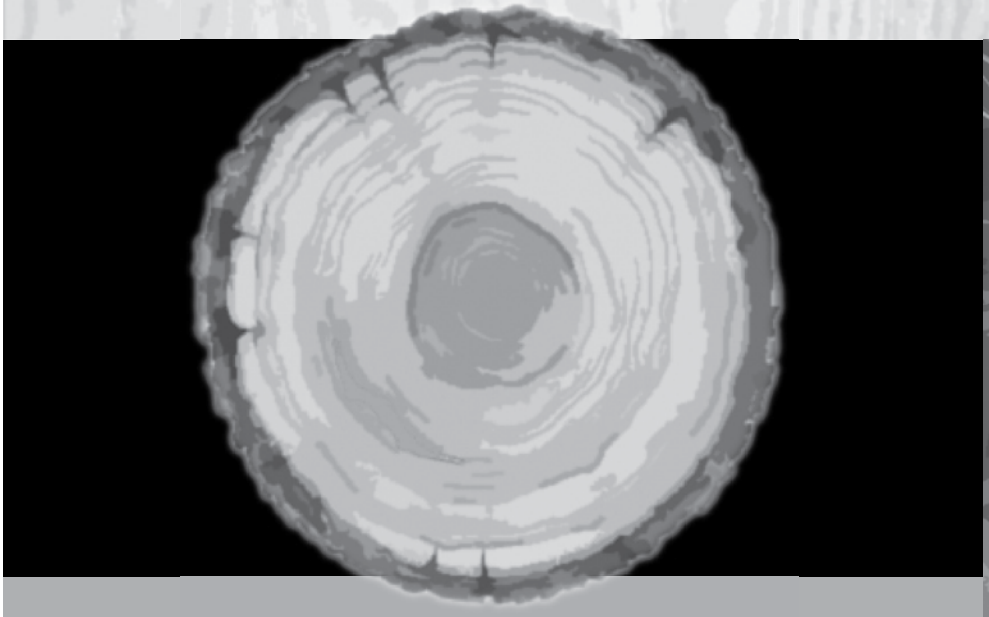
Progress Report for FY 2007

Center for Wood Utilization Research

at Oregon State University



Corvallis, OR 97331 • (541) 737-4257 • USDA Special Grant

PROGRESS REPORT FOR
FISCAL YEAR 2007

CENTER FOR WOOD UTILIZATION RESEARCH

AT OREGON STATE UNIVERSITY

A USDA CSREES Special Research Grant Program

CONTENTS

EXECUTIVE SUMMARY 1

PROGRESS REPORTS 3

- Improving Products and Processes to Enhance the Global Competitiveness of Oregon's Wood Products Industry 3
- Discovering New Knowledge for Future Opportunities and Benefits 5
- Extending the Timber Resource through Improved Harvesting, Transportation, and Manufacturing 6
- Science to Support Environmentally Responsible Wood Procurement 9

PUBLICATIONS, THESES, AND TECHNOLOGY TRANSFER ACTIVITIES AND PRESENTATIONS 11

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Executive Summary

The USDA Special Grant for Wood Utilization Research (WUR) is developing the science, technology, management approaches, and business practices that a) enhance the domestic and global competitiveness of the broad U.S. wood products industry, b) maintain or expand sustainable and environmentally acceptable forest operations and product manufacturing, and/or c) lead to more efficient use of renewable wood-based materials for the benefit of Americans.

Renewable wood is essential to human existence. Wood utilization research is critical to national needs because of the central role that this material plays in American society and the US economy. In Oregon the global competitiveness of our domestic industry is critical to providing jobs, especially in rural areas; reducing dependence on nonrenewable material; and sustaining incentives for landowners to maintain private and public forests.

The vast majority of U.S. wood product manufacturers are small- to medium-sized businesses that have little capacity for research. With the WUR Special Grant, Oregon State University is part of a larger national program to address critical wood utilization research needs that vary across the U.S. and by discipline. Our principal focus is on the utilization of western species and the economic heath of the Pacific Northwest industry. This report summarizes grant activities for FY2007.

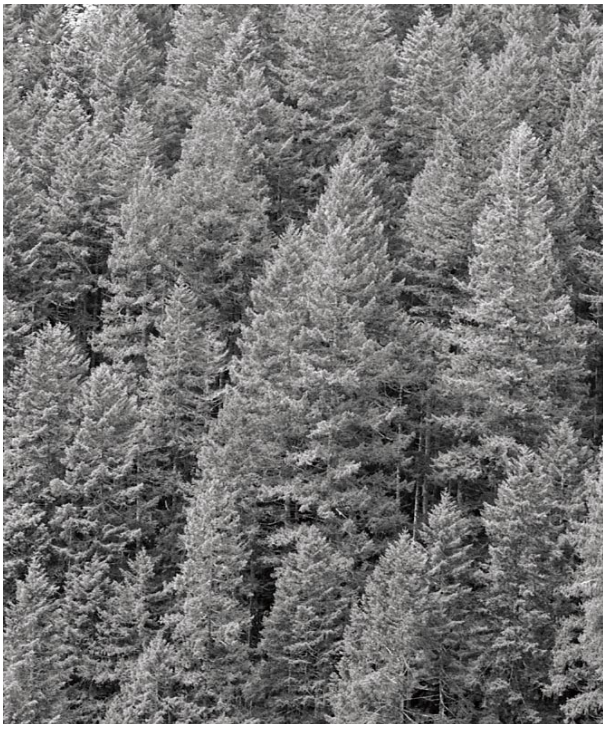
Eight ongoing projects and five new projects were supported by the USDA Wood Utilization Special Grant Program at Oregon State University in 2007. Project research *generated 41 publications*, including *22 in peer-reviewed scientific journals*, and *13 graduate student theses*. Technology transfer continued at a high level of activity, with research results conveyed through *40 activities to scientists and practitioners* in industry, academe, and government agencies, as well as to policy and decision makers and the public.

The WUR Special Grant enables faculty to leverage funding from industry and other sources to develop intellectual capacity and new knowledge. Support for graduate students is especially critical in the face of a looming shortage of well-trained scientists, engineers, managers, and teachers in the field.

Important highlights of completed projects this year include

- a comparison of the impacts of technology advancements over a 20-year period on wood products manufacturing in terms of energy consumption and material efficiency;
- new insights into how the mechanism of mechano-sorption influences the behavior of Pacific Northwest softwoods during varying climatic conditions;
- new opportunities to improve the profitability of forest operations through innovations in inventory techniques.

Congress did not appropriate funds for a WUR Special Research Grant in FY07. They did, however, augment the McIntire-Stennis appropriation to provide a reduced level of funding to wood utilization research at OSU. The five new projects described herein are supported by those new funds. The ongoing and completed projects described in this report are supported by USDA/CSREES Special Grants 2005-34158-16380 and 2006-34158-17189.



Progress Reports

Improving Products and Processes to Enhance the Global Competitiveness of Oregon's Wood Products Industry

New Projects

Assessing the Value of Voice-of-the-Customer Research for the Valued-added Wood Products Industry

Eric Hansen and Chris Knowles

Objectives: (1) to identify user-lead innovations within the wood-window value chain; (2) to identify user needs not currently met with existing product and service offerings; (3) to assess the value of this information to industry managers and R&D personnel

Duration: 10/01/07–9/30/09

Ongoing Projects

Business Systems Innovation in the Global Forest Products Sector: Paths to Competitiveness

Eric N. Hansen

Objectives: (1) to enhance understanding of the potential for increased competitiveness resulting from business systems innovations; (2) to investigate business systems innovations focusing on corporate responsibility, branding, and lean thinking in the forest products industry; in particular, (a) to assess stakeholder demands of forest industry companies regarding corporate responsibility (corporate social responsibility); (b) to document and evaluate principal branding strategies and frameworks employed in the forest products industry; (c) to identify challenges to, and benefits of, implementing lean thinking principles in the U.S. and German secondary wood products industries

Progress and Future Activities:

- Interviews of industry experts (study Stage 1) have been completed. Key responsibility issues were identified from the perspective of a broad set of industry stakeholders. Data collection for Stage 2, which will quantify the attitudes of industry versus consumers with respect to responsibility, is ongoing. A manuscript from Stage 2 will be submitted to *Business and Society*.
- A database of advertisements from the past 25 years has been collected. Content analysis is being completed to quantify the elements of the advertisements with a goal of identifying trends in industry print advertising since 1980. A manuscript will be submitted to the *Journal of Forest Products Business Research*.
- Objective (c) was completed in 2007. A manuscript has been submitted to *Forest Products Journal*.

Duration: 6/1/06–7/31/09

Identification and Improvement of Wood and Log Quality to Enhance Commercial Value

Barbara Lachenbruch

Objectives: to improve our ability to recognize the xylem and log traits that contribute to high commercial wood quality and value through examining (1) the effects of fast growth on strength factors and stem form in Douglas-fir, as well as the heritability of strength factors; (2) log form and quality through a field test on tree form and log dissection for insights into silvicultural management to improve log quality

Progress and Future Activities:

- Little progress was made on the goals, as BL was diverted into administrative tasks for the year. These responsibilities will end in August 2008, and the project will pick up where it left off. Among the plans are finishing a manuscript on the effect of fast growth on stem form heritability of strength factors and work on two manuscripts on log form and quality. An abstract has been accepted for a symposium talk on the latter for November 2008.

Duration: 8/1/06–7/31/09

Completed Projects

Environmental Management of Bio-based Product Manufacture to Reduce Energy Use and Global Warming

James B. Wilson

Objectives: to assess (1) impacts of technology advancements in the wood products industry from the CORRIM I (circa 1970) to the CORRIM II (circa 2000) studies in terms of energy and material use efficiency; (2) impacts of technology selection on the life cycle inventory and life cycle assessment of bio-based composite panels manufacture; (3) management opportunities for reducing energy use, global warming, and emissions in the manufacture of bio-based composite panels

Accomplishments and Impacts:

The study led to the following conclusions:

- Comparing the CORRIM I (1970s) and II (2000s) data on manufacturing practices in the U.S. for the production of OSB, plywood, and dimension softwood lumber indicates a marked improvement in wood usage by the softwood lumber industry over the last 30 years. Plywood and OSB have stayed steady despite declining log size and resource quality. The industry has shifted to a more integrated use of wood.
- The increased wood utilization, together with more energy efficient and productive harvesting and transportation practices, has lowered harvesting energy use dramatically for all three products.
- Between 75% to 90% of the manufacturing process thermal energy use of the industry is now derived from burning wood hogfuel, significantly lessening the industry's reliance on fossil fuels and reducing its impact on global climate change.
- In general, resin systems are becoming more efficient, production rates are increasing based on technology improvements, and gains made over decades of increasing use of wood fuels as substitutes for fossil fuels are decreasing with the mandated installation of emissions control systems. The emissions mitigation technology reduces hazardous air pollutants (HAPs) at the cost of using large quantities of natural gas and electricity for their operation and generating greenhouse gases that contribute to global warming.
- Applied across all single family homes built in the U.S., the industry's greater resource utilization, improved energy efficiency, and declining reliance on fossil fuels result in an annual savings of about 10 million barrels of oil, 9,700 million lb of carbon dioxide emissions that contribute to global warming, and a reduced harvesting level equivalent to 37,066 acres of forest.

Duration: 8/15/05–8/14/08

New Projects

Sorting for and Understanding the Basis of Treatability Differences in Douglas-fir Wood from Different Regions

Barb Lachenbruch and Jeff Morrell

Objectives: (1) to determine whether near infrared spectrometry (NIR) can separate refractory from treatable wood (a) within and among sites for a reference set of wood and (b) from a larger range of sites on an independent set of woods; (2) to assess the relationship between treatability, wood micromorphology, and growing-site rainfall

Duration: 10/01/07–9/30/09

Nanocrystalline Cellulose Electro-optic Devices

John Simonsen
Collaborator: Wei Kong (OSU Chemistry)

Objective: To develop the basic science governing the electro-optic behavior of cellulose nanocrystals (CNXLs) and to build prototype devices based on those principles

Duration: 10/01/07–9/30/09

Ongoing Projects

Three-Dimensional Micron-Scale Characterization of Adhesive Bondline in Wood

Frederick A. Kamke

Objective: to create a technique for the quantitative measure of the three-dimensional adhesive distribution within a wood bondline

Progress and Future Activities:

- Test specimens were scanned last year with the micro x-ray tomography system at the Advanced Photon Source, Argonne National Laboratory, Beamline 5 BM-C, with the assistance of Dr. Denis Keane (APS). The image processing and analysis was done during the current reporting period.
- The scans showed that RbOH is a suitable contrast agent that stays with the PF resin, but x-ray attenuation was perhaps too great at the concentration of RbOH used. X-ray tomography proved suitable to examine the structure of an adhesive bondline in wood, and RbOH is probably an appropriate contrast agent.
- In order to further investigate the nature of the Rb in the adhesive bondline, the tomography specimens were examined by SEM and EDAX. EDAX revealed no significant Rb beyond the observable bondline, further evidence that the Rb does not migrate into the wood.
- Analysis of the 3-D image files is still in progress. We have acquired new computer software (IDL 7.0, ITT Corp.) to perform this analysis. This software package has required a great deal of self learning. We are now able to manipulate the 3-D images and process some of the data. The image analysis so far indicates that we will need to produce and scan a new set of samples, using less RbOH in the PF formulation.
- During FY 2008, new bondline specimens produced from Douglas-fir and three PF adhesive formulations will provide us with three levels of x-ray attenuation. We hope that one of them will improve contrast. Micro x-ray tomographs will be captured using the 5-BM-C beamline at the Advanced Photo Source (APS). We also will attempt to gain access to beamline 2-BM at the APS; its tomography system permits a resolution of 1.3 micron and also has an extremely fast scan time. If successful, we will prepare additional specimens from hybrid poplar and red oak.

Duration: 8/01/06–7/31/09

Completed Projects

Mechano-sorptive Characteristics of Three Northwest Softwood Species in Compression Parallel to the Grain

Lech Muszyński

Objectives: long-term, to develop a foundation for a systematic database of clearly defined hygro-mechanical characteristics of commercial wood species to be used to solve problems with using wood in changing environmental conditions and during commercial drying operations; specifically, to (1) determine the hygro-mechanical properties in compression parallel to the grain of three Northwest softwood species, including the material variation within species (juvenile vs. mature wood, and heartwood vs. sapwood), and (2) examine potential correlations between the mechano-sorptive characteristics and other physical or mechanical properties of wood

Accomplishments and Impacts:

- Earlier projects in this area revealed significant variability in the Poisson ratios (PR) in wood samples subjected to creep. A targeted literature review focused on the Poisson effect in continuous and cellular solids was carried out.
- A simple mathematical model was developed and a parametric study was carried out that included the significance and implications of the variability of the Poisson effect for accuracy of modeling the long-term behavior of wood and wood-based composites and error assessment. Constitutive models that would reflect this phenomenon were proposed.
- A loading fixture for axial creep experiments was designed, manufactured, and calibrated. Four specimens can be subjected to sustained axial loads (tension/compression) at the same time. A small-scale climate chamber was fitted in the loading fixture and adjusted until stable climate conditions and reliable control of the cycles were achieved.
- Sorption tests on the compression specimens of enhanced geometry ("ribbed" sections for optimum lateral stability and enhanced moisture exchange) and plain reference specimens revealed only moderate advantage of the enhanced specimens.
- Green logs of Douglas-fir, ponderosa pine, western hemlock, and red spruce were acquired in February 2008. Fabrication of test specimens is in progress.
- The scope of the research has been extended to include the constrained drying deformations in Western hemlock sections under to various drying regimes. The data generated in this task allow quantitative distinction between the hygro-mechanical deformations in the early- and latewood.
- The data on mechano-sorptive properties in several North American wood species will be used to investigate potential correlations between the mechano-sorptive effect and other physical and mechanical properties of wood, so that the latter can be used for indirect evaluation of the mechano-sorptive properties.
- The long-term goal of this program is to lay a foundation for a comprehensive knowledge base on behavior of wood exposed to varying climate conditions. Improved design procedures based on precise material data allow more efficient use of wood in structural applications and reduces pressure on national forest resources.

Duration: 8/15/05–8/14/08

Extending the Timber Resource through Improved Harvesting, Transportation, and Manufacturing

New Projects

Material Tracking System for Sawmill Analysis

Charles C. Brunner, James W. Funck, James E. Reeb, David Porter

Objective: To investigate the potential for developing a system that can track material flow through a sawmill and identify that material as coming from an individual log

Duration: 10/01/07–9/30/09

Evaluating Opportunities to Reduce Wood Transportation Costs through Research and Outreach

John Sessions, Kevin Boston, Marvin Pyles

Objectives: to (1) synthesize the state of knowledge and identify knowledge gaps preventing reduction of transportation costs; (2) conduct a needs assessment for a Forest Road Transportation Research Center with the objective of lowering transportation costs of woody materials from the forest to the processing facility; (3) develop a framework for research and outreach

Duration: 10/01/07–9/30/09

Ongoing Projects

Developing Methods to Incorporate Wood Density and Modulus of Elasticity Prediction into Forest Inventory for Improved Wood Allocation to Sawmills

Kevin D. Boston

Objectives: (1) to use a case study to determine how the measurements of modulus of elasticity (MOE) and wood density vary within an intensively mapped and measured sample second-growth forest stand; (2) to apply wood quality information to the development of efficient sampling systems that characterize wood quality properties in stands

Progress and Future Activities:

- Protocol for sampling has been finalized. Approximately 25% of the trees have been sampled, and associated laboratory work is being completed.
- Papers have been outlined and analysis goals are nearing completion.

Duration: 8/01/06–7/31/09

Efficient Processing of Wood Through Improved Process Control and Modeling

Michael R. Milota

Objectives: to develop (1) methods for performing a quality assessment of a drying operation on an ongoing basis; (2) a model to simulate the process control required to reduce the moisture variability in kiln-dried lumber

Progress and Future Activities:

- A method was devised to tag packages at the kiln so they can be tracked through the planer. This allows the moisture content of a kiln charge to be determined and variations in moisture content resulting from location in the kiln to be mapped. Barcode scanners work well if the barcode tag is sufficiently large. Printed tags with the tag number entered at the planer have also been successful. A tag applied at the stacker, if linked to information from the green sorter, can be used to track packages through the entire process.
- A project dealing with cost allocation in the log yard was completed. Sorting and handling logs before sawing impacts the moisture distribution and propensity for stain in kiln-dried lumber. Methods of allocating cost were based on either the net realizable value or physical measure of material. The net realizable value method offered the most balanced approach.
- A kiln model that simulates the drying of a stack of lumber was completed. The model will be used to assess how sorting and schedules affect moisture content variability. We have measured drying rates for both hemlock and Douglas-fir. Papers have been submitted on this work.

Duration: 8/01/06–7/31/09

In-Forest Log Segregation Based on Acoustic Measurement of Wood Stiffness by Harvesting Equipment

Glen Murphy

Objectives: to (1) investigate relationships and measurement accuracy among standing, felled supported, and felled unsupported stem acoustic speed measures and the corresponding wood stiffness; (2) develop economic models to predict potential reductions in transportation and manufacturing costs and increases in end product value achievable through in-forest log classification system; (3) evaluate the costs, benefits, and design implications of implementing an in-forest acoustic testing tool as a supplement to a harvester head

Progress and Future Activities:

- During the summer of 2007, OSU's Dunn Forest was chosen as the seventh site for the study. Data analysis has largely been completed for the six Roseburg Forest Products sites measured summer 2006 and has begun for the Dunn site.
- Veneer grade recovery figures were obtained for the Dunn site. Analyses have been carried out on the effects of site and acoustic velocity on grade recovery; the effects of tree size, machine handling, branch size distribution, and log location within a tree on acoustic velocity; and the effect of site and tree size on standing tree acoustic velocity.
- Veneer grade recoveries were lower than expected at two of the seven sites. It was hypothesized that this was due to bark removal by mechanized harvesting equipment; the other sites had been manually felled and

delimbed, with very little bark removal. A brief study to assess the impacts of bark removal was undertaken in Georgia Pacific's Philomath log yard. Acoustic velocities were gathered on 100 logs before and after debarking. Analysis of the data was completed.

Planned activities for 2008 include

- further data analyses, including such areas as the effect of stem length estimation on acoustic velocity predictions and the effect of stand characteristics and tree handling procedures on log stiffness predictions
- developing the economic model for determining potential increases in end product value and evaluating the cost and benefits of fitting acoustic technology to a harvester head
- undertaking discussions with forest industry leaders in the Pacific Northwest to determine the viability of a new industry-led project on log sorting using acoustic technology on a harvester head
- preparing four papers for publication in peer-reviewed journals
- presenting results to students at University of Georgia and Clemson University and to a Wood Quality Conference to be held in Portland, Oregon in May 2008.

Duration: 8/01/06–7/31/08

Completed Projects

Increasing the Efficiency of Timber Harvesting Plans and the Log Supply Chain Through Improved Inventory Analysis Techniques

Kevin Boston, Glen Murphy, Jeff Hamann

Objectives: to (1) quantify the risk and uncertainty contained in operational forest plans; (2) apply spatial statistics to operational inventory data with the goals of reducing the uncertainty in the volume and value estimates and transforming forest inventory information to the warehouse model in which managers have improved estimates of the volume available to harvest and its location; (3) design sampling methods that best implement advanced inventory techniques and allow the industry to adopt this technology rapidly.

Accomplishments and Impacts:

- This research showed that incorporating a spatial estimate of standing tree volume into a daily harvesting scheduling model provides an opportunity to improve the profitability of forest operations. The inventory data need to be gathered slightly differently from typical practice to give the most improved esti-

mates of the spatial volume, and sample plots must be spaced irregularly for maximum benefit. Once collected, such models can be incorporated into a daily harvest scheduling decision model to support log order fulfillment.

  - Significant gains in inventory sampling efficiency, as measured by reduction in sampling error for a given sample size, can be achieved when the appropriate spatial model is used to account for the spatial pattern in standing tree volume within forest stands.
  - In order to achieve these gains, the sampling plots must avoid the rigid grid sampling structure standard in the forest industry. Variable distances between plots improve estimates of the variogram used to fit the models. At a minimum, inventory foresters should consider using a diamond pattern, rather than a square grid, but a grid with randomized offsets from the grid points is the best way to produce the mixture of distances necessary for a reliable estimate when calculating the variogram.

- Once the tree volume inventory data had been spatially referenced, a multi-criteria decision model was developed that showed an improvement in log production resulting from combining log ordering with log-yard inventory and logging costs management. The model documented the potential improvements in the supply chain efficiency when improved standing tree inventory estimates are incorporated into a spatial harvest scheduling model.

Duration: 8/15/05–8/14/08

ONGOING PROJECTS

UTILIZING FOREST FUELS FOR BIOENERGY CONVERSION FROM WILDFIRE RISK REDUCTION SILVICULTURE IN CENTRAL AND EASTERN OREGON

Loren Kellogg, Chad Davis, Michael Vanderberg

Objectives: to (1) investigate alternative forest harvesting equipment and operational techniques to reduce costs of forest biomass harvesting and identify innovative technologies to improve the economics of biomass harvesting; (2) use GIS-driven analysis to quantify transportation distances and costs for biofuels from forest restoration projects at a landscape level in order to evaluate overall project economics; (3) develop an "Oil Consumption Budget" for energy production from a biomass harvesting operation; (4) assess the use of remote sensing to estimate the amount of biomass available from forested settings needing fuel restoration silvicultural treatments

Progress and Future Activities:

- Field trials with a CTL system that integrates removal of sawlogs, pulpwood, and fuelwood for bioenergy during restoration thinning prescriptions were completed. The Forest Service concluded that the forest fuel hazard reduction prescription was adequately accomplished with the integrated harvesting system, and no additional treatment was needed.
- Stand-related silvicultural variables were measured and correlated with harvesting economics to help land managers with decisions on reduction of forest fuel hazard and utilization of biomass. Preliminary results show considerable variation in biomass harvesting productivity and cost because of the uneven-aged structure of mixed conifer stands.
- The integrated harvesting costs compared with the traditional two-step harvesting and fuel treatment operation were mixed, depending on the vegetation and tree stocking in each sample plot. A draft manuscript has been prepared on the study results.
- Other planned research activities presented in the 2007 Progress Report were not completed because of the lack of adequate second-year funding and graduate student assistant availability and not being able to win additional leveraged funding.

Duration: 8/01/06–7/31/09

PLANNING FOR FIRE-KILLED TIMBER SALVAGE CONSIDERING WOOD UTILIZATION OPPORTUNITIES

John Sessions, Michael G. Wing

Objectives: to (1) identify and examine alternative strategies for salvaging fire-killed timber from fire-prone forests, with particular emphasis on evaluating rapid salvage of smaller diameter trees; (2) continue to develop a decision support system for use by forest managers for evaluating wood utilization alternatives for salvaging fire-killed timber; (3) create techniques for remotely measuring fire-killed timber characteristics and establishing correlations with tree diameter in fire-impacted forests

Progress and Future Activities:

- Potential habitat for two cavity-nesting bird species was assessed and operational costs for each of 19 snag retention scenarios were quantified over the 3 years since burn in the Biscuit Fire area, southwestern Oregon. The salvage strategies ranged from leaving the landscape untouched to removing all merchantable snags.
- The findings indicated that adequate habitat and economic considerations can be balanced through selection of an appropriate strategy for salvage. The salvage strategy providing the most favorable habitat for both bird species left all snags standing in the half of the salvage unit farthest away from the yarder.
- Most snag retention strategies generated net revenues per unit volume of merchantable wood greater than

$70/m^3$ immediately after a severe burn and $60/m^3$ 3 years after a burn. Strategies that focused on snag retention of smaller diameter stems had the highest net revenue values and productivity rates. In general, decreased yarding distance and a smaller yarding system resulted in greater net revenue per unit volume with increased time since burn.

- A decision support system was constructed that incorporated these strategy evaluations and supporting landscape simulations. The decision support system allowed manipulation of strategy variables and production of output metrics for strategy evaluations.
- The use of GPS receivers for recording measurements under forest canopy was assessed. Five mapping-grade GPS receivers collected data simultaneously at each of three forest settings. They had different hardware and data-collection configurations, including internal and external antennas, and real-time differential corrections. The findings indicated that GPS receivers, particularly those operating with an external antenna, can be used to provide accurate measurements under forest canopy.
- Field-based and LiDAR-derived positional and height measurements of trees, primarily Douglas-fir and ponderosa pine, were compared at three sites in the Biscuit Fire area. The sites represented a range of burn severity from minimal to extensive. Field-based measurements were recorded by GPS receivers and digital range finders. No significant differences were detected between field-based and LiDAR-derived horizontal positions. This finding provides support for using LiDAR to determine tree locations in support of landscape simulations.
- The study tested the use of LiDAR pulse intensities to differentiate coniferous from deciduous and fire-killed from live trees in burned landscapes and examined whether other tree measurement parameters were related to pulse intensities. Mean and maximum average LiDAR intensities differed significantly between live and dead (fire-killed) trees on at least one site, and LiDAR intensities were significantly different for deciduous and coniferous trees at one site. Tree stem diameter and crown diameter were significant in explaining variation in mean and maximum LiDAR intensity values, respectively, at all sites.
- Future activities will include developing an optimization approach to expand the decision support system developed for strategy evaluations. Individual tree locations will be kept as a goal for the spatial resolution of the decision support system, and an alternate spatial data structure that should result in greater computational efficiencies in representing and analyzing landscape features will be used. A mathematical optimization approach will be developed that identifies the individual trees that should be left to best meet wildlife habitat planning goals in burned landscapes.
- One master's thesis has been published, two peer-reviewed publications have been accepted for publication, and two additional publications are in the peer-review process.

Duration: 8/01/06–7/31/09

Publications, Theses, and Technology Transfer Activities and Presentations

Publications

Acuna, M, and GE Murphy. 2007. Uso de espectrocopia de infrarojo y analisis multivariado para predecir la densidad de la madera de pino oregon. *Bosque* 28: 187–197.

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Wing, MG, and J Sessions. 2007. Geospatial technology education. *Journal of Forestry* 105: 173–178.

Theses

Berberović, A. 2007. *Numerical simulation of wood drying*. MS thesis. Department of Wood Science and Engineering, Oregon State University, Corvallis. 143 p.

Crespell, P. 2007. *Organizational climate and innovativeness in the forest products industry*. MS thesis. Department of Wood Science and Engineering, Oregon State University, Corvallis. 200 p.

Czabke, J. 2007. *Lean thinking in the secondary wood products industry: Challenges and benefits*. MS thesis. Department of Wood Science and Engineering, Oregon State University, Corvallis. 180 p.

Eklund, AA 2007. *Applying LiDAR technology for tree measurement and burned landscapes*. MF paper. Department of Forest Engineering, Oregon State University, Corvallis. 68 p.

Hung, J. 2007. *Development and characterization of new formaldehyde-free soy flour-based adhesives for making interior plywood*. MS thesis. Department of Wood Science and Engineering, Oregon State University, Corvallis. 107 p.

Knowles, CD. 2007. *Measuring innovativeness in the North American softwood sawmilling industry*. PhD dissertation. Department of Wood Science and Engineering, Oregon State University, Corvallis. 197 p.

Leatherman, L. 2007. *Log cost allocation for multiple mill merchandising systems*. MF paper. Department of Wood Science and Engineering, Oregon State University, Corvallis. 143 p.

Mitsuhashi Gonzalez, JM. 2007. *Limiting copper loss from treated wood in near aquatic environments.* MS thesis. Department of Wood Science and Engineering, Oregon State University, Corvallis. 165 p.

O'Connor, JP. 2007. I*mproving wood strength and stiffness through viscoelastic thermal compression*. MS thesis. Department of Wood Science and Engineering, Oregon State University, Corvallis. 111 p.

Schauwecker, CF. 2007. *The phytosanitation of solid wood packaging materials using wood preservatives.* MS thesis. Department of Wood Science and Engineering, Oregon State University, Corvallis. 153 p.

Sinha, A. 2007. *Strain distribution in OSB and GWB in wood frame shear walls*. MS thesis. Department of Wood Science and Engineering, Oregon State University, Corvallis. 158 p.

Toman, EM. 2007. *Reducing sediment production from forest roads during wet-weather use*. PhD dissertation. Department of Forest Engineering. Oregon State University, Corvallis. 162 pp.

Wang, Y. 2007. *Morphological characterization of wood plastic composite (WPC) with advanced imaging tools: Developing methodologies for reliable phase and internal damage characterization*. MS thesis. Department of Wood Science and Engineering, Oregon State University, Corvallis. 179 p.

Technology Transfer Activities and Presentations

Amishev, D, F Belart, and GE Murphy. 2007. Two technologies for capturing additional value through in-forest measurement of internal log properties. 3rd International Forest Engineering Conference, Mont Tremblant, Quebec, Canada.

Berberović, A, and MR Milota. 2007. Simulation of drying using a kiln model. Paper 2-3 in *Proceedings, 10th International IUFRO Division 5 Wood Drying Conference*, August 26–31, Orono, ME.

Crespell, P, and E Hansen. 2007. Creative leadership as a driver of innovation and employee well-being. Presentation to SYLFF North-South Regional Forum, June 11–14, Boston, MA.

Crespell, P, and E Hansen. 2007. Fostering a culture for innovativeness in the forest products industry. Forest Business Solutions Research Brief. Wood Science and Engineering. *Forest Business Solutions* 5(3): 1–2.

Czabke, J, and E Hansen. 2007. Lean thinking: Doing more with less. Forest Business Solutions Research Brief. Wood Science and Engineering. *Forest Business Solutions* 5(1):1–2.

Dodson, E, W Chung, K Mills, and J Sessions. 2007. Transportation planning and decision analysis to determine low volume road stands, long term needs, and environmental risks and tradeoffs. International Mountain Logging and 13th Pacific Northwest Skyline Symposium, April 1–6, Corvallis, OR. Department of Forest Engineering, Oregon State University, Corvallis.

Hansen, E. 2007. Forest Products Management Development (Continuing education course for industry managers), February 25–28. Attendance: 21. Contact Hours: 24.

Hansen, E. 2007. Innovation in the global forest sector. IUFRO All Division 5 Conference, October 29–November 2, Taipei, Taiwan. (Poster).

Hansen, E. 2007. Innovation and innovativeness in the global forest sector. Presentation. BC Forum Distinguished Lecture Series in Vancouver, November 8, Vancouver, British Columbia.

Hansen, E. 2007. Innovation, a key element to improve competitiveness: Evidence from the global forest sector. Presentation. International Conference: Innovation in the Chilean Forestry Sector, December 6–7, Concepcion, Chile.

Kamke, FA (keynote speaker). 2007. Bullet-proof wood composites: Fact or fiction? Coating Wood and Wood Composites: Designing for Durability. Federation of Societies for Coatings Technology, July 23–25, Seattle, WA.

Kang, H-Y, L Muszyński and M Milota. 2007. Full-field optical measurement of deformations in early stages of drying Oregon white oak and western hemlock lumber. Paper 1-6 in *Proceedings, 10th International IUFRO Division 5 Wood Drying Conference*, August 26–31, Orono, ME.

Kellogg, L. 2007. Biomass Field Presentation, June, Warm Springs, OR

Kellogg, L. 2007. CRC Forestry Annual Conference Presentation, July, Adelaide, Australia.

Kellogg, L. 2007. CSIRO, ENSIS, CRC Forestry Presentation, December, Adelaide, Australia.

Knowles, C, and E Hansen. 2007. Developing and refining a new measure of innovativeness in the North American forest products industry. Presentation to IUFRO All Division 5 Conference, October 29–November 2, Taipei, Taiwan.

Knowles, C, and E Hansen. 2007. Measuring innovativeness in North American softwood sawmills. Forest Business Solutions Research Brief. Wood Science and Engineering. *Forest Business Solutions* 5(2): 1–2.

Lachenbruch, B. 2007. Developed and delivered a new 11-week graduate course on Wood Quality. There were nine enrolled graduate students. People from two research cooperatives were invited to attend classes and labs. Attendees for part of the course included six faculty members, one post-doc, one person from industry (Cascade Timber Consulting), one person from the Washington Department of Natural Resources, and four graduate students who were not enrolled.

Lippke, B, and J Wilson. 2007. CORRIM research plan and stages of processing analysis. CORRIM Conference on Life-Cycle Assessment of Forest and Products, January 23–25, University of Washington, Seattle.

Milota, MR, and A Berberović. 2007. Modeling the hemlock drying process. Western Dry Kiln Association Annual Meeting, April 25–27, Spokane, WA.

Modzel, G (speaker), and FA Kamke. 2007. 3D reconstruction of an adhesive bondline. 41st International Wood Composites Symposium, Washington State University, April 26–28, Seattle, WA.

Modzel, G (speaker), and FA Kamke. 2007. Microscopic examination of an adhesive bondline. Wood-Based Composite Center Spring Meeting, May 16–17, Vancouver, British Columbia.

Murphy, GE. 2007. Two technologies for capturing additional value through in-forest measurement of internal log properties. 3rd International Forest Engineering Symposium, October 1–4, Mont-Tremblant, Quebec, Canada.

Murphy, GE, and M Vanderberg. 2007. Modeling the economic impacts of 24/7 logging. 3rd International Forest Engineering Conference, October 1–4, Mont Tremblant, Quebec, Canada.

Murphy, G, and J Wimer. 2007. Controlling truck productivity and costs. International Mountain Logging and 13th Pacific Northwest Skyline Symposium, April 1–6, Department of Forest Engineering, Oregon State University, Corvallis.

Murphy, GE, D Amishev, and F Belart. 2007. Two sensor technologies for in–forest measurement and sorting of logs based on internal wood properties. International Mountain Logging and 13th Pacific Northwest Skyline Symposium, April 1–6, Department of Forest Engineering, Oregon State University, Corvallis.

Muszyński, L, H-Y Kang, and M Milota. 2007. Full-field optical measurement of non-uniform drying deformation and drying check formation in refractory species. 61st International Convention FPS/SWST, June 10–13, Knoxville, TN. (Poster).

Panwar, R, and E Hansen. 2007. CSR and the US forest products industry: Issues and stakeholder views–Implications for global CSR standards. IUFRO All Division 5 Conference, October 29–November 2, Taipei, Taiwan. (Poster).

Toman, EM. 2007. Designing forest roads to minimize turbid runoff during wet weather use. American Society of Agricultural and Biological Engineers, 4th Conference on Watershed Management to Meet Water Quality Standards and TMDLs, March 10–13, San Antonio, TX.

Toman, EM, and AE Skaugset. 2007. Reducing sediment production from forest roads. International Mountain Logging and 13th Pacific Northwest Skyline Symposium, April 1–6. Department of Forest Engineering, Oregon State University, Corvallis.

Vanderberg, M, and GE Murphy. 2007. 24/7 forest harvesting: Implications for production planning. International Mountain Logging and 13th Pacific Northwest Skyline Symposium, April 1–6, Corvallis, OR. Department of Forest Engineering, Oregon State University, Corvallis.

Wilson, J. 2007. Life-cycle inventory of particleboard, MDF and resins. CORRIM Conference on Life-Cycle Assessment of Forest and Products, January 23–25, University of Washington, Seattle.

Wilson, J. 2007. Progress on incorporating LCA/LCI and wood products into green building and purchasing standards. CORRIM Conference on Life-Cycle Assessment of Forest and Products, January 23–25, University of Washington, Seattle.

Wilson, J. 2007. Using wood to reduce global warming. Forest, Carbon, and Climate Change Conference, February 13, Oregon State University, Corvallis.

Wilson, J. 2007. Sustainable development–Building green with wood products. International Wood Composites Symposium, March 27, Seattle, WA.

Wilson, J. 2007. Wood as a Green Building Material–Environmental Profile of Wood Products. Architectural Design with Wood Course, May 24, Oregon State University, Corvallis.

Wilson, J. 2007. Panel discussion on environmental impacts of using wood. Architectural Design with Wood Course, May 25, Oregon State University, Corvallis.

Wilson, J. 2007. Act Green, Be Green–CORRIM's experience of getting LCI data for wood products into the US LCI Database. National Council for Air and Stream Improvement (NCASI) Operating Committee, July 10, Portland, OR.

Wilson, J. 2007. Life-cycle assessment the gateway to green markets. Keynote Presentation, Annual Fall Board Meeting, Composite Panel Association, October 23, Baltimore, MD.

Wilson, J. 2007. Use of carbon trades and credits in the wood products industry. Annual Fall Board Meeting, Composite Panel Association, October 23, Baltimore, MD.