Remote Sensing to ID Ash Trees in Urban Forests
September 22, 2015

Jason Krueger – Ayres Associates

Fugui Wang – Applied Ecological Services
Ayres Geospatial Services

Digital orthoimagery
Aerial and ground-based LiDAR
Planimetric and topographic mapping
GIS consulting
GPS and conventional survey
Key Technical Terms

*Just-in-Time Flight*

*Multispectral Imagery*

*First Return LiDAR DSM*

*Segmentation*

*Classification*

*Ground Truthing*

*User/Producer Accuracy*
Emerald Ash Borer
(Agrilus planipennis)

- EAB discovered near Detroit, MI in 2002
- May 2010, EAB was found in 14 States and 2 Provinces
- EAB spread 2009-2019 on 25 State area of developed land reveal
- 38M landscape ash trees in the area
- Responses include treatment, removal & replacement of >17M ash trees to cost up to $10.7B
This map is current as of August 6, 2014.
Emerald Ash Borer (*Agrilus planipennsis*)

 Dundreary.png

ndsu.edu

dnr.wi.gov
Emerald Ash Borer (*Agrilus planipennis*)
What is at Stake?

Urban Aesthetics (Property Value)

Energy Consumption (Heating/Cooling)

Stormwater Retention

Safety

Economics Impacts!!! Municipal and Private
Why Trees Matter...

Ecosystem services provided by urban trees

- Air pollutant reduction ($O_3$, $NO_2$, $SO_2$, $PM_{10}$)
- $CO_2$ sequestration
- Energy savings & avoided emissions due to shading
- Stormwater runoff reduction
- $$$ Aesthetic value (increased market value)

-Corvallis, Oregon Technical Report

...Ecosystem Services
Over their lifetime, street tree benefits exceed the cost of planting and care, representing 300% ROI.
What is at Stake?
Cost of Removal & Treatment

- Ann Arbor, MI: ~ $4 million to cut down 10,000 trees
- Chicago, IL: estimated ~ $150 mil to remove/replace 97,000 ash trees
- Milwaukee, WI: ~ $600K to treat 13,000 ash trees in 2009
- $10+ billion for removal/treatments in urban & suburban areas over next 10 years.

- [www.DontMoveFirewood.org](http://www.DontMoveFirewood.org) -
Identifying Ash Trees for EAB Management and Mitigation Through Remote Sensing

**GOALS**
Identifying Ash Trees for EAB Management and Mitigation Through Remote Sensing

Ayres and AES Recognize a Problem and an Opportunity to Help

• Programmatic approach to identifying concentrations of ash trees (public right-of-way and private lands).
  
  – Communities have focused on public lands, but no less an issue on private lands

• Establish a baseline of existing forest canopy.

• Data for mitigation efforts (inspections, removals, treatments, replanting).
Identifying Ash Trees for EAB Management and Mitigation Through Remote Sensing

R&D initiative between Ayres & AES

- Test site – abundance of quality data (geospatial and ground trothing)
- Ability to economically acquire new imagery where needed
- Select an area that is already deeply affected
GIS Consortium

Bensenville  Mundelein
Buffalo Grove  Norridge
Carol Stream  Northbrook
Crystal Lake  Oak Brook
Deerfield  Oak Park
Des Plaines  Park Ridge
Elk Grove  River Forest
Glen Ellyn  Riverside
Glen Ellyn  Rolling Meadows
Glen Ellyn  Schiller Park
Glen Ellyn  Skokie
Glen Ellyn  Tinley Park
Highland Park  Skokie
La Grange  Wheeling
La Grange  Winnetka
Lake Forest  Woodridge
Lincolnshire  Woodridge
Lincolnwood  Woodridge
Morton Grove  Woodridge
Municipal Mapping Applications

Base Mapping

Orthoimagery

Topographic Mapping

Planimetric Mapping
Geospatial Tools

Important Considerations for Designing an Approach:

• Data Sources:
  o LiDAR
  o Multispectral Imagery
  o Existing vs. New Data

• Ground Truthing

• Analysis software – GIS, Remote Sensing, models
Data Sources Available in Tinley Park

GIS Consortium Base Mapping Data

- 4-band aerial imagery, 3” GSD, collected with an DMCII camera in March 2011.
- 4-band aerial imagery, 3” GSD, collected with an UltraCAM camera in March 2013.
- Planimetric data – impervious surfaces (1” = 50’ map scale).
- Aerial Lidar, 20 points per square meter, collected with a Trimble Harrier 68i in March 2014.

Customized Data

- 4-band aerial imagery, 5.5” GSD, collected with an RCD30 camera in June 2013.
- 4-band aerial imagery, 5.5” GSD, collected with an RCD30 camera in October 2014.

Provided by the Village

- Street tree inventory (2013), Esri geodatabase
Data Sources Available in Tinley Park

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Data Sources Used

1. LiDAR
2. Multispectral Imagery
3. Ground Truthing
4. Software
1. High Density LiDAR (20 ppsm) 
First Return Point Cloud & DSM
First Return LiDAR & Vegetation Classification
2. Multispectral Imagery

4-Band (RGB, IR), RCD30 Camera
Just-in-Time Flight
3. Ground Truthing

Tree Survey ➔ Ash Trees are Red
<table>
<thead>
<tr>
<th>UniqueID</th>
<th>Address</th>
<th>OnSt</th>
<th>Species</th>
<th>DBH</th>
<th>TRUNKS</th>
<th>Cond</th>
<th>MT</th>
<th>SEC</th>
<th>SUBSEC</th>
<th>SEC</th>
<th>PROPART</th>
<th>DEPCT</th>
<th>RATING</th>
<th>EAB</th>
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<td>NE</td>
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<td>Fair</td>
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<td>1a</td>
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"Treatment in progress" sign was present on DBH 12 but there was no evidence of proper treatment. EAB is present.
J.I.T. Ortho vs. Street Tree Inventory
First Return LiDAR vs. Street Tree Inventory
4. Software

**TIFFS**

www.globalidar.com

**eCognition**

www.ecognition.com

**i-Tree**

www.itreetools.org
# Mapping Workflow

1. “Just-in-Time” Imagery **Acquisition**
2. Use of **Ground Truth** Sampling
3. Data **Compilation and Preparation**
4. Data and Imagery **Segmentation**
5. Object Segment **Classification**
6. Supplemental Manual Photo **Interpretation**
7. **Integration** of Analytical and Manual Results
8. Post-processing and **Quality Assessment**
2013- Summer ➔ Tree Vigor

1. “Just-in-Time” Imagery Acquisition
2014-Fall- Species Distinction

1. "Just-in-Time" Imagery Acquisition
LiDAR-Derivates

DEM and DSM
Street Tree Inventory
Data & Imagery Segmentation Results

Object-oriented approach

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<thead>
<tr>
<th>Max_diff</th>
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<th>Mean_Slope</th>
<th>Mean_DSMns</th>
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Polygons With Attributes
Object-Oriented Approach To Classification

Pixel Vs. Object-Originated Approach

<table>
<thead>
<tr>
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<th>Pixel-based</th>
<th>Object-oriented</th>
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<tbody>
<tr>
<td>Basic units</td>
<td>Single pixel.</td>
<td>Object (cluster of pixels).</td>
</tr>
<tr>
<td>Classification algorithms</td>
<td>Conventional statistical techniques</td>
<td>Nearest neighborhood or fuzzy membership function methods</td>
</tr>
<tr>
<td>Classification training</td>
<td>Spectral properties of every pixel in the images</td>
<td>Spectral and spatial/contextual properties of pixels</td>
</tr>
<tr>
<td>Appropriate applications</td>
<td>Coarse resolution of satellite images</td>
<td>Fine resolution of aerial photos</td>
</tr>
<tr>
<td>Classification result</td>
<td>• Pixels are classified into “yes/no” categories</td>
<td>• Objects are assigned to membership of 0 to 1</td>
</tr>
<tr>
<td></td>
<td>• Result in “salt and pepper” appearance</td>
<td>• More effective and more accurate, in particular at areas that are spectrally heterogeneous</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• A relatively new and now widely used to very fine spatial resolution datasets in an automated fashion</td>
</tr>
</tbody>
</table>
The Object-Oriented Approach To Classification

Pixel Vs. Object-Originated Approach

Experiencing improvement in Mapping accuracies by about 15-20%
Late summery/early fall ortho image
LiDAR Feature Heights
Late summery/early fall ortho image
Tree Survey ➔ Ash Trees are Red
Segmentation-Classification
Valuable outputs

- Establish baseline dataset for quantifying canopy gain or loss
- Identify trends – e.g., Where is the canopy expanding or shrinking, and by how much?
- Extract statistics of canopy cover broken down by parcel, neighborhood, town, metro area, etc.
- Identify the most effective locations for planting trees on public and private land
- Updating and maintaining Tree inventory efforts.
- Inform land management decisions
Before EAB
After EAB

Use imagery and remote sensing to:

1. Update “Street” tree inventory
2. Develop data for “Private” trees
### Confusion Matrix

<table>
<thead>
<tr>
<th>Species Group</th>
<th>Acer</th>
<th>Fraxinus</th>
<th>Gledtsia</th>
<th>Other</th>
<th>Pyrus</th>
<th>Quercus</th>
<th>Tila</th>
<th>Sum</th>
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<td>Gledtsia</td>
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<td>22</td>
<td>118</td>
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<td>5</td>
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<td>Tila</td>
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<tr>
<td>Sum</td>
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<td>26</td>
<td>23</td>
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<td>31</td>
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### Accuracy

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<td>0.1470</td>
<td>0.1463</td>
<td>0.50332</td>
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</table>

### Summary

- **Species Focus:** Ash or Fraxinus accuracy: 60-80%
- **Accuracy for Acer and Gledtsia** also showed 60-80% accuracy
- **Other species** would require different timing to achieve acceptable accuracy levels
- **If we had aggregated** pyrus, quercus and tila overall accuracies would be higher
Other Applications

City of Madison - Parks Forestry: “provides tree planting, trimming and maintenance for over **100,000** trees along Madison's 700 miles of city streets. In addition, the Forestry section is responsible for hundreds of thousands of trees that are located in the City's parks, golf courses, cemetery and greenways.”
Oak Wilt

Legend
- Red: Generally infested county
- Light Red: Township with oak wilt

OAK WILT KILLS TREES
avoid trimming trees from april to july
Tree vigor using NDVI
(normalized difference vegetation index)

\[
\text{NDVI} = \frac{(\text{NIR} - \text{VIS})}{(\text{NIR} + \text{VIS})}
\]
Mapping Invasive Species

15,500 Acres for Five Rivers Metropark, Dayton OH

Woody Invasive Species

“Just-in-Time” Multispectral Imagery

Low Altitude Oblique Imagery
Informing Phragmites Management Practices on Great Lakes- Green Bay, Saginaw Bay

EFFICIENCY Reconnaissance of 400 linear miles of inaccessible Shoreline in 2-days
Informing Phragmites Management Practices on Great Lakes

Legend

- Aerial Spraying

Class Names

- Phragmites Live
- Phragmites Detritus
- Phragmites Dead Stems
Mapping of Invasive Species

Woody Invasive Species Mapped in Yellow
Results Vegetation Mapping: Species Distribution

Yellow Boundaries= Wild Rice Distribution
Crop/Vegetation Stress and Failure
Aquatic Vegetation
Questions?

http://www.ayresassociates.com/
http://www.appliedeco.com/

Thank You!