Status Report
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Economic Use of Beetle-Killed Trees

USDA Forest Service
Forest Products Laboratory

Introduction

In response to the need to find uses for millions of tons of beetle-killed trees as a way to offset forestland restoration costs and find market-oriented ways to use the forest biomass, the USDA Forest Service, Forest Products Laboratory (FPL) has: 1) developed a utilization strategy that provides a framework for how the FPL approaches the economic use of beetle-killed trees and 2) collected and combined information on FPL accomplishments in finding ways to economically utilize beetle-killed trees.

With respect to the Forest Service Western Bark Beetle Strategy (July 7, 2011), FPL work contributes to the following Goal, Objective, and Action Items:

Goal 1: Safety: Ensure that people and community infrastructure are protected from the hazards of falling bark beetle-killed trees and elevated wildfire potential.

> Objective 3—*"Encourage optimal utilization of materials removed from beetle-killed forests benefitting local communities through job creation and potentially decreasing the cost of forest treatments."*
>
> Action Items:
>
> B—*"Work with rural development on a comprehensive approach to increase investments and infrastructure in order to increase biomass utilization in rural communities"*
>
> E—*"Synthesize and conduct research to develop and evaluate various technologies that optimize the use of beetle-killed material including wood composites, biochemicals, biofuels, and biopower"*

Overview

In 2010, 9.2 million acres (Out of 749 million acres of forest land in the United States) of tree mortality was caused by insects and disease. Beetles, including mountain pine, western bark, southern pine, and spruce, annually kill millions of trees on forested landscapes across America with 74% of all mortality caused by the mountain pine beetle (*Dendroctonus ponderosae*), a native insect found in the western United States. Mountain pine beetles have a one-year life cycle and spend most of their life feeding on conductive tissues between bark and wood. Trees are killed by the destructive galleries mined by the beetles and the blue stain fungus carried by the beetles, which decreases the wood moisture content and weakens the tree defence mechanisms. Blue stain carries over into products made from the stained logs, affecting what products can be made profitably and sold from the wood. Infested trees also dry and develop splits and checks as the drying stresses are relieved. The physical condition of the wood affects how it can be processed (Nieh 2011).

Challenges associated with manufacturing wood products from beetle-killed timber stands exist through all phases of production, including harvesting, transportation, log storage, processing, and end-product marketing. However, timber stands left in the wake of the current mountain pine beetle outbreak represent a significant economic resource; therefore, economic uses of this resource need to be carefully considered. A key issue is the amount of time, or shelf life, associated with capturing economic values and how this may vary between locations. In his August 16, 2011, presentation to the USDA Forestry Research Advisory Council (FRAC) in Washington, D.C., World Nieh noted that a literature review reveals that much of the available research information is based on research conducted 20 or more years ago. The FPL has done research reaching back at least that far, and in this we present accomplishments from the last decade.

Byrne, A.; Stonestreet C.; Peter, B. 2008. Current knowledge of characteristics and utilization of post-mountain pine beetle wood in solid wood products, mountain pine beetle initiative working paper 2005–8. Vancouver, British Columbia: Forintek Canada Corporation.

McGovern, J.N. 1951. Pulping of lodgepole pine. USDA Forest Service, Madison, Wisconsin. 17 p.

Nieh,W. L-S. 2011. Wood properties and wood utilization R&D in beetle-killed trees. PowerPoint presentation. Forest Products National Program Leaders. U.S. Forest Service National Headquarters. Presentation given to USDA FRAC on August 16, 2011.

FPL Utilization Strategy for Beetle-Killed Trees

For any given location for sourcing beetle-killed trees, the overall strategy for using beetle-killed trees is as follows:

- Where substantive local existing forest products industry infrastructure exists:
  1) Demonstrate the technical and economic feasibility of using beetle-killed trees as a feedstock for producing products using the already in-place forest products infrastructure and other compatible infrastructure.
  2) If technical and economic barriers are encountered, develop new technologies to overcome them.

This approach oftentimes provides the highest value and greatest returns because investments in capital are usually the lowest and require the least time for implementation.

- Where local forest products industry infrastructure is lacking or non-existent:
  1) Develop and commercialize new value-added uses that have economic and market potential on a scale that matches the scale of forest biomass available and justifies the capital investment required.
  2) Develop, demonstrate, and implement new cost-effective technologies for using the forest biomass available for energy production in local electric generating facilities and combined heat and power (CHP) facilities.

FPL in its work has followed the preceding strategy. Through its Technology Marketing Unit (TMU), the FPL has sought to first carry out a program of work that enables the use of beetle-killed trees in existing local forest products industry facilities. When significant technical and economic problems are encountered, FPL researchers next attempt to 1) develop R&D-based solutions and 2) partner with private sector companies and organizations and non-governmental organizations (NGOs), if possible.

Where local forest products industry infrastructure is lacking, the FPL is advancing new value-added product concepts and technologies such as cross-laminated timber, cellulose nanomaterials, high performance composites, and the forest biorefinery producing chemical feedstocks and fungible Renewable Fuel Standard (RFS2) biofuels.

With respect to use of beetle-killed trees for combined heat and power (CHP) and electric power generation alone, the FPL seeks to partner with substantive public and private sector organizations and institutions focused on the efficient and effective conversion of forest biomass into energy products to best understand and overcome issues related to energy density (e.g., wood versus coal), processing issues and problems, capital investment and overall economics. For example, FPL is a founding member of the Bioenergy Deployment Consortium (BDC). The BDC is a group of 24 companies and organizations interested in the commercialization of biomass to bioenergy. BDC membership draws heavily from the existing pulping and papermaking industry. Its objectives are to get efficient and economical bioenergy facilities deployed to help industry and the nation. The BDC works to keep members informed and to help them broker partnerships that will achieve the deployment goal. In addition, the FPL has worked with individual companies and organizations on CHP uses for beetle-killed trees.

In carrying out its work, the FPL seeks to establish effective public–private sector partnerships by working with substantive partners that bring various needed expertise and capacities that are essential to successful commercialization of new and improved processes and products.

Additionally, in dealing with beetle-killed trees and especially those beetle-killed trees originating on public lands, the FPL also seeks to include working with forestland managers as forest biomass supply and forest restoration issues have large impacts on forest biomass types and amounts of biomass available and affect the overall economics of use.

FPL Contributions and Accomplishments to Mitigating Impact of Bark Beetle-Killed Trees by Working with Existing Local Infrastructure

The FPL TMU provides technical assistance to many small entrepreneurs who are using beetle-killed material. They have provided technical assistance to pellet mills, sawmills, log home manufacturers, and many others. In the last 5 years, the FPL TMU has provided technical assistance to over 200 small forest products businesses, primarily in the West. The technical assistance includes workshops such as the bi-annual national *SmallWood* conferences, a forum for exchange of ideas in 2006, 2008, and 2010; dissemination of publications on topics such as wood energy; and direct hands-on technical assistance to sawmills and CHP facilities. Examples of some of the businesses that the FPL TMU has provided sawmilling assistance to include Fort Apache Timber Company and Reidhead Lumber in Arizona, Skyline Forest Products in Utah, Vaagen Brothers in Washington, Mescalero Forest Products in New Mexico, Confluence Energy in Colorado, and many others. The technical assistance helps these businesses to be more efficient and profitable, while using a resource (beetle-killed trees) that has some unique characteristics to consider for processing.

Since 2005, the FPL TMU has awarded and administered 89 grants totaling $22,536,481 to eight western states most affected by the bark beetle. These states include Arizona, California, Colorado, Idaho, Montana, Oregon, Washington, and Wyoming.

Background on FPL TMU Work

Woody biomass utilization is critical to resolving forest health issues in the West—primarily concerning the current mountain pine beetle infestation epidemic and high risk of catastrophic wildfire associated with excessive forest fuel loading. Technical assistance visits (TAVs) to Wyoming and Colorado discussed several issues and opportunities for salvaging beetle-killed trees and utilizing small-diameter material from forest fuels reduction projects (Dramm and others 2010). The scope of the TAV work is applicable throughout the Western United States.

Technical Assistance Visit Background

Beginning in 1994, the FPL conducted a series of TAVs throughout the U.S. Forest Service Regions. The goal of these TAVs was to foster closer working relationships between the FPL, the National Forests, local and state government, local communities, and the private sector. The purpose of these partnerships was to sustain social and economic vitality in rural communities while conserving natural resources and maintaining and enhancing the health of our Nation's forests.

Coordinated by the FPL TMU, valuable insights gained during the initial TAVs help guide new research, technology transfer, and technical assistance. In addition to research, the *SmallWood* conferences were initiated along with the Hazardous Fuels Woody Biomass Utilization Grants (WBUG) Program, which was authorized to help mitigate the excessively high cost of hazardous forest fuels reduction work on Forest Service lands.

By 2000, follow-up visits began to provide more focused technical assistance in high priority areas. As with the original TAVs, similar issues and opportunities arise time and time again.

The Situation Today

The intermountain West has a history of relatively frequent insect attack outbreaks and wildfires. Fire suppression efforts have been in place for a number of decades. With the exclusion of fire from ecosystems, forest stands have become overstocked, leading to stress, especially during periods of drought. Stressed trees are more susceptible to beetle and other insect attacks and disease infestation.

Opportunities for improved utilization and marketing of small-diameter and beetle-killed trees will help control beetle infestations and reduce the widespread risk of catastrophic wildfire while providing economic development opportunities. The cost of salvaging "red and dead" beetle-killed trees and removing excessive forest fuels can be prohibitively expensive. An economical outlet (market) for such biomass is needed. One viable alternative is to provide economical small-diameter utilization options. Re-establishing integrated forest products utilization capacity and retooling the existing industry for processing small-diameter material and salvaging beetle-killed trees are critical needs. New industry is also needed in many locations that have lost all capacity to harvest and utilize harvested trees (Nieh 2011, Dramm and others 2010).

Colorado Front Range is at High Risk

The Colorado Front Range is aligned in a north-south configuration on the western edge of the Great Plains, where the foothills meet the Rockies. The region contains the largest cities and the majority of the population of Colorado, including the communities of Fort Collins, Greeley, Loveland, Longmont, Boulder, Golden, Denver–Aurora Metropolitan Area, Castle Rock, Colorado Springs, and Pueblo.

On the Front Range in Colorado, private land is interspersed among Federal and state lands with many homes and structures and has a history of insect outbreaks. Slopes are moderate to steep with overstocked, stressed stands of small-diameter to moderately big pine that are creating a heavy fuel load. These conditions are increasing the risk of insect outbreaks and wildfires within the wildland–urban interface (WUI), the exclusion of fire, thinning, and harvesting activities, and forest stands have become stressed from overstocking, leading to beetle and other insect attack, often followed by catastrophic fire. Fuel build-up will be a problem for years to come.

Beetle infestation to the West of the continental divide is exacerbating the situation. Cost-effective small-scale harvesting and biomass removal equipment and techniques that are readily adaptable to small acreages are needed.

HewSaw

One successful project involved the Mobile HewSaw, where the FPL TMU provided grant dollars for defraying the cost of transporting the Mobile HewSaw (HewSaw North America, Abbotsford, BC, Canada) mill from Colville, Washington, to Vesper, Wisconsin. Terry Mace, Wisconsin Department of Natural Resources (DNR), and Rusty Dramm of FPL provided technical assistance and conducted a lumber recovery study for the project. Terry Mace also arranged industry field days to see the HewSaw in operation. The outcome was a Wisconsin sawmill retooling their operation with a permanent HewSaw installation, resulting in 75 additional jobs (logging and trucking primarily).

Mulch Business

One of the TAV site visits was to Renewable Fiber, Inc., in Upton, Colorado, a commercial mulch operation producing soil amendment products from mill and forest residues. There may be opportunities to ship products long distance by dedicated unit train or 40 or more railcars of chips. One opportunity is to consider the export pulp chip market to Asia via a port on the West Coast. Renewable Fiber was awarded a Woody Biomass Utilization Grant in 2008 for shavings mill equipment.

Sort Yards

A sort yard is a drop off point for woody biomass from "red and dead" salvage work. Although a significant obstacle to establishing one is resistance from local residents, the idea of a sort yard appears to be fairly well received by the general public. The FPL TMU provided assistance and extensive technical information for Fred Deneke and John Stewart's "Biomass Feedstock Resource Pocket Guide." Note that the approach of using the log sort yard concept for collecting biomass is a new and innovative but an unproven concept.

Rocky Mountain National Park (Estes Park, Colorado)

Estes Park has legislated that beetle-killed trees must be removed from the land and brought to a designated collection yard for processing and disposal. The yard employs an air curtain burner. Some potential to recover products from the biomass delivered to the Estes Park collection yard exists; however, long distances to potential markets may be prohibitive.

How landowners get salvaged material/biomass to the road side and the way in which it is collected is critical. One thought is to provide small-scale logging equipment, such as an all-terrain vehicle with a log arch as a means of assisting landowners in removal to roadside. This might be provided by a local implement dealer or the County itself, which would then rent/lease out this equipment.

Response to Issues, Concerns, and Opportunities

Industrial Issues and Opportunities

Throughout the Intermountain West, most of the former forest products manufacturing infrastructure that could have utilized beetle-killed timber is gone. For the most part, the limited remaining forest products manufacturing infrastructure is not set up to handle beetle-killed material. Industrial capacity is necessary to help resolve the economics associated with beetle killed trees and other forest health issues. Appropriately scaled industrial capacity can provide an outlet for salvaged woody biomass from beetle-killed trees. The lack of forest products manufacturing capacity is a difficult challenge to overcome.

Industry Revitalization and Rebuilding

The industrial capacity must be matched to the available resource. The immediate goal here should be to focus on improving the existing industrial infrastructure so that it remains viable.

Business Investment Capital

Heavy capital investment will be needed to re-establish wood products infrastructure in today's competitive forest products industry. In terms of economic development, it is far less expense to retain existing industrial infrastructure than to develop new forest products enterprises. Available capital is lacking, so this will be a severe limitation on expanding industrial capacity.

Dramm, John Rusty; Bilek, E.M. (Ted); John L. Zerbe. 2010. Wyoming–Colorado technical assistance visit trip report. General Technical Report FPL–GTR–192. Madison, WI: U.S. Department of Agriculture, Forest Service, Forest Products Laboratory. 24 p.

Other FPL TMU Accomplishments

Bridger-Teton National Forest (Dubois, Wyoming)

Here a mastication demonstration site and a wildland urban interface (WUI) fuels reduction project were established at Union Pass. Material removed from the landowner's property was concentrated in a gravel pit where it was burned. This biomass appears to be a potential source of biomass energy feedstock for local use.

Medicine Bow—Routt National Forest (Saratoga, Wyoming)

Because of high mortality from mountain pine beetle, both short- and long-term resource supplies need close evaluation to properly size a sustainable industry. The lack of a "consistent" long-term supply remains a deterrent to industrial development for establishing beetle-killed trees processing infrastructure. Given the uncertainties of resource supply, forest products market volatility, and financial viability of forest products operations, it is essential that an objectively planned programming approach be used. Planned programming leads to strategic, marketing, business, and operational plans to help guide the development and operation of the enterprise.

2006 WBUG Roseberry Timber, Inc., Crescent, Oregon (Grant work in California Also) (Completed)

The grantee purchased a horizontal grinder to treat 4,050 acres and remove biomass from three Ranger Districts on the Deschutes National Forest in Oregon

and the Plumas National Forest in California. The biomass is ground into chips and is transported to cogeneration power plants.

The Oregon project has yet to be started because of various difficulties. The company is moving operations to Colorado (Arapaho National Forest), where they plan to subcontract for purchasers of sales that are treating the current bark beetle infestation.

2009 ARRA Confluence Energy, Kremmling, Colorado (Ongoing)

The mountain pine beetle infestation in this area is at catastrophic levels. The grantee grinds, hauls, and converts dead or dying trees from northern Colorado and southern Wyoming areas into wood pellets. The company has purchased an excavator, chip conveyor, screener, forklift, bulk trailer, and sensor for a control system and is processing beetle-killed trees into pellets.

Total green tons utilized: 4000 in 2009

2009 WBUG Anthony Moore Independent Log Company, Alamosa, Colorado (Ongoing)

This company's log home building and firewood production business has received funds to purchase equipment to upgrade and utilize the full range of timber diameters available from the Rio Grande, White River, San Juan, Pike/San Isabel, Santa Fe, Grand Mesa Uncompaghre/Gunnison, and Cibola National Forests.

The company has purchased a log lathe and firewood processor and is processing beetle-killed timber.

Total green tons utilized: 750 in 2009

2008 Wood Biomass Utilization Grant (WBUG) Renewable Fiber, Inc., Ft. Lupton, Colorado (Completed)

Renewable Fiber is taking beetle-killed trees. They have installed a wood shaving plant upgrade that triples plant capacity, increases the amount of timber utilized to 6,000 cords (8,100 dry tons), reduces emissions from slash pile burning, and creates 6-1/2 full-time jobs.

Because of the loss of local market for shavings, the company installed a compressed bagging operation that allowed them to bag shavings. This allowed market expansion.

Total green tons utilized: 2,647 in 2008 and 2009

2007 WBUG Ranch Creek Limited, Granby, Colorado (Completed)

This grantee has the objective to harvest and process as much beetle-killed wood as possible within the next 10 years. Ranch Creek has proactive involvements with Roosevelt National Forest and local landowners to put into place a long-term plan for forest maintenance by using a portable sawmill and other wood production equipment. Ranch Creek will generate a very diverse and marketable product line of fence posts, rough cut lumber, house logs, and railing and fencing. This includes slash burning with an air-curtain destructor.

Ranch Creek purchased a log lathe, sorter bays, and log loader. Material was used to produce house logs. The depressed economy has affected their sales. Sorting bays have increased production roughly 5% to 8%. To date, focus has been on fire mitigation. Ranch Creek did more work with the Forest Service in fall of 2008.

Total green tons utilized: 133,156 through December 2009.

Dramm, J.R. 2004. Log sort yard economics, planning, and feasibility. Techline. Madison, WI: U.S. Department of Agriculture, Forest Service, Forest Products Laboratory. 2 p.

Dramm, J.R. 2003. Sawmill technical assistance. Techline. Madison, WI: U.S. Department of Agriculture, Forest Service, Forest Products Laboratory. 2 p.

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Forest Products Laboratory. 2000. Forest Products Laboratory research program on small-diameter material. Gen. Tech. Rep. FPL–GTR–110 (Rev.). Madison, WI: U.S. Department of Agriculture, Forest Service, Forest Products Laboratory. 31 p.

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Han, H-S.; Bilek, T.; Dramm, R.; Loeffler, D.; Calkin, D. 2009: Financial feasibility of a log sort yard handling small-diameter logs. In: Proceedings of 2009 COFE: Environmentally Sound Forest Operations 32nd Annual Meeting of the Council on Forest Engineering. June 15–18, 2009 North Tahoe Conference Center, Kings Beach, CA. Compiled by Bruce Hartsough and Bryce Stokes.

LeVan-Green, S.L.; Livingston, J. 2001. Exploring the uses for small-diameter trees. Forest Products Journal: 51, 9:10–21.

LeVan-Green, S.L. 2009. Successful American Recovery and Reinvestment Act (ARRA) and Woody Biomass Utilization Group (WBUG) Projects.

LeVan, S., Benisch, J. 2009. 2009 Woody Biomass Utilization status report for 2005, 2006, and 2007 Grant Programs.

Livingston, J. 2004. Small-diameter success stories. Madison, WI: U.S. Department of Agriculture, Forest Service, Forest Products Laboratory. 33 p.

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Livingston, J. 2008. Small-diameter success stories III. General Technical Report FPL–GTR–175. Madison, WI: U.S. Department of Agriculture, Forest Service, Forest Products Laboratory. 31 p.

USDA Forest Service, Forest Products Laboratory. 2010. FPL business plan, 2009. Progress through partnerships – working with the Forest Products Laboratory. Madison, WI: U.S. Department of Agriculture, Forest Service, Forest Products Laboratory. 59 p.

FPL Research and Development on Overcoming Technical and Economic Barriers to Use of Beetle-Killed Trees

Evaluation of Mountain Pine Beetle Killed Lodgepole Pine for Biofuel Production

Principal Investigators

J.Y. Zhu, *Forest Products Laboratory*
J. Negron, *Rocky Mountain Research Station*

This project has two objectives: (1) Evaluate the effects of beetle infestation age on the chemical composition of beetle-killed lodgepole pine. (2) Evaluate the suitability of beetle-killed lodgepole pine for cellulosic ethanol production through the sugar platform.

Six trees were harvested from two sites in the U.S. Arapaho–Roosevelt National Forest, Colorado. The infestation age of the trees varied from 0 to about 8 years. Chemical composition analyses indicate that beetle-caused mortality did not affect wood lignin content which is very important to thermal chemical conversion for energy production. The mortality enriched glucan content by as much as 3% (a total of 7.5%) in wood. The glucan enrichment seems to increase with infestation age. Sulfite pretreatment to overcome recalcitrance of lignocellulose (SPORL) pretreatments of wood chips were conducted for sugar and ethanol production from all size trees. The enriched glucan was captured after SPORL pretreatment followed by enzymatic hydrolysis. The beetle-killed trees are more susceptible to SPORL pretreatment, which enhanced substrate enzymatic digestibility (SED). Enzymatic hydrolysis glucose yields (EHGY) from beetle-killed trees were about 5% to 20% higher than the corresponding live trees. Total fermentable sugar productions from dead trees (including a tree lying on the ground) were 4% to 14% higher than corresponding live trees were, depending on pretreatment conditions and infestation age.

Ethanol yields of 200 and 250 L/metric ton wood were achieved from a live tree and a beetle-killed tree (4 years after infestation without process optimization. Ethanol yield of 220 L/metric ton of wood was obtained from a downed beetle-killed tree with more advanced decomposition and was approximately 10% more than that from a corresponding live tree. Process mass and energy balance analyses suggest that net ethanol energy output (before distillation, lignin energy excluded) from the decomposing beetle-killed tree was approximately 3.2 GJ/metric ton of wood, which is 23% more than that from a corresponding live tree. The study demonstrated the robustness of the SPORL process and the utility of beetle-killed trees for cellulosic ethanol production even after many years post mortality.

Luo, X.L., Gleisner, R., Tian, S., Zhu, W.Y., Negron, J., Horn, E., Pan, X.J, Zhu, J.Y., (2010), Evaluation of mountain beetle killed lodgepole pine for cellulosic ethanol production by SPORL. Industrial & Engineering Chemistry Research 49(17):8258–8266.

Tian, S., Luo, X.L., Yang, X.S., Zhu, J.Y. 2010. Robust cellulosic ethanol production from SPORL-pretreated lodgepole pine using an adapted strain S. cerevisiae without Detoxification. Bioresource Technology 101:8678–8685.

Zhu, J.Y., Luo,X., Tian,S., Gleisner, R., Negrone, J., Horn, E. 2011. Efficient ethanol production from beetle-killed lodgepole pine using SPORL technology and Saccharomyces cerevisiae without detoxification. TAPPI Journal 10(5):9–18.

Properties of Wood from Small Diameter and Beetle Killed Trees

Principal Investigators

David Kretschmann, *Forest Products Laboratory*
Bob Ross, *Forest Products Laboratory*

The FPL has a long history of providing baseline information on the properties of wood obtained from a variety of raw materials. FPL has conducted numerous studies to examine the mechanical and physical properties of wood from small diameter trees and the trees killed by various invasive species (see publication list). Information obtained from these studies have shown that, if harvested within certain time frames, wood from infected trees has properties similar to that obtained from live trees. Additionally, these studies have demonstrated the capacity of small diameter members harvested from infected forests for

use in value-added structural applications. The magnitude of the volume of potential wood resource that may come available with beetle damage demands that techniques be developed to rapidly classify and evaluate mechanical and physical properties of this resource.

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Gorman, T.M.; Green, D.W.; Cisternas, A.G.; Hernandez, R.; Lowell, E.C. 2007. Structural lumber from suppressed-growth ponderosa pine from northern Arizona. Forest Products Journal 57,12:42–47.

Green, D.W. 2005. Evaluating the dead yellow-cedar resource. Techline. Madison, WI: U.S. Department of Agriculture, Forest Service, Forest Products Laboratory. 2 p.

Green, D.W.; Evans, J.W.; Murphy, J.F.; Hatfield, C.A. 2005. Mechanical grading of 6-inch-diameter lodgepole pine logs for the travelers' rest and rattlesnake creek bridges. Research Note FPL–RN–0297. Madison, WI: U.S. Department of Agriculture, Forest Service, Forest Products Laboratory. 17 p.

Green, D.W.; Gorman, T.M.; Evans, J.W.; Murphy, J.F. 2006. Mechanical grading of round timber beams. Journal of Materials in Civil Engineering. (Jan./Feb. 2006): 1–10.

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Green, D.W.; Gorman, T.M.; Murphy, J.F.; Wheeler, M.B. 2007. Moisture content and the properties of lodgepole pine logs in bending and compression parallel to the grain. Research Paper FPL–RP–639. Madison, WI: U.S. Department of Agriculture, Forest Service, Forest Products Laboratory. 11 p.

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Green, D.W.; Ross, R. 2005. Better utilization of the dead tree resource. Techline. Madison, WI: U.S. Department of Agriculture, Forest Service, Forest Products Laboratory. 2 p.

Green, D.; Ross, R. 2005. Linking log and product quality for structural wood products. Techline. Madison, WI: U.S. Department of Agriculture, Forest Service, Forest Products Laboratory. 2 p.

Green, D.W.; Wiemann, M.; Gorman, T.M. 2005. Characterization of juvenile wood in Western softwood species. FPL–RIP–4701–001. Madison, WI: U.S. Department of Agriculture, Forest Service, Forest Products Laboratory. 2 p.

Kretschmann, D.E.; Faller, R.; Hascall, J.; Reid, J.; Sicking, D.; Rohde, J.; Shilts, D.; Nelson, T.2007. Investigating the use of small-diameter softwood as guardrail posts: static test results. Research Paper FPL–RP–640. Madison, WI: U.S. Department of Agriculture, Forest Service, Forest Products Laboratory. 23 pages.

Simpson, W.T. 2004. Heat sterilization times of red pine boards. Forest Products Journal 54, 12:240–244.

Simpson, W.T. 2001. Heating times for round and rectangular cross sections of wood in steam. Gen. Tech. Rep. FPL-GTR-130. Madison, WI: U.S. Department of Agriculture, Forest Service, Forest Products Laboratory. 103 p.

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Wang, X; Simpson, W.T. 2005. Acoustic analysis of warp potential of green ponderosa pine lumber. Proceedings: 9th International IUFRO Wood Drying Conference: 2005 August 21-26, Nanjing, China. Nanjing, China: Nanjing Forestry University: pp. 155–160.

Wang, Xiping; Simpson, William T. 2006. Using acoustic analysis to presort warp-prone ponderosa pine 2 by 4s before kiln-drying. Wood and Fiber Science 38, 2:206–214.

Utilization Options for Small Diameter and Beetle Killed Trees

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The FPL has investigated utilization options for small-diameter trees and those killed by invasive species. Various product options have been investigated ranging from the use of materials directly in roundwood form to high value millwork applications. FPL's research has investigated grading options, primary processing requirements such as drying and sterilization needs (Wang and others 2007), and end-use performance requirements. FPL has already had success in developing value-added applications for different types of nonstructural and structural products. The sheer volume of potential wood resource that may come available with beetle damage demands that additional utilization options, such as cross-laminated timbers (CLT), for this resource be developed.

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2- by 8-Foot Panel Fabrication from Recycled and Wood Residues

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Investigative panel materials for a structurally insulated panel were made from beetle-killed siding scraps. This work with beetle-killed material is initial work with BioSIPs International, a start-up company in Boulder, Colorado, looking to produce sustainable materials from underutilized recycled fiber and forest residuals.

BioSIPs International has been working with FPL to develop sustainable materials and panels. As part of their cooperative research with FPL, they took recycled scrap material from siding created from beetle-killed wood. The wood-siding material was chipped and then pressure refined to produce a fiberized material that was wet-formed into 2- by 8-foot by 1/8-in.-thick sheets.

No related technical publications are available yet.

Forest Products Research and Development Needs

Research Needs in Beetle-Killed Wood Utilization

- Determine how much beetle-killed wood is available, their species, and geographic distribution.
- Determine how much of the beetle-killed wood can enter the supply chain and how long will the supply last.
- Survey existing forest products industry infrastructure in major infested areas.
- Conduct wood utilization research to overcome technical and economic barriers for established forest products end uses.
- Develop new cost effective, high-value forest products that have large markets, use large amount of forest biomass and provide economic returns that justify capital investment.
- Technology management, technology transfer post transfer technical support.

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High-Priority Needs for Existing Forest Products

We need to assess the deterioration of post-mountain pine beetle stands as a source of solid wood products and how they vary across site and stand types; measure the impacts of processing grey-stage logs on value and volume recovery; Examine the mechanical properties of grey-attacked wood over time as it goes into mill production; Determine the drying properties of blue-stained wood compared with non-stained wood; Examine post-mountain pine beetle veneer on panel lay-up and hot pressing, product grade, panel stiffness, and bonding strength; and measure chemical characteristics of post-mountain pine beetle wood and impacts on bondability and wetability in panelboards (Byrne and others 2008).

Summary

The Forest Products Laboratory has identified its role and strategy for making contributions to the efficient, effective and economic use of beetle-killed trees to offset the cost of forestland restoration and mitigate the deleterious impacts of beetle-killed trees on the forest landscape. Where existing local infrastructure is in place to produce value-added products, the FPL seeks to demonstrate and overcome any technical and economic barriers to using beetle-killed trees. Where local infrastructure is inadequate or completely lacking, FPL seeks to develop and commercialize new value-added uses that have economic and market potential on a scale that matches the scale of forest biomass available and justifies the capital investment required.

In carrying out work, FPL routinely seeks to work in public–private partnerships with an array of organizations and companies as well as forestland managers to overcome technical and economic barriers and to commercialize use of beetle killed trees to produce traditional and non-traditional forest products and bioenergy. FPL seeks to involve itself in research, development and deployment of new and improved technologies to the degree the FPL has expertise and capabilities its private sector partners need to ensure successful commercialization.