Background

Timely, accurate detection of southern pine beetle (*Dendroctonus frontalis* Zimmerman; SPB) outbreaks is necessary for management of this tree-killing beetle. Early detection is key, and is effectively accomplished in the historical range using aerial flyovers. Stressed trees are known to show spectral signatures that we can't see with just our eyes. **Can SPB early attack be detected by multispectral cameras?**

We compare tree decline symptoms after SPB attack using ground-based surveys and unpiloted aerial vehicles (UAVs, or "drones").

Spectral bands
Blue – 450 nm
Green – 560 nm
Red – 650 nm
Red edge – 730 nm
Near-infrared – 840 nm

DJI P4 Multispectral UAV

Southern pine beetle (SPB)
courtesy of Marc DiGirolomo, US Forest Service

1 mm

Methods

1. Ground survey of SPB-attacked pitch pines (*Pinus rigida*)
2. Collection of multispectral aerial imagery via UAV
3. Image processing, classification, and accuracy assessment

Five classes of trees included in random forest classification:

Deciduous | Healthy pine | SPB green attack | SPB visible attack | Dead pine

The foliage of SPB-attacked trees fades from green to red as the attack progresses. We test the correlation between needle color and SPB stage in over 300 attacked trees.
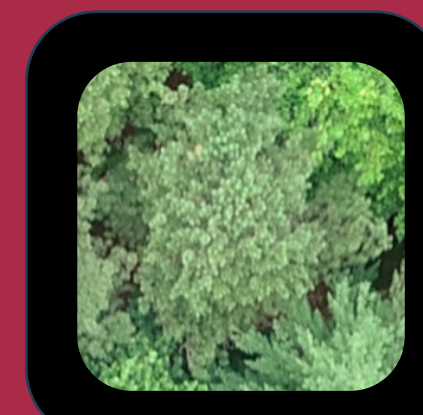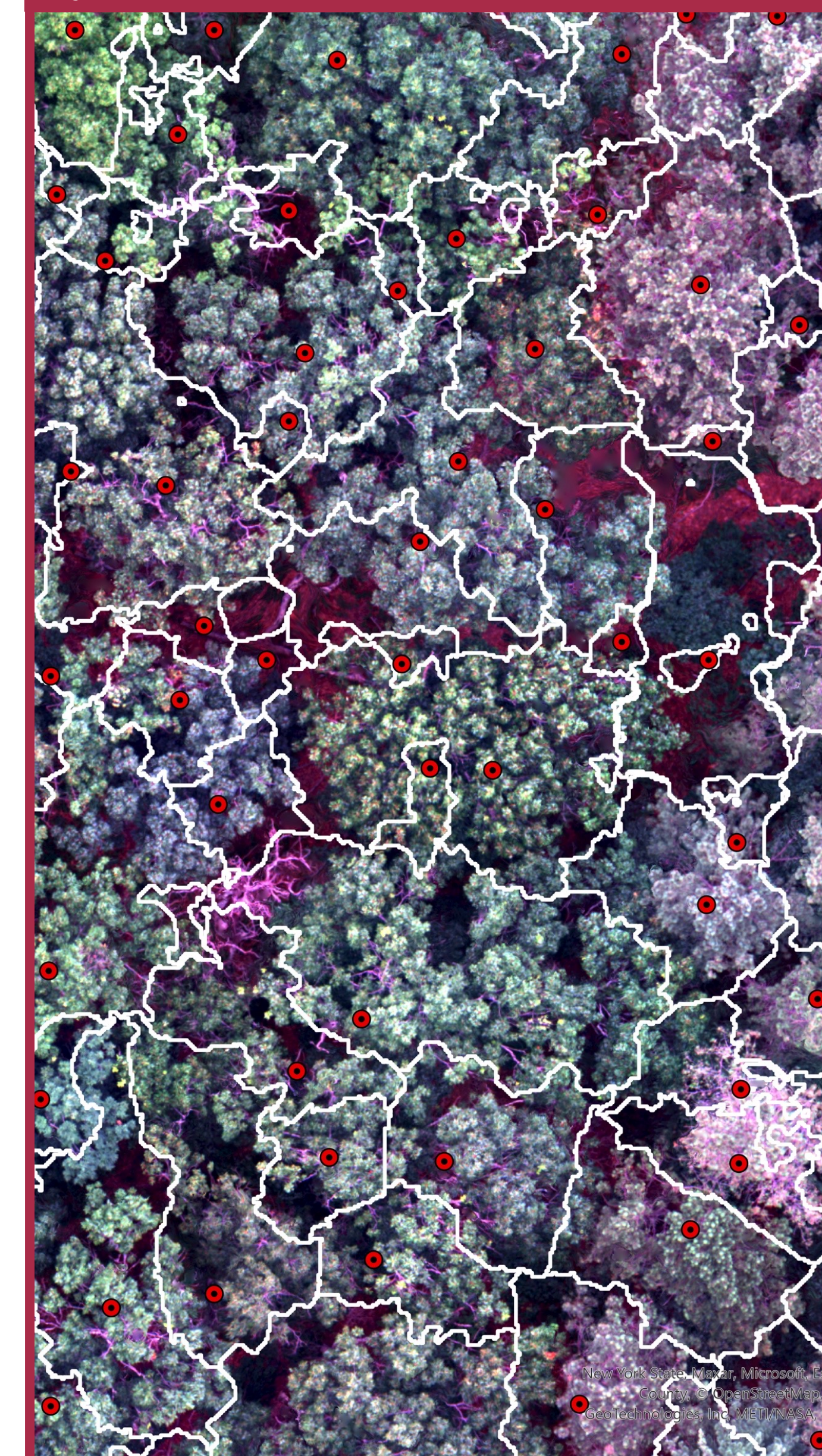
We ground-truthed SPB attack intensity and beetle life stage to be correlated with tree crown condition as recorded from the ground and from above.

Segmentation delineates each tree crown in the imagery. Here, the tree crowns are drawn by ArcGIS in white, and each treetop is indicated by a circular point.

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Drones can detect southern pine beetle early attack

Aerial and ground-based investigation of Long Island pitch pines
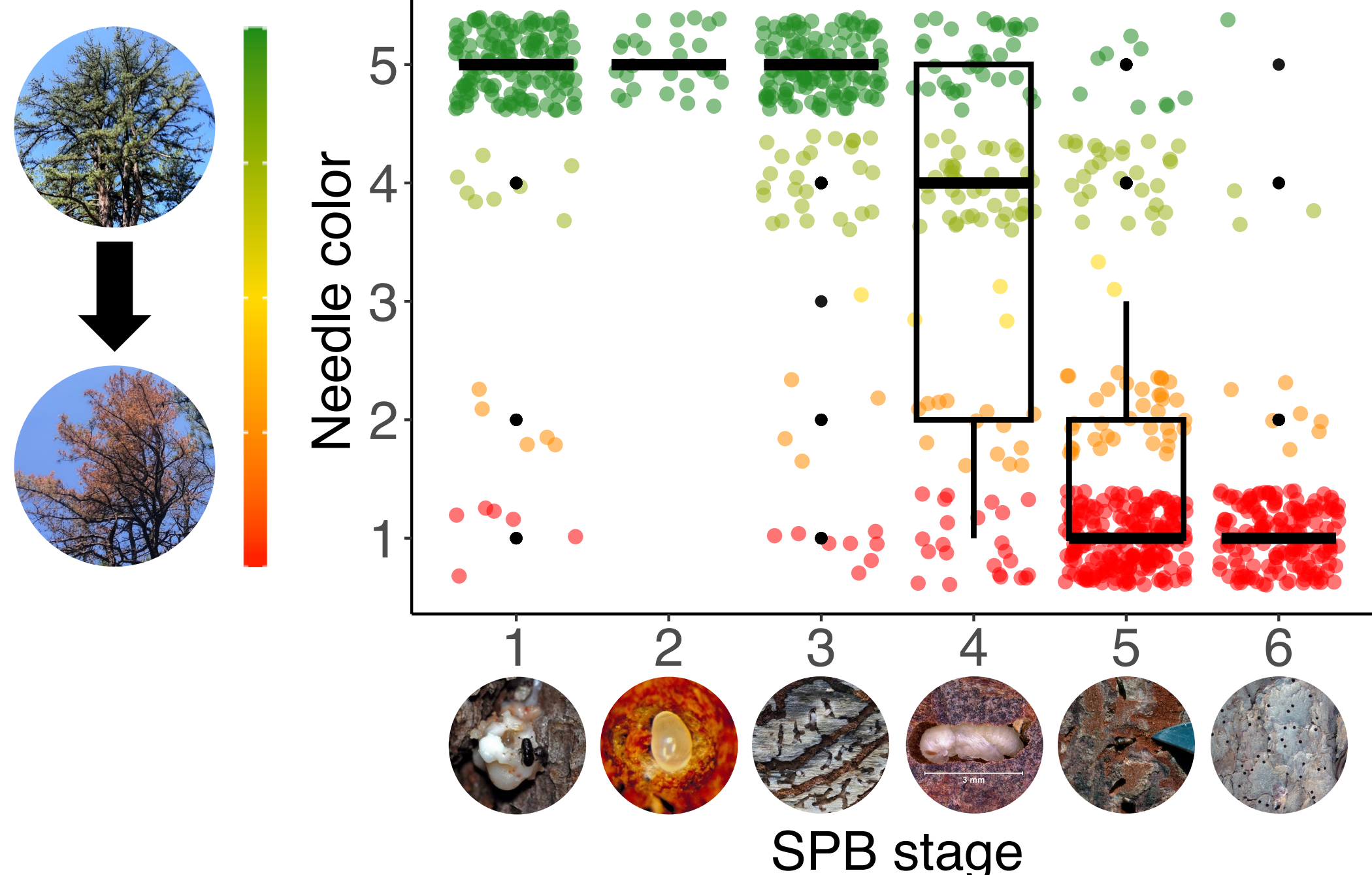
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1 – University of New Hampshire, 2 – Dartmouth College

Results – Ground Data

Needle color | SPB stage
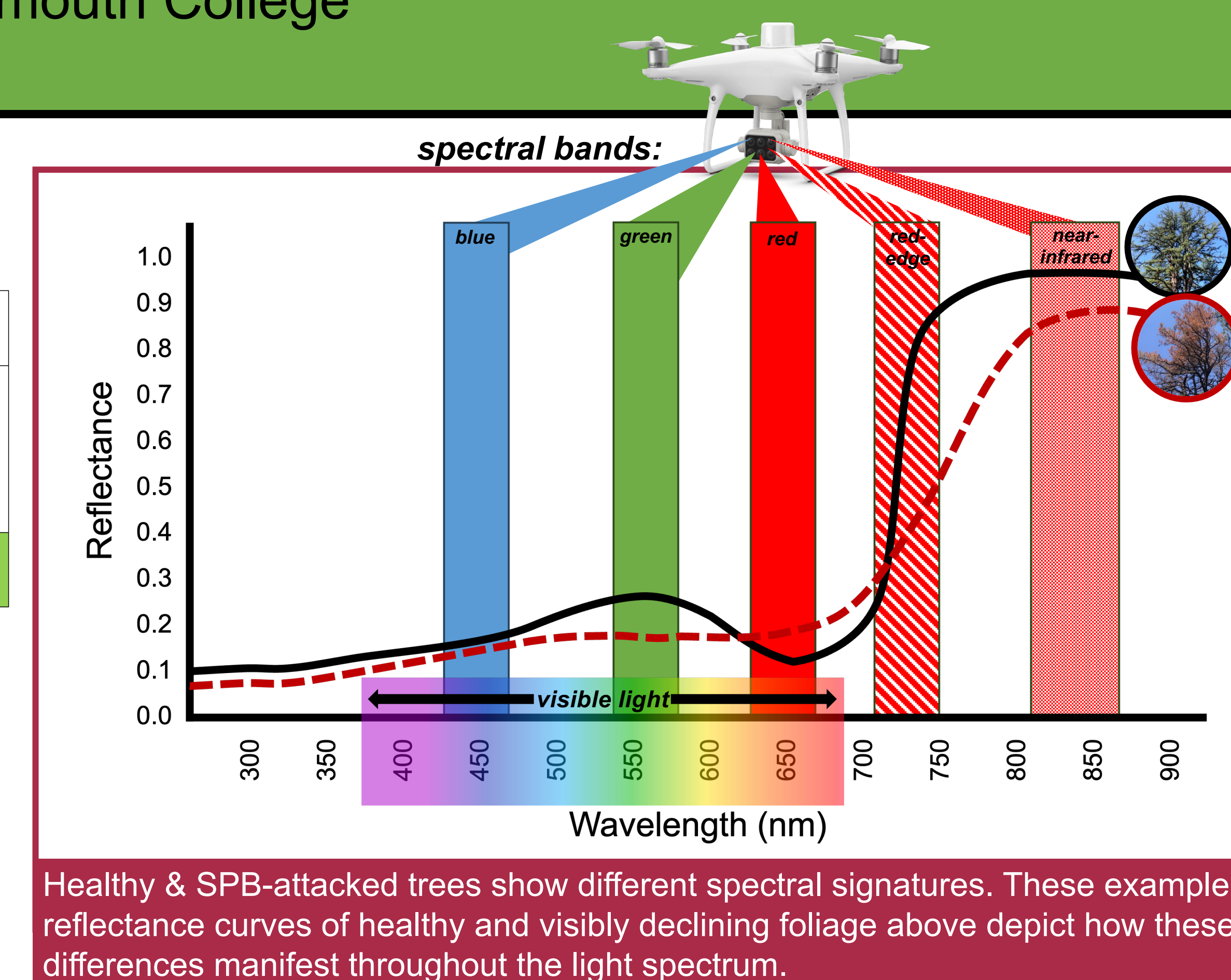
Tree needle color differed based on the SPB stage within the tree ($F = 194$; df = 5,838; $p < 0.001$). Here, we show the relationship between the SPB stage and needle color of each attacked tree in our ground survey. Lowercase letters above the plot show the results of Tukey's HSD ($p < 0.001$). See image references online via our QR code.

Results – UAV Data

	Reference data						
A	Deciduous	Healthy pine	SPB green attack	SPB visible attack	Dead pine	Total	User's accuracy
Deciduous	33	0	7	4	0	44	75.00%
Healthy pine	0	23	0	1	0	24	95.83%
SPB green attack	0	3	23	3	0	29	79.31%
SPB visible attack	0	0	7	21	2	30	70.00%
Dead pine	0	2	0	2	24	28	85.71%
Total	33	28	37	31	26	155	
Producer's accuracy	100.00%	82.14%	62.16%	67.74%	92.31%		Overall accuracy 80.00%

B — Features (top to bottom): RVI, DVI, NDVI, PBI, Green NDVI, Mean green, LCI, GLCM Entropy, St. dev. blue, TVI, ARI, MCARI, Mean red, St. dev. red, St. dev. green
Mean Decrease in Impurity (MDI)

Balanced random forest classification achieved an accuracy of 80% overall, as seen in the error matrix above (A). We assessed feature importance using mean decrease in impurity (MDI, or Gini Index; B). The features with the highest MDI are most important. Nine of the top 15 features shown above require multispectral imagery.

spectral bands: blue, green, red, red edge, near-infrared

Reflectance | Wavelength (nm)
visible light

Healthy & SPB-attacked trees show different spectral signatures. These example reflectance curves of healthy and visibly declining foliage above depict how these differences manifest throughout the light spectrum.

Take-home points

1. We present the first analysis of UAV-collected multispectral imagery in the SPB system.

2. Multispectral imagery can differentiate early (green) attack from healthy pine trees.

3. Needle color may not be a good indicator of SPB brood stage.

Poster Template by Susanna L. Harris