REMOTE SENSING TOOLS FOR STATEWIDE MANAGEMENT: DEVELOPING A LANDSAT 7 IMAGERY DATABASE OF KANSAS

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ABSTRACT

The Kansas Applied Remote Sensing (KARS) Program of the Kansas Biological Survey (KBS) is developing a publicly available multi-seasonal statewide Landsat 7 data archive of Kansas. This opportunity became available for two reasons: a reduced cost in Landsat satellite imagery and the ability to freely distribute the data to the public. The archive will consist of precision rectified spring, summer, and fall Landsat 7 Enhanced Thematic Mapper (ETM+) imagery in formats easily accessible to end users. Each rectified scene is being subset to create a database tiled by county allowing end users to quickly and easily display their area of interest. Each county will have 15 (3 dates, 5 products) images/maps.

This satellite archive will offer educational and research opportunities to government and non-government entities and individuals and enables state agencies to conduct statewide assessments. The Landsat 7 Imagery Archive also will address a variety of policies and programs identified in the Kansas State Water Plan (SWP), including identifying relationships between surface water quality and land use, identification and inventory of agricultural land use types that contribute to non-point source pollution, and providing current information about the location of structures and infrastructure that lie in the floodplain. This database will also be the basis for making

future updates to the Kansas Land Cover Map by exploring automated land use/land cover classification techniques in several pilot projects.

INTRODUCTION

The use of satellite data is becoming more extensive as imagery becomes available from an expanding array of sensors. Near real-time data can be useful to numerous agencies, allowing them to respond quickly to environmental changes. Potential end users include people in the fields of agriculture, civil engineering, education, disaster management, urban planning, resource development, and environmental monitoring.

Previously, Landsat satellite imagery was relatively expensive to acquire ($4400 per scene) and subject to licensing restrictions, hindering distribution in the public domain. The Kansas Applied Remote Sensing (KARS) Program has developed two other TM databases of Kansas. The first database consists of 16 scenes (single-date) dating from 1988 to 1991 and was used to create the Kansas Land Cover Patterns Map. At that time, the TM data itself cost more than $70,000 (Whistler et al, 1995). The second database is multi-seasonal and consists of 48 scenes (three dates per path/row) dating from 1991 to 1997 (Egbert et al, 2001). Today the cost of a Landsat 7 scene is approximately $600 for radiometrically corrected data. The reduced cost of Landsat 7 imagery combined with the ability to freely distribute the data to the public presents a unique opportunity to develop satellite imagery archives for distribution to the public. This has been a goal for nation-wide projects such as AmericaView, a consortium established to expand the use of remotely sensed imagery. AmericaView began with the OhioView Consortium as a pilot program used to identify organizations that require delivery of natural science data in near real-time and ensuring the infrastructure is in place to support such a program. AmericaView now includes California, Mississippi, Ohio, and Texas (as of December 2001) all with the goal of making satellite data easily available to the public. Supplying current geospatial data is also a goal of U.S. Geological Survey (USGS), to address this concern they proposed the National Map project. The vision of that project is that by 2010 the USGS will provide the nation with current, accurate, nationally consistent basic spatial data, including digital data and derived topographic maps (USGS, 2001).

Several state and federal agencies in Kansas have indicated that land use/land cover information is important to their management and planning missions including the Kansas Department of Wildlife and Parks, Kansas Department of Revenue, Kansas Geological Survey and the US Geological Survey. To assist in achieving that goal, in fiscal year 2002, the Kansas GIS Policy Board allocated funds for the Landsat 7 Imagery Database of Kansas. The Landsat 7 Imagery Database was also supported by other state agencies such as the Kansas Biological Survey and Kansas Department of Wildlife and Parks through a cost-share agreement to help purchase imagery.

Landsat 7 was launched in April 1999 and carries the Enhanced Thematic Mapper Plus (ETM+) sensor. The ETM+ sensor offers improvements over previous Landsat sensors, including the addition of a panchromatic band that provides enhanced spatial detail and absolute radiometric calibration techniques that provide higher quality data. Sixteen ETM+ scenes are necessary to provide full coverage for the state of Kansas. Landsat 7 imagery consists of eight wavelength bands in the following portions of the electromagnetic spectrum: 1) blue (.45-.52 µm); 2) green (.53-.61µm); 3) red (.63 - .69 µm); 4) near-infrared (.75-.90 µm); 5) mid-infrared (1.55-1.75 µm); 6) thermal (10.4-12.5 µm); 7) mid-infrared (2.09-2.35 µm); and 8) panchromatic (.52-.90 µm). All bands have a spatial resolution of 30 m except the thermal band (60 m) and the panchromatic band (15 m).

We will acquire a spring, summer and fall image for every path/row in Kansas. The rationale for acquiring three dates of imagery is based on our recent research experience. Classification or identification of vegetated land cover relies on the reflectance properties of the dominant vegetation cover. We have found that to accurately discriminate between vegetation types it is necessary to characterize vegetation over the entire growing season (Price et al, 1997). Our research has explored the utility of land cover classification using from one date of satellite imagery to five dates throughout a growing season. Single date analysis rarely results in accurate classification of all cover types in an agricultural setting over the course of a growing season (Lo et al., 1986).). The use of single-date imagery has resulted in an excessive amount of post-processing manual digitizing to obtain acceptable results (Whistler et al., 1995). Egbert et al, (1995) found that using three dates of satellite data, rather than one, to map Finney County in southwest Kansas increased classification accuracy of cropland by 9% (from 90% using single-date to 99.49 using three dates) and increased accuracy of grassland by than 40% (from 55% to 97.29%). Our research has shown that a minimum of three images, one from spring, one from summer and one from fall, are needed to adequately capture vegetation phenology in Kansas.

DATA ACQUISITION & PROCESSING

Based on previous studies, a triplicate including a spring, summer and fall Landsat Thematic Mapper (TM) scene has been acquired for every path/row in Kansas. The imagery acquired is a mix of 2000 and 2001 data, depending on image quality. After visual inspection of the 2001 data, we discovered that many of the ideal image dates were cloud contaminated. As a result, some cloud-free 2000 scenes were substituted. The ETM+ data were acquired from the EROS Data Center (EDC) and includes both standard EDC products and imagery processed under the Multi-Resolution Land Characteristics (MRLC) 2000 program (Figure 1). The satellite data acquired from MRLC are on a cost-share basis, with the Kansas funding being supplied by the GIS Policy Board and KBS. Standard EDC products contain nine of the TM+ bands (3 visible, 3 infrared, 2 thermal, and 1 panchromatic). MRLC 2000 products do not include the thermal bands, but do include the DEM used for terrain correction

After importing the EDC ETM+ data (non-MRLC) into ERDAS Imagine 8.4 software, we precision rectified the data to Universal Transverse Mercator (UTM) zone 14 using county level digital ortho quads (DOQs) as a georeference source. The MRLC data, which has been previously rectified, was imported into Imagine and reprojected to UTM zone 14.

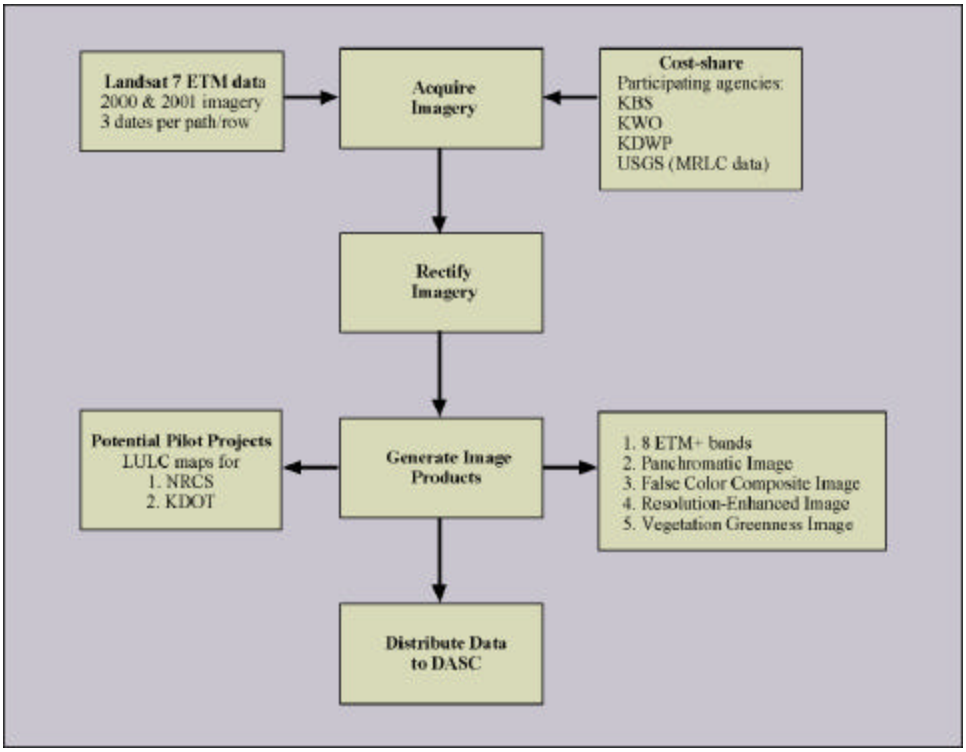

Figure 1. A flowchart illustrating the methodology of developing the Landsat 7 Imagery Database for Kansas.

Two sets of image products will be generated and provided to the Kansas Data Access and Support Center (DASC) for distribution in unsigned 8-bit GeoTIFF format (data values ranging from 0 to 255). The DASC was instituted by the State of Kansas in 1989 by the Geographic Information Systems (GIS) Policy Board to receive, archive, and catalog all core databases, check and verify integrity of data, distribute databases, and promote and assist the use of the core database and GIS technologies. The two sets of products include:

- Eight Landsat ETM+ bands (i.e., the original raw data set)
- A panchromatic image
- A false color-composite image
- A resolution-enhanced natural color composite image, in which the panchromatic band has been merged with a natural color image to produce a sharpened image
- A vegetation greenness map calculated using the Normalized Difference Vegetation Index (NDVI)

The first set of deliverables is designed primarily for visual applications. These products can be easily incorporated into user projects, providing a unique visual reference for viewing existing spatial data. The visual products include a panchromatic image, a sharpened natural color-composite image, and a false color-composite image. Using a spatial resolution merge function the sharpened natural color-composite will be created by integrating high spatial resolution of the panchromatic band with a natural color composite (bands 3, 2, and 1) (Figure 2b). This image product essentially provides high spatial resolution data in color. The false color-composite will be created using a subset (a 4, 3, 2 band combination) of the multispectral data set (Figure 2c).

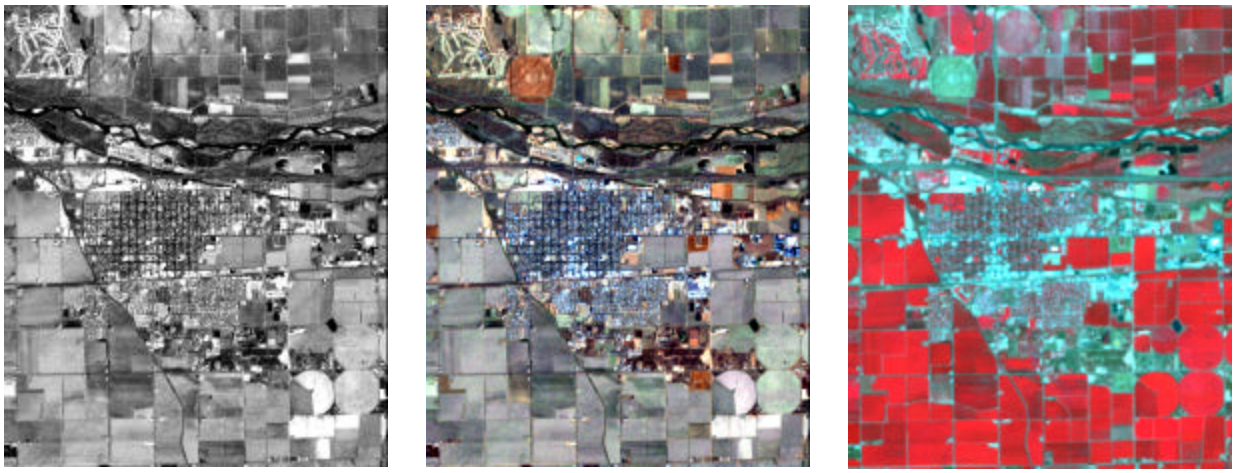

Figure 2a. The panchromatic band with 15m spatial resolution, **2b**. A resolution-enhanced natural color composite (pan merged with multispectral bands 3, 2, and 1), **2c**. A false-color composite (bands 4, 3, and 2).

The second set of products consists of actual data and includes the raw multispectral bands and the panchromatic band from Landsat 7 and NDVI (Figure 3 and 4). The raw bands will be pre-processed (i.e. registered to a map coordinate system) allowing more advanced users to further process the data to meet their specific needs (Figure 3). The products generated from these user applications potentially will provide more valuable additions to available statewide data. For example, the raw data and NDVI can be used in environmental modeling applications. NDVI can be used as a measure of primary productivity while the raw satellite data could potentially be used to determine surface roughness, or to identify impervious surfaces or specialized local land cover maps.

All of the data products will be mosaicked together to create the statewide coverage of Kansas. The statewide coverage will then be tiled by county creating a relatively small file size for quick and easy display. Each county will have 15 (3 dates, 5 products) images/maps.

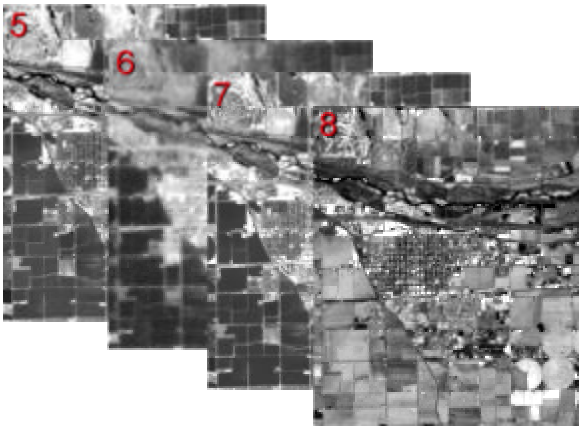

Figure 3. An example of the eight Landsat ETM+ bands.

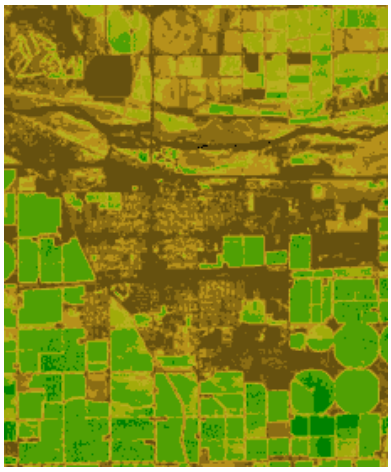

Figure 4. An example of a Normalized Difference Vegetation Index (NDVI) map.

PILOT PROJECTS

Several pilot projects will also be conducted using the 2000-2001 image archive. A general land cover patterns map at the Anderson Level 1 level will be created for a single county in order to explore how rapidly land use/ land cover maps can be generated with acceptable accuracy. Previous statewide land cover mapping projects using satellite imagery have taken three to four years to complete. Map classes will be: commercial/industrial, residential, urban openland, urban woodland, urban water, cropland, grassland, woodland, water, and other.

State agencies have also contacted us in regard to specialized image-derived products that will be useful to them. For example, the Natural Resource Conservation Service (NRCS) has contacted us about a pilot project involving watershed quality. This would entail producing a land cover map that would separate row crops from small grain crops that would then be used as one of several inputs into their existing models. We plan to develop a methodology for this project using unsupervised classification in Barber County. Creating a more in-depth agricultural land cover map differentiating between different crop types (Figure 5), and a map estimating the extent of riparian areas are also pilot projects that will be completed.

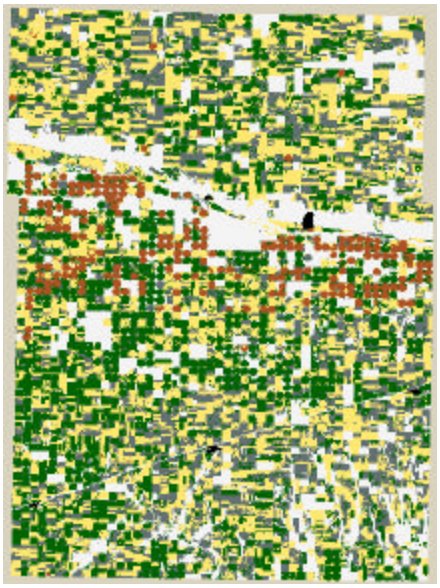

Figure 5. This agriculture map of crop types in Gray County Kansas was created using 1992 satellite imagery and indicate the spatial distribution of alfalfa, wheat, milo, soybeans, corn and fallow fields.

EXPECTED BENEFITS

The expected benefits of creating the Landsat 7 imagery database include:

- Remove the burden from users of learning pre-processing techniques and software.
- Provide near real-time data and image products for planning and decision-making activities.
- Multiple products (image products and raw data) will be available to meet a variety of end-user needs.
- Provides the basis for making updates to current state-wide land use/land cover maps.

Land cover mapping and change detection are just two of the many applications that can be conducted with this database. The satellite archive, and the derived data created from the archive, will also enhance the use of existing spatial data resources. This satellite archive offers educational and research opportunities to government and non-government entities and individuals. For example, the Kansas Department of Revenue, Property Valuation Division (PVD) has interest in using the database to identify changes in land use to assist in determining land valuation. In addition, the Kansas Department of Wildlife and Parks (KDWP) will be acquiring multi-date imagery to help address management issues in the Flint Hills. Ideally, with ongoing support and interest from government and non-government entities, this project will serve as an initial effort to continually make Landsat imagery of Kansas available to the public.

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