Exploratory Use of Raster Images for Freight Modeling

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TRB – SHRP2 SYMPOSIUM
Innovations in Freight Demand Modeling and Data Improvement

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Outline

- California Statewide Freight Forecasting Model
- CropScape
- FAF Disaggregation
- Agriculture Seasonality Analysis
- Other public GIS datasets
CSFFM

• Commodity based
• Developed using FAF3
  – Aggregated to 15 commodity groups
  – All agricultural products are in the same group
• 97 Freight Analysis zones in California
• US network (only major truck routes outside CA)
• Will be integrated with California Statewide Travel demand Model (CSTDM) passenger travel model
  – Spatial disaggregation needed
  – Temporal disaggregation needed
CSFFM

Output from generation/ distribution

Commodity 1 -> Day 1
Commodity 2 -> Day 2
... -> ...
Commodity n -> Day 365

% of total flows moved on each day

Carried over to mode split and assignment

FAF matrices
CropScape

- Project of the United States Department of Agriculture*
- Raster images for all 48 contiguous states from 2008 onwards (since 1997 for some states)

* - [http://nassgeodata.gmu.edu/CropScape/](http://nassgeodata.gmu.edu/CropScape/)
General characteristics

- Developed using remote sensing technology
- Each pixel is 0.77 acre
  - Virtually any spatial aggregation can be used for modeling purposes
- Accuracy:
  - “Generally, the large area row crops have produced accuracies ranging from mid 80% to mid 90%”
- 105 different crops identified
  - 5 types of developed areas and 23 other area types
Obtaining an image

• All areas viewed by remote sensing every 5 days
  – Each pixel in each picture is classified according to its reflectance (256 levels of gray in the picture)
• Ground truth is checked and used to correlate classes to actual soil use (different crops, barren land, water, populated areas, etc.)
• The annual picture is created in consideration of all the classifications for each pixel in each image
CropScape Timeline

- **Start of CropScape**
- **All states become available**
- **Resolution is nearly doubled**
- **New Satellite sensor goes on use**
- **Newest set of satellites start being used**
CropScape Processing

• CropScape presents processed state AND county data for 2010-12
• Images for 2012 sum up to about 13.8Gb
• Processing with free software is painless
  – GDAL tools inside GRASS*
  – Scripting with Python is trivial
• Processing of all images for 2012 on a current high powered laptop takes less than 3h

* - [http://grass.osgeo.org/](http://grass.osgeo.org/)
### Processing Example

The table below shows the land use and area in acres and percentage of the county area for various types of land use in San Joaquin County:

<table>
<thead>
<tr>
<th>Use</th>
<th>Area (acres)</th>
<th>% of County area</th>
</tr>
</thead>
<tbody>
<tr>
<td>Walnuts</td>
<td>74,165</td>
<td>8%</td>
</tr>
<tr>
<td>Alfalfa</td>
<td>73,224</td>
<td>8%</td>
</tr>
<tr>
<td>Corn</td>
<td>70,949</td>
<td>8%</td>
</tr>
<tr>
<td>Grapes</td>
<td>57,885</td>
<td>6%</td>
</tr>
<tr>
<td>Almonds</td>
<td>53,950</td>
<td>6%</td>
</tr>
<tr>
<td>Tomatoes</td>
<td>42,535</td>
<td>5%</td>
</tr>
<tr>
<td>Other Crops</td>
<td>172,151</td>
<td>19%</td>
</tr>
<tr>
<td>Open Land</td>
<td>203,332</td>
<td>22%</td>
</tr>
<tr>
<td>Developed Areas</td>
<td>124,281</td>
<td>14%</td>
</tr>
<tr>
<td>Water</td>
<td>32,776</td>
<td>4%</td>
</tr>
<tr>
<td>Forrest</td>
<td>6,780</td>
<td>1%</td>
</tr>
</tbody>
</table>

![San Joaquin Map Image]
FAF Disaggregation

- FAF* is one of the primary sources for data used to develop freight models
- Frequent topic in the literature
  - Applications in Florida, New Jersey, Washington DC, etc.
- Lack of variables for less than county geographies
  - Agriculture is one of the industries with the least amount of available data

* - http://www.ops.fhwa.dot.gov/freight/freight_analysis/faf/
Disaggregating Agricultural Products

• FAF3 baseline is 2007, but CropScape is only available starting in 2008
  – Disaggregation of 2011 provisional FAF with 2011 CropScape
  – Disaggregation of FAF 3 with 2008 CropScape data

• There is a LOT more that can be tried
  – 30 different grain crops
  – 75 non-grain crops
## Disaggregating Agricultural Products

<table>
<thead>
<tr>
<th>MODELS</th>
<th>Variable 1</th>
<th>Variable 2</th>
<th>R²</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Description</td>
<td>Coefficient (t-test)</td>
<td>Description</td>
</tr>
<tr>
<td>FAF group 1</td>
<td>Live animals &amp; Fish</td>
<td>Pasture land</td>
<td>0.0864 (8.17)</td>
</tr>
<tr>
<td>FAF group 2</td>
<td>grains</td>
<td>All grains crop area</td>
<td>1.511 (37.87)</td>
</tr>
<tr>
<td>FAF group 3</td>
<td>Other crops (non pasture, grains or animal feed)</td>
<td>Other crops (non pasture, grains or animal feed)</td>
<td>-</td>
</tr>
<tr>
<td>FAF Group 4</td>
<td>Animal Feed</td>
<td>Crops related to animal feed (hay, haylage)</td>
<td>2.68E-07 (1.99)</td>
</tr>
<tr>
<td>FAF groups 1-4</td>
<td>All grains crop area</td>
<td>Other crops (non pasture, grains or animal feed)</td>
<td>1.7524 (21.16)</td>
</tr>
</tbody>
</table>
## Disaggregating Agricultural Products

<table>
<thead>
<tr>
<th>MODELS</th>
<th>Variable 1</th>
<th>Variable 2</th>
<th>R²</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Description</td>
<td>Description</td>
<td></td>
</tr>
<tr>
<td>FAF group 1</td>
<td>Pasture land</td>
<td></td>
<td>0.37</td>
</tr>
<tr>
<td>Live animals &amp; Fish</td>
<td>4.1E-05 (6.45)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>FAF group 2 grains</td>
<td>All grains crop area</td>
<td>-</td>
<td>0.54</td>
</tr>
<tr>
<td>Grains</td>
<td>9.95E-04 (8.97)</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>FAF group 3 Other crops</td>
<td>ALL Crops</td>
<td>-</td>
<td>0.38</td>
</tr>
<tr>
<td></td>
<td>9.71E-05 (6.49)</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>FAF Group 4 Animal Feed</td>
<td>Crops related to animal</td>
<td>Pasture</td>
<td>0.18</td>
</tr>
<tr>
<td></td>
<td>feed (hay, haylage)</td>
<td>6.95E-04 (1.41)</td>
<td></td>
</tr>
<tr>
<td>FAF groups 1-4</td>
<td>All grains crop area</td>
<td></td>
<td>0.55</td>
</tr>
<tr>
<td></td>
<td>1.38E-03 (9.28)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
More to explore

• Several commodity groups could be disaggregated with CropScape:
  – Construction related commodities could be disaggregated by using developed area information
  – Logs for paper/construction can be disaggregated using areas classified as forests
Agricultural forecasts

- CropScape allows for the estimation of currently unused land:
  - Provides an upper limit on planted areas
  - Allied to estimates of future yields, it is a robust forecasting tool
  - Expansion of planted area can be tracked
- Precipitation raster images are also available
Seasonality Analysis

• Why compute seasonality factors?
  – FAF presents yearly flows and agriculture is highly seasonal

• Is it possible to use other data sources?
  – Yes, but only CropScape covers ALL crops and areas consistently
Seasonality Analysis

- CropScape
  - Crop Areas
  - Production Summer
  - Production Fall
  - Production Winter
  - Production Spring

- USDA
  - Yields
  - Harvesting periods

% in each season

- FAF
  - Yearly demand
  - FAF Summer
  - FAF Fall
  - FAF Winter
  - FAF Spring
Seasonality Analysis
VegScape

- Information on vegetation vigor/strength
- Just launched in April 2013
- Much coarser resolution than CropScape (~15 acre)
- **Daily/Weekly** information
Other available GIS databases

• USDA – Natural Resources Conservation Service*
  – Topography / Elevation (raster)
  – Conservation Easements (vector)
  – National Land Cover Data Set (NLCD) (raster)
  – Hydrography (vector)
  – Annual average temperatures (vector)
  – Precipitation (vector)