

# Final Report

## UMaine/UMFK START

CAFS.21.92

### Investigators

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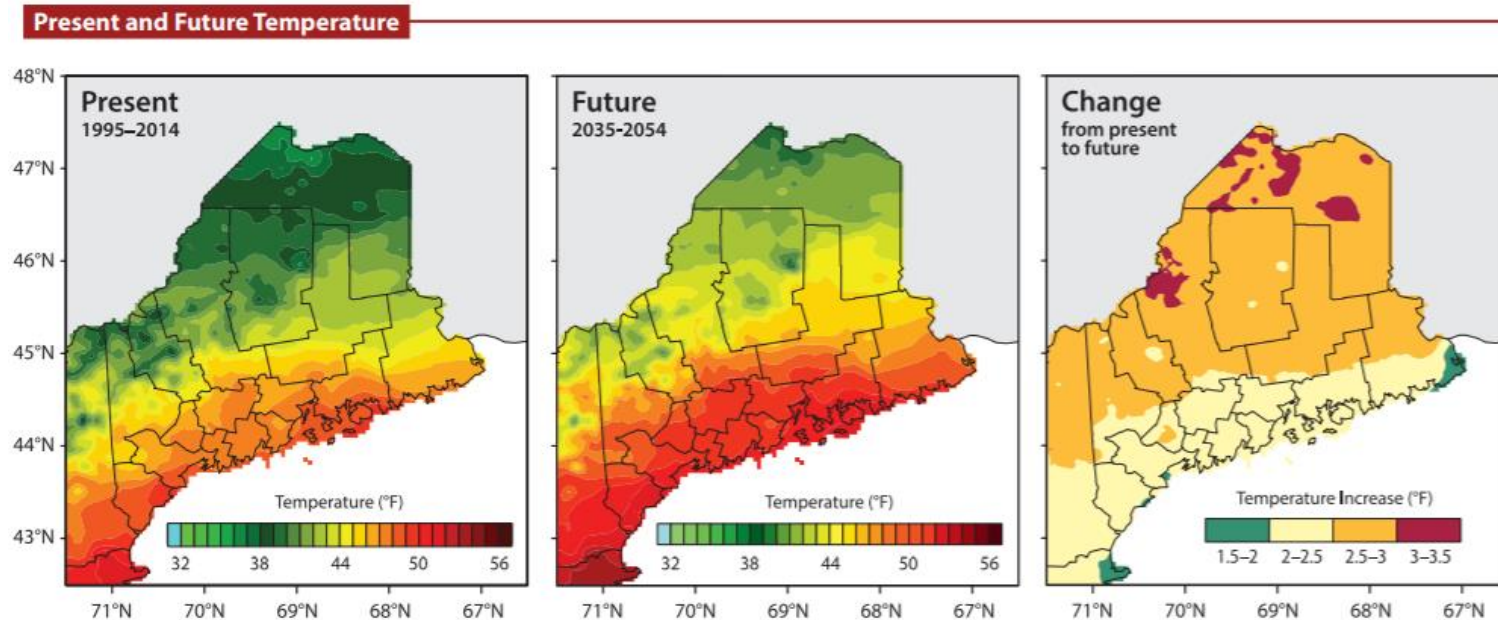
# Justification

## 1.Environmental change affects commercial forests<sup>1</sup>

- Growth + health
- Assessment and forecasting inform management

## 2. Forest products industry requires trained workforce<sup>2</sup>

- Collaboration and leadership skills
- Applied methods + procedures



**Figure 2.** Maps showing mean annual temperature for 1995–2014 (left), 2035–2054 (center), and the predicted change or difference between the two time periods (right). The predicted rise in temperature by 2050 ranges 2.0–3.0 °F from the coast inland to the Canadian border. Maps derived from an ensemble simulation of the IPCC A2 emissions scenario.<sup>1</sup>

1. Fernandez, I.J., Schmitt, C.V., Birkel, S.D. *et al.* (2015) *Maine's Climate Future: 2015 Update*. University of Maine, Orono, ME

2. *Maine Science and Technology Action Plan* (2010) [https://digitalmaine.com/decd\\_docs/1](https://digitalmaine.com/decd_docs/1)



# Objectives

- 1. Assess tree responses to environmental conditions**
- 2. Collect, curate and communicate data for management**
- 3. Prepare future forestry professionals**



# **11+ Synergistic Projects (new at UMFK in AY2024/25)**

1. Rapidly assessing tree health from hyperspectral images  
(Rubert-Nason *et al.* UMFK. Sponsor: *Maine Economic Improvement Fund [MEIF]*)
2. Estimating wood moisture content  
(Li *et al.* UMaine. Sponsor: *Maine Research Reinvestment Fund*)
3. Identifying, ranking causes of, and managing cedar health decline  
(Landry *et al.* UMFK)
4. Evaluating effects of microclimate on forest regeneration  
(Rogers *et al.* UMaine. Sponsor: *Cooperative Forestry Research Unit [CFRU]*)
5. Creating unified database for Maine Adaptive Silviculture Network (MASN) data  
(Louis *et al.* UMFK. Sponsor: *CFRU*)
6. Identifying uses of biochar soil amendments to mitigate climate impacts on trees  
(Rubert-Nason *et al.* UMFK. Sponsor: *MEIF*)
7. Strengthening Maine's research through strategic capacity building (NSF E-CORE)  
(Moeykens *et al.* UMaine & Rubert-Nason UMFK. Sponsor: *NSF*)
8. Enhancing Maine forest economy, sustainability, and technology ecosystem to accelerate innovation (NSF E-RISE) (Weiskittel *et al.* UMaine & Rubert-Nason UMFK. Sponsor: *NSF*)
9. Building collaborative wood quality research capacity at UMFK  
(Rubert-Nason *et al.* UMFK. Sponsor: *MEIF*)
10. Innovative conservation actions to increase biodiversity and resilience in range-margin aspen ecosystems (PENDING, Waring *et al.* Northern Arizona University & UMFK. Sponsor: *NSF*)
11. Promoting economic resilience and sustainability of the Eastern U.S. Forests (PERSEUS) (Fei, Weiskittel & Bettinger. UMaine, Purdue, UGA, UMFK. Sponsor: *NSF*)



# Methods – Shared among projects

- Geospatial analysis (w/ QGIS, ENVI)
- UAV and ground-based remote sensing
- Tree mensuration (morphology, health class, etc)
- Specimen collection, transport & storage
- Soil chemical & physical analysis
- Phytochemical analysis (e.g., tannins, terpenoids)
- Physiological measurements (w/ Licor-6800 analyzer)
- Climate monitoring equipment operation
- Data curation and analysis (e.g., Google sheets, Access)





# Progress 2024-25

1. Rapidly assess tree health from hyperspectral images
  - Data analysis, ESA2024 presentation
3. Identify, rank order probable causes of, and manage cedar health decline
  - Collecting data in 2025 field season
5. Create unified database for Maine Adaptive Silviculture Network (MASN) data
  - Database and analytics tools developed in Microsoft Access and Power BI
6. Identify uses of biochar soil amendments to mitigate climate impacts on trees
  - Implemented container garden representing 4 tree species, 4 types of biochar, 2 moisture treatments
7. Strengthen Maine's research through strategic capacity building (NSF E-CORE)
  - Currently analyzing eDNA to assess impacts of forest management on soil microbiomes

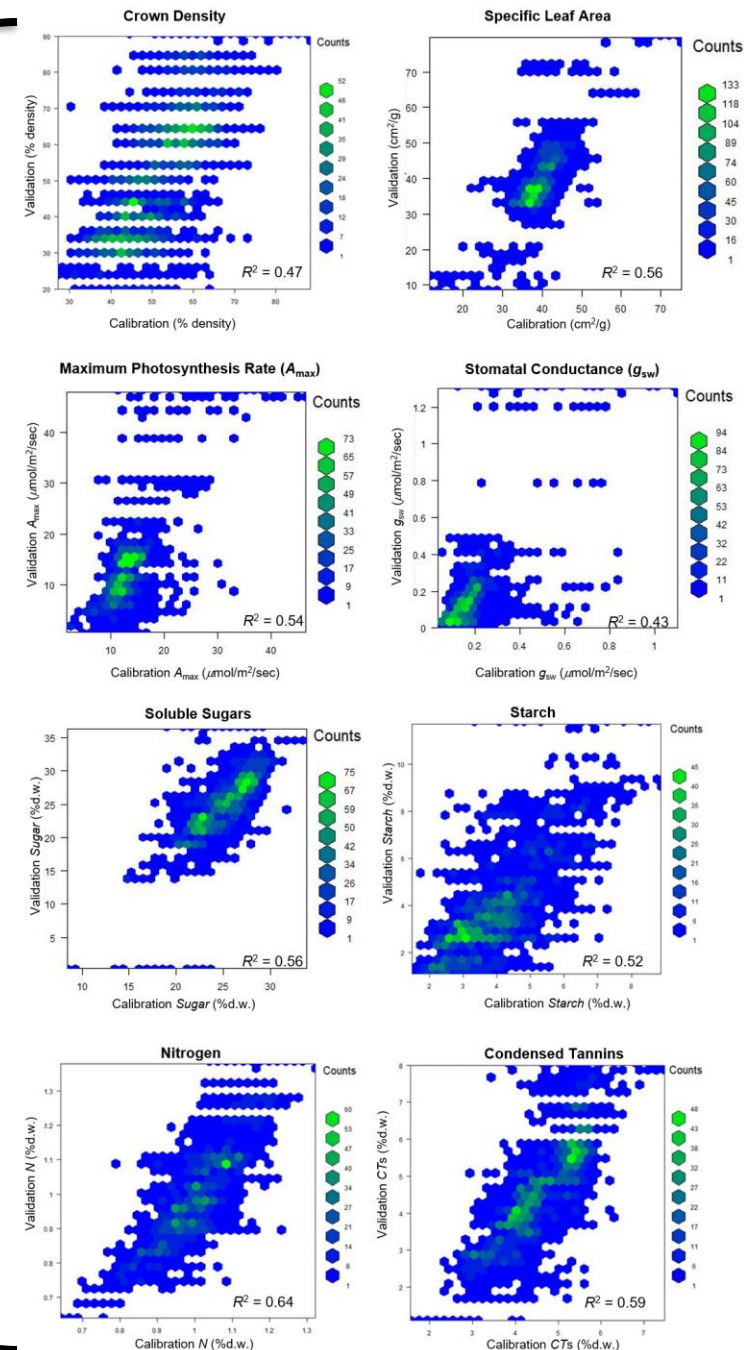
## New projects in AY2024-25

8. Enhancing Maine forest economy, sustainability, and technology ecosystem to accelerate innovation (NSF ERISE)
9. Building collaborative wood quality research capacity at UMFK (MEIF)
10. Innovative conservation actions to increase biodiversity and resilience in range-margin aspen ecosystems (NSF)
11. Promoting economic resilience and sustainability of the Eastern U.S. Forests (PERSEUS) forest inventory and trait data collection initiative



# Major Findings

- Demonstrated feasibility of assessing differences in spruce tree health using aerial hyperspectral imaging (manuscript in prep.)
- Developed method for Wood moisture content determination by handheld near-infrared reflectance spectrometer (Thapa et al. 2024. Wood & Fiber Science, doi: 10.22382/wfs-2024-18)
- Identified and monitored traits associated with northern white cedar decline
- Identified relationships among microclimate variables and forest regeneration
- Created a unified, FAIR-compliant database for Maine Adaptive Silviculture Network (MASN) forest inventory plot data



## **Communications: Forest health & workforce development**

## **Deliverables**

- Presentations (3): *Hyperspectral imaging for rapid health assessment of spruces* (#80221). Ecol. Soc. Am. Natl. Mtg. Aug. 4-9, 2024. Long Beach, CA; *Empowering Maine's rural workforce to advance forest and community resiliency*. University of Maine System Rural Issues Symposium, Orono, ME. Nov. 1, 2024; *Impacts of low-intensity fire damage on Populus morphology, physiology and phytochemistry*. Ecol. Soc. Am. Natl. Mtg., Baltimore, MD, Aug. 10-15, 2025.
- Publication: *Wood moisture content determination by handheld near-infrared reflectance spectrometer*. Thapa, Li, Rubert-Nason, Wang, Mirtes, Brown, Pelletier, Zhang. *Wood & Fiber Science*, doi: 10.22382/wfs-2024-18)
- Publication (in prep): *Hyperspectral imaging for tree health assessment*. *Can. J. For. Res.*

## **Data Collection: Informs forest management decisions**

- Cedar health pilot data
- Microclimate effects on forest regeneration
- Create unified MASN plot database

**New collaborations**: PERSEUS project - Estimating tree traits by hyperspectral imaging

## **New funding (2021-2025)**

- MEIF: Building collaborative wood quality research capacity at UMFK (Rubert-Nason *et al.*, \$46k)
- NSF ERISE: Enhancing Maine forest economy, sustainability, and technology ecosystem to accelerate innovation (Rubert-Nason *et al.*, Maine-FOREST, #OIA-2416915, \$80k)
- NSF ECORE RII: Strengthening Maine's research ecosystem and pathways through strategic capacity building (Rubert-Nason *et al.*, Maine-SMART, #OIA-2412130, \$99k)
- CFRU: Building a database from MASN inventories (Louis *et al.*, \$35k)
- MEIF: Repurposing biochar residues as soil amendments (Rubert-Nason *et al.*, \$181k)
- MEIF: Microclimate effects on forest regeneration (Rogers & Rubert-Nason, \$25k)

## **Career preparation for UMFK Forestry students**





# Company Benefits

## **1. Remote sensing can be used to rapidly identify changes in tree health**

- Financial loss mitigation: Fast, affordable ways to identify tree health changes
- Optimize site selection for future plantings and management to maximize yield
- Synergistic projects

## **2. Data collection & curation**

- Forest inventory + environmental data inform management decisions
- Pilot data on tree health-environment connections

## **3. Workforce preparation for forestry professionals (10+ undergraduates)**

- Collaborative and leadership skills
- Field and lab work
- Logistics
- Critical thinking
- Tools, technologies & procedures
- Networking



# Future Plans

## 1. Collaborative research on identifying and mitigating impacts of environmental change impacts on forests

- NSF ECORE (explore forest management impacts on soil microbiomes)
- NSF ERISE (explore forest management impacts on tree health/growth)
- NSF (promote aspen resilience and biodiversity in forests of the Rocky Mtns)
- MEIF (develop uses for biochar in forestry to promote tree resilience and soil carbon storage)
- Sustain CAFS partnership

## 2. Workforce preparation for undergraduate students

- Mentoring (collaboration, critical thinking, tools/technologies, etc)
- NSF ECORE (partnerships with Maine Math & Science Alliance & UMFK Early College/Concurrent Enrollment to support STEM pipeline)
- NSF ERISE (partnership with Wabanaki Youth in Science to support integration of Indigenous knowledge into contemporary forestry)



# Summary: CAFS START funds facilitated...

- **Launch of new projects: 10+ underway (+3 from 2024)**

- *Thrusts:* Environmental change impacts on forests
- *Innovation:* Research and uses of technology
- *Mentoring:* Embedded teaching + mentoring

- **Data collection & curation:** Increase availability and accessibility of data to inform decisions

- **Collaborations**

- PERSEUS
- NAU oystershell scale study (pending)

- **Workforce preparation (10+ undergraduates):**

- Collaboration and leadership skills
- Logistics + field work
- Critical thinking
- Tools, technologies & procedures
- Networking

