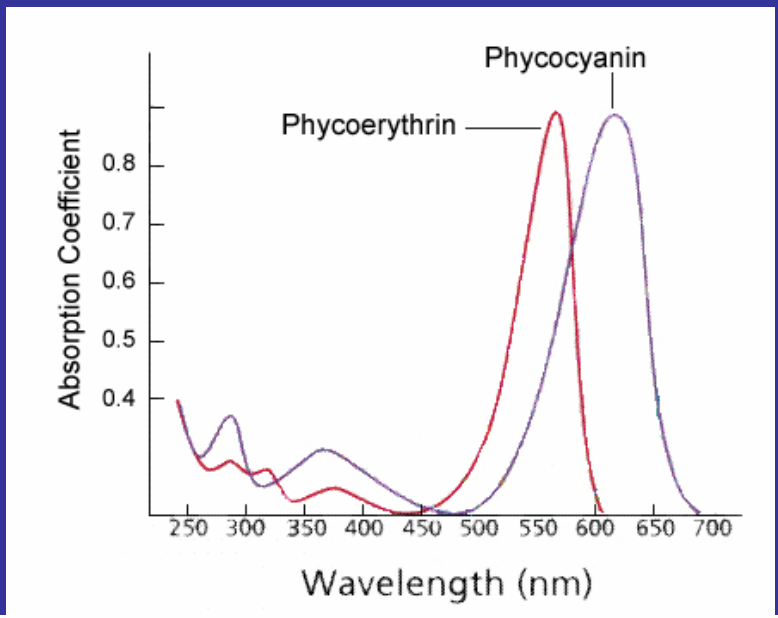






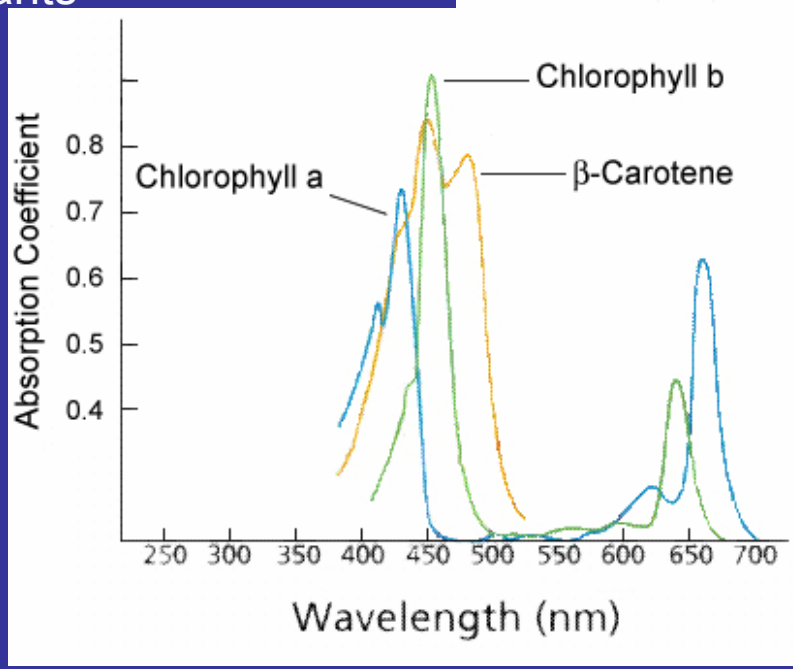


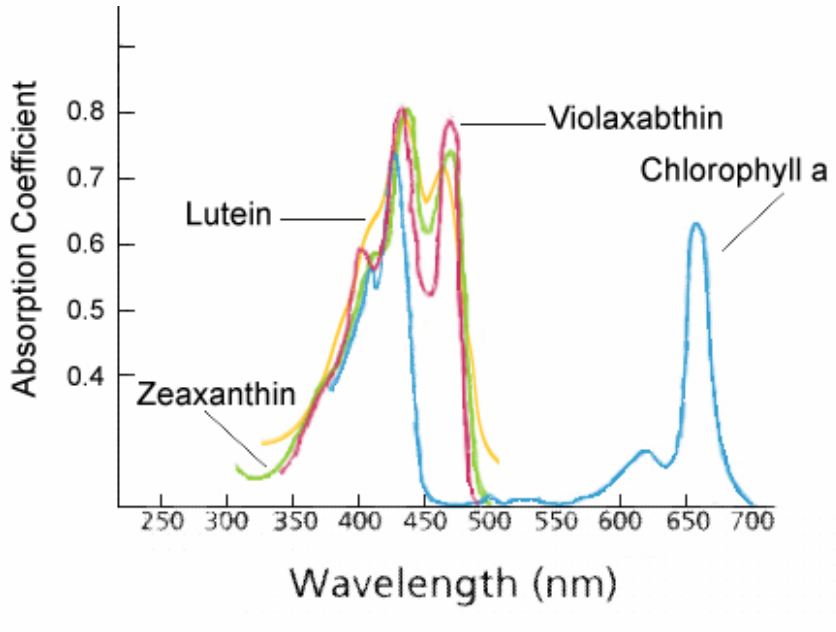
Absorption Coefficients for Common Photosynthetic Pigments



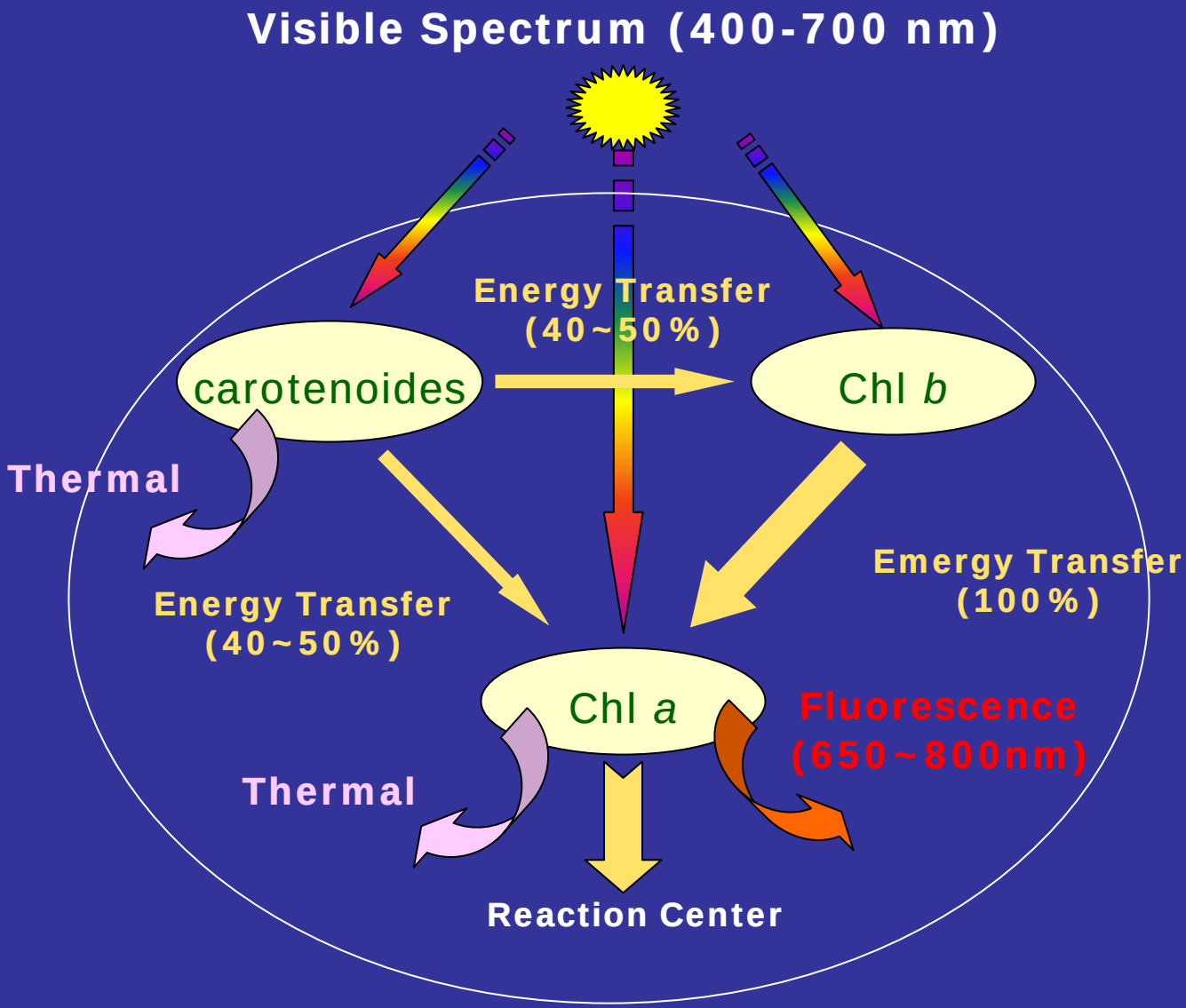
Characteristic of:
Blue-Green Bacteria
(cyanobacteria)
Red algae

Characteristic of:
Green algae & all Land Plants





Photosynthetic pigments: excitation energy transfer



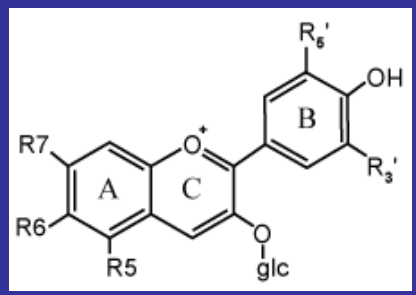
Source : Ismaël Moya (LMD-IPSL)

Stress: Loss of Chlorophyll & Increase in Carotenoids

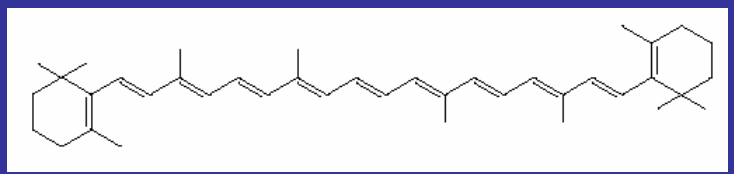
Chemical Structures of Pigments are Known

β-Cryptoxanthin
Lycopene
α-Carotene
β-Carotene

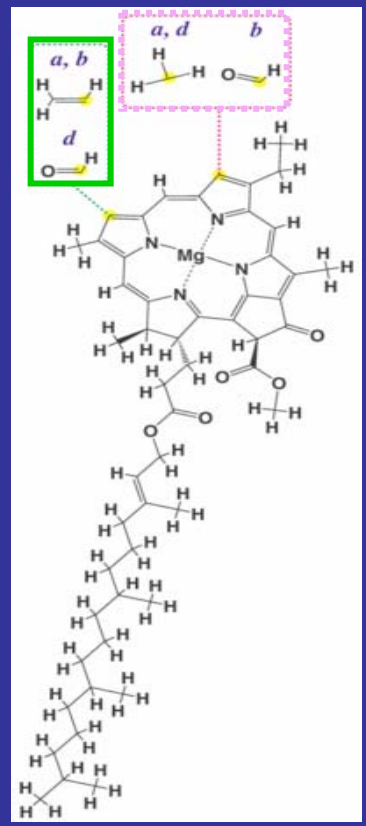
Xanthphylls:
Lutein
Zeaxanthin
Violaxanthin
Abtheraxathin



Anthocyanin + glucose

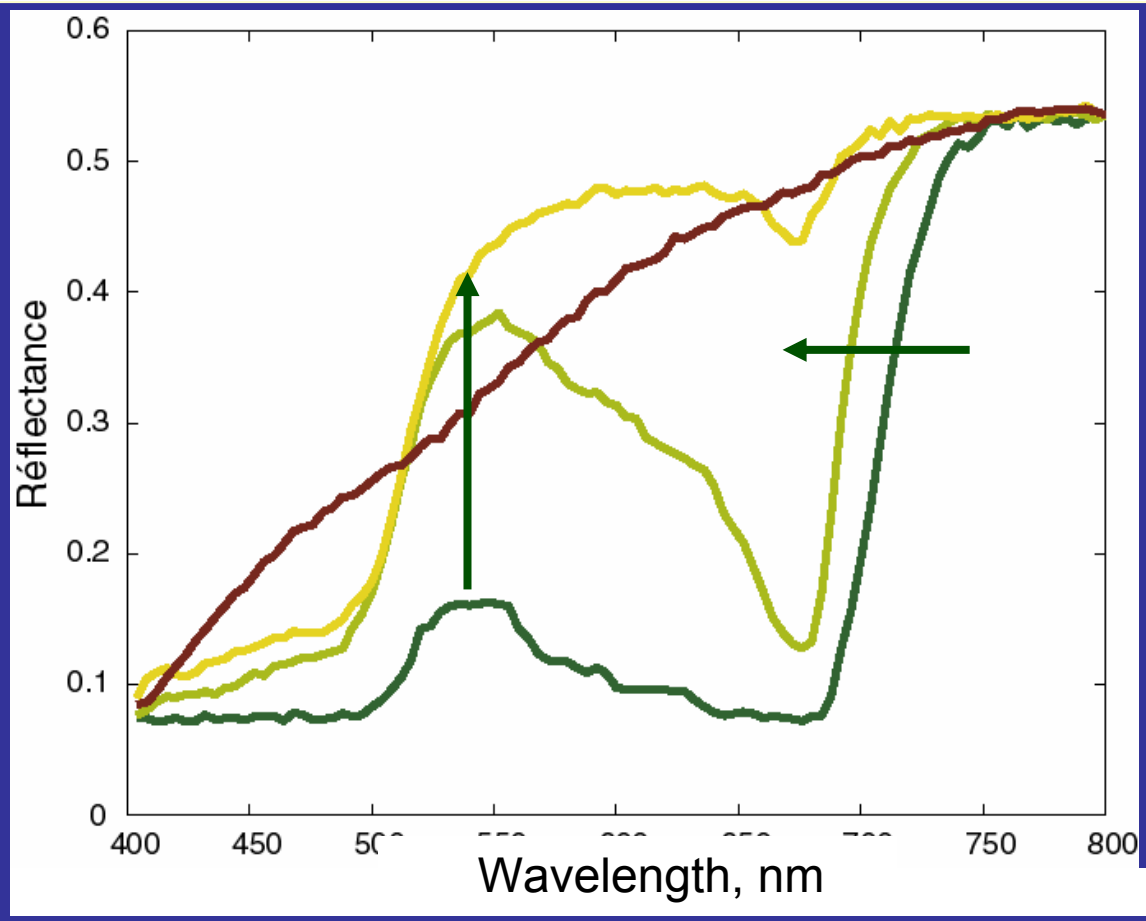


β-carotene



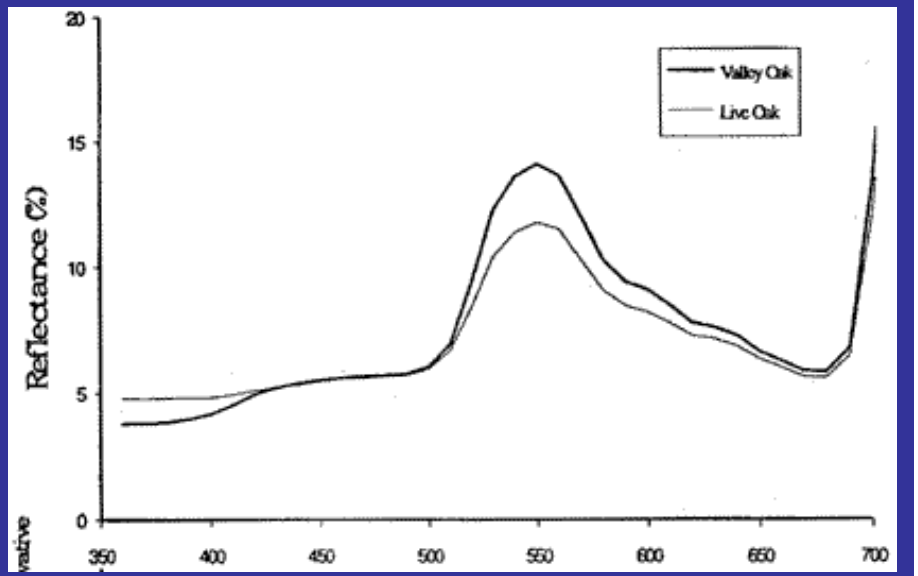
Chlorophyll a, b, d

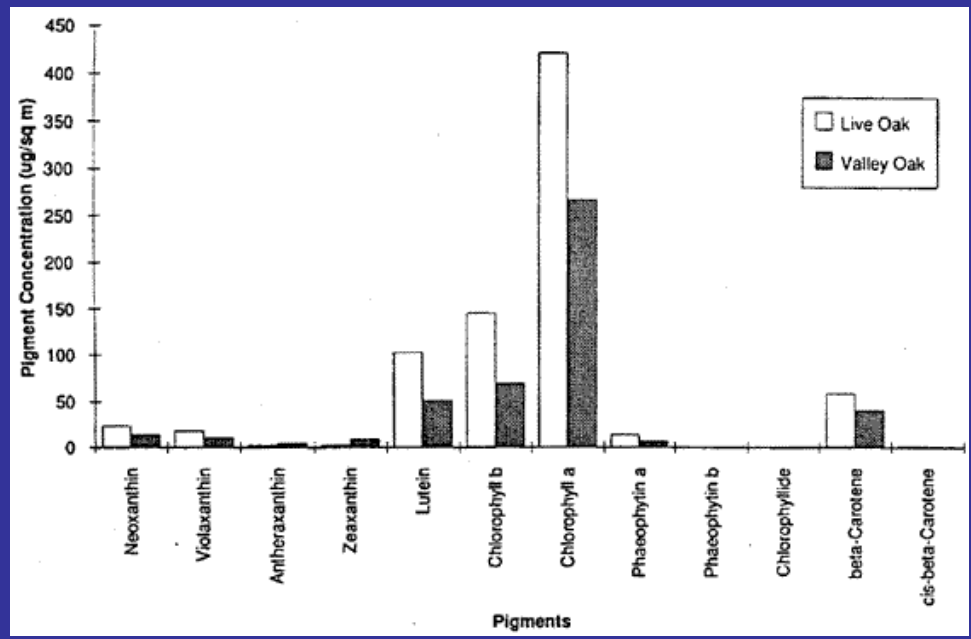
Leaf Senescence Follows Consistent Pattern of Pigment Changes



Pigment Composition Varies between Species, even Closely Related Ones

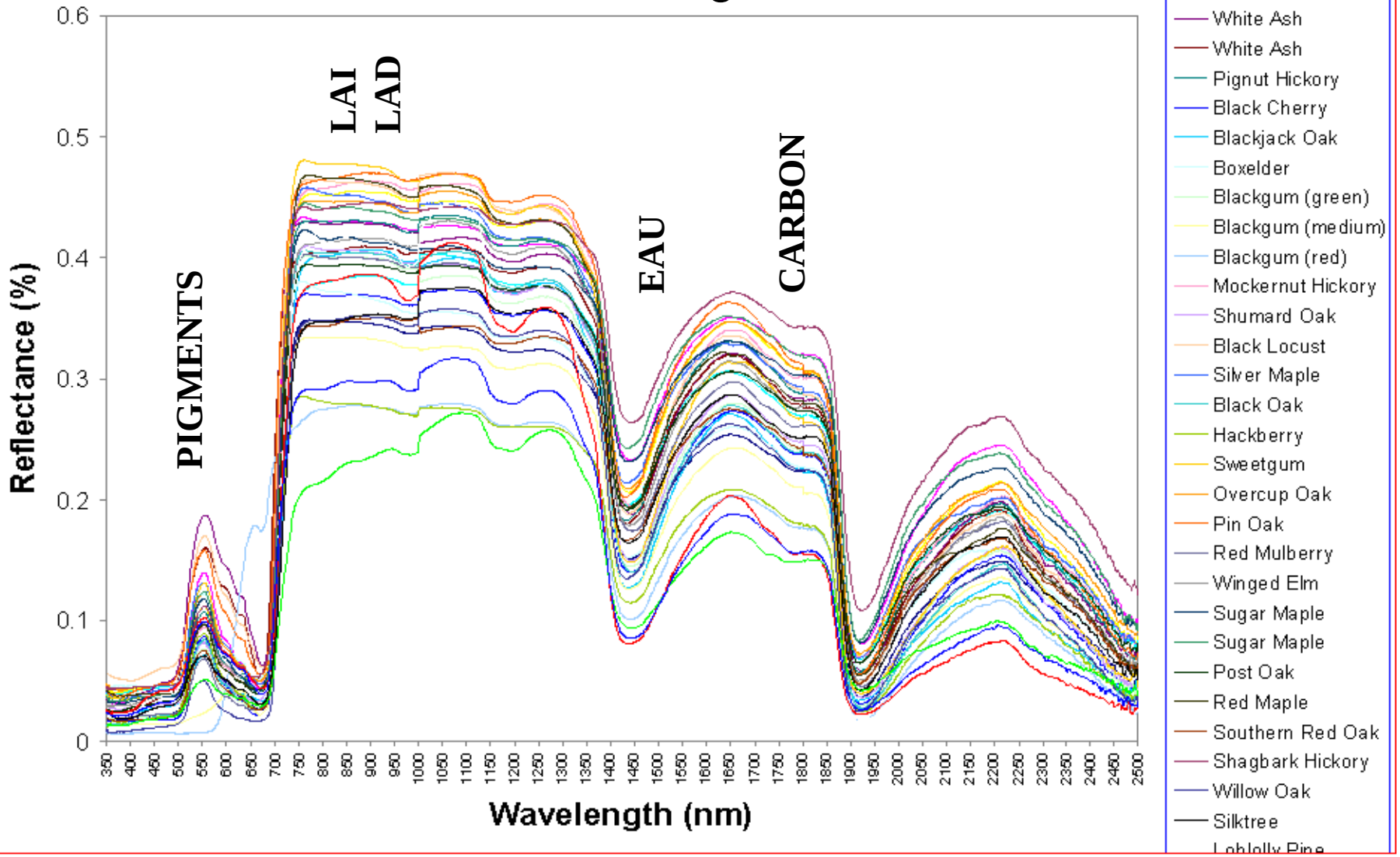
Mature Valley Oak (deciduous) vs. Coast Live Oak (evergreen)
Reflectance and Pigment Composition & Concentrations





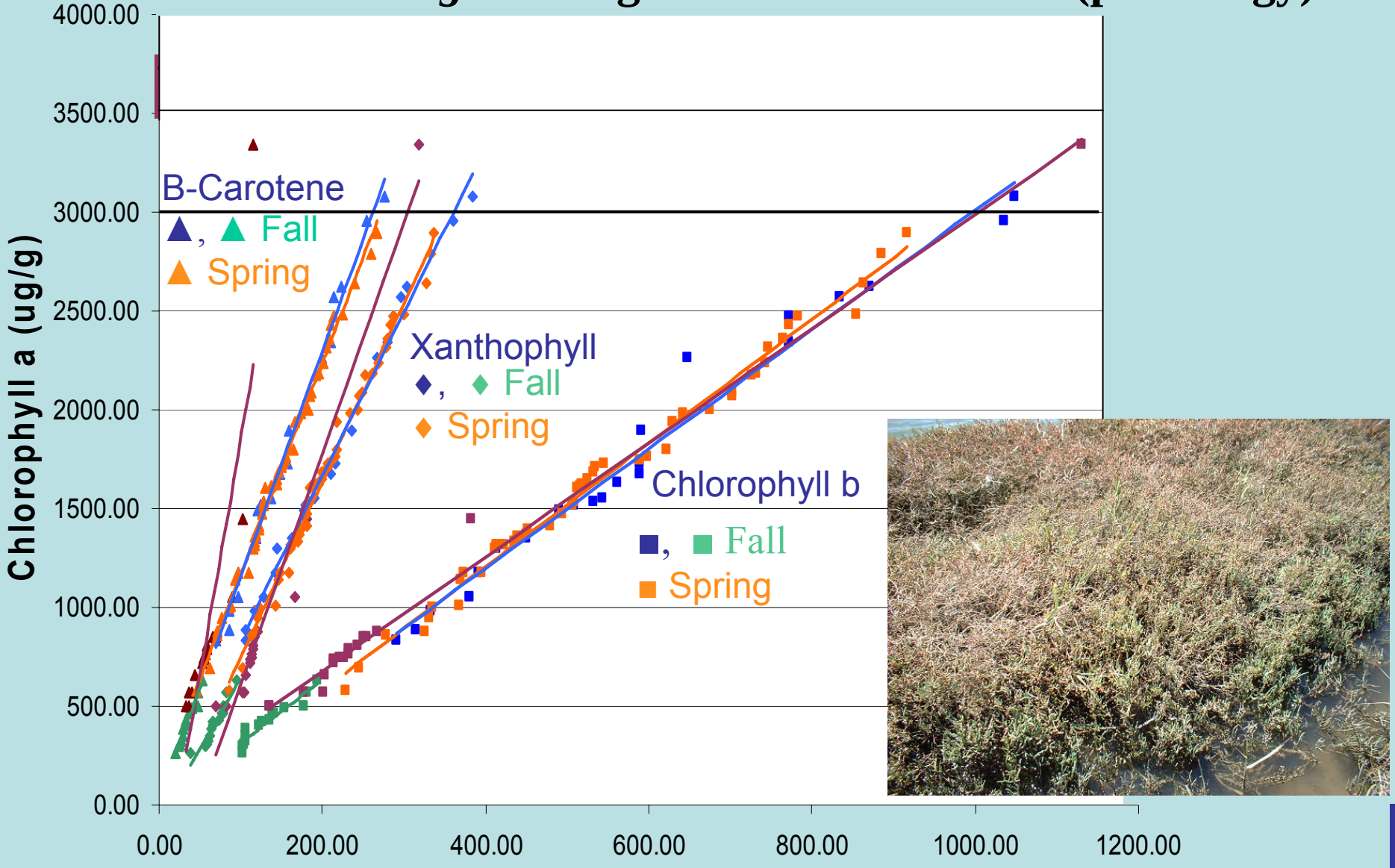
Ustin et al. 1998

Variability in Pigment Composition and Concentration in Vegetation



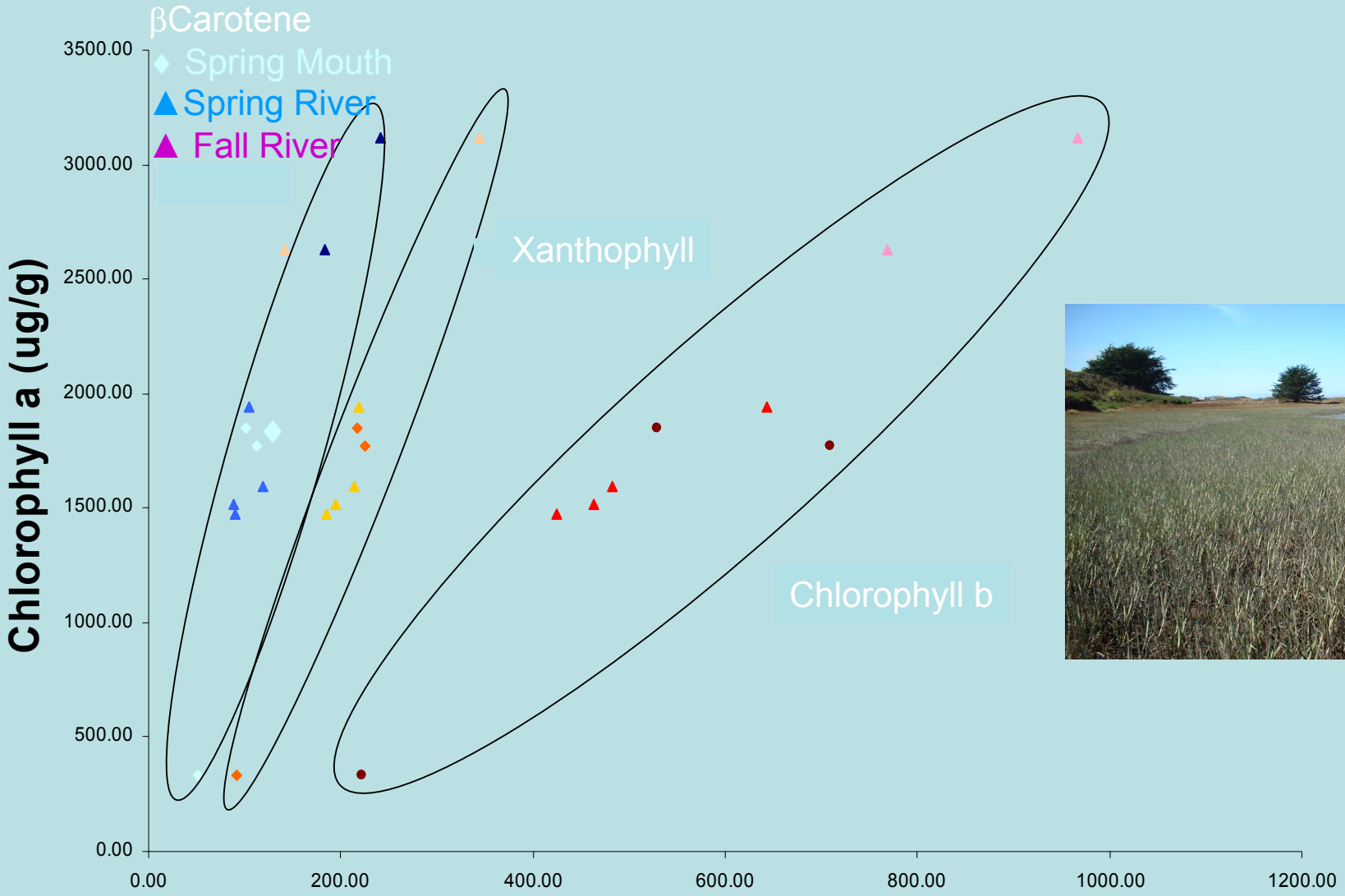
Source : Mid-America Remote Sensing Center - Murray State University

Salicornia virginica Pigment Concentration (phenology)

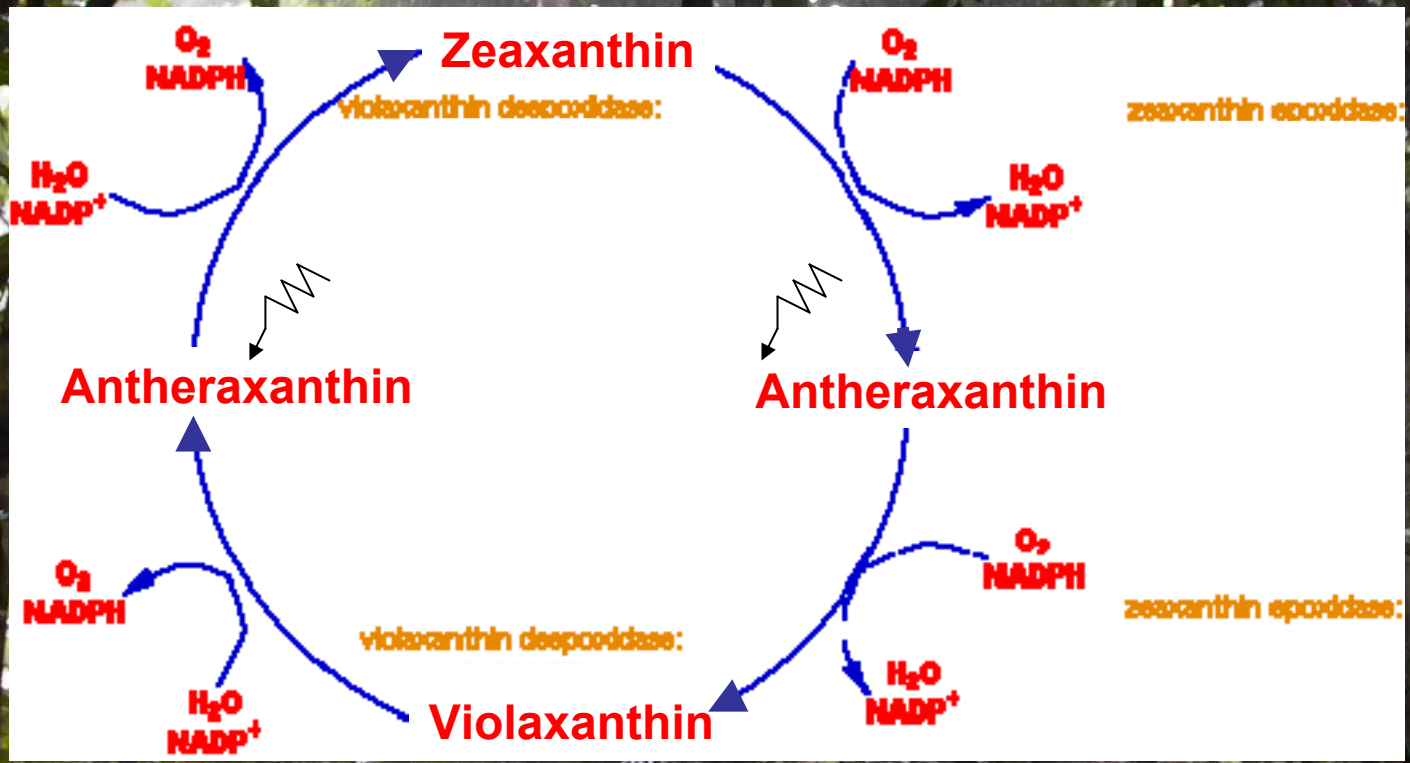


B-Carotene, Xanthophyll, and Chlorophyll b Concentrations (µg/g)

Spartina foliosa Pigment Concentration (salinity, phenology)

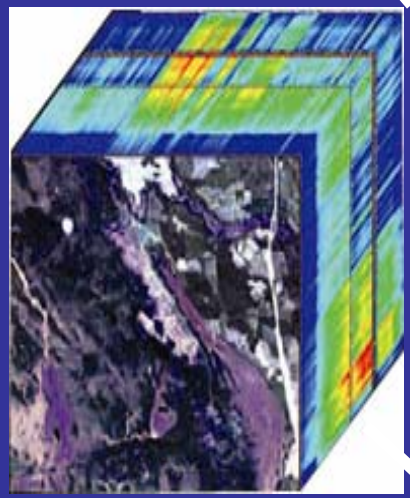


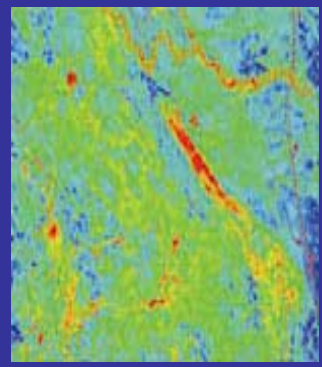
Xanthophyll Cycle: Light Mediated Photosynthesis



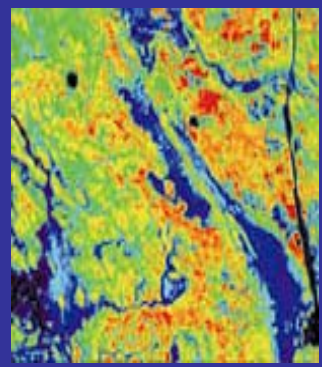
Pigment Indexes

AVIRIS IMAGE CUBE

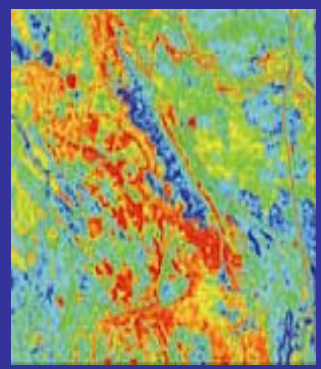




ANTHOCYANINS



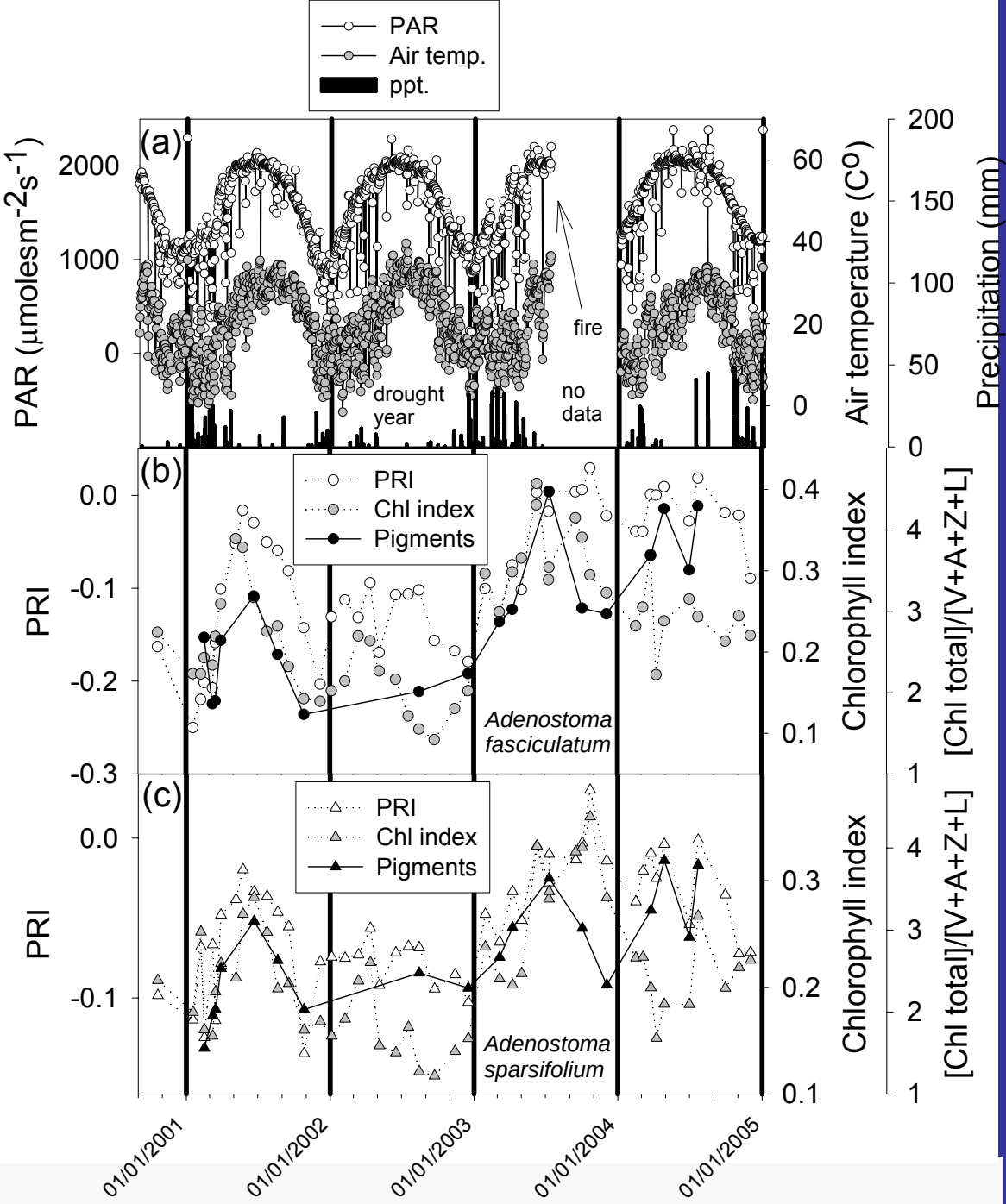
CHLOROPHYLL



CAROTENOIDS

RGB IMAGE:
RED=ANTHOCYANINS
GREEN=CHLOROPHYLL
BLUE=CAROTENOIDS

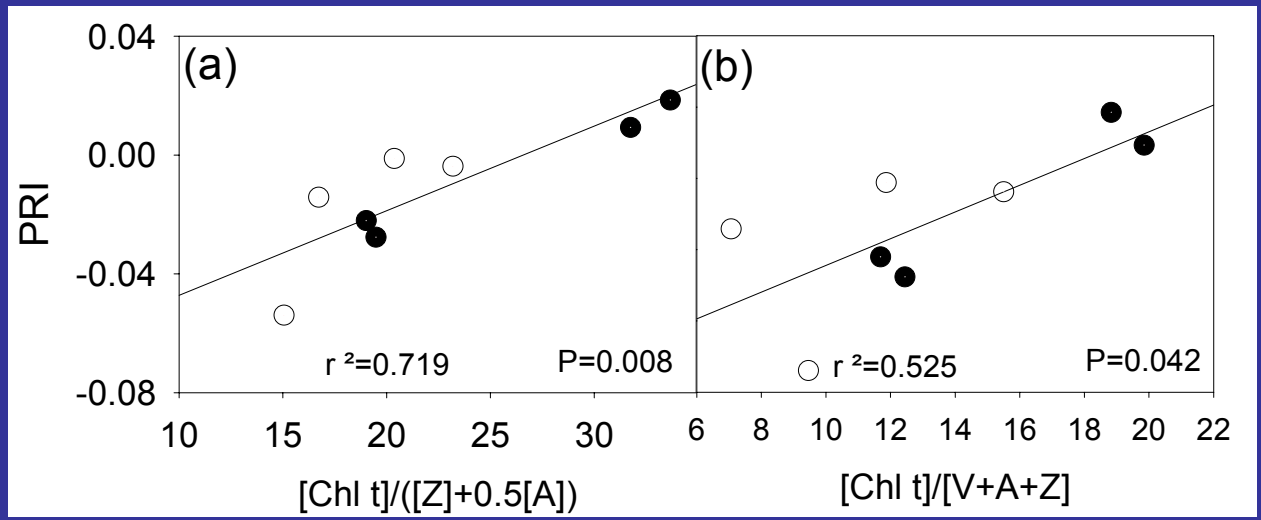
See Rahman et al. 2001
Gamon & Colleagues,
From Ustin et al., 2004



Mean Diurnal cycle For Month

José Alfonso Silva Sepúlveda, 2006 Honors Thesis CSU-LA

Leaf photochemical reflectance index (PRI)
versus
(a)de-epoxidation of the xanthophyll cycle pigments normalized to chlorophyll and
(b) total xanthophylls cycle pigments normalized to chlorophyll



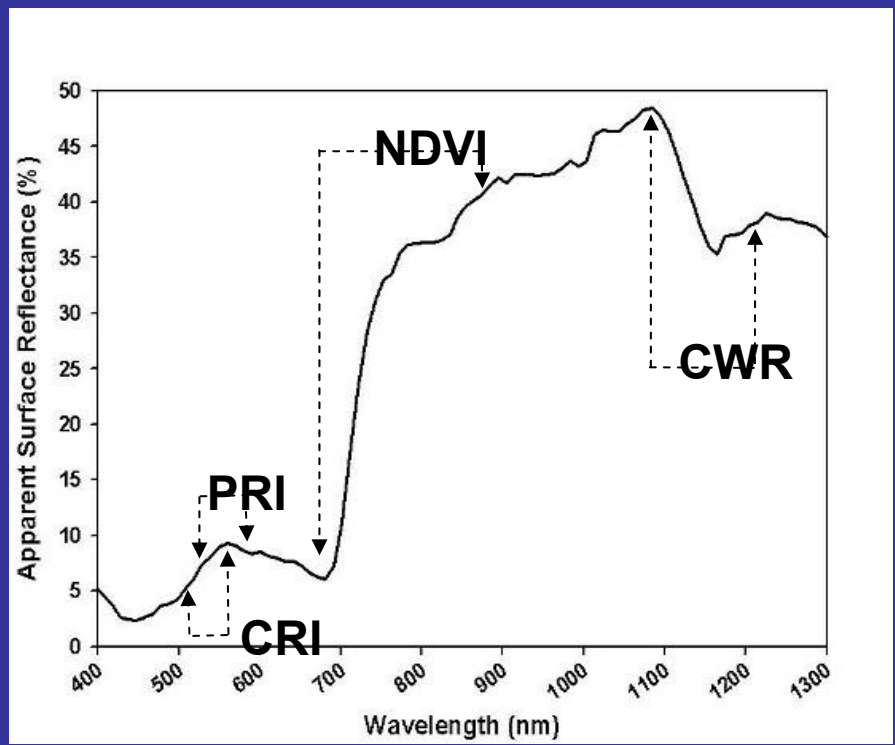
Adenostoma fasciculatum (black circles)
Adenostoma sparsifolium (white circles)

Site: Skye Oaks, California; Chaparral

José Alfonso Silva Sepúlveda,
2006 Honors Thesis
CSU-LA

EO-1 Hyperion Hyperspectral Physiological Indices

PRI = photochemical reflectance index
CRI = carotenoid reflectance index
NDVI = normalized difference vegetation index
CWR = canopy water retrieval (curve-fitting, not reflectance index)



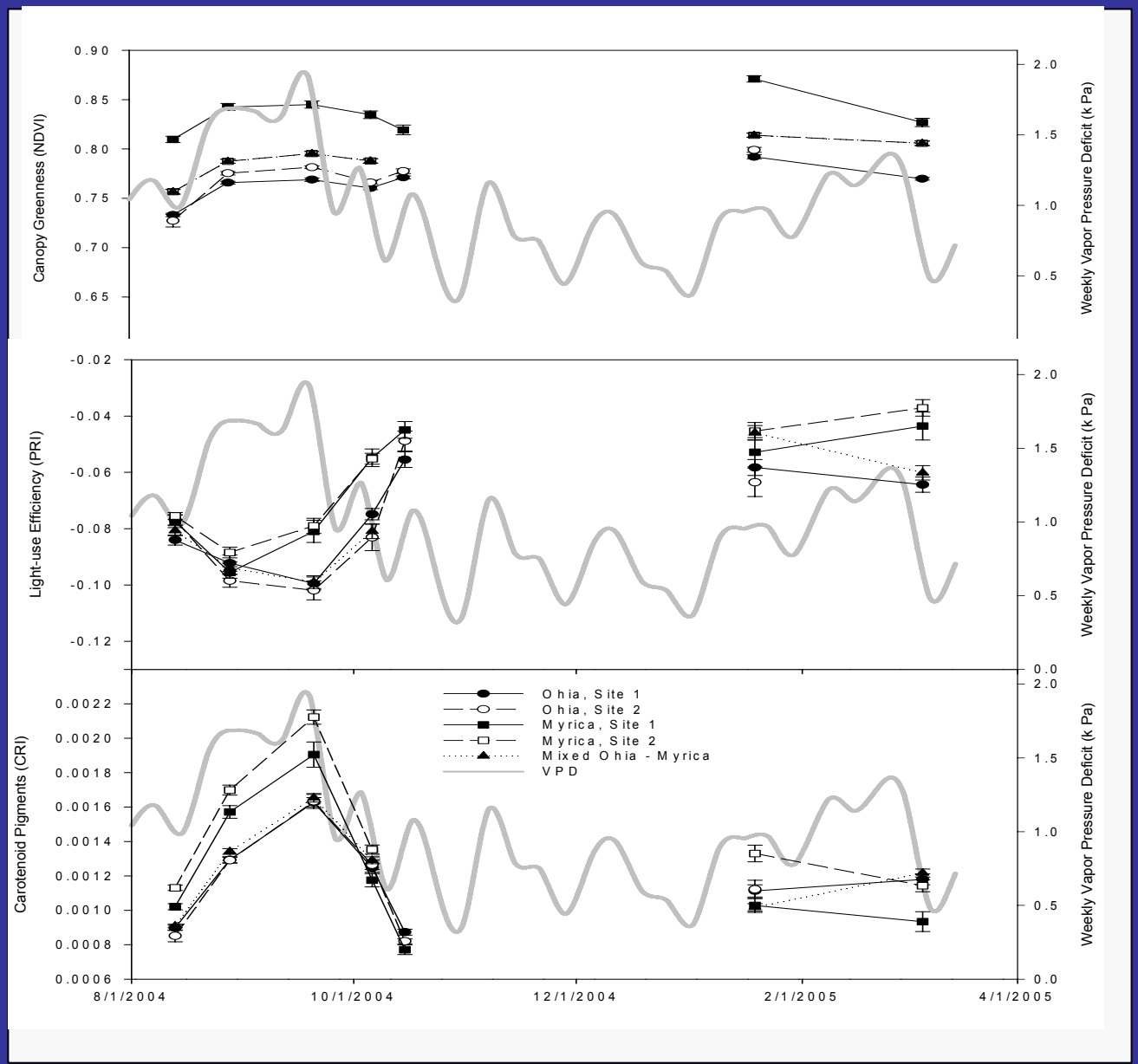
G. Asner et al.,
In Press Ecosystems

Vegetation Indices Related to Vapor Pressure Deficit

NDVI

PRI

CRI

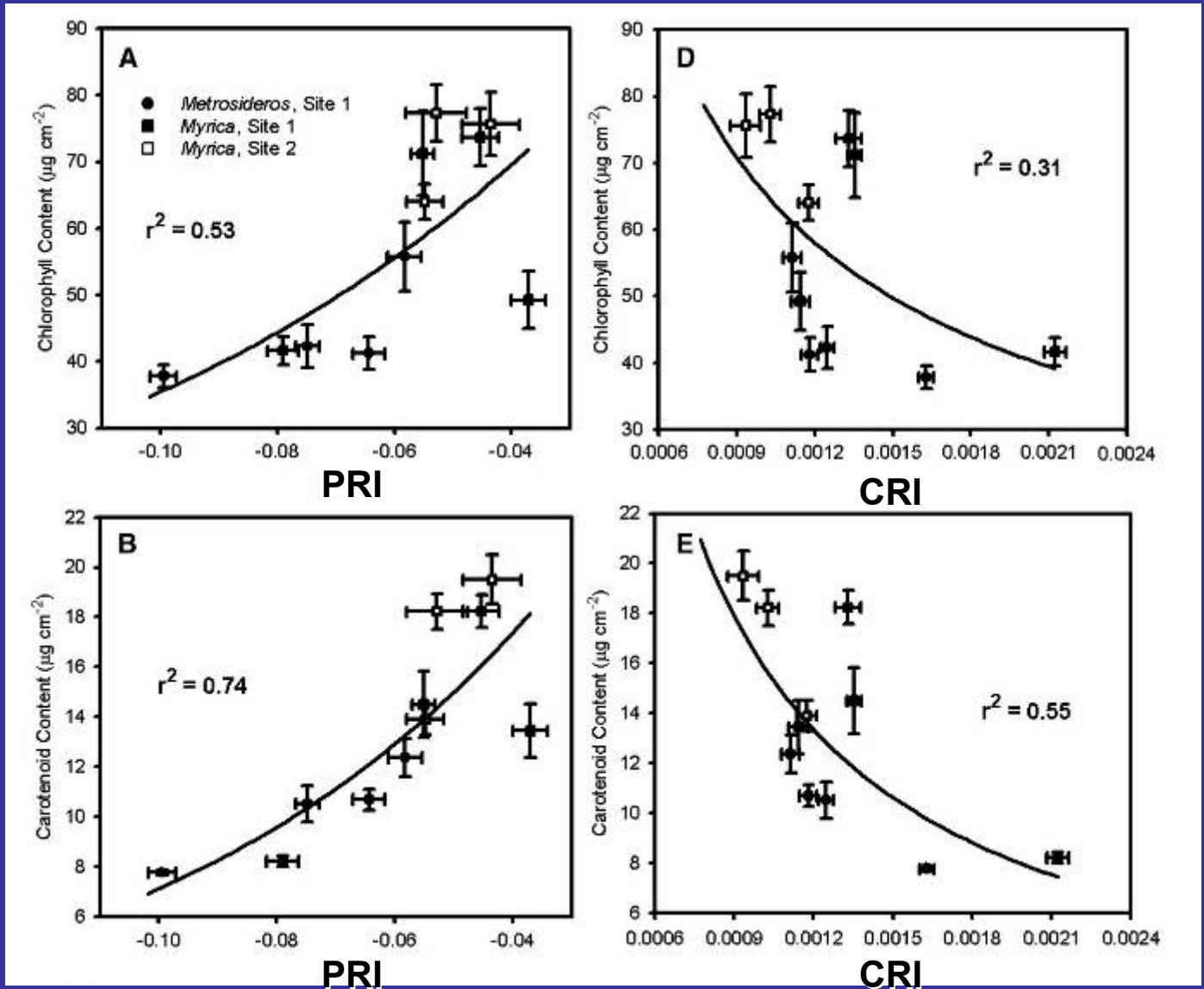


Vapor Pressure Deficit

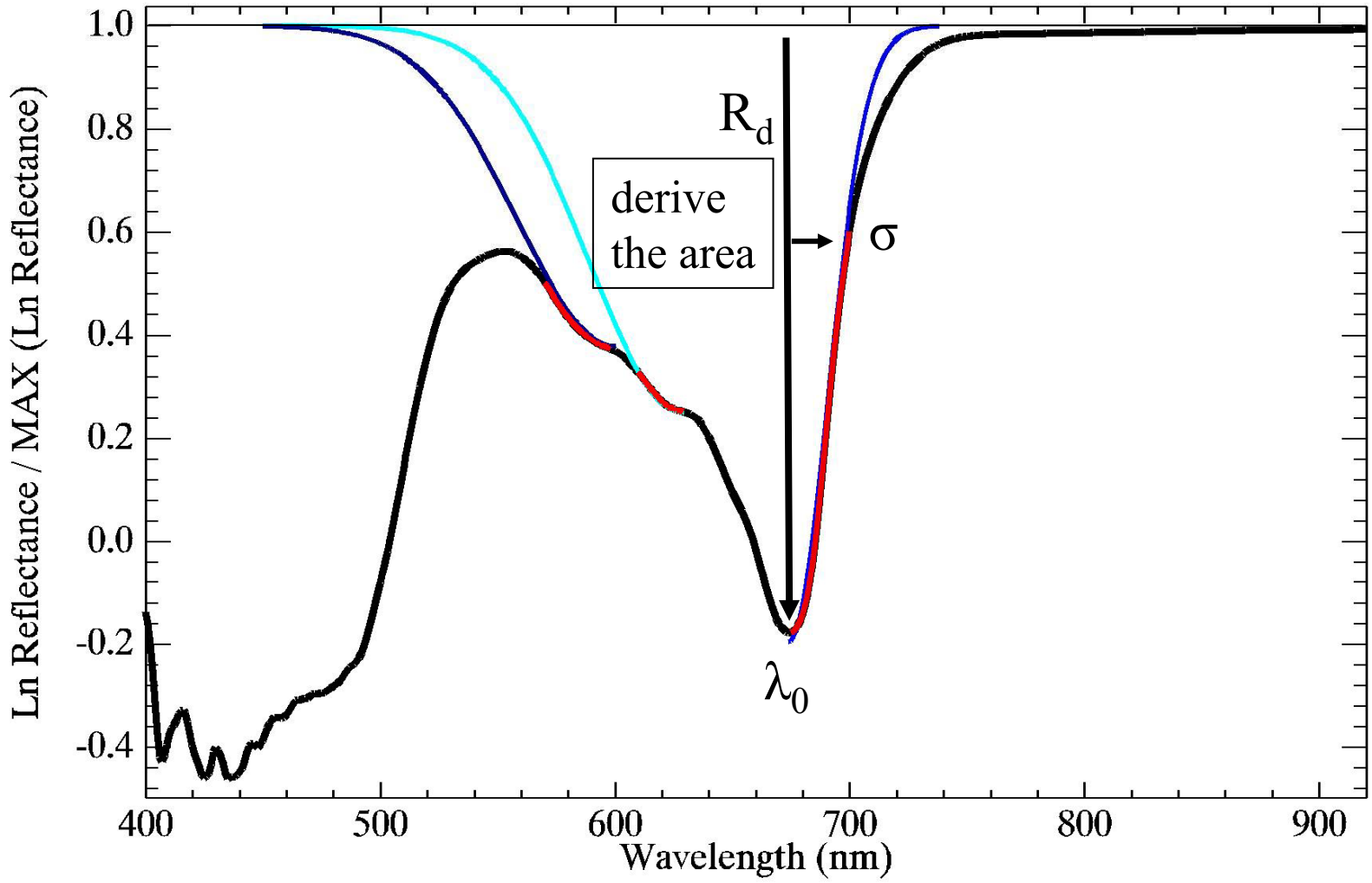
Hawai'i Volcanoes National Park

Ohia, Site 1 (native)
Myrica, Site 1 (n-fixing invasive)
Myrica, Site 2
Mixed Ohia-Myrica

Satellite Hyperspectral Physiological Indices vs. Top-of-canopy Leaf Pigments Measured in the Field

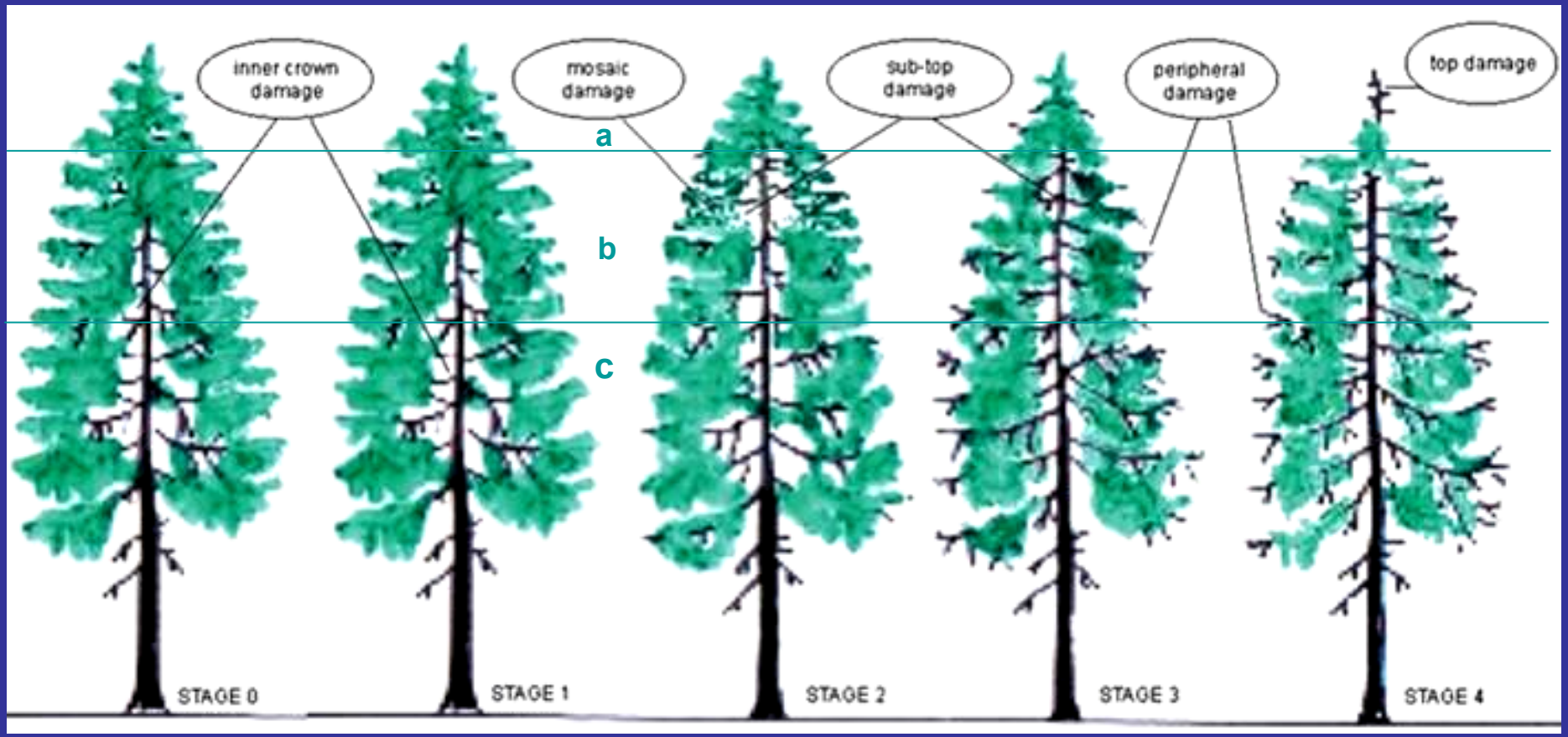


Fitting Multiple Gaussian to Spectrum to Identify & Quantify Multiple Pigments



Acala Cotton Leaf Reflectance, ASD Data

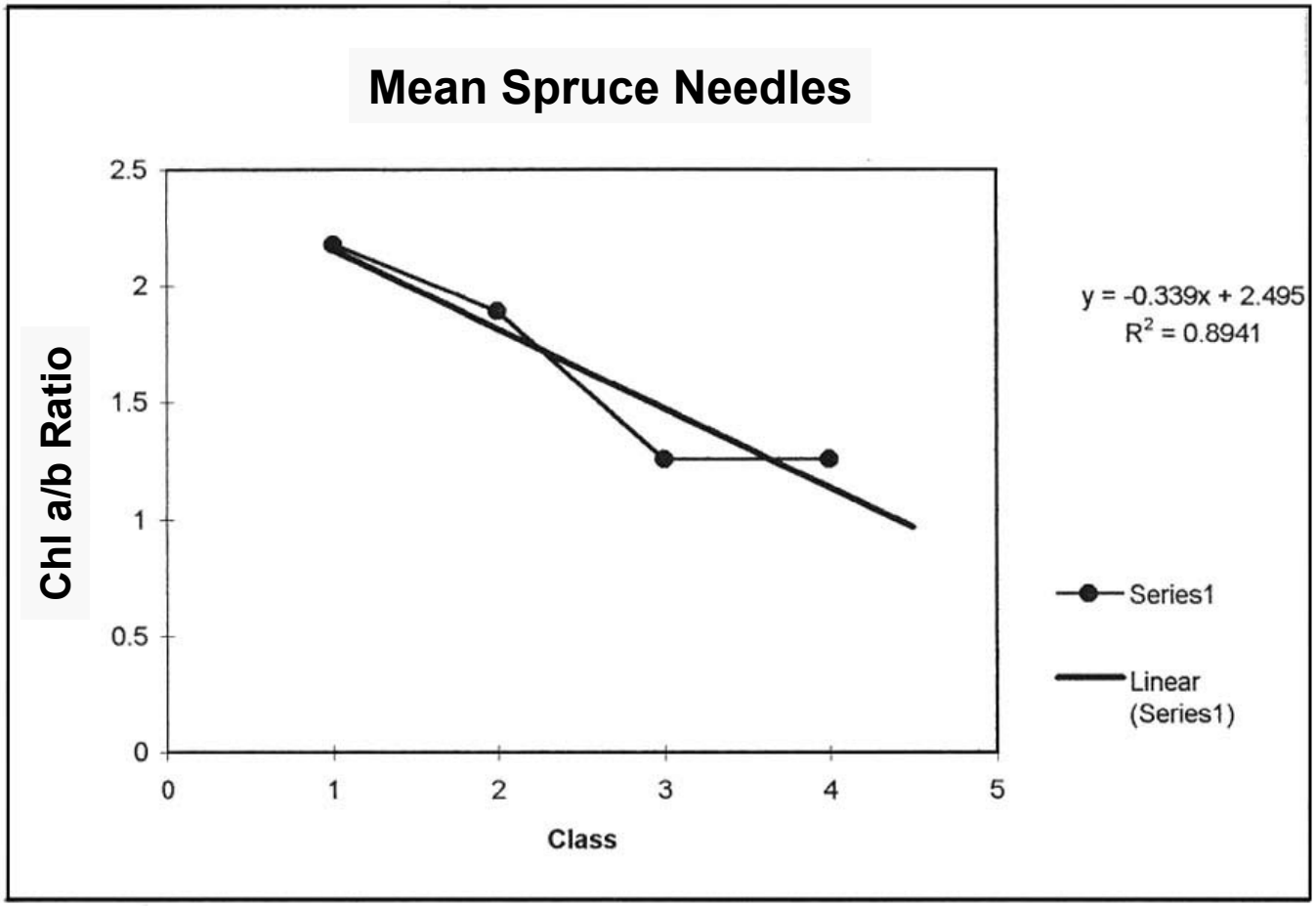
Chronic stress - Crown Transformation



Norway spruce functional crown parts:
a/ juvenile part
b/ production part
c/ saturation part

Michael Schaepman

Spruce Damage from Austria: Acid Deposition

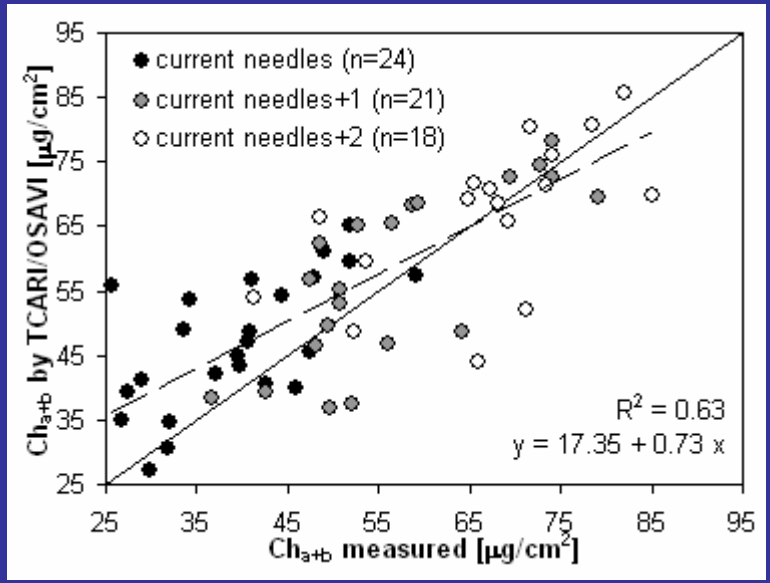


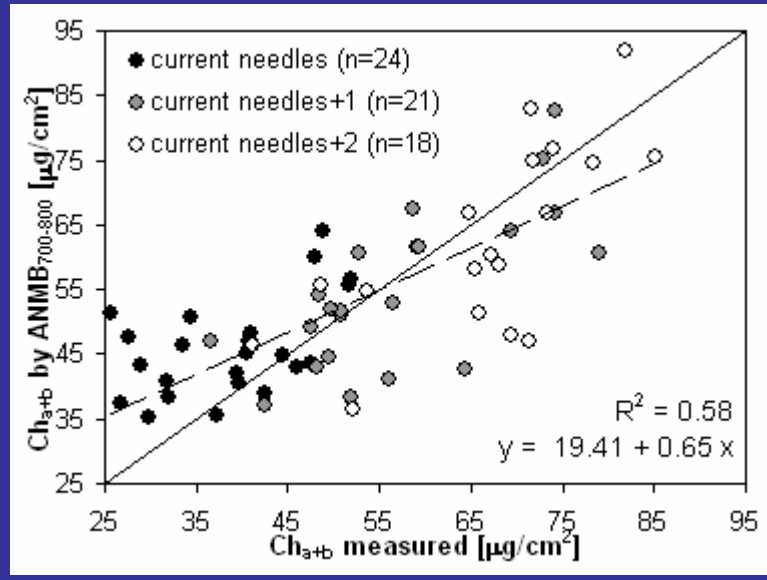
Spruce Branch Samples from Cliff Banninger, Gratz Austria

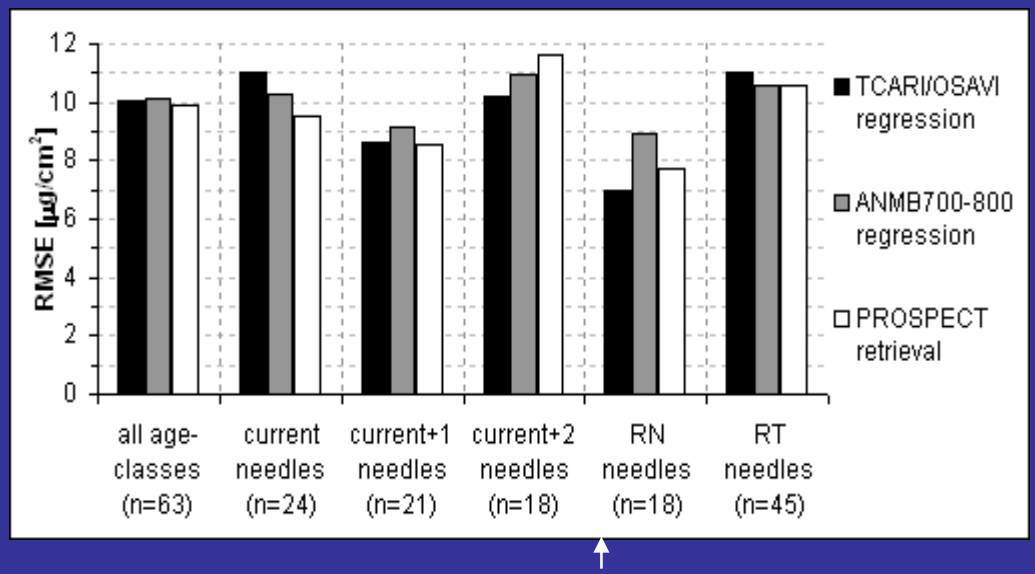
CSTARS: Pigment Analysis

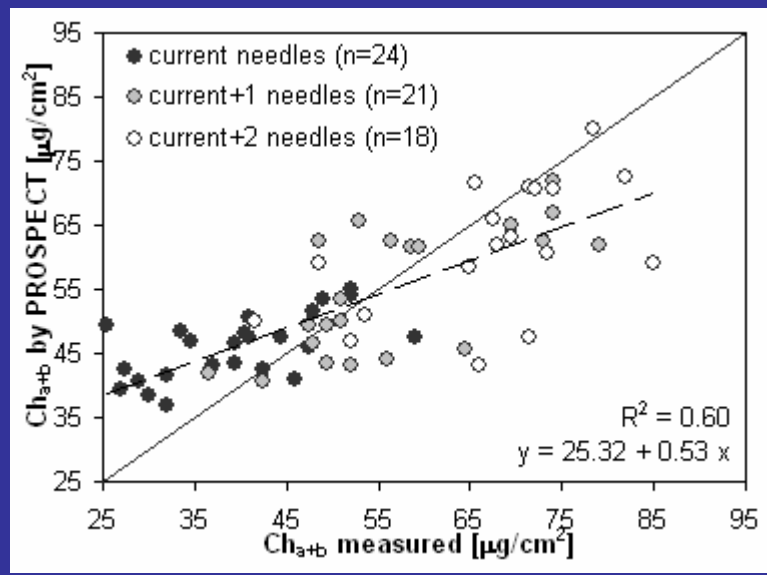
Chlorophyll Retrieval from Indexes, ANMB, PROSPECT

Testing data





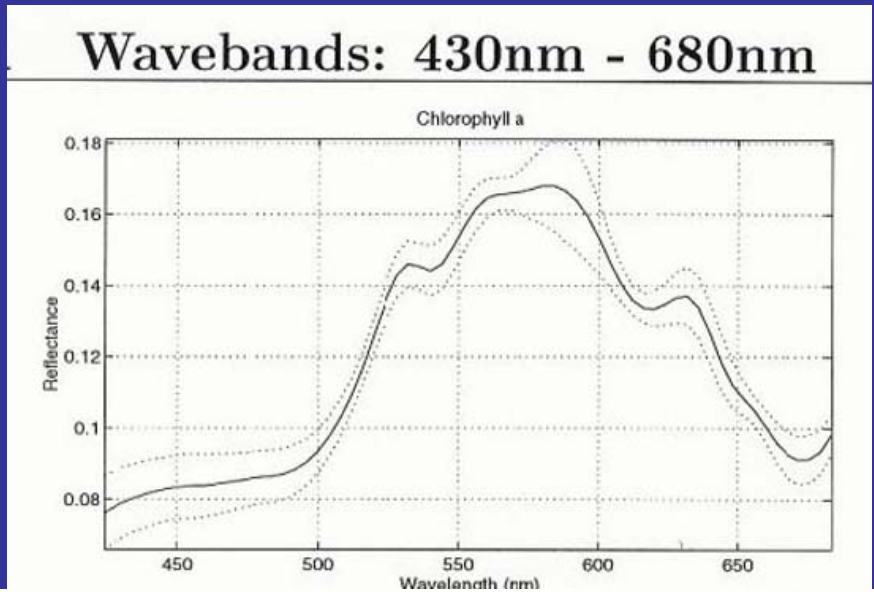




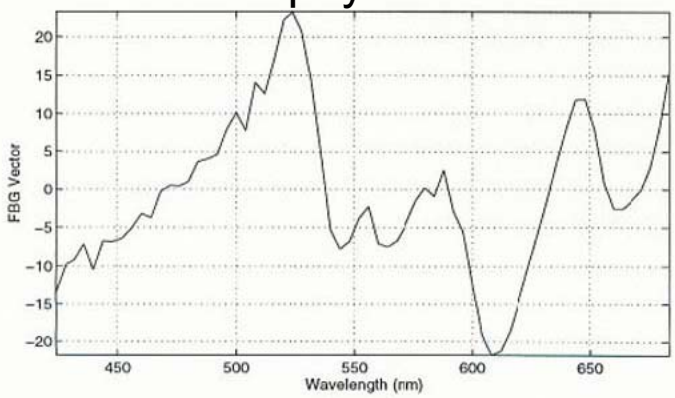
Comparison of the RMSE between measured and retrieved Ch_{a+b}

Spectral Based Approaches: Spectral Identification Methods

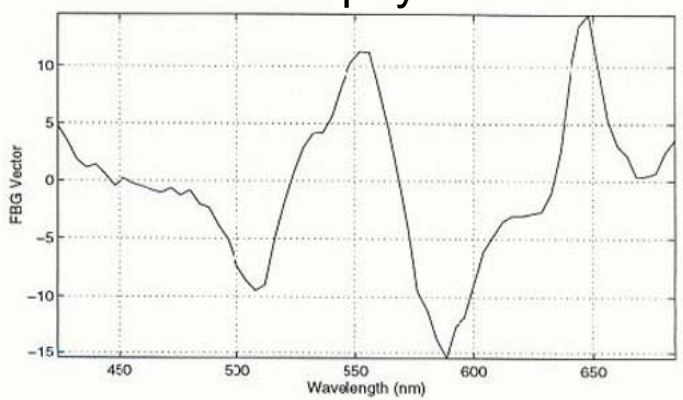
Reflectance



Chlorophyll a



Chlorophyll b

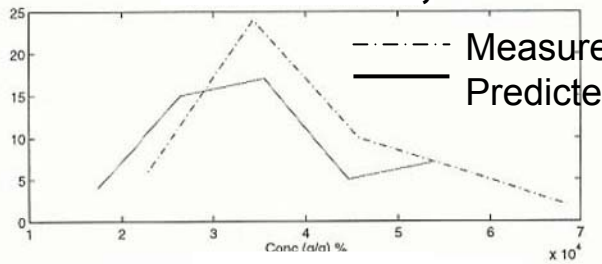


Foreground/Background Vectors

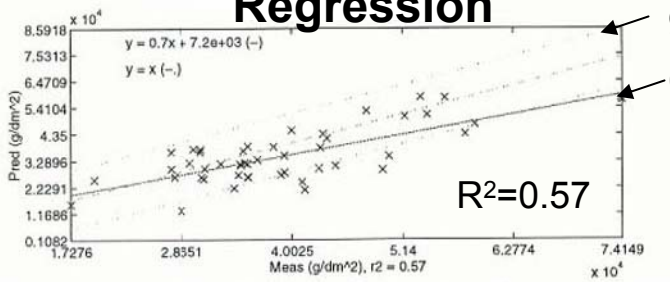
Claudia Castenada & Jorge Pinzon, et al.

Measured & Predicted Pigments

Needle Class 1, 2: Chl a



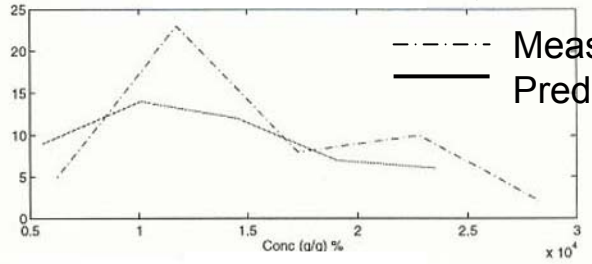
Regression



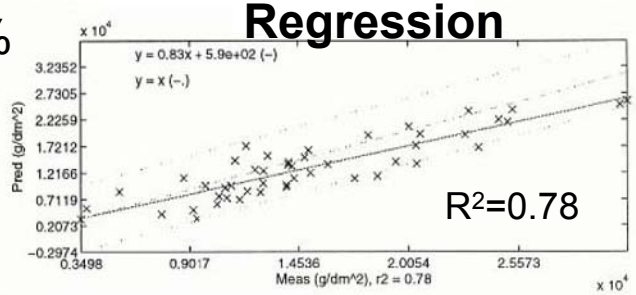
95% C.I.

R^2=0.57

Needle Class 1, 2: Chl b

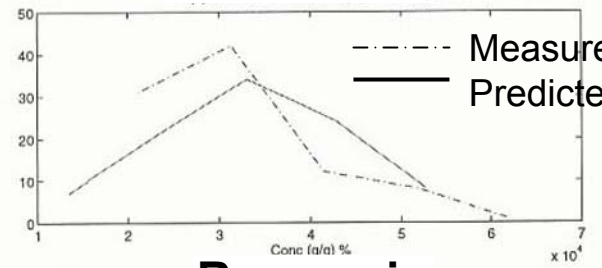


Regression

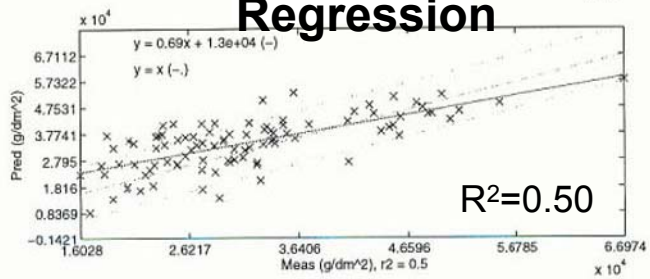


R^2=0.78

Needle Class 3, 4: Chl a

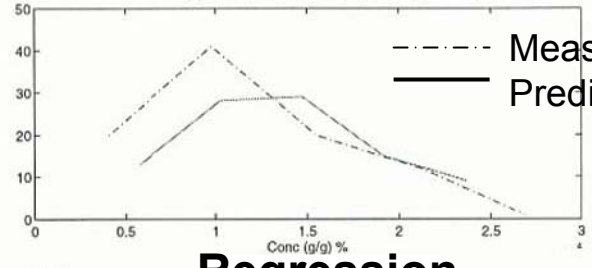


Regression

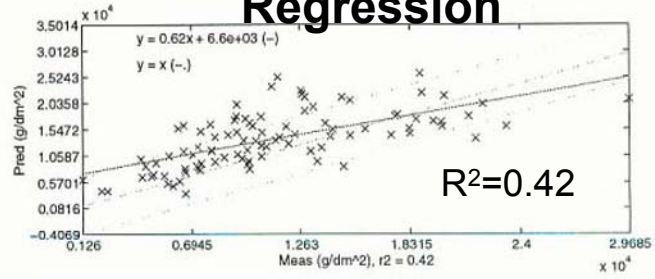


R^2=0.50

Needle Class 3, 4: Chl b

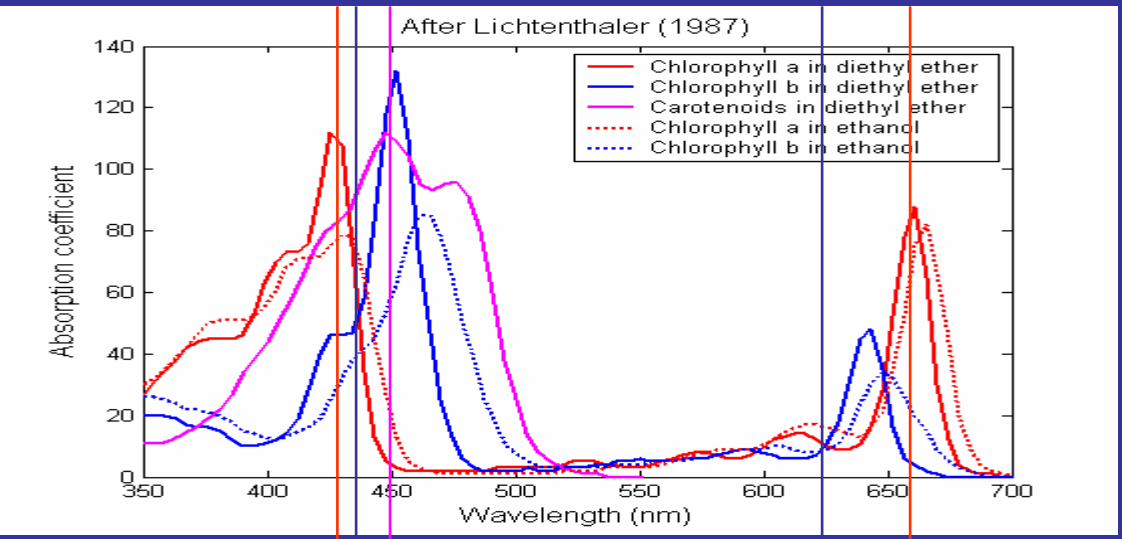


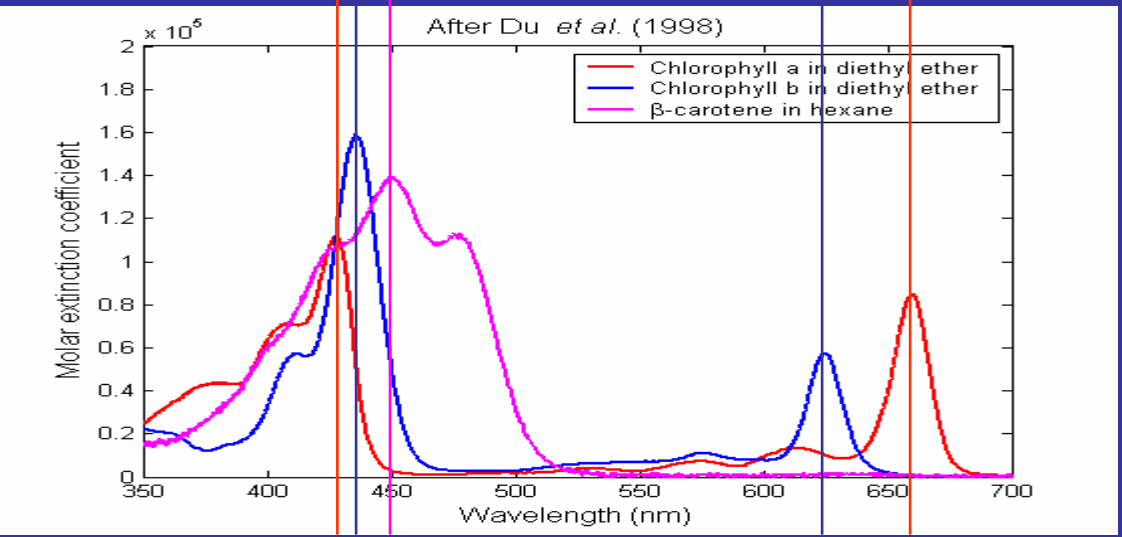
Regression

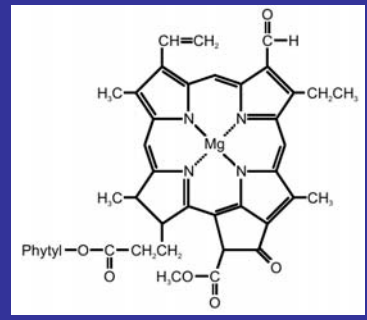


R^2=0.42

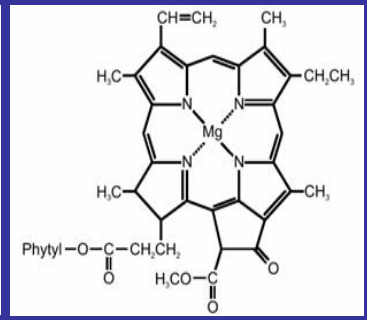
First strategy: Pigments



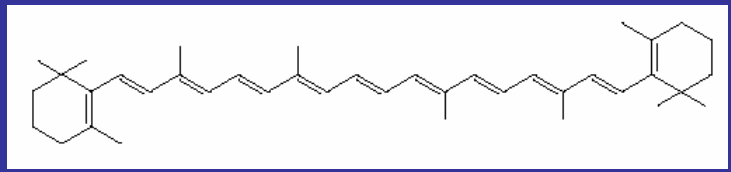




chlorophyll a



chlorophyll b



β-carotene

The end

S. Knap & N. Knight, 2001, *Flora*, Harry N Abrams, 80 pages.