Discovery Challenge Proposal – Mass Timber Construction

The future development of our planet includes two opposing pressures: projected population growth and a need to reduce atmospheric carbon dioxide levels. World population is expected to grow from 7 billion in 2011, to 8.6 billion in 2030, with the majority of this growth predicted in urban areas[1]. Accompanying this population growth will be an enormous demand for shelter and structures. During this period, atmospheric CO_2 levels are predicted to rise from 390 ppm to between 417 and 432 ppm, depending on our actions[2].

A solution to align imminent population growth with atmospheric carbon reduction would be a sustainable building material that would significantly reduce the carbon impact of current construction practices while simultaneously increasing carbon sequestration. Such a solution is being rapidly developed, and ESF is uniquely positioned to become a leader in its implementation.

Mass timber construction eliminates the carbon emissions from production of steel or concrete, while sequestering carbon from the atmosphere into growing trees and then storing in the structure. This approach is founded upon combining composite wood panels (0.5' x 10' x 40') with built-up wood members (1'x1'x 40') to exceed traditional height limitations for buildings made of wood. Mass timber buildings up to 18 stories have been completed, and projects are underway to reach 30 stories. A paradigm shift is underway, and ESF leadership and the transdisciplinary integration of some of its historic strengths with new areas of teaching and scholarship can accelerate the path forward.

Efforts in the last three decades have addressed a number of the challenges to widespread mass timber adoption: The risk potential due to fire has been mitigated to be equivalent to steel and concrete construction. Production systems have been developed and standardized to create controlled manufacturing processes. Application of mass timber in tall buildings has been addressed and has resulted in the projected acceptance of mass timber construction into the 2021 International Building Code.

A Discovery Challenge exists to create the ecosystem - environmental, technical, social, and economic - for this new generation of wood buildings to flourish. This program will involve faculty from FNRM, PBE, LA, EFB, ES and will impact various majors in these departments. Within FNRM, the Construction Management and Sustainable Energy Management (SEM) programs will develop a more integrated set of options for students to interact across these majors. In addition this program will create an interdisciplinary minor for students interested in various aspects of mass timber using mostly existing courses. Following the launch of this minor we will create a major in this field that will require an additional faculty hire to be successful.

The Department of Forest and Natural Resources Management is ideally suited to provide leadership in addressing the management, economic, and policy issues that will ensue from mass timber construction. The Forestry and Natural Resources Management programs (including studies on species from ESF Forest Properties) will help prepare New York and the Northeast for the growth of this industry. Under utilized species and lower grade material can be effectively incorporated into this structural system using sustainable management and harvesting practices of New York State forests. Project leads – Drs. René Germain and Chris Nowak

The sustainable Construction Management program will train leaders in the best practices for design, delivery, and rapid adoption of this new technology. The construction industry is notoriously slow to change, and adoption of this method will require a well-trained workforce to effectively "break trail" in this new realm. While students in this major currently have excellent

opportunities in the traditional building industry, the opening of this new field will ensure them a career as leaders in this transformation. Project lead – Dr. Paul Crovella

The Sustainable Energy Management program will be needed to ensure that development of these buildings is done with a net positive impact on a life cycle basis. Mass timber in the exterior surfaces provides an inherent insulation and resilience not found in other building materials, making these structures ideal candidates for integration of renewable energy technologies for self-sufficiency in operational energy. Analysis of building energy use will provide practical applications and job skills necessary for employment in this growing sector. Workforce development projects currently underway will complement this addition to the program and assist with a rapid start of this new area. Project lead – Dr. Tim Volk

A melding of the life cycle attributes of this construction approach with an effective policy structure to recognize and reward these attributes will greatly aid in the rapid uptake of this approach. Existing ESF expertise in technoeconomic analysis (TEA), life cycle analysis (LCA) and environmental policy will allow the Forest Resources Management and Sustainable Energy Management programs to contribute effectively to this development. Project leads – Dr. Bob Malmsheimer, Dr. Tristan Brown, and an LCA expert that is scheduled for hire this year

The undergraduate degree in Renewable Materials Science, and the graduate program in Wood Science, in the Department of Paper and Bioprocess Engineering, will be natural paths for students interested in the new products being created. Research in this area will capitalize on existing lab facilities equipped for fabrication and testing. Studies in building science, durability and preservation, fabrication, and the modelling of mechanical performance of these products is essential to ongoing product development. Work with two New York State manufacturers has shown great interest on their part in entering this market. One of these manufacturers built their own building using these products. Unfortunately, the products had to be imported from Austria due to a lack of local production. Project leads – Drs. Bill Smith and Susan Anagnost

Digital design and fabrication of mass timber products is part of the efficiency of this system. The nascent digital fabrication lab led by the Landscape Architecture Department aligns well with needs for mass timber development. Project lead – Aidan Ackerman

The Department of Environmental Studies is well positioned to address the potential social issues associated with forest management. The cutting and processing of trees as part of a timber harvest is not embraced by a majority of the general public. Research and outreach on this front will be critical to promoting the idea that "healthy working forests make for healthy people which make for a healthy planet."

Identification and management of invasive species has been critical in selecting species for mass timber development in the Western US. A similar understanding of future forest changes in the Northeast will be found in collaborating with existing expertise in the Department of Environmental Forest Biology.

International, national, and state entities have identified mass timber development as a priority need that they intend to promote and support. The US EPA was recently appropriated $5,000,000 for "novel earlier-stage research, development, and demonstration of technologies to advance energy efficient, high-rise Cross-Laminated Timber building systems." The EPA is directed "to support university research, in partnership with the national laboratories, for developing, building, and evaluating Cross-Laminated Timber wall systems for embodied energy content, operating energy efficiency, wall moisture profiles, structural connector durability, and health monitoring sensors." The US Forest Service has a current RFP for Wood Innovation Grants, with a total of $8,000,000 to be distributed. Mass timber is a centerpiece of their recent

funding in this program. A SUNY Performance Improvement Fund grant is currently supporting ESF with $300,000 for workforce development related to training students in energy efficiency in buildings, NYSERDA has supported mass timber research at the college in 2014-6 with $100,000 grant, and NYSERDA expressed interest in further mass timber funding through their Advanced Buildings, Commercial New Construction, and RetrofitNY programs. Private foundations, such as the Charles Pankow Foundation, offer opportunities for funding of transformative construction approaches. Organizations such as the Empire State Forest Products Association are logical partners for supply chain research support. Existing relationships with the Consortium for Research on Renewable Industrial Materials (CORRIM) for LCA support, Syracuse CoE for indoor building environment, and Syracuse University for structural performance will be strengthened through opportunities for collaborative research. NY State manufacturers (Unalam and New Energy Works) have both expressed interest in incorporating mass timber in their operations, and each have visited the college for discussions of this topic.

Founded in 1911 to "help in the solution of forestry problems", ESF and its 25,000 acres of forestland can play a critical role in mass timber related research. Like many of the other forests in the Northeast, these forests suffer from a lack of economically viable end uses for their products, especially for the lower grades and underutilized species. In the USDA announcement for $3,000,000 for the US Tall Wood Competition, Erica Spiritos stated that mass timber is “a new method of urban construction that is ecologically conscious and supportive of rural economies”. Research performed at ESF in 2014-6 identified the properties of lower grades of White Pine, White Ash, and Red Maple when fabricated into mass timber panels. Current efforts to locate a Red Pine sawmill in NY (DEC and ESFPA) will require further work to identify properties of this and other species in possible use for mass timber. In partnership with ESF Forest Properties, the college forests provide a perfect testing ground for practical scale silvicultural trials, including individual tree species testing and possibly work on fast-growing dedicated crops (e.g., hybrid poplar), for end use in mass timber assemblies.

The strategic planning efforts from the last five years at ESF have defined a path for ESF to develop a nationally prominent reputation and ensure global impact in our work. One of the most pressing questions identified during these efforts was the area of “Climate Change Mitigation”. In response to this challenge, the ESF solution was clearly defined as “Sequestering CO2 in the built environment through timber engineering and construction for sustainable systems.” At a broader level, the National Academy of Engineering identified 14 Grand Challenges. Two of these: Restore and Improve Urban Infrastructure, and Develop Carbon Sequestration Methods, are clearly met by the ESF Discovery Challenge in mass timber.

Current resources from a SUNY PIF grant would allow for a new hire shared in the area of energy and buildings for two years – this could include extensive support of the mass timber construction project. Additionally, a post-Doc would be hired to support laboratory and research work of all team members. Both of these positions could be made permanent at the end of the grant period, based on the team research productivity. The initial year of funding would be used to provide collaborators seed funding for their individual initiatives. At the end of the first year, the team successes will be used to identify strategic investments for years 2 and 3 in transitioning to sustainable operations. If a faculty line were funded during that time, collaboration with the USDA Forest Products Laboratory (which offers support for shared positions) would be pursued.

1 http://esa.un.org/unpd/wpp/Publications/Files/WPP2017_Methodology.pdf (retrieved 11/27/2018)

2 https://data.giss.nasa.gov/modelforce/ghgases/Fig1A.ext.txt (retrieved 11/27/2018)

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Project Feasibility Statement Part 1 - *Initial start-up of the project* - Our goal is to implement a complete system that removes barriers, lowers costs, and reduces risk for mass timber construction. Team members will work in four areas to implement these actions. The "Forest resource characterization and availability" team members will conduct a forest products supply chain analysis to determine the sustainable flow of timber species available for establishing a mass timber manufacturing facility in New York State. The "Material properties, performance, and fabrication" team members will acquire a press to fabricate and test panels of all species studied by the forest resource members. The "System evaluation" team members will use data from ESF panel manufacture to produce unique Life Cycle Assessment (LCA) and Technoeconomic Analyses (TEA) of studied species. The "Market acceptance, demonstration, and outreach" will use panels fabricated from ESF Forest Properties timber in a demonstration structure at the new athletic field in Tully. Using this experience, they will remove barriers to allow for the Onondaga Lake Science Center to be built as a showpiece of mass timber. This will be followed by outreach seminars and a social media site that will serve to share our mass timber information and policy options for communities to accelerate adoption.

Project Feasibility Statement Part 2 - *How the project will grow into a self-sustaining program beyond seed period*. Funding in each of the four areas is available to advance our work. The "Forest resource" group will be able to access the USDA Wood Innovation Grants ($8,000,000 per year) to implement the state forest plan, which emphasizes mass timber development. The "Materials" group will be able to access funding in the five year Farm Bill passed this week. This bill specifically requires federal support for mass timber, and lists research requirements, including material improvement and LCA. The "Systems" group will be able to access $5,000,000 set aside in the 2019 DOE budget for "novel earlier-stage research, development, and demonstration of technologies to advance energy efficient, high-rise Cross-Laminated Timber building systems." The "Market" group will be able to access NYSERDA Commercial New Construction Program funding and the SUNY Concierge for projects. Current SUNY Performance Improvement Fund funding ($300,000) will allow the college to hire a full time position for two years that will provide LEED training for students, and can also provide energy analysis of mass timber buildings. A $10,000 grant from the CoE is currently studying the worldwide impact of mass timber construction. The mass timber effort will enroll interested students in Renewable Materials Science, Construction Management, and Sustainable Energy Management. We also plan the creation of a minor within FNRM for growth into a new major.

Transformative *How the discovery idea is transformative* This project reaches outside of ESF to not only share results, but to implement, demonstrate, and educate the decision makers to the vast potential of mass timber. This project brings ESF Forest Properties to a centerstage role in transforming the built environment in cities like New York. The social media site moves ESF into a new domain of environmental communication, activism, and policy. The digital fabrication lab becomes a hub of exploration for innovation in developing new, cross-disciplinary applications in materials science, manufacturing, and design.