Developing an Enterprise GIS for Interdisciplinary Research

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Biofuels and Climate Change: Farmers’ Land Use Decisions
Broad Research Objectives

• Employ qualitative and quantitative analysis to understand farmers’ responses under:
  • changing climate conditions
  • emerging biofuel feedstock markets

• Assess impact of land use decisions on
  • water quantity (e.g., groundwater)
  • water quality

• Model future Kansas climate conditions and farmers’ responses.
Biofuels and Climate Change: Farmers’ Land Use Decisions

Funding

National Science Foundation

KU Transportation Research Institute

FY: 2009-2014
Biofuels and Climate Change: Farmers’ Land Use Decisions
Interdisciplinary Research Team

- Dietrich Earnhart (Economics)
- Joseph Aistrup (Political Science)
- Jason Bergtold (Agricultural Economics)
- Chris Bishop (KARS)
- Chris Brown (Geography, Enviro. Studies)
- Nate Brunsell (Geography)
- Marcellus Caldas (Geography)
- Kevin Dobbs (KARS)
- Kyle Douglas-Mankin (Engineering)
- Stephen Egbert (Geography)
- Johannes Feddema (Geography)
- Jane Gibson (Anthropology)
- Russell Graves (Agricultural Economics)
- Eric Hanley (Sociology)
- Nathan Hendricks (Agricultural Economics)
- Jude Kastens (KARS)
- Laszlo Kulcsar (Sociology, Anthro, Social Work)
- Dave Mechem (Geography)
- Kate Meyer (Spencer Museum of Art)
- Joane Nagel (Sociology)
- Dana Peterson (KARS)
- Jeffrey Peterson (Agricultural Economics)
- Larry Schwarm (Art)
- Val Smith (Ecology and Evolutionary Biology)
- Belinda Sturm (Environmental Engineering)
- Stacey White (Urban Planning, Enviro. Studies)
GIS Team Tasks

**Year 1:** Develop a statewide LULC time-series (2000-2012)
- Enhance existing data
  - Irrigation mapping
  - Take pixel level classification and create field level representations
- Create LULC in years where no data were available

**Year 2:** Focus of the GIS Team changed
- Purchase of databases from FarmMarket iD (FMiD), LULC mapping no longer needed.
- With a better understanding of types and quantity of data, developed a need for data integration and an enterprise GIS.

**Year 3:** Focus of the GIS Team changed
- Limited use of FMiD data, LULC mapping needed (2003-2012)

Lesson #1: Research projects and tasks can & often evolve.
GIS & Cyberinfrastructure Team

- Chris Brown, Team Lead
- Stephen Egbert, Team Lead
- Dana Peterson, Research Assistant, GIS Coordinator
- Kevin Dobbs, Research Assistant
- Vijay Barve, GRA, PhD
- Jude Kastens, Research Assistant Professor
- Gina Ross, Research Assistant, Cyberinfrastructure
- Chris Bishop, Research Assistant
- Ryan Callihan, GRA, MA
- Emma Averna, Undergraduate
Desktop to Enterprise

• Once we began receiving data, realized desktop ArcGIS and Access couldn’t manage: the types, volume and integration of data.

• Conduct multi-scale analysis of farmers’ land use decisions in Kansas, including grower level and field level.

• Multiple people or teams may need access to the data.

• All relationship types present:
  • 1-to-1
  • 1-to-Many
  • Many-to-Many

• Multiple data sets are sensitive and proprietary.
  • Non-disclosure agreement
  • KU’s Information Technology Policy
Desktop to Enterprise

• Challenges:
  • No existing framework to leverage.
  • No clear vision on who will use what data, how it will be used and how it will need to be accessed.
  • No specific research questions to guide framework or to prioritize data collections and database related tasks.
  • → goal was to build a GIS to allow for flexibility and expansion.
Enterprise GIS

• ARCSDE and Microsoft SQL 2008 relational database management system (RDBMS).

• Dell server outfitted with dual 6-core processors, 64Gb of RAM, and a 2Tb hard-drive.

• Create and use a “test database” to explore and integrate data. Once data are final, move to a “production database”.

• Replicate the production database at KSU.

• Database maintenance plan: weekly local back-ups and monthly offsite back-ups.
Spatial Units for Analysis*

*(To Date)

County

Grower

Field
Spatial Data

Administrative/Political Boundaries:
- State, County
- Zip-Code
- PLSS

Level I-IV Ecoregions

Hydrologic Unit Codes (HUCs)
- Hydrography (NHD)
- Rail & Road Networks
- Biofuel & Grain Elevators

Agricultural Statistic Districts

Water Rights for Irrigation
Spatial Data

**Climate (NARR & PRISM):** 1970-2012, Daily & Monthly; Tmin, Tmax, Precip (32km and 4km). Stored as grid footprints and SQL tables.

**Soils:** gsURRGO (10m); SSURGO processed incorrectly twice.

**Terrain:** Elevation, Slope & Aspect; (10m NED)

*Lesson #2: Conduct your own QAQC of incoming data. Establish metadata requirements (including scripts and coding).*
Spatial Data

Statewide Land Use & Land Cover Time-Series (2003-2012):

• Enhance existing LULC data (2005-2012)
  • Map irrigation status by crop type using MODIS NDVI time-series.
  • Generalize pixels to a meaningful unit (field level).
• Create LULC maps (2003 & 2004)
  • Map crop type & irrigation status using Landsat TM & MODIS NDVI.
CLU to Field

• “A Common Land Unit (CLU) is the smallest unit of land that has a permanent, contiguous boundary, a common land cover and land management, a common owner and a common producer association. “

• 2007 Spatial CLU boundaries purchased (& associated tabular data from FMiD).
Field Delineations

- County level CLU have varying levels of spatial detail.

Refined field boundaries are used for generalization of LULC and creation of grower and field level databases.
Tabular Data

Rural Household Data
- 23,000 Growers
- County
- Grower
- Name
- Address
- Gender
- DOB

Grower Totals
- 2000-2011
- County
- Grower
- Corn
- Sorghum
- Soybean

Successful Farm Survey
- County
- Grower
- Corn Total
- Corn Conventional Till Acres
- Corn No Till Acres
- Sorghum Total

Farm Service Agency Compliance Data
- Records 14.8 M; 2003-2007
- County
- Grower
- Field
- Crop Type
- Crop Description
- Irrigation Status

Crop Insurance Data
- 2000-2010
- County
- Grower
- Crop Year
- Crop Type
- Insurance Plan Code
- Yield Year 1...Yield Year 10

KARS NSF EPSCoR
Biofuels and Climate Change: Farmers’ Land Use Decisions
Lessons Learned

Lesson #3:

Expensive data ≠ quality data.

- Significant time devoted to develop novel approaches to QAQC tabular data purchased.

- Temporal linkages broke between the FSA data (crop type and irrigation) and field boundaries represented in the CLU.

<table>
<thead>
<tr>
<th>Year</th>
<th>% of FSA Data Joins to a Field</th>
</tr>
</thead>
<tbody>
<tr>
<td>2007</td>
<td>69%</td>
</tr>
<tr>
<td>2008</td>
<td>66%</td>
</tr>
<tr>
<td>2006</td>
<td>63%</td>
</tr>
<tr>
<td>2005</td>
<td>57%</td>
</tr>
<tr>
<td>2004</td>
<td>55%</td>
</tr>
<tr>
<td>2003</td>
<td>18%</td>
</tr>
</tbody>
</table>
Tabular Data

Demographics
- County
- Demographics
- Education
- Employment
- Farm Numbers
- Government
- Operator

Income
- County
- Farm Income and Expenses
- Income
- Kansas Farm Wages
- Personal Income by Industry
- Sales

Crop Production
- County
- FSA Acreage
- Acres Harvested
- Acres Planted
- Crop Production (Total)
- Crop Production (Yield)

Irrigation
- County
- Groundwater Depth
- Groundwater Energy Use
- Groundwater Irrigation
- Surface water irrigation

Livestock
- County
- Beef Cow Inventory
- Calf Crop
- Cattle on Feed Inventory
- Milk Cow Inventory
- Number of Feedlots

Policy
- County
- Federal Payments
- CRP Enrollment
- EQUIP Data
- EQUIP Acres
- CRP Rates
Surveys & Interview Data

- This data provides meaningful context for results in various modeling and analysis.

Community Surveys

- County
- Grower
- Field
...

Farmer Interviews

- County
- Grower
- Coded, nvivo software
Photography

http://larryschwarm.com/Kansas%20Farmers.html
And more data...

- Distance from each grower to another grower within a 100mi radius
- Distance from each grower to each biofuel plant and grain elevator
- Weather Research and Forecasting (WRF) Model data
- County level water budget models, 12 variables
Data Integration

- Tabular data are imported into SQL and registered to the geodatabase.
- Spatial data are imported into the geodatabase.
- Spatial data are integrated using multi-level unions.
Data Access & Visualization

• Remote Database Access
  • Users have unique id’s and passwords with varying levels of access and permissions.
  • Users login to the GIS server with their unique id and password to create a customized query for data extracts.
  • OR email data query/request to the GIS team and the data extract is generated and provided to the data user.

• Data extracts are data views and/or spatial views.
Create Query
Views within SQL
Counts of Farms by County with: Continuous Grower Totals Data (98-09), Rural Household Data, Successful Farming Survey Data, and Spatial Representation in the 2007 CLU Boundaries

The spatial representation of the farms are displayed in green.
Online Data Access

- Individual datasets archived in GeoNetwork Metadata Catalogue
Online Data Access
Online Data Access

- Unique user names and passwords assigned to protect sensitive data.
Online Data Access
Data Access and Output

While the quantity of data continues to grow:

• Number of remote users = 1
• Number of data views created for team members = 1
• Number of requests for online data access = 4
• Number of web mapping applications requested = 0

Requested Data Output:

• County level dataset, multiple .csv files
• Grower level dataset, multiple .csv files
• Field level dataset, multiple .csv files
Lesson #4: Not all people understand how, why and when to use spatial data.

- This may take time.
- More effort for collaborative research among team members is key.
  - Explore data together.

- Researchers outside of the geospatial community may not understand the efforts required to generate, integrate and manage data.
**Additional Challenges:**

- There may be such a thing as data hoarders. To help prioritize tasks we inquire how the data will be used, is it an immediate data need, future or on a wish list.
- There is little time for novel GIS or remote sensing research questions.
- Metadata and documentation
  - No built in mechanism in SQL to document processing (outside of commenting queries).
- How will ongoing maintenance of the database be funded after project ends?
Research Outcomes

• Given the challenges our team faced, there is a lot of interesting research coming from this project.

• Individuals and teams are interested in the spatial element of their research. Increased collaboration with our team and other teams.

• The database is a infrastructure and capacity building endeavor that can be leveraged for future funding opportunities and research.
Research Outcomes

• Evaluation of empirical models coupled with EUTROMOD for water quality prediction in Kansas reservoirs
• Factors Affecting Farmers’ Willingness to Grow Alternative Biomass Feedstocks for Biofuels across Kansas
• Crop Supply Dynamics and the Illusion of Partial Adjustment
• Opportunities and Constraints: Actor-Networks, Farmer Decisions, and Identity
• ‘Tractorettes’ or Partners? Farmers’ Views on Women in Kansas Farming
• Hyper-Extractive Counties in the U.S.: A coupled-systems approach
• Effects of Great Plains Irrigation on Regional Climate
Research Outcomes

• Economic Linkages to Changing Landscape
• The Effects of Weather on Agricultural Profits and the Role of Irrigation
• Agricultural Land-Use and Spatial Proximity to Ethanol Production: A County-Level Analysis Within Kansas
• Factors Affecting CRP Re-enrollment Decisions in Kansas
• ‘Til the Well Runs Dry: Water Scarcity, Climate Change and Farmer Adaptations in Southwestern Kansas
• Water Quality Perceptions vs. Reality: Lessons for Planners
Research Outcomes

Billboards on our highways now proclaim, 1 Kansas Farmer Feeds 155 People + You. In 1978, the number was 55.

The sharp increase is a testament to Kansas productivity. Agriculture is the number one industry in the state, and 100% of the food we depend on is grown here.

On the other hand, this statistic masks complex realities, such as the declining number of farmers in Kansas, the increasing size of farms, the rising global population, and the slippery slope of defining the term "food." Most Kansas farmers grow wheat, grains, corn, soybeans, or soy, much of which is used to feed cattle, not people. These commodities become familiar grocery items, but their journey from field to plate is a long one.

Farmers

To better understand the role Agriculture plays in our daily lives and our daily food, scientists are looking to Kansas farmers.

32% of Kansas farmers are older than 54. The average Kansas farmer is more likely to be white and male.

1 in 5 Kentuckians, rural and urban, work in jobs related to Agriculture and Food Production.
• Questions?

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