INITIATIVE ON
Livestock and Climate

ICARDA
Science for resilient livelihoods in dry areas

Fundamentals of geoinformatics and its applications for monitoring silvopastoral systems

07 - 09 May 2024

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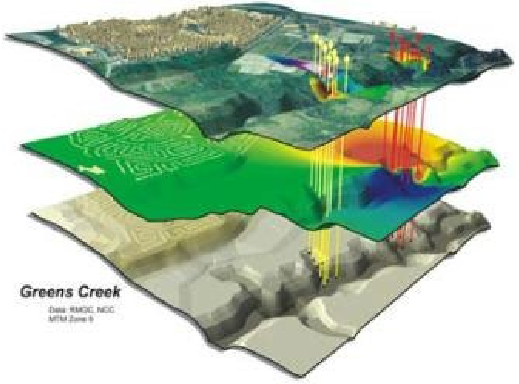
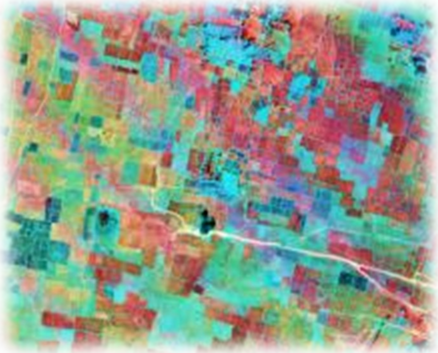
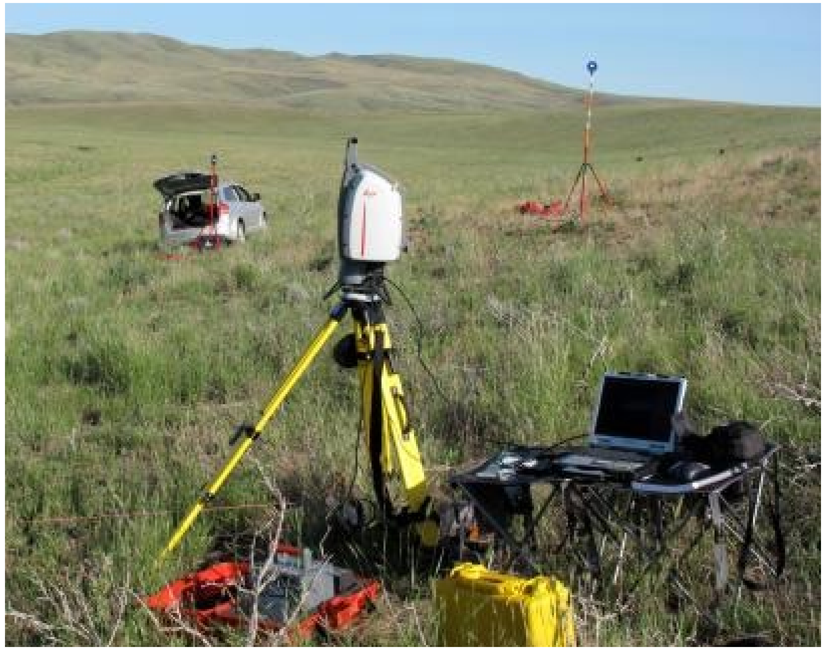




Course objective(s)

This training course is designed for participants with no GIS or mapping experience. Following a brief lecture, the workshop will include interactive exercises to:

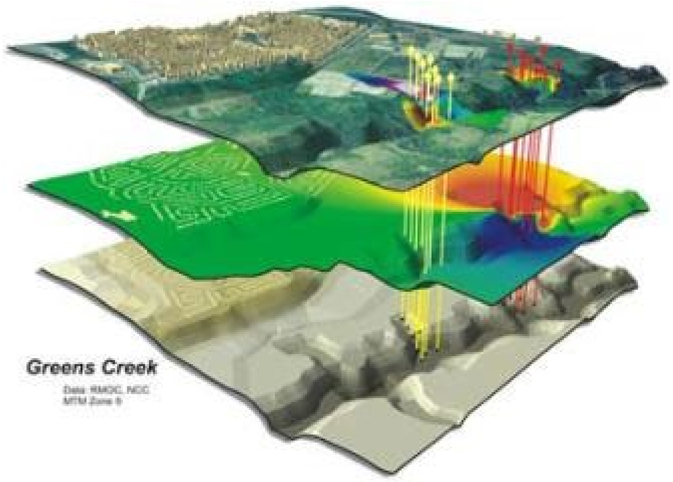
- Generate land use map using waypoint collected by handheld GPS and digitizing on screen in Google Earth.
- Acquire proficiency in using VegMeasure computerized vegetation-management program. It uses image-processing software to process digital images which are collected in a standardized manner, to classify vegetation and measure changes over time.
- Estimate carrying capacity for an improved silvopastoral site using nondestructive technique.




GIS
RS
GPS

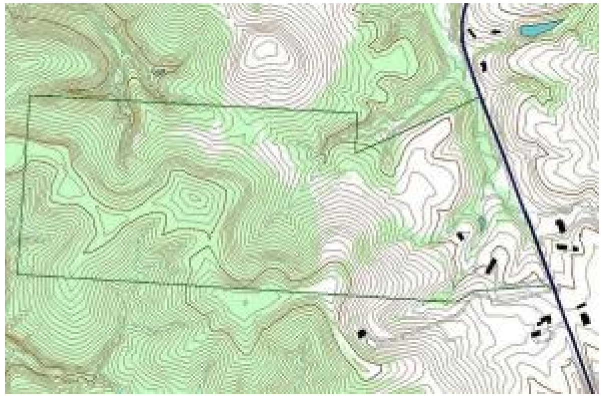
What is GIS?

- A computer system for capturing, storing, checking, integrating, manipulating, and displaying data related to positions on the earth's surface for informing decision making (data management and analysis).



- Deals specifically with geographic (spatial) information, represented as different layers.

- Layers hold data about a particular feature, linked to a geographic position.



What is GIS?

- Layers (also known as themes) are used to overlay different types of information. Each represents a category of information
- Used for problem solving with an ability to combine general with specific information
- Computerized tool for solving geographic problems
- A tool for performing operations on geographic data that are too tedious, expensive or inaccurate if performed by hand (i.e. manual analysis of maps)
- Inventory of features and facilities

Purposes of GIS

Visualize

Organize

Combine

Analyze

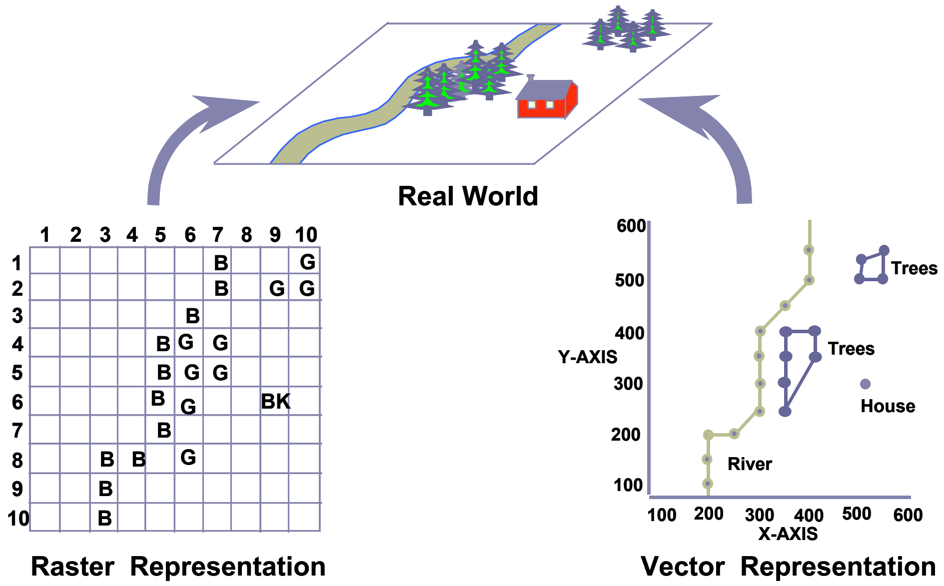
Predict

Question

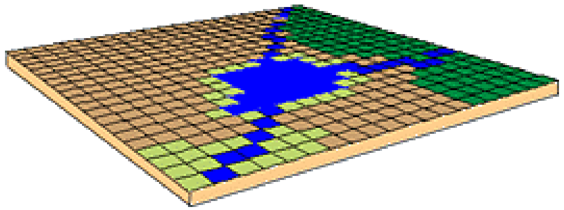
Query

Data Structure in GIS

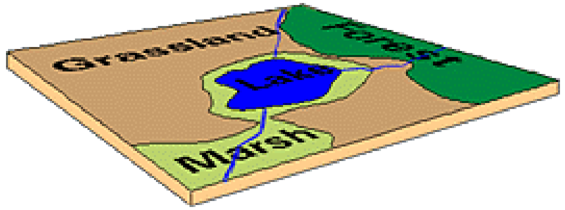
- The two most common formats (or data models) for representing real world objects are **Vector** and **Raster** data models.



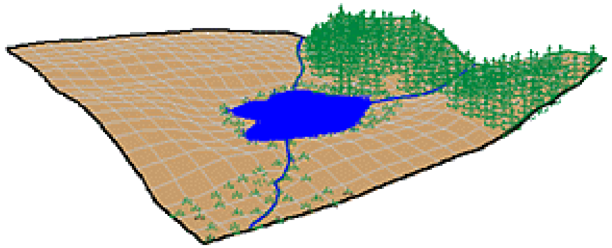
- RASTER



- VECTOR



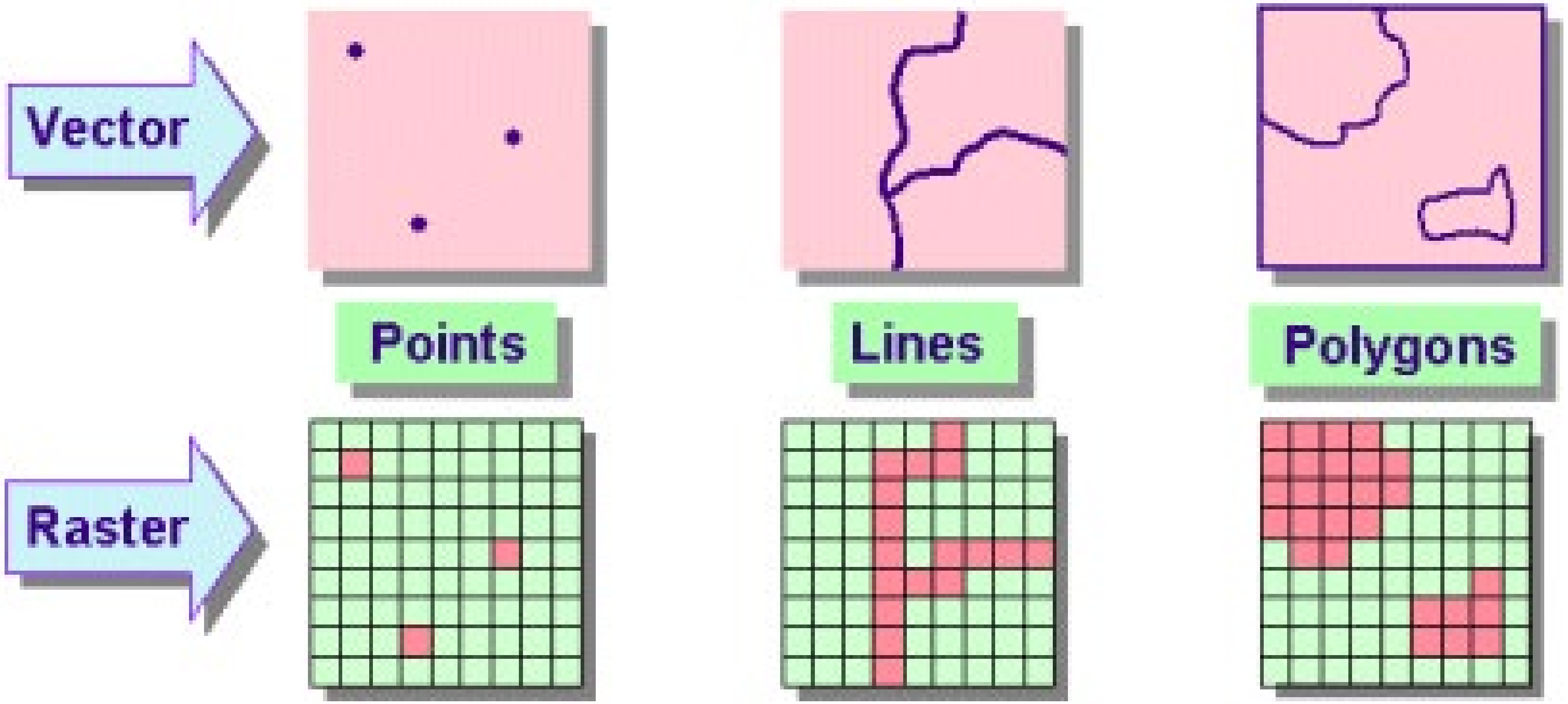
- Real World



Raster vs. vector Data Model

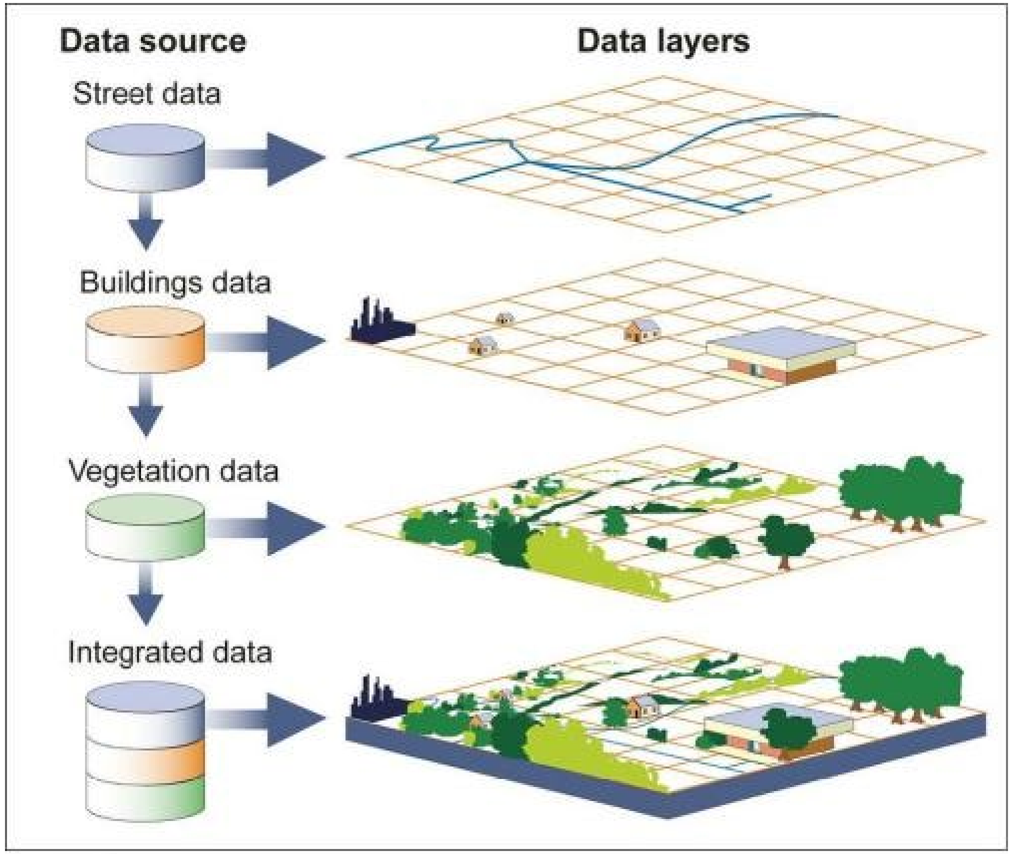
- This graphic illustrates the visible differences between vector and raster data models.

Give examples of vector and raster data?



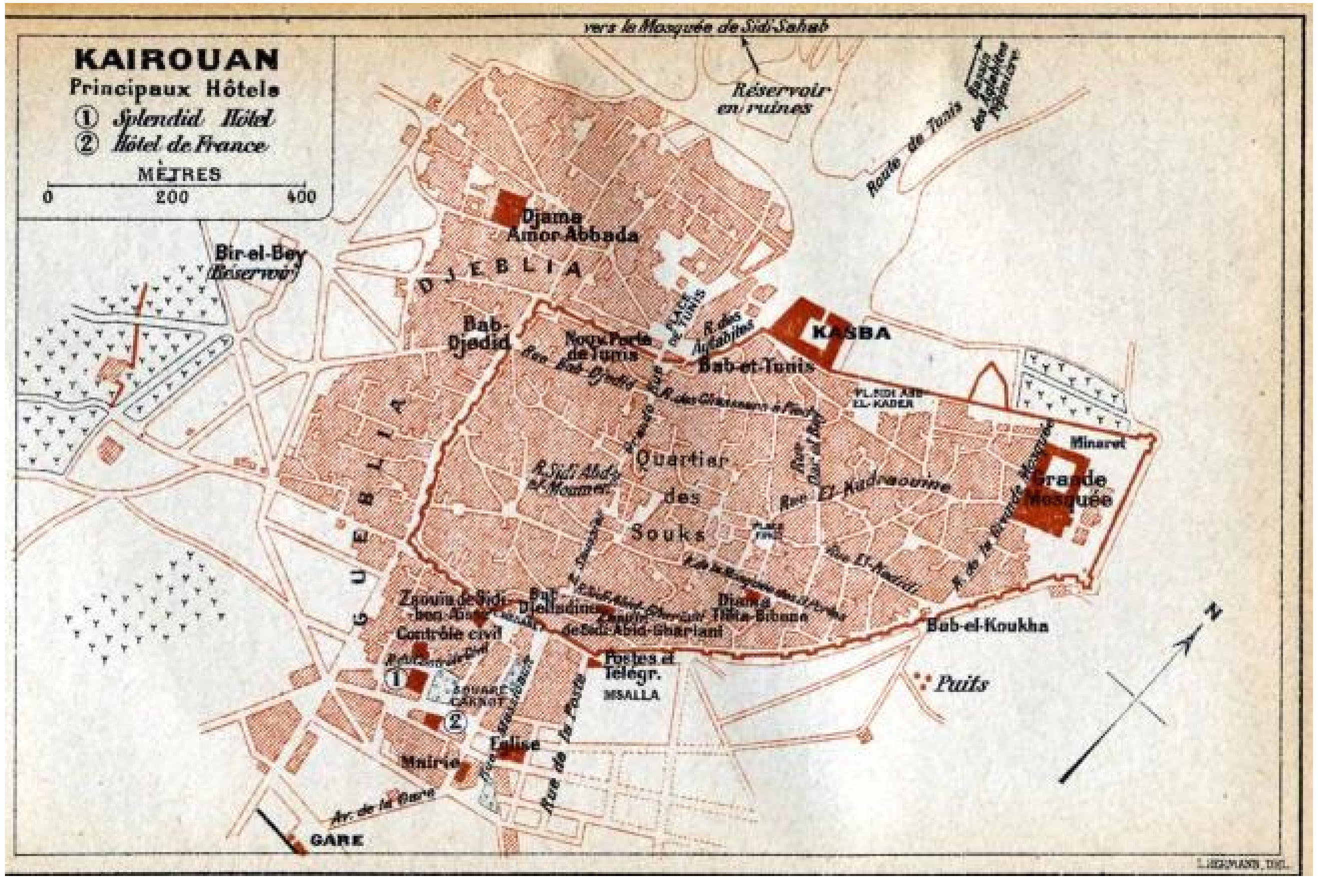
Potential Data Sources

- Remote Sensing
- Digitized paper maps/scanner
- Field Collected Data
  - GPS
  - Census (count of population/geographic area)
- Government Data Sources
- Private (commercial) Data Sources



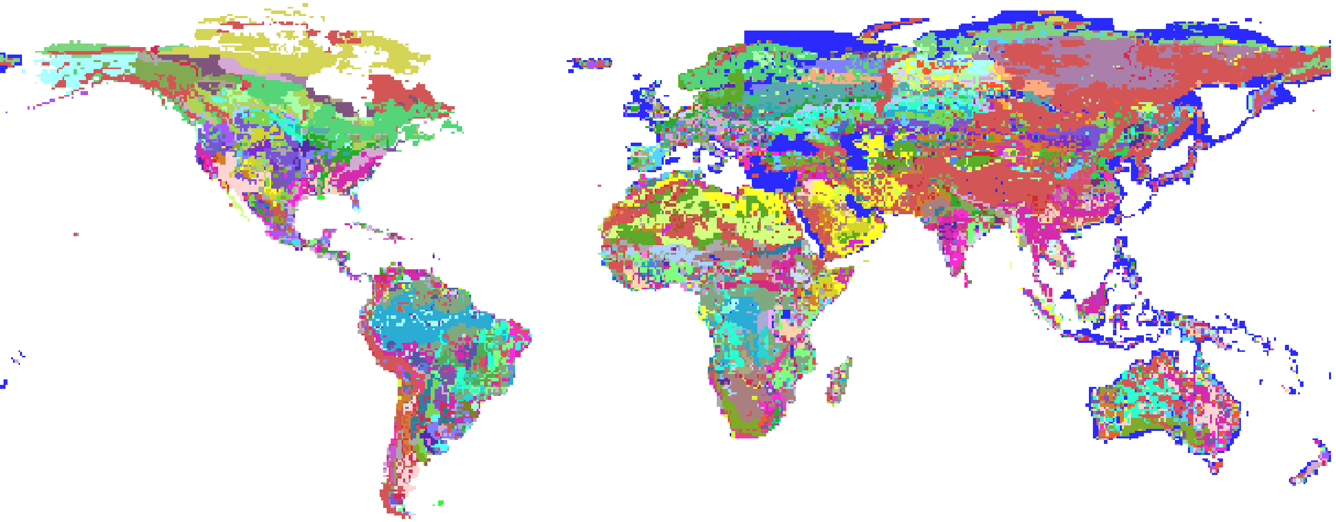
Source: GAO.

Manual Digitizing paper maps Scanning



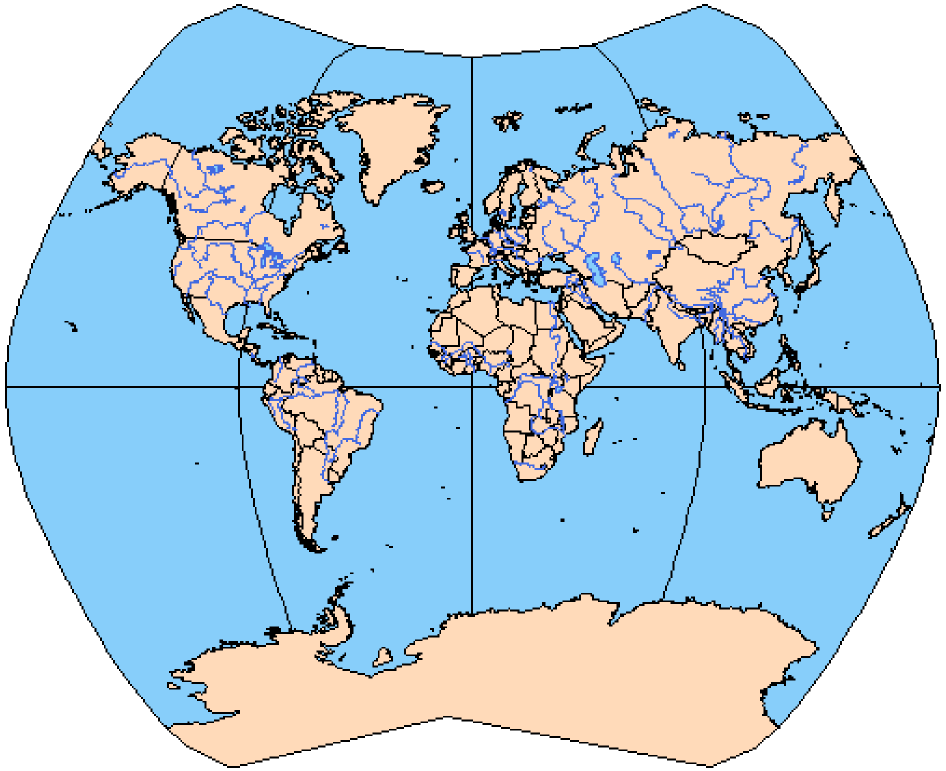
Field data collection using hand GPS or LandPKS

UNESCO Soils



- The Digital Soil Map of the World (version 3.0) was released in May 1994
- Scale of 1:5,000,000

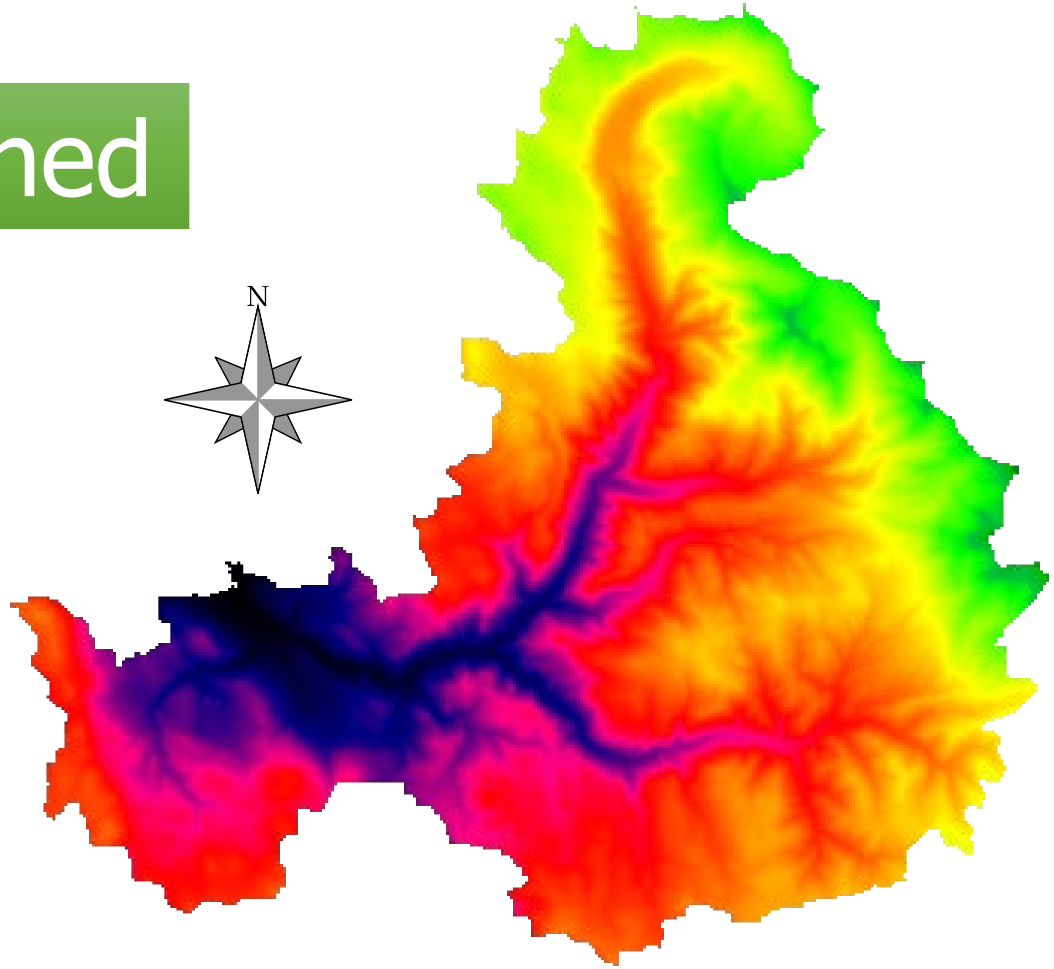
Digital Chart of the World



Elevation Layer (DEM)

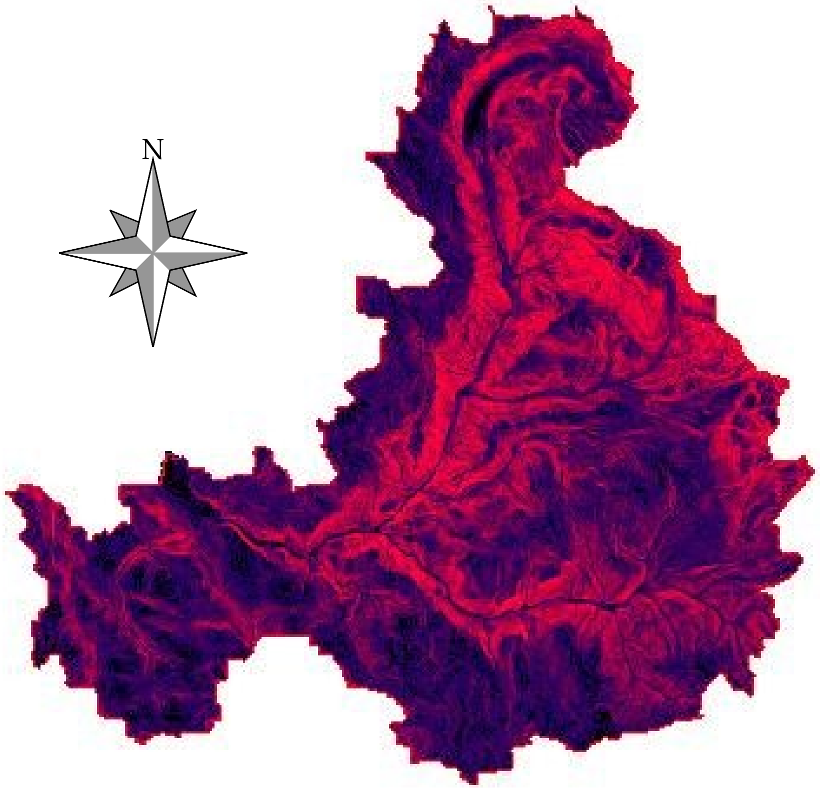
Elevations in a Watershed

What layers you can derive from DEM?



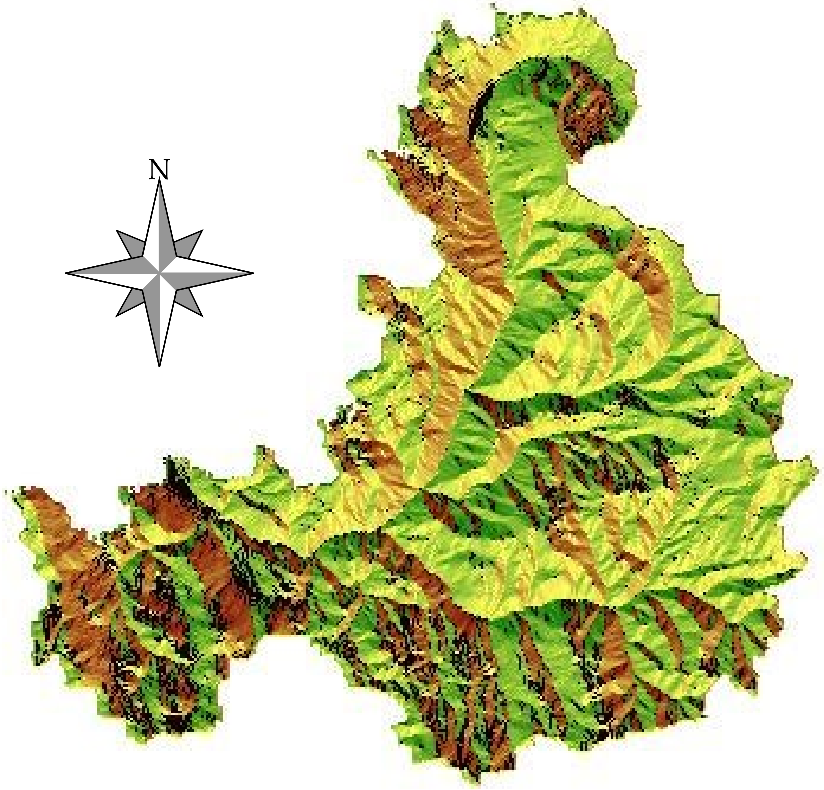
Derived Information from DEM

Slopes Layer

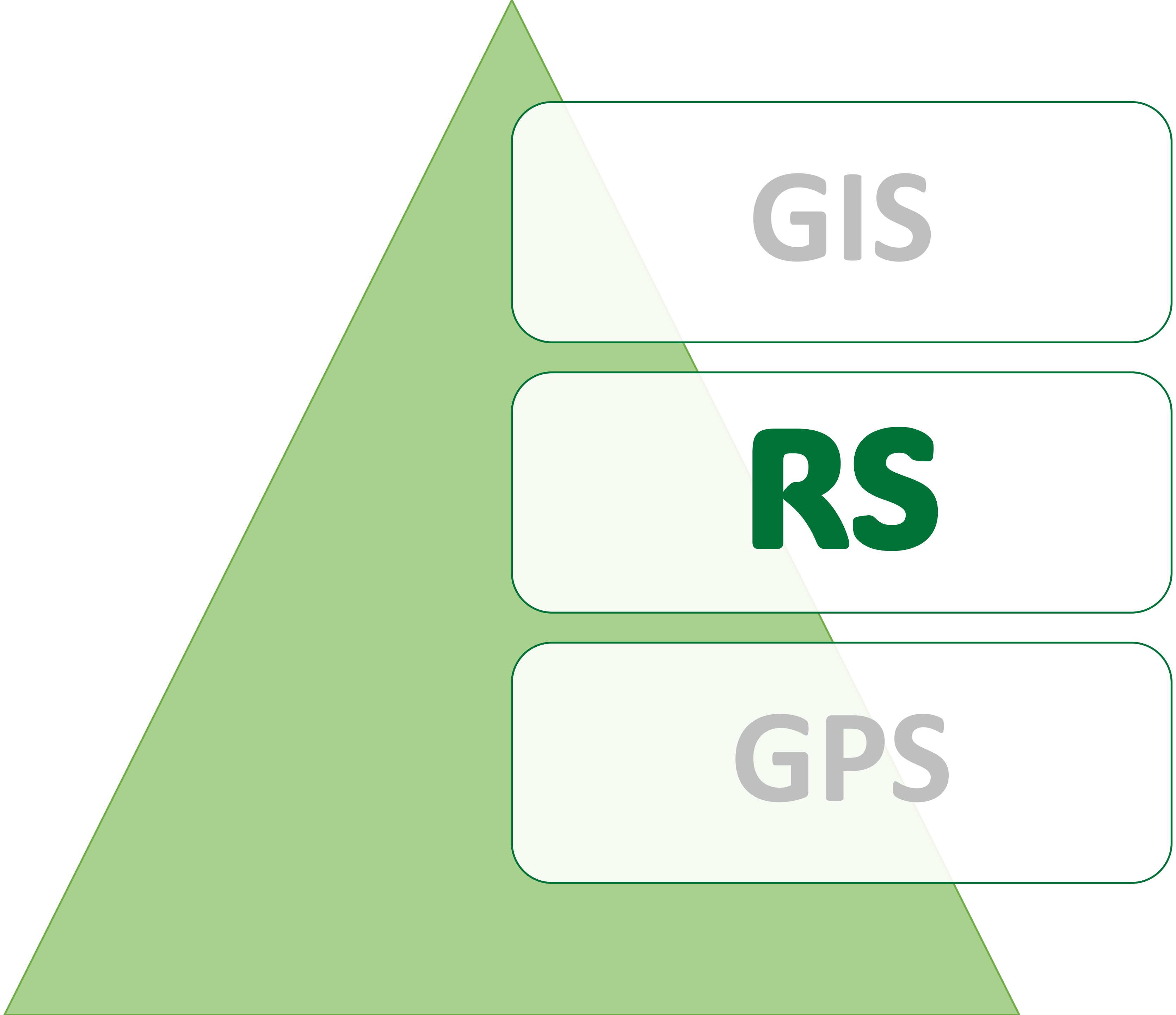


Steeper slopes are in red

Aspects

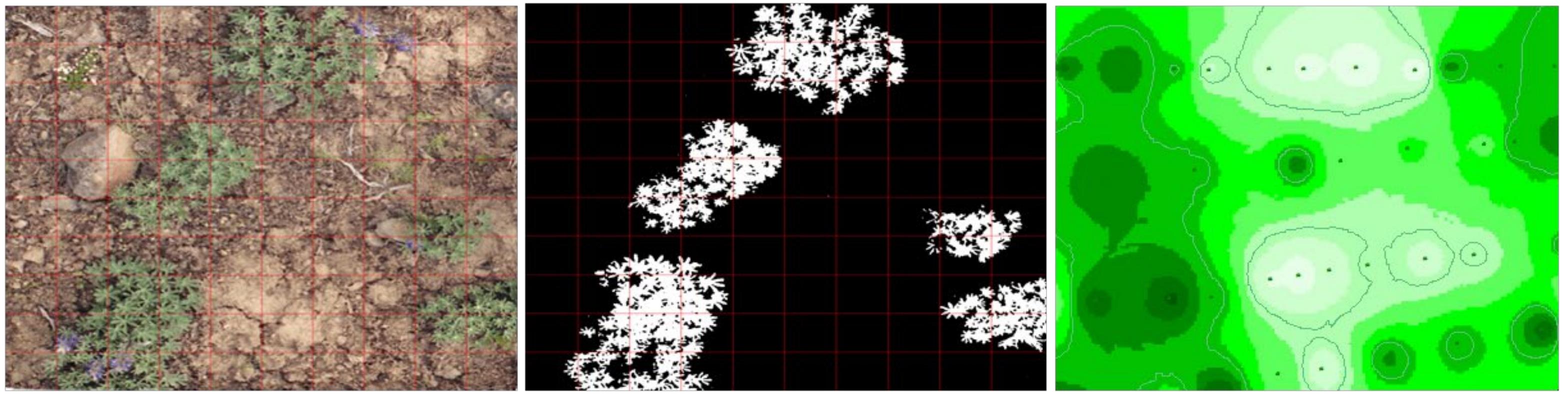


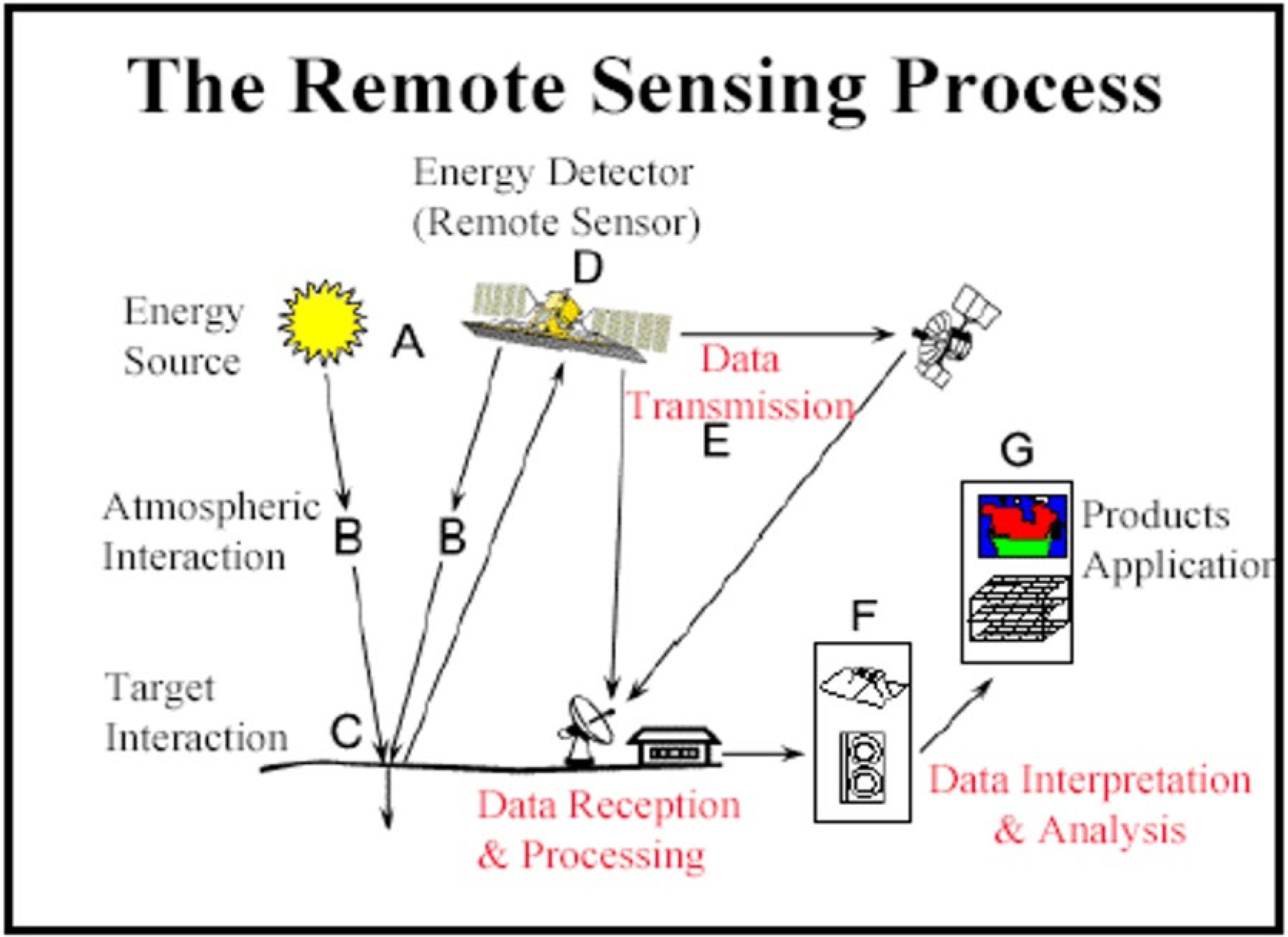
The orientation of the earth's surface with respect to the sun


GIS
RS
GPS

Definition of Remote Sensing

Remote sensing is the science (and to some extent, art) of acquiring information about the earth's surface without actually being in contact with it. This is done by sensing and recording reflected or emitted energy and processing, analyzing, and applying that information"




The Remote Sensing Process
Energy Detector
(Remote Sensor)
D
Energy
Source
A
Data
Transmission
E
G
Products
Application
Atmospheric
Interaction
B
B
F
Target
Interaction
C
Data Reception
& Processing
Data Interpretation
& Analysis

How it works?

How it works?

- **Energy Source or Illumination (A)** - the first requirement for remote sensing is to have an **energy source** which illuminates or **provides electromagnetic energy** to the target of interest.
- **Radiation and the Atmosphere (B)** - as the energy travels from its source to the target, it will come in contact with and interact with the **atmosphere it passes through**. This interaction may take place a second time as the energy travels from the target to the sensor.
- **Interaction with the Target (C)** - once the energy makes its way to the target through the atmosphere, it interacts with the target depending on the properties of both the target and the radiation.
- **Recording of Energy by the Sensor (D)** - after the energy has been scattered by, or emitted from the target, we require a sensor (remote - not in contact with the target) to collect and record the electromagnetic radiation.

How it works?

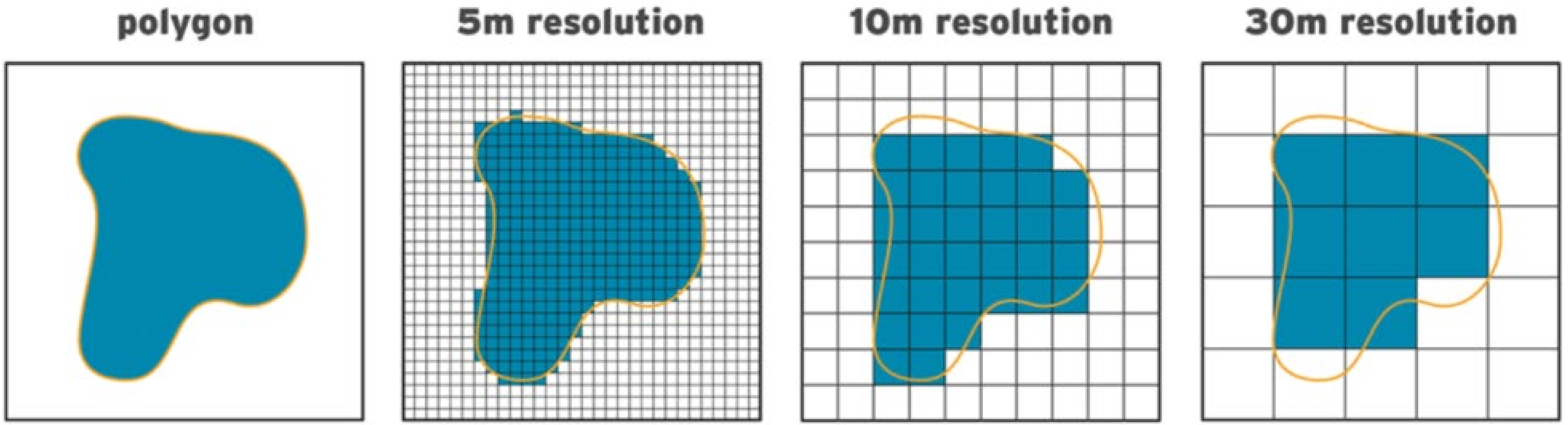
- **Transmission, Reception, and Processing (E**) - the energy recorded by the sensor has to be transmitted, often in electronic form, to a receiving and processing station where the data are processed into an image (hardcopy and/or digital).
- **Interpretation and Analysis (F)** - the processed image is interpreted, visually and/or digitally or electronically, to extract information about the target which was illuminated.
- **Application (G)** - the final element of the remote sensing process is achieved when we apply the information we have been able to extract from the imagery about the target in order to better understand it, reveal some new information, or assist in solving a particular problem.

Applications of RS

- Agriculture
- Soil moisture
- Soil mapping
- Deforestation detection
- Disease
- Hydrology
- Forestry
- Environmental monitoring
- Control forest fires
- Geology
- Environmental Impact As...
- Locating construction an...
- Land use
- Precision farming
- Health
- Biomass estimation
- Estimating forest supplies
- Weather

Spatial resolution

Spatial resolution pertains to the size of pixels representing the ground area in an image.

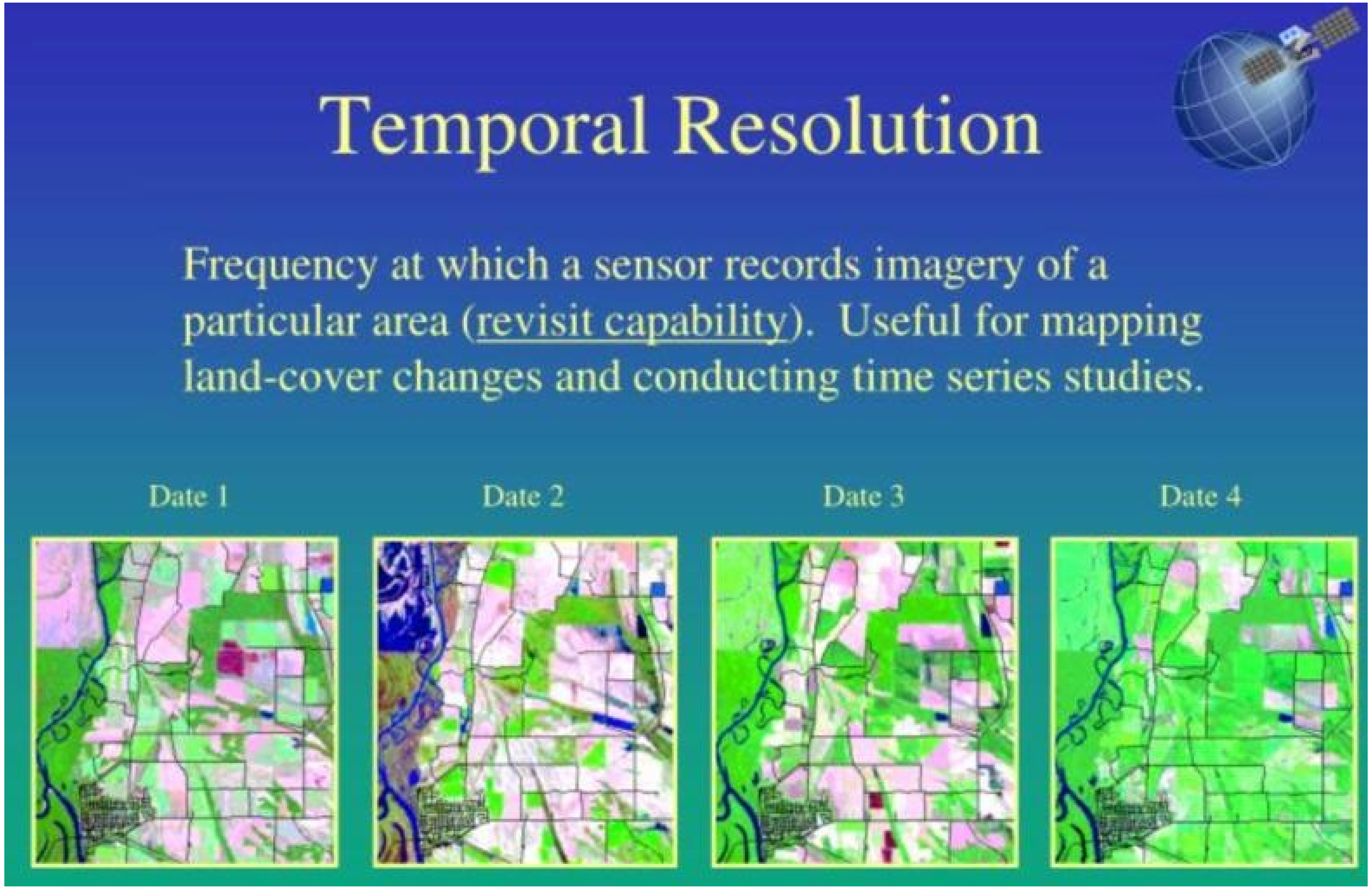


Which map is more accurate?

https://www.jbarisk.com/

Temporal resolution

Temporal resolution refers to the time required to revisit and gather data for the same location



Radiometric resolution

Radiometric resolution signifies the precision with which signal intensities can be captured

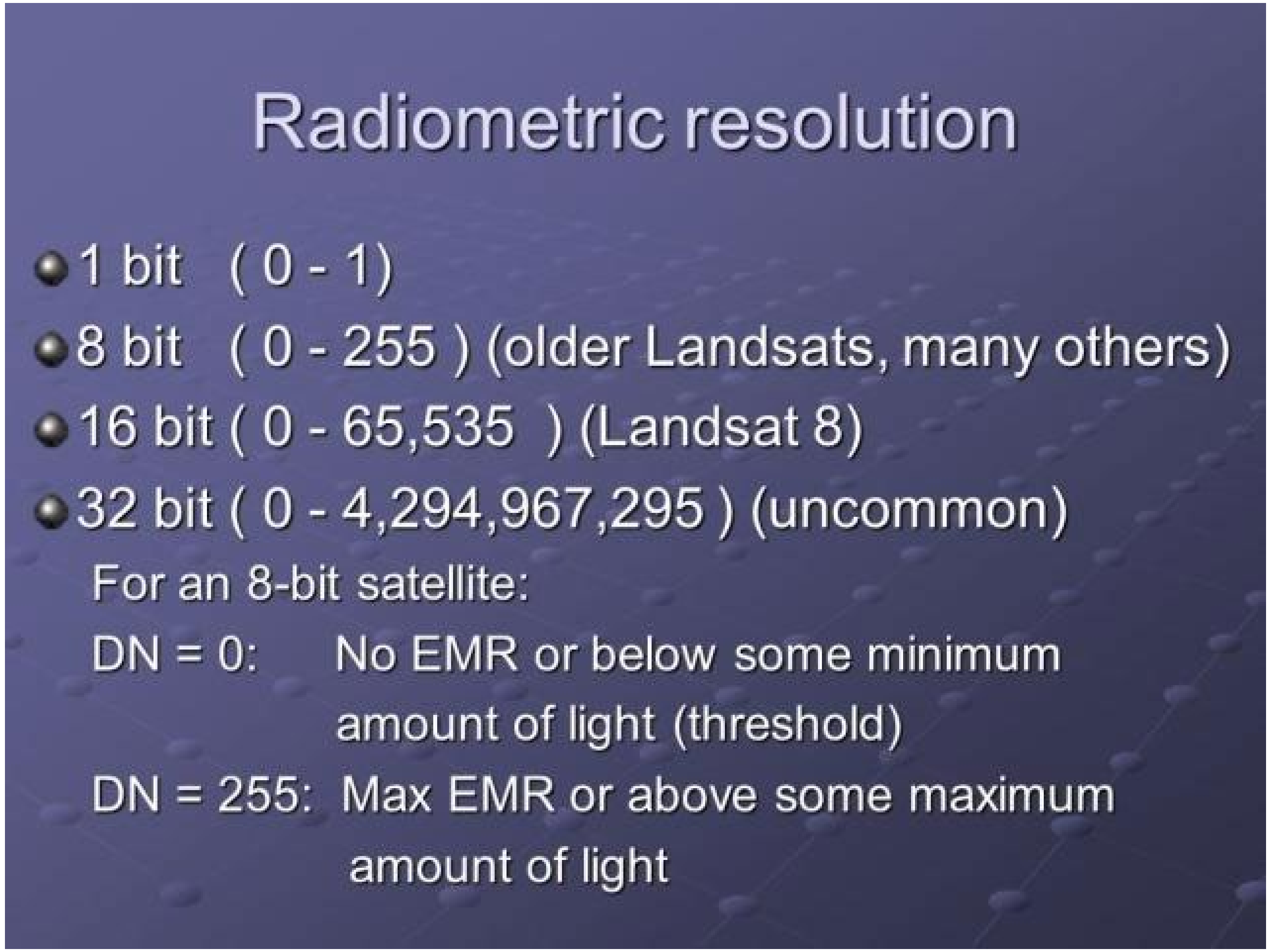


Image classification

Unsupervised Classification

The unsupervised classification approach is an automated method of deriving groups of pixels that have similar spectral characteristics.

The user must then analyze the groupings and attach a land cover type to them in order to make them meaningful.

Unsupervised classification involves computer generated spectral ‘clusters

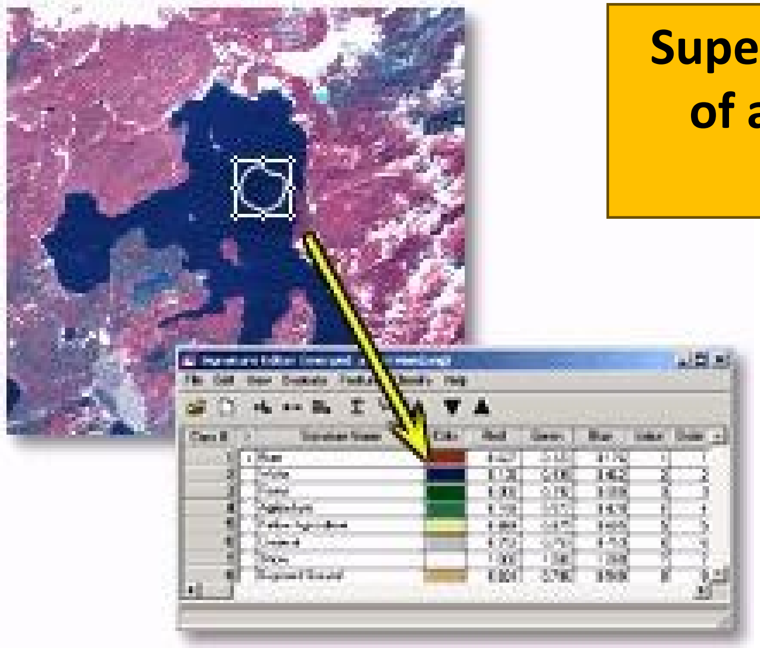
Image classification

Supervised Classification

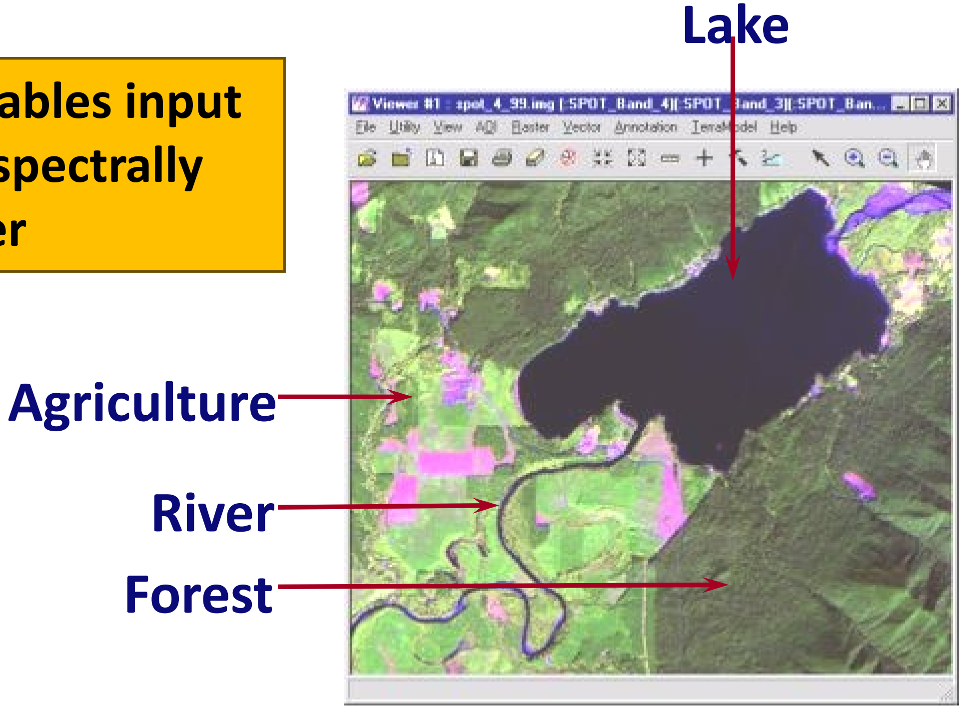
The supervised classification technique uses selected training samples collected from the image or other sources to guide the definition of pixel clusters.

Training samples, also called training signatures, are groups of pixels that represent a homogeneous area, discernible pattern, or potential class.

Samples are either imported into the Signature Editor or collected through on-screen AOI (Area of Interest) creation.



Supervised classification enables input of a priori information to spectrally 'train' the classifier



Advanced Very High-Resolution Radiometer (AVHRR)

- Visible, NIR, Thermal
- **1.1 km resolution**
- Meteorological studies
- Vegetation pattern analysis
- Global monitoring
- General vegetation patterns

AVHRR 16km

simulated natural colour

pixel size: 16km

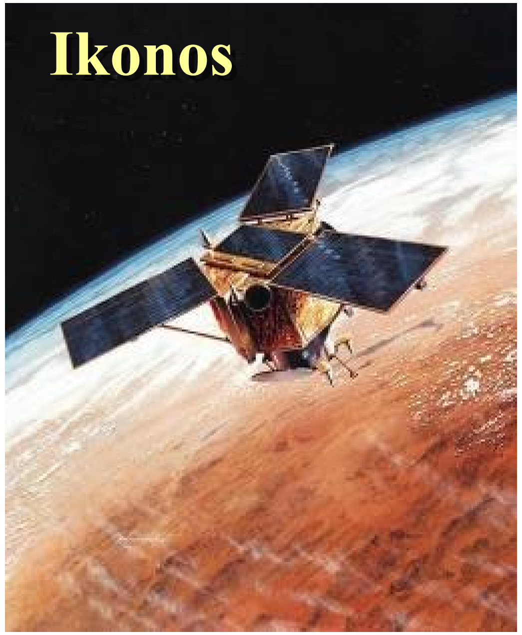
coverage: global

example: Europe

© 1998 Planetary Visions

Quickbird

- Owned by Digital Globe
- 0.61 m resolution
- Used for change detection in landuse, agriculture, and forest systems
- Launched 2001
- Sun-synchronous
- Panchromatic, blue, green, red, NIR



Moderate Resolution Imaging Spectroradiometer (MODIS)

MODIS data are useful to track changes in the landscape over time:

- monitoring of vegetation health by means of time-series analyses with vegetation indices
- monitor deforestation rates

Spatial resolution: 250 m (bands 1–2) 500 m (bands 3–7) 1000 m (bands 8–36)

Spectral resolution: 36 spectral bands with wavelengths ranging from 0.4 to 14.385 µm.

Temporal resolution: 1–2 days

Land Sat 8

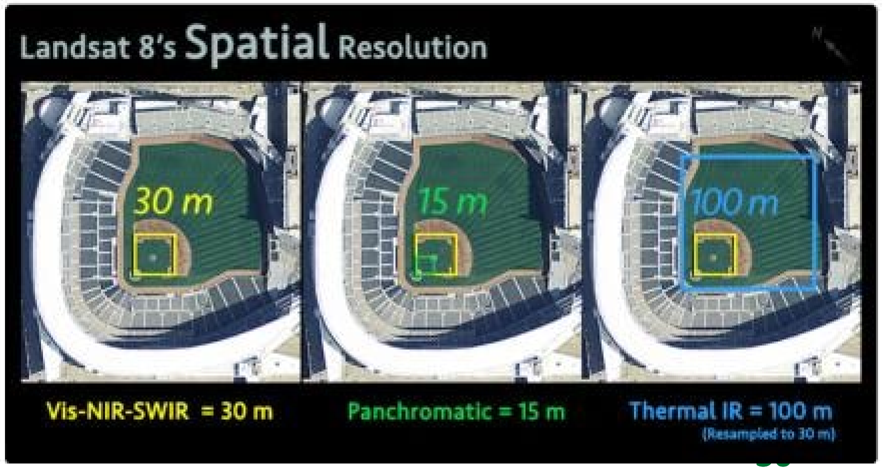
- The Landsat Program's continuous archive (1972-present) **provides essential land change data and trending information not otherwise available.**
- Landsat 8 images have **15-meter panchromatic and 30-meter multi-spectral spatial resolutions** along a 185 km (115 mi) swath.
- Temporal resolution is **16 days**
- Visible, NIR, MIR, Thermal
- Multispectral
- MSS

  80-meter spatial resolution

  4 spectral bands
- TM

  30 m resolution

  7 bands (blue, green, red, NIR, MIR, MIR, thermal



Satellite Pour l'Observation de la Terre (SPOT)

SPOT covers large areas in a single pass at resolutions up to 1.5m. It is ideal for applications at national and regional scales from 1:250000 to 1:15000.

A single SPOT scene covers a footprint of 3,600 km² at resolutions of 20 m to 2.5 m, with a location accuracy up to 10 m.

Temporal resolution: 2-3 days

Spatial resolution: Panchromatic: 2.5 m – 5 m – 10 m

Multispectral: 2.5 m – 5 m – 10 m – 20 m

SPOT-6 and SPOT-7 (Azersky) Multispectral Mode

Type	Spectral Range	Resolution
Blue	0.45 – 0.52 µm	6 m
Green	0.53 – 0.59 µm	6 m
Red	0.61 – 0.68 µm	6 m
Near infrared	0.78 – 0.89 µm	6 m

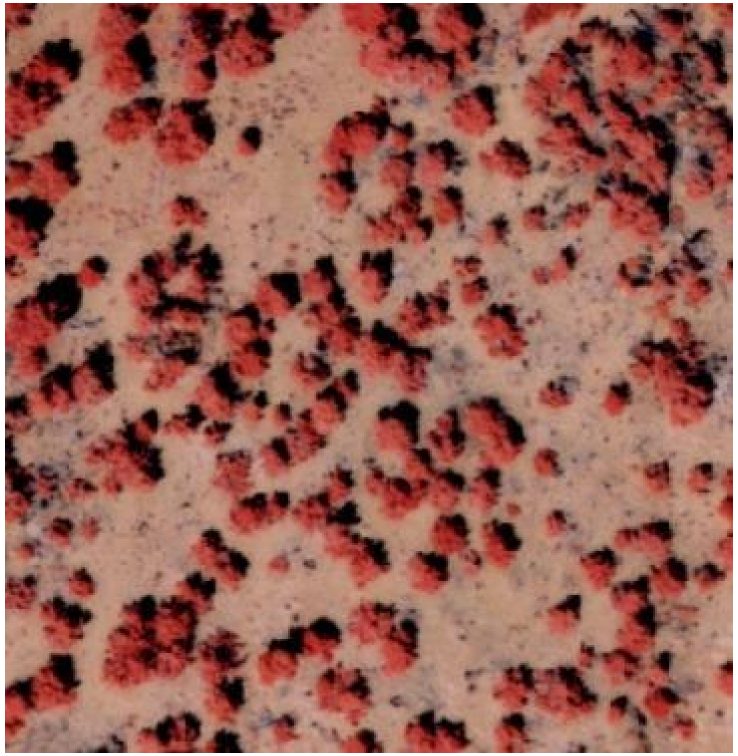
SPOT-6 and SPOT-7 Panchromatic Mode

Type	Spectral Range	Resolution
Panchromatic	0.45 – 0.71 µm	1.5 m

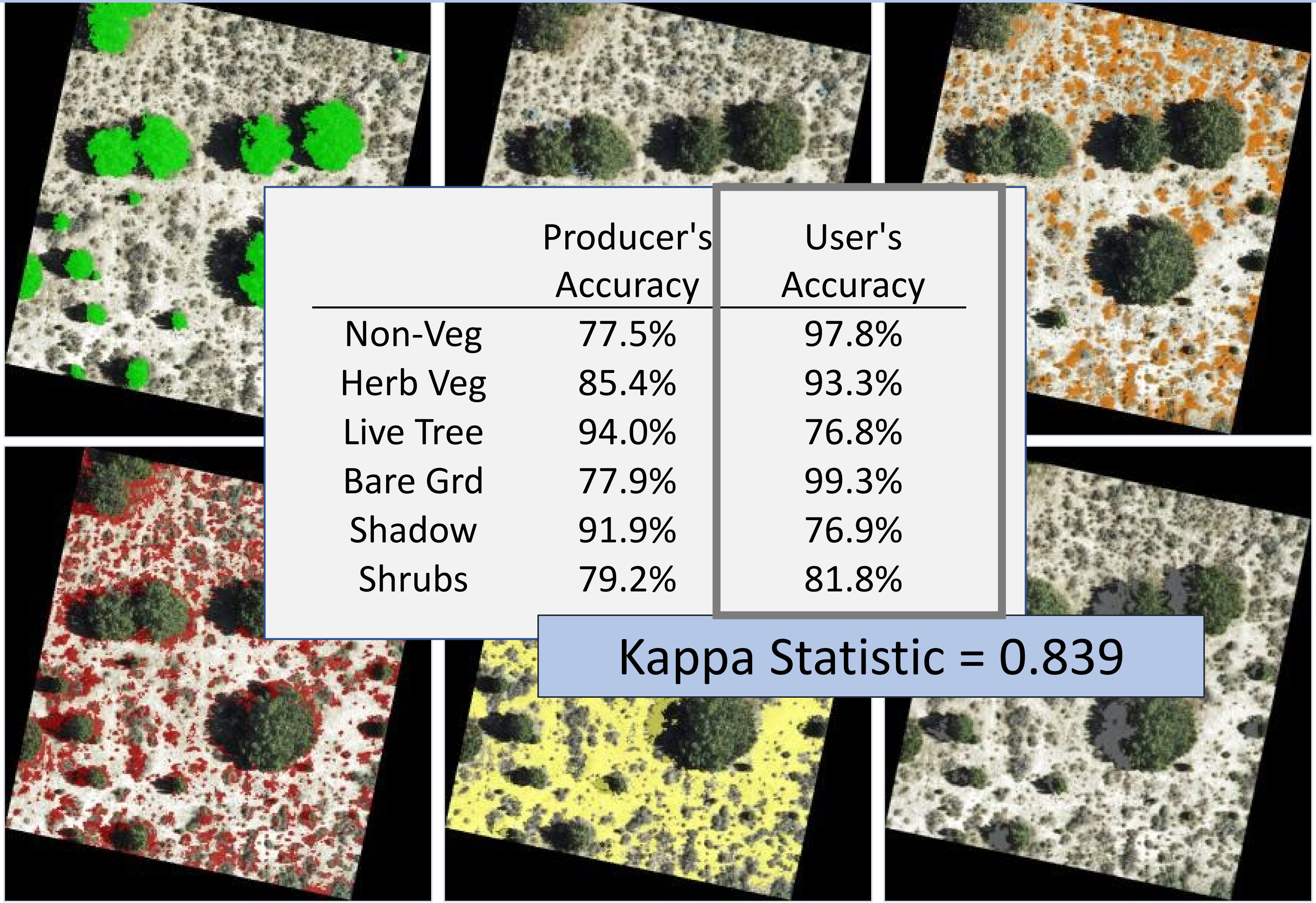
High Resolution Aerial Photography

Color (B,G,R)

Color-Infrared (G,R, Near IR)



Accuracy Assessment



	Producer's Accuracy	User's Accuracy
Non-Veg	77.5%	97.8%
Herb Veg	85.4%	93.3%
Live Tree	94.0%	76.8%
Bare Grd	77.9%	99.3%
Shadow	91.9%	76.9%
Shrubs	79.2%	81.8%

Kappa Statistic = 0.839

Woody Plant Assessment at the Landscape Scale

Feature Analyst

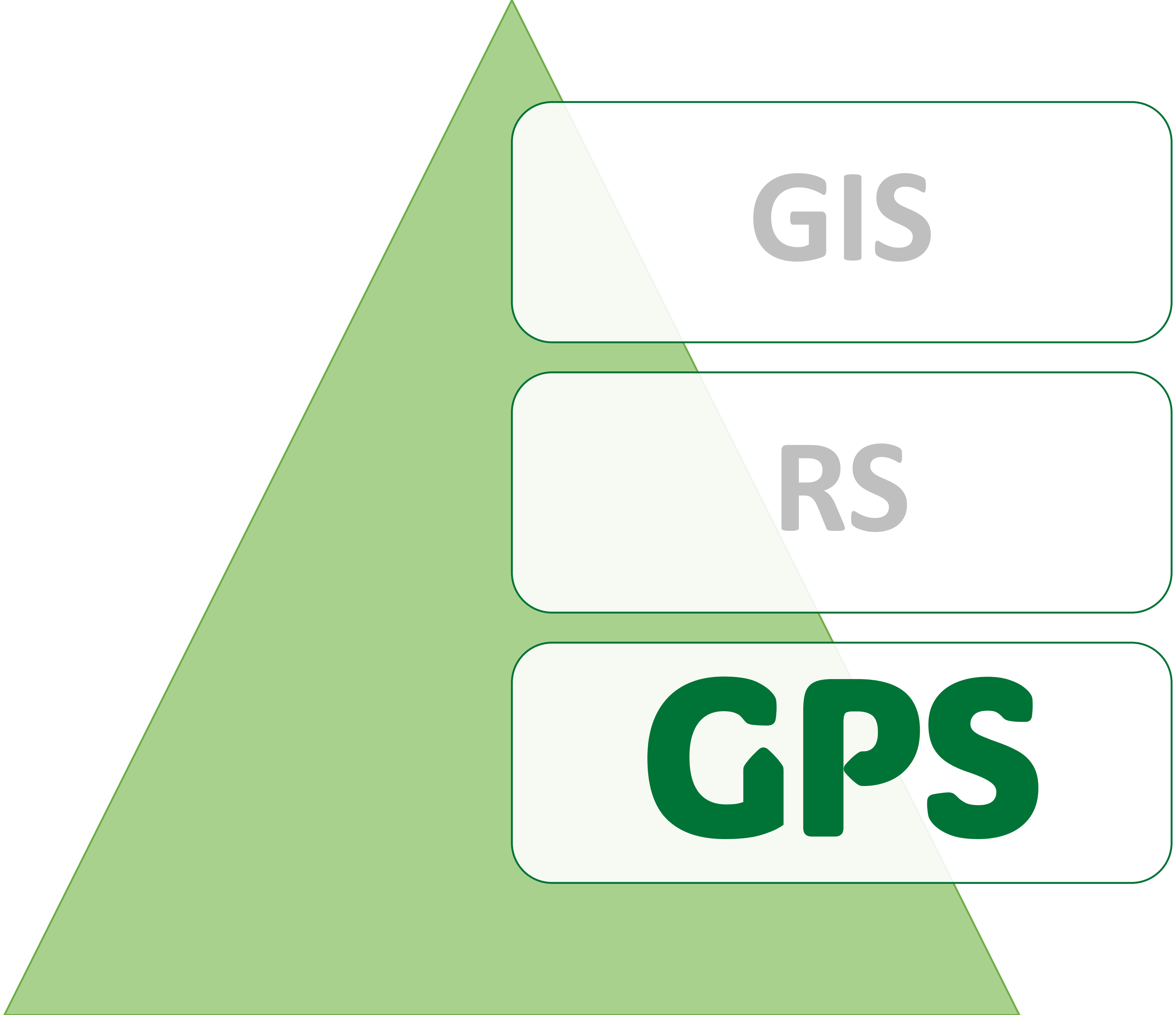
Time change analysis

Projecting Responses of Ecological Diversity In Changing Terrestrial Systems

From PREDICTS 1 to PREDICTS 2:

It's about time

Figure: Satellite images of the change of land use overtime in the Amazon (image from: http://deforestationamazonrainforest.blogspot.co.uk/)


GIS
RS
GPS

GPS (global positioning system)

- Satellite based navigation system.
- Based on a constellation of about 24 satellites
- Developed by the United States Department of Defense (DOD)

The GPS is comprised of three segments

1. **Satellite constellation called space segment**: it provides the **ranging signals and data messages** to the user equipment.
2. **Operational control segment:** it **tracks and maintains the satellite** in the space
3. **User equipment segment:** it **performs the navigation, timing** or other related function

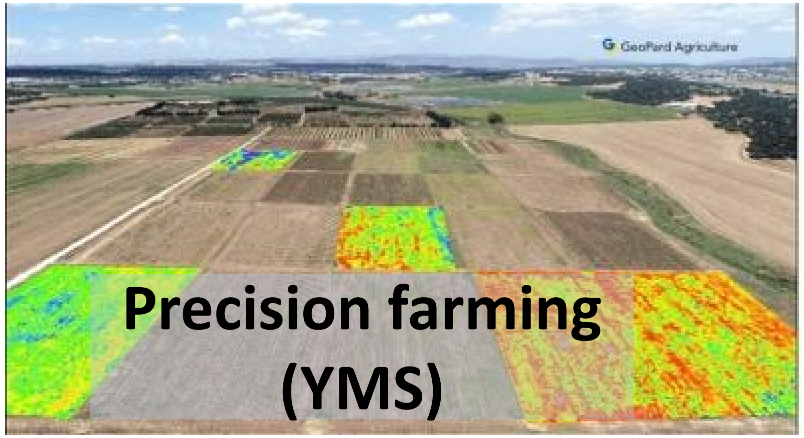
Space Segment

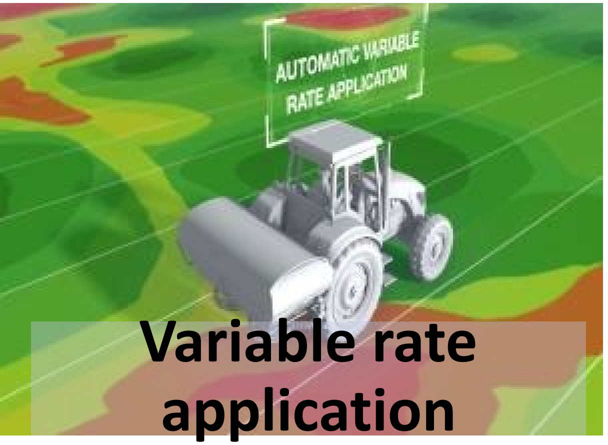
Control Segment

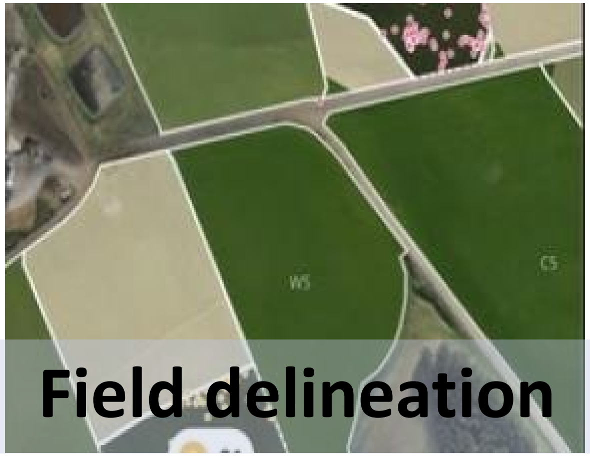
User Segment

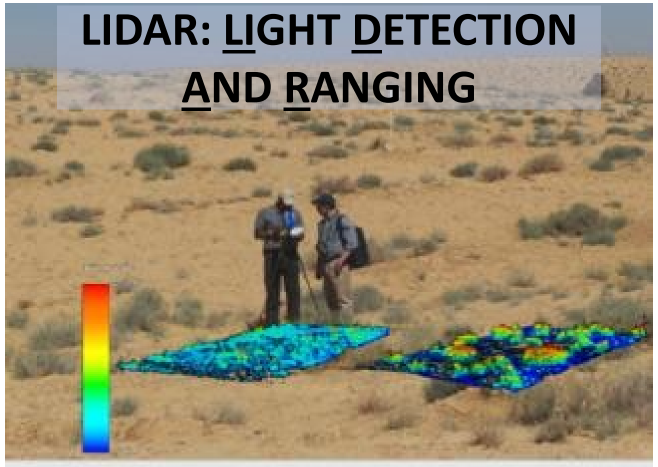
How many satellites are needed to calculate a precise location on the Earth?

Uses and applications of GPS in agriculture:









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