Spatial Resolution describes how much detail in a photographic image is visible to the human eye.

The ability to "resolve," or separate, small details is one way of describing what we call spatial resolution.
Spatial resolution of images acquired by satellite sensor systems is usually expressed in meters.

For example, we often speak of Landsat as having “30-meter” resolution, which means that two objects, thirty meters long or wide, sitting side by side, can be separated (resolved) on a Landsat image.

Other sensors have lower or higher spatial resolutions.

<table>
<thead>
<tr>
<th>Spectral Resolution (μm)</th>
<th>Multispectral Scanner (MSS) Landsat 1-5</th>
<th>Thematic Mapper (TM) Landsat 4 &amp; 5</th>
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| Temporal Resolution (revisit days) | 18 (Landsat 1,2,3) | 16 | 16 | 16 |
Spatial Resolution

Planimetric data – roads, buildings, driveways

80 meter MSS w/ planimetric overlay
Spatial Resolution
30 meter TM w/ planimetric overlay

Spatial Resolution
10 meter SPOT w/ planimetric overlay
Spatial Resolution
1 meter DOQ w/ planimetric overlay

Spatial Resolution
Sub-meter data w/ planimetric overlay
The best spatial resolution?

Resolutions of Remote Sensing

1. Spatial (what area and how detailed)

2. **Spectral** (what colors – bands)

3. Temporal (time of day/season/year)

4. Radiometric (color depth)
Spectral Response Curve

EMR patterns are recorded by sensors with separated spectral bands.

Electromagnetic Radiation (EMR)
Spectral Response Curve

The spectral reflectance curves, or spectral signatures, of different types of ground targets provide the knowledge base for information extraction.
Spectral responses from ground targets are recorded in separate spectral bands by sensors.
Spectral Resolution

- Number of spectral bands (red, green, blue, NIR, Mid-IR, thermal, etc.)
- Width of each spectral band
- Certain spectral bands (or combinations) are good for identifying specific ground features

- Panchromatic – 1 band (B&W)
- Color – 3 bands (RGB)
- Multispectral – 4+ bands (e.g. RGBNIR)
- Hyperspectral – hundreds of bands
### Spectral Scanner (MSS) Landsat 1-5
- 0.5-0.6 (green)
- 0.6-0.7 (red)
- 0.7-0.8 (NIR)
- 0.8-1.1 (NIR)

### Thematic Mapper (TM) Landsat 4 & 5
1. 0.45-0.52 (B)
2. 0.52-0.60 (G)
3. 0.63-0.69 (R)
4. 0.76-0.90 (NIR)
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### Enhanced Thematic Mapper Plus (ETM+) Landsat 7
1. 0.45-0.52 (B)
2. 0.52-0.60 (G)
3. 0.63-0.69 (R)
4. 0.77-0.90 (NIR)
5. 1.55-1.75 (MIR)
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7. 2.09-2.35 (MIR)
8. 0.52-0.90 (Pan)

### Operational Land Imager (OLI) Landsat 8
1. 0.43-0.45 (Ultra-B)
2. 0.45-0.51 (B)
3. 0.53-0.59 (G)
4. 0.64-0.67 (R)
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### Spectral Response Curve

**April and May Spectra for P. australis and S. patens**

- **Blue**
- **Green**
- **Red**
- **NIR**

![Spectral Response Curve](image)

**Reflectance (%)**

**Wavelength (nm)**
Spectral Response Curves

April and May Spectra for *P. australis* and *S. patens*

- **Band 1: 0.45-0.52μm (blue)**
  - Provide increased penetration of water bodies, as well as supporting analysis of land use, soil, and vegetation characteristics.

- **Band 2: 0.52-0.60μm (green)**
  - This band spans the region between the blue and red chlorophyll absorption bands and therefore corresponds to the green reflectance of healthy vegetation.

- **Band 3: 0.63-0.69μm (red)**
  - This is the red chlorophyll absorption band of healthy green vegetation and represents one of the most important bands for vegetation discrimination.
• Band 4: 0.76-0.90µm (reflective infrared). This band is responsive to the amount of vegetation biomass present in the scene. It is useful for crop identification and emphasizes soil-crop and land-water contrasts.
• Band 5: 1.55-1.75µm (mid-infrared) This band is sensitive to the amount of moisture in plants and therefore useful in crop draught and in plant vigor studies.
• Band 6: 2.08-2.35µm (thermal infrared) This band measures the amount of infrared radiant flux emitted from surface.
• Band 7: 2.08-2.35µm (mid-infrared) This is an important band for the discrimination of geologic rock formation. It is effective in identifying zones of hydrothermal alteration in rocks.

Hyperspectral Data

Example:

Hyperion hyperspectral sensor is capable of resolving 220 spectral bands at 10 nm interval (from 0.4 to 2.5 µm) with a 30 meter spatial resolution.

The shown image, acquired April 6, 2004, is displayed as

-- 640.50 µm in Red color
-- 548.92 µm in Green color
-- 457.34 µm in Blue color
Hyperspectral Data

AVIRIS Data
Ninigret Pond
Rhode Island

True Color vs. Pseudo Color

Thermal Band (Landsat TM band 6)
Resolutions of Remote Sensing

1. Spatial (what area and how detailed)

2. Spectral (what colors – bands)

3. **Temporal** (revisiting time interval)

4. Radiometric (color depth)

Temporal Resolutions

*Time of day/season image acquisition*

- Leaf on/leaf off
- Tidal stage
- Seasonal differences
- Shadows
- Phenological differences
- Relationship to field sampling
Seasonal Considerations

**Spring** -
Landsat TM bands 4,5,3 in RGB

**Summer** -
Landsat TM bands 4,5,3 in RGB
How much has changed?
How severe was the damage?
What would be the ecosystem responses?

......

Repeat Coverage

• Revisit period for satellites – how often can you make a measurement for the same area
  – Landsat – 16 days (continuous collection)
  – Quickbird – varies (point-and-shoot)
  – MODIS – daily (continuous collection)

• Airborne images – collected as needed
### Resolutions of Remote Sensing

1. **Spatial** (what area and how detailed)
2. **Spectral** (what colors – bands)
3. **Temporal** (time of day/season/year)
4. **Radiometric** (color depth)
Radiometric Resolution

Every time an image is acquired by a sensor, its sensitivity to the magnitude of the electromagnetic energy determines the radiometric resolution.

The finer the radiometric resolution of a sensor, the more sensitive it is to detecting small differences in reflected or emitted energy.

Imagery data are represented by positive digital numbers which vary from 0 to a selected power of 2. This range corresponds to the number of bits used for coding numbers in binary format. Each bit records an exponent of power 2.

The maximum number of brightness levels available depends on the number of bits used in representing the energy recorded. Thus, if a sensor used 8 bits to record the data, there would be \(2^8 = 256\) digital values available, ranging from 0 to 255.

Data volume will increase as the radiometric resolution increases?