Remote Sensing of Agriculture

NASS’ Cropland Data Layer Program

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USDA/NASS
NASS Overview

Provider of timely, accurate, and useful statistics in service to U.S. agriculture
Research and Development Division
Geospatial Information Branch
Spatial Analysis Research
Remote Sensing Acreage Estimation Program

Objectives

- “Census by Satellite”
  - Without area duplication
  - Major corn and soybean regions

- Provide timely, accurate, useful independent estimates
  - Measurable error
  - County and state level

- Public domain crop specific crop classification
  - [http://nassgeodata.gmu.edu/CropScape](http://nassgeodata.gmu.edu/CropScape)
  - [NRCS Geospatial Data Gateway](http://www.nass.usda.gov/research/Cropland/SARS1a.htm)
  - [http://www.nass.usda.gov/research/Cropland/SARS1a.htm](http://www.nass.usda.gov/research/Cropland/SARS1a.htm)
  - Google CropScape!
What is the Cropland Data Layer (CDL)?

The Cropland Data Layer product is a raster-formatted, geo-referenced, crop specific, land cover map.

Released Jan. 31, 2012
National 30m Product
2011 Cropland Data Layer Inputs

Satellite Imagery – Landsat

Satellite Imagery – Deimos & UK2

Farm Service Agency: Common Land Unit

2006 NLCD & Derivative products
Landsat Imagery
1997-2012

Landsat 5 launched 1984 (3 yr design life!)
  – Thematic Mapper (TM) Sensor
Landsat 7 launched 1999 Thematic Mapper (ETM+) Sensor
The Landsat Data Gap

Landsat 7 ETM+

Landsat 5 TM

Source: USGS, Landsat Project:

News Release

November 30, 2005  Ron Beck

Landsat 5 Experiencing Technical Difficulties

On November 26, 2005, the back-up solar array drive on Landsat 5 began exhibiting unusual behavior. The solar array drive maintains the proper pointing angle between the solar array and the sun. The rotation of the solar array drive became sporadic and the solar array was not able to provide the power needed to charge the batteries. Maintaining power to the batteries is critical to sustain proper operation of the spacecraft. The primary solar array drive failed under similar circumstances last January. As a result of this current situation, imaging operations will be suspended for at least the next two weeks or until attempts to solve the problem have been resolved.
Deimos and UK2 Micro Satellites

(22-metre, multi-spectral DMC imager
600km imaging swath)
# Sensor Specifications Compared

<table>
<thead>
<tr>
<th></th>
<th><strong>TM</strong></th>
<th><strong>Deimos/UK2</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Launch Date</strong></td>
<td>1984</td>
<td>2009</td>
</tr>
<tr>
<td><strong>Altitude</strong></td>
<td>705 km</td>
<td>686 km</td>
</tr>
<tr>
<td><strong>Temporal Resolution</strong></td>
<td>16 days</td>
<td>4 days</td>
</tr>
<tr>
<td><strong>Spatial Resolution</strong></td>
<td>30 x 30 m (reflective) 120 x 120 m (thermal)</td>
<td>22 x 22 m (reflective)</td>
</tr>
<tr>
<td><strong>Radiometric Resolution</strong></td>
<td>8 bit (256)</td>
<td>10 bit (1024)</td>
</tr>
<tr>
<td><strong>Spectral Resolution</strong></td>
<td>6 (B, G, R, NIR, SWIR, MIR) + Thermal IR</td>
<td>3 (G, R, NIR)</td>
</tr>
<tr>
<td><strong>Swath wide</strong></td>
<td>185 km</td>
<td>600 km</td>
</tr>
</tbody>
</table>
Image Timing

Source: National Agricultural Statistics Service (NASS), Crop Progress Report

Cropland Data Layer Program
Components

- Satellite Imagery: Landsat TM, Deimos and UK2 data
- Ground truth: FSA/CLU + 578 & NLCD
- Ancillary data sets
- Commercial Software Suite
- See5 Decision Tree Methodology
- Estimation
- CropScape
Ground Truth – Land Cover

**Agriculture Ground Truth**
Provided by Farm Service Agency
Identifies known fields and crops

Divide known fields into 2 sets
70% used for training software
30% used for validating results

**Non-Agriculture Ground Truth**
USGS National Land Cover Dataset
Identifies urban infrastructure and non-agriculture land cover
Forest, grass, water, cities
Cropland Data Layer Program Components

- **Satellite Imagery:** Landsat TM and Deimos and UK2 data
- **Ground truth:** FSA/CLU + 578 & NLCD
- Ancillary data
- **Commercial Software Suite**
- **See5 Decision Tree Methodology**
- Estimation
- **CropScape**
Ancillary Data – USGS/NASA Products

Elevation

Imperviousness

Forest Canopy

NASA MODIS Terra
(16-day NDVI composite)
Cropland Data Layer Program
Components

- **Satellite Imagery**: Landsat TM, Deimos and UK2 data
- **Ground truth**: FSA/CLU + 578 & NLCD
- **Ancillary data sets**
- **Commercial Software Suite**
- **See5 Decision Tree Methodology**
- **Estimation**
- **CropScape**
Commercial Software Suite

- Imagery Preparation
  - Leica Geosystems ERDAS Imagine
- Image classification
  - Decision tree software
    - See5.0 [www.rulequest.com](http://www.rulequest.com)
- Ground Truth Preparation
  - ESRI ArcGIS
- Acreage Estimation
  - SAS/IML workshop
See5 Decision Tree Classifier

State-of-the-art technique for image classification

- Relatively cheap ($750)

Incorporates a powerful ensemble method known as “boosting”

The “NLCD Mapping Tool” was integrated into ERDAS Imagine

- Provided gratis by USGS
Accuracy Assessments

<table>
<thead>
<tr>
<th>Cover Type</th>
<th>Attribute Code</th>
<th>Correct Pixels</th>
<th>Correct Accuracy</th>
<th>Producer's Error</th>
<th>Omission Error</th>
<th>Kappa</th>
<th>User's Accuracy</th>
<th>Commission Error</th>
<th>Cond'l Kappa</th>
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<td>Corn</td>
<td>1</td>
<td>28358</td>
<td>95.36%</td>
<td>4.64%</td>
<td>0.9528</td>
<td>93.08%</td>
<td>6.92%</td>
<td>0.9297</td>
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<td>Cotton</td>
<td>2</td>
<td>11757</td>
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<td>4.92%</td>
<td>0.9505</td>
<td>94.59%</td>
<td>5.41%</td>
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<td>Rice</td>
<td>3</td>
<td>2</td>
<td>28.57%</td>
<td>71.43%</td>
<td>0.2857</td>
<td>66.67%</td>
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<td>Sorghum</td>
<td>4</td>
<td>21251</td>
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<td>0.8972</td>
<td>92.46%</td>
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<td>Soybeans</td>
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<td>13.85%</td>
<td>0.8604</td>
<td>88.61%</td>
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<td>Sunflowers</td>
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<td>102</td>
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<td>10.53%</td>
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<td>0.9014</td>
<td>92.09%</td>
<td>7.91%</td>
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<td>21</td>
<td>785</td>
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<td>0.7194</td>
<td>97.39%</td>
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<td>Durum Wheat</td>
<td>22</td>
<td>48</td>
<td>42.86%</td>
<td>57.14%</td>
<td>0.4286</td>
<td>100.00%</td>
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<td>Spring Wheat</td>
<td>23</td>
<td>205</td>
<td>56.47%</td>
<td>43.53%</td>
<td>0.5647</td>
<td>99.03%</td>
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<td>Winter Wheat</td>
<td>24</td>
<td>580437</td>
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<td>2.46%</td>
<td>0.9631</td>
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<tr>
<td>Other Small Grains</td>
<td>25</td>
<td>1120</td>
<td>56.97%</td>
<td>43.03%</td>
<td>0.5694</td>
<td>93.57%</td>
<td>6.43%</td>
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<tr>
<td>Win Wht/ Soyb Dbl Crop</td>
<td>26</td>
<td>14758</td>
<td>79.51%</td>
<td>20.49%</td>
<td>0.7932</td>
<td>90.06%</td>
<td>9.94%</td>
<td>0.8996</td>
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<td>Rye</td>
<td>30</td>
<td>13249</td>
<td>66.90%</td>
<td>33.10%</td>
<td>0.6664</td>
<td>91.39%</td>
<td>8.61%</td>
<td>0.9129</td>
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<td>Oats</td>
<td>28</td>
<td>2941</td>
<td>64.85%</td>
<td>35.15%</td>
<td>0.6479</td>
<td>95.18%</td>
<td>4.82%</td>
<td>0.9517</td>
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<td>Millet</td>
<td>29</td>
<td>439</td>
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<td>22.98%</td>
<td>0.7701</td>
<td>96.48%</td>
<td>3.52%</td>
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<td>Canola</td>
<td>31</td>
<td>337</td>
<td>75.90%</td>
<td>24.10%</td>
<td>0.7590</td>
<td>98.83%</td>
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<td>Alfalfa</td>
<td>36</td>
<td>19653</td>
<td>88.21%</td>
<td>11.79%</td>
<td>0.8807</td>
<td>91.78%</td>
<td>8.22%</td>
<td>0.9168</td>
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<tr>
<td>Dry Beans</td>
<td>42</td>
<td>115</td>
<td>88.46%</td>
<td>11.54%</td>
<td>0.8846</td>
<td>93.50%</td>
<td>6.50%</td>
<td>0.9350</td>
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<tr>
<td>Potatoes</td>
<td>43</td>
<td>49</td>
<td>96.08%</td>
<td>3.92%</td>
<td>0.9608</td>
<td>100.00%</td>
<td>0.00%</td>
<td>1.0000</td>
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<tr>
<td>Other Crops</td>
<td>44</td>
<td>50</td>
<td>45.87%</td>
<td>54.13%</td>
<td>0.4587</td>
<td>80.65%</td>
<td>19.35%</td>
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<tr>
<td>Misc Veggies &amp; Fruits</td>
<td>47</td>
<td>33</td>
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<td>45.90%</td>
<td>0.5410</td>
<td>86.84%</td>
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<tr>
<td>Watermelon</td>
<td>48</td>
<td>24</td>
<td>77.42%</td>
<td>22.58%</td>
<td>0.7742</td>
<td>85.71%</td>
<td>14.29%</td>
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<td>Peas</td>
<td>49</td>
<td>188</td>
<td>72.59%</td>
<td>27.41%</td>
<td>0.7258</td>
<td>96.91%</td>
<td>3.09%</td>
<td>0.9691</td>
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<tr>
<td>Clover/Wildflowers</td>
<td>58</td>
<td>21</td>
<td>36.21%</td>
<td>63.79%</td>
<td>0.3621</td>
<td>75.00%</td>
<td>25.00%</td>
<td>0.7500</td>
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<tr>
<td>Fallow/Idle Cropland</td>
<td>61</td>
<td>30612</td>
<td>69.78%</td>
<td>30.22%</td>
<td>0.6922</td>
<td>90.48%</td>
<td>9.52%</td>
<td>0.9025</td>
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<tr>
<td>Peaches</td>
<td>67</td>
<td>9</td>
<td>36.00%</td>
<td>64.00%</td>
<td>0.3600</td>
<td>100.00%</td>
<td>0.00%</td>
<td>1.0000</td>
<td></td>
</tr>
<tr>
<td>Other Tree Nuts &amp; Fruit</td>
<td>71</td>
<td>69</td>
<td>33.82%</td>
<td>66.18%</td>
<td>0.3382</td>
<td>83.13%</td>
<td>16.87%</td>
<td>0.8313</td>
<td></td>
</tr>
</tbody>
</table>

*Correct Pixels represents the total number of independent validation pixels correctly identified in the error matrix.
## Accuracy Assessments

<table>
<thead>
<tr>
<th>Cover Type</th>
<th>Attribute Code</th>
<th>Correct Pixels</th>
<th>Producer's Accuracy</th>
<th>Omission Error</th>
<th>Kappa</th>
<th>User's Accuracy</th>
<th>Commission Error</th>
<th>Cond'k Kappa</th>
</tr>
</thead>
<tbody>
<tr>
<td>Corn</td>
<td>1</td>
<td>2197719</td>
<td>96.58%</td>
<td>3.42%</td>
<td>0.9226</td>
<td>97.86%</td>
<td>2.14%</td>
<td>0.9509</td>
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<td>Soybeans</td>
<td>5</td>
<td>1471094</td>
<td>96.24%</td>
<td>3.76%</td>
<td>0.9392</td>
<td>95.78%</td>
<td>4.22%</td>
<td>0.9320</td>
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<td>Corn</td>
<td>5</td>
<td>2258219</td>
<td>98.06%</td>
<td>1.94%</td>
<td>0.9527</td>
<td>98.58%</td>
<td>1.42%</td>
<td>0.9650</td>
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<td>Soybeans</td>
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<td>1339089</td>
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<td>3.64%</td>
<td>0.9438</td>
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<td>Corn</td>
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<td>1856422</td>
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<td>2.71%</td>
<td>0.9605</td>
<td>97.32%</td>
<td>2.68%</td>
<td>0.9608</td>
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<td>Soybeans</td>
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<td>849249</td>
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<td>4.17%</td>
<td>0.9513</td>
<td>96.95%</td>
<td>3.05%</td>
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<td>5</td>
<td>803251</td>
<td>94.29%</td>
<td>5.71%</td>
<td>0.9342</td>
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<td>Soybeans</td>
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<td>4.97%</td>
<td>0.9439</td>
<td>97.72%</td>
<td>2.28%</td>
<td>0.9741</td>
</tr>
</tbody>
</table>

State level accuracies are very high

- **Producer’s Accuracy**: relates to the probability that a ground truth pixel will be correctly mapped and measures errors of omission.
- **Errors of Omission**: occur when a pixel is excluded from the correct category.
- **User’s Accuracy**: indicates the probability that a pixel from the classification actually matches the ground truth data and measures errors of commission.
- **Errors of Commission**: occur when a pixel is included in an incorrect category.
- **Kappa Coefficient**: A statistics measure of agreement, beyond chance, between two maps.
Cropland Data Layer Program
Components

- Satellite Imagery: Landsat TM, Deimos and UK2 data
- Ground truth: FSA/CLU + 578 & NLCD
- Ancillary data sets
- Commercial Software Suite
- See5 Decision Tree Methodology
- Estimation
- CropScape
Regression-based Acreage Estimator

Regression used to relate categorized pixel counts to the ground reference data

- \( (X) \) – Cropland Data Layer (CDL) classified acres
- \( (Y) \) – June Agricultural Survey (JAS) reported acres

Using both CDL and JAS acreage results in estimates with reduced error rates over JAS alone

Outlier segment detection - removal from regression analysis

Acreage not just about counting pixels
<table>
<thead>
<tr>
<th>Month</th>
<th>Crop Production Report</th>
<th>Crop Acreage Report</th>
<th>Small Grains Annual Summary</th>
<th>Historical: Crop Production Annual Summary</th>
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</thead>
<tbody>
<tr>
<td>January</td>
<td>CDL all crops</td>
<td>CDL winter wheat</td>
<td>CDL small grains</td>
<td>CDL all crops/county estimates</td>
</tr>
<tr>
<td>February</td>
<td>CDL all crops</td>
<td></td>
<td></td>
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<tr>
<td>March</td>
<td></td>
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<tr>
<td>April</td>
<td>CDL all crops</td>
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<td>May</td>
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<td>June</td>
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<td>July</td>
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<td>October</td>
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<tr>
<td>November</td>
<td></td>
<td></td>
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</tbody>
</table>
Upcoming Release:
2008 & 2011 national coverage

Future portal upgrade:
Map Printing
Change detection
Cultivated masks/crop intensity

nassgeodata.gmu.edu/CropScape
CropScape

• CropScape web portal
• A web service based interactive map visualization, dissemination and querying system for U.S. cropland
  – No burden on users
    • No client software development & installation
    • No special software tools needed
  – Equitable cropland information access, automatic and timely delivery, geospatial navigation, retrieval, queries and dissemination

• Collaboration with George Mason University/ Center for Spatial Information Science and Systems
CropScape Cont.

- State of the art CDL visualization, querying and dissemination tool
- Interactive geospatial statistical analysis tools
  - Online/interactive analytics, charting and mapping
  - Geospatial information access, navigation
  - CDL map and statistical result retrieval and dissemination web services
- Open geospatial standards compliant
CropScape Portal Defined

Visual Tools
Point Query
Stats/Change/Download

Layer/Legend
AOI Query

Map Overview
Select Area of Interest

Select a State
State: Iowa

Select an ASD
ASD: [Select an ASD...]

Or Select a County
County: [Select a county...]

Define Area of Interest By State/ASD/County
- [Reset]
- [Submit]
- [Cancel]

www.nassgeodata.gmu/CropScape

State
ASD
County

Iowa
Pocahontas
CropScape Change Analysis

Cropland Data Layer Changes between 2009 and 2008

<table>
<thead>
<tr>
<th>2009</th>
<th>2008</th>
<th>Pixel Counts</th>
<th>Acreage</th>
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<tbody>
<tr>
<td>Rice</td>
<td>Soybeans</td>
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<td>103453.6</td>
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<tr>
<td>Soybeans</td>
<td>Rice</td>
<td>129916</td>
<td>100674.7</td>
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<tr>
<td>Cotton</td>
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<td>Soybeans</td>
<td>Soybeans</td>
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<td>NLCD - Developed/Open Space</td>
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<td>85414</td>
<td>66189.2</td>
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<tr>
<td>NLCD - Woody Wetlands</td>
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<td>83660</td>
<td>64830</td>
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<td>NLCD - Deciduous Forest</td>
<td>NLCD - Deciduous Forest</td>
<td>73312</td>
<td>56811.1</td>
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</tr>
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Note: Pixel counts are not official estimates.
CropScape Download & Export

Specify Years and Projection

Preview and Download

nassgeodata.gmu/CropScape
CropScape w/ Google Earth

nassgeodata.gmu/CropScape
CDL Distribution

- http://nassgeodata.gmu.edu/CropScape
- http://www.nass.usda.gov/Research_and_Science
Thank you

Questions?

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USDA/NASS/RDD
Feb 22, 2012