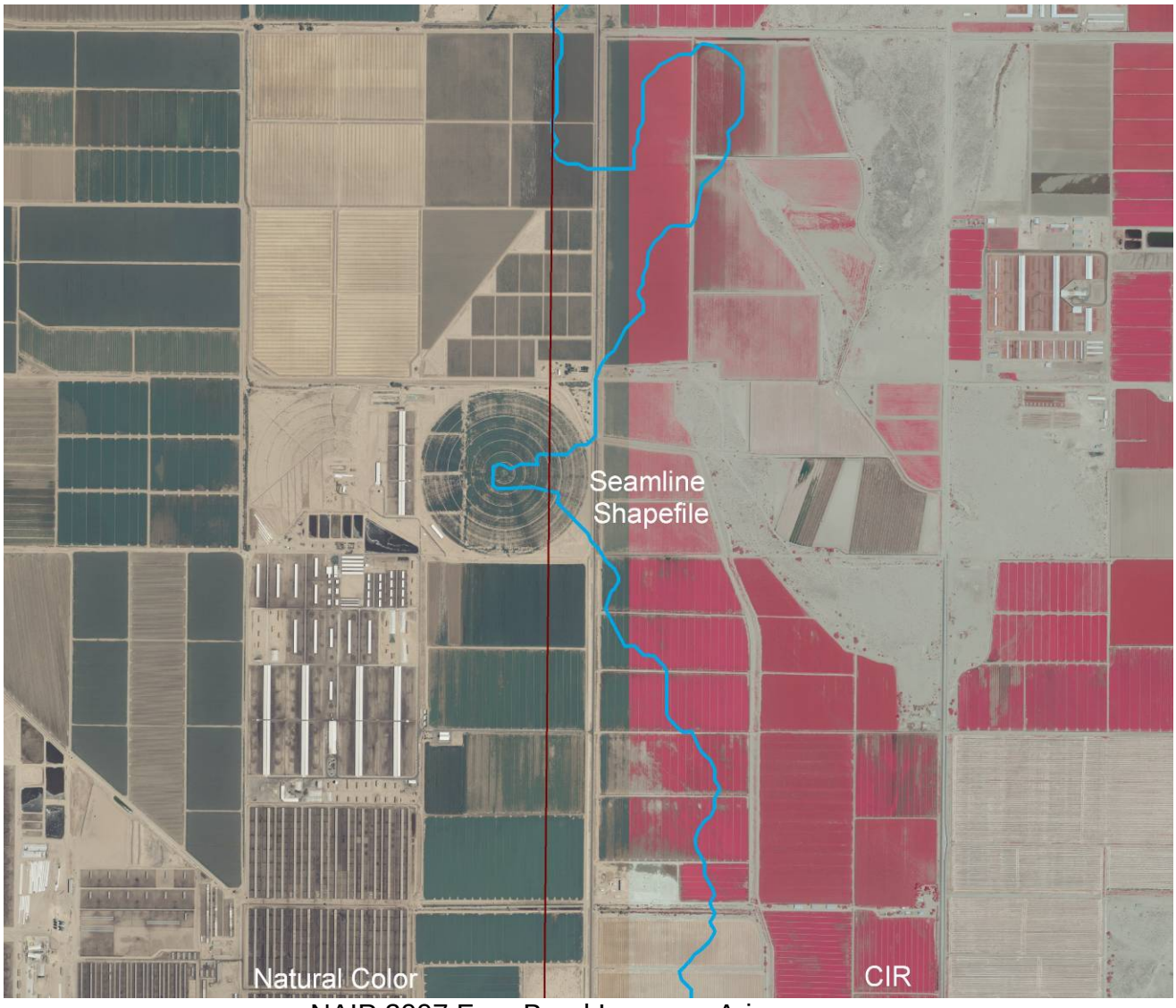
Geospatial Data and the APFO: Past, Present and Future

By Louise Mathews and Brian Vanderbilt



NAIP 2007 Four Band Imagery, Arizona

Prepared for the 2008 ESRI International Users' Conference

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Abstract

The primary role of United States Department of Agriculture (USDA), Farm Service Agency (FSA), Aerial Photography Field Office (APFO) is to acquire, manage, archive and distribute digital ortho imagery in support of farm programs administered by the USDA-FSA. APFO provides imagery stewardship services for USDA Service Center Agencies (SCA), cost share partners and the general public, including knowledge about data sources, archiving, distribution and support services.

APFO has played a vital role in the management of geospatial data, including imagery and agricultural boundary information, for many years prior to, and through the advent of geographic information systems (GIS) technology. This paper will cover the transition from the analog to digital geospatial world. It will address acquisition, management, inspection, archiving, and distribution of geospatial data for USDA-FSA agricultural purposes, from the standpoint of past, present, and future practices.

I. A History of Aerial Imagery for Farm Programs

The Aerial Photography Field Office in Salt Lake City has provided aerial imagery for use with USDA farm programs for over 70 years. In that time period, the office has changed from being primarily a photo lab to playing a vital role in the management of geospatial data, providing digital aerial imagery to the Farm Service Agency, other federal agencies, and the general public. The transition from an analog to digital world is now been in progress for over a decade. It is a good time to review the past, present, and future of geospatial data for USDA-FSA agricultural purposes.

Rationale for Using Aerial Photography

The U.S. Department of Agriculture was founded in 1862, under the Lincoln administration, as a non-cabinet level agency; in 1889 it became a cabinet level agency. The agency's need for aerial photography had its roots in the difficult years of the great Depression and Dust Bowl. The Agricultural Adjustment Act of 1933, part of the New Deal, sought to aid farmers by "establishing farm programs designed to balance production and stabilize farm produce prices." The programs of the Agricultural Adjustment Administration (AAA) focused on conservation and production controls, and it became imperative to accurately measure farm fields. Experiments with aerial photography were conducted in Oregon and Washington in 1934 and 1935. (Monmonier, 2002, quoting Tolley, 1937). The areas which were scheduled to be mapped in 1937 are shown in Figure 1.

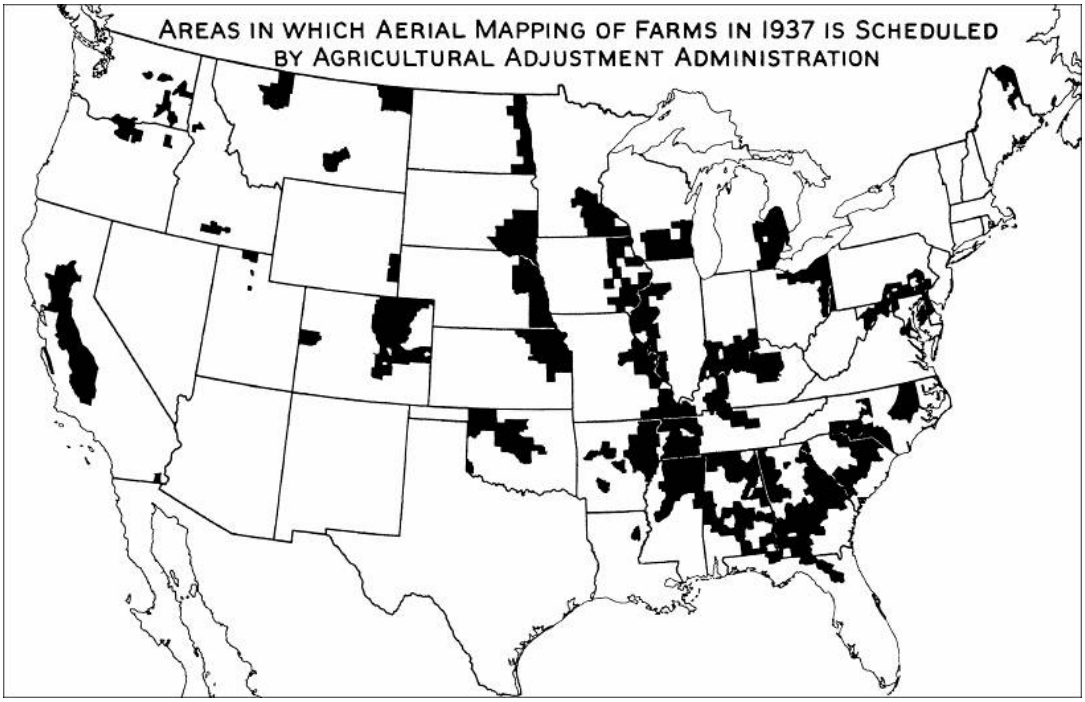

Figure 1: 1937 Mapping. Source: Harry Tubis (1937), photogrammetrist with the Tennessee Valley Authority, printed in Monmonier (2002).

One of the problems with aerial imagery which was not addressed initially was that of representing a three dimensional surface, particularly in rolling terrain, on a two dimensional photograph, especially if the airplane was not parallel to the ground when flying. The agency devised scale factors to use when calculating acreages from photography to account for these issues, but photogrammatists were critical about the lack of attention to tilt and topographic relief. In 1937, two photographic laboratories were established, in Washington D.C. and Salt Lake City, UT. The profession of photogrammetry sought to address the scale issue, and unemployed civil engineers were put to work. (Monmonier, 2002). Their efforts paved the way for the work done at APFO until the end of the 20th century.

A 1949 article reported that nearly all agricultural land in the nation had been flown before the beginning of World War II. (Monmonier, 2002, citing Moyer, 1949). A status map of land flown by 1949 is shown in Figure 2.

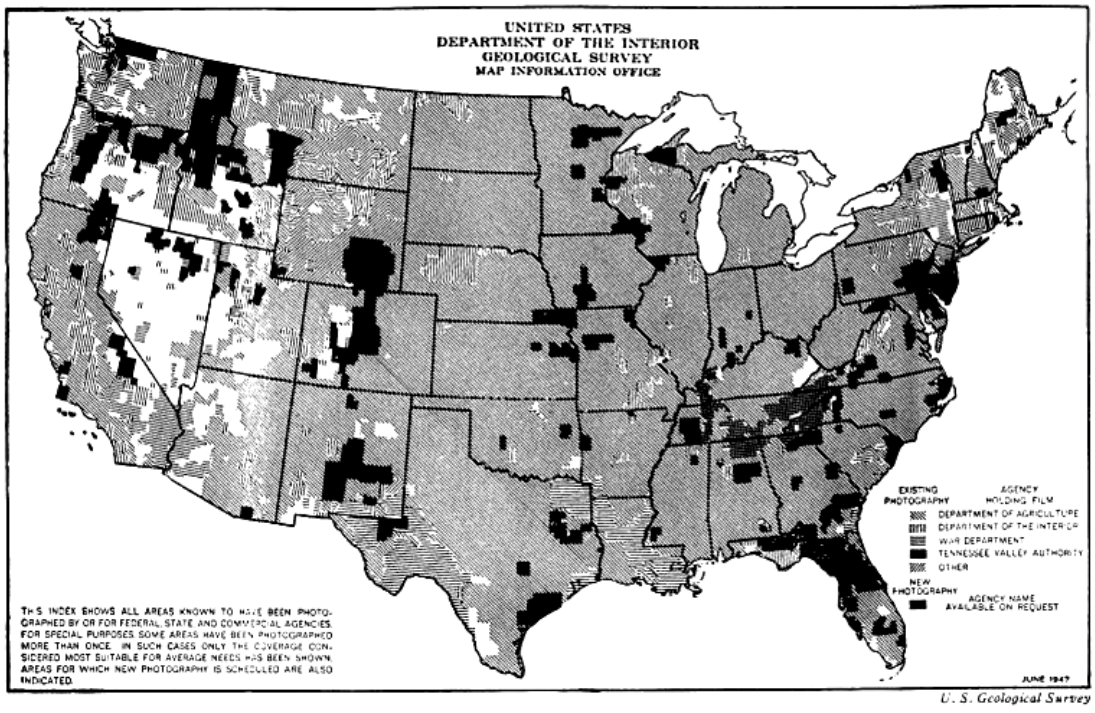

Figure 2. Status map of aerial photography in the United States, June 1947. U.S. Geological Survey map reproduced in Spurr (1948, p. 66).

Figure 2: Status Map of Aerial Photography, 1947. Printed in Monmonier (2002).

In 1962 the Washington D.C. photo lab was moved to Asheville, NC. The two labs used photogrammetric processes which had been developed in the 1930s, and 24” x 24” rectified enlargements were printed to compensate for the tip and tilt of the plane at the time of exposure. These were at a scale of 1:7920. Areas of greater topographic variation were “zoned;” two or more versions of the “ratioed prints” were made, to accommodate scale differences at different elevations.

Zoning was done in order to ensure that areas measured “would not differ by more than one percent from their true value” (Monmonier, 2002).

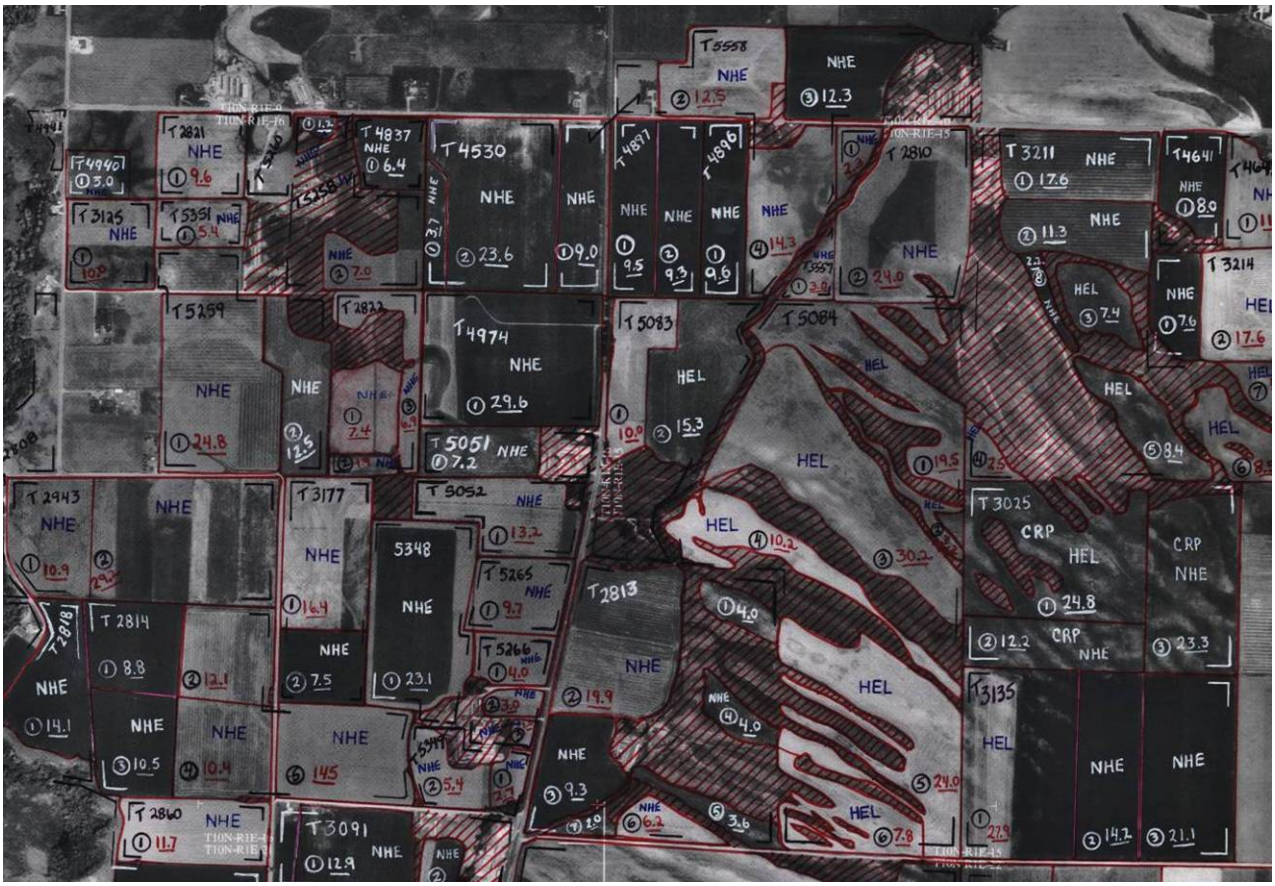

Figure 3: Part of a 24” x 24” Enlargement. Field boundaries and acreages are notated.

In the County Offices, tract and field boundaries were drawn directly onto the enlargements, and notations were made. These edits were the basis of the later Common Land Unit shapefiles. Measurements were made from the enlargements using planimeters (Figure 4). Experiments in the 1930s judged measurements from aerial photography to be more efficient than ground surveying (Monmonier, 2002). This method of operating was used in the county offices until they began the transition to GIS in the late 1990s.

Figure 4: Measuring Acreages with a Planimeter.

Mark Monmonier (2002) wrote that the use of aerial photography by the AAA "had substantial and lasting effects on agriculture and mapping: …cost-effective compliance monitoring, experienced photogrammatrists for the war effort, and imagery support for soils mapping and regional planning." The photos helped with the 1945 Census of Agriculture, and aided in communication between farmers and local conservation agents. He felt that "…the AAA may have pioneered the concept of public participation GIS."

Post-War Farm Programs

The agency running the farm programs has had several different names over its history. During World War II, the War Food Administration was organized to meet the country's needs at that time. A1953 reorganization led to the Commodity Stabilization Service, and in 1961 it became the Agricultural Stabilization and Conservation Service (ASCS). This was the agency's name when much of the APFO film library was acquired. (Source: *http://www.fsa.usda.gov/FSA/*).

The agency ran two photo labs; the Eastern lab in Asheville, North Carolina, processed photography for states east of the Mississippi, while states west of the Mississippi were processed by the Western lab in Salt Lake City. Both labs processed high altitude aerial photography, and in 1975, the two labs were consolidated. The facility in Asheville was closed, and the office in Salt Lake City became known as the Aerial Photography Field Office (McGirt, 2008).

Figure 5: Employees of the Eastern Photography Lab in Asheville, North Carolina; before the consolidation with the Salt Lake City lab. Photo courtesy of John McGirt.

The county offices used the 24” x 24” enlargements to record field boundaries and information, but they needed a method for crop compliance checks. In the late 1970s, the county offices began using 35mm cameras every summer to fly their agricultural areas. The compliance imagery was delivered in slide format, and was projected onto the 24” x 24” enlargements. The 35mm slides allowed county personnel to check the crops in the field against the boundaries on the enlargements and the records for each farm. This method was used until the GIS program and NAIP were initiated. It is estimated that there are over a billion slides in existence, and they could potentially be scanned and georeferenced or ortho-rectified as a source of historical imagery. They are occasionally being used for different types of research, such as a 2001 NRCS project to evaluate hydrology. In that instance, 20 years of old compliance slides were used.

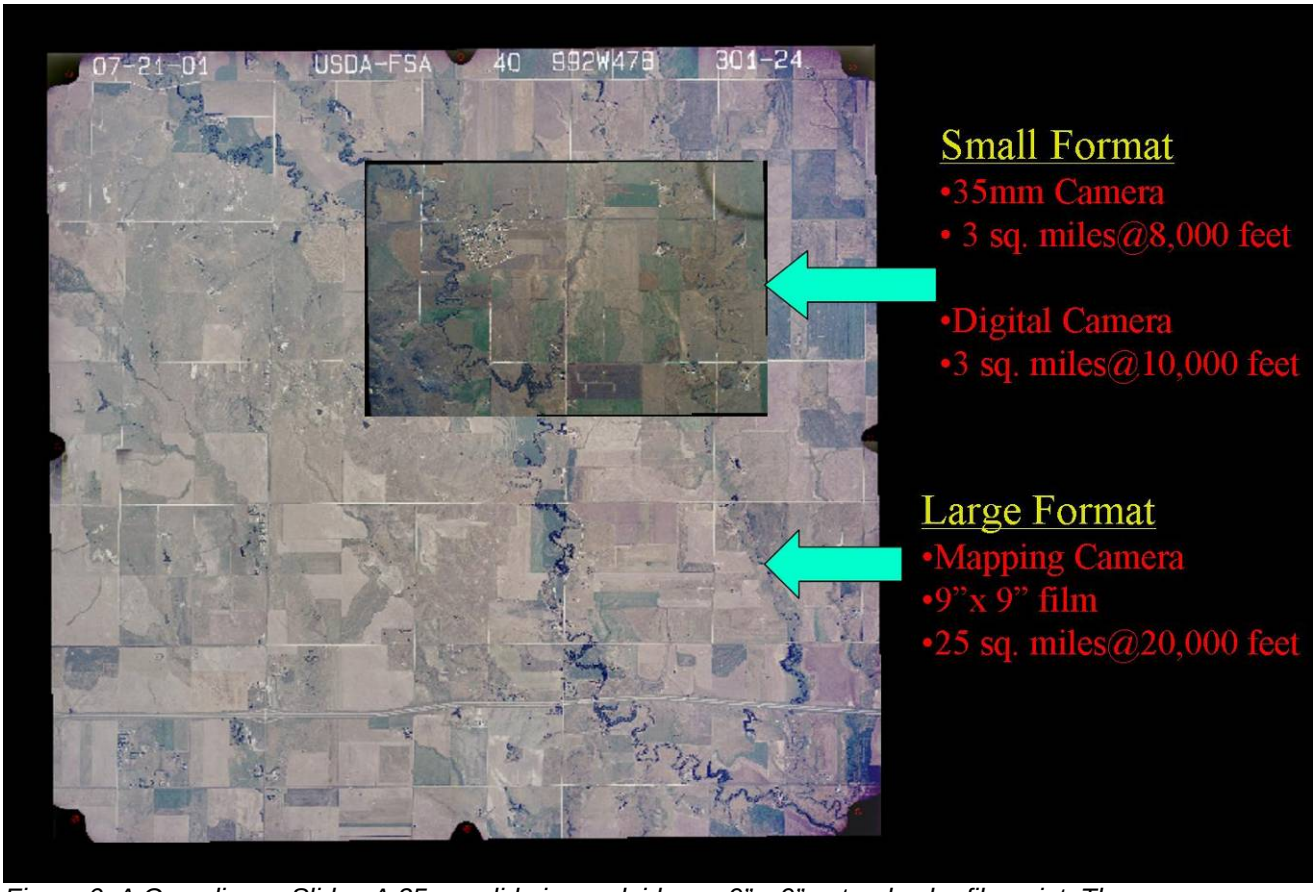

Figure 6: A Compliance Slide. A 35mm slide is overlaid on a 9" x 9" natural color film print. These slides were flown locally every summer for program compliance checks.

As the years passed, more and more rolls of photography were archived at APFO. From 1955 – 1980, over 23,000 rolls of film were flown for ASCS (now FSA) at a nominal scale of 1:20,000. Over 19,000 rolls of film were flown for the Forest Service, and over 2,000 rolls were flown for the Soil Conservation Service (now the Natural Resources Conservation Service, or NRCS).

Cooperative Aerial Photography Programs

The National High Altitude Program began in 1980, and ran until 1989. Federal agencies faced continual pressure to avoid redundancy in governmental programs; as a result, a consortium was formed for the purpose of acquiring aerial photography. The program, coordinated by the U.S. Geological Survey, flew the 48 contiguous states on a five year cycle, with the coverage varying according to budgets. CIR imagery was delivered at a 1:58,000 scale, and black and white was delivered at a 1:80,000 scale. APFO archived 1500 rolls of film from this program.

The National Aerial Photography Program, which replaced NHAP, was in existence from 1987 – 2003. It was also coordinated by USGS; Hawaii was

added to the program, which ran on a 5 -7 year cycle. 5,000 rolls of film were added to the APFO film library during the NAPP years.

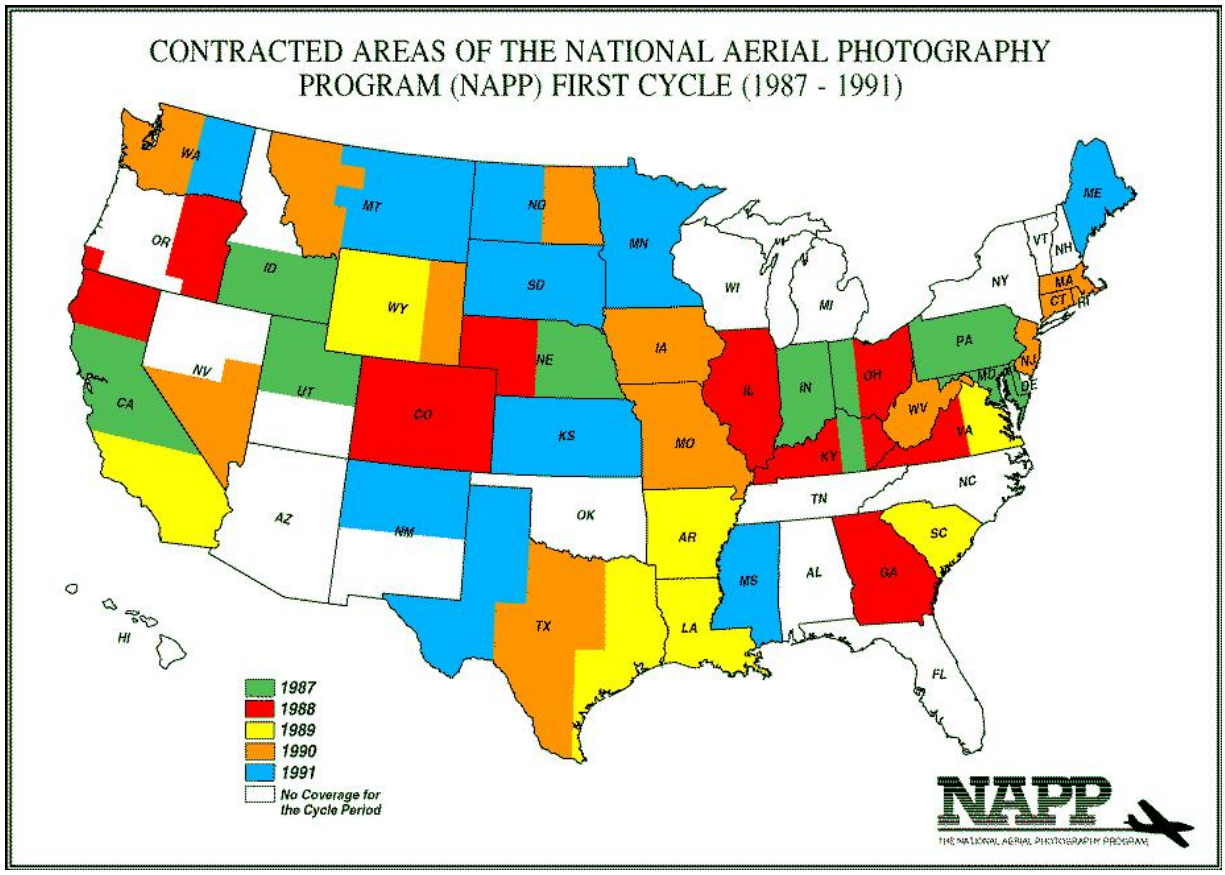

Figure 7: NAPP First Cycle. States flown during the first cycle of the National Aerial Photography Program (NAPP), from 1987 through 1991.

In 1994, the agency was reorganized again, and ASCS, along with the Federal Crop Insurance Corporation (FCIC) and the farm credit portion of the Farmers Home Administration, became the Consolidated Farm Service Agency (CFSA). In 1995, the name was changed to simply Farm Service Agency (FSA) and in 1996 FCIC became the Risk Management Agency.

II. The Move to GIS

In the 1990s, the agency began to consider the use of Geographic Information Systems software and digital aerial imagery to replace the paper enlargements and manual record keeping. Computers were used in the County Service Centers for tabular records, but GIS offered more efficient and accurate spatial analysis in working with farm issues.

Mosaicked Digital Ortho Quads

APFO began work in 1997 to create seamless mosaics from USGS Digital Ortho Quarter Quads. The product was called Mosaicked Digital Ortho Quad (MDOQ). These mosaics, made with SocetSet®, were tonally balanced, and seamlines were placed manually to minimize offset between images. The MDOQs were compressed with LizardTech's MrSID© compression software into Compressed County Mosaics (CCMs). The period of creating MDOQs and installing computers with GIS software in the county Service Centers lasted from 1997 to 2004.

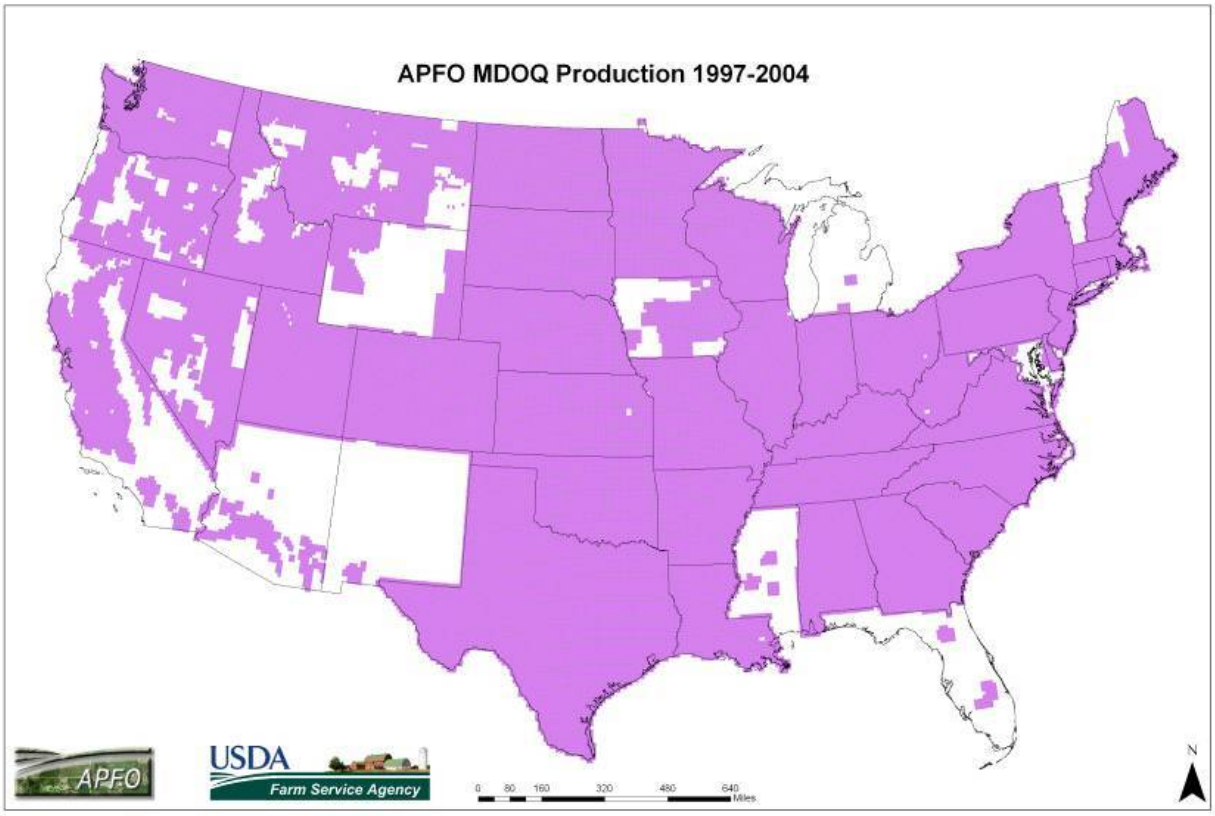

Figure 8: MDOQ production at APFO.

The 24" x 24" enlargements, which had been in continual use in the county offices, provided the locations of the field and tract boundaries, which were digitized on top of the new CCMs. The old photomaps were scanned, and used as a reference, in digital or paper format, for heads-up digitizing with the digital imagery as a base. Digitizing centers around the country worked with the photos, or scans of the photos, to create Common Land Unit (CLU) shapefiles for each county. Standards were established on a national level for file naming conventions and data directory structures. The attribute tables needed to be populated; a CLU Maintenance Tool was developed in the national office, and state GIS specialists trained County Executive Directors and Program Technicians in the often overwhelming task of migrating from an analog to digital

way of doing business. Personnel were trained initially on ArcView 3.x, and later converted to ArcGIS 9.x (Johnson, 2008).

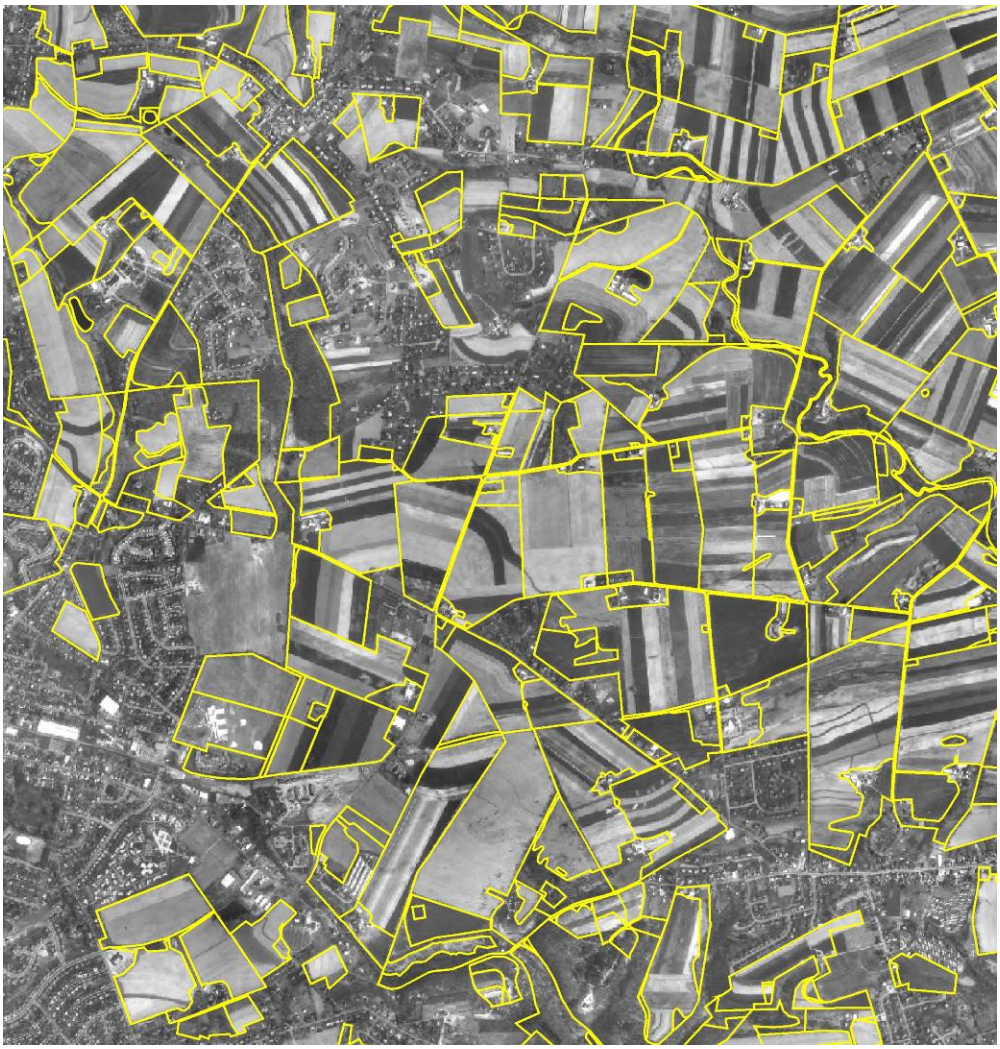

Figure 9: CLUs digitized on an MDOQ..

The National Agriculture Imagery Program

After GIS was implemented in the Service Centers, several questions remained about the methods for moving forward into the digital world. One question was the need to continually update the imagery, as had been done with the film-based photo programs. Another question related to the compliance program; something needed to be done to replace the 35mm slides which had been flown locally every summer. The answer to these, and other, questions was the National Agriculture Imagery Program (NAIP). The plan for this program was to fly selected states for replacement imagery at a 1 meter pixel resolution, and to fly agricultural areas in the remaining states at a 2 meter resolution, for use with compliance. The new imagery would be flown in Natural Color, with leaf on, unless CIR was requested.

The first pilots for NAIP were flown in 2002, acquiring small areas in a few Midwestern states. The program began in earnest in 2003 with eight states flown. By the end of the 2007 flying season, 46 states had received 1 meter NAIP as base replacement imagery, and the first 5 year cycle of NAIP was complete.

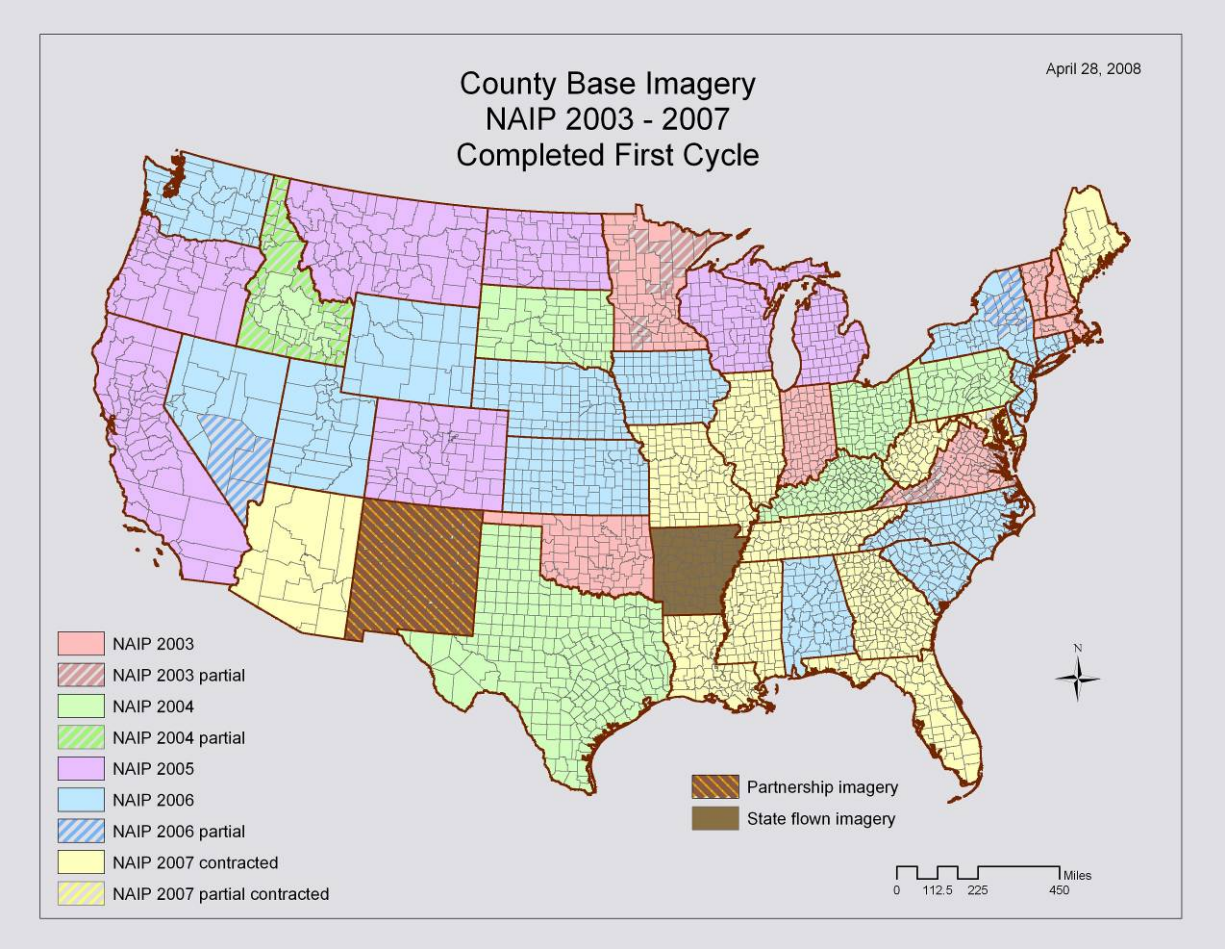

Figure 10: Imagery acquisitions from the first cycle of NAIP.

III. NAIP Innovations Implemented in 2008

Transition from Film to Digital Imagery

As the NAIP program continued and gained strength, changes were made to the products being contracted. The most obvious change resulted from industry transitions - a move from film to digital image acquisition. In 2003, one state was flown with digital imagery; for 2008, 16 states are planned with digital acquisition.

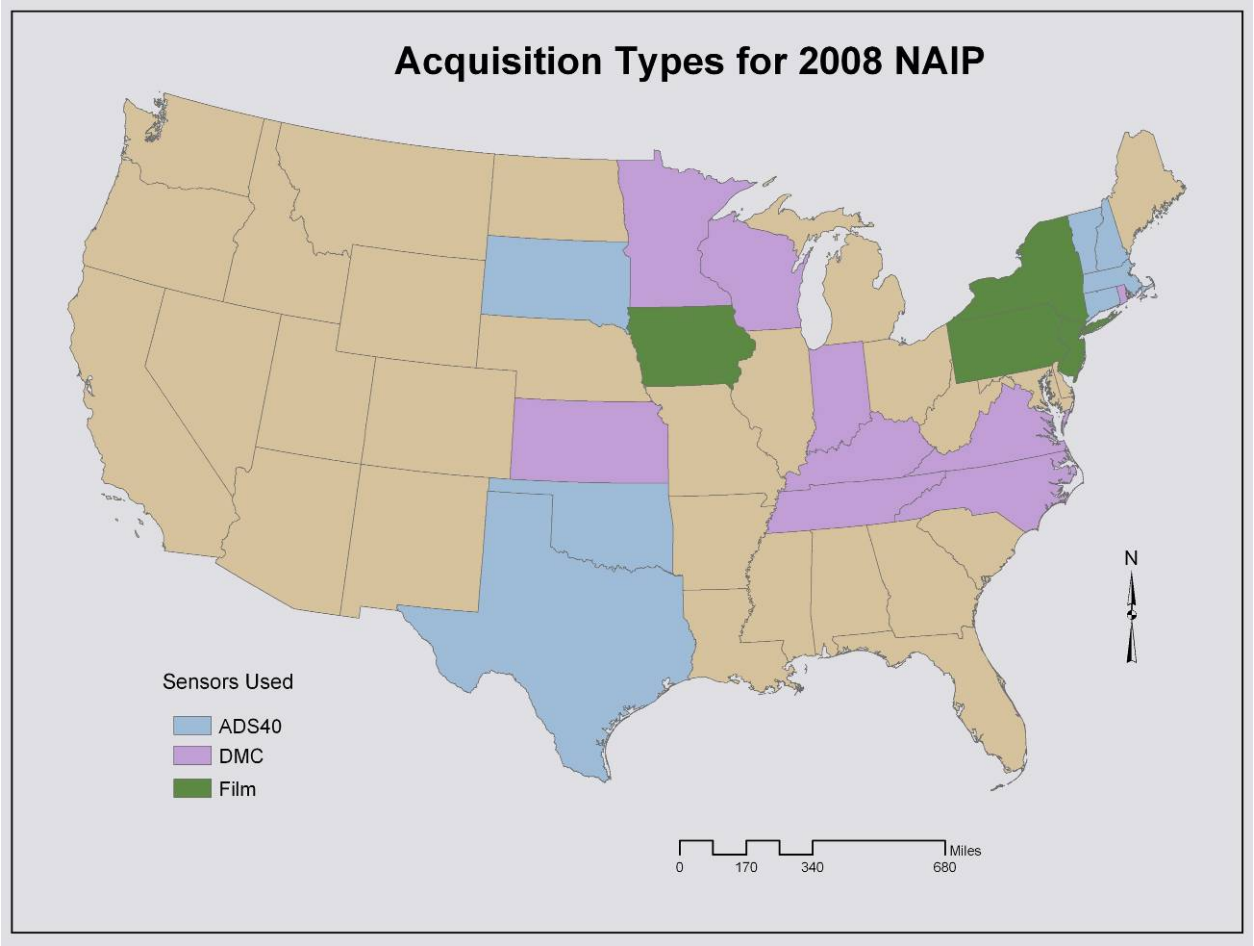

Figure 11: Film and Digital Acquisitions for 2008. Imagery contracted for 2008 shows the diminishing use of film.

Transition from Relative to Absolute Control

In 2006, Utah was selected for a pilot in which the imagery was rectified to true ground control points, rather than to existing imagery. The change was made because it was felt that imagery should be as accurate as possible, and that any errors in the originals would be passed on to the updates – or even increased. In addition, this method of terrain correction had been requested by partners. Since the MDOQs had an accuracy specification of ± 5 meters to true ground, and 1 meter NAIP had a requirement of ± 5 meters to the MDOQs, a position could potentially combine the two tolerances and be ± 10 meters from the true ground position. Also, vector layers created from other sources might not match the imagery.

In 2006, Utah imagery was terrain corrected with photo identifiable ground control points from several different sources. APFO obtained pre-existing control, and a partnership with Utah state government assisted in obtaining other survey grade points. For 2007, the same process was used for Arizona NAIP. Some of

these points were provided to the vendors, but most were used for accuracy assessments by the APFO Quality Assurance section.

In the 2008 contract, seven states will receive imagery which has been terrain corrected with “absolute” control. These are: Indiana, Minnesota, New Hampshire, North Carolina, Texas, Virginia, and Vermont. Members of APFO’s Service Center Support Section have been working closely with state personnel to acquire ground control points to be used for Quality Assurance assessments

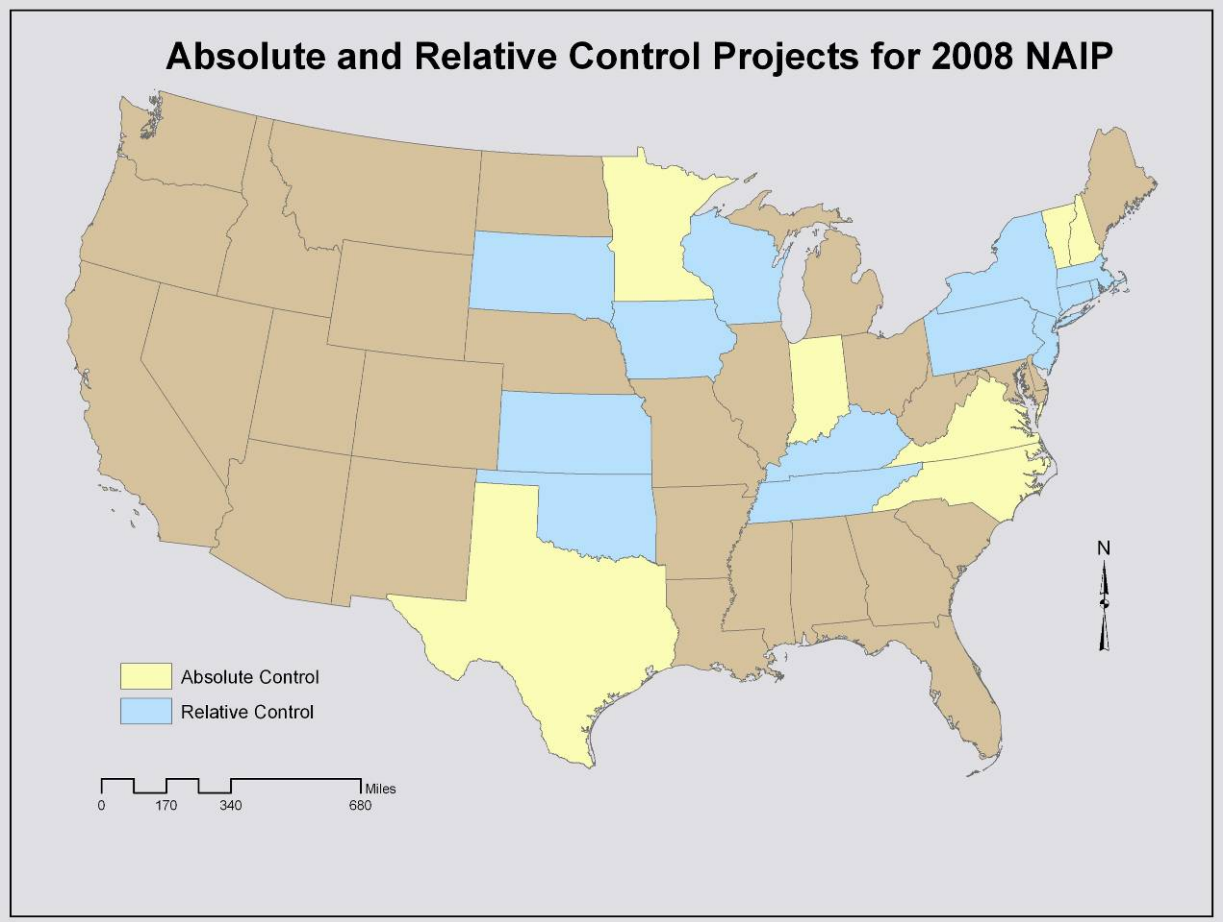

Figure 12: Absolute and Relative Control Projects for 2008. After two pilot years, terrain correction to true ground positions is being expanded to seven states.

In future years, other states will be phased into the program of terrain correction to true ground position. Once a state has received imagery corrected with this method, it will not revert to “relative” control.

Transition from Three Band to Four Band Acquisition

Another pilot study in 2007 was the acquisition of four band imagery, also in Arizona. Four band imagery is acquired in red, green, blue and near infrared frequencies. The user can select either Natural Color or Color Infrared in the application by changing the band assignments. The decision to acquire four

bands was made because this product would allow more options for FSA users. It also would be more attractive to potential partners, allowing more viewing options. The cost of adding the fourth band to the deliverable product is not significantly more, since most digital cameras will acquire the infrared band at the same time as the customary three bands for Natural Color. The DOQQs from this project were delivered as 4 band Geotiffs, and the CCMs were 3 band Natural Color.

The 2008 contract will also expand to nine the number of states to be delivered in a four band format. The states receiving this format will be: Connecticut, Indiana, Kansas, Minnesota, Rhode Island, Tennessee, Texas, Virginia, and Vermont.

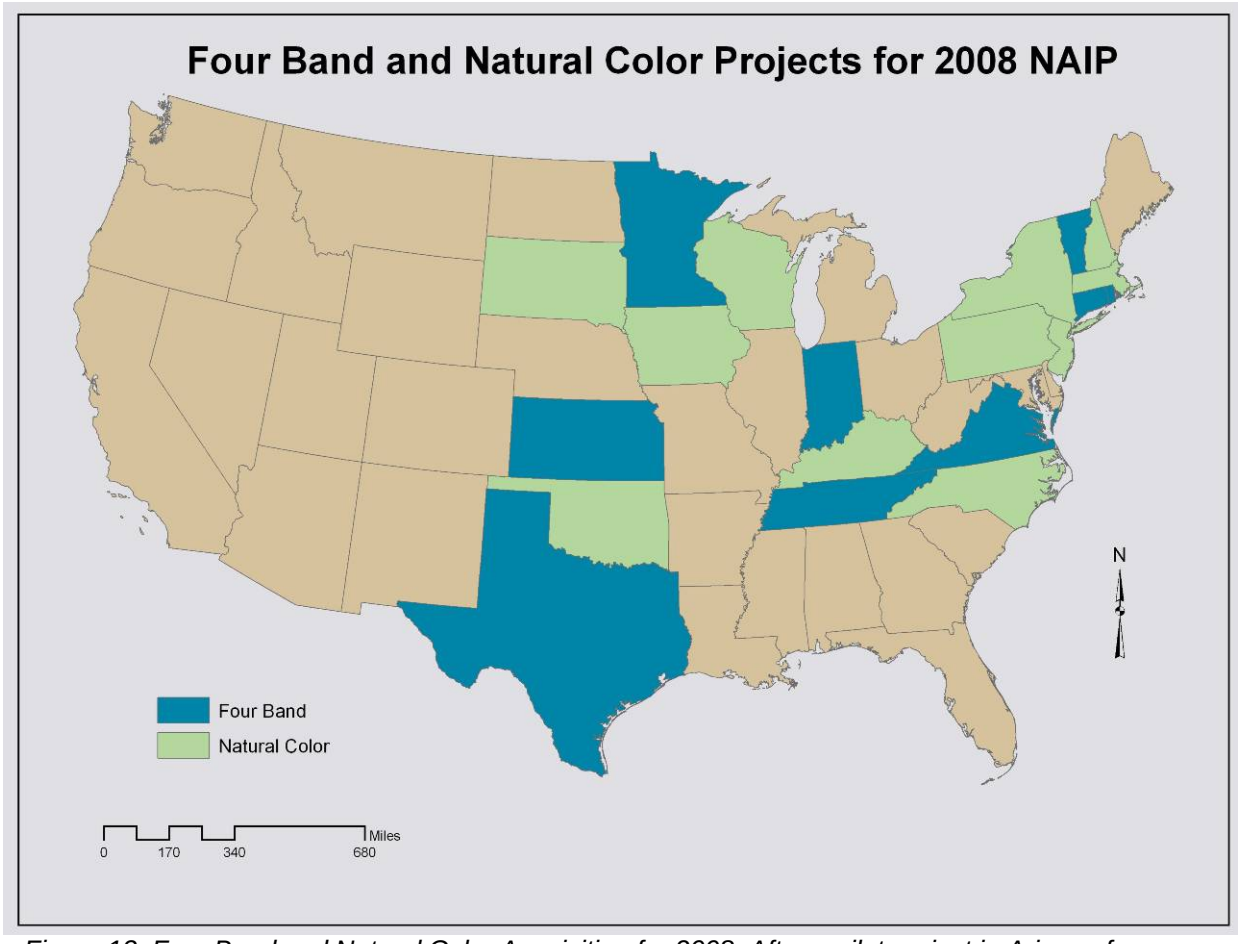

Figure 13: Four Band and Natural Color Acquisition for 2008. After a pilot project in Arizona for 2007, eight states have been selected to receive four band imagery in 2008

Figure 14: Natural color (left) and color infrared versions of the same area; from the Arizona 2007 four band project.

Figure 15: Natural color (left) and color infrared versions of the same area; from the Arizona 2007 four band project

Transition to JPEG2000 Compression Format

The compression format used for the NAIP program has been a topic of consideration for several years. In 2008, all of the states receiving four band imagery will receive CCMs compressed in the JPEG2000 format. This will be done because MrSID©, which has been used until now, currently does not allow more than three bands. The new format will allow four band CCMs as well as DOQQ geotiffs.

Transition from Rectangular Shapefiles to Seamline Shapefiles

Arizona was also the site of a pilot study in seamline shapefiles, created from the track of an ADS40 sensor. The state received a seamline shapefile detailing the flying date, with start and end times, for each portion of the compressed county mosaic. This was in place of the standard DOQQ shapefile, which had outlined the borders of the DOQQs, even though parts of the DOQQ may have come from a different film exposure or flight line.

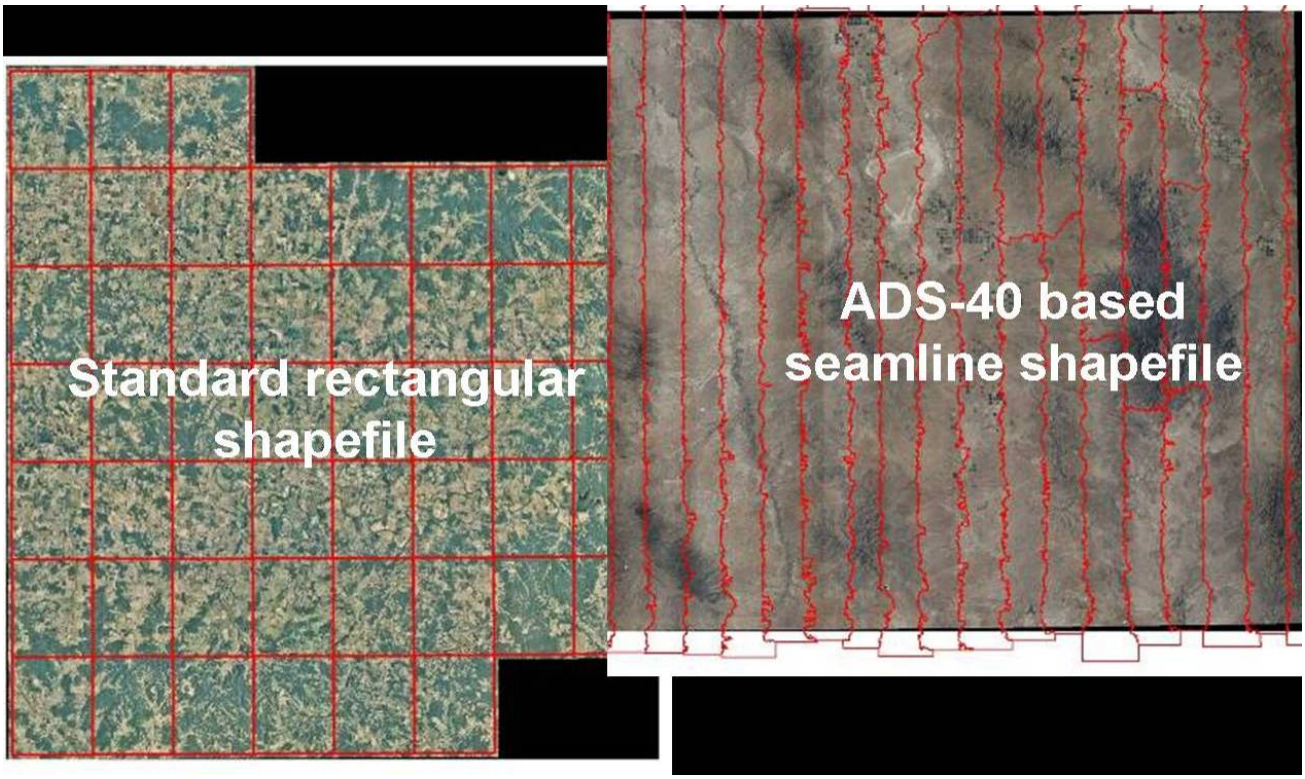

Figure 16: Rectangular and Seamline Shapefile Footprints. Rectangular and seamline shapefiles will have different footprints

IDAT	SDATE	EDATE	CAM_TYPE	CAM_MAN	CAM_MOD	SENSNUM	SHAPE_AREA
6/9/2007	06/09/2007 15:37	06/09/2007 16:10	Digital	Leica Geosystems	ADS52	30022	1373900000.0000000000
6/9/2007	06/09/2007 16:14	06/09/2007 16:38	Digital	Leica Geosystems	ADS52	30022	1132200000.0000000000
6/9/2007	06/09/2007 16:43	06/09/2007 17:15	Digital	Leica Geosystems	ADS52	30022	1136900000.0000000000
6/9/2007	06/09/2007 17:19	06/09/2007 17:43	Digital	Leica Geosystems	ADS52	30022	766640000.0000000000
6/9/2007	06/09/2007 17:47	06/09/2007 18:19	Digital	Leica Geosystems	ADS52	30022	521530000.0000000000
6/9/2007	06/09/2007 18:22	06/09/2007 18:46	Digital	Leica Geosystems	ADS52	30022	569680000.0000000000
6/10/2007	06/10/2007 15:13	06/10/2007 15:46	Digital	Leica Geosystems	ADS52	30022	420920000.0000000000
6/10/2007	06/10/2007 15:50	06/10/2007 16:13	Digital	Leica Geosystems	ADS52	30022	416480000.0000000000
6/10/2007	06/10/2007 16:18	06/10/2007 16:37	Digital	Leica Geosystems	ADS52	30022	50555000.0000000000
6/10/2007	06/10/2007 16:41	06/10/2007 16:58	Digital	Leica Geosystems	ADS52	30022	27035000.0000000000
6/25/2007	06/25/2007 16:18	06/25/2007 16:46	Digital	Leica Geosystems	ADS52	30022	860710000.0000000000
6/25/2007	06/25/2007 16:50	06/25/2007 17:19	Digital	Leica Geosystems	ADS52	30022	1241700000.0000000000
6/25/2007	06/25/2007 17:16	06/25/2007 17:45	Digital	Leica Geosystems	ADS52	30102	719610000.0000000000
6/25/2007	06/25/2007 17:22	06/25/2007 17:50	Digital	Leica Geosystems	ADS52	30022	1071600000.0000000000
6/25/2007	06/25/2007 17:54	06/25/2007 18:22	Digital	Leica Geosystems	ADS52	30022	1102900000.0000000000
6/25/2007	06/25/2007 18:26	06/25/2007 18:54	Digital	Leica Geosystems	ADS52	30022	1069300000.0000000000
6/25/2007	06/25/2007 18:57	06/25/2007 19:24	Digital	Leica Geosystems	ADS52	30022	1082600000.0000000000
6/25/2007	06/25/2007 19:28	06/25/2007 19:56	Digital	Leica Geosystems	ADS52	30022	986610000.0000000000
6/30/2007	06/30/2007 15:14	06/30/2007 15:33	Digital	Leica Geosystems	ADS52	30022	333340000.0000000000
6/30/2007	06/30/2007 15:37	06/30/2007 15:46	Digital	Leica Geosystems	ADS52	30022	544800000.0000000000
6/30/2007	06/30/2007 16:04	06/30/2007 16:23	Digital	Leica Geosystems	ADS52	30022	592820000.0000000000
6/30/2007	06/30/2007 16:34	06/30/2007 16:43	Digital	Leica Geosystems	ADS52	30022	684610000.0000000000
6/30/2007	06/30/2007 16:47	06/30/2007 17:00	Digital	Leica Geosystems	ADS52	30022	699940000.0000000000
6/30/2007	06/30/2007 17:09	06/30/2007 17:24	Digital	Leica Geosystems	ADS52	30022	1100700000.0000000000

Figure 17: Seamline Shapefile Attribute Table. The attribute table for a seamline shapefile shows start and end dates and times.

The shapes of the polygons in the shapefiles will vary according to the sensor type. A pushbroom type scanner, such as an ADS40 (shown in Figure 18) would create polygons which are elongated along the flight line. A shutter type sensor, as shown below, would deliver polygons which are more "boxy."

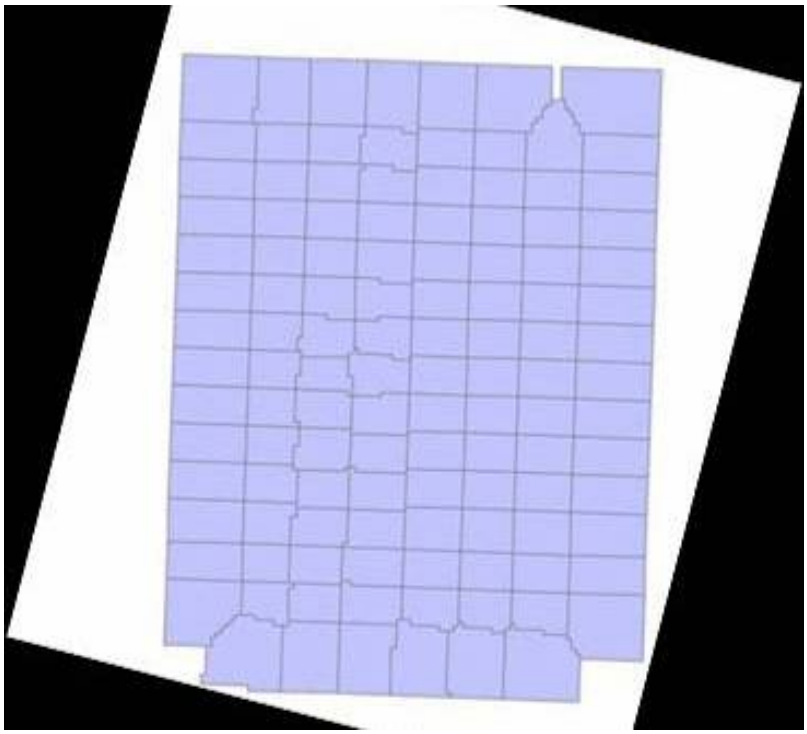

Figure 18: The Seamline Shapefile from a Shutter Type Sensor. This will have will have a more "boxy" pattern

In 2008, the seamline shapefile requirement will be expanded, and seamline shapefiles will be created for six states. These are: Indiana, Iowa, Kansas, Oklahoma, Texas, and Virginia. Iowa will be flown with film, while the other five states will be acquired with either an ADS40 or DMC sensor. The remaining states being contracted will receive the standard rectangular shapefiles. The 2008 contract will ask for seamline shapefiles from different types of cameras, in order to test various possibilities before making this a requirement for all states. Three states will receive a shapefile derived from a DMC, two from an ADS40, and one from film.

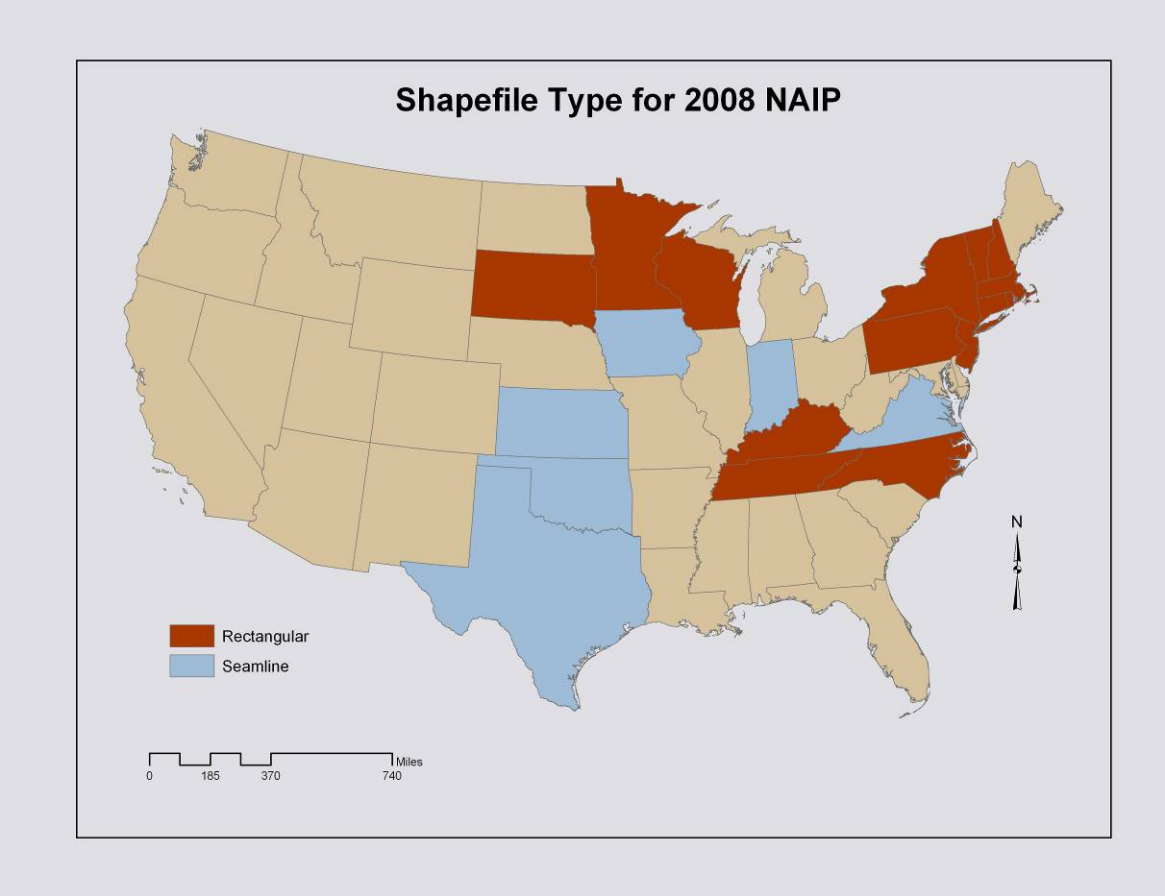

Figure 19: Rectangular and Seamline Shapefiles for 2008. After a pilot project in Arizona, six states will receive seamline shapefiles. They will come from different types of sensors.

Transition to Tighter Specifications for Radiometric Quality

In the fall of 2006, FSA worked through ITT Space Systems of Rochester NY, on a study to determine parameters for image quality. In early February 2007, they delivered an assessment of Best Practices to be used in image creation. 2007 imagery was required to meet metric standards for four parameters: histogram peak, contrast, overall clipping, and color balance. The company provided APFO with detailed reports and image samples. Recommendations were also made for color saturation, sharpness, and noise, but these were not specified in the 2007

contract. In addition, ITT provided guidelines for monitor calibration, an important element when working with digital imagery.

ITT provided APFO with image samples to demonstrate ideal metrics, which were then provided to the vendors. Their initial recommendations for contrast, color balance, clipping, and histogram peak are shown in Figure 23. (ITT, 2007)

In 2008, APFO's Quality Assurance section reviewed the metrics for projects flown in 2007, comparing the results to the specifications set in the contract. Two of the parameters are being changed for the 2008 contract. One change in specification is for contrast. The contrast value describes the range of tonal values in an image, with a possible 256 values, and describes the width of an image's histogram. The requirement had been that contrast must be at least 120, with 150 being the ideal. This parameter was found to be inadequate for producing good quality imagery. The new specification will be that the Contrast value must fall between 140 –160, with 150 as the optimal value. The other change was in the specification for Color Balance. The 2007 contract stated that the differences between the values in the triplet (for Red, Green, and Blue bands) should be no greater than ± 10. For 2008, that requirement was tightened to state that the difference between any two values in the triplet should be no greater than ± 5.

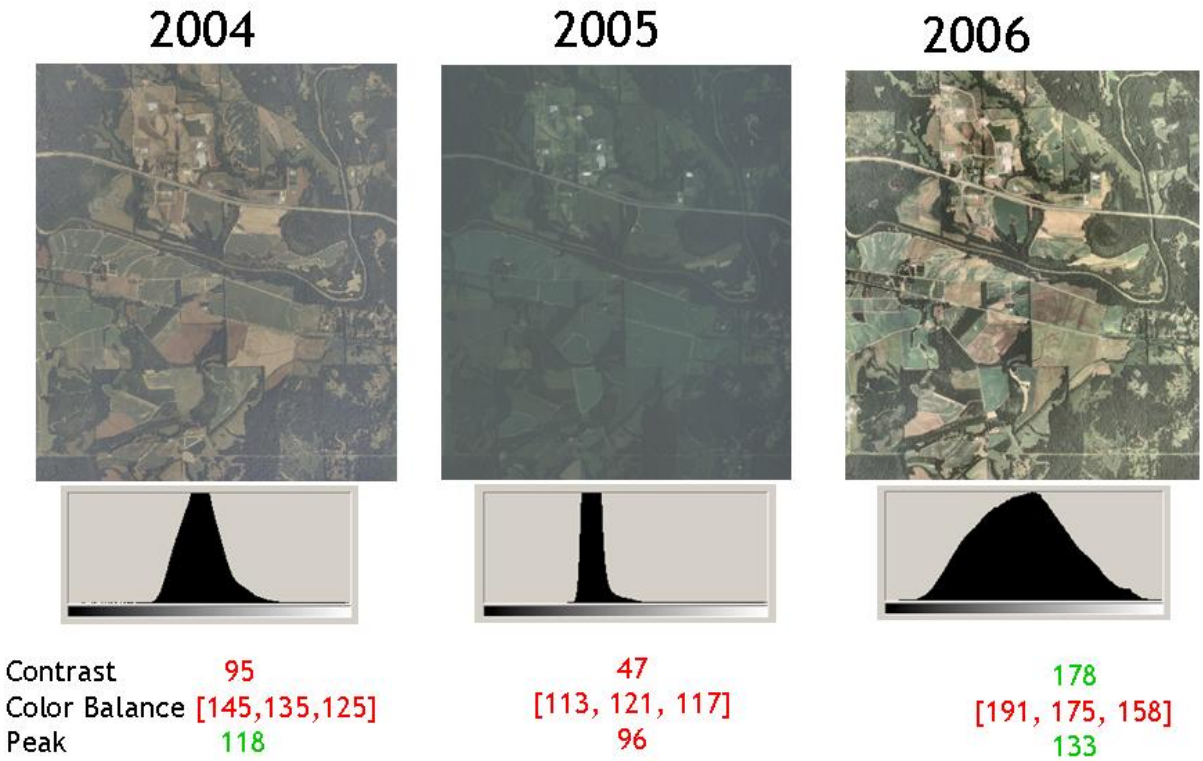

Figure 20: Different Tonal Quality in Mississippi. Metrics for imagery from different NAIP years, for the same area in Mississippi, displayed variations in tonal quality
Graphics by ITT, 2007.

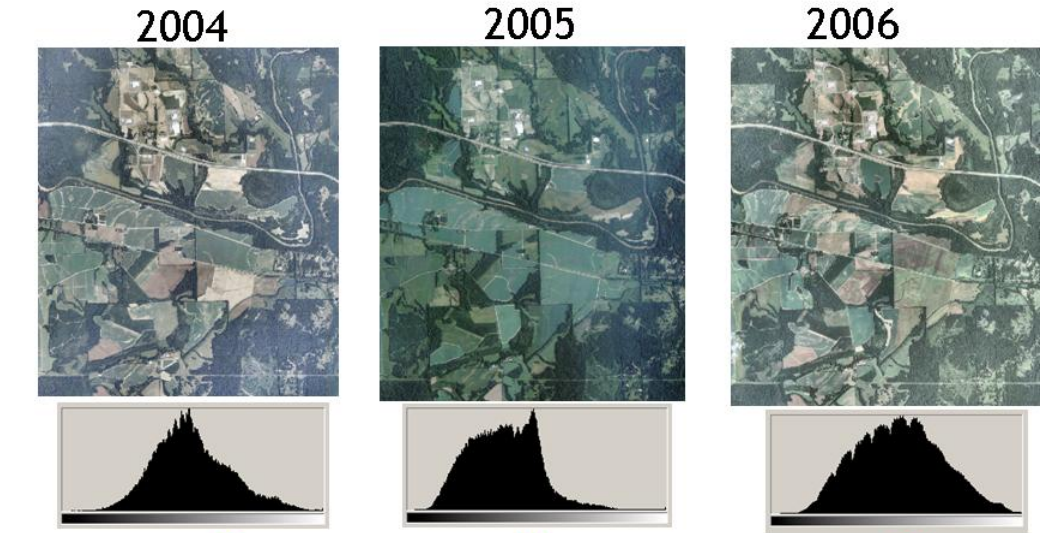

Figure 21: Metrics for Adjusted Mississippi Imagery. Metrics for the same imagery after it was adjusted to meet 2007 contract specifications.
Graphics by ITT, 2007.

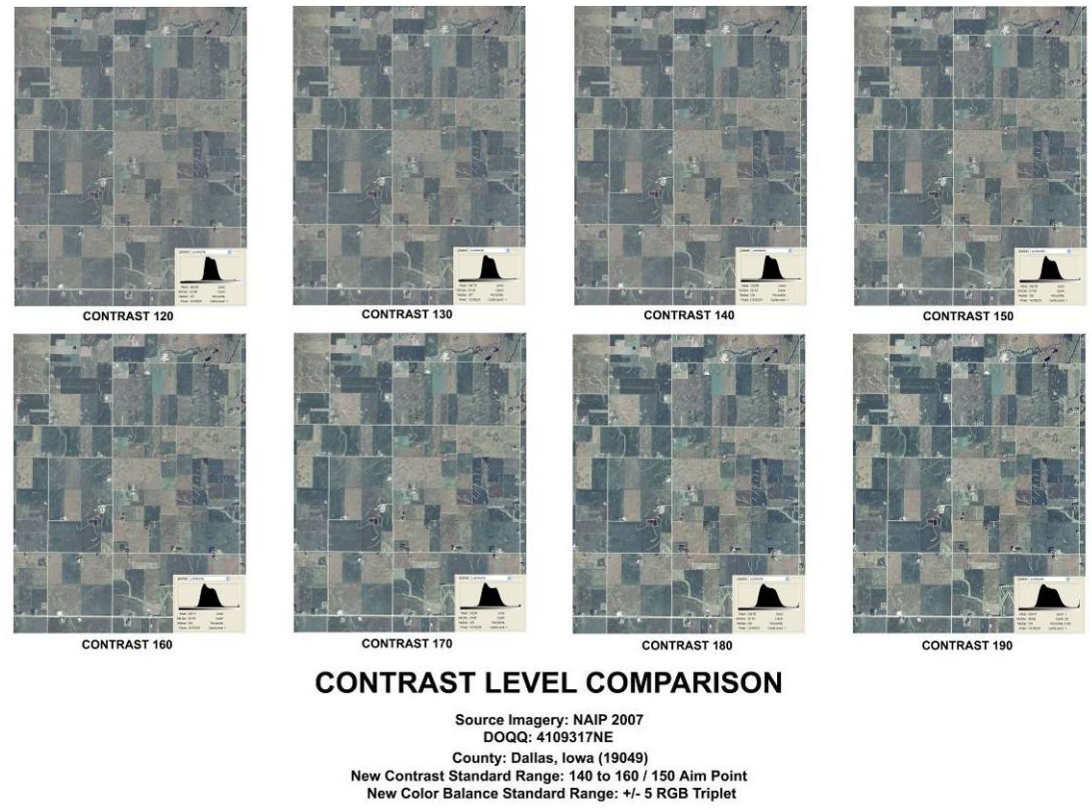

Figure 22: Imagery Contrast Levels Comparison. Samples of an imagery with differing contrast levels applied. Graphics by Scott Kelly.

In the graphic above, the imagery samples change gradually as the contrast is adjusted in increments of 10, using Photoshop 7.0.1. The imagery with a lower contrast value would appear "washed out,'" as there would be little difference between high and low reflectance. An image with a higher contrast might appear to be too "blown out," with white areas such as buildings and roads appearing too bright. (Kelly, 2008)

The Quality Assurance section is testing methods for improving the standards for image tonal quality. The contrast metric is related to the luminosity histogram (shown on top of the images in the graphic above) and this is an area of current research. In future years, more requirements for tonal quality will be included in the contract.

NAIP Contracts for 2008: Building on Earlier Pilots

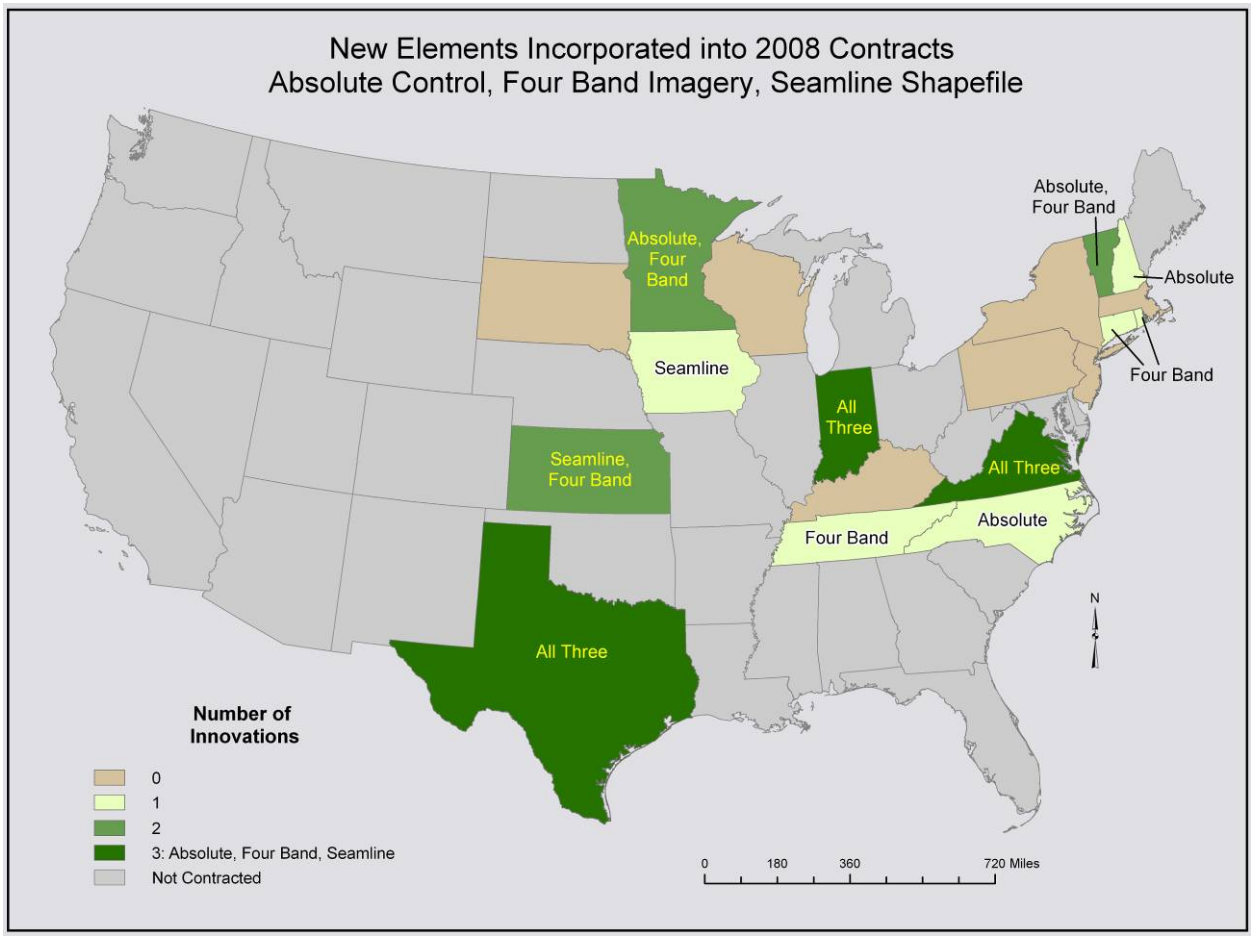

Figure 23: 2008 Imagery Innovations. States being flown in 2008 reflect changes in the products delivered.

A total of 20 states will receive imagery through the NAIP program in 2008. Fourteen will be acquired with digital sensors, and four with film cameras. Twelve

of these states will receive imagery reflecting the 2007 pilots: either four band imagery, absolute control, or a seamline shapefile. Texas, Indiana, and Virginia will receive all three. Seven states will receive the conventional three band imagery, which is terrain corrected to existing imagery: Massachusetts, New Jersey, New York, Pennsylvania, South Dakota, Kentucky, and Wisconsin.

In the final contract awards for 2008, all of the states will receive full coverage, with one exception. This is Texas; an area in the eastern part of the state will instead receive 1 meter leaf off, contracted by the state government. Imagery in the state project will follow NAIP specifications; it will be four band, and rectified using absolute control.

IV. Vector Files at APFO

Control Database

In 2006 and 2007, APFO worked to find photo identifiable ground control points for use by the vendors and in the quality inspection process. In 2008, seven more states are being added to the group. APFO's Service Center Support Section inspected existing control points, primarily from USGS and the Forest Service, and held teleconferences with people from the states involved in order to get their assistance with the point collection. At present, there are over 4,000 points, from nine main states, in the database, which will eventually be in Oracle. Utah is represented by over 400 points, and Arizona by 530. Some control points from these two states were provided by APFO to the vendors, but in 2008 and future years the control points will be used only for inspection check points. As the years go by, and NAIP converts to "absolute" control for all states, APFO hopes to have a control point database large enough to make available to the public without compromising the inspection process.

CLU Repository

When the Farm Service Agency undertook a plan to centralize its GIS business model and associated GIS assets and data, the APFO was selected as a key participant in assisting FSA with this plan. APFO had the infrastructure and capabilities for hosting large geospatial datasets, and much of the data housed at APFO was already being made available on the Geospatial Data Gateway for download by the county offices and by the general public.

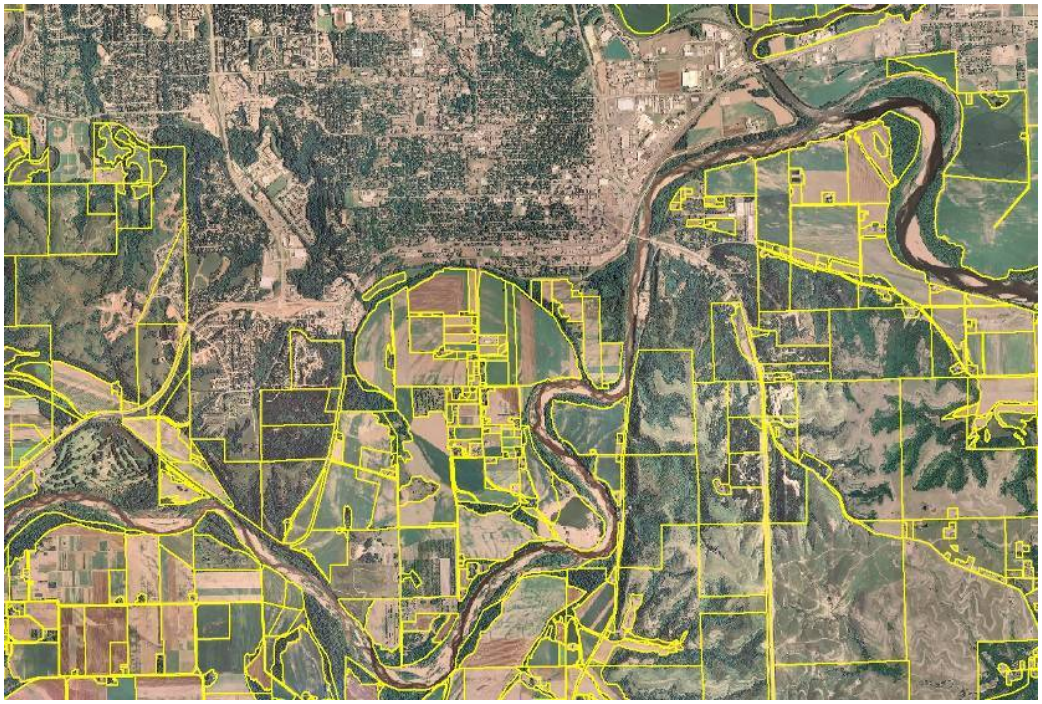

Figure 24: A CLU Shapefile Displayed with NAIP Imagery.

The Common Land Unit dataset is FSA's Agricultural Cadastral layer, keeping track of farm ownership and land usage information, and is currently managed at a county based level. Initially the CLUs were maintained in shapefile format via ArcView applications. Recently FSA has migrated their county offices to the ArcSDE and ArcGIS platform, enabled for multi-user access via the Desktop applications and secure storage of the CLU data.

The CLU files went through a one time certification process by county personnel. This involved reconciling the calculated acreages for the polygons in ArcGIS with the acreages in the tabular data stored at FSA's office in Kansas City. The aggregate acreage total for the county needed to be within a given tolerance of the tabular acreage. The certification process involved working with the individual polygons, and the farmers involved, to verify the acreage. Often the polygons needed to be re-digitized, and sometimes the tabular data needed to be changed.

Maintaining the CLU data in county based datasets, across the 2,350+ offices in each county made most national scale operations and analysis impossible, and FSA moved forward with a plan to replicate the county based datasets to the Geospatial Data Warehouse at APFO for aggregation. This process is currently in development, whereby once a week each county office, via an automated batch process, replicates the weekly changes to the CLU county data to APFO for inclusion in UTM based aggregate layers. APFO checks the topology between counties, along the county perimeters, and sends error reports to the counties if necessary.

FSA also required its county office personnel to perform monthly extracts of the entire CLU ArcSDE layer into shapefile format for delivery to APFO. These county based shapefiles are then made available via the Geospatial Data Gateway for download by the public and other authorized users. (http://datagateway.nrcs.usda.gov/). (Clarke, 2008)

V. The Future of Geospatial Data at APFO

Planning for the Second Cycle of NAIP

One of the major changes in the second cycle, beginning in 2008, is the elimination of 2 meter imagery acquisition for compliance. All projects flown in the coming season will be 1 meter. The proposed plan for 2009 is to only fly the areas with CLU. The five year cycle, which had been used for the first NAIP cycle, may become a three year cycle.

Partnership opportunities under a new NAIP program would include adding DOQQ coverage in areas where there are no CLUs; adding a fourth band to the imagery acquisition, and flying a state during an out of cycle year. There is also the possibility of contracting derivative products directly from the NAIP contractor.

Possibilities for New Image Formats

In the 2007 flying season, a pilot was flown in Yazoo County, Mississippi, with GeoSAR, owned by Fugro EarthData Inc. GeoSAR employs Interferometric Synthetic Aperture Radar (IFSAR). The 16 flight lines of data were collected between August 29 and August 31, 2007. The data from the study is still being processed, but APFO will receive X and P band images. (X being the first surface and P being the detail below the canopy). APFO will also receive Digital Elevation Models (DEMs) derived from the X and P bands (Pugh; Fugro, 2008)

Figure 25:2007 NAIP and GeoSAR Imagery. NAIP 2006 (Left) and a GeoSAR composite for the same area in Yazoo County Mississippi..

The pilot was flown for several reasons. One was to demonstrate that this sensor could produce imagery which was comparable to the NAIP imagery and CLU datasets. Another part of the study was to evaluate GeoSAR's ability to acquire imagery under conditions that would be impossible with digital cameras, such as cloud cover or at night. The weather in the U.S. Southeast, in particular, makes image acquisition very difficult.

Another aspect to be studied was the ability to use GeoSAR imagery for semi-automated crop classification. Fugro scientists, along with USDA, conducted ground data collection, visiting 25 study sites to study and photograph such things as crop type, plant height, local soil roughness, row spacing and compass direction of rows. They also collected soil cores for later laboratory analysis. Fugro also acquired approximately 220 oblique, natural color images form an altitude of 150 – 200 meters. They are using the Classification and Regression Tree (CART) analysis to predict a variable (crop class) from multiple independent variables. (Shaffer, 2008)

The results of their analysis can be combined with FSA's compliance data to check the model for accuracy. The data will not be delivered to APFO until August 2008.

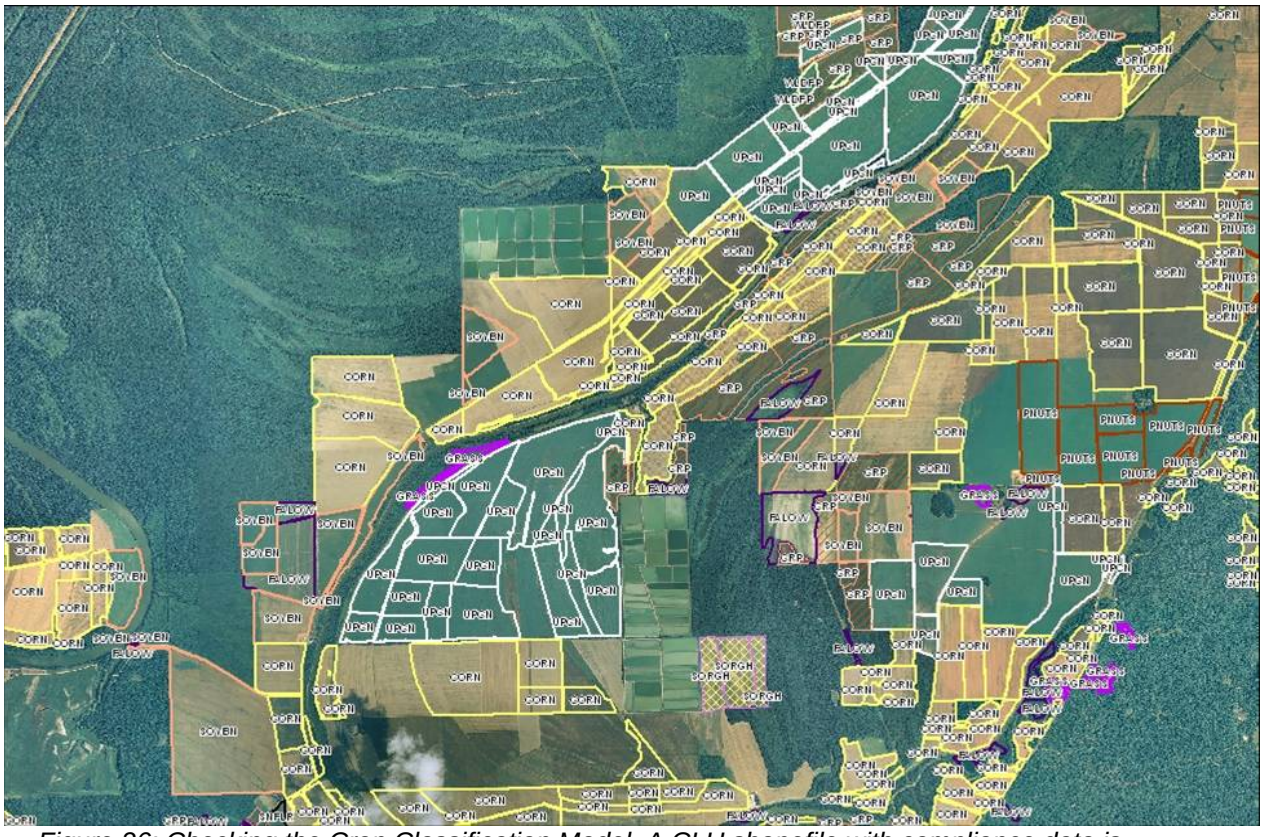

Figure 26: Checking the Crop Classification Model. A CLU shapefile with compliance data is displayed over a NAIP image This will be compared to a model developed with GeoSAR.

VI. Expanded Geospatial Services at APFO

APFO will continue to support geospatial data efforts: to contract for, develop, and carry out the imagery and remote sensing programs within the FSA (APFO 2007 Annual Report).

Scanning from the Historical Library

APFO has the capacity to provide other imagery services besides the NAIP program. After so many years of imagery programs, the Salt Lake City office is home to one of the largest aerial photography film libraries in the country. In addition to film flown for agricultural programs, the collection includes imagery flown for the Forest Service and several other federal agencies.

Figure 27: The APFO Historical Film Library. This collection is one of the largest in the country.

The APFO provides custom scanning services from the historical film collection. The output product can be digital media or paper photograph. All requests are different, and the customer does not have to pay any set-up fees. Media costs and shipping are also included in the price of the scans.

Film scanned at APFO is not georeferenced (unless this is specifically requested and approved). Scans done for individual customers are not saved or archived. Because they are scanned at different resolutions, in different formats, and of different sized areas, they would not fit into a standard archiving system. Until a system is set up, scanning will be done by request only.

Scanning the entire film library would be a huge project; the value of the film library is incalculable, and the need to archive it is recognized. As a first step, the entire collection of line, spot, and photo indexes has been scanned. As of May 2008, about half of the scanned and georeferenced indexes have been delivered and inspected at APFO.

Geospatial Services

Over the past year, APFO has repaired imagery, and has re-formatted non-standard imagery used in some states so that it meets NAIP specifications. The office has worked on custom geo-referencing projects, custom DOQQ and CCM creation, custom cartographic work, GIS processes, posters and displays, and multi-media presentations. These are all areas in which APFO could expand its role in the coming years.

Imagery for the Nation

The Imagery for the Nation Initiative plans to use NAIP as an integral part of the program. NAIP would be 1 meter resolution, natural color, flown every year with leaf-on. Other parts of the program would have 1' or 6" resolution, but flown on a 3 year cycle, with leaf off.

IX. Contracting Services

APFO provides contracting services for several different agencies as well as FSA, with the primary focus being contracting imagery. They work in four main areas:

1) NAIP.
2) Resource aerial photography. These are smaller projects flown primarily for the Forest Service. Occasionally APFO will contract photography projects for other agencies.
3) Small area contracts. These are usually single shots, flown at a lower altitude, for programs such as the National Resource Inventory (NRI), the Wetlands Reserve Program (WRP) and the Forest Inventory Assessment (FIA).
4) APFO contracts for some Information Technology purchases within the office.

Contracting will also be done for non-recurring activities, such as the contract to scan the indexes from the historical film library.

VIII. Data Distribution

Distribution of APFO's geospatial products is very much as it was last year. NAIP imagery is in the public domain, and is available for free download, or for the cost of reproduction. At present there are several methods for accessing NAIP:

- The NAIP Viewer and the MDOQ Viewer are online tools found at
  http://gdw.apfo.usda.gov/naip/viewer
  http://gdw.apfo.usda.gov/mdoq/viewer
  No GIS software is necessary to view the imagery
- The Geospatial Data Warehouse (GDW) allows the user to add MDOQ or NAIP DOQQs into a GIS session for viewing only. The DOQQs have not been mosaicked, and tonal differences exist between images. The URL is: http://*gdw.apfo.usda.gov*, and can be accessed through the "Add IMS Server" selection in ARCMap. There are also some vector layers available on the GDW.
- The Geospatial Data Gateway allows the user to download CCMs free of charge. DOQQs would need to be ordered through APFO. The Gateway hosts a number of other data layers. The URL is:
  http://datagateway.nrcs.usda.gov
- The Customer Service Center at APFO can provide digital imagery on CD, DVD, or bulk orders on hard drive disks. APFO can also provide custom scans of historical imagery.
- Access the APFO office at:

Email: apfo.sales@slc.usda.gov
Telephone: 801- 844-2922
Fax: 801-956-3653

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