PERSEUS

2024 UNDERGRADUATE SUMMER RESEARCH PROGRAM

SUMMER 2024

PURDUE UNIVERSITY

2024 Undergraduate Summer Research Program

A primary component of the Promoting Economic Resilience and Sustainability of the Eastern US Forests (PERSEUS) Project is to provide educational opportunities that will lay the foundation for a long-term paradigm shift in forestry toward data-driven, AI-supported forest management systems that increase both the provision of ecosystem services and efficiency of forestry operations.

Educational programs will contribute to measurable national impacts for the USDA through the development of competent and capable practitioners, managers, and researchers who can pipeline into successful academic, industry or governmental careers.

Objective 4 of the PERSEUS Project - Mindset

- Promote the development of a digitally competent mindset in students for sustainable natural resources management.
- Train or retrain diverse cohorts of students through immersive learning experiences and develop a digitally skilled workforce.

To accomplish these goals, undergraduate students interested in digital forestry were recruited to engage in an immersive research experience by embedding with Purdue's Institute for Digital Forestry faculty researchers.

Summer Research Goals

- Immerse undergraduate students in mentored digital forestry research projects.
- Provide training on advanced digital research tools and professional skills through a workshop series.
- Develop and present research to a scientific audience through a poster symposium.
- Engage in scientific discussions with research community.
- Contribute to PERSEUS goals by conducting research relative to Objectives 1-3.

Summer Research Program Summary

11 students from six departments across three colleges participated in PERSEUS-related projects.

Participated in active research for 12 weeks.

Engaged with faculty mentors regularly about research projects.

Participated in workshops regarding scientific literature synthesis, data lifecycle, protocol development, collaboration best practices, and data visualization.

Presented a poster at annual meeting of Purdue's Institute for Digital Forestry.

Participated in program evaluation pre- and post-surveys.

Project 1

Data Acquisition

Challenge

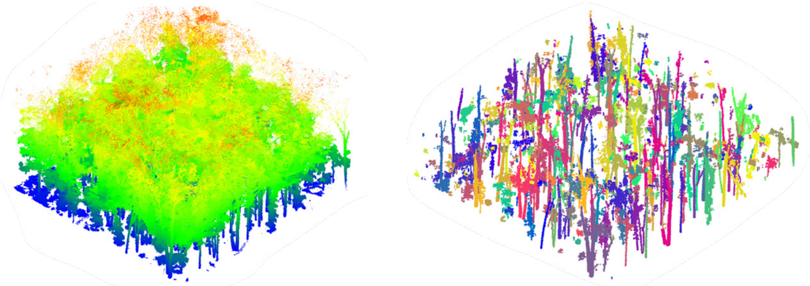
Improving digital acquisition techniques for collecting forestry data.

BackPack

Methods:

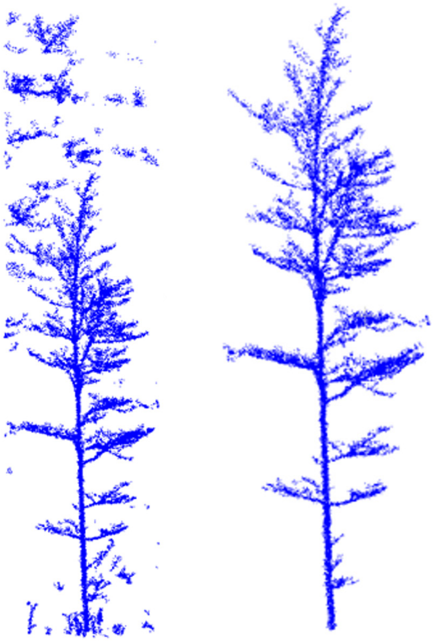
1. Acquired BackPack data.
2. Collected labeled data for deep learning-based semantic segmentation of LiDAR data.
3. Cross labeled among different data acquisition systems (UAV vs. BackPack).

Outcomes:



Martell 4D BackPack Dataset Sideview, before Point Cloud Filtering (left, colored by height), and after (right, colored by cluster ID).

1. Processing of BackPack datasets (point cloud reconstruction).
2. Preprocessing of the derived point cloud (tiling, ground filtering, and normalized height point cloud generation).
3. Evaluation of the results from the pipeline for individual tree segmentation.
4. Evaluation of the performance of semantic segmentation results.



Sample tree before (left) and after (right) correction.

Colton Gomoll

Civil Engineering BS & Anthropology Minor, Spring 2026

StemMapper (Obj. 1.2)

Mentor: Dr. Ayman Habib
Digital Photogrammetry Research Group

Project 2

Disease Monitoring

Challenge

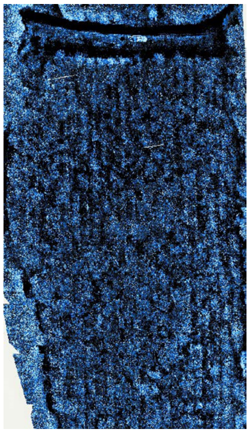
Identification of genetic hybridization between US native and Japanese butternut to improve Butternut Canker Disease research.

Methods:

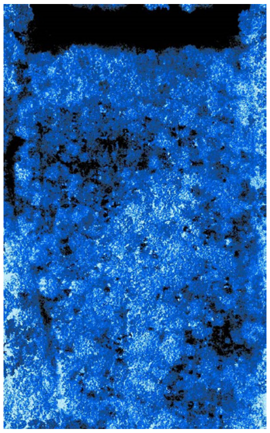
1. Conducted UAV flights with RGB and multispectral instruments.
2. Calculated VARI, NDVI, NDVI Red Edge, RTVI.
3. Evaluated if tree stress can be identified due to delayed leaf emergence.

Outcomes:

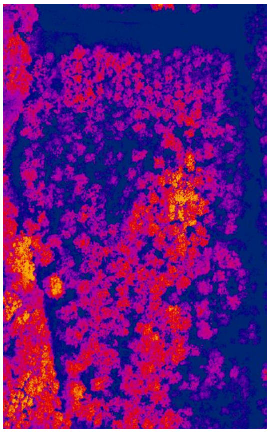
RGB
(Visible light)



VARI
(Visible Atmospherically Resistant Index)



NDVI
(Normalized Difference Vegetation Index)



RTVI
(Red-edge Triangulated Vegetation Index)

1. RTVI had the strongest correlation (~49%) with tree health and vegetative stress.
2. Demonstrated the viability of drone imagery for determining phenological stages at the individual tree level, providing a robust tool for monitoring and managing tree health and stress in butternut orchards.

Mason Santana
Unmanned Aerial Systems BS, Spring 2026

Atharva Vaibhav Thakur
Computer Science BS & Management Minor, Fall 2025

Luke Tatalovich
Unmanned Aerial Systems BS, Spring 2025

Luhanhai Ying
Statistics BS, Spring 2025

StemMapper (Obj. 1.2)

Mentors:
Dr. Joe Hupy and
Dr. Aziz Ebrahimi

Aviation and Transportation Technology and Hardwood Tree Improvement and Regeneration Center

Project 3

Fire Risk Prediction

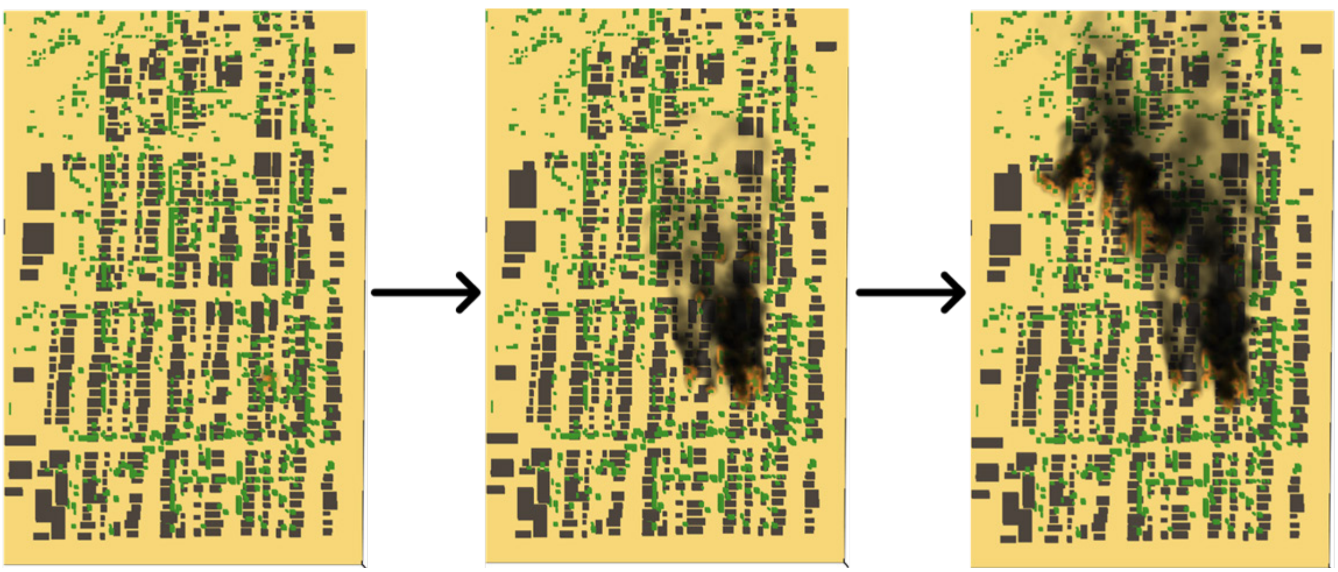
Challenge

Tools for predicting and simulating fire spread within urban environments are limited.

Methods:

Used multiple spatially explicit layers to identify hazardous regions and develop simulations to predict fire spread.

Outcomes:



Example of visualization output chain configuration for fire spread: Initial (left), Middle (center), and End (right) stages.

A new tool prototype to locate and classify hazardous urban fire zones and a simulation framework to provide estimated fire-related quantities such as the total emissions of CO, CO_2 and soot.

Nicholas Myrick
Computer Science BS & Mathematics Minor, Spring 2025

Mridu Prashanth
Computer Science & Mathematics BS, Spring 2026

Landowner optimization (Obj. 2.1)
Value chain (Obj. 2.3)

Mentors: Dr. Aniket Bera and Dr. Daniel Aliaga
Intelligent Design for Exploration and Augmented Systems Lab

Project 4

Tree Monitoring

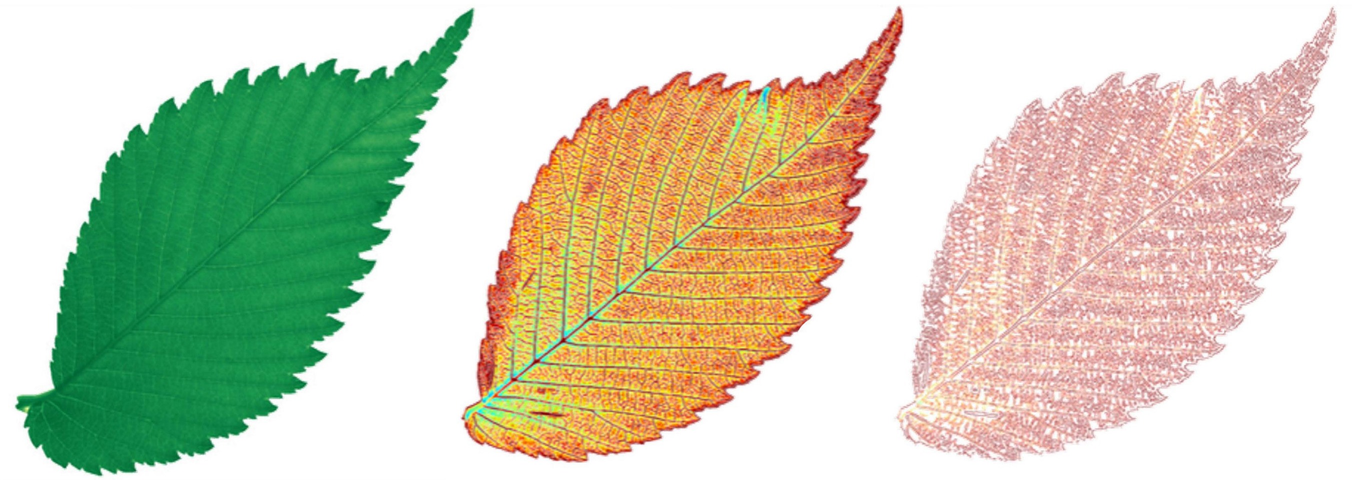
Challenge

Accessible in-situ instrumentation to improve tree monitoring.

Methods:

1. Developed smartphone based single leaf imaging device.
2. Developed of new tree leaf image processing algorithms.
3. Collected forest leaf images with various imaging devices.

Outcomes:



RGB (left), NDVI (center), and vein pattern (right) of a red elm leaf.

1. Enabled high quality, high resolution tree leaf images collection.
2. Utilized the high resolution camera.
3. Improved LeafSpec® Multispectral Handheld Imaging Device.
4. Developed tissue level leaf image processing algorithm, and a web server for demonstrating the standard leaf headshot image library.

Charles Wang
Biological Engineering BS, Fall 2025

Alden Mo
Data Analytics, Technologies, and Applications BS & Statistics Minor, Spring 2026

Value Chain (Obj 2.3)

Mentor: Dr. Jian Jin
Plant Sensor Lab

Project 5

Tree Monitoring

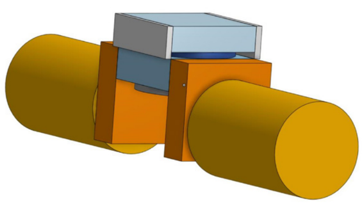
Challenge

Efficient and less labor intensive ways to access tree canopy to evaluate tree health.

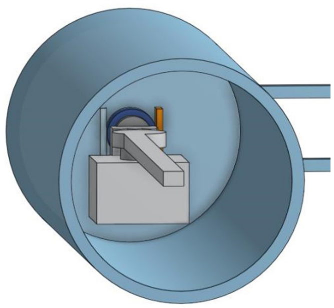
Methods:

1. Utilized CAD to design and model the tree climbing robot, implementing a motion simulation to visualize and refine the robot's movement on trees.
2. Tested various hardness of silicone for the microspines and integrated Arduino-controlled servo motors to validate the feasibility of the design.

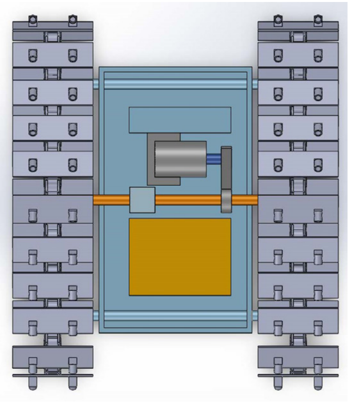
Outcomes:



Turning roller design to dodge branches



Additional degree of freedom design to clamp on smaller trees



Single Motor Track Robot

1. Developed a new design for a tree climbing robot to improve data collection under tree canopies where drones are less effective.
2. Included the use of microspines for better grip on tree bark and a belt system for carrying heavier loads, aimed at increasing the speed and efficiency of tree health assessments.

James Peng

Mechatronics, Robotics, and Automation Engineering BS, Fall 2026

Value Chain (Obj 2.3)

Mentor: Dr. She Yu
Mechanisms and Robotic Systems Lab

Project 6

Tree Health

Challenge

Traditional methods for monitoring forest health are time-consuming and logistically challenging.

Methods:

1. Exposed black walnut and red oak seedlings to abiotic and biotic stressors in a greenhouse.
2. Collected leaf spectral data using a SVC HR-1024i spectroradiometer.
3. Utilized spectral models estimating traits to determine which traits are associated with specific stressors.

Outcomes:

Black walnut (Juglans nigra L.)

Red oak (Quercus rubra L.)

1. Identified stressed and non-stressed trees using spectral data.
2. Identified stress-specific conditions using foliar functional traits estimated from spectral data.

Aditya Tiwari

Computer Science BS, Spring 2027

Value Chain (Obj 2.3)

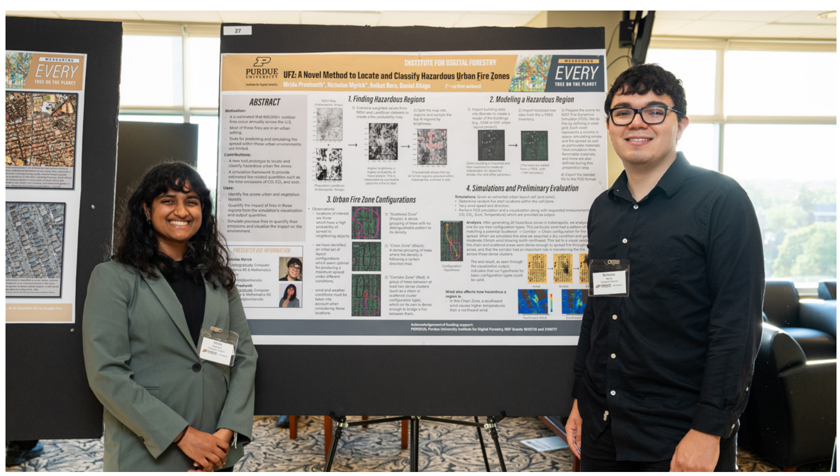
Mentors: Dr. John Couture and Dr. Sylvia Park
Lab of Plant-insect Chemical Ecology

Achieving Research Program Goals

Student participants achieved progress toward Digitally Competent Mindsets in several areas

Train and enhance student skills in tools and techniques

- Used a wide variety of digital tools and techniques including: code editors, GIS, scientific programming languages, spreadsheets, as well as specialized instrumentation.
- Students reported learning to use multiple new tools and technologies.



Engage students in immersive research experiences

- Collaborated on active research projects with their faculty mentors.
- Engaged with research meetings and discussions which included graduate students, post-doctoral researchers and their faculty mentors.
- Participated in workshops focused on research skill development.
- Presented their research at a poster symposium and discussed with researchers.

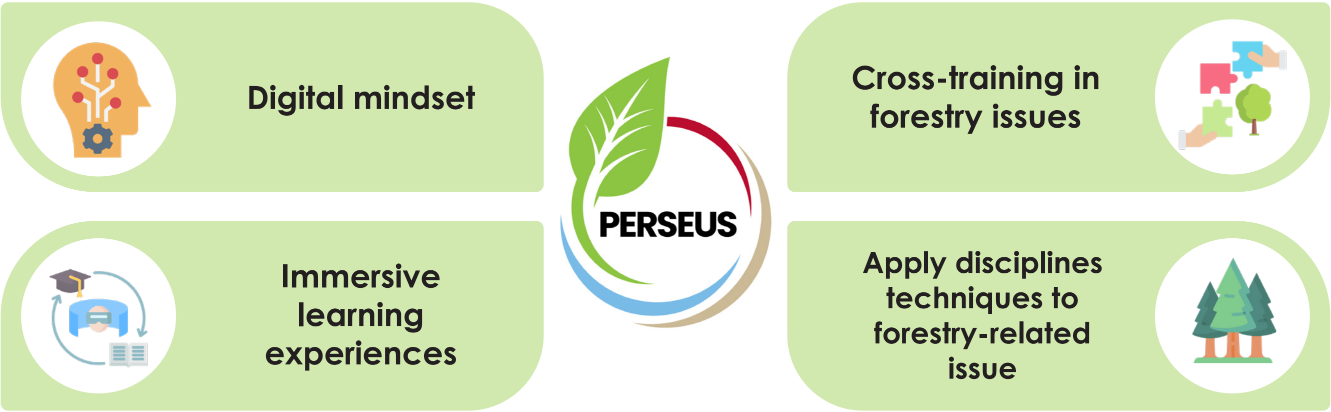
Lasting Student Impacts

Colton's (Project 1) enabled a campus-wide BikePack data acquisition, which will be used for the generation of a dynamic digital twin of the Purdue Campus.

Luke (left) and **Mason** (right) (Project 2) participated in an extension workshop to provide training and insight on piloting drones to local stakeholders (Obj 3.4 Technology Application).

Charles (Project 4) decided to continue in the lab to complete a master's program after his summer research experience.

Aditya (Project 6) has continued to work in Dr. Couture's lab during the fall 2024 semester and is writing a paper on his work for submission in 2025. He also presented his research at the 2024 Center for Advanced Forestry Center and the Ecological Society of America annual meetings.



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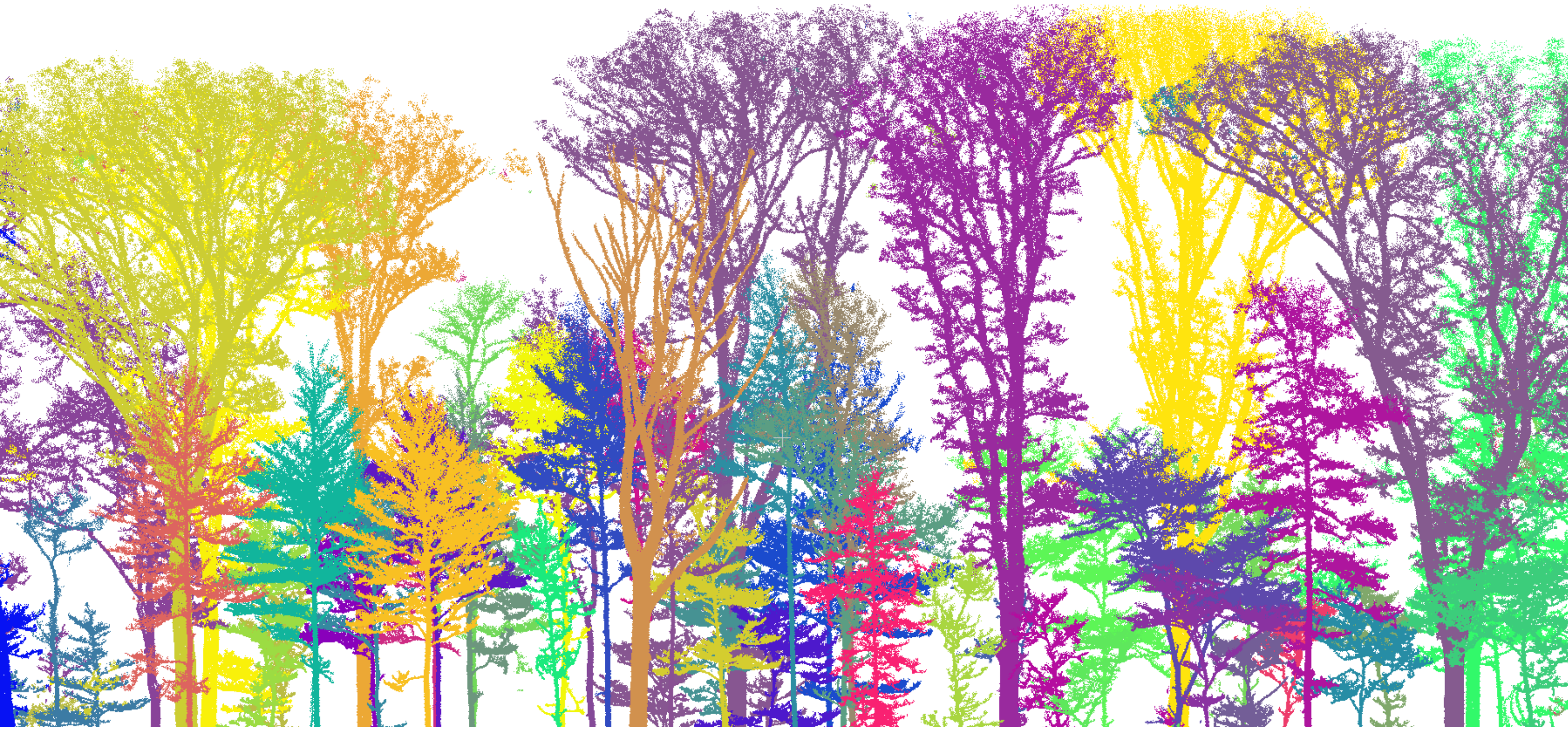

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