So, what absorbs in functioning leaves?

Leaf Spectral Reflectance

\[ \text{Reflectance}_\lambda = 1.0 - \text{Absorption}_\lambda \]

Liquid Water Absorption

\[ \text{Reflectance}_\lambda = 1.0 - \text{Absorption}_\lambda \]

Leaf Photosynthesis

Photosynthesis Determines Optical Properties

\[ \text{CO}_2 + \text{H}_2\text{O} \rightarrow \text{CH}_2\text{O} + \text{O}_2 \]
Leaf Photosynthesis

Photosynthesis Determines Optical Properties

**PHOTOSYNTHESIS**

- Must capture photons to drive chemical reactions (energy input)
- Must be in presence of H2O
- Must be in presence of CO2
- Must get rid of O2 (poisonous)
- Must live in hostile setting...

Internal Leaf Structure

- Intercellular air labyrinth
- Chloroplasts

Leaf Photosynthesis

- Stomata regulate gas exchange and water loss
- CO₂ in/O₂ out

Leaf Reflectance & Absorption

- in the Spongy Mesophyll

Vegetation indices--future topic

Piers Seller’s PAR Diagram

**PAR = photosynthetically Active**

\[
\text{PAR} = \text{photosynthetically Active} (0.4 - 0.7 \mu m)
\]

\[
\text{Normalized Difference} = \frac{(\lambda - \text{red})}{(\lambda + \text{red})}
\]

\[
\lambda = 0.6 
\]
**Leaf Optical Properties**

**Photosynthesis Action Spectrum**

**Leaf Reflectance**

More leaves = more leaf biomass

**Nondestructive Biological Mass (or biomass) Objective**

Grassland system -- very simple

Plant biomass is source of energy for system

Anything is better than clipping!!!

Clipping is limited for time & space extrapolations

**Time flies when you’re having fun**

**Regress Reflectance, vs plot variables**

At 0.385 µm a higher correlation between total dry biomass and reflectance than LWC.
Near UV-blue reflectance

Red & near IR reflectances

Summary of $r^2$ values vs. $\lambda$

High near-UV & lower blue reflectance-total biomass regression significance

Retention of carotinoids in dead leaves would explain this for 50% live & 50% dead experiment--carotinoids and chlorophyll a & b are in live fraction (why leaves are red in fall)

High green leaf biomass with no dead leaf biomass

All dead leaf biomass--no pigments remain
50% live & 50% dead

Leaf Reflectance & Absorption
Reflectance, \( R \), = 1.0 - Absorption, \( A \)
Transmission, transient if not absorbed, then reflected.

5880 K

Maple & Pine reflectance

Leaf Reflectance & Absorption
If no absorption, then the photons can be reflected or transmitted; transmitted photons are ultimately absorbed or reflected.

Leaf Reflectance & Absorption
Photosynthesis requires CO\(_2\) from atmosphere to be in contact with the plant cell surfaces. The intercellular labyrinth allows movement of CO\(_2\) into leaves and O\(_2\) out. Part of the “deal” is H\(_2\)O is lost.
**Leaf Reflectance & Absorption**

Beer-Lambert Law

\[ \text{Out}_\lambda = \text{In}_\lambda e^{(-\text{abs}_\lambda x)} \]

\[ \text{Out}_\lambda = \text{Flux out} \]

\[ \text{In}_\lambda = \text{Flux in before “x”} \]

abs\_\lambda = absorption coeff.

X = thickness of medium

How can a small concentration of absorbers (plant pigments) maximize absorption? — increase X

---

**Air-Cell Refraction of Light**

Index of refraction (n): \( n = c/c_n \)

Where \( c \) = speed of light in vacuum

\( c_n \) = speed of light in medium

Snell’s Law: \( n \sin \theta = n' \sin \theta' \)

\( n \sin \theta = n' \sin \theta' \)

---

If no absorption, photons can be reflected internally and/or refracted between air (1.0) and hydrated cells (1.33)