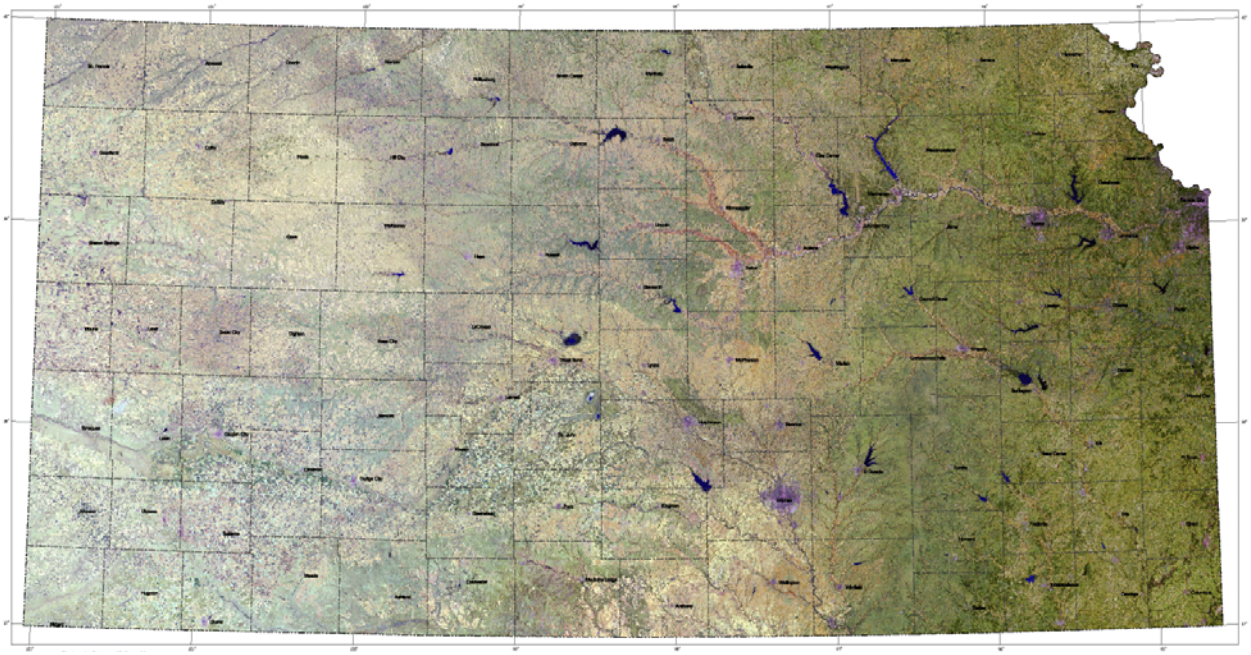
The Kansas Satellite Image Database: 2004-2005 Landsat Thematic Mapper Imagery

Final Report



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Credits

The Kansas Satellite Image Database (KSID) 2004-2005 was created at the Kansas Applied Remote Sensing (KARS) Program of the Kansas Biological Survey. The database was funded by the Kansas GIS Policy Board with funds from the Kansas Water Plan that are administered by the Kansas Water Office (Contract 2005-2099).

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Tables

Introduction

This report summarizes the methods and results for construction of the Kansas Satellite Image Database (KSID) 2004-2005. The KSID 2004-2005 was constructed using terrain-corrected, precision rectified spring, summer, and fall Landsat 5 Thematic Mapper (TM) imagery. Six of the sixteen path/row image triplicates date wholly from either 2004 or 2005, while the other 10 image triplicates were constructed with imagery from both 2004 and 2005. Raw image data and derived image products were extracted and tiled by county and exported in GeoTiff format. Although previous KSIDs 2001-2002 and 2003-2004 contain Landsat 7 ETM+ imagery, on May 31, 2003 the Scan Line Corrector (SLC) in this instrument failed making data from it not suitable for inclusion into KSID 2004-2005.

As mentioned, the KSID 2004-2005 is comprised of raw data and visual products. The raw data set includes the seven Landsat TM bands with image values in their original units (DN values). The visual data set consists of three products: Normalized Difference Vegetation Index (NDVI) images, false-color infrared composite images, and resolution-enhanced natural color composite images. Because the 15m panchromatic band from the ETM+ instrument was not available, the resolution-enhanced imagery was created using resampled imagery from the 2005 USDA National Agricultural Imagery Program (NAIP).

KSID was developed to provide federal, state, and local government and non-government entities and individuals a source for deriving recent land cover for application in natural resource management. In addition, the database is an essential component that will enable a future update to the Kansas land cover map, a core spatial database of Kansas. This satellite imagery database is also designed to provide educational and research opportunities using recent satellite imagery in K-12 classrooms and state universities.

Methods

Data Acquisition

Forty-eight Landsat 5 Thematic Mapper (TM) scenes were obtained to compile a multiseasonal (spring, summer, and fall), nearly cloud-free satellite image database for the state of Kansas. The primary criteria for scene selection, therefore, were the date of acquisition for the image and images that had little or no cloud contamination (Table 1).

The Landsat satellite imagery was ordered terrain-corrected, in UTM NAD83 projection, with imagery resampled using cubic convolution processing. These scenes were ordered through the USGS Earth Resources Observation Systems (EROS) Data Center (EDC) and were processed using National Land Archive Production System (NLAPS).

Table 1. Image acquisition dates for Landsat 5 TM scenes in the Kansas Satellite Image Database: 2004-2005.

Path/Row	Image Date		
	Spring	Summer	Fall
26/34	03/11/2005	6/15/2005	10/02/2004
27/32	05/21/2005	8/09/2005	10/28/2005
27/33	04/16/2004	06/22/2005	10/28/2005
27/34	04/16/2004	08/09/2005	09/10/2005
28/32	03/22/2004	07/12/2004	11/04/2005
28/33	03/22/2004	07/12/2004	11/04/2005
28/34	03/22/2004	07/12/2004	11/04/2005
29/32	04/14/2004	07/19/2004	10/23/2004
29/33	04/01/2005	07/19/2004	10/23/2004
29/34	04/01/2005	07/22/2005	10/23/2004
30/32	05/10/2005	07/29/2005	11/18/2005
30/33	05/10/2005	07/29/2005	11/18/2005
30/34	05/10/2005	07/29/2005	11/18/2005
31/32	03/11/2004	08/02/2004	10/24/2005
31/33	03/30/2005	07/20/2005	10/24/2005
31/34	03/27/2004	07/20/2005	10/24/2005

The Landsat 5 TM sensor collects data from seven bands of the electromagnetic (EM) spectrum: 1) blue (0.45-0.52 :m); 2) green (0.52-0.60 :m); 3) red (0.63-0.69 :m); 4) near-infrared (0.76-0.90 :m); 5) mid-infrared (1.55-1.75 :m); 6) thermal (10.4-12.5 :m); and 7) mid-infrared (2.08-2.35 :m). All bands have a spatial resolution of 30m except for the thermal band (120m).

The failure of the SLC on the Landsat 7 ETM+ instrument resulted in anomalies (data gaps) within the imagery. The failure also resulted in a concurrent lack of additional dates of imagery to choose from, creating problems in constructing a cloud-free image database. Although the USGS EROS Data Center is able to fill the gaps with data from older scenes and began offering this product in the fall 2003, this product was deemed unsuitable for use in the KSID.

While best available TM imagery was acquired for the KSID 2004-2005 image database, not all best available imagery was cloud-free. As a result, twenty-three counties contained some type and extent of haze or cloud cover (Table 2). Two county image dates were contaminated with haze, Harper (spring) and Pratt (fall) and were left as is. Twenty one counties were contaminated with varying degrees of cloud cover and include Allen (summer), Barber (spring), Chautauqua (summer), Cheyenne (spring), Greeley (spring), Greenwood (summer), Kearny (spring), Kingman (spring), Marshall (summer), Mitchell (spring), Montgomery (spring and summer), Nemaha (summer), Pottawatomie (summer), Riley (summer), Sherman (spring and summer), Sumner (spring), Thomas (spring), Wabaunsee (summer), Wallace (spring and summer), Wichita (spring), and Wilson (summer). For five county images contaminated by clouds, a cloud-free product was created by substituting imagery from a cloud-free overlapping scene. These counties include Allen (summer), Nemaha (summer), Kingman (spring), Pottawatomie (summer), and Wabaunsee (summer). For these county/date combinations, two summer multispectral and multispectral derived products (one containing clouds and the other cloud-free) are available in the KSID 2004-2005 database.

Data Pre-processing

The Landsat satellite imagery was purchased from the USGS Earth Resources Observation Systems (EROS) Data Center (EDC). The imagery was ordered with the following specifications: terrain corrected, 30m pixel size, cubic convolution resampling, National Land Archive Production System (NLAPS) data format in the Universal Transverse Mercator Projection, WGS84.

Each TM scene was imported from its native format on CD-ROM to the local hard drive using ERDAS Imagine 8.7 software. Each scene was inspected for cloud cover, line dropout, and system noise. As an additional check of a scene's spatial accuracy, each was compared to a corresponding scene from the KSID 2000-2001 TM/ETM+ archive. The scenes were then reprojected to UTM, NAD83.

Table 2. Images and counties affected by cloud cover. Cloud location identifies the general location of cloud cover within each county. Haze effects could not be removed and counties affected by haze are *italicized*. Where possible, overlapping imagery was used to produce alternate products for cloud affected counties and are indicated in **bold** text.

Path/Row	Date	County	Cloud Location
27/34	08/09/05	**Allen**	East, popcorn clouds
		Chautauqua	West, popcorn clouds
		Greenwood	South-central, popcorn clouds
		Montgomery	South-central, popcorn clouds
		Wilson	Central
	04/16/05	Montgomery	East, popcorn clouds
28/32	07/12/04	Marshall	East-central
		Nemaha	Central and Southeast
28/34	03/22/04	*Harper*	Southwest, haze
		Sumner	South-central
29/34	04/01/05	Barber	Central, East, popcorn clouds
		Kingman	Central
	10/23/04	*Pratt*	Central, haze
28/33	07/12/04	**Pottawatomie**	Southeast, popcorn clouds
		Riley	Central, popcorn clouds
		Wabaunsee	Northeast, popcorn clouds
29/33	04/01/05	Mitchell	South, popcorn clouds
31/32	03/11/04	Cheyenne	Southeast, popcorn clouds
31/33	03/30/05	Greeley	East, popcorn clouds
		Sherman	West
		Thomas	West
		Wallace	Central
		Wichita	Scattered throughout
	07/20/05	Sherman	East
		Thomas	Northwest
31/34	03/27/04	Kearny	North, popcorn clouds

Product Generation

Product 1, Raw Imagery.

Full-scene TM images for Path 27 were reprojected from UTM 14 to UTM 15 to allow processing of counties that lie on either side of the UTM boundary. The thermal band was then subset from all the full-scene images resulting in 2 image files per Path/Row; a 6-band image file (TM bands 1, 2, 3, 4, 5, 7) and a 1-band image file (TM band 6). For counties that lay fully within the footprint of a TM Path/Row, the 2 image files were clipped using the appropriate county boundary to create the 'raw imagery' data set. For counties that lay on the boundary of two Path/Rows, the image files for the Path/Rows were spliced together and were then clipped to the county. Table 3 contains a listing of the scenes used to cover each county. Source data for the county boundaries used in clipping were from the Kansas Cartographic Database that we converted to ArcInfo shapefiles.

After creating the county-tiled raw data set, three image products were created: a Normalized Difference Vegetation Index (NDVI) image, a false-color composite image, and a resolution enhanced natural color composite image.

Product 2, NDVI Image.

NDVI is a measure of vegetation greenness and provides an indication of vegetation condition or health. The higher the NDVI values, the more photosynthetically active vegetation is present. Conversely, low NDVI values indicate little or no vegetation. NDVI was calculated using the standard equation (TM4 - TM3)/(TM4 + TM3) where Landsat TM band 4 is the near-infrared band and Landsat TM band 3 is the red band. The data values were then rescaled from an original range of -1.0 to +1.0 to an 8-bit range of 0 to 255. In the GeoTIFFs, NDVI values between 1 and 127 are represented by decreasing saturation of the color red while NDVI values between 128 and 255 are represented by increasing saturation of the color green.

Product 3, False-color Composite Image.

The false-color composite (FCC) image visually resembles a color-infrared photograph. The FCC image is useful because it is easy to differentiate between vegetated and non-vegetated features. Vegetation is highly reflectively of near-IR energy and appears red. Various shades of red indicate vegetated features, while blue and gray areas indicate non-vegetated features. Because water absorbs near-IR energy, water bodies are also more easily identified in a FCC image. This is especially true for water bodies with low suspended sediment loads, which often appear black. FCC images were created by assigning the colors red, green, and blue to TM bands 4, 3, and 2, respectively.

Product 4, Resolution-enhanced Image.

As mentioned previously, the failure of the Scan Line Corrector (SLC) on the Landsat 7 ETM+ instrument precluded using its 15m panchromatic band to create resolution enhanced imagery, and since KSID 2004-2005 is built entirely from Landsat 5 TM data, an alternate source for the high-resolution data was used. The resolution-enhanced natural color

Table 3. Image acquisition dates for the county-tiled satellite image database. Twenty-four counties required two images to create the county scene and are indicated in *italic* type. Of the 82 (24 counties x 3 image dates) "split" county image datasets, 32 use two different dates of imagery and are indicated in **bold** type.

County	**Path/Row**	**Image Date**		
		Spring	**Summer**	**Fall**
Allen	27/34	04/16/2004	08/09/2005	09/10/2005
Anderson	27/33	04/16/2004	**06/22/2005**	**10/28/2005**
	27/34	04/16/2004	**08/09/2005**	**09/10/2005**
Atchison	27/33	04/16/2004	06/22/2005	10/28/2005
Barber	29/34	04/01/2005	07/22/2005	10/23/2004
Barton	29/33	04/01/2005	07/19/2004	10/23/2004
Bourbon	26/34	03/11/2005	06/15/2005	10/02/2004
Brown	27/32	05/21/2005	08/09/2005	10/28/2005
Butler	28/34	03/22/2004	07/12/2004	11/04/2005
Chase	28/33	03/22/2004	07/12/2004	11/04/2005
Chautauqua	27/34	04/16/2004	08/09/2005	09/10/2005
Cherokee	26/34	03/11/2005	06/15/2005	10/02/2004
Cheyenne	31/32	**03/11/2004**	**08/02/2004**	10/24/2005
	31/33	**03/30/2005**	**07/20/2005**	10/24/2005
Clark	29/34	**04/01/2005**	**07/22/2005**	**10/23/2004**
	30/34	**05/10/2005**	**07/29/2005**	**11/18/2005**
Clay	28/33	03/22/2004	07/12/2004	11/04/2005
Cloud	29/32	**04/14/2004**	07/19/2004	10/23/2004
	29/33	**04/01/2005**	07/19/2004	10/23/2004
Coffey	27/33	04/16/2004	**06/22/2005**	**10/28/2005**
	27/34	04/16/2004	**08/09/2005**	**09/10/2005**
Comanche	29/34	04/01/2005	07/22/2005	10/23/2004
Cowley	28/34	03/22/2004	07/12/2004	11/04/2005
Crawford	26/34	03/11/2005	06/15/2005	10/02/2004

Decatur	30/32	05/10/2005	07/29/2005	11/18/2005
	30/33	05/10/2005	07/29/2005	11/18/2005
Dickinson	28/33	03/22/2004	07/12/2004	11/04/2005
Doniphan	27/32	05/21/2005	08/09/2005	10/28/2005
Douglas	27/33	04/16/2004	06/22/2005	10/28/2005
Edwards	29/34	04/01/2005	07/22/2005	10/23/2004
Elk	27/34	04/16/2004	08/09/2005	09/10/2005
Ellis	29/33	**04/01/2005**	**07/19/2004**	**10/23/2004**
	30/33	**05/10/2005**	**07/29/2005**	**11/18/2005**
Ellsworth	29/33	04/01/2005	07/19/2004	10/23/2004
Finney	30/34	05/10/2005	07/29/2005	11/18/2005
	30/33	05/10/2005	07/29/2005	11/18/2005
Ford	30/34	05/10/2005	07/29/2005	11/18/2005
Franklin	27/33	04/16/2004	06/22/2005	10/28/2005
Geary	28/33	03/22/2004	07/12/2004	11/04/2005
Gove	30/33	05/10/2005	07/29/2005	11/18/2005
Graham	30/33	05/10/2005	07/29/2005	11/18/2005
Grant	31/34	03/27/2004	07/20/2005	10/24/2005
Gray	30/34	05/10/2005	07/29/2005	11/18/2005
Greeley	31/33	03/30/2005	07/20/2005	10/24/2005
Greenwood	27/34	04/16/2004	08/09/2005	09/10/2005
Hamilton	31/33	**03/30/2005**	07/20/2005	10/24/2005
	31/34	**03/27/2004**	07/20/2005	10/24/2005
Harper	28/34	03/22/2004	07/12/2004	11/04/2005
Harvey	28/34	03/22/2004	07/12/2004	11/04/2005
Haskell	30/34	05/10/2005	07/29/2005	11/18/2005
Hodgeman	30/33	05/10/2005	07/29/2005	11/18/2005
	30/34	05/10/2005	07/29/2005	11/18/2005
Jackson	27/33	04/16/2004	06/22/2005	10/28/2005
Jefferson	27/33	04/16/2004	06/22/2005	10/28/2005

Jewell	29/32	**04/14/2004**	07/19/2004	10/23/2004
	29/33	**04/01/2005**	07/19/2004	10/23/2004
Johnson	27/33	04/16/2004	06/22/2005	10/28/2005
Kearny	31/33	**03/30/2005**	07/20/2005	10/24/2005
	31/34	**03/27/2004**	07/20/2005	10/24/2005
Kingman	28/34	**03/22/2004**	**07/12/2004**	**11/04/2005**
	29/34	**04/01/2005**	**07/22/2005**	**10/23/2004**
Kiowa	29/34	04/01/2005	07/22/2005	10/23/2004
Labette	27/34	04/16/2004	08/09/2005	09/10/2005
Lane	30/33	05/10/2005	07/29/2005	11/18/2005
Leavenworth	27/33	04/16/2004	06/22/2005	10/28/2005
Lincoln	29/33	04/01/2005	07/19/2004	10/23/2004
Linn	27/33	04/16/2004	06/22/2005	10/28/2005
Logan	31/33	03/30/2005	07/20/2005	10/24/2005
Lyon	27/33	04/16/2004	**06/22/2005**	**10/28/2005**
	27/34	04/16/2004	**08/09/2005**	**09/10/2005**
Marion	28/33	03/22/2004	07/12/2004	11/04/2005
	28/34	03/22/2004	07/12/2004	11/04/2005
Marshall	28/32	03/22/2004	07/12/2004	11/04/2005
McPherson	28/33	03/22/2004	07/12/2004	11/04/2005
	28/34	03/22/2004	07/12/2004	11/04/2005
Meade	30/34	05/10/2005	07/29/2005	11/18/2005
Miami	27/33	04/16/2004	06/22/2005	10/28/2005
Mitchell	29/33	04/01/2005	07/19/2004	10/23/2004
Montgomery	27/34	04/16/2004	08/09/2005	09/10/2005
Morris	28/33	03/22/2004	07/12/2004	11/04/2005
Morton	31/34	03/27/2004	07/20/2005	10/24/2005
Nemaha	28/32	03/22/2004	07/12/2004	11/04/2005
Neosho	27/34	04/16/2004	08/09/2005	09/10/2005
Ness	30/33	05/10/2005	07/29/2005	11/18/2005

Norton	30/32	05/10/2005	07/29/2005	11/18/2005
	30/33	05/10/2005	07/29/2005	11/18/2005
Osage	27/33	04/16/2004	06/22/2005	10/28/2005
Osborne	29/33	04/01/2005	07/19/2004	10/23/2004
Ottawa	28/33	**03/22/2004**	**07/12/2004**	**11/04/2005**
	29/33	**04/01/2005**	**07/19/2004**	**10/23/2004**
Pawnee	29/33	04/01/2005	**07/19/2004**	10/23/2004
	29/34	04/01/2005	**07/22/2005**	10/23/2004
Phillips	30/32	05/10/2005	07/29/2005	11/18/2005
Pottawatomie	28/33	03/22/2004	07/12/2004	11/04/2005
Pratt	29/34	04/01/2005	07/22/2005	10/23/2004
Rawlins	31/32	03/11/2004	08/02/2004	10/24/2005
Reno	28/34	**03/22/2004**	**07/12/2004**	**11/04/2005**
	29/34	**04/01/2005**	**07/22/2005**	**10/23/2004**
Republic	29/32	04/14/2004	07/19/2004	10/23/2004
Rice	29/33	04/01/2005	07/19/2004	10/23/2004
Riley	28/33	03/22/2004	07/12/2004	11/04/2005
Rooks	30/33	05/10/2005	07/29/2005	11/18/2005
	30/32	05/10/2005	07/29/2005	11/18/2005
Rush	29/33	04/01/2005	07/19/2004	10/23/2004
Russell	29/33	04/01/2005	07/19/2004	10/23/2004
Saline	28/33	03/22/2004	07/12/2004	11/04/2005
Scott	30/33	05/10/2005	07/29/2005	11/18/2005
Sedgwick	28/34	03/22/2004	07/12/2004	11/04/2005
Seward	30/34	05/10/2005	07/29/2005	11/18/2005
Shawnee	27/33	04/16/2004	06/22/2005	10/28/2005
Sheridan	30/33	05/10/2005	07/29/2005	11/18/2005
Sherman	31/33	03/30/2005	07/20/2005	10/24/2005
Smith	29/32	**04/14/2004**	07/19/2004	10/23/2004
	29/33	**04/01/2005**	07/19/2004	10/23/2004

Stafford	29/33	04/01/2005	07/19/2004	10/23/2004
	29/34	04/01/2005	07/22/2005	10/23/2004
Stanton	31/34	03/27/2004	07/20/2005	10/24/2005
Stevens	30/34	**05/10/2005**	**07/29/2005**	**11/18/2005**
	31/34	**03/27/2004**	**07/20/2005**	**10/24/2005**
Sumner	28/34	03/22/2004	07/12/2004	11/04/2005
Thomas	31/33	03/30/2005	07/20/2005	10/24/2005
Trego	30/33	05/10/2005	07/29/2005	11/18/2005
Wabaunsee	28/33	03/22/2004	07/12/2004	11/04/2005
Wallace	31/33	03/30/2005	07/20/2005	10/24/2005
Washington	28/32	03/22/2004	07/12/2004	11/04/2005
	28/33	03/22/2004	07/12/2004	11/04/2005
Wichita	31/33	03/30/2005	07/20/2005	10/24/2005
Wilson	27/34	04/16/2004	08/09/2005	09/10/2005
Woodson	27/34	04/16/2004	08/09/2005	09/10/2005
Wyandotte	27/33	04/16/2004	06/22/2005	10/28/2005

composite images were created by merging 2005 National Agricultural Imagery Program (NAIP) with Landsat TM bands 7, 5, and 3. NAIP imagery is acquired in natural color and has a spatial resolution of 1m. To serve as a surrogate for the panchromatic 15m ETM+ band, DN values from the 3 NAIP color bands were summed and divided by 3. This intensity image was then degraded (resampled) to 15m. Since NAIP is collected just once during the growing season, this single date was used for all three (spring, summer, fall) merges. The Brovey Transform, a simple mathematical technique, was used to merge the data. The formulae used are:

RED = band7(band2+band5+band7)*Pan
GREEN = band5(band2+band5+band7)*Pan
BLUE = band3(band2+band5+band7)*Pan

This product is actually a simulation of a natural color image because the resolution-enhanced image utilizes two infrared bands (7 and 5). The advantage to using the IR bands is a haze-free image with superior image contrast. The trade-off is that the color of some features is exaggerated (e.g., dry or senescent vegetation will appear as shades of purple and orange rather than taupe and tan) and in some cases may be inaccurate (e.g., wet bare fields appear blue-gray).

GeoTIFF Export

All county-tiled data products were exported from ERDAS Imagine files to GeoTIFF files. To minimize the need for users to adjust image contrast and brightness when displaying the visual products, data values were rescaled (stretched) for the panchromatic, false-color infrared composite, and the resolution-enhanced natural color composite images. The contrast stretch uses the following steps:

1. Calculate the mean and standard deviation for the entire image.

2. Calculate two gray-level values (Z1 and Z2), which are X standard deviation units below (Z1) and above (Z2) the mean. Where X = 3.0 for panchromatic imagery, X = 2.0 for FCC imagery, and X = 2.2 for resolution-enhanced imagery.

3. The range Z1 to Z2 represents the range of gray-levels that will be mapped to the new range of 0 to 255. The input range of 1 to Z1 is mapped as 1 and the input range of Z2 to 255 is mapped as 255 (saturation).

The general equation for stretching image data values between Z1 and Z2 is:

stretch value = (original image value - Z1) * (255 / (Z2 - Z1))

The two raw data images files were not stretched for export.

File Naming Convention

Except for the NAIP pan image, file names consist of the 2-letter county code, an underline ('_'), a six-digit date (month, day, year), and a 3-5 letter mnemonic for the image type. NAIP pan file names consist of the 2-letter county code and the character string '_NAIP05_pan'.

Mnemonics:

mult: original visible and near-IR 30m data (6 bands)
therm: original thermal 60m data (1 [TM] or 2 [ETM+] bands)
ndvi: Normalized Difference Vegetation Index image (1 band)
fcc: False Color Composite image (3 bands)
fuse: resolution-enhanced/fused (3 bands)

Example name #1: jf_062205fcc.tif. This file name is for the false color composite image of Jefferson County that was acquired June 22, 2005.

Example name #2: jf_NAIP05_pan.tif. This file name is for the NAIP panchromatic image of Jefferson County that was acquired in 2005.

Summary

For all 105 counties in Kansas, a spring, summer, and fall data set comprised of raw image data and derived image products was constructed and exported into GeoTiff format. The KSID 2004-2005 was constructed using terrain-corrected, precision rectified Landsat 5 Thematic Mapper (TM) imagery. Six of the sixteen the path/row image triplicates date wholly from either 2004 or 2005, while the other ten image triplicates use images from both 2004 and 2005. Although best available imagery was acquired for the 2004-2005 TM image database, not all best available imagery was cloud-free. Twenty-three counties contained some type and extent of haze or cloud cover. Two county image dates were contaminated with haze and were left as is. Eighteen counties were contaminated with varying degrees of cloud cover on one date, while three counties were contaminated with cloud cover on two dates. For five cloud contaminated county scenes an alternate, more cloud-free, image set was created.

Appendix 1

Suggestions for Displaying Images in ArcMap

Displaying the NAIP Panchromatic, TM False Color Composite, and TM Resolution-enhanced images.
The NAIP panchromatic, TM false color composite (fcc), and TM resolution merged (fuse) images have been stretched to provide good brightness and contrast for application in both GIS and simple graphic display. The display background value of '0' should be set to 'No Color'.

Displaying the NDVI images.
The NDVI image has been given a color ramp color scheme. Low NDVI values are represented by dark brown, while high NDVI images are represented by dark green. This color scheme is standardized between counties (i.e., values and colors are directly comparable). If desired, the NDVI image can be displayed in black-and-white. Using a stretch similar to that described next will improve contrast. The display background value of '0' should be set to 'No Color'.

Displaying the Landsat TM images.
ArcMap will display multiband tif images. The initial defaults for the display are to assign bands 1,2,3 to RGB with no stretch. The defaults do not produce a satisfactory display for viewing. Two standard ways (a and b) and one enhanced way (c), of displaying Landsat TM imagery are given below.

To modify the display, begin by opening the Layer Properties for the tif and select Symbology, then follow the instructions for the type of display desired:

a) False color composite (traditional)
1. set Band assignment 4,3,2 to RGB
2. under Stretch, set Type to Standard Deviations with 'n' set between 2 and 3
3. build histogram for bands by clicking Histograms
4. set Display Background Value of '0' to 'No Color'

b) False color composite (enhanced grasslands)
1. set Band assignment 4,5,6 to RGB
2. under Stretch, set Type to Standard Deviations with 'n' set between 2 and 3
3. build histogram for bands by clicking Histograms
4. set Display Background Value of '0' to 'No Color'

c) Natural color composite
1. set Band assignment 3,2,1 to RGB
2. under Stretch, set Type to Standard Deviations with 'n' set between 2 and 3
3. build histogram for bands by clicking Histograms
4. set Display Background Value of '0' to 'No Color'