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

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Preview of Award 0855370 - Final Project Report

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Cover

| | |
|-----------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------|
| Federal Agency and Organization Element to Which Report is Submitted: | 4900 |
| Federal Grant or Other Identifying Number Assigned by Agency: | 0855370 |
| Project Title: | University of Maine Proposal for Joining the NSF Center for Advanced Forestry Systems |
| PD/PI Name: | Robert G Wagner, Principal Investigator Aaron Weiskittel, Co-Principal Investigator |
| Recipient Organization: | University of Maine |
| Project/Grant Period: | 02/15/2009 - 01/31/2015 |
| Reporting Period: | 02/01/2014 - 01/31/2015 |
| Submitting Official (if other than PD\PI): | Robert G Wagner Principal Investigator |
| Submission Date: | 04/23/2015 |
| Signature of Submitting Official (signature shall be submitted in accordance with agency specific instructions) | Robert G Wagner |

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.

Significant Results:

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 bdf/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/Mbdf) 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 an 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.

Key outcomes or
Other achievements:

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

Russell, M.B.; Weiskittel, A.R. (2010). *Assessing model prediction uncertainty in forecasting long-term tree basal area and diameter increment for the primary Acadian tree species.* In Proceedings of Eastern CANUSA Forest Science Conference, October 14 - 16, 2010,. Université de Moncton, Edmundston, New Brunswick.. Status = PUBLISHED; Acknowledgement of Federal Support = No

Bataineh, M.M., R.G. Wagner, and A.R. Weiskittel. (2012). *Capturing value through thinning - Forty-year results from the Austin Pond study.* Cooperative Forestry Research Unit Forester's Workshop, May 16, 2012,. Orono, ME.. Status

= PUBLISHED; Acknowledgement of Federal Support = No

Clune, P., R.G. Wagner, A. Weiskittel, R.S. Seymour, and S. Meyer. (2010). *Commercial Thinning Research Network: New site additions and plans for future analysis of commercial thinning responses in Maine spruce-fir stands.* Eastern CANUSA Forest Science Conference, October 14 - 16, 2010,. Université de Moncton, Edmundston, New Brunswick.. Status = PUBLISHED; Acknowledgement of Federal Support = No

Russell, M.B. and Weiskittel, A.R. (2009). *Development of a growth index for application in the mixed-species Acadian Forest.* In Gove, J, (Ed.) Proc. 13th Annual Northeastern Mensurationist's Meeting.. Durham, NH.. Status = PUBLISHED; Acknowledgement of Federal Support = No

Russell, M.B.; Weiskittel, A.R. (2010). *Estimating tree crown widths for the primary Acadian species in Maine.* In Proc. 2010 FIA Symposium.. Knoxville, TN. Status = PUBLISHED; Acknowledgement of Federal Support = Yes

Clune, P., R. Wagner, R. Seymour, A. Weiskittel. (2011). *Growth and Development of Maine Spruce-fir Forests Following Commercial Thinning (CAFS.10.32).* Center for Advanced Forestry Systems (CAFS) 2011 Annual Meeting, June 14-16, 2011,. Seattle, WA.. Status = PUBLISHED; Acknowledgement of Federal Support = No

Clune, P., R. Wagner, R. Seymour, A. Weiskittel. (2012). *Growth and Development of Maine Spruce-fir Forests Following Commercial Thinning.* Center for Advanced Forestry Systems (CAFS) 2012 Annual Meeting, June 26-28, 2011,. Bangor, ME.. Status = PUBLISHED; Acknowledgement of Federal Support = No

Clune, P., R. Wagner, A. Weiskittel, and R. Seymour. (2013). *Growth and development of Maine spruce-fir stands following commercial thinning.* Center for Advanced Forestry Systems (CAFS) Annual Meeting, April 9-11, 2013,. St. Simmons, GA.. Status = PUBLISHED; Acknowledgement of Federal Support = No

Bataineh, M., A. Nelson, R. Wagner, B. Roth, and A. Weiskittel. (2013). *Individual-tree response to commercial thinning in northern Maine: Influence of including competition, site, and treatment regime in growth and yield models.* Center for Advanced Forestry Systems (CAFS) Annual Meeting, April 9-11, 2013,. St. Simmons, GA.. Status = PUBLISHED; Acknowledgement of Federal Support = No

Wagner, R.G., M.M. Bataineh, and M.G. Olson. (2014). *Long-term stand development and financial returns following herbicide and precommercial thinning combinations in the Acadian Forest of Maine, USA.* In Proc. 8th International Forest Vegetation Management Conference, August 25-28, 2014,. Halmstad, Sweden.. Status = PUBLISHED; Acknowledgement of Federal Support = Yes

Russell, M., A. Weiskittel, and R. Wagner. (2012). *Refinement of Regional Growth and Yield Models for Naturally-Regenerated, Mixed Species Stands in the Northeast.* Center for Advanced Forestry Systems (CAFS) 2012 Annual Meeting, June 26-28, 2011,. Bangor, ME.. Status = PUBLISHED; Acknowledgement of Federal Support = No

Russell, M., A. Weiskittel, and R. Wagner. (2011). *Refinement of Regional Growth and Yield Models for Naturally-Regenerated, Mixed Species Stands in the Northeast.* Center for Advanced Forestry Systems (CAFS) 2011 Annual Meeting, June 14-16, 2011,. Seattle, WA.. Status = PUBLISHED; Acknowledgement of Federal Support = No

Pekol, J., A. Weiskittel, R.G. Wagner, and R. Seymour. (2010). *The effects of precommercial and commercial thinning on individual-tree mortality in red spruce – balsam fir stands across Maine.* pp. 92 In Proceedings of Eastern CANUSA Forest Science Conference, October 14 - 16, 2010,. Université de Moncton, Edmundston, New Brunswick.. Status = PUBLISHED; Acknowledgement of Federal Support = No

Bataineh, M.M., L. Kenefic, A.R. Weiskittel, R.G. Wagner, J. Brissette, and R.S. Seymour. (2012). *The relative importance of harvesting and local site factors in structuring regeneration abundance and composition in partially harvested stands in central Maine.* Eastern CANUSA Forest Science Conference,. Durham, New Hampshire. Status = PUBLISHED; Acknowledgement of Federal Support = No

Inventions

Journals

Bataineh, M., Wagner, R.G., and Weiskittel, A.R. (2013). . Long-term response of spruce-fir stands to herbicide and precommercial thinning: Observed and projected growth, yield, and financial returns in central Maine, USA.. *Canadian Journal of Forest Research*. 385-395.. Status = PUBLISHED; Acknowledgment of Federal Support = Yes ; Peer Reviewed = Yes

Bataineh, M.M., L. Kenefic, A.R.Weiskittel, R.G. Wagner, and J. Brissette. (2013). . Influence of partial harvesting and site factors on the abundance and composition of natural regeneration in the Acadian Forest of Maine, USA.. *Forest Ecology & Management*. 306 96–106.. Status = PUBLISHED; Acknowledgment of Federal Support = Yes ; Peer Reviewed = Yes

Bataineh, M.M., R.G. Wagner, M.G. Olson, E.K. Olson. (2013). Midrotation response of ground vegetation to herbicide and precommercial thinning in the Acadian Forest of Maine, USA.. *Forest Ecology & Management*. 313 132–143.. Status = PUBLISHED; Acknowledgment of Federal Support = Yes ; Peer Reviewed = Yes

Kershaw, J.A., Benjamin, J.G., and Weiskittel, A.R. (2009). Approaches for modeling vertical distribution of maximum knot size in black spruce: A comparison of fixed and mixed effects nonlinear models.. *Forest Science*. 55 230-237.. Status = PUBLISHED; Acknowledgment of Federal Support = Yes ; Peer Reviewed = Yes

Li, R. and Weiskittel, A.R. (2010). Development and evaluation of regional taper and volume equations for the primary conifer species in the Acadian Region of North America.. *Annals of Forest Science*. 67 302. Status = PUBLISHED; Acknowledgment of Federal Support = Yes ; Peer Reviewed = Yes

Li, R. and Weiskittel, A.R. (2011). Estimating and predicting bark thickness for seven conifer species in the Acadian Region of North America using a mixed-effects modeling approach: Comparison of model forms and subsampling strategies.. *European Journal of Forest Research*. 259 1912-1921.. Status = PUBLISHED; Acknowledgment of Federal Support = Yes ; Peer Reviewed = Yes

Li, R., Stewart, B., Weiskittel, A.R. (2012). A Bayesian approach for modeling nonlinear longitudinal/hierarchical data with random effects in forestry.. *Forestry*. 85 17-25.. Status = PUBLISHED; Acknowledgment of Federal Support = Yes ; Peer Reviewed = Yes

Li, R., Weiskittel, A.R., and Kershaw, J.A. (2011). Modeling annualized occurrence, frequency, and composition of ingrowth using mixed-effects zero-inflated models and permanent plots in the Acadian Region of North America.. *Canadian Journal of Forest Research*. 41 2077-2089.. Status = PUBLISHED; Acknowledgment of Federal Support = Yes ; Peer Reviewed = Yes

Li, R., Weiskittel, A.R., Kershaw, J.A., and Dick, A. (2012). Regional stem taper equations for eleven conifer species in the Acadian Region of North America: Development and assessment.. *Northern Journal of Applied Forestry*. 29 5-14.. Status = PUBLISHED; Acknowledgment of Federal Support = Yes ; Peer Reviewed = Yes

McGarrigle, E., Kershaw, J.A., Lavinge, M., Weiskittel, A.R., Ducey, M.J. (2011). Predicting small tree diameter distributions using predictions from a two-parameter Weibull distribution in the Acadian Forest region.. *Forestry*. 84 431-439.. Status = PUBLISHED; Acknowledgment of Federal Support = Yes ; Peer Reviewed = Yes

Rice, B., Weiskittel, A.R., Wagner, R.G. (2014). Efficiency of alternative forest inventory methods in partially harvested stands. *European Journal of Forest Research*. *European Journal of Forest Research*. 133 261-272.. Status = PUBLISHED; Acknowledgment of Federal Support = Yes ; Peer Reviewed = Yes

Rijal, B., Weiskittel, A.R., Kershaw, J.A. (2012). Development of height to crown base models for thirteen tree species of the North American Acadian Region.. *Forestry Chronicle*. 88 60-73.. Status = PUBLISHED; Acknowledgment of Federal Support = Yes ; Peer Reviewed = Yes

Rijal, B., Weiskittel, A.R., Kershaw, J.A. (2012). Development of regional height to diameter static equations for fifteen species in North American Acadian Region.. *Forestry*. 85 379-390.. Status = PUBLISHED; Acknowledgment of Federal Support = Yes ; Peer Reviewed = Yes

Russell, M.B, Weiskittel, A.R., and Kershaw, J.A. (2014). Comparing strategies for modeling individual-tree height and height-to-crown base increment in mixed-species Acadian forests of northeastern North America.. *European Journal of Forest Research*. 133 1121-1135.. Status = PUBLISHED; Acknowledgment of Federal Support = Yes ; Peer Reviewed = Yes

Russell, M.B. and Weiskittel, A.R. (2011). Maximum and largest crown width equations for fifteen tree species in Maine.. *Northern Journal of Applied Forestry*. 28 84-91.. Status = PUBLISHED; Acknowledgment of Federal Support = Yes ; Peer Reviewed = Yes

Russell, M.B. and Weiskittel, A.R. (2012). Assessing and modeling snag survival and decay dynamics for the primary species in the Acadian forest of Maine, USA.. *Forest Ecology and Management*. 284 230-240.. Status = PUBLISHED; Acknowledgment of Federal Support = Yes ; Peer Reviewed = Yes

Russell, M.B., Kenefic, L.K., Weiskittel, A.R., Puhlick, J., and Brissette, J. (2012). Assessing and modeling standing deadwood attributes under alternative silvicultural regimes in the Acadian Forest region of Maine, USA.. *Canadian Journal of Forest Research*. 42 1873-1883. Status = PUBLISHED; Acknowledgment of Federal Support = Yes ; Peer Reviewed = Yes

Russell, M.B., Weiskittel, A.R., and Kershaw, J.A. (2013). Benchmarking and calibration of Forest Vegetation Simulator individual tree attribute predictions across the northeastern US.. *Northern Journal of Applied Forest Research*. 30 75-84. Status = PUBLISHED; Acknowledgment of Federal Support = Yes ; Peer Reviewed = Yes

Russell, M.B., Weiskittel, A.R., Kershaw, J.A. (2011). Assessing model performance in forecasting long-term individual tree diameter versus basal area increment for the primary Acadian species.. *Canadian Journal of Forest Research*. 41 2267-2275.. Status = PUBLISHED; Acknowledgment of Federal Support = Yes ; Peer Reviewed = Yes

Weiskittel, A.R., Hofmeyer, P.V., Seymour, R.S., and Kershaw, J.A. (2010). Modelling primary branch frequency and size for five conifer species in Maine, USA.. *Forest Ecology and Management*. 259 1912-1921.. Status = PUBLISHED; Acknowledgment of Federal Support = Yes ; Peer Reviewed = Yes

Weiskittel, A.R., Kenefic, L.S., Li, R., and Brissette, J.C. (2011). Long term influence of early spacing treatments on stand-level attributes in a northern conifer stand in Maine.. *Northern Journal of Applied Forestry*. 28 92-96.. Status = PUBLISHED; Acknowledgment of Federal Support = Yes ; Peer Reviewed = Yes

Weiskittel, A.R., Kenefic, L.S., Seymour, R.S., and Phillips, L.M. (2009). Long-term effects of precommercial thinning on stem dimensions, form, and branch characteristics of red spruce and balsam fir crop trees.. *Silva Fennica*. 43 397-409.. Status = PUBLISHED; Acknowledgment of Federal Support = Yes ; Peer Reviewed = Yes

Weiskittel, A.R., Kershaw, J.A., Hofmeyer, P.V., and Seymour, R.S. (2009). Species differences in total and vertical distribution of branch- and tree-level leaf area for the five primary conifer species in Maine, USA.. *Forest Ecology and Management*. 258 1695-1703.. Status = PUBLISHED; Acknowledgment of Federal Support = Yes ; Peer Reviewed = Yes

Licenses

Other Products

Other Publications

Weiskittel, A.R., Wagner, R.G., and Seymour, R.S. (2011). . *Refinement of the Forest Vegetation Simulator northeastern variant growth and yield model: Phase 2*. In CFRU 2010 Annual Report, University of Maine. Orono.. Status = PUBLISHED; Acknowledgement of Federal Support = No

Meyer, S.R., R.G. Wagner, R.S. Seymour, and M. Russell. (2009). *Commercial Thinning Research Network*.. pp. 25-26. In Cooperative Forestry Research Unit, 2008 Annual Report, Maine Agriculture and Forest Experiment Station, Orono. 90 p.. Status = PUBLISHED; Acknowledgement of Federal Support = No

Wagner, R., P. Clune, A. Weiskittel, R. Seymour, and S. Meyer. (2014). *Growth and Development of Maine Spruce-Fir Forests Following Commercial Thinning.* In pp. 69. Meyer, S. 2013 Annual Report for Center for Research on Sustainable Forests (CRSF). University of Maine. Orono. 141p.. Status = PUBLISHED; Acknowledgement of Federal Support = No

Pekol, J., A. Weiskittel, R. Seymour, and R. Wagner. (2012). *Influence of Commercial Thinning on Stand & Tree-Level Mortality Patterns of Balsam Fir and Red Spruce Forests in Maine With and Without Precommercial Thinning.* pp. 56-65, In Roth, B. (Ed.) 2012. Cooperative Forestry Research Unit: 2011 Annual Report. University of Maine, Orono, ME. 110p.. Status = PUBLISHED; Acknowledgement of Federal Support = No

Weiskittel, A., M. Russell, R. Wagner, and R. Seymour. (2012). *Refinement of the Forest Vegetation Simulator Northeast Variant Growth and Yield Model: Phase III.* pp. 85-93, In Roth, B. (Ed.) 2012. Cooperative Forestry Research Unit: 2011 Annual Report. University of Maine, Orono, ME. 110p.. Status = PUBLISHED; Acknowledgement of Federal Support = No

Weiskittel, A., M. Russell, R. Wagner, R. Seymour, J. Kershaw, and C. Hennigar. (2014). *Refinement of the Forest Vegetation Simulator Northeastern Variant Growth and Yield Model.* In pp. 71. Meyer, S. 2013 Annual Report for Center for Research on Sustainable Forests (CRSF). University of Maine. Orono. 141p.. Status = PUBLISHED; Acknowledgement of Federal Support = No

Seymour, R.S., S.R. Meyer, and R.G. Wagner. (2014). *The Cooperative Forestry Research Unit Commercial Thinning Research Network: 9-Year Results.* In: Kenefic, Laura S.; Brissette, John C., compilers. 2014. Penobscot Experimental Forest: 60 years of research and demonstration in Maine, 1950-2010. Gen. Tech. Rep. NRS-P-123. Newtown Square, PA: U.S. Department of Agriculture, Forest Service, Northern Research Station. 185 p.. Status = PUBLISHED; Acknowledgement of Federal Support = Yes

Patents

Technologies or Techniques

Thesis/Dissertations

Clune, P.M.. *Growth and development of Maine spruce-fir forests following commercial thinning.* (2013). University of Maine, Orono, ME.. Acknowledgement of Federal Support = No

Russell, M.B.. *Modeling individual tree and snag dynamics in the mixed-species Acadian forest.* (2012). University of Maine, Orono, ME.. Acknowledgement of Federal Support = Yes

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?

| Name | Most Senior Project Role | Nearest Person Month Worked |
|----------------|--------------------------|-----------------------------|
| Wagner, Robert | PD/PI | 5 |

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?

| Name | Type of Partner Organization | Location |
|--------------------------------------|--------------------------------|----------|
| Appalachian Mountain Club | Other Nonprofits | Maine |
| BBC Land, LLC | Industrial or Commercial Firms | Maine |
| Frontier Forest, LLC | Industrial or Commercial Firms | Maine |
| Huber Engineered Woods, LLC | Industrial or Commercial Firms | Maine |
| Irving Woodlands, LLC | Industrial or Commercial Firms | Maine |
| Katahdin Forest Management, LLC | Industrial or Commercial Firms | Maine |
| LandVest | Industrial or Commercial Firms | Maine |
| Maine Bureau of Parks & Public Lands | State or Local Government | Maine |
| Mosquito, LLC | Industrial or Commercial Firms | Maine |
| New England Forestry Foundation | Other Nonprofits | Maine |

| | | |
|------------------------------------------|--------------------------------|-------|
| North Woods Maine, LLC | Industrial or Commercial Firms | Maine |
| Plum Creek Timber Company, Inc. | Industrial or Commercial Firms | Maine |
| Baskahegan Corporation | Industrial or Commercial Firms | Maine |
| Prentiss and Carlisle Company, Inc. | Industrial or Commercial Firms | Maine |
| ReEnergy Holdings, LLC | Industrial or Commercial Firms | Maine |
| Robbins Lumber Company | Industrial or Commercial Firms | Maine |
| SAPPI Fine Paper | Industrial or Commercial Firms | Maine |
| Seven Islands Land Company Full \$42,354 | Industrial or Commercial Firms | Maine |
| Simorg North Forest, LLC | Industrial or Commercial Firms | Maine |
| Snowshoe Timberlands, LLC | Industrial or Commercial Firms | Maine |
| St. John Timber, LLC | Industrial or Commercial Firms | Maine |
| Sylvan Timberlands, LLC | Industrial or Commercial Firms | Maine |
| The Forestland Group, LLC | Industrial or Commercial Firms | Maine |
| Baxter State Park, SFMA | State or Local Government | Maine |
| The Nature Conservancy | Other Nonprofits | Maine |
| Timbervest, LLC | Industrial or Commercial Firms | Maine |
| UPM Madison Paper | Industrial or Commercial Firms | Maine |
| Wagner Forest Management | Industrial or Commercial Firms | Maine |
| Canopy Timberlands Maine, LLC | Industrial or Commercial Firms | Maine |
| Clayton Lake Woodlands Holding, LLC | Industrial or Commercial Firms | Maine |
| Downeast Lakes Land Trust | Other Nonprofits | Maine |
| EMC Holdings, LLC | Industrial or Commercial Firms | Maine |
| Field Timberlands | Other Nonprofits | Maine |
| Forest Society of Maine | Other Nonprofits | Maine |

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.