Hydrologic Application of LIDAR Data: Case Study at the UNH Burley-Demeritt Farm

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Presentation Overview

• Intro to LIDAR Technology

• Overview of Agro-Ecosystem Project at UNH Organic Dairy Farm
  • LIDAR Applications for Hydrologic Study at Farm
    • Watershed Delineation
    • Accurate Monitoring Well Elevations
    • Floodplain Delineation
LIDAR: \textbf{L}ight \textbf{D}etection and \textbf{R}anging

- Laser pulses used to determine distance to an object
- GPS system on plane and base station at the site for positioning
- Data synthesized to produce DEM with elevation (+/- 10 cm) mapped on 1 meter horizontal grid
Why LIDAR?

- **HIGH** resolution – 1 m grid size

- Typically Available DEMs
  - USGS Seamless Website / GRANIT
    - 10 m for selected areas
    - 30 m for entire U.S.

- High resolution particularly important for small scale projects like UNH Organic Dairy Farm
LIDAR Data Availability

• National Center for Airborne Laser Mapping (NCALM) out of University of Florida is one of main centers for LIDAR data

• Currently only available on project by project base

• Former UNH Masters Student Dana Truslow received grant through NCALM to have portion of SE NH mapped (~40 km²/15.4 mi²)
Agro-Ecosystem Project at Burley-Demeritt Farm

USDA project with funding from Sustainable Agriculture Research and Education (SARE)

Location: UNH Organic Dairy in Lee, NH
Entire Farm 300 Acres (1.2 km²)

Project Objective: First phase is to measure all material and energy flows across the farm

Our Part: Characterize the hydrology (water budget / groundwater model)

LIDAR Use:
- Watershed Delineation
- Monitoring Well Elevations
- Floodplain Delineation
Watershed Delineation in ArcMAP

In ArcGIS Spatial Analyst Hydrology Toolbox:

1. **FILL** DEM, eliminates sinks

2. Calculate **FLOW DIRECTION** & subsequently **FLOW ACCUMULATION**

3. Designate a pour point (outlet), then **SNAP POUR**

4. **WATERSHED DELINEATION**
Watershed Delineation Comparison

1 meter resolution
341,185 m²

10 meter resolution
283,042 m²

30 meter resolution
291,063 m²
Watershed Delineation Comparison
Implications for Water Budget

<table>
<thead>
<tr>
<th></th>
<th>1 meter</th>
<th>10 meter</th>
<th>30 meter</th>
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<tbody>
<tr>
<td>Watershed Area</td>
<td>341,185 m²</td>
<td>283,042 m²</td>
<td>291,063 m²</td>
</tr>
<tr>
<td>% Change in Area</td>
<td>-</td>
<td>-17%</td>
<td>-15%</td>
</tr>
</tbody>
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Water Budget

\[(P - ET) \times \text{AREA} - Q = \text{Change in Storage}\]

**Water Budget for UNH Organic Dairy Farm from 8/6/09 – 9/26/09**

<table>
<thead>
<tr>
<th></th>
<th>1 meter</th>
<th>10 meter</th>
<th>30 meter</th>
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<tbody>
<tr>
<td>Change in Storage</td>
<td>15,435 m³</td>
<td>13,619 m³</td>
<td>13,870 m³</td>
</tr>
<tr>
<td>% Change in Storage</td>
<td>-</td>
<td>-12%</td>
<td>-10%</td>
</tr>
</tbody>
</table>
Monitoring Well Elevations

Traditional Survey vs. LIDAR Elevations

* Surveyed relative elevations, Error in survey not quantified

RMSE = 0.0974 m
RMSE/Range = 0.75 %
Monitoring Well Elevations

Unlike traditional DEMS…

- Rely on LIDAR elevations for all terrain – especially useful for remote areas
  - Accurate water level elevations for groundwater contour map and groundwater model calibration
Floodplain Delineation

Importance of Floodplain

- Lamprey River backs up into farm stream during spring/fall floods
- Effects timing of discharge of stream into Lamprey
- Floodplain may also enhance nitrate removal from stream
Floodplain Delineation

Delineation Method

• Gage height recorder set up over stream in floodplain

• Use LIDAR to convert gage height to elevation

• Fill LIDAR to recorded gage height elevations to delineate floodplains
Floodplain Delineation

Inundation Maps

Max Recorded Stage Height Fall ’08
11/27/09 – 3.92 ft

Max Recorded Stage Height Spring ’09
4/8/09 – 2.65 ft

* Future work: field checking with GPS
Acknowledgements

• NCALM and Dana Truslow for making the LIDAR image of Organic Dairy Farm available

• USDA and SARE for their generous funding of Agro-Ecosystem Project