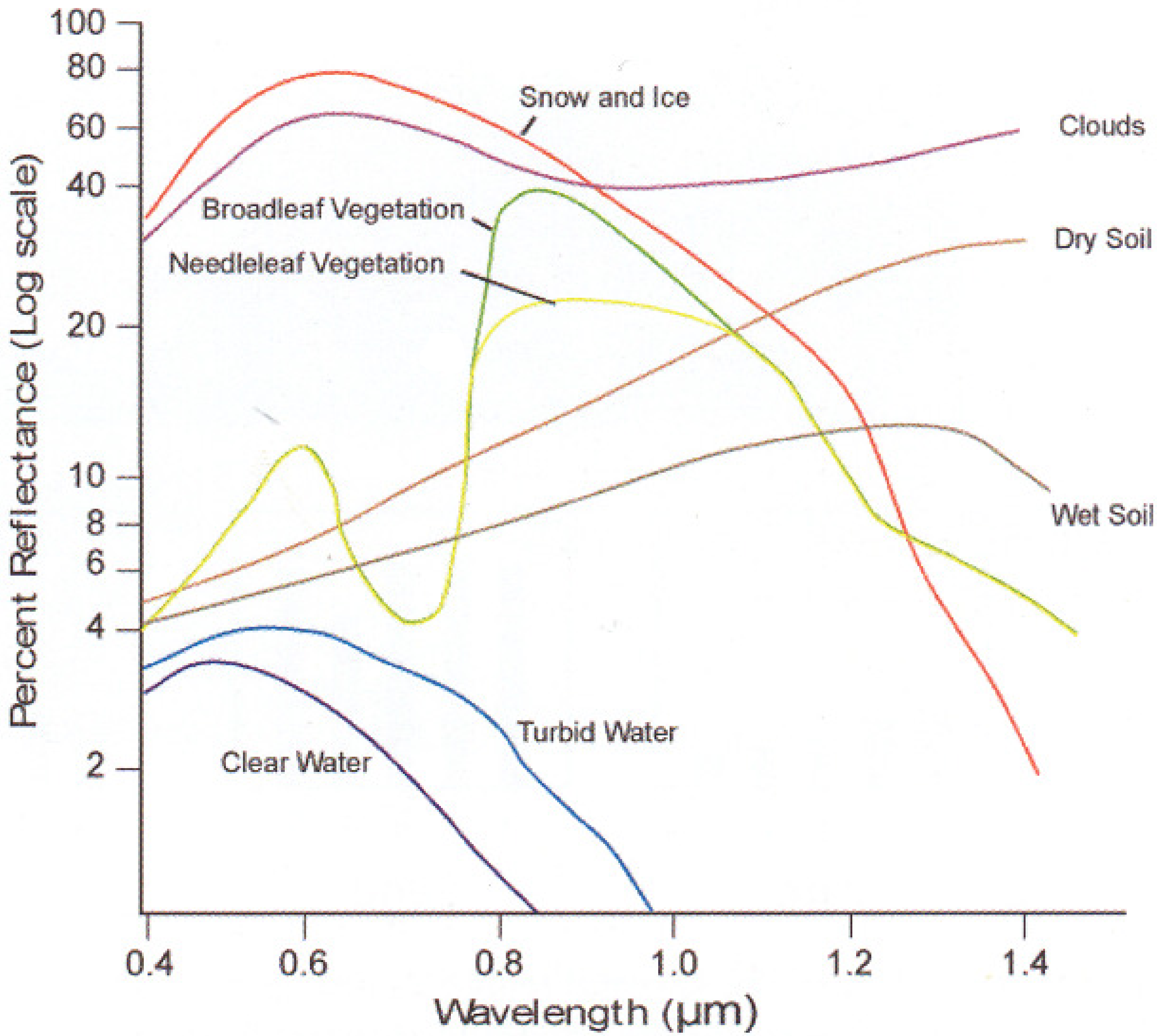
Remote sensing of vegetation

Remote sensing of vegetation

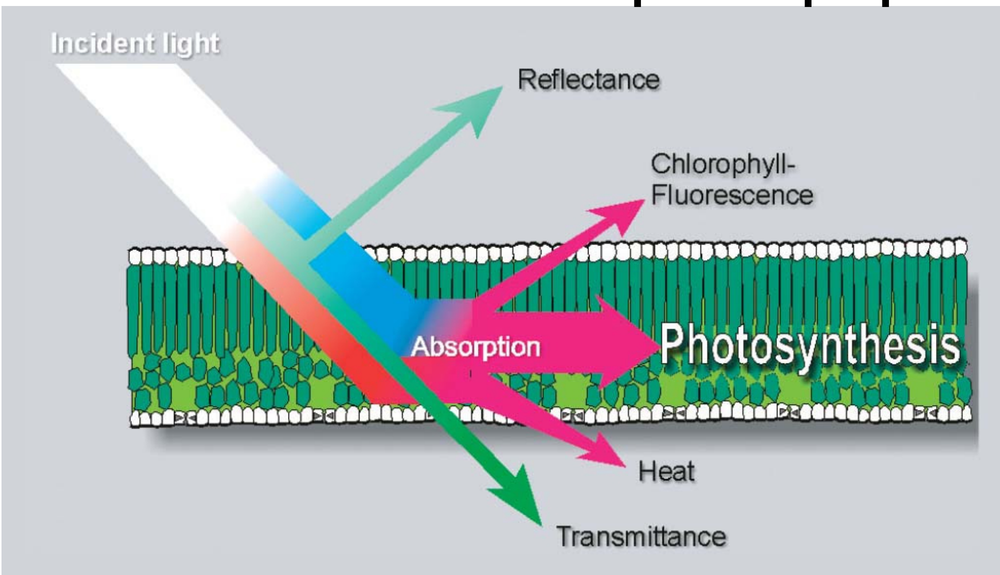
Spectral properties of plants

Spectral curves = spectral characteristics



Remote sensing of vegetation

Spectral properties of plants

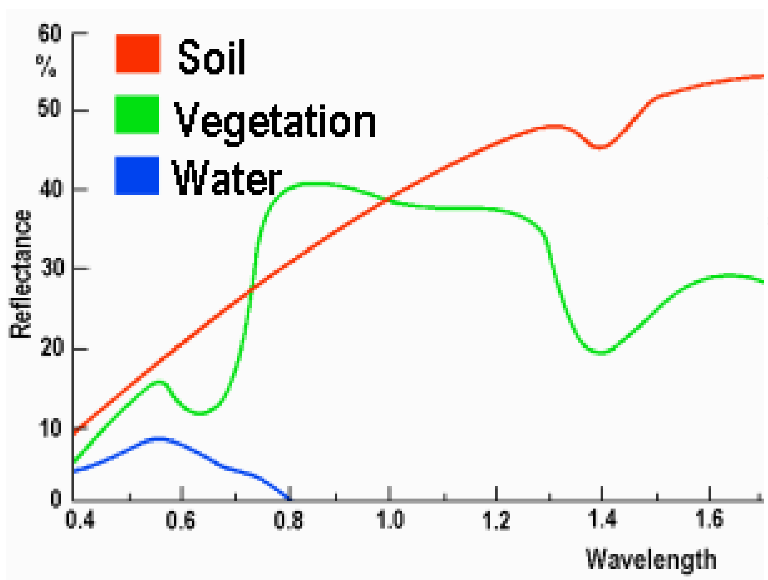


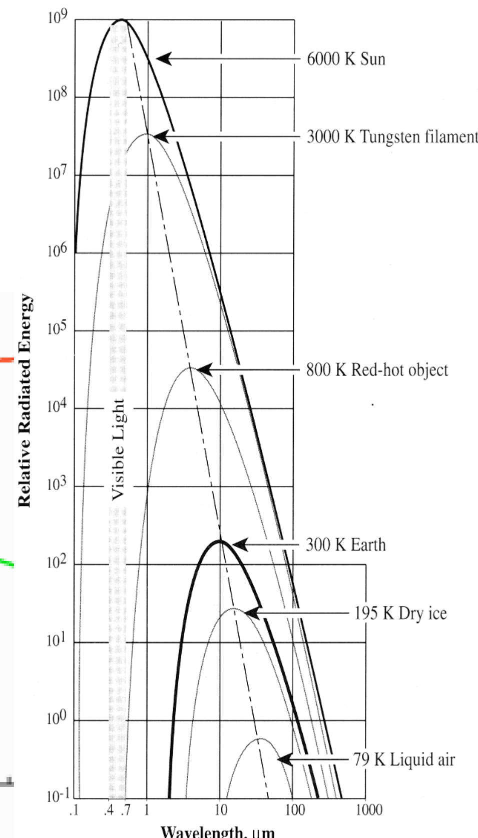
Radiation budget equation:

$$\Phi_{i_\lambda} = r_\lambda + \tau_\lambda + \alpha_\lambda$$

Green vegetation has a distinctive reflectance curve:

-Absorption in blue
-Reflection in green
-Absorption in red
-Strong reflection in NIR
-Absorption in SWIR

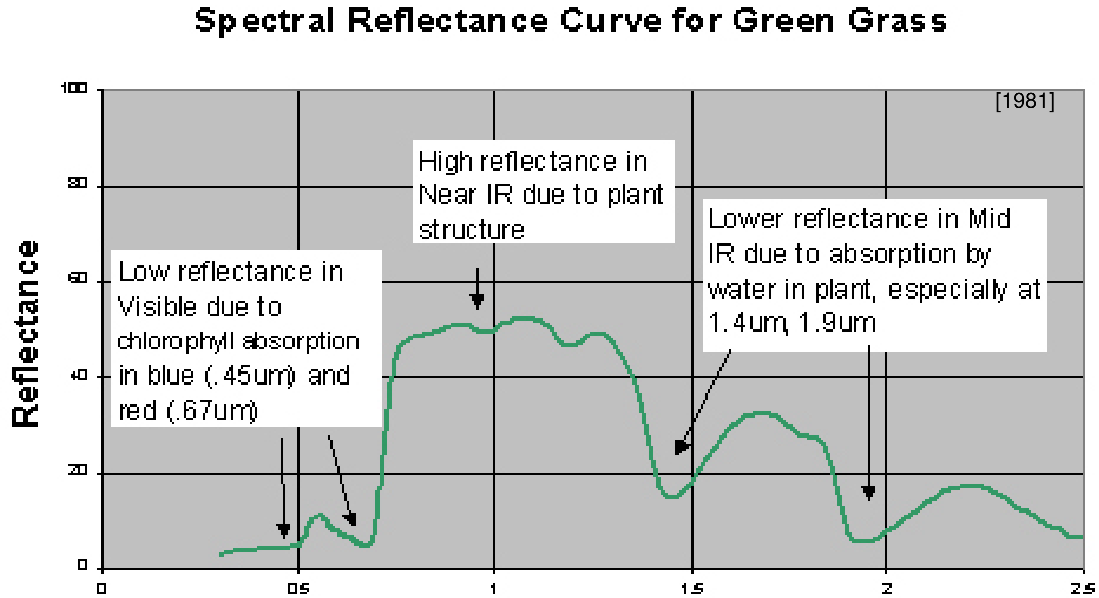




Jensen 2000

Remote sensing of vegetation

Spectral properties of plants - reflectance



Planophile - horizontal leaves
Erectophile - vertical leaves

This reflectance curve is due to:

Visible

-Plant pigments (particularly chlorophyll)

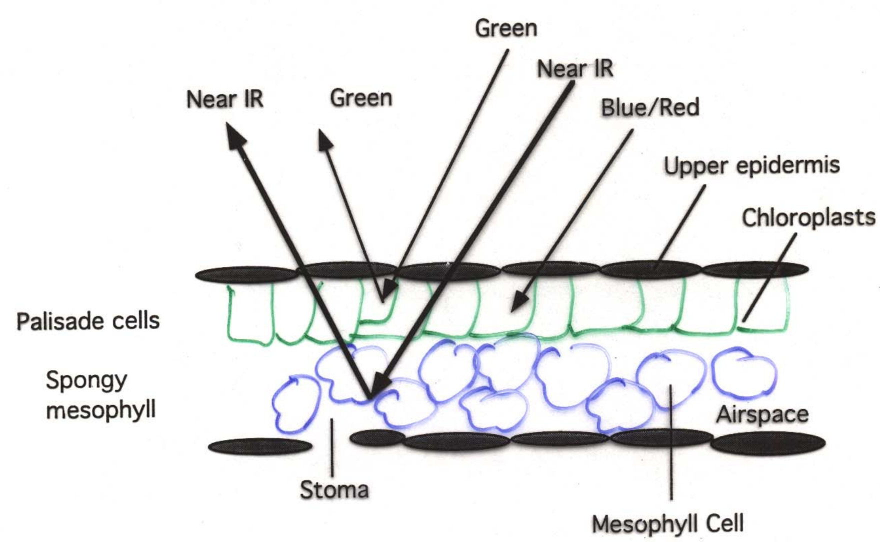
NIR

-Result of the structure of the spongy mesophyll

-Cell moisture

SWIR

-Cell moisture

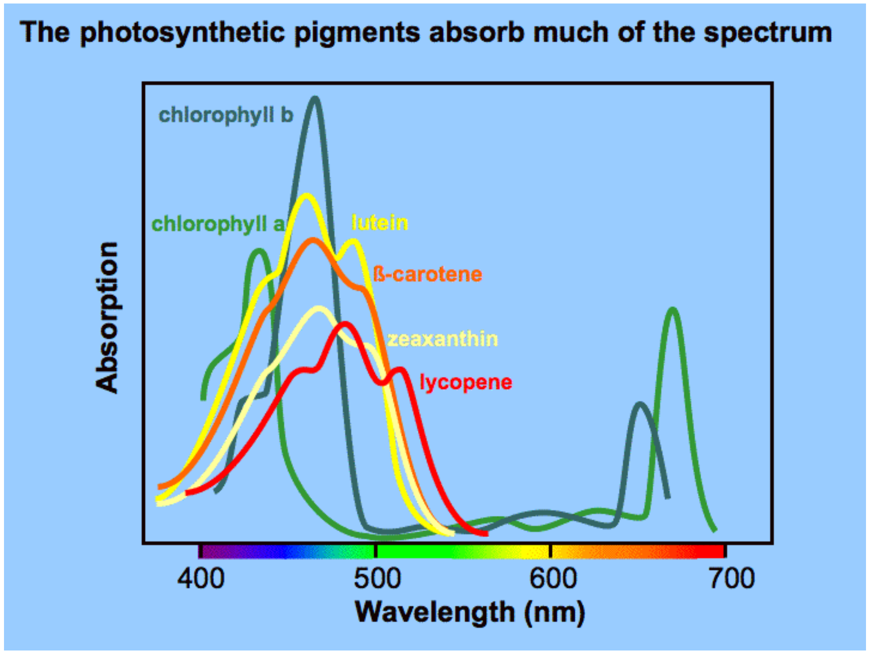


Remote sensing of vegetation

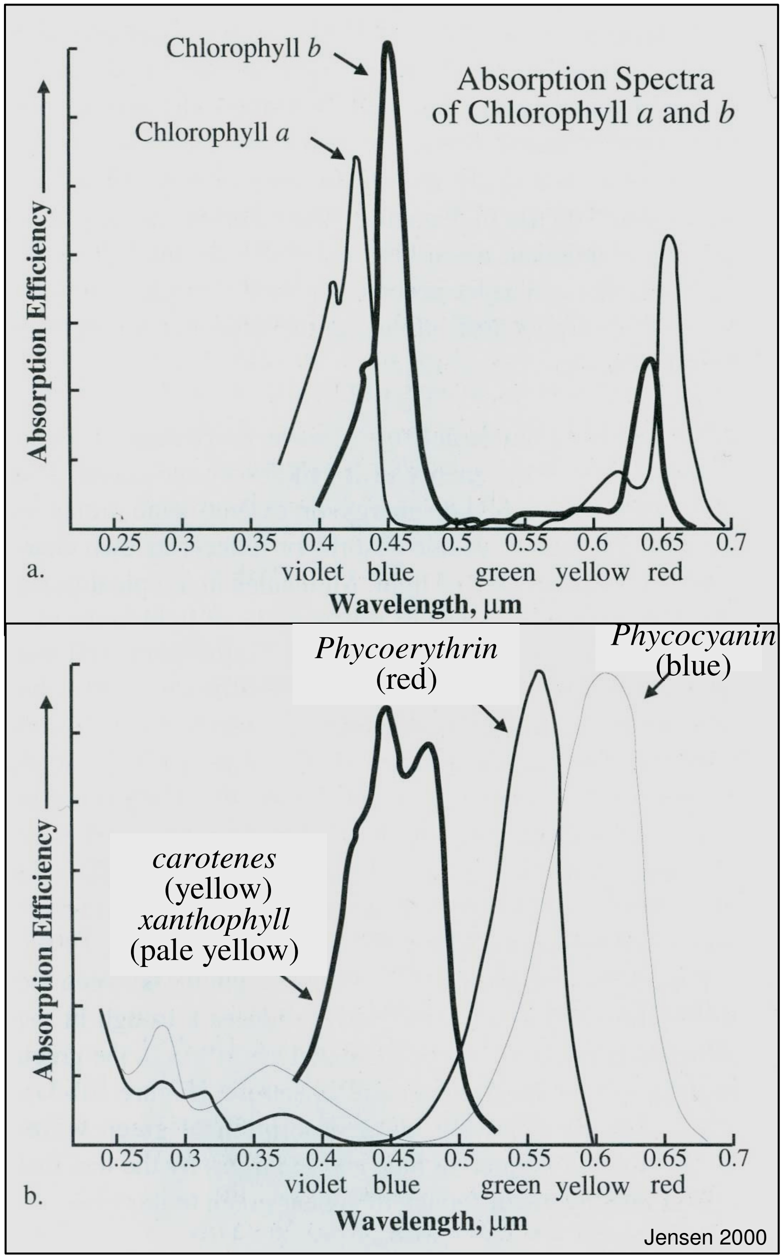
Visible Light Interaction with Pigments

Chlorophyll *a* peak absorption is at 430 and 660 nm.

Chlorophyll *b* peak absorption is at 450 and 650 nm.

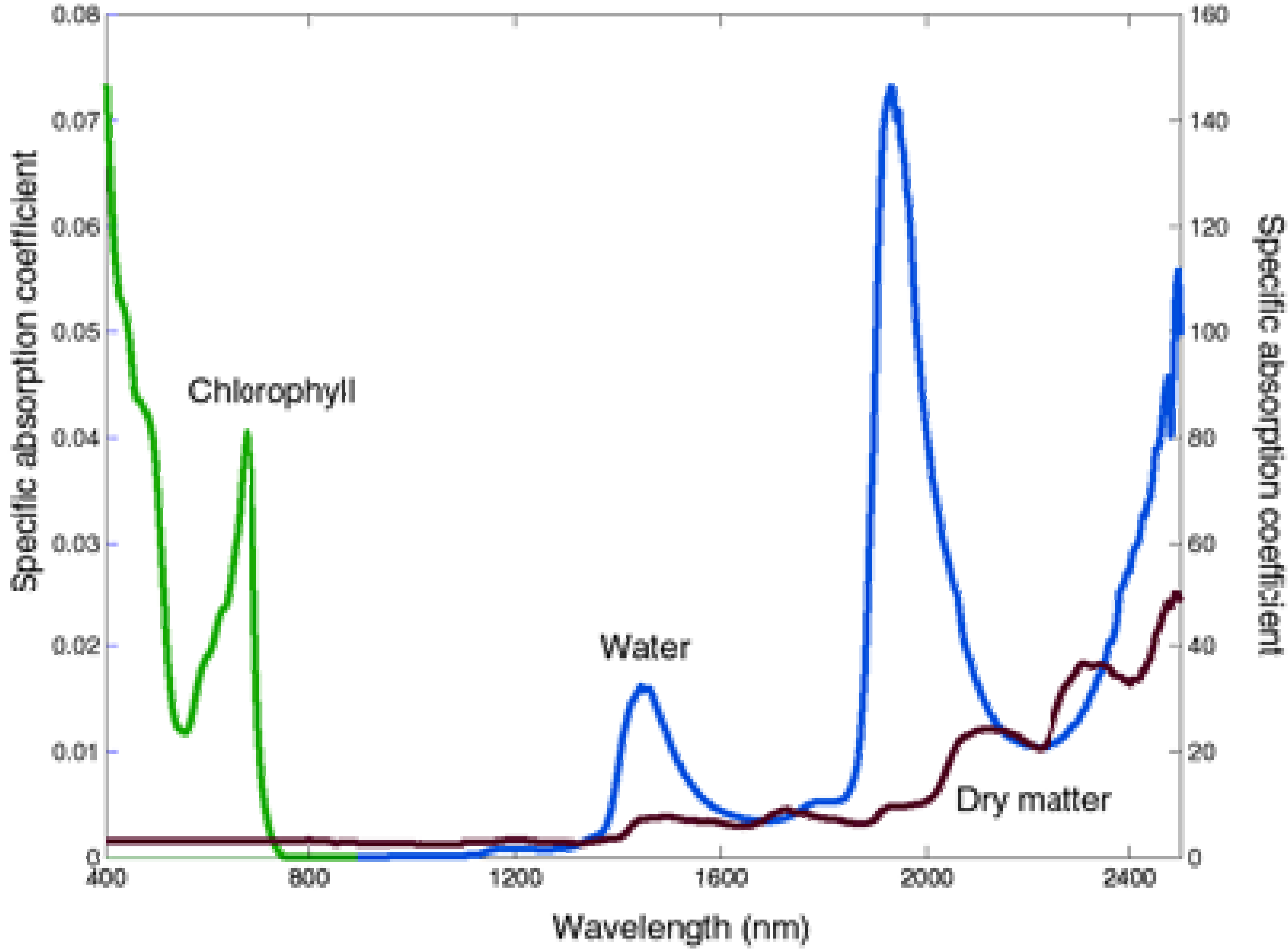


The two optimum spectral regions for sensing the chlorophyll absorption characteristics of a leaf : 450 – 520 nm and 630 – 690 nm



Remote sensing of vegetation

Spectral properties of plants - absorption



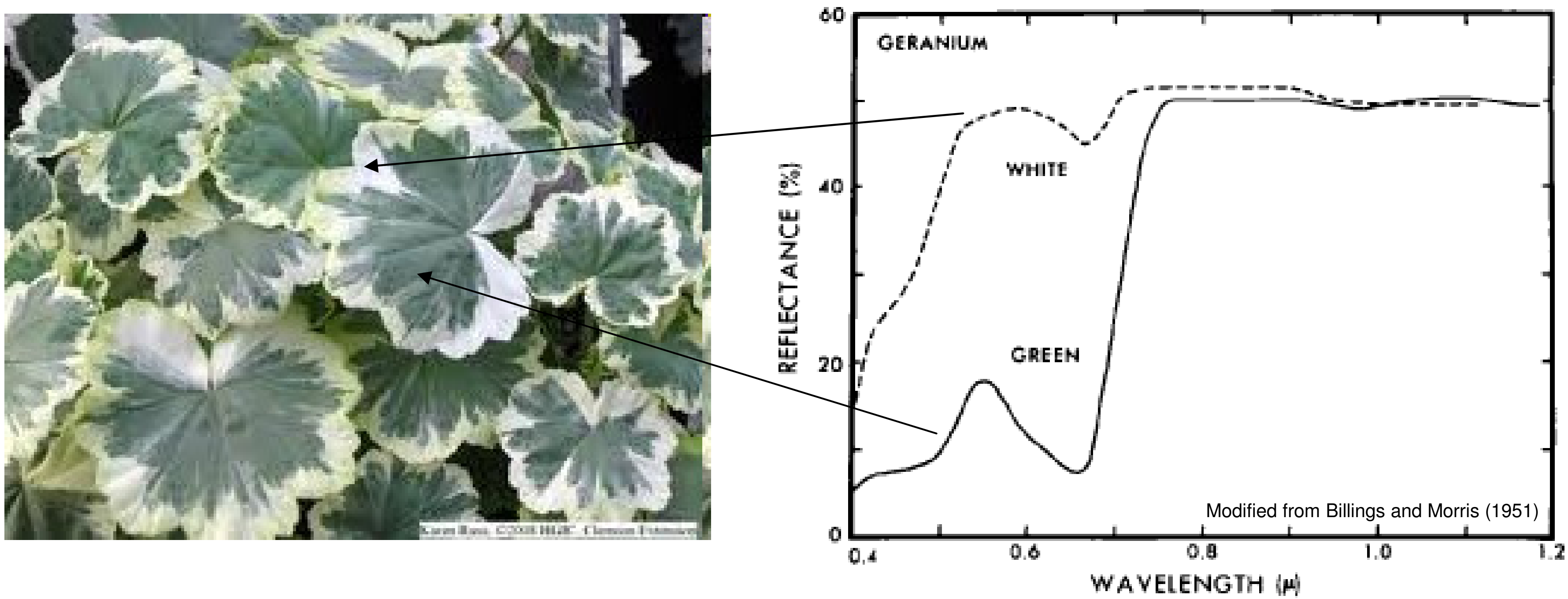
Specific absorption coefficient of chlorophyll a+b (cm^2 μg^{-1}) on the left axis, of water (cm^{-1}) and dry matter (cm^2 g^{-1}) on the right axis

(after Jacquemoud et al., 2000). [2508]

Remote sensing of vegetation

Visible Light Interaction with Pigments

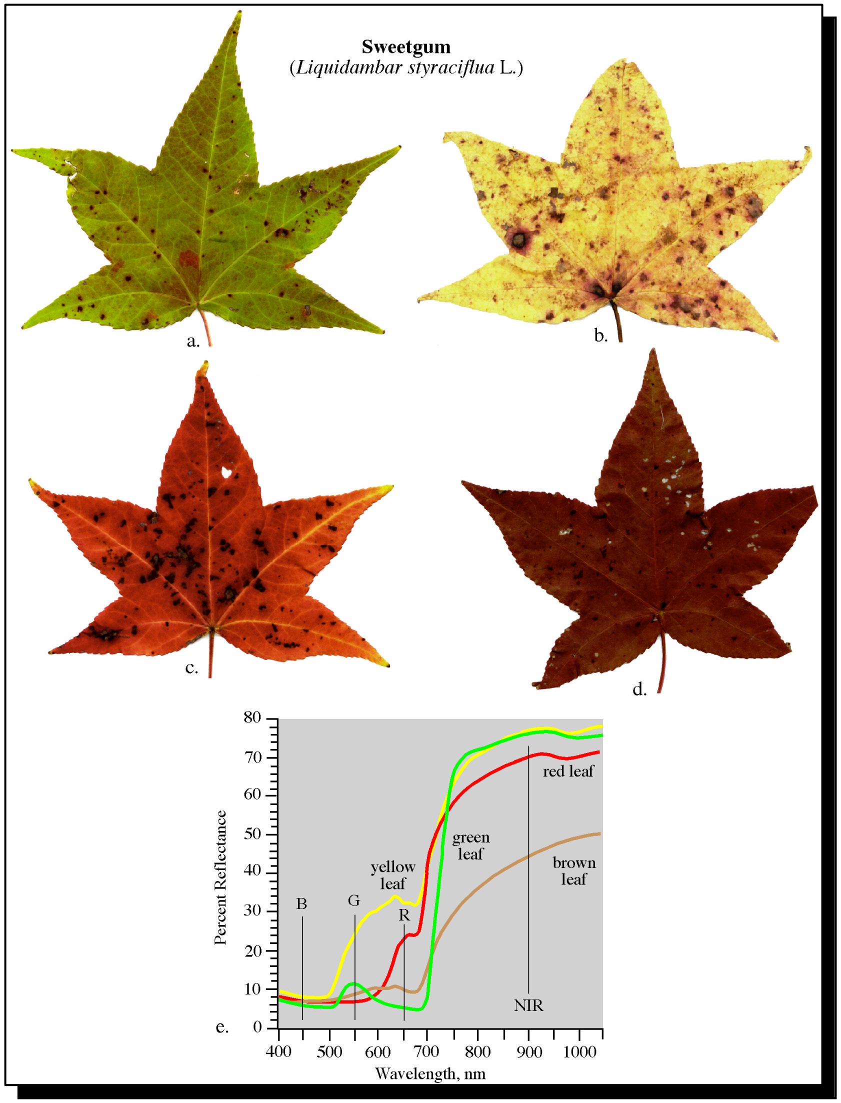
Reflectance spectra of the white and green portions of a variegated geranium leaf



Modified from Billings and Morris (1951)

Remote sensing of vegetation

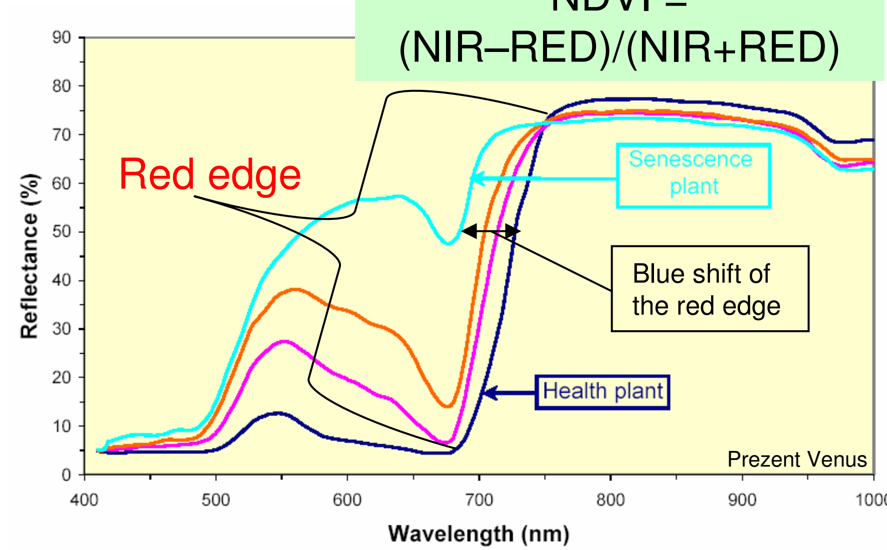
Visible Light Interaction with Pigments



Spectral Reflectance Characteristics of Sweetgum Leaves (*Liquidambar styraciflua* L.)

Leaf spectral reflectance is most likely to indicate plant stress first in the sensitive 535 - 640 and 685-700 nm visible light wavelength ranges.

NDVI = (NIR–RED)/(NIR+RED)

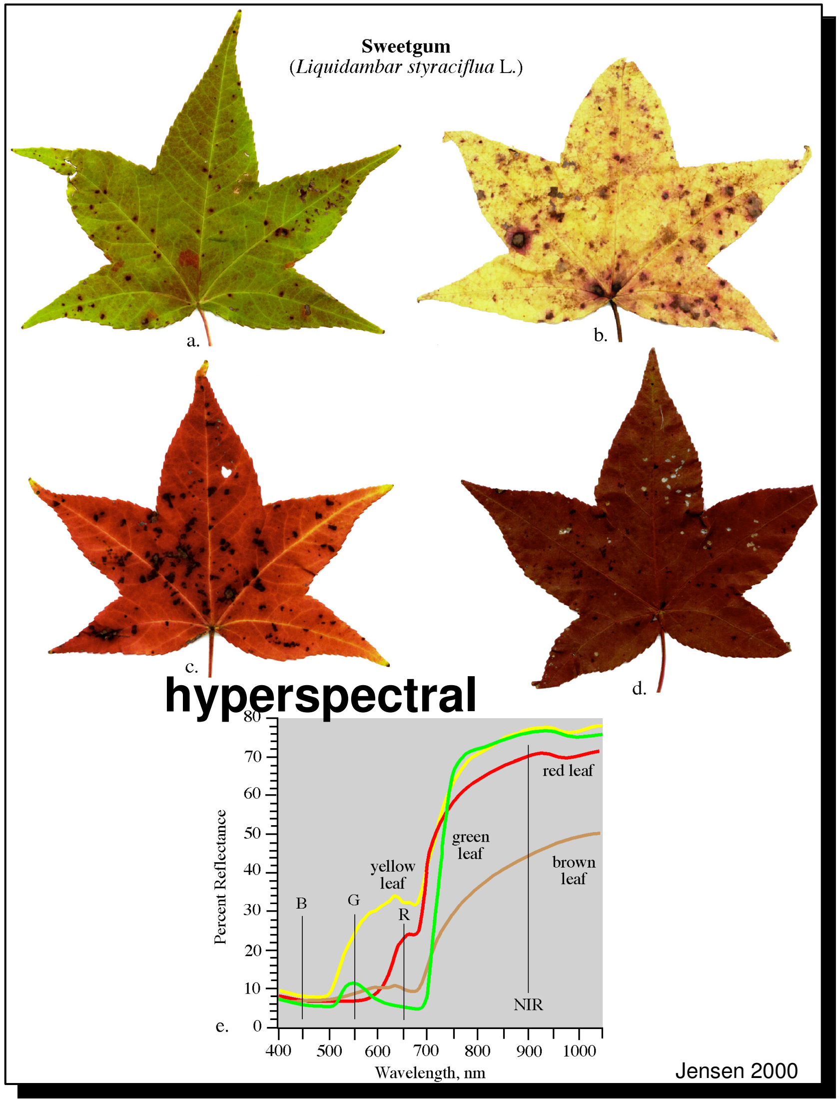


Natural color image (RGB = RGB) of a N.Y. Power Authority lake at 0.3 x 0.3 m.

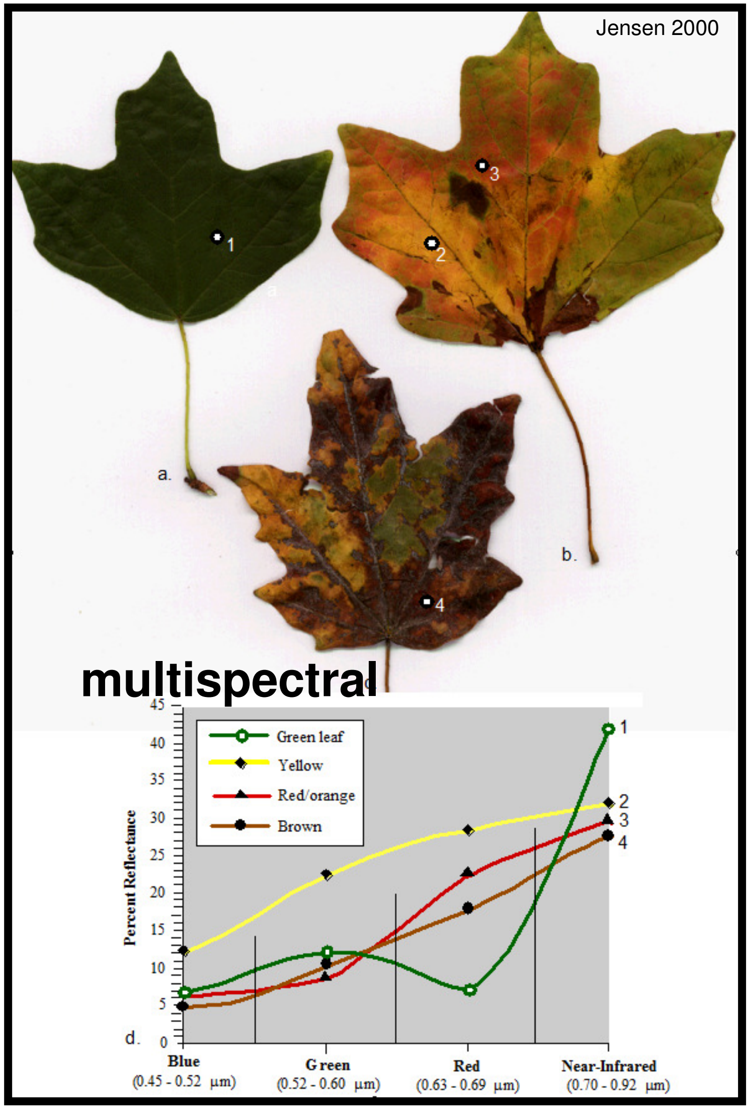
Jensen 2000

Remote sensing of vegetation

Visible Light Interaction with Pigments



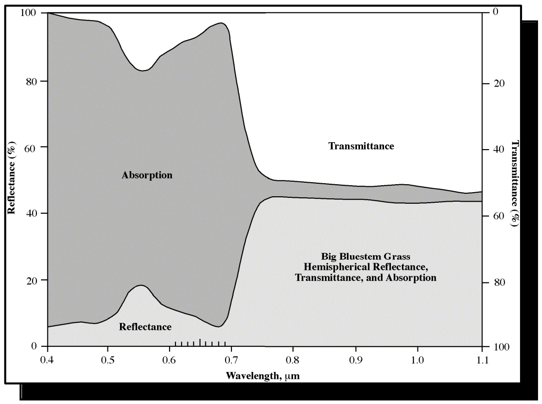
Spectral Reflectance Characteristics of Sweetgum Leaves (*Liquidambar styraciflua* L.)



Spectral Reflectance Characteristics of Selected Areas of Blackjack Oak Leaves

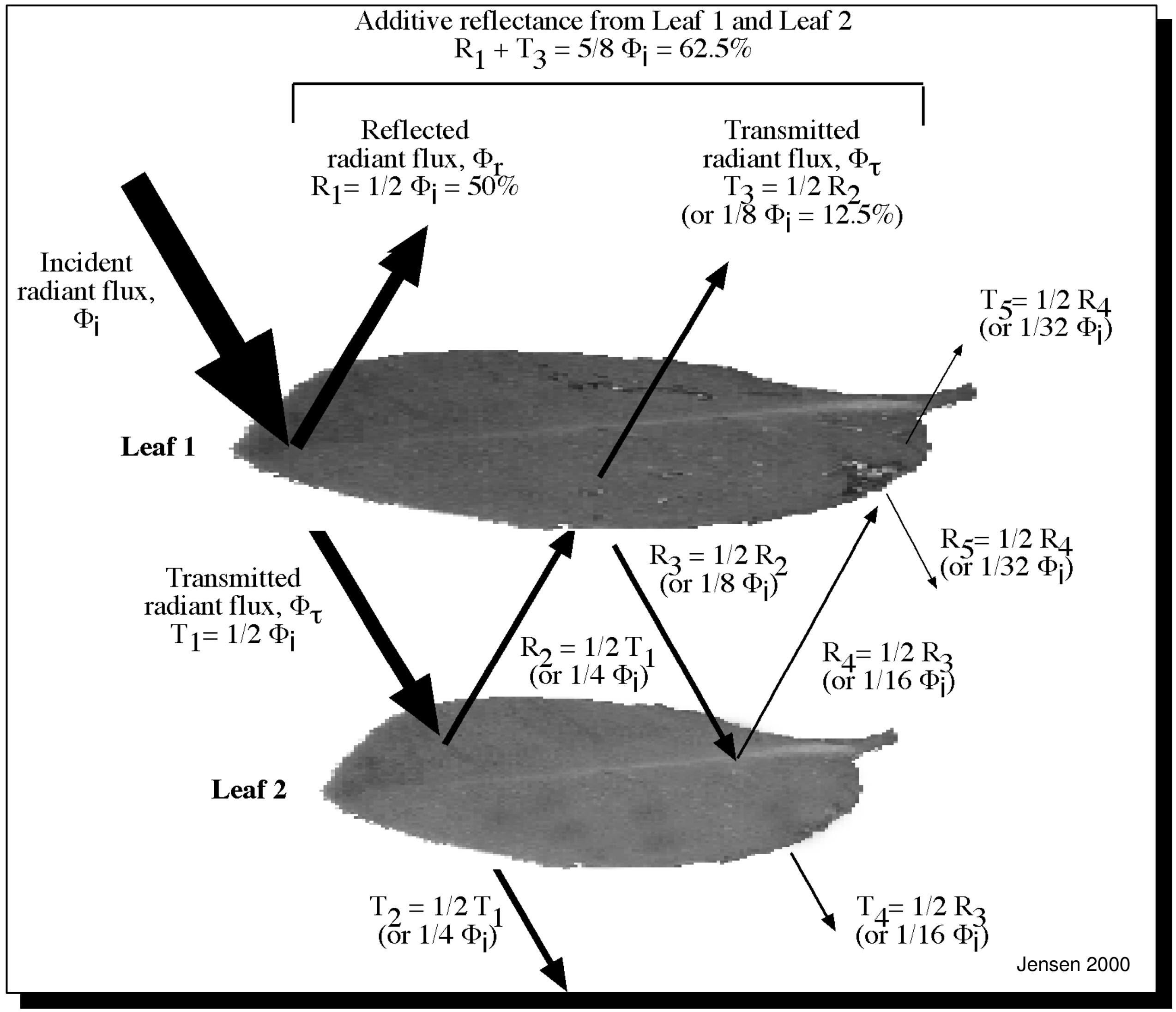
Remote sensing of vegetation

Near-Infrared Energy Interaction Within the Spongy Mesophyll Cells



Hemispherical reflectance, transmittance, and absorption Characteristics of Big Bluestem Grass

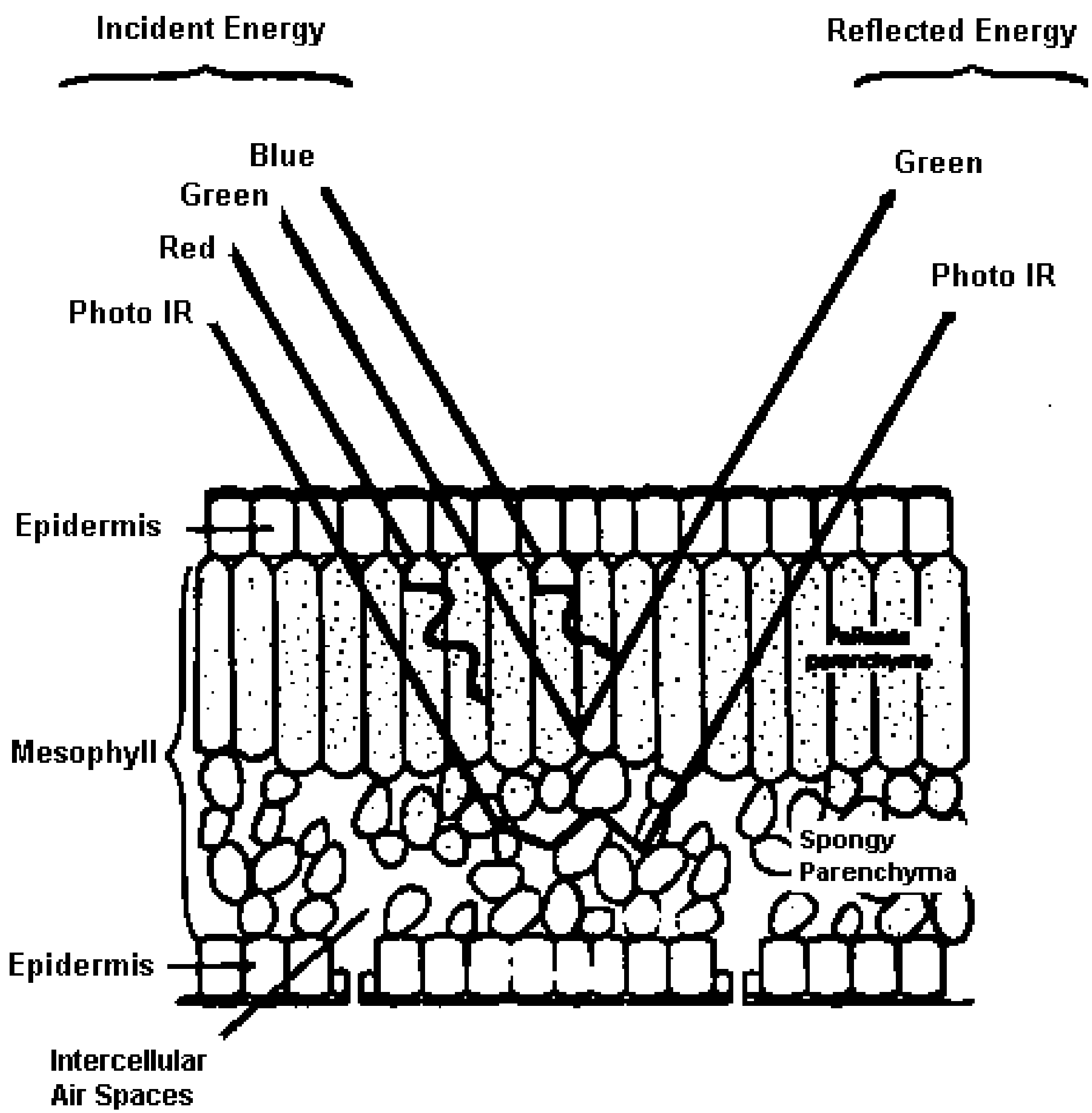
Additive Reflectance from A Canopy with Two Leaf Layers



Leaf additive reflectance
- the energy penetrates (is transrnitted) through the leaf and can be reflected once again by leaves below it.

Remote sensing of vegetation

Near-Infrared Energy Interaction Within the Spongy Mesophyll Cells



Remote sensing of vegetation

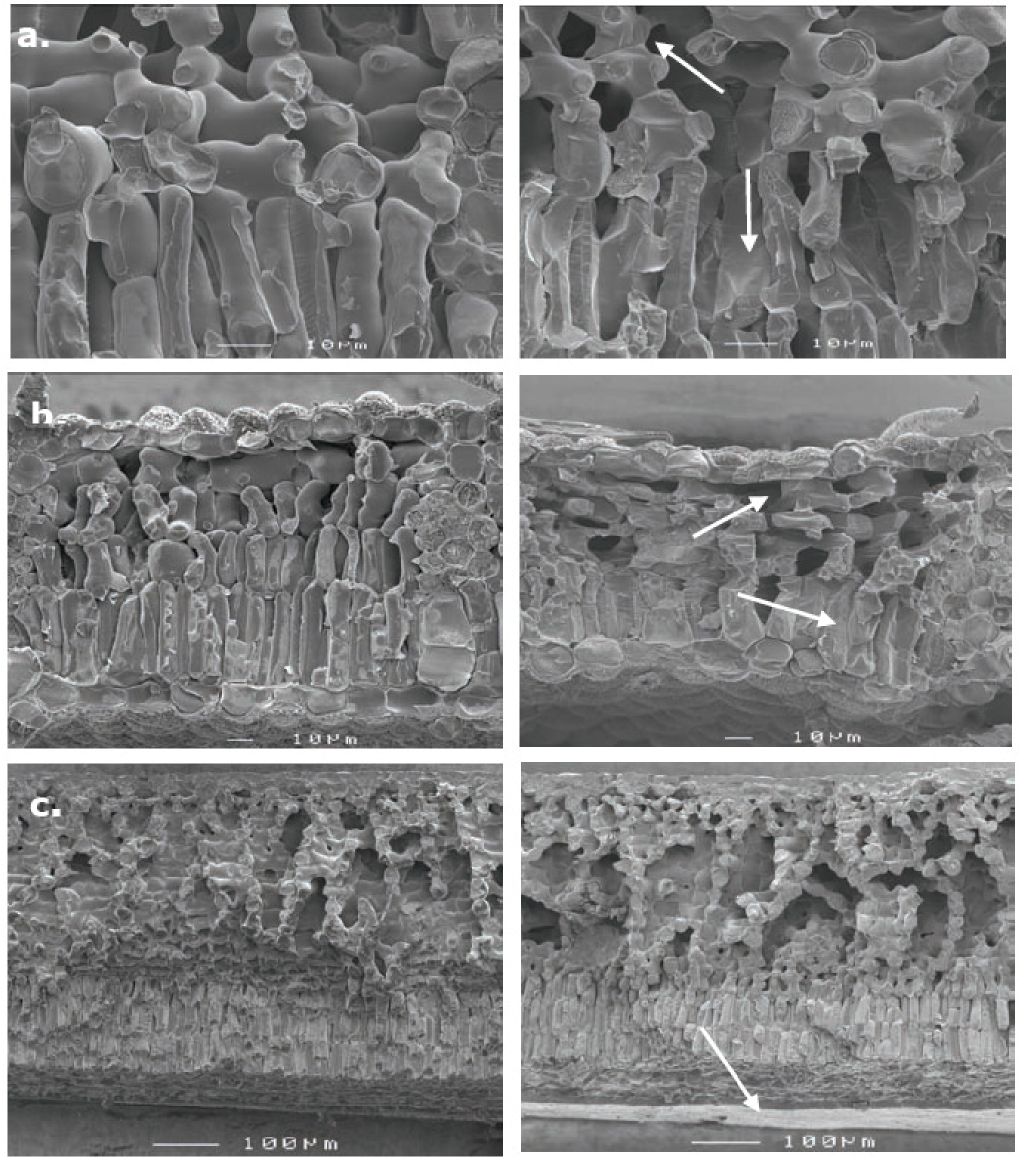
Near-Infrared Energy Interaction Within the Spongy Mesophyll Cells

Leaves: 2 h after breaking 24 h after breaking

European Beech
(Fagus silvatica L.)

Black locust
(Robinia pseudoacacia L.)

European holly
(Ilex L.)



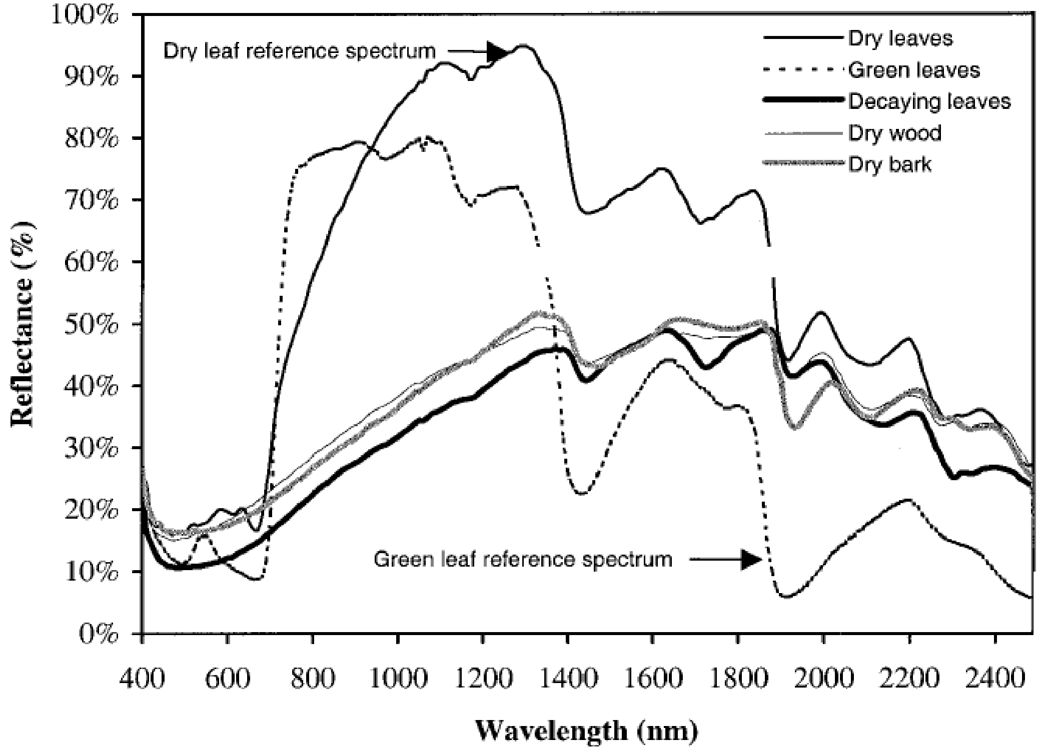
Shrinkage and collapse of the mesophyll cells.

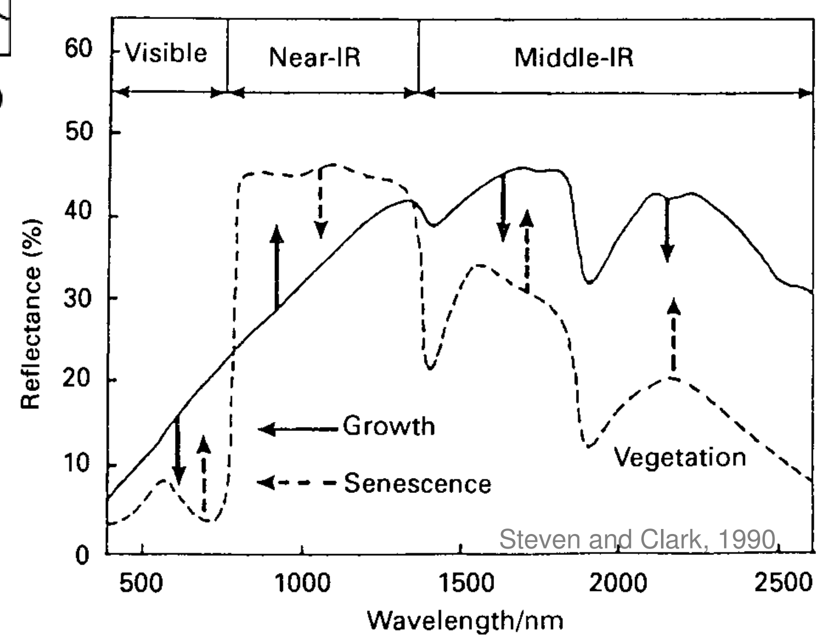
Thick protective layer of wax on the epidermis

Sobhan 2007

Remote sensing of vegetation

Nonphotosynthetic vegetation (NPV)

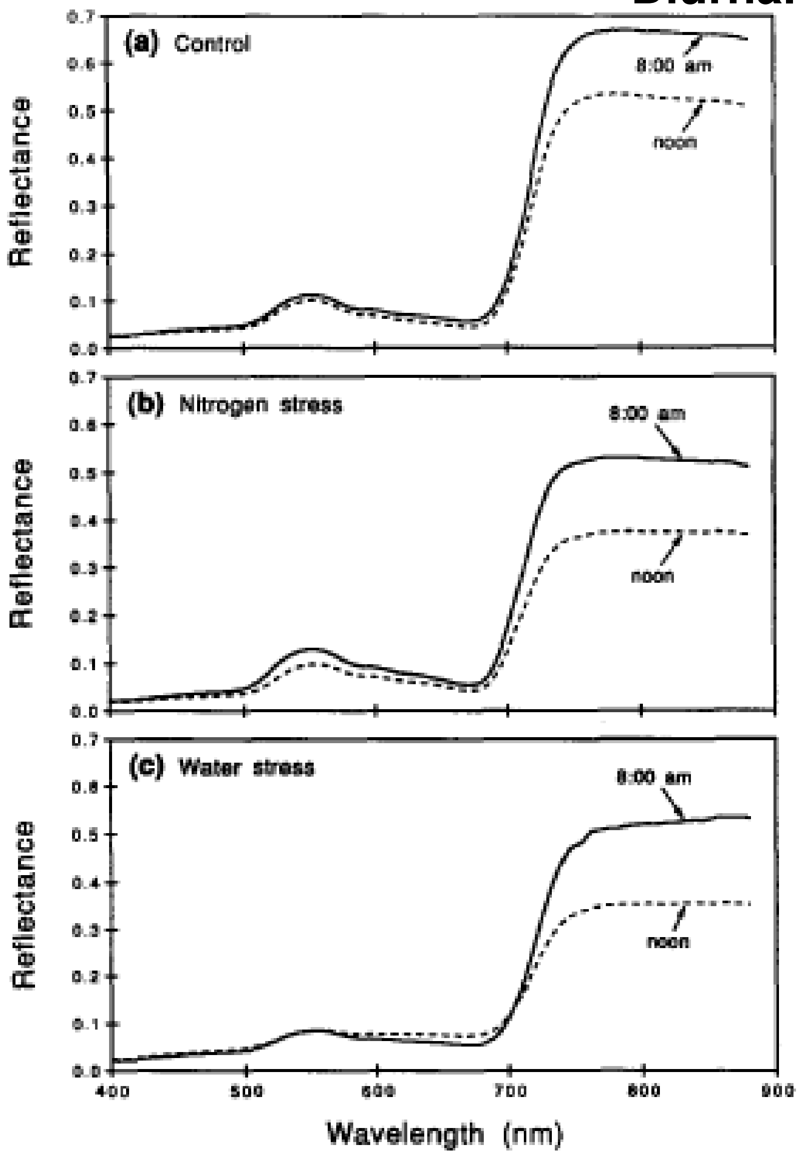




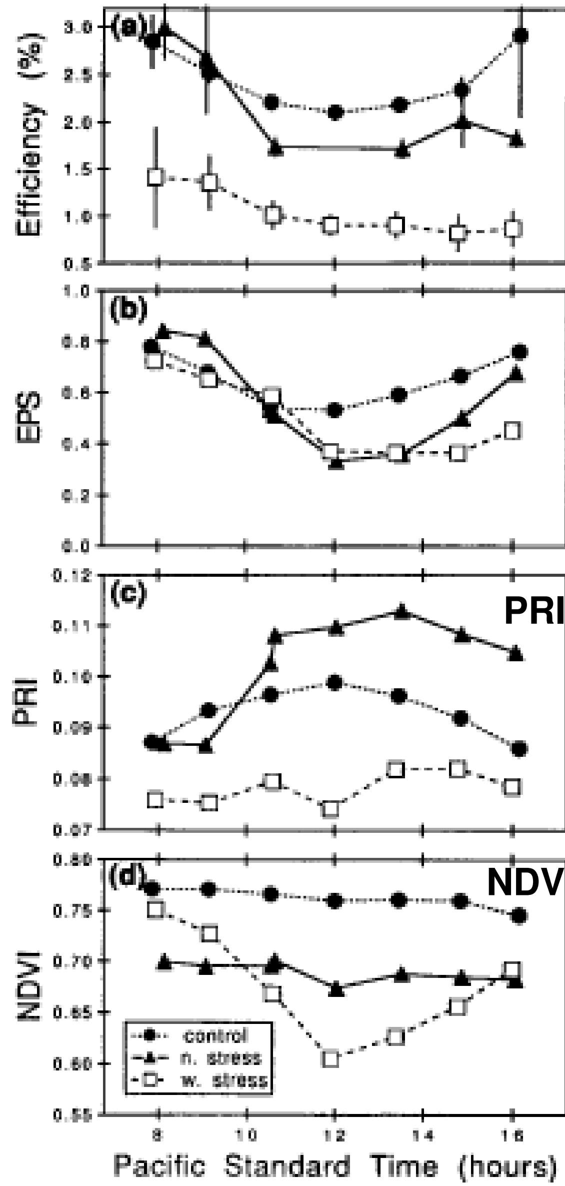
Steven and Clark, 1990

Remote sensing of vegetation

Diurnal changes & stress



Spectral reflectance at noon and at 8 a.m. for control (A), nitrogen stress (B), and water stress canopies ©.



photosythetic efficiency

EPS=(*V*+O.5A*)/(*V*+*A*+*Z*)**
the area-based, molar con-centrations of the:
***V* – violaxanthin,**
***A* – antheraxanthin,**
***Z* -- zeaxanthin**

PRI=[(R_{550}-RR_{531})/(R_{550}+R_{531})]

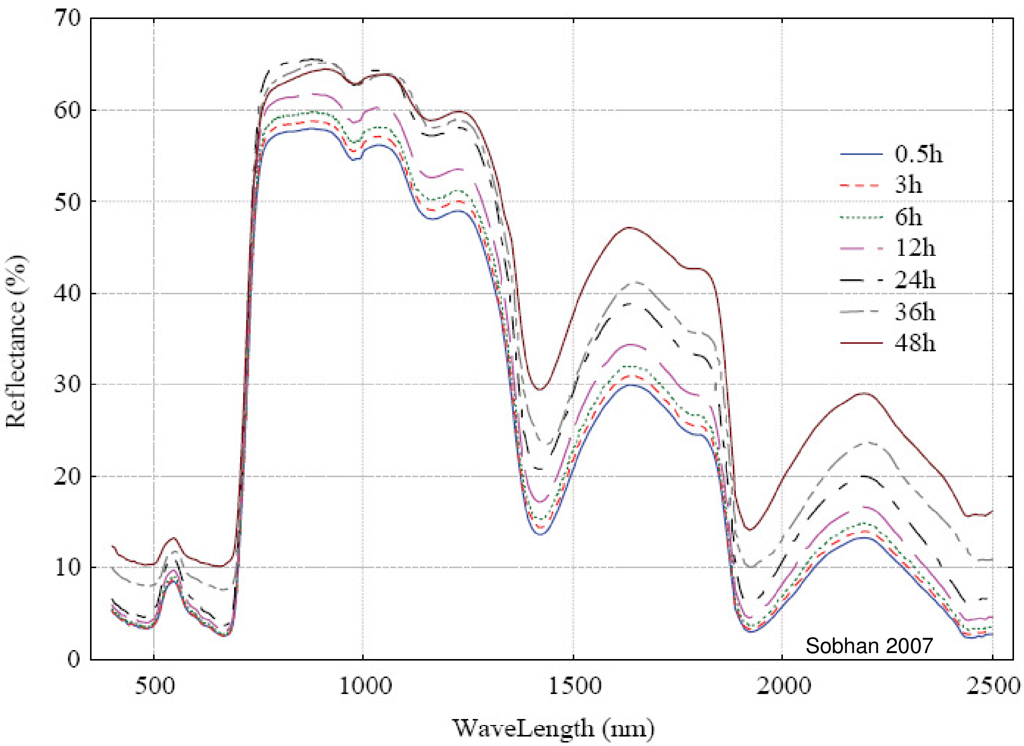
NDVI = (R_{NIR}-R_{RED})/(R_{NIR}+R_{RED})

Gamon et al.. 1993

Remote sensing of vegetation

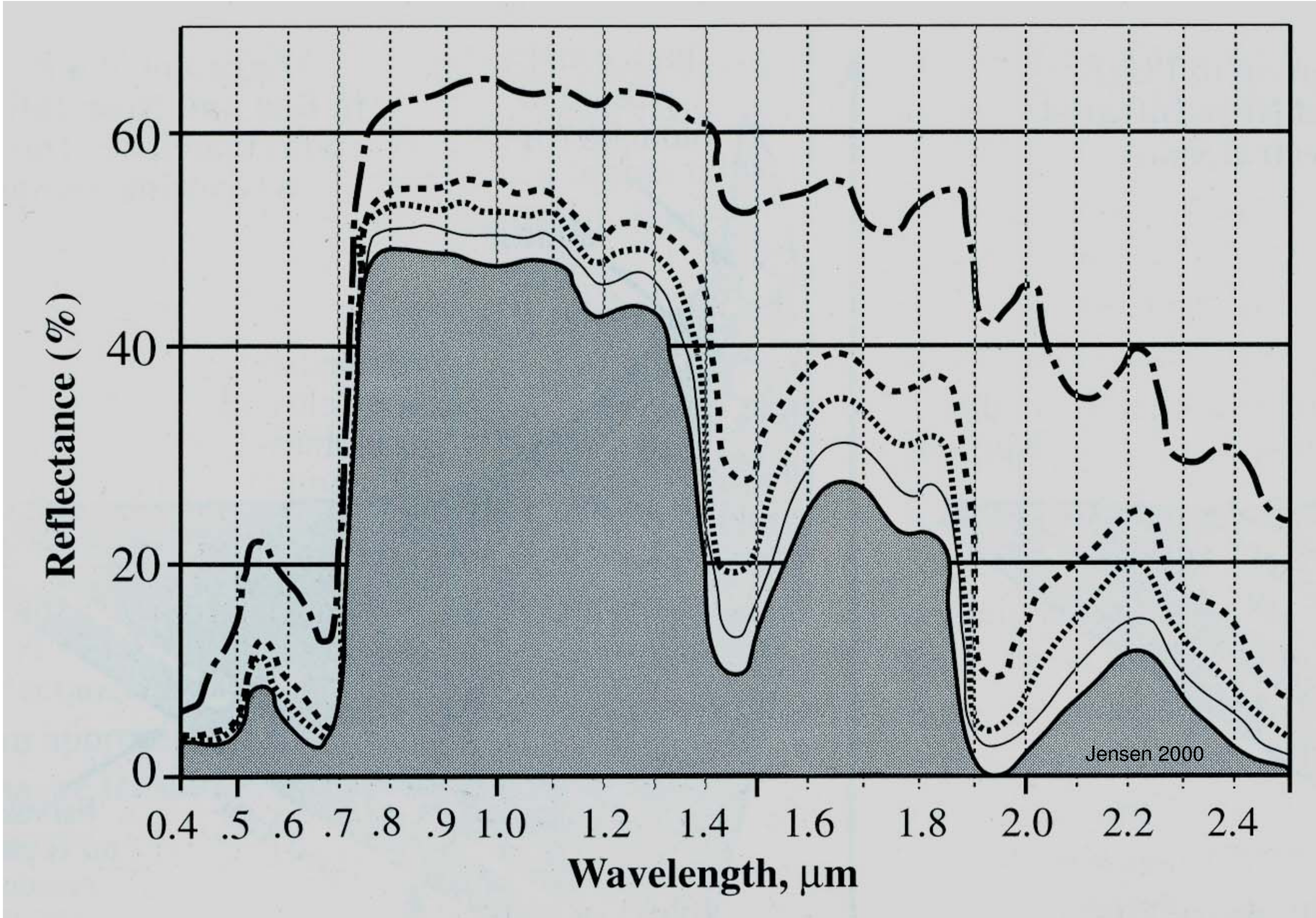
Stress

Changing nature of reflectance spectra of birch-tree (*Betula pendula)* leaves, from immediately after collection (0.5 h) through 48 hours after collection.



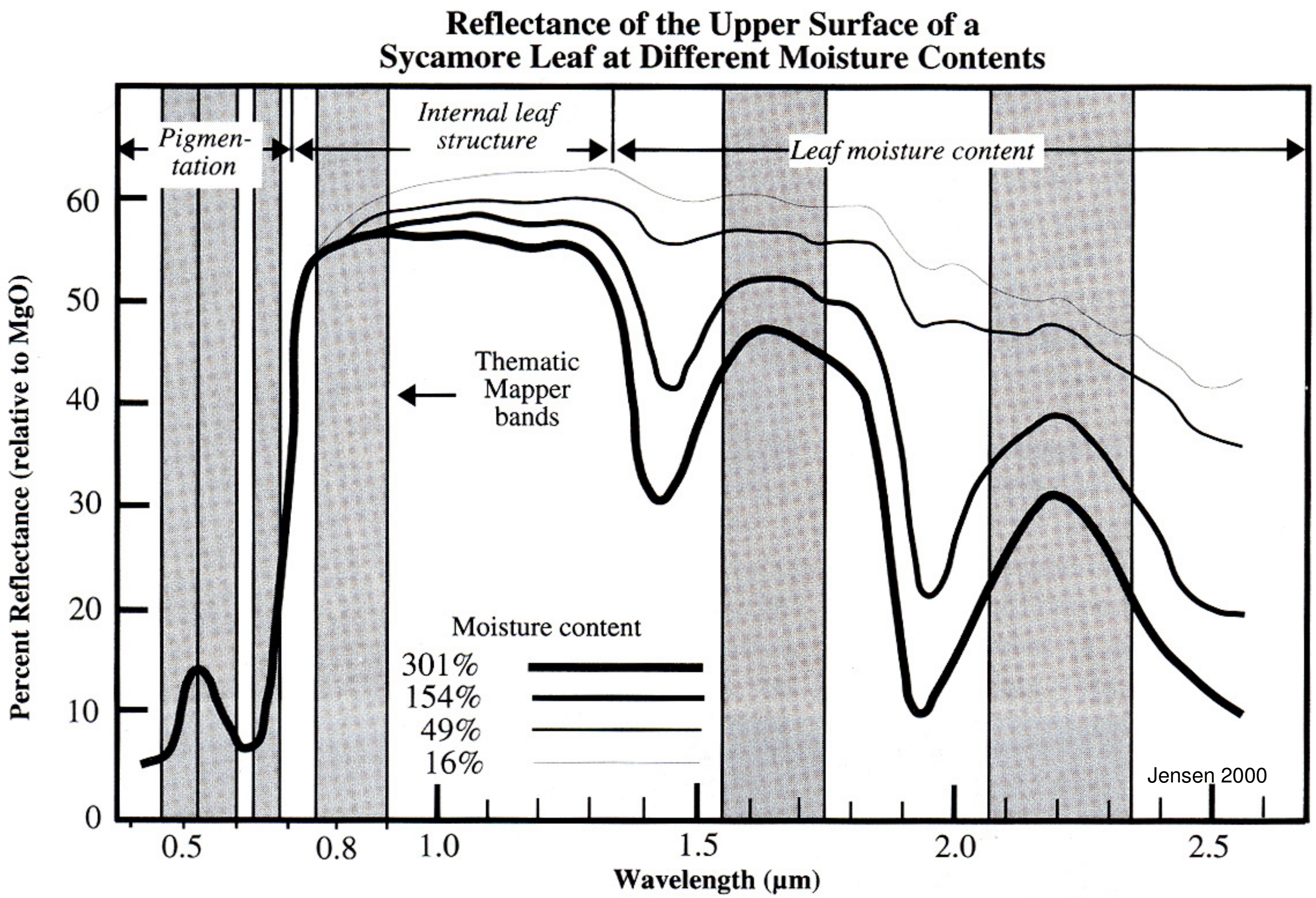
Remote sensing of vegetation

Middle-Infrared Energy Interaction with Water in the Spongy Mesophyll



Remote sensing of vegetation

Middle-Infrared Energy Interaction with Water in the Spongy Mesophyll



Strong atmospheric water absorption bands:

-***primary and secondary*** : 1450, 1940, and 2500 nm,

- ***secondary*** : 980 and 1240 nm.

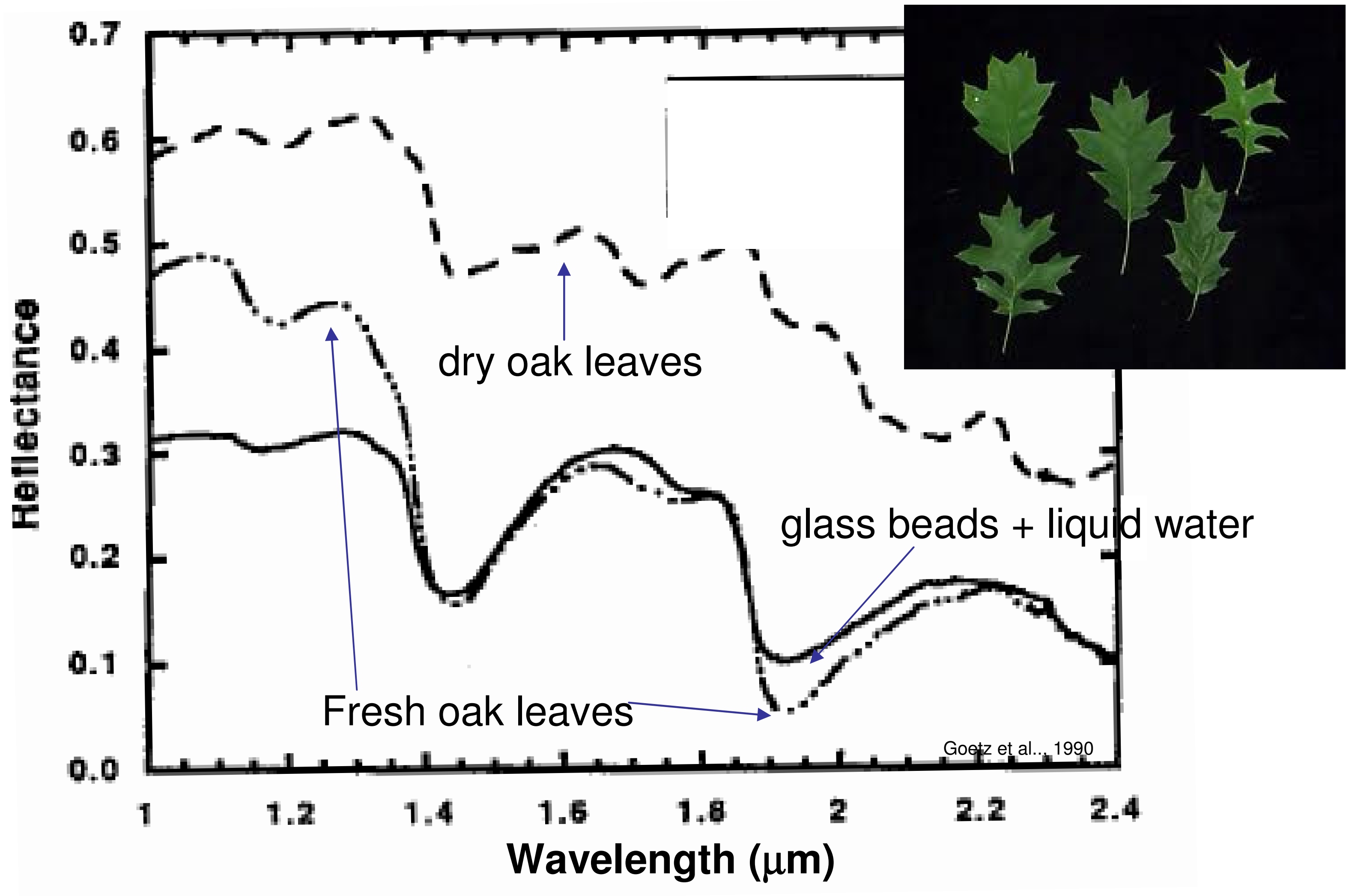
Carter, 1991 [2508 Jacquemoud]

Vegetation index:

$STVI=(R_{1650}*R_{650})/R_{850}$

Remote sensing of vegetation

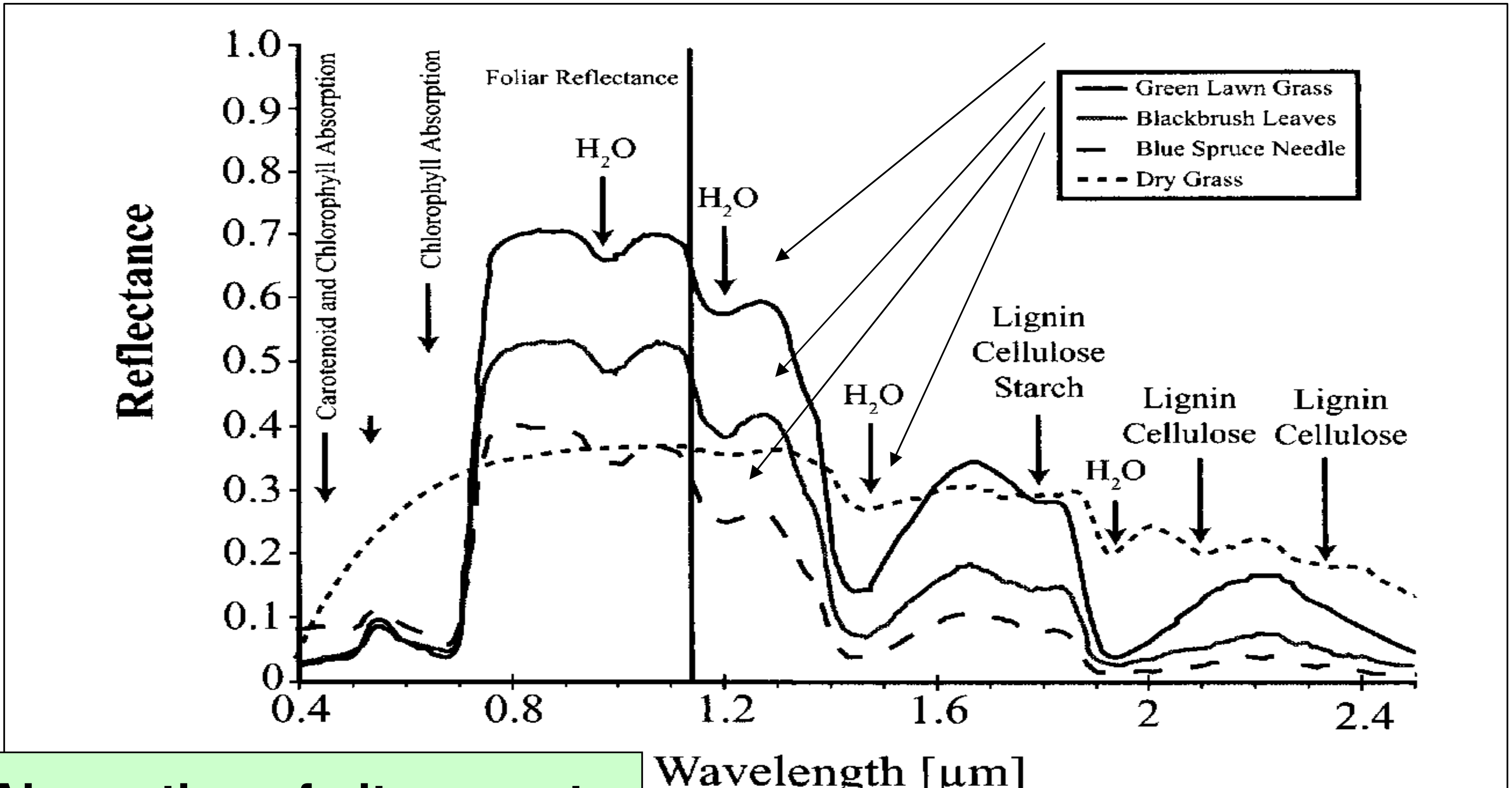
Middle-Infrared Energy Interaction with Water in the Spongy Mesophyll



Reflectance spectra of fresh and dried oak leaves and glass beads plus water

Remote sensing of vegetation

Absorption by other leaf components



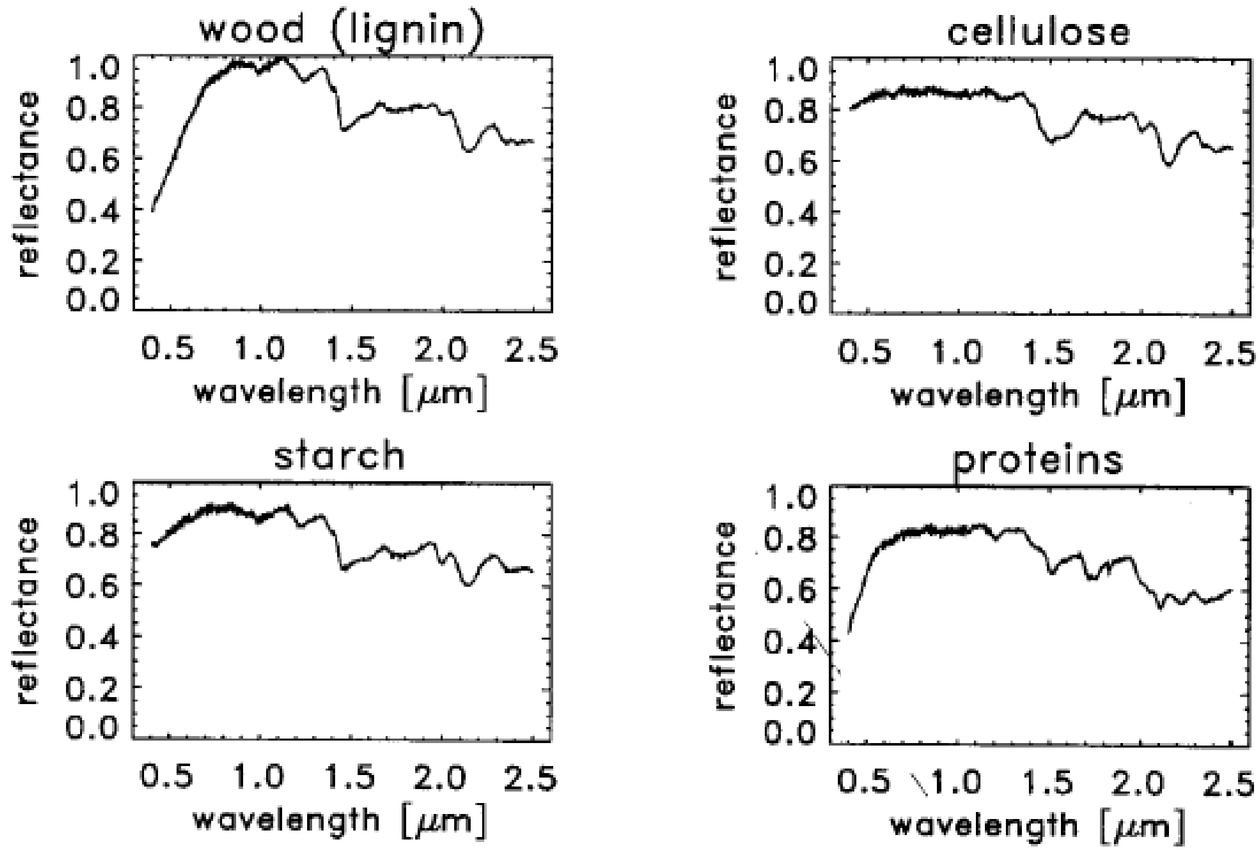
Absorption of nitrogen at:

1510, 1980, 2060 and 2180 nm

Remote sensing of vegetation

Absorption by other leaf components

Reflectance spectra of four biochemical components found in leaves, obtained on "pure" substances



Remote sensing of vegetation

Major variables affecting the spectral properties of plants

Vegetation - Canopy
- type (plant or tree nominal class)
- closure (%)
- orientation
  - systematic (e.g., rows 0° -360°)
  - unsystematic (random)

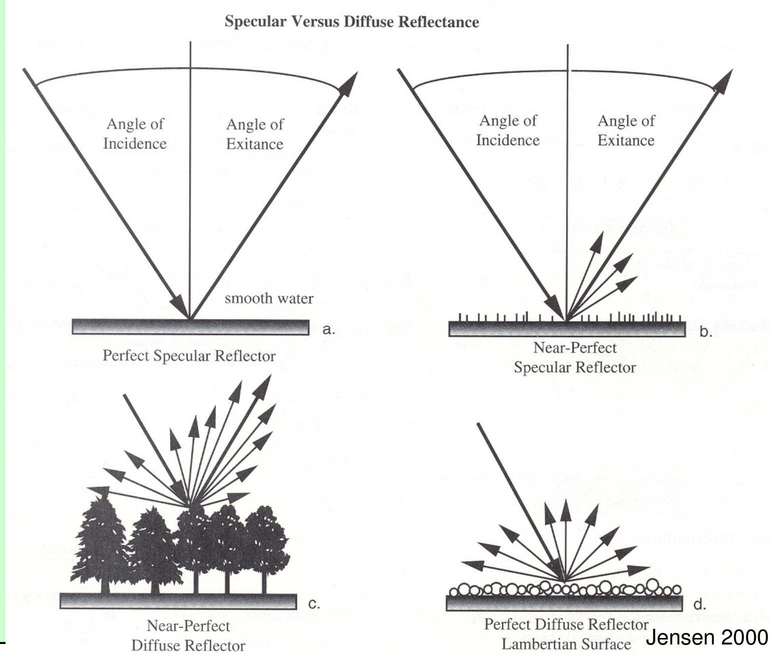
- Crown
  - shape (e.g., circular, conical)
  - diameter (m)
- Trunk or stem
  - density (units per m^2)
  - tree diameter-at-breast-height (LAD) (planophile, erectophile)

Understory same as vegetation

Soil - Texture
- Color
- Moisture content

Illumination - Geometry
- angle-of-incidence of Sun (or radar)
- azimuth
- Spectral characteristics (λ)

Sensor - Geometry
- angle of view (e.g., 0° = nadir)
- azimuth look direction 0-360°)
- Spectral sensitivity (λ)
- IFOV (miliradians)



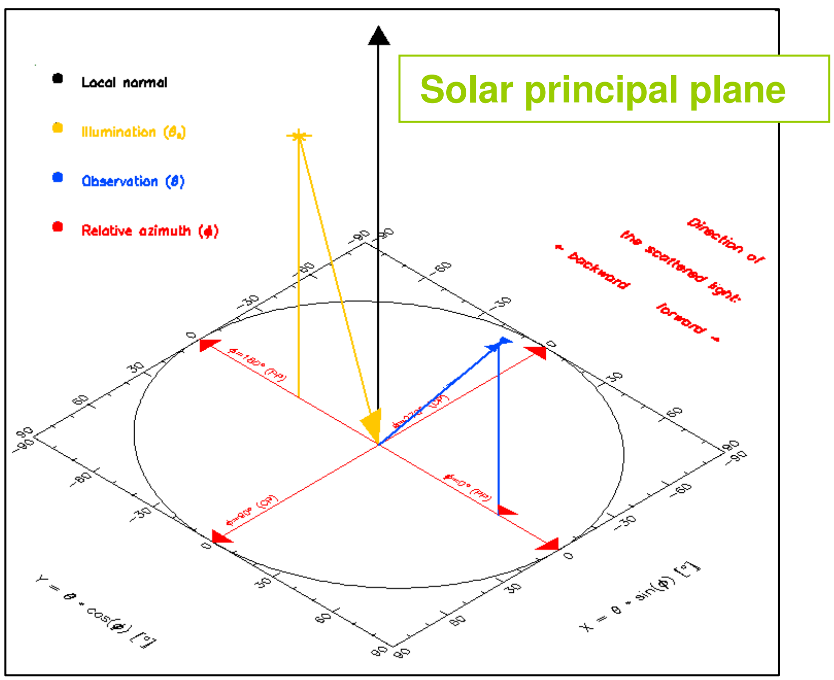
Jensen 2000

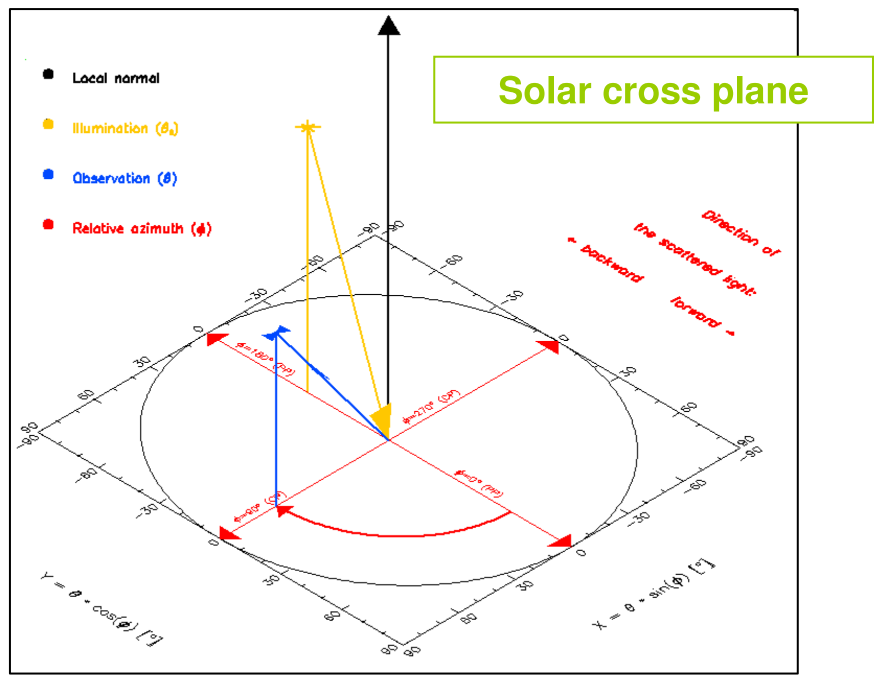
Remote sensing of vegetation

Bidirectional Reflectance Distribution Function (BRDF)

The ***bidirectional reflectance distribution function*** **BRDF** – is a four-dimensional function that defines how light is reflected at an opaque surface.

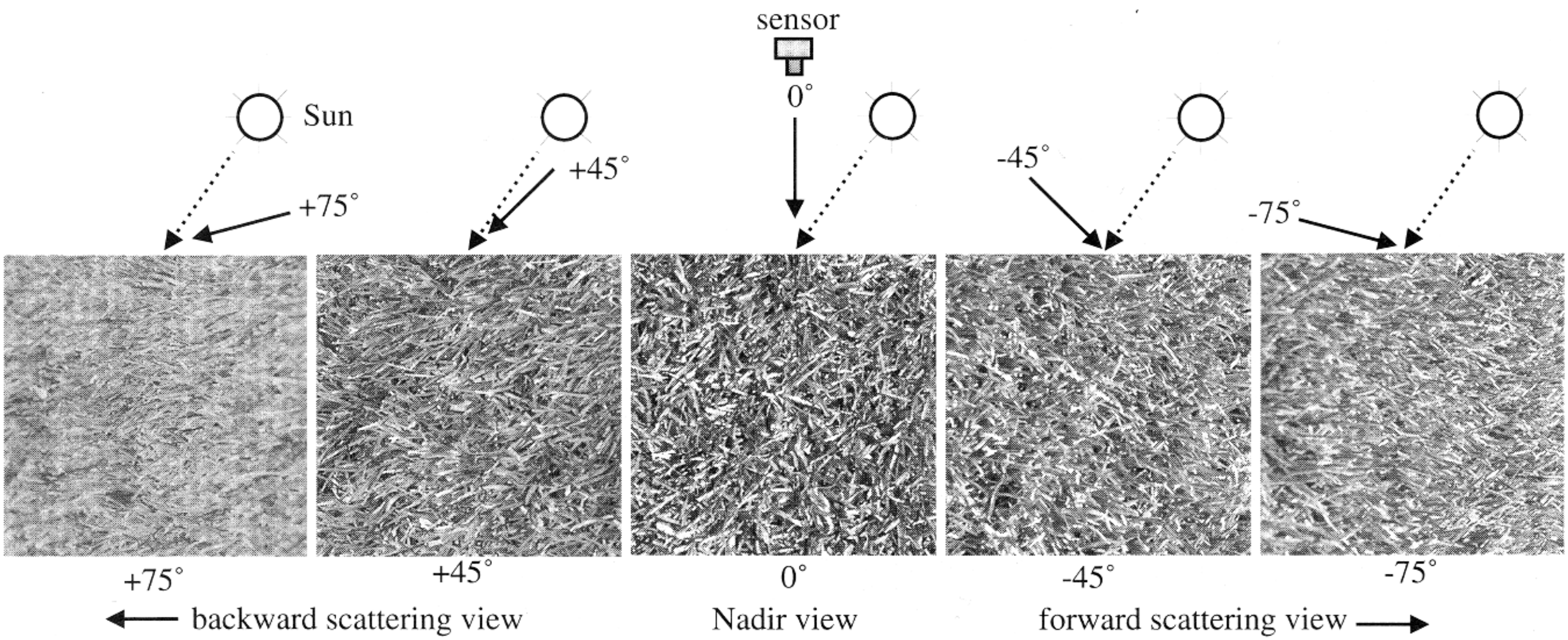
BRDF takes an *incoming* **light direction and** *outgoing* **direction, both defined with respect to the surface normal, and returns the ratio of reflected radiance exiting along to the irradiance incident on the surface from a given direction. Note that each of these directions is itself parameterized by** *azimuth angle* **and** *zenith angle***. The BRDF has units sr−1, with steradians (sr) being a unit of solid angle.**



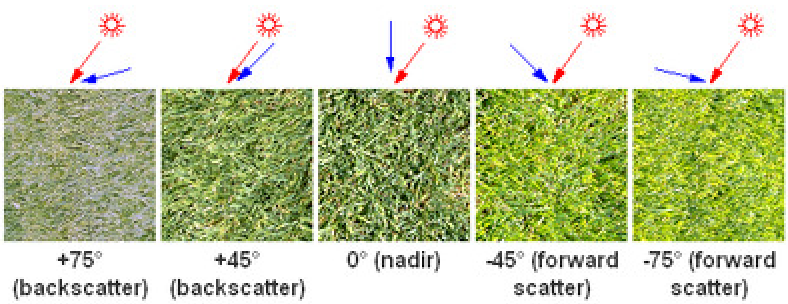


Remote sensing of vegetation

Bidirectional Reflectance Distribution Function (BRDF)



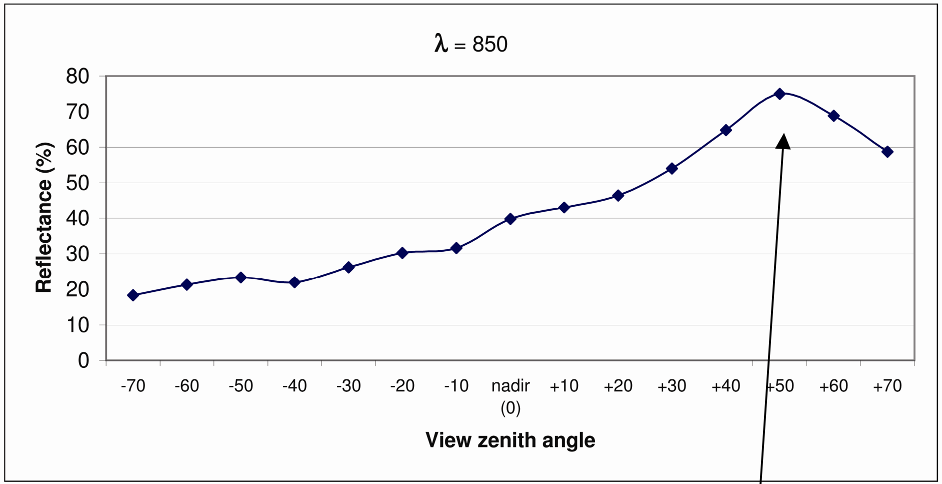
The bidirectional reflectance effect on a field of ryegrass (Lolium perenne L.) observed under different viewing angles in the solar principal plane



Jensen 2000

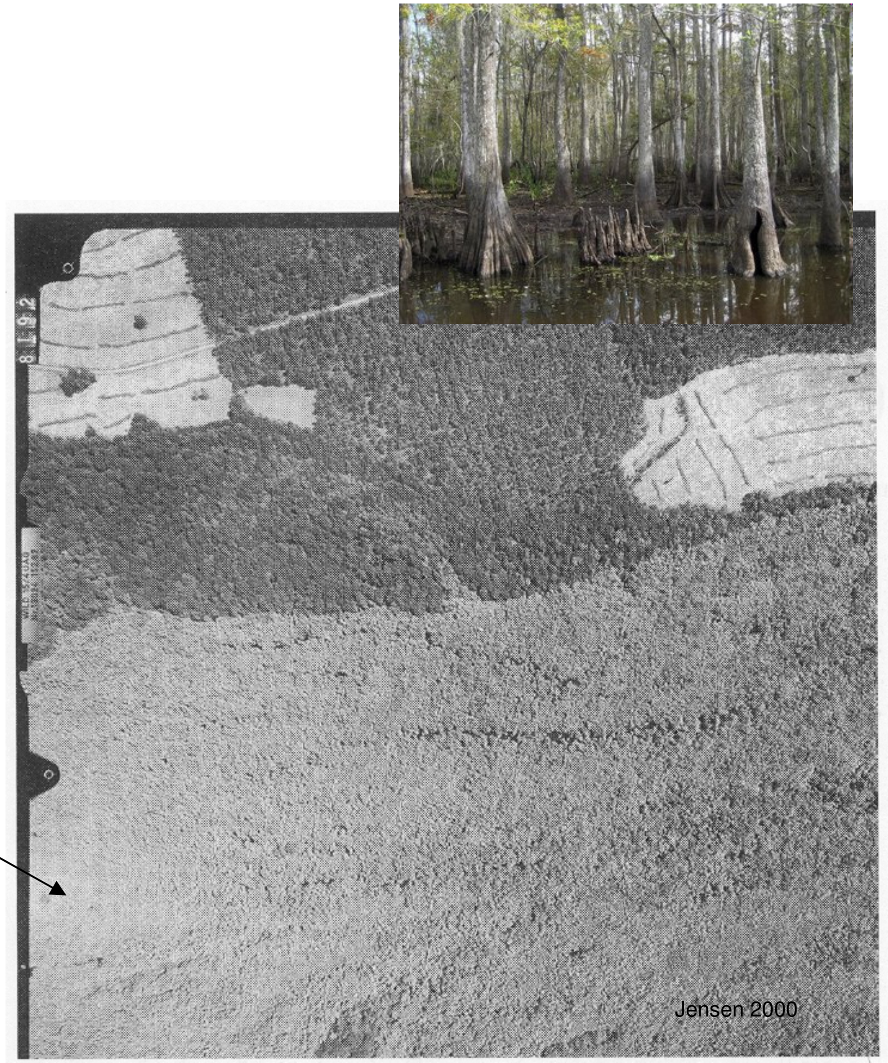
Remote sensing of vegetation

Bidirectional Reflectance Distribution Function (BRDF)



Hot spot

(a shadow is not visible)

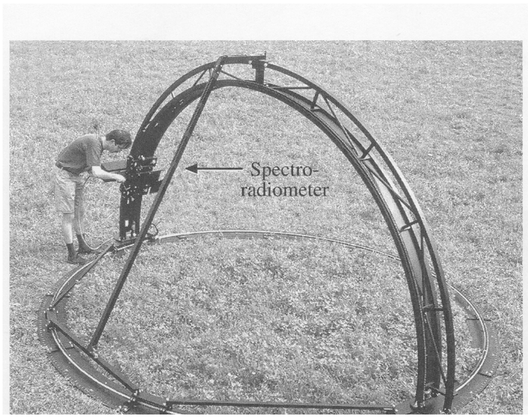


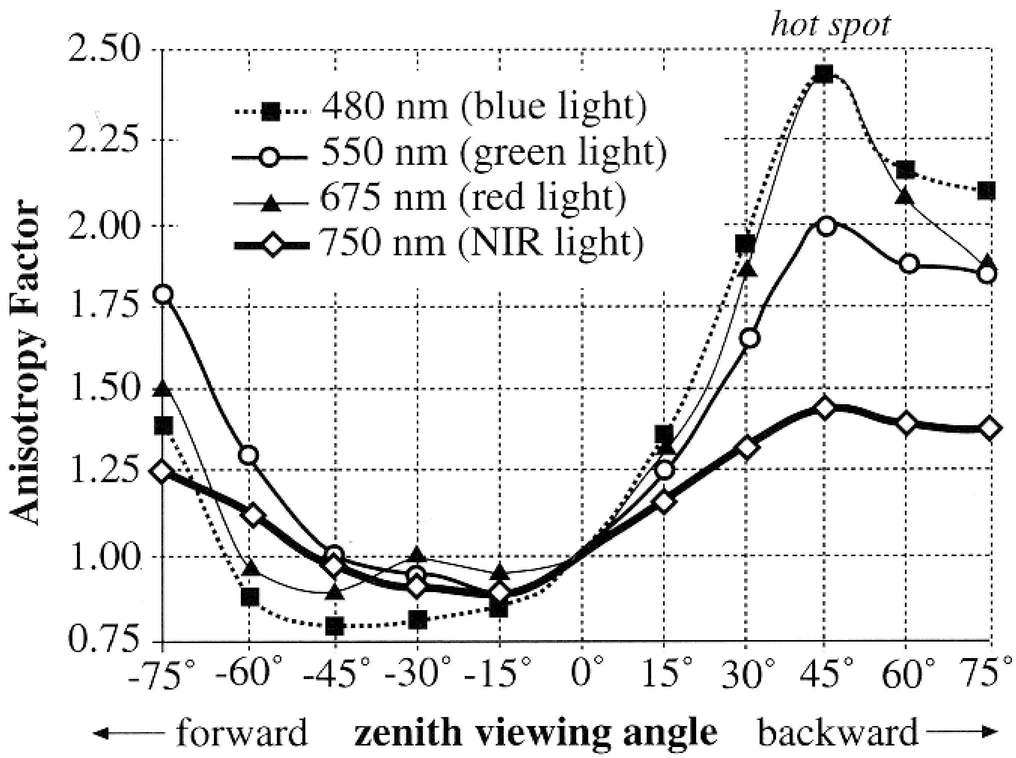
A hot spot on a vertical aerial photograph of the Savannah River swamp in South Carolina (The Cypress-Tupelo forested wetland)

The ***solar principal plane*** is formed when the source, target, and the sensor are in the same plane (in the solar azimuth angle).

Remote sensing of vegetation

Bidirectional Reflectance Distribution Function (BRDF)





BRDF effects should be concerned in order to:

-identify and select the bands that are impacted the least by BRDF effects,

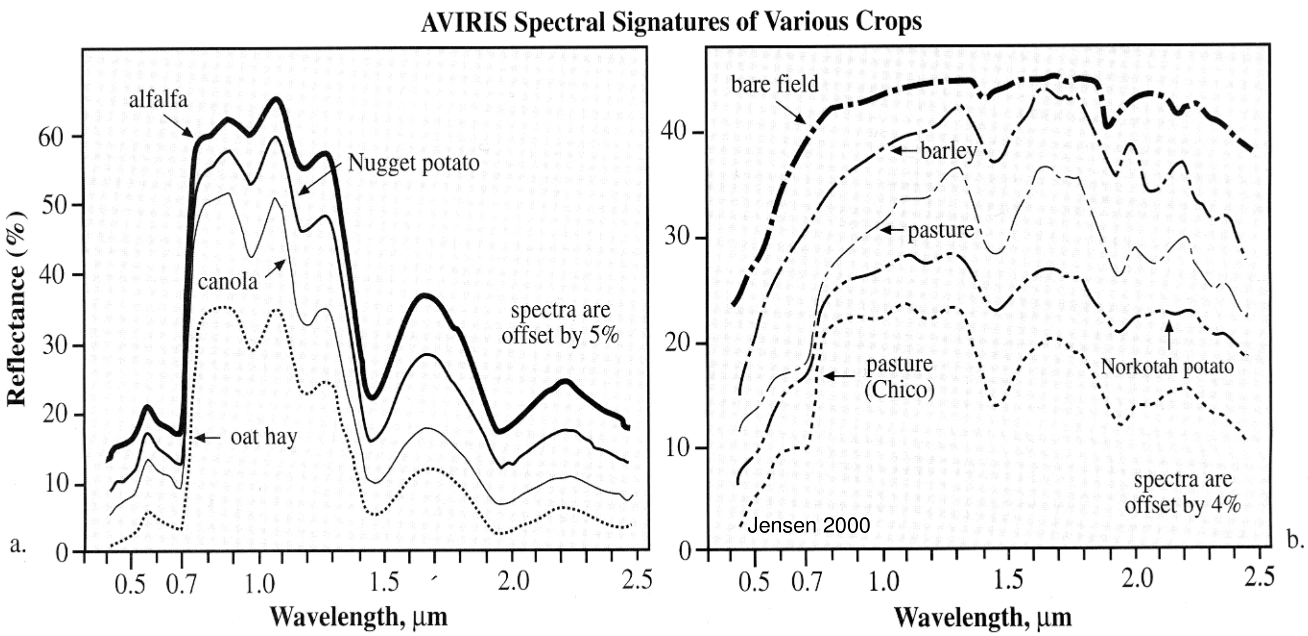
-recognize that there are certain Sun and/or sensor angle-of-view relation- ships that should be avoided when collecting remotely sensed data,

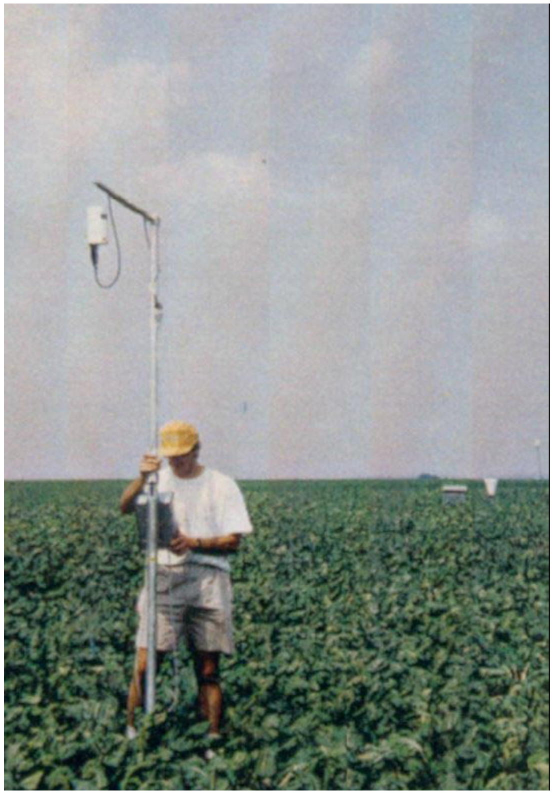
- provide methods to radiometrically adjust the remote sensor data to minimize BRDF effects.

Jensen 2000

Remote sensing of vegetation

Vegetation spectra – ground measurements





Vegetation Spectral library contains information on:

1) the spectral reflectance and emittance characteristics of every type of vegetation in the region from 350 - 1400 nm,
2) how these data appear on different dates throughout the pertinent growing seasons,
3) what these spectra should look like in the event of stress or insect infestation.

Remote sensing of vegetation

Temporal Characteristics of Vegetation

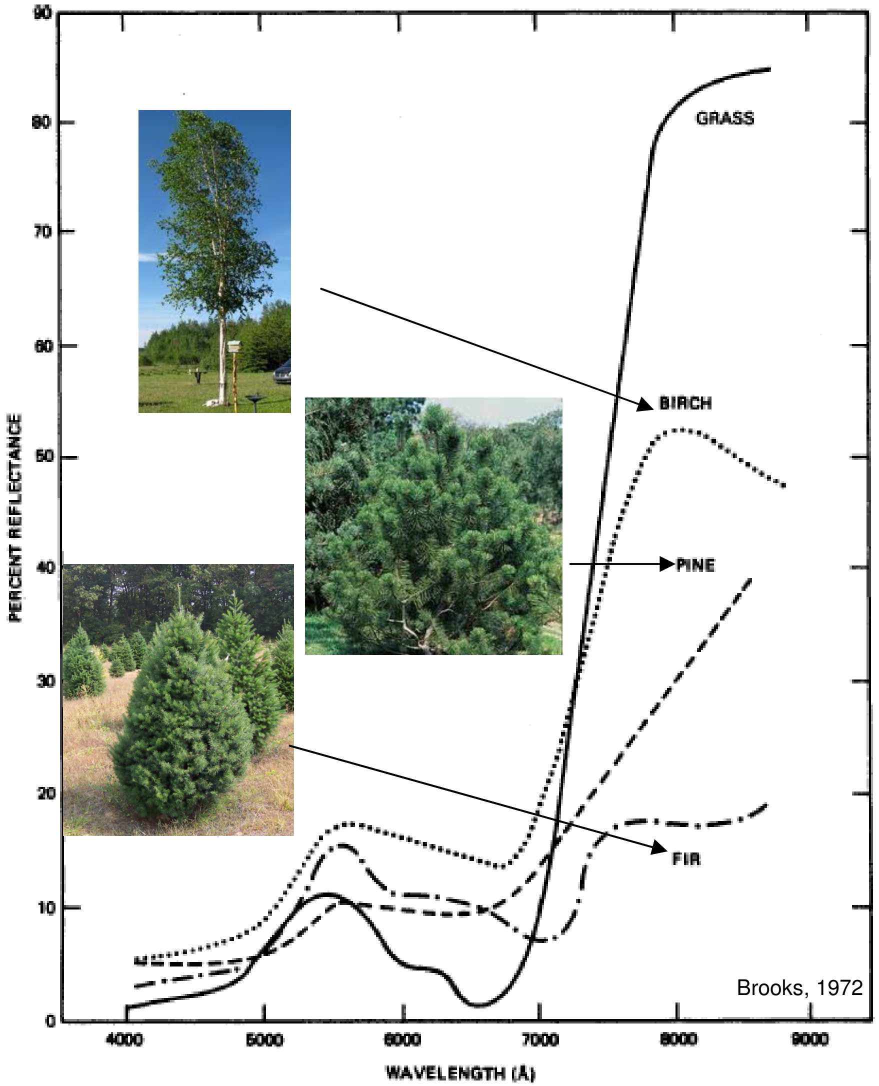
Discrimination between two crops using remote sensor data is possible if the crops were:

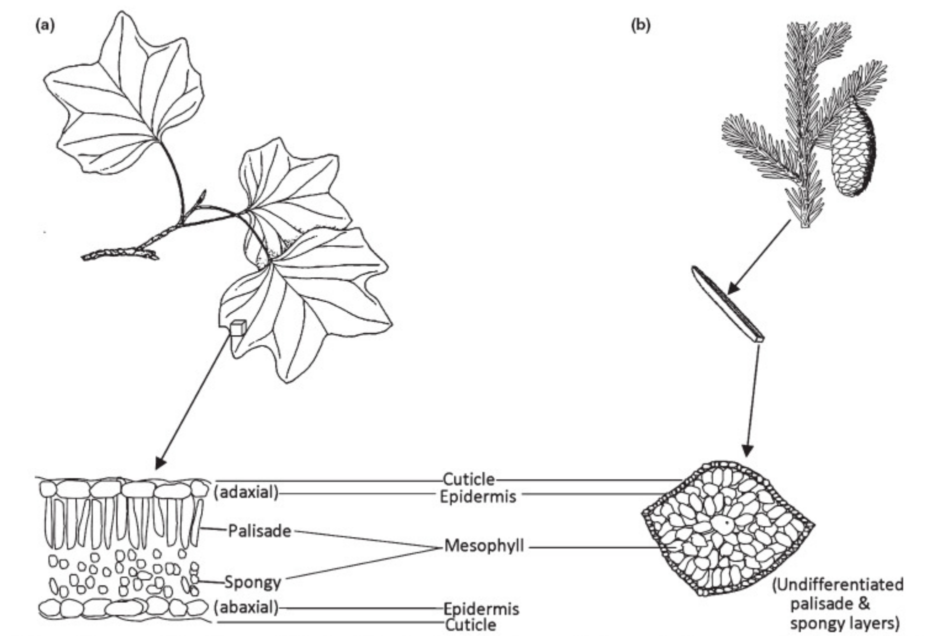
- planted at slightly different times in the growing season (e.g., 10 days apart),
- one crop received significantly different irrigation and/or fertilization than the other, causing it to produce more or less biomass;
- one crop matured more rapidly than the other (e.g., through fertilization or careful weeding) ;
- the row spacing or field orientation was dramatically different for the two crops;
- one crop has a different canopy structure.

Soil background or understory materials

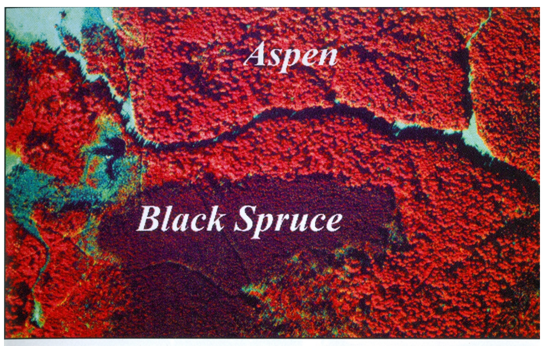
Remote sensing of vegetation

Species differences





Color Infrared photo

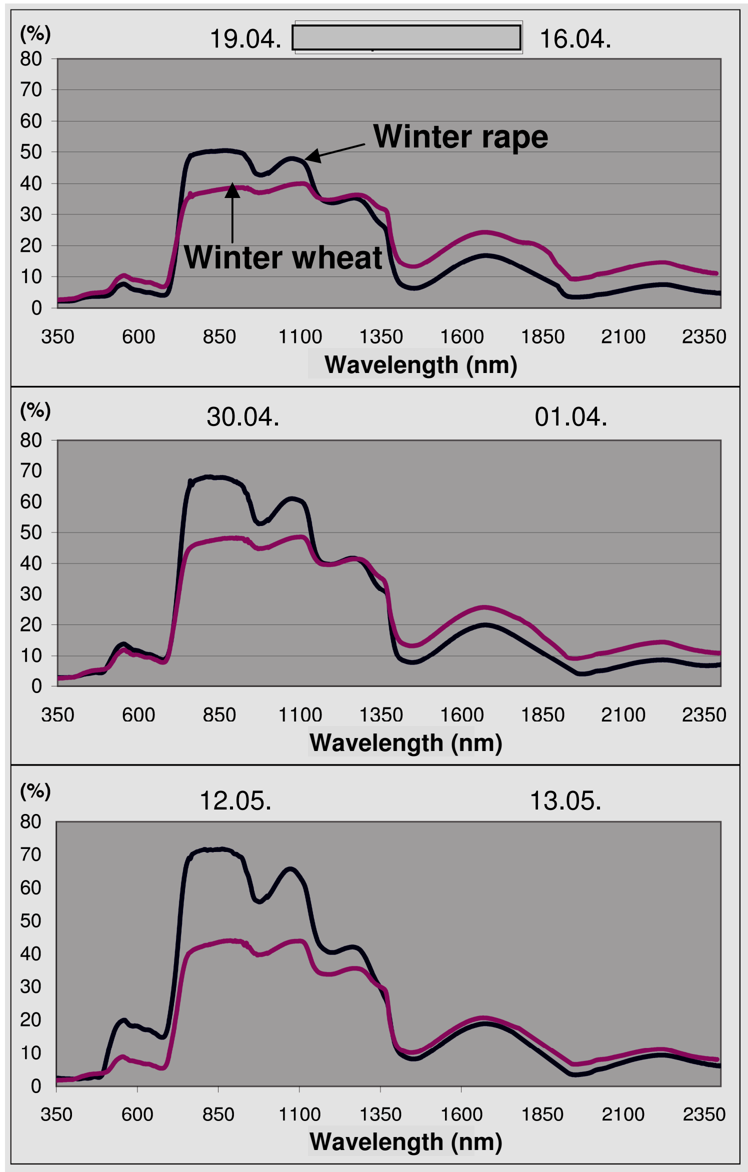


Remote sensing of vegetation

Temporal Characteristics of Vegetation

Spectra of winter rape and wheat crops

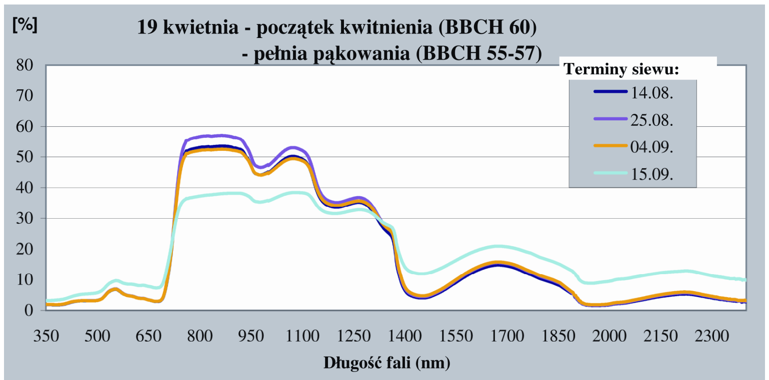
Winter rape plant soil cover		Winter wheat plant soil cover
50,6 %		34,4 %
67,9 %		57,7 %
73,1 %		58,0 %

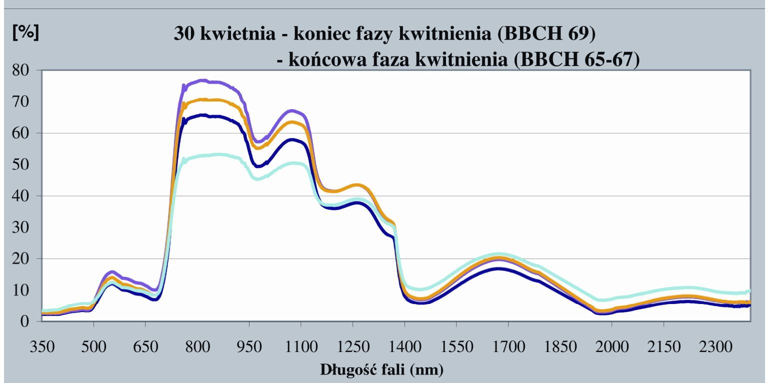


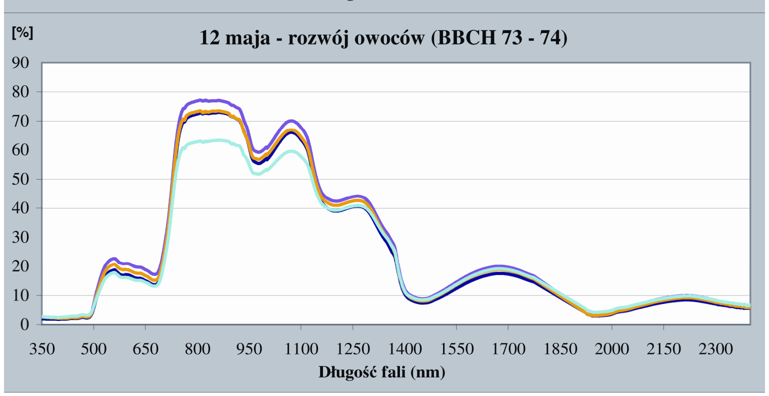
Remote sensing of vegetation

Temporal Characteristics of Vegetation

Winter rape – different sowing dates







Winter wheat – different N fertilization schemes