Maine EPSCoR FY24-29 NSF EPSCoR RII Track-1
Proposal Development Process
Phase I – Research Concept Papers

To prepare for the next round of NSF EPSCoR RII Track-1 funding, Maine EPSCoR is executing a formal proposal development process.

For Phase 1, researchers from Maine are invited to submit a concept paper that describes a current research problem/need for the state that might be applicable for the next Maine NSF EPSCoR RII Track-1 project.

The Track-1 grant is required to address a comprehensive, integrated, transdisciplinary, statewide focus that creates a substantial academic research infrastructure and includes strong intellectual engagement of diverse participants from institutions of higher education across the submitting EPSCoR jurisdiction, as well as productive partnerships between the jurisdiction's academic institutions and organizations in its governmental, nonprofit, and commercial or industrial sectors.

INSTRUCTIONS:

Please fill in the template below, using standard NSF font size requirements and margins. The allowable maximum is three pages. If you require additional space, you may delete unused lines in the Senior Personnel section, blank lines, or instructions in the document.

Sections:

1) Indicate the general focus area of the research that you are proposing.
2) Indicate the contact person for this concept.
3) Indicate potential key personnel who could be part of the effort to address this research concept. (only include individuals who have granted permission to be listed)
4) Intellectual Merit – provide a brief description in each of the sections, relating to the research focus that you have identified as a current problem/need in Maine.
5) Broader Impacts – provide a brief description in each of the sections describing the likely impacts and outcomes that can be achieved.

Due by:	**January 7, 2022**
Submit to:	shane.moeykens@maine.edu (as pdf or Word doc)

By submitting this concept paper, you are giving Maine EPSCoR permission to post this document on a public website to encourage statewide discussions and collaborative engagements prior to the next phase of the RII Track-1 project development process.

For more information see: https://umaine.edu/epscor/track-1-rii-development-process/
https://www.nsf.gov/pubs/2021/nsf21586/nsf21586.htm

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1) Proposed Research Focus:		**Renewable nanomaterials (RenewNano) for packaging, construction, and medical applications.**			
2) Primary Contact Person:					
Name:	**Institution:**	**Title:**	**Dept.**	**E-mail:**	**Phone:**
Doug Bousfield	UMaine	Professor	CBE	bousfld@maine.edu	581-2300
3) Suggested/Potential Key Senior Personnel:					
Name:	**Institution:**	**Title:**	**Dept.**	**E-mail:**	**Phone:**
Mehdi Tajvidi	UMaine	Assoc. Prof.	Forest Resources	mehdi.tajvidi@maine.edu	581-2852
Caroline Noblet	UMaine	Assoc. Prof.	Economics	caroline.noblet@maine.edu	581-3172
Erin Carter	UMaine/BART Inst.	Assist. Prof.	Business School	erin.p.carter@maine.edu	581-5944
Scott Eaton	USM	Assist. Prof.	Mech. Eng.	Scott.eaton@maine.edu	
Asheesh Lanba	USM	Assist. Prof.	Mech. Eng.	asheesh.lanba@maine.edu	
Michael Mason	UMaine	Professor	CBE	Michael.mason@maine.edu	581-2344
Caitlin Howell	UMaine	Assoc. Prof.	CBE	Caitlin.howell@maine.edu	581-2277
Mark Hutchinson	Compost School/Coop Ext.	Ext. Prof.	NA	mhutch@maine.edu	832-0343
William Gramlich	UMaine	Assoc. Prof.	Chemistry	William.gramlich@maine.edu	581-1173
Jinwu Wang	Forest Products Laboratory (Forest Service)	Scientist	NA	jinwuwang@fs.fed.us	
Andrew Crawley	UMaine/EDA Center	Assist. Prof.	Economics	Andrew.crawley@maine.edu	
Colleen Walker	UMaine	Director	PDC	Colleen.walker@maine.edu	581-2387
Aaron Weiskittel	UMaine	Prof.	Forest Resources	Aaron.weiskittle@maine.edu	
Hemant Pendse	UMaine/FBRI	Director	CBE	pendse@maine.edu	581-2266

4) Intellectual Merit:

A. ***Need***:

Society demands materials for packaging, construction, and other uses that are sustainable, sequester carbon, decomposes if left in the environment, and can be recycled. Maine's sustainably harvested forests are already being used in traditional packaging and construction applications. However, these industries are under pressure due to aging infrastructure, global competition, and other issues. New cellulose-based materials could meet these market demands if certain attributes can be obtained. For example, if barrier properties of paper can be enhanced, a novel food packaging system can be developed that displaces plastic based films: these systems should be compostable, able to recycled, improve shelf life, and sequester carbon if placed in a landfill. At the University of Maine, low-cost methods to produce cellulose nanofibers (CNF) from wood fibers have been developed and numerous applications for this material have been demonstrated. However, resources are needed to identify the best feed stocks, understand fundamental properties of these material, develop processes to make unique products, demonstrate the use of these materials in novel applications, as well as to overcome various technical, economic, and social acceptance issues. For example, it is important to understand the customer demand for plastic free packaging, the influence of a new product in the market, and the resulting implications on the labor market as well as rural communities if this product was brought to market. Limitations in equipment and personnel have put Maine and the United States at a disadvantage compared to the funding in this area in Sweden, Finland, Japan, and other countries.

B. ***Research Goal & Objectives:***

1) Evaluation and optimization of the cellulose sources, processing conditions, modifications, and additives on the final properties of products that leverage these nanomaterials.
2) An improved characterization and modification of the surface properties of films and structures produced from these nanomaterials including anti-microbial behavior, surface chemistry, chemical interactions, mechanical properties, and nanometer-scale texture.
3) An objective understanding of the life-cycle of these nanomaterials in terms of the ability to be

recycled, composted, and break down in the environment as well as sequester carbon if placed in a landfill and comparison with current materials.
4) A clear understanding of the social acceptance, market demand, influence on labor markets, and economic development implications for these nanomaterials.

C. ***Research Actions:*** Many of the actual projects will be organized as multi-disciplinary teams that focus on a single end-use but will perform these various tasks related to that specific product. A convergent research approach will be used on these teams to generate a complete understanding from process technology to consumer acceptance. Therefore, these actions will be in parallel for most potential products that is in the current program.

1) Characterize the influence of the cellulose feed source (wood fibers, recycled paper, wood waste, crop residuals) on the physical and chemical nature of the fibers as well as the properties of products produced.
2) Perform life-cycle analysis of specific applications of these materials to benchmark with existing materials.
3) To determine the influence of new products on Maine's labor market, forest resources, and ability to raise capital.
4) To quantify the sequestering of carbon caused by the use of these materials in various applications. For example, wall board replacement that contains CNF would sequester more carbon, have lower transportation costs, and have superior thermal insulation properties compared to gypsum wall board.
5) Determine consumer acceptance, ability to be recycled with paper, composability, and environmental decomposition of products.
6) To understand the impact of a new Maine based product on the labor market, fiber supply, rural communities, and other aspects of the economy.

D. ***Priority:***

This activity fits within both national and state priorities. Nationally, carbon sequestering and sustainability are noted as important topics. The US is behind other nations in funding nanomaterials produced from renewable resources even though these have the potential to sequester carbon, reduce energy use, and improve our sustainability in packaging and other applications. The state of Maine is the most heavily forested state in the nation. Helping find high value products produced from this resource, and developing the work force to make these discoveries, is critical. The Maine Innovation Economy Action Plan highlights cellulose-based nanomaterials.

5) Broader Impacts:

E. ***In-state collaborations****:*

The proposed work would involve a range of institutions and industries within the state such as the University of Southern Maine, Maine Composting School, BARD Institute, Cooperative Extension, SAPPI, Irving, Twin Rivers, ND Paper, Pleasant River Lumber, EDA Center

F. ***Regional/national collaborations****:*

The proposed work would involve personnel from the Forest Products Laboratory and Oak Ridge National Laboratory. The effort would continue to build UMaine as the center for innovation around renewable nanomaterials, supplying other groups outside of the state with materials and support such as characterization of materials sent, advise about the use of the materials, and promotion of product ideas nationally.

G. ***Economic development****:*

New products that utilize cellulose nanomaterials will be developed that use Maine's fiber resource and the infrastructure associated with the paper industry. In addition, these products can spawn new businesses that may use shut down mill sites like what recently occurred with GoLab at Madison. With the technical, economic, and social issues associated with these new products well understood, Maine businesses can raise

capital, build facilities, and start producing and selling these products nationally and globally. This activity will bring a new revenue stream into the state as well as create jobs and opportunities. For example, if a new paper grade is developed that can keep dry goods fresh and resist grease penetration, this system could displace the current plastic-based systems, generate a new grade of paper for the paper industry, that can bring in increased sales and earnings to a paper company, solidifying its long-term presence in Maine. Another example is the potential to generate a high porous board or box with low-cost wood, fibers, and CNF that can replace expanded polystyrene (Styrofoam™): if this system is developed, a start-up could start producing this product that should have high demand for shipping materials that need to be kept cold. Paper surfaces that are textured with a CNF layer could lead to a new biomedical test device that is easy to produce on the large scale and does not involve plastic. Another example is the production of a lid for coffee cups based on cellulose instead of plastic; a Maine based start-up company is already exploring this topic and has been successful with small business NSF funding.

H. ***Workforce Development****:*

A novel program will be developed for high school level students that involve a "competition" for innovative use of cellulose nanomaterials: student teams will work to develop new uses for the material and submit results via a video and report. This program would be like a science fair but with a narrow focus. Materials and instructions will be delivered to high schools that want to compete as well as seminars that discuss the properties of these nanomaterials. In the past, Bangor Highschool students have shown ways to use the materials for water treatment and filtration projects.

Project work will include undergraduate and high school students working in laboratories and other locations. Undergraduates will be employed part time during school year and full time in summer months to work on various aspects of the various projects. Emphasis on women, first generation college students, and minorities in attracting these students will be important. Cross-disciplinary meetings of faculty and students around specific applications will provide a rich environment for development of students for a well-rounded view of the development of new products, product innovation, and business issues. A sub-group of people will evaluate the success of outreach to underrepresented groups and suggest methods to improve this aspect of the work.

I. ***Infrastructure****:*

In order to understand the molecule level interactions of these nanomaterials with other materials, an Atomic Force Microscope with Infrared Absorption attachment would be valuable. As far as we know, this would be the only AFM-IR system in the state of Maine. In addition, a rapid prototype laboratory will be set up that has the needed equipment to use cellulose nanomaterials in various applications (coating, water removal, pressing, drying), characterize the suspensions and the final products (mechanical, chemical and structural). Some funding to augment pilot scale demonstrations of products is also needed.