Optical properties of vegetation and VIs

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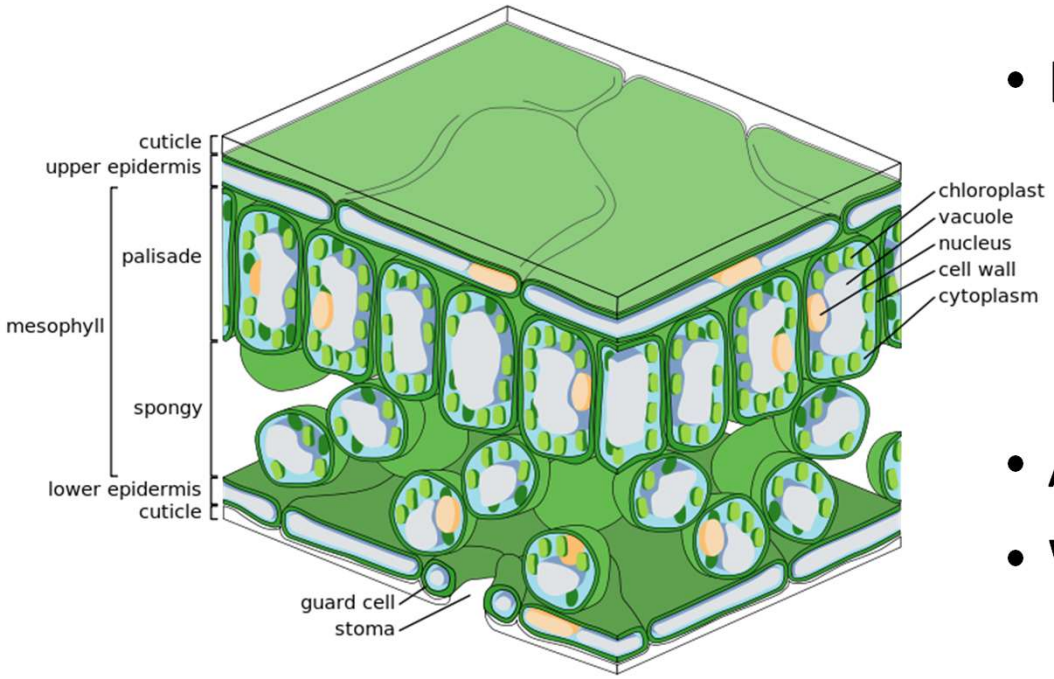
TerraNor Remote sensing user meeting - Ås, 06.02.2020

Image: colourbox

Leaf tissue structure – optical properties



- Leaf pigments
  - Chl A
  - Chl B
  - Beta Carotene
  - Anthocyanine
- Airspaces
- Water content

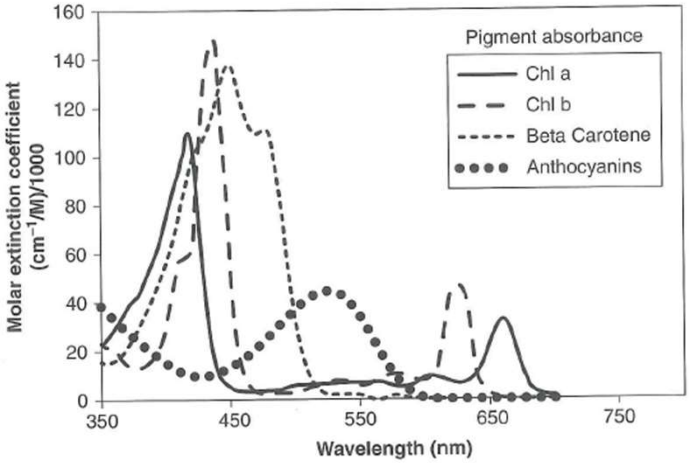
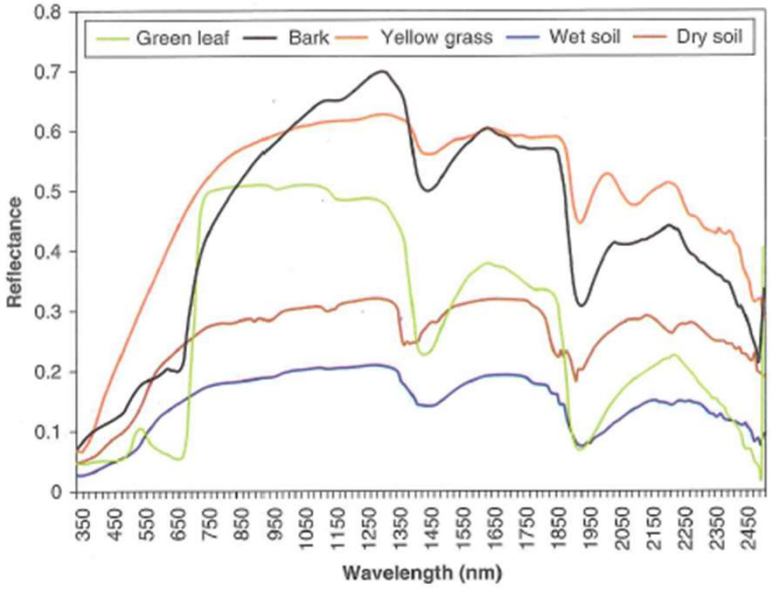
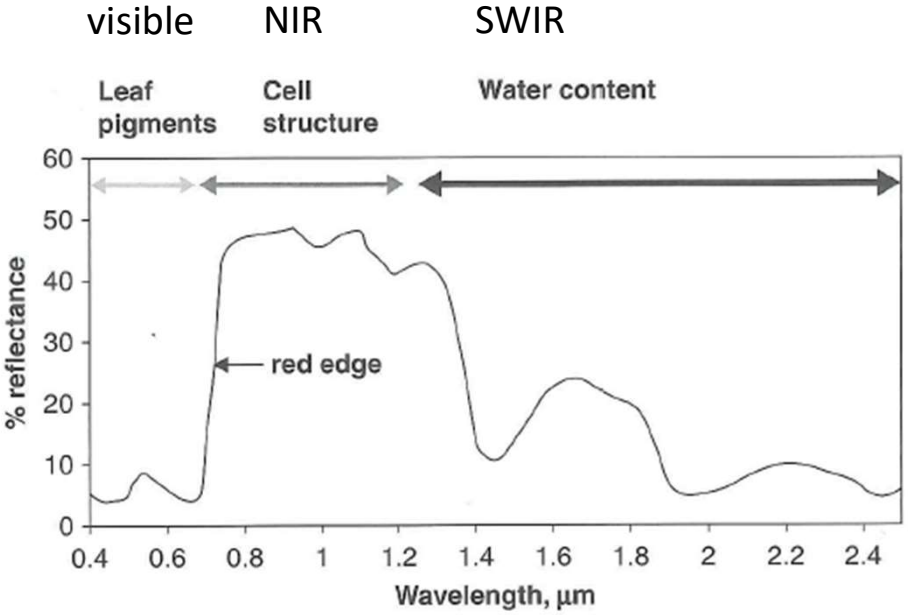


Figure from Eamus et al, 2016

Spectral signatures



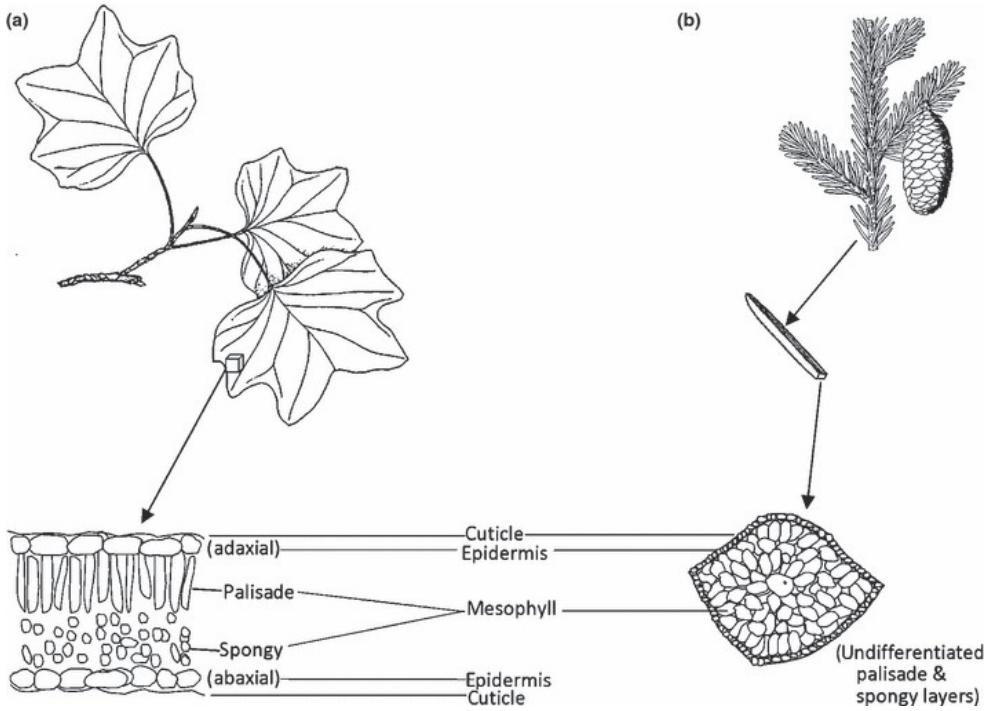
- Comparison of reflectance from vegetation and soil

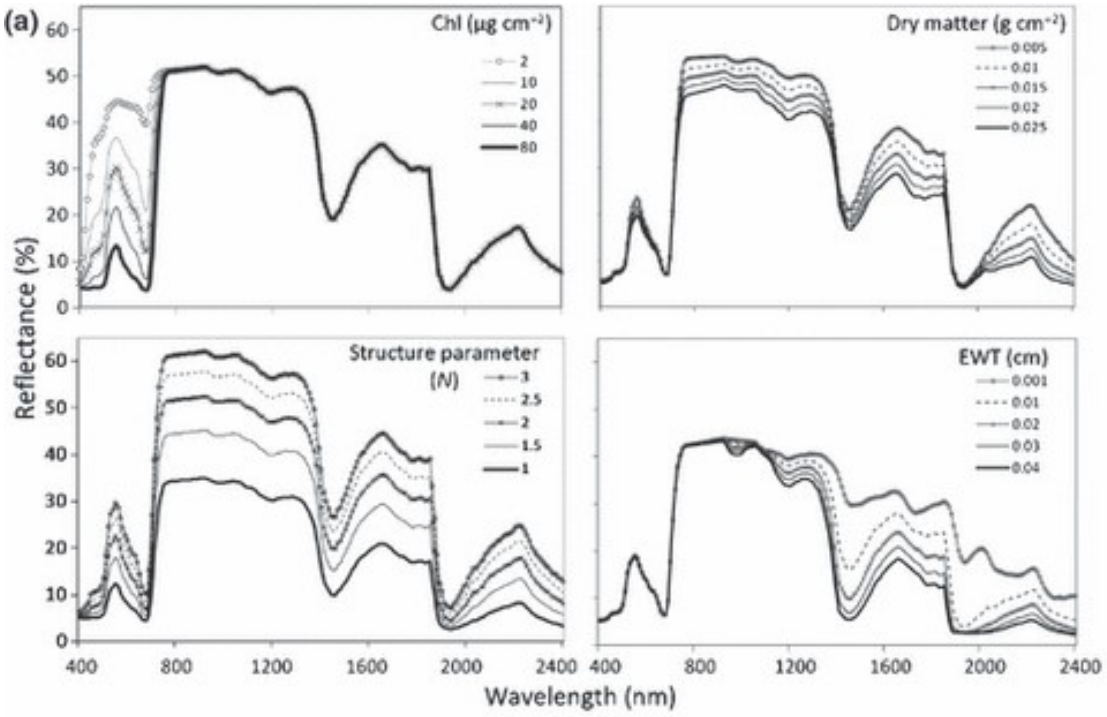


- The three main spectral regions for a green leaf

Figures from Eamus et al, 2016

Leaf structure and spectral reflectance varies

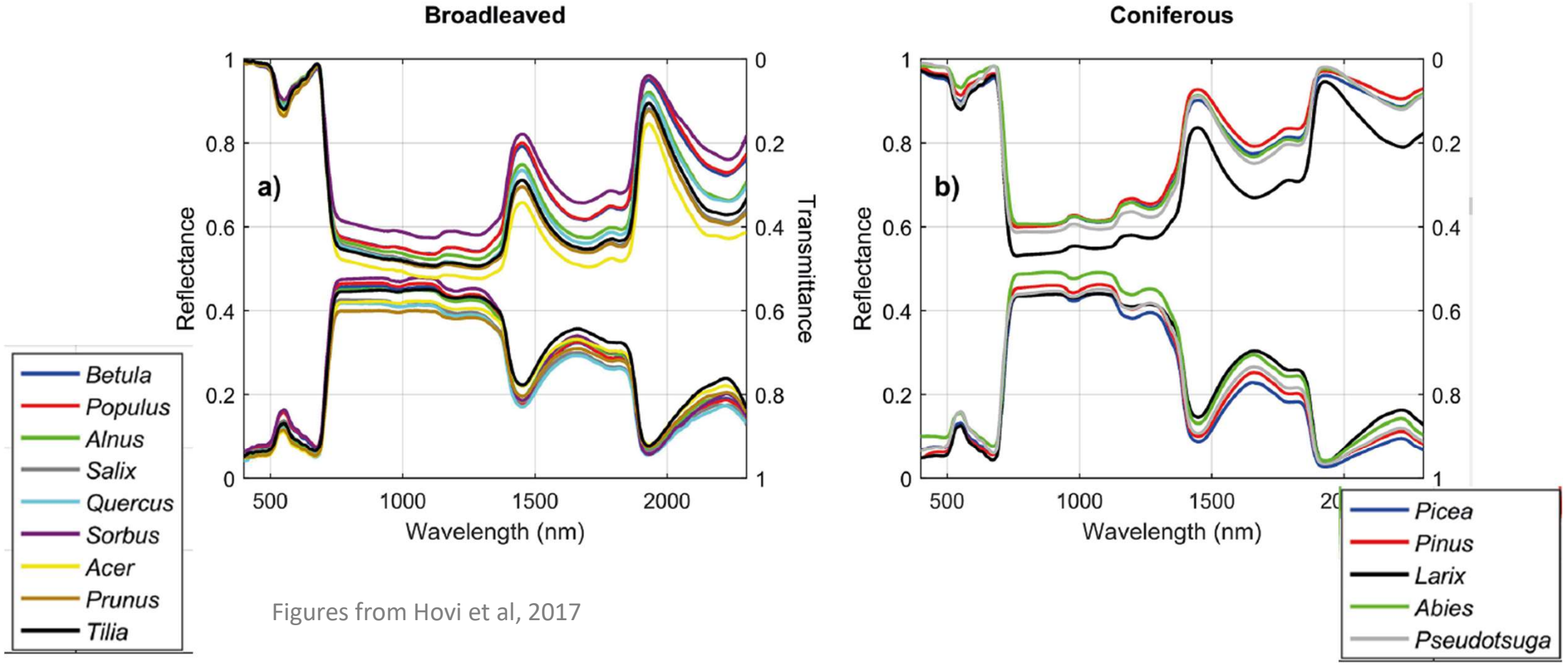




EWT –
Liquid water content

Figures from Ollinger, New Phytologist, Volume: 189, Issue: 2, Pages: 375-394, First published: 16 November 2010, DOI: (10.1111/j.1469-8137.2010.03536.x)

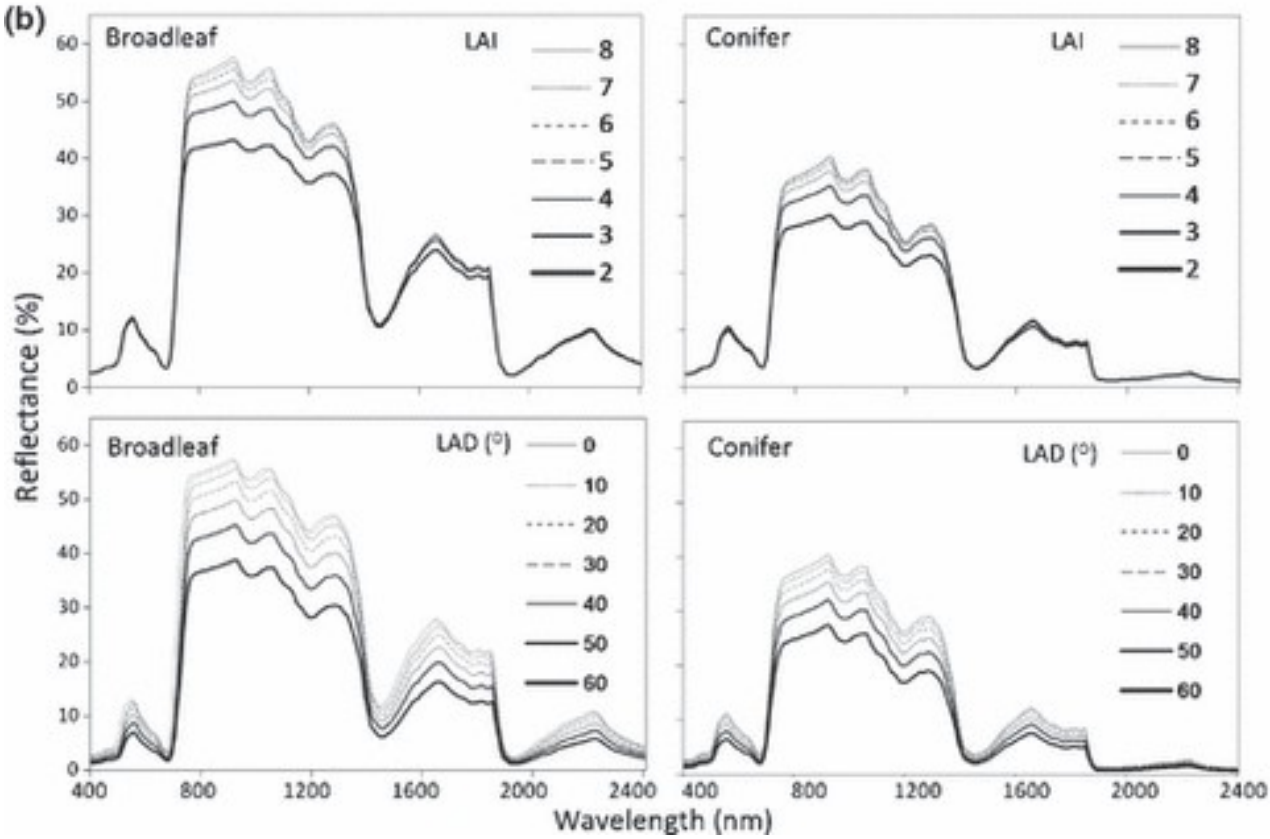
Spectral signature variation across species



Figures from Hovi et al, 2017

Leaves build canopies

- leaf area index (LAI)
  - One of the most widely used descriptors of canopy structure
  - defined as the ratio of total leaf area to ground area.
- leaf angle distribution (LAD)
  - incorporates the gradient between vertically and horizontally inclined leaves within
  - describe the general shape of the crown



Figures from Ollinger, New Phytologist, Volume: 189, Issue: 2, Pages: 375-394, First published: 16 November 2010, DOI: (10.1111/j.1469-8137.2010.03536.x)

The satellite sensor receives a mix of signals

- Leaves – canopies
  - Phenology, structure, …
- Brown vegetation parts
- Litter on the ground/soil/background
- Other factors also influence the signal
  - Solar - view geometry
  - Atmosphere/aerosol

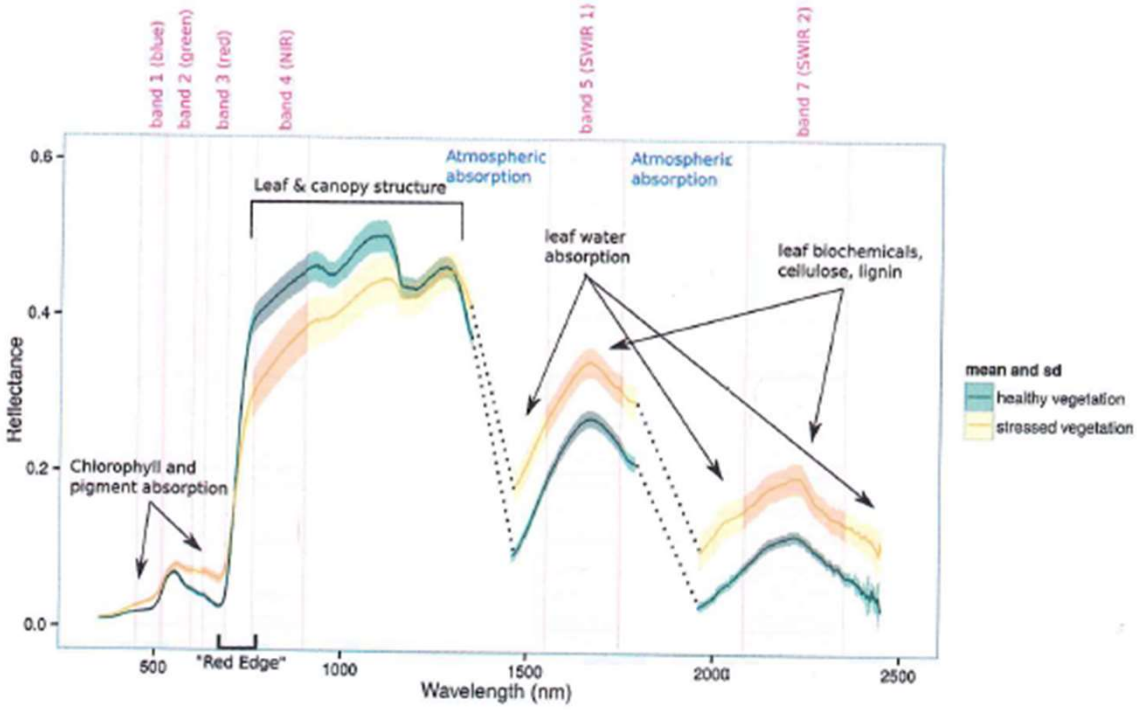
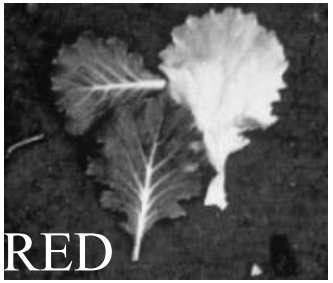
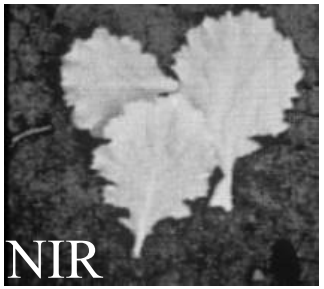


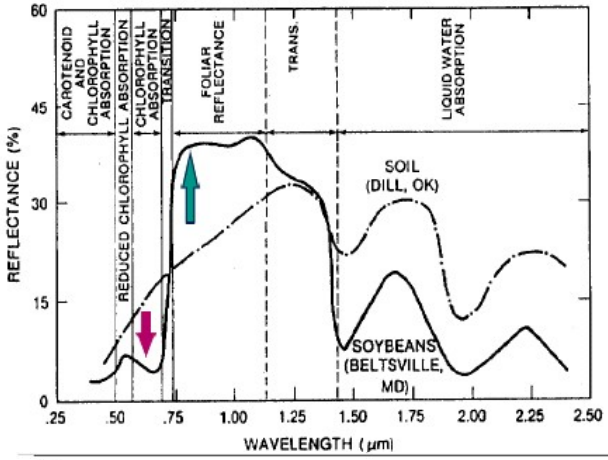
Fig. from Remote sensing and GIS for ecologists

Vegetation indices





- Measures green foliage status of a canopy / greeness
  - Leaf physiology, Canopy structure, Canopy photosynthetic acticity
  - Proxy for biophysical variables
- Contrast between R and NIR, in relation to soil line

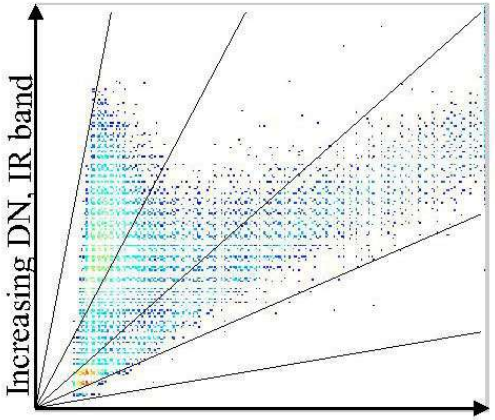


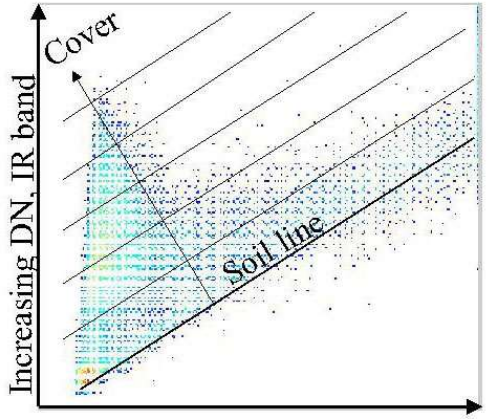
Index	Definition	Reference
MRESR	$\frac{(\rho_{750}-\rho_{445})}{(\rho_{705}-\rho_{445})}$	[104, 105]
MSAVI2	$0.5*\left[(2\mathrm{NIR}+1)-\sqrt{(2\mathrm{NIR}+1)^2-8(\mathrm{NIR}-R)}\right]$	[106]
MSBI	$(0.406\mathrm{MSS}_4+0.60\mathrm{MSS}_5+0.645\mathrm{MSS}_6+0.243\mathrm{MSS}_7)$	[102]
MSAVI	$0.5*\left\{2R_{800}+1-\mathrm{SQRT}\left[(2R_{800}+1)^2-8(R_{800}-R_{670})\right]\right\}$	[51]
MSR	$\frac{[(R_{800}/R_{670})-1]}{[\mathrm{SQRT}(R_{800}/R_{670}+1)]}$	[106]
MSI	$\frac{\rho_{1599}}{\rho_{819}}$	[107]
MTVI	$1.2*[1.2(R_{800}-R_{550})-2.5(R_{670}-R_{550})]$	[101]
MTVI2	$\frac{1.5*[1.2(R_{800}-R_{550})-2.5(R_{670}-R_{550})]}{\sqrt{(2*R_{800}+1)^2-(6*R_{800}-5*\sqrt{R_{670}})-0.5}}$	[101]
MYVI	$(0.723\mathrm{MSS}_4-0.597\mathrm{MSS}_5+0.206\mathrm{MSS}_6-0.278\mathrm{MSS}_7)$	[102]
NDGI	$\frac{(G-R)}{(G+R)}$	[78]
NDI	$\frac{(\mathrm{NIR}-\mathrm{MIR})}{(\mathrm{NIR}+\mathrm{MIR})}$	[108]
NDI1	$\frac{(R_{780}-R_{710})}{(R_{780}-R_{680})}$	[109]

Extracts of 4 pages of tables of Vis from Xue and Su, 2017

Categories of VIs

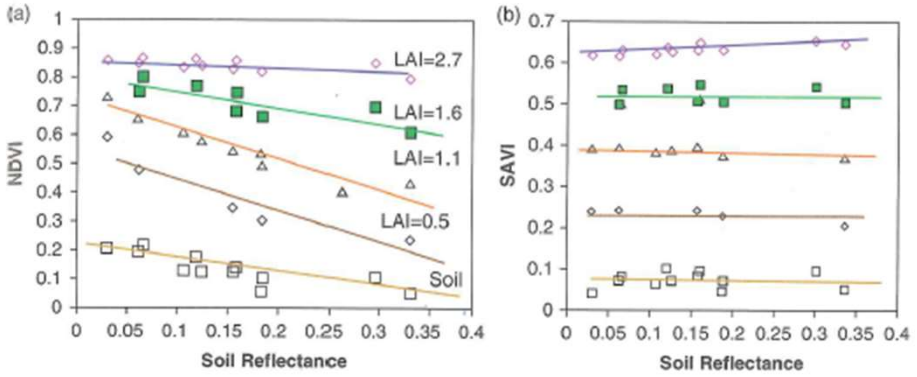
- Ratio – simple and normalised VIs
  - VI and NDVI
- Linear VIs
  - PVI, tasseled cap greeness
- Optimised VIs
  - Basic radiative transfer theory to account for soil/atmosphere interactions
  - SAVI
- Spectral Mixture Analysis
  - Model pixel value based on spectral signals and cover of each element





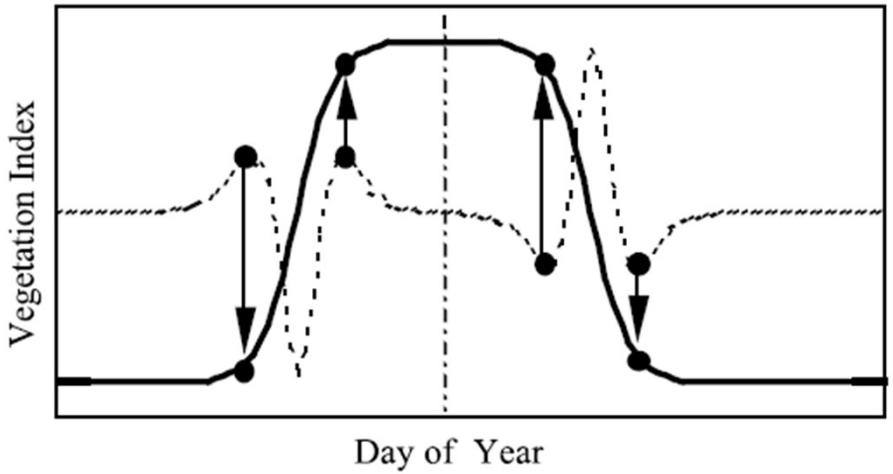
VI = IR/R
NDVI = (IR – R)/ (IR+R)

PVI = $\sqrt{(\rho soil - \rho veg)^2_R - (\rho soil - \rho veg)^2_{NIR}}$
PVI= (IR-(a*R)- (b))/(SQRT(1+(a**2)))

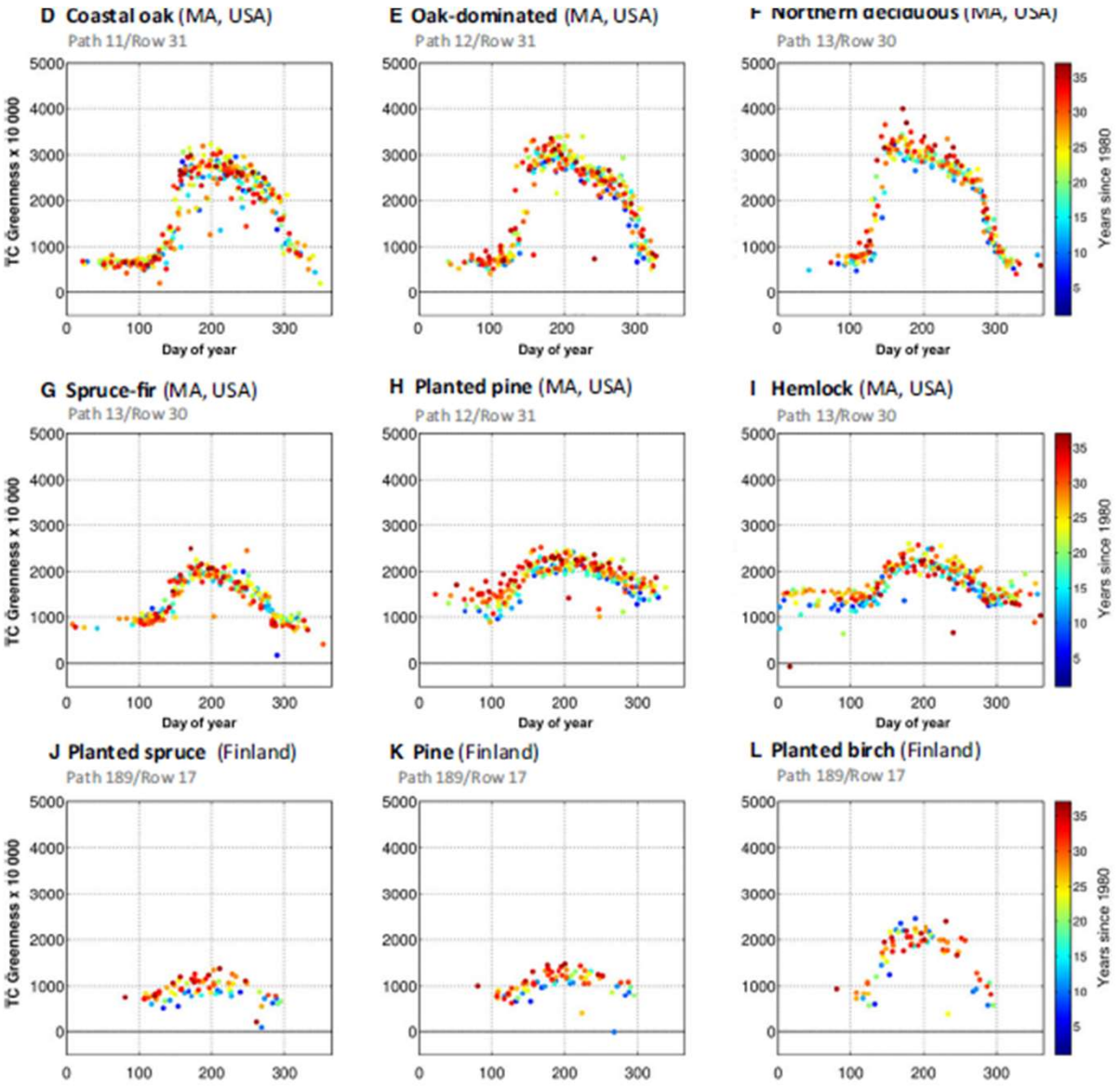


SAVI = ((IR- R) / (IR+R+0.5))*(1.5)

Time as an extra signature variable

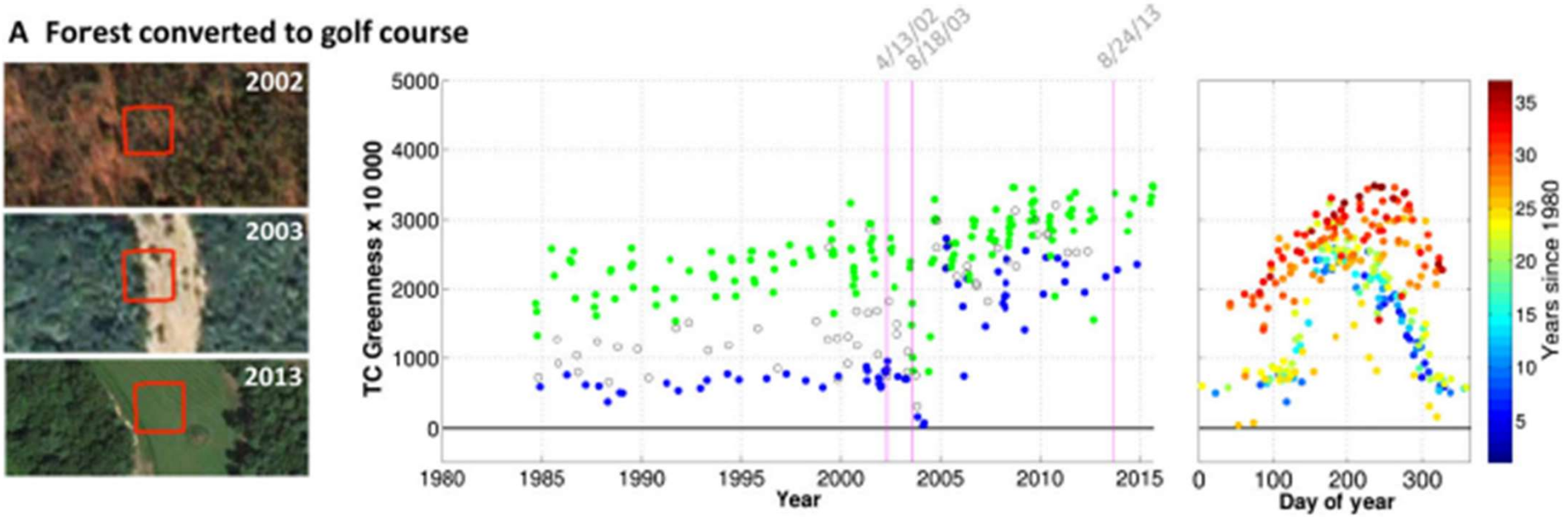


From Zhang et al , 2003



Pasquarella et al., 2016

Timeseries and change



Pasquarella et al., 2016

Conclusion

- **A VI is more than NDVI**
- **Different VIs can emphasize different vegetation properties**
- **Different VIs can be used in combination**
- **Leaf – canopy – background – a complex mix of signals**
- **Be aware of noise and bias**
  - BDRF /viewing geometry
  - Topographic effects (sun/shade)
  - Cloud/aerosols

Thank you

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