



ITT

FSA User Sensitivity Study for Quality of NAIP Imagery

(GS-23F-0284M ORDER #AG-8447-D-06-0026)

December 7, 2006

Sharon Lunt (585)269-5089

Tracey Bjick

Tom Heaton

Seth Weith-Glushko

Engineered for life

Agenda

- Background and goals of Study
- FSA User Study methodology
- Observations and preliminary conclusions

2006 USDA AFPO Product Quality Support

- Phase 1 – User Sensitivity Investigation
 - Defining FSA quality needs
- Phase 2 – Processing Chain “Best Practices”
 - Applying FSA needs to vendor “Best Practices” recommendations
- Final Report Due February 2, 2007

User Study Motivation

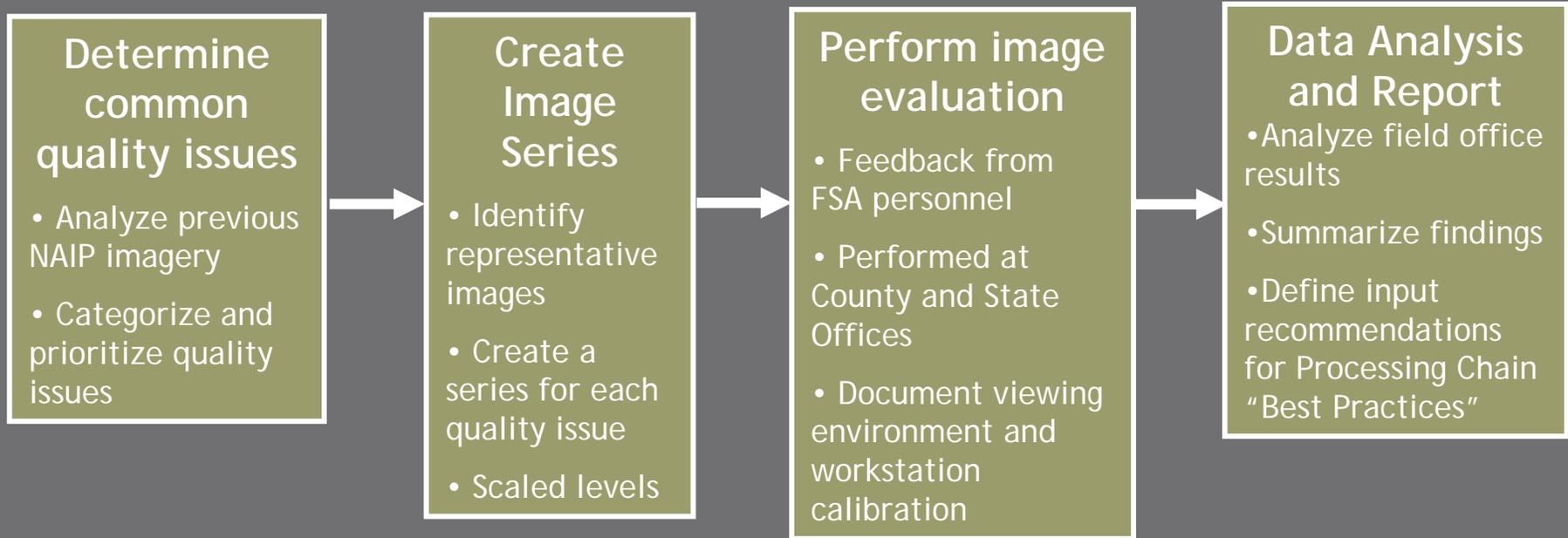
- NAIP imagery can be of very high quality, however multiple vendors and image processing procedures can sometimes provide inconsistent imagery to APFO



User Sensitivity Investigation Goals

- Determine the sensitivity of FSA end users at county and state offices to variations in quality
- Determine type of improvements that might be necessary in upstream processing to provide quality consistent with end user needs

User Sensitivity Investigation Plan



FSA Field Office Image Evaluation

■ Goals

- To obtain FSA personnel input
- To understand general and area specific usage/preference of imagery
- Observe and quantify image viewing environment and tools

■ Areas of concentration

- Color balance
- Dynamic range
- Tone scale
- Sharpness
- Misregistration of color records
- Noise
- Clipping

FSA Field Sites included

Monroe County, NY
Box Elder County, UT
Cache County, UT
Utah FSA State Office
Pottawatomie County, KS
Clay County, KS
Kansas FSA State Office
Waller County, TX
Burleson County, TX
Texas FSA State Office

User Study Methodology

- Test takers were FSA state and county employees that used NAIP imagery for their jobs
- All users saw an Oklahoma common image (2 Meter) selected by APFO as being representative of good imagery
- All users also saw an image from their home state selected to be close to the common image in contrast and color
- Both qualitative (subjective impression) and quantitative (numeric) information was obtained
- Information regarding user's current image viewing setup was also collected

FSA User Evaluated Images



Grady Co., OK
Control



Box Elder Co., UT



Clay Co., Kansas



Hicks Co., TX



Mikado Co., MI

Regional

Mosaic Non-Uniformities

Users rated

- Image quality
- Type of non-uniformity
- Levels of usability in different areas
- Frequency of non-uniformities in delivered imagery

RESULTS - Preliminary

- Contrast variation
 - Users split whether the low contrast dark, or low contrast light region was less usable
 - Users see images like it frequently in some areas (~25% of the time)
- Exposure variation
 - Most users found the overexposed (bright) quadrant the most difficult to locate boundaries

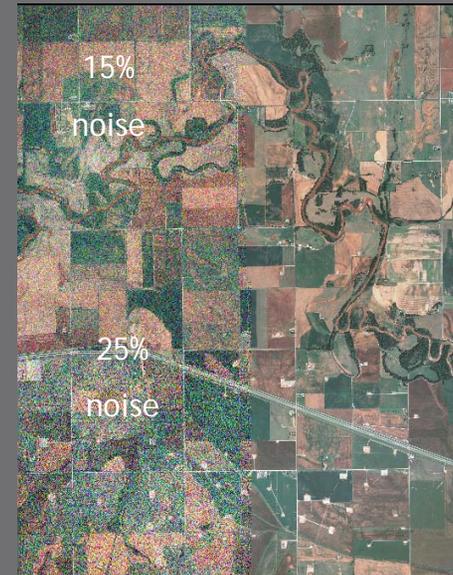


Mosaic Non-Uniformities

RESULTS - Preliminary

- Noise variation
 - Users tended to rate the complete image not usable

- Color variation
 - Users tended to rate the whole image as usable



Sharpness Threshold Task

User Threshold

Users ranked a series of variations in sharpness

RESULTS - Preliminary

- Low tolerance to poor sharpness
- Impacts CLU definition



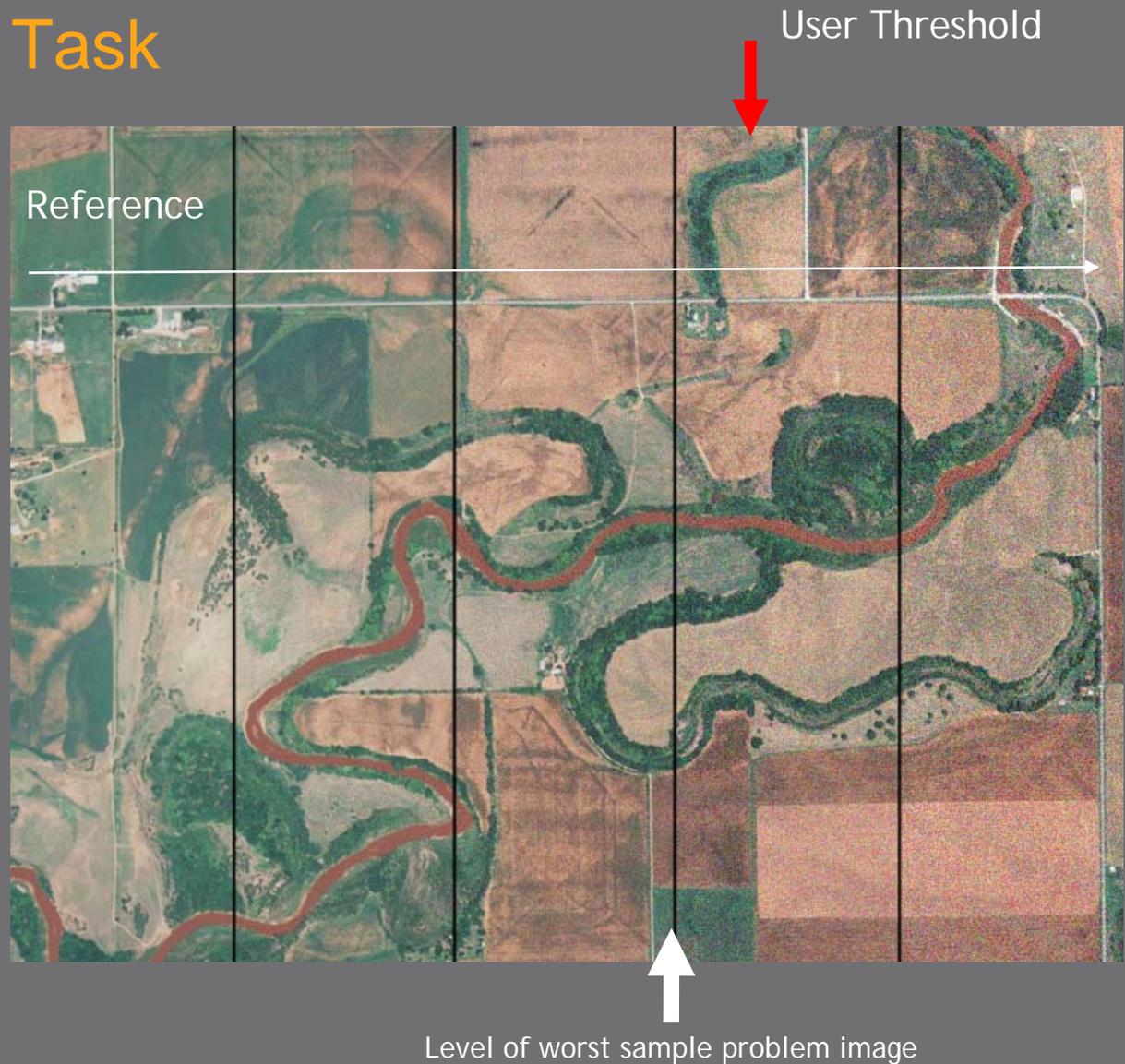
Level of worst sample problem image

Noise Threshold Task

Users ranked a series of variations in noise

RESULTS - Preliminary

- Tolerant to noise until level obscures CLU definition
- High noise fatigue factor identified by users

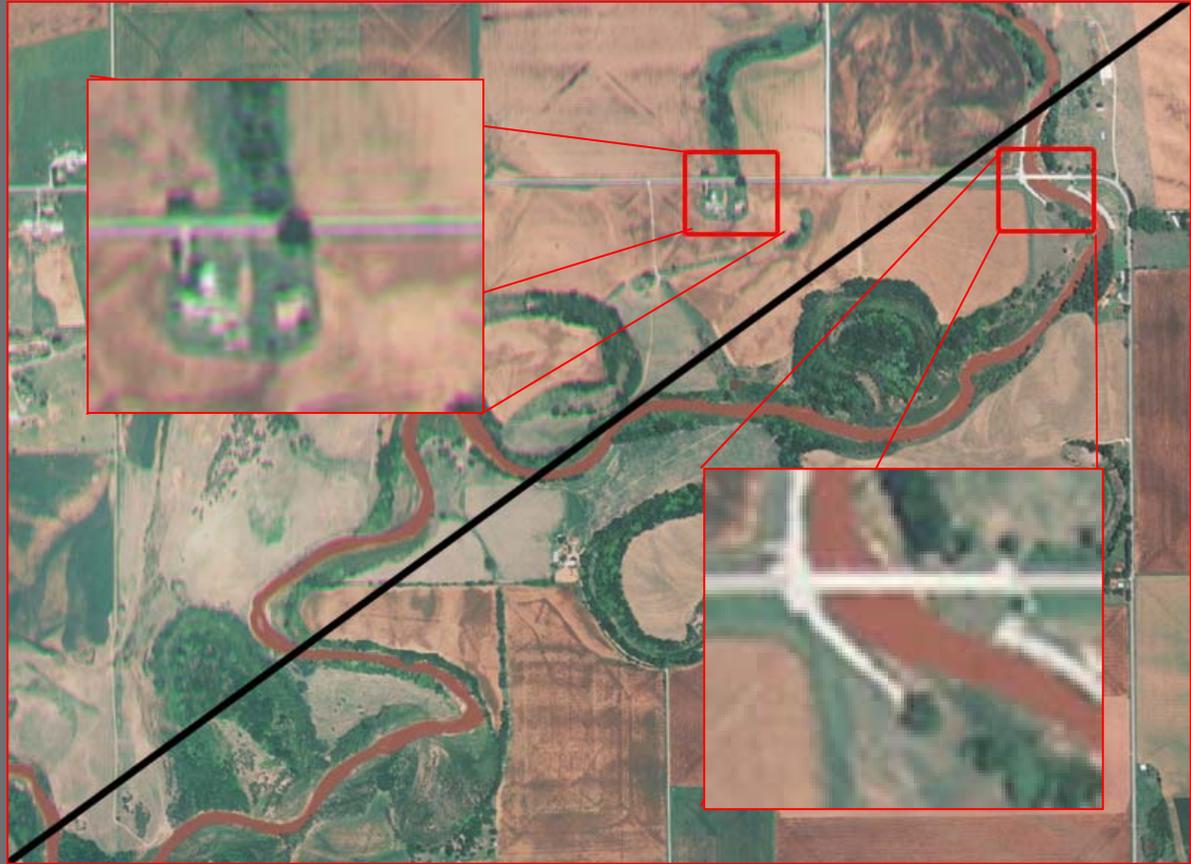


Misregistration Threshold Task

Users ranked a series of variations in misregistration

RESULTS - Preliminary

- A two pixel shift was found to make an image too difficult to use without strain



Saturation Task

Users ranked a series of variations in saturation from 1-5 (Best to Worst)

RESULTS -

Preliminary

- Users tended to pick the center as preferred.
- Very high saturation and very low not preferred



Not Preferred

Preferred

Color Balance Variations

- Paired Comparison of images
 - Test taker picked preferred image from a pair
- Color variations were 6% and 12% changes in cyan, green, blue, and yellow

RESULTS – Preliminary

- Neutrally balanced image preferred overall
- Users not tolerant to large color shifts
 - Least tolerant to large green shifts
 - Most tolerant to blue/yellow variations

Color Balance Variations



Green



Yellow



Cyan



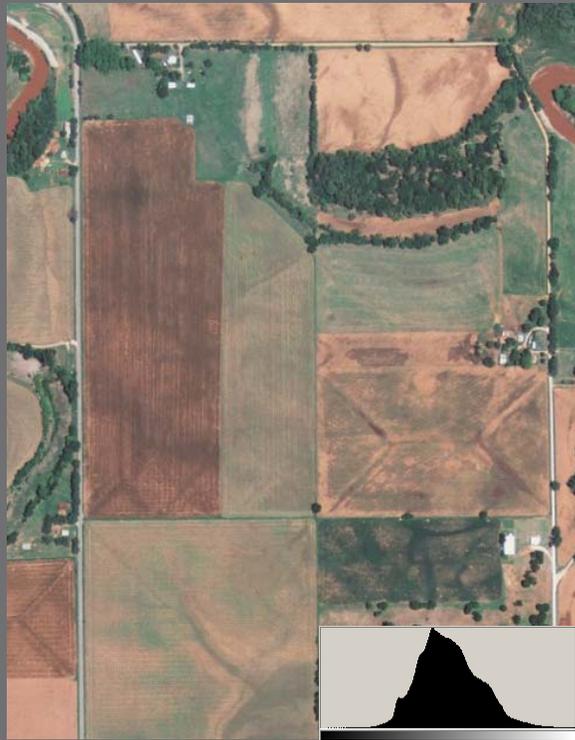
Blue



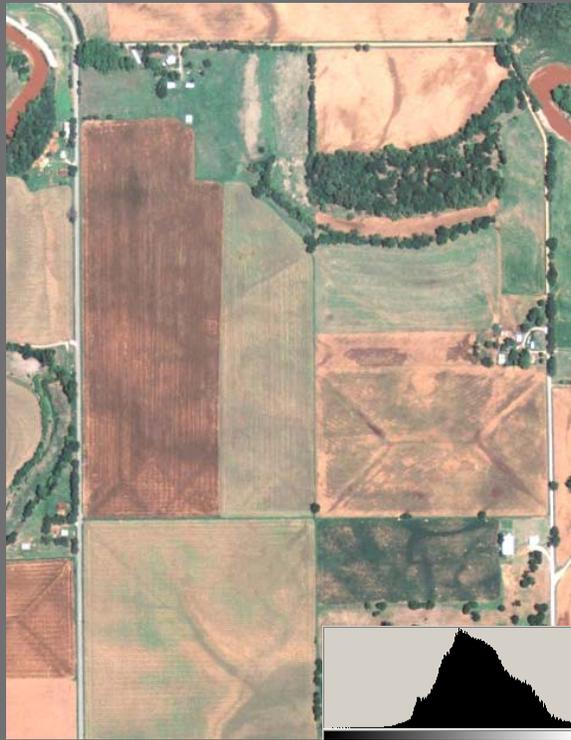
Quality Rating of Images on a 5-point Subjective Usability Scale

- Users were presented with images that varied in apparent contrast due to the introduction of clipping or manipulation of the histogram.
 - Images presented one at a time
- Users were asked to rate the image based on a on a 5-point Subjective Usability Scale

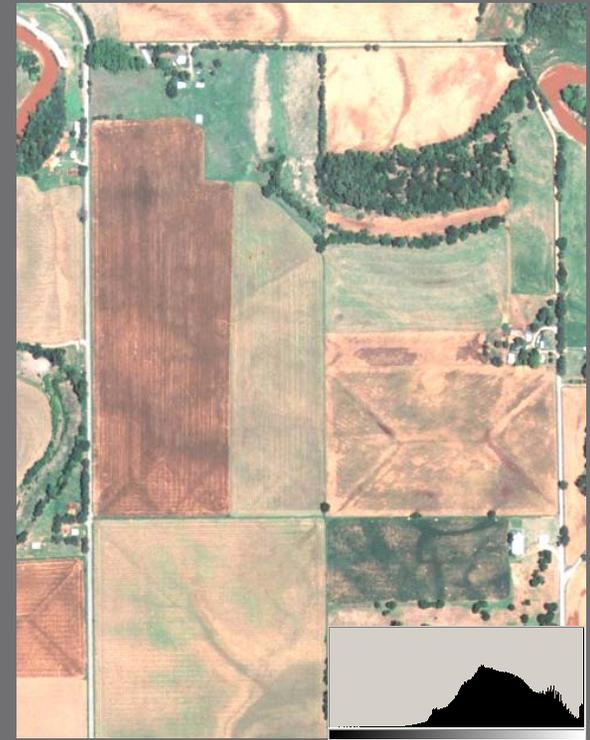
Clipping Variations – High-End (White) Clipping



Original



1% Clipped



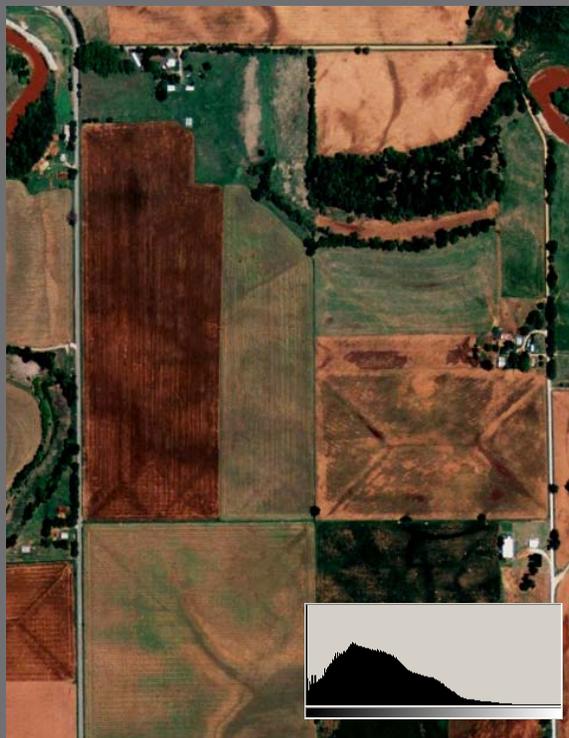
3% Clipped



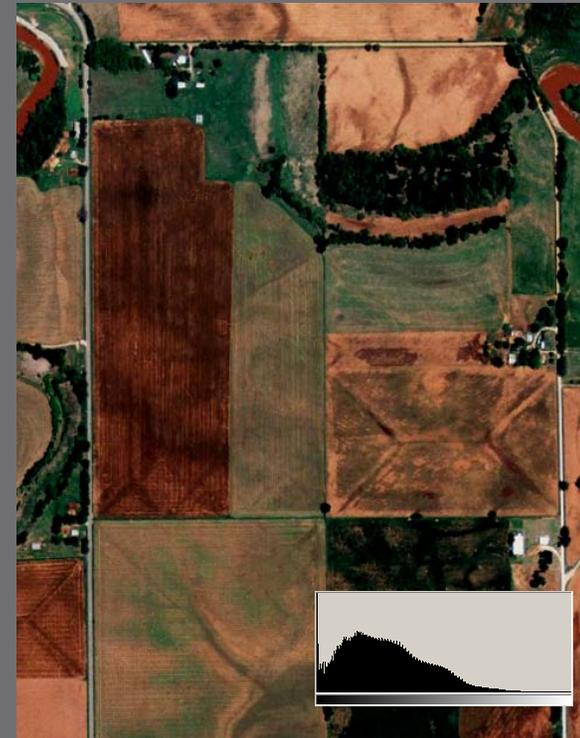
Clipping Variations – Low-End (Black) Clipping



Original



2% Clipped



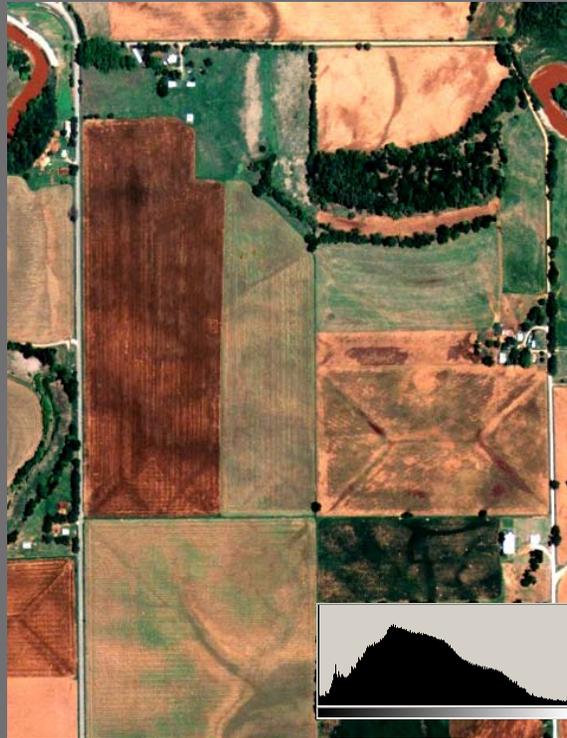
3% Clipped



Clipping Variations – Equal-End Clipping



Original



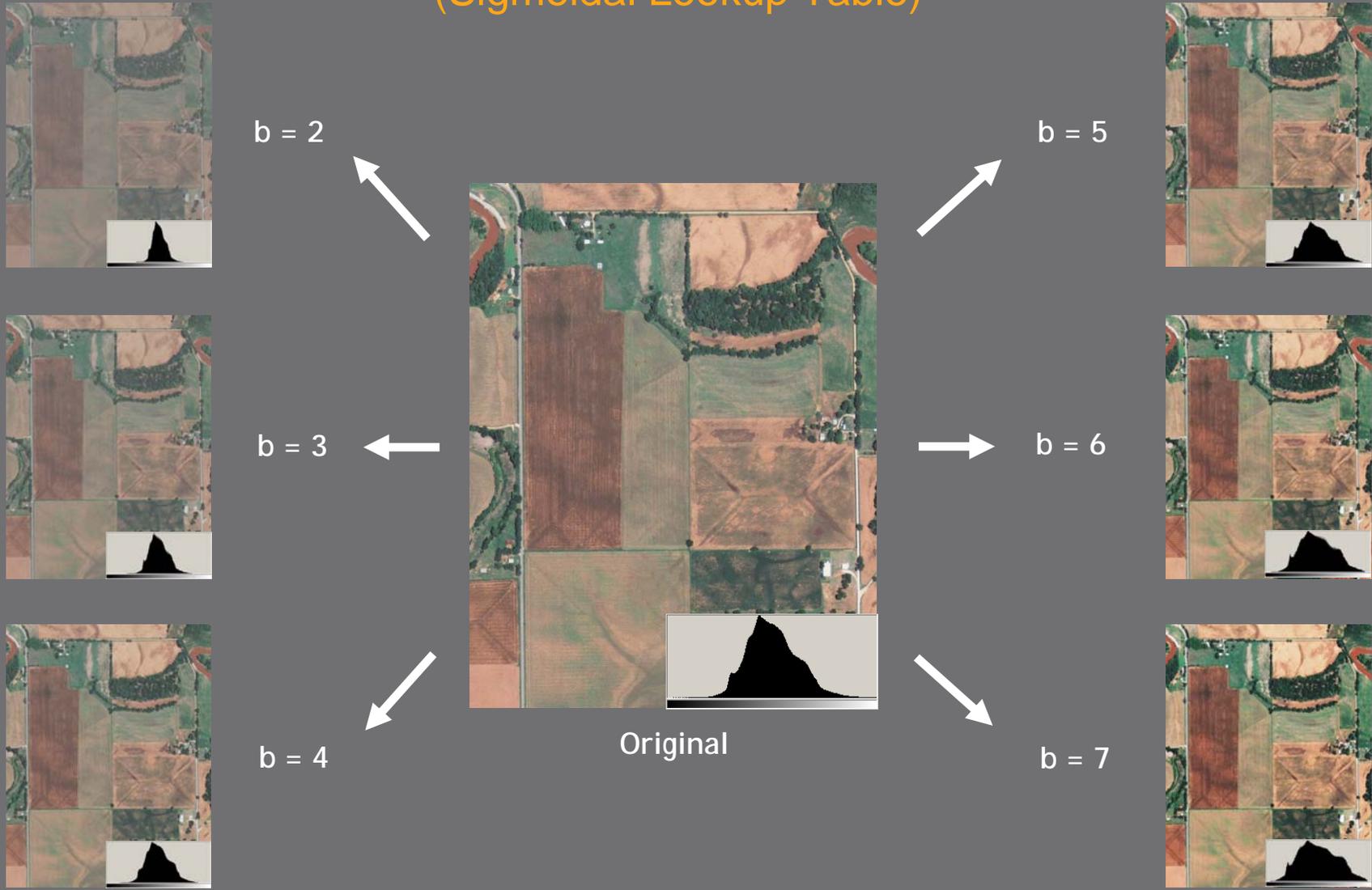
1% Clipped Each Side



2% Clipped Each Side



Tone Scale Variations – Histogram Stretch and Compress (Sigmoidal Lookup Table)



Rating Scale Definitions

1 – Not Usable

This image would be difficult to get information from to do the type of job I do

2- Somewhat Usable

This image would provide some information with some effort, but is not what I'd prefer using.

3 – Usable

This image would provide the information for me to do the type of job I do, but could be improved

4- Very Usable

It is easy to find information in this image to do the type of job I do

5- Best Image

This image is optimum for finding information for the type of job I do. I'd like all images to look like this.

Clipping and Contrast Task

Quality Rating of Images on a 5-point Subjective Usability Scale

RESULTS - Preliminary

- Contrast Variations:
 - Users selected higher contrast images in preference to the reference
 - Users rated low contrast images significantly lower than the reference and the clipped images
- Clipping Variations:
 - A small amount of clipping (~1%) was acceptable
 - Greater than 1% rated consistently lower than reference image
 - Clipping of dark (shadows) considered worse than light (highlights)

Results (Preliminary) – Top two rated images – both higher contrast images



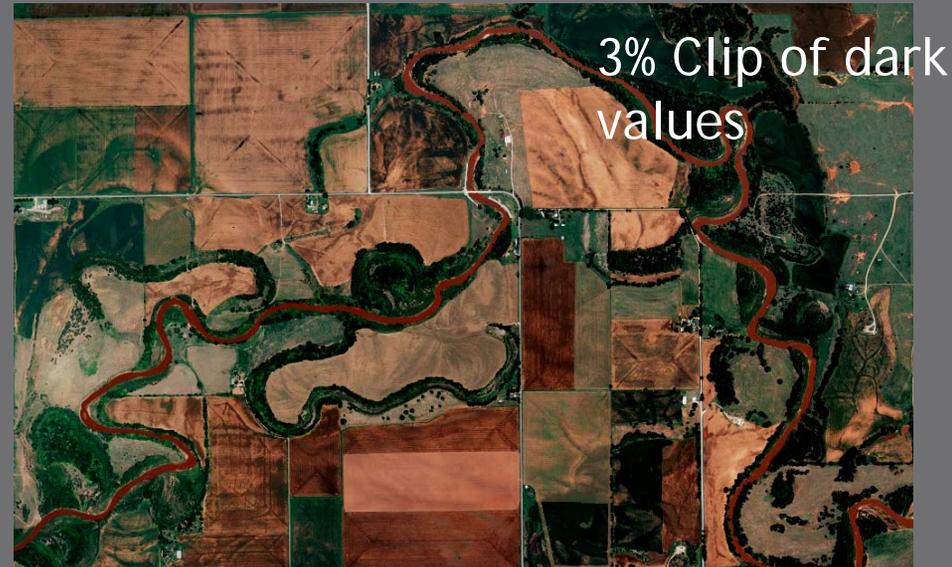
Reference



Results (Preliminary) – Bottom two rated images



Reference



3% Clip of dark values



Low Contrast
(Sigma 2)

Observations on Current Viewing Setups

- Large variation in lighting levels and set-up
- Monitors set at factory defaults which are not optimum for viewing imagery
 - 9300K Color Temperature
 - Lower resolution and/or 60 Hz refresh rate
 - No calibration software
- Monitor responses are not consistent and so the users may see the imagery differently than APFO QA or Vendor QA (or each other)



Calibrated



User Monitor 1



User Monitor 2

Summary (Preliminary Results)

- Mosaic: Users very sensitive to non-uniformities
- Sharpness: Strong preference for well-defined boundaries
- Noise: Minimal noise preferred (impacts boundary delineation)
- Misregistration: Less than 2-pixels required to keep images easily usable
- Color balance: Neutral with allowance for small color shifts
- Saturation: Users preferred more natural looking images overall
- Clipping: Only small amount allowable
- Contrast: Dynamic range maximum with minimal clipping
- User Viewing Environment: Monitor optimization aided ability to more easily extract information
 - Many positive comments to set-up suggestions and changes

Overall Conclusions

- FSA users require well defined image detail to delineate and verify CLUs
- FSA users want good color balance and definition to aid in determining crop type
- Improvements in upstream processing are warranted
 - Addressed in Phase 2– Processing chain “Best Practices”
 - Applying FSA needs to vendor “Best Practices” recommendations

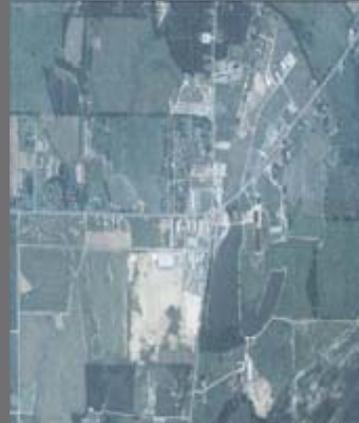
Phase 2 – Development of Best Practice Recommendations

- Definition of protocols, procedures and metrics, for controlling:
 - Clipping
 - Contrast and Dynamic Range
 - Saturation
 - Color balance
 - Noise
- Collection and processing parameters around exposure, film scanning, and color record registration

Variation in NAIP imagery and demonstration of potential “Best Practice” improvements

Problematic NAIP imagery samples

- Original images delivered to APFO
- Reprocessed to bring out information content



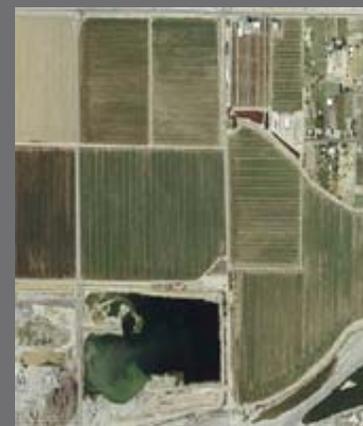
Original



ITT corrected



Original



ITT corrected