University of Maine Proposal for Joining the NSF Center for Advanced Forestry Systems

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Accomplishments

* What are the major goals of the project?

Major goals for this project were to: (1) refine existing regional growth and yield models for the Acadian Forest Type, (2) evaluate alternative commercial thinning regimes in spruce-fir forests, (3) collaborate with a national network of
universities and industrial partners on research to improve forest growth models, and (4) build research partnerships with regional forestland owners and forest product manufacturers.

The University of Maine CAFS site brings a unique region-species and silvicultural practice mix that is not covered by any of the other 9 CAFS sites part of this industry/university research cooperative. However, our modeling efforts on naturally regenerated forest stands also have applicability to the Lake States and Intermountain regions of the US.

* What was accomplished under these goals (you must provide information for at least one of the 4 categories below)?

Major Activities: Accomplishments toward achieving Goal #1 above included development of a regional growth and yield database from Maine, Nova Scotia, New Brunswick, Newfoundland, and Quebec. These data include compiling over 4 million individual records in a relational database that was challenging and computationally demanding, even on today’s computers. These data were then organized, cleaned, and recompiled into a common format that could be used to develop a new forest simulator for the region. Spatial information also was obtained to create the necessary GIS layers. A database of managed stands in the region, which is rare and badly needed to model the effects of silviculture and harvesting, also was compiled and served as the basis for quantifying the influence of thinning and vegetation management on forest growth and yield.

Efforts to achieving Goal #2 included maintaining and measuring a Commercial Thinning Research Network (CTRN) that was established on forestlands across Maine that are owned/managed by our industrial collaborators. The CTRN involves two experiments that are testing the influence of commercial thinning timing, intensity, and method on the growth and stand development of spruce-fir stands. We gathered and analyzed annual data from a decade of growth and survival measurements from more than 15,000 individual trees on a dozen study sites.

Specific Objectives: During Phase I of CAFS, the University of Maine site accomplished two primary objectives with our industrial members: 1) developed a new forest growth & yield simulator for commercial forestlands in the region, and 2) refined our understanding about how forestland owners can optimize commercial thinning prescriptions in spruce-fir stands.

To build a new forest growth & yield simulator, we compiled an extensive database (>4 million observations) of existing permanent growth and yield plots for the Acadian Region. These data were used to develop an Acadian variant of the Forest Vegetation Simulator (FVS-AD) to serve as a new regional growth & yield model for the Acadian Forest region. FVS-AD represents a significant improvement over the previous model in the size of the data set used to derive the model, the updated model structure, and especially the inclusion of management inputs that are included in the model. An improved forest model was vital to better prediction of the long-term consequences (wood supply and rate of return) of forest management activities because the current growth & yield model being used is outdated, poorly maintained, geographically constrained, and limited by an array of additional factors. As a result, there has been substantial external financial and database support from CAFS member organizations in developing and testing this new model.

The reason for this strong support from forest industry is that prediction bias for net stand basal area growth with the current FVS-NE model is 10.7% per year of projection. Assuming a conservative board foot volume to basal area ratio of 50, this represents nearly 84 bdft/ac/yr of bias. If we multiply that across the 8.3 million acres represented by our CAFS members and using an average stumpage value
($120/MBdft) for spruce-fir sawlogs, this represents a $83,664,000 prediction error born by Maine forest industry every year. Through our CAFS modeling efforts, we have reduced this bias by over 75%. In addition, a useful forest science spin off in the development of FVS-AD was the production of a high-resolution map of potential forest site productivity for the Acadian region that has a number of ecological and management applications, and is currently being used for forest sampling stratification and forest management planning by several CAFS members.

As part of developing this new regional model we were able to develop close collaborations with other CAFS university partners (Goal #3). These collaborations were important to our creating a regional growth index and key allometric relationships for predicting maximum & largest crown width, total tree height, and height to crown base. Better individual-tree diameter, height increment, crown recession equations were developed, as well as improved equations to predict the occurrence, frequency, and composition of natural ingrowth. Improved allometric equations accounted for more observed variation and were significantly improved over the equations that are being used by land managers and researchers in the region. For growth modeling, equations that use species as a random effect are performing better or equal to species-specific equations. We also found that projecting diameter rather than basal area increment was important for minimizing the amount of model error. Despite the complexity of the original data, the ingrowth model is providing biologically consistent results and suggests that ingrowth composition is driven primarily by overstory composition.

A second major accomplishment of Phase I CAFS at the University of Maine included providing specific recommendations for commercial thinning (CT) of spruce-fir stands across northern Maine, including the desired timing of entry, best residual stand density, and method of thinning in both mature, unthinned spruce-fir stands and young, previously thinned fir-spruce stands. Using 10-year measurements from a statewide network of commercial thinning experimental plots on CAFS member sites across northern Maine, we found that the net present value of mature spruce-fir stands following 33% low thinning was higher than all other thinning treatments. Results indicated that older spruce-fir stands should not be commercially thinned from above due to wind losses to the residual stand. If CT is desired in older stands, low thinning to one-third relative density produced the most resilient stand structure with highest stand value and NPV. In younger, previously thinned fir-spruce stands, highest financial gains occurred with early 33% relative density reduction. If the objective is to increase mean tree size and reduce the age at which trees reach a minimum size, delayed CT at higher intensity removal (50%) was best. If the objective was to increase stand value and financial returns, early CT at medium intensity (33%) was indicated. CAFS members and other forest managers across the state are now using these recommendations to commercially thin millions of acres that have become merchantable for CT over the past decade. Based on the 4.5 million acres of spruce-fir timberlands that are in need of a commercial thinning (i.e., fully or overstocked), the $185 increased net present value per acre we identified with an improved CT prescription can generate an additional $832 million by Maine CAFS members during the next 10 years of commercial thinning.

Accomplishments toward achieving Goal #4 included developing a strong partnership with industry, government, and other organizations in the region to conduct industrially relevant research, as well as leveraging research and development (R&D) investments from these organizations. During Phase I of
CAFS, the Maine site has attracted investments from 34 forest management organizations that own or manage 8.3 million acres of forestland in Maine (half of the state’s total forestland). The CAFS Maine site attracted $2.37 million in member contributions that supported 29 silviculture, growth & yield, and wildlife habitat research projects funded to address member needs during Phase I.

Efforts of the CAFS Maine site have become a model of stakeholder-driven forest research where Timber Investment Management Organizations (TIMOs), Real Estate Investment Trusts (REITs), industrial landowners, wood processors, and forest conservation organizations (such as The Nature Conservancy, Appalachian Mountain Club, Baxter State Park, and Forest Society of Maine) have worked together to develop forest research priorities and implement projects that improves the management of commercial forestland in the region. The CAFS Maine site also provides a direct link between Maine’s forestry community and the faculty, graduate students, and undergraduate students in UMaine’s forest resources programs. This linkage enhances the relevance of UMaine to the state’s forests and forestry community, as well as strengthening the research, teaching, and service mission of our Land Grant institution.

* What opportunities for training and professional development has the project provided?

During Phase I of CAFS we were able to train two graduate students (1 MS and 1 PhD) and two post-doctoral research fellows. In addition, more than 50 undergraduate students worked as summer technician gathering and analyzing data from the various experiments. These students gained strong forestry field skills, strong database management capabilities, and valuable statistical analysis skills that are demanded by industry, government, and other organizations across the country. The MS student was hired by a CAFS member organization upon completion of his degree. The PhD student was hired as a post-doc by another Land Grant University and then was hired as a Research Scientist by the US Forest Service Northern Research Station. Both post-doctoral research fellows were able to develop extramural grant-writing capabilities and improve their journal publication record. One of the post-docs was hired last year into a tenure-track position at a Land Grant University.

* How have the results been disseminated to communities of interest?

The results of the forest modeling and commercial thinning research have been widely disseminated at numerous meetings and workshops with Maine CAFS site members, which include 34 forest management organizations that own or manage 8.3 million acres of forestland in Maine (half of the state’s total forestland). In addition, research results have been presented at numerous scientific conferences and other meetings with other CAFS member universities. Twenty-three refereed journal articles have produced from this work to date, as well as 22 research reports, conference proceedings, and other publications.

**Products**

**Books**

**Book Chapters**

**Conference Papers and Presentations**


Inventions
Journals


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Licenses

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Patents

Technologies or Techniques

Thesis/Dissertations


Websites

Participants/Organizations

Research Experience for Undergraduates (REU) funding

Form of REU funding support: REU supplement

How many REU applications were received during this reporting period? 1

How many REU applicants were selected and agreed to participate during this reporting period? 1

REU Comments:

What individuals have worked on the project?

<table>
<thead>
<tr>
<th>Name</th>
<th>Most Senior Project Role</th>
<th>Nearest Person Month Worked</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wagner, Robert</td>
<td>PD/PI</td>
<td>5</td>
</tr>
</tbody>
</table>
Weiskittel, Aaron  Co PD/PI  10

Full details of individuals who have worked on the project:

Robert G Wagner
Email: robert.wagner@maine.edu
Most Senior Project Role: PD/PI
Nearest Person Month Worked: 5

Contribution to the Project: Site Director
Funding Support: Maine Agriculture and Forest Experiment Station
International Collaboration: No
International Travel: No

Aaron R. Weiskittel
Email: aaron.weiskittel@maine.edu
Most Senior Project Role: Co PD/PI
Nearest Person Month Worked: 10

Contribution to the Project: Lead Scientist
Funding Support: Maine Agriculture and Forest Experiment Station
International Collaboration: No
International Travel: No

What other organizations have been involved as partners?

<table>
<thead>
<tr>
<th>Name</th>
<th>Type of Partner Organization</th>
<th>Location</th>
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</thead>
<tbody>
<tr>
<td>Appalachian Mountain Club</td>
<td>Other Nonprofits</td>
<td>Maine</td>
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<tr>
<td>BBC Land, LLC</td>
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<tr>
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<td>North Woods Maine, LLC</td>
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<td>Downeast Lakes Land Trust</td>
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<td>Field Timberlands</td>
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<tr>
<td>Forest Society of Maine</td>
<td>Other Nonprofits</td>
<td>Maine</td>
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</table>
Full details of organizations that have been involved as partners:

**Appalachian Mountain Club**

**Organization Type:** Other Nonprofits  
**Organization Location:** Maine

**Partner's Contribution to the Project:**  
Financial support  
In-Kind Support  
Facilities  
Collaborative Research  
Personnel Exchanges

**More Detail on Partner and Contribution:**

**BBC Land, LLC**

**Organization Type:** Industrial or Commercial Firms  
**Organization Location:** Maine

**Partner's Contribution to the Project:**  
Financial support  
In-Kind Support  
Facilities  
Collaborative Research  
Personnel Exchanges

**More Detail on Partner and Contribution:**

**Baskahegan Corporation**

**Organization Type:** Industrial or Commercial Firms  
**Organization Location:** Maine

**Partner's Contribution to the Project:**  
Financial support  
In-Kind Support  
Facilities  
Collaborative Research  
Personnel Exchanges

**More Detail on Partner and Contribution:**

**Baxter State Park, SFMA**

**Organization Type:** State or Local Government  
**Organization Location:** Maine

**Partner's Contribution to the Project:**  
Financial support
In-Kind Support
Facilities
Collaborative Research
Personnel Exchanges

More Detail on Partner and Contribution:

Canopy Timberlands Maine, LLC

Organization Type: Industrial or Commercial Firms
Organization Location: Maine

Partner's Contribution to the Project:
Financial support
In-Kind Support
Facilities
Collaborative Research
Personnel Exchanges

More Detail on Partner and Contribution:

Clayton Lake Woodlands Holding, LLC

Organization Type: Industrial or Commercial Firms
Organization Location: Maine

Partner's Contribution to the Project:
Financial support
In-Kind Support
Facilities
Collaborative Research
Personnel Exchanges

More Detail on Partner and Contribution:

Downeast Lakes Land Trust

Organization Type: Other Nonprofits
Organization Location: Maine

Partner's Contribution to the Project:
Financial support
In-Kind Support
Facilities
Collaborative Research
Personnel Exchanges

More Detail on Partner and Contribution:

EMC Holdings, LLC

Organization Type: Industrial or Commercial Firms
Organization Location: Maine

Partner's Contribution to the Project:
Financial support
In-Kind Support
Facilities
Collaborative Research
Personnel Exchanges

More Detail on Partner and Contribution:

Field Timberlands

Organization Type: Other Nonprofits
Organization Location: Maine

Partner's Contribution to the Project:
Financial support

More Detail on Partner and Contribution:

Forest Society of Maine

Organization Type: Other Nonprofits
Organization Location: Maine

Partner's Contribution to the Project:
Financial support
In-Kind Support
Facilities
Collaborative Research
Personnel Exchanges

More Detail on Partner and Contribution:

Frontier Forest, LLC

Organization Type: Industrial or Commercial Firms
Organization Location: Maine

Partner's Contribution to the Project:
Financial support
In-Kind Support
Facilities
Collaborative Research
Personnel Exchanges

More Detail on Partner and Contribution:

Huber Engineered Woods, LLC

Organization Type: Industrial or Commercial Firms
Organization Location: Maine

Partner's Contribution to the Project:
Financial support
In-Kind Support
Facilities
Collaborative Research
Personnel Exchanges

More Detail on Partner and Contribution:

Irving Woodlands, LLC

Organization Type: Industrial or Commercial Firms
Organization Location: Maine

Partner's Contribution to the Project:
Financial support
In-Kind Support
Facilities
Collaborative Research
Personnel Exchanges

More Detail on Partner and Contribution:

Katahdin Forest Management, LLC

Organization Type: Industrial or Commercial Firms
Organization Location: Maine

Partner's Contribution to the Project:
Financial support
In-Kind Support
Facilities
Collaborative Research
Personnel Exchanges

More Detail on Partner and Contribution:

LandVest

Organization Type: Industrial or Commercial Firms
Organization Location: Maine

Partner's Contribution to the Project:
Financial support
In-Kind Support
Facilities
Collaborative Research
Personnel Exchanges

More Detail on Partner and Contribution:
Maine Bureau of Parks & Public Lands

Organization Type: State or Local Government
Organization Location: Maine

Partner's Contribution to the Project:
Financial support
In-Kind Support
Facilities
Collaborative Research
Personnel Exchanges

More Detail on Partner and Contribution:

Mosquito, LLC

Organization Type: Industrial or Commercial Firms
Organization Location: Maine

Partner's Contribution to the Project:
Financial support
In-Kind Support
Facilities
Collaborative Research
Personnel Exchanges

More Detail on Partner and Contribution:

New England Forestry Foundation

Organization Type: Other Nonprofits
Organization Location: Maine

Partner's Contribution to the Project:
Financial support
In-Kind Support
Facilities
Collaborative Research
Personnel Exchanges

More Detail on Partner and Contribution:

North Woods Maine, LLC

Organization Type: Industrial or Commercial Firms
Organization Location: Maine

Partner's Contribution to the Project:
Financial support
In-Kind Support
Facilities
Collaborative Research
Personnel Exchanges

More Detail on Partner and Contribution:

Plum Creek Timber Company, Inc.

Organization Type: Industrial or Commercial Firms
Organization Location: Maine

Partner's Contribution to the Project:
Financial support
In-Kind Support
Facilities
Collaborative Research
Personnel Exchanges

More Detail on Partner and Contribution:

Prentiss and Carlisle Company, Inc.

Organization Type: Industrial or Commercial Firms
Organization Location: Maine

Partner's Contribution to the Project:
Financial support
In-Kind Support
Facilities
Collaborative Research
Personnel Exchanges

More Detail on Partner and Contribution:

ReEnergy Holdings, LLC

Organization Type: Industrial or Commercial Firms
Organization Location: Maine

Partner's Contribution to the Project:
Financial support
In-Kind Support
Facilities
Collaborative Research
Personnel Exchanges

More Detail on Partner and Contribution:

Robbins Lumber Company

Organization Type: Industrial or Commercial Firms
Organization Location: Maine

Partner's Contribution to the Project:
Financial support
In-Kind Support
Facilities
Collaborative Research
Personnel Exchanges

More Detail on Partner and Contribution:

SAPPI Fine Paper

Organization Type: Industrial or Commercial Firms
Organization Location: Maine

Partner's Contribution to the Project:
Financial support
In-Kind Support
Facilities
Collaborative Research
Personnel Exchanges

More Detail on Partner and Contribution:

Seven Islands Land Company Full $42,354

Organization Type: Industrial or Commercial Firms
Organization Location: Maine

Partner's Contribution to the Project:
Financial support
In-Kind Support
Facilities
Collaborative Research
Personnel Exchanges

More Detail on Partner and Contribution:

Simorg North Forest, LLC

Organization Type: Industrial or Commercial Firms
Organization Location: Maine

Partner's Contribution to the Project:
Financial support
In-Kind Support
Facilities
Collaborative Research
Personnel Exchanges

More Detail on Partner and Contribution:

Snowshoe Timberlands, LLC
Organization Type: Industrial or Commercial Firms
Organization Location: Maine

Partner's Contribution to the Project:
Financial support
In-Kind Support
Facilities
Collaborative Research
Personnel Exchanges

More Detail on Partner and Contribution:

St. John Timber, LLC

Organization Type: Industrial or Commercial Firms
Organization Location: Maine

Partner's Contribution to the Project:
Financial support
In-Kind Support
Facilities
Collaborative Research
Personnel Exchanges

More Detail on Partner and Contribution:

Sylvan Timberlands, LLC

Organization Type: Industrial or Commercial Firms
Organization Location: Maine

Partner's Contribution to the Project:
Financial support
Facilities
Collaborative Research
Personnel Exchanges

More Detail on Partner and Contribution:

The Forestland Group, LLC

Organization Type: Industrial or Commercial Firms
Organization Location: Maine

Partner's Contribution to the Project:
Financial support
In-Kind Support
Facilities
Collaborative Research
Personnel Exchanges

More Detail on Partner and Contribution:
The Nature Conservancy

Organization Type: Other Nonprofits
Organization Location: Maine

Partner's Contribution to the Project:
Financial support
In-Kind Support
Facilities
Collaborative Research
Personnel Exchanges

More Detail on Partner and Contribution:

Timbervest, LLC

Organization Type: Industrial or Commercial Firms
Organization Location: Maine

Partner's Contribution to the Project:
Financial support
In-Kind Support
Facilities
Collaborative Research
Personnel Exchanges

More Detail on Partner and Contribution:

UPM Madison Paper

Organization Type: Industrial or Commercial Firms
Organization Location: Maine

Partner's Contribution to the Project:
Financial support
In-Kind Support
Facilities
Collaborative Research
Personnel Exchanges

More Detail on Partner and Contribution:

Wagner Forest Management

Organization Type: Industrial or Commercial Firms
Organization Location: Maine

Partner's Contribution to the Project:
Financial support
In-Kind Support
Facilities
Collaborative Research
Personnel Exchanges

More Detail on Partner and Contribution:

What other collaborators or contacts have been involved?
NO

Impacts

What is the impact on the development of the principal discipline(s) of the project?

The two forestry disciplines addressed in this project include forest modeling and silviculture. Advances to the forest modeling discipline include the compilation of a new forest growth & yield database that includes more than 4 million observations that documents the growth and development of thousands of permanent forest plots across the Acadian Forest region. This database is a milestone contribution to forest modeling in the Northeastern US and eastern Canada. A major spin-off accomplishment of this effort is development of a high-resolution map of potential forest site productivity for the Acadian region that has a number of ecological and management applications. In addition, improved equations developed in this project represent a new level of understanding about the influence of allometric relationships and site on the growth and development of eastern forest stands. The repeated measurements and analysis from a long-term commercial thinning experiment developed under this project also have provided a major leap forward in our silvicultural understanding about how spruce-fir stands respond to various types of thinning.

What is the impact on other disciplines?

The new regional growth & yield model for the Acadian Forest region (FVS-AD) developed under this project will contribute to a variety of ecological, geographical, biological, conservation, and environmental disciplines that rely on better predictions of forest growth and development over time.

What is the impact on the development of human resources?

The two post-doctoral fellows, two graduate students, and more than 50 undergraduates students hired to work on these projects have developed a wide variety of new skills that are contributing to the capabilities of a number of organizations that hire these students across the US.

What is the impact on physical resources that form infrastructure?
Nothing to report.

What is the impact on institutional resources that form infrastructure?
Nothing to report.

What is the impact on information resources that form infrastructure?

The compiled forest growth & yield database, which includes more than 4 million observations documenting the growth and development of permanent plots for the Acadian Region, is the largest of its kind ever developed in the Northeastern US and eastern Canada. This database and the improved component allometric and growth equations represent a significant contribution to the information infrastructure for understanding and analyzing the biological growth of managed forests in the Northeast region of North America.

What is the impact on technology transfer?

The improved forest model (FVS-AD) developed under this project is being used to help the public understand how forest resources are changing and developing over time. For commercial forest landowners and products
manufacturers, the FVS-AD model is being used to predict the long-term consequences of forest management activities on wood supply characteristics and availability over the coming decades. This information is vital for forestland investments and the assessment of forest products manufacturing investments in the region. The project is also providing specific recommendations for commercial thinning of spruce-fir stands across northern Maine (including the desired timing of entry, best residual stand density, and method of thinning), which is assisting land managers with decisions about silvicultural investments in the region.

What is the impact on society beyond science and technology?

Improved understanding about the region’s forests provide more accurate information to rural communities, policy makers, and others about the future condition of forest resources, and thus more reliable information about the sustainability of the region’s natural resources.

Changes/Problems

Changes in approach and reason for change
Nothing to report.

Actual or Anticipated problems or delays and actions or plans to resolve them
Nothing to report.

Changes that have a significant impact on expenditures
Nothing to report.

Significant changes in use or care of human subjects
Nothing to report.

Significant changes in use or care of vertebrate animals
Nothing to report.

Significant changes in use or care of biohazards
Nothing to report.

Special Requirements

Responses to any special reporting requirements specified in the award terms and conditions, as well as any award specific reporting requirements.
Nothing to report.