35mm Aerial Compliance Slide Scanning

Recommendations for the scanning and naming of aerial compliance 35mm slides

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Scanning 35mm Aerial Compliance Slides

Background

The US Department Of Agriculture, Farm Service Agency (FSA) acquires on a yearly basis compliance photography using 35mm slides. As the USDA/FSA enters the digital age Geographic Information Systems (GIS) will have the ability to incorporate the slides in a digital format into a Service Center GIS. These scanned slides along with the MDOQ's (*Mosaicked* Digital orthophotography) provided by the USDA/FSA Aerial Photography Field Office (APFO) can be used for up to date compliance work.

If the compliance imagery is georeferenced, whether that be georectified or even orthorectified, the Common Land Unit (CLU) layer can be *superimposed* over the imagery and adjustments to the CLU layer can be made to reflect the current tract, farm, and field boundaries using GIS Software.

Compliance imagery is generally obtained once per year in most counties and several times per year in certain counties with special crops. Therefore, it is necessary to have a uniform method of capturing this information in digital form so that all counties embracing this technology as part of their GIS analysis, will have similar end results.

Scanning Resolution

Testing was done to determine an appropriate scanning resolution that would provide excellent viewing capabilities with a manageable file size. The following information describes some of the testing done at APFO to determine the optimum scanning resolution and contrast settings to give the best possible results using 35mm emulsion-based slides scanned on a Nikon LS-2000 slide scanner.
The following counties were scanned as part of the initial testing at APFO:

Page County, Virginia	FIPS Code: 51139
Rockingham County, Virginia	FIPS Code: 51165
Olmsted County, Minnesota	FIPS Code: 27109
Callaway County, Missouri	FIPS Code: 29027

The team felt it was important to have this test represent slides of different geographic areas to ensure the ground cover, soil types and different cropping methods indigenous to each area be evaluated to reflect a fair and accurate end-result.

Scanning Criteria:
The scanner used for this project, as identified in the introduction, is the Nikon LS-2000 Slide Scanner. The following list shows the versions numbers, operating system, and hardware configuration.

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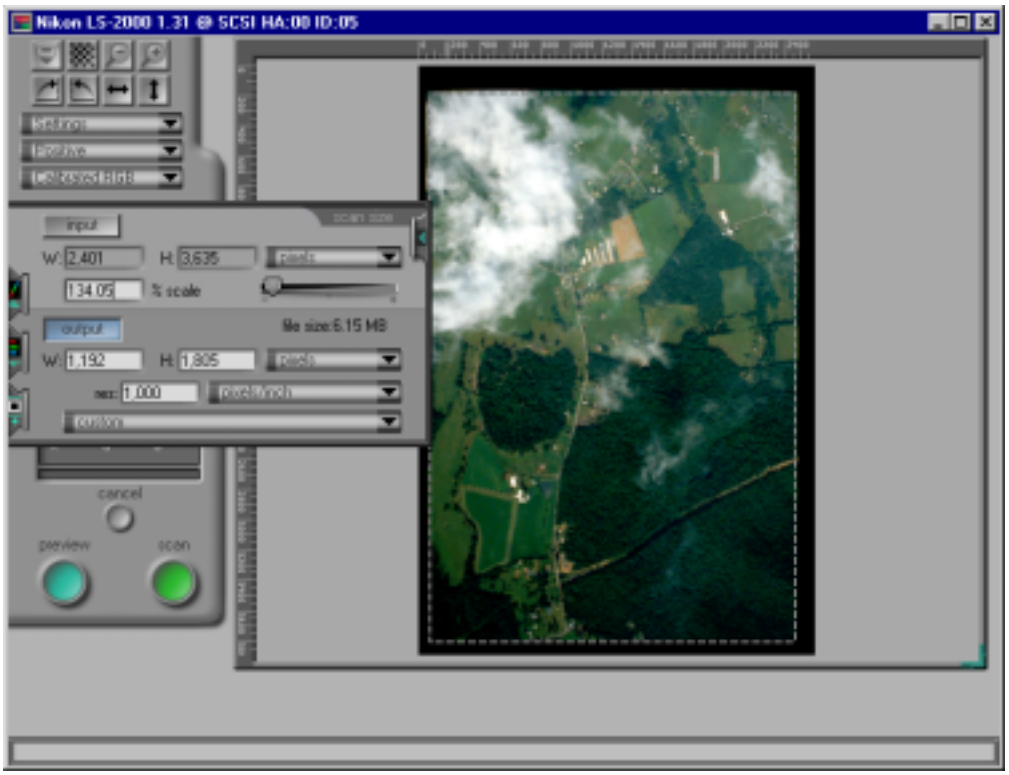
Computer System: Dell OptiPlex GX1 Pentium II 400 Mhz
128 Megabyte RAM, 4 Gigabyte Hard disk
Operating System: Microsoft Windows N/T, Service Pack 5
Scanner: Nikon LS-2000
Scanner Software: Nikon Scan 2.5

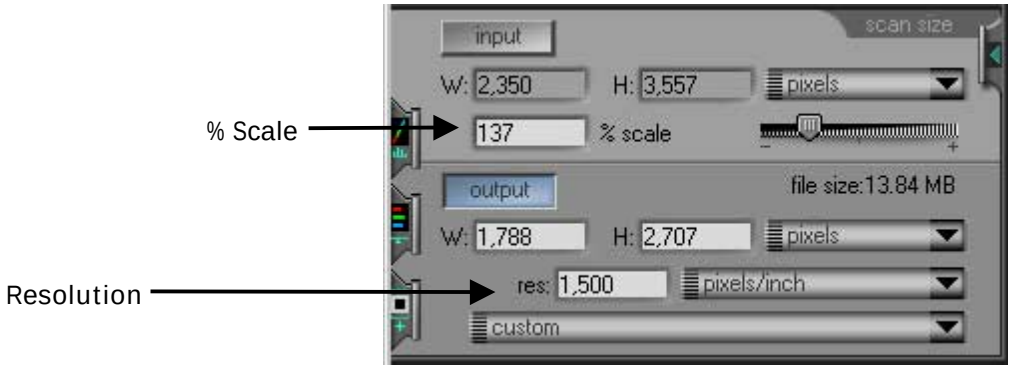
The following graphic reflects the Nikon Scan 2.5 software settings required for compliance scanning.



As can be seen in the example above, the **res:** setting is **1,000** and the **% scale:** setting is **134.05.** As seen in the preview area (the area with the scanned slide), the *dashed line* surrounding the scanned slide represents the area to be cropped or scanned. This will keep any non-data areas from becoming part of the slide and eventually the final rectified mosaic.

Scanning Matrix:
The scanning matrix is a table representing the different **% scale:** and Pixels/Inch (**res:**) settings. **FYI:** If the *dashed line* surrounding the preview area does not include the area desired, move the mouse cursor to the preview area, and move either the entire *dashed line* box using the panning hand or re-size the box by grabbing one of the corners .

Resolution	% scale:	File Size	Approximate Scan Time
250 ppi	137	394KB	12 seconds
500 ppi	137	1.53 MB	40 seconds
750 ppi	137	3.46 MB	41 seconds
1,000 ppi	137	6.15 MB	41 seconds
1,250 ppi	137	9.61 MB	1 minute 15 seconds
1,500 ppi	137	13.84 MB	1 minute 21 seconds



The **% scale** and the **res:** variables are the only items to change. The matrix above gives the necessary information to do a scanning job. The term at the end of the resolution (ppi) is Pixels Per inch. This is the proper terminology for identifying scanning resolution; DPI is used when referring to printing.

Optimum Scanning Resolution:
The table below reflects a *rating scale*. The scale is from 1 to 5, where 1 is poor quality/performance and 5 is best quality/performance. The weighting factor has the same rating system as the *rating scale* (5 most important and 1 least important) and is based on the following criteria:

Clarity of field boundaries:	5
Ability to identify crop differences:	4
Ability to see through shadows:	3
Scanning Speed:	2
File size of (for CD-ROM Archival):	1

Criteria	250 ppi	500 ppi	750 ppi	1000 ppi	1250 ppi	1500 ppi	Weight
Clarity field boundaries	1	2	3	4	5	4	**5**
Crop Differences	1	1	2	5	5	4	**4**
Shadows	1	2	3	4	5	4	**3**
Scan Speed	5	4	4	4	1	1	**2**
File Size	5	5	4	3	2	1	**1**
Score	**27**	**33**	**44**	**63**	**64**	**51**	

The rating was determined using the following methodology.

1. Criteria of Scan resolution MULTIPLIED by Weight
2. After weight of criteria was calculated, the numbers were added to get the score.
3. Field with the highest score represents the best scan.

As can be seen in the table above, the resolution of **1,000** or **1,250** pixels per inch provides acceptable quality. The APFO has found the 1,000 ppi scan to be sufficient for the heads-up rectification and CLU alignment process. At either of these two resolutions, enlargements to a hardcopy (5x5, or 5x7) printout will provide sufficient detail to see the CLU boundary and the image features.

With further testing it was determined that the best overall scanning resolution for the aerial compliance slide is **1350** ppi. This achieves a very good balance between file size, image quality, and scanning time.

A number of aerial photography companies and photographic scanning facilities were contacted to determine standards being used by other professional organizations. Most of the scanning by these companies is for images that will be used on websites. Because of this the resolution level they use is very low, sometimes less than 100 dpi. None of the aerial photography companies or photographic laboratories contacted were performing scanning at the level needed for the aerial compliance slides.

Image Enhancement

Extensive testing and experimenting was done with the scanning software to produce images that maintain the natural color of the landscape while at the same time enhancing the imagery to make it easier to view. By using appropriate scanner settings more detail is visible in shadow areas and the overall tone makes for more accurate image interpretation. The next step is to establish tone matching settings. A system like that used for making the MDOQ's would work well where in each and every image is made with the same settings. This insures that the tonal balance of all scanned slides will match no matter where the imagery was taken. Should mosaicking software be used, the tonal balance across an entire county would match well.

Scanning Procedure

The Nikon LS-2000 35mm slide scanner is the current tool used at the Aerial Photography Field Office for scanning 35mm transparencies. The LS-2000 is also capable of scanning 35mm color and black and white negatives. A 35mm color slide is commonly referred to as a positive transparency.
For the best balance between quality and speed it is recommended to use a setting of 1350 ppi (pixels per inch) at a scale of 125% to 130% and adjust the cropping marquee for a file size of approximately 9.50 Mb. These settings can be adjusted for individual project needs.

To begin scanning click on the Nikon scan icon on the computer desk top screen. This will start the Nikon scan program. Two windows will open. The Nikon Scan 2.5 window will appear on the left and the Nikon LS-2000 window will be on the right. The Nikon LS-2000 window contains the buttons and pull tabs used to initiate and control a scan. The Nikon scan 2.5 window is where the final scanned images will appear.

If this is a new project click on the settings bar in the Nikon LS-2000 window and select the menu item titled *reset to factory defaults*. This will clear any previous settings used for other projects. In the same area select *positive* on the bar just below the settings bar. Then select *calibrated RGB* (Red, Green, Blue) on the third bar.

Notice the series of four pull tabs running vertically down the left edge of the Nikon LS-2000 window. These tabs will help manage the scanned image. Click on the first (top) pull tab. A window will open with highlighted areas used to set image size. In the highlighted, % scale window, type in a number between 125% and 130%. Notice the file size on the right side of the window. The file size should not exceed 10.0 Mb. File size is a balance between speed, and quality. A higher quality scan will have a larger file size. File size also determines how fast the image will be scanned and how much space will be used on a hard drive or storage medium such as a CD. Check the highlighted resolution window. The factory default should be set at 1350 pixels per inch. The ppi can be set between 70 ppi and 2000 ppi. 1350 ppi is an average setting. The percent of scale and pixels per inch will determine the image quality. They will also control the size of the file for each slide. 1350 ppi at 130% scale should give a file size of 9.5 Mb. This setting will allow above average quality without increasing the scan time. The file size can be increased or decreased by adjusting the marquee area of the preview window. Make sure the cropping selection does not eliminate the side lap or end lap between images.

The second tab down will set contrast by adjusting the D-max and D-min. These settings are more for output to a printer and should be left at the default settings.

The third tab down is used for adjusting brightness, contrast, and color balance for output to a printer and should also be left in the default settings.

The fourth and last tab is labeled *scanner extras*. This window is where you will make most of your adjustments to the settings. Click on the tab to open the window. Then click on the long horizontal bar to open the menu. *Clean image* should be set at normal or higher. This selection will digitally clean the slide to remove any dust and minor defects. *Manual focus* is not needed unless the auto focus fails. *Analog gain* is where adjustments are made for brightness and color balance of the scanned transparency. Using *analog gain* is the easiest way to maintain a consistent brightness, contrast, and color balance. *Color balance* should be set to match the original 35mm transparency. It may take a few preview scans to find which settings match the original transparency. Start with the following settings:

Master 0.65 This sets the gain (power of the light) for brightness of the scanned image. The higher the gain the faster the light will burn out and have to be replaced. It is recommended not to have a setting higher than for any length of time.

Red 0.35 This will remove atmospheric haze from the image and help create definition (contrast) in soil areas.

Green 0.15 A low setting for green will create separation in the green field areas.

Blue -0.15 A minus blue (+ yellow) will also reduce atmospheric haze and create color separation in green crop areas.

These settings are suggested for a starting point. Correcting color balance is a skill that will be developed with increased experience. The goal is to match or slightly improve the quality of the transparency being scanned.

Click on the menu bar and then select *image scan*. *Image scan* also relates to image quality. A 1X scan (sample) is a single pass scan. A 4X scan will sample the slide four times while a 16X scan will sample the slide sixteen times. The more a slide is sampled the more depth to the byte size in the final image. A 1X scan takes approximately 2.5 minutes, a 4X scan takes about 5 minutes, while a 16X scan will take about 7.5 minutes. A 1X scan is highly recommended for viewing imagery on a computer monitor. A multi-scan is recommended only if the image is to be printed out to a hard copy. This should complete the necessary settings in the analog gain menu.

Close the *analog gain* window and find the two buttons marked, *apply curves* and *apply A-gain* (analog gain). Click on the *analog gain* button to turn it on. A green dot (button) will appear when the selection is activated. Turn off the *apply curves* button. A green dot should not appear. Apply curves is used for a hard copy print out.

Insert a slide, emulsion side down and narrow side first, into the LS-2000 scanner. Click on the *preview button*. After the preview image appears in the view window adjust the dashed marquee line to just inside the image area until you have a file size of 9.50 Mb. Click on the scan button. After the scan is complete the scanned image will appear on the left in the Nikon 2.5 window. Click on the slide window to activate it and then click on the *save icon* on the tool bar. Open and label a file using the recommended naming convention. The image should be saved as a TIFF file. Click on save. After you have saved the image file remove the slide from the scanner, insert another slide, and repeat the process.

File Format

Various options were evaluated such as tiff, geotiff, JPEG, and Kodak PhotoCD. The most appropriate format would be that which could most easily be used by the service centers as well as the general public. The non-georeferenced slides are being scanned in tiff format. The georeferenced slides will be in either tiff with tiff world or in geotiff format. These formats can be used in any GIS or Remote Sensing software. The original scanned slides need to be saved in a non-compressed and non-proprietary format such as tiff. If not the possibility of working with a format that is no longer supported or with imagery that has lost too much detail because of compression could occur. The original, uncompressed imagery as well as compressed images or county mosaics will likely be provided to the county service centers. By providing both compressed and non-compressed imagery the service centers will have the detail and standardized format of tiff as well as the smaller file size and mosaicking options of compressed images.

Naming Convention

The aerial compliance program has never used a standardized naming convention for the slides. To enable easier use by the service centers as well as others who may use the aerial compliance slides a standard naming format needs to be implemented. Ordering images and keeping track of the images from year to year would be nearly impossible without a standardized naming convention that is used by all counties.

Several naming structures were discussed and evaluated for ease of understanding and the ability to insure that all images would have a unique number no matter what the location or year of photography. Some of the options examined including using an 8.3 format as well as others that include information such as date, roll, image number, and fips code. RSAC uses an 8.3 format but it did not meet our needs for insuring a unique identifier for all images. The naming structure would need to work within the "Standard for Geospatial Dataset File Naming" system being used by the USDA.

The naming convention that is thought to best fit the needs of the aerial compliance program and that has been used to scan the slides of several counties at APFO is described below.

The file name will consist of the following attributes:

<State Abbreviation><CountyFIPS_No>y<ImageYear>c<Cycle>_<Flight><Exposure>

The y is placed *before* the image year and the c is placed *before* the cycle.

Here is an example of the naming convention:

Item	***Test Attributes***	***Type***	***Example Attributes***
State Abbreviation	VA	Character (2)	va
County FIPS_No	139	Numeric (3)	139
Image Year	2000	Numeric (2)	00
Cycle	1	Numeric (1)	1
Flight	48	Numeric (2)	03
Exposure	9	Numeric (3)	009

The attributes can be defined as follows:

State Abbreviation Postal State Abbreviation
County FIPS_No County FIPS Number
Image Year Image Year (year slides were taken)
Cycle Cycle of imagery (1 – 9) Some counties are flown more than once per year
Flight Flight Number or Roll Number
Exposure Exposure Number on Roll/Flight.

The files will appear as such:

va139y00c1_48009.tif

Image Compression

Compressing the images would serve several useful purposes. The smaller file sizes would make it possible to store many more images on a CD-ROM or on a computer hard drive. Imagery for an entire county could easily fit on a single CD-ROM. It is advisable to scan and store the images in their original TIFF format. These images could then be enhanced and/or compressed but the original scans would still be available in the TIFF format. If the original scans where saved in some type of compressed format such as JPEG, MrSID, or ECW much of the quality and functionality would be lost forever. One can easily convert a TIFF file into a compressed file but it is impossible to convert a compressed file back to an original quality TIFF. The compressed images can be saved as a TIFF file but this process cannot restore the original scan data.

Also MrSID compressed images can be used on a PDA or handheld PC with Windows CE (Pocket PC or Handheld PC) and ArcPad from ESRI. A PDA with a 1 Gb microdrive could store approximately 105 uncompressed 9.5 Mb scanned slides, 2100 scanned slides compressed at 20:1 ratio, or 5260 slides compressed at 50:1. Microdrive capacity continues to increase with 2Gb and 5 Gb models now available. Any PDA or other handheld device with a type II card slot can use a microdrive. This would enable a county employee to take into the field all of the imagery and vector layers such as the CLU data for one or even several counties.

The ArcPad software is capable of editing data or entering new data. The software can work directly with a GPS unit making it possible to enter data in the field. The updated data on the PDA could then be transferred to the computers back in the county office. ArcPad can view images compressed in the MrSID format. A plug-in making it possible to view ECW compressed images in ArcPad should be available by the end of 2001.

Compression Software Options

Software	**Vendor**
MrSID	LizardTech
ER Mapper (ECW)	Earth Resource Mapping
JPEG2000	Beta versions from several vendors
Genuine Fractals	Altamira

Currently the only compression formats used by the main stream geospatial community are MrSID and ECW. Both of these formats can be used with the ESRI products being used in the service centers as well as nearly all of the GIS and remote sensing software on the market.

No cost compression programs are available for download from both LizardTech (MrSID) and ER Mapper (ECW). LizardTech's MrSID Photo Solo can only compress images as large as 1600 X 2100 pixels (approximately 3.3 Mb). The ECW Compressor ver. 2.3 from ER Mapper can compress single images with a file size as large as 500 Mb.

Disclaimer: The mention of software or products in this report does not constitute an endorsement or guarantee by the USDA, FSA, or APFO over other comparable products.