Remote Sensing
INFORMATION SHEET
April 2011

- **What does the term "remote sensing" mean?**

  Remote sensing is the science and art of obtaining information about an object, area or phenomenon through the analysis of data acquired by a device that is not in contact with the object, area, or phenomenon under investigation." (Lillesand & Kiefer, 1994, 1). The most basic remote sensing devices are our own eyes and ears.

  The USDA Aerial Photography Field Office (APFO) has historically acquired aerial photography on film. At present, most aerial imagery acquisitions are collected by digital aerial sensors.

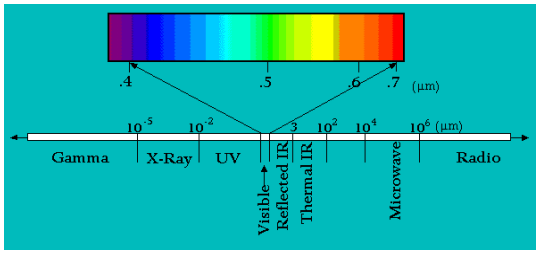
- **How do remote sensing devices acquire data?**

  At the present time, aerial imagery is collected by aircraft with film or digital cameras, and by satellites with multi-spectral sensors. These sensors collect data simultaneously from several regions of the electromagnetic spectrum.

  There are many devices and methods of data collection, but they all interact with electromagnetic energy. This energy includes such things as radio waves, thermal energy, ultraviolet rays, and X rays, but for our purposes the definition refers primarily to the visible light and near infrared waves in the electromagnetic spectrum.

- **What is the electromagnetic spectrum?**

  The electromagnetic spectrum is a continuum of electromagnetic waves organized by frequency and wavelength which includes the range of wavelengths from Cosmic rays, at 10^{-7} micrometers (μm) through television and radio waves, at 10^{8} μm. There are no clear cut divisions between areas of the spectrum; visible light is regarded as the area from 0.4 μm (blue) through 0.7 μm (red). Infrared waves are slightly longer than "red" waves of visible light. Colors are perceived when rays of a certain wavelength are reflected or emitted from an object and detected by the human eye.



- **How is imagery from remote sensing devices represented in a digital format?**

  Digital imagery is displayed through the use of very small squares called pixels (picture elements.) Each pixel contains a Digital Number (DN), which indicates the range of colors from black (0) to white (255 in an 8 bit image.) In natural color images, three different bands contain data from the red, green, and blue parts of the visible spectrum; the DN ranges from darkest to lightest tone. Color Infrared (CIR) imagery is comprised of three bands: red, green, and near infrared.

- **What is the spatial resolution of remotely sensed imagery?**

  Spatial resolution determines the level of detail visible on an image, and it refers to the size of the smallest possible feature captured by the sensor. Spatial resolution is not always the same as pixel resolution, also known as Ground Sample Distance (GSD). GSD refers to the area on the ground covered by each pixel.

  At present, Landsat imagery available for free download has a spatial resolution (GSD) of 30 meters. Imagery from the National Agriculture Imagery Program (NAIP) has a GSD of 1 meter. An image with a finer GSD such as NAIP will have a much larger file size than a 30 meter image covering the same geographic area.

- **What is the spectral resolution of remotely sensed imagery?**

  Spectral resolution refers to the number and dimension of specific wavelength intervals a sensor is able to record. The spectral resolution of a sensor capturing natural color bands of red, green, and blue is finer than a black and white sensor, which would capture all of the visible light wavelengths as one band. Hyper spectral sensors can have hundreds of data bands.

- **What is the radiometric resolution of remotely sensed imagery?**

  Radiometric resolution refers to the sensor's ability to capture slight differences in energy. This is related to the bit depth of the sensor. Since data collection is stored using the binary system, all Digital Numbers are multiples of 2. 8 bit data has 256 possible values, from 0 – 255, while 2 bit data would have only 4 possible values (0 – 3).

A larger bit depth allows more tonal variety, but requires more storage space. The combination of a larger bit depth and finer GSD will produce a more detailed image which has a much larger file size than an 8 bit image with a coarser GSD, such as Landsat.

- **What is a histogram?**

An image's histogram is a graph showing the number of occurrences of each DN within each band of the image. An image with more than one band will have a separate histogram for each band. A histogram may be skewed to one side of the range of values, and it may have more than one peak.

- **What is stretching?**

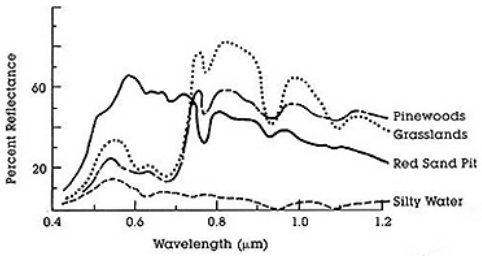
Stretching is an enhancement technique used to expand the range of tonal values in the display. An image's histogram may show that the range of DNs is much smaller than the total range of possible values. A stretch will expand the raw data values to use the range allowed. Various mathematical formulas can be used to stretch the data, with the end result being greater contrast in the image. The raw image is not changed; the stretched values are accessed through an image lookup table.

- **What is the temporal resolution of remotely sensed imagery?**

Temporal resolution is more commonly used with satellite imagery; it is the time within which the same area will be captured on a subsequent orbit. Satellite imagery is generally available for the same area with a much greater frequency than aerial photography, but the spatial resolution of easily obtainable imagery is often coarser.

- **Why is multispectral imagery valuable?**

Every physical object has a unique spectral signature; this is why our eyes perceive a wide variety of colors, while some animals can see parts of the electromagnetic spectrum that human eyes cannot. Imagery acquired by multispectral scanners use red, green and blue channels to display varying combinations of data from infrared bands, as well as the visible color parts of the spectrum. These images are often referred to as "false color" since the colors displayed may not be the actual color of the spectrum detected. Data from the different bands – alone and in combination – can be used to identify features more clearly.



This diagram shows spectral reflectance curves for four different land covers. Multispectral imagery has many applications, such as geology, geomorphology, hydrology, agriculture, forestry, and urban land use.

- **What is supervised or unsupervised classification?**

Image processing programs allow users to classify features in the imagery based on pixel clusters. With unsupervised classification, the user enters some basic parameters, and the program generates the classification. In supervised classification, the user specifies "training sites" – areas in the image representative of a feature type to be extracted. The program uses this input to identify other parts of the image containing this feature.

Object-based classification programs allow the user to specify a number of parameters besides pixel values. These include size, shape, and texture. The program searches for features based on the combination of parameters entered.

All of these methods require a thorough knowledge of the remote sensing principles, as well as the characteristics of features to be identified. Any features that cannot be interpreted by the human eye will not be detected by a computer program.

- **How can I learn more about remote sensing?**

Remote sensing is a subject which could easily fill an entire university level study program. There are a number of more detailed tutorials online. Three of these are:

NASA:
http://rst.gsfc.nasa.gov/Front/overview.html
Canada Centre for Remote Sensing:
http://ccrs.nrcan.gc.ca/resource/tutor/fundam/chapter1/01_e.php
University of Singapore:
http://www.crisp.nus.edu.sg/~research/tutorial/rsmain.htm

- **Where can I obtain imagery?**

Many websites provide information about imagery for purchase or free download. Most states have geospatial data portals. Two federal sites are:
http://datagateway.nrcs.usda.gov/ for free downloads of NAIP, MDOQs, and other geospatial data.
http://glovis.usgs.gov/ for free downloads of Landsat imagery dating from 1972.

- **Who do I contact for more information?**

1) For sales information, contact the Customer Service Section, APFO-USDA-FSA at 2222 W 2300 S, Salt Lake City UT, 84119-2020; call 801-844-2922; email apfo.sales@slc.usda.gov or visit http://www.apfo.usda.gov.
2) For more information, contact GIS Specialists Joan Biediger 801-844-2951, Zack Adkins 801-844-2925, David Davis 801-844-2933, Louise Mathews 801-844-2934 or Nathan Pugh 801-844-2927.