Quantifying Ground Vegetation within a Closed-canopy Forest: Sub-canopy Mapping with Unmanned Aerial Vehicle

Sam Dippold, Dr. Paporn Thepbanya, Department of Geography, Towson University
Dr. Harald Beck, Department of Biological Sciences, Towson University

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Abstract
The overabundance of white-tailed deer (Odocoileus virginianus) has resulted in devastating overbrowsing of forest plants. Assessing the ecological damage of white-tailed deer is time consuming and labor intensive. For our preliminary study, we utilized a small, highly maneuverable, Unmanned Aerial Vehicle (UAV) quadcopter to obtain sub-canopy aerial imagery for a supervised classification analysis. We compared understorey vegetation in one open and one control plot in Monkton, Maryland. The analysis of the plots was accomplished through imagery collection in a documented UAV flight pattern. The images were converted into a composite using Adobe Photoshop and georeferenced for image analysis using ESRI ArcMap 10.6, followed by a supervised classification which compared pixels of vegetation versus non-vegetation. Our preliminary results revealed that the understorey vegetation polygon compared to 35% vegetation in the open control. Our findings highlight the large impact of deer on the understorey plants and forest community. Because our UAV took images underneath the forest canopy and was able to avoid treetops, i.e., small trees and shrubs in the sub-canopy, this method might be a more useful technique than acquiring imagery from the aircraft, satellite, or ground survey. In addition, our study suggests that a consumer level piece of technology can be used on projects with a smaller budget and with a demanding time constraint.

Introduction

• This study aimed to assess the impact of deer density on the forest community, using data collected from the UAV (Figure 1).
• The study used deer exclosures and same-sized control plots to test the impact of overbrowsing. Ground cover and understorey vegetation have been censored repeatedly to quantify the impact of deer over browsing on the forest ecosystem on foot, but not from an aerial perspective.
• With the aid of in-atmosphere aerial imagery as well as data from space orbiting satellites, vegetation land cover can be calculated. Satellites and aircraft can acquire imagery of sub-canopy land surface through radar imagery techniques, but traditional aerial photography techniques are often shrouded by canopy (Earth Observatory 2013).
• On foot, calculating the vegetation density of a study area is possible, but can be very time consuming, likely to be cost effective and there is high potential for inaccuracies.
• The unmanned aerial vehicle, or UAV quadcopter is a valuable and capable asset in collecting the imagery needed for the application. It can gather data that an airplane and satellite would not be able to access. With the aid of a camera mounted on a UAV, aerial imagery can be collected, georeferenced, and classified to assess vegetation below the tree canopy during seasons with leaves present on trees.

Methods

1. Collecting Imagery & Ground Control Points
- Images were collected in October, 2020 using an Autel Robotics Evo 2 Pro quadcopter with a 6K camera mounted to a gimbal system.
- Control Plot: 19 Images,
- Exclosure Plot: 26 Images
- Image altitude range: 1-10 meters
- Garmin 60Cx navigation unit used to collect ground control points

2. Mosaicking Imagery
- Adobe Photoshop was used to stitch drone imagery
- Tree trunks obscuring image due to relief displacement were removed from imagery

3. Image Preprocessing and Georeferencing
- Mosaics were imported to ESRI ArcMap 10.6
- Images were reprojected from WGS 1984 to Maryland State Plane coordinate system

4. Image Processing: Supervised Classification
- Both plots (control & exclosure) had 15 samples of vegetation & non-vegetation pixels

5. Area Calculation
- Output return from classification was converted to polygons (Raster to polygon tool)
- Polygons were dissolved, then grouped as a single vegetation, or non-vegetation polygon
- A mask was used to clip the study area from the converted supervised classification (Figures 4 and 6)
- Areas were calculated for the vegetation & non-vegetation polygons

Table 1. Calculated areas of vegetation presence.

<table>
<thead>
<tr>
<th>Study Area</th>
<th>Total Area (sq. ft)</th>
<th>Non-Vegetation Area (sq. ft)</th>
<th>Vegetation Area (sq. ft)</th>
<th>% Vegetation Present</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control Plot</td>
<td>1488.66</td>
<td>1024.55</td>
<td>464.11</td>
<td>31.18%</td>
</tr>
<tr>
<td>Exclosure Plot</td>
<td>1347.34</td>
<td>659.30</td>
<td>688.04</td>
<td>51.07%</td>
</tr>
</tbody>
</table>

Results

• The calculated area of vegetation presence indicated that the exclusion had more vegetation than that of the control site (Table 1).

Conclusions

• The calculated area of vegetation presence indicated that the exclusion had more vegetation present than that of the control site, as shown in the Table 1.
• This project applied aerial imagery collection, which usually has no physical obstacles inhibiting the flight path and dealt with excessive obstacles. Accuracy of the calculations can be improved, but the methods used were able to successfully calculate and compare vegetation percentage of the control and exclosure sites.
• Creating georeferenced mosaics of the forest floor from sub canopy aerial imagery is not an appropriate application for large areas. This can be a technique that has the capability of providing extremely high resolution in an obstacle filled environment on a smaller research budget.

Future Research:
An investigation into forest survey techniques to improve marking and helping ensure better image overlap for easier mosaic stitching.

Sources: