Using Remote Sensing for Direct Land Use Change Detection Related to Biofuels Production

September 2018
Types of Land Use Change Analysis

- Direct Comparison Between Years

2008

2017

Difference
Types of Land Use Change Analysis

- Spectral Changes Between Years

<table>
<thead>
<tr>
<th></th>
<th>2008</th>
<th>2017</th>
<th>Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Blue</td>
<td>6</td>
<td>4</td>
<td>2</td>
</tr>
<tr>
<td>Green</td>
<td>6</td>
<td>0</td>
<td>6</td>
</tr>
<tr>
<td>Red</td>
<td>6</td>
<td>0</td>
<td>6</td>
</tr>
<tr>
<td>NIR</td>
<td>32</td>
<td>6</td>
<td>26</td>
</tr>
</tbody>
</table>

Spectral Curve

- Blue
- Green
- Red
- NIR
## Land Use Accuracies

<table>
<thead>
<tr>
<th>Land Use</th>
<th>2008 Accuracy</th>
<th>2017 Accuracy</th>
<th>Potential Combined Accuracy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Corn</td>
<td>94%</td>
<td>84.40%</td>
<td>78.4%</td>
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<tr>
<td>Soybeans</td>
<td>96.40%</td>
<td>89.60%</td>
<td>86.0%</td>
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<tr>
<td>Winter Wheat</td>
<td>60%</td>
<td>61.50%</td>
<td>21.5%</td>
</tr>
<tr>
<td>Non-Ag Areas</td>
<td>78%</td>
<td>85.10%</td>
<td>63.1%</td>
</tr>
</tbody>
</table>
Actual Accuracy for Converted Areas with Brazil as an Example

2001 Accuracy Likelihoods In Brazil
- <50% likelihood correct
- 50% likelihood correct
- 100% likelihood correct

Red Areas Were Predicted to Be Forest in 2001 and Crops In 2007

- Change is not predicted to occur where accuracies are highest
- EPA Stochastic Analysis performed using highest accuracies

Accuracy Likelihood for All Forested Areas in Brazil 2001: 90%
Accuracy Likelihood for All Crop Areas in Brazil 2007: 69%
Accuracy Likelihood for Specific Forested Areas Converted to Crop in Brazil 2001: 59%
Accuracy Likelihood for Specific Crop Areas Converted from Forest in Brazil 2007: 62%
"Reducing Errors"

a) Raw CDL Data

2007 CDL

2008 CDL

Remove any unlikely scenarios: Any scenario where conversion back and forth from forest to ag. These are most likely mixed areas.

b) Correct for Road Buffers and Unlikely Rotations

2010 CDL

2009 CDL

Quarter acre road buffers neutralize Mixed classes along roadways

c) Vetted Change Matrix

<table>
<thead>
<tr>
<th>2007</th>
<th>2010</th>
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</thead>
<tbody>
<tr>
<td>Unimportant classes</td>
<td></td>
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<tr>
<td>Crop</td>
<td>Crop</td>
</tr>
<tr>
<td>Crop</td>
<td>Pasture/Hay</td>
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<tr>
<td>Crop</td>
<td>Forest</td>
</tr>
<tr>
<td>Pasture/Hay</td>
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<tr>
<td>Forest</td>
<td>Urban</td>
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<tr>
<td>Urban</td>
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</table>
New 2017 Study on Remote Sensing Errors in Land Use Analysis

• Some studies assert that ecologically important, carbon-rich natural lands in the United States are losing ground to agriculture.

• We investigate how quantitative assessments of historical land-use change (LUC) to address this concern differ in their conclusions depending on the data set used in 20 counties in the Prairie Pothole Region using:
  o the Cropland Data Layer,
  o a modified Cropland Data Layer dataset,
  o data from the National Agricultural Imagery Program,
  o and in-person ground-truthing.

We find:
  o The Cropland Data Layer analyses overwhelmingly returned the largest amount of LUC with associated error that limits drawing conclusions from it.
  o Analysis with visual imagery estimated a fraction of this LUC.
  o Clearly, analysis technique drives understanding of the measured extent of LUC; different techniques produce vastly different results that would inform land management policy in strikingly different ways.
  o Best practice guidelines are needed.
Total Cropland

Figure 1. Total cropland hectares and individual crop hectares from 1920 to 2015.
CDL vs. NAIP vs. Groundtruthing
Using the Cropland Data Layer or the Modified Cropland Data Layer (with aggregated classes) produces significantly higher land use change than NAIP and ground truthing.
Cropland Data Layer Total Corn Acres Compared to USDA NASS Statistics

Planted
Harvested
CDL

CDL to Planted
CDL to Harvested
Are In-field Buffers Included in Ag Acreage?

2017 NAIP Image

Dekalb County, IL

2017 Cropland Data Layer

- Forest
- Grass
- Soybeans
- Corn
Project Team

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• Ken Copenhaver, Managing Director, CropGrower LLC
• Jennifer B. Dunn, Ph.D., Director of Research, Northwestern-Argonne Institute of Science and Engineering, Research Associate Professor, Chemical and Biological Engineering
• Yuki Hamada, Ph.D., Biophysical Remote Sensing Scientist; Environmental Science Division; Argonne National Laboratory/ Argonne National Laboratory
The goal of this research effort is to provide insights into the accuracy of using different methods of analysis on remotely sensed imagery to determine land use change such as land use conversion associated with bioenergy crop production.

This analysis is particularly important in the light of current and future corn demand for ethanol production including increased ethanol demand from higher ethanol blends to produce higher octane fuels.

It is important to gain the scientific understanding of why different remote sensing instruments and classification methodologies result in different land use change areas.
Relevant Works

- The proposed research improves and builds on analyses techniques developed by the project team since inception of the RFS2 and refined over the years.
- Of particular interest to this project is an analysis where Mueller and Copenhaver identified the corn draw area around the Illinois River Energy Center (now CHS Rochelle) and determined land use characteristics before and after the ethanol plant start up.
- Land use change accuracy in that study was improved by removing roadway layers and field fringes as well as unlikely multiple native, non-native conversions in short time frames.

Figure 3: ProExporter polygon for Illinois River Energy plant
Relevant Works

- The analysis created a land demand balance which assessed corn demand created by the ethanol plant against corresponding rotational adjustments, land offsets from DDG production, land offsets from yield increases, and finally native land conversions.
- The overall land demand balance for the corn draw area was indicative of whether indirect land use pressure was created by the plant and the associated error analysis established the uncertainty of the estimates.
Additional Considerations

• The recently revised Renewable Energy Directive Two (RED2) released June 2018 by the European Council provides some additional insights which should be of interest for indirect land use considerations.

• The RED2 creates blending quotas for ethanol classified as low indirect land use change risk biofuels if the feedstock comes
  o from feedstock land for example that is double cropped (cover cropped);
  o generates crop yields through improved inputs and management practices (including presumably field buffer strips); including better fertilization, seeds and equipment;
  o expands agriculture on previously non-agricultural land with low carbon stock and low biodiversity value, and other considerations.
  o Detailed guidance documents are currently being drafted by European certification bodies and will be available shortly.
Research Approach

- We will select 1 ethanol plant in each of the following states for which we will determine land use change and establish the land demand balance: CO, IN, IL, IA, KS, KY, MI, MN, MO, NE, ND, SD, OH, WI.

- The diversity of states ensures that ethanol operations include regions with mature corn growing areas as well as sensitive regions such as parts of the Prairie Pothole Region.

- We will work with the sponsoring states to obtain the ethanol and DDG production values, to evaluate effect on reducing demand for animal feed, for the studied ethanol plants.
Research Approach

2) We will perform a land use change assessment for each of these ethanol plants using 2006/2007 and 2017/2018 Cropland Data Layers. We will incorporate several methods to quantify error (including the use of the new USDA Cropland Data Layer confidence layers) and explore error reduction:

- combination of classifications
- road way removal
- field fringe buffer removal.
Research Approach

- Field fringes and buffer layers created by the CDL will also be compared to the land use change analysis to determine locations that may be identified as change but are actually confusion generated by the buffers (which may go into and out of agriculture from year to year as they are typically about the width of one pixel).
- To reduce this source of error we will utilize imagery from the Sentinel-2A and Sentinel-2B satellites to create a buffer mask and remove that layer from the analysis (similar to the roadway layer).
3) Using the newly released USDA confidence layers for the CDL classifications, we will also examine the error specific to locations identified as change.

- We will evaluate whether the accuracy at these locations is greater, less than, or commensurate with the error of the overall classification.
- Furthermore, we will consider how this location-specific error will impact the overall accuracy of identified land use change.
Research Approach

4) We will randomly select at least 100 and 200 points where land use change was and was not delineated by the CDL layer, respectively.

We will have two different people visually assess each of these points using USDA NAIP aerial photography at a 0.6 to 2 meter resolution from 2006/2007 and 2017/2018 to determine the likelihood that land use change occurred in this area. Automated scripts will allow for the rapid production and assessment for the locations in the photography.

- If within the 200 random points where change has not occurred in the CDL the NAIP reanalysis finds locations where land use change has in fact occurred (according to an assessment of the NAIP photography) but was not identified by the CDL classifications these would be errors of omission.
- The 100 points where land use change was identified will be examined to determine errors of commission (identifying land use change that did not occur but was targeted as change by the CDL).
Research Approach

• We will quantify several additional considerations relevant to the indirect land use discussion including
  o the establishment of field buffers, double cropping/cover cropping, fallow/unused lands, release of CRP lands.
  o Where datasets are available (such as in Illinois for 2017), the group will calculate total acres in double crop/cover crop and in conservation tillage in ethanol plant draw areas as well as CRP release (just for land use consideration, not as calculable credits for carbon sequestration).

• Note: In some situations, for some states, 2007 and/or 2017 NAIP photography may not be available. We will select the year most approximate (2008 or 2016) if this does occur.
Questions/Comments/Discussion