Vegetation Remote Sensing

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Outline

• Why do we study vegetation remote sensing?
• What characteristics of vegetation (or vegetation cover) do we usually measure?
• How can we quantify these characteristics from remotely sensed imagery?
• A case study of quantifying fractional vegetation cover
GEOBASE results for: **kw: vegetation and (kw: remote w sensing)**. Records found: **4,593**

GEOBASE results for: **kw: vegetation and (kw: remote w sensing) and kw: climate**. Records found: **322**;

GEOBASE results for: **kw: vegetation and (kw: remote w sensing) and kw: ecology**. Records found: **814**;

GEOBASE results for: **kw: vegetation and (kw: remote w sensing) and kw: hydrology**. Records found: **138**;

GEOBASE results for: **kw: vegetation and (kw: remote w sensing) and kw: agriculture**. Records found: **238**;

GEOBASE results for: **kw: vegetation and (kw: remote w sensing) and kw: forest**. Records found: **792**
Vegetation effect on climate

Global distribution of tropical savannas (Hoffmann & Jackson, 2000)
Modeled change from replacing savannas with grassland (Hoffmann & Jackson, 2000)
Modeled change from replacing savannas with grassland (Hoffmann & Jackson, 2000)
Ecological change

Pictures courtesy of Bradford Wilcox, Texas A&M
Vegetation and hydrology

From Scanlon et al. 2005
Creosote: ~0 mm/yr
Grass: < 0.1
Juniper: 0.4
Ponderosa: 2.3

Recharge:

Sandvig, 2005
Agriculture

- Crop types and areas
- Irrigation
- Growth regulator application
- Stress detection
- Yield estimates
- ...

www.flightgear.org/
An example, remotely sensed fuel moisture content

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What do we measure?

• Fractional vegetation cover
• Vegetation type
• Vegetation health status
  – Stress (water, disease, …)
• Leaf area index, …
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Big Bluestem Grass
Hemispherical Reflectance, Transmittance, and Absorption
Absorption Spectra of Chlorophyll a and b, β-carotene, Pycoerythrin, and Phycocyanin Pigments

Chlorophyll a peak absorption is at 0.43 and 0.66 µm.

Chlorophyll b peak absorption is at 0.45 and 0.65 µm.

Optimum chlorophyll absorption windows are:

0.45 - 0.52 µm and 0.63 - 0.69 µm

Jensen, 2000
Water absorption bands:
- 0.97 µm
- 1.19 µm
- 1.45 µm
- 1.94 µm
- 2.70 µm

Primary absorption bands:
- Chlorophyll absorption bands
- Atmospheric water absorption bands

Dominant factors controlling leaf reflectance:
- Leaf pigments in the palisade mesophyll:
  - chlorophyll $a$, $b$
  - $\beta$-carotene, etc.
- Scattering in the spongy mesophyll
- Leaf water content

Jensen, 2000
Spectral reflectance changes with foliage water content

Relative Water Content of *Magnolia grandiflora*

- 5%
- 25%
- 50%
- 75%
- 100%

Jensen, 2000
The diagram shows the reflectance spectra of spruce and soil across different wavelengths. The graph plots reflectance on the y-axis against wavelength (nm) on the x-axis. The red region is labeled as 'Red' and the near-infrared region is labeled as 'Near infrared'. The data points for spruce are indicated with green asterisks, and the data points for soil are indicated with orange dots.
The generic normalized difference vegetation index (NDVI):

\[
NDVI = \frac{NIR - \text{red}}{NIR + \text{red}}
\]

has provided a method of estimating net primary production over varying biome types (e.g. Lenney et al., 1996), identifying ecoregions (Ramsey et al., 1995), monitoring phenological patterns of the earth’s vegetative surface, and of assessing the length of the growing season and dry-down periods (Huete and Liu, 1994).
Vegetation Indices

Other vegetation indices (condensed from p. 363 in Jensen)

Infrared index $II = \frac{NIR_{TM4} - SWIR_{TM5}}{NIR_{TM4} + SWIR_{TM5}}$

Moisture stress index $MSI = \frac{SWIR_{TM5}}{NIR_{TM4}}$

Soil adjusted index $SAVI = \frac{(1 + L)(NIR - \text{red})}{NIR + \text{red} + L}$, where $L \approx 0.5$

Enhanced vegetation index $EVI = \frac{P_{\text{nir}}^* - P_{\text{red}}^*}{P_{\text{nir}}^* + C_1 P_{\text{red}}^* - C_2 P_{\text{blue}}^* + L} (1 + L)$

where the $P^*$ terms are atmospherically corrected reflectances
Vegetation Indices

More indices related to vegetation water stress (reviewed by Stimson et al. 2005):
1. Water absorption index (R895/R972)
2. Normalized difference infrared index [(R819-R1649)/(R819+R1649)]
3. Equivalent water thickness (R867~R1049)
4. Red edge

(less subject to background effect)
Vegetation Indices

Derive biophysical variables from vegetation indices

For example,

1) Leaf area index: \( \text{LAI} = a + b \text{ NDVI} \)

2) Fractional photosynthetically active radiation
   \( \text{FPAR} = a + b \text{ NDVI} \)

Both are related to NPP, a measurement of plant growth obtained by calculating the quantity of carbon absorbed and stored by vegetation.
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Study sites
Method

(1) Pixel reflectance = Vegetation reflectance * Fr
                  + Soil reflectance *(1-Fr)

Or

(2) Pixel NDVI = Vegetation NDVI * Fr
                  + Soil NDVI *(1-Fr)
Collect
End-member
Spectral signature
For shrub site

Reflectance model gave:
Fr = 0.30;

NDVI model gave:
Fr = 0.12

Measured Fr:
~ 0.3

Results

For Pinyon ~ Juniper site

Why?
Work undergoing

October 19, 2005
Exercises

(1) Convert radiance measurements to spectral reflectance, and plot the result

(2) Find the red-edge inflection point by looking at the first derivative of the reflectance-wavelength curve

(3) Calculate NDVI using Landsat ETM bandwidths
   Red: 630-690, NIR: 780-900

(4) Calculate NDVI using MODIS bandwidths
   Red: 620-670, NIR: 841-876

(5) How much difference are the numbers from (2) and (3)?