

SPECTRAL REFLECTANCE PROPERTIES OF VEGETATION AND SOIL

TMT Bangladesh

Roshanak Darvishzadeh

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LEARNING OBJECTIVES:

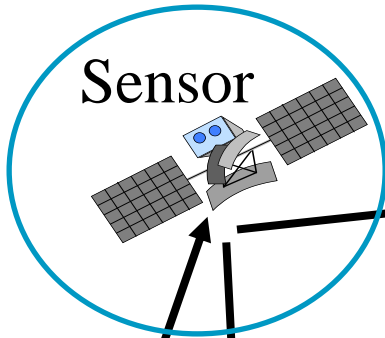
- To familiarize with the factors affecting:
- Leaf reflectance
- Canopy reflectance
- Soil reflectance

REMOTE SENSING OF VEGETATION

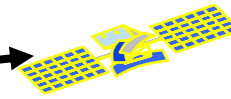
Energy Source



Sensor



SatCom



Vegetation target



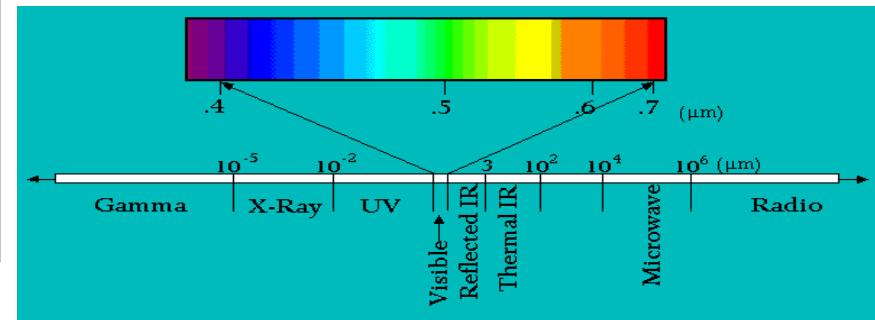
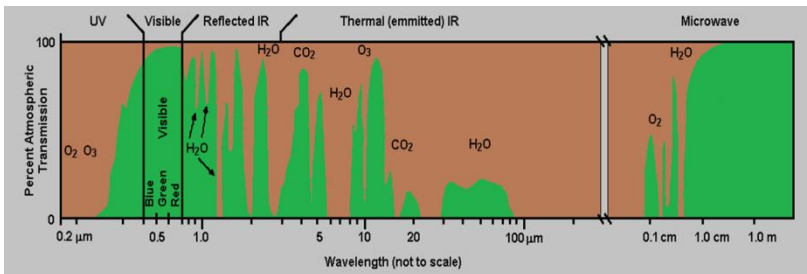
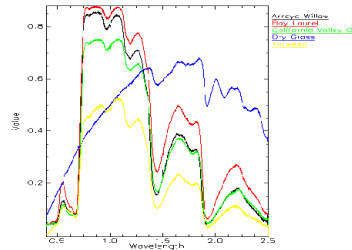
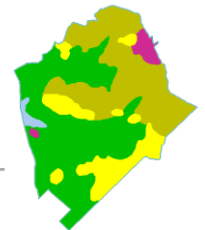
Processing
Station



Analysis



Application



RADIATION'S INTERACTION WITH LEAVES

E_I : Incident radiation

E_A : Absorbed radiation

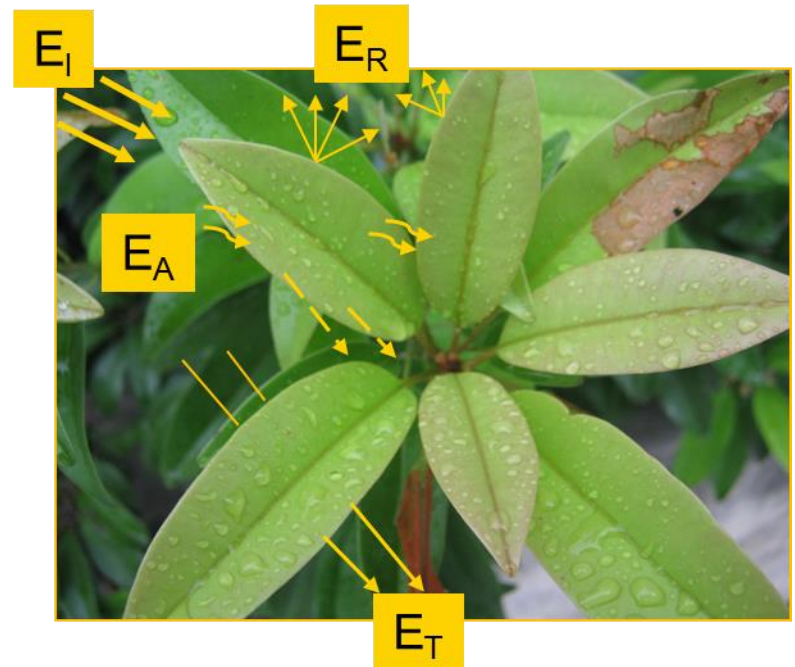
E_T : Transmitted radiation

E_R : Reflected radiation

$\alpha = E_A / E_I$ (Absorptance)

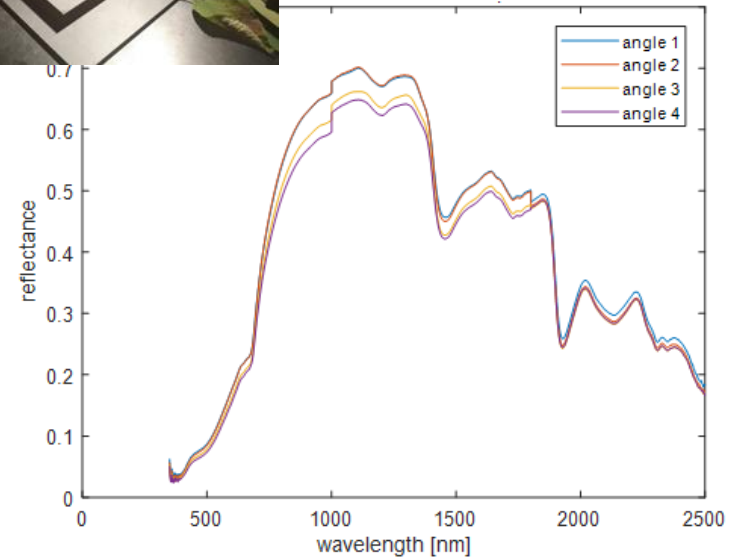
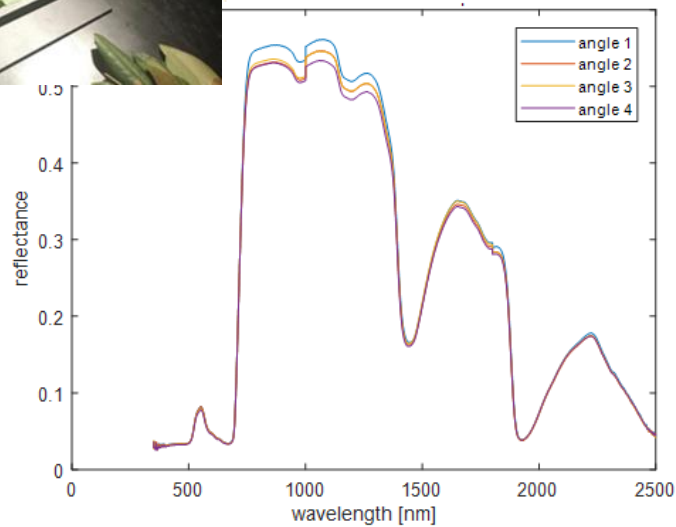
$\tau = E_T / E_I$ (Transmittance)

$\rho = E_R / E_I$ (Reflectance)

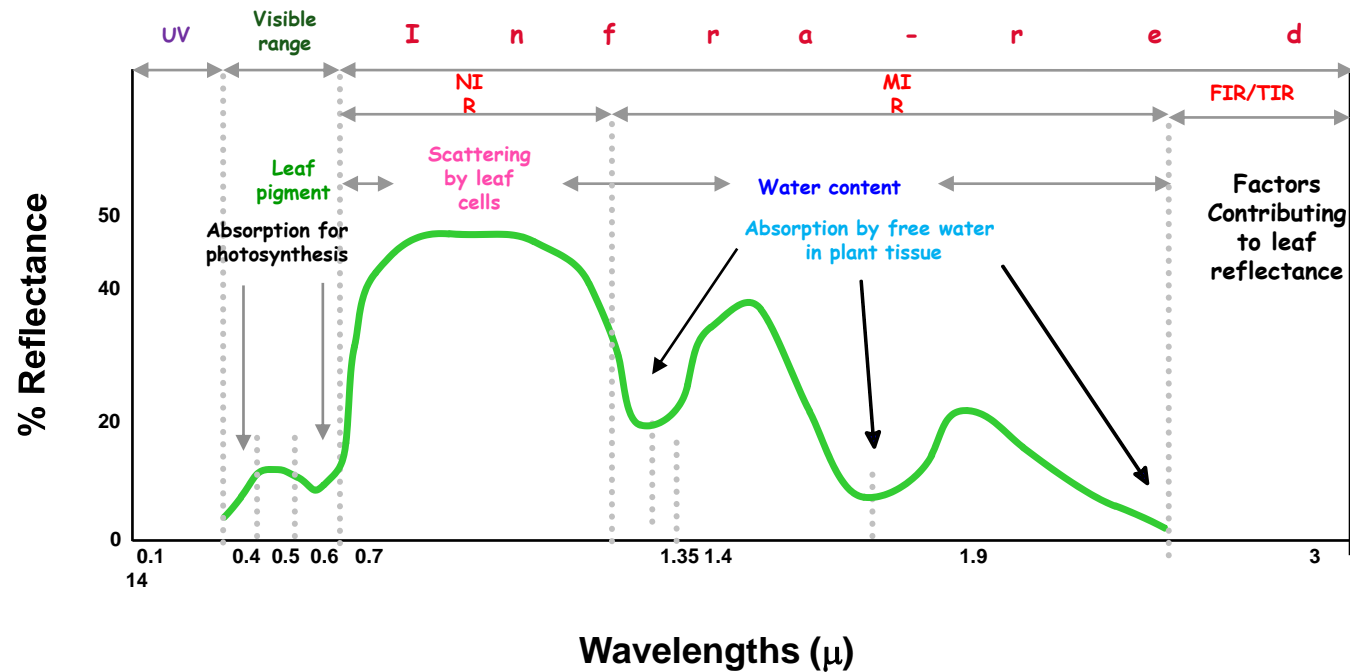


$$\rho + \alpha + \tau = 1$$

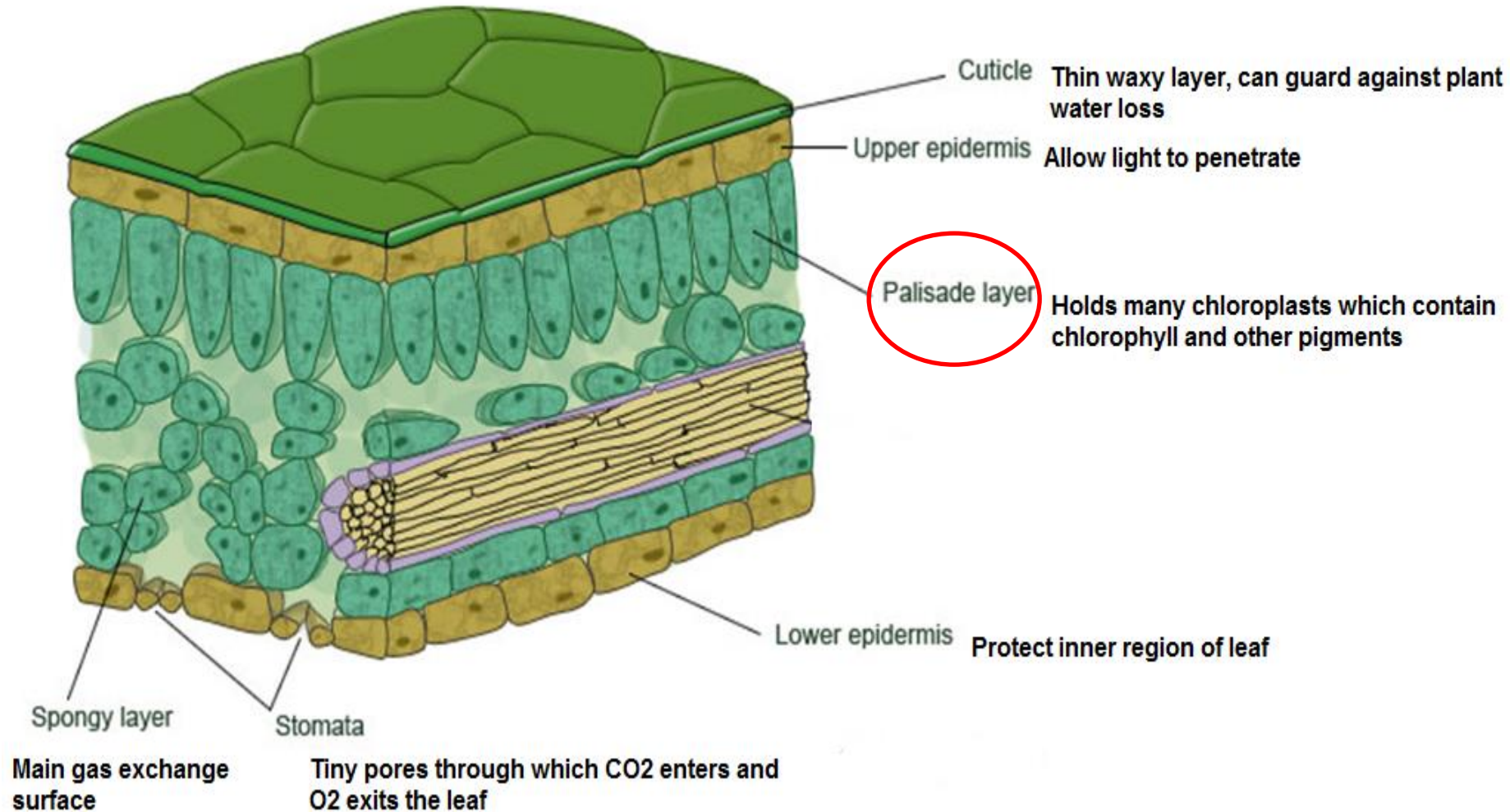
SPECTRAL REFLECTANCE OF LEAVES



Spectral reflectance of healthy, green Leaf



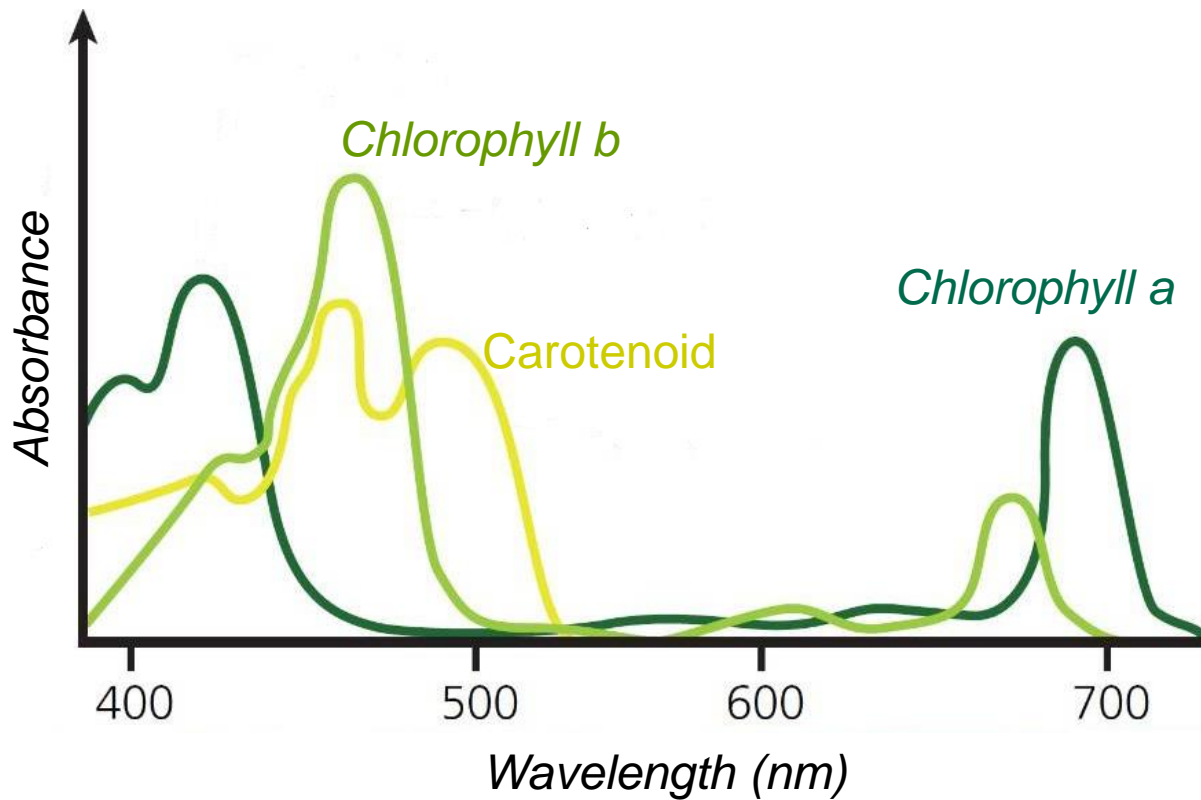
LEAF MAJOR STRUCTURAL COMPONENTS



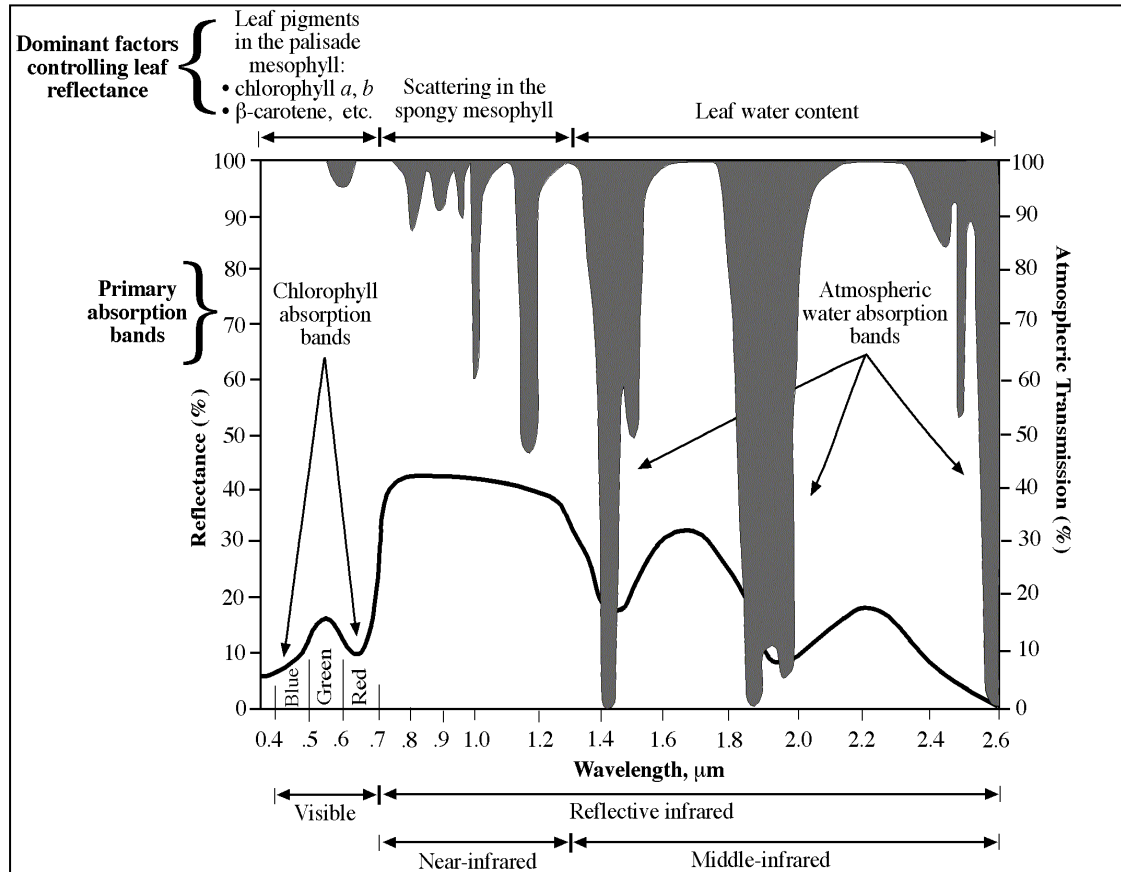
ROLE OF CHLOROPHYLL

- Chlorophyll is vital for photosynthesis, which allows plants to absorb energy from light.
- Chlorophyll is a fundamental biochemical parameter and is related to many other leaf biochemical content such as nitrogen.
- Useful for many environmental and ecological investigations, and is linked for instance to:
 - Productivity
 - Vegetation stress
 - Vegetation health and growth
 - Recognized as essential variable for Biodiversity and Crop monitoring

PIGMENT ABSORPTION



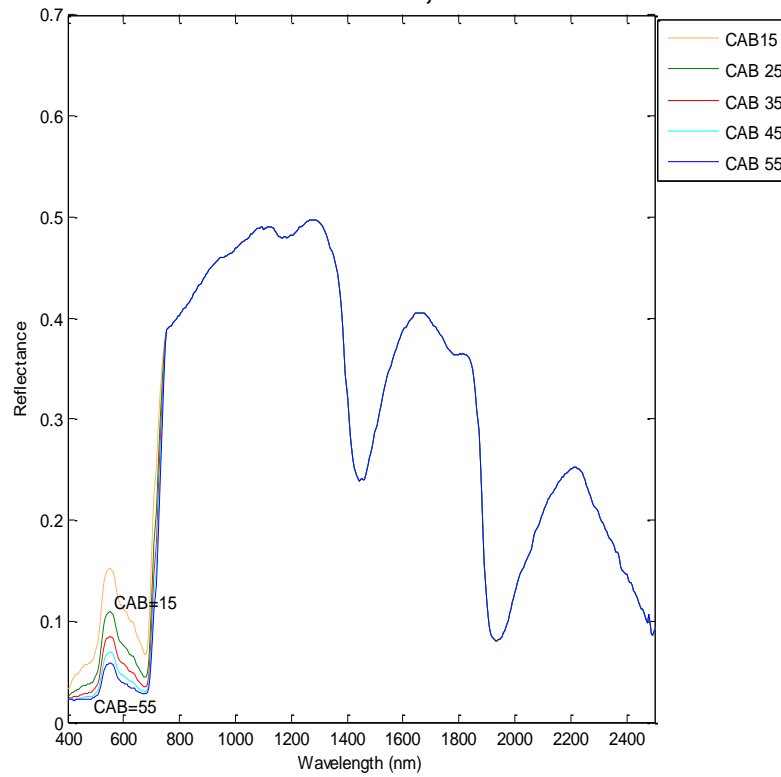
DOMINANT FACTORS CONTROLLING LEAF REFLECTANCE



LEAF PARAMETERS AND REFLECTANCE

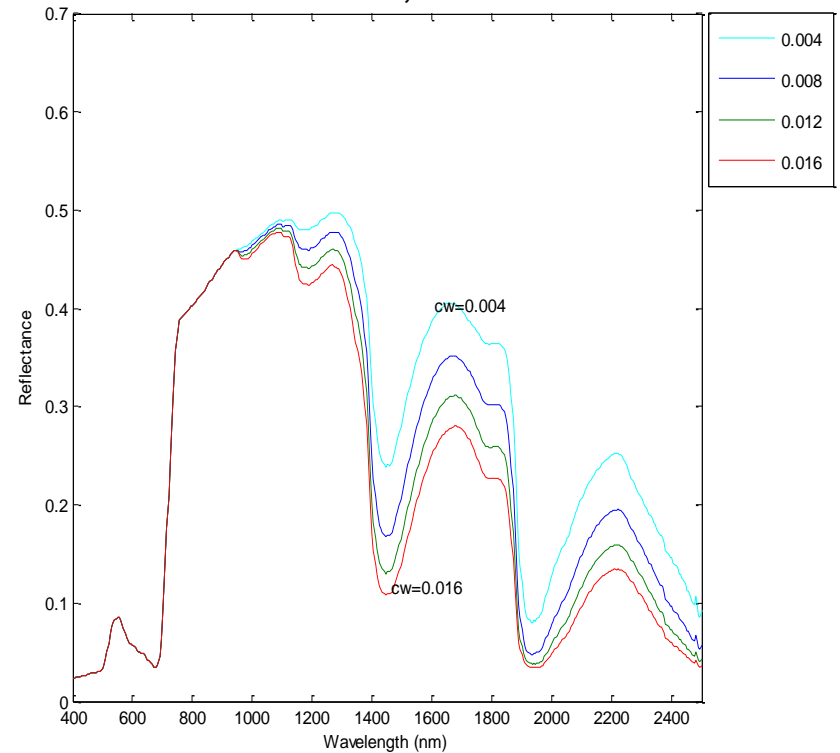
Chlorophyll *ab*

Variation of CAB, 15-55

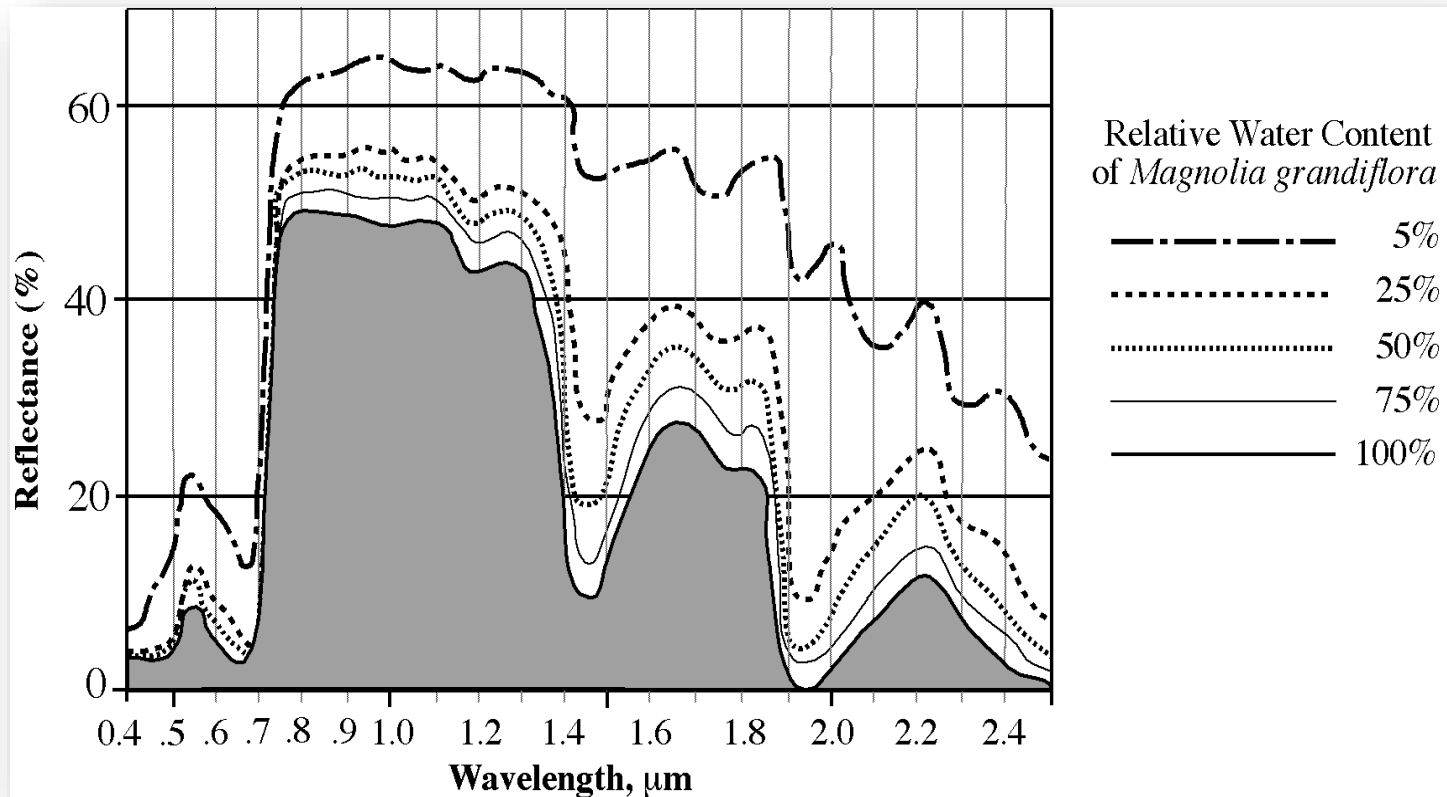


leaf water content

Variation of cw, 0.004-0.016

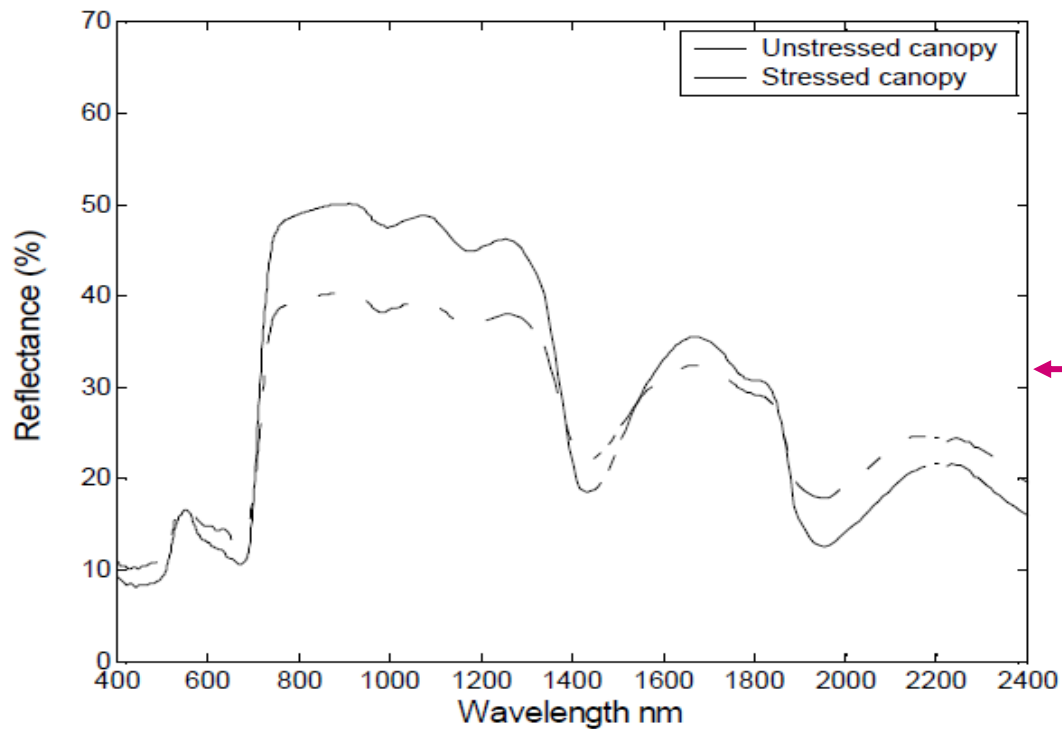


VEGETATION WATER STRESS



Reflectance response of a single magnolia leaf (*magnolia grandiflora*) to decreased relative water content

VEGETATION WATER STRESS OF ASPLENIUM NIDUS



Asplenium nidus

Spectral reflectance of Asplenium nidus (LAI of 1.5)

QUESTION

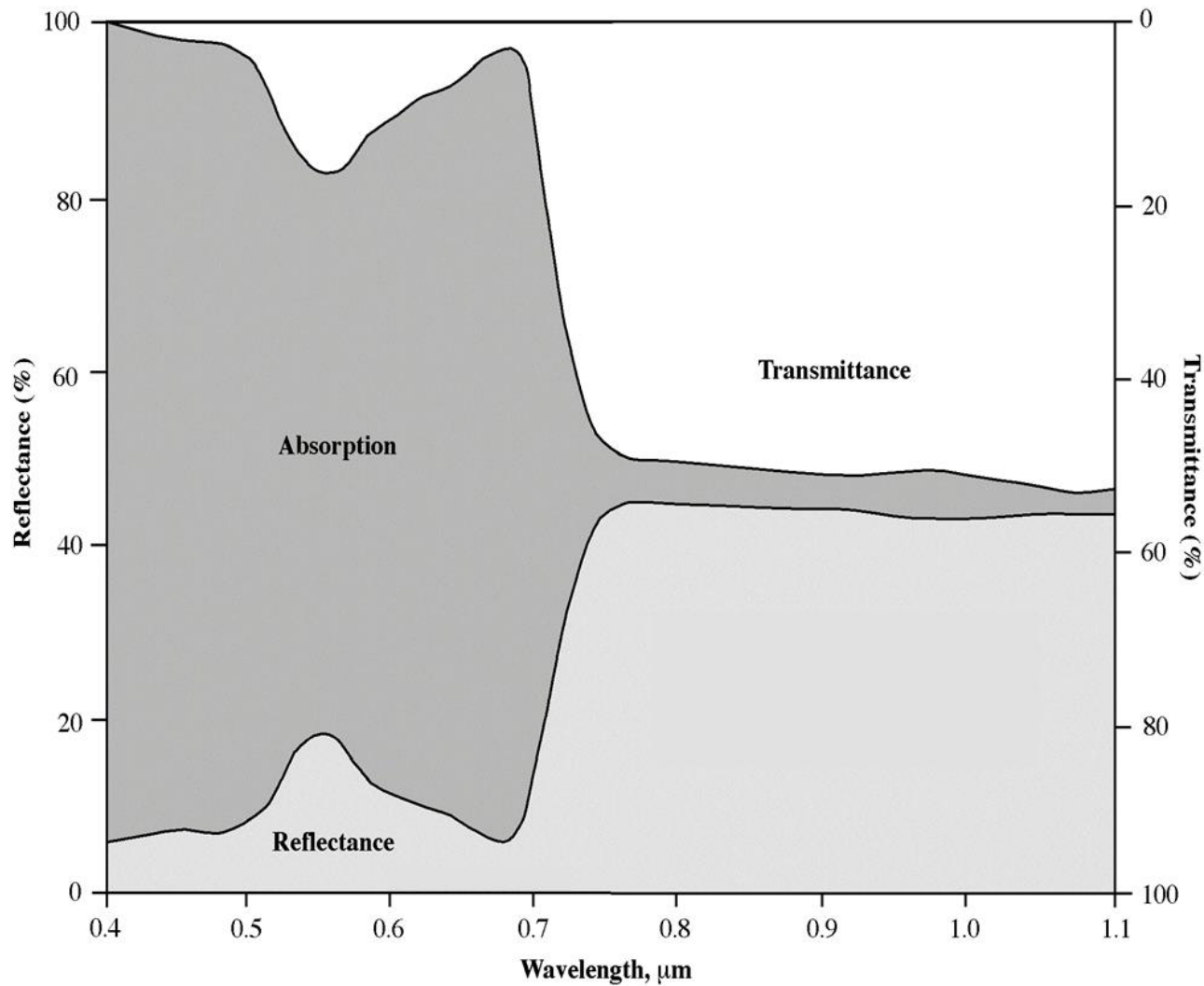
- Would it be possible to obtain the leaf reflectance from satellite data? what do we receive then?

CANOPIES: MULTIPLE LEAVES



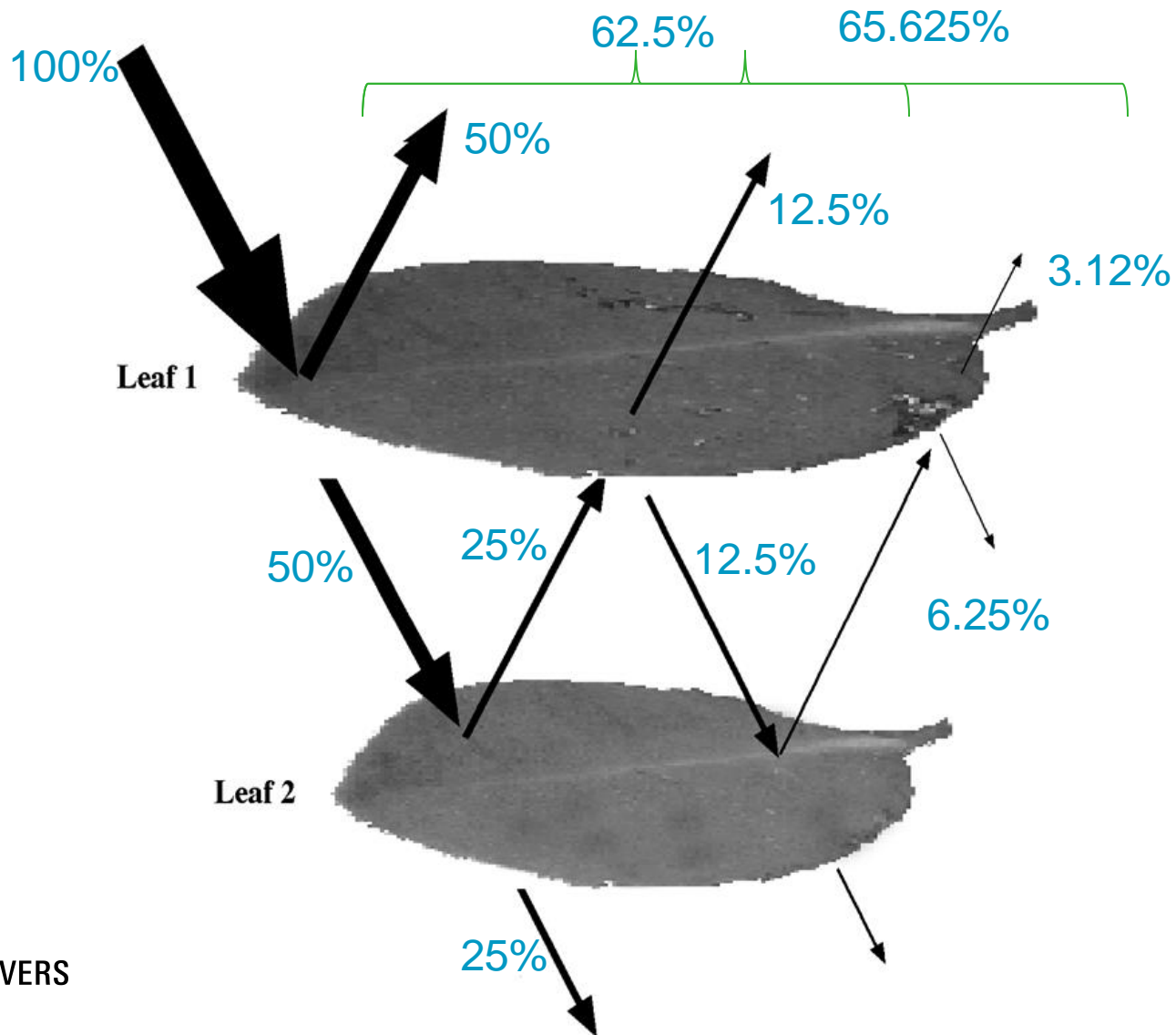
REFLECTANCE AND TRANSMITTANCE

$$\rho + \alpha + \tau = 1$$

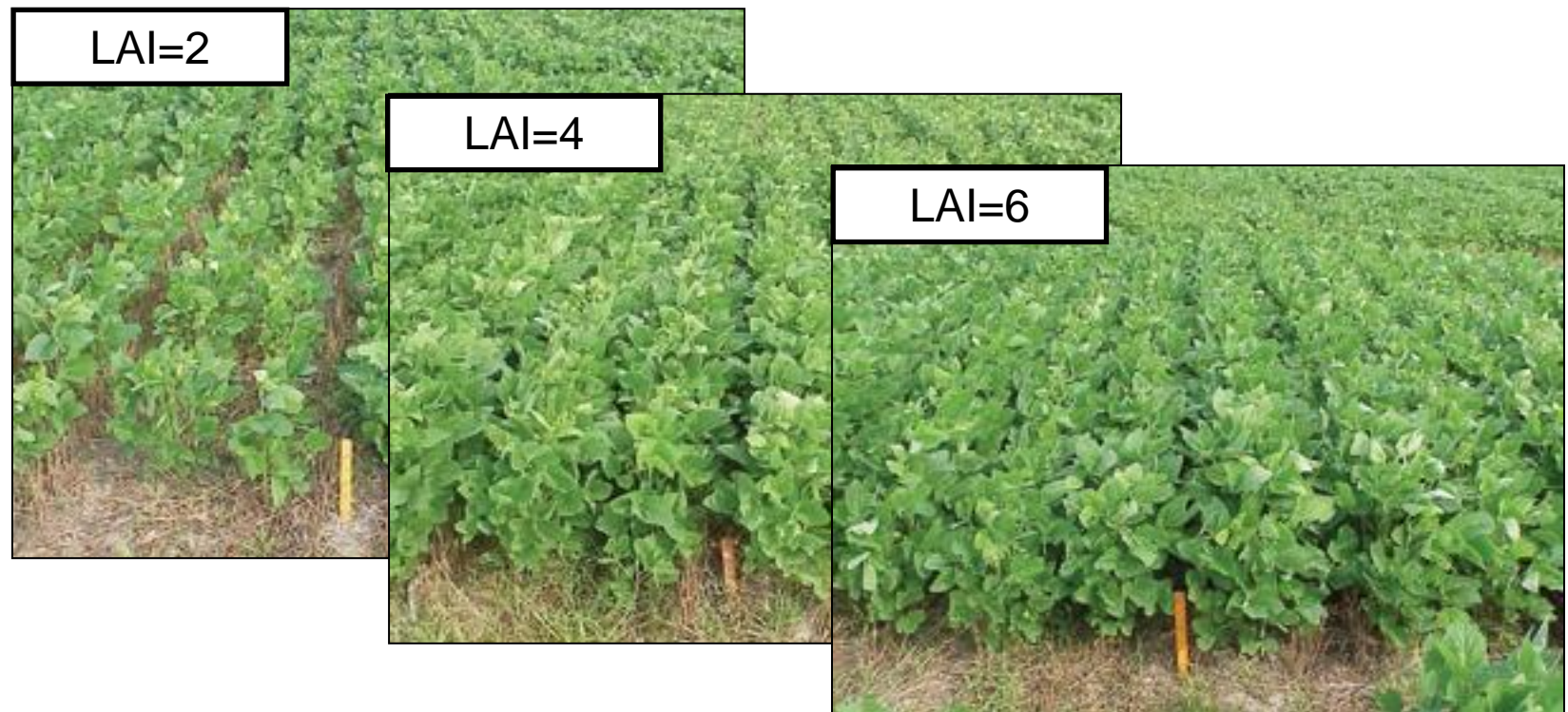


LEAF ADDITIVE REFLECTANCE

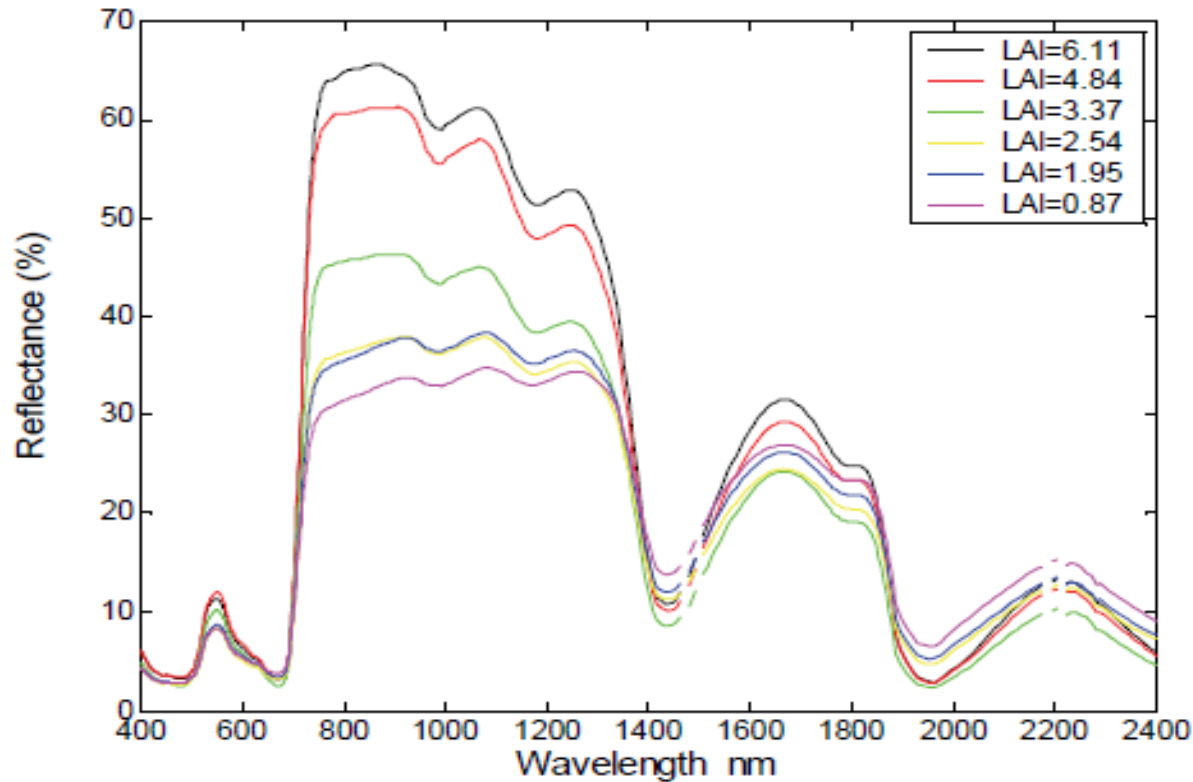
$$\rho = \tau = 50\%$$



LEAF AREA INDEX

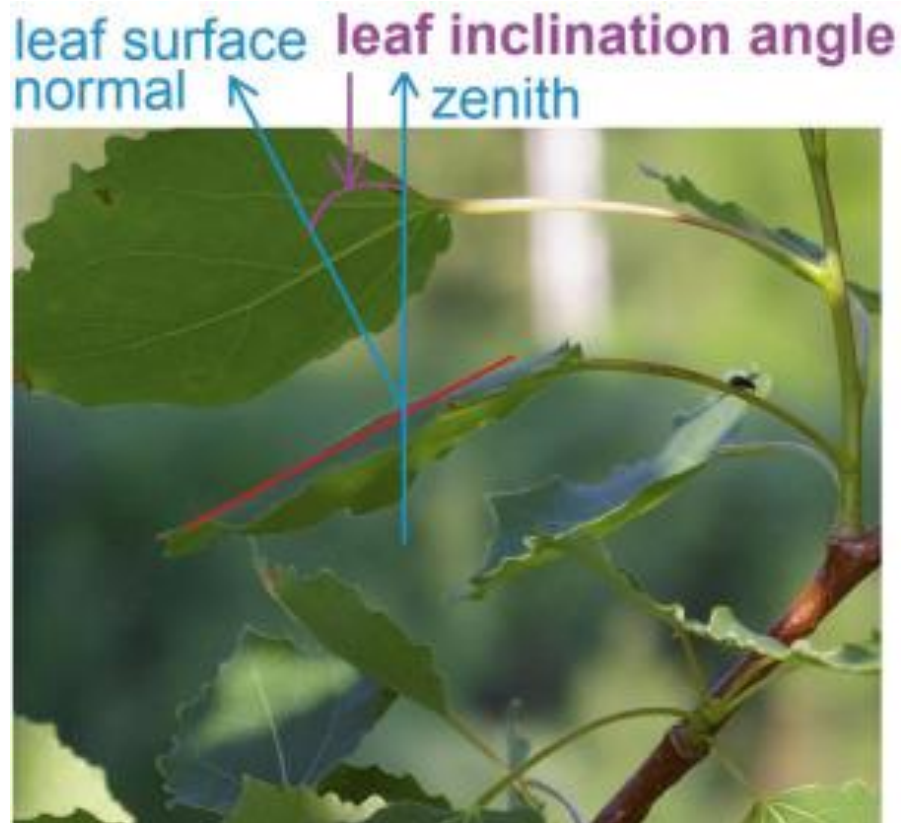


SPECTRAL RESPONSE TO LAI VARIATION



Spectral reflectance of *Asplenium nidus* corresponding to LAI between 0.87 and 6.11

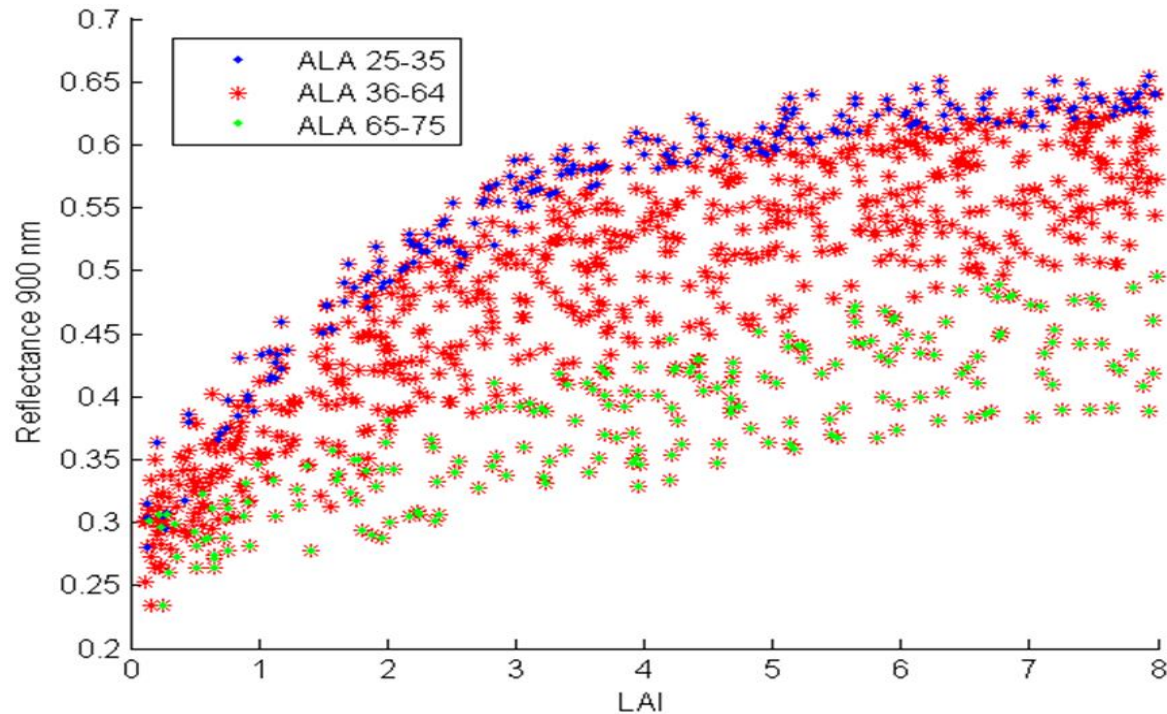
LEAF INCLINATION



Rabee et. al (2015),
Agricultural and forest
meteorology



LEAF ANGLE / LAI EFFECTS: MODELLED WITH PROSAIL

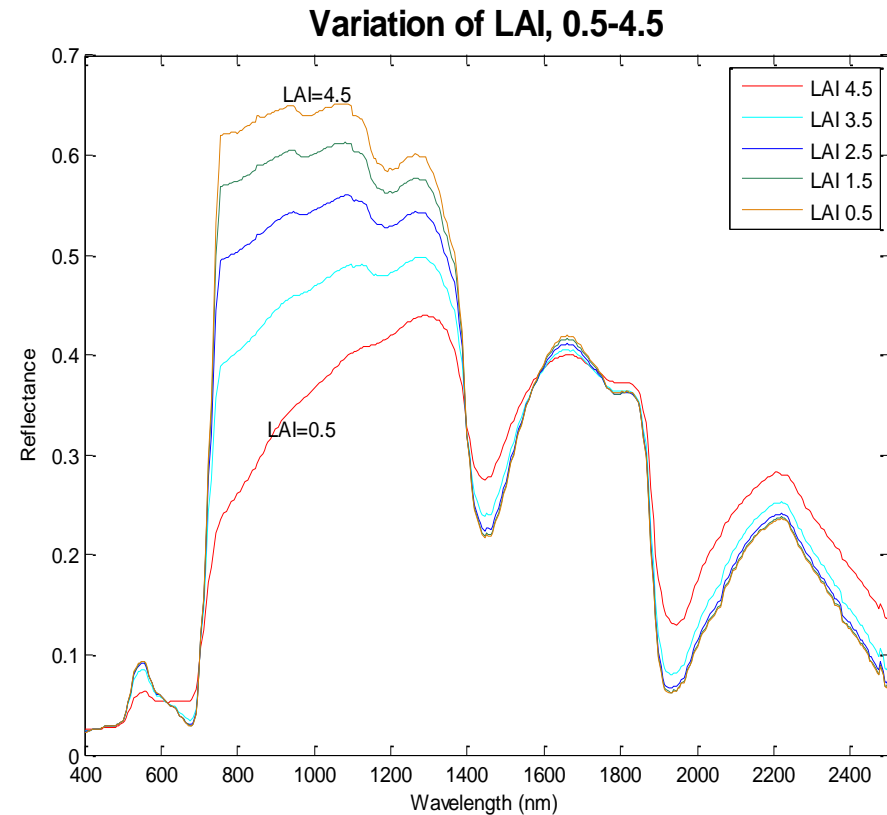
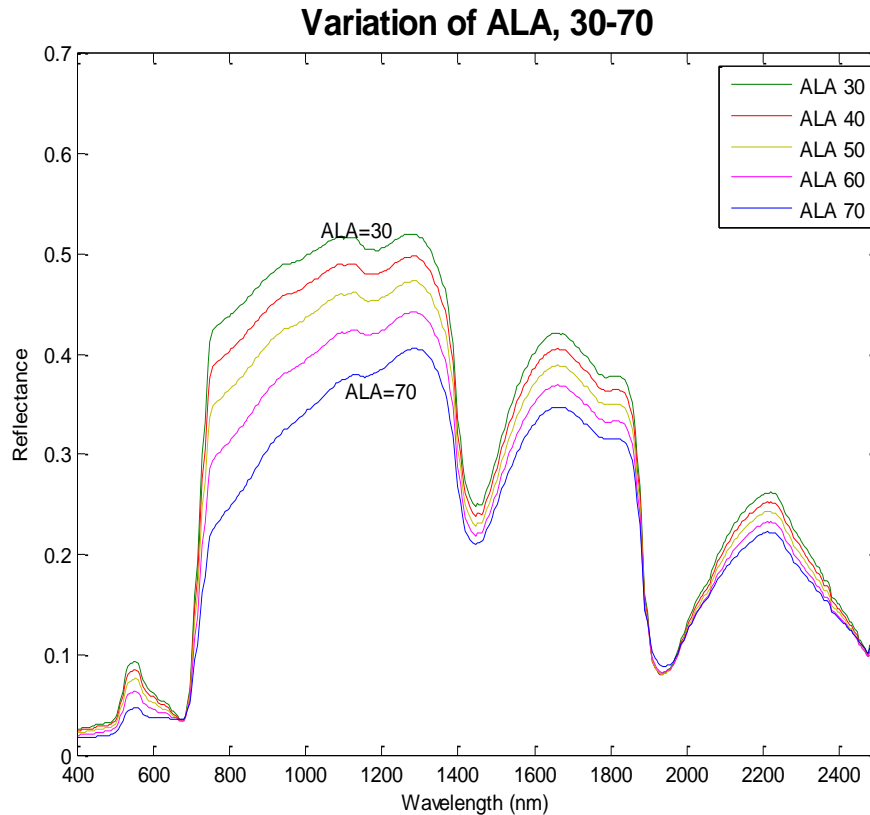


Further reading:

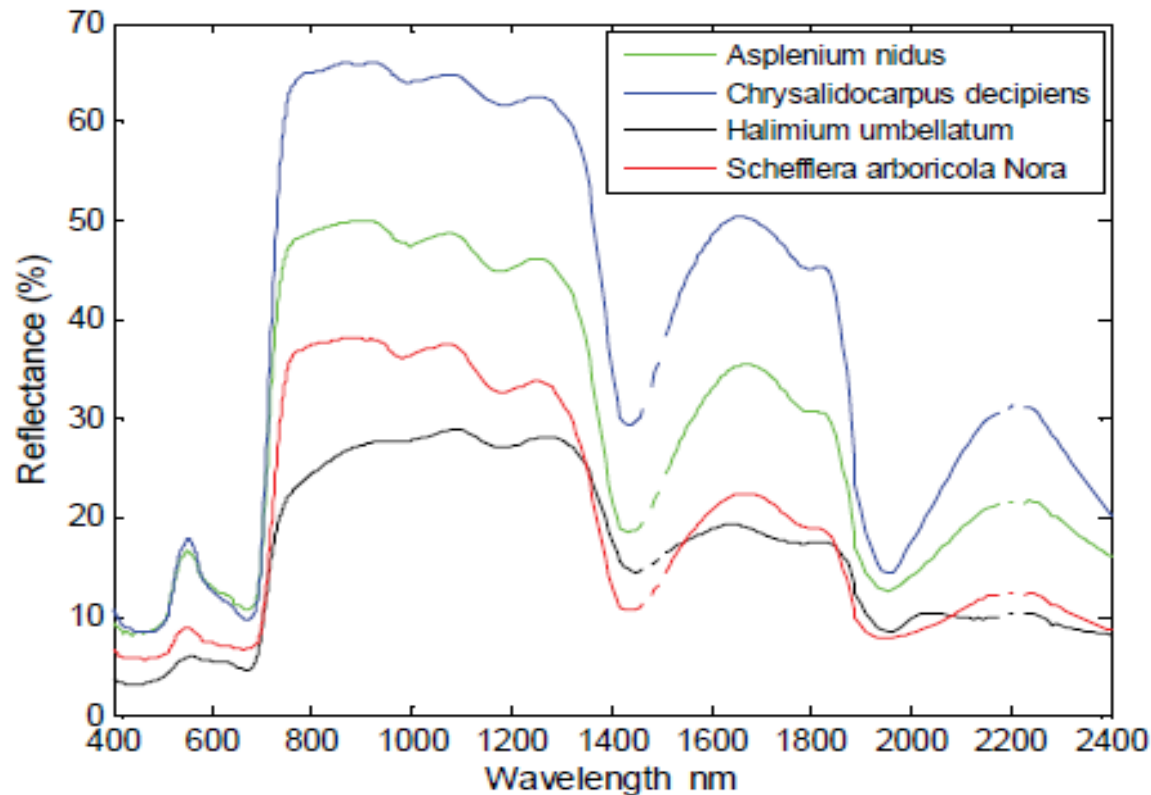
Jacquemoud S, W Verhoef, F Baret, C Bacour, PJ Zarco-Tejada, GP Asner, C Francois, SL Ustin, 2009. PROSPECT plus SAIL models: A review of use for vegetation characterization. Remote Sensing of Environment 113, S56-S66.



CANOPY STRUCTURE AND REFLECTANCE



SPECTRAL RESPONSE OF CANOPIES WITH DIFFERENT STRUCTURE



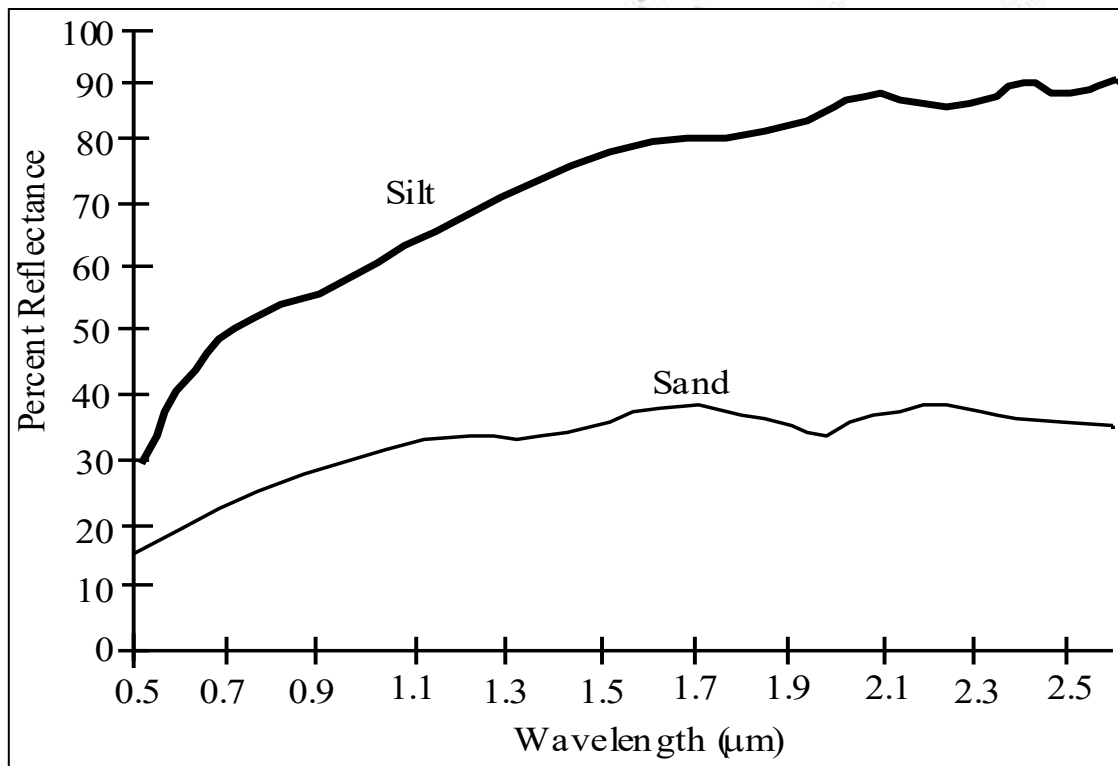
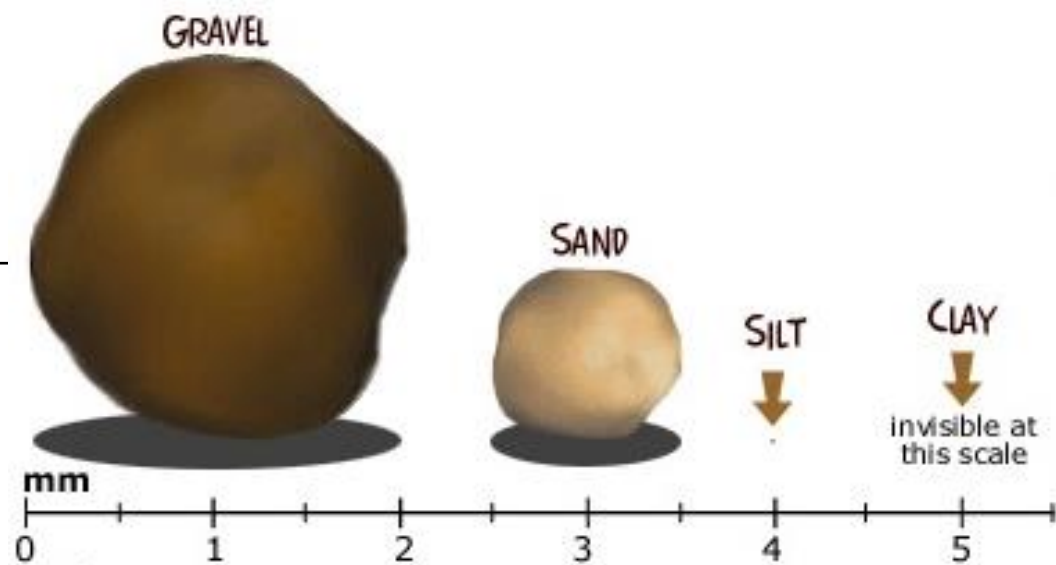
Spectral reflectance of different canopy species with same LAI values.

SOIL REFLECTANCE

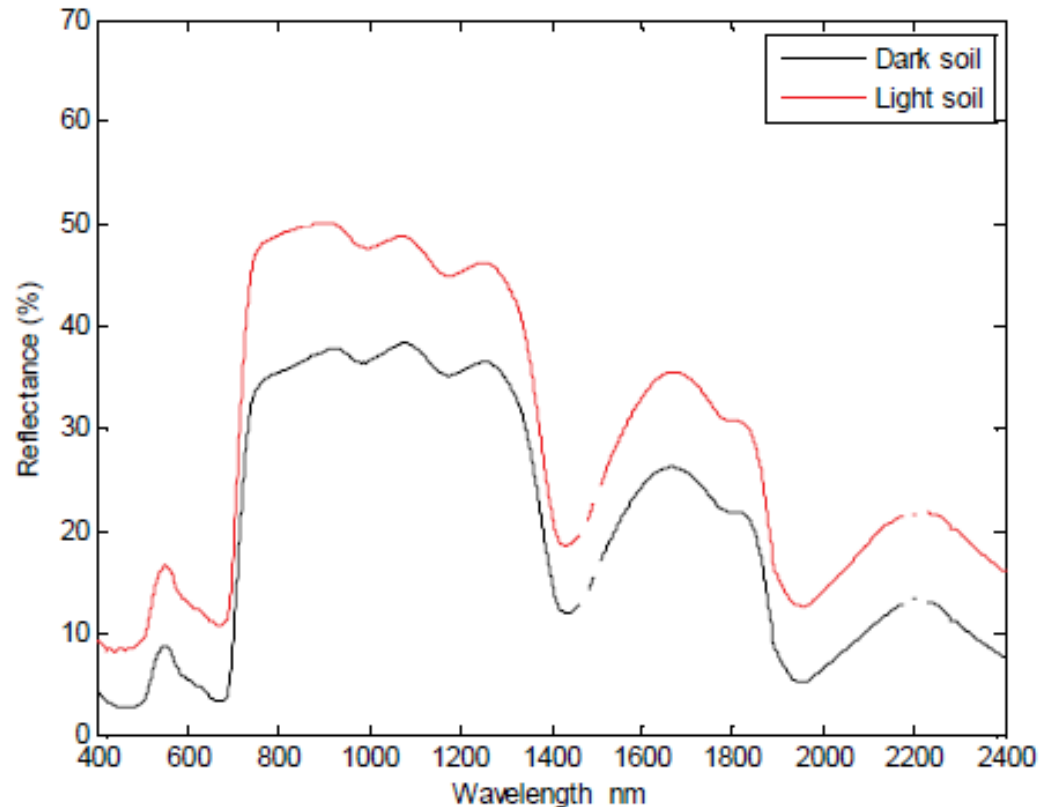
Spectral reflectance (brightness) of soils is a function of:

- Soil texture (percentage of sand, silt, clay)
- soil moisture content (e.g. dry, moist, saturated),
- organic matter content
- iron-oxide content
- surface roughness

SOIL TEXTURE



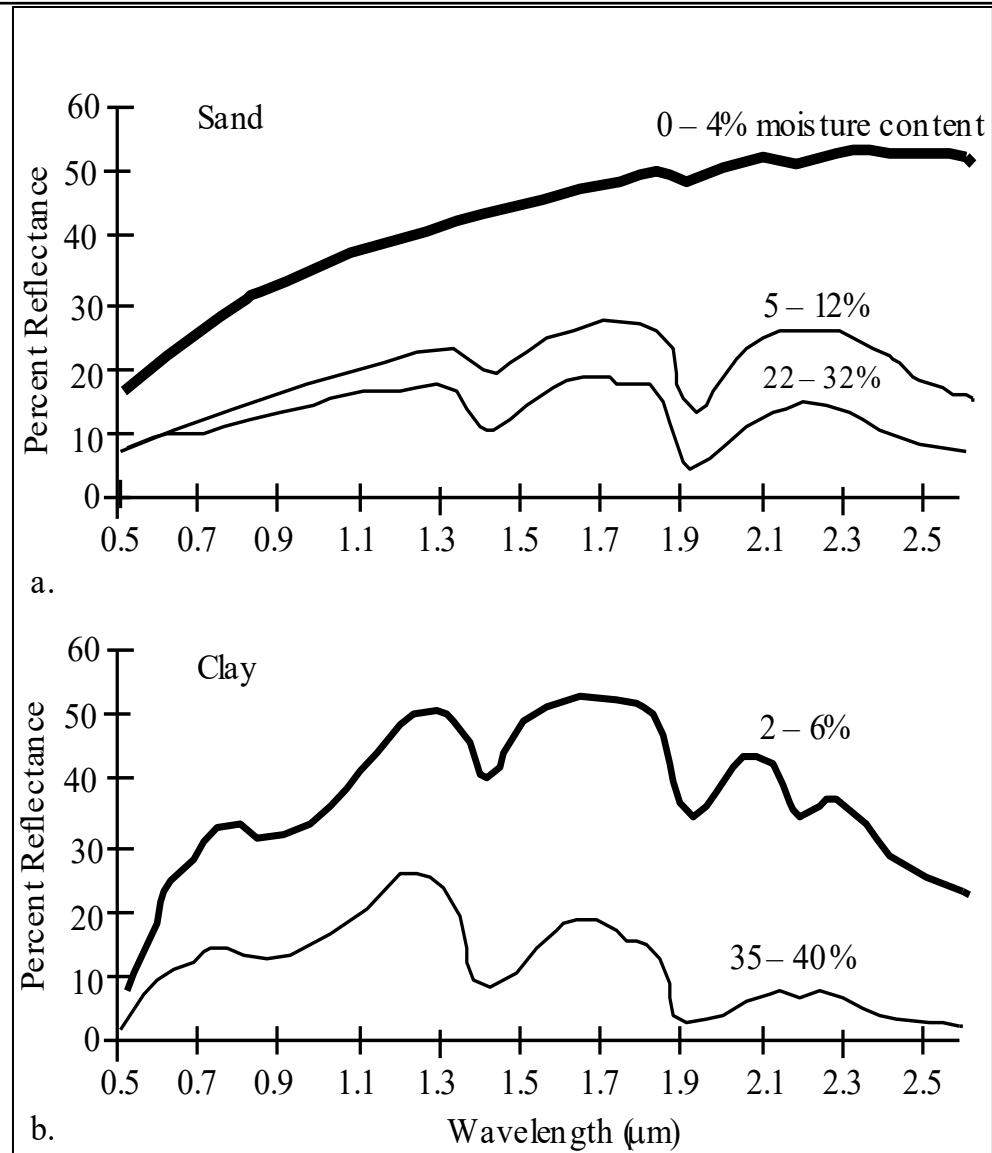
SOIL BRIGHTNESS AND CANOPY REFLECTANCE



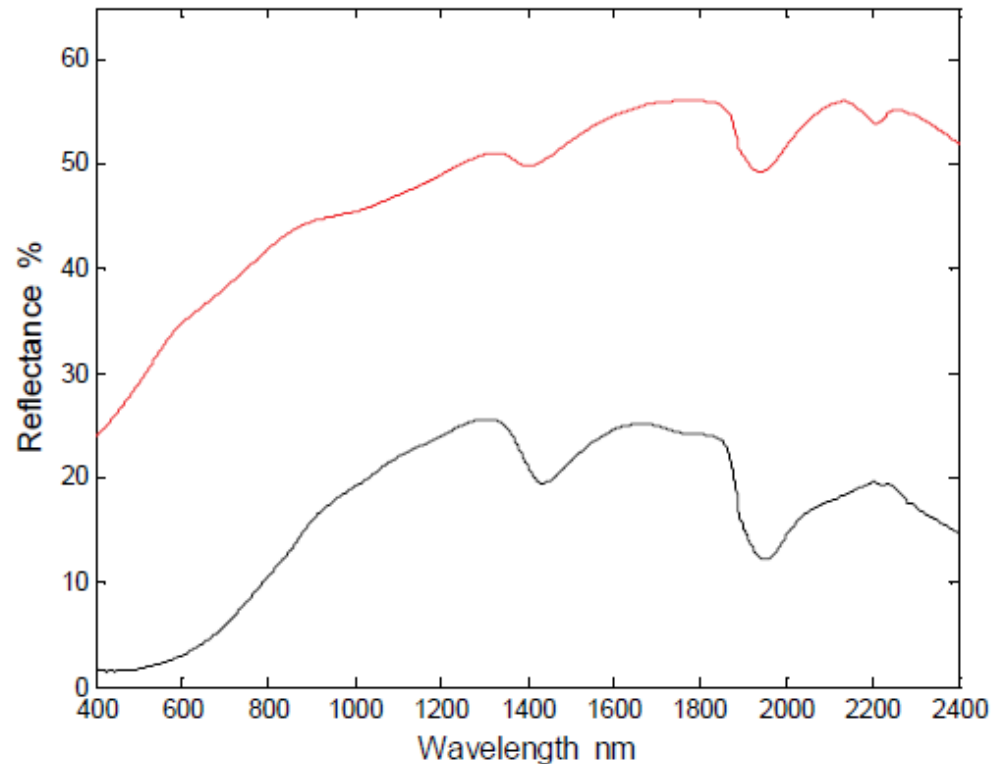
Spectral reflectance of *Asplenium nidus* with similar LAI value in dark and light soils.

SOIL MOISTURE

- Higher moisture content results in decreased reflectance
- Especially in the water-absorption bands at 1.4, 1.9, and 2.7 μm .

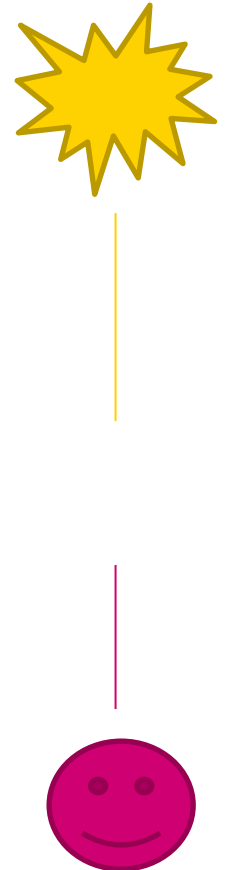
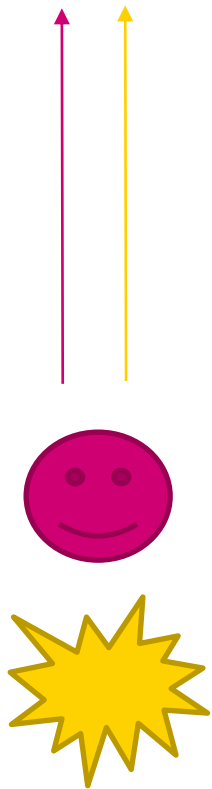


SOIL ORGANIC EFFECT/ SOIL COLOUR

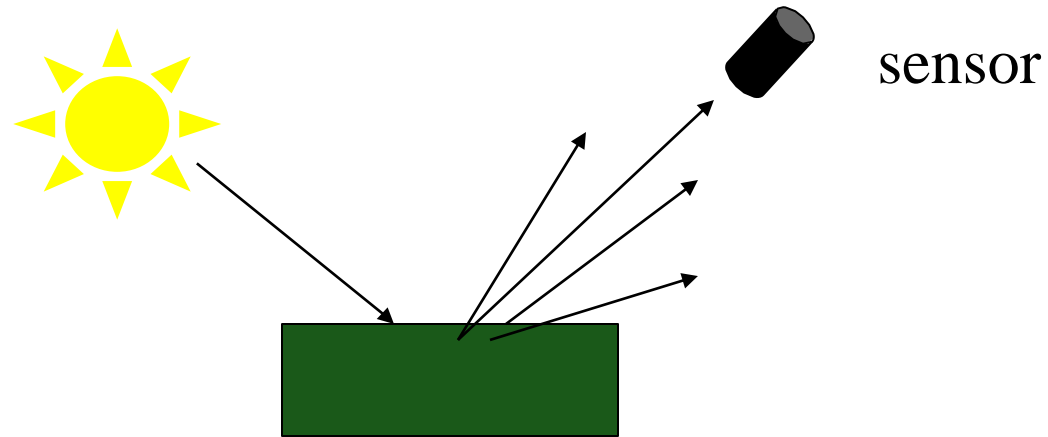


Spectral reflectance characteristics of the organic poor (red) and rich (black) soils. Each curve represents the average of 64 bare soil reflectance measurements.

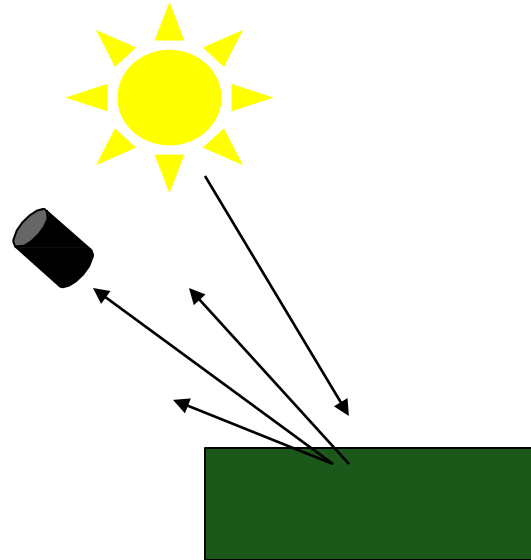
SUN AND SENSOR GEOMETRY



BIDIRECTIONAL REFLECTANCE DISTRIBUTION FUNCTION (BRDF)



Forward scatter direction



Back scatter direction

EXTERNAL FACTORS: BI-DIRECTIONAL REFLECTANCE

Backscatter direction



Forward scatter direction





SUMMARY

- The reflectance that optical sensors measure depends on the properties of the leaves, canopy architecture, soil properties, observation geometry and external factors:
 - Leaf properties: chlorophyll, water and other pigments
 - Canopy reflectance: leaf area index, leaf angle distribution, soil background, measuring geometry
 - Soil properties: grain size, moisture content, organic matter content, iron oxides
 - Observation geometry: view and sun angles,
 - Atmosphere....