CUYAHOGA COUNTY URBAN TREE CANOPY & LAND COVER MAPPING

FINAL REPORT

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**OVERVIEW**

At the request of Cuyahoga County, SavATree, in collaboration with the University of Vermont’s Spatial Analysis Laboratory (SAL), mapped high-resolution land cover for Cuyahoga County, Ohio (Figure 1) to support a follow-on Urban Tree Canopy (UTC) assessment. An object-based approach was employed in which a combination of remotely sensed data (imagery and LiDAR) and vector GIS datasets were used to extract land cover. The output consisted of two land cover datasets, a 7-class and a 10-class, both of which are based on summer 2011 ground conditions. In addition, several supporting datasets were delivered included updated building footprints, updated hydrology polygons, an image mosaic, and LiDAR surface models.

![Figure 1. Area of Interest (AOI) for the project, which consists of the entirety of Cuyahoga County, Ohio.](image)

**MATERIALS AND METHODS**

**Source Data**

The list of datasets used for the land-cover classification are presented in Table 1.

<table>
<thead>
<tr>
<th>Data</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>Leaf-on National Agricultural Imagery Program (NAIP) 2011 4-band aerial imagery</td>
<td>USDA</td>
</tr>
<tr>
<td>Leaf-off 2011 3-band color infrared aerial imagery</td>
<td>CEGIS</td>
</tr>
<tr>
<td>LiDAR point cloud, 2006</td>
<td>CEGIS</td>
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<tr>
<td>----------------------------</td>
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<tr>
<td>Building polygons</td>
<td>CEGIS</td>
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<tr>
<td>Road polygons</td>
<td>CEGIS</td>
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<tr>
<td>Property parcel polygons</td>
<td>CEGIS</td>
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<tr>
<td>Hydrography polygons</td>
<td>CEGIS</td>
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<tr>
<td>Impervious surface polygons</td>
<td>NEORSD</td>
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</tbody>
</table>

**Software**

- Image preparation tasks such as mosaicking and clipping were performed in ERDAS IMAGINE 2013.
- All vector processing and editing tasks were performed using ArcGIS 10.2.
- LiDAR datasets were prepared in Quick Terrain Modeler 8.0.0.
- eCognition 8.9 was used for all object-based land cover classification.

**Hardware**

- Image processing and vector processing/editing were performed using a variety of Dell workstations with 6-12GB of RAM and dual/quad-core processors.
- LiDAR preparation and object-based classification were performed on a Dell Precision T7500 workstation with 96GB of RAM and dual XEON quad core processors.

**Methods**

**Approach**

The final workflow for the land cover mapping is presented in Figure 2. In general, the project was comprised of three phases: 1) data preparation, 2) individual class feature extraction, and 3) composite land-cover mapping.
Figure 2. Workflow diagram showing the source data, processing steps, intermediate output, and deliverables.

**Data Preparation**

During the data-preparation phase, both the 2011 NAIP and 2011 aerial imagery were mosaicked into composite image datasets. A composite raster Normalized Digital Surface Model (nDSM) representing the height of features relative to ground was generated from the first return LiDAR point cloud data. A composite raster Normalized Digital Terrain Model (nDTM) representing the height of features relative to ground was generated from the last return LiDAR point cloud data. For loading into eCognition, the CEGIS color infrared 2011 imagery was resampled to 1ft resolution and were diced into tiles measuring 2000ft x 2000ft with 200-ft overlap between tiles (Figure 3).
FEATURE EXTRACTION

Hydrography polygons were edited to reflect the 2011 imagery. Tree canopy was mapped using a rule-based expert system within eCognition (Figure 4), then manually edited at a scale of 1:2,500. In a similar fashion buildings were updated to 2011 conditions first through the implementation of a rule-based expert system within eCognition, then through manual edits. The design, development, and implementation of the rule-based expert system within eCognition followed MacFaden et al. (2012) and O’Neil-Dunne et al. (2012). Bare soil could not be accurately mapped using automated processes and thus was done entirely through heads-up digitizing. Minor edits were made to the roads and railroads datasets through heads-up digitizing.
COMPOSITE LAND COVER MAPPING

These updated datasets, plus the roads, railroads, and impervious vector datasets were loaded into eCognition to generate the final land cover datasets. The output was then subjected to quality assurance/quality control (QA/QC) procedures in which manual edits were performed. GIS technicians who digitized polygons on top of the land-cover raster; each polygon was assigned a “from” class and a “to” class. The actual process of modifying the draft land-cover map was subsequently performed in eCognition using a routine that re-classified individual objects according to each manually-digitized corrections polygon. In this process, all pixels encompassed by a corrections polygon and belonging to the “from” class were converted to the “to” class. If no “from” class was present, all pixels in the polygon were converted to the “to” class. The corrections process produced tiled raster output, which was subsequently merged into a single raster land-cover mosaic. Two separate land cover products were generated, a 7-class land cover and a 10-class land cover. The 7-class land cover represents a strict top-down approach to mapping in which tree canopy, regardless of the features underneath the canopy, was classified as tree canopy (Figure 5). The 10-class land cover subdivided the tree canopy based on the underlying features. The classes for the 7-class tree canopy consist of: (1) tree canopy, (2) grass/shrub, (3) bare earth, (4) water, (5) buildings, (6) roads, and (7) other paved surfaces. The classification system for the 10-class land cover dataset are: (2) grass/shrub, (3) bare earth, (4) water, (5) buildings, (6) roads, (7) other paved surfaces, (8) tree canopy over vegetation or soil, (9) tree canopy over building, (10) tree canopy over road/railroad, and (11) tree canopy over other paved surfaces (class 1 was left empty so as to distinguish from the 7-class land cover). Both land cover datasets were stored as 4-bit rasters in ERDAS IMAGINE (.img) format.
Figure 5. Example of the final 7-class land cover product.

**DELIVERABLES**

1. Updated building polygons
2. Updated hydrography polygons
3. eCognition rule set
4. 7-class land cover dataset
5. 10-class land cover dataset
6. LiDAR surface models
7. Final presentation via webinar
8. Final report
CONCLUSIONS

This project succeeded in mapping land cover for the Cuyahoga County urbanized area with a high level of accuracy. The project was able to achieve its goals by leveraging existing data. The 7-class land cover will be useful for producing tree canopy and land cover metrics consistent with the USDA Forest Service’s UTC Assessment protocols to support a UTC assessment. Following the completion of the UTC assessment the data can be used to assist in prioritizing locations for new tree planting initiatives (see Locke et al., 2013 and Locke et al., 2010).

LITERATURE CITED


ACKNOWLEDGEMENTS

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