# Elements of Remote Sensing Images

Ghazanfar A. Khattak

National Centre of Excellence in Geology

University of Peshawar

NCEG

# What is an image?

- An image refers to any pictorial representation, regardless of what wavelengths or remote sensing device has been used to detect and record the electromagnetic energy.

# Image vs. Photograph

- A **photograph** refers specifically to images that have been detected as well as recorded on photographic film.

- Photos are normally recorded over the wavelength range from 0.3 – 0.9 micrometers

- Thus, all photographs are images, but not all images are photographs.

# Digital Images
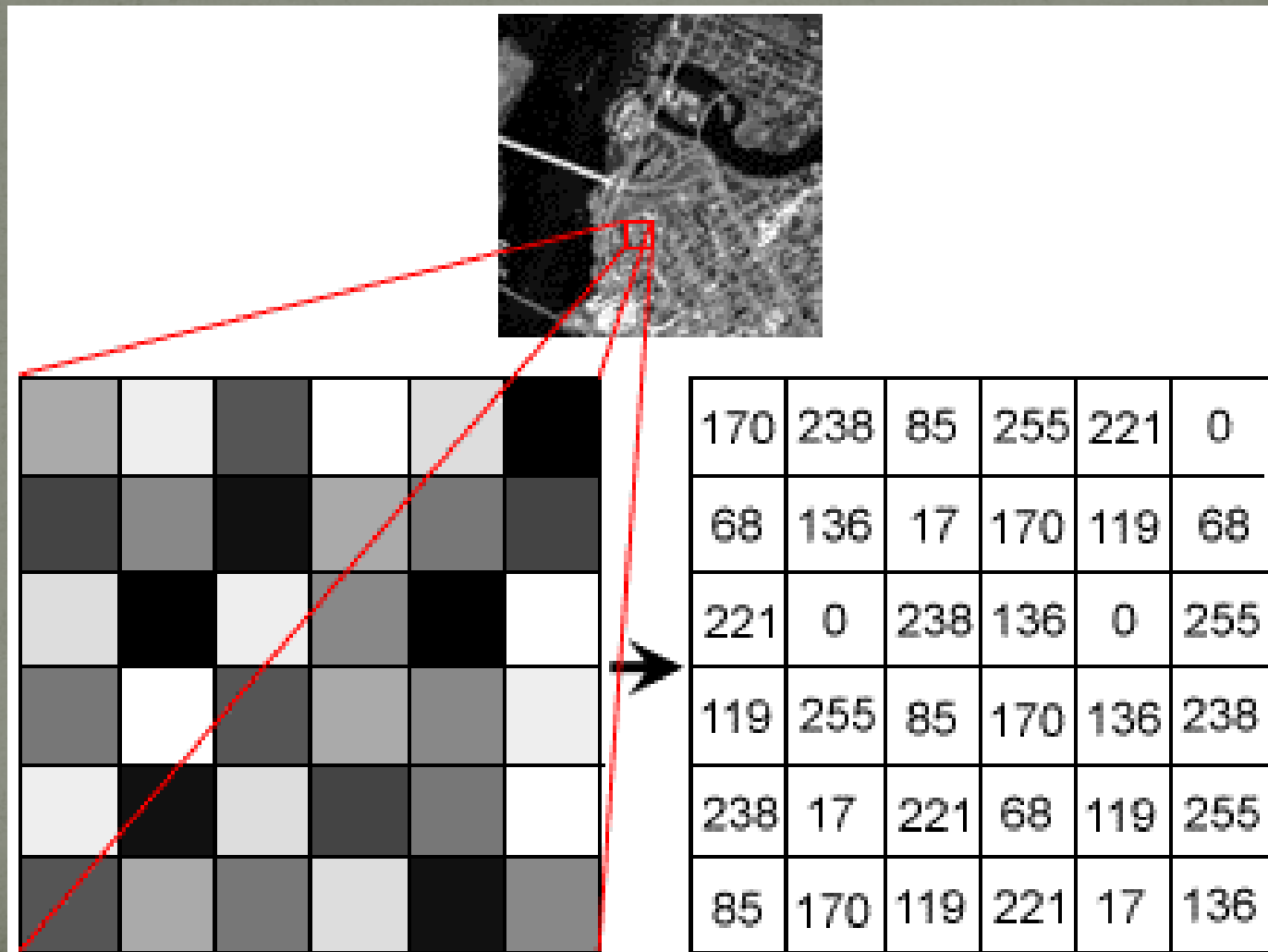
# Pixels

- Picture elements represent a single brightness value or digital number in an image.
- Pixel has both spatial and spectral property
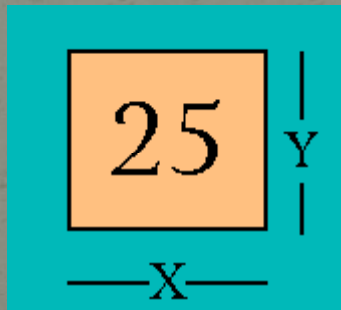
# Image

- An image is composed of pixels
- geographically ordered and
- adjacent to one another consisting
- of 'n' pixels in the x direction and
- 'n' pixels in the y direction.

| Columns → | | | |
|---|---|---|---|
| 10 | 15 | 17 | 20 |
| 15 | 16 | 18 | 21 |
| 17 | 18 | 20 | 22 |
| 18 | 20 | 22 | 24 |

Rows ↓

# Image Bands or Channels

- Information from a narrow wavelength range is gathered and stored in a **channel**, also sometimes referred to as a **band**.

# Single Band

- When only one band of the EM spectrum is sensed, the output device (color monitor) renders the pixels in shades of grey (there is only one data set).
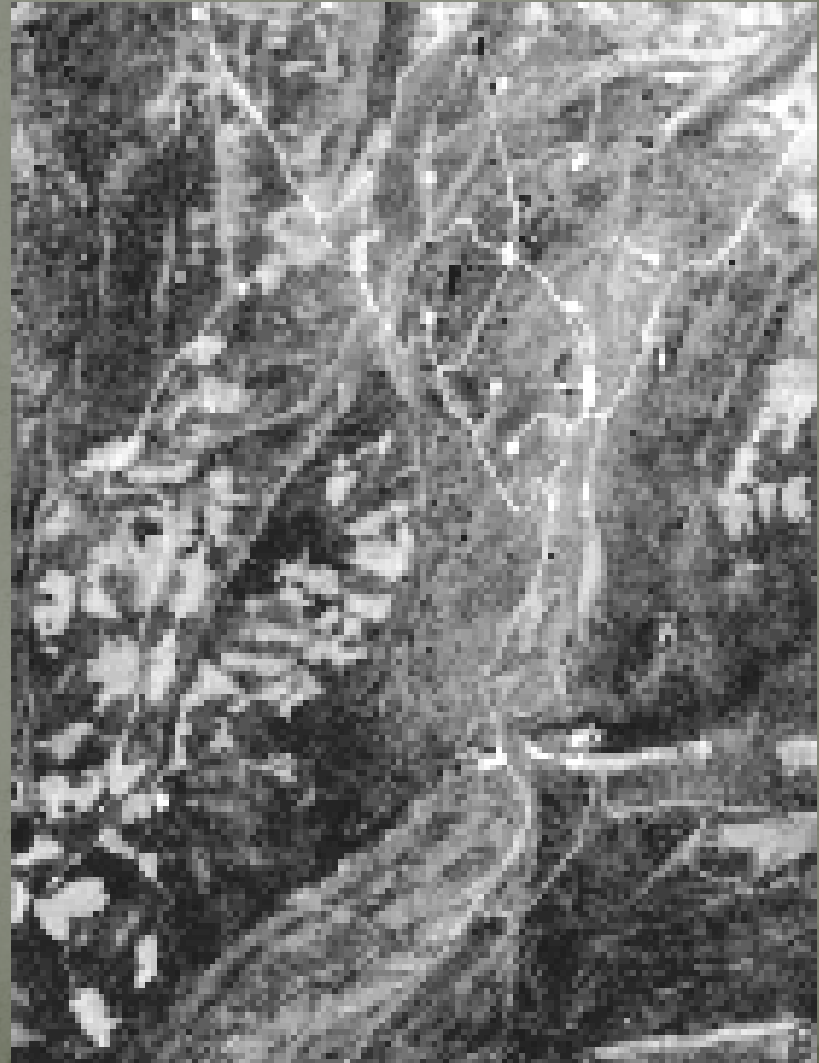
# Multiple Bands: Multispectral Remote Sensing

- Multispectral sensors detect light reflectance in more than one or two bands of the EM spectrum.

- These bands represent different data.

- When combined into the red, green, blue guns of a color monitor, they form different colors.

# Multispectral Remote Sensing
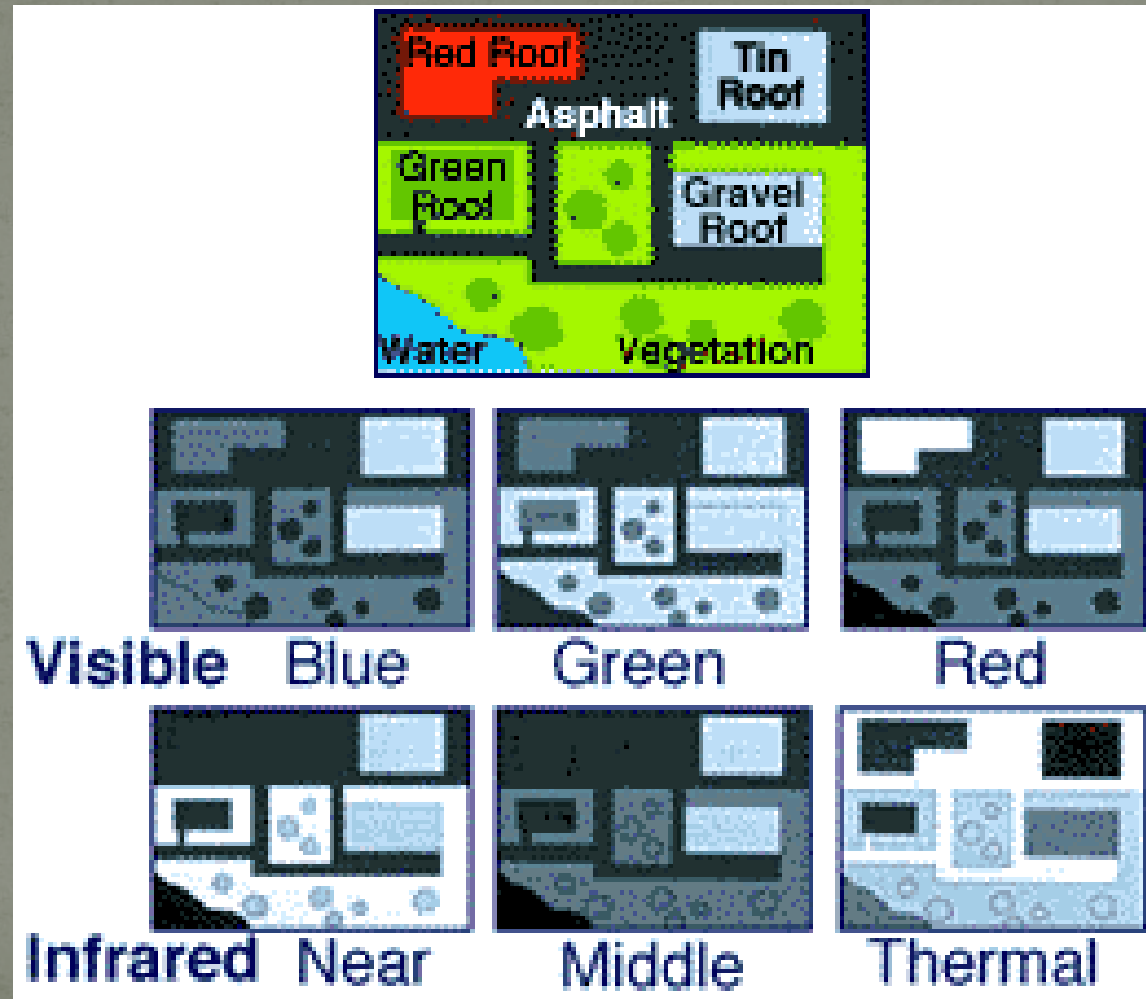
# MultiSpectral Remote Sensing

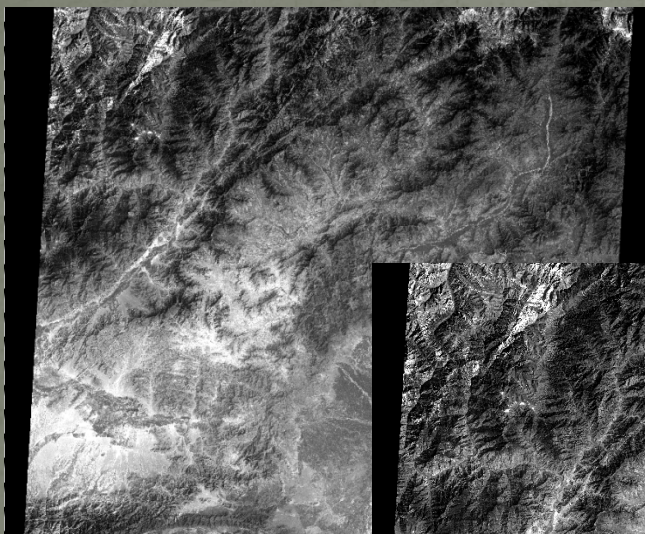- Example Landsat TM captures 7 regions in the electromagnetic spectrum
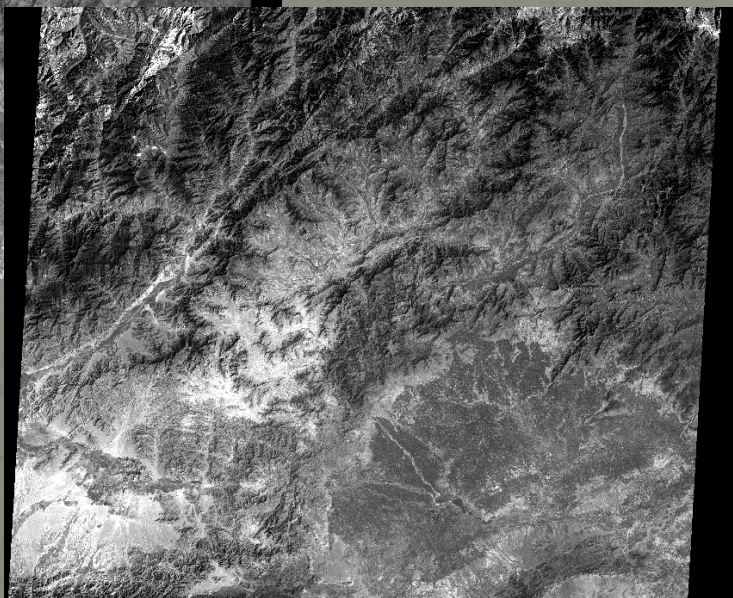
# Displaying a Remote Sensing Image

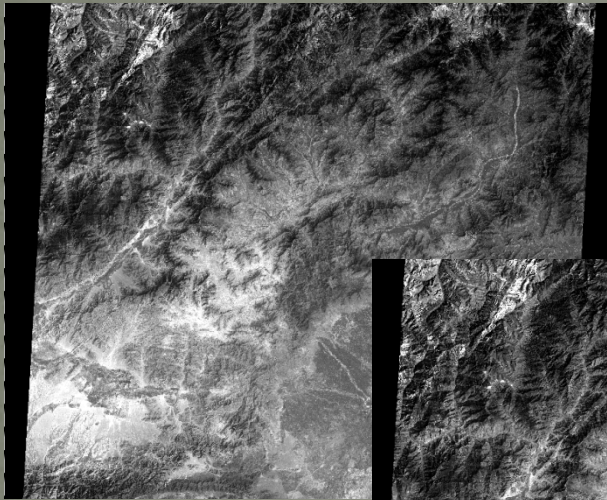*Band 1*

# Displaying a Remote Sensing Image

*Band 1*



*Band 2*

# Displaying a Remote Sensing Image

*Band 1*



*Band 2*

*Band 3*

# Displaying a Remote Sensing Image

*Band 1*

# Displaying a Remote Sensing Image
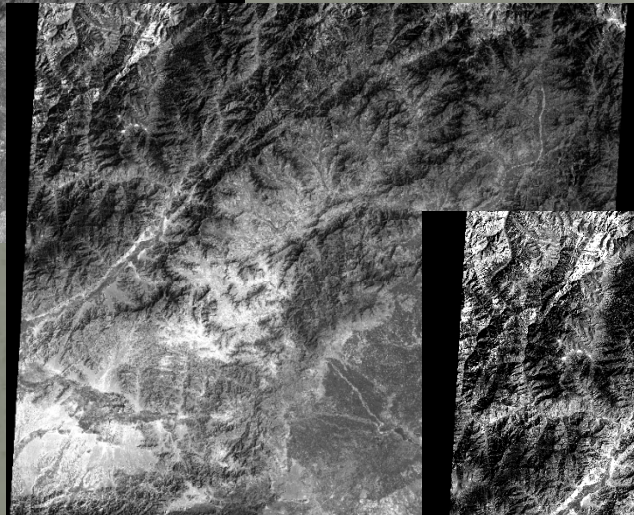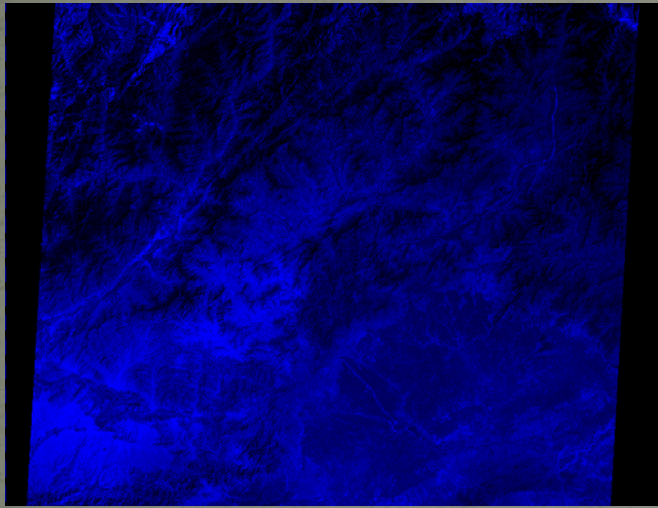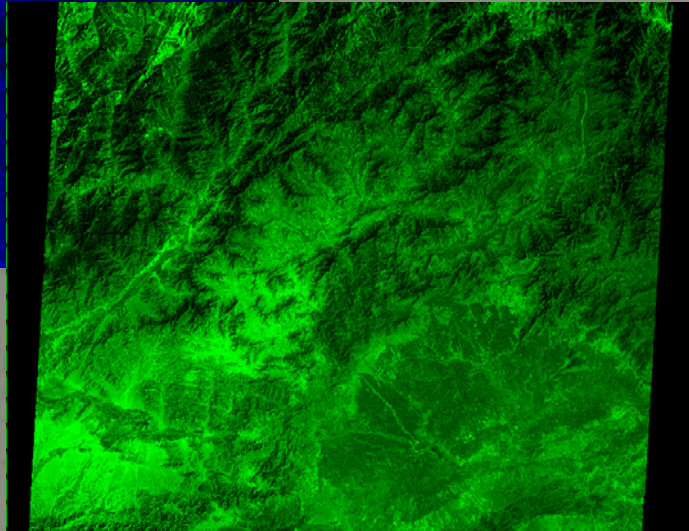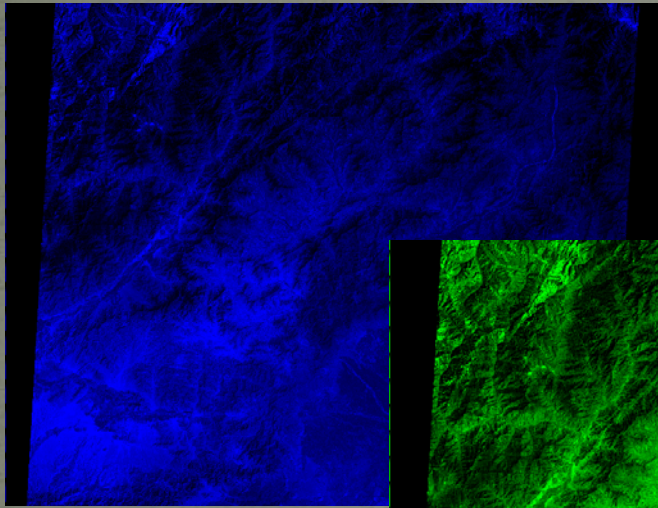
*Band 1*



*Band 2*
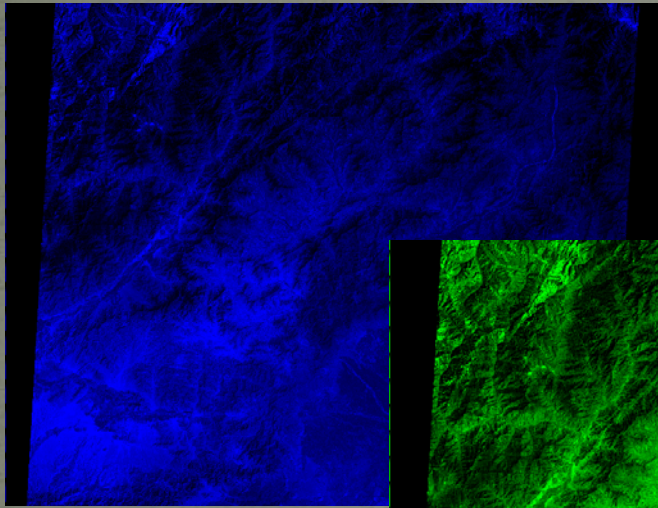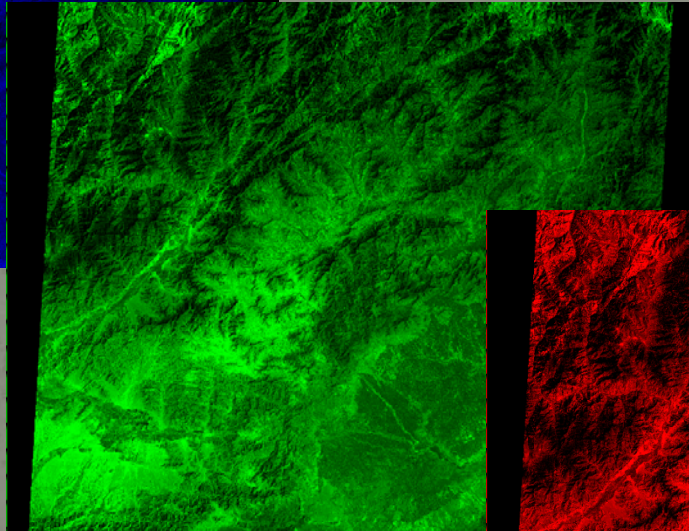
# Displaying a Remote Sensing Image

*Band 1*

*Band 2*

*Band 3*
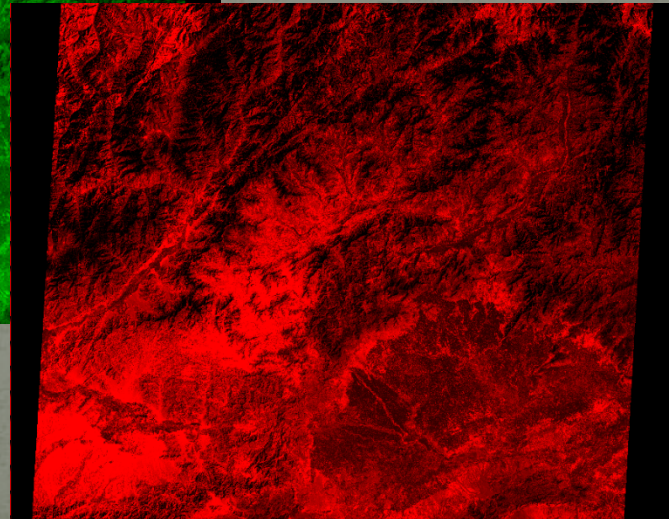
# Displaying a Remote Sensing Image

*Landsat TM RGB 321*
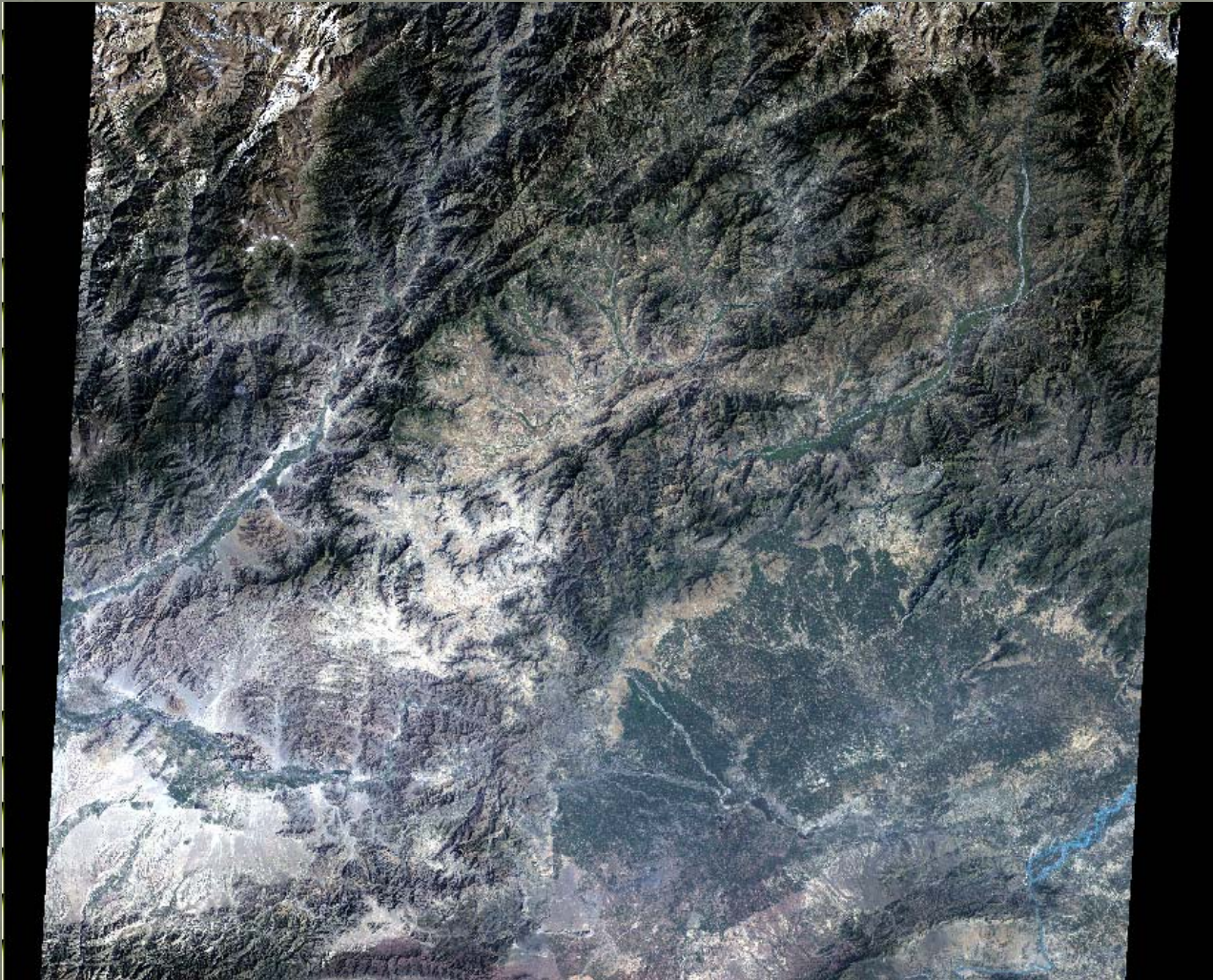
# False Color-IR Image

- Near-IR = Red Gun
- Red = Green Gun
- Green        = Blue Gun

# False Color IR Image

*Landsat TM RGB 432*
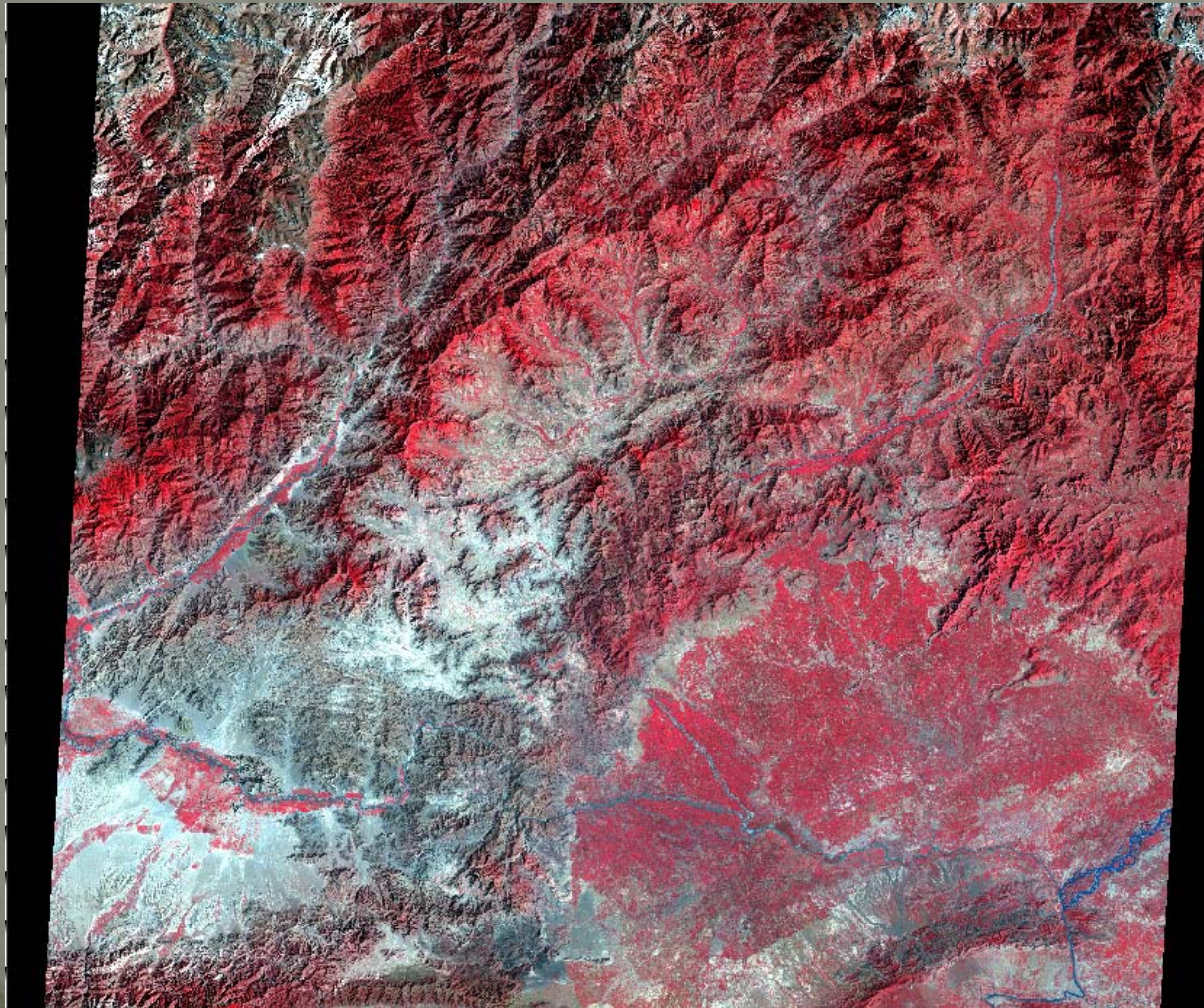
# True/Natural Color Image

- Red = Red Gun

- Green = Green Gun

- Blue = Blue Gun

# True/Natural Color Image

# Spectral Signatures

Cuticle

Upper Epidermis

Simplified cross-section of the internal structure of an individual leaf. Adapted from Campbell (1996).
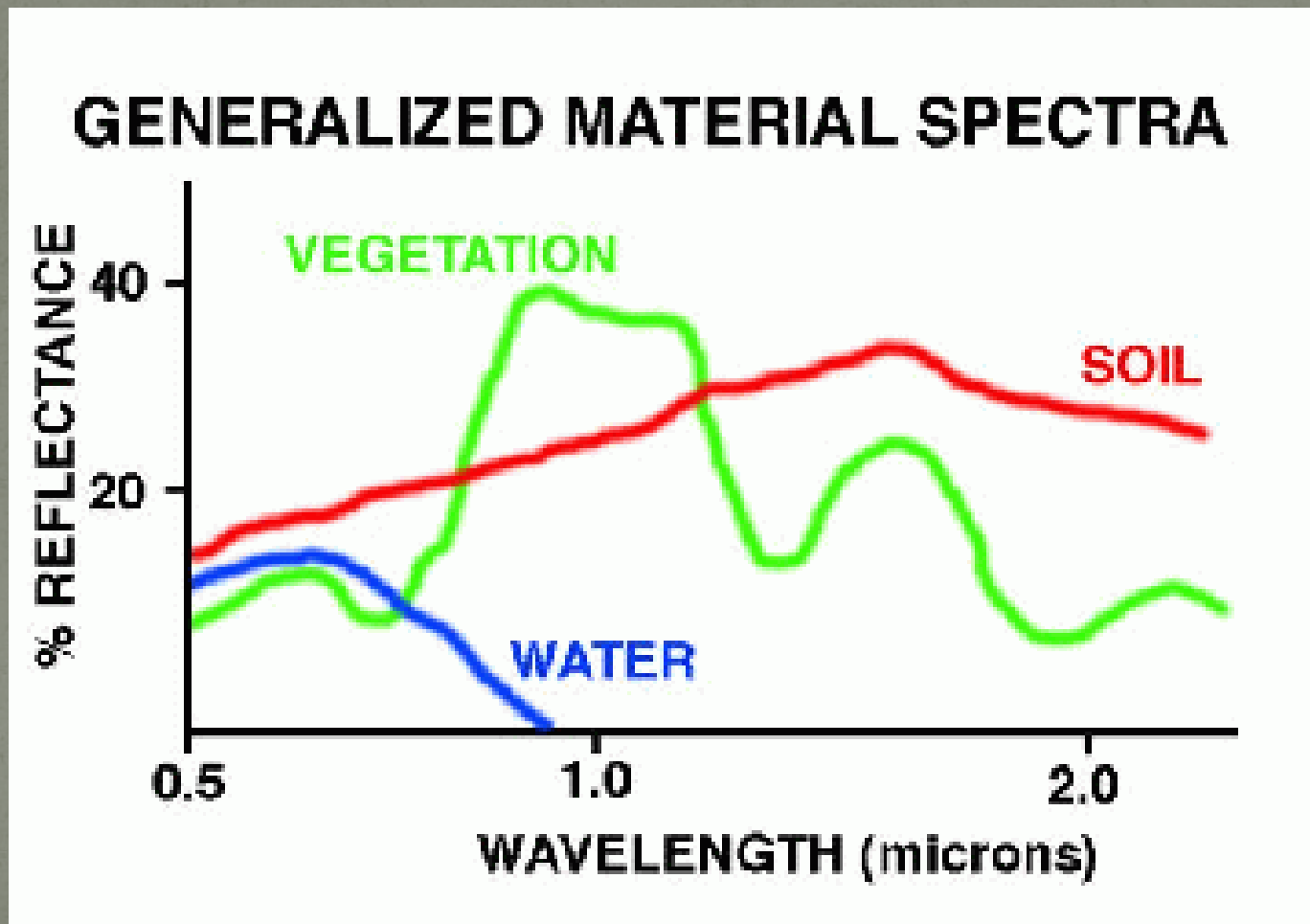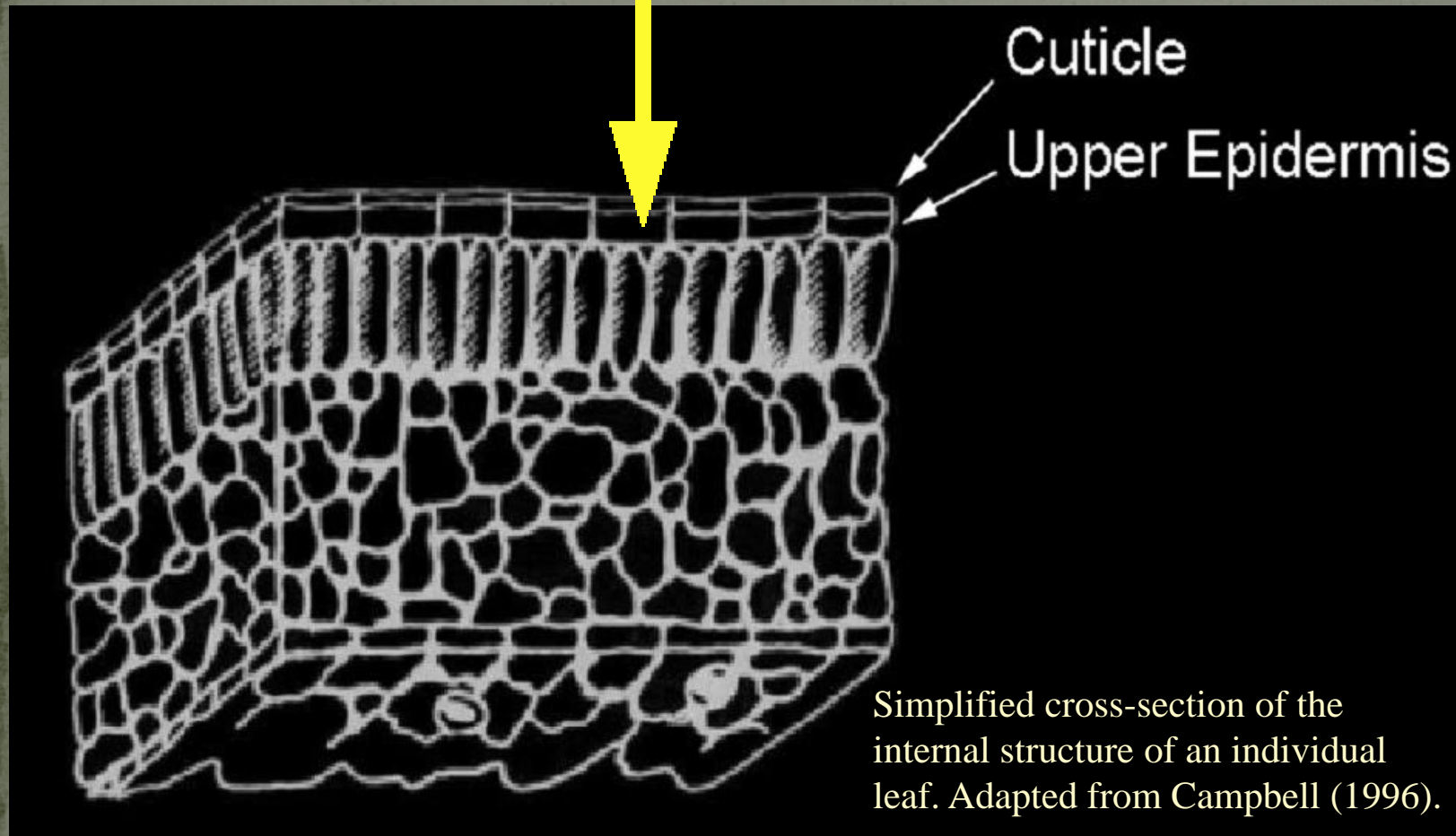
1) The <u>cuticle</u> and <u>epidermal cell layer</u> diffuse and transmit most of the incident light.

Cuticle

Upper Epidermis

Palisade Layer

Simplified cross-section of the internal structure of an individual leaf. Adapted from Campbell (1996).
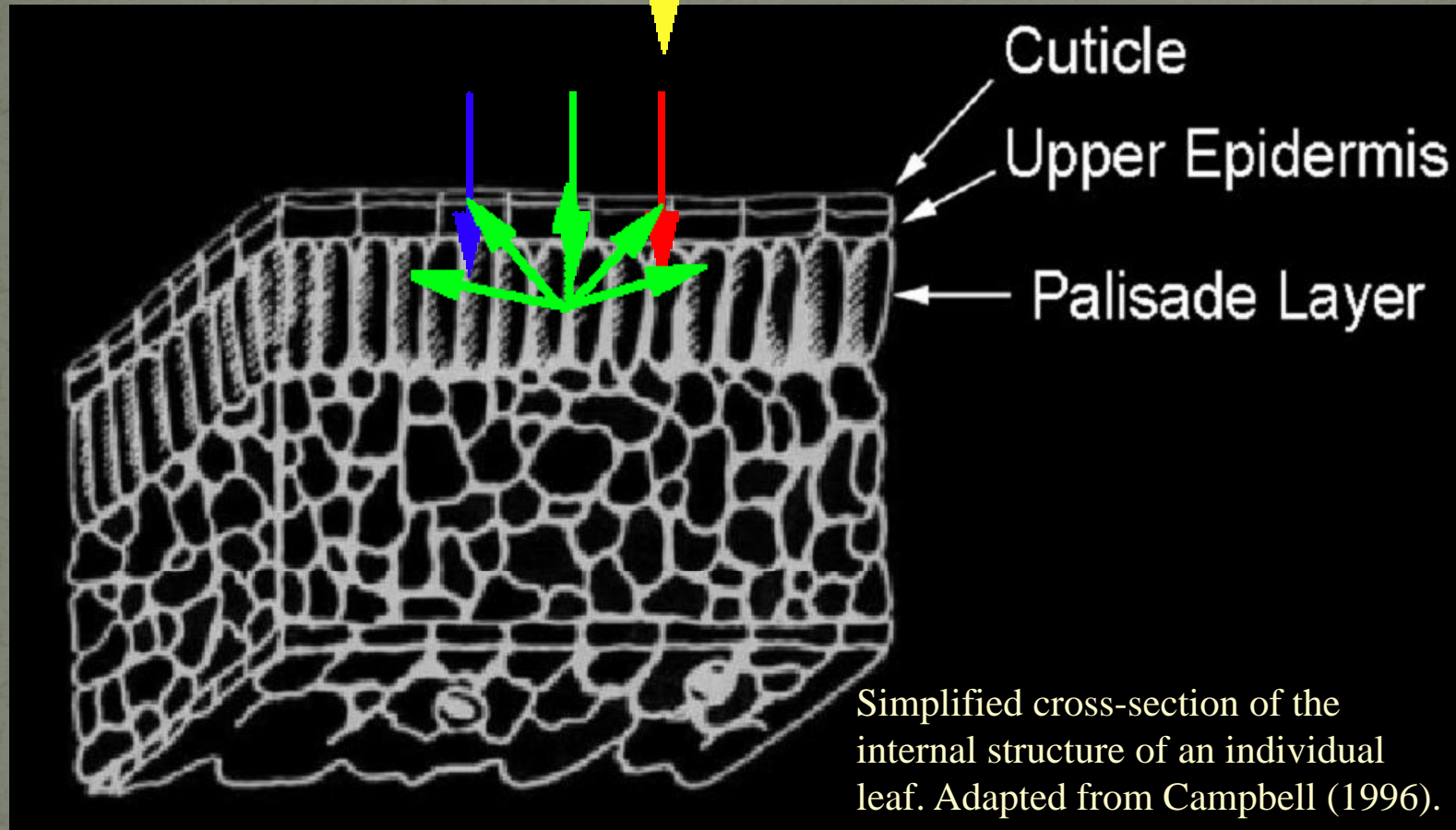
2) The <u>palisade layer</u> contains chloroplasts, which hold chlorophyll pigments. Chlorophyll absorbs up to 90 percent of incident blue and red energy.

*Endo-Atmospheric Full-Spectrum EMR:*

NIR

Cuticle

Upper Epidermis

Palisade Layer

Spongy Mesophyll

Simplified cross-section of the internal structure of an individual leaf. Adapted from Campbell (1996).
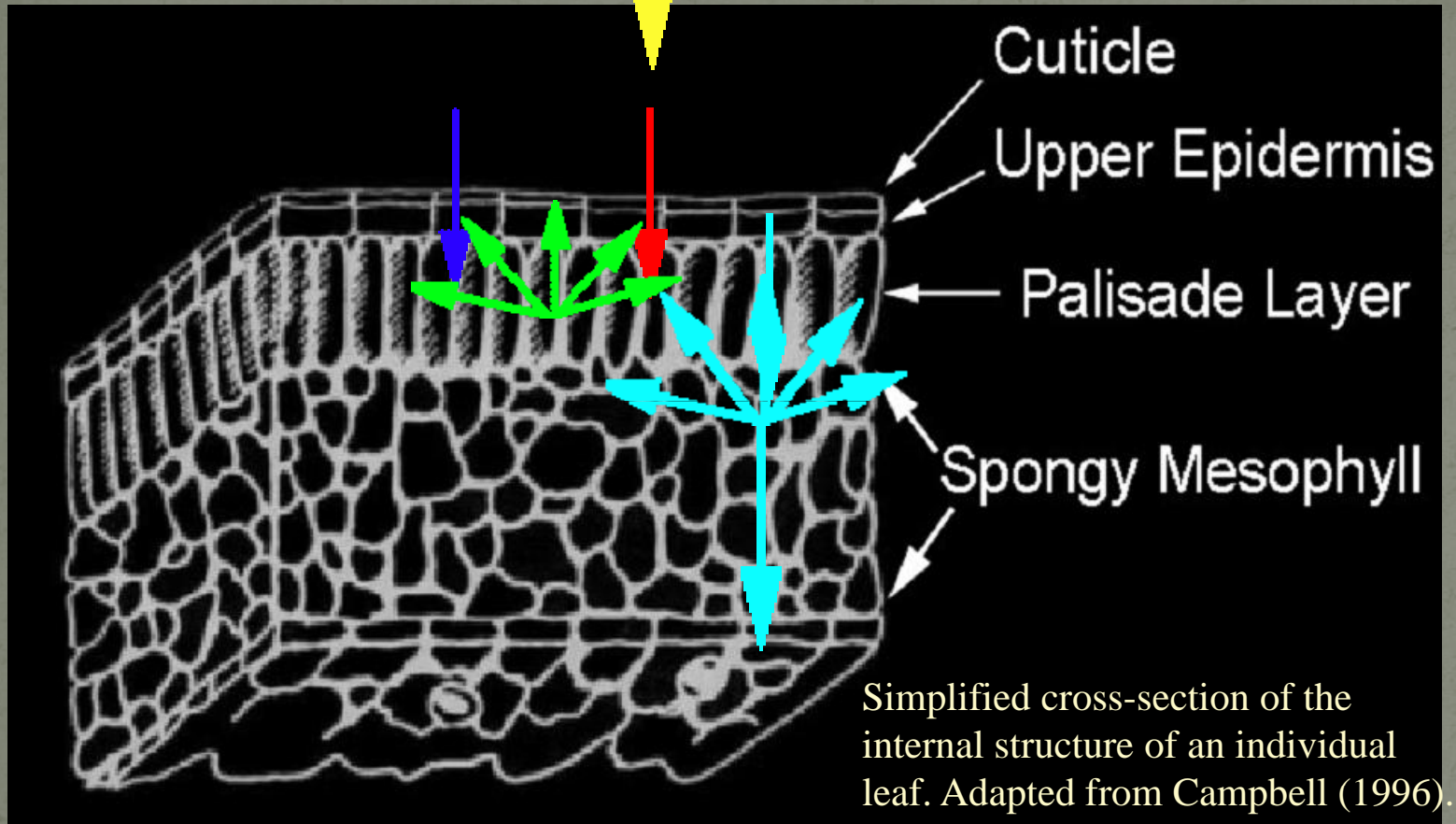
3) The spongy mesophyll controls interaction with NIR. Forty to 50 percent of incident NIR is reflected by the walls of the spongy mesophyll, the rest is transmitted.

*Endo-Atmospheric Full-Spectrum EMR:*

NIRMIR

Cuticle
Upper Epidermis
Palisade Layer
Spongy Mesophyll
Lower Epidermis

Simplified cross-section of the internal structure of an individual leaf. Adapted from Campbell (1996).
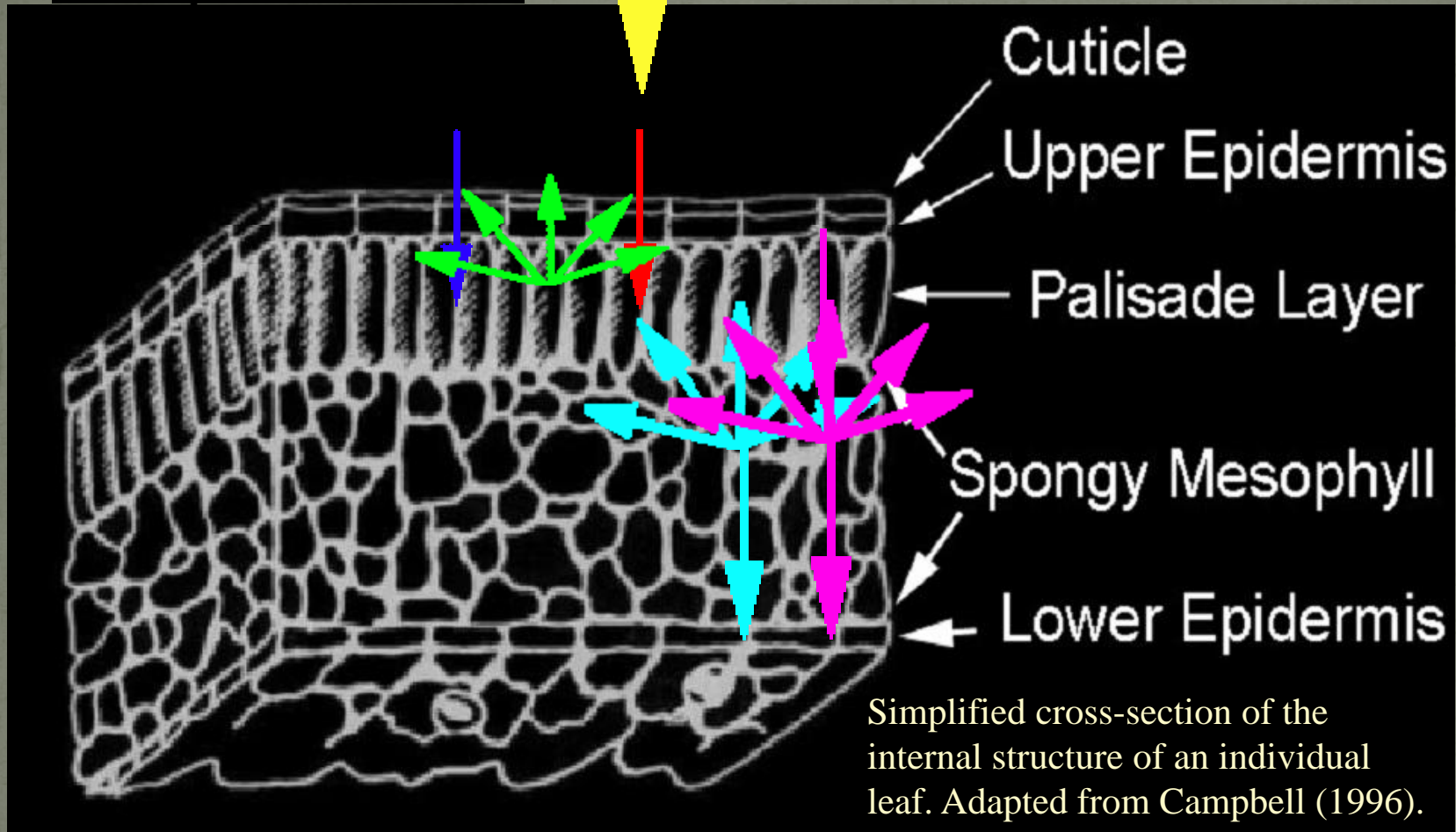
4) MIR reflectance is highly and inversely correlated with water content of leaves. As water content increases, MIR reflectance decreases

# Spectral Signatures

# Spectral Signatures
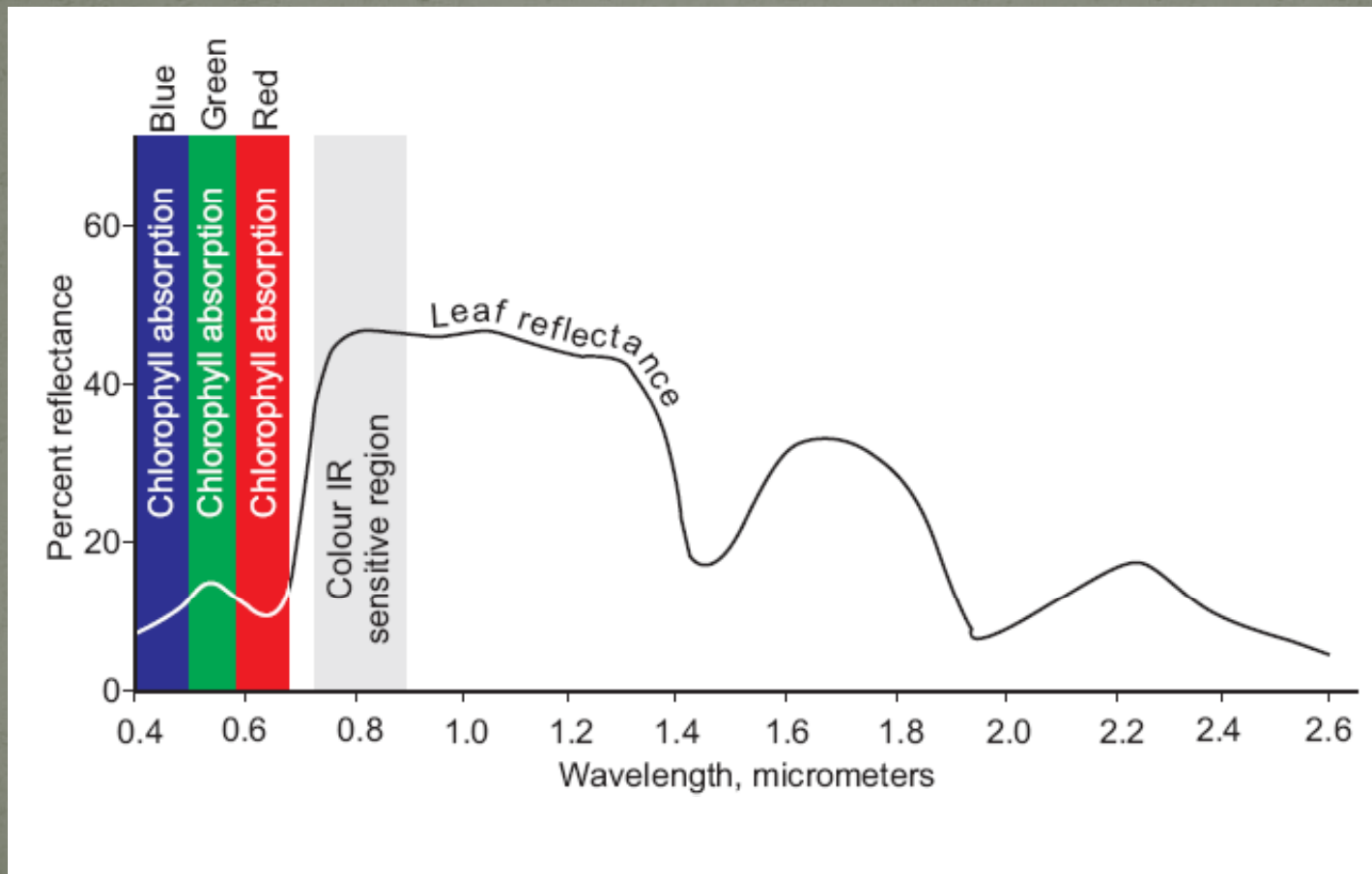
# Spectral Signatures
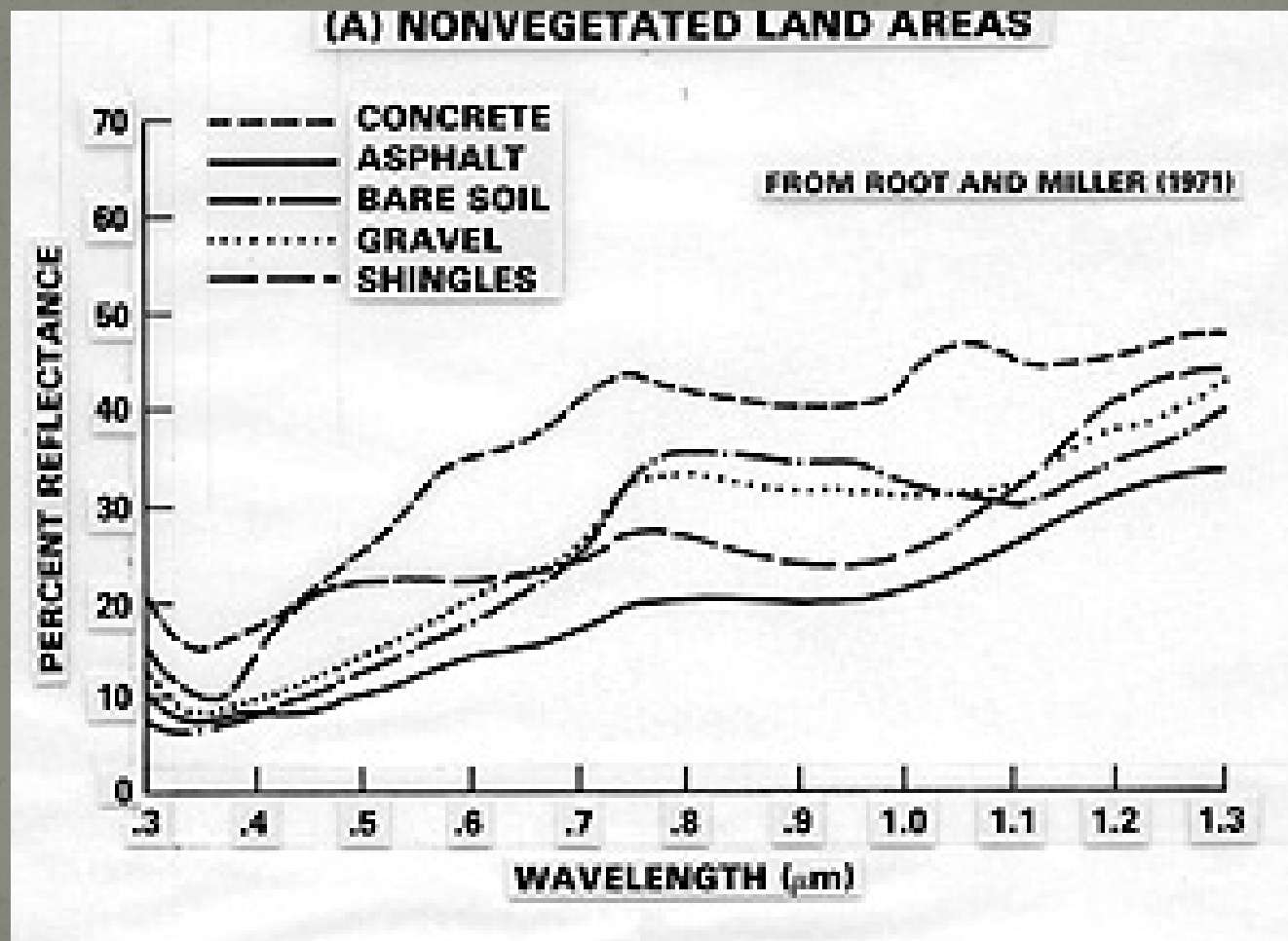


(B) VEGETATED LAND AREAS
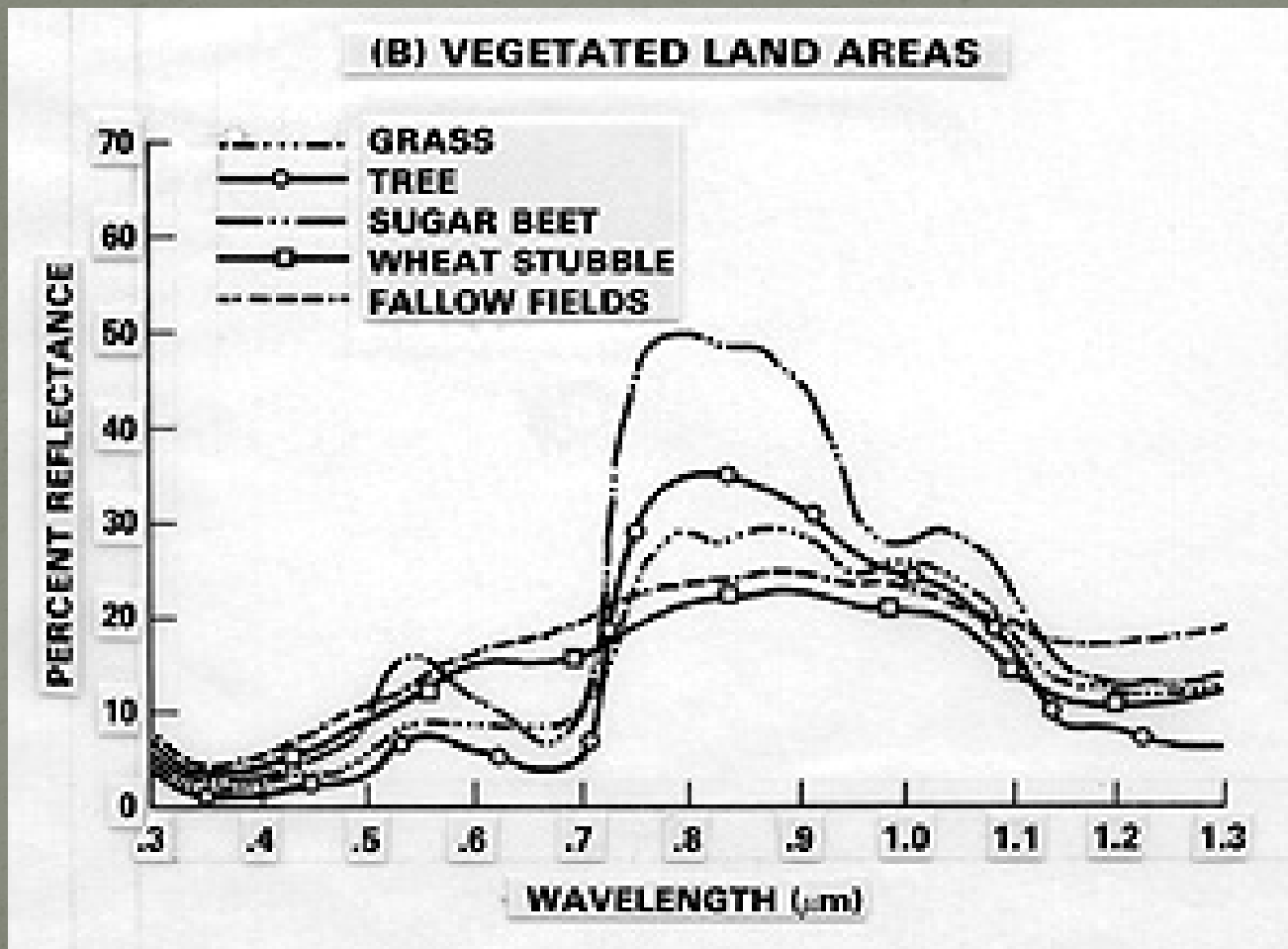
# Image Resolution

- (1) Spatial
- (2) Spectral
- (3) Radiometric
- (4) Temporal

# Spatial Resolution

- This represents the ability of the sensor to detect and distinguish small objects and fine detail in larger objects.

- Depends on the instrument's sensitivity and distance from the object, and defines the pixel size of a digital image.

# Spatial Resolution
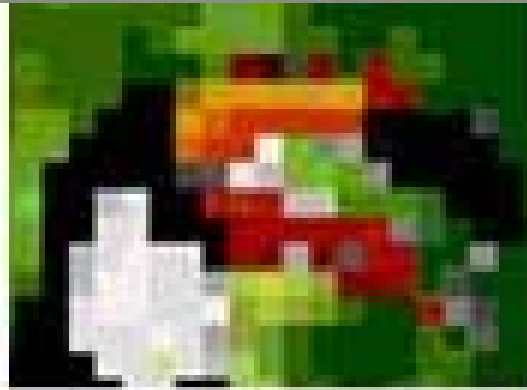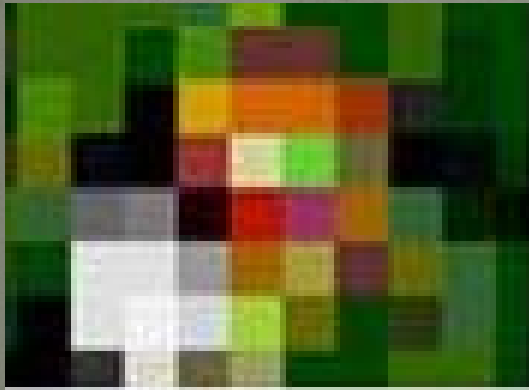


Examples of different resolutions

# Spectral Resolution

- This refers to the number of bands in the spectrum in which the instrument can take measurements

# Radiometric Resolution

- This is the sensitivity to small differences in the radiation of an observed object.

- Radiometric resolution is determined by the number of discrete levels into which signals may be divided.

# Temporal Resolution

- Represents the frequency with which a satellite can re-visit an area of interest and acquire a new image.

- Depends on the instrument's field of vision, and the satellite's orbit.

# Elements of Image Interpretation

- Tone
- Shape
- Size
- Pattern
- Texture
- Shadow
- Site
- Association

# 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.

# Tone

# Tone

# Shape

- Refers to the general outline of objects.

- Regular geometric shapes are usually indicators of human presence and use.

- Natural features, such as forest edges, are generally more irregular in shape.

# Shape

# Shape

# Size

- Size 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.

# Size

- Eg. large buildings such as factories or warehouses would suggest commercial property, whereas small buildings would indicate residential use.
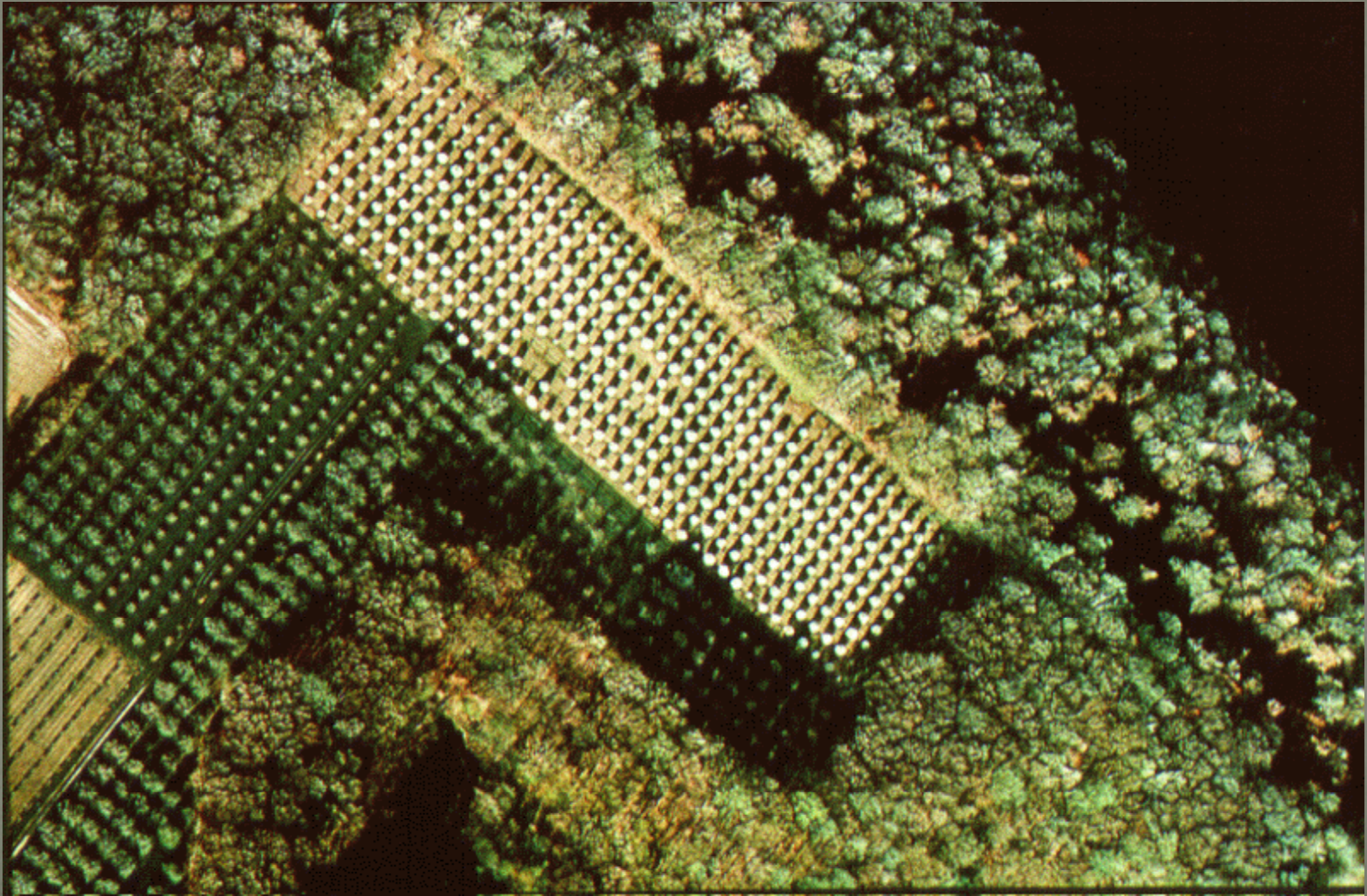
# Pattern

- Refers to the spatial arrangement of visibly discernible objects.

- Orchards with evenly spaced trees, and urban streets with regularly spaced houses are good examples of pattern
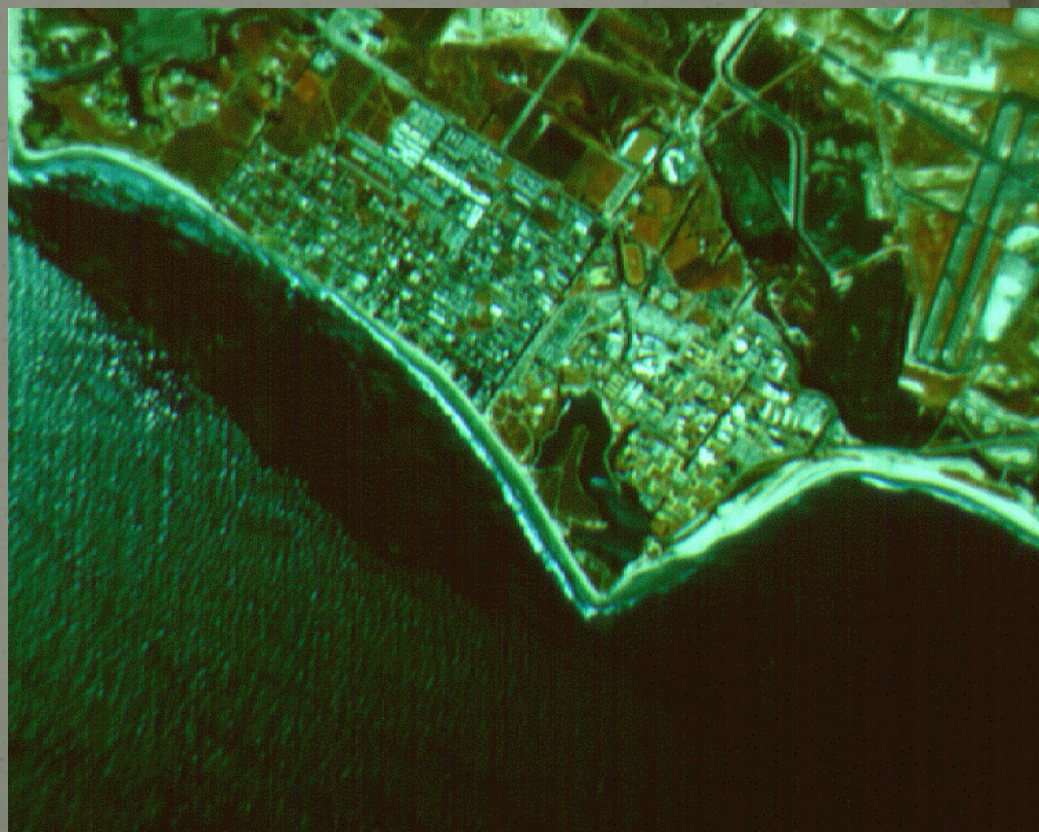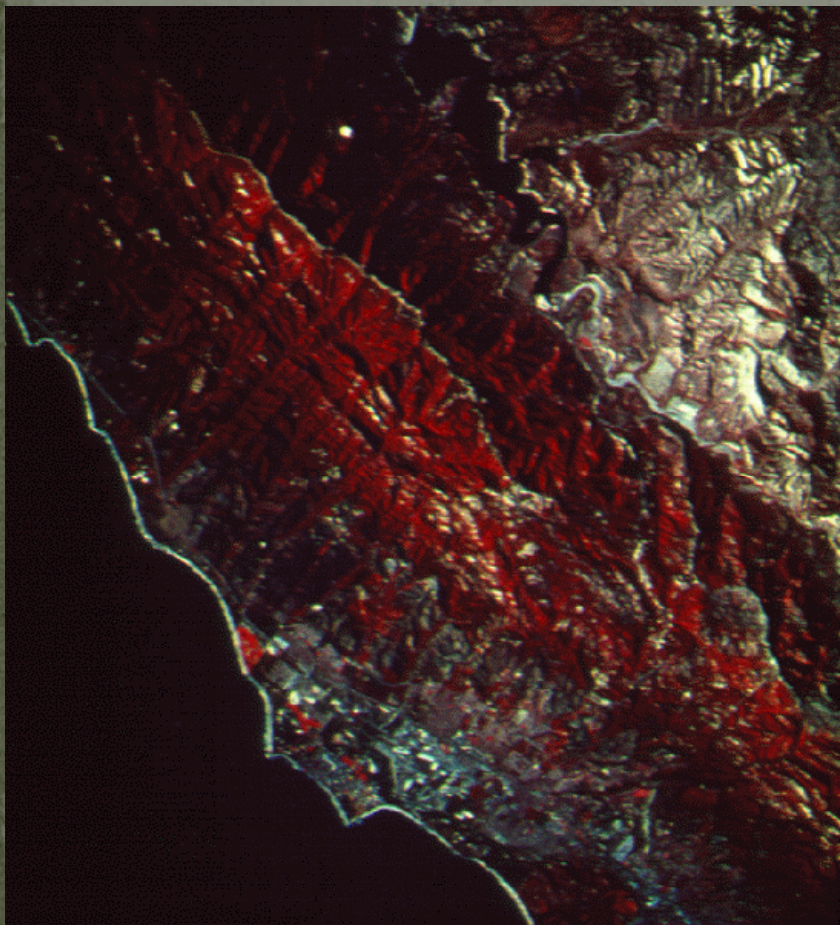
# Pattern

# Pattern

# Texture

- The impression of "smoothness" or "roughness" of image features is caused by the frequency of change of tone in photographs.

- It is produced by a set of features too small to identify individually.

- Grass, cement, and water generally appear "smooth", while a forest canopy may appear "rough".
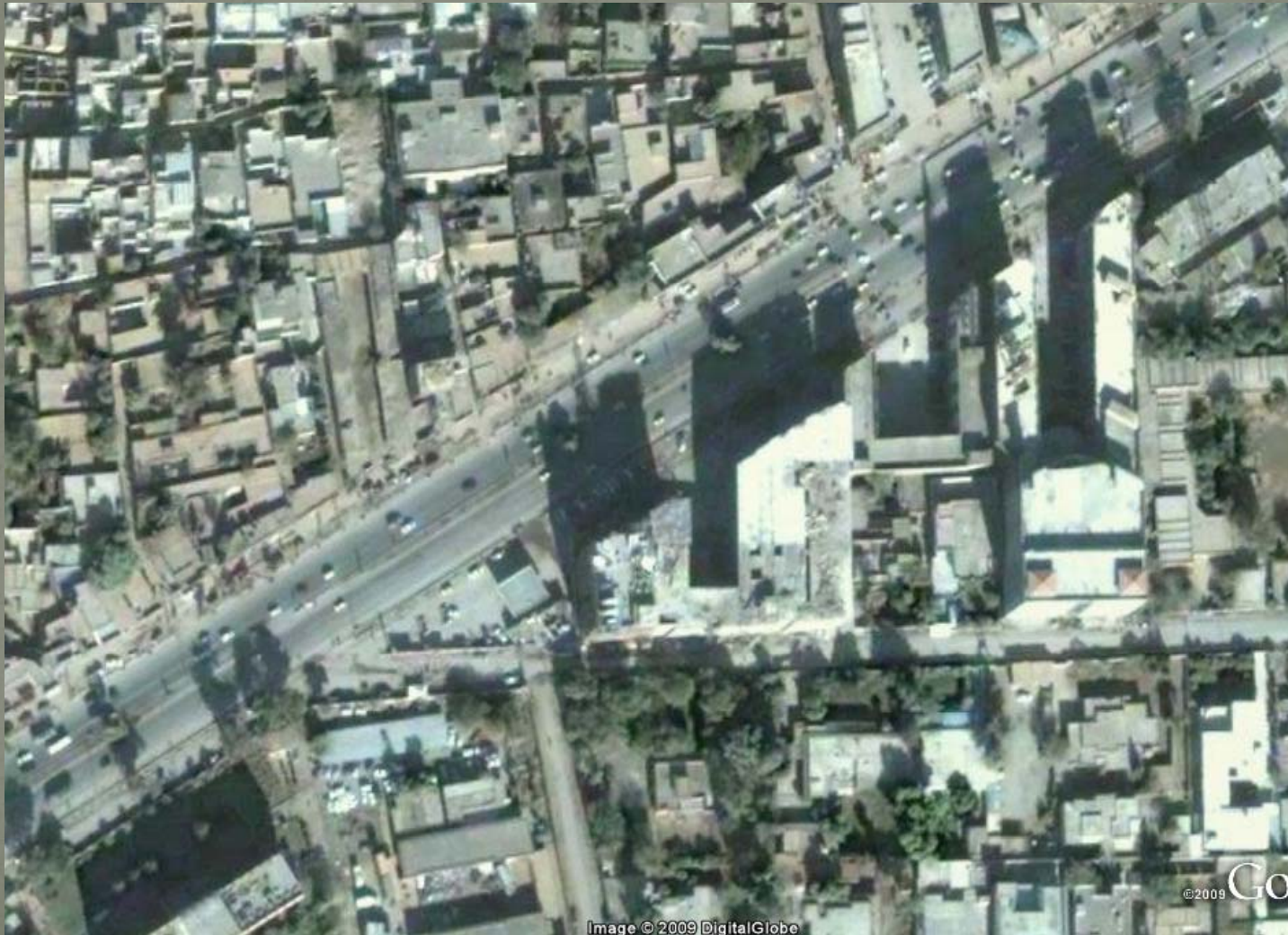
# Texture

# Effects of Scale on Pattern and Texture

# Shadow

- Shadows aid interpreters in determining the height of objects

- However, they also obscure objects lying within them

- Shadows are useful for enhancing or identifying topography and landforms, particularly in radar imagery.

# Shadow

# Site

- refers to topographic or geographic location.
- This characteristic of images is especially important in identifying vegetation types and landforms.

# Site

# Association

- Takes into account the relationship between other recognizable objects or features in proximity to the target of interest.

- For example, commercial properties may be associated with proximity to major transportation routes, whereas residential areas would be associated with schools, playgrounds, and sports fields.

- A lake is associated with boats, a marina, and adjacent recreational land.

# Association