

COOPERATIVE FORESTRY RESEARCH UNIT

Research Proposal

Date of Proposal

April 14, 2010

Project Title

Early Commercial Thinning Harvest Systems: A Silvicultural and Operational Assessment

Abstract

Due in part to regenerating clearcuts from the budworm era, there are over 2 million acres forestland in Maine dominated by dense spruce and fir saplings with a small component of hardwood. Another half million acres are expected to grow into this condition in the next five years. According to six-year results from the CFRU's Commercial Thinning Research Network, these areas would benefit from thinning, but they are decades away from being commercially operable with traditional harvesting systems involving small cut-to-length processors. The presence of an active energy wood market provides an opportunity to further utilize small stems and tops harvested in an early commercial thinning.

Contractors are hesitant to conduct such a harvest with their current mix of equipment which is typically not designed to handle and process small-diameter stems. Specialized equipment for harvesting small diameter trees is commercially available; however, given current market realities, contractors are reluctant to invest heavily in specialized equipment. There is a need to provide both landowners and contractors sound data on production and costs associated with harvesting small diameter stems in a commercial thinning context, using a combination of existing equipment and newer technology in partnership with local equipment dealers.

Using a factorial combination of two stand conditions (PCT and No-PCT), two harvest methods (CTL and WT), and two products (pulpwood and biomass, and biomass only), the objectives of this study are to investigate the operational and silvicultural effectiveness of early commercial thinning treatments in spruce-fir dominated stands in Maine. Silvicultural implementation will be measured in terms of final tree spacing, residual stem damage, and area in trails. Operational performance will be measured in terms of productivity, cost, and product utilization.

Principal Investigators

<u>Name</u>	<u>Organization</u>	<u>Phone</u>	<u>Email</u>
Jeffrey Benjamin	University of Maine	581-2727	jeffrey.g.benjamin@maine.edu
Robert Seymour	University of Maine	581-2860	rseymour@maine.edu
Jeremy Wilson	University of Maine	581-9213	jeremy.wilson@maine.edu

Principal Research Establishment

University of Maine – School of Forest Resources
5755 Nutting Hall Orono, ME 04469

Potential Cooperating CFRU Members or Other Research Organizations

<u>Name</u>	<u>Organization</u>
John Bryant	American Forest Management
Kip Nichols	Seven Island Land Management Co.
Travis Howard	Wagner Forest Management
Dave Dow	Prentiss and Carlisle
Marko Mattila	Ponsse North America
John Theborge	Chadwick-BaRoss
Kevin Fowler	Nortrax Equipment
Jack Frost	Tigercat Industries
Dan Phillips	The Oliver Stores
Brian Souers	Treeline Inc.
Tony Madden	A.W. Madden
Jeannot Carrier	EJ Carrier

Start and Termination Dates of Study

2 years (October 1, 2010 to September 30, 2012)

Background

There are 1.5 million acres of 20 to 39-year-old spruce-fir forestland in Maine and an additional 0.9 million acres in the 40 to 59-year-old class (FIA 2004-2008). Many of these areas are regenerating clearcuts from the budworm era and are dominated by dense spruce and fir saplings (< 6 in. dbh) with a small component of hardwood. Some of these stands were pre-commercially thinned; others, however, have grown beyond the stage where brush-saw treatment is feasible. Such stands are overstocked and would benefit from thinning, but they are decades away from being operable with traditional harvesting systems. The Maine Forest Service (2008) estimates that thinning these overstocked stands could provide an additional 1.4 million green tons of wood annually.

The CFRU's ongoing Commercial Thinning Research Network (CTRN) is monitoring growth response to commercial thinning trials across a variety of sites. These trials were implemented on older sites where most stems had already reached commercial size. Six-year results suggest that investment in commercial thinning may yield substantial returns. These treatments, however, were designed for a small cut-to-length system (e.g., a small Rottne harvester and forwarder) producing exclusively roundwood products. Given the presence of an active regional energy wood market, and because the dominant harvest method in Maine is still whole-tree, it is important to consider such commercial thinning treatments from a different perspective.

There is no consensus within the industry as to how these young stands should be treated. Landowners feel growth will be improved with early commercial thinning, and that the economic

value of the harvested material should be adequate to cover harvest costs. This view has been enhanced with recent government initiatives such as the Biomass Crop Assistance Program. Contractors are unsure if they can conduct early commercial thinning treatments without subsidies from the landowners given their current mix of equipment which is not designed to handle and process small-diameter stems. Local equipment dealers and manufacturers are eager to test their versions of specialized equipment that is commercially available for both harvesting and transporting this material to roadside. This study will allow three sectors of the forest industry (landowners, contractors, and equipment dealers & manufacturers) to develop silviculturally effective, operational solutions for implementing early commercial thinning treatments.

Specialized equipment is commercially available for both harvesting and transporting this material to roadside. For example, Ponsse (2008) and Pentin Paja Oy (2008) in Finland have manufactured a series of harvester heads exclusively for energy wood (biomass) harvests. There is potential to sort for both pulpwood and energy wood with these systems. Logging residues can be transported in loose form using conventional forwarders (Anderson et al. 2002), but payloads can be increased with the addition of compaction technology (CBI 2006, Paiement 2008). Composite residue logs can be produced by bundling and compacting logging residue into log form (Anderson et al. 2002, Turner 2005, Schmidt 2009). Mobile chippers are another possibility for increasing bulk density of logging residues prior to transport (Anderson et al. 2002, Turner 2005). The shortcoming of all of these machines is that they represent significant capital investment and, given current market realities, contractors are reluctant to invest heavily in specialized equipment. There is a need to conduct operational tests on the specialized equipment to allow contractors to make informed purchase decisions. There is also an opportunity to provide both landowners and contractors with objective data on production and costs associated with harvesting small diameter stems in a commercial thinning context, using both current and new technology.

Project Objectives

The objectives of this study are to determine the effectiveness of early commercial thinning treatments using cut-to-length (CTL) and whole-tree (WT) harvest methods with respect to:

- silvicultural implementation measured in terms of final tree spacing, residual stem damage, and area in trails; and
- operational performance measured in terms of productivity, unit cost of production, and product utilization.

Methods

We propose installing a factorial combination of two stand conditions (PCT and No-PCT), two harvest methods (CTL and WT), and two product types (pulpwood and biomass, and biomass only) to investigate operational and silvicultural effectiveness of early commercial thinning treatments in spruce-fir dominated stands in Maine.

Site Selection

Two sites with potential for good response to thinning treatments, based on preliminary results from the CTRN, will be selected from CFRU member lands. Consideration will be given to sites that can be added into the CTRN for continued measurement and assessment. An example of the initial site conditions targeted in this study can be found using Compartments 23A (includes the CTRN installation) and 23B of the Penobscot Experimental Forest (Figure 1). Stand density, in stems per acre, is 2500 and 4355 for C23A and C23B respectively. Merchantable volume, based on Honer's equations, is 1510 and 900 cubic feet for C23A and C23B respectively.

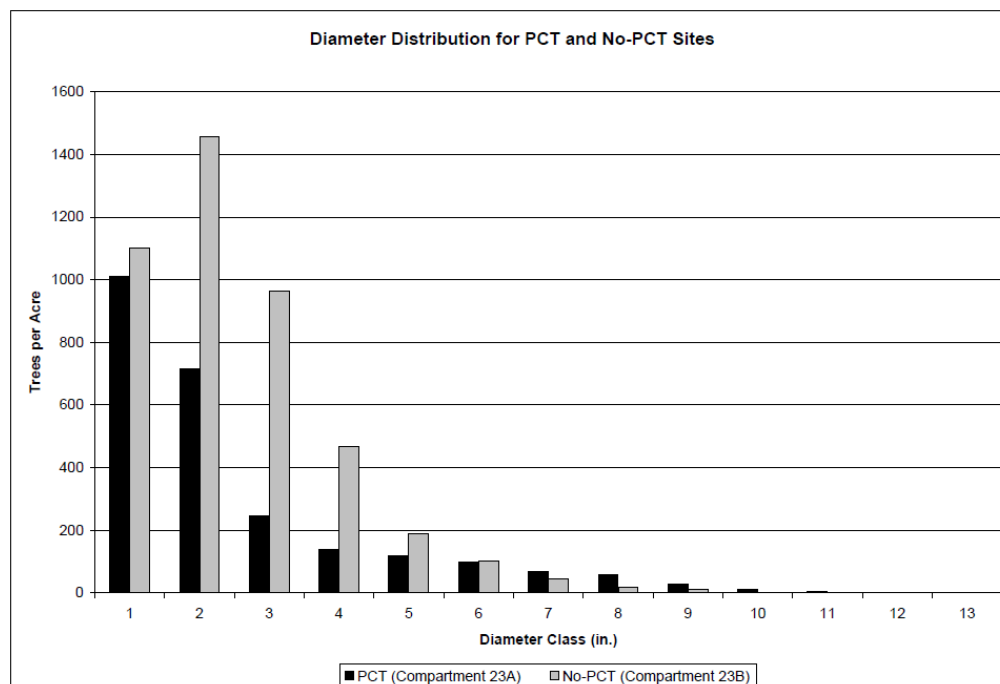


Figure 1. Example of initial site conditions targeted in this study based on PCT and No-PCT sites within the Penobscot Experimental Forest.

Figure 2 and 3 summarize estimated harvest removals from each compartment based on a uniform removal over all dbh classes from 4 to 12 inches for a target of 300 crop trees per acre. Removals were estimated to be 43 and 64 percent for compartments 23A and 23B respectively. Table 1 provides green weight estimates for both product options using assumptions of 85 cubic feet per cord and 4200 pounds per cord. Weight estimates only include bolewood of living trees, so total weight will increase in actual operations with the addition of branches, foliage, and standing dead stems as appropriate. Pulpwood is merchandized from stems greater than 4.5 inches dbh to a 3 inch top. Biomass is produced from tops and unmerchantable stems greater than 4.5 inches dbh. *Unmerchantable* weight in Table 1 includes stems from the 3 and 4 inch diameter class. It is expected that some of that material will be processed as biomass, but that will be dependent on the harvest system selected.

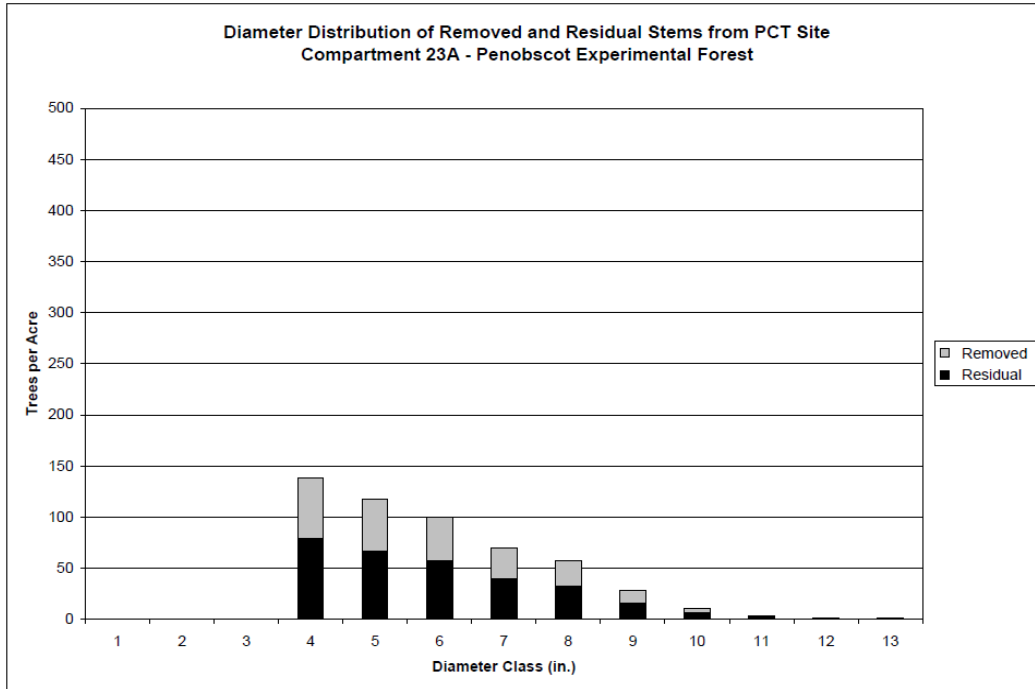


Figure 2. Diameter distribution of removed and residual stems per acre for PCT site.

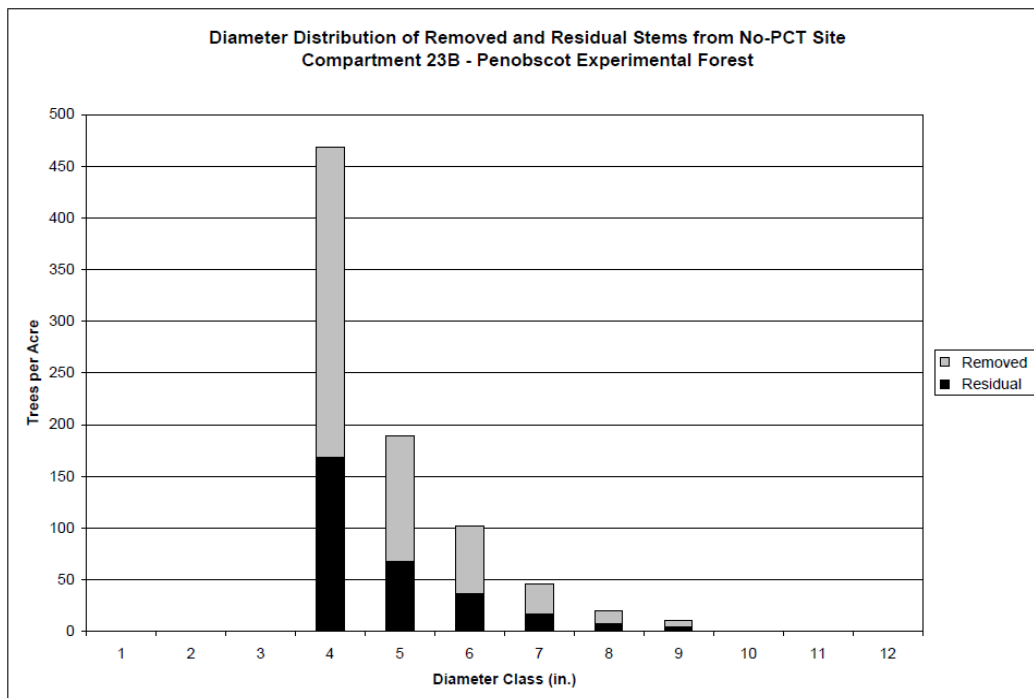


Figure 3. Diameter distribution of removed and residual stems per acre for No-PCT site.

Table 1. Removal estimates (thousand pounds per acre (green)) by site condition.

Stand Condition	Product Options		
	Pulpwood & Biomass	Biomass Only	<i>Unmerchantable</i>
PCT (23A)	32.0 & 7.4	39.4	8.2
No-PCT (23B)	19.2 & 6.7	25.9	38.9

Equipment Selection

Two harvest methods (CTL and WT) will be compared for silvicultural and operational performance. Specific equipment for each method, including roadside processing equipment, will be selected after consultation with local contractors and equipment dealers to match machine specifications to site conditions, landowner preferences, and silvicultural objectives. In all cases, we will ensure the most fuel efficient equipment is being used.

A preliminary investigation over the last year has revealed several options for system selection. Several local contractors have used existing WT systems (i.e., feller buncher and grapple skidder) to harvest stands of a similar condition to those described in this proposal. The feller bunchers used often feature a high-speed saw with an accumulating pocket and a carrier with a low tail swing. These systems have been used to produce both pulp wood and biomass, and biomass only. Several equipment dealers and contractors have previously spoken in favor of this option for conducting such treatments (Kneeland and Madden 2008, Collins 2009, Phillips 2010). Our intent is to compare this high production system with equipment specially design to harvest and handle small diameter stems in a commercial thinning context.

There are several CTL systems commercially available, featuring small thinning harvesters, which can be used to conduct early commercial thinning treatments. Chadwick-BaRoss Inc. and Nortrax Equipment Ltd., representing forestry equipment manufacturers Ponsse and John Deere respectively, as well as Tigercat Industries, are in support of this project and they have several energy wood harvesting options within their product lines (Frost 2010, Heistand 2010, Thebarga 2010). Table 2 summarizes equipment specifications important to silvicultural and operational success of this project for each thinning machine under consideration. All of the machines have a low width to reach ratio (less than 0.3) as compared to conventional feller bunchers (as high as 0.5). The John Deere 1070E and Ponsse Buffalo Dual have been specially designed with a harvesting head capable of harvesting and processing multiple small stems simultaneously. The engines are smaller than other harvesting equipment (130 – 200 hp compared to 200 – 250 hp) so fuel consumption will be less which will have a positive impact on the carbon footprint of the operation.

Table 2. General specifications of thinning equipment under consideration for this initiative.

Machine	Specifications				
	Width (ft)	Weight (lbs)	Reach (ft)	Clearance (in)	Gross Power @ 2000 (hp)
John Deere 1070E	8.5	32,400	32-35	22	182
Ponsse Buffalo Dual	9	37,000	33	27	206
Tigercat H09 ¹	7	24,200	25	22	130

¹ The H1135 has replaced the H09 as Tigercat's thinning machine. A prototype is currently being tested in Sweden.

Experimental Design

The functional unit for this study will be a one-acre block. Site conditions will vary by previous silvicultural treatment: PCT and No-PCT. Each harvest method, producing two products (pulpwood and biomass, and biomass only), will be applied to each stand condition. Three replicates for each combination will be installed for a total of 24 acres treated within this study (Figure 4). Nested within each block will be 0.20 acre plots where all measurements will be taken.

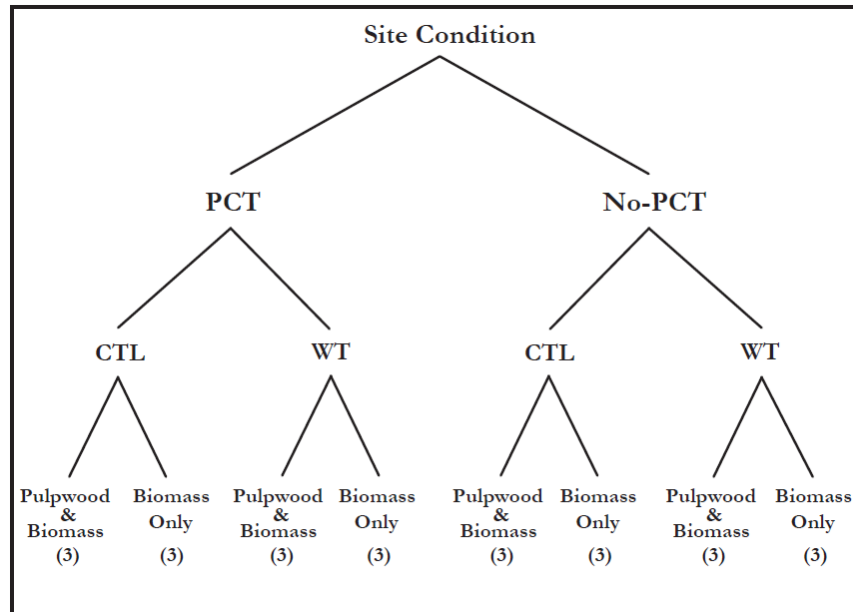


Figure 4. Experimental design and sample size for site condition, harvest system, and product combinations.

Measurements

Pre-Harvest

Pre-harvest measurements will closely follow procedures developed within the CTRN. At each plot corner, an 8-foot radius sub-plot will be established where species and dbh of trees taller than 4.5 feet and smaller than 2.5 inches dbh will be tallied. These sub-plots will be used to monitor in-growth of saplings over time. Species and dbh will be recorded for all trees greater than 2.5 inches dbh within each plot. The location of each stem will be referenced to plot center and a sub-sample of trees across the full range of diameter classes will be measured for total height and height to crown base.

Operations

Productive time to harvest, transport, and process plots for each site and system combination will be measured and compared with total weight of each product. Product weights within each plot will be estimated using biomass equations (Young et al. 1980, Ter-Mikaelian and Korzukhin 1997), and compared to actual weights measured using a load cell at the yard. Overall production within each block will be tracked using weigh-scale trip tickets. Machine rates will be developed for each machine using standard forest operation principles as outlined by Brinker et al. (2002). A detailed operations assessment will be conducted to determine the effect of stem size on each phase of the harvest. The functional unit for this assessment will be a single hitch for the whole-tree system, and

a single forwarder load for the cut-to-length system. Stem size distribution and total weight of each unit will be measured. Time and motion studies, including production analysis, will be conducted using both on-site data collection and video analysis.

Post-Harvest

Using the stem map prepared in the pre-harvest phase, final removals and effective tree spacing will be determined. Following the approach outlined by Ostrofsky and Dirkman (1991), residual stem damage, including trail area, will be assessed and summarized per acre. Plots will be established so that they can be relocated and measured in the future to evaluate long-term forest dynamics and inform ongoing growth modeling efforts at the university.

Analytical Approach

Time and motion studies, including production analysis, will be conducted using on-site data collection and video analysis to compare the two harvest methods among each site condition and product combination. System performance will be measured and compared on a green ton per hour basis for each machine and harvest system. Differences in residual stand damage, area in trails, and final tree spacing between harvest systems will also be evaluated on each site and product combination using Analysis of Variance as appropriate.

Anticipated Benefits to the CFRU

A regional energy wood market and the presence of thousands of acres of small-diameter, overstocked stands regenerated during the budworm era have created an opportunity for investment in early commercial thinning throughout Maine. Upon completion of this project, CFRU members will have baseline production and cost data for early commercial thinning treatments using CTL and WT harvest methods, and will thus be able to assess profitability of such treatments for the landowner. Given the CFRU's commitment to improving commercial thinning strategies, this project serves to increase opportunities for stand improvement on areas currently considered infeasible for such treatments. By partnering with motivated contractors and local equipment dealers, CFRU members will have a network of support to continue such treatments across their land base and within the CTRN.

Schedule of Deliverables

Deliverable	2010			2011												2012									
	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	
Site and Equipment Selection																									
Pre-harvest Survey																									
Active Harvest																									
Post-harvest Silvicultural Assessment																									
Preliminary Results (CFRU)																									
Harvest System Evaluation																									
Final Reports and Dissemination of Results																									

Communications Plan

Presentations harvesting system comparison results will be presented at CFRU meetings and workshops, as well as regional, national, and international scientific meetings. CFRU annual reports and technical reports will be submitted as appropriate and as required. All results will be submitted for publication in refereed forest engineering and forestry journals. Target journals include: International Journal of Forest Engineering, Biomass and Bioenergy, Forest Products Journal, Journal of Forestry and the Northern Journal of Applied Forestry.

LITERATURE CITED

- Andersson, G., A. Asikainen, R. Björheden, P.W. Hall, J.B. Hudson, R. Jirjis, D.J. Mead, J. Nurmi, and G.F. Weetman. 2002. Chapter 3.2 Integration of energy production into forest management. In: Richardson J., R. Björheden, P. Hakkila, A.T. Lowe, C.T. Smith (eds). *Bioenergy from sustainable forestry: guiding principles and practice*. Dordrecht; Boston; London: Kluwer Academic. p. 67-84.
- Brinker, R.W., J. Kinnard, B. Rummer, and B. Landford. 2002. Machine Rates for Selected Forest Harvesting Machines. Alabama Agriculture Experiment Station – Circular 296.
- CBI 2006. Brush Transport System. Accessed 07/22/08. http://www.cbi-inc.com/pdfs/BTS_DS_DR11.pdf.
- Collins, P. 2009. Milton CAT representative. Personal communication. March 24. Holden, ME.
- Frost, J. 2010. Tigercat Industries representative. Personal communication. March 17.
- Heistand, D. 2010. Nortrax Equipment representative. Personal communication. March 12.
- Kneeland, M., and A. Madden. 2008. Nortrax Equipment representative and Principal A.W. Madden Inc. Personal communication. December 23. Passadumkeag, ME.
- Maine Forest Service. 2008. Maine Forest Service Assessment of Sustainable Biomass Availability. www.maine.gov/doc/mfs/pubs/pdf/biomass_memo_071708.pdf. Accessed 02/18/10.
- Ostrofsky, W.D. and J.A. Dirkman 1991. A Survey of Logging Damage to Residual Timber Stands Harvested for Wood Biomass in Southern Maine. *In* CFRU Information Report 27. University of Maine, p. 10.
- Paiement, P. 2008. Gestion Cyclofor Inc. Personal communication. February 18. Toronto, Ontario.
- Pentin Paja Oy 2008. Naarva Grip Felling Heads. Accessed 12/30/08. http://www.pentinpaja.fi/main.site?action=app/prodinfo/view_all
- Phillips, D. 2010. Oliverstores representative. Personal communication. March 11.
- Ponsee 2008. The Ponsee EH25 Energy Wood Harvesting Head. Accessed 12/30/08. http://www.ponsse.com/images/brochures_pdf/Brochures_eng/EH25_en.pdf.
- Schmidt, M. 2009. Forest Resources Industrial Forum: Forestry Equipment Update – The Latest and Greatest in Wood Energy Production. January 8. Brewer, ME.
- Ter-Mikaelian, M.T. and M.D. Korzukhin 1997. Biomass equations for sixty-five North American tree species. *Forest Ecology and Management*. 97:1-24.
- Theborge, J. 2010. Chadwick-BaRoss representative. Personal communication. March 12.
- Turner, D. 2005. Harvesting for bioenergy. *In* *Atlantic Forestry Review*, pp. 40-43.
- Young, H.E., J.H. Ribe and K. Wainwright 1980. Weight tables for tree and shrub species in Maine. Life Sciences and Agriculture Experiment Station, Orono, ME, p. 84.

RESUMEOF PRINCIPAL AND CO-PRINCIPAL INVESTIGATORS:

Curriculum Vitae for Jeffrey G. Benjamin

School of Forest Resources, University of Maine, 247 Nutting Hall, Orono, ME 04469
Phone: (207) 581-2727 Fax: (207) 581-2875 E-mail: jeffrey.g.benjamin@maine.edu

Educational Background:

- Ph.D. Faculty of Forestry and Environmental Management, University of New Brunswick, Fredericton NB. 2006.
B.S. Forest Engineering – University of New Brunswick, Fredericton NB. 1997.

Professional Experience:

- 2007 - Present University of Maine, Cooperative Forestry Research Unit, *Cooperating Scientist*
2007 - Present University of Maine, Center for Research on Sustainable Forestry, *Cooperating Faculty*
2006 - Present University of Maine, *Assistant Professor of Forest Operations*
2006 - 2007 University of Maine, Forest Operations Science, *Program Leader*

Professional Designations:

Society of American Foresters, Council on Forest Engineering, Association of Professional Engineers & Geoscientists of NB, Canadian Institute of Forestry

Peer Reviewed Publications:

- Benjamin, J.G. (Editor). 2010. *Considerations and Recommendations for Retaining Woody Biomass on Timber Harvest Sites in Maine*. University of Maine, MAFES. Orono, ME. Misc. Pub. 761. 68p.
Benjamin, J.G., R.J. Lilieholm, and D. Damery. 2009. Challenges and Opportunities for the Northeastern Bioindustry. *Journal of Forestry* 107(3):125-131.
Benjamin, J.G., J.A. Kershaw, and Y.H. Chui. 2009. Circular distribution of knots in black spruce. *Northern Journal of Applied Forestry* 26(1):15-20.
Benjamin, J.G., J.A. Kershaw, A. Weiskittel, Y.H. Chui, and S.Y. Zhang. 2009. External knot size and frequency in black spruce trees from an initial spacing trial in Thunder Bay, Ontario. *Forestry Chronicle*. 85: 618-624.
Damery, D., J. Benjamin, M. Kelty, and R. Lilieholm 2009. Developing a Sustainable Forest Biomass Industry: Case of the U.S. Northeast. *ECOSUD 2009: Conference on Ecosystems and Sustainable Development – Topic Area Natural Resource Management*. July 8-10.
Kershaw, J.A., J.G. Benjamin, A.R. Weiskittel, and Y.H. Chui. 2009. Modeling Vertical Maximum Knot Distribution Using Nonlinear Mixed Effect Models: A Modeling Approach. *Forest Science* 55(3): 230-237.

Professional Presentations:

- Benjamin, J.G. 2009. *State of the Logging Industry in the Northeast*. New England Regional Council on Forest Engineering Annual Meeting. University of Maine, Orono ME. March 9.
Stone, I., J.G. Benjamin, and J. Leahy. 2008. *Feasibility of Using Insurance Company Records to Inventory Logging Equipment in the State of Maine*. SAF 2008 National Convention – Student Poster Session. Reno, NV. November 5-9.
Coup, C.E., J.G. Benjamin, and R.G. Wagner. 2008. *An Assessment of Residual Stand Damage Following Whole-Tree Biomass Harvesting in Central Maine*. Eastern CANUSA Forest Science Conference – Poster Session. University of Maine. October 17-18.
Briedis, J., J.S. Wilson, R.G. Wagner, and J.G. Benjamin. 2008. *Logging Residue Quantities on Sites in Maine Following Integrated Whole-Tree Harvests of Biomass and Roundwood*. Eastern CANUSA Forest Science Conference – Poster Session. University of Maine. October 17-18.

Curriculum Vita - Robert S. Seymour

School of Forest Resource, College of Natural Sciences, Forestry, and Agriculture

211 Nutting Hall University of Maine; Orono, ME 04469-5755

(207) 581-2860 FAX: (207) 581-2875

Email: rseymour@maine.edu Web page: www.forest.umaine.edu/facstaff/facstaff_pages/seymour/

Education:

Ohio State University (BS, 1974); Yale School of Forestry and Environmental Studies (MF 1976, PhD 1980)

Professional Experience:

Curtis Hutchins Professor of Forest Resources (Quantitative Silviculture) 1987-Present (tenured 1990).

Research Interests: canopy structure-stemwood growth relationships; development of managed and old-growth stands; growth and yield modeling; green certification

Awards:

Pew Fellow, Conservation and the Environment, 1995-98.

Outstanding Public Service Award, College of Natural Sciences, Forestry, and Agriculture, 2002-03.

G. Peirce and Florence Pitts Webber Outstanding Forestry Teaching Award, 2004-05

Fellow, Society of American Foresters, 2008

Selected Publications -- Journal Articles, Research Bulletins, and Book Chapters

MacLean, D.A., R.S. Seymour, M.K. Montigny & C. Messier. 2009. Allocation of conservation efforts over the landscape: the TRIAD approach. P. 283-303 In: Villard, M.A. and Jonsson, B.G. Setting Conservation Targets for Managed Forest Landscapes. Cambridge Univ. Press, NY, N.Y. 411 p.

DeRose, R.J. and R.S. Seymour. 2009. The effect of site quality on growth efficiency of upper crown class *Picea rubens* and *Abies balsamea* in Maine, USA. *Can. J. For. Res.* 39:777-784.

Hofmeyer, P.V., R.S. Seymour and L.S. Kenefic. 2009. Influence of soil site class on growth and decay of northern white-cedar in Maine. *North. J. Appl. For.* 26(2):68-75.

Fraver, S., A.S. White, and R.S. Seymour. 2009 Patterns of natural disturbance in an old-growth landscape of northern Maine, USA. *Journal of Ecology* 97: 289–298.

Moore, A.R., R.S. Seymour, and L.S. Kenefic. 2007. Height development of shade-tolerant conifer saplings in multi-aged Acadian forest stands. *Can. J. For. Res.* 37:2715-2723.

Seymour, R.S. 2007. Low-density management of white pine crop trees: a primer and short-term research results. *Northern Journal of Applied Forestry*: 24(4):301-306.

Fraver, S., R.S. Seymour, J.H. Speer, and A.S. White. 2007. Dendrochronological reconstruction of spruce budworm outbreaks in northern Maine, USA. *Can. J. For. Res.* 37:523-529.

Seymour, R.S., J.Guldin, D.Marshall, and B.Palik 2006. Large-scale, long-term silvicultural experiments in the United States. *Allgemeine Forst-und Jagdzeitung* 177:104-112

Seymour, R.S. and L.S. Kenefic. 2002. Influence of age on growth efficiency of *Tsuga canadensis* and *Picea rubens* trees in mixed-species, multi-aged northern conifer stands. *Can. J. For. Res.* 32:2032-2042.

Seymour, R.S., A.S. White and P.G. de Maynadier. 2002. Natural disturbance regimes in northeastern North America – Evaluating silvicultural systems using natural scales and frequencies. *Forest Ecology and Management* 155:357-367.

Seymour, R. S. and M.L. Hunter, Jr. 1999. Principles of Ecological Forestry. Ch. 2 (p. 22-61) In: *Managing Biodiversity in Forest Ecosystems*. M.L. Hunter, Jr., editor. Cambridge Univ. Press. 698 p.

Seymour, R. S. 1995. The Northeastern Region. p. 31-79 In: *Regional Silviculture of the United States*, Ed. 3. Ed. J. W. Barrett. Wiley and Sons, N. Y. 643 p.

Seymour, R. S. 1992. The red spruce-balsam fir forest of Maine: Evolution of silvicultural practice in response to stand development patterns and disturbances. Ch. 12 (p. 217-244) In: Kely, M. J., Larson, B. C. and Oliver, C. D., eds. *The Ecology and Silviculture of Mixed-species forests. A festschrift for David M. Smith*. Kluwer Publishers, Norwell, MA. 287 p.

Jeremy S. Wilson

Associate Professor of Forest Resources

EDUCATION

Ph.D. in Silviculture, 1998, University of Washington, College of Forest Resources, Seattle, WA

M.F. in Forestry, 1993, Yale University, School of Forestry and E. S., New Haven, CT

A.B. in Economics, 1987, Bowdoin College, Brunswick, ME

PROFESSIONAL EXPERIENCE

2006 – present Associate Professor and Irving Chair for Forest Ecosystem Management,
Department of Forest Management University of Maine, Orono, ME.

2001 – 2006 Assistant Professor and Irving Chair for Forest Ecosystem Management,
Department of Forest Management University of Maine, Orono, ME.

1998 – 2000 Research Forester, USDA Forest Service, PNW Research Station, Seattle, WA.

1993 – 1998 Research Analyst, The Landscape Management Project, College of Forest Resources,
University of Washington, Seattle, WA.

SELECTED PUBLICATIONS

Binks, L.A., D.A. Maclean, J.S. Wilson, and R.G. Wagner. 2010. Temporal changes in species composition of mixedwood stands in northwest New Brunswick: 1946-2008. *Canadian Journal of Forest Research* 40:1-12.

Holmes, T., Bell, K.P., Byrne, B., and J. Wilson. 2008. Economic Aspects of the Management of Invasive Forest Pests, in T. Holmes, J. Prestemon, and K. Abt (eds.), *The Economics of Forest Disturbances: Wildfires, Storms and Invasive Species*, Springer Publishing. 415 p.

Small, E.D., J.S. Wilson, and A.J. Kimball. 2007. A methodology for the relocation of permanent plot markers. *Northern Journal of Applied Forestry* (24)1:30-36.

Etheridge, D.A., D.A. MacLean, R.G. Wagner, and J.S. Wilson. 2006. Effects of intensive forest management on stand and landscape characteristics in northern New Brunswick, Canada (1945-2027). *Landscape Ecology* 21:509-524

Etheridge, D.A., D.A. MacLean, R.G. Wagner, and J.S. Wilson. 2005. Influence of intensive management on landscape composition and stand structure of a northern New Brunswick forest from 1946-2002. *Canadian Journal of Forest Research* 35:1965-1977.

Wilson, J.S. 2005. Nineteenth century lumber surveys for Bangor, Maine; implications for pre-European settlement forest characteristics in Northern and Eastern Maine, USA. *Journal of Forestry* 103(5):218-223.

Wilson, J.S. 2004. Combining search techniques and stand visualization to explore and analyze forest inventory databases. *Computers and Electronics in Agriculture* 43:251-256.

Wilson, J.S. 2004. Vulnerability to wind damage in managed landscapes of the Pacific Northwest. *Forest Ecology and Management* 191:341-351.