Unmanned Aerial Systems as a Tool for Investigating Edge Influences in New Hampshire Forests

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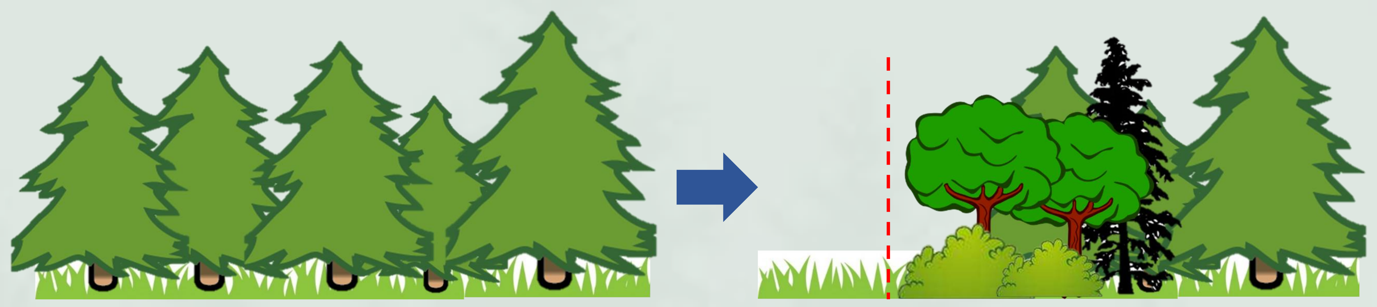
Introduction

New Hampshire forests provide numerous, invaluable services but are on the decline due to increased development that not only removes them but potentially degrades the remaining forest patches due to forest edge influences.

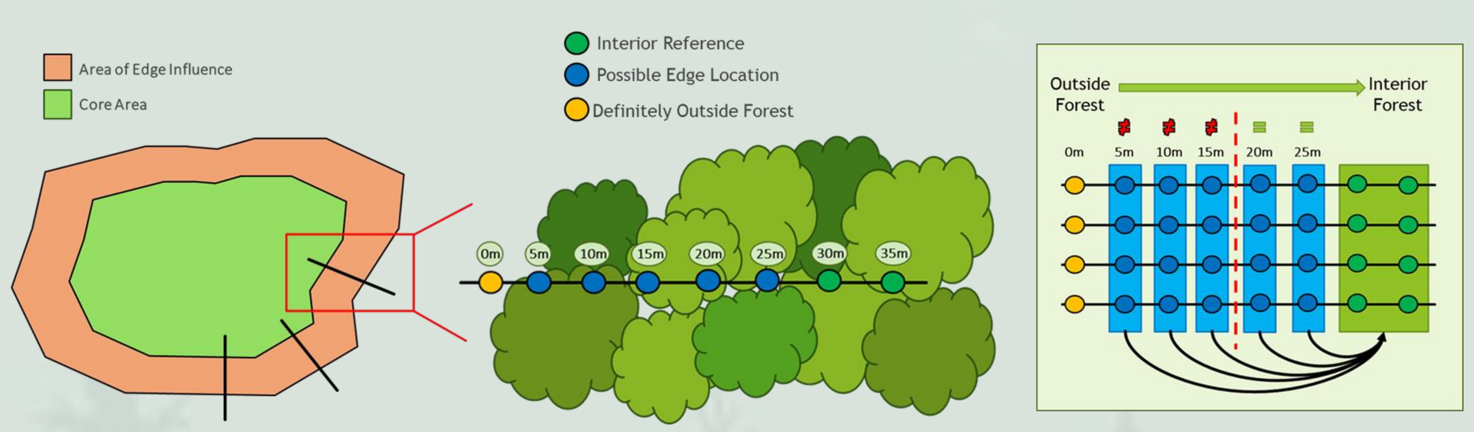
Edge Influences (EI) – the effect of processes at the edge that alter the structure, composition, and ecological processes within the forest near the edge [1]. For example:



•Tree Mortality •Understory Release •Change in Spp. Composition

Why is this important? If changes at the forest edge are extensive enough, the impacted portions of the forest may become unusable for many species that originally resided there, making the patch much smaller to survive in [2].

Depth-of-edge influence (DEI) tells us how far into a patch EIs are having an impact. DEI is typically measured by walking transects towards the interior of the patch and measuring forest attributes known to be impacted by edge conditions like canopy cover [2]. Conditions at the edge are then compared to the interior.



Some attributes can be measured from remotely sensed data collected by unmanned aerial systems (UAS). UAS provide us the opportunity to understand EIs for a significantly lower cost compared to fieldwork and traditional remote sensing platforms like satellites and airplanes

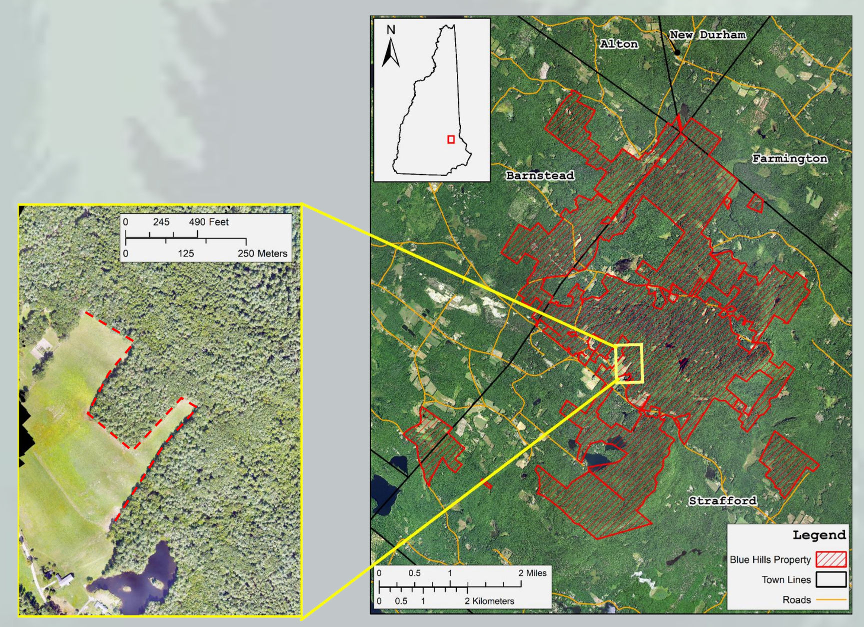
Objective:

Can estimates of forest structure generated from UAS imagery be used to assess depth of edge influence based on canopy openness

Study Area

Blue Hills Foundation Conservation Lands

- 2946.95 ha
- Spans across five New Hampshire towns
- High conservation value land with ample edges adjacent to large fields



Restricted focus to measuring canopy openness / foliage cover at one edge shown in yellow box

Methods

UAS Data Collection

Field was flown on September 13th, 2019

- Sensefly eBee X with an Aeria DSLR camera
- 100m above the canopy
- 90% forward overlap / 80% side overlap

UAS images processed with Agisoft Metashape on high settings. A dense point cloud (nominal point spacing ≈ 2.5cm) was exported

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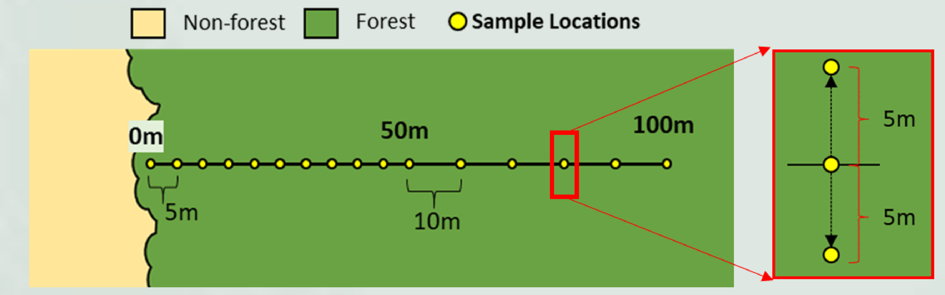
Ground Data Collection

A random point along the forest edge was chosen for Transect 1. Subsequent transects were 100m apart and/or >50m from a corner.

At each Transect:

- Transect bearing was perpendicular to edge with 0m point at the edge
- GPS setup at least 10m into the field in line with transect

Transect Setup:



Digital canopy photographs were collected at sample locations [3]

- Canon Rebel T6i w/ focal length set at 55mm ≈ 15.42° vertical AOV
- Lifted 4m into the air on extension pole

Photos were thresholded to classify the pixels into either sky or vegetation [4]. Canopy openness (CO_{field}) was calculated as shown:

$$CO_{field} = \frac{\#\ Vegetation\ Pixels}{Total\ \#\ of\ Image\ Pixels}$$

The three CO measures at each distance on each transect were averaged

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Processing Photogrammetric Point Cloud

20m x 5m rectangular plots centered at each sample distance on the transect were generated

The photogrammetric point cloud was clipped to each 20m x 5m plot and normalized to height above ground. The UAS based estimate of canopy openness (CO_{UAS}) was calculated as shown

$$CO_{UAS} = \frac{\#\ Points \geq 4m\ Above\ Ground}{Total\ \#\ of\ Points}$$

Calculating Depth-of-Edge Influence

Randomization Test of Edge Influence (RTEI) [5] was used to calculate the DEI from CO_{field} and CO_{UAS} estimates

- For 50m Transects: 40m-50m was used as interior
- For 100m Transects: 90m and 100m were used as interior

Results

Nine transects were measured between 9/28 - 9/30/2019:

5 – 50m Long Transects
4 – 100m Long Transects

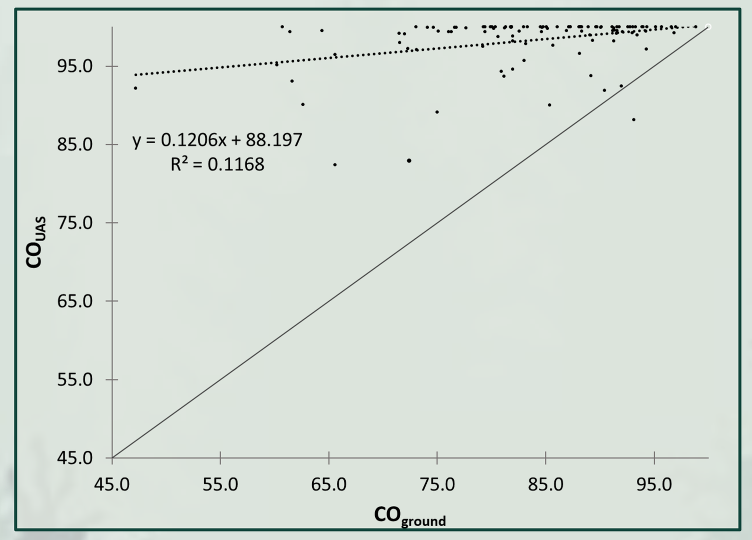
Image A - transect lines based on GPS and field measured bearings.

Image B - 20m x 5m rectangular plots centered at each transect sample distance

Comparison of CO_{field} and CO_{UAS} at each sample plot

UAS-based measurements tended to overestimate CO. Errors increased as CO decreased.

RMSE = 9.06%



Edge Distance	Field Means	UAV Means
5	87.6 (0.134)	98.79 (0.788)
10	84.88 (0.453)	99.03 (0.939)
15	87.03 (0.168)	96.63 (0.037)
20	82.85 (0.848)	96.53 (0.122)
25	82.06 (0.969)	98.49 (0.486)
30	83.99 (0.603)	99.17 (0.946)
35	84.98 (0.392)	99.28 (0.939)
Interior Distance		
40	81.79	98.74
45	83.66	99.01
50	80.95	99.35

Results of the RTEI. Values represent mean CO at each distance for each method. P-value in ( ) indicate whether that distance was significantly different from interior

No significant EI with either UAS or Field data within 50m. No EI within 100m (data not shown)

Field means gives slight indication of ↓ CO with ↑ distance from edge

Conclusions

1. No strong relationship between UAS and field estimates of CO
   - Photogrammetric point clouds have been found to have lower canopy penetration in other studies [6,7] and supported here
   - CO_{UAS} estimates saturated at almost complete canopy closure. Never dropped below 80% even when CO_{field} suggested high openness in a plot
   - Visual inspection showed few is any points in canopy gaps. A result of the method used to generate the dense point cloud.
2. No evidence of EI using the UAS. Mean CO measured in the field gives slight indication of ↓ CO with ↑ distance from edge, but not significant
   - Studies have found increases in tree growth at the edges in temperate broadleaved forests [8,9]. Trees in smaller size classes compensated as larger trees weakened or died [10]
   - The Inability of the UAS to detect small opening and gaps meant it was not sensitive enough to detect any EI

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