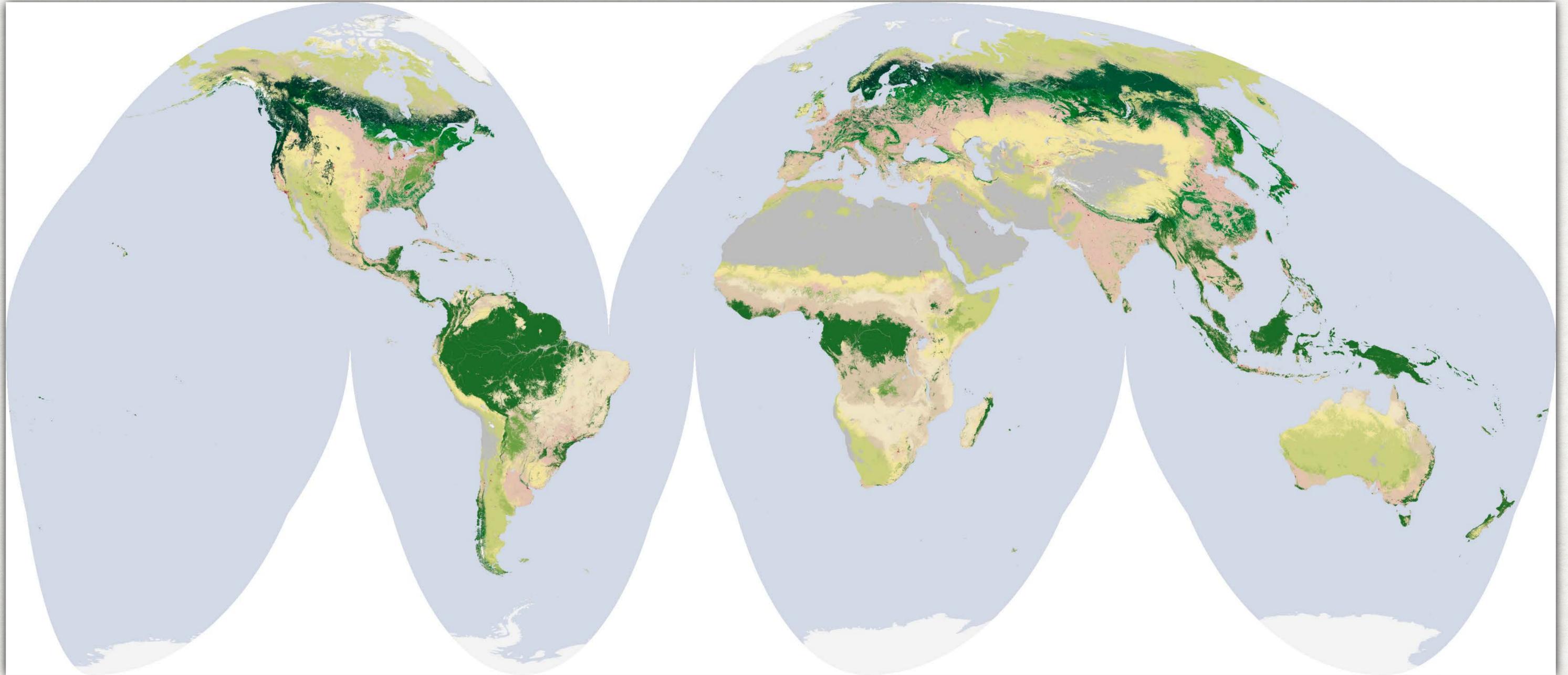


Forests and the goods and services they provide are important not just for Maine but for the entire globe.



The earth is 71% water and 29% land

Forests cover approximately 1/3 of land



THE UNIVERSITY OF MAINE ROLE IN SUPPORT OF MAINE'S FOREST ECONOMY

STEPHEN SHALER, DIRECTOR - SCHOOL OF FOREST RESOURCES
UNIVERSITY OF MAINE
SEPTEMBER 13, 2016

STUDENTS

- UMaine welcomed its largest incoming class ever - with 2,300 new students and 450 transfer students.
- Total enrollment of undergraduate and graduate students is 11,000 - with students from every county in Maine.
- UMaine's goal is to attract the best and brightest to the state's only public research university to advance economic development and partner in the future of Maine's workforce.



STUDENTS

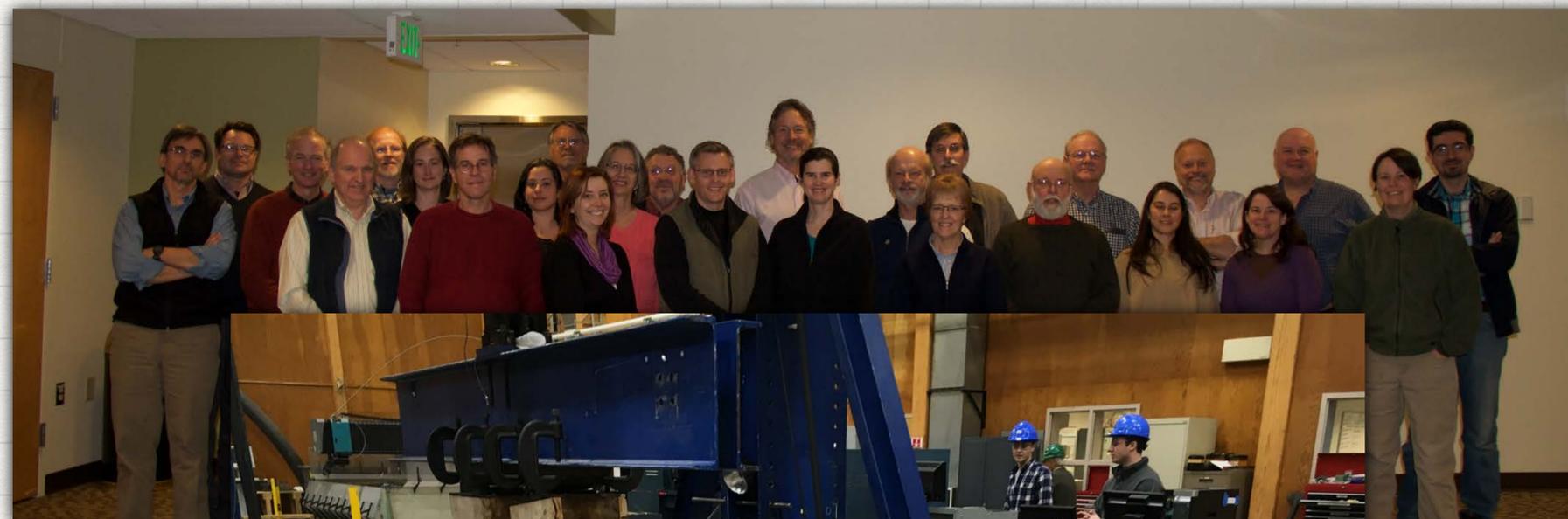


- 1902 - Department of Forestry established (> 5,000 graduates).
- 1908 - First courses in Chemical Engineering



PEOPLE & FACILITIES

- > 35 Faculty (CE, CH, ChBE, SBE, SFR, SOE, WFCB).
- > 100 Research staff, technicians, engineers, graduate students, and scientists associated with nine non-academic units/research programs (AMC, ASCC, CFRU, CRSF, FBRI, MCSPC, MS, PDC, PSSP).
- Extensive facilities (> 100,000 ft² of laboratory space - including pilot scale facilities).



R&D SUPPORTING MAINE'S FOREST ECONOMY

THE FOREST
RESOURCE

PRODUCTS &
PROCESSING

ECONOMICS,
MARKETS,
SUSTAINABILITY

R&D SUPPORTING MAINE'S FOREST ECONOMY

THE FOREST
RESOURCE

ECONOMICS,
MARKETS, POLICY

PRODUCTS &
PROCESSING

R&D SUPPORTING MAINE'S FOREST ECONOMY

INDUSTRIAL CONTRACT
RESEARCH

BIOFUELS

LUMBER AND
WOOD
COMPOSITES

NANOCELLULOSE
APPLICATIONS

PRODUCTS &
PROCESSING

BIOENERGY

WOOD SUGARS &
BIOPOLYMERS

Over \$1 million annual expenditures

- Paper Surface Science Program (PSSP) - 10 members (30% Maine)
- Process Development Center (PDC) - 29 companies in FY15 (35% Maine)
- Wood Composites (ASCC) - 13 companies in FY15 (25% Maine)
- Advanced Machining Center (AMC) - 7-10 companies in FY15 (100% Maine)



Projects



Shingle production system



High speed sawmill, wood labeling printer armature

CURRENT PSSP PROJECTS

- Improve paper coating properties
- Improves efficiency of use of binders
- Open new markets in food packaging
- Improves quality control of paper
- Helps with trouble shooting of paper problems.
- Improve the strength of coating layers to reduce problems

Pilot Capabilities

- Pilot paper machine



- Web coater / laminator





Technology Research Center



“The Technology Research Center allows us to take the research out of our labs and demonstrate and validate it at industrially relevant scales to help rapid commercialization.”

—Hemant Pendse, Director, Forest Bioproducts Research Institute



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Norway Spruce Testing

- Researchers tested 1,320 boards - in bending and tension - cut from trees harvested in Maine, Vermont, Wisconsin and four regions of New York state.
- Evaluating Norway spruce to determine if it meets industry standards for inclusion in the Spruce-Pine-Fir South (SPF-S) grouping of wood species for construction-grade dimensional lumber.
- Inclusion in the SPF South grouping would mean that tens of millions of "new" trees could enter the North American lumber economy for the first time.



NELMA®



Impact of *Caliciopsis pinea* on white pine wood quality and lumber yield

Kara K.L. Costanza¹, William H. Livingston¹, Shawn Fraver¹, Robert W. Rice¹, Isabel Munck², William Ostrofsky³, Kyle Lombard⁴

¹*School of Forest Resources, University of Maine, Orono, ME 04469.*

²*Northeastern Area State & Private Forestry, USDA Forest Service, Durham, NH 03824.*

Caliciopsis pinea



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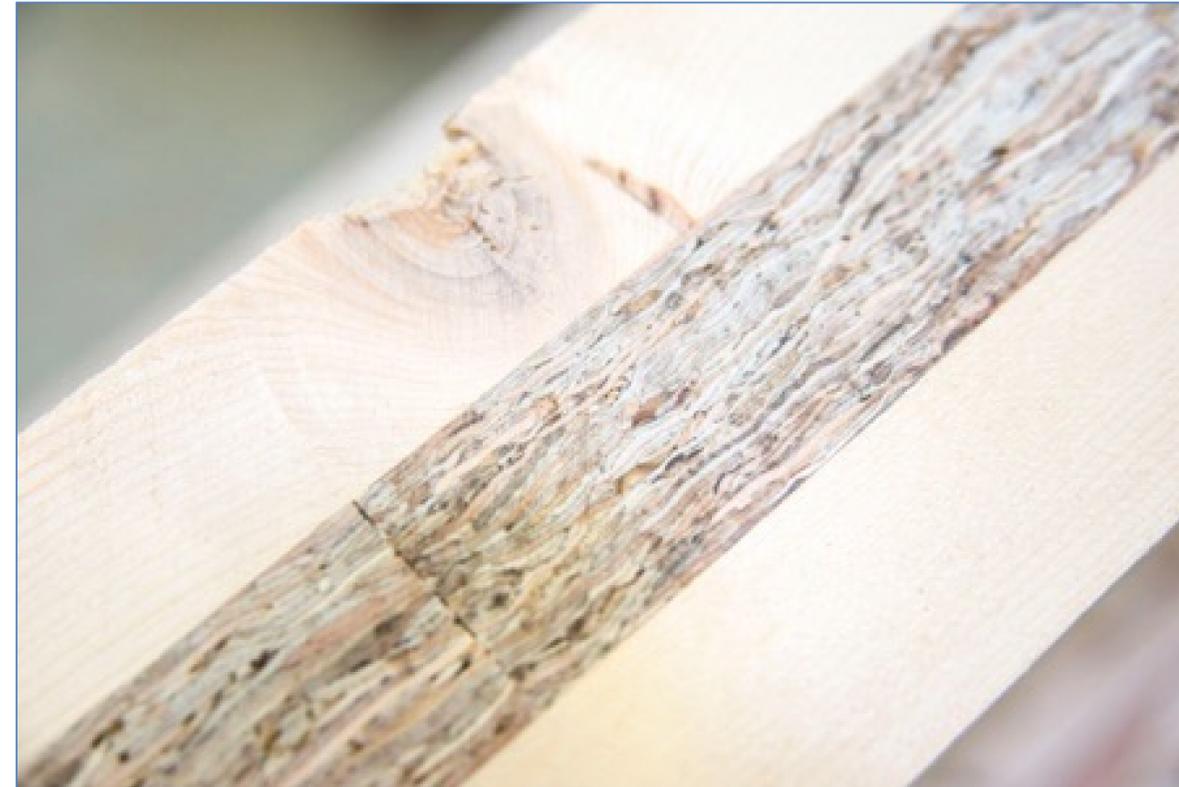
Objectives

- (1) Quantify reduction in lumber yield, grade, and economic losses due to C. pinea*
- (2) Develop management guidelines to reduce C. pinea infestation*

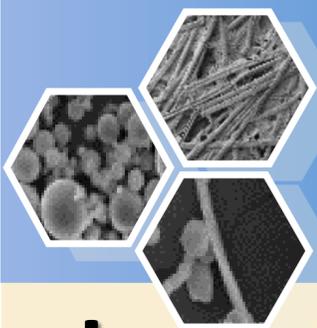


Cross-laminated Timber (CLT)

- Massive timber construction product; two-by solid-sawn, or composite lumber glued together and stacked in alternating directions
- Developed in Switzerland in the 1990s.
- Offers rapid construction times and improved environmental profiles relative to concrete.
- Buildings with 18 stories have been built with CLT; designs for high rise “plyscrapers” in the works.
- Two manufacturers in Canada; limited use/demand in the US with only two production facilities (OR and MT).
- UMaine is manufacturing and testing CLT made with both solid sawn and composite lumber (and hybrids including both) from Maine and the Northeastern forests of the United States.



UMaine is also investigating the technical and economic feasibility of the creation of a facility to manufacture and market CLT and/or hybrid CLT systems to the northeastern US.

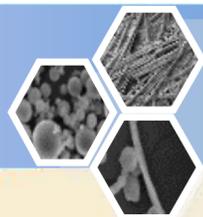


USDA/ARS Forest Products 2016 Annual Research Meeting

Long-term durability evaluation of structural WPC timber in aquaculture fish cage application



PI: Doug Gardner, PhD.
Co-PI: Yousoo Han, PhD.
Steve Ruell



Aquaculture applications

Aquaculture Market*

- Global Market valued at USD 135 B in 2012
- Market estimated at USD 203 B in 2020
- Growing at a CAGR 5.1% until 2020
- Aquaculture is 40% of the total fish marketplace
- Global 2013 production: 70 MT with CAGR 2.3%

AQUAPOD™

Aquapod is a unique containment system for marine aquaculture, suited for open ocean conditions and a diversity of species. Aquapod is constructed of individual triangle net panels fastened together in a spheroid shape.



* Reported by Transparency Market Research, 2013 & Grand View Research, Inc., 2015

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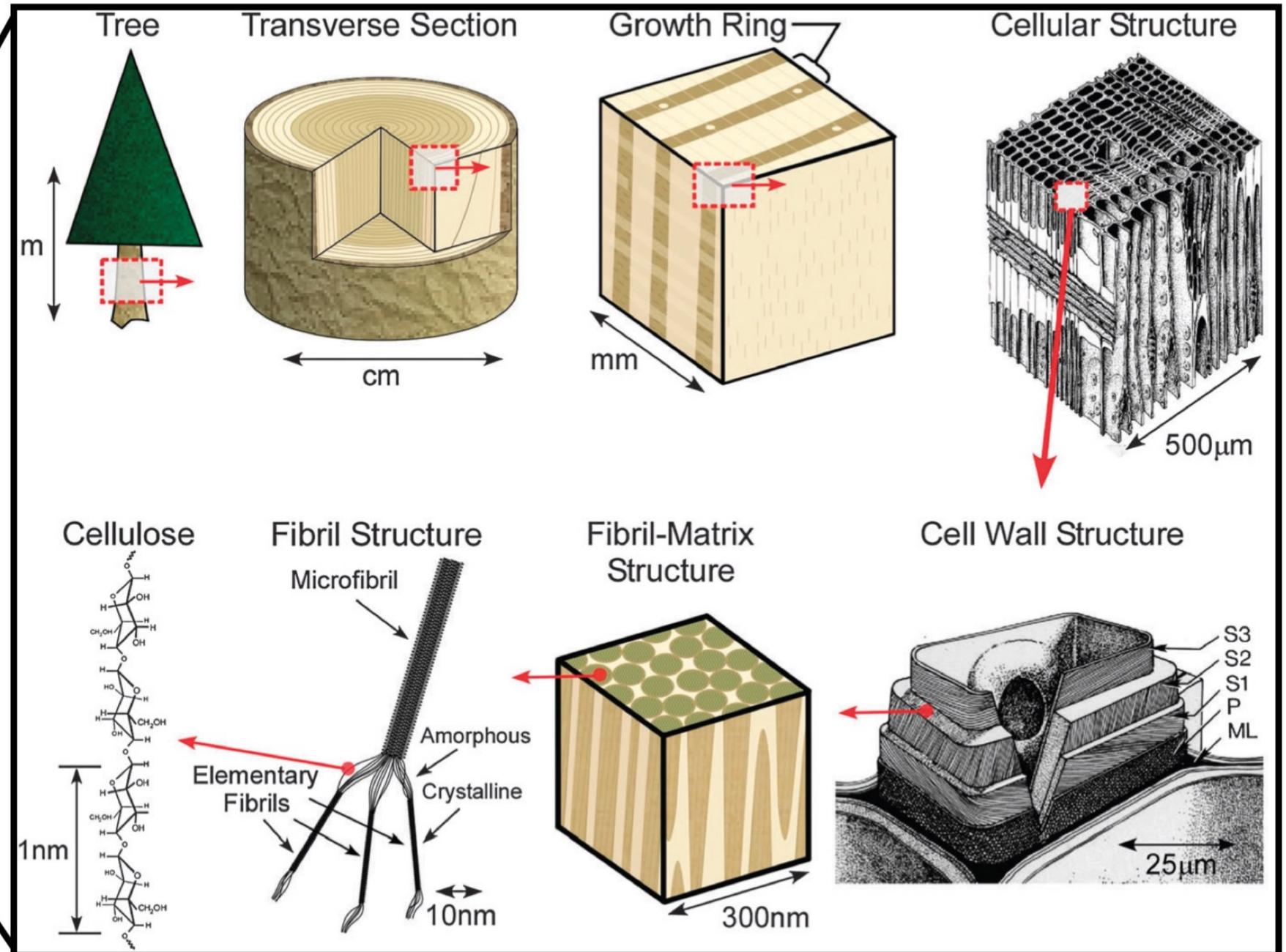
PRODUCTS &
PROCESSING

BIOENERGY

WOOD SUGARS &
BIOPOLYMERS

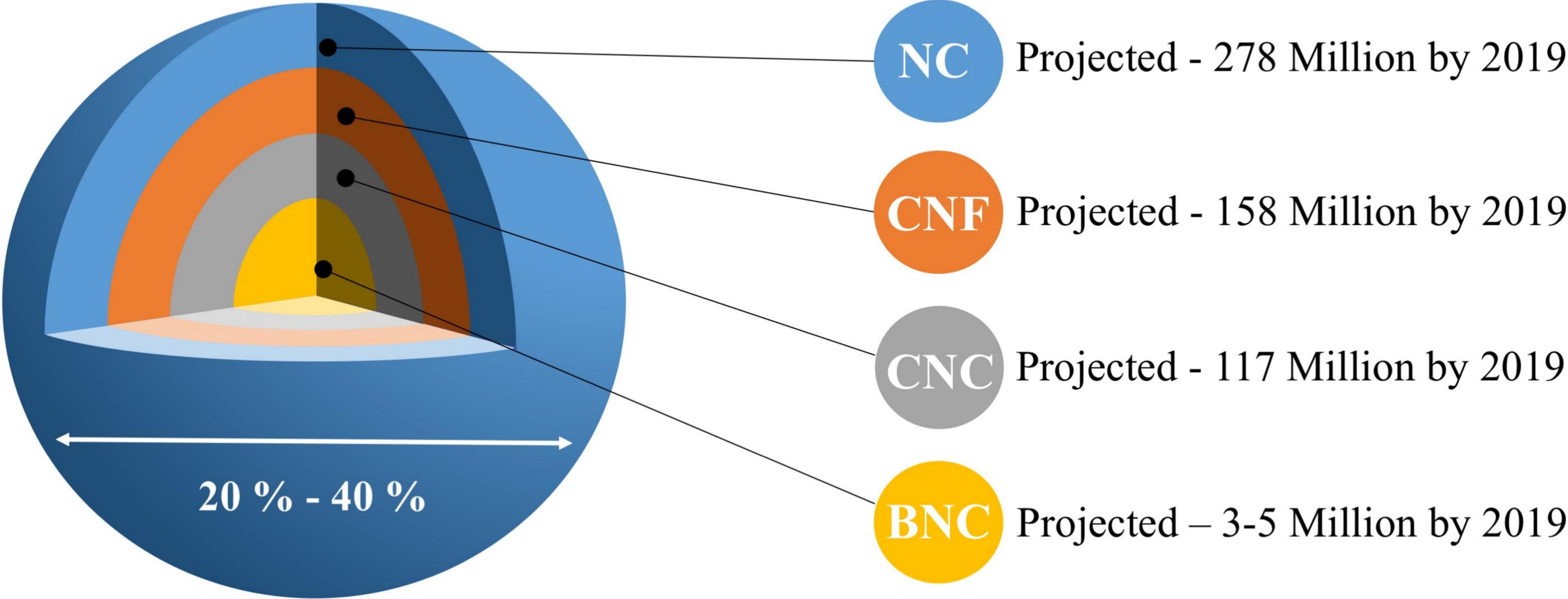
Nanocellulose as sustainable raw material

Mechanically produced wood based Cellulose nanofibrils (CNF) were used.

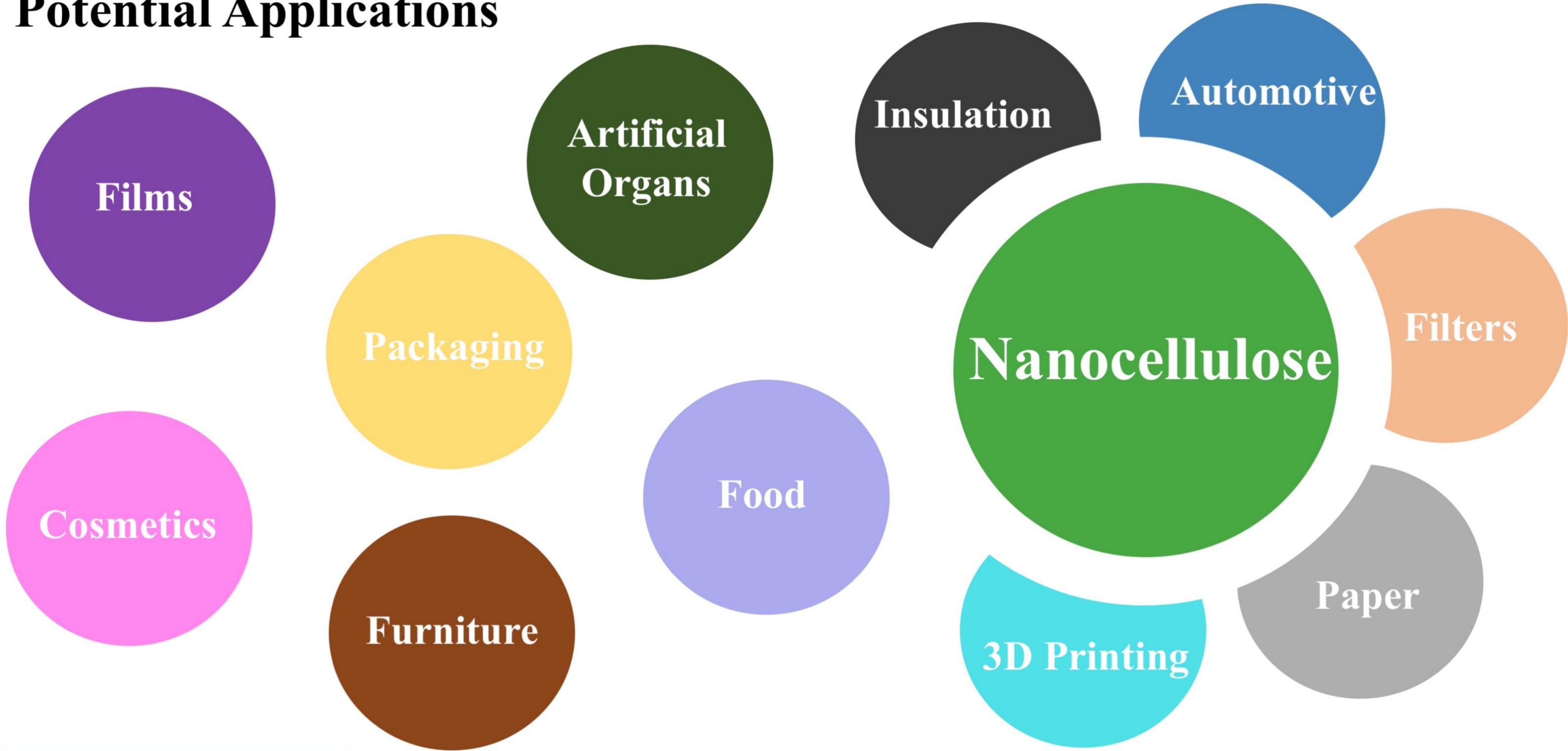


Ref. Moon et al., Cellulose nanomaterials review, structure properties and nanocomposites. Chem. Soc. Rev. 40, 3941-3994, 2011.

Market – BCC Research Report



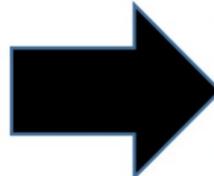
Potential Applications



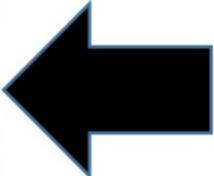
Results

Multiple ways, solutions were developed for hydrophobicity.

**Commercial product currently
on market**



**Nanocellulose product under
development**



High Value Papers from Surface Applied Cellulose Nanofibrils

Co:PIs

Michael Bilodeau

Process Development Center

Mehdi Tajvidi

School of Forest Resources

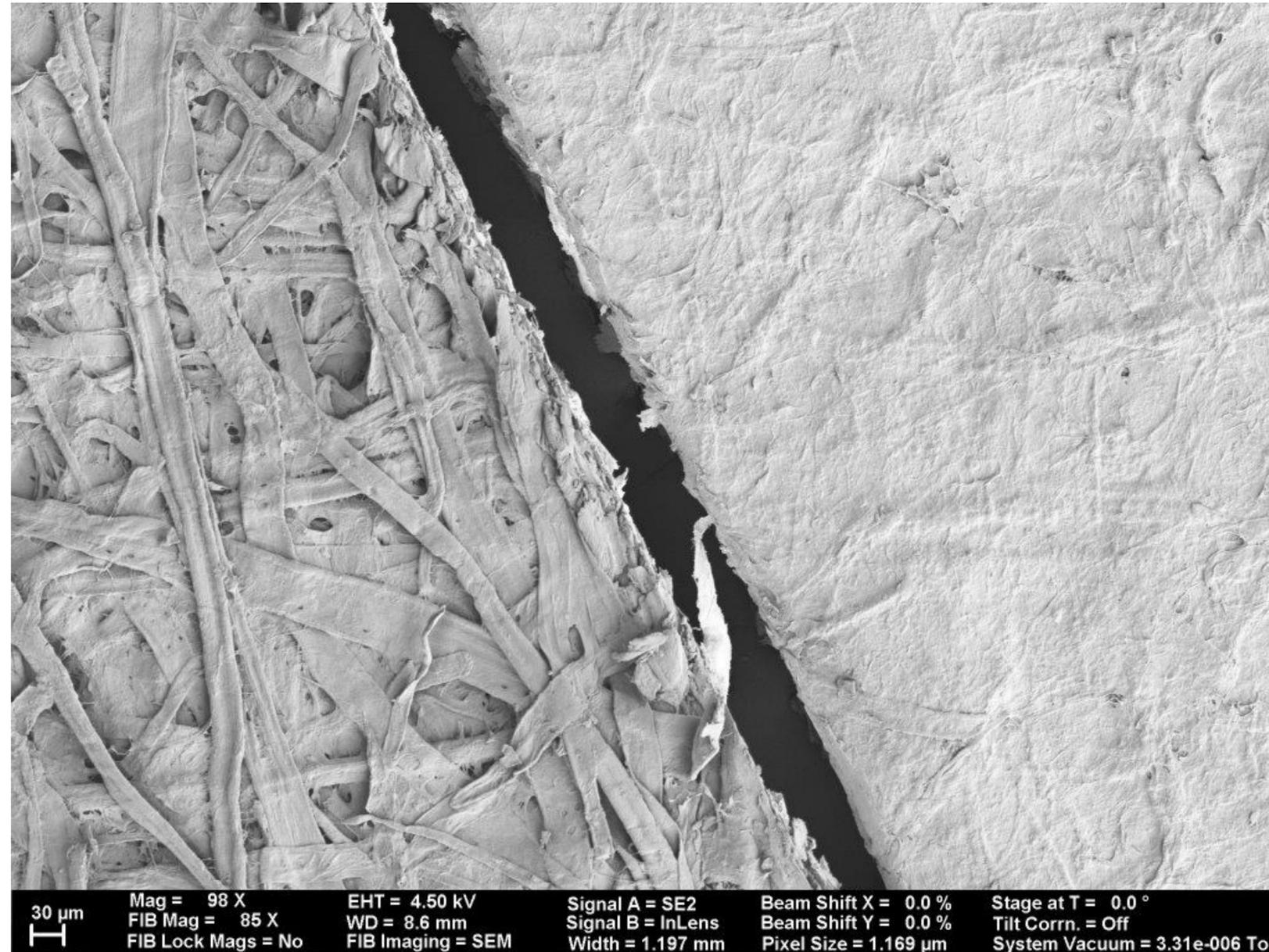


Objectives

- Develop, demonstrate, and commercialize advantaged, high value packaging and specialty papers.
- Attract new capital and increase manufacturing activity in the region's Forest Product Industry.

Approach

Untreated OCC surface 10.8 gsm (6%) CNF added to surface of OCC web



Industrial Collaborators

Sappi Fine Papers

Twin Rivers Paper Company

GL&V

Paperlogic Paper Company

Monadnock Paper Company

Paper-based Agricultural Mulch with Added Environmental Benefits

Co:PIs

Michael Bilodeau

Process Development Center

Mehdi Tajvidi

School of Forest Resources



Motivation

- “Plasticulture” growing in importance for fruit and vegetable production worldwide.
- Use of agricultural mulch increases yield, allows for earlier planting, effective weed control, and lowers water demand.



Source: Department of Horticultural Science, North Carolina State University

Accomplishments

- Developed greenhouse testing protocol for biodegradation rate testing.
- 12 prototype products produced at the pilot scale
- Commercially produced product in May 2016.



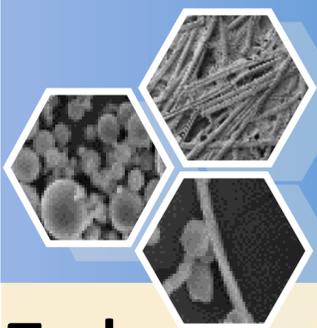
Test plots of agricultural mulch at the University of Maine Cooperative Extension's Highmore Farm in Monmouth, ME. July 15, 2016. Experimental paper mulch, Biodegradable Mater-Bi mulch, standard PE ag film, from left to right.

Stakeholder and Maine Economic Impact

- Demonstrated product design and commercial manufacturing of novel, new high value paper grade commercial paper mulch.
- Potential market of 4 million tons and growth of 4%-6% per year.
 - Revenue \$12 billion
 - Would require more than all idled and operating paper making capacity in ME
- Established product development methodology and testing protocol for future line extensions and improvements.
- Improve economics of ME agriculture.

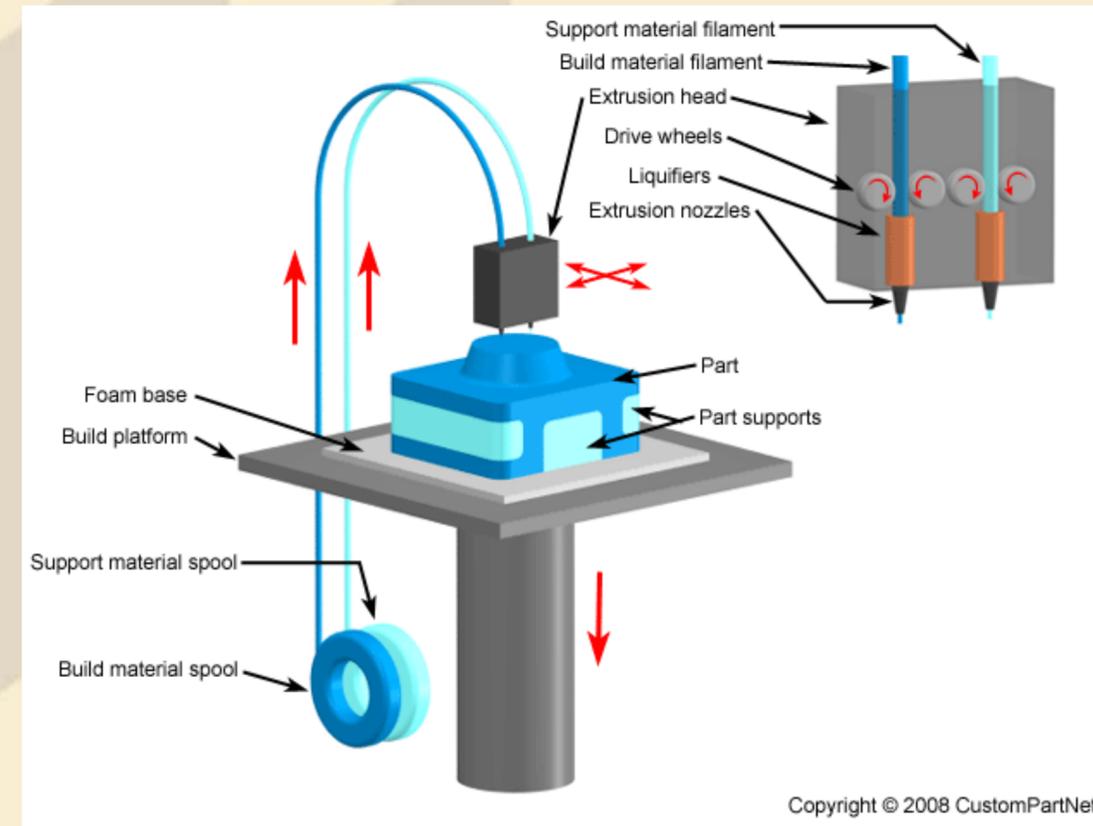


*Experimental paper mulch at the University of Maine
Cooperative Extension's Highmore Farm in Monmouth, ME
July 15, 2016.*



USDA/ARS Forest Products 2016 Annual Research Meeting

Enhanced Material Property Performance in Three Dimensional (3-D) Printing using cellulose nanofibril-filled polymer composites



PI: Doug Gardner, PhD.
Co-PI: Yousoo Han, PhD.
Ellen Lee, Ford Motor Company

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Relationships between Wood Pellet Industry Network Size, Structure, and Performance in Northern New England

PI: Jessica Leahy, University of Maine, School of Forest Resources

Co-PI: Cecilia Danks, University of Vermont, School of Environment and Natural Resources

Co-PI: Maura Adams, Northern Forest Center

Co-PI: Emily Silver, USDA Forest Service (soon: Michigan State University, Department of Forestry)

Assessment of Critical Factors Affecting the Quality and Competitiveness of Fuel Pellets in Maine

R. W. Rice, Ph.D

Professor of Wood Science and Technology

Manufacturing Potential and Issues

- In the Northeast, there are 23 plants with a capacity of 1.5 millions tons
- In Maine, we have the capability to produce about 500,000 tons
- Pellets are transported by truck; there are problems with pellet fragmentation/fracture known as durability in the trade
- Consumer complaints about which pellet type (softwood, hardwood or blend) is best for burning

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FBRI Highlights



- In collaboration with Old Town Mill, FBRI has demonstrated the feasibility for pulp mills to make cellulosic sugars that can be fermented to make value-added biochemicals as well as transportation fuels.
- Using Technology Research Center (TRC) facilities, FBRI researchers have developed UMaine-patented technologies, and produced jet fuel and diesel samples that met almost all military fuel specifications.



Contact Information

Director Dr. Hemant Pendse

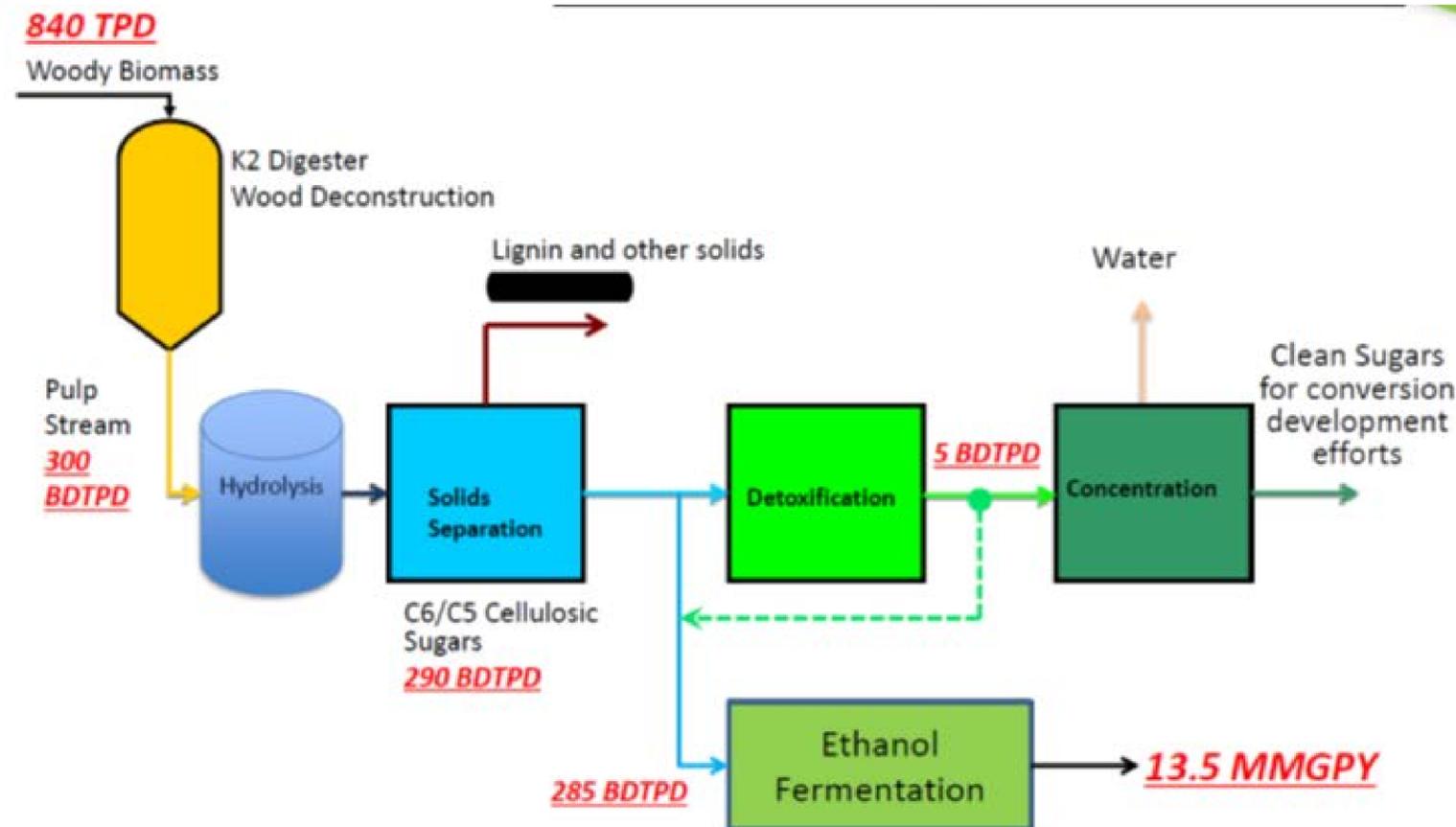
pendse@maine.edu

Associate Director Dr. M. Clayton Wheeler

mcwheeler@maine.edu

TRC Manager Amy Luce

aluce@umche.maine.edu



- Old Town sugar quality has received third-party certification from several potential users, including National Renewable Energy Laboratory (NREL).
- Validation studies on fermentation to ethanol were done by ICM using Old Town sugars.



Wood to Jet Fuel

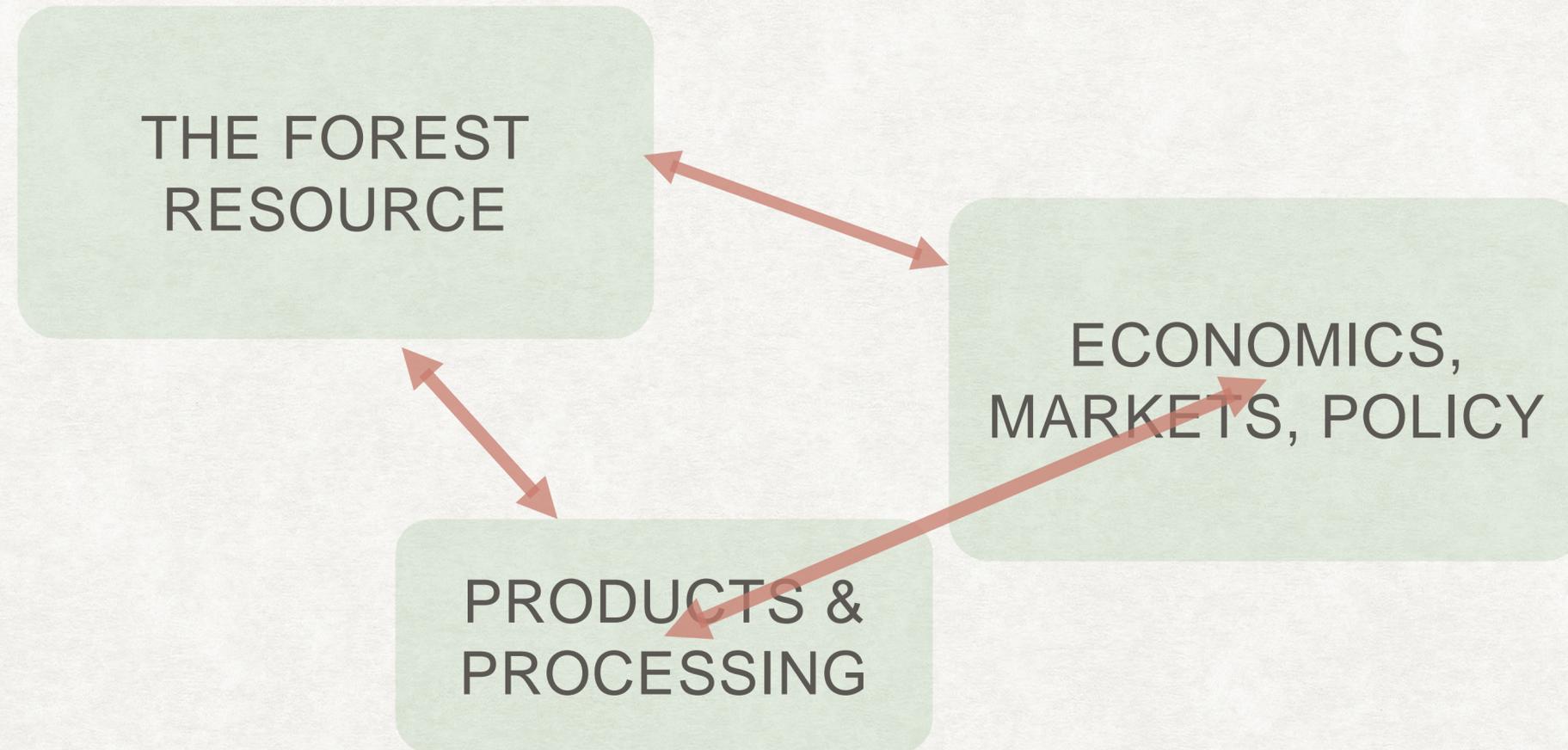
- ~18 kg of oil was produced from organic acid salts by multiple runs in a 50 L semi-batch reactor
- Hydroprocessing was optimized in a 0.5" tubular flow reactor and then scaled-up to a 1.0" reactor
- More than 11 kg of oil was hydroprocessed in a single campaign lasting 29 days



- UMaine Hydrotreated Kerosene fraction JP-8 comparison- UMaine sample tested at AFRL was deemed likely blendable as is.
 - Specifications met for flash point, freezing point, acid number, corrosion, sulfur, viscosity, smoke point, aromatics, and naphthalene
 - Specifications related to hydrogen content were close:
 - Heat of combustion 42.6 MJ/kg (42.8 spec)
 - Hydrogen content 12.88% (13.4 spec)
 - Density 0.875 kg/L (max 0.84 spec)



R&D SUPPORTING MAINE'S FOREST ECONOMY



USDA FOREST BIOECONOMY CONFERENCE

“Garnering stakeholder perspectives and input to help shape the vision, strategic planning, and implementation to promote and expand the bioeconomy”

Date: October 18, 2016 Time: 9 AM – 4 PM (local time)

Location: Wells Conference Center, University of Maine, Orono

Meeting Purpose: To introduce the “Federal Activities Report on the Bioeconomy,” and the subsequent “Bioeconomy Challenges and Opportunities for the Billion Ton Vision” report and to hear from stakeholders in (1) industry; (2) state and local government; (3) economic and workforce development; (4) investment & finance; (5) academia; and (6) agricultural and environmental organizations, to accelerate the bioeconomy.

Aboveground Woody Biomass (tons per hectare)

0 25 100 225 400