Detection of Brown Spot Needle Blight Using UAV Remote Sensing

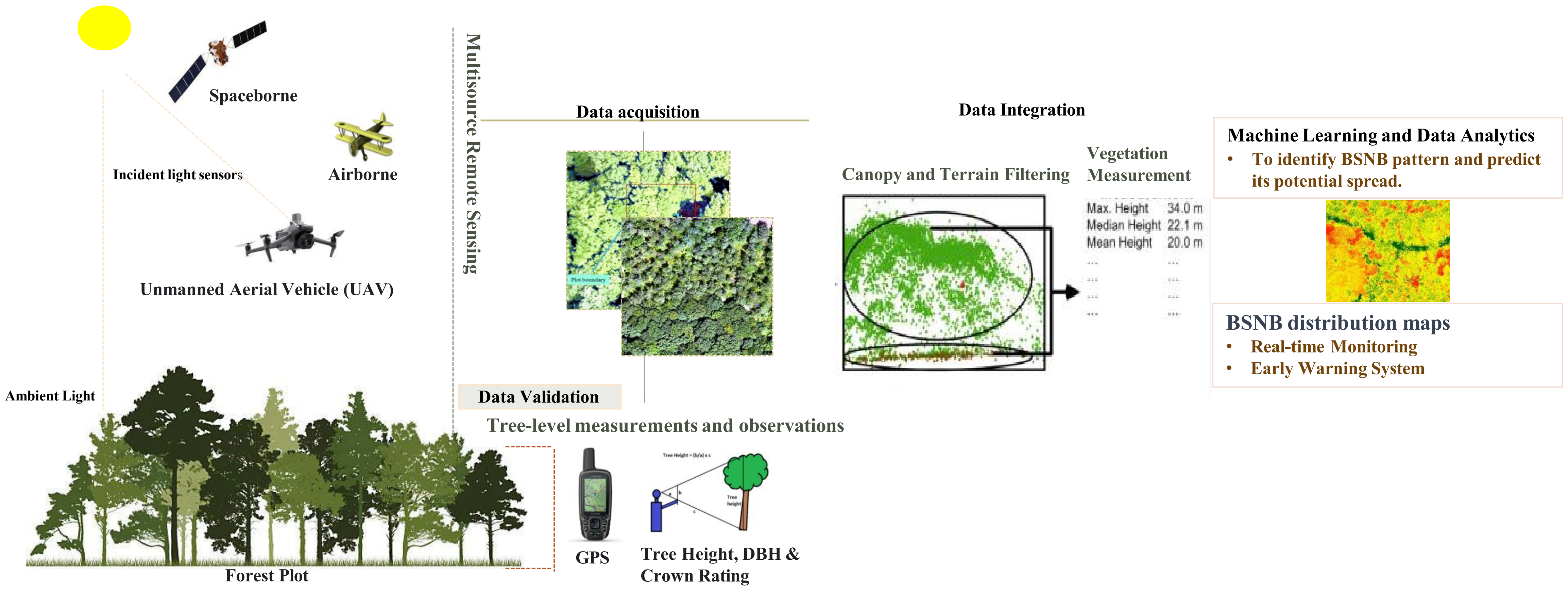
Project Component 3: Detection and movement of *Lecanosticta acicola* with remote sensing

Brown Spot Needle Blight Assessment Workshop, *August 12-13, 2024*

Advisor
Dr. Lana L. Narine
Assistant Professor
Geospatial Analytics Lab
College of Forestry, Wildlife, and Environment
Auburn University

PhD student
Swati Singh
Graduate Research Assistant
Geospatial Analytics Lab
College of Forestry, Wildlife, and Environment
Auburn University

Overall Project Goal: ***To develop a remote sensing-based framework using multi-source data for the detection and monitoring of Brown Spot Needle Blight (BSNB).***



Introduction

Problem Statement: *Pine forests in the Southeastern US face significant threats from Brown Spot Needle Blight (BSNB).*

Extent of Issue: *Documented in 36 of Alabama's 67 counties.*

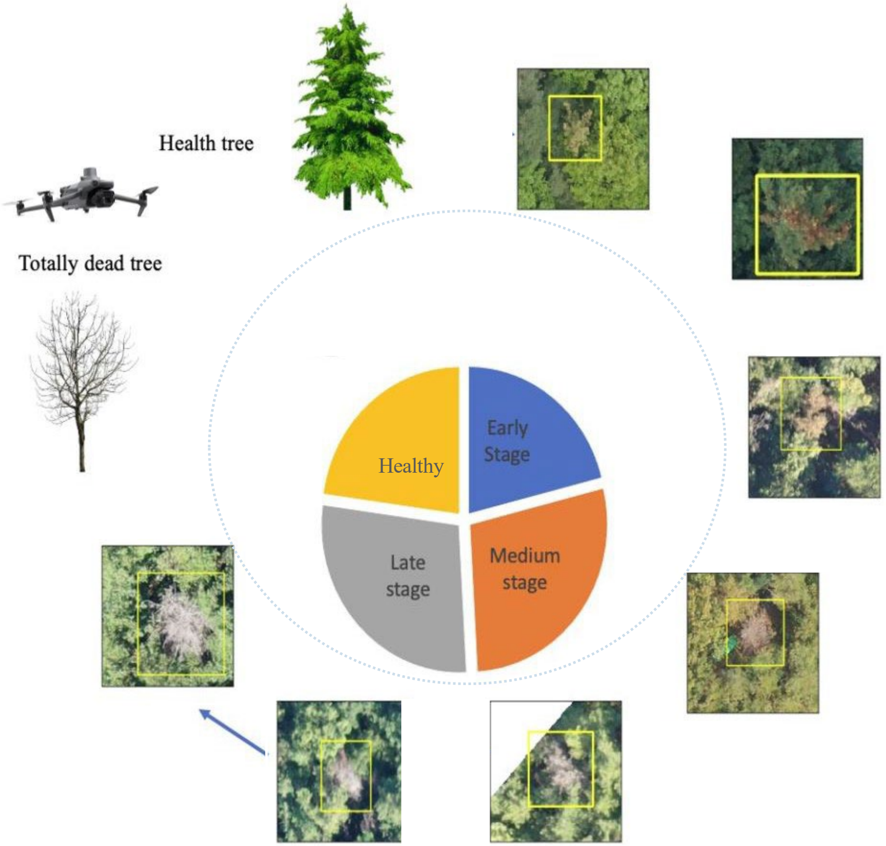
Causal Agent: *Fungal disease caused by Lecanosticta acicola.*

Impact: *Leads to substantial needle defoliation, affecting the health, density, and quality of pine trees.*

Figure 1: An image showing BSNB symptoms on a Southeastern Pine with brown spots on needles (a, b) in the lower crown (c).

How do Unmanned Aerial Vehicles work in detecting Brown Spot Needle Blight?

- **Healthy vs. Infected Trees**: UAVs distinguish between healthy and infected trees using high-resolution imaging.
- **Severity Levels**: UAVs assess and categorize the severity of BSNB infection (early, middle and late stages).
- **Dead Tree Identification**: UAVs identify dead trees affected by BSNB.



Introduction

➢ Notably, Unmanned Aerial Vehicles (UAVs) equipped with multispectral and light detection and ranging (lidar) sensors offer high spatial precision for tree-level analyses and characterization (Lin et al. 2023).

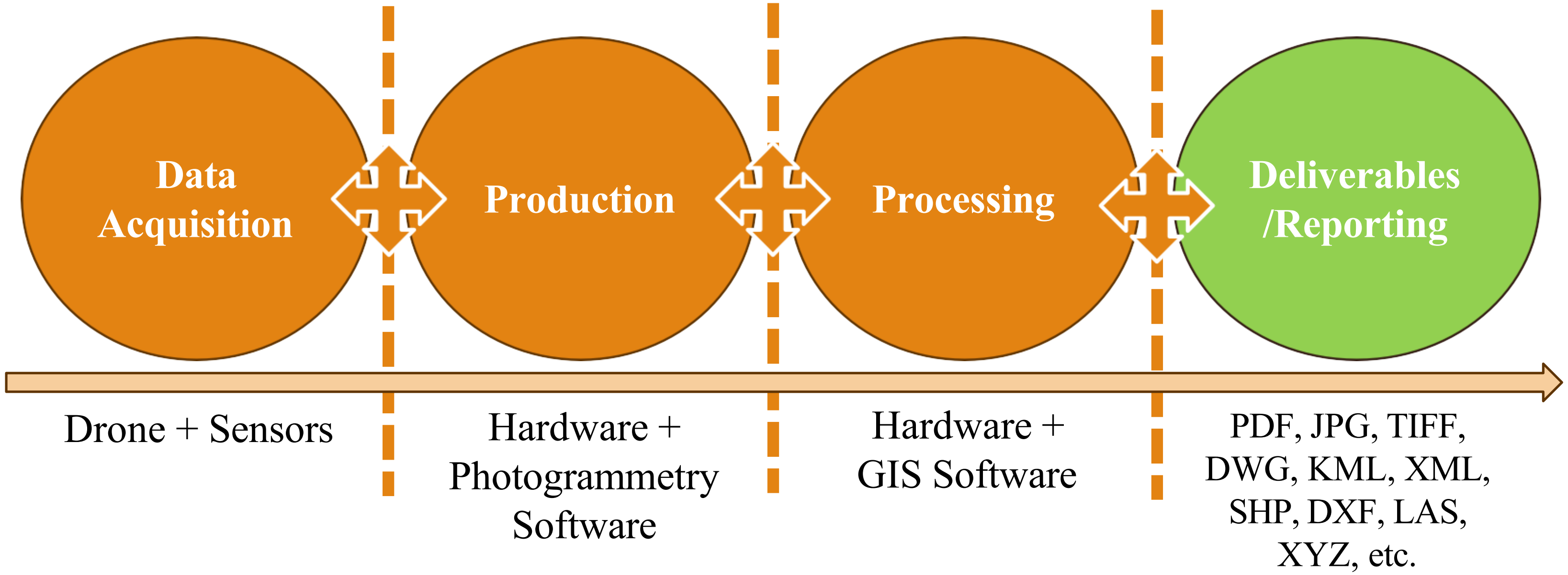


Figure 2. From data acquisition to deliverables operational workflow.

Study Area

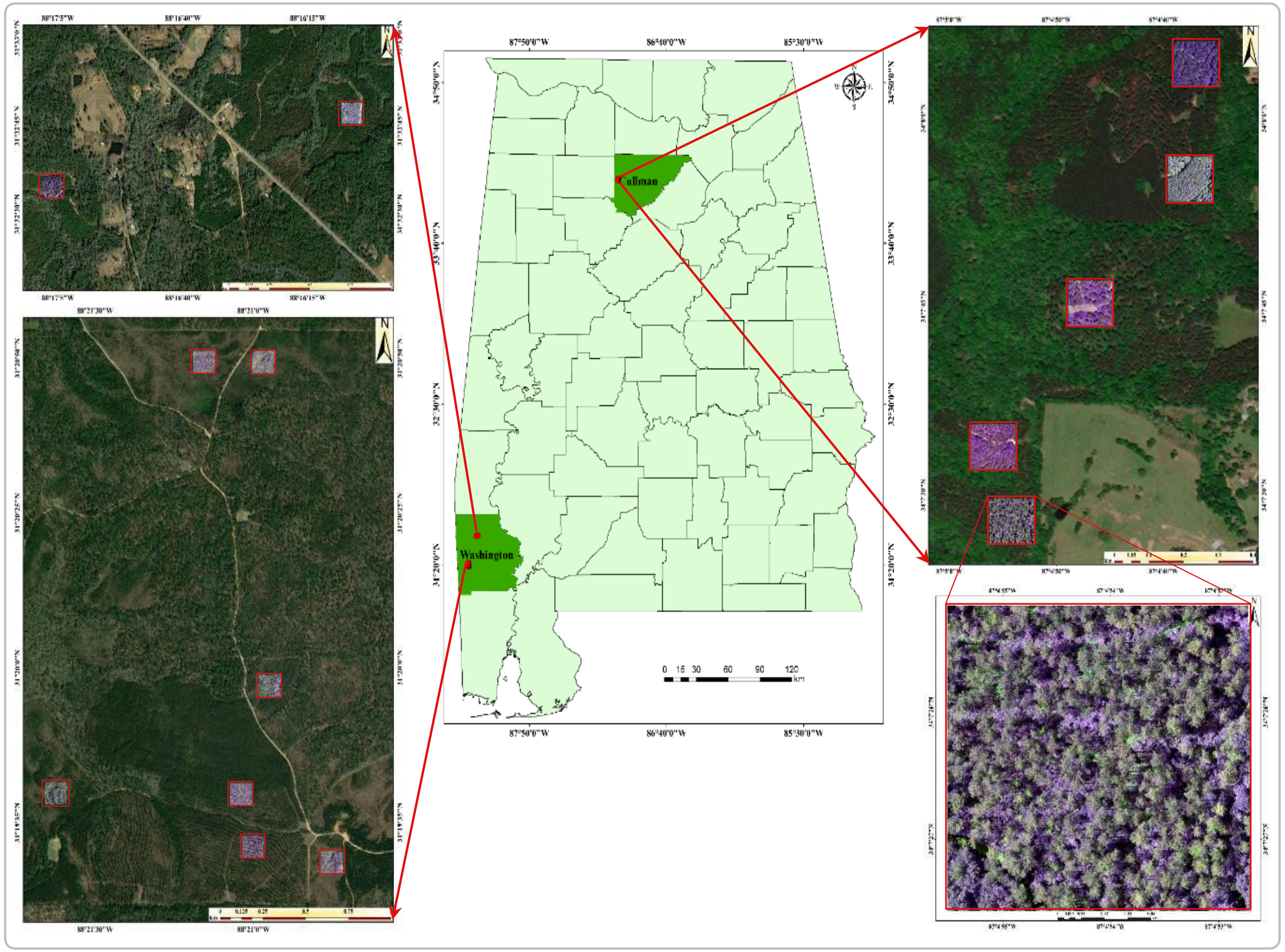


Figure 3. Study area in Washington and Cullman County, USA.


16 May 2024, 7:57 am

Results and Discussion

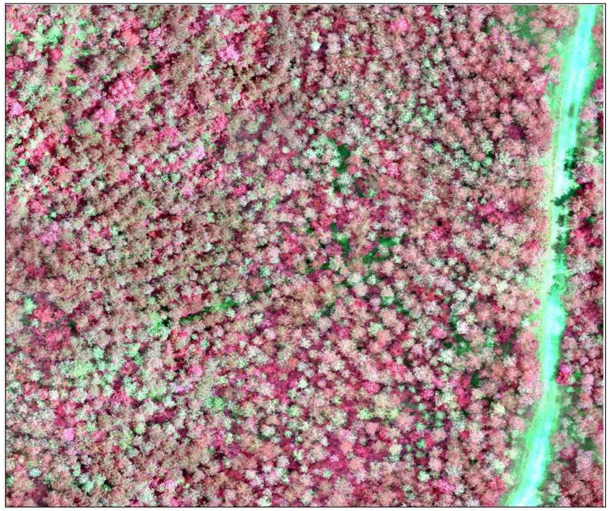


Figure 4 (a). Image with soil background.

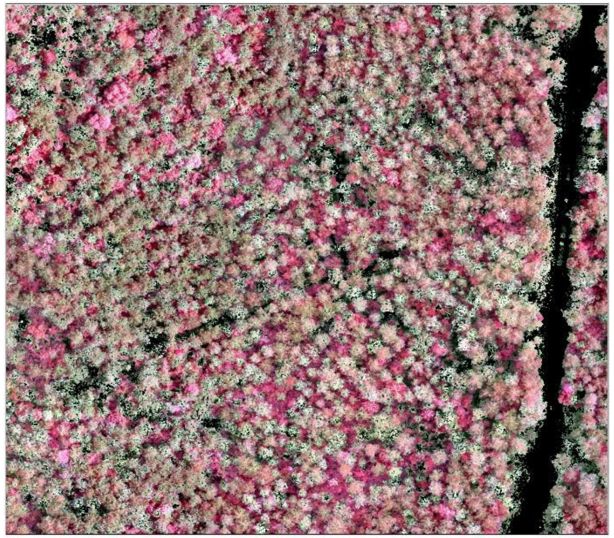


Figure 4 (b). Image after soil background removed.

Soil Background Removal

- Soil background was removed using NDVI (Normalized Difference Vegetation Index) threshold values, an effective technique to distinguish between vegetation and soil in remote sensing imagery.

- By applying a specific threshold value to the NDVI, areas with values below the threshold can be classified as soil, effectively masking out the non-vegetative background.

- This process enhances the clarity of vegetative regions in the imagery, facilitating more accurate analysis and classification.

- For instance, if a threshold value of 0.25 is set, all pixels with NDVI values below 0.25 are identified as soil and dead trees and masked out, leaving only the vegetative regions for further study.

Spectral Profile Characteristics

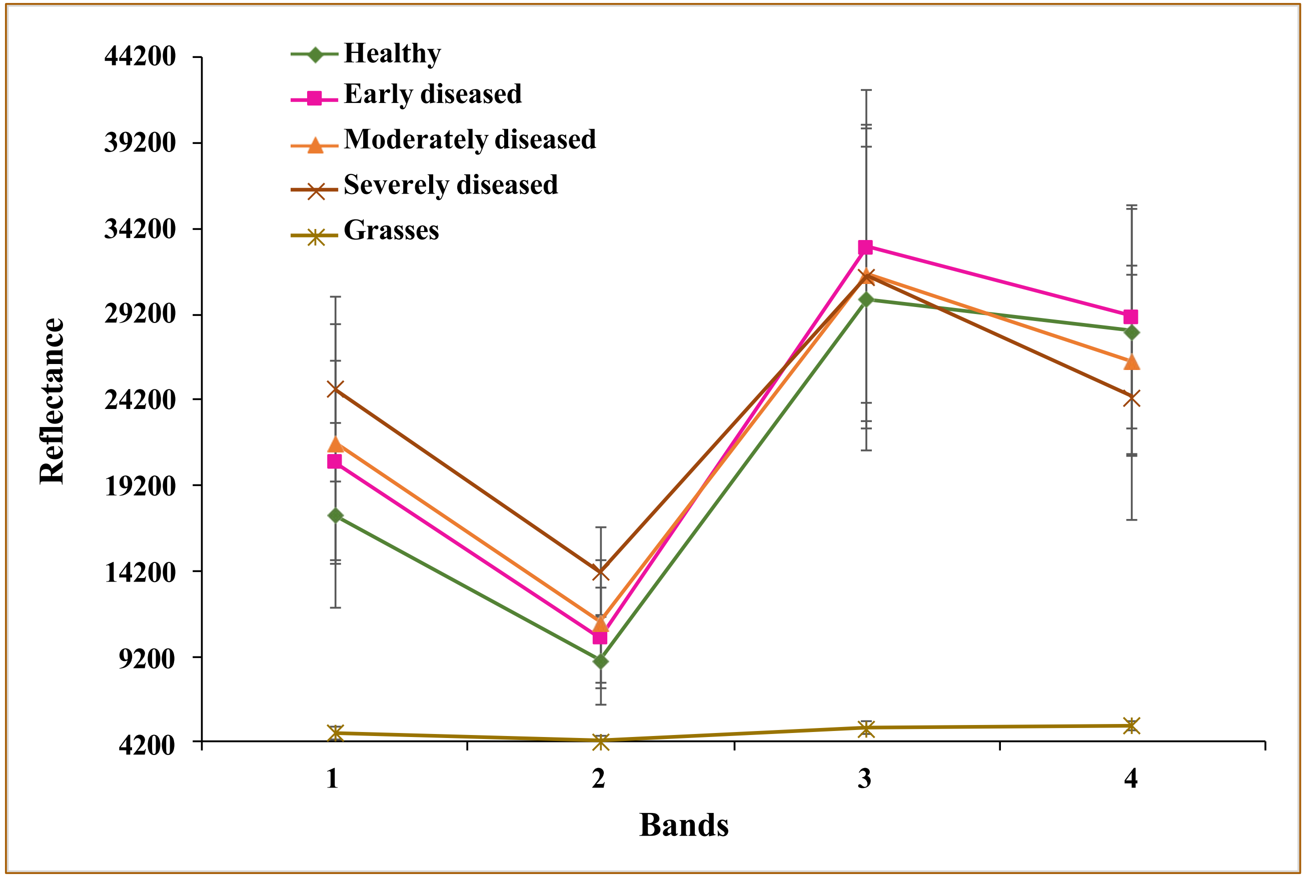


Figure 5. Spectral profile characteristics of different classes.

- **Healthy Plants:** Show lower reflectance values with a peak in the Red Edge band, indicating good health compared to diseased plants.

- **Diseased Plants:** Reflectance is highest in the Red Edge band, with Early Diseased having the highest values, followed by Moderately Diseased and Severely Diseased.

- **Grasses:** Have consistently lower reflectance across all bands with minimal variation, providing a distinct spectral signature compared to other classes.

Training ROIs Generation

- Training signatures were generated using an orthomosaic image masked for soil, incorporating ground truth data and spectral index thresholding.

- GPS locations and class information were overlaid on the image to create Region of Interest (ROI) training sets for each class.

- Using the 'Region of Interest Tools' in ENVI-5.6 software, polygon elements were added to define selected areas.

- Training sets were developed for five classes—Healthy, Early Diseased, Moderately Diseased, Severely Diseased, and Grasses—each representing different developmental stages and levels of vegetation cover.

Classification Techniques

- **Artificial Neural Network (ANN):** ANNs are highly effective for classification tasks, learning complex, non-linear patterns through multiple layers of interconnected nodes.

- **Support Vector Machine (SVM):** SVMs handle complex, noisy data well by maximizing class margins with a decision surface, efficiently managing large feature spaces without overfitting.

Individual Tree Detection (ITD)

Table 1. MS-lidar metrics.

Multispectral-Lidar Metrics		
Metric	**Multispectral**	**Lidar**
True Positive	28	29
False Positives	21	20
False Negatives	2	2
Precision	0.57	0.59
Recall	0.93	0.94
F-score	0.71	0.72
Omission	0.07	0.06
Commission	0.43	0.41
Height Mean Error	0.89	0.43
Height RMSE(m)	1.71	2.66
No of Trees	415	453

- The analysis shows strong correlation between multispectral and lidar measurements for BSNB detection, with lidar offering precision and multispectral being a cost-effective alternative.

Conclusions

- The application of UAV-based multispectral and lidar sensors significantly improves the accuracy and efficiency of Brown Spot Needle Blight (BSNB) detection and classification in pine forests.

- UAV multispectral imagery, combined with vegetation indices, provides detailed understandings into vegetation health, allowing for early detection of BSNB symptoms and effective monitoring of disease progression.

- Lidar data enhances the structural analysis of vegetation, facilitating accurate individual tree detection (ITD), canopy structure assessment, and elevation modeling.

- **One major challenge** is the need for advanced data processing capabilities and timely analysis to handle the large volume of high-resolution UAV data effectively. Additionally, laboratory confirmation is required before UAV classification to ensure the accuracy of remote sensing results.

- **Future work** will involve integrating airborne lidar and spaceborne Sentinel-2 data to develop broad-scale BSNB detection methods and improve spatial risk mapping capabilities.

Thank you to all **Collaborators, Professors, Colleagues,** and **Summer Interns** for your exceptional support.

Questions & Suggestions?