

Arnot Forest Project Summary

ACER 1 - Efficient, Profitable and Sustainable Maple Production through Applied Research, Education and Innovative Technologies

Project Title	Efficient, Profitable and Sustainable Maple Production through Applied Research, Education and Innovative Technologies
Project Duration (dates)	Oct 2018 – Sept 2022
Brief narrative description, 2 – 3 sentences. (use the Executive Summary or problem statement)	The College of Agriculture and Life Sciences at Cornell University will extend research and education efforts of the Cornell Maple Program to increase maple syrup production per tap, improve sap collection and processing efficiency, and promote productive and sustainable sugarbush management practices through applied research, the development of innovative technologies and educational outreach.
Project Objectives	Areas of focus will include: 1) Development of sugarbush management guidelines for optimal sugar production, sustainable forest regeneration and enhanced ecological function; 2) Increased sap yield and quality through advances in taphole sanitation, vacuum efficiency, filtration and sap handling technologies; 3) Increase syrup quality, flavor and processing energy efficiency through advances concentration technology 4) Improved profitability and sustainability of maple businesses through the efficient production of high quality value-added maple products and the development of new value-added maple products.
Key Personnel (faculty and staff with college & department or similar institutional affiliation)	Peter Smallidge, CALS Dept of Natural Resources and the Environment Stephen Childs, CALS Dept of Natural Resources and the Environment Aaron Wightman, CALS Dept of Natural Resources and the Environment Ailis Clyne, CALS Dept of Natural Resources and the Environment
Students	3 work study employees
Sponsor	USDA AMS



Maple Sports Drink

Catherine Belisle, Ph.D., 2022



Overview

The Cornell Maple Program developed two athlete-approved recipes for a Tart Cherry and a Tangerine Maple Sports Drink. These beverages are designed to hydrate and replenish carbohydrates and electrolytes lost during physical activity. Because of the health-benefits (antioxidants, vitamins, and minerals), Maple Sports Drinks can be marketed as a functional beverage, a lucrative market projected to increase 7.8% from 2021 to 2028 (Report Linker, 2022).



The Science of Sports Drinks

Electrolytes are minerals that are essential for the body to function (Felman & Tinsley, 2021). Sodium and potassium are the most common electrolytes in need of replenishment after physical activity. Sodium contributes to improved hydration (Cerullo et al., 2020) and performance (Oöpik et al., 2003), while potassium contributes to increased energy expenditure (James et al., 2015) and decreased muscle contractions (Maughan et al., 2009). Maple syrup contains potassium (50-81 mg/L) in addition to calcium (35-75 mg/L), magnesium (3.9-8.1 mg/L), manganese (1.7-5.5 mg/L), and trace amounts of other minerals (Perkins & van den Berg, 2009). Sports medicine research recommends supplementing sodium at a rate of 230 to 690 mg/L (Maughan et al., 2009) and potassium at 117 mg/L (González-Alonso et al., 1992). Sodium citrate and potassium chloride are easily accessible and valuable sources of these electrolytes.

Glycerol is naturally occurring in the body; multiple studies have reported benefits when consumed before, during, and after physical activity. It helps to maintain a lower heart rate, lower core temperature, and helps with hydration (Anderson et al., 2001; Maughan et al., 2009). The current recommendations for rehydration are 46 to 60 g/L of glycerol in water for a 150 to 200 lb individual (van Rosendal et al., 2010).

Carbohydrates serve as fuel for the muscles and brain. Sports drinks contain 4 to 8% (40-80 g/L) carbohydrates. This low concentration is quickly absorbed as energy, while a higher concentration slows hydration (Coombes & Hamilton, 2000).

Screenshot of maple sports drink fact sheet; a product developed at the Arnot Maple Lab new product development kitchen

Arnot Forest Project Summary

ACER 2 - Expanding Knowledge for the Efficient and Profitable Production of Quality Maple Syrup and Value-Added Products

Project Title	Expanding Knowledge for the Efficient and Profitable Production of Quality Maple Syrup and Value-Added Products
Project Duration (dates)	October 2019 – September 2023
Brief narrative description, 2 – 3 sentences. (use the Executive Summary or problem statement)	Maple sugar is still an underutilized sweetener, despite continued growth of the maple industry. Factors limiting the expanded use of maple sugar include several types of process inefficiencies that increase costs and negatively impact quality. The Cornell Maple Program will expand current research and education efforts to address these inefficiencies through applied research and broad outreach to the maple industry.
Project Objectives	Areas of focus will include: 1) Sap collection system design and maintenance enhancements 2) Syrup processing efficiency and quality improvements 3) Value-added production process innovations. As a result of this work, maple producers will improve the efficiency of syrup production and quality of syrup. They will also gain access to new production methodologies for the large-scale, efficient production of value-added products, including granulated sugar, refined sugar, cotton candy, and maple candy. New maple producers will be trained in the basics of production efficiency and quality control.
Key Personnel (faculty and staff with college & department or similar institutional affiliation)	Peter Smallidge, CALS Dept of Natural Resources and the Environment Stephen Childs, CALS Dept of Natural Resources and the Environment Aaron Wightman, CALS Dept of Natural Resources and the Environment Catherine Belisle, CALS Dept of Natural Resources and the Environment Ailis Clyne, CALS Dept of Natural Resources and the Environment Robert Daniel, CALS Dept of Natural Resources and the Environment
Sponsor	USDA AMS



Experimental ultrafiltration unit at Arnot Maple Lab removes microbial bodies from sap. Prefiltered concentrate on left, filtered concentrate on right

Arnot Forest Project Summary

ACER 3 - Maximizing productivity of maple enterprises through increased sap utilization and development of new value-added products

Project Title	Maximizing productivity of maple enterprises through increased sap utilization and development of new value-added products
Project Duration (dates)	October 2020 – September 2024
Brief narrative description, 2 – 3 sentences. (use the Executive Summary or problem statement)	Continued expansion of the maple products industry requires producers to address several key constraints to growth. These limiting factors include the productive capacity of the sugarbush and demand for maple products in the marketplace. The Cornell Maple Program will address these impediments with a four-part plan that includes innovative research approaches coupled with rigorous extension activities to promote increased production of maple products
Project Objectives	1) Develop high-value options for buddy maple syrup, allowing producers to utilize a greater amount of the total productive potential of the sugarbush. 2) Create novel, high-value maple products, including gourmet maple chocolate, and improve the quality of existing maple confections to give maple producers access to lucrative new markets. 3) Establish technical guidelines for the safe bottling and sale of maple sap to expand the presence of maple in the beverage industry 4) Produce a monthly podcast series to improve accessibility to research in the maple industry.
Key Personnel (faculty and staff with college & department or similar institutional affiliation)	Aaron Wightman, CALS Dept of Natural Resources and the Environment Adam Wild, CALS Dept of Natural Resources and the Environment Ailis Clyne, CALS Dept of Natural Resources and the Environment Catherine Belisle, CALS Dept of Natural Resources and the Environment Robert Daniel, CALS Dept of Natural Resources and the Environment
Students	Multiple food science capstone projects each year
Sponsor	USDA AMS



Maple Marshmallow Spread

Xingrui Fan, Anna Bica, Young Kim, Jordan Roth, Catherine Belisle PhD, 2023



Overview

The Cornell Maple Program works with industry collaborators and university partners to facilitate the development of new maple products. This product is a shelf-stable maple marshmallow spread, sweetened solely with maple syrup and maple sugar. It was developed using amber maple syrup and maple sugar for one formulation and dark syrup and sugar in a second formulation.

Maple marshmallow spread is designed to compete as a gourmet version of popular marshmallow spreads. It has a variety of suggested uses such as a hot beverage topping, sandwich spread, baking ingredient, and enjoyed by the spoonful as a treat. This product is formulated with physical properties and additives to ensure a quality, stable, and safe product. Commercial production requires an approved, food safe process and a certified facility.



Maple Lip Balm

Ailis Clyne, 2023



Overview

Lip balm is a popular and easy to produce personal care product. Maple syrup can be incorporated into lip balm recipes to add flavor, aroma, label appeal, and nutrients with possible skin care benefits. Potential market opportunities include direct to consumer sales, inclusion in maple gift baskets, and bulk sales of maple syrup to producers of natural skin care products.

This document provides a recipe for a basic maple lip balm containing glycerin; this is the formulation that was used for market testing at Cornell University (see **Market Testing** section). For recipe variations, see the **Maple Skin Care and Bath Products Notebook**.

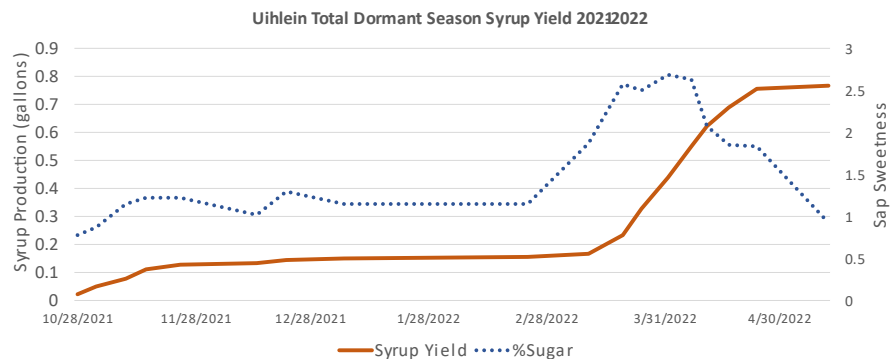
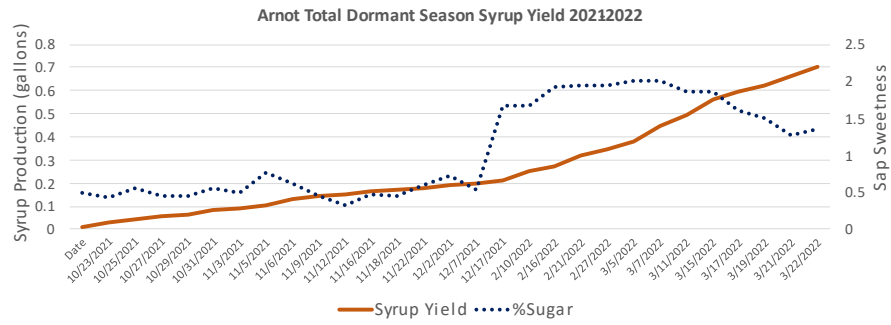


Factsheets for new products developed in the Arnot Maple Lab are available on the program website www.cornellmaple.com

Arnot Forest Project Summary

ACER 4 - Best Practices for Increasing Maple Production through Forest Management and Extending Sap Collection Season

Project Title	Best Practices for Increasing Maple Production through Forest Management and Extending Sap Collection Season
Project Duration (dates)	October 2020 – September 2024
Brief narrative description, 2 – 3 sentences. (use the Executive Summary or problem statement)	Maple producers can expand the productive capacity of their sugarbush by growing more trees, purchasing additional land and equipment, or by increasing the productive output of individual trees. Of these options, the most cost and time effective is increasing individual tree productivity. By overcoming barriers that limit the duration of the sap collection season and the volume of sap collected from each tree, this project will increase syrup production for maple businesses while also creating guidance to ensure the health and long-term sustainability of maple trees
Project Objectives	The Cornell Maple Program will accomplish these objectives by establishing guidelines for maximizing sap collection from all dormant season sap flows while protecting the tappable sustainability of the trees, thinning forests for increased light availability to promote health and sugar production and, providing proper soil nutrients. Additionally, real-time comparison benchmark data will be generated and made available online for producers to utilize as a decision making tool during the sugaring season. By establishing a robust educational framework that communicates these strategies, we will increase the productivity and profitability of maple operations
Key Personnel (faculty and staff with college & department or similar institutional affiliation)	Peter Smallidge, CALS Dept of Natural Resources and the Environment Adam Wild, CALS Dept of Natural Resources and the Environment Aaron Wightman, CALS Dept of Natural Resources and the Environment Ailis Clyne, CALS Dept of Natural Resources and the Environment Keith Otto, CALS Dept of Natural Resources and the Environment
Sponsor	USDA AMS



Parallel studies of total dormant season sugar production at Arnot and Uihlein forests highlight key differences in sap flow timing and characteristics between sites in New York with different climate conditions

Arnot Forest Project Summary

ACER 5 - Improving Resilience of Maple Businesses in a Warming Climate

Project Title	Improving resilience of maple businesses in a warming climate
Project Duration (dates)	October 2022 - September 2025
Brief narrative description, 2 – 3 sentences. (use the Executive Summary or problem statement)	This proposal addresses two challenges to production and profitability created by warmer weather conditions associated with climate change: 1) the development of off-flavors which decrease crop value 2) diminished sap production due to spoilage in the sap collection system.
Project Objectives	Through an integrated approach of applied research and extension programming, this project: 1) identifies sensory signatures of consumer liking in maple syrup, 2) quantifies the drop in perceived value arising from sap collected late in the season when sensory defects are more prevalent, 3) provides maple farmers with strategies to preserve sap quality and maximize taphole productivity through collection system design, maintenance, and sap management.
Key Personnel (faculty and staff with college & department or similar institutional affiliation)	Robin Dando, CALS Dept of Food Science Aaron Wightman, CALS Dept of Natural Resources and the Environment Catherine Belisle, CALS Dept of Natural Resources and the Environment
Students	Graduate research assistant
Sponsor	USDA AMS



Sensor monitors sap temperature in a collection system demonstrating strategies for sugaring in a warming climate in the Arnot Teaching and Research Forest

Arnot Forest Project Summary

ACER 6 - Preserving and Adapting Maple Flavor for New Market Opportunities

Project Title	Preserving and adapting maple flavor for new market opportunities
Project Duration (dates)	October 2023 - September 2026
Brief narrative description, 2 – 3 sentences. (use the Executive Summary or	In this project we propose the development of several line extensions to maple syrup, such as barrel aging or flavor infusion, that will open up new markets to maple producers particularly for lower value late-season syrup. Further, we propose the exploration of best practices for storage of maple syrup, where in preliminary testing we find both light and temperature can alter the color of maple syrup in a manner common in many agricultural products containing light-sensitive or easily degradable organic compounds, which in these food systems also leads to flavor changes.
Project Objectives	With these experiments we will uncover 1) new market opportunities for growth in the maple industry, and 2) ensure that existing syrup gets to consumers in a consistent and optimal manner.
Key Personnel (faculty and staff with college & department or similar institutional affiliation)	Robin Dando, CALS Dept of Food Science Catherine Belisle, CALS Dept of Natural Resources and the Environment
Students	Graduate research assistant
Sponsor	USDA AMS



Sensor monitors sap temperature in a collection system demonstrating strategies for sugaring in a warming climate in the Arnot Teaching and Research Forest

Arnot Forest Project Summary

Climate and Applied Forestry Research Institute

Project Title	Climate and Applied Forestry Research Institute
Project Duration (dates)	2021-2023 (ongoing)
Brief narrative description, 2 – 3 sentences. (use the Executive Summary or problem statement)	<p>The Climate & Applied Forest Research Institute (CAFRI) was founded by SUNY ESF and Cornell College of Agriculture and Life Sciences (CALs) in 2018 to provide policymakers and the public with knowledge and tools so they can make data-driven, practical, efficient, and sustainable decisions about climate solutions, through science-based stewardship of New York's natural and working forest lands.</p> <p>CAFRI offers advanced capabilities in systems modeling and data science—including life-cycle, technoeconomic, and geospatial assessments—to identify climate mitigation strategies that are scalable and achievable.</p>
Project Objectives	<p>CAFRI 1.0</p> <ul style="list-style-type: none"> • Slash walls sequester more carbon through effective and complete forest regeneration. • York sourced hardwood, especially white oak, for wine and spirit barrels and wood adjuncts. • Assessing benefits and barriers to reforesting shrub lands with forests for carbon sequestration and wood products. <p>CAFRI 2.0</p> <ul style="list-style-type: none"> • Reduce uncertainty in monitoring, reporting, and verification (MRV) for carbon storage and sequestration in NY forest ecosystems. • Describe patterns of regeneration within slash walls and young forest ability to sequester carbon. • Identify silvopasture’s contribution to New York’s carbon sequestration and storage, agricultural enterprise development and carbon offsets as compared to remotely produced meat.
Key Personnel (faculty and staff with college & department or similar institutional affiliation)	<p>Peter Smallidge, CALs Natural Resources and Environment Peter Woodbury, CALs SIPS Crop and Soil Sciences Section Brett Chedzoy, CCE Schuylers County Rich Stedman, CALs Natural Resources and Environment Anna Katharine Mansfield, CALs Food Science & Cornell AgriTech Xiangtao Xu, CALs Ecology and Evolutionary Biology Bruce Lauber, CALs Natural Resources and Environment David Weinstein, CALs Natural Resources and Environment Paul Curtis, CALs Natural Resources and Environment Katie Walsh, CALs Natural Resources and Environment</p>

	Marc Goebel, CALS Natural Resources and Environment
Students	Jen Neubauer
Sponsor	NYS Agriculture and Markets NYS Department of Environmental Conservation

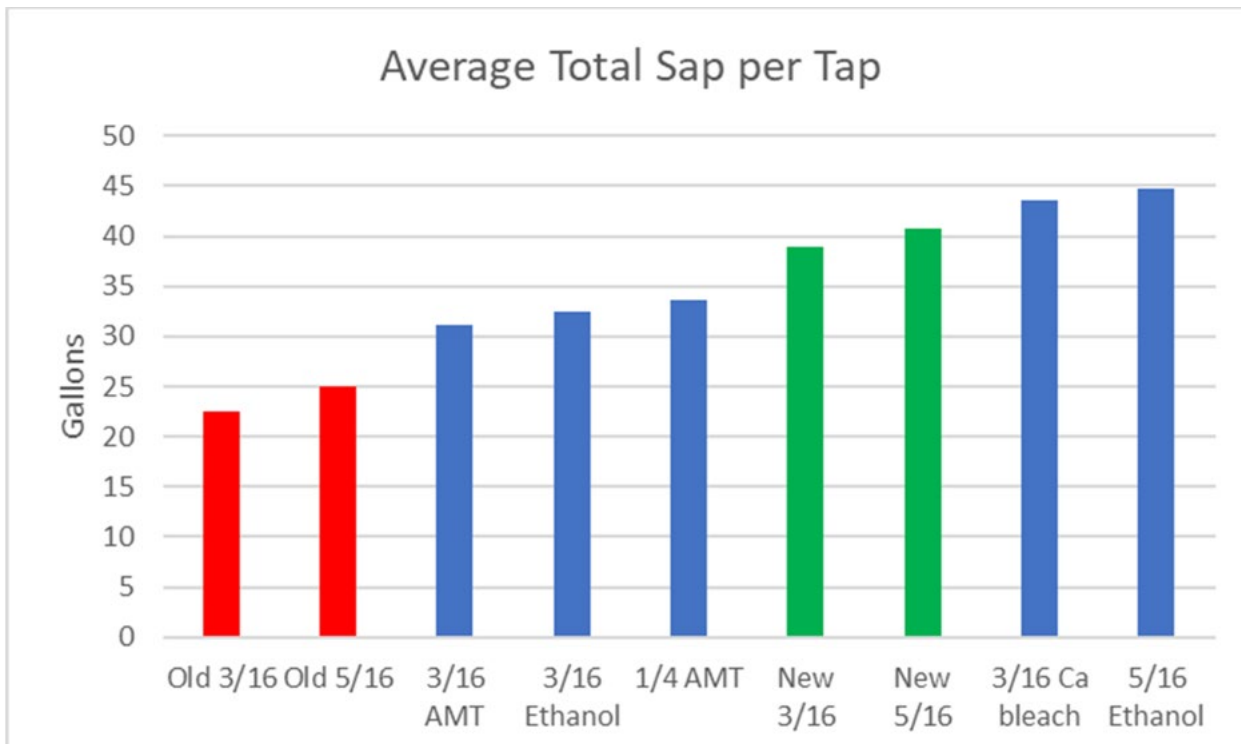


The Cornell CALS and SUNY ESF research team review methods of hardwood plantation establishment within brush walls at the Arnot Forest.

Arnot Forest Project Summary

Cornell University Maple Research Program

Project Title	Cornell Maple Research Program
Project Duration (dates)	Ongoing with annual renewal (2016 - current)
Brief narrative description, 2 – 3 sentences. (use the Executive Summary or problem statement)	The Cornell Maple Program is a research and extension program at Cornell University with a mission to support the sustainable growth of the maple products industry. Work is performed on a wide range of topics at the Arnot Maple Lab in Van Etten, NY
Project Objectives	This project provides core funding for program activities directed specifically at NY maple businesses. Program staff will participate in statewide and local efforts to increase production of high-quality products, improve practices for sustainability, and diversify product offerings.
Key Personnel (faculty and staff with college & department or similar institutional affiliation)	Aaron Wightman, CALS Dept of Natural Resources and the Environment Catherine Belisle, CALS Dept of Natural Resources and the Environment Ailis Clyne, CALS Dept of Natural Resources and the Environment Robert Daniel, CALS Dept of Natural Resources and the Environment
Sponsor	NYS Department of Agriculture and Markets



Ongoing studies at Arnot Forest have helped improve taphole productivity over 70%

Arnot Forest Project Summary

Designing Sustainable Multistory Cropping Systems for Maple Sugarbushes

Project Title	Designing sustainable multistory cropping systems for maple sugarbushes
Project Duration (dates)	October 2021 - September 2024
Brief narrative description, 2 – 3 sentences. (use the Executive Summary or	This projects aims to generate knowledge to enable maple syrup producers to develop multicrop systems within the sugarbush and integrate these crops into multi ingredient, value-added maple products.
Project Objectives	<ol style="list-style-type: none">1. Identify best-suited crops and best commercial varieties for cultivation in a partial-shade maple forest system. Evaluate crop survival, vigor, and yield for plantings at the Arnot Forest.2. Identify best practices for maintaining key crops in a maple forest system.3. Identify best practices for spatial arrangement of crops for ease of harvesting and maintenance, ideal light conditions, and economical use of space.4. Research & develop new recipes and processes for value-added maple products featuring forest grown crops.
Key Personnel (faculty and staff with college & department or similar institutional affiliation)	Peter Smallidge, CALS Dept of Natural Resources and the Environment Aaron Wightman, CALS Dept of Natural Resources and the Environment Ailis Clyne, CALS Dept of Natural Resources and the Environment Catherine Belisle, CALS Dept of Natural Resources and the Environment
Students	Laboratory site for students in Practicum in Forest Farming
Sponsor	Federal Capacity Funds



Black currants growing in the Arnot sugarbush agroforestry research plot

Arnot Forest Project Summary

Educational Tours of Applied Research and Management

Project Title	Educational Tours of Applied Research and Management at the Arnot Forest
Project Duration (dates)	Annually
Brief narrative description, 2 – 3 sentences. (use the Executive Summary or problem statement)	We routinely hosts groups who are interested in the Arnot’s innovative forest management activities. In the past two years over 100 visitors from at least nine groups representing forest industry, state and federal agencies, academic institutions and organizations like the NY Forest Owners Association have received guided tours upon request.
Project Objectives	Provide tailored and detailed learning experiences for key stakeholder groups and partners
Key Personnel (faculty and staff with college & department or similar institutional affiliation)	Chedzoy, Brett – CCE Schuyler County Curtis, Paul - CALS Natural Resources and Environment Smallidge, Peter, CALS Department of Natural Resources and Environment Stedman, Rich - CALS Natural Resources and Environment Sullivan, Kristi - CALS Natural Resources and Environment Weinstein, David - CALS Natural Resources and Environment Wightman, Aaron - CALS Natural Resources and Environment Woodbury Peter - CALS SIPS Crop and Soil Sciences Section Xu, Xiangtao – CALS Ecology and Evolutionary Biology
Students	
Sponsor	Project related



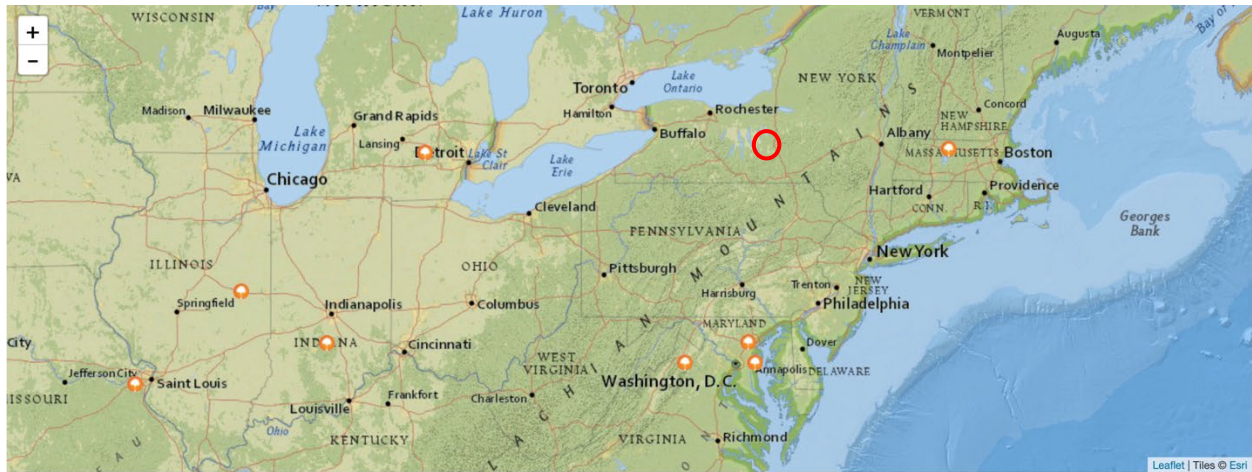
Tours and field days bring a variety of stakeholders to the Arnot Forest to learn about woodland and forest management.

Arnot Forest Project Summary

ForestGEO site at Pine Creek Watershed of Arnot Forest

Project Title	ForestGEO site (with the Smithsonian Institute)
Project Duration (dates)	Initiation in the summer of 2024
Brief narrative description, 2 – 3 sentences. (use the Executive Summary or problem statement)	Establish a 400 m by 400 m (16 ha) ForestGEO site and contribute to the 79 existing ForestGEO site worldwide. At Arnot Forest, it will be the first site on the Westside of the Appalachian Mountain range, representing and monitoring the forest dynamics of NE temperate forests. https://forestgeo.si.edu
Project Objectives	<p>ForestGEO sites were established to fully represent the global-scale forest network, which now contains forest research sites in tropical and temperate climatic zones.</p> <ul style="list-style-type: none"> • Increase scientific understanding of forest ecosystems. • Guide sustainable forest management and natural resource policies. • Monitor the impacts of global climate change. • Build capacity in forest science. <p>https://forestgeo.si.edu/what-forestgeo</p>
Key Personnel (faculty and staff with college & department or similar institutional affiliation)	Marc Goebel, CALS Natural Resources and Environment Stephen Rodriguez, CALS Natural Resources and Environment Xiangtao Xu, CALS Ecology and Evolutionary Biology Peter Smallidge, CALS Natural Resources and Environment
Students	Grad student, undergrad students
Sponsor	In progress <ul style="list-style-type: none"> • https://forestgeo.si.edu/training-and-fellowships • Atkinson, CU summer internships, etc.

If possible, please attach a picture as a separate file related to the project but doesn't need to be taken at the Arnot Forest.



Red circle - establishing a ForestGEO site at Arnot Forest will be the first ForestGEO site on the Westside of the Appalachian Mountain range, representing and monitoring the temperate forests of the NE. Orange symbols represent other ForestGEO sites in the NE and mid/northern USA.

Arnot Forest Project Summary

Forests in Flux: Strategies for Resilience in the Face of Environmental Change

Project Title	Forests in flux: strategies for resilience in the face of environmental change
Project Duration (dates)	2020-2026
Brief narrative description, 2 – 3 sentences. (use the Executive Summary or problem statement)	We have been developing techniques to incorporate woody material in the form of treetops and branches into the forest floor ecosystem. Our findings indicate that these techniques buffer extremes in soil moisture and ground temperatures, enhance tree seedling survival, increase sapling and herbaceous species diversity, improve soil, and provide essential habitat for ground-dwelling and avian species (and potentially pollinators), maintain biodiversity and improve forest regeneration and health.
Project Objectives	The primary project objective is to develop implementable strategies for forest land owners and managers by providing practicable methods to enhance diversity and generate resilient forest ecosystems that are diverse and resistant to new threats and environmental disturbance.
Key Personnel (faculty and staff with college & department or similar institutional affiliation)	Morreale, Stephen – CALS Natural Resources and Environment Sullivan, Kristi – CALS Natural Resources and Environment Smallidge, Peter – CALS Natural Resources and Environment Weinstein, David – CALS Natural Resources and Environment
Students	One to three undergraduate interns each year One MPS student each of the last 3 years
Sponsor	McEntire Stennis grant, Arnot Undergraduate Intern Fund

Arnot Forest Project Summary

Game of Logging Chainsaw Safety and Efficiency Trainings

Project Title	"Game of Logging" Chainsaw Safety and Efficiency Trainings
Project Duration (dates)	Annually since 2000
Brief narrative description, 2 – 3 sentences. (use the Executive Summary or problem statement)	The Game of Logging is a nationally recognized training that capitates chainsaw operators to more safely and effectively work in the woods. The Arnot Forest partners with the NY Center for Agricultural Medicine and Health (NYCAMH) to offer at least two trainings annually.
Project Objectives	Affordable, high-quality chainsaw training to help woodland managers work safely and productively
Key Personnel (faculty and staff with college & department or similar institutional affiliation)	Peter Smallidge – Arnot Forest Director, CALS Natural Resources and Environment Brett Chedzoy – Arnot Forest Manager, CCE Schuyler County
Students	
Total budget for project	
Sponsor	NY Center for Agricultural Medicine and Health



A certified chainsaw instructor teaches woodland owners how to safely fell a tree at the Arnot Forest.

Arnot Forest Project Summary

Guise plots - 89-year-old, Long-term Forest Monitoring

Project Title	Guise plots - 89-year-old, long-term forest monitoring
Project Duration (dates)	100+ years, 1935 to continuing
Brief narrative description, 2 – 3 sentences. (use the Executive Summary or problem statement)	Monitoring 24 1-acre permanent plots scattered throughout the Arnot forest established in 1935. Long-term monitoring, analysis, and estimation of structure and species diversity dynamics in Northeastern (NE) temperate forest without management practices for 89 years. Estimating of long-term carbon sequestration dynamics and computer modeling of forest growth.
Project Objectives	<ul style="list-style-type: none"> • Long-term data monitoring on growth dynamics and structural development of NE forest stands and their species diversity. • Base for Carbon sequestration estimates of unmanaged forest stands in the NE. • Continuous ground truthing data collection for future LIDAR measurements and forest growth simulation.
Key Personnel (faculty and staff with college & department or similar institutional affiliation)	Marc Goebel (CALs, DNRE) Joseph Yavitt (CALs, DNRE) David Weinstein (CALs, DNRE) Timothy Fahey (CALs, DNRE)
Students	Student internships
Sponsor	Doris Duke Fund; Department of Natural Resources and the Environment in support of Dr. Marc Goebel research and teaching.

Publications:

New publication from recent inventories to be published in 2025, currently in preparation..

Fahey, T.J., R.E. Sherman, and D.A. Weinstein. 2013. Demography, biomass and productivity of a northern hardwood forest on the Allegheny Plateau. *The Journal of the Torrey Botanical Society*, 140 (1): 52-64

Fahey, T. J. 1998. Recent changes in an upland forest in south-central New York. *J. Torrey bot. Soc.* 125: 51–59.

Volk, T. A. and T. J. Fahey. 1994. Fifty-three years of change in an upland forest in south-central new york: growth, mortality and recruitment. *Bull. Torrey bot. Club* 121: 140–147.

Arnot Forest Project Summary

Improve Sustainable Forest Production with Forest Biomass Monitoring Using Terrestrial LiDAR Technology

Project Title	Improve Sustainable Forest Production with Forest Biomass Monitoring Using Terrestrial LiDAR Technology
Project Duration (dates)	10/1/2021 – 9/30/2024
Brief narrative description, 2 – 3 sentences. (use the Executive Summary or problem statement)	Our project aims to improve sustainable forest production and management by developing new tools to non-destructively and cost-effectively monitor forest biomass changes using terrestrial Lidar technology. Accurate measurements on tree biomass/volume changes and their allocation into commercial volume and harvest residuals are critical to forest management but remain challenging and labor-intensive. We are developing new toolsets that leverage novel portable and cost-effective terrestrial lidar to reconstruct high-resolution 3D structure of forests and monitor fine-scale biomass changes.
Project Objectives	<p>Research:</p> <p>Objective 1: <i>Evaluate the accuracy of TLS</i> and the state-of-the-art digital tree segmentation.</p> <p>Objective 2 : Build biomass/volume allometric relationships for both commercial tree volume and harvest residuals based on TLS samplings over key commercial species.</p> <p>Objective 3: Monitor high-resolution tree volume gain and loss from multi-year TLS.</p> <p>Extension:</p> <p>This project offers a practical way to demonstrate the utility of terrestrial LiDAR (light detection and ranging). The project will help practitioners better estimate the cost of high-quality slashwalls by accomplishing the following objectives:</p> <ol style="list-style-type: none"> 1. Develop annual field TLS tours at slash wall and sugarbush sites. 2. Develop biannual lay audience research updates to post to existing internet sites. 3. Develop and disseminate educational resources for foresters to acquaint them with practical applications of TLS technology. 4. Develop tools and models that foresters can use to apply TLS technology. 5. Develop numbers and equations that foresters can use to optimize slash wall constructions.
Colleges, departments, collegial institutions	Xiangtao Xu, CALS, Ecology and Evolutionary Biology Peter Smallidge, CALS Natural Resources and Environment Brett Chedzoy, CCE Schuyler County

Post docs and Students	Tao Hun, Nick Cranmer, Steve Rodriguez, Ogden Olivas, Fredy Escobar
Sponsor	USDA NIFA (McIntire-Stennis, Smith-Lever)



LiDAR is being used to quantify the volume of wood used to build slash walls. Foresters learn about LiDAR technology and other forestry applications.

Arnot Forest Project Summary

Improving Maple Technology and Syrup Quality: ARC Maple Lab Equipment

Project Title	Improving Maple Technology and Syrup Quality
Project Duration (dates)	May 2020 – April 2021
Brief narrative description, 2 – 3 sentences. (use the Executive Summary or problem statement)	This project funded the purchase and installation of this equipment at the Arnot Teaching and Research Forest Maple Lab
Project Objectives	The intent of this project was to procure and install equipment to create a state-of-the-art maple syrup processing facility that would serve both research and demonstration purposes. This mix of intended uses required careful selection of equipment and special modifications to create a system that simultaneously represents the industry standard, and also allows enough flexibility to perform a wide range of research functions.
Key Personnel (faculty and staff with college & department or similar institutional affiliation)	Aaron Wightman, CALS Dept of Natural Resources and the Environment Peter Smallidge, CALS Dept of Natural Resources and the Environment
Sponsor	Appalachian Regional Commission

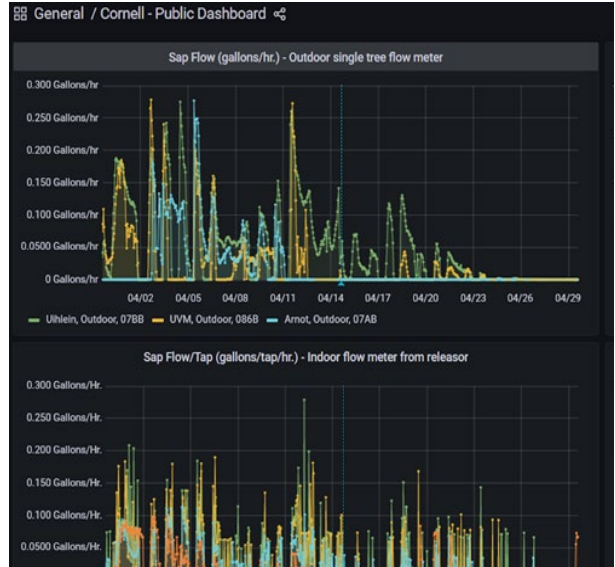


Energy saving reverse osmosis units at Arnot Maple Lab

Arnot Forest Project Summary

Maple Climate Network

Project Title	The Maple Climate Network
Project Duration (dates)	October 2022 – September 2025
Brief narrative description, 2 – 3 sentences. (use the Executive Summary or problem statement)	This project will develop and deploy sensor systems across the maple syrup producing region of North America to better understand the impact of climate and climate change on sap production and sap sugar content.
Project Objectives	<ol style="list-style-type: none">1) Develop version 2.0 of LoraWAN sensors to measure a range of climate and tree response variables2) Establish online dashboard with public access displaying real-time data from sugarbush3) Deploy sensor arrays at Arnot, Uihlein, and 6 collaborator sites4) Create long term database for use in future study
Key Personnel (faculty and staff with college & department or similar institutional affiliation)	Adam Wild, CALS Dept of Natural Resources and the Environment Aaron Wightman, CALS Dept of Natural Resources and the Environment
Sponsor	North American Maple Syrup Institute



Maple climate sensors and online dashboard at www.cornellsaprun.com

Arnot Forest Project Summary

Arnot Forest Maple Lab and Sugarhouse Renovation

Project Title	Arnot Forest Maple Lab and Sugarhouse Renovation
Project Duration (dates)	2019 - 2021
Brief narrative description, 2 – 3 sentences. (use the Executive Summary or problem statement)	An existing 4,000 sqft maintenance building was fully renovated with upgrades to structure, plumbing and electric to create new experimental sap processing facility and new product development kitchen. Project replaces rustic 900 sqft facility
Project Objectives	Create laboratory space to research a wide range of issues affecting maple syrup production including sap collection, processing, and value added product development.
Key Personnel (faculty and staff with college & department or similar institutional affiliation)	Aaron Wightman, CALS Dept of Natural Resources and the Environment Stephen Childs, CALS Dept of Natural Resources and the Environment Peter Smallidge, CALS Dept of Natural Resources and the Environment Brian Fish, CALS Facilities
Sponsor	NYS Department of Agriculture and Markets



Maple syrup production research trials underway at Arnot Maple Lab

Arnot Forest Project Summary

New York Master Naturalist Volunteer Program

Project Title	New York Master Naturalist Volunteer Program
Project Duration (dates)	2010 to 2024
Brief narrative description, 2 – 3 sentences. (use the Executive Summary or problem statement)	The New York Master Naturalist Volunteer Program is a program to enhance volunteer and broader community well-being, while developing a knowledgeable corps of environmental stewards able to recognize and understand a diversity of organisms, assess environmental conditions, detect patterns of change, and help solve problems. They educate the public, engage in active environmental monitoring, and implement impactful, on-the-ground conservation projects. Currently Master Naturalists serve as local resources for natural resource agencies and organizations across the state, increasing the local capacity for management and protection of local environmental resources and maintaining the ecological integrity of their widespread communities.
Project Objectives	To develop a knowledgeable corps of volunteers able to assess environmental conditions, and address current conservation issues.
Key Personnel (faculty and staff with college & department or similar institutional affiliation)	Sullivan, Kristi – CALS Natural Resources and Environment Instructors: Morreale, Stephen– CALS Natural Resources and Environment Smallidge, Peter – CALS Natural Resources and Environment Schneider, Rebecca – CALS Natural Resources and Environment Gilbert, Cole – CALS Entomology Bowe, Audrey – CALS Botanic Gardens Curtis, Paul – CALS Natural Resources and Environment
Students	Jessica Park, Student Program Assistant
Sponsor	Renewable Resources Extension Act, Smith Lever Grants, funds generated via training fees



A recent cohort of trainees for Cornell's Master Naturalist program learning about local ecosystems at the Arnot Forest.

Arnot Forest Project Summary

Permanent Inventory Plots (PFI) at Arnot Forest

Project Title	Permanent inventory plots (PFI) at Arnot Forest
Project Duration (dates)	Long-term, stand representative forest inventory plots (initiation in 2001 and expanded in 2015/2016).
Brief narrative description, 2 – 3 sentences. (use the Executive Summary or problem statement)	Establish permanent plot samples throughout the Arnot to measure the change in various forest characteristics through time. Be able to describe changes in forest species composition, structure, and habitat availability that result from natural forest dynamics and as result of management practices.
Project Objectives	<ul style="list-style-type: none"> • Maintain representative, long-term plots for stands a Arnot Forest, independent to management treatments. • Continuous assessment of forest plots in all stages of forest development, stand structure and plant / tree species diversity and calculable carbon stock.
Key Personnel (faculty and staff with college & department or similar institutional affiliation)	Marc Goebel, CALS Natural Resources and Environment Peter Smallidge, CALS Natural Resources and Environment David Weinstein, CALS Natural Resources and Environment Stephen Morreale, CALS Natural Resources and Environment Kristi Sullivan, CALS Natural Resources and Environment
Students	Student internships
Sponsor	Doris Duke Fund and other CU summer internship funds; Department of Natural Resources and the Environment in support of Dr. Marc Goebel research and teaching

If possible, please attach a picture as a separate file related to the project but doesn't need to be taken at the Arnot Forest.

Arnot Forest Project Summary

Professional development and training

Project Title	Professional development and trainings at the Arnot Forest
Project Duration (dates)	Annually
Brief narrative description, 2 – 3 sentences. (use the Executive Summary or problem statement)	The Arnot hosts at least two to three popular professional development events every year that include the annual “Sustainable Forest Field Practicums” every September (~ 50/year), a day-long agenda of forestry, agroforestry and maple research and extension as part of the annual CCE Ag In-Service in November (~ 20/year), and unique trainings like the “Tree to Table” portable sawmilling workshop (50 participants) and an inaugural three-day “Silvopasturing for Professionals” last summer attended by 35 land managers and support professionals.
Project Objectives	<ul style="list-style-type: none"> • Leverage applied research and demonstration at the Arnot Forest to help professional natural resource managers improve their decision making capabilities. • Learn what challenges exist for professional natural resource managers and how faculty and facilities at the Arnot Forest can contribute to their resolution.
Key Personnel (faculty and staff with college & department or similar institutional affiliation)	Chedzoy, Brett – CCE Schuyler County Curtis, Paul - CALS Natural Resources and Environment Smallidge, Peter, CALS Department of Natural Resources and Environment Stedman, Rich - CALS Natural Resources and Environment Sullivan, Kristi - CALS Natural Resources and Environment Weinstein, David - CALS Natural Resources and Environment Wightman, Aaron - CALS Natural Resources and Environment Woodbury Peter - CALS SIPS Crop and Soil Sciences Section Xu, Xiangtao – CALS Ecology and Evolutionary Biology
Sponsor	Multiple sponsors



CCE educators visit the Arnot Forest for an annual in-service training about forest, maple and natural resource management programs, resources and tools they can use in their county.

Arnot Forest Project Summary

Quantifying pond greenhouse gas emissions and carbon burial

Project Title	Quantifying pond greenhouse gas emissions and carbon burial
Project Duration (dates)	April – November 2023
Brief narrative description, 2 – 3 sentences. (use the Executive Summary or problem statement)	Inland waters are an important component to the global carbon budget as they sequester carbon in their sediments and emit greenhouse gases (CO ₂ , CH ₄) to the atmosphere. For standing (lentic) waterbodies, greenhouse gas emissions scale inversely with waterbody size, meaning that our smallest waterbodies (i.e., ponds) emit the most. Yet, existing studies underscore the high variability in greenhouse gas emissions across ponds and through time, calling for further work to be done. To address this knowledge gap, we are studying carbon cycling in human-made ponds in central New York.
Project Objectives	The objective of this study is to quantify greenhouse gas emissions and carbon sequestration potential of artificial ponds, which range in land use, size, depth, and pond age. Ultimately, we'd like our work to inform best practices for constructing and managing artificial ponds to reduce methane (CH ₄) emissions and increase carbon burial.
Key Personnel (faculty, staff)	Meredith Holgerson, CALS, Ecology and Evolutionary Biology Katie Gannon, CALS, Ecology and Evolutionary Biology Pascal Bodmer, CALS, Ecology and Evolutionary Biology
Students	Emma Zatz, Cornell University Rachel (Ruby) Ricisak, Cornell University Isaac Webster, Cornell University
Sponsor	New York State Department of Environmental Conservation Office of Climate Change



Boyce Pond at the Arnot Forest was one of the first constructed ponds at the Arnot and a useful data point for assessing greenhouse gas emissions.

Arnot Forest Project Summary

Slash Walls and LIDAR: Measuring Plantation and Young-Forest Carbon

Project Title	Slash Walls and LIDAR: Measuring Plantation and Young-Forest Carbon
Project Duration (dates)	10/1/2022 – 9/30/2025
Brief narrative description, 2 – 3 sentences. (use the Executive Summary or problem statement)	Young, fully stocked forests are essential to sequestering carbon as well as sustaining commercial forestry operations. Equally important is the ability to accurately forecast the rate of carbon sequestration in young and maturing forests. However, deer often prevent forest regeneration, and current models estimate carbon sequestration in young stands with high levels of uncertainty in the rates of sequestration. New methods of estimation and baseline data are needed. Estimating carbon sequestration in young forests is particularly challenging. Traditional inventory methods make direct measurements of portions of trees, yet these fail to accurately estimate tree growth and carbon storage in young stands. Meanwhile, dense saplings in regenerating young forests also challenges lidar sampling because of increased occlusion.
Project Objectives	<p>Research Objectives: List clear, complete, logically arranged statements of the specific Research objectives of the project or program for the time period specified.</p> <ol style="list-style-type: none"> 1. Assess the detection range of terrestrial LIDAR within natural and plantation young forests (6 to 25 years old). 2. Document baseline patterns for forest regrowth inside slash walls and adjacent unprotected controls 3. Compare LIDAR and conventional inventory of young forest to estimate stem density, stem dimensions and stem biomass/volume as estimates for carbon sequestration. <p>Research objectives integrate with these extension objectives:</p> <ol style="list-style-type: none"> 1. Work with partners to establish two demonstration slash walls. 2. Develop and refine educational and technical resources that support adoption of slash wall technology.
Key Personnel (faculty, staff with college & department or similar institutional affiliation)	Peter Smallidge, CALS Natural Resources and Environment Xiangtao Xu, CALS Ecology and Evolutionary Biology Peter Woodbury, CALS IPS Section Crops and Soils Brett Chedzoy, CCE Schuyler County
Students	Tao Hun, Nick Cranmer

Sponsor	USDA NIFA (McIntire-Stennis, Smith-Lever)



Foresters, loggers and woodland owners learn about how slash walls, which originated at Cornell's Arnot Forest, provide a lower cost and more effective tool to exclude deer and encourage the establishment of young forests.

Arnot Forest Project Summary

Sustaining the Productivity of NY's Private Woodlands - A Solution to Conservation Needs

Project Title	Sustaining the Productivity of NY's Private Woodlands - A Solution to Conservation Needs
Project Duration (dates)	Annually renewed October 1 – September 30
Brief narrative description, 2 – 3 sentences. (use the Executive Summary or problem statement)	<p><i>Forestry</i> – The resilience of forests is stressed by inadequate regeneration, encroachment by invasive plants, and tree death by invasive insects. Forest owners lack knowledge and networks to increase forest resilience.</p> <p><i>Maple</i> – The Cornell Maple Program works to support the sustainable growth of the maple products industry. This is accomplished through applied research and extension in four key areas 1) sugarbush management for forest health and productivity, 2) sap collection systems to improve crop yield 3) process efficiency and quality to lower costs and increase product value 4) value-added product development to improve profit margins and expand into new markets.</p> <p><i>Wildlife</i> – New York State’s ecosystems and communities continue to experience serious environmental stresses. Climate change is exerting diverse pressures on both aquatic and terrestrial ecosystems and organisms. Invasive plants, pests and pathogens threaten our forests and, combined with heavy deer impacts, impede successful forest regeneration across the state. At the same time, heavy rain events, droughts, and warmer temperatures are exacerbating water quality issues in our lakes and streams, affecting wildlife and human health.</p>
Project Objectives	Ensure the citizens, woodland owners, maple producers and professionals of NY are aware of and have access to information that allows them to make informed decisions about forest resources they influence. This project provide primary support for the Master Forest Owner Volunteer program which uses the Arnot Forest for field tours, demonstrations and applied research.
Key Personnel (faculty and staff with college & department or similar institutional affiliation)	Peter Smallidge, CALS Natural Resources and Environment Aaron Wightman, CALS Natural Resources and Environment Kristi Sullivan, CALS Natural Resources and Environment Brett Chedzoy, CCE Schuyler County Tom Cross, CCE Onondaga County Kristopher Williams, CCE Saratoga County Shane Stevens, CCE Columbia-Green County
Sponsor	USDA NIFA (Renewable Resources Extension Program)



The Arnot Forest is the home base for training Cornell's Master Forest Owner volunteers. These volunteers are located throughout NY and visit other woodland owners to guide them towards woodland educational decision support resources.

Arnot Forest Project Summary

UPCYCLING ASH TO GLULAM: Towards New Manufacturing Technology and Sustainable Market Applications for Emerald Ash Borer (EAB) Infested Tree Populations.

Project Title	UPCYCLING ASH TO GLULAM: Towards new manufacturing technology and sustainable market applications for Emerald Ash Borer (EAB) infested tree populations.
Project Duration (dates)	7/1/2020 – 6/30/2022
Brief narrative description, 2 – 3 sentences. (use the Executive Summary or problem statement)	Infested and dying ash trees form an enormous and untapped material resource for sustainable wood construction. The current fate of infested ash trees is all the more tragic when considering that ash wood can be used as a material for furniture, flooring, or baseball bats and has been historically used as a resource in heavy timber construction. However, infested ash is often comprised of mature growth, including many trees with irregular bent trunk and fork geometries. Innovative research and applications are needed that acknowledge infested ash trees as a valuable resource beyond firewood.
Project Objectives	The goals of this research project are to create a novel robotic manufacturing process, develop a new and sustainable market-ready commercial wood product, clearly demonstrate that EAB-infested ash wood can be used in a commercial high-tech building product, and reduce greenhouse gas emissions by upcycling infested ash tree populations.
Key Personnel (faculty, staff with college and department or similar affiliations)	Sasa Zivkovic, AAP Architecture Matthew T. Reiter, CALS Civil and Environmental Engineering Mark Milstein, SC Johnson, Director, Center for Sustainable Global Enterprise Peter Smallidge, CALS Department of Natural Resources and Environment Craig Van Cott, President UNALAM
Students	Lawson Spencer
Sponsor	Cornell Atkinson Center for Sustainability Academic Venture Fund 2020



Ash boards salvaged from Arnot Forest EAB infested trees were used as part of a demonstration at UVA. Boards were sawn at Cornell's CAAP Robotics Construction Lab. Similar applications were developed for laminated beams in partnership with a NYS forest products industry.



Glulam beam made from white ash obtained through a pre-salvage harvest at the Arnot Forest. Boards and beam were produced through Cornell's CAAP Robotics Construction Lab.

Arnot Forest Project Summary

Wildlife Use of Slash Walls

Project Title	Preliminary Evaluation of Wildlife Use of Slash Walls in Hardwood Stands at the Arnot Forest in southcentral New York State
Project Duration (dates)	January to July, 2022
Brief narrative description, 2 – 3 sentences. (use the Executive Summary or problem statement)	The browsing of white-tailed deer has caused many issues with the regeneration of hardwood forests in the northeastern U.S. Constructing perimeter slash walls has been successful for excluding deer and helping tree seedlings regenerate. However, little is understood about slash walls and the role they serve for other taxa. We examined how wildlife interacted with slash walls using infrared-triggered trail cameras. The study was conducted at Cornell University’s Arnot Teaching and Research Forest in Van Etten, New York. Camera traps ($n= 32$) were placed at random locations both facing slash walls and in adjacent control plots for 3 months during April-July 2022. Several species were photographed interacting with slash walls, and sufficient data were recorded for white-tailed deer, red foxes (<i>Vulpes vulpes</i>), and coyotes (<i>Canus latrans</i>). These three species were significantly more likely to be observed near slash walls than at adjacent control plots in open forest stands. The species diversity recorded indicated that slash walls do serve a larger purpose and may have significant conservation implications for wildlife.
Project Objectives	The primary objective for this study was to understand how wildlife responded to and interacted with slash walls. We hypothesized that some species, (e.g., red fox), might use slash walls for shelter and denning purposes, while other species, (e.g., white-tailed deer) would perceive slash walls as a significant barrier to movements.
Key Personnel (faculty and staff with college & department or similar institutional affiliation)	Prof. Paul Curtis, Professor, Department of Natural Resources and the Environment, Cornell University Michael Ashdown, Research Technician, Department of Natural Resources and the Environment, Cornell University
Students	Patrick, McGee, MPS student, Department of Natural Resources and the Environment, Cornell University
Sponsor	MPS Program, Department of Natural Resources and the Environment, Cornell University

Figure X. Wildlife species observed at camera sites in Stands 3 -10 at the Arnot Teaching and Research Forest, Van Etten, New York, during April through July 2022.

