Some elements of photo interpretation

- Shape
- Size
- Pattern
- Color (tone, hue)
- Texture
- Shadows
- Site
- Association

- Olson, C. E., Jr. 1960. Elements of photographic interpretation common to several sensors. Photogrammetric Engineering, Vol. 26(4):651-656.

Tone

Tone refers to the relative brightness or color of objects in an image. Generally, tone is the fundamental element for distinguishing between different targets or features. Variations in tone also allows the elements of shape, texture, and pattern of objects to be distinguished.

Shape

Shape refers to the general form, structure, or outline of individual objects. Shape can be a very distinctive clue for interpretation. Straight edge shapes typically represent urban or agricultural (field) targets, while natural features, such as forest edges, are generally more irregular in shape, except where man has created a road or clear cuts. Farm or crop land irrigated by rotating sprinkler systems would appear as circular shapes.

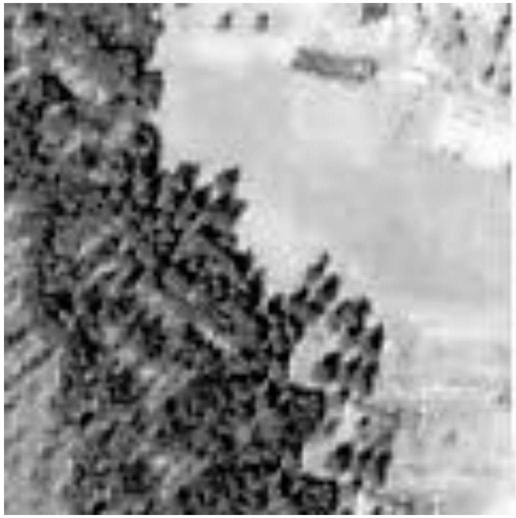
Size

Size of objects in an image is a function of scale. It is important to assess the size of a target relative to other objects in a scene, as well as the absolute size, to aid in the interpretation of that target. A quick approximation of target size can direct interpretation to an appropriate result more quickly. For example, if an interpreter had to distinguish zones of land use, and had identified an area with a number of buildings in it, large buildings such as factories or warehouses would suggest commercial property, whereas small buildings would indicate residential use.

Pattern

Pattern refers to the spatial arrangement of visibly discernible objects. Typically an orderly repetition of similar tones and textures will produce a distinctive and ultimately recognizable pattern. Orchards with evenly spaced trees, and urban streets with regularly spaced houses are good examples of pattern.

Texture



Texture refers to the arrangement and frequency of tonal variation in particular areas of an image. Rough textures would consist of a mottled tone where the grey levels change abruptly in a small area, whereas smooth textures would have very little tonal variation. Smooth textures are most often the result of uniform, even surfaces, such as fields, asphalt, or grasslands. A target with a rough surface and irregular structure, such as a forest canopy, results in a rough textured appearance. Texture is one of the most important elements for distinguishing features in radar imagery.

Shadow

Shadow is also helpful in interpretation as it may provide an idea of the profile and relative height of a target or targets which may make identification easier. However, shadows can also reduce or eliminate interpretation in their area of influence, since targets within shadows are much less (or not at all) discernible from their surroundings. Shadow is also useful for enhancing or identifying topography and landforms, particularly in radar imagery.

Association

Association takes into account the relationship between other recognizable objects or features in proximity to the target of interest. The identification of features that one would expect to associate with other features may provide information to facilitate identification. In the example given above, commercial properties may be associated with proximity to major transportation routes, whereas residential areas would be associated with schools, playgrounds, and sports fields. In our example, a lake is associated with boats, a marina, and adjacent recreational land.

Fundamental Image Analysis Tasks
- Detect, Identify, Measure
- Solve Problems

Application of the ***Multi*** concept
- Multispectral - Multifrequency - Multipolarization
- Multitemporal - Multiscale - Multidisciplinary

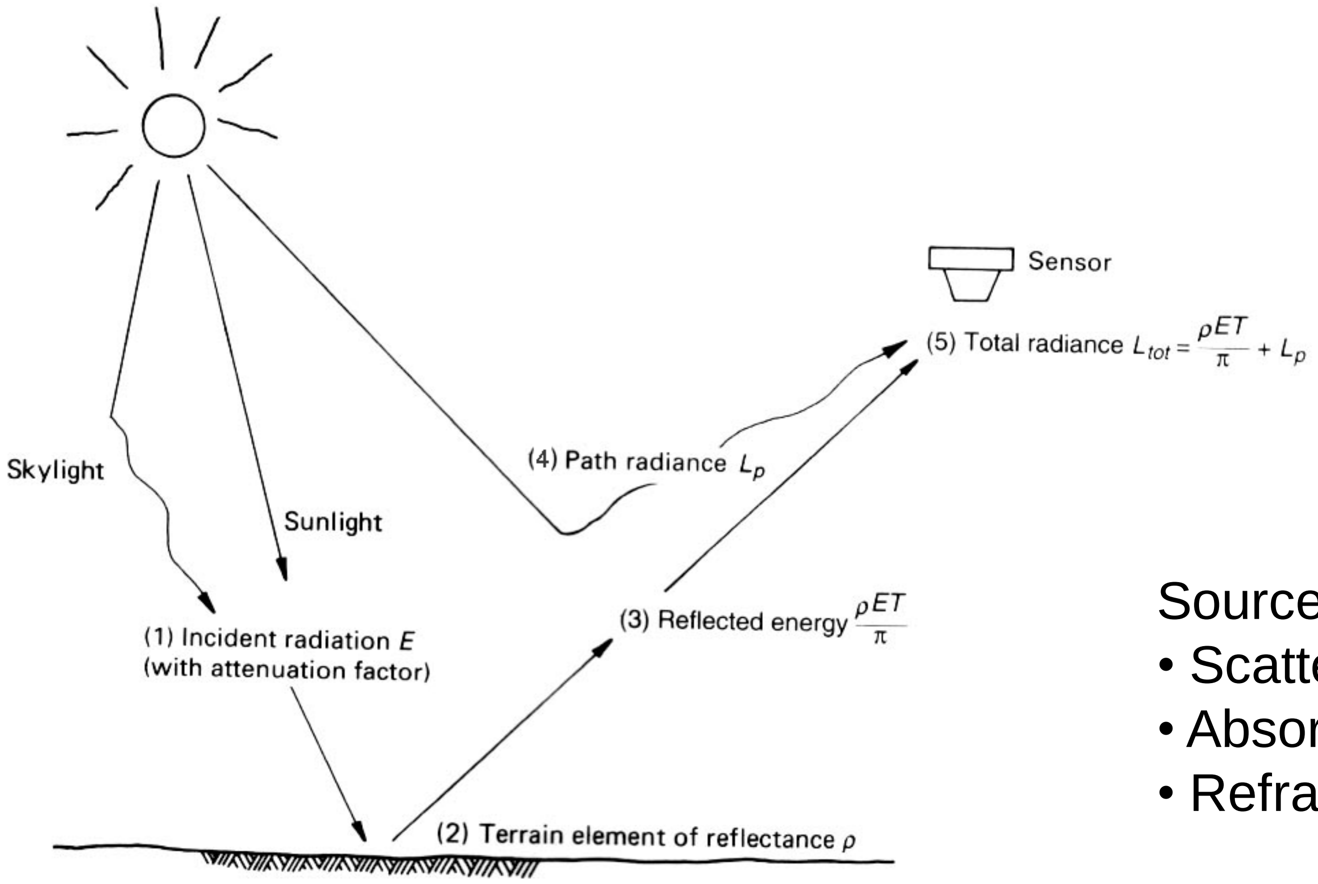
Use of ***Collateral Information***
- Literature - Laboratory spectra - Dichotomous keys - Prior probabilities
- Field training sites - Field test sites - Soil maps - Surficial geology maps

Analog (Visual) Image Processing	**Digital Image Processing**
Elements of Image Interpretation	***How the Elements of Image Interpretation Are Extracted or Used in Digital Image Processing***
• Grayscale tone (black to white)	• 8- to 12-bit brightness values, or more appropriately scaled surface reflectance or emittance
• Color (red, green, blue = RGB)	• 24-bit color look-up table display - Multiband RGB color composites - Transforms (e.g., intensity, hue, saturation)
• Height (elevation) and depth	• Soft-copy photogrammetry, LIDAR, radargrammetry, RADAR interferometry, SONAR
• Size (length, area, perimeter, volume)	• Soft-copy photogrammetry, radargrammetry, RADAR interferometry, measurement from rectified images
• Shape	• Soft-copy photogrammetry, radargrammetry, RADAR interferometry, landscape ecology spatial statistics (metrics), object-oriented image segmentation
• Texture	• Texture transforms, geostatistical analysis (e.g., kriging), landscape ecology metrics, fractal analysis
• Pattern	• Autocorrelation, geostatistical analysis, landscape ecology metrics, fractal analysis
• Shadow	• Soft-copy photogrammetry, radargrammetry, measurement from rectified images
• Site, using convergence of evidence	• Contextual, expert system, neural network analysis
• Association, using convergence of evidence	• Contextual, expert system, neural network analysis
• Arrangement, using convergence of evidence	• Contextual, expert system, neural network analysis

Digital Image Analysis

- Digital vs. analog
- Digital number (DN), brightness value (BV)
- Pixels
- Bands (channels)
- Resolution
- Platform and sensors
- GIS

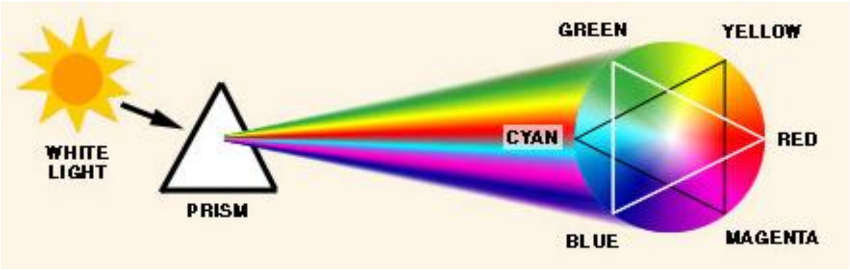
Measuring EMR

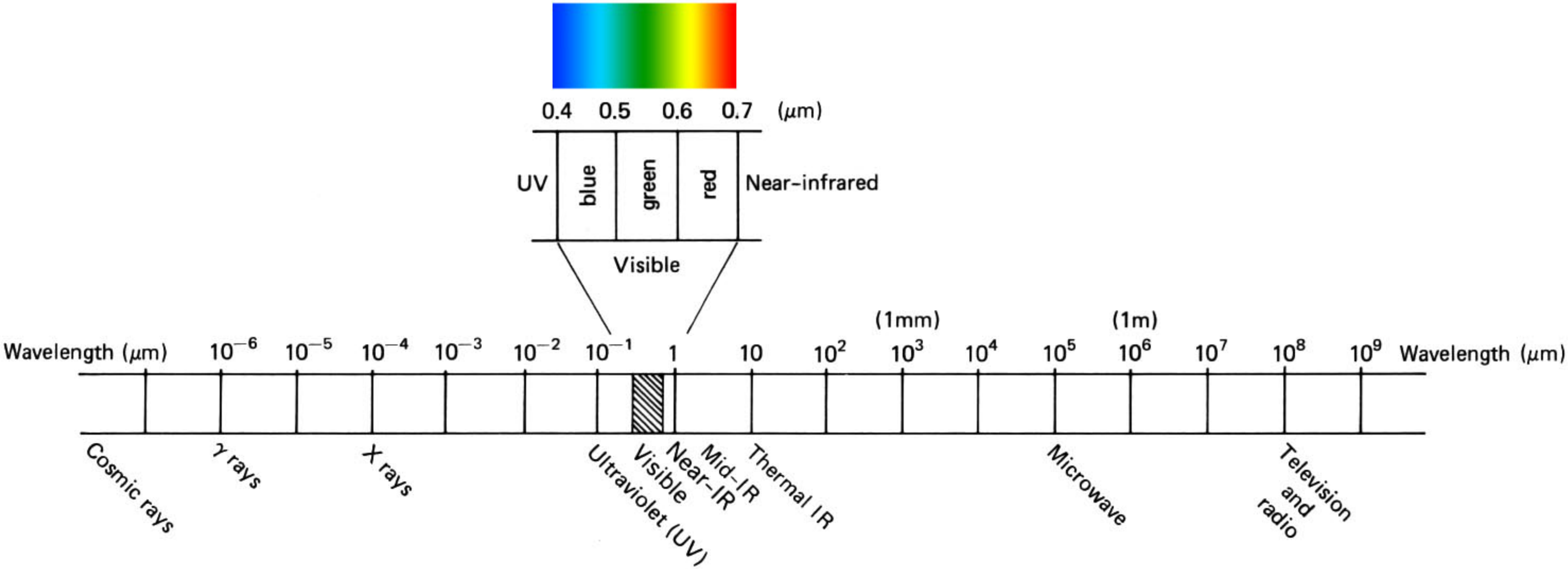


Sources of Noise
- Scattering
- Absorption
- Refraction

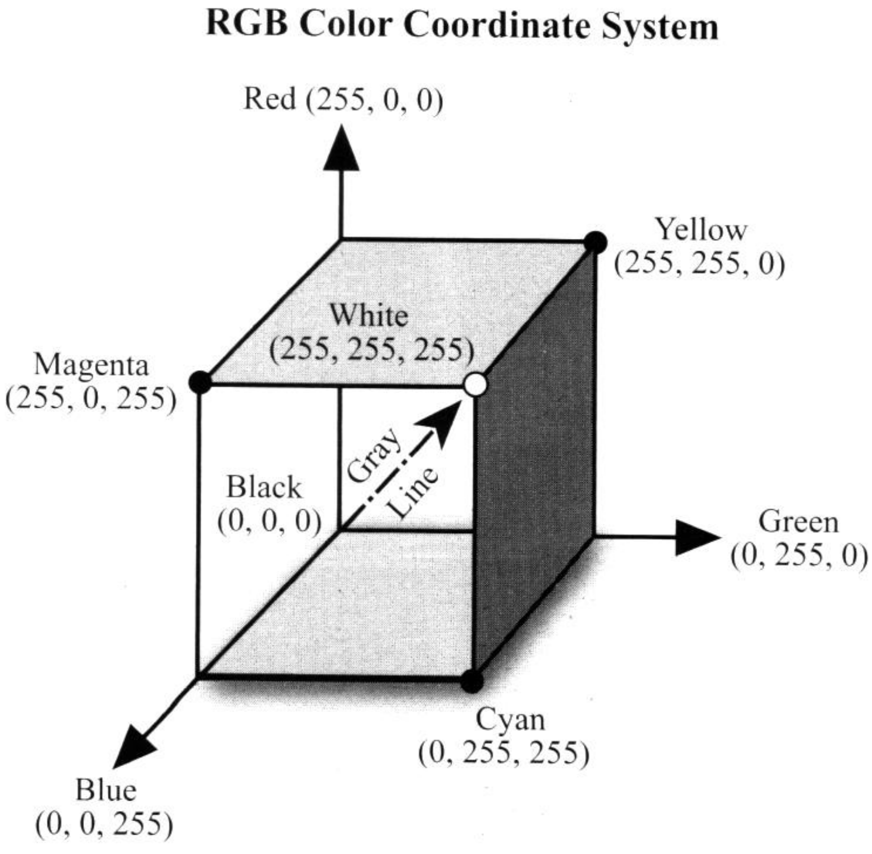
- T = transmission of atmosphere

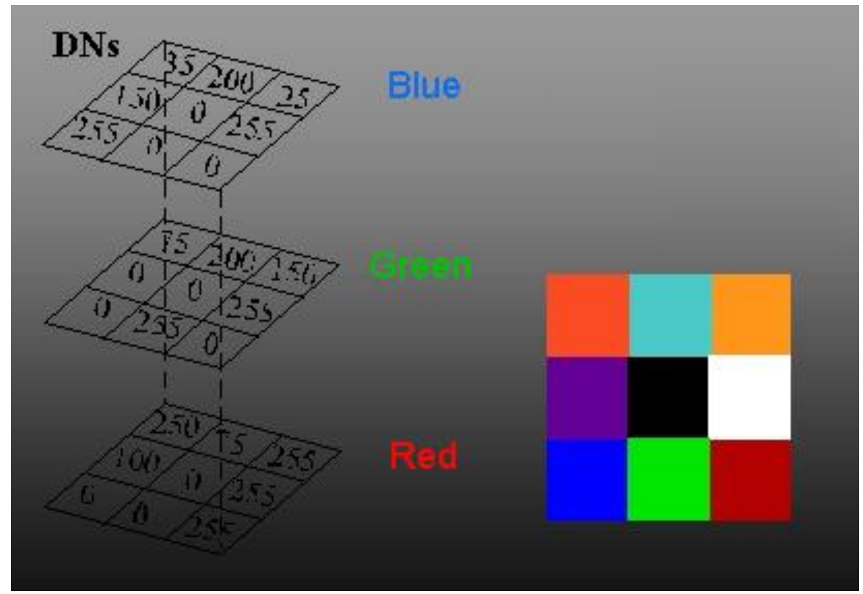
EMR Color Spectrum



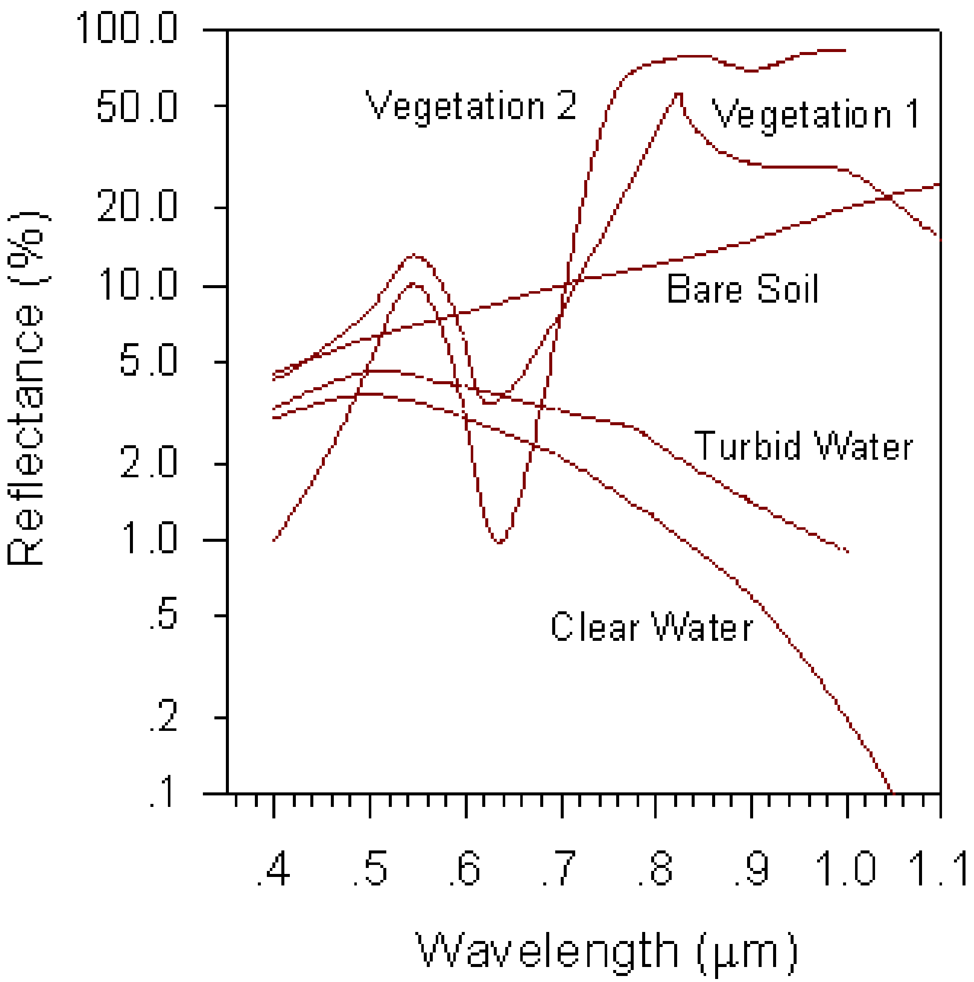


Cathode-Ray Tube (CRT) & RGB Color

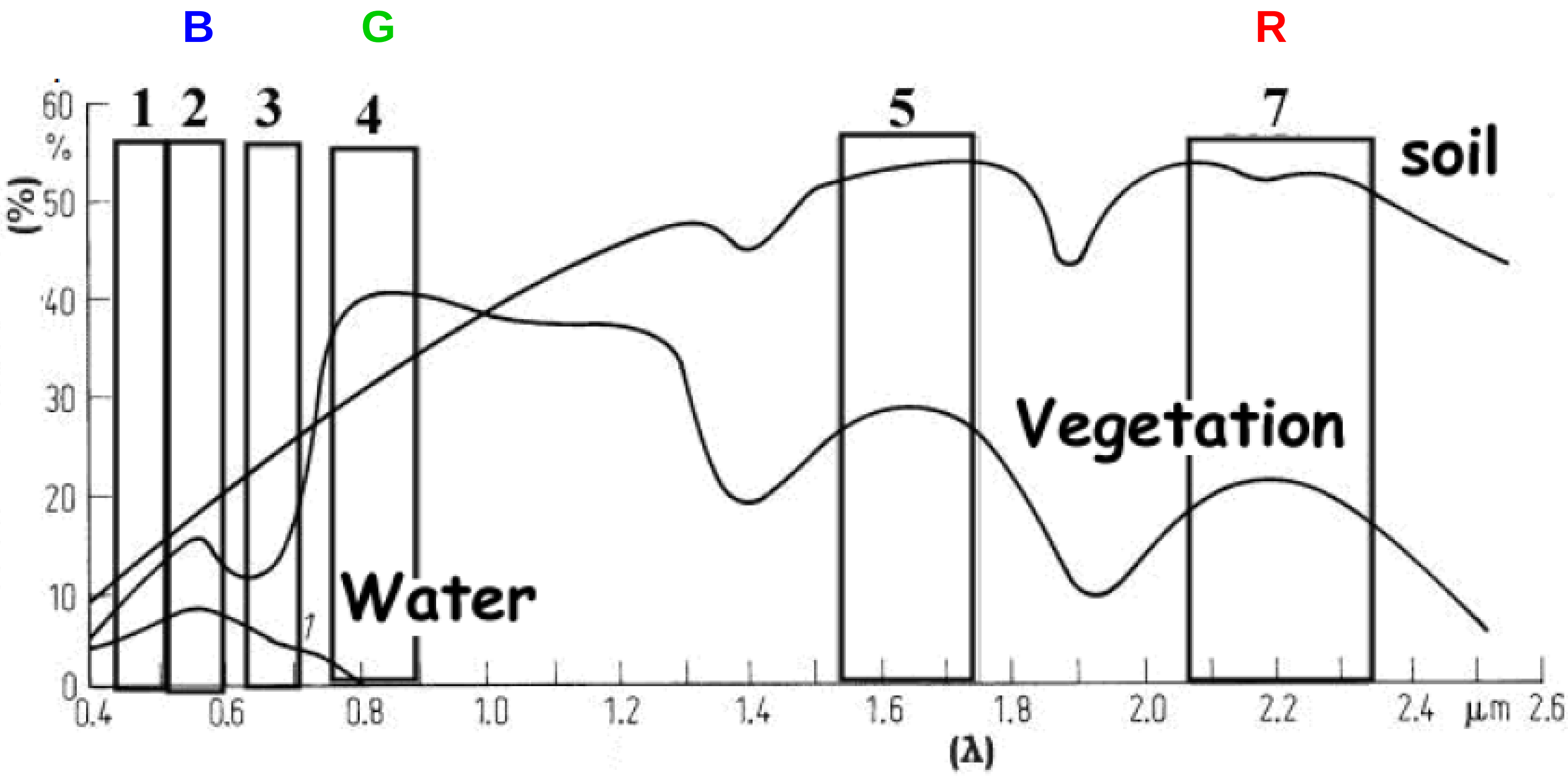


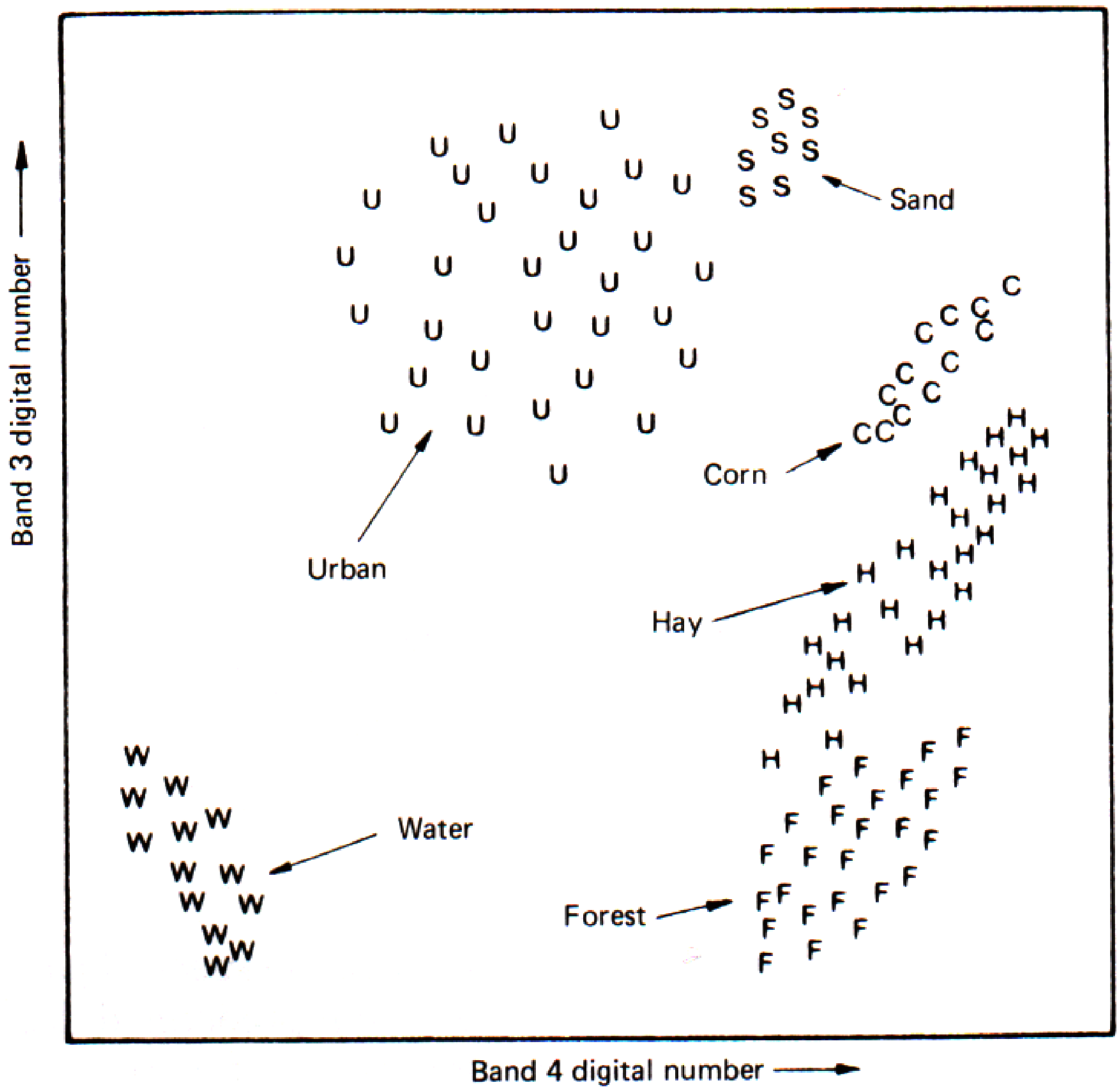


Why do plants appear green?



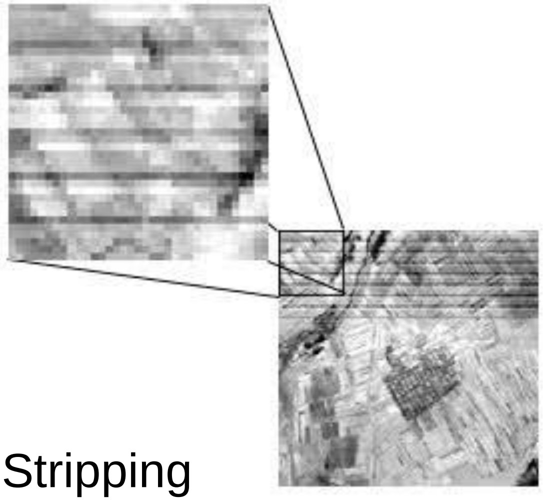
TM/ETM+ bands


B
G
R
1
2
3
4
5
7
soil
Vegetation
Water
60
%
(%)
50
40
30
20
10
0
0.4
0.6
0.8
1.0
1.2
1.4
1.6
1.8
2.0
2.2
2.4
µm
2.6
(λ)

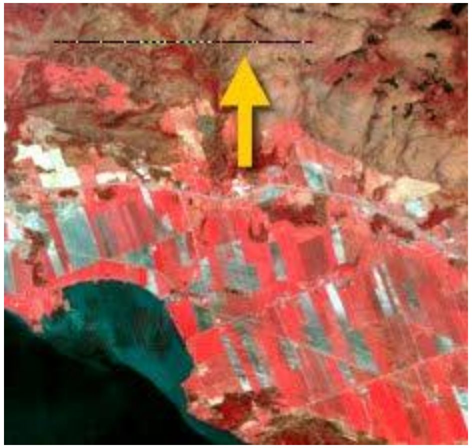

Sand
Corn
Urban
Hay
Water
Forest
Band 3 digital number
Band 4 digital number

Pre-processing

- **Preprocessing** functions involve those operations that are normally required prior to the main data analysis and extraction of information, and are generally grouped **as radiometric or geometric corrections**.
- **Radiometric corrections** include correcting the data for sensor irregularities and unwanted sensor or atmospheric noise, and converting the data so they accurately represent the reflected or emitted radiation measured by the sensor.
- **Geometric corrections** include correcting for geometric distortions due to sensor-Earth geometry variations, and conversion of the data to real world coordinates (e.g. latitude and longitude) on the Earth's surface.



Stripping

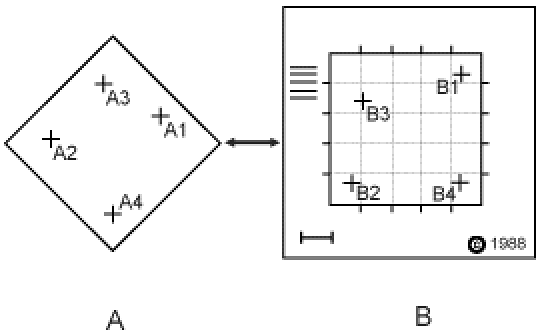


Dropped lines

Pre-processing operations, sometimes referred to as **image restoration and rectification**, are intended to correct for sensor- and platform-specific radiometric and geometric distortions of data.

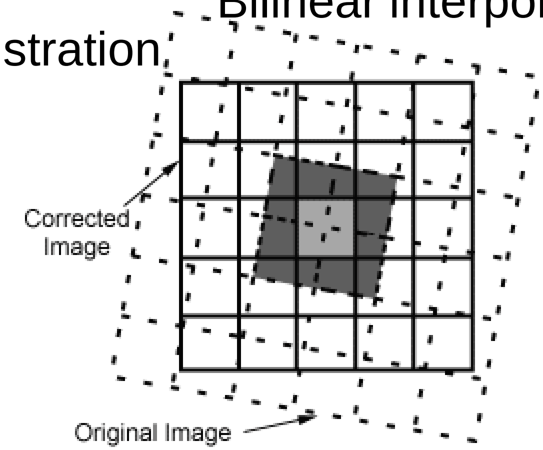
Radiometric corrections may be necessary due to variations in scene illumination and viewing geometry, atmospheric conditions, and sensor noise and response. Each of these will vary depending on the specific sensor and platform used to acquire the data and the conditions during data acquisition. Also, it may be desirable to convert and/or calibrate the data to known (absolute) radiation or reflectance units to facilitate comparison between data.

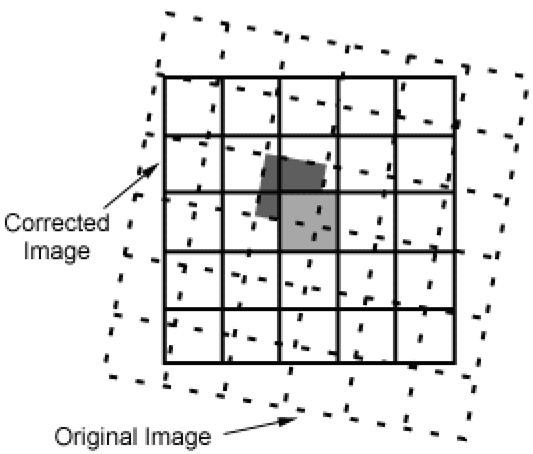
Geometric registration and correction via resampling



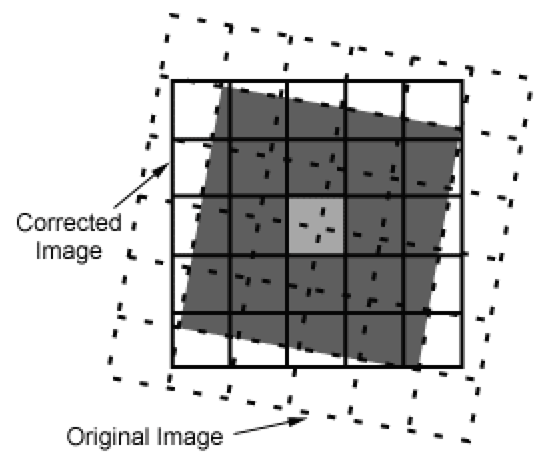
Geometric registration

Bilinear interpolation



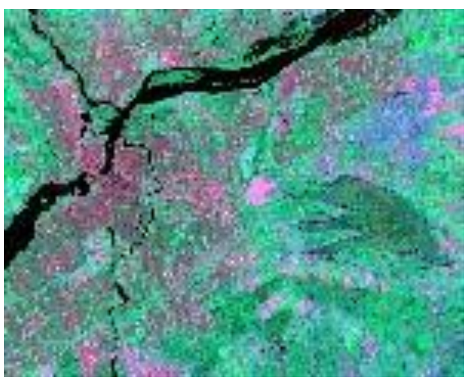


Nearest neighbor resampling



Cubic convolation

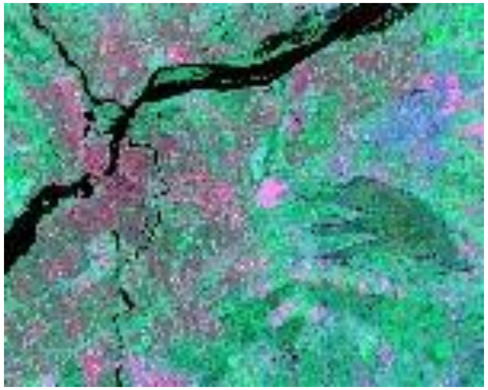
Image enhancement

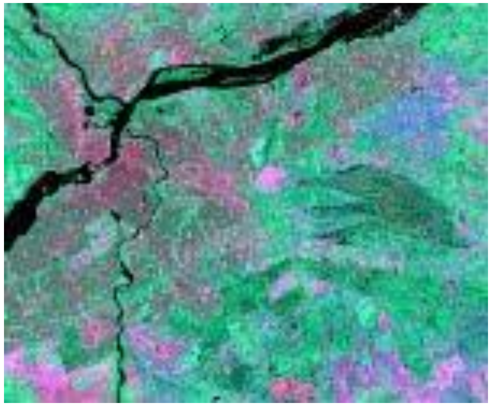


The simplest type of enhancement is a linear contrast stretch.

This involves identifying lower and upper bounds from the histogram (usually the minimum and maximum brightness values in the image) and applying a transformation to stretch this range to fill the full range. A linear stretch uniformly expands this small range to cover the full range of values from 0 to 255. This enhances the contrast in the image with light toned areas appearing lighter and dark areas appearing darker, making visual interpretation much easier. This graphic illustrates the increase in contrast in an image before (top) and after (bottom) a linear contrast stretch.

Spatial filtering

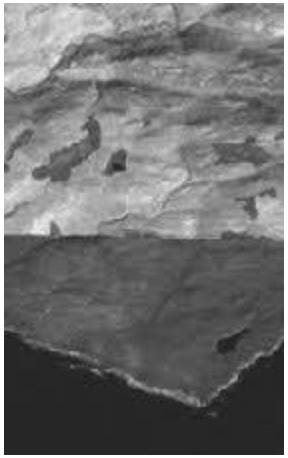


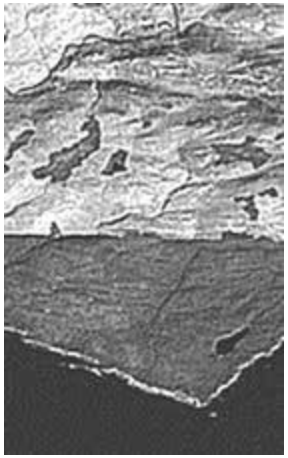


Low pass filter

- **Spatial filtering** encompasses another set of digital processing functions which are used to enhance the appearance of an image. **Spatial filters** are designed to highlight or suppress specific features in an image based on their **spatial frequency**.
- **Spatial frequency** refers to the frequency of the variations in tone that appear in an image. "Rough" textured areas of an image, where the changes in tone are abrupt over a small area, have high spatial frequencies, while "smooth" areas with little variation in tone over several pixels, have low spatial frequencies. A common filtering procedure involves moving a 'window' of a few pixels in dimension (e.g. 3x3, 5x5, etc.) over each pixel in the image, applying a mathematical calculation using the pixel values under that window, and replacing the central pixel with the new value.
- **A low-pass** filter is designed to emphasize larger, homogeneous areas of similar tone and reduce the smaller detail in an image. Thus, low-pass filters generally serve to smooth the appearance of an image. Average and median filters, often used for radar imagery (and described in Chapter 3), are examples of low-pass filters.
- **High-pass filters** do the opposite and serve to sharpen the appearance of fine detail in an image. One implementation of a high-pass filter first applies a low-pass filter to an image and then subtracts the result from the original, leaving behind only the high spatial frequency information.

Directional or edge detection filter





Directional, or edge detection filters are designed to highlight linear features, such as roads or field boundaries. These filters can also be designed to enhance features which are oriented in specific directions. These filters are useful in applications such as geology, for the detection of linear geologic structures.

Image Transformation

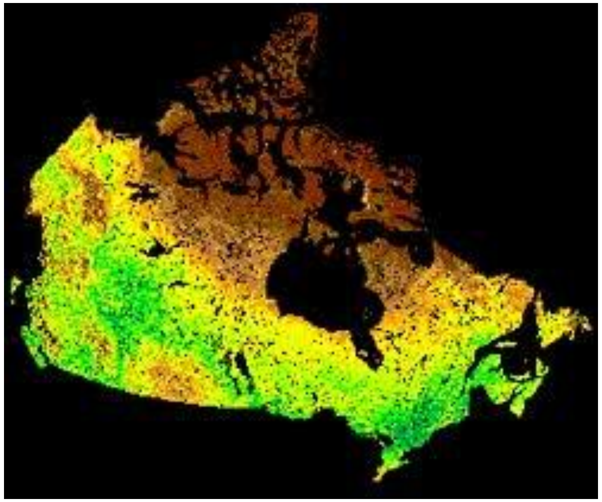


Image division or **spectral ratioing** is one of the most common transforms applied to image data. Image ratioing serves to highlight subtle variations in the spectral responses of various surface covers. By ratioing the data from two different spectral bands, the resultant image enhances variations in the *slopes of the spectral reflectance curves* between the two different spectral ranges that may otherwise be masked by the pixel brightness variations in each of the bands.

One widely used image transform is the Normalized Difference Vegetation Index (NDVI) which has been used to monitor vegetation conditions on continental and global scales using the Advanced Very High Resolution Radiometer (AVHRR) sensor onboard the NOAA series of satellites

Band	Bandwidth (μm)	IFOV (m)	Quanti-zation (bits)	Off Nadir Viewing	Temporal Resolution (days)	Altitude (km)	Total Data Rate (Mbits/s)	Number Pixels per Line	Swath Width (km)
Landsat Multispectral Scanner (MSS) on ERTS 1, 2 and Landsat 3, 4, and 5									
4[a]	0.50–0.60	79 × 79	6-8	No	18	917	15	2340	185
5	0.60–0.70								
6	0.70–0.80								
7	0.80–1.10								
8[b]	10.4–12.6	240 × 240							
Landsat Thematic Mapper (TM) on Landsat 4 and 5									
1	0.45–0.52	30 × 30	8	No	16	705	85	3000	185
2	0.52–0.60	30 × 30							
3	0.63–0.69	30 × 30							
4	0.76–0.90	30 × 30							
5	1.55–1.75	30 × 30							
6	10.4–12.5	120 × 120							
7	2.08–2.35	30 × 30							
NOAA Advanced Very High Resolution Radiometer (AVHRR -12) Local Area Coverage (LAC) Data									
1	0.58–0.68	1100 × 1100	8	No	Daily	861 and 845	—	—	2700
2	0.725–1.10	1100 × 1100							
3	3.55–3.93	1100 × 1100							
4	10.3- 11.3	1100 × 1100							
5	11.5–12.5	1100 × 1100							
French SPOT High Resolution Visible Sensor Systems (HRV) 1, 2, and 3									
Multispectral Mode									
1	0.50–0.59	20 × 20	8	Yes	Variable	832	25	3000	60
2	0.61–0.68	20 × 20							
3	0.79–0.89	20 × 20							
Panchromatic Mode									
1	0.51–0.73	10 × 10	8	Yes	Variable	832	25	6000	60

Spectral Range

Landsat ETM Band characteristics

Sensor and #	Description	Landsat	Wavelength (µm)	Resolution
ETM+ band 1	blue	7	0.45 - 0.515	30 m
ETM+ band 2	green	7	0.525 - 0.605	30 m
ETM+ band 3	red	7	0.63 - 0.690	30 m
ETM+ band 4	near infrared	7	0.75 - 0.90	30 m
ETM+ band 5	shortwave IR	7	1.55 - 1.75	30 m
ETM+ band 6	thermal IR	7	10.40 - 12.5	60 m
ETM+ band 7	shortwave IR	7	2.09 - 2.35	30 m
ETM+ band 8	panchromatic	7	0.52 - 0.90	15 m

1 Coastal water mapping, soil/vegetation discrimination, forest classification, man-made feature identification

2 Vegetation discrimination and health monitoring, man-made feature identification

3 Plant species identification, man-made feature identification

4 Soil moisture monitoring, vegetation monitoring, water body discrimination

5 Vegetation moisture content monitoring

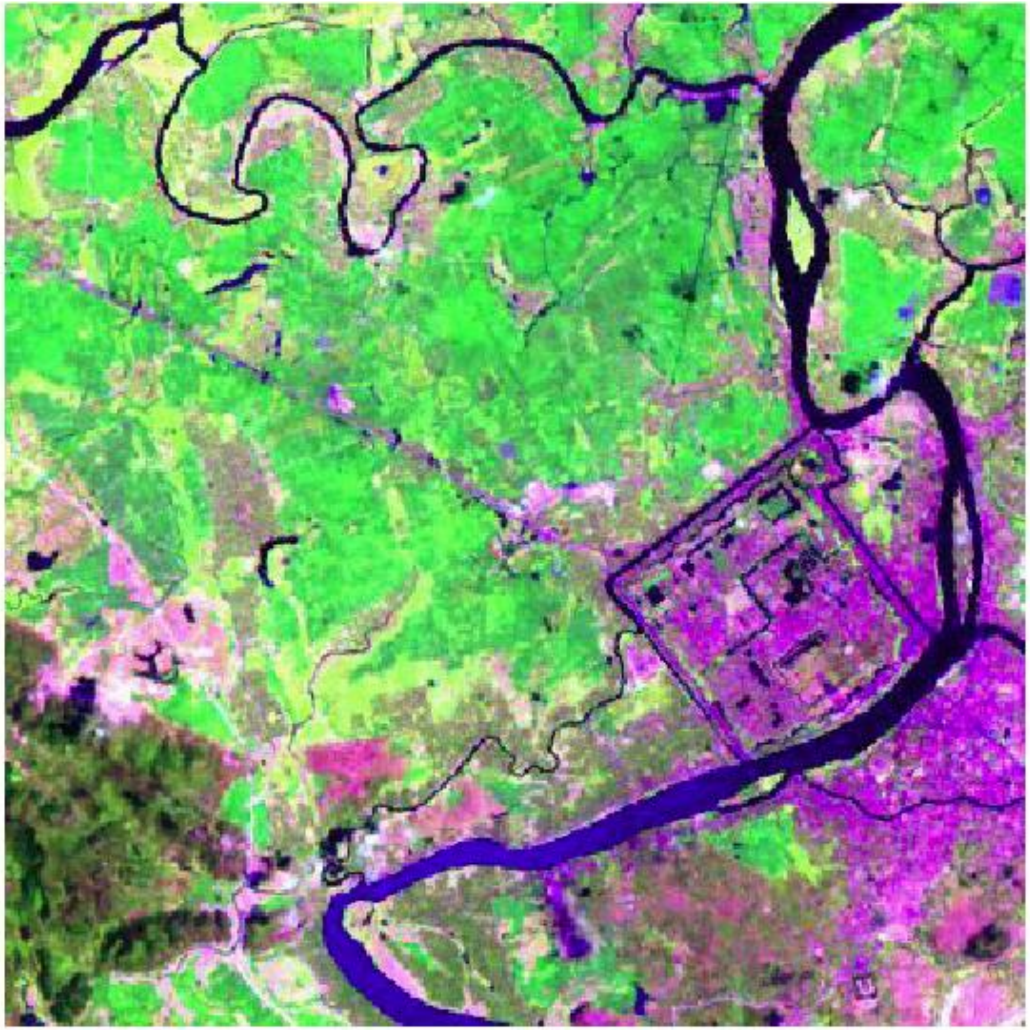
6 Surface temperature, vegetation stress monitoring, soil moisture monitoring, cloud differentiation, volcanic monitoring

7 Mineral and rock discrimination, vegetation moisture content

1. Agriculture, Forestry and Range Resources	2. Land Use and Mapping	3. Geology	4. Hydrology	5. Coastal Resources	6. Environmental Monitoring
1.1 Discriminating vegetative, crop and timber types	2.1 Classifying land uses	3.1 Mapping major geologic features	4.1 Determining water boundaries and surface water areas	5.1 Determining patterns and extent of turbidity	6.1 Monitoring deforestation
1.2 Measuring crop and timber acreage	2.2 Cartographic mapping and map updating	3.2 Revising geologic maps	4.2 Mapping floods and flood plain characteristics	5.2 Mapping shoreline changes	6.2 Monitoring volcanic flow activity
1.3 Precision farming land management	2.3 Categorizing land capabilities	3.3 Recognizing and classifying certain rock types	4.3 Determining area extent of snow and ice coverage	5.3 Mapping shoals, reefs and shallow areas	6.3 Mapping and monitoring water pollution
1.4 Monitoring crop and forest harvests	2.4 Monitoring urban growth	3.4 Delineating unconsolidated rocks and soils	4.4 Measuring changes and extent of glacial features	5.4 Mapping and monitoring sea ice in shipping lanes	6.4 Determining effects of natural disasters

1.5 Determining range readiness, biomass and health	2.5 Aiding regional planning	3.5 Mapping volcanic surface deposits	4.5 Measuring turbidity and sediment patterns	5.5 Tracking beach erosion and flooding	6.5 Assessing drought impact
1.6 Determining soil conditions and associations	2.6 Mapping transportation networks	3.6 Mapping geologic landforms	4.6 Delineating irrigated fields	5.6 Monitoring coral reef health	6.6 Tracking oil spills
1.7 Monitoring desert blooms	2.7 Mapping land-water boundaries	3.7 Identifying indicators of mineral and petroleum resources	4.7 Monitoring lake inventories and health	5.7 Determining coastal circulation patterns	6.7 Assessing and monitoring grass and forest fires
1.8 Assessing wildlife habitat	2.8 Siting transportation and power transmission routes	3.8 Determining regional geologic structures	4.8 Estimating snow melt runoff	5.8 Measuring sea surface temperature	6.8 Mapping and monitoring lake eutrophication
1.9 Characterizing forest range vegetation	2.9 Planning solid waste disposal sites, power plants and other industries	3.9 Producing geomorphic maps	4.9 Characterizing tropical rainfall	5.9 Monitoring and tracking 'red' tides	6.9 Monitoring mine waste pollution
1.10 Monitoring and mapping insect infestations	2.10 Mapping and managing flood plains	3.10 Mapping impact craters	4.10 Mapping watersheds		6.10 Monitoring volcanic ash plumes
1.11 Monitoring irrigation practices	2.11 Tracking socio-economic impacts on land use				

Landsat TM (WRS-2) Path = 125 Row = 49
April 21, 2003
Bands 5, 4, 3 represented with red, blue and green
The city of Hue in Vietnam



In this image the town of Hue, Vietnam is colored purple. The dark green color in the lower left portion of the image is forest and the green patches throughout the image represent grass, shrubs, and rice. The blue and black linear features are rivers, streams, and a moat around the old city of Hue.

Credit: *American Museum of Natural History, Center for Biodiversity and Conservation*

View:

Landsat band 1

Landsat band 2

Landsat band 3

Landsat band 4

Landsat band 5

Landsat band 6

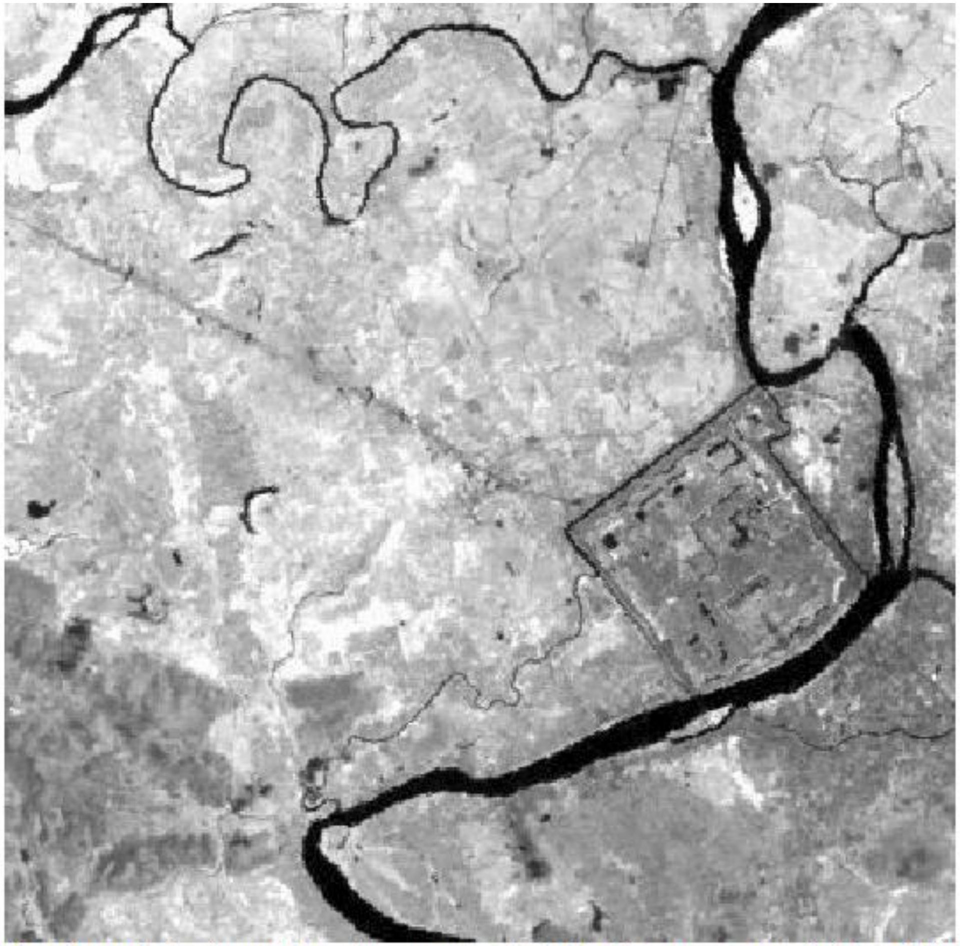
Landsat band 7

Landsat band 2 - (wavelength range = 0.52-0.60 µm = blue light)

View:
Landsat band 1
Landsat band 2
Landsat band 3
Landsat band 4
Landsat band 5
Landsat band 6
Landsat band 7

Landsat band 3 - (wavelength range = 0.63-0.69 µm = green light)

View:
Landsat band 1
Landsat band 2
Landsat band 3
Landsat band 4
Landsat band 5
Landsat band 6
Landsat band 7



Landsat band 4 - (wavelength range = 0.76-0.90 µm = near infrared light)

View:

[Landsat band 1]

[Landsat band 2]

[Landsat band 3]

[Landsat band 4]

[Landsat band 5]

[Landsat band 6]

[Landsat band 7]

Landsat band 5 - (wavelength range = 1.55-1.75 μm = mid-infrared light)

View:
Landsat band 1
Landsat band 2
Landsat band 3
Landsat band 4
Landsat band 5
Landsat band 6
Landsat band 7

Landsat band 7 - (wavelength range = 2.08-2.35 μm = mid-infrared light)

Landsat TM (WRS-2) Path = 125 Row = 49, April 21, 2003, The city of Hue in Vietnam

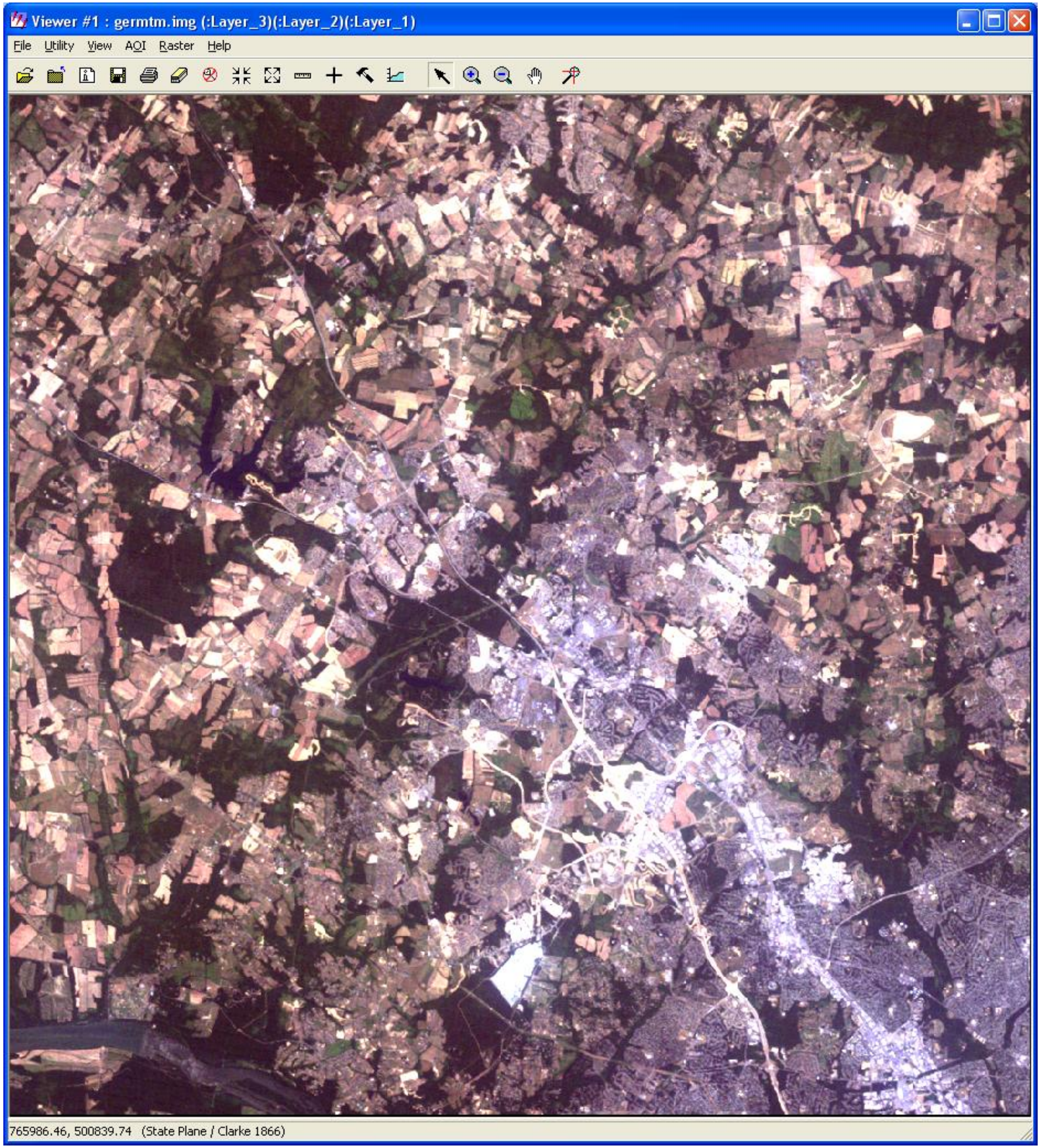
View:
Example 1
Example 2
Example 3
Example 4

Red = band 3, Green = band 2, Blue = band 1

This color composite is as close to true color that we can get with a Landsat ETM image. It is also useful for studying aquatic habitats. The downside of this set of bands is that they tend to produce a hazy image.

Credit: *American Museum of Natural History, Center for Biodiversity and Conservation*

TM
R,G,B = 3,2,1


Viewer #1 : germtm.img (:Layer_3)(:Layer_2)(:Layer_1)
File Utility View AOI Raster Help
765986.46, 500839.74 (State Plane / Clarke 1866)

Examples of different color composites

Landsat TM (WRS-2) Path = 125 Row = 49, April 21, 2003, The city of Hue in Vietnam

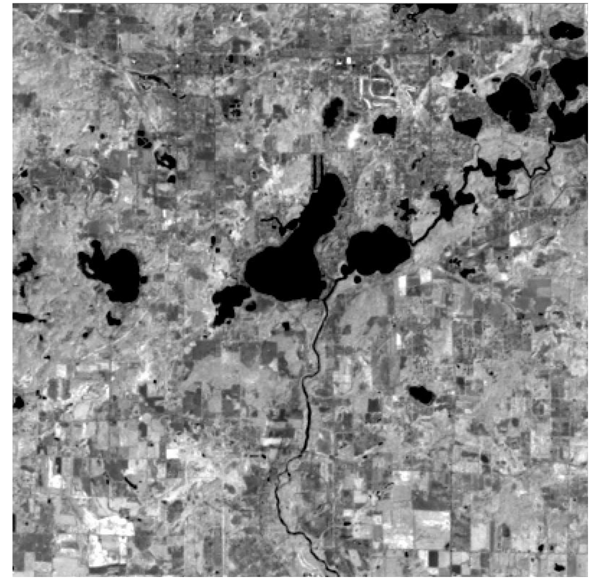
View:
Example 1
Example 2
Example 3
Example 4

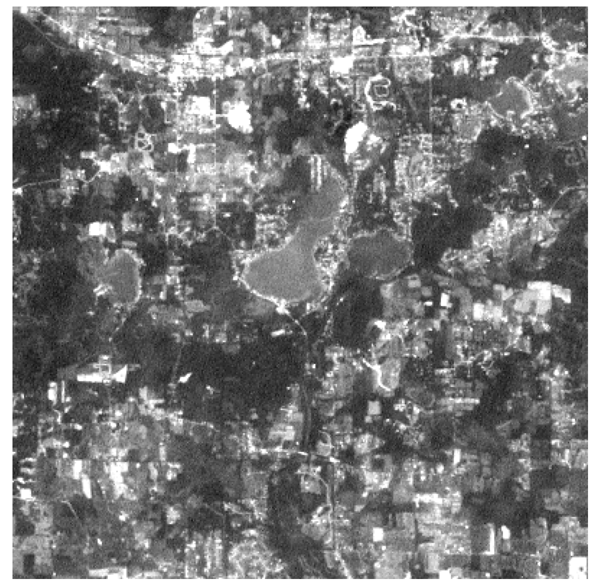
Red = band 4, Green = band 3, Blue = band 2

This has similar qualities to the image with bands 3,2,1 however, since this includes the near infrared channel (bar 4) land water boundaries are clearer and different types of vegetation are more apparent. This was a popular bar combination for Landsat MSS data since that did not have a mid-infrared band.

Credit: *American Museum of Natural History Center for Biodiversity and Conservation*

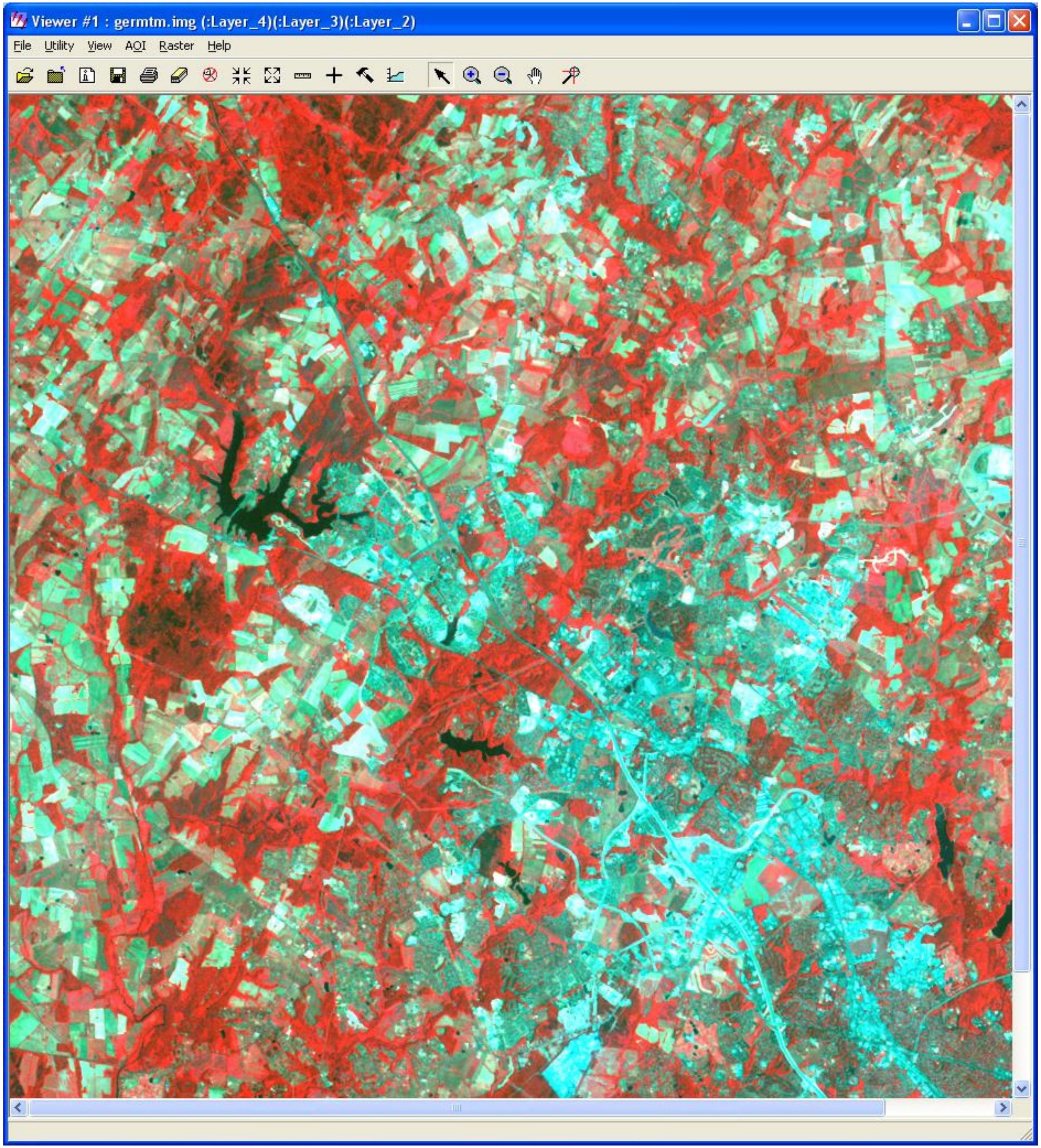
ETM+: CIR False Color Composite Image





TM

R,G,B = 4,3,2


Viewer #1 : germtm.img (:Layer_4)(:Layer_3)(:Layer_2)
File Utility View AOI Raster Help

Examples of different color composites

Landsat TM (WRS-2) Path = 125 Row = 49, April 21, 2003, The city of Hue in Vietnam

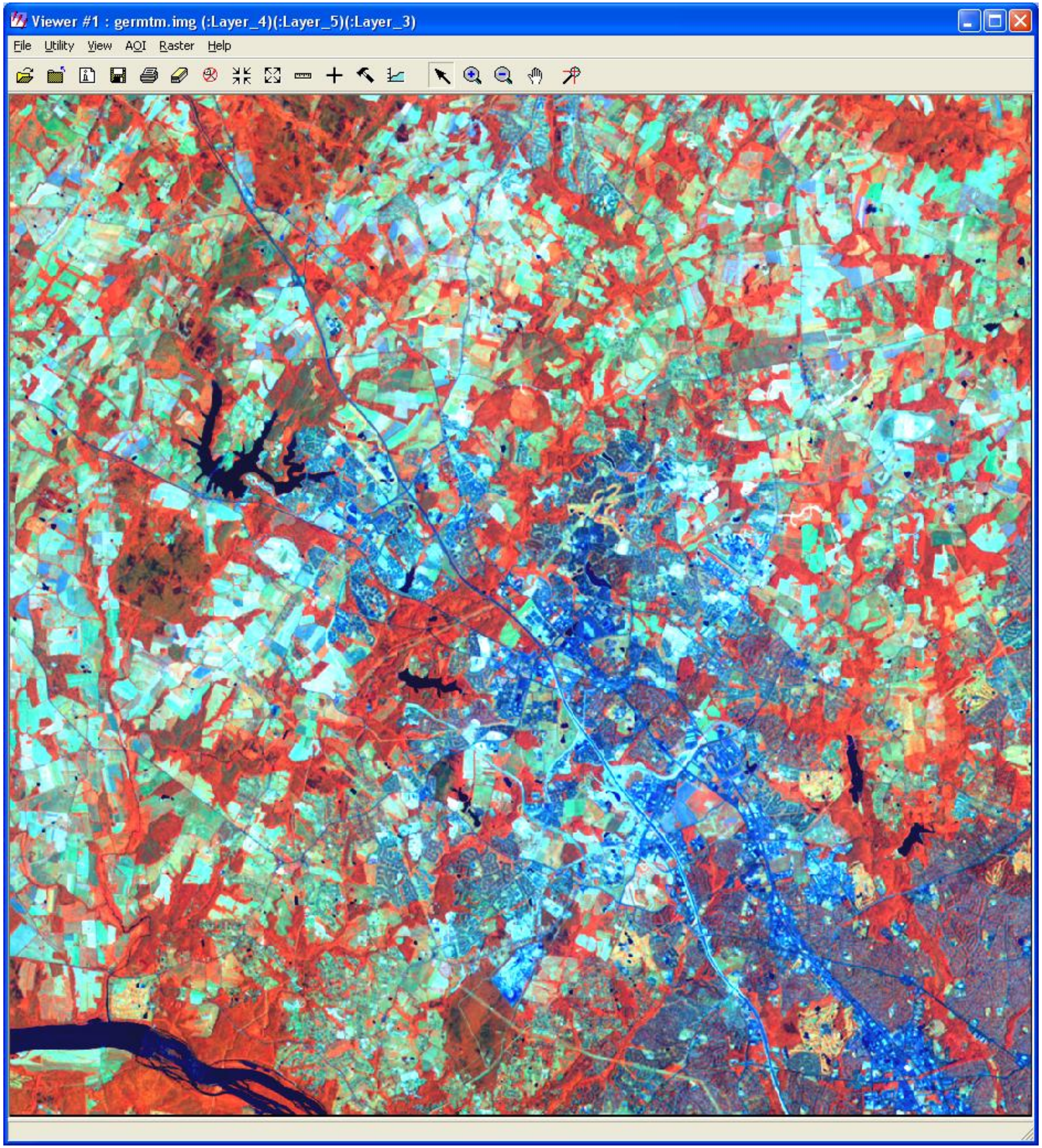
View:
Example 1
Example 2
Example 3
Example 4

Red = band 4, Green = band 5, Blue = band 3

This is crisper than the previous two images because the two shortest wavelength bands (bands 1 and 2) are not included. Different vegetation types can be more clearly defined and the land/water interface is very clear. Variations in moisture content are evident with this set of bands. This is probably the most common band combination for Landsat imagery.

TM

R,G,B = 4,5,3



Viewer #1 : germtm.img (:Layer_4)(:Layer_5)(:Layer_3)
File
Utility
View
AOI
Raster
Help

Examples of different color composites

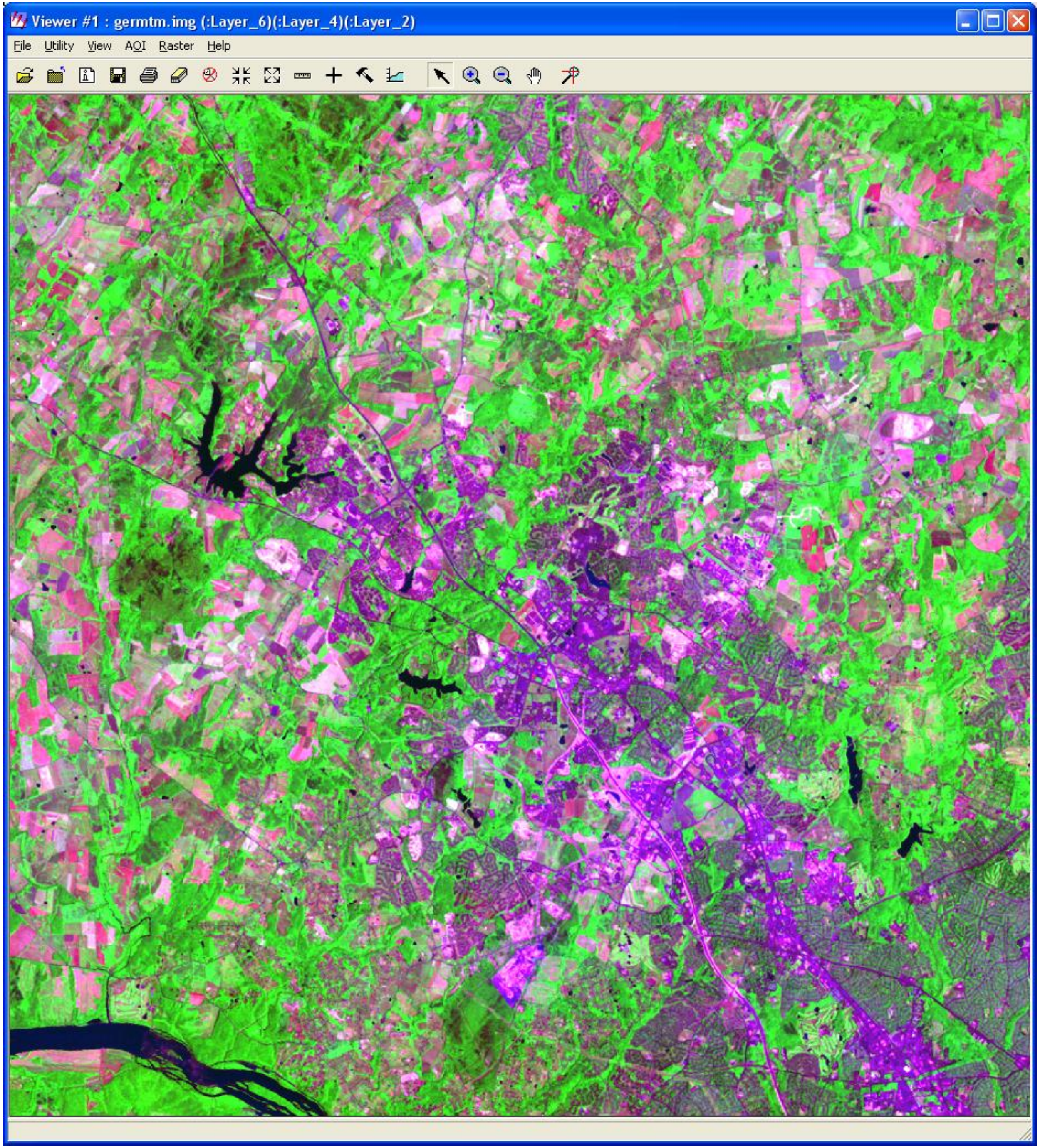
Landsat TM (WRS-2) Path = 125 Row = 49, April 21, 2003, The city of Hue in Vietnam

View:
Example 1
Example 2
Example 3
Example 4

Red = band 7, Green = band 4, Blue = band 2

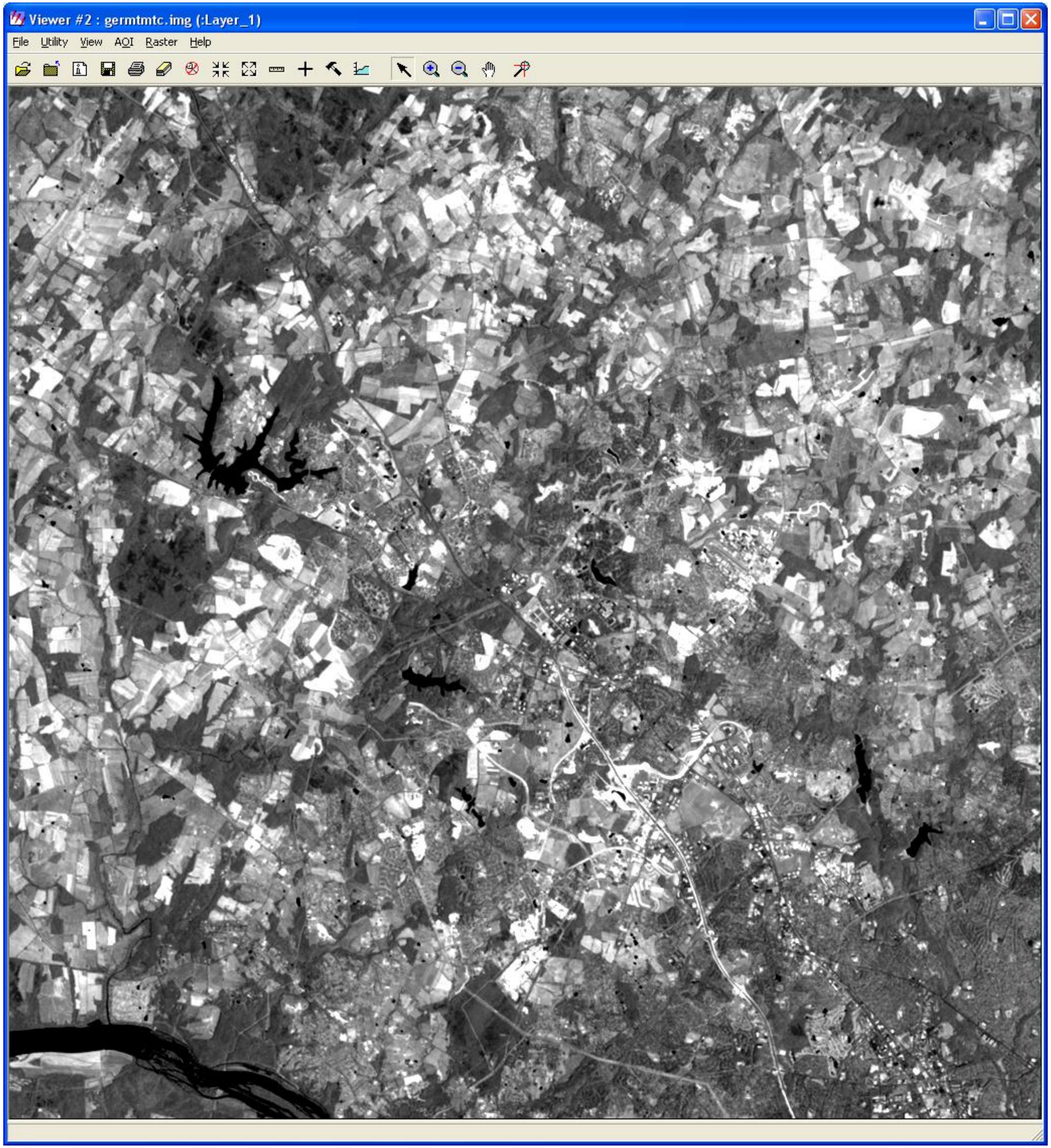
This has similar properties to the 4,5,3 band combination with the biggest difference being that vegetation is green. This is the band combination that was selected for the global Landsat mosaic created for NASA.

TM
R,G,B = 7,4,2

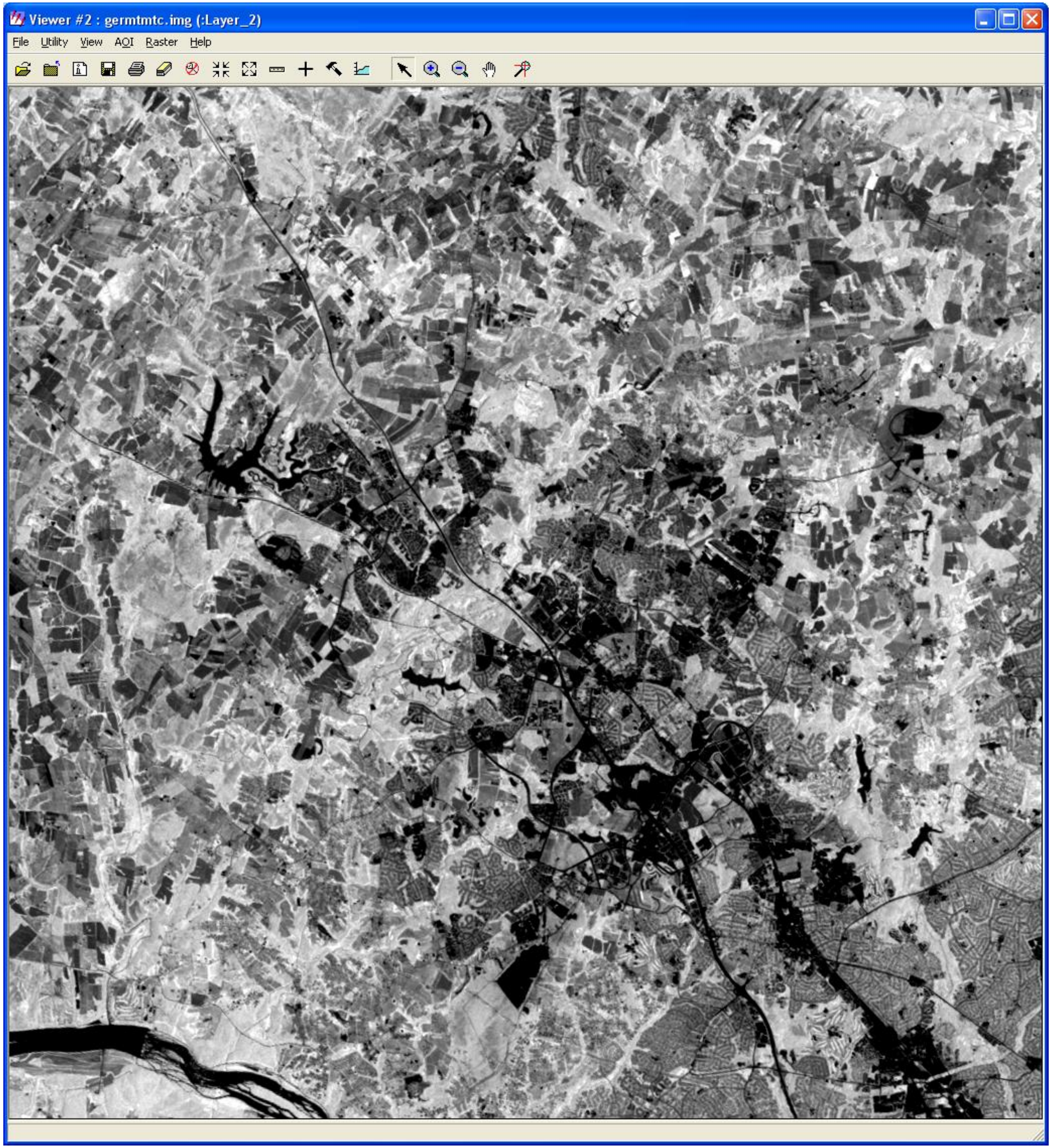


Viewer #1 : germtm.img (:Layer_6)(:Layer_4)(:Layer_2)
File Utility View AOI Raster Help

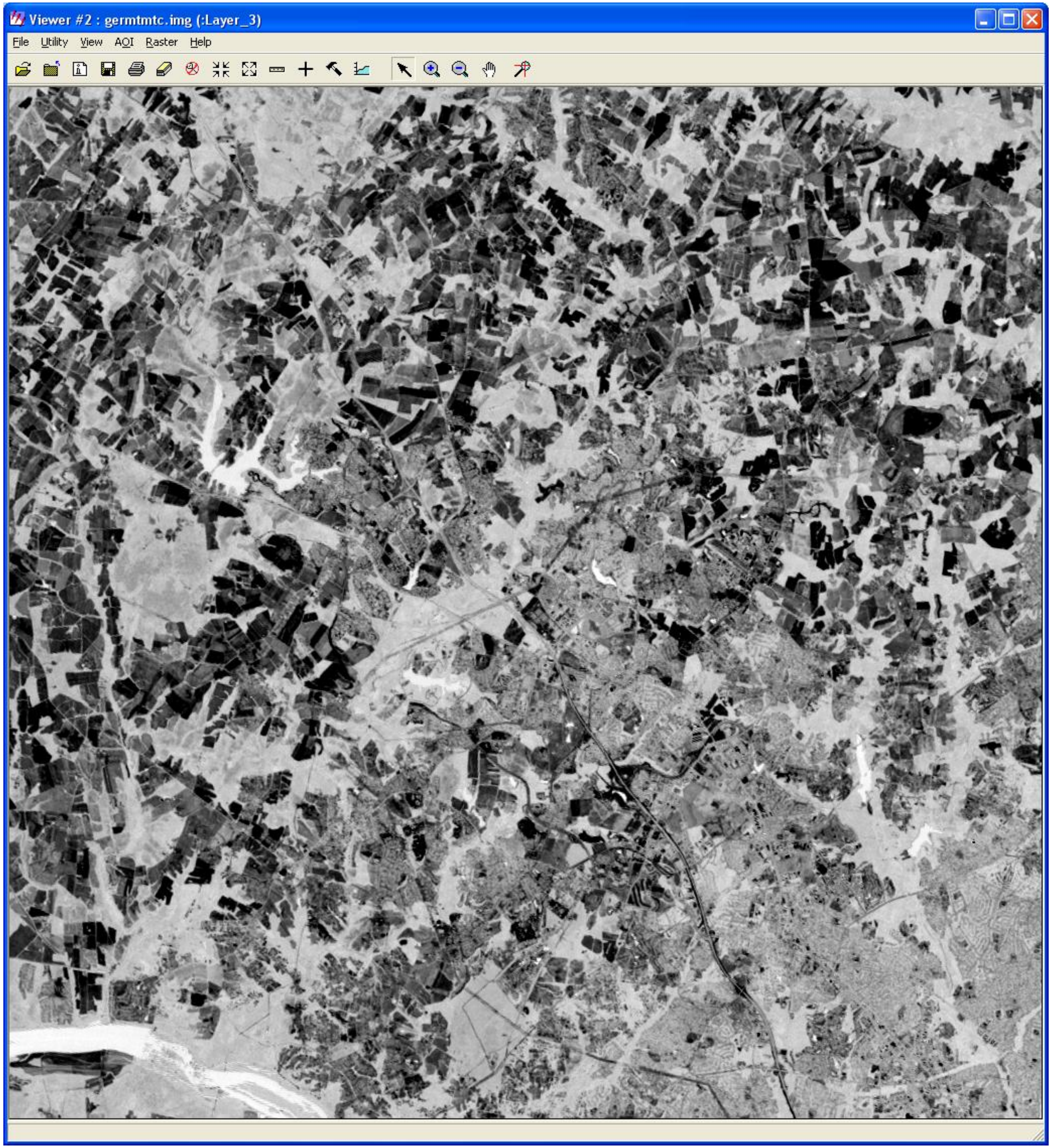
Tasseled Cap: Brightness



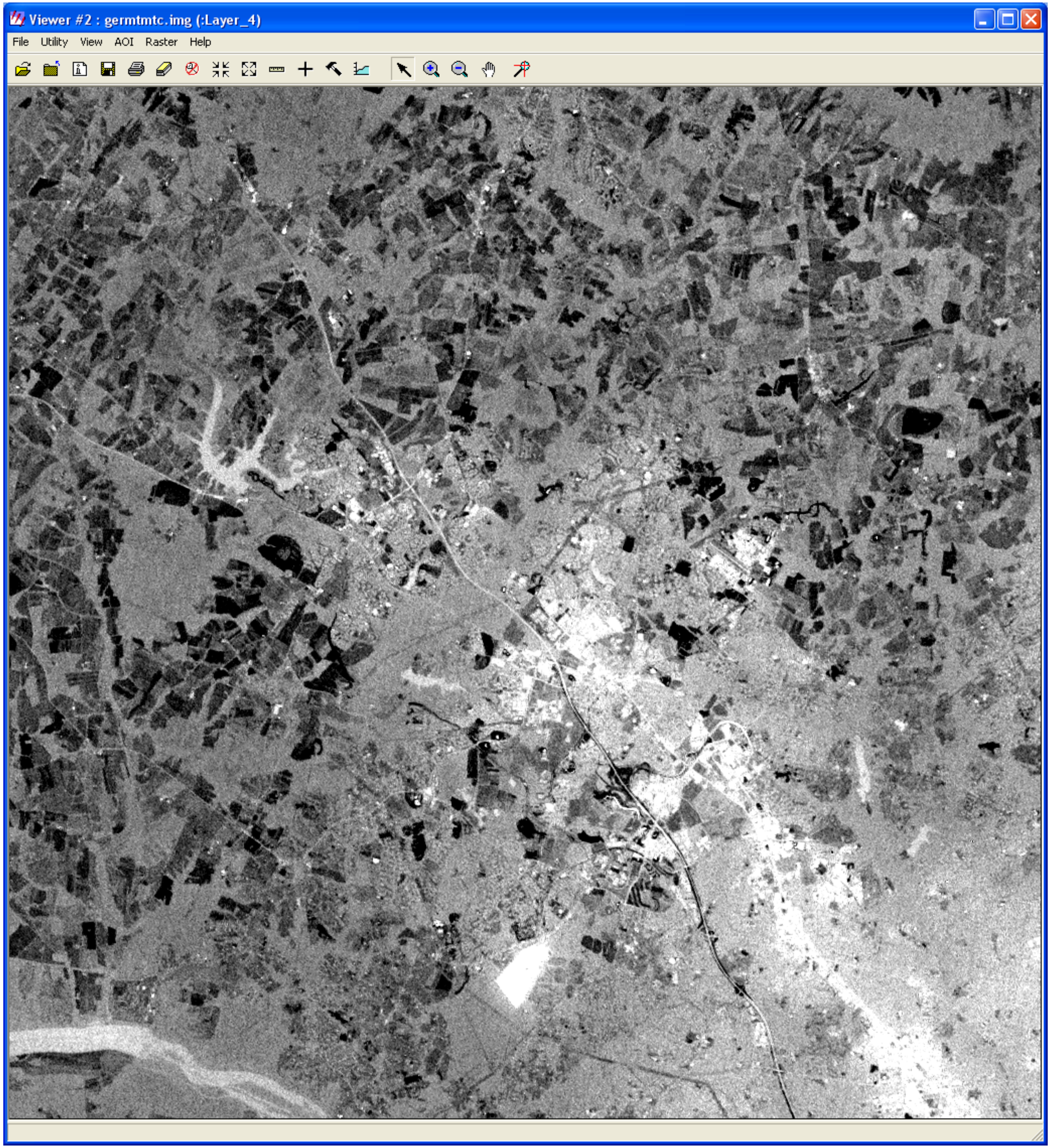
TC: Greenness



TC: Wetness


Viewer #2 : germtmtc.img (:Layer_3)
File Utility View AOI Raster Help

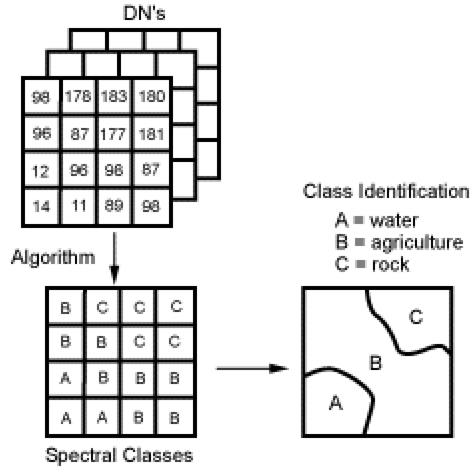
TC: Haziness



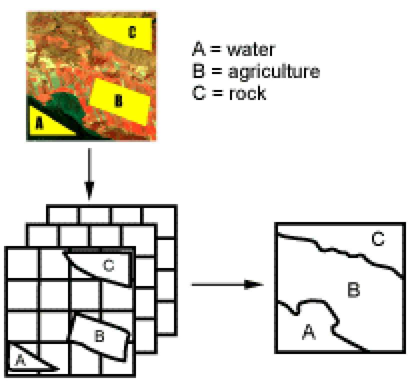
Viewer #2 : germtmtc.img (:Layer_4)
File Utility View AOI Raster Help


yer_3)(:Layer_2)(:Layer_1)
arke 1866)
img (:Layer_3)(:Layer_2)(:Layer_1)
elp

Classification



- Classification scheme
- Class signatures
  - Unsupervised classification (ISODATA)
  - Supervised classification
    - Training sites
- Classification rules (classifiers)



Classification Approaches

- Unsupervised: self organizing
- Supervised: training
- Hybrid: self organization by categories
- Spectral Mixture Analysis: sub-pixel variations.

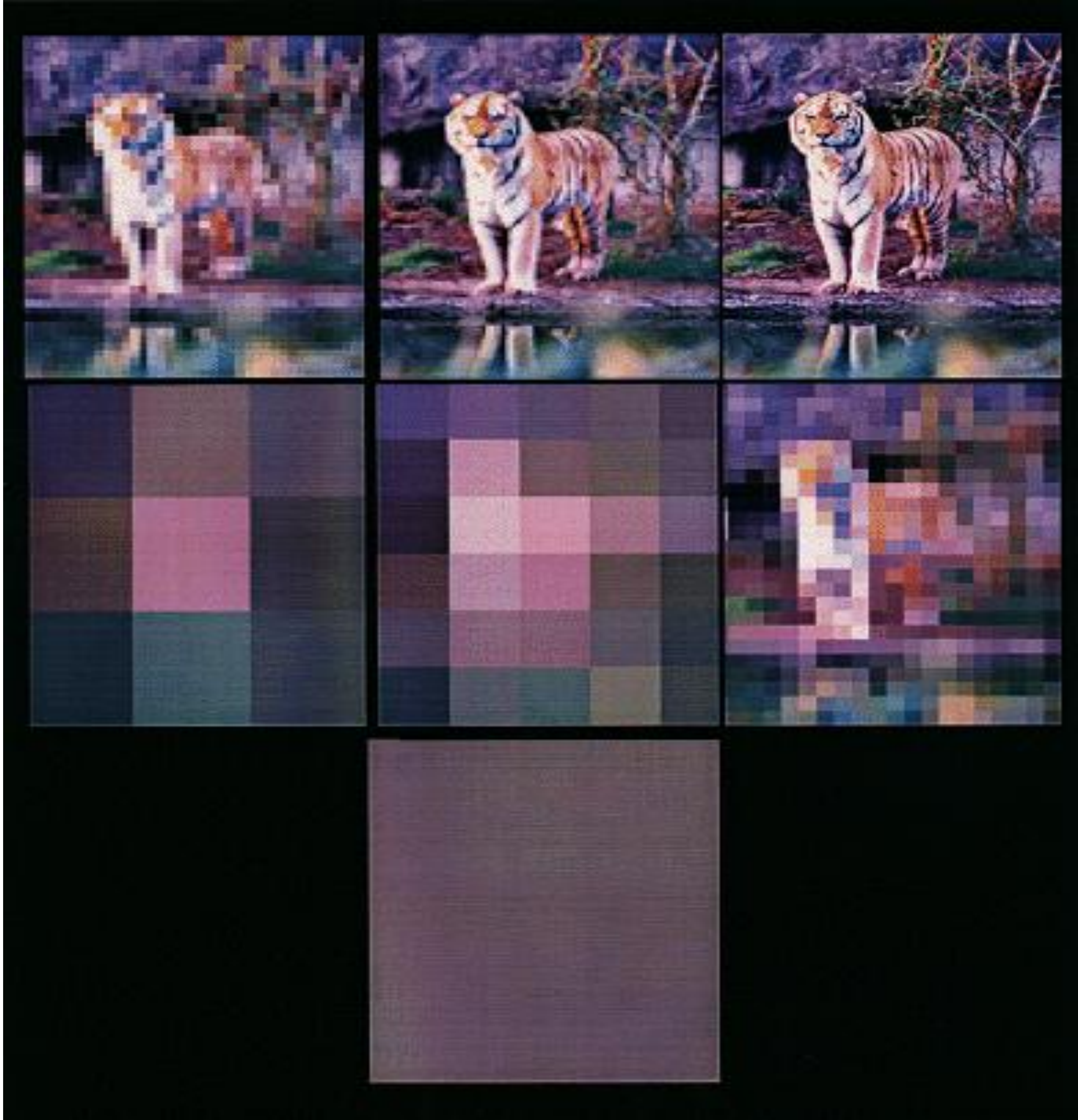
Clustering / Classification

- Clustering or Training Stage:
  - Through actions of either the analyst's supervision or an unsupervised algorithm, a numeric description of the spectral attribute of each "class" is determined (a multi-spectral cluster mean signature).
- Classification Stage:
  - By comparing the spectral signature to of a pixel (the measure signature) to the each cluster signature a pixel is assigned to a category or class.

terms

- Parametric = based upon statistical parameters normal distribution (mean & standard deviation)
- Non-Parametric = based upon objects (polygons) in feature space
- Decision Rules = rules for sorting pixels into classes

Resolution and Spectral Mixing



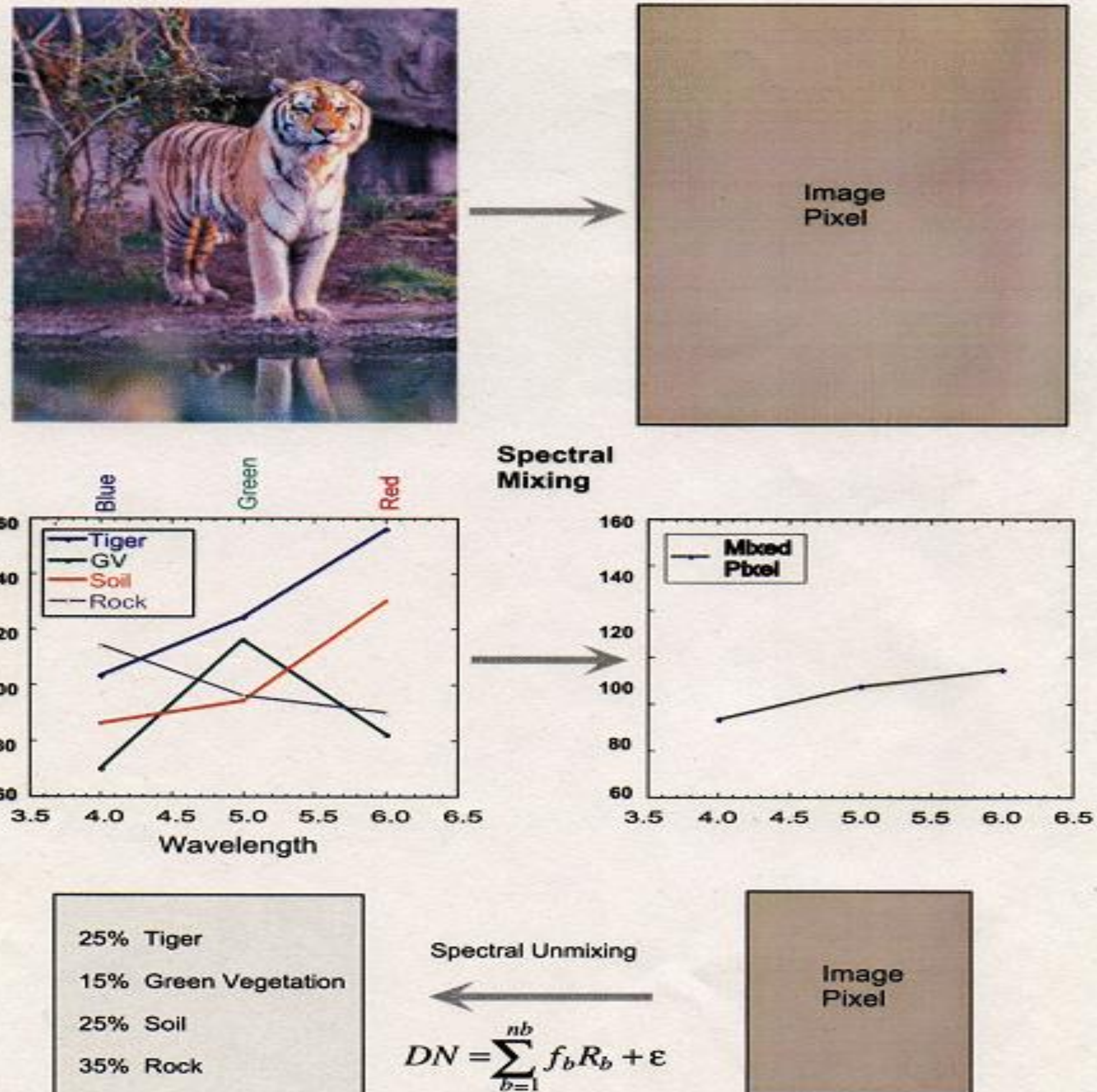


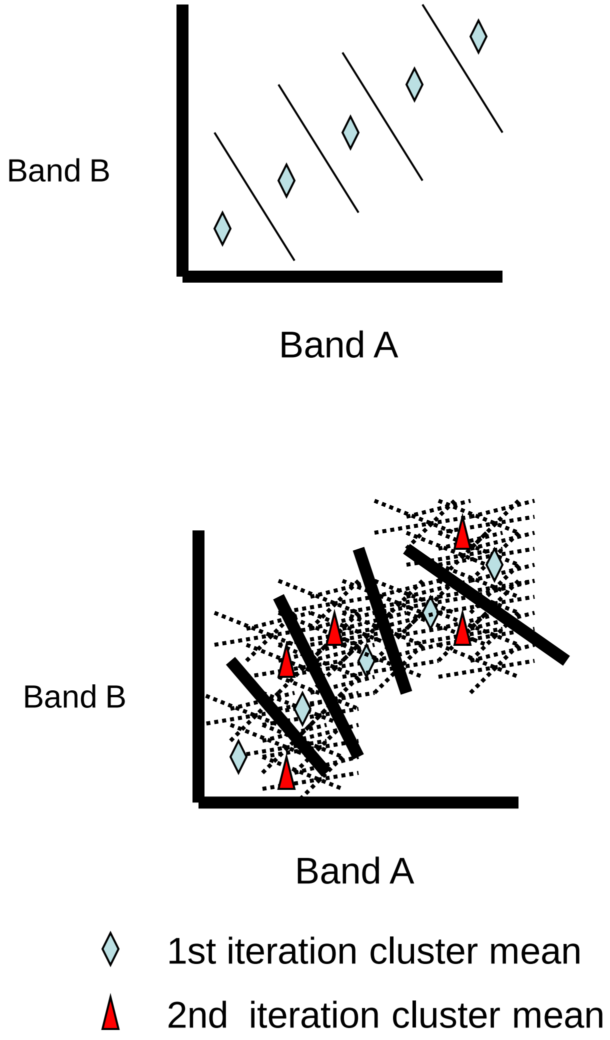
Image
Pixel
Spectral
Mixing
Blue
Green
Red
Tiger
GV
Soil
Rock
160
140
120
100
80
60
3.5
4.0
4.5
5.0
5.5
6.0
6.5
Wavelength
Mixed
Pixel
25% Tiger
15% Green Vegetation
25% Soil
35% Rock
Spectral Unmixing
$DN = \sum_{b=1}^{nb} f_b R_b + \varepsilon$
Image
Pixel

Clustering

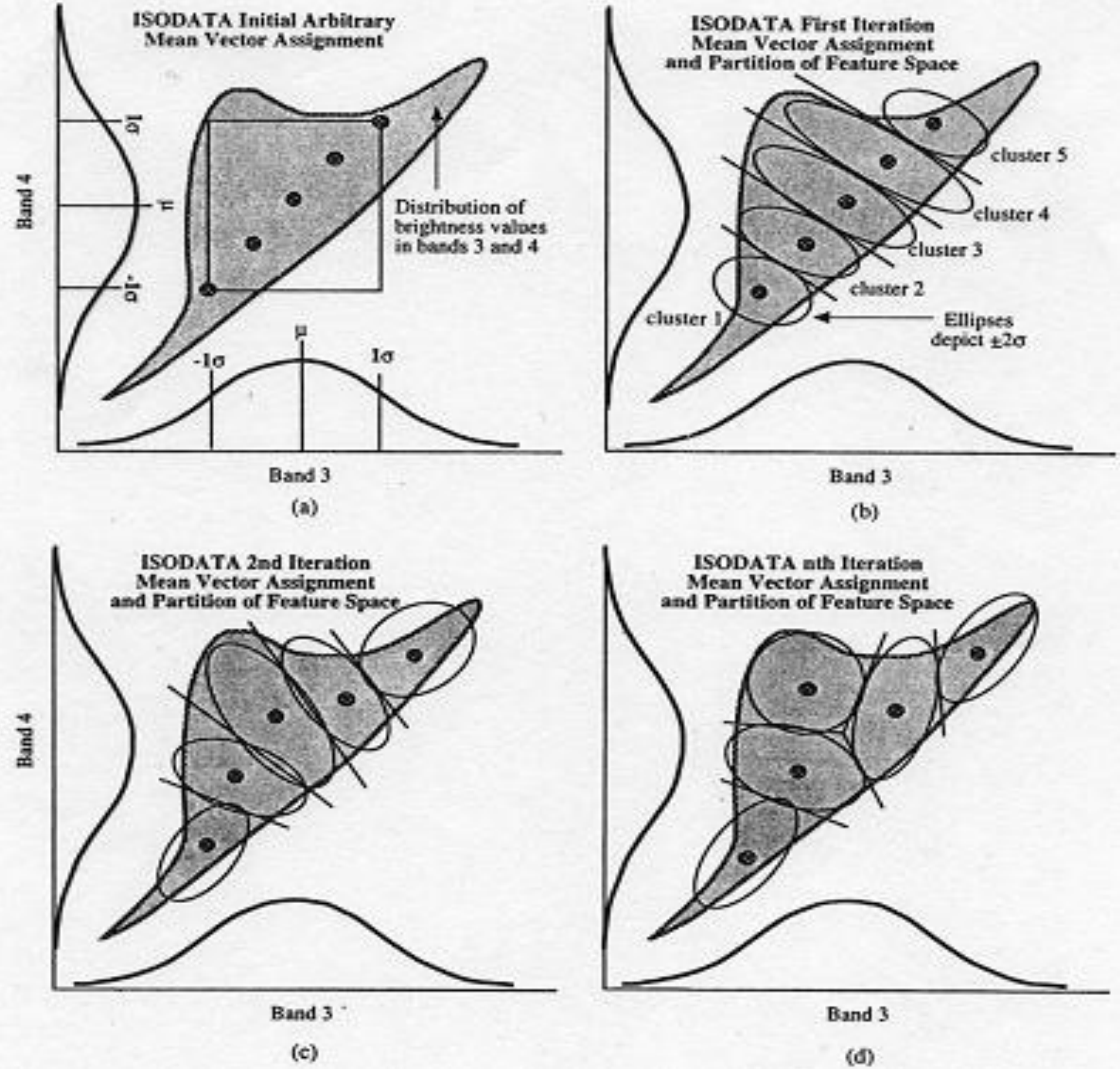
Minimum Spectral Distance - unsupervised

ISODATA

I - iterative
S - self
O - organizing
D - data
A - analysis
T - technique
A - (application)

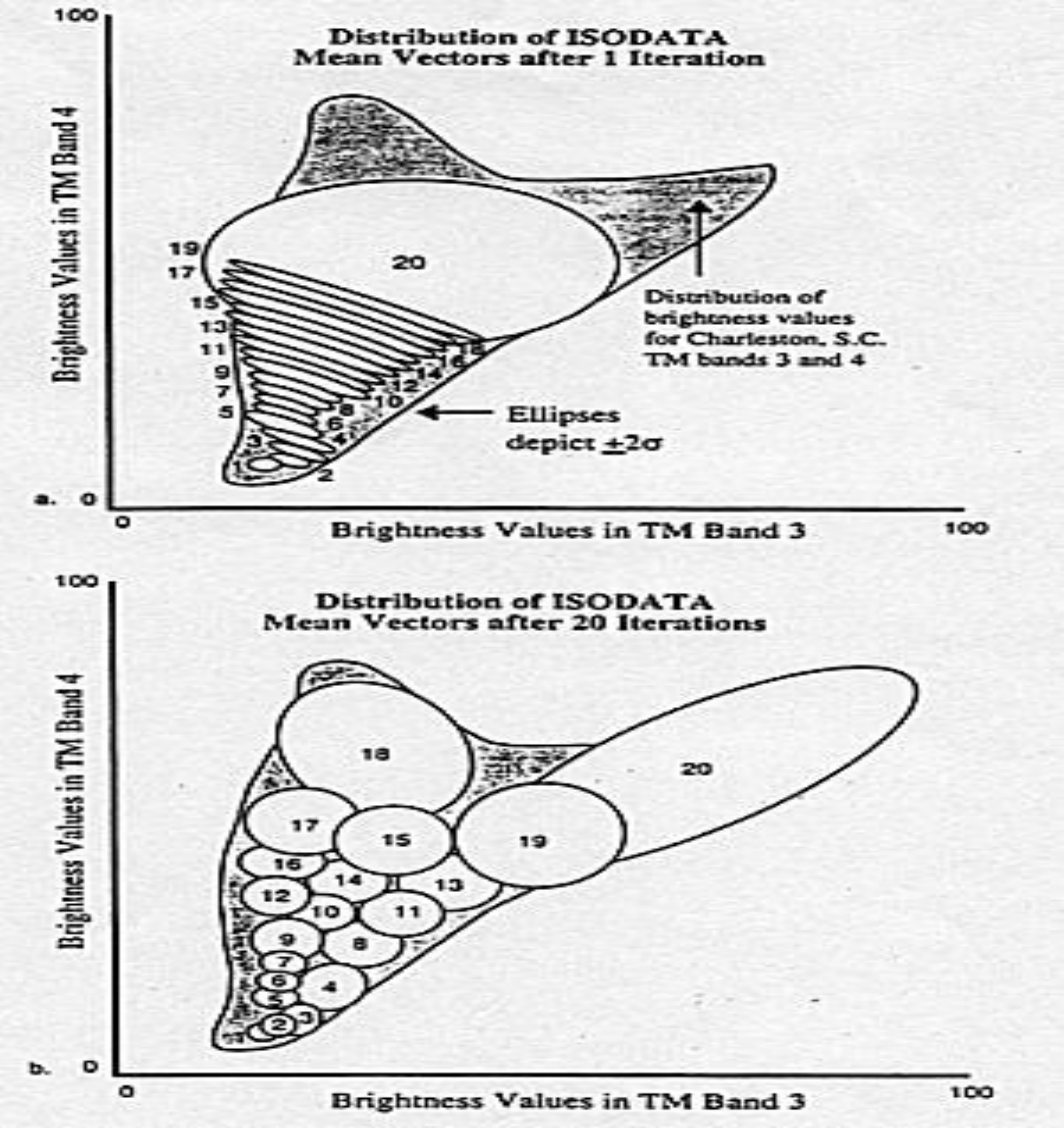


ISODATA clusters

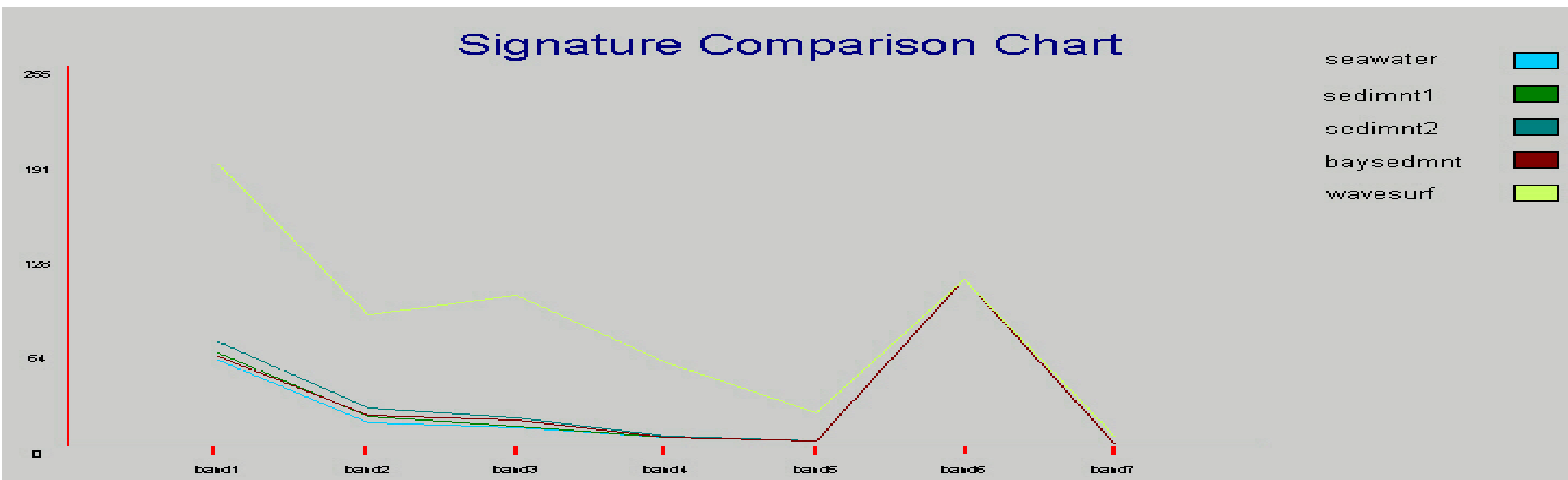


Unsupervised Classification ISODATA -

Iterative Self-Organizing Data Analysis Technique



Supervised Classification



Classification Decision Rules

- If the non-parametric test results in one unique class, the pixel will be assigned to that class.
- if the non-parametric test results in zero classes (outside the decision boundaries) the the "unclassified rule applies … either left unclassified or classified by the parametric rule
- if the pixel falls into more than one class the overlap rule applies … left unclassified, use the parametric rule, or processing order
- Useful fact: we aren't limited to using only raw DNs, radiance, or reflectance in our classifier. We can use ratio or difference indices, LSU fractions, spatial data (distance from some target) or any other data transformation we might think would be appropriate in the classifier.

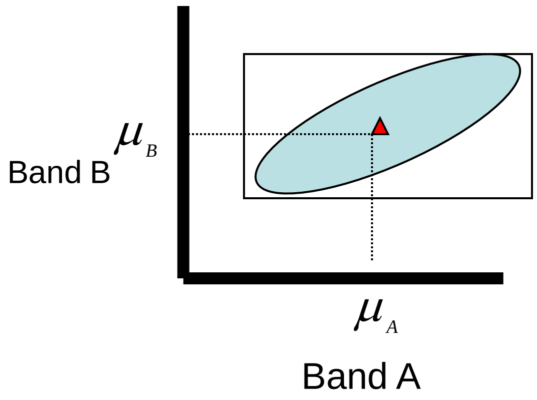
Non-Parametric
•parallelepiped
•feature space

Unclassified Options
•parametric rule
•unclassified

Overlap Options
•parametric rule
•by order
•unclassified

Parametric
•minimum distance
•Mahalanobis distance
•maximum likelihood

Parallelepiped



Maximum likelihood

(bayesian)

- probability
- Bayesian, a prior (weights)

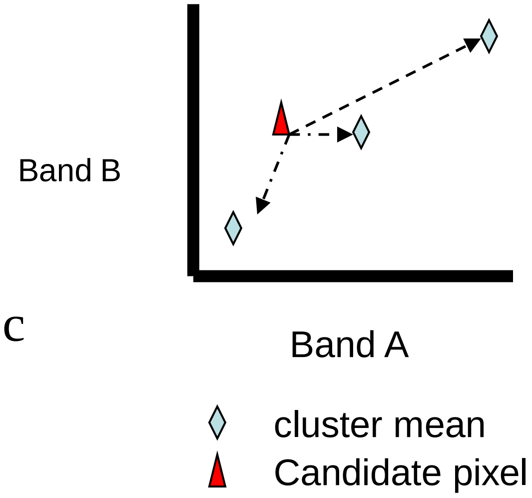
Minimum Distance

$$SD_{xyc} = \sqrt{\sum_{i=1}^{n} \left(\mu_{ci} - X_{xyi}\right)^2}$$

$c = \text{class}$

$X_{xyi} = \text{value of pixel x, y in i class}$

$\mu_{ci} = \text{mean of values in i for sample for class c}$

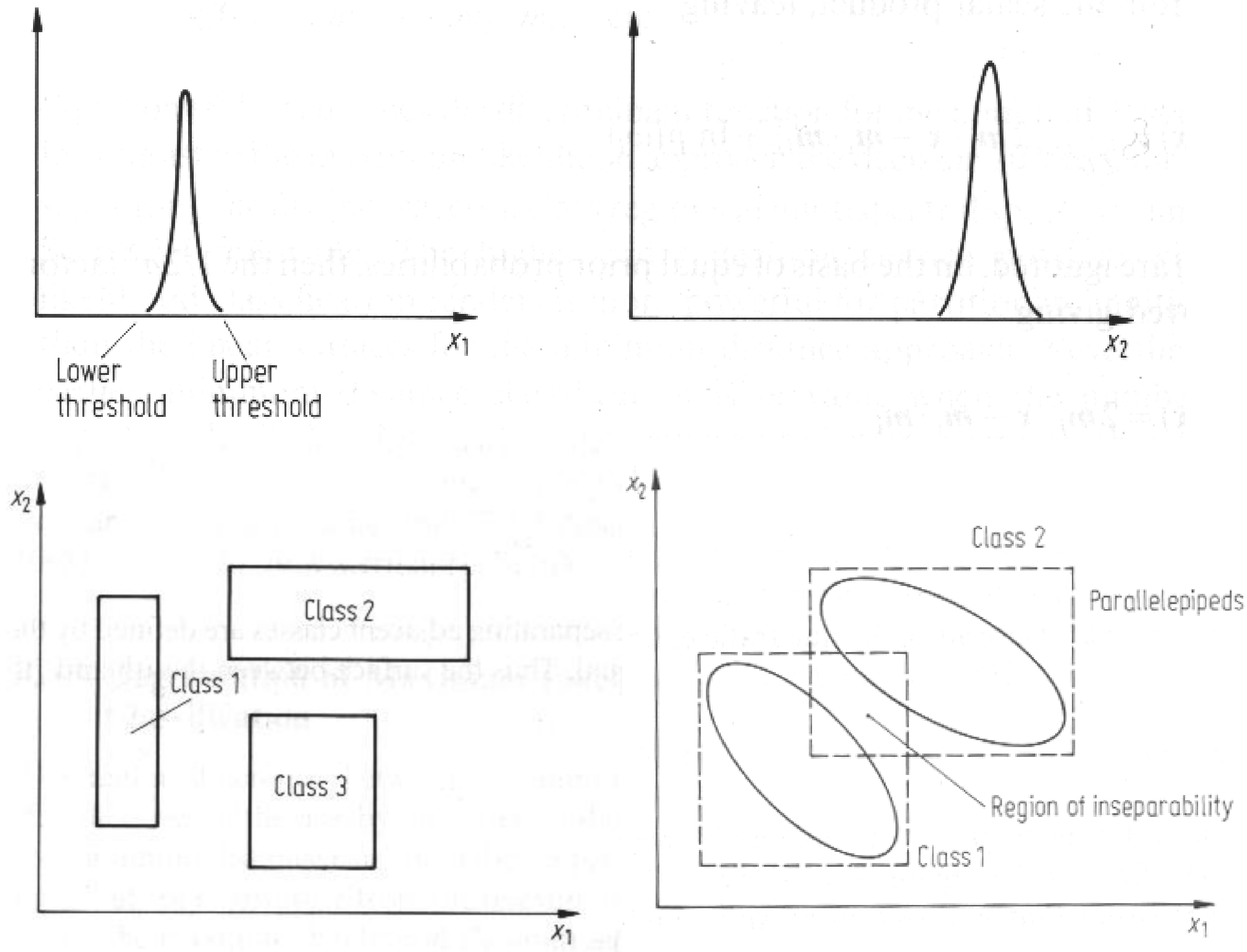


Parallelepiped Classifier

- The minimum and maximum DNs for each class are determined and are used as thresholds for classifying the image.
- Benefits: simple to train and use, computationally fast
- Drawbacks: pixels in the gaps between the parallelepipes can not be classified; pixels in the region of overlapping parallelepipes can not be classified.

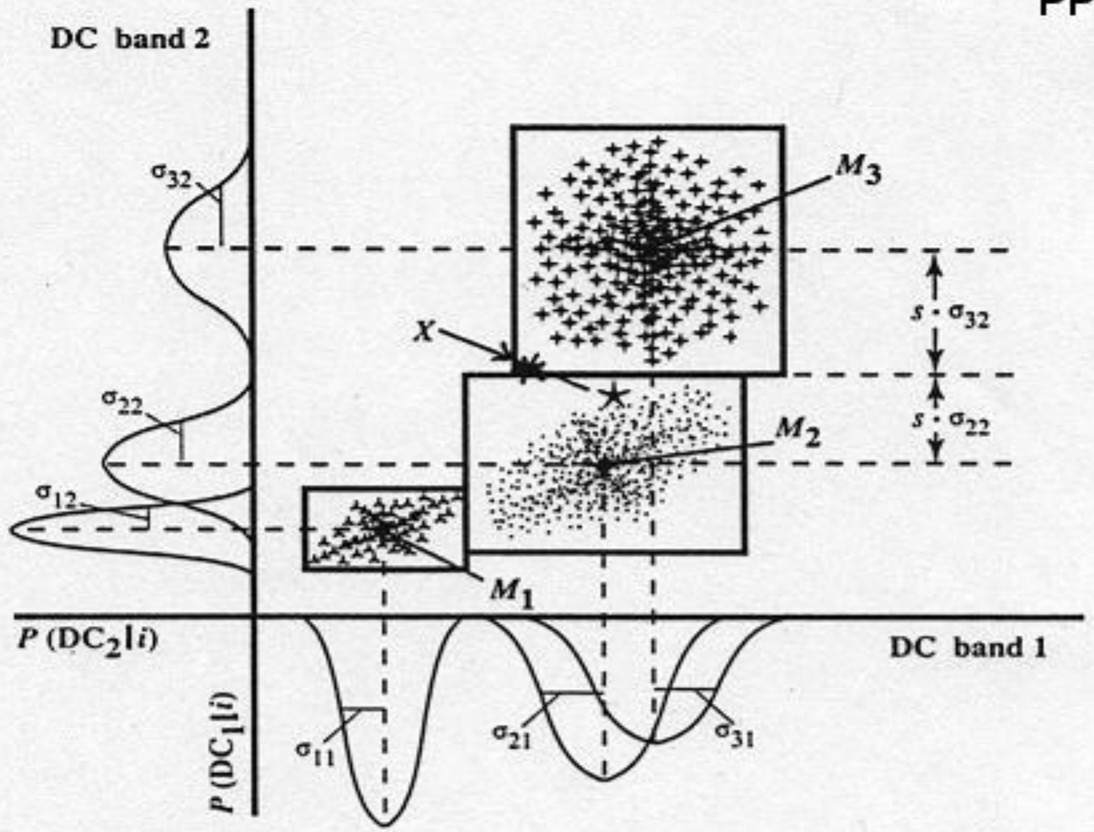
How it works ...

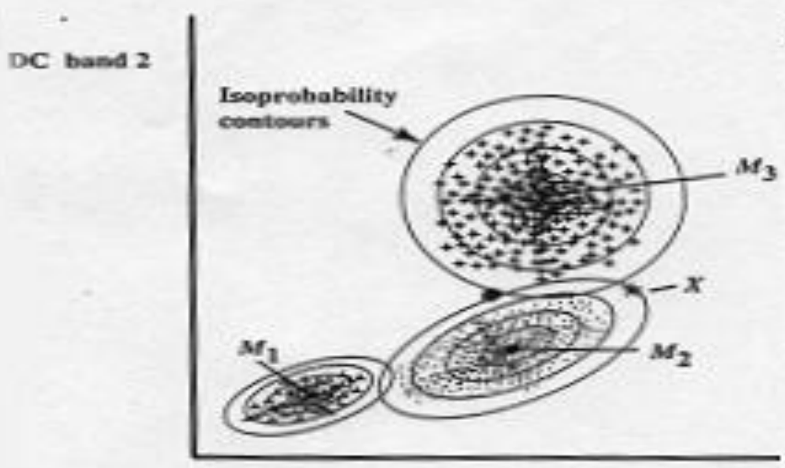
Parallelepiped Classifier

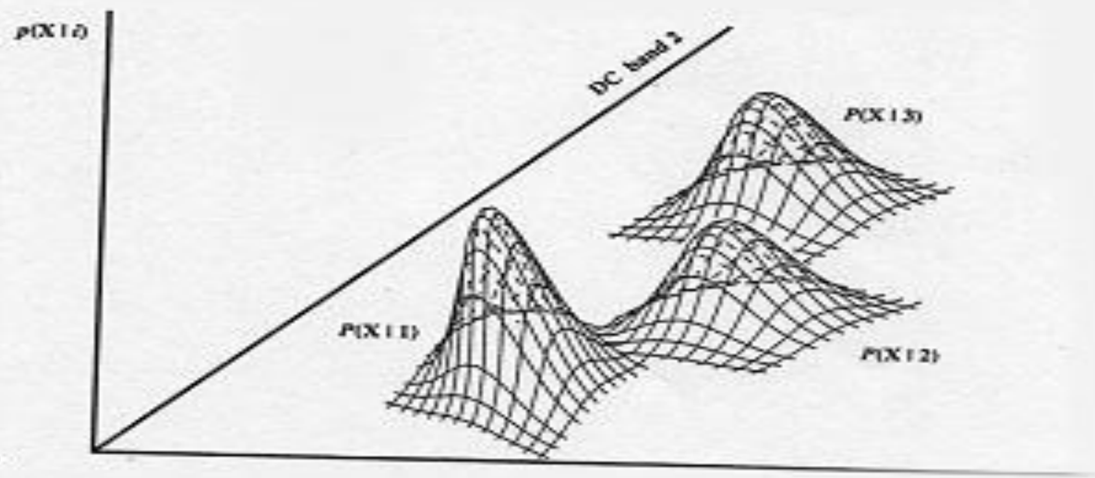


Parametric classifiers

PP

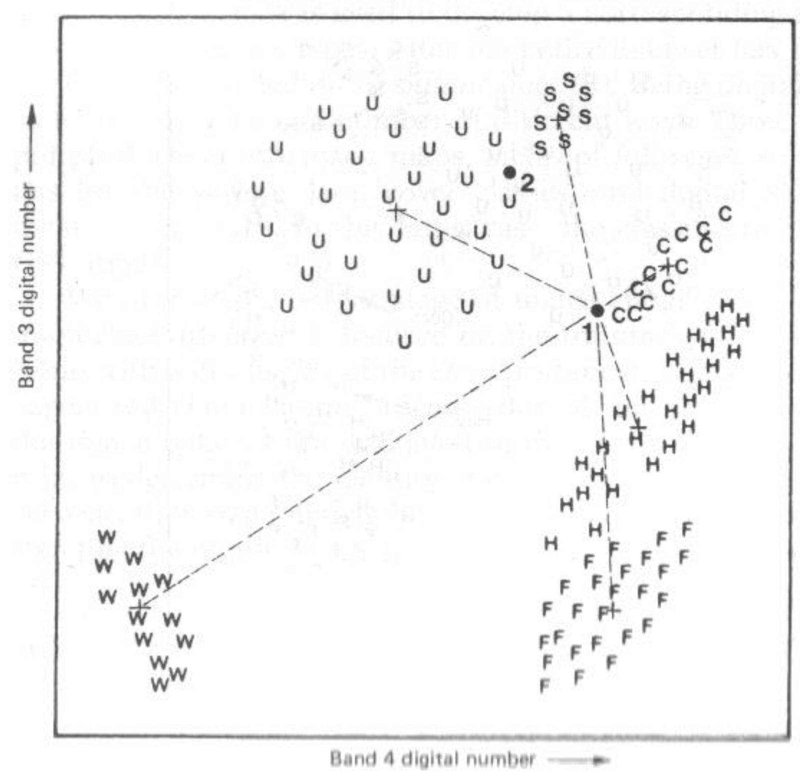






Minimum Distance Classifier

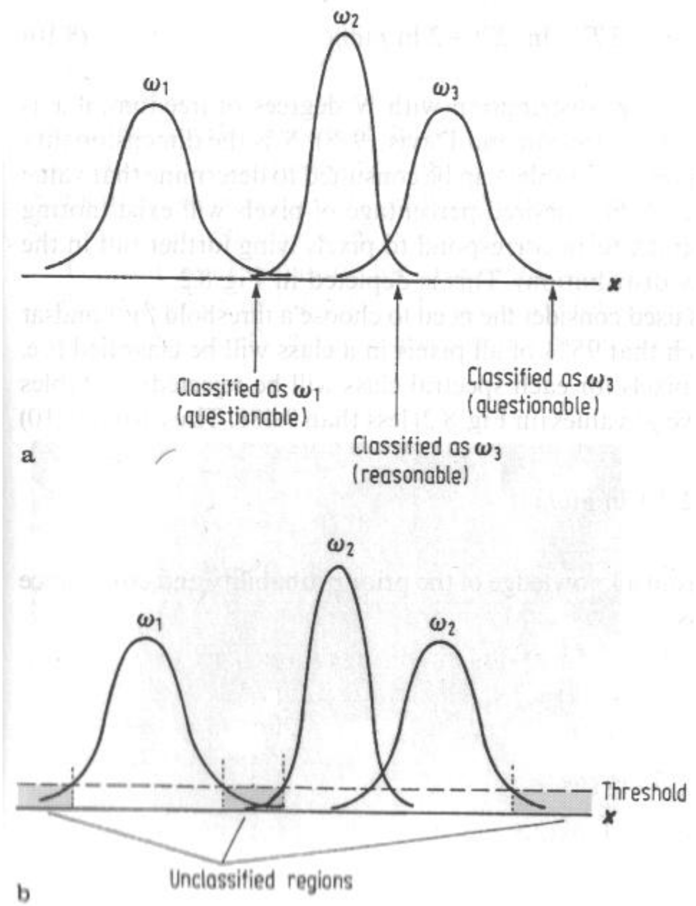
- A "centroid" for each class is determined from the data by calculating the mean value by band for each class. For each image pixel, the distance in n-dimensional distance to each of these centroids is calculated, and the closest centroid determines the class.
- Benefits: mathematically simple and computationally efficient
- Drawback: insensitive to different degrees of variance in spectral response data.



Maximum Likelihood Classifier

- Max likelihood uses the variance and covariance in class spectra to determine classification scheme.

- It often, but not always, assumes that the spectral responses for a given class are normally distributed.

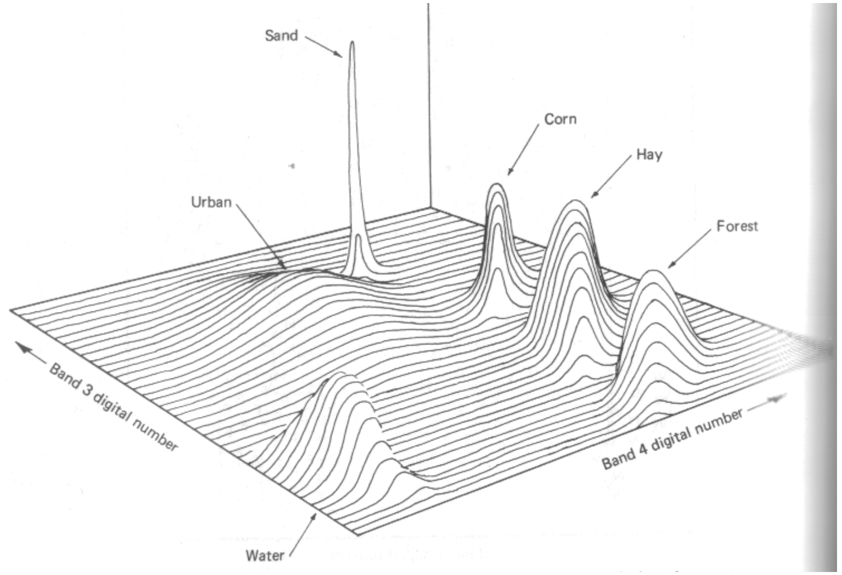


Maximum Likelihood Classifier

- We can then determine a probability that a given DN is a member of each class. The pixel is classified by using the most likely class or “Other” if the probability isn’t over some threshold.

- Benefits: takes variation in spectral response into consideration.

- Drawbacks: computationally intensive; multimodal or non-normally distributed classes require extra care when training the classifier, if high accuracy is to be achieved.



Classification Systems

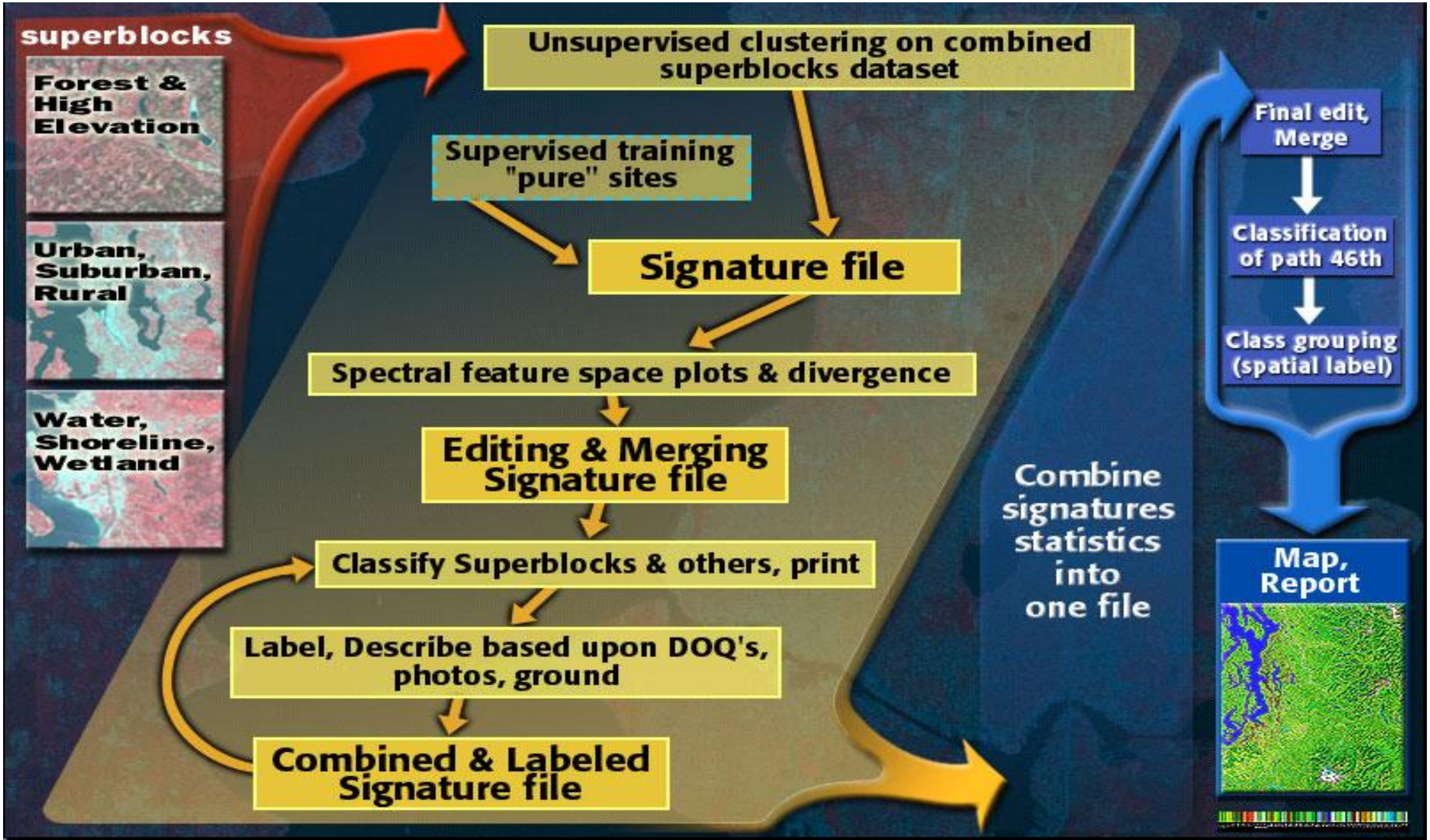
USGS - U.S. Geological Survey Land Cover Classification Scheme for Remote Sensor Data
USFW - U.S. Fish & Wildlife Wetland Classification System
NOAA CCAP - C-CAP Landcover Classification System, and Definitions
NOAA CCAP - C-CAP Wetland Classification Scheme Definitions
PRISM - PRISM General Landcover
King Co. - King County General Landcover (specific use, by Chris Pyle)

Level

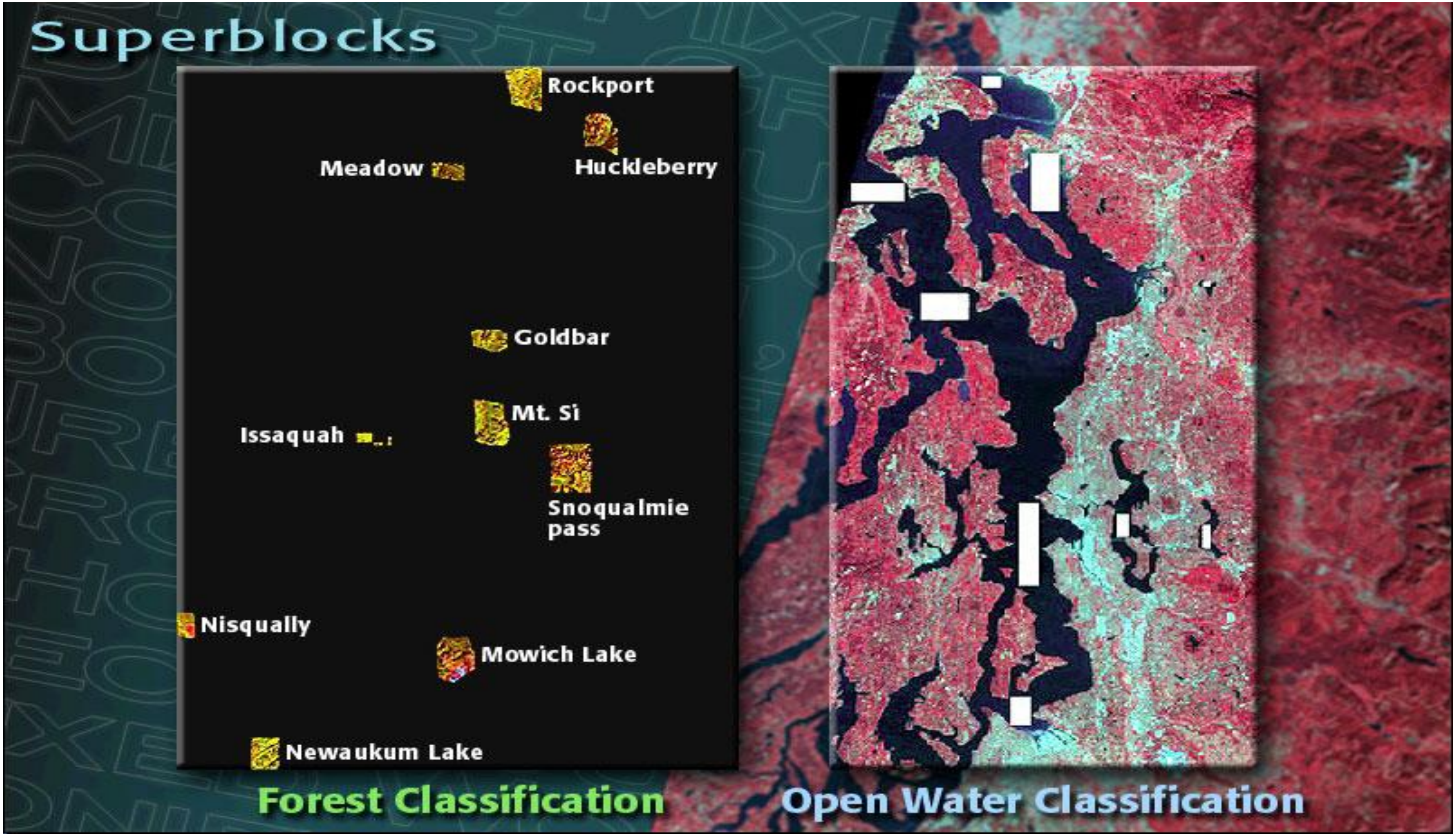
- 1 Urban or Built-Up Land
  - 11 Residential
  - 12 Commercial and Services
  - 13 Industrial
  - 14 Transportation, Communications and Utilities
  - 15 Industrial and Commercial Complexes
  - 16 Mixed Urban or Built-Up
  - 17 Other Urban or Built-up Land
- 2 Agricultural Land
  - 21 Cropland and Pasture
  - 22 Orchards, Groves, Vineyards, Nurseries and Ornamental Horticultural Areas
  - 23 Confined Feeding Operations
  - 24 Other Agricultural Land

http://boto.ocean.washington.edu/oc_gis_rs/lawrs/classify.html

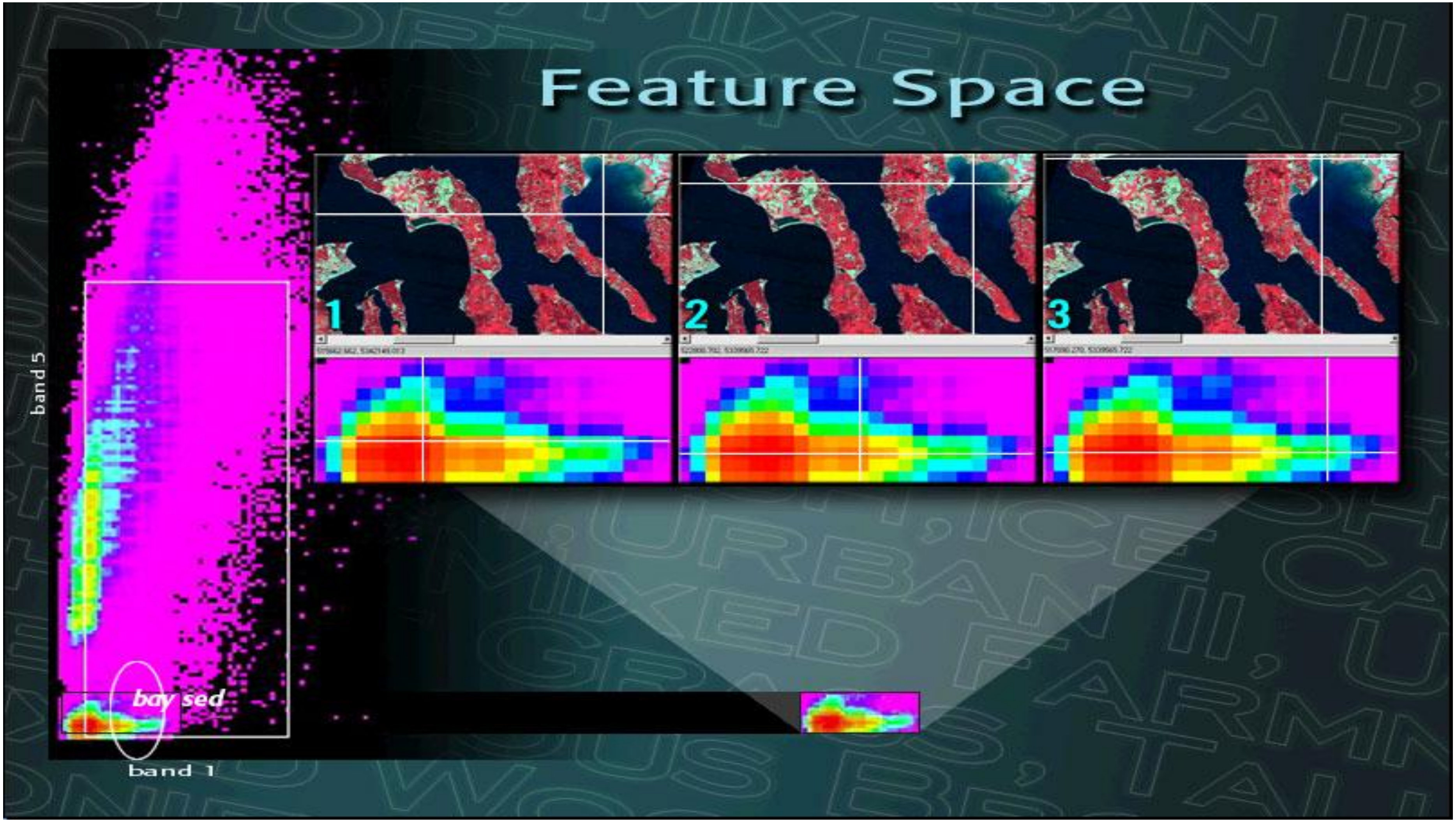
Hybrid Classification



Hybrid - “superblocks”



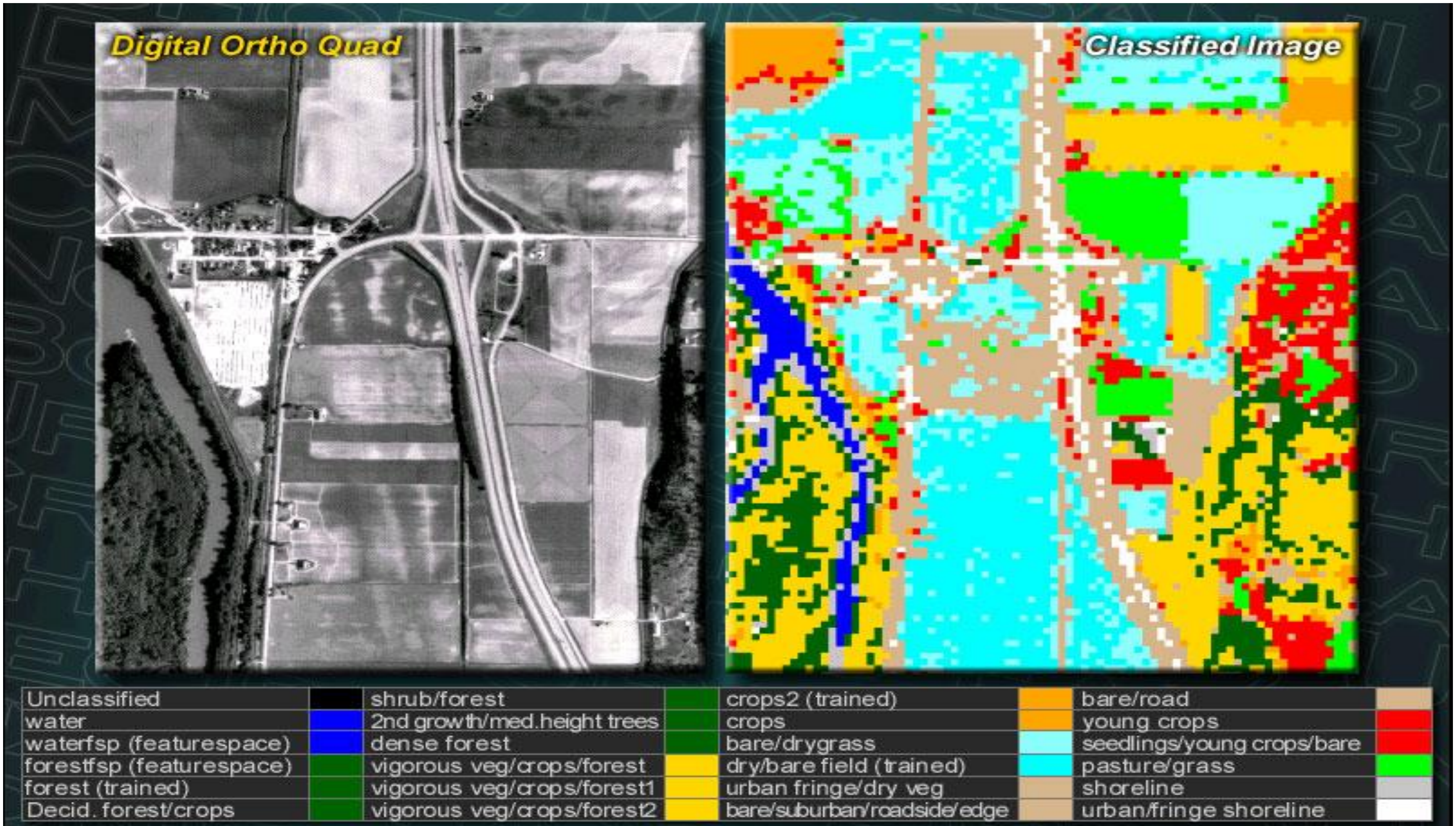
Feature Space



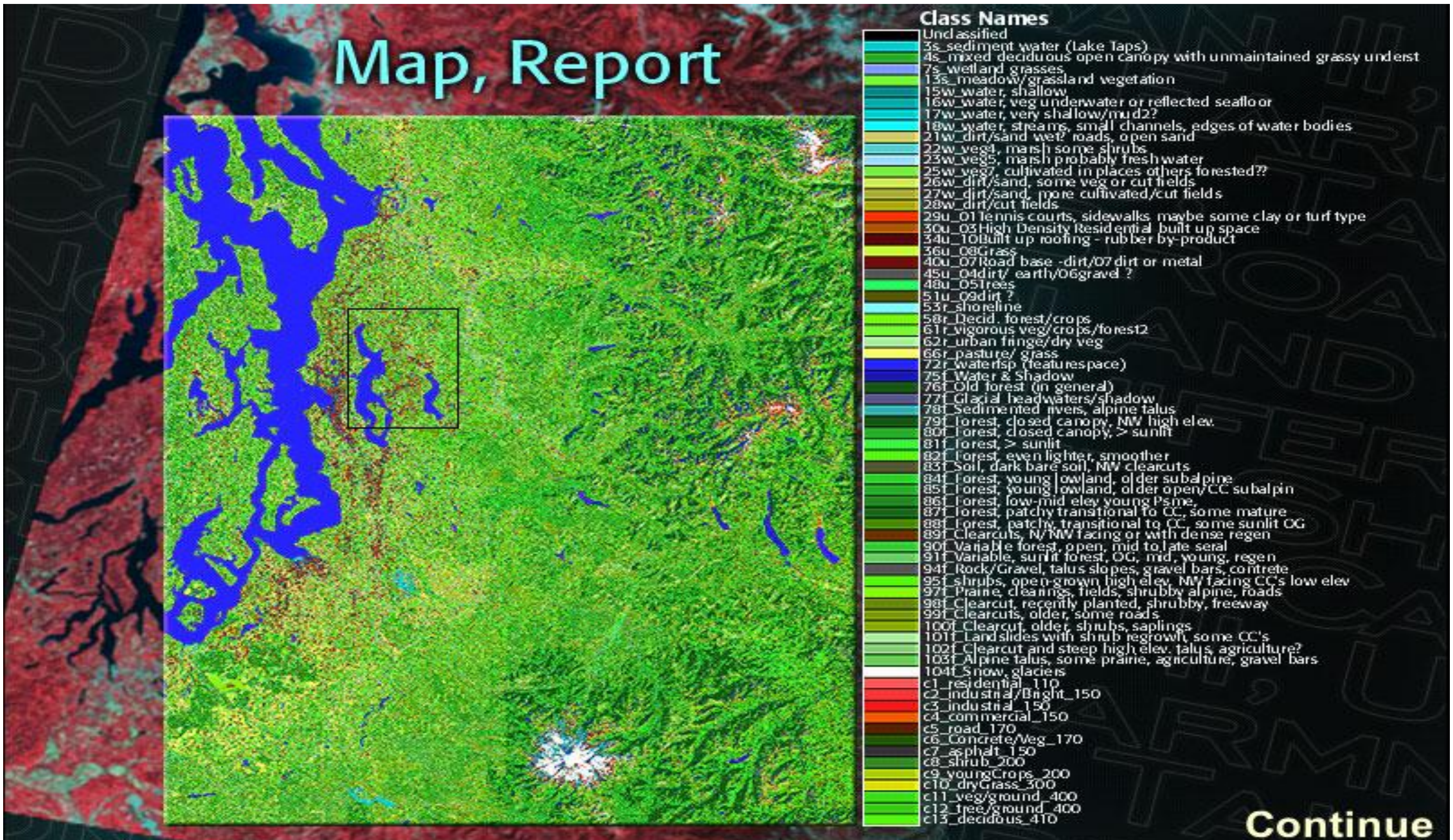
Accuracy assessment

- Classified map
- Reference (ground trued) sample points
- Error matrix (contingency table)
  - PCC

Ground Truth



Classified Product



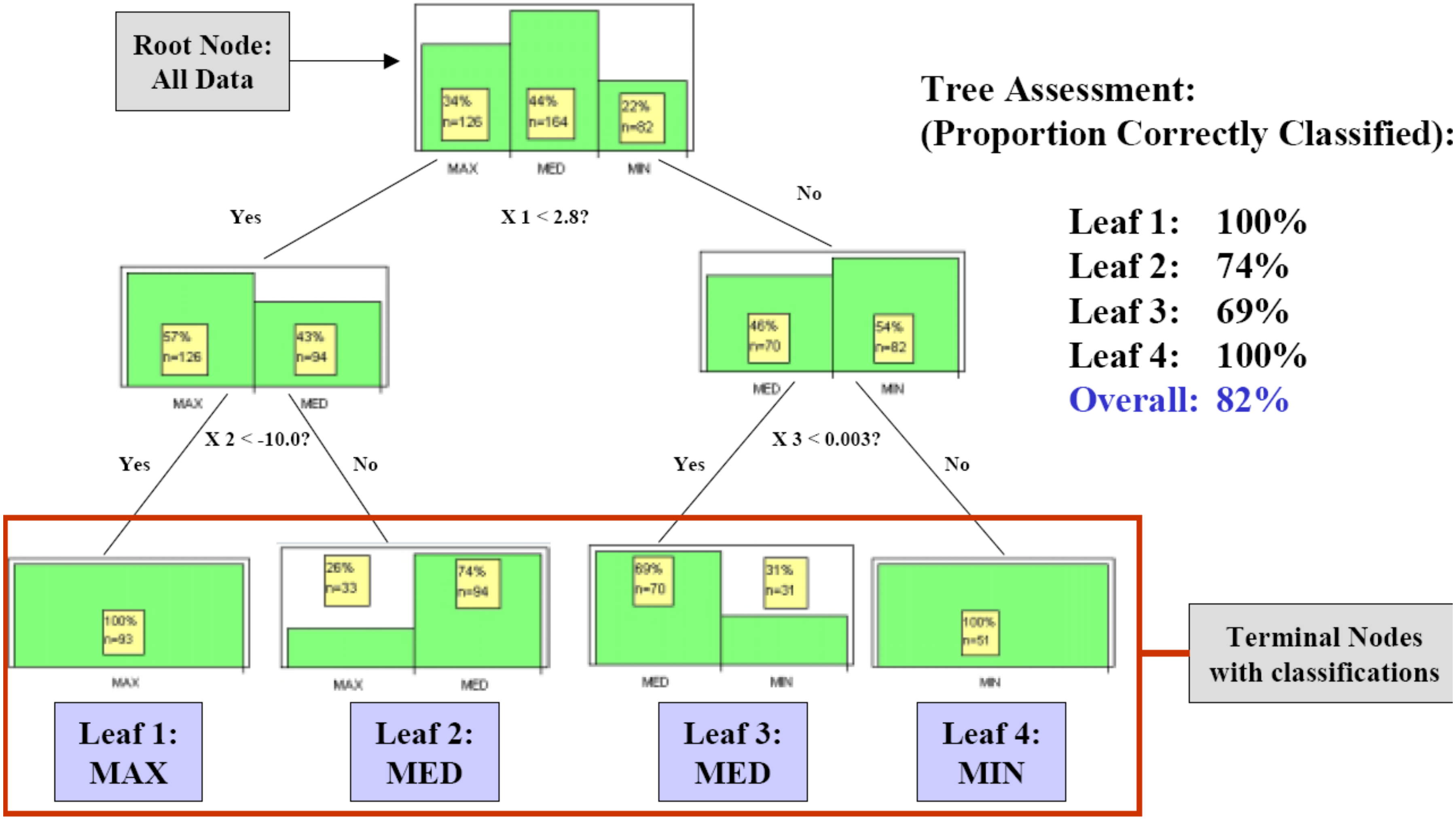
Lab 2. Decision (Classification) Tree

- Represented as a set of hierarchically-arranged decision rules (i.e., tree-branch-leaf)

- Could be generated by knowledge engineering, neural network, or statistic methods.

- S-Plus:
  - Tree Models: successively splitting the data to form homogeneous subsets.

Classification Example



Tree Assessment:
(Proportion Correctly Classified):

Leaf 1:	**100%**
Leaf 2:	**74%**
Leaf 3:	**69%**
Leaf 4:	**100%**
Overall:	**82%**

Rules:

- if X1 < 2.8 and X2 < -10 then class = MAX
- if (X1 < 2.8 and X2 > -10) or (X1 > 2.8 and X3 < 0.003) then class = MED
- if X1 > 2.8 and X3 > 0.003 then class = MIN