HOW TO ORDER APFO PRODUCTS

You can send to APFO by e-mail, fax, or mail one of the following:

- A legal description of the area you are interested in (township, range, and section numbers).
- Latitude and longitude coordinates (point and radius, four corner points, or two opposite corner points).
- A topographic, county, or city map outlining your area of interest as accurately as possible.
- Digital shapefiles preferably with UTM NAD83 projection and corresponding zone.

Services are rendered only after an order and payment or, official purchase order has been received. Methods of payment are:

- Check, money order, and credit cards. We accept Visa, MasterCard, American Express, and Discover.
- Official purchase orders *from tax-supported agencies, colleges, and universities only (State, County, City, Tribal).*

You may order over the phone with a credit card if you know the complete aerial imagery identification number(s).

All products are made to order and completion time may vary depending on existing workload. Please allow up to ten days for shipping.

Please visit our website at www.apfo.usda.gov for further information regarding APFO's aerial imagery and services.

Imagery before 1955 may be obtained from:

The National Archives
Cartographic & Architectural Branch
8601 Adelphi Road
College Park, MD 20740-6001
Phone: 1-866-272-6272
Website: www.archives.gov

USES FOR AERIAL IMAGERY

Aerial images are valuable for many things besides crop measurement. The historical records available at APFO could benefit many customers. APFO's digital products, in combination with GIS, can expand the uses for aerial imagery.

Among the uses are:

- Education
- Conservation Practices
- Urban Development and Planning
- Tax Assessment
- Pollution Studies
- Drainage Programs
- Boundary Determinations
- Road and Highway Location
- Pipeline and Power Line Construction
- Watershed and Reservoir Planning
- Historical Record of Property Changes
- Urban Development and Planning
- Recreation
- Land Change Analysis
- Personal Enjoyment

**United States
Department of Agriculture
Farm Service Agency
Aerial Photography Field Office
2222 West 2300 South
Salt Lake City UT 84119-2020
Telephone: 801-844-2922
Fax: 801-956-3653**

**E-mail: apfo.sales@apfo.usda.gov
Website: www.apfo.usda.gov
NAIP Coverage Viewer: gis.apfo.usda.gov/naipcoverage
Order Online: https://coes.apfo.usda.gov/oe/search.jsp**

**United States
Department of Agriculture
Farm Service Agency
Aerial Photography Field Office**

Leaflet 571

USDA   FSA
FARM SERVICE AGENCY

APFO

IMAGERY PRODUCTS & SERVICES

Historical & Custom Imagery

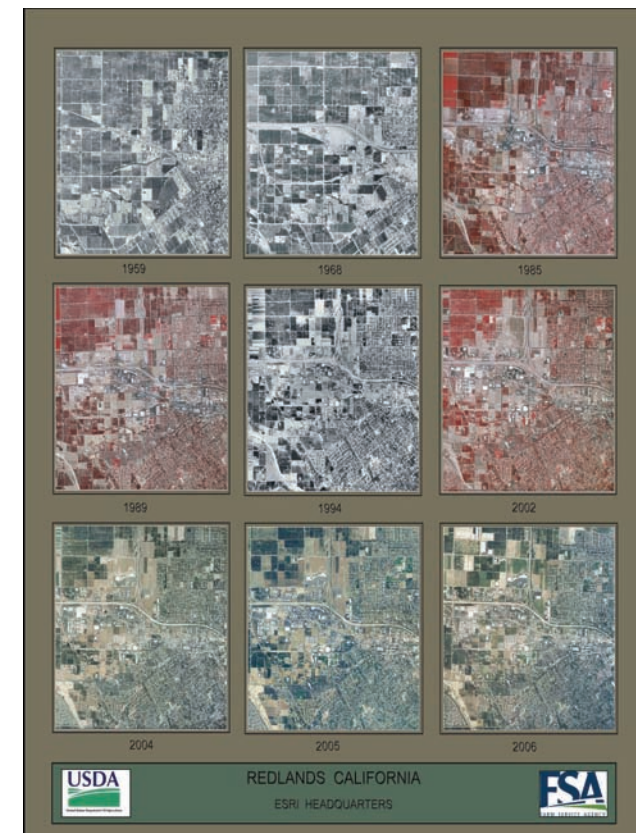## A picture is worth a thousand words.

REDLANDS CALIFORNIA
ESRI HEADQUARTERS

INTRODUCTION

The Agricultural Adjustment Act of 1933 established farm programs designed to balance production and diversify crops. Farmers (producers) participating in the Federal farm programs needed to have accurate measurements made of their fields. However, precise measurements were still being made by an older method of surveying, with chains carried around the fields. Maps were drawn by hand. A quick, accurate, and inexpensive method had to be developed to measure the millions of acres of farmland across the country.

The mission of the Aerial Photography Field Office (APFO) was to provide rectified aerial photographs for accurately measuring field acreage. Field measurements were made from aerial enlargements with a planimeter. Aerial photographs, when properly delineated and annotated with field boundaries and acreage, served as the basic record of producer land use information for each county office to administer programs.

Over the years, APFO joined with other federal agencies in cooperative photography programs. The latest program is the National Agriculture Imagery Program (NAIP). APFO now provides NAIP digital imagery to the USDA Service Center Agencies that utilize Geographic Information Systems (GIS) as the method for administering federal farm programs to streamline daily operations and facilitate updates of vital information. This includes the updating of digitized farm field boundaries known as Common Land Units (CLU).

2009 Road & Trail Photo - Abajo Mountains Utah

PHOTO PRODUCTS

Photographs - APFO's photo products have long been available to the general public. Traditional and custom photos are available in different types and scales ranging from
1" = 5,000' to 1" = 200'. Paper sizes range from 10"x10" to 38"x38". Please refer to the price list form FSA-441A for more details.

Indexes - Available as photo, line or spot (ozalid), or digital. All indexes have recently been scanned to a digital format and will soon be available for download and viewing.


2008 NAIP - Hidalgo County, Texas

HISTORIC FILM LIBRARY

APFO is home to one of the country's largest aerial film libraries. We currently house more than 70,000 rolls of film (10 million plus images). Our film dates from 1955 to the present . We have coverage of most of the United States and its territories. We are also one of the last federal government wet labs in the country. Historic aerial images are playing a more vital role today which include environmental assessments, change detection, and property boundary disputes.

As the years go by, the historical imagery become more and more valuable. These images are available as photographs or in a digital format.
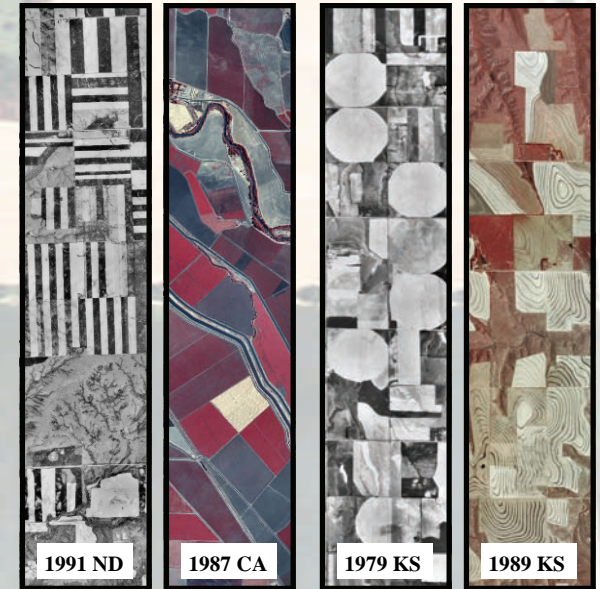
| 1991 ND | 1987 CA | 1979 KS | 1989 KS |
| Strip Farming | Waterways | Pivot Irrigation | Terraced Farming |

FILM SCANNING

APFO offers 10"x10" scans of any image in our film library using state of the art photogrammetric scanners from Black and White, Color Infrared, and Natural Color film. Film scans are furnished in standard tagged image file (.tif) format.

DIGITAL PRODUCTS

Compressed County Mosaics (CCM) - Countywide imagery coverage in various compressed ratios depending on the year. CMM's are used by the USDA Service Center Agencies for crop compliance farm programs and widely used by the public for base layer imagery. Available in 1m or 2m resolution.

Quarter Quads (QQ) - Individual images (tile) covering one quarter of a standard 7.5' topographical quad map which are used to create the CCM's. These images are used for those who prefer working with an uncompressed format. Available in 1m or 2m resolution.

Common Land Units (CLU) - The farm field boundaries are digitized as countywide shapefile datasets. The 2008 Farm Bill Section 1619 limits CLU data to USDA cooperators and contractors. Distribution to the general public is prohibited.

Common Land Unit (CLU)
INFORMATION SHEET
June 2010

🌐 What is a Common Land Unit (CLU)?

A CLU is an individual contiguous farming parcel which is the smallest unit of land that has:
1. A permanent, contiguous boundary
2. Common land cover and land management
3. A common owner, and/or
4. A common producer association.

🌐 Isn't that just a farmer's field?

A CLU is closely related to a farm field by definition. The Farm Service Agency (FSA) Handbook for Acreage Compliance Determinations Revision 15 (2-CP) states a field is a tract separated by permanent boundaries such as:
1. Fences
2. Permanent waterways
3. Woodlands
4. Croplines not subject to change because of farming practices, or
5. Other similar features.

🌐 What is a CLU used for?

USDA FSA digitizes CLU into Geographic Information System (GIS) shapefiles or geodatabases and populates the associated attribute data.

There are many uses for CLUs, including but not limited to:
1. Providing a link between tabular farm records and a map or image of the land
2. Using GIS for acreage calculations
3. Replacing paper maps with digital images that can be easily updated and can produce high quality prints whenever necessary
4. Drawing crop boundaries to better define or use with other data, such as:
    a. Crop patterns
    b. Subdivisions
    c. Conservation Plans
5. Creating a central database for land unit boundaries and linking it to customers and other data sources,
6. Speeding up the process for implementing disaster payment and other specialized systems.

🌐 Yes, but what are the benefits?

CLUs:
1. Provide timely and accurate program related data for more efficient and successful program implementation and delivery
2. Improve communication and data flow between Service Center Agencies and with farmers or other customers
3. Improve communication between geospatial software applications by providing:
    a. Common set of data elements to describe every CLU
    b. Common identifiers for each unit of land, and
    c. Common framework for locating data in relation to the ground.
4. Facilitate the creation of shared data warehouses for land related data
5. Provide for the incorporation of data from outside sources, including
    a. Census or other demographic data
    b. Satellite imagery
    c. GPS data
    d. Elevation data
    e. NOAA or other data sources
6. Provide for more consistent and more accurate land measurements, such as
    a. Field acreage
    b. Riparian buffers
    c. Wetland areas
7. Provides the ability to summarize agricultural information at the county, region, State, congressional district, or national level
8. Encourage the establishment of agreements with Federal agencies to
    a. Facilitate data exchange, to
    b. Reduce resource and acquisition costs

🌐 How were CLUs developed?

Originally, CLUs were digitized by 13 FSA digitizing centers in 7 states, and contracts with data conversion companies. CLUs were digitized on 1980s and 1990s National Digital Orthophoto Program (NDOP) imagery, using legacy photo-maps as source documents.

Who maintains the CLU data?

There are data managers at the national, State, and local level. Generally speaking, the local County Service Center employees are the maintainers of the CLU data for their area.

How often is CLU data maintained?

CLU data is continuously maintained by USDA county-based Field Service Centers through interaction with producers and with submissions of new imagery via the National Agriculture Imagery Program (NAIP).

NAIP?

NAIP is a program to:
1. Acquire peak growing season "leaf on" imagery, and
2. Deliver this imagery to USDA county Service Centers in order to
   a. Maintain the common land unit (CLU) boundaries and
   b. Assist with a multitude of other farm programs.

More information on NAIP can be obtained from the APFO website at http://www.apfo.usda.gov/.

What format are the CLUs in?

The CLU is maintained in ArcSDE geodatabase format and stored as both shapefiles and geodatabases. The UTM, NAD83 coordinate system is used for both. The different formats are used to meet various program and application needs of the Service Center Agencies.

Why GIS for CLUs?

The principal reasons are to enable a quick, automated method for calculating acreage and for a georeferenced, graphical view of farm records. In GIS, there is a plethora of other information that can be associated with CLUs. By utilizing GIS, high quality analysis of CLUs can be accomplished; thus better tracking and decision making can be made. Some associated layers could include but are not limited to:
1. High Risk Lands
2. Wetlands
3. Land Cover
4. Conservation Practices
5. Soils
6. Roads
7. Hydrography, and of course
8. Orthoimagery

What attribute data is associated with CLUs?

Some of the attributes include:
1. Shape
2. Area
3. Perimeter
4. Field ID
5. State FIPS
6. County FIPS
7. Tract
8. Farm
9. CLU Number
10. Calculated Acres
11. Highly Erodible Land Code
12. CLUID
13. CLU Land Classification Code
14. Comments

Can I get a copy of the data?

CLU is not in the public domain. Section 1619 of the Food, Conservation, and Energy Act of 2008 (Farm Bill), only allows the sharing of this data to individuals or organizations (governmental or non-governmental) certified by FSA as working in cooperation with the Secretary of Agriculture by providing assistance to USDA programs and requiring access to CLU data to complete that work.

Do I need special software to view the CLU data?

Most GIS software can view CLU shapefiles. Some GIS viewing software is free for download at http://www.apfo.usda.gov/. This list is provided for convenience; USDA-FSA-APFO does not support or endorse these products or services.

Who do I contact for more information?

1. For APFO sales and product information, contact USDA-FSA-APFO at 2222 W 2300 S, Salt Lake City UT, 84119-2020, call (801)844-2922, or visit http://www.apfo.usda.gov.
2. For further information contact GIS Specialists, Zack Adkins, at (801)844-2925 or David Davis at (801)844-2933.

Geographic Information System (GIS) Data Viewers
INFORMATION SHEET
June 2010

🌐 **What is a GIS data viewer?**

A GIS data viewer is software that can view vector and raster format data; it is an automated system for spatially managing and analyzing geographic data.

🌐 **Why do GIS data viewers matter to the USDA Farm Service Agency (FSA) and Aerial Photography Field Office (APFO)?**

FSA and APFO produce two main datasets: The Common Land Unit (CLU) and digital ortho imagery.

CLU is vector data. It resides in shapefile format and geospatial databases. Digital ortho imagery is raster data. It primarily resides in TIFF, GeoTIFF, MrSID (MG2 or MG3), and JPEG2000 formats, or web services.

This data is produced for management of USDA programs, and much of the work is done in GIS. Much of thisdata is also available for public consumption.

🌐 **Are all viewers created equal?**

No. Viewers vary greatly. Factors affecting overall functionality include levels of licensing, speed, primary purpose for the software, and bells and whistles. In the end, however, the use of one viewer over another is left up to personal preference and financial considerations.

🌐 **How much do viewers cost?**

Viewers range in price from free to upwards of $10,000, depending on levels of licensing and software extensions the user may require. Specific pricing information should be obtained directly from software vendors as prices and products change frequently.

🌐 **What are some of the free viewers?**

The following is a list of some software available at no cost for viewing GIS data:

1. Tatuk GIS Viewer
   a. Views MrSID MG2/MG3, JPEG2000, and ECW formats.
   b. Views shapefiles.
   c. Seven languages available on menu bar.
   d. Can create PDF format maps.
   e. Download website:
   http://www.tatukgis.com/products/viewer/viewer.aspx

2. Global Mapper
   a. Views MrSID MG2/MG3, ECW, and JPEG2000 formats.
   b. Views shapefiles/feature classes.
   c. Views JPEG2000 and ECW formats.
   d. Download website:
   http://www.globalmapper.com/

3. PCI Geomatica FreeView
   a. Views shapefiles.
   b. Many image enhancement options.
   c. **Can view 4 band imagery in geotiff and JPEG2000 formats.**
   d. Download website:
   http://www.pcigeomatics.com/index.php?option=com_content&view=article&id=97&Itemid=12

4. ESRI ArcGIS Explorer
   a. Supports JPEG2000, GeoTIFF, and MrSID
   b. Support for shapefiles, geodatabases, and KML files.
   c. Can perform some spatial analysis.
   d. Supports Web Services
   e. Download website:
   http://www.esri.com/arcgisexplorer
   f. Online Version
   http://explorer.arcgis.com/

- **I received my digital imagery order from APFO. What should I view it with?**

That depends on the product. Some viewers can view almost any product, while others can only view selected formats. The following can view most imagery APFO delivers:

1. Tatuk GIS Viewer.
2. Global Mapper .
3. ESRI software including:
    a. ArcGIS 9.x
    b. ArcGIS Explorer

- **What data viewers does the Aerial Photography Field Office (APFO) use?**

APFO employs the ESRI ArcGIS software suite, selected extensions, and custom tools to accomplish GIS production level work. APFO also uses other viewers identified in this document, in support of customer related inquiries and needs.

- **What about the States/FSA Service Centers?**

USDA FSA State Offices and Service Centers use ArcGIS 9.2, ArcGIS Server Services and ArcSDE geodatabases for management of CLU.

- **Any advice on choosing the right viewer?**

Research the viewers thoroughly, especially if you are going to pay for the software. Determine what your core requirements are, the purpose for which you need the software, and identify the viewer that best meets your needs.

Consider whether you're just using the viewer to view imagery, or if you want to work with vector data (points, lines, and polygons), Global Positioning Systems (GPS), spreadsheets and databases as well.

Also remember if you pay for a license, many times you need to pay annual maintenance fees to continually upgrade to the newest version without paying for the software all over again.

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

1. For information on data viewers, contacting software vendors directly or browsing their website is always recommended. For more information on free GIS data viewers and viewer downloads, go to the following sites:
http://software.geocomm.com/viewers/
http://gislounge.com/ll/freedataviewers.shtml
http://spatialnews.geocomm.com/features/viewers2002/
2. If you have general questions about data viewers, contact GIS Specialist Zack Adkins at (801)844-2925 or GIS Specialist Nathan Pughat (801)844-2927.
3. For APFO sales and product information, contact USDA-FSA-APFO at 2222 W 2300 S, Salt Lake City UT, 84119-2020, call 801-844-2922, or visit www.apfo.usda.gov.

- **Note to reader:**

Information regarding data viewers contained within this document is provided for customer convenience only. USDA-FSA-APFO does not support or endorse these products or services.

Four Band Digital Imagery
INFORMATION SHEET
April 2010

🌐 What is four band imagery?

Four band imagery is multispectral, which means that it is collected from several parts of the electromagnetic spectrum. The spectrum is the entire range of light radiation, from gamma rays to radio waves, including X-rays, microwaves, and visible light. Four band imagery, when delivered to a customer, typically contains red, green, blue, and near infrared bands. Only three bands can be viewed at one time in most software applications in use at present. A user can choose to display an image as either natural color (red, green, and blue bands) or color infrared (infrared, red, and green bands).

🌐 What is color infrared imagery?

Color infrared (CIR) film is a three layer product, with individual layers being sensitive to red, green, and near infrared wavelengths. Near infrared (NIR) wavelengths are slightly longer than red, and they are outside of the range visible to the human eye. Blue wavelengths, a part of natural color film, are filtered out of CIR.

Digital imagery acquisition uses charge coupled devices (CCDs) which are sensitive to different wavelengths in the electromagnetic spectrum. All four bands are routinely collected in digital acquisition. A CIR product can be created from the raw digital data, or all four bands can be delivered to the customer.

🌐 How does a color infrared display differ from natural color?

A natural color image displays the colors as they would appear to human eyes under normal conditions. Conventionally, a CIR image is set up to display the infrared band data with a red tone. Red wavelengths will appear green, and green wavelengths will appear blue. Blue wavelengths are not displayed. Because the healthy green vegetation will appear to be bright red, a CIR image is also known as a "false color" image.

🌐 How can a user change from natural color to CIR in the display?

The user must have software which will recognize all four bands. The software will usually have some type of interface where the band assignments can be changed.

If an image is set up with the red (wavelength) band as band 1, green as band 2, blue as band 3, and near infrared as band 4, a natural color display on the computer screen would be set up with the red (display) channel as band 1 (red), green channel as band 2 (green), and blue channel as band 3 (blue). CIR would be set up with the red channel as band 4 (NIR), the green channel as band 1 (red) and the blue channel as band 2 (green). Band 3 (blue) is omitted.

🌐 Why was color infrared developed?

CIR film was developed during World War II by Eastman Kodak to assist in detecting camouflage, because it can distinguish a plant cover from other materials. It has since been used for many other applications involving vegetation; the primary purpose being to monitor the health of crops or forests. Trained analysts can sometimes distinguish different plant species from their tone in the image, known as the "spectral signature."

🌐 What is the advantage of CIR?

Color infrared is especially useful because the internal cell structure of healthy plants reflects near infrared wavelengths. Chlorophyll in plants reflects green wavelengths; this is why healthy plants appear green to humans. In addition, the reflected infrared is more reliable in monitoring plant health than the reflected green wavelengths.

CIR tends to penetrate atmospheric haze better than natural color, and it provides sharper imagery. This makes CIR especially valuable in areas of the country which are hot and humid in the summer.

🌐 How is four band imagery used in agriculture?

Four band imagery is useful in agriculture because a bright red color is an indication of healthy vegetation. Variations in the red color can indicate stressed vegetation. These stresses can include a lack of fertility, insect infestation, soil deficiencies, and over or under watering.

CIR can be used for such purposes as crop inventory and analysis, crop stresses, monitoring fertilizer applications, and yield estimates. CIR can also help analyze soil properties, such as permeability, salinity, and erosion. The Normalized Difference Vegetation Index (NDVI), can be derived from digital CIR data, and is key indicator in plant analysis. (Source: Crook)

How does a leaf react to solar radiation?
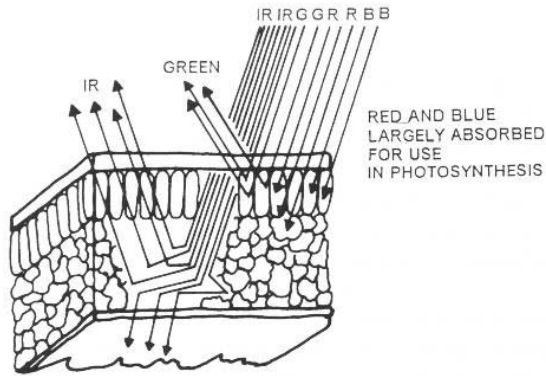
Green wavelengths are reflected off the outer palisade tissue, while infrared is reflected off the inner mesophyll tissue. (Source: Campbell, 1996).

What is the NDVI?

The NDVI is one of several indexes mentioned in literature dealing with plant health. The Forest Service uses it in assessing wildfire risk. This index is "derived from a mathematical normalization technique that utilizes only the red and near-infrared energy measurements…

The NDVI measurement takes into account the amount of red energy that is absorbed by chlorophyll and the amount of near-infrared energy that is reflected by the cellular structure of the leaf (because the red and near-infrared measurements are normalized in an indirect measure of vegetation health)." (Source: Servilla).

The formula is (NIR – Red)/ (NIR + Red), where NIR is the Near Infrared channel, and Red is the Red channel.

How is four band imagery used in precision agriculture?

Precision agriculture uses technological advances, such as GIS, GPS, and Remote Sensing, to assist with agricultural operations. Four band imagery gives the farmer two views of the fields, with CIR providing a clearer picture of plant health, as well as the data for calculating the NDVI.

Ground level sensors owned by a farmer can be mounted on a vehicle or be handheld, and will remotely sense and/or map the field while driving through it. They can output raw imagery or index values calculated from the data capture. The output can be used with four band imagery to provide greater temporal resolution for indexes such as the NDVI. (Source: Casady & Palm)

How does four band imagery benefit FSA's agricultural programs?

CIR provides more detail in the imagery than natural color, and the vegetative and cropping boundaries are more distinct in the image. Crop health and soil moisture variations are more apparent with CIR.

Data analysis (uncompressed data) benefits from CIR, as supervised, or automated unsupervised, classifications can identify crops and characteristics not evident to the naked eye. CIR provides the county offices with the opportunity for greater visual interpretation and digital analysis. The continued option for a natural color image allows FSA personnel the opportunity to print out color maps for farmers with the fields appearing in their natural tones. (Source: Crook)

How many NAIP projects have been flown in CIR?

Natural color is the default for NAIP projects. CIR is available on request by the states or partners, and four band imagery is a "buy-up" product. Missouri was flown with CIR in 2003, and Illinois, Pennsylvania and Texas received CIR in 2004. Michigan received CIR in 2005, and Texas again received CIR in 2006.

Have there been any other CIR acquisitions?

Some of the imagery from earlier film photography programs were flown as CIR. Some of this film was scanned and orthorectified as part of the National Digital Orthophotography Program (NDOP).

What states are available in four band?

In 2007 Arizona was the pilot state for the first four band imagery acquisition through the NAIP program. In 2008, eight states received four band imagery. They were: CN, IN, KS, MN, TN, TX, VT, and VA. In 2009, fifteen states received four band imagery. They were: WA, OR, MT, CA, CO. WY, ID, ND, NE, AL, GA, SC, NC, MD, DE. This trend will likely continue in 2010

Sources:
Casady, William and Harlan Palm. *Precision Agriculture: Remote Sensing and Ground Truthing*. University of Missouri Extension.
Crook, Brian. FSA GIS Coordinator, Texas. 2008.
Servilla, Mark. *The First Steps to Understanding Agriculture Remote Sensing*: Modern Agriculture, 1999.
Campbell, James. *Introduction to Remote Sensing*, 1996.

Who do I contact for more information?

1. For sales information, contact USDA-FSA-APFO at 2222 W 2300 S, Salt Lake City UT, 84119-2020, call 801-844-2922, or visit http://www.apfo.usda.gov.
2. For further information contact GIS Specialist Nathan Pugh at 801-844-2927, or GIS Specialist Louise Mathews at 801-844-2934.

Geographic Information System (GIS)
INFORMATION SHEET
April 2010

🌐 What's a Geographic Information System?

A Geographic Information System (GIS) describes any automated system for managing and analyzing geographic information.

In simplest terms, most everything has a physical location on the face of the earth; by default it has a spatial component. GIS is the managing, leveraging, and/or virtual display of information about things that have a spatial component.

Most but not all geographic data has a projection, which is a mathematical attempt to place what is seen on a flat computer screen, or printed page, at the coordinates/location of where it really exists in the three dimensional world.

GIS is part of a larger field called Geographic Information Science, a more overarching, and academic field dealing with the totality of hardware, software, geospatial data, and their interactions.

🌐 What kinds of data can a GIS use?

Generally speaking, GIS stores two types of spatial data: Vector and Raster.

Vector data is a coordinate-based data structure.. Each feature is represented as a list of ordered x, y coordinates. Attributes can be associated with the feature. Vector data includes:

1. Point features (signs, tractors, grain silos, etc.)
2. Line features (roads, fences, sidewalks, etc.)
3. Polygon features (fields, land use, wetlands, etc.)

Raster data is data displayed as discrete picture elements (pixels). It is a cellular data structure composed of a matrix of rows and columns. Groups of cells represent features. The value of each cell determines the tonal value of the feature. Raster data can include aerial photography, scanned images, and any other information displayed and stored as pixels.

GIS can also store almost any kind of attribute data. Attribute data further describes spatial data. For example, a point feature may be a sign, but the attribute data could specify what type of sign it is: stop, yield, or speed limit. Attribute data is stored in associated tables, text files, or databases. The real power of GIS is in accurate attribute data.

🌐 For what purposes do people use GIS?

1. Map the location of things: Mapping where things are located assists users in finding geographic features, and in measuring distances or transportation routes between features. Visualizing locations on a map can assist in decision making.

2. Finding patterns: Observing the distribution of features on the map can reveal patterns, which can assist in analysis.

3. Map densities: Mapping features will display their geographic concentration, but in areas with many features it may be difficult to determine which areas have a higher concentration than others. A density map displays measurements of the number of features, so you can clearly see the distribution.

4. Map quantities: Quantities are mapped to assist with study objectives, or to compare data in different places. This type of map can aid with decision making, because it gives an additional level of information beyond simply mapping the locations of features.

5. Find what's inside something: Mapping quantities or densities in specific areas could help to monitor what's happening and to take specific action. For example, maybe within a particular city district, crime is higher than in other districts. This finding could lead police to increase patrols.

6. Find what's nearby something: Create buffer zones and discover what's occurring within a set distance of a feature. This type of analysis is crucial to environmental planning.

7. Map changes: Map changes in a particular area in order to predict future conditions, decide on a course of action, or to evaluate the results of a previous decision.

🌐 How does the Farm Service Agency (FSA) and Aerial Photography Field Office (APFO) use GIS?

USDA-FSA programs help agricultural producers purchase and operate farms, stabilize farm income, conserve land and water, and recover from the effects of disasters.

In order to determine producer benefits for most FSA program areas, FSA must know the specific crop acreage or other land use information. Also, for many programs, producers agree to certain provisions on their land, such as conservation compliance.

GIS helps FSA staff to more efficiently measure land features by allowing computer-generated maps to interact with databases that store information about the land (attribute data). This technology gives local offices tools to:

1. Help producers to exercise sensible land stewardship;
2. Provide quicker, more accurate information for decision-making purposes; and
3. Reduce the amount of time a producer must spend working with local FSA staff in order to participate in USDA programs.

USDA-FSA-APFO helps manage two primary datasets:

1. Aerial Imagery
2. Common Land Unit (CLU)

Aerial Imagery, a raster dataset, is the base layer in GIS over which other data, such as CLU, which is a vector dataset, are overlaid and digitized.

Depending on the purpose of the work, other data layers may also be added. The end product is a group of layers that represent real world features in the form of a map. GIS allows for much more detailed information than is contained in a hard copy map with a color-coded legend; the attributes could be used to create an entire series of maps. Each GIS layer can store and display vast amounts of information, such as soil types, crops, land boundaries, place names, and populations.

No matter how vast the GIS database is, it can be queried and organized to propagate efficient data management practices. A simple GIS query can locate one farm number from thousands, in just seconds.

Further uses of GIS by USDA FSA relate to:

1. Farm Commodity and Conservation Programs
2. Farm Loan Programs
3. Emergency Preparedness
4. Compliance

What is a CLU used for?

The most critical component of GIS for FSA is the development and maintenance of the Common Land Unit (CLU). CLU is the smallest land unit with a permanent contiguous boundary and land cover; in other words, a farm field. USDA-FSA digitizes CLU into Geographic Information System (GIS) compatible files and populates associated attribute data.

There are many uses for CLU, including but not limited to:
1. Providing a link between tabular farm records and a map or image of the land;

2. Using GIS for acreage calculations;
3. Replacing paper maps with digital images that can be easily updated and can produce high quality prints whenever necessary;
4. Drawing crop boundaries to better define or use with other data, such as:
    a. Crop Patterns
    b. Subdivisions
    c. Conservation Plans
5. Creating a central database for land unit boundaries and linking it to customers; and
6. Speeding up the process for implementing disaster payment and other specialized systems.

How do farmers benefit from GIS?

GIS technology can help agricultural producers improve production history and farm planning through precision agriculture. Producers can request copies of USDA imagery, farm and field boundaries, and soils data to help them with:

1. Planning, such as determining crop planting strategies
2. Crop production, such as mapping and monitoring fertilizer and herbicide application.

Can I build my own GIS?

Yes. All you need to get started is software and data.

Do I have to purchase GIS software?

No. Software for basic GIS functionality is free for download; more advanced GIS software does come with a substantial associated cost.

For more information on free GIS software and downloads, go to the following sites:

http://software.geocomm.com/viewers/
http://gislounge.com/ll/freedataviewers.shtml
http://spatialnews.geocomm.com/features/viewers2002/

This list is provided for convenience; USDA-FSA-APFO does not support or endorse these products or services.

Do I have to purchase GIS data?

No. There is an abundance of free data, in numerous data warehouses, on the web. The key is having a clear objective in seeking data. The Geospatial Data Gateway, at http://datagateway.nrcs.usda.gov/ , contains a great deal of imagery and vector data available for public consumption. Many state governments also have their own clearinghouses.

Who do I contact for more information?

1. For APFO sales and product information, contact USDA-FSA-APFO at 2222 W 2300 S, Salt Lake City UT, 84119-2020, call 801-844-2922, or visit www.apfo.usda.gov.
2. For further information on GIS, contact GIS Specialists at APFO: Louise Mathews, 801-844-2934; or Nathan Pugh, 801-844-2927

National Agriculture Imagery Program (NAIP)
INFORMATION SHEET
March 2010

What is the National Agriculture Imagery Program (NAIP)?

NAIP is a program to acquire peak growing season "leaf on" imagery, and deliver this imagery to USDA County Service Centers, in order to maintain the common land unit (CLU) boundaries and assist with farm programs.

The goal of NAIP is to collect 1 meter imagery for the entire conterminous United States. The imagery is acquired in natural color, with a "four band" product available through a contract "buy up". Image products are available in the year of acquisition.

While the focus of NAIP is on agricultural areas, cost share partnerships between federal agencies are leveraged to acquire full state coverage.

Who acquires the imagery?

Independent contractors acquire the NAIP imagery. There are currently 6 primary contractors flying imagery for the USDA Farm Service Agency (FSA).

Contractors are selected via "best value" criteria. Contract bids are evaluated on past performance, ability and capacity to perform the work, and cost. Secondary contracts between NAIP cost share partners and NAIP vendors are allowed, subject to FSA approval.

A downloadable PDF of the contract can be found on the APFO website (http://www.apfo.usda.gov), under the Contract Services subject, Business Opportunities topic.

How is the imagery acquired?

NAIP imagery is acquired from aircraft that have sensor systems meeting rigid calibration specifications. Digital sensors may use a continuous collection technology, or may use set "exposures," as in film based flying.

Aircraft…what about satellites?

Commercial satellite imagery may also be used in NAIP contracts. In 2004, the contract specified spatial resolution of 1 meter or less in all color bands. In 2005, the requirement was changed to allow PAN sharpening of color bands to reach a resolution of 1 meter ground sample distance (GSD). Although commercial satellite imagery can be used, it hasn't been to date.

What is the spectral resolution of the imagery?

The default is natural color, or RGB imagery. A "buy-up" option is "four band" imagery, with red, green, blue, and near infrared bands. Either natural color or color infrared imagery is displayed by changing the band assignments.

What spatial resolution is the imagery?

NAIP imagery has a 1 meter ground sample distance (GSD) with a horizontal accuracy; inspected locations match photo-identifiable ground control points with an accuracy of within 6 meters at a 95% confidence level <u>or</u> (in the earlier years of NAIP) match within 5 meters of reference ortho imagery.

In earlier years of the NAIP program, some states were flown at a 2 meter GSD for compliance purposes. , NAIP is now 1 meter GSD only.

What is reference ortho imagery?

The reference ortho imagery was the mosaicked digital ortho quarter quads (MDOQs), initially used to digitize FSA common land unit (CLU), or earlier years of NAIP.

In order to measure the accuracy of deliverable imagery, it must be compared to some type of control imagery/points. Until a pilot in 2006, the control imagery was the existing baseline imagery.

What is the absolute accuracy specification?

From 2006 – 2008, nine states were selected to meet absolute ground control specification: Utah in 2006, Arizona in 2007, and Indiana, Minnesota, New Hampshire, North Carolina, Texas, Vermont, and Virginia in 2008. Beginning in 2009, all states flown adhered to this specification.

The contract states that "95% of well-defined points tested shall fall within 6 meters of true ground". Ground control points used in production and/or inspection should ensure a more horizontally accurate product.

Is the imagery reviewed to make sure it is accurate?

APFO has stringent imagery compliance guidelines, and all deliverables are inspected to ensure accuracy and compliance with the contract. Because NAIP is an annual program with short flying seasons, some defects are accepted.

How long has NAIP been in existence?

NAIP pilot projects began 2001-2002. The program has continued and grown since. After an initial five year cycle and a transition year (2008), 2010 is the second year of the 3 year acquisition cycle.

The cycle schedule avoids flying states lying in areas where weather conditions make acquisition difficult within the same year.

Much of the funding for the program is provided by other federal, state, and regional governments. Partnering on an endeavor such as NAIP is important because it reduces duplication of effort and fiscal waste.

In what formats can I receive the imagery?

Imagery comes in two main formats:
1. Compressed County Mosaic (CCM)
    a. Mosaics are generated by compressing digital ortho quarter quads (DOQQs) into a single mosaic.
    b. Compression for 2005 – 2009 Natural Color NAIP was MrSID MG3 at a ratio of 15:1.
    c. Compression for 2004 NAIP and earlier was MrSID MG2 at a ratio of 50:1 or 20:1 for 1m or 2m resolution imagery respectively.
    d. In 2008, 4-band imagery was compressed with JPEG2000. JPEG2000 is no longer used due to lack of support.
    e. In 2010 compression will be 3 band MrSID MG3..
    f. Coverage of the CCM extends up to 1 mile beyond the county boundaries.
    g. The mosaic may cover all or portions of an individual final product.
2. Digital Ortho Quarter Quad (DOQQ).
    a. Each individual image tile (DOQQ) within the mosaic covers a 3.75 x 3.75 minute quarter quadrangle plus a 300 meter buffer on all four sides.
    b. The DOQQs are available in GeoTIFF format.
    c. In 2007: 4 band acquisition for AZ.
    d. In 2008: 4 band acquisition in CT, IN, KS, MA, RI, TX, VA, VT.
    e. In 2009: 4 band acquisition for CO, DE, GA, ID, MD, MT, ND, OR, SC, WA.

All individual DOQQs and the resulting mosaic are rectified to the specified UTM coordinate system.

How can I get NAIP imagery?

1. Compressed County Mosaics (CCMs) are available for delivery 30 days after imagery acquisition, through the USDA Geospatial Data Gateway (http://datagateway.nrcs.usda.gov). All available imagery for all years flown may be downloaded, whether 1 and 2 meter CCMs. Downloads are at no charge, but download times may be slow. It may be recommended to order the imagery on CD or DVD.
2. Full resolution quarter quads (DOQQs) are available, after being inspected and accepted , through APFO's Customer Service Section, on media only. Media options include hard copy, CD/DVD and portable hard disc drives (firewire and USB2).
3. Orders for CCMs and DOQQs on media can be placed at the Aerial Photography Field Office (APFO) in person, or at http://www.apfo.usda.gov/. Select *Find out more about the NAIP Imagery Program*, then *Ordering NAIP Imagery*.
4. NAIP DOQQs can be added into a GIS project for viewing only through APFO's ArcIMS or ArcGIS servers. For more information, visit the APFO website and follow the steps given in #3., above.

How much does it cost?

Costs vary greatly by product and volume. Contact the APFO Customer Service Section at apfo.sales@slc.usda.gov or at 801-844-2922 for detailed information.

Do I need special software to view the imagery?

1. CCMs from 2005 - 2010 NAIP require software that reads the MG3 or JPEG2000 format. Four band imagery will require software which can recognize all four bands. A list of free viewing software is available at http://www.apfo.usda.gov. Select *Get a viewer for my digital imagery*. This list is provided for convenience; USDA-FSA-APFO does not support or endorse these products or services.
2. Most image viewing software will open and view GeoTIFF files.

Who do I contact for more information?

1. For sales information, contact USDA-FSA-APFO at 2222 W 2300 S, Salt Lake City UT, 84119-2020, call 801-844-2922, or visit http://www.apfo.usda.gov.
2. For further information contact the NAIP Program Manager Kent Williams at 801-844-2908, or GIS Specialist Nathan Pugh at 801-844-2927.

Remote Sensing
INFORMATION SHEET
August 2009

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 term relates to APFO because the office has historically acquired aerial photography on film. At present, most aerial imagery acquisitions gave been through 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 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 larger than "red" waves of visible light. Colors are perceived when rays of a certain wave length are reflected or emitted from an object and detected by the human eye.
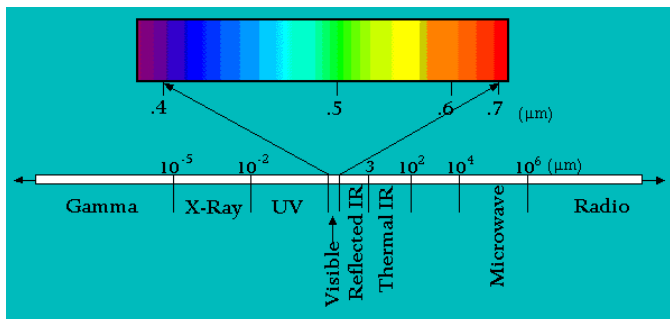
How is imagery from remote sensing devices represented in a digital format?

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 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 be a much larger file than a 30 meter image covering the same geographic area.

What is the spectral resolution of remotely sensed imagery?

Spectral resolution refers to the ability of a sensor to capture smaller wavelength intervals. 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 is a much larger file 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 a 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 resolution of easily obtainable imagery is much 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. Data from the different bands – alone and in combination – can be used to identify features more clearly.
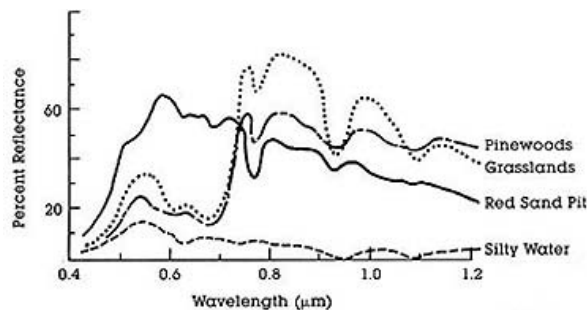
This diagram shows spectral reflectance curves for four different land covers. Multispectral imagery has a many applications, such as geology, geomorphology, hydrology, agriculture, forestry, and urban land use.

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.html

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 Brian Vanderbilt, 801-844-2930, or Louise Mathews, 801-844-2934.