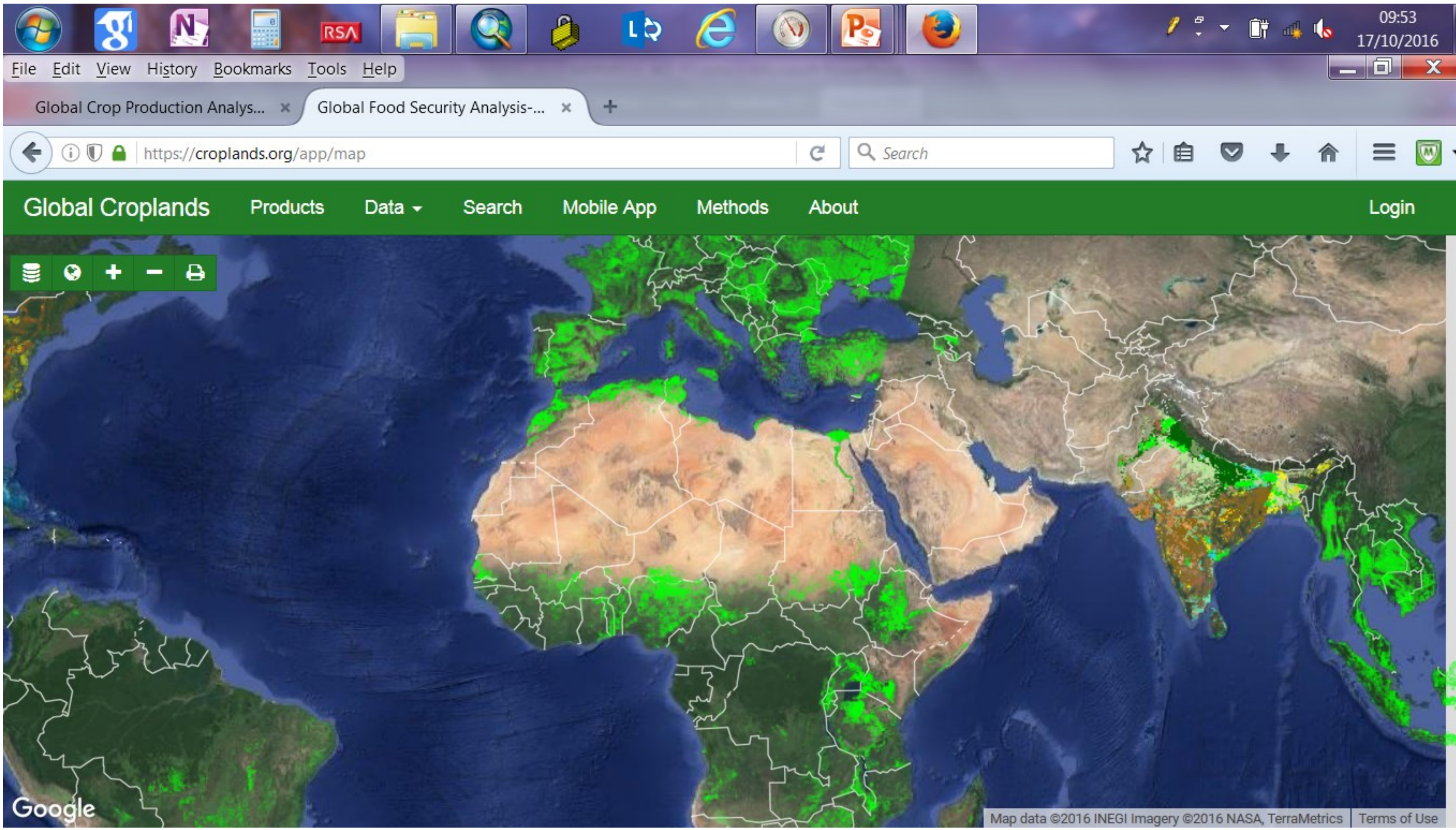
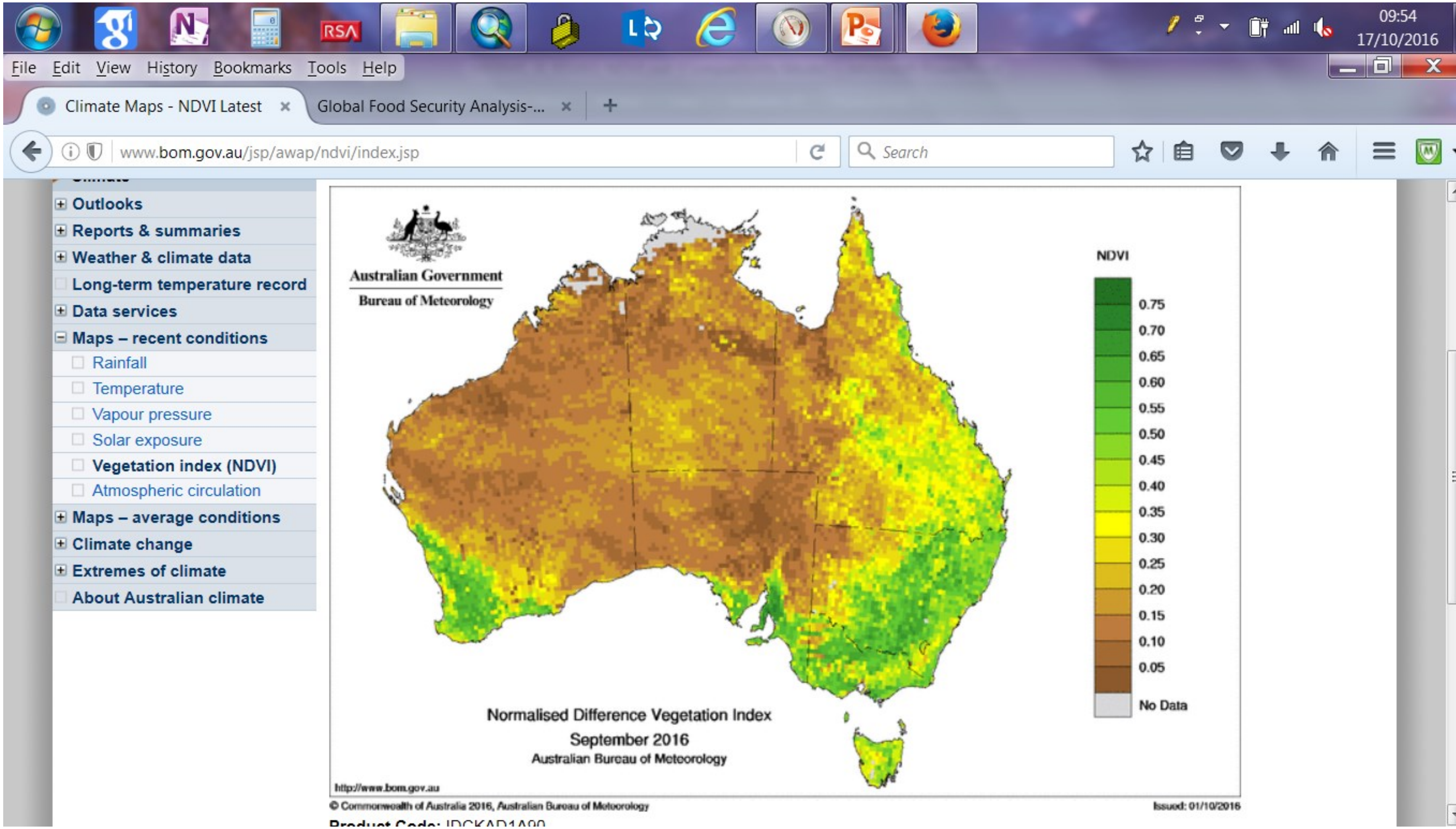
# Remote Sensing Classifying vegetation: Indices ,Thresholds & Unsupervised Classifcation

***Stuart Green***

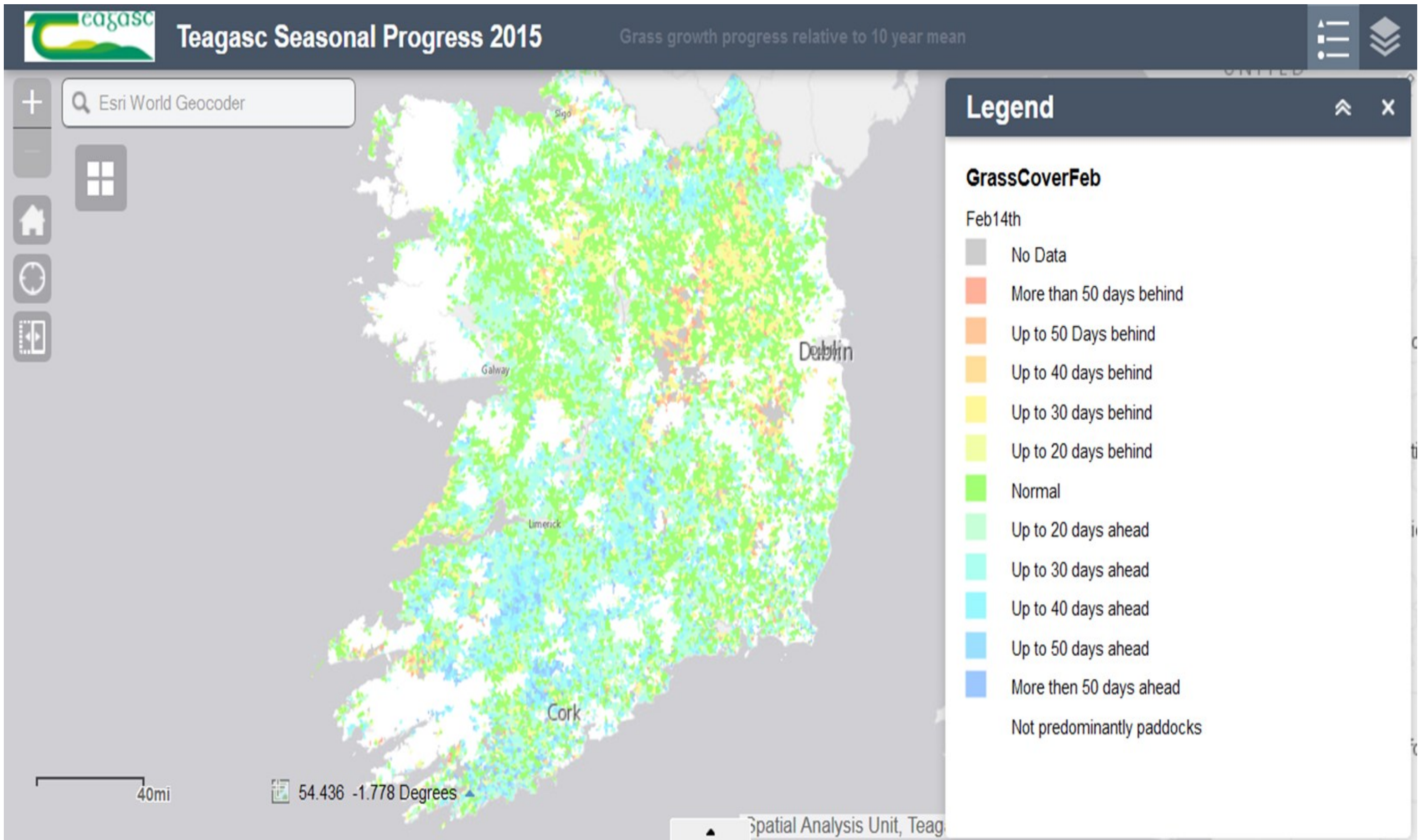
*Stuart.green@teagasc.ie*

# Quantifying "Greeness"





09:54
17/10/2016
File Edit View History Bookmarks Tools Help
Climate Maps - NDVI Latest
Global Food Security Analysis-...
www.bom.gov.au/jsp/awap/ndvi/index.jsp
Search
Outlooks
Reports & summaries
Weather & climate data
Long-term temperature record
Data services
Maps – recent conditions
Rainfall
Temperature
Vapour pressure
Solar exposure
Vegetation index (NDVI)
Atmospheric circulation
Maps – average conditions
Climate change
Extremes of climate
About Australian climate
Australian Government
Bureau of Meteorology
NDVI
0.75
0.70
0.65
0.60
0.55
0.50
0.45
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
No Data
Normalised Difference Vegetation Index
September 2016
Australian Bureau of Meteorology
http://www.bom.gov.au
© Commonwealth of Australia 2016, Australian Bureau of Meteorology
Issued: 01/10/2016



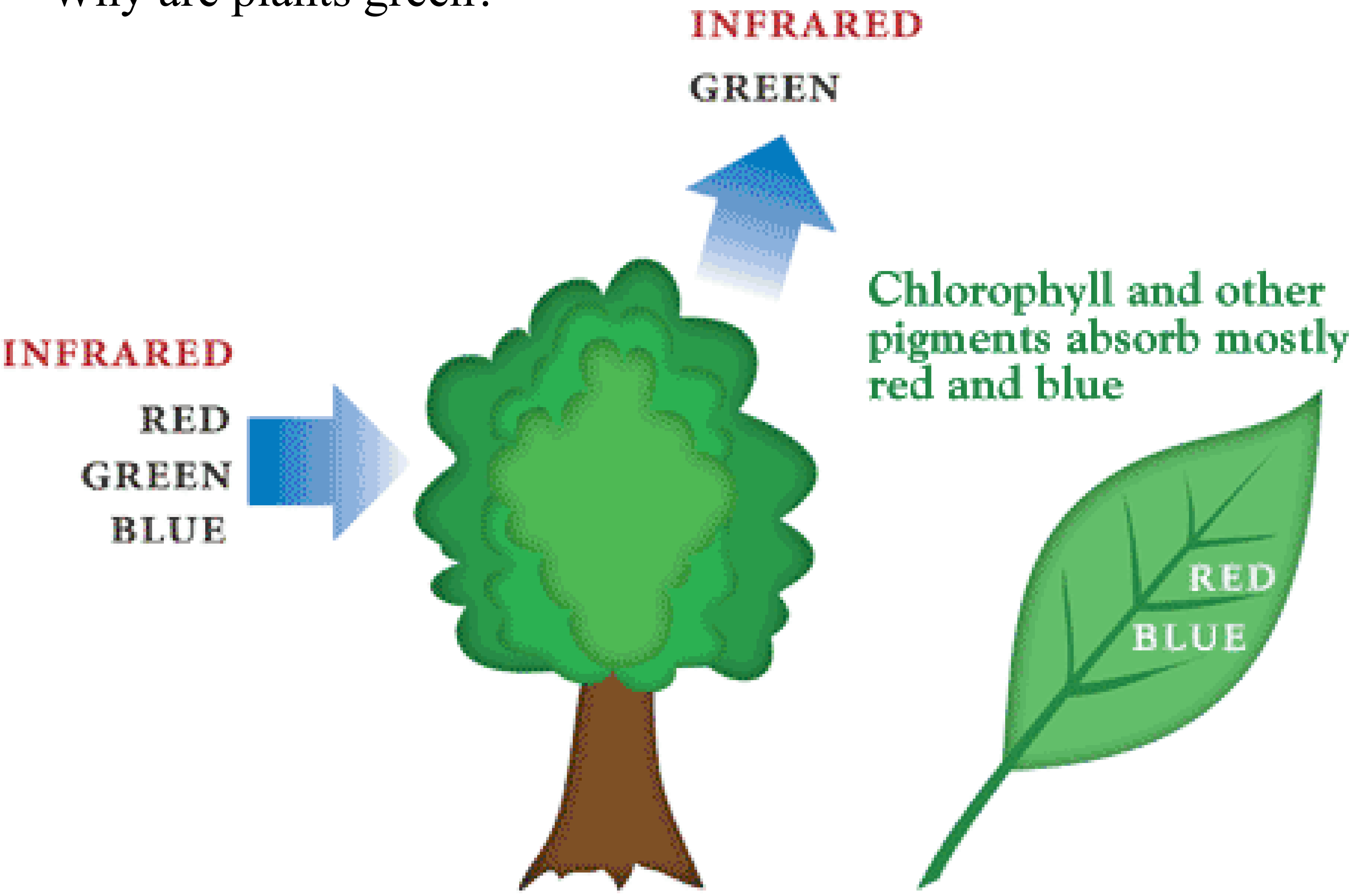
Teagasc Seasonal Progress 2015
Grass growth progress relative to 10 year mean
Esri World Geocoder
Legend
GrassCoverFeb
Feb14th
No Data
More than 50 days behind
Up to 50 Days behind
Up to 40 days behind
Up to 30 days behind
Up to 20 days behind
Normal
Up to 20 days ahead
Up to 30 days ahead
Up to 40 days ahead
Up to 50 days ahead
More then 50 days ahead
Not predominantly paddocks
Dublin
Galway
Limerick
Cork
40mi
54.436 -1.778 Degrees

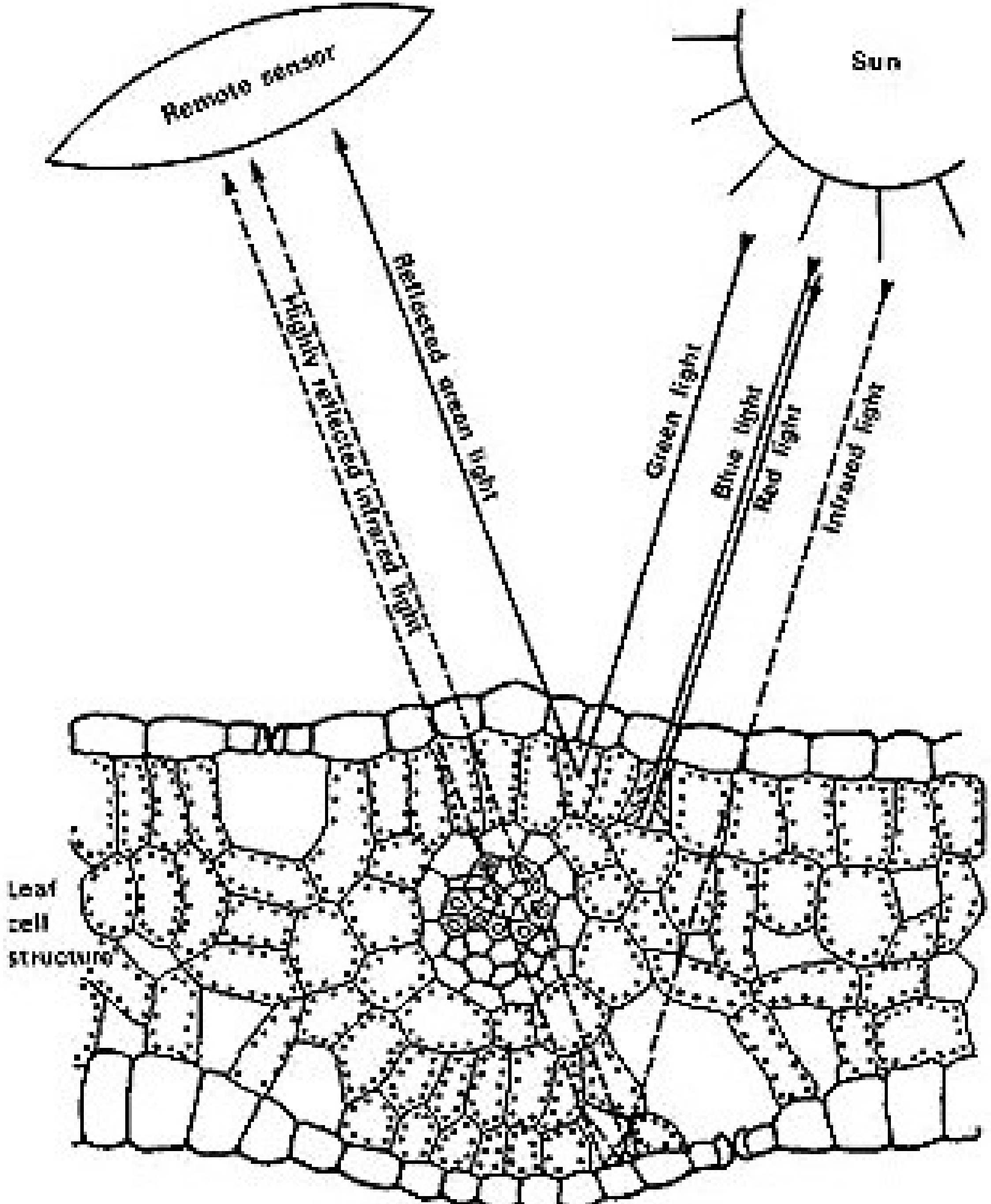
# Cover, leaf area, LAI, and biomass

# Conventional Methods

• **Biomass**: The mass per unit area of vegetation.
• **Cover**: The vertical projection of the plant parts on the ground surface per unit area
of ground. Usually expressed as a percent. No species can have more than 100% cover.
• **Leaf Area Index:** The ratio of the area of leaves and green vegetation in theplant canopy per unit area of ground surface. LAI can exceed 1.The only way to get true leaf area is to strip all the leaves off the plants and measure their area. All other methods provide an "index" of this value
**FPAR** measures the proportion of available radiation in the photosynthetically active wavelengths (400 to 700 nm) that a canopy absorbs.
• **Normalized Difference Vegetation Index** (NDVI): An index of *vegetation greenness* derived from remote sensing methods. Often used as an index
of biomass.

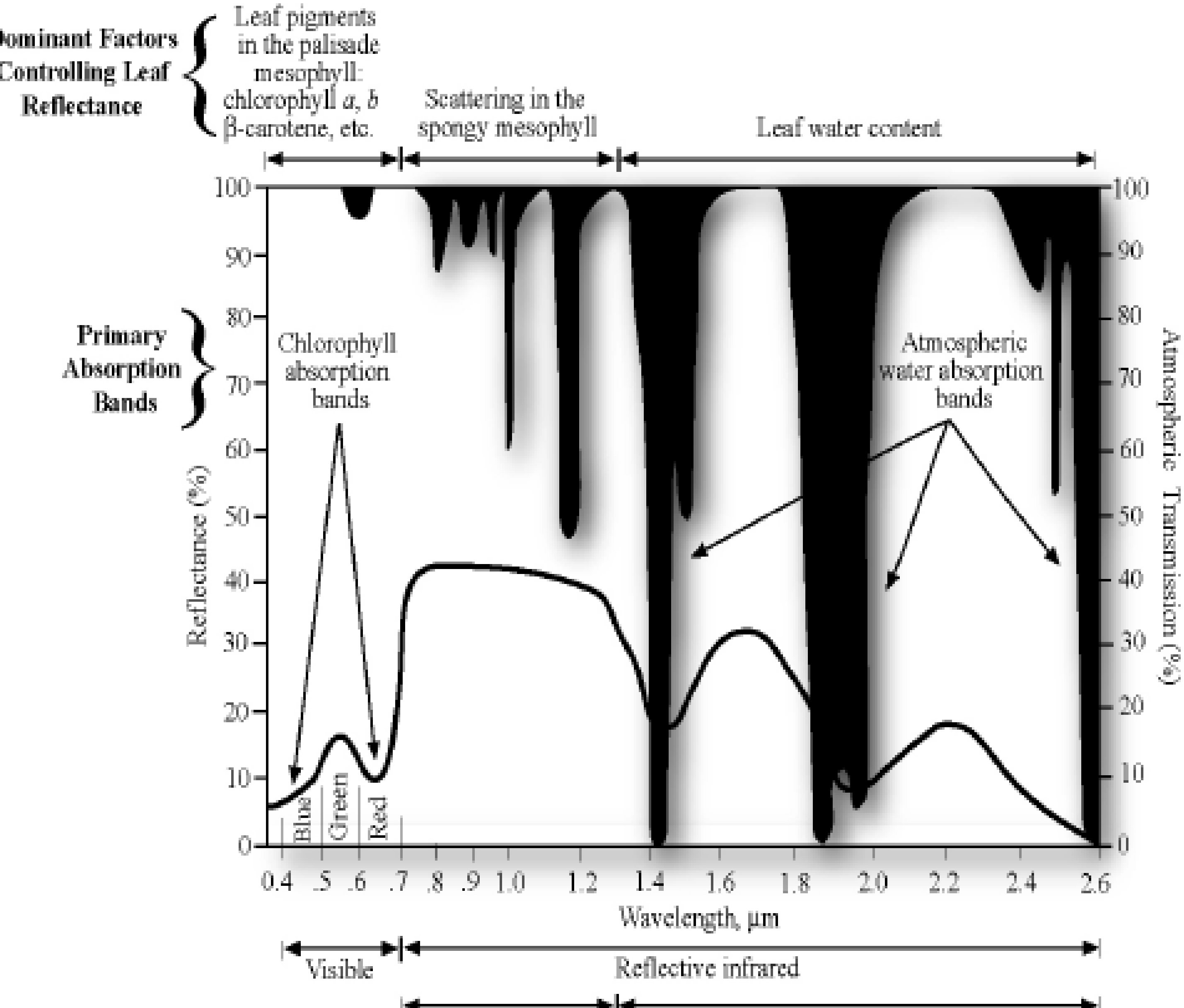
# Why are plants green?





Remote sensor
Sun
Highly reflected infrared light
Reflected green light
Green light
Blue light
Red light
Infrared light
Leaf
cell
structure

# DOMINANT FACTORS CONTROLLING LEAF REFLECTANCE




**Water absorption bands:**
0.97 µm
1.19 µm
1.45 µm
1.94 µm

# DOMINANT FACTORS CONTROLLING LEAF REFLECTANCE

SUMMARY:

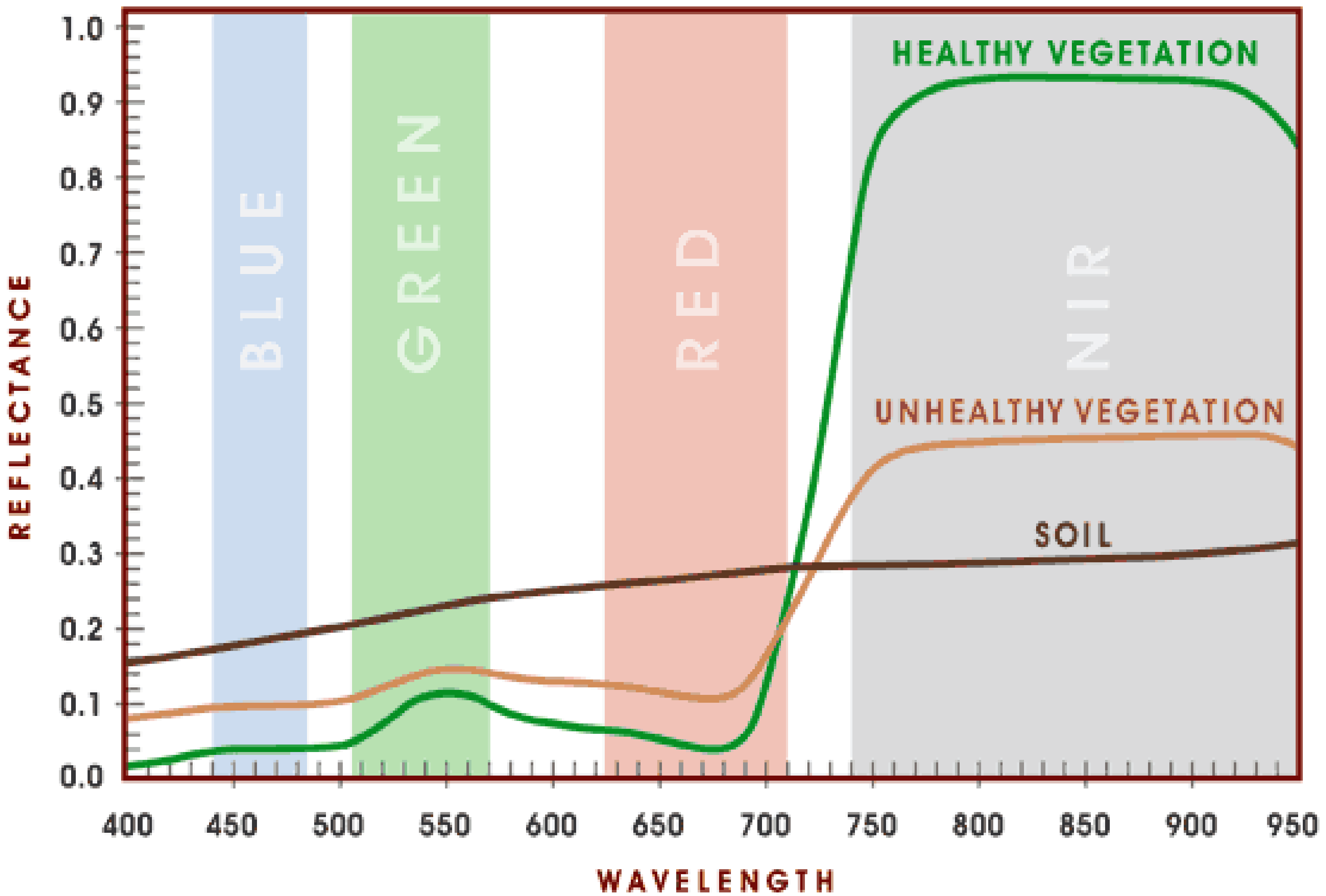
The dominant factors controlling leaf reflectance are…

- 0.4 – 0.75μm: the various leaf pigments in the palisade mesophyll (*e.g.* chlorophyll *a* & *b*, and β-carotene).
- 0.75 – 1.35μm: the scattering of near infrared (NIR) energy in the spongy mesophyll, and
- 1.35 – 2.8μm: the amount of water in the plant.

# Vegetation Indices?

- The gigantic chlorophyll absorption well distinguishes vegetation from non-vegetation.
- Its size tells us chlorophyll concentration in the leaf and the canopy.
- Many vegetation indices are a simplistic attempt to estimate the size of this absorption well.

A Vegetation Index is a single number- usually from 0-1 that uses measurement o reflected light form the vegetation canopy to tell us information about the biomass in the canopy



REFLECTANCE
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
BLUE
GREEN
RED
NIR
HEALTHY VEGETATION
UNHEALTHY VEGETATION
SOIL
400
450
500
550
600
650
700
750
800
850
900
950
WAVELENGTH

# Vegetation Indices

Vegetation indices (VI's) can be broken up into two basic categories:

Ratio based indices – VI's based on the ratio of two or more radiance, reflectance, or DN values (or linear combinations thereof).

Difference indices – VI's based on the difference between the spectral response of vegetation and the soil background.

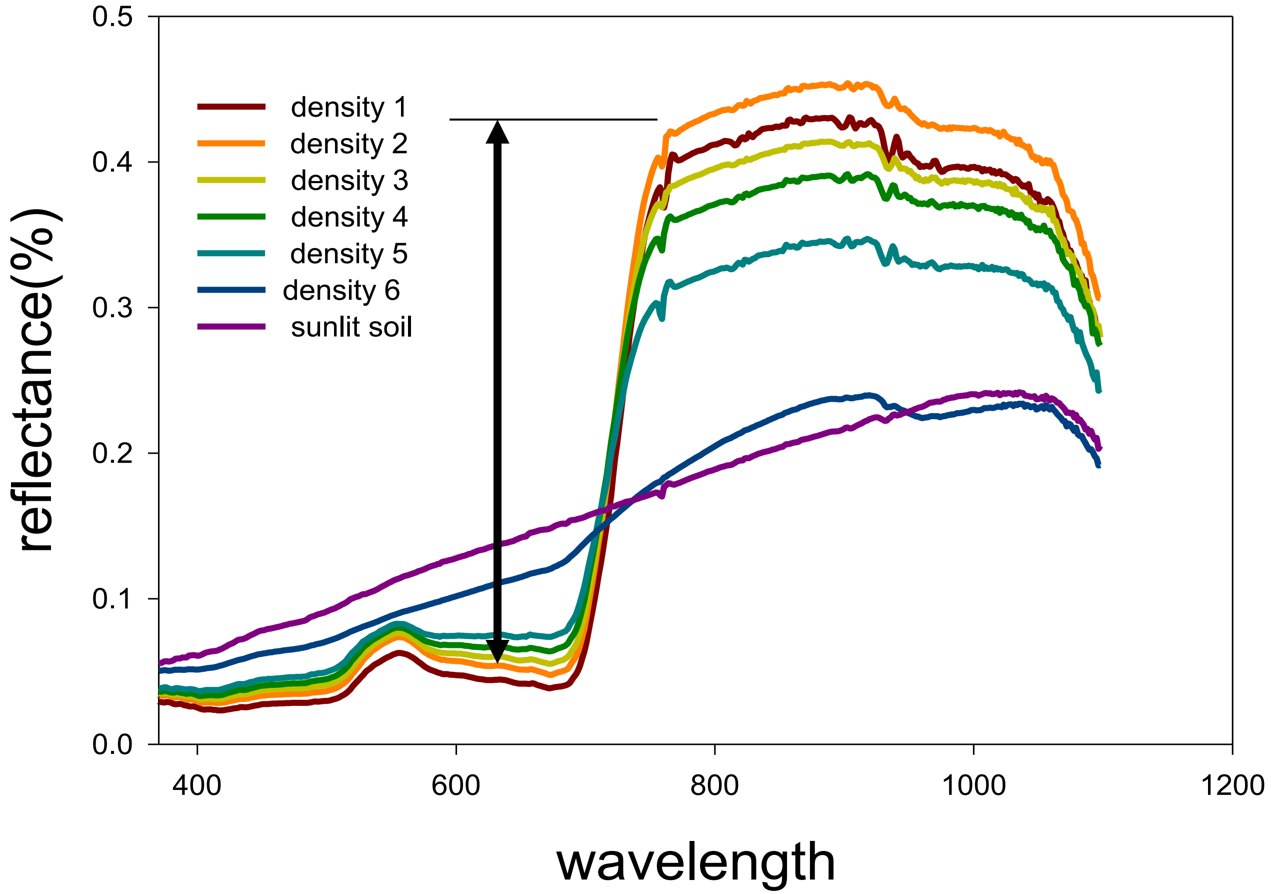
# Common Ratio Indices

Simple Ratio Index (SR) = NIR/R

Normalized Difference Vegetation Index (NDVI) =

$$\frac{NIR - R}{NIR + R}$$

# Estimating the size of the absorption well



- (B8-B4)/(B8+B4) for Sentinel 2a
- A pixel by pixel mathematical process

https://earth.esa.int/web/sentinel/technical-guides/sentinel-2-msi/level-2a/algorithm

Remember the images are stored in the image file (eg. Jpeg) as xy matrices with a pixel in one band corresponding with the pixel in another band with same xy coordinates

| | | |
|---|---|---|
| 45 | 12 | 19 |
| 44 | 10 | 16 |
| 27 | 90 | 56 |

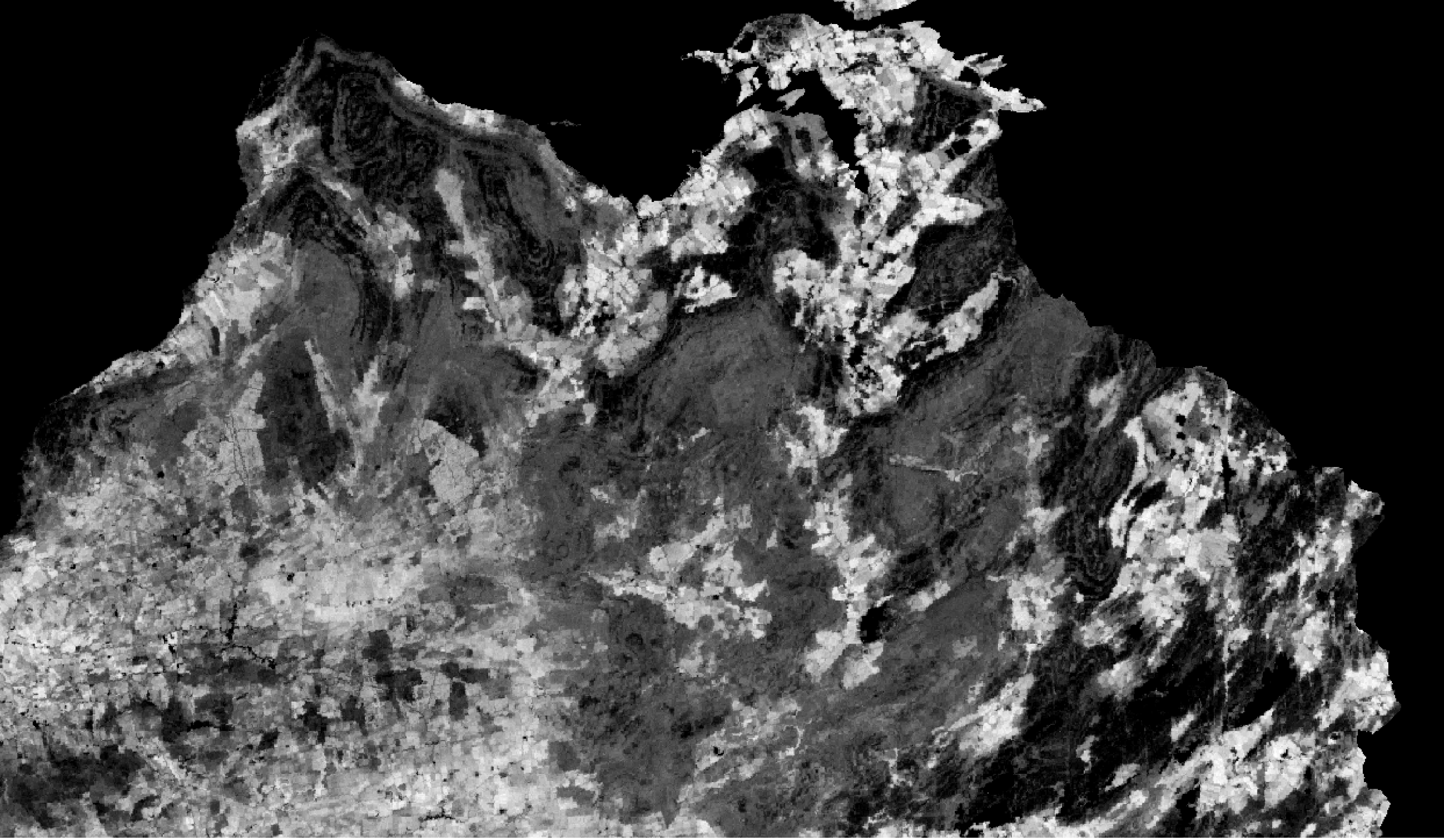
B8

| | | |
|---|---|---|
| 10 | 67 | 12 |
| 99 | 70 | 53 |
| 2 | 98 | 1 |

B4

| | | |
|---|---|---|
| 55 | 79 | 31 |
| 143 | 80 | 69 |
| 29 | 188 | 57 |

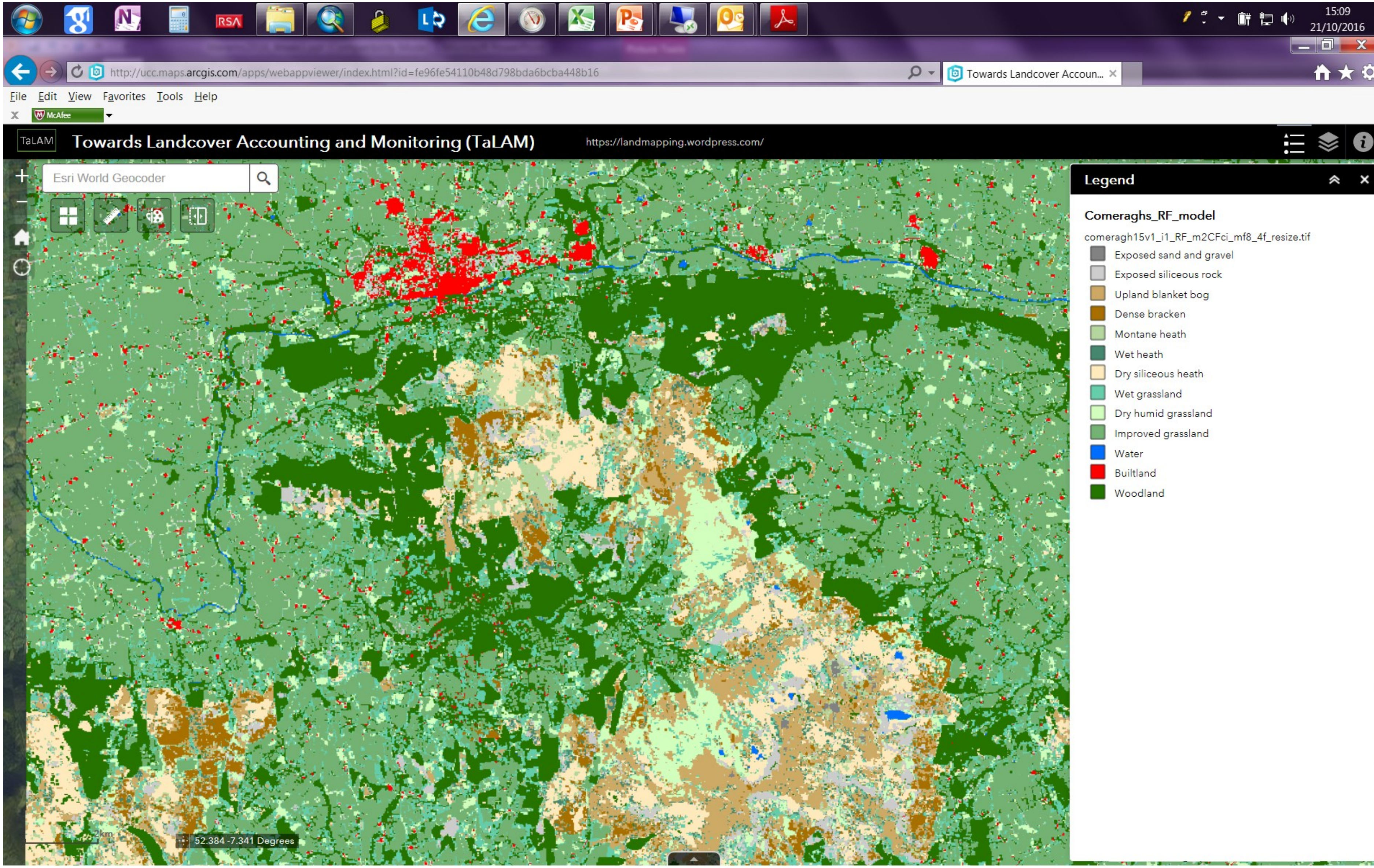
B1+B2



# Classifying

- Replacing the digital numbers in each pixel (that tell us the average spectral properties of everything in the pixel) , with a single number-a code that might represent the majority landuse/cover in the pixel, a biophysical property in the pixel (amount of biomass) or a relative value for a Landover (percentage of pixel that is forestry).

- https://landmapping.wordpress.com/


15:09
21/10/2016
http://ucc.maps.arcgis.com/apps/webappviewer/index.html?id=fe96fe54110b48d798bda6bcba448b16
Towards Landcover Accoun...
File Edit View Favorites Tools Help
McAfee
TaLAM
Towards Landcover Accounting and Monitoring (TaLAM)
https://landmapping.wordpress.com/
Esri World Geocoder
Legend
Comeraghs_RF_model
comeragh15v1_i1_RF_m2CFci_mf8_4f_resize.tif
Exposed sand and gravel
Exposed siliceous rock
Upland blanket bog
Dense bracken
Montane heath
Wet heath
Dry siliceous heath
Wet grassland
Dry humid grassland
Improved grassland
Water
Builtland
Woodland
52.384 -7.341 Degrees

MERMS 12 - L4

# Main Routes to creating a Thematic Landcover Map

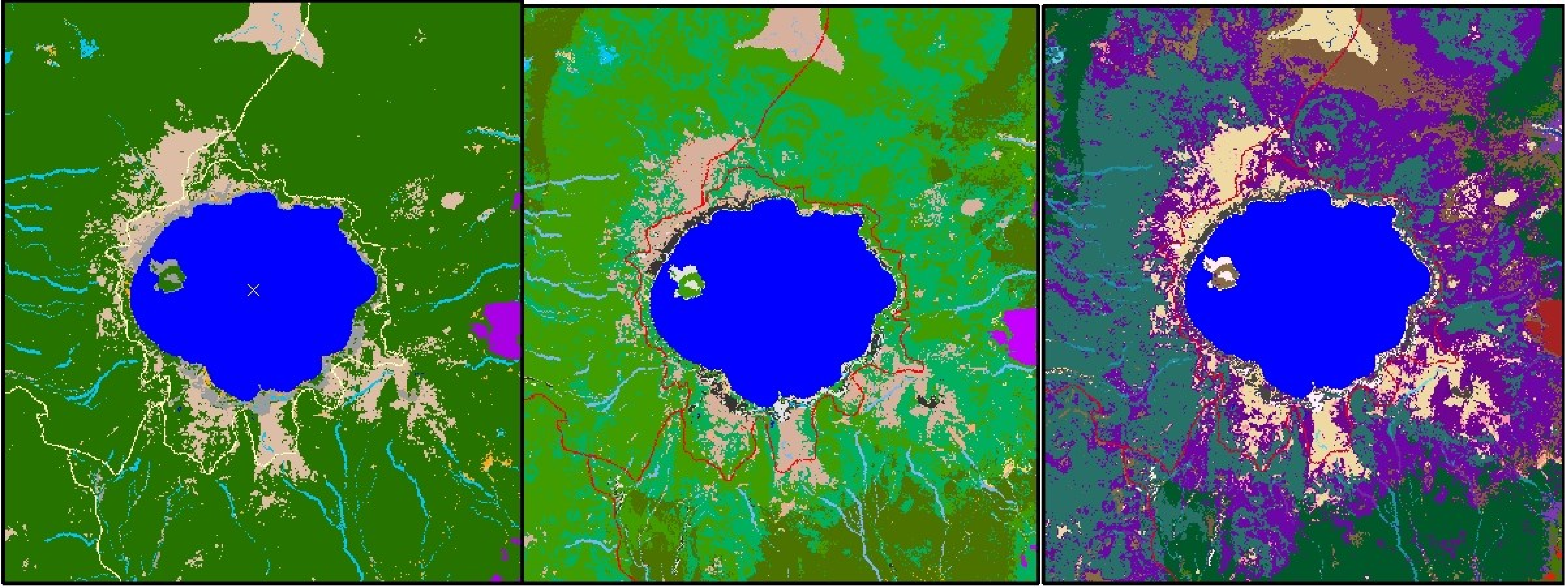
- Manual Digitisation and Interpretation
- Photomorphic Labelling
- Unsupervised Classification
- Supervised Classification
  - Maxiumum Likelihood
  - Random Forest
  - Support Vector Machine
- Object Orientated
- Hybrid Approaches

# Whats the differnce between landuse and landcover

- **http://oceanservice.noaa.gov/facts/lclu.html**

- **Land cover indicates the physical land type such as forest or open water whereas land use documents how people are using the land**

Or landcover is what is under your feet- landuse is what you might do with that



**Level 1- Land Cover Classes**

- Human land use
- Aquatic
- Sparse and barren system
- Forest and woodland systems
- Shrubland,steppe and savanna systems
- Grassland systems
- Recently disturbed or modified
- Riparian and wetland systems

**Level 2- Land Cover Classes**

- Developed
- Open water
- Alpine sparse and barren
- Other sparse and barren
- Conifer dominated forest/woodland (xeric-mesic)
- Conifer dominated forest/woodland (mesic- wet)
- Mixed deciduous/coniferous forest
- Alpine and avalanche chute shrublands
- Alpine grassland
- Recently burned
- Floodplain and riparian

**Level 3 - Land Use Classes /Ecological Systems**

- Developed- Open space
- Open water
- North Pacific Alpine and Subalpine Bedrock and Scree
- North Pacific Volcanic Rock and Cinder Land
- Sierra Nevada Subalpine Lodgepole Pine Forest
- North Pacific Mountain Hemlock Forest
- Northern California Mesic Subalpine Woodland
- Mediterranean California Red Fir Forest
- North Pcific Dry and Mesic Alpine Dwarf-Shrubland
- North Pacific Alpine and Subalpine Dry Grassland
- Recently burned forest
- North Pacific Montane Riparian Woodland/Shrubland

http://conservationmaven.com/frontpage/first-detailed-national-map-of-us-land-cover-vegetation-rele.html

# Manual Digitisation as in LPIS for SFP

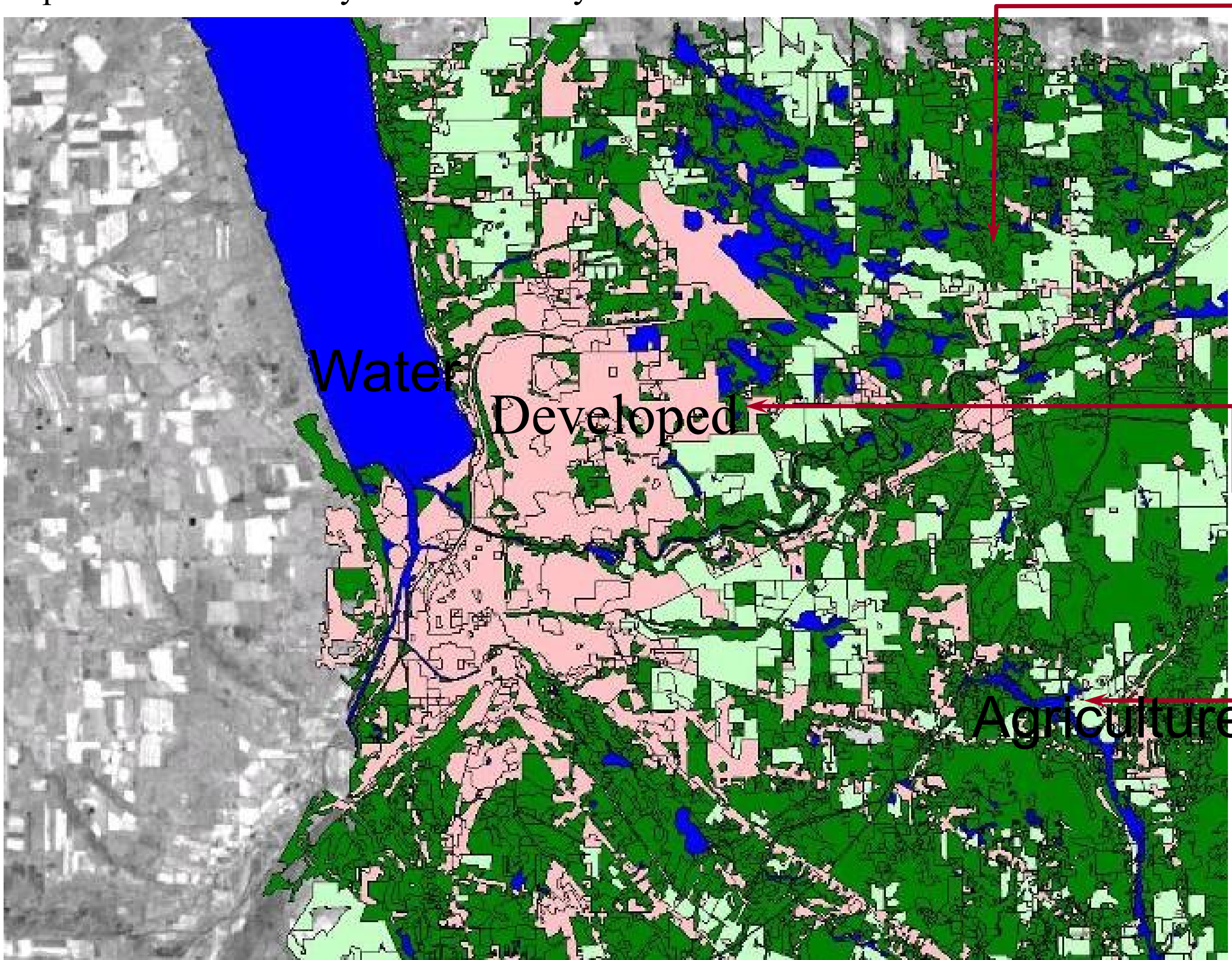
# UNSUPERVISED CLASSIFICATION

The computer performs a clustering exercise on the image:
The user tells the computer how many clusters to look for
and the computer then analysis the image to \produce this number
of statistaclly sound clusters.
Most commonly the ISODATA algorithm is used

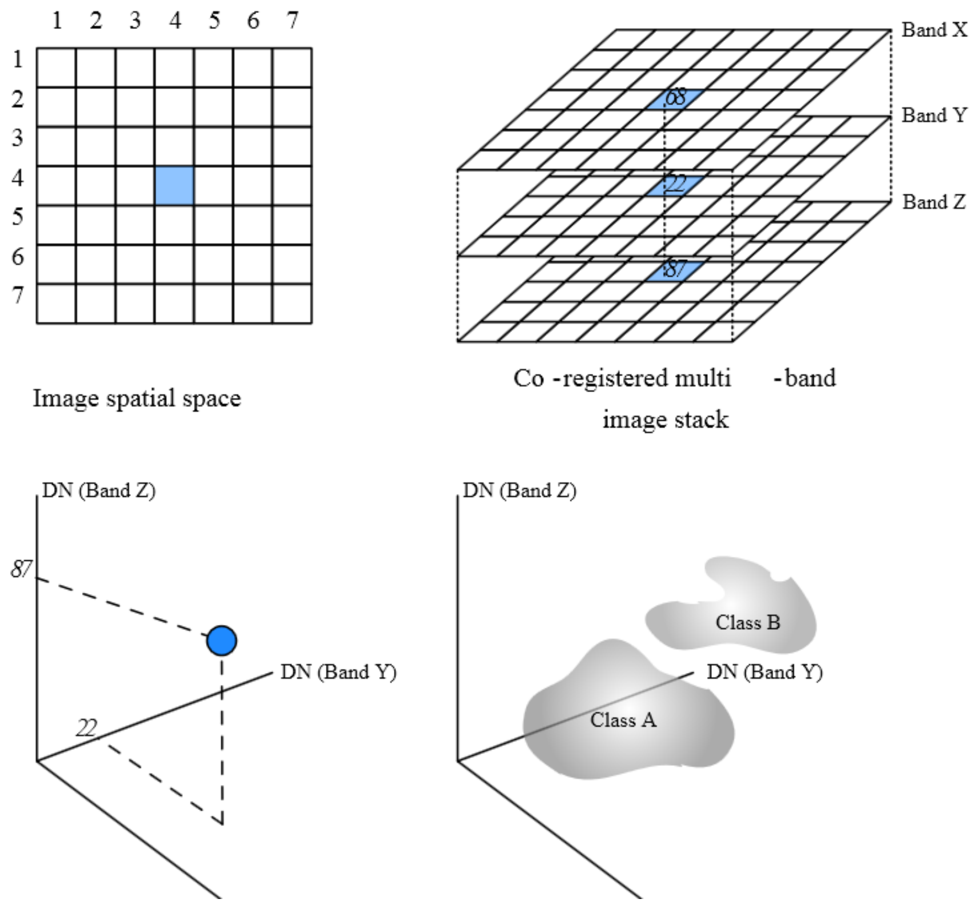
# Principle of Classification

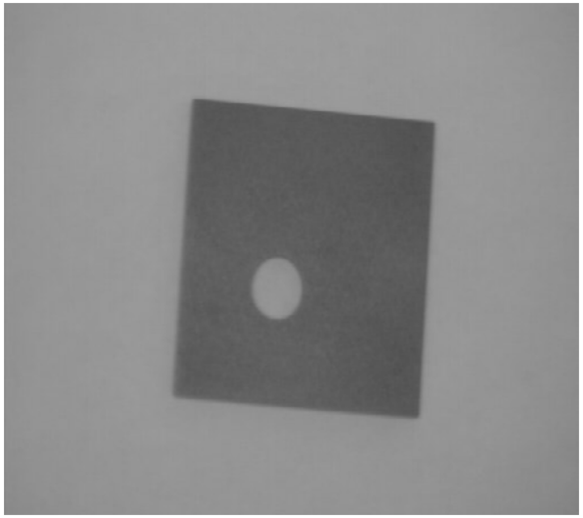
- Each class is known as a *cluster (or a theme)*. It is possible, using statistics draw boundaries between clusters.
- Unsupervised classification does not require prior knowledge. This type of classification relies on a computed algorithm which clusters pixels based on their inherent spectral similarities.

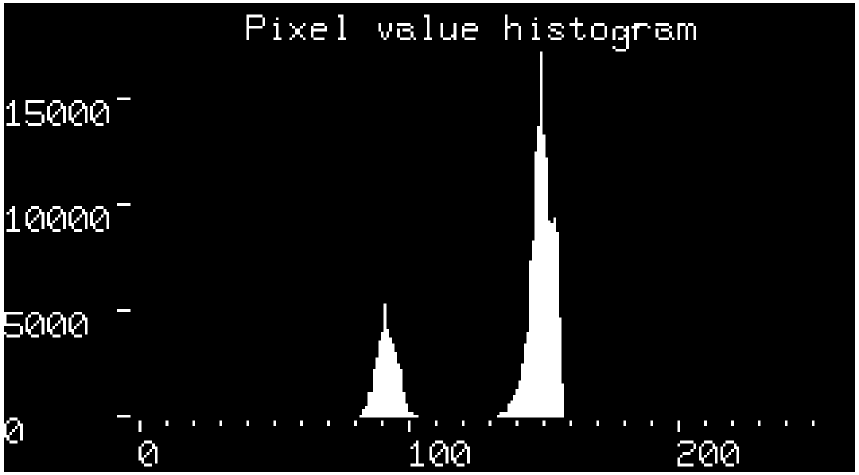
- the concept of image classification can also be described as:
- using the brightness values in one or more spectral bands, and classifies each pixel based on its spectral information The goal in classification is to assign remaining pixels in the image to a designated class such as water, forest, agriculture, urban, etc.
- The resulting **classified** image is comprised of a collection of pixels, colorcoded to represent a particular theme. The overall process then leads to the creation of a thematic map to be use to visually and statistically asses the scene.



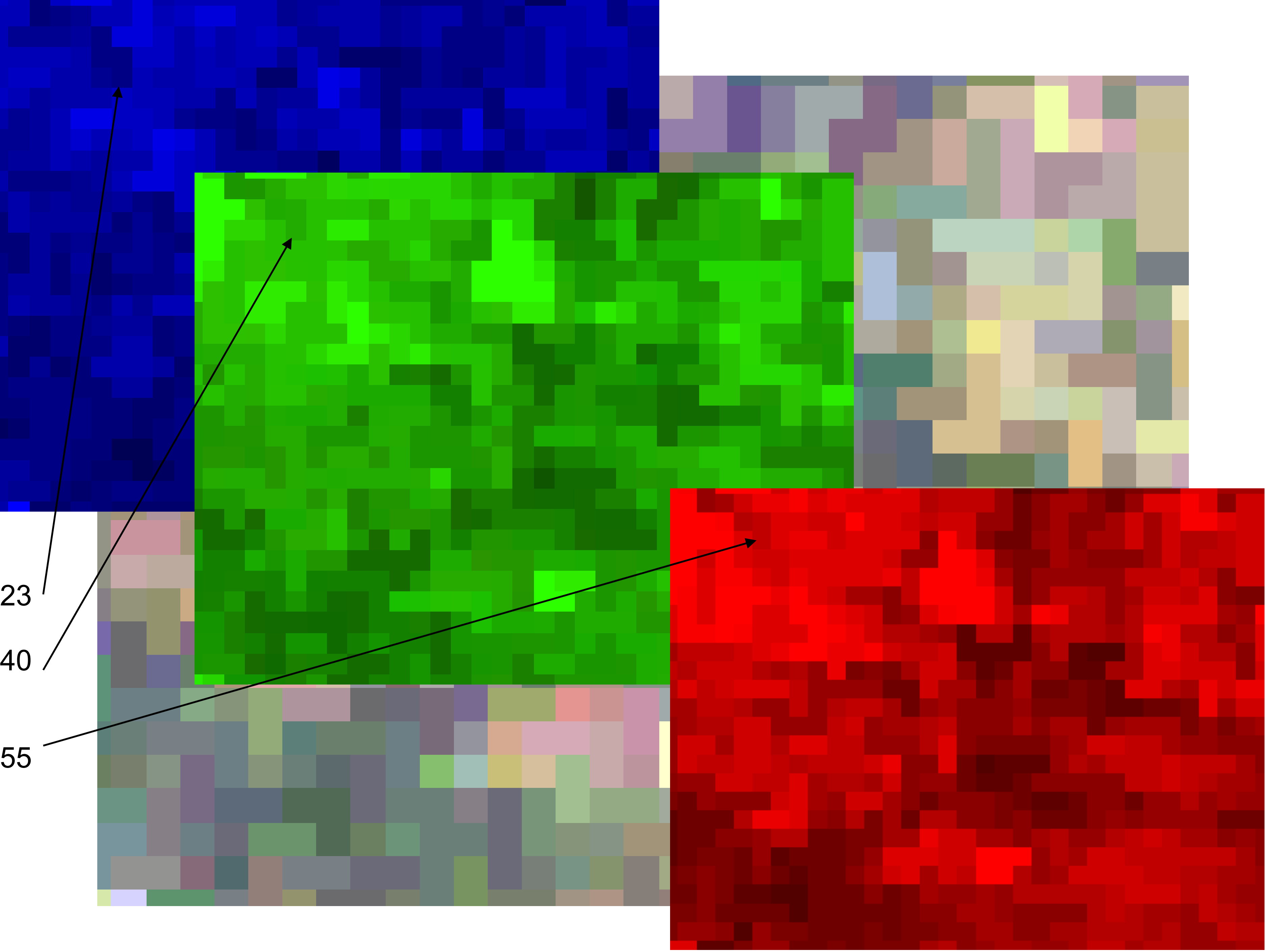
# These images are just arrays of numbers



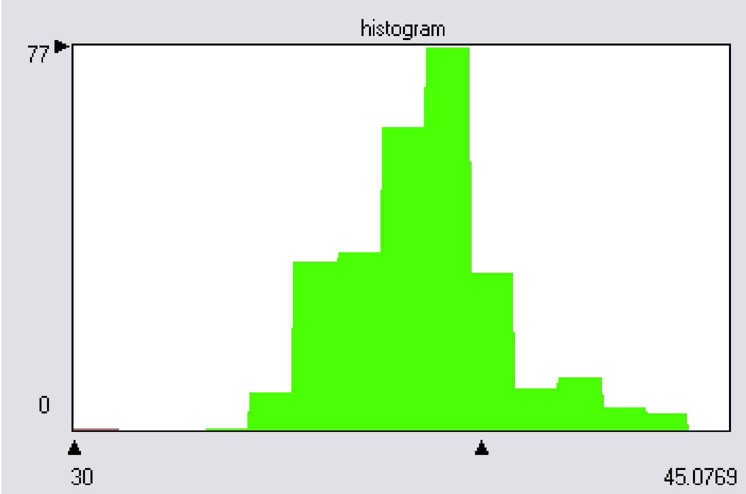


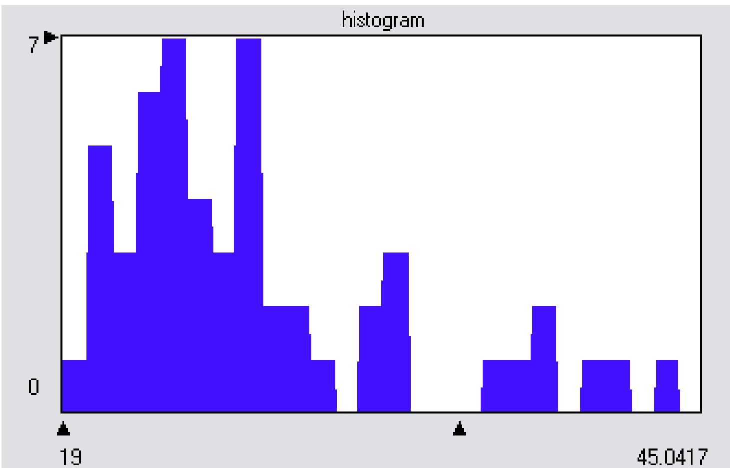


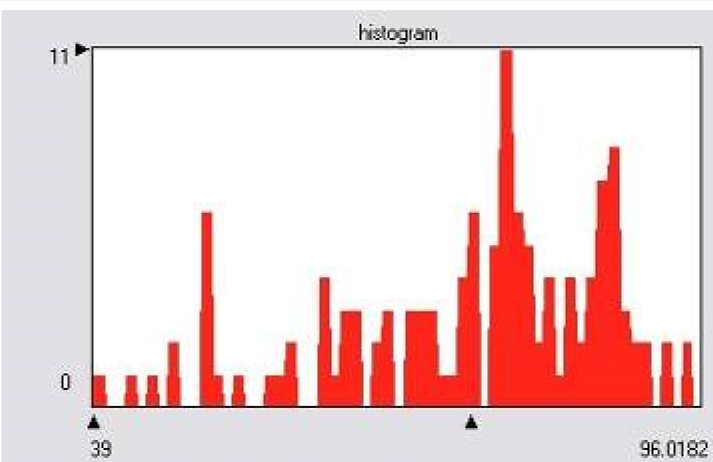
Pixel value histogram
15000
10000
5000
0
0
100
200

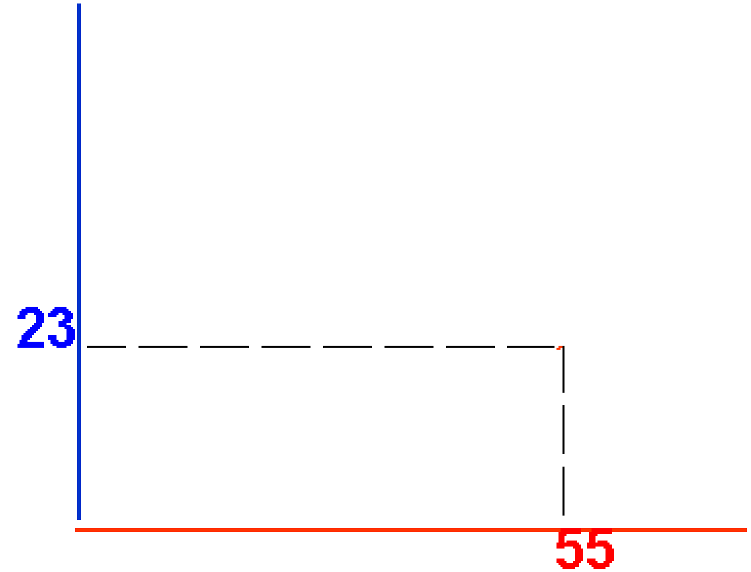


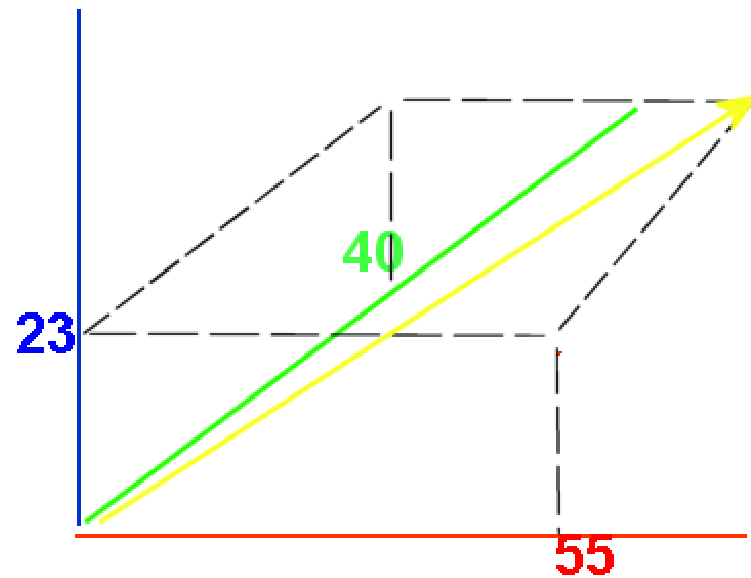
23
40
55


histogram
77
0
30
45.0769


histogram
7
0
19
45.0417

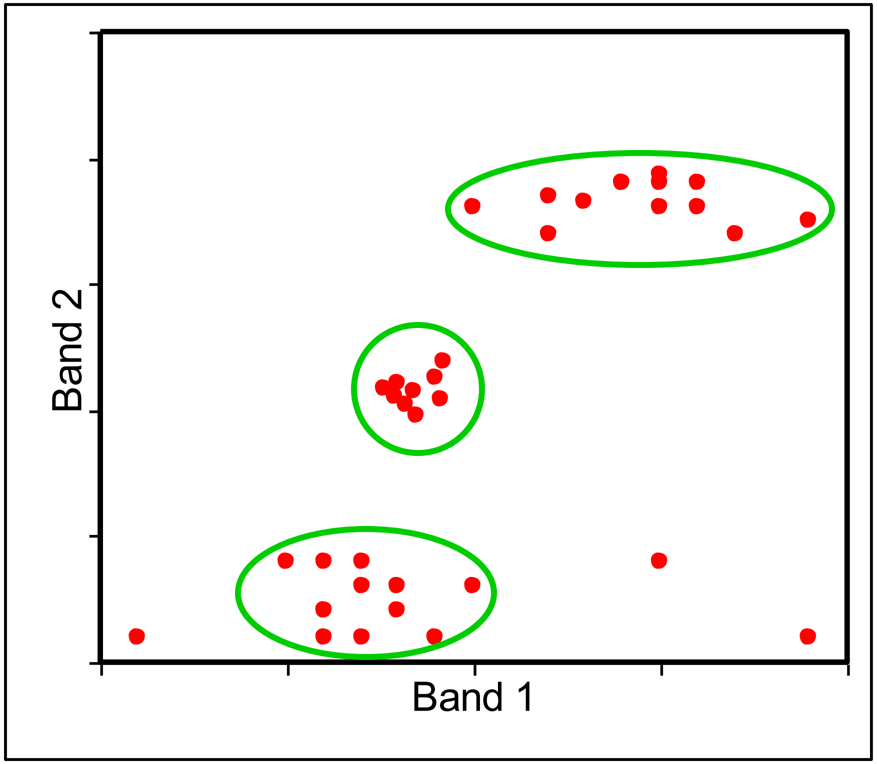

histogram
11
0
39
96.0182


23
55


40
23
55

# Example spectral plot

Rory Hutson
Remote Sensing Group
Plymouth Marine Laboratory




- Two bands of data.
- Each pixel marks a location in this 2d spectral space
- Our eye’s can split the data into clusters.
- Some points do not fit clusters.

# ISODATA clustering procedure

- Begins by determining N arbitrary cluster means.

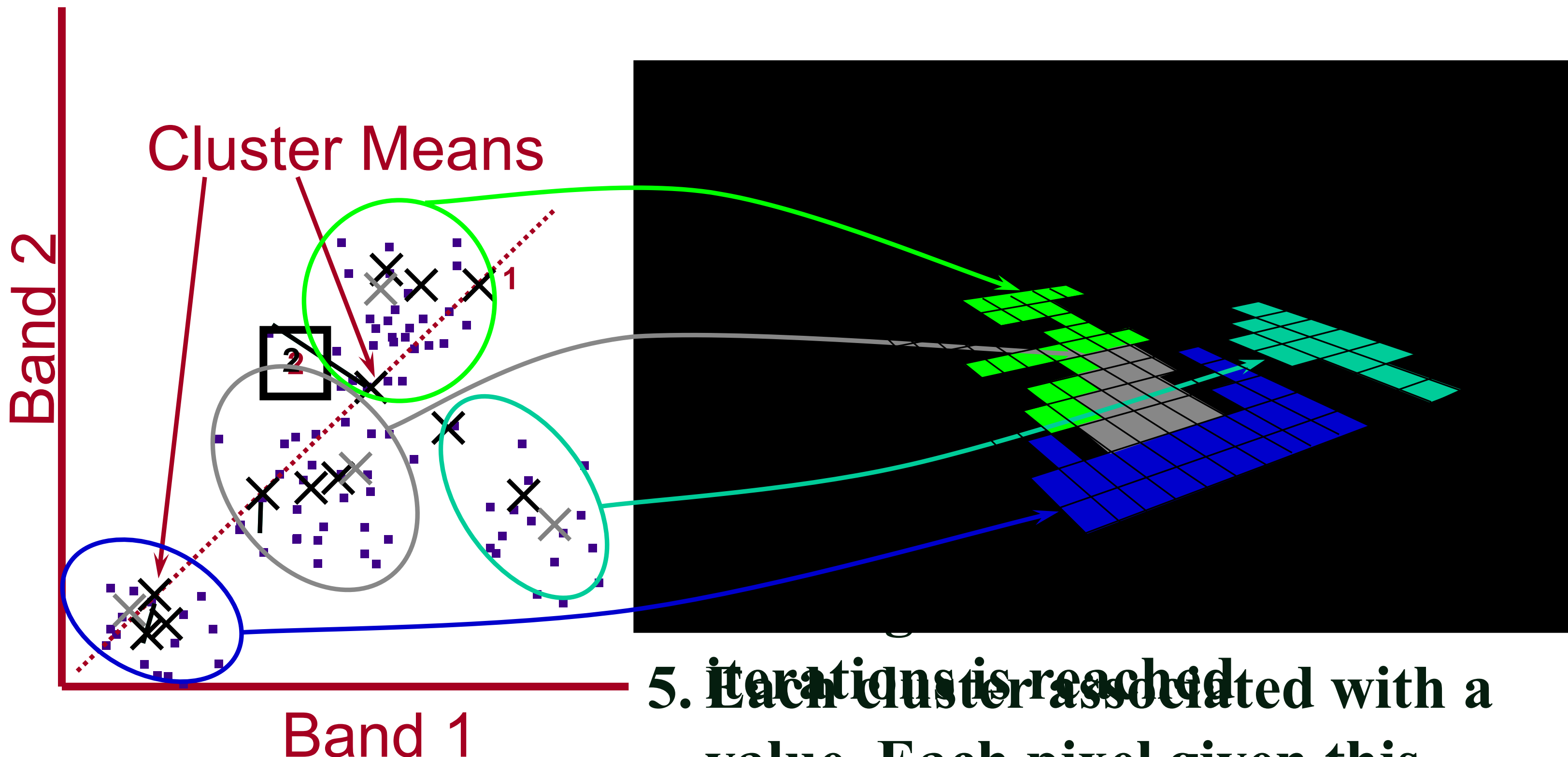
- The spectral distance between the candidate pixel and each cluster means is calculated. The pixel is assigned to the cluster whose mean is the closest.

- After each iteration, the means for each cluster are recalculated, based on the actual spectral locations of the pixels in the clusters, causing them to shift in feature space. Then these new means are used for defining clusters in the next iteration.

- The process will terminate until either the convergence threshold T or the maximum number of iterations M is reached

# Separate Data into Groups with unsupervised classification

- Unsupervised classification- the objective is to group multi-band spectral response patterns into clusters that are statistically separable
- Our example uses 3 bands
  - More bands can be used, but it can't be shown in this 3-D plot
- A = Agriculture; D= Desert; M = Mountains; W = Water




iterations is reached

5. Each cluster associated with a value. Each pixel given this value

We can modify these clusters, so that their total number can vary arbitrarily.

When we do the separations on a computer, each pixel in an image is assigned to one of the clusters as being most similar to it in DN combination value.

Generally, in an area within an image, multiple pixels in the same cluster correspond to some (initially unknown) ground feature or class .

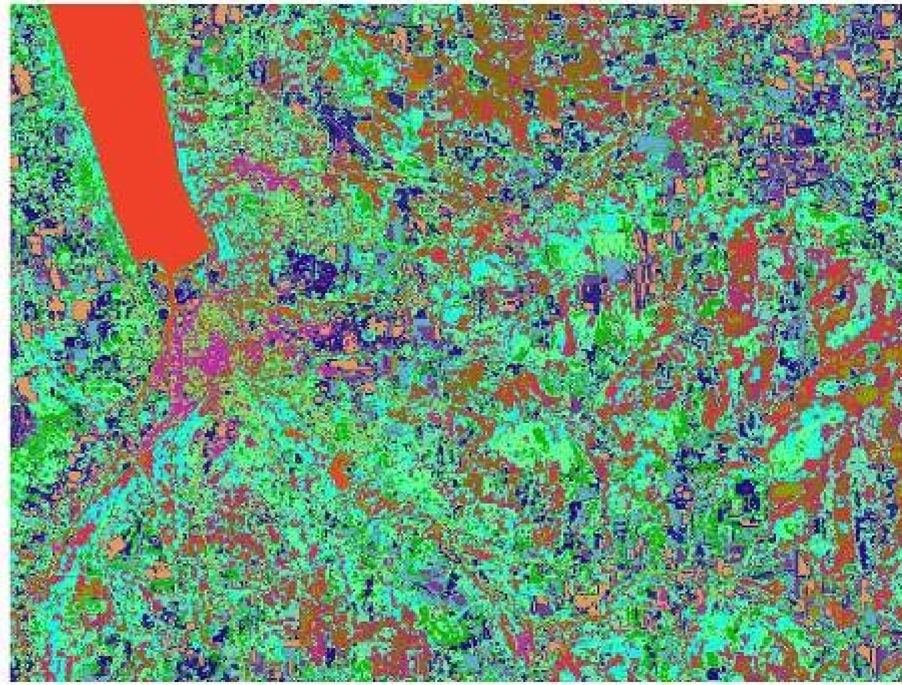
The trick then becomes one of trying to relate the different clusters to meaningful ground categories. We do this by either being adequately familiar with the major classes expected in the scene, or, where feasible, by visiting the scene (**ground truthing**) and visually correlating map patterns to their ground counterparts.

# Classify Data into Groups

Unsupervised classification using 20 different categories was carried out. Now, the task will be to group these categories into some kind of smaller grouping. In our case we have been using 5 classes: Agriculture, Developed, Natural, Forest, and Water.

Obviously, the red is water, we can see the Lake. Also, the purple looks like a city, so we would call that developed.

The rest of the colors are anyone's guess. So, the laborious process of assigning a category to the different classes (colors) will now begin.



# Assign a name to each group

After about 20 minutes, I was able to assign the classes with four of the categories to create a final land use map.

But where is Natural?  This is sometimes a problem in digital image processing.  Natural can look like the other classes
  And, based on the digital numbers, we were unable to discriminate the spectral differences

This is known as spectral confusion.  We may be able to discriminate between the extractive and developed if we chose more classes, but even then it might not be enough.  So, that is part of the struggle we will have as image processors.