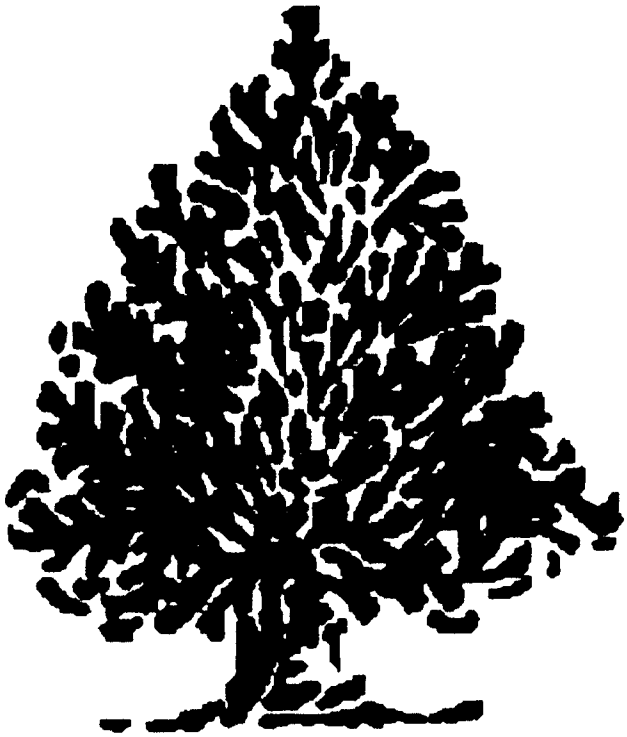
BIOGRAPHIES & ABSTRACTS



Forest Products Society
54th Annual Meeting

June 18-21, 2000
Harveys Resort Hotel & Casino
South Lake Tahoe, Nevada, USA

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54TH ANNUAL MEETING
GENERAL CHAIR

Frank C. Beall
Director
Forest Products Lab.
Univ. of California
Richmond, California

Frank C. Beall is a Professor and Director of the Forest Products Laboratory at the University of California, Richmond, California. His research interests include nondestructive evaluation; adhesives and adhesion; thermal degradation; moisture measurement and control; fire research; and duration of load. He is the author of numerous publications, has received many awards, and has served on several committees. He is currently serving as Vice President of the Forest Products Society (FPS) and General Chair of the FPS 54th Annual Meeting. He received a BS degree in Wood Utilization from Pennsylvania State University, University Park, Pennsylvania, and MS and PhD degrees in Wood Products Engineering from the State University of New York, Syracuse, New York.

INDUSTRY FOCUS DAY SESSION SPEAKER AND PANEL MEMBER BIOGRAPHIES AND ABSTRACTS

Dr. Patrick Moore

Dr. Patrick Moore has been a leader in the international environmental field for over 25 years. He is a founding member of Greenpeace and served for 9 years as President of Greenpeace Canada and 7 years as Director of Greenpeace International. As the leader of many campaigns, Dr. Moore was a driving force shaping policy and direction while Greenpeace became the world's largest environmental activist organization. Recently, Dr. Moore has been focused on British Columbia and the promotion of sustainability and consensus building among competing concerns. He was a member of BC government-appointed the Round Table on the Environment and Economy from 1990 to 1994. In 1990, Dr. Moore founded and chaired the BC Carbon Project, a multi-stakeholder group that worked to develop a common understanding of climate change. Dr. Moore is the former Vice President of Environment for Waterfurnace International, the largest manufacturer of geothermal heat pumps for residential heating and cooling with renewable earth energy. As Chair of the Forest Practices Committee of the Forest Alliance of BC, he leads the process of developing the "Principles of Sustainable Forestry," which have been adopted by a majority of the industry. In 1995, Dr. Moore published Pacific Spirit - The Forest Reborn, a photo book that explores the beauty, biodiversity, and health of new forests growing back after logging in British Columbia and the Pacific Northwest. In 1991, Dr. Moore founded GreenSpirit, a consultancy focusing on environmental policy and public involvement in the resource and energy sectors. He received a Ford Foundation Fellowship; a PhD degree in Ecology from the Institute of Resource Ecology, University of British Columbia, and a BS degree (Honors) in Forest Biology from the University of British Columbia.

Keynote Address: Green Spirit - Trees are the Answer

In recent years, there has been a high-profile battle over the future of the forests of the Pacific Northwest of the United States and Canada, which includes the largest area of temperate rainforest in the world. Environmentalists have been locked in confrontation with forest companies, and in many instances with governments, over a variety of forest management issues, the most contentious concerning clearcut logging and old growth forests. These campaigns have had some very positive effects. They have increased public awareness of the value of old growth coastal rainforest, and greater support for the creation of more protected parks and wilderness areas. Environmentalists have pressed for, and often achieved, higher standards for forest management. Unfortunately, these campaigns have also spread misinformation and confusion about forests and forestry. This presentation gives an alternative view of the environmental arguments used to support a drastic reduction in forest harvesting, not only in the Pacific Northwest, but also around the world. It is my belief that this is exactly the opposite of what we should be doing to improve the environment. Rather than cutting fewer trees and using less wood we should be growing more trees and using more wood. And contrary to conventional environmental wisdom I argue, for example, that clearcutting of some forests is beneficial for them and for humans, rather than harmful. To help understand this I explain how misconceptions arose from popular myths about deforestation, forest life cycles, and endangered species. I believe that much of the environmental movement has gone astray and lost its perspective on the subject of forests. All human activity has an impact on the environment, but forestry is the most sustainable of all the primary industries that provide us with energy and materials. Indeed, wood is the most renewable material used in large quantities to build and maintain our civilization.

Professor William McKillop

William McKillop has been Professor of Forest Economics at the University of California since 1964 specializing in a range of topics including assessment of economic impacts of alternative forest policies, economics of forest management, econometric studies of forest products supply, demand and trade, modeling of regional timber supply, forest taxation and valuation, and analyses of forest-based economies. He has held numerous appointments as a scientist, consultant, and visiting professor with state, national, and international governmental agencies, forest industry, and foreign universities. Currently, he is working on projects dealing with National Forest management, economic aspects of forest practice regulation, and regional timber supply modeling. He received a BS degree in Forestry from the University of Aberdeen, an MS degree in Forestry from the University of New Brunswick, and an MA degree in Statistics and a PhD degree in Agricultural and Resource Economics from the University of California, Berkeley. He is a member of the American Economic Association, Society of American Foresters, and a Registered Professional Forester.

Economic Implications of Policies that Restrict U.S. Timber Output

Policies, such as ecosystem management on the National Forests, roadless area set-aside, and implementation of the Endangered Species Act, that restrict U.S. timber output have far-reaching economic consequences. On the domestic scene they reduce regional and national income and employment, decrease tax revenues of federal, state and local government and diminish consumer welfare through increases in prices for wood products and substitute materials. On the international scene, they harm the U.S. balance of trade by decreasing our exports of forest products and increasing imports, notably from Canada. In addition, reductions in North American supply to other regions decrease consumer welfare in those regions, encourage them to import more from other sources, log their forests more heavily, and use more substitute materials. Such changes in the patterns of production, consumption, and trade will, in general, have significant adverse environmental effects. In recent years, policy makers have given too little attention to the direct and indirect adverse economic and environmental implications of policies that restrict timber output in the U.S.

Douglas MacCleery

Douglas MacCleery is Assistant Director, Forest Management, National Forest System, USDA Forest Service, Washington, D.C. He received Bachelors and Masters degrees in Forest Resource Management & Policy from Michigan State University. His early career was spent as a Field Forester in northern California on the Tahoe and Shasta-Trinity National Forests (1967-1973). He then left the Forest Service for a time as a Forest Policy Analyst for the National Forest Products Association in Washington, D.C. (1973-1981). Between 1981-1987, he was Deputy Assistant Secretary for National Resources & the Environment, a position that provided policy oversight for the Forest Service and Soil Conservation Service. He then returned to the Forest Service, most recently as Assistant Director of Forest Management for Ecosystem Management & Planning. In recent years, he has been writing on the history of human uses of forests in the U.S.

Integrating Forest Values, Forestry, and Forest Products for Sustainability

Americans, as always, want it all. We want our forests to look like forests with lots of big trees. We want our forested watersheds to yield clean water in natural flow regimes. We want our forests to not be vulnerable to insect epidemics or burn up in wildfires. And we want our woods to have a rich compliment of native plants and animals. We also use a lot of wood, more per capita than any nation in the world. And we flock to the forests to recreate and try out the latest in outdoor toys in record numbers. Forestry, the art and science of tending forests to sustain and provide for the needs and wants of forest owners, is essential to meet American desires from forests. But forestry in the woods alone cannot meet all the needs. Advances in forest products development and technologies and intelligent consumption patterns are crucial to improve utilization and life expectancy of wood as a raw material. America's increasing protection of forests and forest environmental values coupled with increasing use of wood has often shifted production to other nations with lower standards for environmental protection, and it has also increased the costs of domestic production to a point that impinges on the willingness of private landowners to invest in sustainable forestry. Forest sustainability requires resilient, diverse, productive ecological systems with high capacity for renewal and adaptability in the face of change. It depends on the expected flow of uses, values, and services from a particular forest; on starting conditions which in many cases are heavily affected by prior human activity; and on the kinds of environments we are likely to face in the future. Because forests are relied upon to provide everything from wood to wildlife to wilderness, sustainability spans a range of forest uses from tree farms to multiple-use forests to wilderness areas. The National Forest System, managed by the USDA Forest Service, includes 31 million hectares of forestland in 42 states, and represents 73 percent of the major vegetation types in the country. By using this land to test new ideas on sustainable forest management the USDA Forest Service could play a major role in advancing knowledge that will encourage conservation of biological diversity, improve understanding of ecosystem processes, and foster the economic vitality needed to ensure responsible management of forest resources. This presentation will describe part of that role. Sustainability of dynamic forest ecosystems means that, over the long-term, growth and loss (from human use as well as natural decomposition) will be about equal. For the past 500 years, the growth of the human elements of Earth's ecosystems has far exceeded loss, consuming ever-increasing amounts of land, water, energy, crops, wood, and biodiversity. Regardless of desires for sustainable forests, we will not achieve forest sustainability without simultaneously developing technologies to extend the utility of resource raw materials and reaching reasonable sustainability in the human component of Earth's ecosystems. Thus, the grand experiment in sustainable forestry cannot stop at the forest border; it must encompass the human enterprise as well.

Dr. Robert J. Hrubes

Dr. Robert J. Hrubes, is Senior Vice President of Scientific Certification Systems (SCS), an Oakland, California, firm offering several certification services to the market place, including forest management certification under the aegis of the Forest Stewardship Council. Dr. Hrubes is a registered professional forester and forest economist with degrees awarded by the University of California-Berkeley, University of Michigan, and Iowa State University. He has been actively engaged in third-party forest certification work for the past 9 years and has been instrumental in developing certification evaluation protocols, in establishing international policies and procedures governing certification activities, and in conducting certification evaluations throughout the United States, as well as Sweden, Canada, Japan, Malaysia, Chile, and New Zealand. Dr. Hrubes has worked professionally for 27 years, having spent the first 15 years of his career with the USDA Forest Service and the following 12 years as a private consultant. He assumed his current position at SCS in February of this year. He served for 4 years on the Board of Directors of the Forest Stewardship Council and is presently Chair of the Board of Directors of the Forest Stewards Guild, a U.S.-based professional forestry society.

The Contribution of Third-Party Certification in Forestry and Forest Products to Sustainability

Third-party forest management certification, particularly as conducted under the aegis of the Forest Stewardship Council (FSC), has been rapidly gaining acceptance in regional and international forest products markets for the past decade. As an alternative to traditional command and control mechanisms for achieving public policy objectives regarding management practices on the world's forest areas, market-based mechanisms as exemplified by FSC-endorsed certification offer distinct advantages. Whereas regulatory approaches are designed to sanction non-compliance with mandatory, minimum levels of expected performance (and thereby place greatest focus on the "bottom feeders"), certification focuses the spotlight on the leaders of the industry with respect to forest stewardship, through a voluntary process expressly designed to afford market benefits to those entities that achieve certification. That is, certification is a means by which forest products markets can internalize and reward exemplary forest management. While pecuniary effects, such as price premiums and maintained or expanded market share can and frequently are direct benefits of achieving certification, benefits regularly and significantly include other phenomena that collectively contribute to reduced long-run costs of doing business. By corroborating a company's own message of responsible forest management, certification can assist in the process of reassuring a broad range of stakeholders. But to realize these potential benefits, certification schemes must, above all else, be perceived as credible to the stakeholders and customers whose perceptions and attitudes are of concern. Credibility is achieved by a combination of factors, including: 1) Real independence of the certification scheme from the industry; 2) Technically defensible and substantive standards that, in fact, distinguish exemplary performance from the rest; 3) Process transparency while protecting proprietary information; 4) Technically competent

evaluation protocols fundamentally reliant about interdisciplinary expertise; and 5) Balanced input from the full spectrum of stakeholder groups including environmental, economic, and social perspectives.

Dr. Charles R. Goldman

Dr. Charles R. Goldman, Professor of Limnology in the Department of Environmental Science and Policy, has been with the University of California, Davis, since 1958. He developed the first courses in limnology and oceanography at UC Davis, served as Chair of the Division of Environmental Studies from 1988-1992, and was founding Director of the Institute of Ecology, serving from 1966-1969 and again in 1990-1992. Prior to his 40-year tenure at UC Davis, he earned Bachelor and Masters degrees from the University of Illinois, and a PhD in Limnology-Fisheries from the University of Michigan. He has supervised 86 graduate students and 30 post-doctorals during his 40 years at UC Davis. Dr. Goldman's many prestigious awards include an NSF Senior Post-Doctoral Fellowship in 1964 for limnological research in the Arctic (Lapland), a Guggenheim Fellowship in northern Italy in 1965, the "Goldman Glacier" in Antarctica named in 1967, served as President of the American Society of Limnology and Oceanography in 1967-1968, awarded the Antarctic Service Medal by Congress in 1968, and elected a Fellow by the California Academy of Sciences in 1969. In 1973-1974, he was elected Vice President of the Ecological Society of America, and accepted a Fulbright Distinguished Professorship to Yugoslavia in 1985. He was awarded the Vollenweider Lectureship in Canada in 1989, the Chevron Conservation Award and Culver Man-of-the Year in 1991, the Earle A. Chiles Award in 1992, and the UC Davis Distinguished Public Service & Research Lecturer awards in 1993. He was elected Vice President of the International Society of Limnology (SIL) for 1992-1998, and presented the prestigious Baldi Lecture at the triennial SIL Congress in Ireland in August 1998. Dr. Goldman has published four books and over 400 scientific articles, and has produced four documentary films, which are in worldwide distribution. He has served on many national and international committees and is frequently sought for consultation and research missions to foreign countries on major environmental problems. In 1990, he was a member of a UNESCO team to qualify Lake Baikal as an International Heritage Lake and Senior Scientist for the National Geographic Baikal project. His single most important and sustained contribution is the 40 years of research on Lake Tahoe. Dr. Goldman is Director of the Tahoe Research Group and has pursued long-term ecological research simultaneously at Lake Tahoe and Castle Lake, California, since 1958. He successfully combined effective research and social action with his pioneering studies of lake eutrophication. These have been directly applied to engineering solutions, social needs, and legal decisions. This work has recently included the development of artificial wetlands and research on alternatives to conventional road salt for deicing highways. This relationship of basic science to political change has been of particular importance to the Lake Tahoe basin. During the summer of 1997, Dr. Goldman hosted President Clinton and Vice President Gore aboard the UC Davis research vessel John Le Conte during the Lake Tahoe Presidential Forum. Similar studies have extended Dr. Goldman's research-social action efforts to analysis of lakes like Baikal in Russia and hydroelectric impoundments throughout the world. Thus, while aggressively pursuing basic research on lake dynamics, he has also been able to translate the findings directly to state, national, and international policy decisions, contributing decisively to the conservation and judicious use of aquatic resources from the Antarctic to the lakes and wetlands of South and Central America, New Guinea, Africa, Asia, Europe, and the United States. Dr. Goldman's career work has now been honored with his most prestigious award yet: he received the 1998 Albert Einstein World Award of Science in a formal ceremony last November in New Zealand. The Einstein Award, bestowed annually to a single individual by a council of eminent scientists, which includes 25 Nobel laureates, recognizes those who have accomplished scientific and technological achievements that have advanced scientific understanding and benefited humanity.

Luncheon Address: Science-Based Decision Making in the Tahoe Basin: Moving Beyond the Conflicts

Lake Tahoe in the Sierra Nevada mountains of North America is the eleventh deepest lake in the world and one of the clearest. The gradual loss of clarity marks the earliest onset of eutrophication. It has become increasingly evident that we must consider the health of the lake in the context of the entire watershed. This includes forest health, the contributing tributaries, as well as atmospheric and groundwater inputs. The continuous record of primary productivity at Tahoe shows a steady 5.0 percent annual increase since 1959 with a great deal of interannual variability related most significantly to the annual depth of mixing. Cyanobacteria, which herald the arrival of serious eutrophication, to date are found only in the periphyton. Since 1959 the average transparency has decreased at about 0.3 meters per year, with temporary improvements during years of incomplete mixing. We are currently developing a predictive water quality model for Lake Tahoe, taking advantage of the long-term data set. The host of environmental stresses on aquatic ecosystems worldwide and so evident at Tahoe has necessitated a more rapid conversion of basic limnological studies into management decisions. A multidisciplinary approach is essential for developing effective water management strategies for increasingly complex environmental problems. For example bioengineering of exposed slopes on some Tahoe valleys will be required to arrest erosion. At Lake Baikal in Russian Siberia, the need is particularly acute since more than 2,500 endemic species will be at risk if more pollution occurs or careless development of the watershed is permitted. So much damage has already been done to aquatic resources worldwide that restoration-oriented research is of increasing importance. The prospect of global climate change has underscored the importance of the collection and careful analysis of long-term data in order to better understand and better manage surface waters everywhere. In the past, many policy decisions by regulatory agencies have been based on scanty, short-term data that are sometimes lacking methodologically and subject to superficial interpretation. Modern foresters and limnologists have a responsibility to help meet this global challenge for better management of watersheds and increasingly apportioned surface and ground water supplies. Strong environmental science must be at the forefront in developing better management practices and providing science-based decisions as we face the ever-mounting demands for water, a most-essential and increasingly limited resource.

Panel A - The 2000+Raw Material

Moderator: *Donn Zea*, President, California Forest Products Commission, Auburn, California

Donn Zea

Donn Zea is President of the California Forest Products Commission. His responsibilities include managing a variety of public education strategies to enhance the public's understanding of the benefits of forestry and forest products in California. He is a graduate of Cal Poly, Pomona, with a Bachelor of Arts degree in Political Science. He spent more than 2 years working as an associate political consultant for Allen Hoffenblum & Associates in Los Angeles, managing political strategies for a variety of local, state, and federal election candidates. In 1988, he moved to Sacramento to work for the State Legislature as a political advisor under the Assembly Republican leadership. He later became a principle committee consultant for Assembly Republicans, where he served on the Housing and Community Development, and Economic Development and Technology Committees. In 1990, he joined the California Forestry Association as a political consultant in the campaign to defeat Proposition 130, the Earth First Initiative. After its successful defeat in November 1990, he continued working with the forest products industry developing communications and public affairs programs and in September 1991, he became the Vice President of Industry Affairs for the California Forestry Association. He and his staff directed media relations, coalition and grassroots development, political management, government affairs, and various projects for more than 100 forest products companies in the state. In May 1997, he became the President of the California Forest Products Commission.

The business of forestry and forest products manufacturing in California continues to become more complex, as public opinion, regulatory, and legal challenges cast a shadow of uncertainty on the future. Ironically, Californians demand more wood products than any state in the nation and the land's biological capacity to grow trees is among the best in the world. This accomplished panel of forest industry leaders will help us to understand the enormous challenges of running a profitable forest products company in this state. Their diverse personal and professional backgrounds, company profiles, and strategies for remaining competitive promise to make this panel both informative and interesting.

Panel Members

Kent Duysen

Kent Duysen is the President of Sierra Forest Products, a family-run lumber company co-founded by his father, Glen Duysen, in 1968. Kent is a 1974 graduate of the Forest Products program at Oregon State University and has worked in the company for 30 years in various positions including timber sale acquisition, sawmill manager, lumber sales manager, and general manager. The company has two sawmills in the southern Sierra region of California that are quite dependent on the Federal Timber Sale Program. He is a Registered Professional Forester in California, Past Chair of the California Forest Products Commission, Board Member of the Forest Foundation, Board Member of the California Forestry Association, and a member of the Society of American Foresters and the California Licensed Forester Association.

A tidal wave of federal regulatory actions have drastically reduced the supply of timber from California's U.S. Forest Service lands. Harvest curtailments in the Southern Sierra Nevada region have hit local companies particularly hard, most recently with the signing of the Sequoia National Monument designation by President Clinton. Kent Duysen will discuss the outlook for timber supply from these lands and his strategy to keep the family business competitive in the future.

Dennis Scott

Dennis Scott is President and Chief Executive Officer of Eel River Sawmills, Inc., a California Corporation located in Fortuna, California. Eel River was incorporated in 1963 as the successor to the Lindsey Lumber Company, which was founded in 1948. The company owns and operates two Douglas-fir and redwood sawmills, operates a whole log chipping plant, and a remanufacturing plant, in addition to a wholly owned subsidiary, Fairhaven Power Company, that operates a stand-alone 17.25 megawatt biomass power plant. All of the company's operations are located on the north coast of California. He has been with the company for 23 years and has previously held the positions of Vice President and Controller. He is a graduate from California State University at Hayward in Accounting and is a Certified Public Accountant, licensed to practice in California. Before joining Eel River, he was employed at Philo Lumber Company and Ernst & Ernst, San Francisco. He currently serves on the Board of Directors of the California Forestry Association and is the Vice Chairman of the McLean Foundation, a non-profit foundation established by the founder of Eel River, Mel McLean.

A growing percentage of fiber to feed Eel River Sawmills is coming from sources outside of California, while, at the same time, the company continually seeks ways to strengthen its future by exploring other opportunities. These opportunities include expanding offshore log sources and considering the pooling of company resources with other established companies. Dennis Scott will explain why the company feels a sale of Eel River Sawmills would be beneficial and why further consolidations will continue to occur in the forest products industry.

Paul M. Harlan

Paul M. Harlan is the Vice President of Western Lumber Operations for the Collins Companies based out of Portland, Oregon. His duties include oversight of the Collins Pine Company - Chester Division in northern California, along with the Fremont Sawmill Division in Lakeview, Oregon. The Collins Companies, started in 1855 in northwestern Pennsylvania by the Collins family, consist of timber ownership and manufacturing facilities on both the east and west coast. The company includes three sawmills, a panel manufacturing complex including particleboard, plywood, and exterior hardboard siding, and three retail yards. In 1993, The Collins Companies became the first privately owned forest products company in North America to become certified under the (FSC) guidelines. Today, its related land bases total 293,000 acres of FSC certified timberlands. He is an Oregon State University graduate in Forest Engineering and a licensed Registered Professional Forester in California. For more information on the company, visit their web site at www.collinswood.com.

Collins Pine Company was one of the first U.S. landowners to commit to third-party certification of its timberlands. With the benefit of hindsight, Paul Harlan will address the impact of that bold decision in terms of forestry, manufacturing and positioning the company in the marketplace.

John Campbell

John Campbell is President and Chief Executive Officer of the Pacific Lumber Company (PALCO), a company founded in 1863 in the redwood region of northern California with the purchase of 6,000 acres of timberland along the Eel River. Today, PALCO is a leading producer of high-quality Douglas-fir and redwood lumber, solid-wood panels, siding, and building materials. The company employs more than 12,000 with four mills and a 25 megawatt co-generation plant. PALCO is in the center of many of the redwood regions discussions of forest conservation, stewardship, and providing wood-based building materials on a sustained basis. He is a native of Australia and began his 30-year career with PALCO as a sales trainee after receiving an accounting degree from Sydney University. He worked his way through various manufacturing and management positions becoming President in 1989 and elected CEO in 1993.

With the emotional debate over Headwaters Forest behind it, The Pacific Lumber Company has embarked on a new era of operation with a rigorous set of environmental guidelines designed specifically for the characteristics of its land base. John Campbell will discuss the details of the far-reaching environmental protection plan and how it affects the future of the company and forestry in California.

Panel B - The 2000+ "Wood" Products

Moderator: *Dr. Frank C. Beall*, Annual Meeting General Chair and Director, Forest Products Laboratory, University of California, Richmond, California

Dr. Frank C. Beall

Dr. Frank C. Beall is Professor and Director of the Forest Products Laboratory at the University of California, Richmond, California. His research interests include nondestructive evaluation; adhesives and adhesion; thermal degradation; moisture measurement and control; fire research; and duration of load. He is the author of numerous publications, has received many awards, and has served on several committees. He is currently serving as Vice President of the Forest Products Society (FPS) and General Chair of the FPS 54th Annual Meeting. He received a BS degree in Wood Utilization from Pennsylvania State University, University Park, Pennsylvania, and MS and PhD degrees in Wood Products Engineering from the State University of New York, Syracuse, New York.

Panel Members

A. William Boehner

William Boehner has been associated with the forest products industry since the mid-1960's when he received BS and MS degrees from the University of Maine in Forestry and Pulp & Paper Technology, respectively. He received a PhD in 1975 from the College of Forestry at the University of Minnesota's Department of Forest Products. He worked in the wood-based composites sector for 25 years in research, product development, and manufacturing. From 1975-1993, he worked in research and manufacturing for the Weyerhaeuser Company doing project work in particleboard, medium density fiberboard, medium density siding, and oriented strandboard plants. He was the technical director at an oriented strandboard plant for several years and worked closely with customers on product development projects. In 1993, he began working for Trus Joist MacMillan in Boise, Idaho. He continued his association with wood-based composites as a Research Department Head responsible for research activities directed toward laminated strand lumber. He has been a member of the Forest Products Society (FPS) since 1972, serving 4 years on the Executive Boards of both FPS and the Society of Wood Science and Technology and holding the offices from Vice President through Past President. Throughout his career he has been concerned with using our forest resource as efficiently as possible and with improving the efficiency of manufacturing processes.

A short history of wood-based composite materials will be presented, with an emphasis on wood utilization and effi-

ciency. The discussion will focus on the products that have been developed and commercialized and the wood elements used as raw materials. The question of whether or not existing composites have utilized the maximum potential of the wood element will be explored. Also, we'll take a quick look at how construction techniques have changed with the development of these new composites.

Steve Sage

Steve Sage is the Marketing Director of Kafus Industries Ltd., Cardiff, California. He has 30 years of experience marketing wood products at the retail, wholesale, and mill level. His experience encompasses working for industry leaders such as Georgia-Pacific and Roseburg Forest Products as well as being the highest volume retail lumber salesman in the country. He was also the Marketing Director for the Rainforest Alliance SmartWood Program. His accomplishments include implementing Forest Stewardship Council forest certification in the U.S. and gaining Home Depot's support. Working for both industrial forest products companies and a conservation organization has given him a unique perspective of the wood product markets.

With the world population and demand for wood fiber dramatically increasing over the next 50 years, the use of recycled and alternative fibers have become essential to building a sustainable civilization. Steve Sage will discuss manufacturing and marketing of the first 100 percent recycled wood fiber MDF using urban wood waste as a source of fiber. CanFibre, a subsidiary of Kafus, is currently producing this MDF product in a new plant in the Los Angeles urban area.

Alan F. Preston

Alan F. Preston is Vice President of Technology for Chemical Specialties Inc. (CSI) based in Charlotte, North Carolina. He is responsible for the R&D and regulatory affairs aspects of Laporte's wood products preservation businesses worldwide. Dr. Preston received a PhD in Organic Chemistry from the University of Auckland in New Zealand, where his research focused on synthetic pathways from natural products. Prior to joining CSI in 1986, he had been a Post-Doctoral Fellow at the University of British Columbia in Vancouver, a Research Scientist at the Forest Research Institute in Rotorua, New Zealand, and served as Director of the Institute of Wood Research at Michigan Technological University. He is a Past President of the American Wood Preservers' Association and is active in various other technical and industry associations, including being the Finance Chairman of the International Research Group on Wood Preservation, and serving on the Wood Preservation Committee in the International Union of Forestry Research Organization, Division 5.

This presentation will focus on trends in the wood preservation industry worldwide in regards to novel approaches to wood preservation and the pressures that may or may not lead to any or all of these trends seeing significant commercial growth in North America.

Dr. Robert J. Tichy

Dr. Robert J. Tichy is Associate Professor in the Wood Materials & Engineering Laboratory at Washington State University (WSU), Pullman, Washington. He received a BS degree in Wood Technology from the University of Illinois, an MS degree in Wood Engineering from Colorado State University, and a PhD degree in Materials Science & Engineering from WSU in 1981. Prior to joining WSU in 1992, he worked in the forest products industry, where he held positions with the Western Wood Products Association, Portland Oregon, as Manager of Engineering Research and Development; with Weyerhaeuser Company, Tacoma Washington, as a Senior Engineer with the Engineered Systems & Products Group; and as President of Technology Management & Implementation, Inc. His research focus is on the development of engineered wood-based building construction materials and systems.

Composite products are discussed as opportunities to grow the presence of wood materials in building construction and other applications. This presentation is focused on combinations of materials beyond wood and glue (e.g., in combination with steel, nonwood reinforcing fibers, etc.) and in using product geometry to enhance and expand the use of our natural resources.

SUNDAY AFTERNOON, JUNE 18

SESSION 1: Changing Raw Material, Changing Technology

Comparison of Organic Emissions from Small- and Large-Scale Lumber Kilns

Michael R. Milota, Assoc. Prof., Dept. of Forest Products, Oregon State Univ., Corvallis, OR; *Leonard Ingram*, Prof., Forest Products Lab., Mississippi State Univ., Mississippi State, MS; *Richard Law*, Research Engineer, NCASI, Gainesville, FL; *Curry Templeton* and *Rubin Shmulsky*, Research Assts., Forest Products Lab., Mississippi State Univ., Mississippi State, MS; *Mark Lavery*, Research Asst., Dept. of Forest Products, Oregon State Univ., Corvallis, OR

Volatile organic compounds (VOCs), methanol, formaldehyde, and other hazardous air pollutant (HAP) emissions were measured from southern pine lumber as it dried. Measurements were made at commercial facilities by the National Council for Air and Stream Improvement and from laboratory kilns at Mississippi State University and Oregon State University. The objective of the project was to determine if a laboratory kiln could be used to predict the emissions generated at a commercial facility.

Assessment of Twist Potential in Softwood Lumber

Mark A. , Senior Engineering Specialist, Weyerhaeuser Co., Tacoma, WA

Twist in softwood lumber is commonly associated with the presence of pith and spiral grain. This presentation will explain the key factors governing the mechanics of twist and explore how those factors interact to determine the twist behavior of individual boards. An analysis of the shrinkage and resulting distortion of a single growth ring provided a preliminary tool to explore the quantitative relationships between twist and spiral grain angle, shrinkage, and distance from the pith. To further our understanding, a finite-element model (FEM) of lumber that incorporates grain orientation, shrinkage, and elastic deformation was developed to enable a more sophisticated analysis that better reflects the behavior of real boards. Furthermore, experimental studies were conducted to characterize the physical and mechanical properties and the twist instability of real lumber and to verify the FEM results. This work indicated that twist depends on a combination of spiral grain angle, tangential and longitudinal shrinkage, and ring geometry. The patterns in which these properties typically vary in softwood trees would give rise to lumber with twist characteristics consistent with the empirical associations with pith and spiral grain. However, the twist potential of a particular board usually cannot be accurately predicted using typical log properties. Rather, twist behavior is a product of the unique patterns of grain orientation, ring structure, and shrinkage variation within an individual board, which in turn arise from the corresponding patterns within the source log.

Method for Estimating Air Drying Times of Lumber from Weather Data

William T. Simpson, Forest Products Technologist, Forest Products Lab., USDA Forest Service, Madison, WI

Estimating the time required to air-dry lumber is useful for production planning, but is not an easy task because of the many variables involved. Drying time depends on both species and thickness. In general, low-density species dry faster than high-density species, and thinner lumber dries faster than thicker lumber. Estimation becomes more complicated when the influence of weather is considered. Even at a given location, temperature and relative humidity, which have major effects on drying rate, and vary from year to year. In addition to geographical and seasonal temperature and relative humidity differences, another major effect weather has on air-drying time is the influence of the time of the year that the lumber was stacked. Lumber stacked in the spring will usually dry relatively quickly, but lumber stacked in the fall may require much longer to air-dry. The objective of the study was to develop a method for estimating air-drying times for red oak, beech, sugar maple, yellow-poplar, ponderosa pine, and Douglas-fir lumber of any thickness stacked at any time of the year at any location where weather data was available. Three key items of information were used to accomplish this objective: 1) existing experimental air-drying data for the six species; 2) computer drying simulation; and 3) weather data. The method of analysis involved a least-squares fitting of the experimental data to the drying simulation in order to determine the values of simulation parameters that could then be used to estimate air drying times at locations other than where the experimental data originated. Agreement between experimental and simulation air-drying times was good enough to justify applying the simulation to other locations and thus met the objective of the study.

Super Heated Vacuum Drying of Lumber

Charles Clement, Research Asst., Dept. of Forestry, Purdue Univ., W. Lafayette, IN; *Yves Fortin*, Prof., and *Alain Cloutier*, Asst. Prof., Dept. des sciences du bois, Univ. Laval, Ste-Foy, QC, Canada

The purpose of this study was to analyze the evolution pattern of the moisture content (MC), internal pressure, and temperature profiles in wood during superheated-steam vacuum-drying. The measurements were conducted on three species presenting different drying characteristics, namely American beech, sugar maple, and white pine. The MC evolution curves are similar to conventional-drying curves except that the transition point occurs at about 18 percent MC. The MC profiles indicate fast evaporation of freewater at the lumber surface and rapid movement of water vapor from center of the board, below 15 percent MC. The temperature profiles confirm rapid evaporation at high MC with the sudden lowering of initial temperature followed by the gradual rise towards kiln temperature. The temperature gradients within the specimen itself are fairly weak, which indicates a progressive movement of moisture through the lumber. The total-pressure profiles indicate a relationship between absolute pressure in the wood and MC, where MC is above the fiber-saturation point (i.e., presence of liquid water) inhibits the removal of gases from within the lumber and therefore slows the drying process down.

Estimating the Energy Used During the Kiln-Drying of Wood Using Moisture-Content Based Schedules

Robert W. Rice, Assoc. Prof., Dept. of Wood Science & Technology, Univ. of Maine, Orono, ME

Within the past several years, there has been renewed interest in the use of energy in kiln-drying solid wood. In particular, several types of air-to-air heat exchangers have been marketed that recover a portion of the energy from vented gasses. A knowledge of the potential savings using these exchangers should be a part of the decision-making process prior to buying a system. An updated and computerized model of the kiln energy program developed by Shotaffer and Shuler (1974) has been developed. The program has been written to cover moisture-content-based schedules operating below 212ºF and allows the user to input a number of critical variables including the composition of the walls and the ambient conditions. The program output partitions the energy into six components including the energy required to heat the wood, heat the water in the wood, evaporate the water from the wood, vent losses, and building losses.

This presentation will discuss the assumptions used to develop the model and its output for several input schedules.

Determination of Layer Thickness of Particleboard and Medium Density Fiberboard from Vertical Density Profiles

Salim S. Hiziroglu, Asst. Prof., Dept. of Forestry, Oklahoma State Univ., Stillwater, OK

Density profile of wood composite panels is one of the major factors influencing both the physical and mechanical properties of these products. In order to improve overall panel quality and to analyze raw material and manufacturing variables, density of individual layers and their thickness should be accurately determined. Density profiles of commercially- and laboratory- manufactured particleboard and medium density fiberboard (MDF) were studied using a x-ray density profiler. Thickness of face and core layers of six different panel products were analyzed from density profiles of 2-inch by 2-inch samples. Correlation coefficient values of 0.91, 0.80, and 0,89 were determined between ratio of face density to overall board density and ratio of face thickness to the total board thickness of MDF and two types of particleboard, respectively. Laboratory manufactured MDF showed a lower correlation coefficient of 0.77 for the above relationship due to less distinctive densification of unsanded face layers. Based on the initial results of this study it appears that face/core thickness ratio values from density profiles of particleboard and MDF can be used as a quality control tool to determine and improve properties of such wood-based panels.

Material Behavior in Wood-Drying Environments: Instantaneous Stress-Strain Relationships for Radiata Pine

Christopher A. Lenth and *Shusheng Pang*, Scientists, and *Tony Haslett*, Project Ldr., Wood Drying Technologies, New Zealand Forest Research Inst. Ltd., Rotorua, New Zealand

A greater knowledge of the behavior of wood in environments relevant to timber drying will increase our understanding of material properties during lumber manufacture. This information provides insight into the development of stresses in wood that are responsible for drying degrade, and is a prerequisite for effective modeling of drying-induced stresses. A study has begun in which the mechanical properties of wood is evaluated at temperature and moisture conditions reflecting those encountered during the drying of softwood lumber. The acquisition of this data, however, has required that samples be evaluated in environments that exceed the capabilities of typical material testing instrumentation. Therefore, a specialized testing device that can generate and maintain the necessary temperature and pressure conditions, while applying loads to and measuring displacements within specimens, was constructed. Samples were tested in tensile and compressive loading arrangements with loads applied in the longitudinal, tangential, and radial directions at temperatures from 20° to 150°C and moisture contents from green to 5 percent. This presentation will illustrate the novel testing equipment used and review the instantaneous stress-strain behavior of radiata pine as influenced by temperature and moisture content. Implications on the development of drying stresses and their modeling will also be discussed.

SESSION 2: Papermaking - Changes in Chemistry, New Additives, and the Use of Synthetics with Lignocellulosic Fibers

Ag-Fibers: They Look Like Fibers - They Act Like Fibers (Shouldn't We Utilize Them as Fibers?)

Donald E. Lengel, P.E., Pres., Lengel Consultants, Seattle, WA

Currently, there is great interest in the utilization of agricultural waste products. This is partly due to a perceived shortfall in the availability of raw material. Ag-fibers such as from wheat straw, cotton, and cornstalks, are considered to be in bountiful supply and inexpensive. These are erroneous perceptions. While an enormous amount of these materials has grown, many farm scientists believe that they should be kept in the field for erosion control and for nutrients. While the farmer may receive only $5 to $10 per ton in the field, the cost delivered to a utilization plant can run from $30 to $40 and more per dry ton, and the overall decrease in yield in the plant can further increase the actual net cost of the material. There is an urgent need for development of methods to increase the yield and quality of the ag-fiber materials to benefit both the utilization plants and the farmers. As part of this work there should be consideration of the need for leaving some material in the field to benefit the land. In the panelboard field, despite an investment of at least $200,000,000 in recent years, there does not appear to be a truly successful plant. The author attributes this, in great part, in the failure to consider the ag-fiber as a fibrous material, not as a particle. In addition, it is evident that certain "green" characteristics have not resulted in premium panel prices.Long-term subsidies are neither warranted, nor very likely. As a result, it is necessary to design and build ag-fiber plants of any type to be directly competitive with wood-based plants.

Composite Pulps from Refining Mixtures of Polyethylene and Wood Chip Stock

George A. Grozdits, Research Assoc., and *Mark D. Gibson*, Prof., Sch. of Forestry, and *Ronald H. Thompson*, Prof./Dir., Nuclear Center, College of Engineering & Science, Louisiana Tech Univ., Ruston, LA

The pulp and paper industry utilize plastic filaments and fibers to improve wet strength, change paper flexibility, and in general, counteract the hydrophilic properties of cellulosic biomass. The technical challenges are adequate mixing of two different materials and the bond formation between the various raw materials. Comen reported experiments where polyethylene and polypropylene fibers were mixed prior to refining to produce high-density, thin hardboard. They preheated the plastic/wood-fiber mixture before refining and used refiners only for mixing the material without further attrition (large 0.010" clearance between refiner plates). This led to inadequate mixing and the preheating plasticized some of the plastic fibers into amorphous bodies. In this experiment, incense-cedar (higher acidity and lower hygroscopicity) and polypropylene fibers (higher softening point compared to polyethylene) were refined together with tight 0.005" refiner plate clearance to promote mixing and reduce plastic coagulation. Results showed (hardboard processed under commercially acceptable press times, temperatures and pressure cycles) a two percent polypropylene fiber addition improved board properties by as much as 200 percent and made the polypropylene-hardboard comparable to phenol-formaldehyde bonded hardboard. The wet/wet process provided better polyethylene-hardboard compared to the wet/dry process, which is in contrast to commercial phenol-formaldehyde bonded hardboard processes, where the wet/dry process provides higher-strength boards.

Chemical and Chemi-mechanical Pulps from Black Locust (*Robinia pseudoacacia*)

Raymond C. Francis, Prof., Empire State Paper Research Inst., State Univ. of New York, Syracuse, NY; *D. Pascal Kamdem*, Assoc. Prof., Dept. of Forestry, Michigan State Univ., E. Lansing, MI

Chemical and chemimechanical pulps from black locust (*Robinia pseudoacacia*) kraft pulping followed by ECF (element chlorine-free) bleaching produced a black locust pulp with high strength values at a high yield. The tear index was 9.3 mN•m²/g at a tensile index of 80 N•m²/g. This tear value was higher than for hardwood kraft pulps from several other species. The final bleached yield of 49.5 percent on chips was 1.8 percent higher than the 47.7 percent obtained from silver maple (*Acer scharinum*). The black locust also produced a strong chemimechanical pulp but a higher than normal NaOH application was required to dissolve the high polyphenol content of the wood. The possibility of adding Cu to the effuent and using it for wood preservation is being investigated and will be reported on. Once most of the polyphenols are washed out of the pulp it could easily be bleached to brightnesses > 80 percent ISO by 4 percent H_2O_3.

Cultivation of *Camptotheca Acuminata* and Other Exotic Species for Production of Chemicals for Medicinal Purposes

John C. Adams, Prof., Sch. of Forestry, Louisiana Tech Univ., Ruston, LA; *Zhijun Liu*, Asst. Prof., Sch. of Forestry, Wildlife, & Fisheries, Louisiana State Univ. Agricultural Center, Baton Rouge, LA

For thousands of years the Chinese have utilized native plant materials for medicines and, in some cases, cultivated them for medicinal purposes. Historically, a high percentage of the drugs available today have their origins from plants. In many plants, chemicals are isolated that have positive effects on a disease and as soon as the chemist can determine the chemical structure they are synthesized in the laboratory and it is no longer necessary to grow them. There are chemicals in certain species of plants that are very difficult or very expensive to manufacture in the lab and these require the use of raw-plant materials for efficient manufacturing. When a chemical that has medicinal properties is isolated in a plant, that species needs to be grown and understood to provide the pharmaceutical industry material to produce the drug. However, the cultivation of plants for medicinal use is in a very early stage of development in this county. This presentation describes two species being studied for cultivation for medicinal purposes. The tree of joy (*Camptotheca acuminata*) and eucommia (*Eucommia ulmoides*) are currently under investigation with studies ranging from seed germination to genetic variation in chemical production to practical silvicultural techniques for growing these exotics. Problems associated with working with relatively obscure exotic species are discussed with recommendations for solving the problems associated with short material supply, political implications and restrictions, and a general lack of knowledge of the silvics of these species.

Supercritical Extraction of Biomass Materials

Trevor P. Castor, Pres./CEO, Aphios Corp., Woburn, MA

Forests can be a unique source of pharmaceuticals and nutraceuticals. The isolation of bioactive molecules such as Taxol® (or by its generic name, paclitaxel) from trees like *Taxus brevifolia* are difficult because such compounds often occur in trace quantities, require large quantities of toxic organic solvents for processing, and are co-extracted with waxes, lipids, chlorophylls, steroids, etc. Such difficulties represent significant barriers to the commercialization of health-care products from the forest. The isolation and manufacturing of natural medicines can be significantly enhanced by the use of near-critical and supercritical fluids with or without polar cosolvents (*SuperFluids*™). These fluids are normally gases, which when compressed, exhibit enhanced thermodynamic properties. *SuperFluids*™ are being exploited for the selective extraction and chromatographic purification (*CXP*) of paclitaxel and related taxoids such as 10-deacetyl baccatin III (10-DAB) and cephalomannine from the bark, needles, and roots of the yew tree. The *CXP* process has proven to be rapid (isolation times between 40 mins. and 4 hrs.), efficient (yields of more than 90%), cost-effective (as much as 75% lower in costs than organic phase techniques), and environmentally friendly (eliminates use of toxic organic solvents and utilizes renewable leaves/needles). The *SuperFluids*™ *CXP* process has also been proven generally applicable for natural pharmaceuticals such as camptothecins, bryostatins, and michellamines, and nutraceuticals such as St. John's Wort, Kava Kava and Saw Palmetto. The marketplace for Taxol® exceeds $2 billion and the marketplace for natural medicines from the forest may exceed $100 billion.

Fiber Morphology During Drying as Observed with Low-Vacuum Scanning Electron Microscopy

Robert B. Hanna, Prof., and *Susan E. Anagnost*, Research Assoc., Center for Ultrastructure Studies, Dept. of Wood Products Engineering, State Univ. of New York, Syracuse, NY

Low-vacuum scanning electron microscopy was utilized to observe the morphological changes that occur during the drying of fibers. Operating in the low-vacuum mode, it was possible to observe uncoated, fully-hydrated fibers in the scanning electron microscope. We monitored the morphological changes, which occurred as the fibers dried in the chamber of the microscope. Particular attention was paid to the changes in surface morphology and size. We have demonstrated that the newly-developed technique of low-vacuum scanning electron microscopy has considerable potential in the field of pulp and paper science. The specimens employed in this study were macerated fibers, thermomechanical pulpfibers, and beaten and unbeaten kraft pulpfibers.

TUESDAY MORNING, JUNE 20

SESSION 3: Biofuels and Bioproducts: Avenues for Forest Health

Woody Biomass Utilization in California: Challenges and Opportunities

John R. Shelly, Extension Advisor, Biomass Utilization, Forest Products Lab., Univ. of California, Richmond, CA

Much of the west has seen an excessive accumulation of vegetation (biomass) in forested and urban-wildland areas, in response to the fire management and timber-harvesting policies of our recent past that have created an unacceptably high fire hazard. Without the regular occurrence of natural fires, other management strategies are needed to reduce the potential for costly and dangerous wildfires. Traditional wildfire fuel reduction strategies such as prescribed fire or disposal in landfills are costly and often present unwanted environmental consequences. There is a strong incentive to find other alternatives, such as using biomass as a raw material to produce value-added products such as composite panels, energy (electricity, ethanol, etc.), organic chemicals, and other wood-based or wood-derived products. Using California as an example, a state with more than 36 million bone dry tons (BDT) of woody biomass readily available for processing, this overview paper describes the challenges (technology, political, economic, and environmental) faced in the various biomass management and utilization options. Although California has the existing capacity to use more than 10 million BDT's of biomass to produce electricity, the continued production is in question because of the high costs when compared to other electrical generation methods.

Other issues discussed include the interest of the governors of many western states to develop biomass-based ethanol facilities and the interest of the federal government to help find forest management options that protect the health of the forest and address the interests of the people and communities most directly affected.

Implementing Projects for Utilization of Small-Diameter, Low-Valued Material Within Existing Forest Service Authorities

Bill Wickman, Asst. Section Head, Timber Sale Administration & Pilot Stewardships, USDA Forest Service, Vallejo, CA

Utilization of small-diameter, low-valued material is a current issue in the national forest of the western United States. The issue has been driven by emphasizing forest health associated with the catastrophic wildfire threats in stands that have become overcrowded because of decades of fire exclusion. Over this same time period, the typical forest treatment was associated with removal of older-growth timber. Recent environmental issues are limiting the size and amount of timber that can be treated. The rapid change in the size of the trees being treated has meant an associated need for changes in the processing markets. To be able to meet the supply needs to develop these markets the Forest Service has addressed new contract mechanism, as as well as what is currently available within existing authorities. Section 347 of the Fiscal Year 1999 Omnibus Appropriations Act (Public Law 105-277) authorized 28 stewardship contracting pilot projects to try new contracts. However, most of the existing timber treatments can be accomplished within existing authorities. It can be concluded that by providing information on these existing authorities, most forest health and catastrophic fire issue and the associated stand treatments can be addressed.

Economic Impact of Alternative Management Schemes on the Washington State Capitol Forest

Michelle Ludwig, Grad. Research Asst., and *Bruce Lippke*, Dir., CINTRAFOR, Univ. of Washington, Seattle, WA

The Capitol Forest Study project provides an opportunity to identify economic parameters and quantify the benefits and costs in a variety of silvicultural treatments. This ongoing research effort is a joint study initiated by the Pacific Northwest Research Station (PNW) and the Washington Department of Natural Resources (DNR). The main objective of this study was aimed at evaluating forest harvest practices and silvicultural systems that could be used in a landscape management program to reduce the visual impacts of timber management operations while maintaining a high level of timber production. The 90,000-acre Capitol Forest near Olympia, Washington is comprised almost entirely of second-growth Douglas-fir stands. This project is the first replica of a three-part study. It compares the economic implications of six treatment regimes: 1) clearcut; 2) 2-age; 3)patchcut; 4) group selection; 5) extended rotation with commercial thinning; and 6) extended rotation without commercial thinning. The Pacific Northwest has few representative Douglas-fir stands that have been managed intensively through a rotation. Thus, the research on comparative silvicultural systems in the Douglas-fir region is less than sufficient to make associated policy decisions. This study provided an in-depth analysis of timber valuation and the accessibility, processing, and harvesting costs associated with these various silviculture treatments. The proposed treatments represent a wide range of possible silvicultural systems, which seem plausible for application under conditions existing in the Pacific Northwest.

The Sustainability of Hybrid Poplar Plantations: What Are the Costs?

Paul R. Blankenhorn, Prof. of Wood Technology, *Todd W. Bowersox*, Prof. of Silviculture, and *Charles H. Strauss*, Prof. of Forest Economics, Sch. of Forest Resources, Pennsylvania State Univ., Univ. Park, PA

Short-rotation intensive culture (SRIC) Populus plantations involving four management strategies (control, fertilization, irrigation, and fertilization-irrigation) were established on two different sites and evaluated for two rotations. Biomass yield, height, and diameter data were collected and analyzed. First rotation yields from the selected management strategies ranged from 33 to 42 ovendry metric tonne per hectare. The average biomass yield increase in the second coppice rotation was 12 percent. Economic evaluations focused on plantation establishment, production, harvesting, and storage costs for the two rotations. The control strategy had the lowest production costs among the four management strategies for two rotations. Harvesting and storage requirements nearly doubled the biomass production costs for two rotations. Over 50 percent of the total costs (production, harvesting, and storage) were associated with equipment, fuel, and material inputs. Labor and land costs were nearly 30 and 20 percent, respectively, of the total SRIC costs for two rotations.

Biomass in Flood Plains

Bruce E. Cutter and *Gene Garrett*, Profs. of Forestry., and *Mike Gold*, Research Assoc. Prof. of Forestry, Univ. of Missouri-Columbia, Columbia, MO

In the past decade, two 500-year floods visited the Missouri River floodplain. First in 1993 and then again in 1995, record-breaking floods inundated cities, towns, and fields. Levees failed where the impact of fast-flowing waters were felt full-force. But in areas where trees were growing on the river side of the levee, levees were not breached. As a result, the United States EPA has initiated a major study in the Midwest dealing with the multipurpose use of biomass in flood plains to reduce the effects of flooding, provide some amelioration of hazardous materials in the groundwater and soil, provide cover and habitat for wildlife, and to provide woody biomass that could be converted to either energy or wood-based products. This study employed agroforestry management techniques to integrate the numerous objectives of the study. In this paper, we present the study design and early results of this multi-faceted study that includes scientists from three states (IA, MO, NE) and two agencies (USDA NRCS and USDA FS).

Wood in the Waste Stream: An Update on Pallet Landfilling, Recovery, and Recycling

Robert J. Bush, Assoc. Dean, Research & Graduate Studies, and *Daryl T. Corr*, Grad. Research Asst., Dept. of Wood Science & Forest Products, Virginia Tech, Blacksburg, VA; *Philip A. Araman*, Project Ldr., Southern Research Sta., USDA Forest Service, Blacksburg, VA

The desire to preserve space in landfills is one force driving an emphasis on increasing the recovery, reuse, and recycling of materials in the waste stream. Wood in various forms is a component of this waste stream, although a relatively small percentage. Pallets are a portion of the wood component and a relatively attractive product from the standpoint of recovery and reuse. As a result, both landfill operations and other firms recover wood pallets for various uses. A study of pallet recovery at landfills during 1995 identified the number of landfills operating pallet-recovery facilities, the level of pallet recovery, and uses of recovered material. Also, the study identified the prices realized for products from recovered pallets. This study was replicated to cover recovery activity in 1998. Both studies included licensed Municipal Solid Waste (MSW) and Construction/Demolition (C&D) landfill operations in all U.S. states (except Alaska and Hawaii) and both studies sought data

from a census of this population. Comparisons of the results of the two studies reveals trends in pallet recovery at landfills, as well as changes in markets for recovered-wood products. These trends highlight opportunities for increased pallet recovery. Combined with information concerning pallet recovery and recycling by firms outside of the landfill industry, the results help further describe the fate of the large volume of wood used for the manufacture of pallets each year.

Wood for Energy and its Impact on the Environment

Béla Marosvölgyi, Prof., Dept. of Energetics, *Ilona M. Peszlen*, Prof. (currently Asst. Prof., Dept. of Forestry, Iowa State Univ., Ames, IA), Inst. of Wood Science, and *Róbert Tamás*, Grad. Student, Dept. of Energetics, Univ. of Sopron, Sopron, Hungary

This presentation is concerned with biomass production and its use for energy. Analyses were made to assess the feasibility and environmental benefits of converting biomass, especially wood, into energy in Hungary, where more than 90 percent of energy demand is supplied by fossil fuel and nuclear sources. Roughly 60 percent of that energy must be imported. Due to environmental restrictions as well as for economic reasons, the cost of such imported energy is ever increasing. In addition, energy production from fossil fuels contributes significantly to the greenhouse effect on earth. According to calculations, the conversion of some agricultural land to energy plantations is feasible and would also result in environmental benefits in Hungary. In regular forestry practices, biomass growth and yield in terms of ton/ha/yr. or GJ/yr. is relatively low, only about 110 GJ/yr. However, at the time of normal harvesting, the total accumulated energy concentration is quite high, some 2000-2200GJ/ha. Thus, harvesting for energy appears to be economically feasible. The disadvantage of regular forestry operations is that harvesting occurs only every 40-60 years. On the other hand, agricultural by-products are available on an annual basis, but their energy concentration is low, about 30-145 GJ/ha. Results obtained for high-yield poplar, black locust, and willow energy plantations indicate that such plantations may become economically feasible. Harvesting may be on a 3 to 4 year rotation. Thus, the potential energy yield of energy plantations is quite high, 240-310 GJ/ha/yr., resulting in 700-1250 GJ/ha at the time of the harvest.

SESSION 4: Secondary Wood Products Trade and Production

Validation of Rip-First Roughmill Yield Optimization Software

Urs Buehlmann, Asst. Prof., Dept. of Wood & Paper Science, North Carolina State Univ., Raleigh, NC; *R. Edward Thomas*, Research Computer Scientist, Northeastern Research Sta., USDA Forest Service, Princeton, WV

The USDA Forest Service's ROMI-RIP roughmill rip-first simulation program is a popular tool for analyzing roughmill conditions, determining more efficient roughmill practices, and finding optimal lumber board cut-up patterns. However, until now, the results generated by ROMI-RIP have not been validated in an actual roughmill. Validation of the ROMI-RIP processing model involved comparing gang-rip, crosscut, and overall yields to those obtained in an actual state-of-the-art roughmill. To this end, a 1,000 BF lumber sample was digitized, thereby recording all defect locations and sizes as well as board size and grade. This sample was then processed in the actual roughmill and on the ROMI-RIP simulator. Thus, both, the roughmill and the ROMI-RIP software did process identical lumber samples. Results showed that the ROMI-RIP software accurately simulated the actual roughmill. No significant yield differences were found to exist when ROMI-RIP was forced to adhere to the roughmill's settings. However, when ROMI-RIP was allowed to search for global optimum yield, it produced yields that were as much as 7 percent higher (71.1 percent vs 64.0 percent) than the actual roughmill. These results point to a significant potential for saving scarce lumber and decreasing production cost by using modern, computerized yield optimization software.

International Trade in Furniture/Fixtures - Strategies for a Competitive Global Business Environment

Albert T. Schuler, Research Economist, Northeastern Research Sta., USDA Forest Service, Princeton, WV; *Russ Taylor*, Pres., R.E. Taylor & Associates Ltd., Vancouver, BC, Canada; *Philip A. Araman*, Project Ldr., Southern Research Sta., USDA Forest Service, Blacksburg, VA; *Cynthia D. West*, Dept. Head, Forest Products Lab., Mississippi State Univ., Mississippi State, MS

Furniture imports account for one third of the value of U.S. consumption and are now equal to one half the value of domestic shipments. The imports come from Asia, Canada, Europe, Mexico, and more recently, South America. The obvious question: Why is this happening and will these trends continue? Some problems facing domestic producers include rising fiber costs, expensive production labor, and unfavorable exchange rates. In the softwood molding market, similar circumstances led to substitution and more imports that ultimately led to a 50 percent market share loss by the domestic industry. What is particularly frustrating is that the U.S. furniture industry is not sharing in one of the best housing markets in history. As the market grows, imports are taking more market share while domestic production remains flat. What can be done? The softwood molding “case study” taught us that before remedial strategies can be recommended, the domestic industry must do some “bench marking” and then develop survival strategies based on cost competitiveness combined with unique processing and product capabilities. Some possibilities for strategies could include: JV's for import/export/distribution alliances; increased focus on exports to China, Japan, and other far Eastern destinations; continued improvement in quality and customer service; and last but not least, a reduced number of items/suite. By judiciously reducing the number of product offerings, (focus versus diversification) production costs can be reduced thus enhancing competitive position. A useful comparison is the spectacular invasion of the U.S. auto market by the Japanese auto industry twenty years ago. Automation, statistical quality control, and fewer, but more market-focused product offerings (e.g., fewer models and colors) allowed the Japanese to cut cost while increasing quality. This strategy allowed them to go from less than 10 percent market share to over 30 percent in less than two decades. Perhaps a similar strategy could work for the domestic furniture industry?

Design and Testing of Wood School Chairs for Developing Countries

Eva Haviarova, Ph.D. Candidate, *Carl A. Eckelman*, Prof., and *Yusuf Z. Erdil*, Research Asst., Dept. of Forestry, Purdue Univ., W. Lafayette, IN

The education of children in developing countries has long been regarded as an important element of economic development. Although well-designed school furniture has been shown to contribute to the learning process, school furniture used in these countries often detracts from, rather than facilitates, education. The purpose of the study was to address school furniture problems using a multidisciplinary approach by combining design, product engineering, and material engineering to create furniture that is ergonomically correct, strong and durable, low in cost, requires little maintenance, and can be made by local industries from locally available materials such as woody plantation thinning. Results of the study indicate that strong, durable school chairs can be constructed using simple techniques including cross-lap lamination, shrink- and swell- round mortise and tenon construction. The high strength of the chairs results both from the relatively even distribution of internal

resisting forces among the stretchers and rails and also from the strength of the round mortise and tenon joints and the cross-lap joints. Deep hole saws provide a convenient method of cutting round tenons of uniform diameter without the need for close quality control. The shrink- and swell- method of assembling joints provides a means of producing uniformly tight-fitting joints. Overall, the study demonstrates that durable school furniture can be produced by local industry by from largely local woody materials by means of low-technology processes.

Fatigue Strength of Two-Pin Dowel Joints Constructed of Wood and Wood Composite

Jilei Zhang, Asst. Prof., and *Franklin Quin, Jr.* and *Robert E. Tackett*, Research Assts., Forest Products Lab., Mississippi State Univ., Mississippi State, MS

Two-pin dowel connections are commonly used at critical joints in upholstered-furniture frames. With the increased use of engineered composite materials in upholstered frames, fatigue behavior of the joints constructed of composites should be investigated and compared with joints traditionally constructed of solid wood. This presentation describes fatigue behavior of T-type, two-pin dowel joints constructed of red oak, yellow-poplar, southern yellow pine plywood, engineered strand lumber, and particleboard. A technique of predicting the fatigue life of the joints subjected to given cyclic stepped loading will be presented. Experimental results indicated that the moment-cycle curves of joints could be used to predict fatigue life of joints subjected to cyclic stepped loading. This information is especially invaluable to furniture manufacturers in their frame-design process. It can assist in optimizing frame design to meet different strength requirements specified by frame testing standards such as the General Services Administration performance tests. It is recommended that moment-cycle curves of various types of joints be gathered.

Comparison of Properties of Poplar Crossband Versus Synthetic Crossband and Its Application

Karla M. Coenen, R&D Chemist, Dyno Overlays, Inc., Hayward, WI

The use of a synthetic crossbands to replace poplar crossband in furniture is undergoing a revolution due to the increase in availability of high-quality synthetic crossbands. This presentation details information that compares the properties of poplar crossbands to that of a phenolic-saturated crossband and three optimized application techniques. Poplar crossbands have been traditionally used as a component to mask the substrate, strengthen the overall panel, and provide a balanced construction. A synthetic crossband comprised of a phenolic saturated kraft paper has been engineered to meet and exceed the properties of poplar. The application techniques that are typically used include 5-ply and 3-ply lay-up utilizing polyvinylacetate and urea-formaldehye adhesives. A third technique is the application of the synthetic crossband in a 2-ply application using a phenolic glue film with a decorative face with subsequent application to a core substrate. Good-quality poplar is becoming more limited and costly. A synthetic crossband can offer an alternate substitute to poplar crossbands that is uniform with high strength and ensures a good balanced panel.

Factors Influencing Veneer Checking in Furniture Panels

Daniel L. Cassens, Prof., and *Yuelong Leng*, Grad. Student, Dept. of Forestry, Purdue Univ., W. Lafayette, IN

Veneer check development in hardwood panels at the time of pressing, as well as in-service, is a serious problem for wood-furniture manufactures and consumers. This study looked at the effect of several processing parameters and humidity cycling on check development in flat-sliced red oak and hard maple cut on a half-round machine. The factors evaluated included all combinations of veneer at an initial equilibrium moisture content (EMC) of 7 or 12 percent, urea-formaldehyde (UF) and catalyzed cross-linked polyvinyl adhesive, a 1-minute and 10-minute assembly time, as well as tight side and loose side of the veneer. After pressing, the panels were exposed for 3 weeks to 75 to 80 percent relative humidity and then 3 weeks at 20 to 25 percent relative humidity. This cycle was repeated three times. The number of veneer checks were determined immediately after pressing and after each 3-week humidity exposure. The best combination of factors for both species was a veneer EMC of 7 percent, UF adhesive, and 1-minute assembly time. However, for red oak less checking was evident when the loose side was turned out. For hard maple, less checking occurred with the tight side turned out.

Consumer Perceptions of Character-Marks on Eastern Hardwood Veneer and Panels

Cynthia D. West, Dept. Head, Forest Products Lab., Mississippi State Univ., Mississippi State, MS; *Larry G. Jahn*, Prof./Dept. Extension Ldr., Dept. of Wood & Paper Science, North Carolina State Univ., Raleigh, NC; *Matthew S. Bumgardner*, Research Forest Products Technologist, Northeastern Research Sta., USDA Forest Service, Princeton, WV; *Craig L. Forbes*, Dir. of Marketing, New South, Inc., Myrtle Beach, SC

This study investigated consumer perceptions of character-marked cabinets. Visitors to a large home show were asked to rank, in order of preference, 12 cabinet doors that contained different levels of character-markings, as well as different species and styles. Cluster analysis and conjoint analysis were used to group and profile the respondents based on the rankings. For many respondents, wood species was clearly the most important criterion for evaluation, suggesting that more character could be included in cabinet products with little additional promotional effort. However, for a substantial subset of the sample, the presence of character was the most important ranking criterion. For this character-sensitive group, preference for character declined from clear to light to heavy levels, but there appeared to be opportunities for inclusion of light character. The groups were also profiled in terms of demographic characteristics. Understanding consumer segments for character-marked wood products can ultimately result in more efficient utilization of hardwood resources.

Adoption of Automated Lumber-Grading Technology in the Secondary Wood-Products Industry

D. Earl Kline, Assoc. Prof., *Dan W. Cumbo*, Grad. Student, and *Robert L. Smith*, Assoc. Prof./Extension Specialist, Dept. of Wood Science & Forest Products, Virginia Tech, Blacksburg, VA

To increase the overall effectiveness and marketability of emerging automated lumber-scanning and-grading technologies, the goal of this study was to understand and characterize the need for such technologies within the secondary wood products industry. Four secondary wood products sectors were surveyed to identify and characterize differences between adopters and nonadopters of automated lumber-grading technology and to identify the desirable attributes or "benefit bundle" of such new technology. These sectors included the cabinet, furniture, dimension, and flooring industries. This study found that potential adopters of automated lumber-grading technology would most likely be larger companies, in terms of sales, number of employees, and lumber volume processed. The majority of adopting firms reported annual sales in excess of $5 million and employed greater than 100 people. In addition, analysis showed that dimension and flooring manufacturers would best represent adopters of automated lumber-grading technology. The key system attribute in such a technology was found to be the ability to increase yield and production efficiency. Furthermore, technical support and equipment warranties were viewed just as important as increased yields and production efficiency. Companies also expressed a high interest in

observing a working system in an industrial setting before they would consider investing in this technology. Results from this study can be used by equipment manufacturers to design more effective lumber scanning and grading systems that meet the need of the secondary wood products industry.

SESSION 5: Creating Value Through Marketing and Communication

Japanese Attendee Perspectives on Building Products Trade Shows

Kazuyo Hama, Research Asst., and *Paul M. Smith*, Prof., Sch. of Forest Resources, Pennsylvania State Univ., Univ. Park, PA; *Timothy M. Smith*, Asst. Prof., Dept. of Wood & Paper Science, Univ. of Minnesota, St. Paul, MN

Complicated distribution systems create entry barriers into the Japanese building materials market. However, these channels are slowly being streamlined to reduce costs and increase efficiencies. Trade shows provide a means by which international vendors can communicate directly with Japanese distributors and end-use buyers of building materials. This study examined key-buying and non-buying objectives that Japanese building materials buyers have set for their attendance at two wood products trade shows: the National Association of Home Builders (NAHB) International Builders' Show '99, Dallas, TX, and the Japan Home Show (JHS) '98, Tokyo, Japan. A mail questionnaire, translated into Japanese, was mailed to all 602 Japanese attendees to the NAHB International Builders' Show '99. An adjusted response rate of 35 percent (n=190) was obtained with 112 respondents attending only the NAHB show and 78 respondents attending both the NAHB and JHS shows. This study provided insight into the trade show use and objectives of a key buying segment and how these buying and non-buying attendance objectives differ between an "in-country" international show and an overseas show. In addition, trade show selection criteria provides insight into the reasons Japanese attendees choose one domestic or international trade show versus another. This information will allow exhibitors to tailor their communication strategy during, before and following a major show and provide show exhibitors with key information to better attract exhibitors and attendees to subsequent shows.

Strategies for Introducing Alternative Outdoor Decking Materials Through the Retail Home Center Channel

George M. Carter, Doctoral Fellow, and *Paul M. Smith*, Prof., Sch. of Forest Resources, Pennsylvania State Univ., Univ. Park, PA

A number of entrenched products currently compete in the outdoor residential decking market, including pressure-treated lumber, redwood, and cedar. New products are entering this market and challenging the existing products for a piece of the $107 billion residential repair and remodeling market. One class of products entering the field are wood-plastic composite deckboards and railing systems. These products, knows as WPCs, represent a unique development in the wood industry: an emerging material class based on process and performance innovation with the potential to combine favorable performance and cost attributes of wood and thermoplastics. The marketing problems facing producers of this new material are similar to those faced by any company introducing a new product into an established market. Our research study examines the deployment of an optimal marketing mix for various channel strategy combinations to overcome initial buyer resistance and help producers develop integrated marketing communication strategies. Our reasons for pursuing this line of investigation include: 1) little or no work has been published on optimizing the promotional mix for new or existing products in the wood products field; 2) the selection of a channel is of critical concern to producers of new products and/or technologies; and 3) the implications of integrated marketing communications (IMC), while promising, are at best elusive. This paper will present preliminary results of our primary data collection from various channel intermediaries (buyers) regarding their material attribute preferences, their level of innovation, and how they prefer to be reached and with what message. Additionally, we will discuss the impact and implementation of IMC on this industry and its potential to help producers capture and maintain market share positions.

Decision-Making in the Purchase of Siding: A Survey of Architects, Contractors, and Homeowners in the U.S. Northeast

David T. Damery, Lecturer, and *Paul R. Fisette*, Asst. Prof., Dept. of Natural Resources Conservation, Univ. of Massachusetts, Amherst, MA

Architects, builders, and homeowners in 12 Northeastern states were surveyed to learn how siding, decking, and trim products were selected in new residential construction projects. This study reveals that several issues, do in fact, control the selection and purchase of specific materials and products. Responses in this study define existing market shares of wood and non-wood products in the Northeast region. A profile of buyer perceptions describe the relative importance of performance, cost, appearance, and other factors in the product-selection process. Multiple regression analysis tests the significance and correlation of the demographic data with the decision-making variables. A very small number of homeowners indicate they chose the siding for their home. However, architects and contractors indicate that homeowner opinion was a primary consideration in the ultimate choice of siding. The influence of appearance and performance seems to dominate the effect that cost and personal recommendations have on the selection of siding. Significant attributes include that the siding fits the style of house and that it holds up over time. Respondents were less concerned with the environmental record and service life of their preferred siding. They were, however, concerned that siding may be easily damaged. Installation cost and having a good warranty ranked highest. Other important factors were product reputation and the respondents' first-hand knowledge of the product. Many of these results point to life cycle cost as a driving force in the selection process.

Integrating Marketing Communications and Measuring the Results

Timothy M. Smith, Asst. Prof., Dept. of Wood & Paper Science, Univ. of Minnesota, St. Paul, MN; *Paul M. Smith*, Prof., Sch. of Forest Resources, Pennsylvania State Univ., Univ. Park, PA

Integrated marketing communications (IMC) has received a tremendous amount of attention in the academic press in recent years. However, little empirical research has addressed the impact of these communications on company returns or other industrial marketing mix elements. The following paper examines the effectiveness of two dominant elements of the business marketing mix - trade show and follow-up personal selling efforts - for a woodworking machinery exhibitor. The authors examine the synergy between these activities in terms of direct effects (sales) and indirect effects (product interest), under carefully controlled conditions. They find that, on average, distributors attending the show purchase higher quantities of the product on display than those not attending the show. In addition, the sales generated by the "exposed" distributors required less personal selling effort compared to "unexposed" distributors. The authors conclude by discussing the implication of their research for practitioners and academicians.

Assessment of Information Gaps in the Marketing of Forest Products

Christopher Gaston, Group Ldr., Markets & Economics, and *David R. Fell*, Forest Products Market Researcher, Forintek Canada Corp., Vancouver, BC, Canada

We will present an overview of the main end-uses of wood in the United States including new residential starts, repair and renovation, nonresidential buildings, and industrial applications, and will include a recent study completed by Forintek, "Wood Use in the United States - a Gap Analysis." The study included two major components: 1) a quantitative market segmentation exercise on where wood is used in the United States; and 2)a literature/efforts review on how wood is used. The effort review investigated what we as an industry have done to help wood product suppliers maximize value. Combined, the "gap analysis" on these two components of knowledge identifies and prioritizes future research needs.

Forest Products Industry eBusiness: A Comparison Between the United States and Canada

Richard P. Vlosky, Assoc. Prof., and *Olivian Pitis*, Research Assoc. Specialist, Sch. of Forestry, Wildlife, & Fisheries, Louisiana State Univ. Agricultural Center, Baton Rouge, LA

Experts say that business-to-business eCommerce will grow tremendously in the next several years and bring significant change to most industries. According to Forrester Research, by the end of 2000, business-to-business eCommerce in the United States is expected to reach $251 billion, and jump to $1.4 trillion by 2003, compared with $19 billion in 1997. Increasing competition and globalization are two factors fueling eCommerce growth. In 1998, eBusiness was studied in the context of the forest products industry in the United States and Canada. One thousand solid-wood products and 300 pulp and paper companies were surveyed. The sample frames included the top 100 companies (by production volume) in each sector (solid-wood products, pulp and paper). The remaining companies sampled were randomly selected from the population. Overall, respondents were asked to discuss their current or planned eBusiness strategies and the impacts that this will have on their companies. Results indicated that on average, United States and Canadian respondents began using the Internet at about the same time, mostly between 1996-1998. In addition, respondent expenditures for eBusiness technologies were similar for both countries. Current and planned use of the Internet as a platform for business applications were also examined. Although Canadian respondents have a higher frequency of Internet use (current and planned) for 11 of the 15 business applications studied, the difference in frequency was statistically significant and higher (at a=0.05) only for Internet EDI. Of the four applications used with a higher relative frequency by U.S. respondents, the Internet as a marketing tool was statistically significant (at a=0.05). With regard to extranets, more sophisticated Internet linkages with customers or suppliers, Canadian respondents had a higher frequency of use (current and planned) for 14 out of the 15 business applications (all except the use of email). Frequency of Canadian extranet business application usage was statistically significant (at a=0.05) for "customer contacts", "inventory management", and "purchases from suppliers." These and other results have implications for competitiveness for both U.S. and Canadian forest product manufacturers.

(Session 5 continued Tuesday afternoon)

SESSION 6: Current Topics in Composite Panel Research

The Use of Panel Products by Furniture and Cabinets Manufacturers in the Southern United States

Qinglin Wu, Asst. Prof., and *Richard P. Vlosky*, Assoc. Prof., Sch. of Forestry, Wildlife, & Fisheries, Louisiana State Univ. Agricultural Center, Baton Rouge, LA

Particleboard and medium density fiberboard (MDF) are primary composite panel products used in the manufacture of furniture, cabinets, millwork, moulding, door parts, floor underlayment, laminate flooring, and many other products. The objectives of this study were to understand the southern U.S. furniture and cabinet manufacturer perspective in using these composite panel products relative to a noncomposite panel (plywood), and to determine their selection criteria. The study addresses technical, economic, and performance characteristics. It was found that nearly half of the total value of raw materials used by respondents in 1997 was comprised of these three panel products. In all but one industry sector studied, respondents said that they planned to increase usage of all three panel types. The main reason respondents use these products are that they are economical to use while the main reason that they are not used is customer preferences.

Aspen-Kenaf Composite Boards

Dilpreet S. Bajwa, Grad. Research Asst., and *Poo Chow*, Prof., Dept. of Natural Resources & Environmental Sciences, Univ. of Illinois, Urbana, IL

In the last decade, environmental concerns have dominated the research, technology, and production of forest products. Exploring alternative-fiber resources and recycling the products has been a key issue. Kenaf is another alternative-fiber crop that can substantially reduce the usage of traditional raw materials. This study focused on investigating the feasibility of aspen-kenaf composite boards. The composite boards were made using both kenaf and aspen flakes. Kenaf stems were treated to produce flakes similar to commercial aspen flakes. Two different kinds of boards were produced based on the direction of flakes - homogenous with no orientation and OSBs with strands oriented in cross-directional layers. The other variables included were aspen-kenaf ratio, density, and glue content. The amount of aspen in these aspen-kenaf composite boards varied from 0, 25, 50, 75, and 100 percent. Composite panels had 42 pcf and 46 pcf densities. Phenol-formaldehyde (PF) resin was used at the rate of 4 and 6 percent. These composite boards were made using a press temperature of 400ºF and a press-cycle time of 6 minutes. The mechanical and physical properties of these boards were analyzed, including modulus of elasticity, modulus of rupture, tension strength parallel to face, internal bond strength, thickness swelling, and linear expansion using ASTM standards. Other Kenaf composite panels made from elements of both particles and fibers were also studied.

Development of The Wood-Composite Industry in Malaysia

Salim S. Hiziroglu, Asst. Prof., Dept. of Forestry, Oklahoma State Univ., Stillwater, OK; *Rokiah Hashim* and *Othman bin Suleiman*, Asst. Profs., Sch. of Industrial Technology, Univ. Sains Malaysia, Penang, Malaysia

Malaysia has approximately 25-million hectares of forestland covered by closed forest, which includes almost 60 percent of the total land area. Having such a rich forest resource makes forest products one of the most important industries in the country. The share of wood composite in the overall forest products industry has increased remarkably. Total production capacity of particleboard manufacture has risen from 110,000 m^3/yr. to 630,000 m^3/yr. since 1986. Medium density fiberboard (MDF) was first introduced in the early 1990s and today

peninsular Malaysia has 10 MDF mills with a total production capacity of 900,000 m^3/yr., and a further 210,000 m^3/yr. capacity exists in two more MDF mills in East Malaysia. Today, the Malaysian wood-composite industry plays a significant role in South East Asian markets. Low-quality rubberwood (*Hevea brasilinesis*) and mixed tropical hardwood species are the main raw materials for both particleboard and MDF manufacture. Raw-material properties, manufacturing processes, and further developments such as using palm oil fiber in the wood-composite industry in Malaysia are presented in this study.

Nonwoven and Melt-Blended Composite Panels From Recycled Plastics, Wastepapers, and Natural Fibers

James H. Muehl, Forest Products Technologist, *Andrezj Krzysik*, Scientist, and *John A. Youngquist*, Project Ldr., Forest Products Lab., USDA Forest Service, Madison, WI; *Poo Chow*, Prof., *Charles T. Bowers*, Grad. Student, and *Dilpreet S. Bajwa*, Grad. Research Asst., Dept. of Natural Resources & Environmental Sciences, Univ. of Illinois, Urbana, IL

This report presents the progress of an ongoing research to concentrate on optimizing the manufacturing techniques and testing of air-laid, nonwoven, and melt-blended natural fiber/plastic panels from plant and wastepaper and recycled plastics. These materials could be used in building and farm construction panels and plastic floor tiles that are water resistant and easy to clean. A coupling chemical agent will be used to improve the bonds between the recycled plastic molecules and the plant fibers and wastepaper fibers. To form the panels, two methods of mat forming will be used: 1) air-laid nonwoven mats; and 2) melt-blend technology formed mats using preformulated and palletized stocks. Each series of experiments to be conducted with specific amounts of adhesive, wax, copolymer chemical agent, virgin or recycled post-industrial polypropylene powder, recycled plastic-fiber from soda bottles, and plant or wastepaper fibers. The physical properties including the dimensional stability performance and mechanical properties of the experimental composite panels will be determined and reported.

SESSION 7: Too Many Small Trees in the West: Management and Utilization Challenges

Integrating Silviculture, Harvesting, and Utilization to Achieve Social Goals: Why Sweat the Small Stuff?

Steven D. Tesch, Head, Dept. of Forest Engineering, Oregon State Univ., Corvallis, OR

Large acreages of unmerchantable small-diameter trees have challenged foresters in the West for at least a century. Forest operations involving small-diameter trees have been expensive due to inefficient harvesting practices and historically poor markets for material of this size. Small-diameter trees can contribute to complex stand structures that have intrinsic value for certain types of wildlife habitat and watershed protection. However, when existing stands are dominated by small trees that do not meet societal goals for growth, species composition, or structure, the rate of stand development into desirable characteristics can be very slow. Land managers are becoming increasingly interested in actively managing such stands to improve tree growth, increase resistance to insects and diseases, reduce fire hazard, and promote development of structurally diverse wildlife habitat. Success in actively managing large acreages of such stands requires an understanding of stand dynamics, innovative development of logging systems (i.e., often with mechanized equipment), and research and development on the utilization of small-diameter logs to increase product values. Significant progress has been made in understanding the potential ecological benefits of active management in these stands. The challenges that remain are largely social and economic. A synergistic and systematically focused partnership among silviculturalists, logging-systems specialists, and wood utilization and marketing specialists is critical to meeting this challenge. The purpose of this presentation is to introduce a framework for discussing these issues and to highlight the topics that will be covered by the other speakers in the remainder of the technical sessions.

Silvicultural Treatments for Ecological Restoration in the Rocky Mountains

Carl Fiedler, Research Assoc. Prof., Sch. of Forestry, Univ. of Montana, Missoula, MT

Ecological restoration is a major focus of management efforts on public forestlands in the western United States. Yet, several factors severely limit application of restoration treatments. The first is the propensity for managers to select stands for treatment that are dominated by small trees. Prescriptions designed to initiate restoration in such stands typically require a subsidy to cover the costs of treatment, thereby limiting the acreage that will ultimately be treated. Another obstacle to broadscale application of restoration treatments is the nature of the treatments themselves. The commonly prescribed treatment is thinning-from-below. The objective of this treatment is to reduce or remove the sapling/pole component that provides surface fires an avenue to torch into the overstory. Thinning-from-below typically does not pay for itself, because the trees removed have low value for products. Furthermore, this treatment does not address the shade-tolerant trees in the overstory, nor does it open stands sufficiently to promote regeneration of shade-intolerant species, thereby promoting sustainability. Because a vast array of stands would benefit from restoration treatment, it is critical to select those that already have a large-tree component. It is also critical to prescribe comprehensive treatments that address the ladder fuel problem, the increasing composition of shade-tolerant species, and the high stand density that precludes regeneration of shade-intolerant species.

Harvesting Small Timber: Effective Use of New and Old Technologies

Leonard R. Johnson, Assoc. Dean, College of Natural Resources, Univ. of Idaho, Moscow, ID

The harvest and handling of small timber presents significant economic challenges. These challenges are magnified when additional environmental constraints decrease the density of haul roads, limit the use of mechanized equipment, and limit the density of the trails used to accomplish removal. Operations under these conditions often require a blend of newer harvesting technologies with more traditional or labor-intensive harvesting methods. Several options for blending new and old technologies are discussed with the cost and production results observed in several demonstration research projects. In one instance, trees were felled manually, winched to forwarder trails where they were processed into log lengths, and forwarded to a landing with mechanized equipment. In the second, a mechanized cut-to-length processor worked on steep slopes to cut and process logs for a cable system. In the third demonstration, several options were developed to decrease the density of skid or forwarder trails in harvesting small timber on gentle slopes. These projects were conducted over a 4-year period on public lands in the interior region of the Pacific Northwest.

Processing Alternatives for Small-Diameter Trees: Balancing Scale with Ecological Objectives

R. James Barbour, Team Ldr., Ecologically Sustainable Product of Forest Resources Team, Pacific Northwest Research Sta., USDA Forest Service, Portland, OR

Society's expectations for forests and forestry on public land have broadened considerably in recent years. With those changing expectations have come an enhanced interest on the part of public land managers to provide a range of ecological and social outputs that might include reduced risk of fire, insect

attack, or disease; healthy riparian areas or connected blocks of late-successional forests that provide habitat for threatened and endangered species; high-quality recreational opportunities, etc. Resource managers are finding they must both plan at larger scales then is required for single resource management and operate in stand types they would not typically enter if timber were their primary objective. They frequently face the challenge of changing the structural conditions, developmental trajectories, and patterns of landscapes with a large proportion of relatively high-density stands of small-diameter trees. Management plans frequently call for killing or removing some of these small stems, but the high cost of these operations and the low value of the volume removed can make the implementation of these plans a challenge. This presentation reports on the continuing discussion among resource managers, planners, and policymakers on the merits of different scales of processing facilities from portable sawmill operations to pulpmills.

Regional Industry Infrastructure and Its Influence on Forest Ecosystem Treatments in the Western United States

Charles E. Keegan III, Assoc. Dir., Bureau of Business & Economic Research, Univ. of Montana, Missoula, MT

The infrastructure of the forest products industry can significantly enhance or hinder the land manager's ability to undertake restoration treatments needed to address wide-ranging forest ecosystem health problems in the western United States. Industry infrastructure and the related capability to utilize small and low-quality timber is quite varied and may or may not be compatible with timber products from restoration treatments. For example, sawmills in the northern Rocky Mountain region have relied for some time on small-diameter timber for a high proportion of their raw material mix. Many restoration projects in those areas should produce timber that has a positive value. Managers in regions with an industry infrastructure geared to large logs, or with little or no infrastructure, will find it much more difficult to financially support restoration projects. Restoration projects also produce low-quality material suitable primarily for pulp chips, and the nature of roundwood pulpwood markets varies dramatically throughout the west.

The Sierra Nevada Project: Conservation Through Collaboration

Kent P. Connaughton, Project Mgr., Sierra Nevada Project, Pacific Southwest Region, USDA Forest Service, Sacramento, CA

The Sierra Nevada Framework for Conservation and Collaboration is a joint effort between the Pacific Southwest Region and Pacific Southwest Research Station of the Forest Service to refine policies for managing the 11.5 million acres of national forests in the Sierra Nevada and Modoc Plateau. The approach for policy formulation in the Framework is to employ the latest scientific thinking in a collaborative decision-making approach to federal conservation. Part of this effort is the development of an environmental impact statement to update 11 national forest plans. A draft environmental impact statement was issued May 5 for public comment. It presents eight alternatives dealing with five problem areas: 1) old forest ecosystems; 2) aquatic, riparian and meadow ecosystems; 3) fire and fuel management; 4) noxious weeds; and 5) lower westside hardwood ecosystems. Citizens, elected officials, tribal representatives, land managers, scientists, resource specialists, academics, and interest groups were among the thousands of people who helped identify the problem areas and who have contributed to the ideas represented in the alternatives. The alternatives represent integrated ecosystem approaches to managing simultaneously for solutions to the five problem areas. All alternatives have similar goals for four of the problem areas; 1) they all increase old forests; 2) adopt a common set of aquatic conservation goals; 3) take steps to prevent the spread of noxious weeds; and 4) protect and restore lower westside hardwood ecosystems in the Sierra Nevada. The means for achieving these outcomes varies, as do the environmental, social, and economic consequences. The alternatives vary in both goals and means in dealing with fire and fuel. A fundamental question confronting citizens is whether, and to what degree, they wish to change prospective losses from wildfires; the alternatives provide an array of choices. The environmental, economic, and social consequences vary within the range of alternatives, and represent substantial change relative to recent and past management practices on the national forests. None of the alternatives provide a sustainable supply of timber as an industrial raw material. Instead, all provide varying levels of timber (typically in small diameters) as a consequence of treating the national forests to reduce wildfire losses in the urban wildland intermix and, in the case of several alternatives, in the broader national forest landscape.

SESSION 8: Dynamic Performance of Wood Systems

Dynamic Performance of Wood-Framed Floor Systems with Bridging/Blocking Enhancements

Steve Taylor, Project Ldr., Systems Development, and *George Hua*, Structural Systems Specialist, Trus Joist - A Weyerhaeuser Business, Boise, ID; *Don Onysko*, Consultant, DMO Associates, Ottawa, ON, Canada; *Harvey Manbeck*, Distinguished Prof., Dept. of Agricultural & Biological Engineering, Pennsylvania State Univ., Univ. Park, PA

The concluding report of an industry-funded consortium to the Canadian Construction Materials Center (CCMC) recommended changes to the requirements in the National Building Code of Canada (NBC, 1995) for the development of vibration-controlled span tables. These modifications allowed significant span extensions for both basic floors and extensions related to bridging enhancements. Allowable span increases of as much as 8 feet are possible, based on the effect that bridging has on the point-load response of floors. Field observations suggest that floors built to the longer extended spans with bridging systems do not have the same performance as the unbridged floors at the base span. Furthermore, these span increases result in floors with unsatisfactory dynamic performance and human acceptability. Experiments were conducted on floors fabricated with engineered wood I-joists to demonstrate whether equality in performance was achieved by using bridging in an extended span floor compared with a code minimum base 20-foot unbridged floor built to the same joist spacing, depth, and sheathing specifications. Although the extended span floors at 25 feet with bridging met or exceeded the CCMC deflection limit criterion, it is clear the performance was not equivalent to the 20-foot floor based on ratings of six human evaluators. The predicted and measured fundamental frequencies of all the extended span floors were lower than that of the 20-foot floor. When the span of the extended floor was reduced to 22-feet the bridged and strapped floor was rated by several evaluators as being nearly equal to the 20-foot base floor.

Floor Vibration and Control - A New Floor Vibration Controlled Criterion

Lin J. Hu, Research Scientist, Building Systems Dept., Forintek Canada Corp., Ste-Foy, QC, Canada

Several criteria for controlling vibrations in wood-based floors were evaluated. It was found that none of them properly addressed the effects of such factors as bridging, topping, and long spans on floor-vibration performance. These issues are particularly important for floors in multifamily and commercial buildings. To better address these issues, Forintek Canada Corporation conducted a research project aimed at developing a new serviceability design criterion for multifamily and commercial floors. A total of 133 field floors were tested and subjectively evaluated across Canada using field tests and survey

protocols developed at Forintek. A total of 112 field floors formed a main database on which several forms of a tentative criterion were formulated. They were tested using a new database of 58 floors. The simplest tentative criterion, based on 1 kN static deflection and fundamental natural frequency, performed best. The methods for determining 1 kN static deflection and for fundamental frequency were evaluated using data of 88 floors tested in various laboratories. It was found that these two methods did not handle double-span continuous floors well, but they were promising for single-span floors even though they tended to overestimate the floor stiffness. It is concluded that the tentative criterion developed under this project defines the serviceability limit states for a broad range of wood-based floors. It shows the potential to address the unresolved issues in the criteria already in the codes or proposed. It is recommended that the tentative criterion should be used exclusively with validated data for the time being. Further work is needed to develop a good design methodology for a serviceability design check using the criterion.

Dynamic Response of Wood-Floor Systems - A Possible Nondestructive Evaluation Technique

Robert J. Ross, Supervisory General Research Engineer, Forest Products Lab., USDA Forest Service, Madison, WI; *Michael O. Hunt*, Dir., Wood Research Lab., Purdue Univ., W. Lafayette, IN; *Xiping Wang*, Research Scientist, and *Lawrence A. Soltis*, Retired Research Engineer, Forest Products Lab., USDA Forest Service, Madison, WI; *Zhiyong Cai*, Process Research Engineer, Temple-Inland Forest Products Corp., Diboll, TX

A variety of dynamic testing techniques have been investigated for use in the inspection of wood structures. Currently, nondestructive testing techniques are used to assess individual members in wood structures. The purpose of this research was to investigate using the dynamic response of floor systems as a possible nondestructive evaluation technique for inspection purposes. We conducted a systematic investigation of the response of floor systems to both impact-induced and forced vibrations. Our floor systems were constructed from used, deteriorated joists as well as new joists. A strong correlation was observed between both dynamic methods.

Strength and Ductility of Plywood Shear Walls with Fiberglass Edge Reinforcement

Fernando S. Fonseca, Asst. Prof., and *Trevor R. Pratt*, Grad. Research Asst., Dept. of Civil & Environmental Engineering, Brigham Young Univ., Provo, UT

Thousands of buildings throughout the western United States rely on timber shear walls to resist lateral forces caused by seismic activity. Common failure modes observed in recent earthquakes, however, critically limit wall capacity. These failure modes include nail tear-through and pull-through along the edges of the sheathing. A method of mitigating these failure types was investigated. The method consisted of reinforcing the edges of plywood sheathing with plain-weave fiberglass tape. Thirty plywood coupon specimens were tested using the Sequentially Phased Displacement (SPD) protocol. Twenty coupons were tested plain while 10 were reinforced with fiberglass. In addition, 6 8-by-8 foot shear walls were tested using the SPD protocol. Four walls were tested plain and two were reinforced. The edge reinforcement altered the failure modes by elimination of tear-through and delaying nail pull-through. The strength of the reinforced coupons increased 33 percent while ductility increased 18 percent. The reinforced shear walls experienced strength and ductility gains of 21 and 6 percent, respectively. These results suggest that fiberglass edge reinforcement may be a viable means of increasing the strength and ductility of plywood shear walls to more effectively resist lateral loads from earthquakes.

System Effects and Load Sharing in an L-Shaped One-Story Wood Building

Bo Kasal, Assoc. Prof., Dept. of Wood & Paper Science, North Carolina State Univ., Raleigh, NC; *Greg C. Foliente*, Principal Research Scientist, CSIRO, Melbourne, Australia; *Michael Collins*, Grad. Student, Dept. of Wood & Paper Science, North Carolina State Univ., Raleigh, NC; *Phillip Paevere*, Research Engineer, CSIRO, Melbourne, Australia

A full-scale, L-shaped, one-story light-frame residential wood building was subjected to lateral static monotonic and cyclic loads applied at the ceiling line. The building was instrumented with three-dimensional reaction load cells beneath each wall and displacements were measured at various locations in the house. Diagonal distortions of shear walls and ceiling diaphragm were also recorded. Properties of connections and materials in the building were measured. Shear walls included openings to achieve different stiffnesses for each wall. The load distribution within the structure was measured during the course of loading. Static monotonic and cyclic test results of a perforated shear wall in isolation were compared with a similar wall that is part of the house. The whole-house experimental data was used to verify whole-building analytical models for deterministic and stochastic analyses of light-frame buildings.

Variables Defining Dynamic Performance and Their Impact on Wood Structures

J. Daniel Dolan, Prof., Dept. of Wood Science & Forest Products, Virginia Tech, Blacksburg, VA

As design of wood structures continues to become more rigorous and detailed, the dynamic response of the elements, components, and structural systems needs to be defined in a uniform manner. There are several options and different variables have been proposed for defining the dynamic response of wood structures. Some of the variables currently being used have traditional definitions that are used for structural design for all materials, while other variables are being defined specifically for wood construction. The differences in these definitions are sometimes in conflict with the definitions used by other building-material researchers. The differences can cause committees developing design and building code provisions to penalize wood construction due to a misunderstanding of definitions. Some variables are intended only for use in modeling the dynamic response of wood buildings. To this end, it is important that these variables, such as hysteretic damping versus equivalent viscous damping, be defined in a uniform manner to allow wide use of test results. The current direction of research is to model the response of three-dimensional buildings using cyclic test results for connections and components. While this provides improved prediction of the building response, differences in definitions of variables and the testing protocols used, require the modeler to understand the definitions of reported variables completely. This presentation provides some direction on variables describing dynamic performance and how the variables will be used in design code development to allow the designer to effectively predict the dynamic response of wood buildings.

SESSION 9: Field Investigative Techniques for Wood Science

Field Use of Moisture Meters

Stephen L. Quarles, Research Assoc./Head, Service to Industry Program, Forest Products Lab., Univ. of California, Richmond, CA

The objective of this presentation is to review the construction related field-uses of handheld or portable moisture meters, and will use a case study approach to demonstrate advantages and limitations of these meters in in-service conditions. Basic information regarding potential uses will be reviewed. Examples will focus on resistance- and capacitance-type meters, but

meters based on other sensing techniques, such as infrared, will be discussed to a lesser degree. Specific topics that will be covered include: 1) the use of resistance (pin) meters to evaluate the condition of large solid-wood or glued-laminated beams; 2) the use of capacitance meters to evaluate the moisture content of construction materials behind siding; and 3) the effect that certain treatments can have on meter performance. Some nonstandard applications, based largely on projects conducted by the UCFPL Service to Industry Program, will also be discussed. Moisture meters have proven to be powerful tools in investigating in-service performance problems, however in order to effectively utilize them, it is important to understand the limitations of meters, and the significance of relative moisture contents changes and meter readings on the wood product being examined.

Geometry: The Key to Moisture Content History

William A. Dost, Consulting Wood Technologist, El Cerrito, CA

The moisture content (MC) of lumber is often a characteristic of critical concern to users at the time of fabrication, assembly, or installation because of its direct link to size; yet changes in MC can occur rather rapidly with changes in the surrounding environment. Failures can result if the difference between actual MC and optimum MC for the purpose are too great. The resulting losses, when significant, can lead to litigation and a request to establish fault. Simple measurement of MC is meaningless by the time the question is received. This presentation will discuss methods that allow this difficulty to be addressed. Techniques by which the problem can be approached in a rational way are available, based on an understanding of the size/MC relationship. An assumption is made about the initial condition, and must be based on an understanding of industry practices or on careful observation and measurement. A limited amount of destructive investigation is usually required, followed by laboratory testing and analysis to determine the actual size/MC regression equation for individual pieces. These are quite accurate and typically have correlation coefficients (r^2) of 0.97 or better. Any result with an r^2 lower than 0.95 suggests an error of measurement or calculation and should be discarded and the work repeated. The author has used the technique frequently and in a variety of ways. Examples chosen to illustrate the range of possibilities will be discussed.

Assessing the Condition of Heavy Timber Buildings

Albert L. De Bonis, Pres., and *Matthew E. Anderson*, Wood Technologist, Wood Advisory Services, Inc., Millbrook, NY

We are often contacted by architects, engineers, or builders who are interested in rehabilitating older wood buildings. Frequently, these professionals do not fully understand the complexities associated with evaluating the residual strength of existing wood members. Often these professionals are only interested in obtaining design stresses. Unfortunately, they don't realize that these members generally need to be evaluated for the influence of deteriorating agents such as wood decay, that they will need to be visually graded, and that in many instances, evaluation of residual strength may be required through nondestructive methods. The procedures and equipment discussed here apply only to the evaluation of structural wood members for the presence and extent of wood decay. The other two components, visual grading and residual-strength evaluations, will not be discussed, but are equally important in providing a responsible, overall evaluation of older wood buildings.

Leaky Logs, Weepy Windows, and Faulty Flashing

Joseph R. Loferski, Prof., Dept. of Wood Science & Forest Products, Virginia Tech, Blacksburg, VA

This paper presents three case studies in which investigative techniques in the field of wood science and forest products were used to analyze problems of wood performance in buildings. 1) In a newly-constructed log home, the owners observed that water leaked through the solid log walls during and after rainstorms. The parties involved (a log home company, a building inspector, and a coating and sealant company) identified the problem as improper construction on the part of the builder. However, the owners insisted that the building had been constructed properly. The investigation showed that wood anatomy was not considered in the manufacture of the logs, resulting in checks that penetrated through the walls. 2) This case involved epoxy and paint coatings in the restoration of the Thomas Jefferson Building of the Library of Congress in Washington, DC. Within 1 year after restoration, the finish on many historic windows had failed. Hundreds of wood-framed windows had already been treated with hundreds more to go, and the question was, "What caused the failures and how could it be avoided?" Samples were taken and various microscopic techniques including FTIR, fluorescence, and white-light microscopy were used to analyze the coatings to develop solutions to the problem. 3) Flashing in new construction near windows, doors, and the corners of the building caused paint failures and rotting wood. The problem was investigated. It was determined that the flashing was in direct contact with the back of the siding, causing condensation, which lead to the failures.

Analyzing Broken Ladders and Scaffold Planks

George H. Kyanka, Prof., Dept. of Construction Management & Wood Products Engineering, State Univ. of New York, Syracuse, NY

Wood ladder and scaffold components are involved in the investigations of falls experienced by a variety of users. Broken wood parts are assigned as casual factors because of perceived design or material property shortcomings. Often, investigators with little knowledge of wood find that such things as areas of compression wood, decay, compression wrinkles, or residual drying stresses have caused nearly spontaneous failures. On many investigations, it is necessary for the wood scientist to sort out theories that work on metal or reinforced plastics and explain how they don't apply to wood. Several examples of mis-engineering applied to both ladders and planks are covered. An area often misunderstood in evaluating failures in these products is that of actual in-service force distributions. Although a ladder is a simple structure in concept, the sharing of loads among members is quite complex. The static evaluation of a straight ladder leaning against a wall is, in fact, an indeterminate problem. Some basic force analysis and testing results will be presented to illustrate these concepts. Another factor useful to an accident investigator is the behavior of wood under dynamic loading. Fracture patterns and morphology can be used to determine direction of load, impact effects, and sequence of component failures. Some applications to scaffold plank evaluation will be given. Some questions currently under review by both ANSI Ladder and Scaffold Committees will be presented for consideration.

Wood Science and Technology in the Courtroom

Stephen Smulski, Pres., Wood Science Specialists Inc., Shutesbury, MA

Offered in a courtroom for the first time during the Lindbergh kidnapping trial of 1935, forensic evidence gleaned from wood has since been presented in numerous criminal and civil cases. Use of wood evidence in criminal matters is largely limited to linking a suspect to the crime. Connections are made, for example, by showing that nicks in the blade of a chisel in a suspect's possession match the tool marks left on a jimmied window sash of a burgled house. In civil suits, wood evidence can be employed for a wide range of purposes. Examination of wood products in architect/contractor/ owner building performance disputes, for example, is crucial in sorting out whether design features, construction practices, maintenance, and/or the products themselves are to blame. The same is true in product-liability class-action litigation in which the wood product is

claimed to be inherently defective, and thus unfit, for its intended use. In personal-injury lawsuits, information obtained by inspecting the fracture surfaces of the broken wood product allegedly at fault is invaluable in validating or vanquishing a plaintiff's version of events.

TUESDAY AFTERNOON, JUNE 20

SESSION 5: Creating Value Through Marketing and Communication

(continued from Tuesday morning)

Lumber-Price Forecasting Using Time-Series Methods

David T. Damery, Lecturer, Dept. of Natural Resources Conservation, Univ. of Massachusetts, Amherst, MA

Manufacturers, wholesalers, dealers, and builders depend on timely pricing data in the course of annual business operations. Readily-available forecasting methods can be used to assist businesses in their purchase and production decisions. Research results are presented comparing several time-series forecasting methods using a 10-year (1987-1997), monthly data set of red oak flooring prices and shipments. The strengths and weaknesses of these models were presented. A number of nonseasonal and seasonal time-series forecasting methods are used to forecast lumber shipments and prices. Within-sample and ex-post predictions were made and confidence intervals measured. Modeling assumptions of the various methods were discussed. Performance of individual models were discussed and compared to the performance of a composite model utilizing several forecasting methods. Time-series models studied include: naive, decomposition, Holt-Winters, Box-Jenkins, and vector autoregression. Modeling techniques, assumptions, strengths and weaknesses for each are presented. Their performance in predicting one-period-ahead pricing was presented. Preliminary results indicated superior performance using the Box-Jenkins and composite models. The importance of testing for trend and the presence of unit roots and the role of stationarity were discussed. The general time-series forecasting techniques presented can be used across a broad spectrum of the forest products industry. The example of red oak flooring prices is used but the methods presented can be used in forecasting any hardwood and softwood lumber items for which time-series data are available. Any business with a need to estimate future primary forest products prices or shipments can make use of the techniques.

Development of an Effective Marketing Communications Network for the Successful Transfer of Technology: A Study of Portable-Bridge Technology Diffusion

Ren-Jye (Marshall) Shiau, Dept. Head, Dept. of Business Administration, Yu-Da Inst. of Technology, Miao-Li, Taiwan

The ability to use scientific or engineering advances (new technologies) to meet market needs has become a primary business success factor. New technology is also a major factor influencing growth and productivity within a firm. However, the forces that lead to technological innovation are not always from inside the firm. Often a company receives technology (technology push) from outside sources. However, the transfer process is not always smooth. Public-sector research represents an important source of technology. In the major Western industrialized countries, government and university research organizations account for over 40 percent of the national research and development (R&D) expenditures. However, many technology transfer efforts between public (federal government) and private sectors have been disappointing. In the Wood in Transportation Program (WIT), the USDA Forest Service has exerted considerable effort in transferring timber bridge technology to private industry. However, much of this effort has focused upon permanent bridge structures for highway or pedestrian use. Little research has been conducted on how to facilitate technology transfer via an information-flow system to the target users. Another potentially large market may exist for portable timber bridges for use in forestry and logging operations. The main goal of this study was to evaluate the information flow through the entire logging system and identify intermediaries who can help the WIT Program facilitate technology transfer. This study utilized a unique backward trace method to gain an understanding of how innovations are diffused. The research consisted of the three following steps to attain the final goal of developing strategies to successfully diffuse portable timber bridge technology from public research sectors to private sectors. 1) The research evaluated how the final users (loggers) receive information, why they prefer certain channel(s) over others, and how they make decisions to use or not use technology from the developer (WIT). 2) Intermediaries in the technology transfer process were identified by loggers and they were evaluated on how they receive information from technology developers; how they evaluate the information; and how they currently promote and diffuse ideas or innovations. 3) Technology developers were evaluated on how they currently promote and diffuse ideas or innovations. Upon analysis of the network of information flow, a strategic marketing plan for successful transfer of portable timber bridge technology was developed.

Exploratory Analysis of Market Potential for Tropical Hardwood Lesser-Used Species from Ghana

Kofi Poku, Grad. Research Asst., and *Richard P. Vlosky*, Assoc. Prof., Sch. of Forestry, Wildlife, & Fisheries, Louisiana State Univ. Agricultural Center, Baton Rouge, LA

Increasing demand for traditional market species of Ghanaian timber has led to dwindling stocks and quality within the Ghanaian tropical forest. As a result, there is a pressing need to introduce lesser-used species (LUS) to serve as substitutes. LUS are recognized to provide an important solution to unsustainable management of the tropical forest, even though many companies do not use them in their raw material mix. This poster will provide results of an exploratory market study of *Alstonia boonei*, *Petersianthus macrocarpus*, and *Ricinodendron heudelotti*, three potential LUS from Ghana. Results indicate that a majority of Ghanaian forest products manufacturer respondents are willing to use *Petersianthus macrocarpus* in their raw material mix, provided export buyers or manufacturers are willing to accept them. There is very little interest in the other two species. Overall, it is perceived that export buyers will not accept LUS products in the marketplace unless there is adequate technical information and effective marketing strategies.

Effective Marketing Promotion for Southern Pine Lumber Using Interactive CD Technology

Richard Wallace, Dir. of Communications, Southern Forest Products Assn., Kenner, LA

Traditional methods of communicating a comprehensive, long-term marketing plan have been very limiting, both in terms of usefulness over the life of the plan, and in the suitability of the entire presentation to a specific audience segment. Promotion of southern pine lumber products by the Southern Pine Council to a large number of market segments involves a myriad of tactics, messages, and vehicles to carry those messages. One solution to these information delivery problems was an interactive CD program. Users can study individual “key priorities,” noticing the marketing tactics to be undertaken to accomplish a specific goal. Inclusion of both portable document files (PDFs) and video clips offer supplementary information related to reaching the goal. In addition, convincing case studies, and a convenient reference to the vast marketing resources of the sponsoring organization are provided. A direct link to the sponsor's website offers additional details. A single-screen budget summary

explains funding for the program's current year; users can select any line-item for instant replay and review of the specifics. During the initial setup to run the CD program, a folder is created on the user's hard-drive to accept annual updates (including budgets) as they are created and approved by the sponsor's membership. The ability to update the program via the Internet also permits market priorities to be added or subtracted from the overall program as the market conditions warrant.

Overcapacity in Structural Panels? Possible Solutions to an Age-Old Problem

Albert T. Schuler, Research Economist, Northeastern Research Sta., USDA Forest Service, Princeton, WV; *Craig Adair*, Dir. of Market Research, APA - The Engineered Wood Assn., Tacoma, WA

All commodities, including some wood products (e.g., pulp, newsprint, containerboard, lumber, and MDF) and many non-wood products (e.g., metals, agriculture products, oil and minerals) have a tendency to add too much capacity over a short period of time. The following is a typical scenario: a strong economy/demand leads to higher prices that drives profits, cash flow, confidence, and desire to invest. This makes sense for individual firms; however when everyone does it, industry-wide overcapacity is often the result. Structural panel prices have been good for the past few years thanks to a very robust U.S. housing market and about 6 BSF (3/8") new Greenfield OSB capacity is expected to be installed by the year 2002. Existing applications favor residential construction; however, we are fast approaching saturation, particularly in new housing. Although opportunities exist in nonresidential construction markets, industrial applications, and offshore exports, capturing market share from plywood and other building materials will be challenging. For example, for OSB to capture market share in new markets, better product performance may be needed including stabilized/conditioned boards, fire-resistant boards, insect resistant boards, etc. In addition, improved product performance will be needed just to fight off steel, concrete, and other potential competitors in existing markets. If new markets are not found, the opportunity costs may include years of low margins and intense competition. There are opportunities, but we need innovative strategic thinking that includes new and modified products. And, we must learn how to promote wood products more effectively to all categories of customer and stakeholders including specifiers, users, and the general public.

Identifying Substitution Opportunities for Engineered Lumber Products in the Modular Housing Industry

Sara J. Gurney, Forest Products Marketing Specialist, Ohio State Univ. Extension, Piketon, OH; *Cynthia D. West*, Dept. Head, Forest Products Lab., Mississippi State Univ., Mississippi State, MS

The modular housing industry for the Mid-Atlantic region was evaluated in order to ascertain the current and future structural building material needs for this industry. It was felt that this industry was an important and growing segment of the industrialized housing market, but as yet, little or no information was available concerning their material usage and needs. A survey was mailed to 39 modular housing companies located in the MidAtlantic region. Following the survey, 19 of these companies participated in personal interviews. The combined response rate from the survey and interviews was 82 percent. The most important findings were that homes produced by this industry were becoming larger and more customized in order to compete with stick-built housing. Since 1992, producers have been increasing the amount of engineered lumber used per unit in order to overcome design constraints. Decreases in the quality of dimensional lumber was a high concern to companies and may prompt an increase in the use of engineered lumber over the next 3 to 5 years. The results of this study will lead to a better understanding of how structural building materials are used by this industry and create future opportunities for the use of engineered lumber products.

WEDNESDAY MORNING, JUNE 21

IAWS LECTURE

Tannery Row - The Story of Some Natural (and Synthetic) Wood Adhesives

A. (Tony) Pizzi, Prof., Industrial Chemistry, ENSTIB, Univ. of Nancy, Epinal, France

Tannin adhesives are a relatively old, but limited speciality that has become again topical with the very marked environmentally-friendly outlook of wood science at the beginning of the new century. This lecture will intermingle the technical experience of the author with some humorous stories on the early and not so early beginnings of this speciality. This will be a brief introduction to more recent scientific/technical developments on synthetic thermosetting adhesives and natural adhesives and will include in a very brief form some of the author's experiences with synthetic (and some natural) wood adhesives, and in other fields of wood science and wood technology which might have or have had an impact on the advancement of this field.

SESSION 10: Green Chemistry for Wood Adhesives

Adhesives from Renewable Raw Materials: Design of Adhesives Based on Starch Technology

Robert W.R. Humphreys, Divisional Vice President, Adhesives R&D, and *Daniel B. Solarek*, Senior Research Associate, Natural Polymer Research, National Starch & Chemical Co., Bridgewater, NJ, USA

Starch is a plant carbohydrate reserve material that is easily isolated in huge quantities from agricultural staples such as corn, potatoes, and tapioca root. Formally a condensation polymer of glucose, starch properties depend greatly on the plant source and, in fact, plant biochemistry can be manipulated through both modern breeding methods and biotechnology to produce "designer" starches. Coupled with techniques for physical and chemical modification, industrial starch chemistry has a richness that is unmatched by other polysaccharides. This presentation will begin with a discussion of the structural features of starch and the relationship between the molecular structure of starch and starch properties. It will become apparent that starch molecular architecture and properties depend markedly on the plant source. An overview of how physical and chemical modifications can be applied to the "chosen" starch to alter and fine-tune the physical properties to fit a given application. In this way, modified starches can be employed in materials as diverse as paper additives, adhesives, encapsulants, films, and foams. In many cases, these materials retain the biodegradability inherent in the starch and, thus, are truly renewable. Finally, the potential for such starch-derived materials in wood applications will be discussed.

Wood Adhesives from Biomass: Adhesive Formulation and Optimization Using Thermal Analysis

Bernard Riedl, Senior Prof., Dept. of Wood Science, and *Christian Roy*, Senior Prof., Dept. of Chemical Engineering, Univ. Laval, Ste-Foy, QC, Canada; *Felisa D. Chan*, Post-Doctoral Fellow, Forintek Canada Corp., Ste-Foy, QC, Canada; *Carlos Amen-Chen*, Ph.D. Candidate, Dept. of Chemical Engineering, Univ. Laval, Ste-Foy, QC, Canada

Phenol-formaldehyde (PF) resins are the most prevalent form of adhesives for exterior-grade composite-board products such as OSB and plywood and for composite lumber such as LVL

and I-beams. Part of the phenol can be replaced by wood bark pyrolysis oil (PO). This oil contains a large number of chemical products, some with the characteristics of phenolic compounds. Different adhesives have been made by varying the F/P-PO ratio, the time of cooking, the NaOH/P-PO ratio and other parameters. The curing characteristics of these pyrolysis oil-phenoformaldehyde (POPF) adhesives have been determined as a help to define the best formulations. Such an approach must distinguish between the speed of cure and the amount of cure. We can easily characterize speed of cure. Generally, the faster the better, but in wood adhesives too much of a good thing (i.e. speed) can result in pre-cure. These kinetic considerations do not tell us about the total amount of chemical bonds formed that determine the final bond-forming capacity of the adhesive. What we need is to compare both the speed and absolute, not relative, extent of the curing reaction. Accordingly, we have done adhesive cure modelization, through DSC isoconversional techniques, of different formulations and these results will be compared to, or correlated with, the different composite-board properties. This approach should result in time savings for evaluation of such adhesives, as board manufacture and testing is quite tedious and involves many other factors. The effect of post-cure and speed-enhancing additives could also be followed. This work should provide new insights in the thermal analysis of such thermosetting adhesives.

Development of Phenolic Resins Co-Reacted with Soy Flour Hydrolyzate

Chung-Yun Hse, Research Wood Technologist, Southern Research Sta., USDA Forest Service, Pineville, LA, USA; *Feng Fu*, Research Scientist, Research Inst. of Wood Industry, Chinese Academy of Forestry, Beijing, China; *Ben S. Bryant*, President, Fiber Research International, Inc., Seattle, WA, USA

A series of experiments was performed that led to the development of a co-reacted phenolic adhesive made by substituting up to 30 percent of the phenol content with a hydrolyzate that is directly prepared from low-cost soy flour. First, eight soy flour hydrolyzates, each with three replicates, were prepared in a factorial experiment that included two hydrolization conditions: two caustic-to-soy flour (C/SF) ratios (0.79 and 0.39) and four phenol-to-soy flour (P/SF) ratios (0/4, 1/4 2/4,and 3/4). The phenol-based resin adhesives formulated from these hydrolyzates to a final molar ratio of formaldehyde-to-phenol-to-caustic (F/P/C) at 1.65/1/0.65 were used in fabrication of OSB panels and the panels were tested for internal bond strength (IB). On average, the hydrolyzates prepared from high caustic content (0.4 moles) yielded significantly higher IB (78 psi) than the IB (66 psi) of the low caustic content (0.2 moles). It is interesting to note that IB increased from 74 psi to 87 psi as the P/SF ratio increased from 0/4 to 3/4 for high caustic content; while for low caustic content, the differences in IB among P/SF ratios were not significant. To optimize resin preparation, 34 resins were formulated. The gluebond performance of the panels fabricated from the resin adhesives were evaluated in terms of IB, modulus of rupture (MOR), modulus of elasticity (MOE), thickness swell (TS), and linear expansion (LE). The ranges and (averages) for IB, MOR, MOE, TS, and LE, respectively, were 62 to 105 psi (84.4 psi), 3942 to 6405 psi (4965 psi), 628,800 to 869,200 psi (729,600 psi), 22.1 to 38.9 percent (29.4 %), and 0.26 to 0.47 percent (0.33 %). The most important variables in controlling resin reaction were viscosity, temperature, and caustic additions. Optimum reaction conditions were achieved by increasing the reaction temperature to 85ºC in 60 minutes, maintaining that temperature to develop a resin viscosity of 8500 - 14000 cps, followed by stepwise decreasing of the reaction temperature and making additional caustic additions as required. The reaction was terminated when resin viscosity reached 400 to 700 cps. To evaluate the effect of reactor size on resin preparation, the resin preparation was scaled-up from a 1-liter to a 3-liter reactor. The average IB decreased from 80.7 psi (averaged of 7 resin replications) to 70 psi (averaged of 2 resin replications) when the reactor size increased from 1- to 3-liters. Accordingly, adjustments were made of reaction temperature and caustic addition, and the average IB was increased to 102 psi (averaged of 4 resin replications). The resin preparation was further scaled-up to a 19.9-liter reactor and the gluebond performance was compared with the commercial phenol formaldehyde (PF) resin. The co-reacted soy resins yielded a slightly higher average IB (101.3 psi) than that (100.0 psi) of the commercial PF resins with OSB panels pressed at 370ºF for 5 minutes with a resin content of 4.5 percent. However, the co-reacted soy resin resulted in substantially lower IB (85.2 psi) than IB (100.5 psi) of the commercial PF resin when panels were pressed at 370ºF for 3.5 minutes. It is generally agreed that high F/P ratios enhance resin cure. Thus, the low F/P ratio of co-reacted soy resins (i.e., 1.69) as compared to the F/P ratio of 1.9 to 2.1 for most of commercial PF resins is considered to be one of the major factors affecting the slow curing of the soy resins.

Some Recent Studies on Soy Protein-Based Wood Adhesives

Bhima R. Vijayendran, Senior Program Mgr., and *John Clay*, Principal Research Scientist, Battelle Memorial Inst., Columbus, OH

There is renewed interest in the use of soy-protein-derived adhesives in the bonding of wood products and manufacture of fiber composites. The main driver for this trend is improved performance offered by soy-protein hydrolysates in combination with formaldehyde-based resins at reasonable economics. Recent work has shown that soy-protein hydrolysate in combination with phenol resorcinol formaldehyde resin can effectively bond wet lumber at room temperature in the finger-joining of various species of wood. In this paper, we have attempted to highlight some of the recent developments in the use of soy-protein-derived wood adhesives. Our focus was on a better understanding of some of the fundamental parameters of soy protein that influence its performance as a wood adhesive in combination with phenol formaldehyde (PF), urea-formaldehyde (UF), and phenol resorcinol formaldehyde (PRF) resins. In a typical wood-adhesive formulation, the complex soy-protein structure is broken down by hydrolysis to lower-weight fragments with more of its functional groups such as amine and carboxyl readily available for reaction with PF, PRF, and UF resins. We have correlated hydrolysis conditions of soy protein such as time, temperature, pH, and source of protein (hydrolysate vs flour) on properties of the resultant hydrolysate. Some of the properties studied are molecular weight and its distribution, amine functionality, and rheology. Reaction of the hydrolysates having various levels of amine functionality and molecular weight with PRF and PF resins are characterized for their rate of gelling, physical, and mechanical properties of cross-linked gels. Hydrolysates having different molecular weights, amine functionality, and protein levels are evaluated in PRF-based wood-adhesive formulations in the finger-joining of dry and wet lumber. Wood-bonding properties such as green strength, ultimate tensile strength, and woodfiber tear of finger-joints made with the adhesives are correlated to some of the properties of soy-protein hydrolysate and their gelling chemistry.

Adhesives from Modified Soy Proteins

X. Susan Sun, Asst. Prof., and *Zhikai Zhong*, Research Assoc., Dept. of Grain Science & Industry, Kansas State Univ., Manhattan, KS

Soy-based adhesives were developed first in 1923 when a patent was granted for a soy-meal-based glue, which was soon replaced by petroleum-based adhesives because soy-based adhesive was often low in bonding strength and water resistance. The goal of this research was to develop formaldehyde-free adhesives from soybean proteins, and to evaluate the adhe-

sive performance for plywood applications. Soy proteins were unfolded into different degrees by using sodium dodecyl sulfate (SDS) and guanidine hydrochloride (GH). One percent SDS and 0.9M GH modification gave the soy protein higher shear strength and the highest water resistance in all wood types. No delamination was observed for the 1 percent SDS and 0.9MG-modified adhesive. The bonding strength of the 1 percent SDS-modified adhesive was reduced by about 10 percent and about 50 percent for the 0.9MGH-modified adhesive as compared to bond strength prior to the water-soak test.

Performance of Tannin Resins and Blends as Wood Adhesives in the European Panel Industry

Peter Stracke, Technical Mgr., R&D Phenolic Resins, and *Willi Roll*, Vice Pres., Bakelite AG, Duisburg, Germany

Today within the woodworking industry, raw materials and manufactured panels are carefully scrutinized from an ecological and environmental point of view. These considerations relate primarily to worker and consumer health safety, efficient consumption of recycled energy, and effective use of residual by-products. The limited availability of fossil fuel resources requires a constant search for alternative raw material components, especially wood adhesives. If successful, it should result in the reduction or, if possible, the substitution of petroleum-based raw materials for wood adhesives. Tannin-based wood adhesives as a possible renewable resource offers this opportunity. This presentation describes the current state of tannin-based wood adhesives used for the production of chipboard (particleboard) and medium density fiberboard(MDF). Laboratory panel tests and industrial trials using tannin-resin systems, as well as combinations with phenolic resins are discussed and the benefits of each system are described. The adhesive system consisting of tannin/phenolic demonstrates that exterior-grade panels can be produced at pressing speeds normally obtained with MUPF and PMDI-based adhesives.

SESSION 11: Update in Wood Machining

Use of High-Speed CNC Routers in Furniture Manufacturing

William F. Reiter, Jr., Prof., Dept. of Mechanical Engineering, Oregon State Univ., Corvallis, OR

The use of high-speed CNC routers is shown to be economically beneficial in the manufacture of furniture that requires large numbers of relatively rough-cut wood pieces. A typical application is the manufacture of upholstered furniture where nests of parts are cut from 4- by 8-sheets of plywood or wood composites. Critical issues in the design of high-speed CNC routers are discussed. These include the characteristics of the spindle, the movable machine parts, the cutter, workpiece hold-down strategies, and the CNC controller. These issues are discussed in terms of a CNC router system solution to high-speed machining in wood and wood composites. Current examples and limits in high-speed wood machining are presented.

Vibration and Balance Problems in Wood Machining

John S. Stewart, Prof., Dept. of Wood & Paper Science, North Carolina State Univ., Raleigh, NC

Vibration problems are responsible for a wide range of manufacturing problems in the wood-processing industry and often result in increased machine maintenance costs, reduced tool life, and poor workpiece surface quality. This presentation provides an overview of the range of problems associated with machine/tool vibration; including case histories for several wood machining applications. The case histories include vibration-related bearing failures on CNC router spindles, carbide tool damage caused by spindle vibration, the effect of tool unbalance on surface quality produced by feed-through moulders, and cut quality problems associated with sawblade unbalance. Procedures for correction of these problems through proper tolerancing and balancing procedures are covered. The elimination of vibration problems associated with wood machining can significantly increase productivity and improve wood utilization.

Surface Generation, Modeling, Assessment, and Optimization in Wood Machining

James B. Taylor, Asst. Prof., Dept. of Industrial Engineering, *Richard L. Lemaster*, Research Dir., Wood Machining & Tooling Research Program, and *Andres L. Carrano*, Research Asst., Dept. of Industrial Engineering, North Carolina State Univ., Raleigh, NC

The actual and perceived quality of machined surfaces has long been of great concern to the wood industry. Reducing the costs associated with generating surfaces and having the ability to optimize resources has been and continues to be a concern as well. This talk will outline state-of-the-art surface generation, modeling, assessment, and optimization in wood-machining applications. The interaction of the tool and workpiece for the generation of surfaces has been studied in both knife and abrasive machining. The latest in computer modeling, visualization, and optimization techniques will be presented for an abrasive machining operation, while a case study and the results of extensive experimentation will be reported. The capabilities and use of a laser-based optical profilometry system will also be reported.

Electrical Discharge During Machining of Dry Wood Products

Harold A. Stewart, Research Scientist, Forest Products Lab., Mississippi State Univ., Mississippi State, MS

Electrical potentials among the workpiece, chips, and tool have been shown to be generated when cutting green and dry wood. The voltages have been reported as relatively constant. A series of turning tests on medium density fiberboard (MDF) were undertaken in wood machining. The results indicated numerous discharges generally between the chips and MDF-workpiece (cathode) to the tool (anode). However, voltage and current reversals or discharges also occurred. The possibility of an electrical discharge machining effect on tool wear is also discussed. These electrical discharge characteristics from wood machining could provide insight into wear mechanisms for dry wood and wood products as well as for other dielectric materials.

Machining of Composite Boards

Darrell Wong, Assoc. Dir., Centre for Advanced Wood Processing, Univ. of British Columbia, Vancouver, BC, Canada

Particleboard (PB) and medium density fiberboard (MDF) are major panelboard materials often used in the manufacture of value-added wood products such as furniture and cabinets. Unfortunately, when PB and MDF are sawn or profiled, the cut edges and surfaces are substantially impaired by particle tear-out and void formation. The resulting roughness makes the material difficult to glue, edge-band, or laminate. The cost of the surface treatment required to rectify the edge damage and surface roughness is among the highest in the manufacturing process. Optimal selection of the panelboard manufacturing conditions and of subsequent machining parameters presents an opportunity for a substantial reduction in these costs. However, despite the importance of PB and MDF and their associated machining process parameters, very few specific details are available to give an in-depth understanding of the many process factors and their interactions in the formation of the cut edge and surface. Therefore, machine operators and production managers often find it difficult to set-up and troubleshoot PB and MDF processing effectively. This presentation will discuss the panelboard surface and edge characteristics required by value-added wood product manufacturers and the critical parameters that are important during machining. In-progress results of this machining study will be presented.

SESSION 12: Quality and Process Control: State-of-the-Art in the Forest Products Industry

Real-Time Applications of Statistical Process Control

Thomas C. Maness, Assoc. Prof, and *Robert Kozak*, Asst. Prof., Dept. of Wood Science, and *Darrell Wong*, Assoc. Dir., Centre for Advanced Wood Processing, Univ. of British Columbia, Vancouver, BC, Canada

(Abstract not available at time of printing.)

Quality Assurance for Value-Added Wood Products

Robert Kozak, Asst. Prof., and *Thomas C. Maness*, Assoc. Prof., Dept. of Wood Science, and *Darrell Wong*, Assoc. Dir., Centre for Advanced Wood Processing, Univ. of British Columbia, Vancouver, BC, Canada

Third-party quality assurance has long been embraced by many industrial sectors. Systems like the ISO 9000 series have proven to be an effective means of improving a company's quality, production, and ultimately profitability, to name a few examples. In addition, independent and unbiased quality assurance marks are an effective means of promoting high-quality products, building global demand, and increasing the likelihood of customer acceptance. However, despite these obvious benefits, such programs are relatively rare, and in many instances unknown, in the value-added wood-products industry. This paper examines the process of quality assurance, providing specific examples of systems that are currently in place in other sectors of the economy. Results from a 1998 survey of British Columbia's value-added wood-products industry on issues pertaining to quality are also presented. In general, British Columbia's value-added producers have not yet embraced the notion of third-party quality assurance. Nor are they engaged in formal quality-control activities of any sort, for the most part. In fact, value-added wood producers' definition of quality seems to be very different from that of their customers. All of the above points to the fact that the widespread adoption of a third-party quality-assurance program will prove very challenging in the value-added wood-products industry, perhaps requiring a paradigm shift in how the term “quality” is perceived. One possible solution would be the introduction of an industry-specific quality- assurance organization devoted exclusively to improving the global competitive position of the wood industry through the promotion of quality standards and principles related to wood.

The Impact of Statistical Process Control on Reducing Hardwood Lumber Target Sizes and Thickness Variation: A Case Study

Timothy M. Young, Asst. Prof., Tennessee Forest Products Center, Univ. of Tennessee, Knoxville, TN

The use of statistical process control (SPC) as a methodology for continuous improvement in manufacturing has been well documented. A technology feasibility case study was conducted at a hardwood sawmill in Tennessee to determine if real-time SPC had an effect on reducing hardwood lumber target sizes and thickness variation. Human machine interface (HMI) platforms for real-time display of thickness data in a SPC format were developed at the headrig, resaw, gangsaw, grading station, and manager's office. Remote access of the system was also available via phone modem. Wireless calipers were used in conjunction with a programmable logic controller (PLC) for data acquisition. The short-term effect 1 month after installation of the real-time SPC system was a reduction in target thickness sizes of approximately 0.060 inch for red oak (*Quercus rubra* and *Quercus falcata*) 4/4 lumber. No short-term effect in thickness variation was experienced. The long-term effect 12 months after installation of the real-time SPC system was a reduction in target thickness sizes of red oak 4/4 lumber of 0.130 inch (1/8 in.). The standard deviation of red oak 4/4 lumber over this same 12-month period was reduced from 0.045 inch to 0.030inch. Reductions in thickness standard deviation were the result of root-cause analysis of special-cause sources of variation, e.g., cants not square, operator change, feed-rate, etc. Improvements in financial performance from reductions in lumber target sizes and thickness variation were significant. Return on investment from the initial $12,500 installation costs of the real-time SPC system were substantial.

Evaluation of Multi-Sensor Machine Vision Systems for Automated Lumber Grading

D. Earl Kline, Assoc. Prof., and *Christopher E. Surak*, Grad. Student, Dept. of Wood Science & Forest Products, Virginia Tech, Blacksburg, VA; *Philip A. Araman*, Project Ldr., Southern Research Sta., USDA Forest Service, Blacksburg, VA

Over the last 10 years, scientists at the Thomas M. Brooks Forest Products Center, the Bradley Department of Electrical Engineering, and the USDA Forest Service have been working on lumber-scanning systems that can accurately locate and identify defects in hardwood lumber. Current R&D efforts are targeted toward developing automated lumber-grading technologies. This study evaluates hardwood lumber grading accuracy based on current state-of-the-art multiple-sensor scanning technology that uses laser profile detectors, color cameras, and an x-ray scanner. Eighty-nine red oak boards (originally graded by a line grader) were scanned and graded using Virginia Tech's multiple-sensor scanning system. Hardwood lumber grading software, UGRS (Ultimate Grading and Remanufacturing System), developed by the Forest Service was used to grade the scanned lumber. To establish a consistent “ground truth” for comparison purposes, the boards were manually mapped and digitized for grading defects and graded using UGRS. Finally a certified NHLA lumber inspector graded the lumber. Based on established ground truth, the “per board” grading accuracy was found to be 60.7, 66.3, and 71.9 percent for the line grader, scanning system, and the NHLA inspector, respectively. Further analysis of the data found that the scanning system grading errors were due to over sensitivity to small features such as pin knots, classification confusion between mineral/stain and knots, and difficulties with precise digitization of board crook. These results will help guide the development of future scanning hardware and image-processing software to identify lumber grading features more accurately and more precisely.

Optimizing Plant Operations

Robert A. Kundrot, Principal, RAK Consulting, Springfield, OR

Industry is hesitant to do any in-plant studies or experiments for fear of upsetting operations. Indeed, most industrial experiments can disrupt production and fail to meet expectations. These problems are largely due to failure in planning, study design, or the reporting of results. While TQM, SQC, and SPC are very critical to success, these programs do not provide process understanding, improvement or optimization of plant production. Programs such as SPC are good at keeping you where you are. The key is process understanding and for that you need to run properly designed studies. Even existing plant data provides important data once you understand how to analyze it correctly. Presently, advanced techniques exist for experimentation in the plant that are three to four times more efficient than classical methods. The methods discussed will allow a systematic determination of the best operating conditions at the lowest cost. The tools and procedures stay with the plant so that other plant processes can be studied and optimized. Optimum operating conditions can be reached without production upsets and management decisions will be based on a more complete understanding of plant processes.

On-Line Surface Quality Evaluation of Wood and Wood-Based Composites

Richard L. Lemaster, Research Dir., Wood Machining & Tooling Research Program, and *James B. Taylor*, Asst. Prof., Dept. of Industrial Engineering, North Carolina State Univ., Raleigh, NC

Surface roughness detection, characterization, and evaluation is of ever increasing importance in the furniture and wood-related industries. Research at North Carolina State University has addressed these critical issues by utilizing a pioneering noncontact, laser-based surface profilometry system. This system can obtain information about a wood surface on-line at industrial feed speeds. It is capable of distinguishing between random and periodic surface irregularities and analyzing them accordingly. The output from this system has been integrated with a standard "Statistical Process Control" package to provide the user with trend analysis for their operations. Basic work with the newly-developed system has been completed and validation studies have shown vast improvements in data acquisition rates and capabilities, with otherwise comparable information to stylus-based profilometry systems. This method has been tested in the field at a variety of processing centers. Results from these studies will also be discussed.

SESSION 13: Increasing Recovery in Softwood Sawmills Through Alternative Technologies and Sawmilling Softwoods for Appearance Products

Impact of Log Sweep on Warp, Grade, and Value of Structural Lumber Curve Sawn from Small-Diameter Douglas-fir Logs

Francis G. Wagner, Prof., *Thomas M. Gorman*, Assoc. Prof., and *Keith L. Pratt*, Undergrad. Student, Forest Products Dept., Univ. of Idaho, Moscow, ID; *Charles E. Keegan III*, Assoc. Dir., Bureau of Business & Economic Research, Univ. of Montana, Missoula, MT

Evolving forest management practices are changing the type of raw material available to sawmills in western North America. Much of the sawtimber harvested today is small in diameter, includes sweep, and contains large proportions of juvenile wood. Mill studies are showing that lumber sawn from this type of sawtimber has a high propensity for warp. The purpose of this study was to assess the impact of log sweep on warp, grade, and value of curve-sawn (sawn following the curve of the log) structural lumber produced from small-diameter Douglas-fir logs. One-hundred-twenty 7-inch, 16-foot interior Douglas-fir logs were selected for this study and grouped into three sweep categories; 1-inch or less sweep (straight), 1.5- to 2.5-inches sweep (moderate sweep), and 3-inches and greater sweep (high sweep). All logs were curve sawn, and the resulting 2 by 6-inch 16-foot lumber was dried in a commercial dry kiln, planed, and measured for bow, crook, twist, and MOE. Although warp was recorded in every piece of study lumber, only one piece (moderate-sweep log group) had sufficient warp to be degraded from Select Structural or No. 1 to No. 2 (WWPA Structural Joists and Planks). However, a high proportion of pieces had sufficient warp to be problematic in some markets. Analyses of measurements taken shortly after drying and after 73 days of storage showed that mean bow was significantly greatest and that mean twist was significantly least (marginally) in lumber sawn from the high-sweep log group. Surprisingly, analyses also showed that MOE was significantly greater in lumber sawn from the high-sweep log group than in lumber from the straight log group. These findings challenge traditional thought that straight logs are superior to logs with sweep for the production of lumber.

Assessment of the Timber Quality of Standing Trees and Wood Quality Models for Log Scanning

Jean-Michel Leban and *Renaud Daquitaine*, Researchers, Equipe de Recherches sur la Qualité des Bois, INRA, Champenoux, France; *Marc Jaeger*, Computer Scientist, and *Laurent Saint-André*, Researcher, Programme Modélisation des Plantes, CIRAD, Montpellier, France; *Anders Grönlund*, Prof./Chair, Dept. of Wood Technology, Lulea Univ. of Technology, Skelleftea, Sweden

This presentation discusses recent results and trends in the field of models and tools that permit the assessment of timber quality of the actual forest resource for two different contexts of the primary conversion. 1) In the forest: This method is based upon individual tree measurements, such as they are performed for a forest inventory (DBH, total height, and age). A set of models has been built in order to simulate the individual stem morphology and wood properties. For each simulated tree, the software in which the models are embedded (Win-EPIFN) simulates log cutting and grading, and board sawing in each log. 2) In the sawmill: Using multi-points shadow scanners, the external shape of the logs was recorded. A set of models has been built in order to predict the number of rings, the elliptic shape of the log section, and the pith location within the section. Using an x-ray scanner, it is possible to investigate the internal-log structure. This enabled the analysis of the relationship between external log shape and internal wood quality (ring limits, sapwood area, knots, features, etc.).

Detecting Knots in Softwood Lumber with Infrared Technology

Philip H. Steele, Research Scientist, Forest Products Lab., *Michael D. Patton*, Grad. Research Asst., Dept. of Electrical & Computer Engineering, and *Jerome E. Cooper*, Research Asst., Forest Products Lab., Mississippi State Univ., Mississippi State, MS

Systems to grade softwood lumber by machine vision are currently being developed by several companies. Most systems utilize CCD cameras supplemented by other machine vision devices to ensure accurate detection of all defect types. The need for accurate knot detection has resulted in the addition of x-ray, ultrasound, or radio-frequency-based scanners. Positive knot identification has also been achieved by infrared scanning of heated lumber. By this technique, differential heating between knot wood and clear wood allows accurate identification of knots. Present techniques for heating lumber are too slow for industrial application. This paper gives new results from rapid high-power (35 kilowatts modulated at 100 MHZ) radio-frequency waves and 6000 Watt halogen quartz lamps to rapidly apply heat to the lumber. The differential thermal response was carefully measured from six species of softwoods and six species of hardwoods. The thermal response of the softwood and hardwood species was found to differ considerably. The reason for this differential response appears to be due to the fact that hardwood species show much lower clear versus knot-wood differences in specific gravity, extractives content, equilibrium moisture content, and cell-fibril angle. The differences in clear versus knot wood for these factors are quantified and the potential for knot detection by thermographic means following knot detection is reported.

High-Value Recovery Manufacturing Techniques for Softwood Lumber

Hauke Chrestin, Grad. Student, and *Thomas C. Maness*, Assoc. Prof., Dept. of Wood Science, Univ. of British Columbia, Vancouver, BC, Canada

Lumber-manufacturing technologies in British Columbia's sawmill industry that were originally developed to produce high volumes of commodity products at high speed are inflexible and prevent today's sawmills from producing custom-tai-

lored, high-value lumber products that would give them a competitive edge in world markets. In the European sawmill industry, on the other hand, value is commonly added to lumber products through simple techniques such as drying, planing, and strength-grading of structural lumber. The production strategy of many European mills is customer-oriented and product-driven; cutting-to-order is standard rather than an exception. By means of a qualitative survey, sawmills in Europe were interviewed about their raw-material supply, processing technologies, product mix, and marketing techniques. A two-page questionnaire translated into three different languages was mailed to approximately 1,600 statistically selected companies in Norway, Sweden, Finland, Germany, Austria, and Switzerland. Approximately 300 companies replied; about 70 percent of them returned a completed survey. Almost all of these mills began optimizing the extraction of high-value wood products already on their log yards where they sorted logs by diameter, species, and according to the intended purpose. Many mills were specialized for certain lines of products and processing technologies were well-tuned to the mix. The majority of the interviewed mills were cutting between 60 and 100 percent of their production to specific customer orders, and besides standard dimension lumber many of them also produced specialty products such as gluelam and laminated window stock. Based on the survey, recommendations are being made to softwood-lumber producers in British Columbia and throughout Canada on how they can change their manufacturing strategies to achieve a value-uplift of their production output and how more jobs-per-tree-felled can be generated.

Value-Adding Processes in Swedish Sawmills

Armas Jäppinen, Ph.D. Student, *Anders Roos* and *Matti Flinkman*, Profs., and *Mats Warensjö*, Ph.D. Student, Dept. of Forest Products & Management, Swedish Univ. of Agriculture Sciences, Uppsala, Sweden

The sawmilling industry in Sweden exports over two thirds of its annual production. The world market is highly competitive and further processing, value-added production, is often claimed to be a solution for sawmills to increase revenue and profit margins. This study aim at identifying main strategies adopted by Swedish sawmills, and determining if the strategies can be explained by basic sawmill descriptors. The study is based on a questionnaire from a 1995 sawmill inventory in Sweden, where 98 percent of the 300 sawmills producing over 5000 m3 lumber participated. The database contains information on procured and produced volumes of different species and value-added products, technology, and productivity. About 90 percent of the sawmills process part of their production further after initial sawing and drying, and 70 percent of the sawmills apply two or more processes. The total share of value-added production was higher than average for independent sawmills, and for mills in southern Sweden, but without any significant association to species or mill size. Factor analysis was used to reduce the large variation between mills into a few basic strategies. The strategies identified as most important were: Extra drying and production of blanks for doors/windows and for furniture; planing, associated with preservation and painting/surface treatment; length trimming and pallet production; extra drying, and production of edge-glued panels and laminated beams; stress grading and production of building components. These strategies are thought to partly reflect market strategies. The different strategies were associated with different species, for example, building components were associated with Norway spruce and blanks to Scots pine.

Optimizing Sawmills' Activities Through Simulation Software

Sorin Chiorescu, Ph.D. Student, and *Anders Grönlund*, Prof., Div. of Wood Technology, Lulea Univ. of Technology, Skelleftea, Sweden

In recent years, much effort has been expended in implementing the concept of an integrated forestry-wood-chain. Good management of such a complex system requires a clear understanding of the effect that different factors involved may have on the final output of the chain. Raw material database and simulation software capable of spanning wood-processing operations are now developed and are being used as a support tool in understanding and optimizing the forestry-wood-chain. This presentation reports results of simulation tests using the virtual SawMill (vSM) software and the Swedish Pine Stem Bank (SPSB) database. The simulated scenario tries to mirror a very customer-oriented production philosophy. The bucking, sawing, crosscutting, and board-grading procedures were simulated for different end-user requirements and a statistical model was built. The purpose of the model was to investigate the theoretical sensitivity of the final product to parameters such as external sawlog features (taper, ovality, and bow), harvester measurement accuracy (for length and diameter), sawing pattern optimization, and log positioning in the saw-line. Special emphasis was placed on evaluating the role of the harvester within this "puzzle." The results showed that small improvements in the harvester's measuring performance could lead to considerable improvements in the wood transformation chain.

Lumber Recovery from Small-Diameter Ponderosa Pine from Flagstaff, Arizona

Eini C. Lowell, Research Scientist, Pacific Northwest Research Sta., USDA Forest Service, Portland, OR; *David W. Green*, Research General Engineer, Forest Products Lab., USDA Forest Service, Madison, WI

Thousands of acres of densely-stocked ponderosa pine forests surround Flagstaff, Arizona. These stands are at risk from both a forest health viewpoint (insect and disease) and also are susceptible to uncharacteristically severe fires. Stand-density management activity can be expensive, but product recovery from the thinned material could help defray removal costs. This project evaluated the yield and economic return of lumber recovered from small-diameter, suppressed ponderosa pine. A sample of 150 trees ranging from 6- to 16-inches DBH was selected. Half of the sample was sawn as dimension lumber and the other half as appearance-grade lumber. Value recovery depends upon both the volume and the lumber grade recovered from a log. Lumber-grade recovery is important, as higher grades of lumber command higher prices. This study yielded about 25 percent No. 2 and Better Common for appearance lumber, with the majority of lumber (66%) graded No. 3 Common. About 50 percent of the dimension lumber was No. 2 and Better, with very little of the highest grade produced. Volume recovery was slightly higher for dimension lumber, yet the lumber from the logs sawn for appearance grade was worth significantly more than that from the logs sawn for dimension lumber.

Automatic Presorting of Sawlogs by Grade Using External Geometry

Armas Jäppinen and *Christina Lundgren*, Ph.D. Students, and *Mats Nylinder*, Prof., Dept. of Forest Products & Management, Swedish Univ. of Agriculture Sciences, Uppsala, Sweden

Most mills in Sweden presort sawlogs. More than 95 percent of the volume is sorted by dimension, but only 10 percent of the volume is presorted with respect to other grade properties, manually or automatically. A common grade-sorting criteria is knot type, for which external log geometry using data from optical log scanners has proven useful. External log geometry variables include taper, surface unevenness, sweep, and out-of-

roundness. The adoption of 3D-scanners has increased the interest in utilizing external geometry variables. Two studies, one utilizing Scots pine (*Pinus sylvestris*) and one utilizing Norway spruce (*Picea abies*) are reported. Each study was based on 200 medium-sized logs. The scanners provided 20 to 30 measuring points around the log at approximately every second centimeter along the log. The logs were cant-sawn and grade recovery was recorded for each board. External geometry variables were utilized in logistic regression models to calculate lumber-grade probability. Knot-related grades were able to be predicted from external geometry(i.e., visual-stress grade, knot size, and type. Commodity grades like Nordic timber, or machine stress grades based on stiffness, were also been able to be predicted. One way to increase grade recovery is to only select logs with a high probability of the desired grade, which is feasible in those cases when the requested volume is limited.

SESSION 14: Latest Developments in Structural Panel Testing and Performance Standards

Structural Panels in Engineered Wood Systems

Thomas G. Williamson, P.E., Technical Dir., APA - The Engineered Wood Assn., Tacoma, WA

Structural wood panels have long been used in engineered wood systems for residential and commercial building markets due to their unique ability to carry both gravity loads and transfer lateral loads induced by wind and seismic events. However, building systems using structural wood panels are being challenged by design professionals and competitive building products. Recent research activities at APA on the effects of airborne missiles, narrow shear walls, perforated shear walls, and the performance of shear walls under dynamic loading have been undertaken to address concerns raised by design professionals. The perception of poor performance of structural wood panels from a durability aspect is an area of concern that is being addressed by an aggressive APA educational program called “proper building practices.” Closely associated with durability is the misperception that wood-frame walls are not energy efficient, which is also being addressed in this new APA educational program. The use of wood panels as rim boards and the webs of I-joists are growing through the introduction of new performance standards by APA, efforts are underway at APA to expand the use of engineered wood systems in markets such as concrete forming and post frame buildings and to work with member manufactures to introduce new products such as preservative treated OSB and more moisture-resistant panels for large commercial roofs. Thus, while the relative volume production levels for plywood and OSB are changing rapidly, the overall prognosis for the structural wood panel industry is positive due to the many research and educational activities underway at APA and other organizations.

What's New with Plywood and Veneered Wood Products

Borjen Yeh, Ph.D., P.E, Mgr., R&D, and *Thomas G. Williamson*, P.E., Technical Dir., APA - The Engineered Wood Assn., Tacoma, WA

Facing strong challenge from competitive products, the plywood industry in North America is striving to enhance product quality, improve resource utilization, implement new technology, and identify new markets. A new APA Quality Management System (QMS) provides an efficient and timely response to product quality and is being adopted by the wood structural panel industry. Participation in the APA QMS program is expected to grow substantially this year. The North American plywood industry used more and more foreign species, such as eucalyptus and merkus pine in recent years. These foreign species seem to have a common characteristic: high strength and stiffness, thereby enhancing the mechanical properties of plywood. Many new equipment technologies, such as veneer-grading machines, veneer jointers, and panel MSR machines, are being tested by the industry to improve productivity and plant efficiency. Their potential for commercialization is being recognized. APA is involved in several projects to enhance the use of plywood in industrial markets such as bins, containers, pallets, and furniture frames. With respect to laminated-veneer-lumber (LVL), APA has just completed development of a Performance Standard for APA-EWS Rated LVL, PRL-501. This standard provides one set of design properties and end-use recommendations for the majority of LVL products available in North America with the goal of simplifying engineering specifications, purchasing, installation, and field inspection. Combined with the APA Quality Assurance Policy for LVL, the LVL products trademarked under PRL-501 will provide consistent product quality among various manufacturers, which facilitates the interchangeability of the products in the marketplace.

Consolidation of OSB Mats Under Theoretical Laboratory Pressing and Simulated Industrial Pressing

Paul M. Winistorfer, Prof./Dir., and *Siqun Wang*, Post-Doctoral Research Assoc., Tennessee Forest Products Center, Univ. of Tennessee, Knoxville, TN

Hot-pressing is a process of pressing a wood mat between hot platens or hot rollers to compact and set the mat structure by simultaneous application of heat and pressure. One of the major objectives of hot-pressing is to achieve a designed panel density. Our previous research showed that the vertical density profile of wood composites is formed from a combination of actions that occurs both during consolidation and also after the press has reached final position. During pressing, the wood furnish elements are not in a steady state of contact, due to significant consolidation changes that occur throughout the mat during the entire press-cycle, even after the press reaches final position. To achieve a more fundamental understanding of material behavior during the pressing process, an in-press radiation-based system for measuring density of wood composite mats during consolidation is used to build *in situ* cross-sectional density distributions of OSB mats with pressing time. In this presentation, the fundamentals of densification within OSB mats during hot- and cold-pressing are discussed. The pressing schedules include theoretical laboratory pressing schedules and a schedule simulating industrial pressing. The presentation includes stress relaxation of OSB mats during cold- and hot-pressing, stress-strain behavior, *in situ* density-strain behavior, and *in situ* cross-sectional density distributions of OSB mats with pressing time. Effects of the closing time on internal gas pressure will also be presented.

Modeling the Hot-Compression of Wood-Based Composites

Balazs Zombori, Ph.D. Student, *Frederick A. Kamke*, Prof./Dir., Wood-Based Composite Program, Dept. of Wood Science & Forest Products, and *Layne T. Watson*, Prof., Dept. of Computer Science, Virginia Tech, Blacksburg, VA

Hot-compression parameters have a substantial effect on the final properties of wood-based composite boards. The number of interacting variables during the hot-compression process is too large to enable assessment of data by experimental means. Therefore, a numerical model based on fundamental engineering principles was developed and validated to establish relationships between process parameters and the final properties of the board. The model simulates the mat formation, then compresses the reconstituted mat to its final thickness in a virtual press. The mat-formation part of the model is based on the Monte-Carlo simulation technique to reproduce the spatial structure of the mat. The dimensions and the density of each flake are considered as random variables in the model, which follow certain probability density distributions. The parameters of these distributions are derived from data collected on industrial flakes by using image analysis techniques. The model can simulate the

structure of a three-layer oriented strandboard (OSB) mat as well as the structure of random fiber networks. A grid was superimposed on the simulated mat and the number of flakes, the thickness, and the density of the mat at each grid point were computed. Additionally the model predicts the change in void-volume fraction within the mat and the contact area among the flakes during consolidation. The void-volume fraction is directly related to the physical properties of the mat such as thermal conductivity, diffusivity, and permeability, while the contact area is related to the effectively bonded area within the mat. The heat and mass transfer part of the model predicts the change of air content, moisture content, and temperature at designated mesh points in the crosssection of the mat during hot compression. The water content is subdivided into vapor and bound water components. The freewater component is not considered in the model due to the low (typically 6 to 7%) initial moisture content of the flakes. The gas phase (air + vapor) moves by bulk flow and diffusion, while the bound water only moves by diffusion across the mat. The heat flow occurs by conduction and convection. The spatial derivatives of the resulting coupled equations are discretized by the central-difference scheme, while the time derivatives are solved by a differential-algebraic system solver. The internal environment within the mat can be predicted among different initial and boundary conditions by this part of the hot-compression model. In the next phase of the research, the viscoelastic (time, temperature, and moisture dependent) response of the flake mat will be modeled using the time-temperature-moisture superposition principle of polymers. It will give insight into the vertical density profile formation through the thickness of the mat. The density profile is related to all the mechanical properties of the final board (bending strength, internal bond strength, etc.). The model can assist in the optimization of the hot-pressing parameters of wood-based composites and improve the performance of the final panel.

Development of Design Values for Construction Sheathing OSB Rated to CSA-0325

Dominique P. Janssens, P.E., Technical Dir., Structural Board Assn., Toronto, ON, Canada; *Erol Karacabeyli*, P.E., Group Ldr., Building Systems, Forintek Canada Corp., Vancouver, BC, Canada

In Canada, design values for wood and wood-based products are published in CSA-O86.1, Engineering Design in Wood. The standard provides tabulated capacities for several panel products including softwood plywood and design-rated OSB. In 1997-98, the Structural Board Association undertook a testing program to evaluate the mechanical properties of sheathing-grade OSB currently manufactured by the majority of the OSB producers and certified to CSA-O325. This paper describes the sampling, testing, reliability analysis, and finally the code submission for CSA-O325-rated OSB construction sheathing. Design values promulgated by the APA in the United States were used as the benchmark for comparison purposes and converted to suit the Canadian design format. This offers designers the confidence that design values for OSB are harmonized between the U.S. and Canadian codes. In a separate study OSB panels were supplied and tested for racking resistance to evaluate their use in structural shear walls. The results indicated that OSB rated to CSA-O325 provided the same level of confidence as plywood and design-rated OSB and lateral design capacities for shear walls and diaphragms were proposed to the Technical Committee on Engineering Design in Wood. Currently design values for all grades of OSB apply only to dry service conditions, as per the definitions of the standard. The proposed code changes have been balloted by the Technical Committee and should be endorsed by the next edition of CSA-O86, slated for publication in the Spring of 2001.

SESSION 15: Utilization of Western Hardwoods

Successful Utilization of Western Hardwoods - Lessons from Industries Using Red Alder and California Black Oak

Glenn R. Ahrens, Consultant, GBA Forestry, Inc. and the Western Hardwood Assn., Olympia, WA

The best examples of successful utilization of western hardwoods are provided by industries based on red alder and California black oak. Success with red alder was initially based on abundant and underutilized raw materials and the development of new markets for select quality lumber of this very workable species. Key challenges common to manufacturing of both alder and black oak included the need for efficient manufacturing from logs with relatively low volumes of high-quality material and the need to develop markets for high volumes of lower-quality material. Techniques for kiln-drying to produce uniform color and quality were developed for both alder and black oak. A key to successful manufacturing of these and other western hardwood species lies in the ability of businesses to persist long enough to develop customer recognition and demand for new lumber products while developing consistent production, delivery, and quality. Mills must also be able to survive the sporadic availability of hardwood logs due to the predominance of coniferous species as determinants of forest harvesting behavior. However, if mills can persist in a given locality, consistent demand for hardwood logs developed over time can improve availability. Red alder is now in demand for its own natural color and figure. Similarities between California black oak and eastern red oak allow some immediate access to established demand. Lessons learned with alder and black oak indicate potential for success with other western hardwoods once startup obstacles are overcome.

A Competitive Assessment of the Hardwood-Lumber Industry in the Pacific Northwest

Ivan L. Eastin, Assoc. Dir., Center for International Trade in Forest Products, Univ. of Washington, Seattle, WA; and *Steven R. Shook*, Asst. Prof., Forest Products Dept., Univ. of Idaho, Moscow, ID

The hardwood industry has experienced substantial growth over the past 10 years despite timber harvest restrictions in federal and state forests. This growth has occurred in the domestic U.S. market as well as in the foreign markets that now account for almost 28 percent of red alder lumber production. While harvest restrictions were not perceived to have adversely impacted the industry, riparian zone regulations related to endangered salmon populations could have a severe impact on the hardwood resource, particularly if those regulations are vigorously applied to private forests. Virtually none of the regulatory factors evaluated in the survey were viewed in a positive light, although few were perceived to have a strongly negative impact on the industry. While timber harvest restrictions were perceived to have a moderately negative impact on the industry, resource availability has not yet had an adverse impact on the hardwood industry. Respondents indicated that the marketing variables that influenced a firms' reputation and production efficiency were the most important. In contrast, virtually all of the marketing variables associated with acquiring market information and promoting innovation were perceived to be much less important, suggesting that hardwood manufacturers place a low value on product innovation and differentiation.

The Utilization Potential of Tanoak - A Western Hardwood Species

John R. Shelly, Extension Advisor, Biomass Utilization, Forest Products Lab., Univ. of California, Richmond, CA

California has an underutilized resource of high-density hardwoods, a large hardwood manufacturing and consumer market, skilled woodworkers, and rural economies in need of new busi-

nesses. However, the California hardwood sawmill industry is often described as a fragmented, loosely connected organization of small producers, with significant processing and economic challenges. This paper reports on a recent study that analyzed the utilization potential of tanoak (*Lithocarpus densiflorus*), a high-density hardwood species native to California that is known to compare favorably in processing characteristics with many of the benchmark hardwood species. Approximately 40 MBF (tree volume) of tanoak was harvested from two sites in the north coast region of California. The trees, logs, and lumber were graded and volumes tallied at each step in the processing. All lumber was dried to a final moisture content of 8 percent and surfaced to final thickness. Preliminary results indicate an average tree defect deduction from 10 to 15 percent and green lumber yield of upper grades (No.1 Common and better) resulted in 68 percent from F1 log grade (top grade), 49 percent from F2, and 31 percent from F3 (lowest log grade). Drying results from the study indicate a serious downgrade when the lumber is dried from dead green. Air-drying for 6 months before kiln-drying dramatically reduced the amount of warp and collapse. The high frequency of "mineral streak" in older, larger trees apparently contributed to the drying degrade. Some causes of the mineral streak were explored. The knowledge gained in this study helps to understand the challenges, and provide opportunities for the manufacture of high-value tanoak products.

Manufacturing and Marketing Strategies for the Inland Northwest Hardwood Resource

Ronald L. Mahoney, Prof./Extension Forester, Univ. of Idaho, Moscow, ID

Hardwood species in the Inland Northwest have not been utilized to the extent that they are considered everyday commercial tree species. Public and private inventories may not even include hardwood species, and when they do, these species are often lumped together as "hardwoods." In the Inland Northwest, native hardwood species that reach commercial size include paper birch, cottonwood, aspen, and red alder. When they are inventoried as separate species, diameter classes are often so broad that it is difficult to discern necessary information for manufacturing and marketing plans. There are many exotic hardwood species growing in this region but the supply is too limited for serious consideration for economic development. Small-scale enterprises have been developed to utilize exotic hardwoods, and current research is exploring the potential for commercial hardwood plantations. Recent discoveries of important ecological roles of native hardwood species in the Inland Northwest have broadened interest in their economic use, to help provide a financial justification for hardwood management. Ecosystem management on public and private forests, the development of a West Coast hardwood industry based primarily on red alder, and declines in the softwood industry also have stimulated efforts to utilize the inland hardwood resource. The feasibility of increasing utilization and expanding markets for native hardwoods in the region was explored in recent research at the University of Idaho. This presentation includes the results of that study as well as information gleaned from informal contacts with small to large hardwood manufacturing businesses throughout the region, including the West Coast, British Columbia, and Alaska.

Research Needs of Small-Scale Producers for the Utilization of West Coast Hardwoods

John Rogers, Hardwood Development Coordinator, and *Jude Wait*, Dir. of Community Economic Development, Inst. for Sustainable Forestry, Redway, CA

Small-scale producers working with western hardwoods face numerous technical and competitive challenges. Although western producers lack long-term experience working with refractory species such as madrone and tanoak, many of the processing challenges have been addressed. Small western mills and drying facilities, borrowing from eastern technical experience, can produce quality lumber from western species. Large, high-volume mills have ready access to capital, technology, and expertise unavailable to the typical western hardwood entrepreneur. High-volume mills produce at economies of scale that allow specialization within the work force. The removal of barriers to investment in, and the increase in technology transfers to resource-rich low-wage countries also favor large operations. As technology costs continue to decline, applications for small-operation efficiency becomes more feasible. Log scanning, computerized setworks, in-line lumber scanning and automated grading systems increase accuracy and efficiency, and reduce labor costs. Process simulation software and statistical process control procedures and analytical tools optimize performance and increase recovery. Applications appropriate to community-based efforts need to be researched. Analysis and simulation tools accessible to nontechnical staff, and examples of specific technology configurations need to be created. Small-scale producers require resource efficient production technology that: 1) is accessible to a low-capital budget; 2) recovers high-quality cuttings from lower-grade distributions; 3) is economically efficient at low volumes of throughput; and 4) promotes flexibility in resource utilization. What western hardwood producers need is identification and analysis of opportunities to implement existing technology in configurations appropriate to small-scale production.

Machining, Laminating, and Finishing Properties of Hybrid Poplar

Derek Williams, Secondary Wood Processing Specialist, Forintek Canada Corp., Vancouver, BC, Canada

This study examines the utility of using hybrid poplar in typical woodworking processes. The following three processes were considered: 1) machining (including fastener withdrawal); 2) laminating; and 3) finishing. The machining operations studied were planing, sanding, boring, and shaping according ASTM D 1666-87. The fastener withdrawal were conducted according to ASTM D 1761 for both nails and screws. The laminating tests study the performance of hybrid poplar when four different types of adhesives are used in conjunction with three different types of pressing systems. The samples were tested for delamination and shear strength of the glued joint according to ASTM D 1101 and D 905. The finishing properties of hybrid poplar were evaluated using three types of finishes: paint, furniture, and wax finishes. ASTM D 4541 and D 3359, both standard industry tests for adhesion of a coating were used. The applicability of using hybrid poplar in typical furniture finishing was subjectively evaluated by applying six different types of stains in combination with four types of sealers and six clear finish coats. Similarly, the wax finishes were subjectively evaluated. Hybrid poplar machined moderately well when compared to a selected group of other wood species; its performance in the important planing test was below average to light fuzzy grain that was easily removed by sanding. Hybrid poplar can be glued using commonly available adhesives found in the wood processing industry, however adhesives with low viscosity (thin glues) should be avoided. Hybrid poplar performed very well in the finishing tests; it accepted paint, stain/lacquer, and wax coatings well and had a pleasing appearance.

SESSION 16: Treatment and Protection of Composites

Durability of Plastic/Woodfiber Composites

Peter Laks, Prof., *Steven Verhey*, Grad. Student, *Dana Richter* and *Glenn Larkin*, Research Scientists, and *Erik Keranen*, Research Assoc., Sch. of Forestry & Wood Products, Michigan Tech Univ., Houghton, MI

There is limited information available on the fungal and insect resistance of plastic/wood composites. Composites were made from polypropylene and pine wood particles at 30, 40, 50, 60,

and 70 percent polymer contents. In addition, 50 percent polymer composites were made incorporating 1 percent zinc borate, a well-known preservative for wood composites. Samples of the composites were exposed to standard fungal strains in a soil-block test (AWPA E10) and a ground-contact field test. In the latter, stakes were removed at 3-month intervals and evaluated for modulus of elasticity (MOE), and modulus of rupture (MOR) at the groundline, and impact strength above and below the groundline. It was found that *Gloeophyllum trabeum* produced significant decay in the 50, 60, and 70 percent wood component composites when tested using the soil-block procedure. In the field-exposure specimens, the more surface-decay sensitive tests (MOE and MOR) showed significant strength properties loss after 9 months of exposure. There is some correlation with wood content; higher wood content composites tended to have a reduced MOE after exposure. Impact strength, a better measure of bulk material strength, showed no significant decreases after 9 months exposure. Results from termite testing will also be presented.

Test Methodologies for Testing Wood-Based Composites Against Biodeterioration

Alan F. Preston, Vice Pres. of Technology, Chemical Specialties, Inc., Charlotte, NC

Over the years, a range of different methodologies have been developed for the assessment of wood-based composite products against biodeterioration. This paper discusses various laboratory and field test methods that have been studied and attempts to assess the utility of each method discussed. Results are presented as appropriate. Future needs and standardization issues are also addressed.

Effects of Preservative Treatments on FRP Reinforcement for Wood

Cihat Tascioglu, Grad. Research Asst., and *Barry S. Goodell*, Prof., Dept. of Wood Science & Technology, and *Roberto Lopez-Anido*, Asst. Prof., Dept. of Civil Engineering, Advanced Engineered Wood Composites Center, Univ. of Maine, Orono, ME; *Beckry A. Magid*, Prof., Dept. of Composite Materials Engineering, Winona State Univ., Winona, MN

All wood used in exposed outdoor environments must be treated with appropriate wood preservatives to prevent deterioration from decay and insect attack. Although considerable literature exists on the treatment of laminated timbers and wood composites with wood preservatives, almost no information is available on the exposure of Fiber Reinforced Polymers (FRP) composites to wood preservative chemicals, and no information is available on wood-FRP composites treated for exterior exposures. Because more laminated composite products are being bonded to FRPs and these products are being targeted to exterior exposures, wood-preservation research was necessary to provide appropriate background information to engineers and wood scientists working in the field. The production of preservative-treated composite-reinforced laminated timbers represents the latest stage of investigation and development and is of considerable interest to both the wood preserving and composite-reinforced wood hybrid industry (CRW) for civil infrastructure. In this work, laminated timbers reinforced with FRP material were treated with common preservative chemicals and the effect of wood-preservative treatments including: 1) oil-borne; 2) organo-and organometalic; and 3) acid and amine-based water-borne preservatives, on mechanical properties of GFRP material were investigated. ASTM D-3039 (longitudinal and transverse tensile) and D-2344 (short beam interlaminar shear) tests were used for mechanical characterization of preservative-treated E-glass/phenolic-pultruded material. Although longitudinal MOE was unaffected, some longitudinal strength losses were recorded for water-borne treated FRP coupons. A simple model was used to compute the average fiber strength within preservative-treated FRP coupons. These results were supported by microscopic analyses of single glass fibers taken from failed FRP coupons. The presentation will also cover development of material reduction factors for design criteria and will discuss threshold preservative retention levels. Recommendations for use of wood-FRP composites in exterior environments, based on early data, will be offered for civil engineers and the FRP/wood reinforcement industry.

Laminated-Veneer-Lumber from Preservative-Treated Veneer

Justin A. Zyskowski, Research Asst., and *D. Pascal Kamdem*, Assoc. Prof., Dept. of Forestry, Michigan State Univ., E. Lansing, MI

Laminated-veneer-lumber (LVL) was manufactured with maple veneer that was dipped treated with four different copper-based wood preservatives. Shear testing was used to assess the resin-preservative interaction at the glueline. The LVL from untreated and water-borne preservatives had a stronger shearing strength than samples made with oil-borne-treated veneer. X-ray densitometry was used to show that premanufacturing dip-treatment of the veneer achieved higher preservative penetration within a panel than post-manufacture pressure treatment. The decay resistance of the dip-treated LVL was determined.

Mechanical and Physical Properties of Oriented Strand Boards (OSB) Post-Manufacture-Treated with Copper-Based Wood Preservatives

D. Pascal Kamdem, Assoc. Prof., Dept. of Forestry, Michigan State Univ., E. Lansing, MI

(Abstract not available at time of printing.)

Treated Parallel Strand Lumber in Marine Applications

Paul Merrick, Mgr., Preservation Technology, Trus Joist - A Weyerhaeuser Business, Boise, ID

Parallel strand lumber (PSL) is an engineered, structural composite lumber product manufactured from longitudinally clipped veneer, which are pressed into large billets measuring up to 11-inches-thick, 19-inches-wide, and various lengths with the most common being 48 and 66 feet. Parallel strand lumber possesses excellent structural properties and is inherently easy to treat with both water- and oil-based preservatives. This ideal combination of physical and mechanical properties along with its treatability makes possible the use of PSL in a variety of heavy timber industrial markets, including applications such as docks, piers, and retaining walls. Data will be presented from three field tests where performance is being evaluated using AWPA Standard E5. Also, qualitative assessment of performance from several test structures exposing PSL to saltwater-splash conditions will be reviewed. To date, standard testing and evaluation of field structures indicate that properly treated parallel strand lumber can be used in place of traditional solid-sawn and roundwood products.

Moisture Excluding Effectiveness of Coatings for Preservative-Treated Wood and Wood Composites

Paul R. Blankenhorn, Prof. of Wood Technology, and *Steven W. Bukowski*, Research Asst., Sch. of Forest Resources, Pennsylvania State Univ., Univ. Park, PA; *James A. Kainz*, Grad. Fellow, Colorado State Univ., Fort Collins, CO; *Michael A. Ritter*, Supervisory Research Engineer/ Project Ldr., Forest Products Lab., USDA Forest Service, Madison, WI

Moisture movement into treated wood and wood composites promotes dimensional instability. Finishes and coatings may be applied to the surfaces of treated wood and wood composites to retard rapid moisture movement. This study evaluated selected exterior finishes and coatings on chromated copper arsenate (CCA) and creosote-treated red maple and southern pine specimens for liquid moisture excluding effectiveness. The types of

exterior finishes and coatings used were: water-repellent finishes, water-repellent preservative finishes, a bituminous coal-tar based coating, and an epoxy coating. One and two coats of each finish or coating were evaluated along with a CCA/wax emulsion and a CCA/oil emulsion. Liquid moisture excluding effectiveness was evaluated in both the longitudinal and transverse directions. The analysis focused on the moisture sorption in the preservative-treated specimens coated with the selected finishes for the first day of liquid-moisture exposure and the final day of significant liquid-moisture sorption of the finished preservative-treated specimens. Analysis of the results for the first day moisture sorption revealed that epoxy retarded liquid-moisture sorption into the CCA and creosote-treated longitudinal and transverse specimens of both species better than any other finish. The data also revealed that the best long-term protection against moisture sorption was provided by the epoxy coating. Other coatings had various abilities to retard moisture sorption but had higher total moisture sorption values than the epoxy coatings in the longitudinal and transverse direction for both preservatives and wood species.

Fungal and Termite Protection to Wood-Based Composites

Brian M. Marks, Biologist, *Janet K. Baileys*, Technical Service Administrator, and *Alan S. Ross*, Vice Pres./Technical Dir., Kop-Coat, Inc., Pittsburgh, PA; *Douglas M. Crawford*, Wood Technologist, *Andrzej M. Krzysik*, Visiting Senior Scientist, *James H. Muehl*, Forest Products Technologist, and *John A. Youngquist*, Project Ldr., Forest Products Lab., USDA Forest Service, Madison, WI

The first oriented strandboards (OSB) were manufactured with fire retardants and wood preservatives. As OSB became a commodity, the fire retardants and preservatives were removed. With the recent emphasis on a healthy home, we are looking for ways to prevent the growth of mold and decay in wood composites. A process where one can add a biocide will be described. It will be shown that introducing additives can inhibit the growth of mold and decay. Most recently, the Formosan subterranean termites (*Coptotermes formosanuus*) have been wreaking havoc in the Southern United States. By using various integral treatments, they too can be stopped. Data will be presented on the growth of the decay and mold. Results will be reported using various termiticides.

New Protection Systems for Engineered Wood Products

Louis Graziano, Technical Group Mgr., *Jose Lalas*, Senior Scientist, and *Liam Leightley*, Global Growth Mgr., Rohm & Haas Co., Spring House, PA

Wood composite markets continue to experience rapid growth worldwide. As the production and use of engineered wood products expands, the need for effective, long-term protection from biological degradation becomes essential to the commercial success of this booming market segment. Protection of such products against the same organisms that have plagued the solid-wood industry is needed. These organisms include molds, decay fungi, and insects. This paper will introduce the advantages of using isothiazolone wood preservatives to protect engineered wood products. Data will include resistance to decay fungi, molds, and insects, including the Coptotermes formosanus. The robustness of isothiazolone chemistry to composite wood manufacturing processes will also be addressed. The results of this study showed that isothiazolone preservatives can effectively protect engineered wood products against a broad spectrum of biological adversaries.

SESSION 17: Structural Issues Related to Engineered Wood Systems

Lateral Connection Details for Roof Diaphragms

Thomas D. Skaggs, Ph.D., P.E., and *Edward L. Keith*, M.S., P.E., Senior Engineers, APA - The Engineered Wood Assn., Tacoma, WA

For many years the wood roof system was by far the most dominate form of structural systems for both large structures and small. Its availability, ease of construction, and economic efficiency made wood the roof material of choice for most large commercial structures. Throughout the last 20 years or so, ever increasing building code mandates in the area of seismic resistance has slowly eroded the cost-competitiveness of wood-framed roof systems in the commercial low-slope roof market. Recently, engineers and connection fabricators have developed a number of new techniques and products to more efficiently and economically meet the code-requirements, which results in increasing the viability of wood roof systems in high wind and seismic regions of North America. These same connection types ensure short construction times and provide large, near-flat wood roof systems with even greater economic advantages. These innovations, including the use of the popular panelized roof systems along with new connection details and design techniques, are making wood roofs more lateral resistant and economical than ever. This presentation will cover various design aspects that have improved the efficiency of wood roofs. The concept of panelized roofs will be covered in detail. Panelized roofs are a popular form of construction on the West Coast of the United States. Design issues of these systems are adequate load transfer from the diaphragm to the walls (typically "tilt-up" concrete), and detailing a continuous load path across the diaphragm. The mini-diaphragm concept will also be covered.

Evaluating System Effects in Repetitive-Member Wood Assemblies

Bradford K. Douglas, P.E., Dir. of Engineering, *Philip Line*, P.E., and *Brian R. Weeks*, P.E., American Forest & Paper Assn., Washington, DC

The performance of repetitive-member wood assemblies is a function of several variables related to product variability, construction, and loading. Repetitive member assembly design is typically based on conventional engineering criteria for single members with a "system factor" increase to account for the enhanced performance. System factors have been developed for a range of applications. Varying levels of consideration have been given to variables which account for the improved performance of repetitive-member wood assemblies over single members. Use of differing criteria for determining system factors have resulted in system factors that are not always consistent across different applications and variations in terminology associated with system factors often make comparisons difficult. A new ASTM standard, D6555 Guideline for Evaluating System Effects in Repetitive-Member Wood Assemblies, has been developed to provide guidance on determining system factors from test data and/or computer simulations. The new standard also provides definitions for variables influencing repetitive-member assembly performance. This presentation briefly discusses the issues which arose during the development of this standard and provides examples of its application.

The Benefits of System-Based Design in Residential Construction

Jay H. Crandell, Dir., Structure & Materials Div., NAHB Research Center, Inc., Upper Marlboro, MD

System-based design has been discussed and researched for many decades with very little advancement in terms of application. The reasons for this apparent lack of application are varied; however, there are significant direct and indirect benefits

that also highlight the need for system-based design. Some of the benefits of system-based design are that it: 1) fills the gap in understanding of convention construction practice and engineering practice (addresses apparent disparities in current codes and practices); 2) provides for greater value to the consumer; and 3) uses natural resources more efficiently. Some indirect benefits include: 1) simpler construction detailing that will promote better quality by removing opportunities for misapplication in the field. Quality is a significant issue, and it may be worsening with the introduction of various new engineered wood products and other materials that cannot be treated as one-to-one substitutes for conventional practices; 2) improved energy efficiency associated with efficient lumber utilization in homes (i.e., reduction in framing effect or thermal bridging); and 3) simplification of the number of "parts" in a home, which reduces effort in ordering, storage, handling, and tracking of materials on the job site. In this presentation, the above concepts will be discussed and the work at the NAHB Research Center, Inc. to advance the use of system-based design in housing will be summarized.

Demonstration of Wind Load Design for Timber-Frame Structures Utilizing Diaphragm Action

David M. Carradine, Grad. Research Asst., Dept. of Wood Science & Forest Products, *Frank E. Woeste*, Prof., Dept. of Biological Systems Engineering, *J. Daniel Dolan* and *Joseph R. Loferski*, Profs., Dept. of Wood Science & Forest Products, Virginia Tech, Blacksburg, VA

Current design procedures for timber frame structures that are enclosed by structural-insulated panels (SIPs) do not typically accommodate the contribution made by SIPs in resisting lateral loads. This investigation draws parallels between timber-frame and post-frame structural systems and elucidates the appropriateness of the post-frame diaphragm design methodology for contemporary timber-frame buildings. A sample timber-frame diaphragm design was performed and the parameters needed to effectively complete the design were identified. Typical connection systems currently used in the industry were cataloged.

T-Bracing Effectiveness for Compression-Web Members of Metal-Plate-Connected Trusses

Robert J. Leichti, Assoc. Prof., *I. Hofacker*, formerly Trainee, Dept. of Forest Products, *Ping Cheng*, Grad. Teaching Asst., Dept. of Civil, Construction, & Environmental Engineering, and *Thomas E. McLain*, Prof./Dept. Head, Dept. of Forest Products, Oregon State Univ., Corvallis, OR

Compression-web members in metal-plate-connected wood trusses often meet the criteria of long slender columns, and as such, are prone to axial-force buckling failures. The engineer of record is responsible for permanent bracing in the truss system, and several bracing alternatives are practiced. One common construction technique is to nail a side member onto the compression-web member so that the cross section is "T" shaped, thus increasing the cross-sectional dimensions and consequently increasing the critical buckling capacity. This strategy seems to be effective, but the bracing efficiency of the T-brace is not known. An analytical solution would need to include the non-prismatic characteristics due to geometry and elastic properties of the components, the eccentricity between the position of the axial load and effective center of gravity of the assembly, as well as the slip between the components of the assembly. The objective of this study was to assess the T-bracing efficiency as affected by the main-member length, side-member length, and method of attaching the main and side members, by measuring the critical buckling load of the first buckling mode. Finite-element models were developed for 4-, 6-, 8-, and 10-foot main members having side members that were as long as full length and as short as quarter length in 6-inch increments. The side members were attached with either nails or adhesive. Nails were spaced at 6-inch centers and given a 6-inch end distance. The results of the finite-element investigation were used to determine which T-brace geometries to test. The testing program included 6- and 10-foot main members having side members that were full length, half length, and quarter length. These were attached with either 16d nails or phenol-resorcinol adhesive. The testing results paralleled the finite-element results. The T-brace assemblies exhibited a linear minor-axis bending deflection from the onset of loading until the critical buckling load was reached, and then the deflection increased without bound. Some slipping between the main and side members was observed in the nailed assemblies, and twisting was also evident in the deformed shape. The statistical analysis showed that main-member length, side-member length, and method of attachment were significant variables. T-bracing was most efficient for very long members and efficiently increased with increasing side-member length. Adhesive-attached side members were more effective than nail-attached side members. A design method for T-bracing will be developed from the results of this study.

Permanent Bracing Design for MPC Wood Roof Truss Webs and Chords

Catherine Richardson Underwood, Grad. Research Asst., and *Frank E. Woeste*, Prof., Dept. of Biological Systems Engineering, Virginia Tech, Blacksburg, VA

The objectives of this research were to determine the required net lateral restraining force to brace j-webs or j-chords braced by one or more continuous lateral braces (CLBs), and to develop a methodology for permanent bracing design using a combination of lateral and diagonal braces. Three system analogs used to model multiple truss chords braced by *n*-CLBs and one or two diagonal braces were analyzed using a finite element analysis program. Single member analogs were analyzed that represented web members braced by one and two CLBs and chord members braced by *n*-CLBs. For the three cases studied involving multiple 2 by 4 chords braced as a unit, the bracing force from the single member analog analysis was a conservative estimate for bracing design purposes. It was concluded that the single member analysis analog yields approximate bracing forces for chords larger than 2 by 4 and for typical constructions beyond the three cases studied in this research. For analysis and design purposes, a ratio R was defined as the net lateral restraining force per web or chord divided by the axial compressive load in the web or chord. For both 2 by 4 and 2 by 6 webs braced with one CLB, the R-value was 2.3 percent for all web lengths studied, and for webs braced with two CLBs, the R-value was 2.8 percent for all web lengths studied. Calculated R-values for truss chords braced by n-CLBs assumed to be spaced 2 feet on-center ranged from 2.2 to 3.1 percent. A step-by-step design procedure was developed for determining the net lateral restraining force required for bracing j-chords based on the results of the single member analogs studied.

Creep Response of a Wood I-Joist/OSB Floor System

Ben Wisniewski, Grad. Research Asst., and *Harvey B. Manbeck*, Distinguished Prof., Dept. of Agricultural & Biological Engineering, and *John J. Janowiak*, Assoc. Prof., Sch. of Forest Resources, Pennsylvania State Univ., Univ. Park, PA

The creep behavior of residential floor systems framed with structural composite lumber materials is not well understood. Specifically, creep performance data describing the behavior of floors constructed with LVL-flanged/OSB-webbed I-joists and OSB sheathing is not currently available. Presented are the results from an experimental study in which the cumulative response behavior for the assembly of a wood I-joist frame and OSB sheathed floor system, under typical levels of sustained loads in residential construction, was measured directly. The system creep response was modeled from the creep behavior of the individual elements (i.e., I-joists, OSB, and I-joist/OSB interface) that comprise a floor system. The study included

measuring the time-dependent deflections of the individual components of a floor system in the sustained state of stress anticipated as an element of the floor system (e.g., I-joist in bending, I-joist/OSB interface under shear) and formulating an analytical model to characterize the component creep behavior. The analytical component models were then used as input into a system model to predict the behavior of the composite floor system. One full-scale floor was constructed and exposed to similar loading conditions for direct measurement of the system creep response and for verification of the analytical component system model. Results gained from this study include a long-term deflection prediction model for the floor system and components examined. The average 9-month midspan deflection of the full-scale floor was 1.75 times the initial static deflection; the average 9-month midspan deflection of the bare I-joists was 1.8 times the initial static deflection.

TECHNICAL FORUM (POSTER) PRESENTATION ABSTRACTS

SUNDAY AFTERNOON, JUNE 18

SWST STUDENT POSTER COMPETITION

BOOTH 1

Modeling the Hot-Compression of Wood-Based Composites

Balazs Zombori, Ph.D. Student, *Frederick A. Kamke*, Prof./Dir., Wood-Based Composite Program, Dept. of Wood Science & Forest Products, and *Layne T. Watson*, Prof., Dept. of Computer Science, Virginia Tech, Blacksburg, VA

Hot-compression parameters have a substantial effect on the final properties of wood-based composite boards. The number of interacting variables during the hot-compression process is too large to enable assessment of data by experimental means. Therefore, a numerical model based on fundamental engineering principles was developed and validated to establish relationships between process parameters and the final properties of the board. The model simulates the mat formation, then compresses the reconstituted mat to its final thickness in a virtual press. The mat-formation part of the model is based on the Monte-Carlo simulation technique to reproduce the spatial structure of the mat. The dimensions and the density of each flake are considered as random variables in the model, which follow certain probability density distributions. The parameters of these distributions are derived from data collected on industrial flakes by using image analysis techniques. The model can simulate the structure of a three-layer oriented strandboard (OSB) mat as well as the structure of random fiber networks. A grid was superimposed on the simulated mat and the number of flakes, the thickness, and the density of the mat at each grid point were computed. Additionally the model predicts the change in void-volume fraction within the mat and the contact area among the flakes during consolidation. The void-volume fraction is directly related to the physical properties of the mat such as thermal conductivity, diffusivity, and permeability, while the contact area is related to the effectively bonded area within the mat. The heat and mass transfer part of the model predicts the change of air content, moisture content, and temperature at designated mesh points in the crosssection of the mat during hot compression. The water content is subdivided into vapor and bound water components. The freewater component is not considered in the model due to the low (typically 6 to 7%) initial moisture content of the flakes. The gas phase (air + vapor) moves by bulk flow and diffusion, while the bound water only moves by diffusion across the mat. The heat flow occurs by conduction and convection. The spatial derivatives of the resulting coupled equations are discretized by the central-difference scheme, while the time derivatives are solved by a differential-algebraic system solver. The internal environment within the mat can be predicted among different initial and boundary conditions by this part of the hot-compression model. In the next phase of the research, the viscoelastic (time, temperature, and moisture dependent) response of the flake mat will be modeled using the time-temperature-moisture superposition principle of polymers. It will give insight into the vertical density profile formation through the thickness of the mat. The density profile is related to all the mechanical properties of the final board (bending strength, internal bond strength, etc.). The model can assist in the optimization of the hot-pressing parameters of wood-based composites and improve the performance of the final panel.

BOOTH 2

Development of Ready-to-Assemble Framing System

Vladimir G. Kochkin, Grad. Research Asst., and *Joseph R. Loferski*, Prof., Dept. of Wood Science & Forest Products, Virginia Tech, Blacksburg, VA; *R. Terry Platt*, Pres., RTA Building Systems, Inc., Blacksburg, VA

Objectives of the presentation: 1) introduce the ready-to-assemble (RTA) framing system; 2) introduce the nail-plate connector (NPC) and present an analytical model that predicts nonlinear moment-rotation relationship for the NPCs; 3) present technology used to fabricate and construct a demonstration RTA building. A wood frame construction system that allows for easy and rapid assembly of buildings is being developed. The system utilizes a novel metal nail-plate connector that produces versatile and simple bolted metal-to-metal connections. Using the NPCs pressed into wood members, the structural wood frame is assembled with wrenches by a small crew. The RTA frame members can be stacked into a solid package for efficient transportation to remote locations. The NPCs were tested in translation and rotation to measure strength and stiffness. An analytical model was developed to predict the nonlinear moment-rotation relationship of the NPCs. The model incorporated the resistance provided by both the nails and the plate bearing on the end-grain of the wood member. A closed-form solution was derived and showed good agreement ($r^2 = 0.93$) with the average experimental curve. A RTA building was designed and constructed to demonstrate the feasibility of the concept. The project showed that all manufacturing steps can be readily optimized and automated for efficient mass production of the RTA frame kit. The project included: structural and architectural design, manufacturing of the NPCs and fabrication of the frame members, packaging and transportation of the kit, and on-site assembly of the structure.

BOOTH 3

Investigations into the Nature of PF/PMDI Hybrid Adhesives

Jun Zheng, Grad. Research Asst., and *Charles E. Frazier*, Assoc. Prof., Dept. of Wood Science & Forest Products, Virginia Tech, Blacksburg, VA

Phenol-formaldehyde (PF) and polymeric diphenylmethane diisocyanate (PMDI) are the two widely-used thermosetting adhesives for wood-based composites. There is a strong interest in combining these two adhesives in order to benefit from their positive qualities, while also neutralizing some of their negative qualities. The goal of this research is to investigate the fundamentals of a PF/PMDI hybrid adhesive system. The cure behavior, as well as the penetration of PF/PMDI hybrid adhesives into wood, is presented in this poster presentation. In the adhesive penetration study, fluorescence microscopy and image analysis techniques were used to quantitatively evaluate the adhesive penetration depth. Yellow-poplar (*Liriodendron tulipifera*) and southern pine (*Pinus sp.*) were used as the substrates; two commercial PF and PMDI adhesives were used. Both pre-mixed PF/PMDI blends and sequentially applied PF/PMDI adhesives were investigated. Pure PF and PMDI penetrated well into wood, and dispersed into wood cell lumens and cell walls. Penetration was limited in blend systems where a larger percentage of resin solids remained in the bondline between wood substrates. When PF and PMDI were applied to wood sequentially, they appeared to remain in separate phases. The cure behavior of PF/PMDI hybrid adhesives was investigated by using Dynamic Mechanical Thermal Analysis (DMTA). In this study, wood flakes (35x9x0.2 mm) were used as the substrate to monitor the adhesive cure. Both pre-mixed PF/PMDI blends and sequentially applied PF/PMDI adhesives were investigated.

Dynamic and isothermal scans of wood flakes showed a slight increase in storage modulus, but no distinctive peaks on the tand traces. For wood flakes loaded with pure PMDI, the storage modulus progressively increased, but no characteristic tand peaks were observed. The isothermal cure of pure PF showed a characteristic tand peak, which was assigned as vitrification. For wood flakes loaded with PF/PMDI hybrid adhesives, the dynamic scans showed distinctive tand peaks, in some cases more than one. This implied a separate phase in PF/PMDI hybrid adhesives, or could be due to gelation followed by vitrification. The morphological characteristics of PF/PMDI hybrid adhesives will be further confirmed with other experimental methods. Different PF/PMDI hybrid adhesive systems exhibited difference in vitrification time. Among all the investigated adhesive systems, 33/67 PF/PMDI (solids/solids) blend showed the shortest vitrification time; while pure PF showed the longest vitrification time.

BOOTH 4

Anisotropic 2D Transient Heat Conduction Model for Lumber Drying

Hongmei Gu, Grad. Research Asst., and *Audrey Zink-Sharp*, Assoc. Prof., Dept. of Wood Science & Forest Products, Virginia Tech, Blacksburg, VA

Wood is a strong anisotropic material due to its structure. So when wood is subjected to drying conditions, it shrinks anisotropically. Significant differences between the radial and tangential shrinkage have been found for years and recognized as the main factors for drying defects. Significant differential shrinkage results from the different heat and mass transfer rate in the two directions during drying. Heat and mass transfer coefficients, such as thermal conductivity and diffusivity, play dominant roles during the drying process. Transport coefficients are very structure-dependent and sensitive to the environment. As a result, it is difficult to measure accurate values from experiments. This research attempts to derive a thermal conductivity in the radial and tangential direction from a wood structure model and thermal resistance model proposed in this study. Wood structure characteristics related to heat transfer coefficients are obtained by examining specimens under SEM (Scanning Electron Microscopy). The wood structure model and thermal resistance model are then set up for deriving different thermal conductivities in radial and tangential directions. The ratio of derived thermal conductivity for radial/tangential is about 2:1, with values of 0.096W/m K for radial thermal conductivity and 0.047 for tangential thermal conductivity. A model of anisotropic 2D transient heat conduction is solved in *Mathematica* Software with the Finite Difference Method using the derived values of thermal conductivity. Only pure heat transfer is considered in this study by assuming that heat transfer develops faster and earlier than moisture transfer, based on drying experience. Output from the model is used to examine anisotropic material property effects on drying quality control. Animated heat-transfer processes for lumber drying are shown in the *Mathematica* Environment. *Mathematica* Software is used for the scientific research in engineering analysis and modeling because of its powerful numerical solving technique and plotting options.

BOOTH 5

Measurement of Resin Distribution in MDF Fiber

Keith A. Scott, Grad. Research Asst., Dept. of Wood Science & Forest Products, *Frederick A. Kamke*, Prof./Dir., Wood-Based Composite Program, and *J-B. Ra*, Post-Doctoral Fellow, Dept. of Wood Science & Forest Products, Virginia Tech, Blacksburg, VA

The objective of this study was to develop a technique for quantitatively measuring surface area coverage and statistical distribution of urea-formaldehyde (UF) resin on MDF fiber. By treating the resinated fiber with a reactive stain, the resin and the wood can be distinguished and separated using digital image analysis. An epi-fluorescence microscope, color video camera, A/D image capture board, and image analysis software were used to measure the percent of resin coverage on the wood surface. These measurements can assist companies in making blending improvements, testing new resin formulations, and reducing resin costs. The measured resin coverage of the treated fibers did not correlate with the target resin loading level. This result was surprising because preliminary trials with commercially-blended fiber clearly showed the presence of UF resin when treated with the acriflavine solution. Due to the large number of images to be processed (250 per sample), an automated method was used. It is suspected that slight variations between specimens may have induced significant variations in the processed images. However, a nitrogen analysis was performed using a specimen of similar size, and yet it correlated to the target resin loading levels. It should be noted that the resin coverage results are based on surface area measurements, while resin loading and nitrogen content are based on the mass of resin solids. Since the results of the resin coverage measurements were inconclusive, more research will be needed to refine the treatment process and reduce variability. At this time the technique is only qualitative.

BOOTH 6

Mode I Fracture Energy Testing of Adhesively Bonded Wood

Jerone M. Gagliano, Grad. Research Asst., and *Charles E. Frazier*, Assoc. Prof., Dept. of Wood Science & Forest Products, Virginia Tech, Blacksburg, VA

In order to better understand the mechanical properties and performance of wood adhesives, adhesives should be investigated as part of a bonded system. The standard in the wood adhesive industry is to use an ultimate-strength approach to test adhesive bonds (i.e., the shear block test). This test, however, only measures an average stress level instead of the critical value for failure. Additionally, ultimate strength tests include a certain portion of wood failure. But the most common failure mode in composite laminates is the propagation of an interlaminar crack through the adhesive bond. Therefore, a fracture mechanics offers a desirable approach manner to study the mechanical performance of the adhesive-wood interaction in the bondline. This approach yields a more sensitive comparison tool for adhesives because a critical energy value is being measured, and there is no wood failure. The objective of this research is to refine the testing and analysis procedure for adhesively-bonded wood specimens using Mode I fracture mechanics and a double cantilever beam (DCB) geometry. Specifically, the goals were to: 1) simplify the entire testing and analyzing process; 2) achieve constant SERR values with respect to crack length; 3) correlate dielectric curing profiles and bondline spectroscopy to fracture performance; and 4) get the wood adhesives industry interested in this approach. The system studied was yellow-poplar (*Liriodendron tulipifera*) sapwood bonded with a phenol formaldehyde resin, using ASTM D3433-93. The best-data analysis method (of four) was chosen as the one that gave the "flattest" SERR values when plotted against crack length. By comparing the coefficients of variance (COV) of all four methods on the same sets of data, the shear-corrected method yielded the best results. To test the sensitivity of applying fracture mechanics to adhesively-bonded wood systems, specimens with a phenol-formaldehyde film adhesive were hot pressed at five time intervals (8, 12, 16, 20, and 24 min.). Adhesive performance differences, as a result of different curing times, were detected using the shear-corrected analysis method. As cure time increased, so did the fracture toughness values up to 20 minutes, after which time the values decreased. There was no wood failure ina any of the specimens.

BOOTH 7

Assessing the Product Development Characteristics of Scanning and Optimizing Technology in the Hardwood Sawmill

Scott A. Bowe, Grad. Research Asst., *Robert L. Smith*, Assoc. Prof./Extension Specialist, and *D. Earl Kline*, Assoc. Prof., Dept. of Wood Science & Forest Products, Virginia Tech, Blacksburg, VA; *Philip A. Araman*, Project Ldr., Southern Research Sta., USDA Forest Service, Blacksburg, VA

Significant technological leaps are being made in the hardwood sawmill industry. Advancements in hardwood scanning and optimizing technologies have increased yields and product value with carriage, edging, trimming, and sorting systems. In addition, significant advancements have been made with emerging hardwood automated grading technologies. To develop and market these technologies to industry effectively, the marketing, management, and adoption processes behind these systems must be understood. To develop such an understanding, a nationwide hardwood sawmill study was undertaken by researchers at Virginia Tech. This research focused specifically on edger optimizers, emerging next generation edger optimizers, and emerging automated hardwood lumber grading systems. The objectives of this study were: 1) characterize the differences between companies for both adopters and nonadopters of scanning and optimizing technologies; and 2) identify company expectations of scanning and optimizing technology including the cost and feature levels that will be accepted by the hardwood sawmill industry. Data were collected through a mail survey of over 2000 hardwood sawmills across the United States. A wide size-range of sawmills responded providing to the breadth of the study. The specifics of the study have yet to be reported since the data are currently being analyzed. Data were collected on sawmill's past and present experience with scanning and optimizing technology. In addition, data were collected on specific technology factors such as costs, system features, and personnel/training issues. Given the scope of the study, this research has value in several areas that: compare groups such as adopters versus non-adopters to provide the most effective direction for this technology; inform the scanning and optimizing technology manufacturers of hardwood sawmill expectations; and assist hardwood sawmills in making sound decisions about scanning and optimizing systems.

BOOTH 8

Wood Material Use in the U.S. Cabinet Industry

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This project was a study of material use in the U.S. cabinet industry. The cabinet industry is an integral part of the larger entity of forest products, which is a major part of the U.S. economy. It is a substantial consumer of both hardwood lumber and wood-based panel products, yet little current quantitative information is available regarding this use. High growth within the industry during the past decade requires that current material-use data be collected. Information regarding material use is important to those involved in the industry, both suppliers and producers. It will also create a basis for comparing past research. Another goal of this study was to identify and address current managerial issues facing company executives. It is important that the industry understand where it has been and where it is going in order to promote healthy decisions for future prosperity.

BOOTH 9

Species Dependence of PMDI Adhesive Performance Between Southern Yellow Pine and Yellow-Poplar

Michael J. Malmberg, Grad. Research Asst., Dept. of Wood Science & Forest Products, Virginia Tech, Blacksburg, VA

Polymeric methylenebis (phenylisocyanate) (PMDI) has increasingly been used in the wood particulate composite industry in recent history. These products are made with many different types of wood species. Very little research has been done to investigate how PMDI adhesion is effected by species differences. The present research utilizes Mode-I fracture mechanics; static contact angle; and ^{15}N, ^{13}C cross-polarization, magic-angle spinning (CP/MAS) NMR to investigate the differences of adhesion between the two species. Mode-I fracture double cantilever beam (DCB) specimens were prepared to measure the fracture toughness of the PMDI bondline within each species. DCB specimens were machined from wood laminates cured at 175°C for 20 minutes at 0.55Mpa with an industrial PMDI resin. DCB specimens were conditioned to 10 percent EMC and tested at a constant cross head rate of 2 mm/min. Static contact angle measurements were performed on wood laminae at 10 percent EMC. Contact angles were measured after 0.5 seconds contact with the wood surface using a video image analysis system. A 99 percent ^{13}C, ^{15}N enriched PMDI resin with similar properties to the industrial resin used for the fracture toughness values was synthesized. Groups of wood flake/^{13}C, ^{15}N-PMDI composites, cured as a function of wood precure moisture content and cure temperature were prepared. Mode-I fracture results show that PMDI adhesion is affected differently in southern yellow pine and yellow-poplar. Fracture toughness in pine was significantly higher than yellopoplar. Also the standard deviation was much greater in southern pine samples. The total surface energy in pine was greater than yellow-poplar. The acid and base components of surface energy were greater in pine than poplar. Poplar had higher dispersive component of surface energy. The cross polarization magic angle spinning solid-state NMR data had not been fully acquired at the time of this abstract.

BOOTH 10

Morphology of the Wood-Phenol-Formaldehyde (PF) Interphase Detected by Solid State Nuclear Magnetic Resonance (NMR)

Marie-Pierre G. Laborie, Grad. Research Asst., and *Charles E. Frazier*, Assoc. Prof., Dept. of Wood Science & Forest Products, Virginia Tech, Blacksburg, VA, USA

Intuitively one associates the morphology of the wood adhesive interphase with bond performance. Unfortunately little work has focused on understanding the morphology of the wood adhesive interphase on a molecular scale. In this research, solid state NMR is utilized to probe nanometer and angstrom scale morphology in the wood-phenol-formaldehyde (PF) interphase. Neat PF resins and wood-PF composites were analyzed by CP/MAS NMR with a variable contact time CP pulse. The PF methylene bridge at around 40 ppm does not overlap with any wood signals and holocellulose displays a distinct chemical shift at 105 ppm. Therefore, individual relaxation rates of PF and wood polymers can be measured within a composite and compared to the bulk relaxations from neat wood and neat PF. Specifically, cross polarization rate (T_{CH}) and proton spin lattice relaxation time in the rotating frame (T^H_{1r}) were monitored. While T_{CH} probes molecular motions on angstrom domains, T^H_{1r} is sensitive to motions on nanometer scale domains. Therefore, monitoring the individual polymer relaxation helps evaluate the interphase morphology on a nanometer and angstrom scale.

BOOTH 11

Establishing the Location of the Co-monomer N-methylolacrylamide with Respect to the Latex Particles in Crosslinking Polyvinyl Acetate Adhesives

Nicole Robitaille Brown, Grad. Student, *Charles E. Frazier*, Assoc. Prof., and *Joseph R. Loferski*, Prof., Dept. of Wood Science & Forest Products, Virginia Tech, Blacksburg, VA

Since the 1960's it has been well established that the inclusion of a small amount, typically less than 5 percent, of N-methylolacrylamide (NMA) in polyvinyl acetate (PVAc) adhesives effects noticeable improvements in the durability of bonded wood assemblies. Today, commercial formulations of crosslinking PVAc adhesives remain much the same, as they continue to utilize NMA to enhance durability. However, relatively little is known concerning the chemical mechanisms by which the NMA functions in the adhesive. The primary goal of this project is to elucidate the mechanism by which the crosslinking comonomer, NMA, improves the durability of PVAc adhesives. Considering the nature of latex systems and the coalescence process that these systems undergo, it seems only natural to question whether or not the location of the crosslinking comonomer (with respect to the latex system) impacts the durability of the adhesive. Current work focuses on refining a centrifugation/solution NMR method that allows the relative location of the NMA to be detected. Because of the harsh conditions imposed on the particles during the centrifugation process, and the concern that such conditions could promote coalescence, it has been proposed that other latex washing techniques could be utilized in conjunction with solution NMR to discern the location of the NMA. These developments will be discussed in detail in the presentation.

BOOTH 12

An Economic Analysis of a Soybean Wax Firelog

Jonathan P. Dubroc, Grad. Asst., and *Neils de Hoop*, Assoc. Prof., Sch. of Forestry, Wildlife, & Fisheries, Louisiana State Univ. Agricultural Center, Baton Rouge, LA

The disposal of wood residues is costly and unnecessarily occupies landfill space. One solution to this problem may be the production of an artificial firelog. A firelog manufacturing process is proposed for Louisiana manufacturers that combine wood residues with a soybean-based wax. The major objectives of this project are to create an economic model for the firelog manufacturing process, to estimate a break-even price for the firelogs, to create an investment analysis model suitable for Louisiana producers, and to work with local businesses interested in developing this sector. The economic model will be used to assist secondary wood manufacturers in developing their business plan. This project is important because it will portray the financial opportunities and the risk involved with the investment. Two manufacturing methods are being considered: 1) a facility supported by one large producer of residue; and 2) a collective manufacturing facility supported by many small producers of residues. Capital and operating cost information will be obtained through personal contracts. These contacts range from persons involved with academia nationwide and local industry. The initial calculation and organization will be processed by a combination of Hassler's and Folk's economic models and adapting them to Louisiana business. Louisiana secondary wood manufacturers can use this economic model as a starting point.

BOOTH 13

Resistance of Ofram/Limba (*Terminalia superba*) and Avodire (*Turreanthus africanns*) to Infestation by Molds and Staining Fungi

Samuel Tetteh Akuetteh, Student, Inst. of Renewable National Resources, Kwame Nkrumah Univ. of Science & Technology, Kumasi, Ghana

Freshly-felled wood of Avodire (*Turreanthus Africanns*) and Ofram/Limba (*Terminalia Superba*) are susceptible to fungal discolorations and moulding. The severity of the infection varies with various storage and environmental conditions. The objective of this study is to determine by above-ground field-testing the natural durability of Ofram and Avodire and to compare their natural durabilities. Moreover, the results of this study will help sawmills avoid discoloration by moulds and staining fungi, since the test will define the number of days it takes for fungal growth to appear on freshly-felled Avodire (*Turrean htus africanus*) and Ofram (*Terminalia superba*), thereby enabling processing prior to the appearance of fungal discoloration and moulding. Both Avodire (*Turreanthus africanus*) and Ofram (*Termunalia superba*) are tropical hardwood species. The wood of Avodire (Turreanthus africanus) has cream-colored heartwood and sapwood with an attractive luster. Ofram (*Terminalia Superba*) has pale yellowish-white heartwood and sapwood. Both Avodire and Ofram are naturally nondurable species and care has to be taken to avoid discoloration by moulds and staining fungi. In this study, tests were conducted at the Institute of Renewable National Resource Farm. Tests were carried out at three different sites on the farm and four replicates of each test species were evaluated at each site. The method used is above-ground field-testing and the criteria is based on visual examination of fungal growth on the surface of test samples. The test lasted for about 30 days, starting in January 2000 and ending in early February 2000. The discolorations of the test samples caused by moulds and staining-fungi were assessed visually. The results of the test revealed that a period of 30 days was sufficient for fungal growth on test samples. Ofram was found to be more susceptible at all sites. Also, there was substantial difference in fungal growth on test samples at the different sites as well as within individual samples. Analysis of variance (ANOVA) was used to assess the difference in fungal growth on the surfaces of test samples of Avodire and Ofram.

BOOTH 14

Germination and Growth Studies of *Strombosia Glaucescens*

George Ansah, Student, Dept. of Silviculture & Forest Management, Kwame Nkrumah Univ. of Science & Technology, Kumasi, Ghana

Strombosia glancenscens was propagated artificially to dtermine the effect of specified preserving treatments on the germination of seeds and to monitor the growth of seedlings, both at the nursery and after transplanting in the field. Also, existing information on the species was collected to evaluate its suitability for use as poles. Fresh fruits of *Strombosia glaucescens* were collected from Asenanyo Forest Reserve and kept in a polythene bag for 4 days at a room temperature. The size of the fruit was between 1.20 cm and 2.0 cm. The design employed was complete randomized block using four blocks and four treatments each. Each block, made up of a hundred seeds, were subjected to each of the following four treatments: 1) control (Testa intact) - no treatment; 2) mechemical scarification - the outer layer of the seed coat was scrapped off with a knife; 3) acid treatment - the seeds were soaked in concentrated hydrochloric acid for 5 minutes and washed thoroughly before sowing; and 4) soaking in cold water - the seeds were soaked overnight prior to planting. Germination was poor and delayed. This was suggested to be due to an undeveloped embryo.

Germination was hypogeal, and growth at the nursery was rapid and transplants could be produced within 3 to 4 months. The seedling increased in height from 25 mm at the end of the first week of emergence to 42 mm at the end of the second week. The plumule were well developed at the end of the second week. The shoot grows upright and appears hairy. The first few foliage leaves are simple and are oppositely arranged. The leaf margin is entire and the tip cordate. Growth was sluggish during the later weeks of the study period. Strombosia is strong, tough, durable, and resists fungal and insect attack. It is used for poles, posts, and pit props. It works and finishes well, and takes a high polish.

BOOTH 15

Ergonomic Solutions for the Wood Products Industry

E. Robert Savage, Research Asst., and *Rado Gazo*, Asst. Prof., Wood Research Lab., and *J.D. McGlothlin*, Assoc. Prof., Ergonomics Research Lab., Purdue Univ., W. Lafayette, IN

The issues of quality, lean manufacturing, globalization, environmental compliance, and worker's health have been at the forefront of manufacturing management perspectives for years. Today, these principles and concepts have more interest and more impact than ever before due to the increasing competition for customer needs. However, without discounting these needed efforts, a new issue, ergonomics and human factors, is at the front of manager's perceptions. With future ergonomic legislation on the rise, managers of manufacturing companies are continually keeping an eye on the promulgation horizon. It seems that legislators know the value of sound ergonomic principles and condone the establishment of ergonomic programs. Couple this ergonomic acknowledgement with keen industry management knowledge of profitability and there is an overwhelming argument for increasing worker health through ergonomic practices. After all, being able to meet customer needs while still maintaining or reducing your own costs is the pinnacle of financial viability toward organizational sustainability. This study was conducted to understand and categorize associated risk factors specifically inherent in wood manufacturing environments. Results from heuristic metrics will be presented towards implementing viable, cost effective ergonomic solutions for the secondary-wood products industry.

BOOTH 16

Digitized White Birch Database: Its Creation and Use

Charles Clement, Research Asst., *Henry Quesada*, Researcher, and *Rado Gazo*, Asst. Prof., Dept. of Forestry, Purdue Univ., W. Lafayette, IN; *Robert Beauregard*, Mgr., Forintek Canada Corp., Ste-Foy, QC, Canada

There is growing interest in the exploitation of underutilized wood species in value-added products. This interest is brought about by the increasing scarcity of high-quality hardwoods such as oak and maple and the resulting increase in price. This presentation analyzes white birch (*Betula papyrifera*) boards through the creation of a digitized database and the utility of said database in evaluating the species yield with respect to a determined cutting bill. The procedure for developing the database consists of manually recording the location of each defect on both faces of each board. A computer program then reconstructs this information into boards and computes the relative frequencies of various defect types, the number of defects found per board foot, the area covered per board foot and the percentage of board surface covered. The defects included were both natural (e.g., knots, bark pockets, decay, mineral streaks,etc.) and manufactured (e.g., machine gouge, void, machine burn, etc.). The database can interface with all common simulation and modeling programs. ROMI-RIP and ROMI-CROSS will be used to establish yield potential for the furniture and flooring industries.

BOOTH 17

Construction of School Furniture Prototypes in Costa Rica

Eva Haviarova, Ph.D. Candidate, and *Carl A. Eckelman*, Prof., Dept. of Forestry, Purdue Univ., W. Lafayette, IN

A school furniture project described in this presentation has been well received by representatives of the Costa Rican government, scientists, and all other project cooperators, mainly because of its broad concept. This project emphasizes sustainable development using environmentally-friendly practices, including plans for rural community development, creation of job opportunities for indigenous people, and most importantly a decrease in the school furniture deficit. A pilot study of a prototype building was undertaken in Costa Rica at the Institute of Technology (ITCR) in February 2000, where both solid wood and cross-lap laminated chair and desk prototypes were built. The purpose of the prototype building was to train workers at the Institute of Technology in new furniture making practices. These workers will then equip two classrooms with the new school furniture, and performance will be evaluated after 1 year in service. Overall, the prototype construction in Costa Rica was successful in many ways. First, we demonstrated that it is possible to construct durable designs that were completed with locally available material, machinery, and supplies. Second, we provided training and explained how this type of furniture construction is more suitable for durable school furniture. Third, the prototype demonstration increased the enthusiasm of people interested in solving school-furniture problems.

BOOTH 18

Effects of Preservative Treatments on FRP Reinforcement for Wood

Cihat Tascioglu, Grad. Research Asst., and *Barry S. Goodell*, Prof., Dept. of Wood Science & Technology, and *Roberto Lopez-Anido*, Asst. Prof., Dept. of Civil Engineering, Advanced Engineered Wood Composites Center, Univ. of Maine, Orono, ME; *Beckry A. Magid*, Prof., Dept. of Composite Materials Engineering, Winona State Univ., Winona, MN

All wood used in exposed outdoor environments must be treated with appropriate wood preservatives to prevent deterioration from decay and insect attack. Although considerable literature exists on the treatment of laminated timbers and wood composites with wood preservatives, almost no information is available on the exposure of Fiber Reinforced Polymers (FRP) composites to wood preservative chemicals, and no information is available on wood-FRP composites treated for exterior exposures. Because more laminated composite products are being bonded to FRPs and these products are being targeted to exterior exposures, wood-preservation research was necessary to provide appropriate background information to engineers and wood scientists working in the field. The production of preservative-treated composite-reinforced laminated timbers represents the latest stage of investigation and development and is of considerable interest to both the wood preserving and composite-reinforced wood hybrid industry (CRW) for civil infrastructure. In this work, laminated timbers reinforced with FRP material were treated with common preservative chemicals and the effect of wood-preservative treatments including: 1) oil-borne; 2) organo-and organometalic; and 3) acid and amine-based water-borne preservatives, on mechanical properties of GFRP material were investigated. ASTM D-3039 (longitudinal and transverse tensile) and D-2344 (short beam interlaminar shear) tests were used for mechanical characterization of preservative-treated E-glass/phenolic-pultruded material. Although longitudinal MOE was unaffected, some longitudinal strength losses

were recorded for water-borne treated FRP coupons. A simple model was used to compute the average fiber strength within preservative-treated FRP coupons. These results were supported by microscopic analyses of single glass fibers taken from failed FRP coupons. The presentation will also cover development of material reduction factors for design criteria and will discuss threshold preservative retention levels. Recommendations for use of wood-FRP composites in exterior environments, based on early data, will be offered for civil engineers and the FRP/wood reinforcement industry.

BOOTH 19

Effect of Various Chemical Additives on VOC Emissions from Southern Pine Flakeboard

Shane O'Neill, Grad. Research Asst., and *Douglas J. Gardner*, Assoc. Prof., Advanced Engineered Wood Composites Center, Univ. of Maine, Orono, ME

This study investigated the volatile organic compound (VOC) emissions of flakeboard manufactured from southern pine (*Pinus sp.*) flakes and various chemical additives. The purpose of this study was to observe whether the VOC emissions of southern pine flakeboard could be statistically lowered through the use of chemical additives. If an additive can lower the VOC emissions produced during the production of flakeboard, then there is less a need for pollution control technology, and overhead costs in an OSB manufacturing facility can be reduced. Phenol-formaldehyde (PF) resin was used as an adhesive, and applied using a spinning disk atomizer. Nine chemical additives (aluminum chloride, hydrogen peroxide (30%), urea, aluminum sulfate, hydroxylamine hydrochloride, maleic anhydride, sodium bisulfate, sodium hydroxide, and nitric acid (fuming)) were evaluated for their effectiveness in reducing the VOC emissions from the flakeboard during hot-press consolidation. Application of the additives to the flakes was facilitated by dissolving the chemical in water, and spraying the solution onto the furnish using a pneumatic airbrush. A distilled water application was used as a control to maintain moisture content (MC) levels between the treatments. Each additive was applied at a 1 percent concentration (w:w). Panels were pressed at 191ºC using an electric-platen hydraulic press for 300 seconds (plus 30 sec. degas). Emission collection was conducted via a laboratory-scale closed-caul system. Analysis techniques used to analyze the VOC solutions were gas chromatography-flame ionization detection (GC-FID), gas chromatography/mass spectrometry (GC/MS), and ultraviolet-visible spectrometry (UV-VIS). From the analysis, 21 periodic VOCs were identified and selected. The VOCs analyzed were formaldehyde, methanol, formic/acetic acid, propionic acid, hexanal, 2-heptanone, heptanal, tricyclene, a-pinene, camphene, b-pinene, 2-*n*-pentyl furan, limonene, nonanal, (-)-trans pinocarveol, (E)-2-octenal, 1-octanol, a-terpineol, fenchyl alcohol, estragole, and dehydroabietic acid. Once quantified, the emission levels were compared statistically using a two-way analysis of variance (ANOVA) comparing the treatments to the controls (Dunnett's Test). Formaldehyde emissions were statistically reduced by sodium bisulfate, urea, sodium hydroxide, and hydrogen peroxide. Hexanal emissions were reduced by hydroxylamine hydrochloride and urea. Nonanal was lowered only by the hydroxylamine hydrochloride additive. a-Pinene was lowered by urea. 2-*n*-Pentyl furan was reduced due to the addition of the nitric acid. The total VOC emission levels showed no decrease compared to the control. If methanol was removed from the statistical analysis, it was found that urea statistically lowered the emissions of the remaining 20 VOCs examined.

BOOTH 20

Green Advertising of Forest Products in the United States: A Content Analysis

Ernesto R. Wagner, Grad. Research Asst., and *Eric N. Hansen*, Asst. Prof., Dept. of Forest Products, Oregon State Univ., Corvallis, OR

Green advertising expresses a relationship of a product or service to the environment, promotes a green lifestyle or presents a corporate image of environmental responsibility. Many forest-industry advertisements fall into this new category. This research took a sample of green advertisements from magazines and trade journals and performed a content analysis. This technique, proven useful in advertising research, allows valid inferences to be made from data in their context. The present investigation gives suggestions for improving green advertisements.

BOOTH 21

Use of Anti-Stain Chemical Treatments by the Western U.S. Softwood Lumber Industry, 2000

Roy C. Anderson, Ph.D. Grad. Student, *Eric N. Hansen*, Asst. Prof., and *Jeffrey J. Morrell*, Prof., Dept. of Forest Products, Oregon State Univ., Corvallis, OR

In the spring of 2000, a questionnaire designed to assess the use of anti-stain chemicals was mailed to all producing members of the Western Wood Products Association. Data was gathered from the survey and will be presented. It includes: total volume of lumber treated by respondents, percentage of lumber treated from that produced in the whole western region, species treated, chemicals used, treatment methods used, and the acceptability of stain in specific market segments.

BOOTH 22

Effect of Slope Aspect and Scanning Intensity on the Correlation Between Stress-Wave Speeds in Douglas-fir Trees and Lumber MOE

Shih-Yin Wu, Doctoral Student, Forest Products Dept., Univ. of Idaho, Moscow, ID

Six Douglas-fir (*Pseudotsuga menziesii*) trees were stress-wave scanned on four faces (uphill, downhill, and two side-hill) near their base and over a longitudinal distance of 4 feet. The trees were then harvested, and 12-foot logs just above the tree scans were scanned intensively (longitudinal and transverse scans). Longitudinal stress-wave speeds were measured on four faces over an 11-foot distance, and transverse stress-wave speeds were measured at 10 positions from one face to the opposite face. Both the longitudinal and the transverse stress-wave speeds were then used to calculate an index value for each log. The logs were then sawn into 2-inch by 4-inch lumber, and the MOE of each piece of lumber was measured with a Metriguard 2600 E-computer. As with past research, the correlation of stress-wave speeds on randomly-located tree-faces with average lumber MOE was low. However, the correlation between stress-wave speeds on the downhill face of the trees and average lumber MOE was relatively high (r^2=0.668). In addition, the correlation between the index value calculated from the intensive scans of each log and the average MOE of lumber sawn from the logs was high (r^2=0.872). Results indicate that it may be possible to identify high-stiffness wood within trees with a stress-wave scanner by scanning on the proper face (downhill), over longer-longitudinal distances, and in the transverse direction. These findings are encouraging because of the growing demand for engineered wood products such as roof trusses and laminated veneer lumber (LVL) products that require high-modulus of elasticity (MOE) wood. Knowing the mechanical properties of wood in standing trees could assist forest managers in making informed decisions about which trees to allow

to grow, which trees to harvest, and where to market those trees that are harvested for maximum utility and profit.

BOOTH 23

Mechanical Properties of Ponderosa Pine Dimension Lumber from Small-Diameter, Overstocked Stands in Arizona

Aldo G. Cisternas, Grad. Student, and *Thomas M. Gorman*, Assoc. Prof., Forest Products Dept., Univ. of Idaho, Moscow, ID

Ponderosa pine forests in Northern Arizona typically consist of overgrown, densely-stocked trees that create a fire hazard and are prone to disease. These stands need to be thinned, but the cost of harvesting exceeds the value of the timber produced. The key to economical restoration of ponderosa pine stands to historical density, health, and composition is to produce high-value products from thinning. One concern about selective harvesting of small-diameter trees is that they may have a high percentage of juvenile wood, with lower values for density, stiffness, and strength. To begin the process of evaluating products from this resource, we determined basic information on lumber recovery, grade yield, and mechanical properties. In northern Arizona, Ponderosa pine small-diameter trees were cut, bucked, sawed into 2 by 4 lumber, and shipped to the Forest Products Department at the University of Idaho. The lumber was visually graded using "Light Framing", "Structural Light Framing", and "Machine Stress Rated (MSR)" rules. Dynamic MOE, static MOE, MOR, density, and moisture content were measured following ASTM standard rules. The machine grades were obtained following American Lumber Standard (ALS) procedures. According to visual grading rules, between 30 and 35 percent of the samples did not meet the minimum requirement for inclusion in "Light Framing" or "Structural Light Framing" applications. Lognormal log-scale distribution fitted better the 5th percentile of MOR and MOE in 'Light Framing" and "Structural Light Framing" grades. Lumber with an MOE higher than 1,600,000 psi is not likely from this resource. The potential for MSR lumber seems to be limited to $1450F_b$-1.3E, though $1500F_b$-1.4E with a yield close to 20 percent could be interesting.

BOOTH 24

Influence of the Surface Morphology on the Growth of Transcrystalline Layer (TCL) on Kraft Pulp Fibers

Sang Yeob Lee, Grad. Student, and *Thomas M. Gorman*, Assoc. Prof., Forest Products Dept., Univ. of Idaho, Moscow, ID

This study attempts to predict the increase in mechanical properties resulting from the growth of transcrystalline layer (TCL) on different fiber types. The effects of the crystallization process on the increased strength properties of woodfiber-plastic composites were recently studied using many different approaches with polypropylene (PP) as a semi-crystalline polymer. However, these studies have related to non-wood materials and only limited research has been focused on clarifying the influence of polypropylene crystallization on the surfaces of wood-based materials. This study focused not only on the effect of a coupling agent but also on morphology of the pulp fiber surface to clarify many existing questions for woodfiber-plastic composites. Unbleached and bleached kraft pulp fibers were used for this study with 100 percent polypropylene (PP), 95 percent polypropylene (PP)/5 percent maleic anhydride polypropylene (MAPP), and 100 percent maleic anhydride polypropylene (MAPP) at 150 ± 1°C. The fibers were commercial wood fibers (Potlatch Co. Lewiston, ID), which were collected during the kraft pulping process. Surface characteristics of the woodfibers were observed using oxygen and carbon (O/C) ratios of specified areas on the woodfiber by x-ray analysis, and analysis of surface roughness on the fiber surfaces were carried out by Scanning Electron Microscopy (SEM). Enhanced maleic anhydride polypropylene (MAPP) induced transcrystallization on the woodfiber surfaces, and nucleation density also increased with addition of MAPP. However, no transcrystalline layer (TCL) formed on the bleached and unbleached kraft pulp fibers with 100 percent polypropylene (PP) at 150 ± 1°C. Poor crystallization was observed on the fiber surfaces, but nuclei were induced at the ends of the fibers and on damaged surfaces. The thickness of TCL and the radius of spherulites in the bulk area and on the fiber surface decreased with the proportion of MAPP. It was observed that the MAPP played a potential role in increasing numbers of nuclei on the linear fiber surfaces to induce transcrystallization. Mechanical properties increased 52 percent with 100 percent MAPP compared to the use of 100 percent PP. Different fiber types also affected the nucleation ability and a 26.7 percent increase in modulus was attained using bleached pulp fiber. Therefore, the increased thickness of TCL and nucleation density on the surface of woodfiber positively correlated with the mechanical properties of wood fiber-plastic composites.

BOOTH 25

Influence of Free Copper on Fungal Growth

Rebecca F. Jennings, Research Asst., and *D. Pascal Kamdem*, Assoc. Prof., Dept. of Forestry, Michigan State Univ., E. Lansing, MI

Copper has been shown to be an affective component in many wood preservatives. The mode of toxicity is not fully understood. The objective of this study was to determine if copper must be free in solution to prohibit fungal growth. White-rot fungal species, *Poria placenta* (Pp) and *Gleophyllum trabeum* (Gt), were used to determine the copper toxicity thresholds. Under the experimental conditions used, a copper concentration of 250 ppm inhibited growth of Pp and 50 ppm inhibited Gt. Various organic acids were used to chelate copper in media and fungal growth rate was determined. By adding EDTA in 1:1 mole ratio with copper at toxicity threshold concentrations, fungal growth rate was restored to control levels. The effect of other organic acids will be discussed.

BOOTH 26

A Colorimetric Technique for Determining Surface Moisture Content and Mathematical Procedure to Evaluate Mass Transfer in Wood

Hwanmyeong Yeo, Grad. Research Asst., *William B. Smith*, Assoc. Prof., Wood Products Engineering, and *Robert B. Hanna*, Dir., Center for Ultrastructure Studies, College of Environmental Science & Forestry, State Univ. of New York, Syracuse, NY

The objective was to develop a colorimetric technique for determining surface moisture content (MC) of wood, utilizing the relationship between cobalt chloride ($CoCl_2$) hydrate color change and relative humidity, and to perform a mathematical analysis of mass transfer in wood using this technique. Surface MC and MC distribution in wood are important factors in the potential for formation and prevention of drying defects, and these techniques could prove useful to scientific investigators. Wood surfaces exhibit different color values at varying MC levels. For example, the surface of wet wood is usually relatively dark, while dried surfaces are a lighter color. It is difficult, however, to determine specific MC by color change of wood specimens when there is little variation or change with incremental MC, especially when below the fiber saturation point. To address this problem, wood specimens were treated with $CoCl_2$ hydrate, a compound whose color depends upon and changes with relative humidity. $CoCl_2$-hydrate-treated wood was shown to exhibit a reddish color that changes to a bluish color, over the high to low hygroscopic MC range, respectively. These experiments were carried out with three species, hard

maple, red oak, and southern pine, each utilizing specimen of three different directional orientations, cross, radial, and tangential, with dimensions of 15 (length) by 15 (width) by 5 (thickness) mm, respectively. Saturated $CoCl_2$ solution was dropped (0.005 ml) on the surface of each specimen, and a spectrophotometer was used to correlate CIE Lab color values to surface MC. Utilizing surface MC values determined with the colorimetric technique, one can more accurately determine a surface emission and diffusion coefficients of wood during drying. The surface emission coefficients were obtained using moisture exchange rate and surface MC difference relationships determined by colorimetric technique at any time and equilibrium MC humidity condition. Diffusion coefficients were determined via analytical solution of an unsteady state diffusion equation, obtained by separation of variables and proper boundary conditions. The surface emission coefficient and diffusion coefficients of each species were used in a computer-simulation program based on the finite difference method for determining moisture distribution in wood as parameters. A total of six simulations were run for wood drying, three species at two temperature conditions, and the results of these simulations provided the detail of moisture profiles developed in the specimens. The validity of computational results using the diffusion model was evaluated by comparing with experimental results, and good agreement was obtained.

BIOLOGY & WOOD ANATOMY/ QUALITY & PULP & PAPER

BOOTH 27

Engineering Properties of Illinois Juvenile Hardwoods

Tait Bowers, Grad. Student, *Poo Chow*, Prof., and *Dilpreet S. Bajwa*, Grad. Research Asst., Dept. of Natural Resources & Environmental Sciences, Univ. of Illinois, Urbana, IL

This poster will present the results of an on-going research project that gives more specific information on strength properties of various fast growing tree species. Illinois has a limited amount of forestland, and most of it contains valuable hardwoods. Some species are not as highly utilized, but can be used by certain types of industries to produce value-added products. Six tree species were harvested from the University of Illinois Agricultural Research Station, Dixon Springs, for testing of strength properties. These species included *Populus deltoides* L., *Platanus occidentalis* L., *Acer saccharum* L., *Robinia pseudoacacia* L., *Alnus glutinosa* L., *Populus spp*. The trees were harvested at 20 years from both highland and bottomland sites. Logs were then processed and cut to dimensional size for ASTM D 143 (Standard Methods of Testing Small Clear Specimens of Timber) tests. The results of these tests were compared with values for fully-mature wood and with values from trees harvested from these same plots 10 years ago. The analysis of this juvenile wood will help in evaluating the advantages of harvesting on a shorter rotation.

BOOTH 28

Effects of Silvicultural Treatments on Southern Pine Veneer Quality

Mark D. Gibson, Prof., Sch. of Forestry, Louisiana Tech Univ., Ruston, LA; *Terry R. Clason*, Prof., Hill Farm Agricultural Sta., Louisiana State Univ., Homer, LA; *Gary L. Hill*, Production Analyst, Willamette Industries, Ruston, LA; *George A. Grozdits*, Research Assoc., Sch. of Forestry, Louisiana Tech Univ., Ruston, LA

Veneer production trials were done at a commercial southern pine plant to elucidate the effects of silvicultural treatments on veneer quality and veneer yields. Forty-eight trees were selected from an intensively managed, 50-year-old loblolly pine plantation from the Hill Farm Research Station of Louisiana State University at Homer, LA. Twelve trees were selected from each of four treatments, precommercially thinned (average DBH 19.3 in.); pruned (average DBH 19.1 in.); thinned and pruned (average DBH 19.2 in.); and control (no commercial thinning or pruning with average DBH 15.6 in.). The smaller average DBH of the control treatment reflects the actual increase in tree sizes due to silvicultural treatments. The trees were processed into butt and upper logs, transported, bucked to 101.5-inch-long blocks peeled into 1/8-inch veneer using the plant's normal production process, then dried in a veneer drier. The length and width of full-sized (51 in. by 101.5 in.) veneer sheets, full-length random width strips (including half sheets), and half-length fishtails and strips were recorded to establish veneer yields. The full-size sheets were visually graded according to U.S. Product Standard PS 1-83 in green condition and after drying to establish veneer quality and drier degrades. The dried veneer was also checked with a Metriguard Model 2600 FX veneer tester for determination of modulus of elasticity. Precommercial thinning improved veneer yields by 10 percent, as expected, and also increased tree diameters. Pruning improved veneer yields by only 3 percent and did not increase tree diameters. The average veneer grade improved by one full grade (A, B, C, and lower grades were identified) in pruned trees, while precommercial thinning did not increase veneer quality. Trees from the pruned and thinned treatment increased veneer grade only by a half grade. The A and B veneer grade percentiles increased from 23 percent in the control to 71 percent in pruned trees. Veneer quality increased to a level where plywood mills peeling pruned logs can consider the production of finish-grade furniture veneers.

BOOTH 29

Composition of Brown Kraft Papers and Their Effect on the Corrugation Process

George A. Grozdits, Grad. Student, *Ronald H. Thompson*, Prof./Dir., Nuclear Center, and *Joseph G. Cedotal*, Undergrad. Student, College of Engineering & Science, Louisiana Tech Univ., Ruston, LA

Brown kraft papers during the corrugating process can develop minute splits and actual separation at “the maximum stretch points” between the corrugating rolls. The “maximum stretch points” are just below the ridges at the downhill side of the ribbed corrugating rolls. To enhance the stretching of the paper and to reduce the friction, the base paper is coated with a polyethylene emulsion. Application of a water-base uniform thin polyethylene (PE) coat is difficult under mill conditions. Reflected light microscope studies of the surface of the “well” and “poorly” corrugated papers showed differences (contaminants, number of large fiber bundles, and smoothness) in the fine-microstructure of the papers, which can effect the bending and stretching of the paper during corrugation. The samples from both “poor and well” papers, were hydropulped before and after corrugating. Fiber length, particle size distribution, pH, and the effect of PE coating and corrugation on moisture absorbency were measured. Results showed that the presence of large fiber bundles, amount of contaminants, the pH, and moisture absorbance did not lead to the definitive corrugating problems, but the effect of corrugating on fiber damage did. The "poorly" corrugated papers showed significant differences in fiber length and particle size before and after corrugating. It was concluded, the "fiber qualities," which allow fiber breakage during corrugation, will most likely lead to splits and breaks in the paper during the corrugation process. These, in turn, lead to poor glue-bonds in the lamination process, produce low strength and sometimes defective corrugated cardboard.

BOOTH 30

Responses of an Intensive Culture System to Wood Ash Application: Results of the First 2 Years

Phu V. Nguyen, Asst. Prof., *Raymond O. Miller*, Mgr., Upper Peninsula Tree Improvement Center, and *Donald I. Dickmann*, Prof., Dept. of Forestry, Michigan State Univ., E. Lansing, MI

Land application can provide an attractive alternative to land filling of wood ash, a solid waste product of wood and wood-waste combustion. The potential use of wood ash as a soil amendment is being explored on a field-scale intensive culture system on an abandoned agricultural site in the Upper Peninsula of Michigan. Four poplar clones, one source of aspen, and one source of European larch were used to establish the plantation. The study follows a split-plot randomized-block design with wood ash application rate as the main plot treatment and taxa as the sub-plot treatment, replicated four times. Wood ash, with the neutralizing value of 41 to 48 percent, was applied in fall 1997 at the rates of 4 and 8 tons/acre; planting was done in the spring of 1998. The application of wood ash significantly affected soil properties; soil pH and soil exchangeable cations such as Ca, K, and Mg increased with ash treatment. The improved properties persisted throughout the first two growing seasons. The tree survival rate was high for all taxa and not affected by ash treatment. All hardwood taxa grew well. Height growth among taxa was significantly different but unaffected by ash treatment. Analysis of foliage of trees of all taxa sampled during the first growing season indicated that no additional fertilization was needed for the second growing season. Monitoring of the established plantation will be continued to assess long-term effects of wood ash application on the growth and yield of the trees.

BOOTH 31

Wood Anatomical Characters as Climate Indicators

Michael C. Wiemann, Research Scientist, Northeastern Research Sta., USDA Forest Service, Princeton, WV; *Steven R. Manchester*, Assoc. Curator, Florida Museum of Natural History, and *David L. Dilcher*, Prof., Univ. of Florida, Gainesville, FL; *Elisabeth A. Wheeler*, Prof., Dept. of Wood & Paper Science, North Carolina State Univ., Raleigh, NC

Among woody plants, the percent occurrences of some wood anatomical characters are significantly correlated with growing site temperature and precipitation, although the correlations are much stronger for temperature (r^2=0.7) than for precipitation (r^2 =0.3). This implies that the correlated characters affect the ability of species to grow well on particular sites. However, the high variability in temperature during growing seasons, and the dependence of moisture availability on many factors besides annual precipitation, limit the precision of the climate/anatomy relationships. Nonetheless, site climate has an influence on the overall anatomical physiognomy of the woody vegetation, which is reflected in the properties of the woody resource as a whole.

BOOTH 32

Wood Color in Hard Maple

Michael C. Wiemann and *Janice K. Wiedenbeck*, Research Scientists, Northeastern Research Sta., USDA Forest Service, Princeton, WV

Wood color is an important determinant of the value of hard maple, both as sawn lumber and veneer, with the most valuable wood being light-colored. For example, very white hard maple veneer may sell for $2 per square meter. but darker maple has no value as veneer; in sawn lumber the price differential may be as much as 60 to 70 percent. Color variation may be subtle, with sapwood ranging from white to yellowish, or it may be dramatic when logs contain discolored heart. Although dark-colored wood is often referred to as heartwood, the discoloration is wound initiated, with the discoloring agents entering the tree stem through broken branches, exposed roots, or injured stems. The wounds may be natural or man-made, and discoloration may be extensive or localized. The amount of discolored wood is poorly correlated with tree diameter in hard maple, whereas it is positively correlated with diameter in species that have normal heartwood. Silvicultural and harvesting practices may affect "whiteness" as well as the occurrence and extent of discoloration. The high value of "white" hard maple would justify the additional cost of careful management and harvesting practices.

BOOTH 33

Wood Properties in *Picea abies* Clones

Ilona M. Peszlen, Prof. (currently Asst. Prof., Dept. of Forestry, Iowa State Univ., Ames, IA), *Katalin Szojákné Török*, Senior Researcher, *Róbert Németh*, Asst. Prof., and *Andrea Paukó*, Ph.D. Student, Inst. of Wood Science, Univ. of Sopron, Sopron, Hungary

In many countries, among them Hungary, timber and biomass resources are limited. In those countries, there is an increasing interest in wood-quality assessment. This is particularly true for plantation-grown species in relation to selecting the most suitable hybrids or clones of certain species and increasing their utilization potential based on their wood characteristics. In this study, 42 spruce (*Picea abies* L.) clones from a clone trial in Sweden were investigated in connection to an EU project on genetic improvement of wood quality. The 158 trees, 2 to 5 ramets per clone, were sampled to examine the pattern of variation, structure, and property relationship for selected wood quality parameters. Sample disks were obtained at breast height. Growth ring width, eccentricity, and percentage of reaction wood were measured. Some anatomical parameters, such as tracheid length and cell wall-lumen area percentage, and some physical properties, such as density, permeability, and compression strength were also measured and analyzed to assess differences among and within clones. This paper presents the measurement methods applied and some of the preliminary results of this ongoing investigation.

BOOTH 34

The Influence of Leverage on Performance of North American Pulp and Paper Companies

Dorothy Paun, Prof., *J. Cameron Crump*, *Olivier Trendel*, and *Edie Sonne*, Grad. Students, *Chavonda Jacobs-Young*, Prof., *Karl Howard* and *Kevin Ceder*, Grad. Students, and *Chad Oliver*, Prof., College of Forest Resources, Univ. of Washington, Seattle, WA

The purpose of this ongoing study is to determine the profitability, effectiveness, and efficiency of the North American pulp and paper industry by dissecting and comparing the annual reports of all pulp and paper companies in Canada and the United States. By calculating and comparing various accounting ratios, we can observe trends relating company size, product line, profitability, and firm success. This presentation will show the comparison of leverage to return-on-equity for these firms. We found that the pulp and paper industry is more highly leveraged than other industries, due to its capital intensive nature, and that there is no correlation between debt financing and success of the company (there were both successful and unsuccessful highly leveraged firms). Success was more a factor of what was being debt financed and the product line of the company. We also found that Canadian companies are far less leveraged on average than their U.S. counterparts.

PHYSICS

BOOTH 35

Wood Material Behavior in Severe Environments

Christopher A. Lenth, Scientist, New Zealand Forest Research Inst. Ltd., Rotorua, New Zealand; *Frederick A. Kamke*, Prof./Dir., Wood-Based Composite Program, Virginia Tech, Blacksburg, VA

An improved knowledge of wood material behavior in hot-pressing environments can provide an increased understanding of material properties during the manufacture of wood-based composites as well as insight into the development of new processes and products. Two specific areas where additional knowledge is needed are: high temperature equilibrium moisture content (EMC) behavior and moisture-dependent softening behavior. EMC data was collected and desorption isotherms were generated for mature and juvenile wood of aspen, loblolly pine, and yellow-poplar at 50º and 160ºC. High-temperature EMC behavior was found to be distinct from that at lower temperatures, and considerable differences between the isotherms for juvenile and mature wood were detected. Substantial thermal degradation was observed during desorption at 160ºC and found to be strongly influenced by relative humidity. The thermal softening behavior of wood was evaluated using dielectric thermal analysis (DETA) at moisture levels from 0 to 20 percent. Coincident *in situ* relaxations of hemicellulose and amorphous cellulose in the range of 20º to 200ºC were observed and found to exhibit the characteristics of a secondary (glass) transition. The moisture dependence of this transition was characterized, and differences in the observed Tg were detected between juvenile and mature wood. Time-temperature superposition was also shown to be applicable to the wood-water system.

BOOTH 36

Evaluation of Wood Lightness Variation by Fractal Dimension of Triangular Prism Surface Area Method

Jun Liu, Grad. Student, and *Takeshi Furuno*, Prof., Dept. of Science & Technology, Shimane Univ., Matsue, Japan

Lightness variation of wood surfaces of fifteen species was characterized by the fractal dimension of triangular prism surface area method. Fractal dimension ranges from 2 to 3 and sharp lightness variation cause high fractal dimension while low values relate to weak variation. Based on this index, specimens were generally divided into the hardwood group when the value was greater than 2.50 and the softwood group when it was less than 2.50. Six types of fractal dimension distribution were explored in our experiments, including plane, inclined plane, concave, convex, zigzag distribution and hilly distribution, from which both the features of local textures and general variation tendency of whole surface can be illustrated. It was strongly proposed that the fractal dimension method should be adopted to quantitatively evaluate wood texture with coarseness and evenness, because such variation was related with the number of grains, surface orientation and location. For wood color-matching, fractal dimension can be used to ensure texture-matching that can achieve a constructed surface texture that is close to the features of natural variation. Little variation in fractal dimension along the grain was demonstrated and this finding can be used to simplify the texture-matching process No significant relationship was found between fractal dimension and lightness, which implies that fractal dimension was independent from lightness.

BOOTH 37

Quantitative Infrared Spectroscopic Analysis of Acetylated Wood

Audimar P. Bangi, Researcher, Dept. of Wood & Paper Science, North Carolina State Univ., Raleigh, NC; *Kimberly A. Ivey*, Chemist III, Clemson Univ., Clemson, SC; *Perry N. Peralta*, Asst. Prof., Dept. of Wood & Paper Science, North Carolina State Univ., Raleigh, NC

A quantitative infrared spectroscopic analysis was performed on acetylated wood based upon the application of the Beer-Lambert Law, commonly referred to as the Beer's Law. This law relates absorbance to the concentration of a substance (in a sample) and the sample pathlength. Wood strands with varying levels of acetylation (B0=control, B1=12.26%WPG, B2=16.50%WPG, B3=20.54%WPG) were ground and screened to pass a No. 100 wire-screen mesh. The samples were then ovendried and stored in air-tight containers (containing a dehydrating salt). Wood-KBr pellets were prepared by carefully mixing 1 milligram of ground wood and 0.2 gram of KBr. Each mixture was pelletized under a vacuum pressure of 8,270 kPa and analyzed immediately to prevent moisture reabsorption. The infrared absorption of each pelletized sample was measured using a Bio-Rad FT-IR spectrometer. Three samples were analyzed for each level of acetylation to establish a calibration curve. For purposes of validating this calibration standard, 50:50 by weight mixtures of B0 and B1 (6.13%calculated WPG), B1 and B2 (14.38% calculated WPG), and B2 and B3 (18.52% calculated WPG) were pelletized and scanned for infrared absorbance. Peak ratios at absorption peaks of 3400 cm-1, 2920 cm-1, and 1510 cm-1 were computed relative to the intensity of the carbonyl absorption peak at 1740 cm-1. Functional relations between the peak ratio and acetyl weight gain were established using computer-aided linear and nonlinear least-square regression analyses. These functional relations were validated by calculating their relative prediction errors. Results indicate that the acetyl content of unknown samples could be predicted with a reliable degree of accuracy.

TUESDAY AFTERNOON, JUNE 20

COMPOSITES

BOOTH 1

Comparison of Flexural Creep Behavior of OSB Lab Panels Bonded with PMDI-, PF-, and MUPF-Resins

Martin Hoppe, Technical Mgr., *Don Larimer*, Technical Service Rep., *Ted Frick*, Development Scientist, and *Peter Kasperek*, Technical Service Rep., Bayer AG, Leverkusen, Germany; *James A. Thompson*, Dir., Wood & Foundry Products, and *Alexa Sommer*, Technical Mgr., Bayer Corp., Pittsburgh, PA

Because of the importance of long-term structural integrity of OSB panels in applications like sheathing, flooring, decking, and cladding, a laboratory study of flexural creep behavior was conducted under different climatic conditions. PMDI (Desmodur© 1520 A20) was used in core and face layers at dosage levels of 4 and 6 percent ovendried, as well as, in combinations with PF- and MUPF-resins in the face layers. For comparison, panels bonded solely with PF and MUPF in core and face layers were produced. For the short-term structural tests, flexural loads of 12.5, 25, and 40 percent of the bending strength (MOR) were selected with a climatic condition of 23ºC and 50 percent relative humidity for a duration of 335 hours. The results of the study clearly show that boards bonded with Desmodur© 1520 A20 in the core and face layers outperformed all other panels. In particular, the panels with a 6 per-

cent dosage of PMDF demonstrated superior performance at all load levels. Selected panels were tested in a severe environment with 40ºC temperature and 95 percent relative humidity. Under these conditions the panels bonded solely with Desmodur© 1520 A20 again demonstrated the best performance.

BOOTH 2

Update...Low Temperature, Conveyorized Strand Drying Technology

Jeffrey L. Dexter, Sales Mgr., Drying Technologies, George Koch Sons, LLC, Evansville, IN; *William Nowack*, Pres., Industrial Technology Midwest, Wilmot, WI; *Daniel Wolff*, Pres., CoProTech, Inc., Norcross, GA; *Wade Ficklin*, General Sales Mgr., George Koch Sons, LLC, Evansville, IN

With the emergence of low-temperature, conveyorized strand dryers over the past few years, this technical presentation provides an in-depth look at the most recent developments regarding Koch's patented “drying and exhaust abatement” technology, along with its added benefits of low VOCs and particulate emissions. It will also illustrate the specific details for both the “exhaust abatement patent” that was granted in May of 1998, and the “drying methods patent” that was granted earlier. The exhaust abatement process, which is an environmental enhancement, eliminates the need for expensive regenerative thermal oxidizers (RTOs) on the exhaust streams, thereby playing an important role in reducing both capital equipment investment and associated operating costs. With the commissioning of five systems in 1995, one in April of 1996, and now with seven more soon to follow, this drying technology continues to become the preferred choice for select OSB manufacturers. This presentation also highlights the assessment and acknowledgment by the Minnesota Pollutions Control Agency of Koch's drying process as being “Best Available Control Technology” (BACT), along with the compliance test data. Finally, with the increase in demand throughout the industry for both higher production and increased yields, this presentation also features the most recent performance data from Koch’s Generation II systems, which have been specifically designed to evaporate 40,000 pounds of water per hour, per system. This drying technology, along with discussions concerning lower plant emissions, reduction in fire hazards, improved energy balance, increased wood utilization, and the ability to dry longer strands without curling will be of particular interest to OSB mill managers, environmental engineers, product engineers, process engineers, production managers, and maintenance supervisors.

BOOTH 3

Properties of Grassland Fiber/Polyethylene Composites

Douglas D. Stokke, Asst. Prof., and *Monlin Kuo*, Assoc. Prof., Dept. of Forestry, Center for Crops Utilization Research, Iowa State Univ., Ames, IA

Biomass crops represent a significant potential resource of fiber for a wide variety of value-added agricultural products. In the State of Iowa, substantial acreage of marginal agricultural lands have been planted with grassland crops that serve to reduce soil erosion, improve water quality, and provide income potential for landowners. In Southern Iowa, switchgrass is co-fired with coal in a 650MW electrical-generation facility. The energy project targets 35MW power (5% of electrical generation capacity) to be produced by a co-firing coal switchgrass. In addition to producing biomass energy, landowners participating in this project are interested in finding other uses and markets for their grassland product. This research project is aimed at the evaluation of blends of switchgrass or fescue flour with high-density polyethylene (HDPE). Preliminary data suggest that these lignocellulosic materials may be comparable to wood flour for woodfiber/plastic composites. For example, the tensile modulus of an unfilled HDPE is 342.5 Mpa. For 30/70 weight blends of injection molding materials, the value increases to 500, 680, 770 and 826 Mpa for commercial pine wood flour, switchgrass flour, fescue flour, and commercial flax fiber, respectively. Other tests, such as Izod impact and flexural tests are pending. We will present our current experience in twin-screw extrusion processing and the properties of test materials made from these blends.

BOOTH 4

Typical Compounding Processes Used for Wood Fiber and Polymer Composites: A Review

John Z. Lu, Grad. Research Asst., and *Qinglin Wu*, Asst. Prof., Sch. of Forestry, Wildlife, & Fisheries, Louisiana State Univ. Agricultural Center, Baton Rouge, LA

Compounding processes play a very important role in improving the mixing quality of woodfiber and polymer blends. The mixing quality of woodfiber and thermoplastic blends depends upon the rheological properties of melts, structure of compounding systems (such as screws and rotors), the compatibility of the interface, mixing parameters, and other factors. The objective of this study is to review compounding equipment, process, and modeling approaches for woodfiber and polymer composites (WFPC). Screw extruders, roll mills, and rotor mixers are three kinds of popular compounding equipment used for WFPC. The combinations of these three types also apply to WFPC. Compounding woodfibers and thermoplastics is a process of solid/solid mixing. The melted fiber-matrix blends are normally unsteady, non-isothermal, and non-Newtonian. A mechanism of mixing woodfiber in the thermoplastic matrix is proposed. Measurement of shear stress, shear rate, and melt viscosity helps understand mixing characteristics of fluid flow in a mixer. The incompatibility between hydrophilic fibers and hydrophobic polymers results in poor adhesion at the interface and even causes processing problems. Coupling treatments in mixing processes help solve these problems. Compounding technology in WFPC, including optimum ratios of woodfibers versus thermoplastics, concentrations of coupling agents, dispersing agents, and other additives, and mixing conditions, will be discussed.

BOOTH 5

Effects of a New Caul System and Furnish Moisture Content on Mechanical Properties of Southern Pine Flakeboards

Cheng Piao, Grad. Research Asst., Sch. of Forestry, Wildlife, & Fisheries, Louisiana State Univ. Agricultural Center, Baton Rouge, LA; *Chung-Yun Hse*, Research Wood Technologist, Southern Research Sta., USDA Forest Service, Pineville, LA; *Elvin T. Choong*, Prof., Sch. of Forestry, Wildlife, & Fisheries, Louisiana State Univ. Agricultural Center, Baton Rouge, LA

Pressing particles at high moisture contents may be beneficial in the manufacture of flakeboards since it could reduce drying costs and improve panel quality. However, the levels of moisture content (MC) are restricted by the occurrence of blows and delaminations in the traditional hot-pressing system. A perforated-caul system enlarges the area for moisture to move out of the board mat during pressing, making it possible to press boards at high moisture contents. The objectives of this study were to evaluate the effects of perforated platen density (PPD) and MC on the mechanical properties of southern pine (*Pinus sp.*) flakeboards. Three platen densities (no holes, low density, high density) and five flake MC levels (2, 8, 13, 17, and 20%) were selected. The properties measured were: temperature of the board core during pressing, vertical density profile of the board, modulus of rupture (MOR), modulus of elasticity (MOE), and internal bond (IB) strength. The results indicate that no blows or delaminations were found after a 7-minute press cycles at flake MCs up to 17 percent. At the end of the

press cycles, the temperatures of the boards pressed with holed platens were higher than those pressed with traditional cauls. The MOR was highest when the MC was at 8 percent, and decreased thereafter as MC increased for all three platen densities. The MOE increased slightly with an increase in MC up to 10 percent. The IB strength increased with an increase in PPD at all MC levels. The IB strength decreased with an increase in flake MC. This study indicates that the holed platen may be used to reduce operation costs and improve mechanical properties of flakeboards.

BOOTH 6

Through-Thickness Ultrasonic Transmission Properties of Oriented Strand Board

Ronnie Yunheu Vun, Grad. Research Asst., and *Qinglin Wu*, Asst. Prof., Sch. of Forestry, Wildlife, & Fisheries, Louisiana State Univ. Agricultural Center, Baton Rouge, LA; *Mahesh Bhardwaj*, Dir. of Research, and *Gary Stead*, Pres., SecondWave Systems Corp., Boalsburg, PA

Voids are inherent in the manufacturing of structural oriented strandboard (OSB) due to imperfection of processing and intrinsic material parameters. The presence of voids in OSB reduces its elastic moduli and affects its dimensional stability. Thus, quality improvement of OSB depends largely on reduction of the amount of embedded voids. Since voids are strong scatterers of elastic waves, an attempt was made in this study to correlate ultrasonic transmission properties to internal void structure and panel strength of OSB. A through-thickness ultrasonic transmission in laboratory-made OSB panels was done by a direct contact ultrasonic system (i.e., Panametrics PR5058 pulser/receiver with 100 KHz transducers) and a noncontact ultrasonic system (i.e., SecondWave NCA1000-2E analyzer with NCT102-250 KHz transducers). The density of the specimens was shown to be the most significant variable that influences both acoustic velocity and acoustic attenuation in OSB. Good correlations were established among the measured ultrasonic parameters (i.e., transmission speed, attenuation, and real means square), panel strength, density, and other panel processing variables. The noncontact system produces more consistent results due to the high transduction of air transmission and the elimination of transmission variation caused by the transducer-to-specimen coupling, as compared with the localized calibration, instrumentation, and resolution limitations of the contact system. This on-going study demonstrates the frontal capability of using an ultrasonic-based system, especially the noncontact system, in developing an on-line quality monitoring system for OSB production.

BOOTH 7

Modeling the Hot-Compression of Wood-Based Composites

Balazs Zombori, Ph.D. Student, *Frederick A. Kamke*, Prof./Dir., Wood-Based Composite Program, Dept. of Wood Science & Forest Products, and *Layne T. Watson*, Prof., Dept. of Computer Science, Virginia Tech, Blacksburg, VA

Hot-compression parameters have a substantial effect on the final properties of wood-based composite boards. The number of interacting variables during the hot-compression process is too large to enable assessment of data by experimental means. Therefore, a numerical model based on fundamental engineering principles was developed and validated to establish relationships between process parameters and the final properties of the board. The model simulates the mat formation, then compresses the reconstituted mat to its final thickness in a virtual press. The mat-formation part of the model is based on the Monte-Carlo simulation technique to reproduce the spatial structure of the mat. The dimensions and the density of each flake are considered as random variables in the model, which follow certain probability density distributions. The parameters of these distributions are derived from data collected on industrial flakes by using image analysis techniques. The model can simulate the structure of a three-layer oriented strandboard (OSB) mat as well as the structure of random fiber networks. A grid was superimposed on the simulated mat and the number of flakes, the thickness, and the density of the mat at each grid point were computed. Additionally the model predicts the change in void-volume fraction within the mat and the contact area among the flakes during consolidation. The void-volume fraction is directly related to the physical properties of the mat such as thermal conductivity, diffusivity, and permeability, while the contact area is related to the effectively bonded area within the mat. The heat and mass transfer part of the model predicts the change of air content, moisture content, and temperature at designated mesh points in the crosssection of the mat during hot compression. The water content is subdivided into vapor and bound water components. The freewater component is not considered in the model due to the low (typically 6 to 7%) initial moisture content of the flakes. The gas phase (air + vapor) moves by bulk flow and diffusion, while the bound water only moves by diffusion across the mat. The heat flow occurs by conduction and convection. The spatial derivatives of the resulting coupled equations are discretized by the central-difference scheme, while the time derivatives are solved by a differential-algebraic system solver. The internal environment within the mat can be predicted among different initial and boundary conditions by this part of the hot-compression model. In the next phase of the research, the viscoelastic (time, temperature, and moisture dependent) response of the flake mat will be modeled using the time-temperature-moisture superposition principle of polymers. It will give insight into the vertical density profile formation through the thickness of the mat. The density profile is related to all the mechanical properties of the final board (bending strength, internal bond strength, etc.). The model can assist in the optimization of the hot-pressing parameters of wood-based composites and improve the performance of the final panel.

BOOTH 8

The Wood-Based Composites Center

Linda C. Caudill, Managing Dir., and *Frederick A. Kamke*, Prof./Dir., Wood-Based Composite Program, Virginia Tech, Blacksburg, VA

The Wood-Based Composite Center was established in 1999 with a mission of providing relevant and effective education and training, research, and technology transfer to service for the North American wood-based composites, and related industries. Located in the Department of Wood Science and Forest Products at Virginia Tech, VA, the Center is affiliated with universities across North America, including Mississippi State University, Oregon State University, and the University of Minnesota. Membership is open to businesses that manufacture wood-based composites, or who support the industry as a supplier or end-user. Our presentation will introduce the Wood-Based Composites Center to participants of the FPS Technical Program on composites and manufactured products).

BOOTH 9

Measurement of Resin Distribution in MDF Fiber

Keith A. Scott, Grad. Research Asst., Dept. of Wood Science & Forest Products, *Frederick A. Kamke*, Prof./Dir., Wood-Based Composite Program, and *J-B. Ra*, Post-Doctoral Fellow, Dept. of Wood Science & Forest Products, Virginia Tech, Blacksburg, VA

The objective of this study was to develop a technique for quantitatively measuring surface area coverage and statistical distribution of urea-formaldehyde (UF) resin on MDF fiber. By treating the resinated fiber with a reactive stain, the resin and the wood can be distinguished and separated using digital

image analysis. An epi-fluorescence microscope, color video camera, A/D image capture board, and image analysis software were used to measure the percent of resin coverage on the wood surface. These measurements can assist companies in making blending improvements, testing new resin formulations, and reducing resin costs. The measured resin coverage of the treated fibers did not correlate with the target resin loading level. This result was surprising because preliminary trials with commercially-blended fiber clearly showed the presence of UF resin when treated with the acriflavine solution. Due to the large number of images to be processed (250 per sample), an automated method was used. It is suspected that slight variations between specimens may have induced significant variations in the processed images. However, a nitrogen analysis was performed using a specimen of similar size, and yet it correlated to the target resin loading levels. It should be noted that the resin coverage results are based on surface area measurements, while resin loading and nitrogen content are based on the mass of resin solids. Since the results of the resin coverage measurements were inconclusive, more research will be needed to refine the treatment process and reduce variability. At this time the technique is only qualitative.

BOOTH 10

Dielectric Cure Monitoring of Composite Panels During Hot-Pressing: A Fundamental Understanding

Tyler G. Congleton, Grad. Research Asst., and *James B. Wilson*, Prof., Dept. of Forest Products, Oregon State Univ., Corvallis, OR

Dielectric monitoring of adhesive cure during hot-pressing of composite panel products offers significant benefits for optimizing operations and reducing costs. In the production of composite panel products, thermosetting resins are mixed with wood particles or fiber to form a mat. The mat is then hot-pressed at sufficient temperature, pressure, and duration to both consolidate the mat and cure the adhesive. When selecting a press cycle, conservative times are used since it is difficult to predict exactly when an acceptable level of cure has developed. The press schedule is developed as a result of significant testing for each product, and may change with any resultant change in the manufacturing process. Dielectric monitoring provides a means of identifying the exact time of cure for each and every product, thus eliminating the need for using conservative press schedules. The principle behind this technology is that as the resin cures, its molecules become interlaced in a lattice structure, reducing rotational and ionic mobility. Application and monitoring of an alternating electromagnetic field in the mat as the resin cures allows measurement of the dielectric constant, a quantification of the rotational and ionic mobility. This can be done nondestructively and in real time to provide control of the press cycle. Present methods of dielectric monitoring use relative values that require “calibration” for each product. Proposed is an absolute measure of the dielectric value as a means to eliminate this disadvantage.

BOOTH 11

Life-Cycle Assessment: Environmental Modeling of Plywood and Laminated Veneer Lumber

Charles J. Ferrari, Grad. Research Asst., and *James B. Wilson*, Prof., Dept. of Forest Products, Oregon State Univ., Corvallis, OR

Models are proposed for determining the environmental impact of manufacturing plywood and laminated veneer lumber (LVL). These models are part of a major life cycle assessment (LCA) study of structural wood products. The models enable a comparison of a range of management, process, and product alternatives, accounting for all input and output values. Values considered include inputs such as logs, resin, water, electricity, fuels, and ancillary materials, and outputs such as plywood, LVL, wood by-products, air emissions, water emissions, and land emissions. SimaPro, a LCA software program, was used to develop the models. The manufacturing processes are modeled in terms of six machine centers: debarking/bucking, conditioning, peeling/clipping, drying/cooling, layup/pressing, and trimming/sawing; considering all inputs and outputs for each. Two production regions of the United States were analyzed: the Pacific Northwest and the Southeast. Using base scenarios for the models, sensitivity analyses of the parameters were performed. The results of this study are to be used in a comprehensive LCA study being conducted by the Committee on Renewable Resources for Industrial Materials (CORRIM) on structural building materials. The CORRIM study encompasses the environmental impacts of a product from harvesting through manufacturing and transportation, to its use in residential construction, and its eventual disposal or recycling. This study and its use by industry should help to improve the environmental impacts of these forest products and provide valuable data that could be used to increase wood's competitiveness with steel, plastic, and concrete.

BOOTH 12

Development of a Value-Added, Bio-Fiber Composite Panel

Matthew F. Nahan, Research Asst., and *James B. Wilson*, Prof., Dept. of Forest Products, Oregon State Univ., Corvallis, OR

An economic analysis was conducted for building a manufacturing facility in Oregon to produce a composite-panel product based on the use of various agro-fiber resources. The targeted product was a substrate or core panel to be used for making veneer overlaid architectural panels. Examined were both low density (30 pcf) and medium density (45 pcf) panels. To determine the economics, it was first necessary to establish the resource and production parameters. For raw materials the following agro-fibers were studied: annual ryegrass, perennial ryegrass, tall fescue, orchard grass, barley straw, wheat straw, flax shive, and miscanthus. The available tonnage of these fibers was determined, as well as their delivered cost to the plant site. Production parameters were also determined to establish the production rate, as well as the raw material needs. Studied raw material and processing parameters included the resin type, resin addition level, wax level, board density, board thickness, and the press cycle. Optimum values were determined for each. Particular attention was given to establishing a computer-controlled press cycle to provide the fastest possible production rate, while insuring board properties were met without blowing. Three plant site locations, Willamette Valley, Columbia Basin, and Klamath Valley were considered. Furthermore, three production capacities, 30, 76, and 200 MMSF 3/4-inch basis were studied. The economic analysis showed that only a few limited scenarios produced a competitive product. For the attractive cases, operation of such a facility would provide much needed economic development in rural areas, supplement existing wood resources, and provide a product with beneficial attributes as a substrate or core for architectural panels.

BOOTH 13

The Advanced Engineered Wood Composites Center

Stephen M. Shaler, Prof./Asst. Dir., Advanced Engineered Wood Composites Center, Univ. of Maine, Orono, ME

The Advanced Engineered Wood Composites Center is an interdisciplinary research center formed at the University of Maine. The center's focus is development and engineering of hybrid wood composite materials for structural applications. The just completed 30,000 ft.^{2} research laboratory contains over $4 million in new equipment for both manufacturing (compression molding, extrusion, impregnation, lamination, finger-jointing, etc.) and structural testing (reaction floor and reaction walls

allow for static and fatigue loading of up to 300,000 pounds and multi-axial loading of structures up to 90 feet in length and 24 feet in height). Specialized materials laboratories include environmental testing, thermal analysis, laser scanning confocal and light microscopy, and nondestructive evaluation capabilities.

BOOTH 14

Energy Saving Continual Twin-Roll Method of Wood Product Fabrication

Alfred I. Vigdorovich, Senior Scientist, Wood Composites & Molded Products, Far Rockaway, NY; *Yuriy V. Shekhtman*, Senior Researcher, RELANA Corp., Brooklyn, NY

Wink Sutton in the article "Wood in the Third Millennium" (*Forest Products Journal* 50(1):12-21) believes that the production of particleboard, MDF, fiberboard, etc. will decrease because the cost of energy is expected to increase by three times. Therefore, scientists who create wood-composite materials (WCM) and their technology will be focusing their attention on energy-saving technologies. This poster examines a new energy saving-technology. The basis of this technology is three maxims: 1) never cut wood across fibers; 2) transmission of a heat across wood is absurd; and 3) two rolls are much better than many rolls or bands/caterpillars. A continual twin-roll mill process of wood product fabrication reduces energy by 3.4 to 6.7 times in comparison with current technologies. If the cost of energy actually grow by three times, a decrease of energy by 3.4 to 6.7 times allows the development of WCM at the same energy level as at the end of the second millennium. Therefore, using energy-saving continual twin-roll mill technology assures successful developing of fabrication of wood composite products to end of the third millennium.

BOOTH 15

New Protection Systems for Engineered Wood Products

Louis Graziano, Technical Group Mgr., *Jose Lalas*, Senior Scientist, and *Liam Leightley*, Global Growth Mgr., Rohm & Haas Co., Spring House, PA

Wood composite markets continue to experience rapid growth worldwide. As the production and use of engineered wood products expands, the need for effective, long-term protection from biological degradation becomes essential to the commercial success of this booming market segment. Protection of such products against the same organisms that have plagued the solid-wood industry is needed. These organisms include molds, decay fungi, and insects. This paper will introduce the advantages of using isothiazolone wood preservatives to protect engineered wood products. Data will include resistance to decay fungi, molds, and insects, including the *Coptotermes formosanus*. The robustness of isothiazolone chemistry to composite wood manufacturing processes will also be addressed. The results of this study showed that isothiazolone preservatives can effectively protect engineered wood products against a broad spectrum of biological adversaries.

BOOTH 16

The Freeze-Thaw Resistance of Wood-Cement Sidings

Perry N. Peralta, Asst. Prof., and *Thad Weaver*, Student, Dept. of Wood & Paper Science, North Carolina State Univ., Raleigh, NC

Cement-based products are known to be susceptible to the effects of cyclic freezing and thawing. Water contained within the structure expands during freezing and reverts back to its unexpanded volume upon thawing. This change in the volume of entrapped water with phase change causes tremendous stresses in the material, especially if done over several cycles. Wood-based cement sidings are exposed to such cyclic freezing and thawing during winter and from season to season. The effect of 100 cycles of freezing and thawing on the flexural properties of two brands of wood-cement siding is evaluated and compared with the effect of the same phenomenon on hardboard and solid-wood sidings. Micrographs are also presented to show the nature of failure of both the control group and those exposed to cyclic freezing and thawing.

DRYING

BOOTH 17

Effect of Reservoir Water Temperature on the Relative Humidity and Equilibrium Moisture Content Inside a Dry Kiln

Perry N. Peralta, Asst. Prof., Dept. of Wood & Paper Science, North Carolina State Univ., Raleigh, NC; *Shawn Sanders*, Logistics Engineer, NORTEL Networks, Morrisville, NC

A study was conducted to test the hypothesis that the water temperature in the wet-bulb water reservoir will affect the wet-bulb temperature reading thereby changing the relative humidity and equilibrium moisture content inside a dry kiln. The experiments were performed using three dry-bulb temperature levels (150º, 130º, and 110ºF), three wet-bulb depressions levels (5º, 20º, and 40ºF), and three reservoir water temperature levels (60º, 100º, and 150ºF). The condition inside the kiln was maintained by the kiln's heating, humidification, venting, and air-circulation system through a pneumatic recorder-controller. The condition inside the kiln was monitored independently by a dew point sensor. The relative humidity and equilibrium moisture content values that correspond with the dry- and wet-bulb temperatures recorded by the recorder-controller were compared with those that correspond with the dry-bulb and dew point temperatures recorded by the dew point sensor. Analyses of the data show that there are no significant differences in the two sets of readings indicating that the water reservoir temperature does not significantly affect the relative humidity and equilibrium moisture content inside the kiln.

LUMBER PRODUCTION

BOOTH 18

Modeling the Sawing and Grading of Boards According to Knots

Hugo Lemieux, Grad. Research Asst., and *Michel Beaudoin*, Prof., Dept. des sciences du bois et de la forêt, Univ. Laval, Ste-Foy, QC, Canada

A model that simulates primary breakdown and grading of softwood lumber has been developed. It combines knot morphology inside the log along with the sawing pattern to determine the intersection of knots with the sawn boards. The National Lumber Grades Authorities Visual Grading Rules have been adapted to assess board quality. Model inputs are based on results from a black spruce knot morphology study that predicts a knot's internal shape based on its external features on the log surface. Simulations of sawing and grading were performed using actual log data to determine the extent to which board grade could be increased when the knots are considered before primary breakdown. In the experimental setup, half of the logs were sawn according to the best solution and the other half according to the worst solution. The results presented show the difference between the best and worst solutions based on both the model grades and on the visual grading of the actual sawn boards. Also shown are the results of bending tests on the

boards, which sought to find out if the better grade boards as predicted by the model were in reality stronger than the others.

BOOTH 19

Sawmill Linear Programming Model

Dan Seale, Prof., and *Jason Leng*, Forest Products Lab., Mississippi State Univ., Mississippi State, MS

(Abstract not available at time of printing.)

BOOTH 20

Assessing the Product Development Characteristics of Scanning and Optimizing Technology in the Hardwood Sawmill

Scott A. Bowe, Grad. Research Asst., *Robert L. Smith*, Assoc. Prof./Extension Specialist, and *D. Earl Kline*, Assoc. Prof., Dept. of Wood Science & Forest Products, Virginia Tech, Blacksburg, VA; *Philip A. Araman*, Project Ldr., Southern Research Sta., USDA Forest Service, Blacksburg, VA

Significant technological leaps are being made in the hardwood sawmill industry. Advancements in hardwood scanning and optimizing technologies have increased yields and product value with carriage, edging, trimming, and sorting systems. In addition, significant advancements have been made with emerging hardwood automated grading technologies. To develop and market these technologies to industry effectively, the marketing, management, and adoption processes behind these systems must be understood. To develop such an understanding, a nationwide hardwood sawmill study was undertaken by researchers at Virginia Tech. This research focused specifically on edger optimizers, emerging next generation edger optimizers, and emerging automated hardwood lumber grading systems. The objectives of this study were: 1) characterize the differences between companies for both adopters and nonadopters of scanning and optimizing technologies; and 2) identify company expectations of scanning and optimizing technology including the cost and feature levels that will be accepted by the hardwood sawmill industry. Data were collected through a mail survey of over 2000 hardwood sawmills across the United States. A wide size-range of sawmills responded providing to the breadth of the study. The specifics of the study have yet to be reported since the data are currently being analyzed. Data were collected on sawmill's past and present experience with scanning and optimizing technology. In addition, data were collected on specific technology factors such as costs, system features, and personnel/training issues. Given the scope of the study, this research has value in several areas that: compare groups such as adopters versus non-adopters to provide the most effective direction for this technology; inform the scanning and optimizing technology manufacturers of hardwood sawmill expectations; and assist hardwood sawmills in making sound decisions about scanning and optimizing systems.

BOOTH 21

Does Pruning the Lower Logs Affect the Lumber Value of the Upper Logs?

David W. Patterson, Research Prof., Univ. of Arkansas-Monticello, Monticello, AR

Forty years ago, a southern pine plantation was established with test plots which had one of four basal areas and one of four pruning treatments. After 40 years, the test plots needed to be thinned to maintain the desired basal areas. The thinning resulted in 53 trees being harvested. The question addressed in this study was "does pruning the lower logs affect the value of the lumber in the upper logs?" The third and fourth logs from the trees were sawn into 2-inch dimension lumber. The identity of each board was maintained throughout sawing, drying, planning, and grading. The lumber value was determined by averaging the market prices quoted in *Random Lengths* in the first issue for each month during 1999. Even though the mean lumber value for the unpruned trees was higher than for the pruned trees, the difference was not significant. The variation was large and the sample size was small, which results in the conclusion that a large study is needed to find a true answer to this question.

BOOTH 22

Digitized White Birch Database: Its Creation and Use

Charles Clement, Research Asst., *Henry Quesada*, Researcher, and *Rado Gazo*, Asst. Prof., Dept. of Forestry, Purdue Univ., W. Lafayette, IN; *Robert Beauregard*, Mgr., Forintek Canada Corp., Ste-Foy, QC, Canada

There is growing interest in the exploitation of underutilized wood species in value-added products. This interest is brought about by the increasing scarcity of high-quality hardwoods such as oak and maple and the resulting increase in price. This presentation analyzes white birch (*Betula papyrifera*) boards through the creation of a digitized database and the utility of said database in evaluating the species yield with respect to a determined cutting bill. The procedure for developing the database consists of manually recording the location of each defect on both faces of each board. A computer program then reconstructs this information into boards and computes the relative frequencies of various defect types, the number of defects found per board foot, the area covered per board foot and the percentage of board surface covered. The defects included were both natural (e.g., knots, bark pockets, decay, mineral streaks,etc.) and manufactured (e.g., machine gouge, void, machine burn, etc.). The database can interface with all common simulation and modeling programs. ROMI-RIP and ROMI-CROSS will be used to establish yield potential for the furniture and flooring industries.

PROCESS CONTROL

BOOTH 23

Advanced Information Technology for MDF Manufacture

Timothy M. Young, Asst. Prof., and *Paul M. Winistorfer*, Prof./Dir., Tennessee Forest Products Center, and *Frank M. Guess*, Prof., Dept. of Statistics, Univ. of Tennessee, Knoxville, TN

An advanced information technology (IT) system that utilizes human machine interface (HMI) technology and statistical process control (SPC) methodology for MDF manufacture is outlined in this poster. The advanced IT system is operational at a southeastern U.S. MDF manufacturing facility. The advanced IT system uses the Ethernet LAN that exists at the mill. "Real-time" process data are also available across the corporation's WAN. All "real-time" manufacturing data that exists on the plant's programmable logic controller (PLC) system are stored in a Microsoft SQL binary file format database. Approximately 1,200 variables from the PLC are stored at 5-second intervals in the database. Manual entry data from the lab, raw material supply data, and some data from remote sensing devices are also stored in the database. Approximately 15 PC clients, which include three machine operators, access the data across the LAN and WAN. Trending, vector analysis, and control charting of data are available to clients in a "real-time" or historical setting. Clients accessing the control charts can enter reasons for "special-cause" variation by clicking on any out-of-control point. Corrective action procedures are entered into the system for all special cause variation. SPC alarms are given for all out-of-control points. Features of the system also included "real-

time" histograms and Pareto charts. The advanced IT system integrates manufacturing and business data on one common software platform.

WOOD ENERGY

BOOTH 24

Combined Chemicals and Energy Production from Wood

D. Andrew Himmelblau, Principal Engineer, R.W. Beck, Framingham, MA and Pres., Biocarbons Corp., Woburn, MA

Deregulation has reduced the cost of electricity to the point where production of electricity from biomass is no longer economic without tipping fees and/or production credits. The value of woodwastes from lumber or panel production that are not suitable for furnish is only their energy value equivalent for process energy, something less than industrial natural-gas prices. For many operations, wastes are available in surplus over energy requirements. For thinning operations, the cost of removal and transportation are often more than the material's energy value. A potential solution to these problems would be to produce chemicals from the wood wastes by thermal decomposition. Biomass fed to a reactor is broken down into oil/tar, char, and gas products. The gas must be used on-site for energy production. The char can be used for energy production, sold for charcoal or made into activated carbon. Chemicals can be recovered from the oil, which consists of thermally "cracked" lignin, cellulose, and hemicellulose. Because petrochemicals have scale and yield advantages for most commodity chemicals, any new efforts to produce chemicals from wood should focus on higher value products, currently selling for approximately $1.00 per pound or more. Many of the chemicals that can be produced are unconventional in that they do not have large markets because they have not been previously available in large quantities at reasonable cost. Without additional research, the markets cannot be developed. Consequently, chemical company partners will be needed. This poster will survey the reactor technologies and processes available for making chemical (and energy) products and potential chemical products data. The literature data will be supplemented with recent data generated by Biocarbons Corporation, looking at chemical product yields as a function of operating temperature and feedstock. Finally, some suggested chemical products and synthesis/modification of product will be presented. Preliminary production costs and how all this can be integrated into a lumber or panel mill will also be presented.

BOOTH 25

Tree Biomass Utilization for Quality Charcoal Production in Saudi Arabia

S.A.E. Kandeel, Prof./Dept. Head, *A.A. Abohassan*, Dean, and *R.A. Abohassan*, Grad. Student, Faculty of Meteorology, Environment, & Arid Land Agriculture, King Abdulaziz Univ., Jeddah, Saudi Arabia

The current investigation was carried out to estimate the charcoal quality and properties from a few locally grown trees namely *Acacia cyanophylla*, *Eucalyptus camaldulensis* var. obtusa, *Evicenia marina*, *Juniperus procera* Hochst., *Tamarix articulata* var. aphylla, and *Conocarus erectus*. The carbonization conditions (temperatures, heating rates, and residence time) were studied. The resulting data indicated a high yield from tamarisk, mangrove, and eucalypt woods. The gross heat of combustion of charcoal differed according to wood tissue density along with carbonization parameters. However, charcoal's apparent density was only affected by carbonization conditions and correlated with wood density. This study included the determination of charcoal shrinkage, wood tissue zone, and carbonization conditions of each of the tested species. Chemical analysis of charcoal revealed significant differences between the investigated species in the volatile matter and the ash contents of the produced charcoal. The carbonization conditions seemed to be a deterministic variable for the volatile matter conent, while original wood chemical content controlled the ash content of the charcoal. Both carbonization conditions and species factors significantly affected the fixed carbon content. Acacia, mangrove, and eucalypt contained the highest fixed carbon contents. Calculated negative correlation coefficients (r) of –0.83 between volatiles and fixed carbon contents indicated the higher quality of mangrove, eucalypt, and acacia charcoals. While the ash content and apparent density of acacia charcoal were better than tamarisk, it was lower than both mangrove and eucalypt. This investigation revealed the suitability of several locally-grown tree species as a source for fuel wood and charcoal production. This would help stop the nomads from overcutting the naturally-grown acacia habitat on the hills of western Saudi Arabia's Assir mountains.

WOOD ENGINEERING & MECHANICAL PROPERTIES

BOOTH 26

FIRST PLACE WOOD AWARD: Fracture Analysis of Wood Cracking Perpendicular-to-the-Grain

Svetlana Vasic, Post-Doctoral Research Fellow, Advanced Engineered Wood Composites Center, Univ. of Maine, Orono, ME

An analysis will be presented of how cracking in wood can be predicted using fracture mechanics. The focus of the paper was on the experimental issues. *In situ* real-time Scanning Electron Microscopy (SEM) was used as a tool to estimate physical mechanism of fracture in softwoods (spruce) using end-tapered Double Cantilever Beam specimens. It was found that bridging behind the crack tip is the main toughening mechanism that contributes to nonlinear wood behavior in the presence of stress concentrations. A new bridging crack model mimics the observed cracking mechanism, which is why it is considered advantageous to the previously-known models. Encouraging results were obtained, although further work is needed in order to develop and apply numerical models to predict load-carrying capacity of structural members.

BOOTH 27

SECOND PLACE WOOD AWARD: Ultrasonic Inspection of Large Bridge Timbers

Robert Emerson, Asst. Prof., Dept. of Civil & Environmental Engineering, Oklahoma State Univ., Stillwater, OK

Timber bridges are susceptible to attack from wood-decay fungi. Significant losses in wood-material properties are associated with increasing decay. Therefore, timber bridges must be monitored for decay in order to maintain structural safety. Historically, decay has been identifiable in large-timber structural elements only after significant losses in structural performance has occurred. More recent developments of nondestructive evaluation techniques have focused on identifying decay before large strength losses occur. For this study, an ultrasonic inspection technique was developed for identifying incipient decay in large bridge timbers. Two large bridge timbers were nondestructively evaluated via ultrasonic inspection. Relative ultrasonic wave velocity measurements were used to identify locations of moderate to advanced decay. The timbers were then dissected, and the predicted internal condition compared to the actual internal condition. Specimens suspected to contain incipient decay were removed from one of the bridge timbers and subjected to further ultrasonic testing followed by physical testing. The objective was to develop an ultrasonic inspection technique that can be used to identify the presence of decay

before significant losses in physical properties occur. The characteristics of the received signal were then correlated with the physical properties of the specimen. Two main signal parameters can be used to identify decay. Wave velocity can be used to identify the presence of moderate-to-advanced decay but cannot be used to identify incipient decay. Relative ultrasonic wave attenuation can be used to identify incipient through advanced decay. The ability to identify incipient decay will allow for corrective action to take place before structural safety is compromised and before expensive structural repairs are required.

BOOTH 28

Analysis of Stress Distributions Around Veneer-Joints in Yellow-Poplar LVL

Jong N. Lee, Post-Doctoral Researcher, Sch. of Forestry, Wildlife, & Fisheries, Louisiana State Univ. Agricultural Center, Baton Rouge, LA; *R.C. Tang*, Prof., Sch. of Forestry & Wildlife Science, Auburn Univ., Auburn, AL; and *Joe H. Kaiserlik*, Mgr., Engineered Wood Products, Georgia-Pacific Corp., Roxboro, NC

The effects of veneer-joints on the stress concentrations/distributions of yellow poplar laminated veneer lumber (LVL) will be presented. Finite element method (FEM) was used to investigate the stresses distributed around the veneer-joints employed in the LVL for the assessment of stress concentrations at the veneer-joints and their effects on LVL's structural performances. Two-dimensional FEM models were developed prioritizing the simplicity in modeling of stress analysis for LVL member. The stress concentrations in a LVL member due to the presence of different kinds of veneer-joints (i.e., scarf veneer-joint and crushed-lap veneer-joint) were examined comparatively in this study to see which type of veneer-joint performs better in reducing stress concentrations. The effect of veneer stacking sequence on the stress concentrations at the tip of veneer-joints was investigated respectively in the width and the length direction of veneers in order to explain how the LVL with more plies performs better in structural applications when veneer-joints are present. Adhesive joint models were developed by using the combination of general four-node rectangular elements, triangular three-node elements, and special interface elements for the adhesive line at the section of veneer-joint. By employing the special interface element, adhesive properties and dimension were taken into account in FEM modeling so that the displacement and stress values at four nodes of adhesive elements were determined. FEM solution for the adhesive joint models complied with the closed-form solution with reasonable accuracy, and analysis indicated that a crushed-lap veneer-joint showed better performance in reducing stress concentration at the joint than the scarf veneer-joint. A significant effect of the veneer stacking sequence was demonstrated in the FEM solution for both veneer-joint models.

BOOTH 29

Modeling the Dynamic Interaction Between Wood Pallets and Corrugated Containers During Resonance

Timothy G. Weigel, Asst. Prof., Depts. of Packaging & Forest Resources, Clemson Univ., Clemson, SC; *Marshall S. White*, Prof./Dir., Sardo Pallet & Container Lab., Virginia Tech, Blacksburg, VA

The unit load is the form of most commercial and industrial products during storage and distribution. In addition to the product, a unit load consists of primarily corrugated containers stacked on wooden pallets. Products such as electronic equipment and fresh produce are sensitive to vibrations that occur during shipment. Most damage occurs during the large accelerations associated with resonance. A model of the response of unit loads to shipping vibrations was developed using matrix structural analysis techniques. Using this model, the effects of product design, distribution container design, and pallet design on resonant frequencies can be investigated. The components (pallets and corrugated containers) that form a unit load, can be designed to better protect vibration-sensitive products during shipment.

BOOTH 30

Selected Engineering Properties of Southern Hardwoods

Sunyoung Lee, Grad. Research Asst., and *Qinglin Wu* and *Todd F. Shupe*, Asst. Profs., Sch. of Forestry, Wildlife, & Fisheries, Louisiana State Univ. Agricultural Center, Baton Rouge, LA

Bottomland southern hardwoods have been increasingly used to manufacture engineered wood products such as oriented strandboard (OSB) and plywood. Efficient utilization of these species relies largely on the fundamental understanding of their properties. For example, a mismatch of swelling and elastic properties of veneers in the manufacture of mixed hardwood plywood could lead to warped panels upon moisture content change during manufacturing and/or in service. The objective of this study was to develop technical information on both physical and mechanical properties of southern hardwoods. In the study, moisture sorption, swelling coefficients along the three principal directions (i.e., radial, tangential, and longitudinal), stress-wave speed and modulus, tensile strength, and bending modulus of 17 southern hardwoods were measured and compared. The data forms a database on the engineering constants of southern hardwoods.

BOOTH 31

A User-Friendly System for Bridge Superstructure Construction with Glulam Deck Panel Installation on Steel Girders

John J. Janowiak, Assoc. Prof., and *Walter G.M. Schneider*, Grad. Research Fellow, Sch. of Forest Resources, and *Harvey B. Manbeck*, Distinguished Prof., Dept. of Agricultural Engineering, Pennsylvania State Univ., Univ. Park, PA

Glued-laminated (glulam) timber decks are being utilized for various timber bridge construction projects. One design includes glulam deck panels installed on steel girders for bridge superstructure construction. Significant interest exists in this construction type for new and possibly more importantly for rehabilitation of existing steel girder bridges with cast-in-place concrete decks. Many of these bridges are municipality-owned and local governments have inadequate funds to construct new bridges. In Pennsylvania many bridges show early to advanced deterioration due to mechanical wear and to a greater extent the action of deicing salts. PennDOT demonstration projects have shown the need for a simplified deck-to-girder installation procedure. Connection details for this bridge construction traditionally involve a lagged or bolted deck clip device installed from underneath the bridge structure. Installation is labor intensive with added costs associated with scaffold or carriage work platforms. Research has been undertaken to develop a more user-friendly deck-to-girder connection detail that reduces labor requirements and construction costs while minimizing bridge closure duration. Researchers are evaluating a welded steel stud with epoxy grout (WSSEG) connection system with promise to greatly enhance the application of prefabricated glulam decks for steel-girder bridge reconstruction projects. Besides simplification of installation requirements, the WSSEG provides an advanced connection that provides mechanical composite behavior between deck and girder versus a friction-based connection detail. Results are presented on the test program to establish the performance criteria with respect to axial load and shear load transfer capacity for the WSSEG connection system.

BOOTH 32

Assessment of Two Timber Frame Connections with Epoxy Treatment to Enhance Joint Performance

Brandon Schreffler, Grad. Research Asst., and *John J. Janowiak*, Assoc. Prof., Sch. of Forest Resources, Pennsylvania State Univ., Univ. Park, PA

Research results are presented on an experimental study to investigate the potential performance enhancement by applying an epoxy treatment to two types of timber-frame joint connections. The connections included in this study were the Timberlok type A connector system developed by Green Mountain Precision Frames (Windsor, VT) and a European fastener distributed by Bulldog-Simpson of Germany. These systems provide a more aesthetically pleasing method compared to steel plates with lag or bolt in timber frames. The Timberlok system employs a shallow mortise/tenon developed as an alternative to the traditional pegged with full-depth mortise/tenon all timber joint connections. The Bulldog-Simpson system utilizes a double-sided toothed ring for shear load transfer. Both connections employ a through bolt for mechanical attachment via a locking pin installed within the side member. Holes drilled slightly oversized are required for bolt diameter installations. Prior studies on bolted connections have shown that oversizing can diminish load transfer capacity. The study's goal was to evaluate epoxy fill to improve the two connections under direct axial tensile loading (withdrawal performance) and lateral resistance for shear capacity, while providing baseline strength and stiffness for the untreated connection detail. For this study, connection systems were evaluated with both red maple and southern pine glulam timber. Study data indicated epoxy treatment can serve to enhance the performance characteristics for both connection systems. Results indicated performance behavior was enhanced with respect to stiffness and strength for the evaluated glulam timber joints.

BOOTH 33

Cyclic Performance of Plywood Rails Used in Furniture

Yusuf Ziya Erdil, Research Asst., and *Huseyin Akoay*, Grad. Student, Dept. of Forestry, Purdue Univ., W. Lafayette, IN

Although wood composites are widely used in furniture construction, there is little information available that can be used in the rational design of parts constructed from them. Moreover, the information that is available deals largely with static testing of parts loaded in the flat position. When parts constructed of composites are used as structural members in furniture such as upholstered furniture, however, they are ordinarily subjected to both static and cyclic loads, and they are used and loaded on edge rather than in the flat position. An example is the front rail of a sofa, which is repeatedly loaded as individuals use the sofa. Cyclic use failures regularly occur in furniture constructions. Failures of the side rail to back post joint in chairs is one example. Failure of wood furniture parts is less common than joint failures because member-strength to joint strength-ratios are normally high. Use of composites with modulus of rupture (MOR) values substantially lower than those of wood will significantly change these ratios, however, and could lead to increased member failures. Importantly, such failures can occur well below the ultimate static strength of the materials. Thus, it is important that allowable design stresses for these materials be set at levels that ensure they will survive the repetitive cycle loading that must be endured by the furniture during its service life. The results showed there are not clearly definitive values that may be taken as allowable design stresses, yet, it appears that 50 percent of ultimate might be used as a rule of thumb estimate in the initial design of frame parts.

BOOTH 34

In Situ Strength and Stiffness Assessment in Standing Trees Using a Nondestructive Stress Wave Technique

Xiping Wang, Research Scientist, and *Robert J. Ross*, Supervisory General Research Engineer, Forest Products Lab., USDA Forest Service, Madison, WI; *John R. Erickson*, Research Scientist, *John W. Forsman*, Asst. Research Scientist, and *Gary D. McGinnis*, Prof., Sch. of Forestry & Wood Products, Michigan Tech Univ., Houghton, MI; *Michael H. McClellan*, Research Scientist, Pacific Northwest Research Sta., USDA Forest Service, Juneau, AK; *R. Jamie Barbour*, Team Ldr., Pacific Northwest Research Sta., USDA Forest Service, Portland, OR

Nature's engineering of wood through genetics, wind, and weather create a wide variability in wood as a material, which in turn introduces difficulties in wood processing and utilization. Manufacturers sometimes find it difficult to consistently process wood into quality products because of its wide range of properties. The primary objective of this study was to investigate the usefulness of a stress wave technique for evaluating wood strength and stiffness of young-growth western hemlock and Sitka spruce in standing trees. Stress wave measurements were conducted on 168 young-growth western hemlock and Sitka spruce trees. After *in situ* measurements, a 2-foot- (0.61 m) long bole section in the test span was taken from 56 felled trees to obtain small, clear wood specimens. Stress wave and static bending tests were then performed on these specimens to determine strength and stiffness. Results of this study indicated that *in situ* stress wave measurements could provide relatively accurate and reliable information that would enable nondestructive evaluation of wood properties in standing trees. Statistical regression analyses revealed strong relationships between stress wave properties of trees and static bending properties of small, clear wood specimens obtained from the trees. Results of this study also demonstrated that the effect of silvicultural practices on wood properties can be identified with the stress wave properties of trees. This indicates that this nondestructive stress wave technique can be used to track property changes in trees and help determine how forests could be managed to meet desired wood and fiber qualities.

BOOTH 35

Internet Implementation of a Model to Predict Residual Strength of Fire-Retardant-Treated Wood

Patricia K. Lebow, Mathematical Statistician, and *Jerrold E. Winandy*, Research Wood Scientist, Forest Products Lab., USDA Forest Service, Madison, WI

Internet-based programs that implement complicated formulas and tedious calculations, such as predicting material property values, determining experiment sample sizes and power probabilities, and choosing appropriate kiln-drying schedules, are becoming more widely available. Our website www1.fpl.fs.fed.us/webpr.html fhas examples and further details. Running programs over the web offers many advantages, including simplifying method implementation, expediting the availability of research results, and increasing accessibility that allows more thorough evaluations by a wider audience. This is partially accomplished because of minimized hardware/software incompatibilities, no installation/upgrade dilemmas, and improved graphical interfaces. This presentation will discuss the building and implementation of an internet-based program for the prediction of long-term residual material property values of fire-retardant treated (FRT) wood exposed to elevated temperatures. Prediction is based on kinetic models of thermal degradation coupled with actual temperature profiles observed at specified locations in the United States. This program will be made available through the newly created Forest Products Laboratory Engineering Properties of Wood website in addition to the above website.

BOOTH 36

Grain Angle's Effect on the Velocity of Propagation of Ultrasonic Waves Through Radiata Pine Wood

Alejandro M. Bozo, Grad. Research Asst. (Prof. of Wood Engineering, Univ. of Chile, Santiago, Chile), Wood Materials & Engineering Lab., Washington State Univ., Pullman, WA; *Jose T. Karsulovic*, Prof. of Wood Engineering, Univ. of Chile, Santiago, Chile

This study is part of a research project conducted by Wood Technology Department of University of Chile. The goal is the utilization of ultrasonic techniques in the characterization and classification of wood and wood composites. The principal objective was to determine the variation of velocity and acoustic impedance in the longitudinal direction of ultrasonic waves through radiata pine wood at different grain angles (0º, 15º, 30º, and 45º) and at different levels of density (low, medium, and high). The ultrasonic tests to determine velocity of propagation and acoustic impedance were made using the Reflected Eco Method. The equipment used was an Ultrasonic Pulser/Receiver (model 5058PR) and transducers of 0.5 inch of diameter (model V103 RB of 1MHz). The results showed that the velocities of propagation and acoustic impedance are clearly affected by density and grain angle. Increasing density decreases the velocity of propagation and increases the acoustic impedance. Grain angle has the same effects, i.e., velocity of propagation diminishes when the grain angle increases, and the acoustic impedance increases when the grain angle increases. The velocity profile and graphic analysis are good tools to determine the knot influence region, but they have to be developed to obtain an efficient general method.

BOOTH 37

Intensive Stress-Wave Analysis of Douglas-fir Trees May Improve Correlation with Lumber MOE

Shih-Yin Wu, Grad. Research Asst., *Thomas M. Gorman*, Assoc. Prof., and *Francis G. Wagner*, Prof., Forest Products Dept., Univ. of Idaho, Moscow, ID

Past research has shown that correlation between stress-wave speeds in trees and MOE of wood products is low. In this study, six Douglas-fir trees were initially scanned using longitudinal stress-wave speed. The six trees were scanned on four faces over a longitudinal distance of 4 feet. In past research, the correlation between longitudinal stress-wave speed of the trees (individual faces and average of the four faces) with the average MOE of 12-foot lumber sawn from logs just above the stress-wave scans was low. After harvesting, the 12-foot logs above the tree scans (5 to 17 ft. above the base of the tree) were scanned intensively (longitudinal and transverse scans) on the log faces to simulate tree scans. Spikes were driven into the faces of each log, and longitudinal stress-wave speeds were measured on four faces over an 11-foot distance. Transverse stress-wave speeds were measured at 10 positions from one face to the opposite face. Both the longitudinal and the transverse stress-wave speeds were then used to calculate an index value for each log. The correlation between the calculated index value of each log and the average MOE of lumber sawn from the logs was high. The intensive stress-wave analysis in this study was performed on logs. However, this same type of scanning could be performed on standing trees. Although the use of four 11-foot longitudinal scans and 10 transverse scans per tree may be impractical from a forest management perspective, results indicated that more intensive stress-wave analysis of trees could substantially improve the correlation with the MOE of lumber and other wood products.

BOOTH 38

Strength Evaluation of Pre-Drilled Wood Studs

Kevin L. Powell, Research Analyst, National Assn. of Home Builders' Research Center, Upper Marlboro, MD

Research conducted at the University of Minnesota demonstrated a method to produce studs from cook-prone lumber that resulted in straight and stable studs dried to a moisture content more appropriate for installed residential framing. The method used predrilling green studs and vertically stacking them in the dry kiln using a drilling pattern and hole diameter that was consistent with the hole allowance contained within the softwood lumber grading rules for stud grade. NAHB Research Center Inc., evaluated wood studs using the drilling pattern employed in the University of Minnesota study and compared mechanical properties to those of conventional studs. Results from resistance to lateral force tests of shear wall panels constructed of drilled and conventional studs and the future tests to be conducted during the analysis of predrilled studs will be presented.

BOOTH 39

Serviceability Modeling-Predicting and Extending the Useful Service Life of Plywood Roof Sheathing

Jerrold E. Winandy, Research Wood Scientist, and *Patricia K. Lebow*, Mathematical Statistician, Forest Products Lab., USDA Forest Service, Madison, WI

This report presents the findings and implications of a major 10-year research program carried on at the U.S. Forest Products Laboratory. This research program developed serviceability models for untreated and fire-retardant (FR)-treated plywood roof sheathing exposed to elevated in-service temperatures and experiencing thermal degrade. FR-treated plywood roof sheathing is often required by U.S. Building Codes in roof systems for multifamily dwellings having common property walls. This 10-year research program found many important facts. Qualitatively, the mechanism of thermal degrade in FR-treated plywood was acid-hydrolysis. The magnitude of strength loss could be cumulatively related to FR chemistry, thermal exposure during pre-treatment, treatment, and post-treatment processing and in-service exposure. The effects of FR chemistry could be mitigated by use of pH buffers. The strength effects were similar for many levels of plywood quality. Quantitatively, a kinetics-based approach could be used to predict strength loss based on its time-temperature history. This research program then developed models with which to assess current condition, predict future hazard based on past service life, and then predict residual serviceability of untreated and FR-treated plywood used as structural roof sheathing. Each of these findings is briefly described in this report.

WOOD & THE ENVIRONMENT

BOOTH 40

Community-Based Forestry and Appropriately-Scaled Technologies

Susan L. LeVan, Program Mgr., Technology Marketing Unit, Forest Products Lab., USDA Forest Service, Madison, WI; *Lynn Jungwirth*, Dir., Hayfork Watershed Research & Training Center, Hayfork, CA

In the Interior West, 39 million acres of national forests have lost ecological integrity due to major changes in vegetative structure and composition. These ecosystems are at risk from wildfires in a region where historically there were frequent, low-intensity, stand-maintenance fires. Restoration, either mechanical or through prescribed fires, can cost $150 to $500 per acre ($370 to $1,235 ha). Most of these stands are overstocked, with understory trees that are generally less than 10-inches in diameter. Canopy closures could be as high as 80 to

90 percent in some of these stands. The West situation is commonly described as "too many stems, increased fire threat, not enough value, and no jobs in forest-based communities." Reducing processing costs, while developing forest products of higher value from these removals can help offset restoration costs, provide economic opportunities for many small, forest-based communities, and restore watershed health and biodiversity. The USDA Forest Service, Forest Products Laboratory has focused their efforts on helping communities create value-added products from these thinnings and removals. Efforts have focused on working with several rural communities to adapt appropriately-scaled technologies that match the economic strategies for these rural communities. These efforts involved characterizing the small-diameter and thinning material, identifying potential uses, and providing the appropriately-scaled technologies that can help these rural forest-based communities create successful businesses. Some research projects are evaluating the distribution of lumber grades, examining the effect of suppressed growth on properties, overcoming technical problems with kiln-drying and exploring the potential of using this material as roundwood structures.

WEDNESDAY AFTERNOON, JUNE 21

ADHESIVES/ADHESION

BOOTH 1

Special Cereal Protein Products as Adhesive and Furnish Additives in Wood and Ag-Fiber Panelboards

Beth Gallion, Dir., R&D and Quality & Environmental Assurance, The Robertson Corp., Brownstown, IN

Government and academic institutions, as well as industry, have demonstrated an intense interest in developing an ag-fiber panelboard industry for a number of ecological and economic reasons including: 1) extending the forest resource; 2) utilizing the vast and growing quantities of field fiber, which increase arithmetically with the ever-larger yields of such crops as wheat, corn, rice, and soybeans; and 3) adding value to products from the field yields of a farm revenue that need a dramatic infusion of funds in order to survive. A national priority is evolving to accomplish the ecological goals of implementing the concepts of 'zero tolerance' for waste and pollutants. Manufactured products with zero defects subdue the present scrouge of liability lawsuits based on perceptions of poor quality. In the quest for practical commercialization of ag-fiber products, may little-known beneficial characteristics of crops and crop fiber are rediscovered. This presentation will focus on the interest and investment in ag-fiber boards and the consideration of natural adhesive substitution (soy meal of wheat gluten) for adhesive additives or extenders and fiber (Wheatboard Filler™ or Soy Fill Flakes™) for panelboard furnish substitution.

BOOTH 2

Effect of CCA Preservative Retention on Bonding and Resin Properties of Room Temperature Curing Biomass Copolymer Resins

Chia-Ming Chen, Senior Wood Scientist, and *David L. Nicholls*, Research Coordinator, Sch. of Forest Resources, Univ. of Georgia, Athens, GA

The shear strength and wood failure of southern pine test blocks were evaluated at several levels of CCA preservative retention ranging from 0.25 to 2.5 pcf. Biomass materials, including alkaline extracts of pine bark, pecan shell flour, and peanut hull, were used to synthesize the experimental copolymer resins with formaldehyde, phenol, and resorcinol. Resorcinol levels were set to either 12.5 or 15 percent, based on the total resin weight, and the molar ratio of formaldehyde to phenolic materials during resin synthesis was also evaluated at two levels. The quantity of hardener was adjusted to a final molar ratio of formaldehyde to phenolic materials of 1.5. Test blocks were bonded for approximately 18 hours at 190 psi under room temperature. A total of 600 samples were evaluated in either the dry condition or after vacuum-pressure-soak treatment. The test results indicated that CCA retention clearly affected the shear strength and wood failures of the treated pine wood blocks. Certain resins require higher formaldehyde and resorcinol to achieve better water resistance in higher CCA-retention lumber. Some of the biomass copolymer resins require a much higher resorcinol content combined with a higher formaldehyde molar ratio to attain a satisfactory bonding quality.

BOOTH 3

Turn Wood Scraps and Lumber Shorts into Profits

Jerry D. Scheid, Adhesives Consultant, United Soybean Board (Omni Tech International, Ltd.), Medford, OR; *Roland Kreibich*, Research Scientist, Kreibich & Associates, Auburn, WA

Every year, the forest products industry throws tons of profit in the chipper. But, these scraps can be turned into a more valuable product. By finger-jointing, mills can transform yesterday's woodwaste into marketable lumber. Mills have used finger-jointing for years. However, the big limitation was that finger-jointing could only be used on dry lumber. Today, a soy-based adhesive system, PRF/Soy 2000, offers the flexibility to finger-joint green and/or dry lumber with less cost to your pocket book and the environment. These adhesives offer many advantages: 1) transformation of yesterday's woodwaste into marketable lumber; 2) flexibility to finger-joint green and/or dry lumber; 3) provision of a fully-structural gluebond that is boil-proof and waterproof; 4) savings in kiln costs: green finger-jointing allows mills to dry only salable lumber; 5) faster curing time than standard wood adhesives; 6) gelling gives quick handling strength and occurs even on frozen wood; and 7) environmentally friendly by reducing emission and utilizing a renewable resource. Today, there are still tons of green softwood shorts being tossed into the chipper. The United Soybean Board believes these scrapes present lumber mills, pallet manufacturers, remanufacturers, and wood processors the opportunity for sizable profits if the scraps are finger-jointed. Turning these scraps into salable lumber by using the advantages of PRF/Soy 2000 will allow companies to increase their wood utilization today and remain profitable well into the future.

MANAGEMENT

BOOTH 4

Ergonomic Solutions for the Wood Products Industry

E. Robert Savage, Research Asst., and *Rado Gazo*, Asst. Prof., Wood Research Lab., and *J.D. McGlothlin*, Assoc. Prof., Ergonomics Research Lab., Purdue Univ., W. Lafayette, IN

The issues of quality, lean manufacturing, globalization, environmental compliance, and worker's health have been at the forefront of manufacturing management perspectives for years. Today, these principles and concepts have more interest and more impact than ever before due to the increasing competition for customer needs. However, without discounting these needed efforts, a new issue, ergonomics and human factors, is at the front of manager's perceptions. With future ergonomic legislation on the rise, managers of manufacturing companies are continually keeping an eye on the promulgation horizon. It seems that legislators know the value of sound ergonomic principles and condone the establishment of ergonomic programs. Couple

this ergonomic acknowledgement with keen industry management knowledge of profitability and there is an overwhelming argument for increasing worker health through ergonomic practices. After all, being able to meet customer needs while still maintaining or reducing your own costs is the pinnacle of financial viability toward organizational sustainability. This study was conducted to understand and categorize associated risk factors specifically inherent in wood manufacturing environments. Results from heuristic metrics will be presented towards implementing viable, cost effective ergonomic solutions for the secondary-wood products industry.

MARKETING & ECONOMICS

BOOTH 5

Exploratory Analysis of Market Potential for Tropical Hardwood Lesser-Used Species from Ghana

Kofi Poku, Grad. Research Asst., and *Richard P. Vlosky*, Assoc. Prof., Louisiana Forest Products Lab., Louisiana State Univ. Agricultural Center, Baton Rouge, LA

Increasing demand for traditional market species of Ghanaian timber has led to dwindling stocks and quality within the Ghanaian tropical forest. As a result, there is a pressing need to introduce lesser-used species (LUS) to serve as substitutes. LUS are recognized to provide an important solution to unsustainable management of the tropical forest, even though many companies do not use them in their raw material mix. This poster will provide results of an exploratory market study of *Alstonia boonei*, *Petersianthus macrocarpus*, and *Ricinodendron heudelotti*, three potential LUS from Ghana. Results indicate that a majority of Ghanaian forest products manufacturer respondents are willing to use *Petersianthus macrocarpus* in their raw material mix, provided export buyers or manufacturers are willing to accept them. There is very little interest in the other two species. Overall, it is perceived that export buyers will not accept LUS products in the marketplace unless there is adequate technical information and effective marketing strategies.

BOOTH 6

Forest Products Industry eBusiness: A Comparison Between the United States and Canada

Richard P. Vlosky, Assoc. Prof., and *Olivian Pitis*, Research Assoc. Specialist, Sch. of Forestry, Wildlife, & Fisheries, Louisiana State Univ. Agricultural Center, Baton Rouge, LA

Experts say that business-to-business eCommerce will grow tremendously in the next several years and bring significant change to most industries. According to Forrester Research, by the end of 2000, business-to-business eCommerce in the United States is expected to reach $251 billion, and jump to $1.4 trillion by 2003, compared with $19 billion in 1997. Increasing competition and globalization are two factors fueling eCommerce growth. In 1998, eBusiness was studied in the context of the forest products industry in the United States and Canada. One thousand solid-wood products and 300 pulp and paper companies were surveyed. The sample frames included the top 100 companies (by production volume) in each sector (solid-wood products, pulp and paper). The remaining companies sampled were randomly selected from the population. Overall, respondents were asked to discuss their current or planned eBusiness strategies and the impacts that this will have on their companies. Results indicated that on average, United States and Canadian respondents began using the Internet at about the same time, mostly between 1996-1998. In addition, respondent expenditures for eBusiness technologies were similar for both countries. Current and planned use of the Internet as a platform for business applications were also examined. Although Canadian respondents have a higher frequency of Internet use (current and planned) for 11 of the 15 business applications studied, the difference in frequency was statistically significant and higher (at a=0.05) only for Internet EDI. Of the four applications used with a higher relative frequency by U.S. respondents, the Internet as a marketing tool was statistically significant (at a=0.05). With regard to extranets, more sophisticated Internet linkages with customers or suppliers, Canadian respondents had a higher frequency of use (current and planned) for 14 out of the 15 business applications (all except the use of email). Frequency of Canadian extranet business application usage was statistically significant (at a=0.05) for "customer contacts", "inventory management", and "purchases from suppliers." These and other results have implications for competitiveness for both U.S. and Canadian forest product manufacturers.

BOOTH 7

The Use of Panel Products by Furniture and Cabinet Manufacturers in the Southern United States

Qinglin Wu, Asst. Prof., and *Richard P. Vlosky*, Assoc. Prof., Sch. of Forestry, Wildlife, & Fisheries, Louisiana State Univ. Agricultural Center, Baton Rouge, LA

Particleboard and medium density fiberboard (MDF) are primary composite panel products used in the manufacture of furniture, cabinets, millwork, moulding, door parts, floor underlayment, laminate flooring, and many other products. The objectives of this study were to understand the southern U.S. furniture and cabinet manufacturer perspective in using these panel products relative to a noncomposite panel, plywood, and to determine their selection criteria. This study addresses technical, economic, and performance characteristics. It was found that nearly half of the total value of raw materials used by respondents in 1997 was comprised of these three panel products. In all but one industry sector studied, respondents said that they planned to increase usage of all three-panel types. The main reason respondents use these products are that they are economical to use while the main reason that they are not used is customer objection.

BOOTH 8

Assessing Louisiana's Primary Forest Products Industries Competitive Position in Global Markets

W. Ramsay Smith, Program Ldr., Sch. of Forestry, Wildlife, & Fisheries, Louisiana State Univ. Agricultural Center, Baton Rouge, LA; *Anne Burrell-Smith*, Market Research Analyst, Baton Rouge, LA

Competitive advantage is broadly defined as the assets, skills, resources, and positional advantages a firm may possess that enables the them to achieve a superior performance compared to its competition. Porter (1990) identified specific factors to enhance the ability of a nation, and its industries, to be competitive in the global market. Porter's theory, termed the "Diamond Theory," is formulated on four broad points: 1) factor conditions; 2) demand conditions; 3) related and supporting industries; and 4) firm strategy, structure, and rivalry. The research objectives of this study were achieved by using Porter's theory to assess the competitive position of Louisiana's primary forest products industry, develop profiles of the industry's exporting and nonexporting firms, and identify opportunities to increase value-added products and market expansion. The findings indicated a moderate level of competitive advantage for Louisiana's primary forest products industry. This industry's strength lies essentially in the rivalry and demand components, supplemented by the abundance of natural raw materials. Weaknesses are due primarily to the availability of skilled labor, knowledge resources, and weak links with related supported industries. Potential export opportunities for Louisiana's secondary forest products industry include building materials, furniture, cabinets, and millwork. The greatest opportunities for market

expansion were found to be in Germany, Spain, France, and the United Kingdom.

BOOTH 9

Consumer Perceptions of Character-Marks on Eastern Hardwood Veneer and Panels

Cynthia D. West, Dept. Head, Forest Products Lab., Mississippi State Univ., Mississippi State, MS; *Larry G. Jahn*, Prof./Dept. Extension Ldr., Dept. of Wood & Paper Science, North Carolina State Univ., Raleigh, NC; *Matthew S. Bumgardner*, Research Forest Products Technologist, Northeastern Research Sta., USDA Forest Service, Princeton, WV; *Craig L. Forbes*, Dir. of Marketing, New South, Inc., Myrtle Beach, SC

This study investigated consumer perception of character-marked cabinets. Visitors to a large home show were asked to rank, in order of preference, 12 cabinet doors that contained different levels of character-marking, as well as different species and styles. Cluster analysis and conjoint analysis were used to group and profile the respondents based on the rankings. For many respondents, wood species was clearly the most important criterion for evaluation, suggesting that more character could be included in cabinet products with little additional promotional effort. However, for a substantial subset of the sample, the presence of character was the most important ranking criterion. For this character-sensitive group, preference declined as the extent of character increased, but there seemed to be opportunities for development of products exhibiting light character. The groups were also profiled in terms of demographic characteristics. Understanding consumer segments for character-marked wood products can ultimately result in more efficient utilization of hardwood resources.

BOOTH 10

An Update of the Hardwood Chip Market

Carol A. Hyldahl, Research Forester, and *Bruce G. Hansen*, Project Ldr., Northeastern Research Sta., USDA Forest Service, Princeton, WV; *Cynthia D. West*, Dept. Head, Forest Products Lab., Mississippi State Univ., Mississippi State, MS

During the 1900s, hardwood chips have played an ever-increasing role in pulp and paper manufacture both domestically and globally. Domestically, the Southeast region accounted for more than 74 percent of total pulpwood and 33 percent of the hardwood pulpwood receipts. In 1998, satellite chipmills were the second largest supplier (26%) of hardwood fiber in the Southeast. Ever since the Southeast United States began exporting hardwood chips (1998), both the number and location of chipmills, specifically satellites, has caused concern about degrading the environment and the future supply of sawtimber. Statistics regarding the number and age of chipmills in the Southeast, as well as their production, will be presented. Globally, Japan has a virtual monopoly on U.S. exports of hardwood chips. On average, 95 percent of all hardwood-chip exports by weight and 94 percent by value went to Japan from 1993 to 1998. Yearly, since 1990, the U.S. Customs District of Mobile has exported the largest quantity of hardwood chips by weight to Japan. A forecast of Japan's hardwood chip requirements will be included.

BOOTH 11

Evaluating Opportunities for Viable Forest Products Industries in Alaska

Kenneth A. Kilborn, Team Ldr./Research Forest Products Technologist, Pacific Northwest Research Sta., USDA Forest Service, Sitka, AK; *Theodore L. Laufenberg*, Team Ldr., Forest Products Lab., USDA Forest Service, Madison, WI

The recent changes in the forest products industry of southeast Alaska, has provided impetus for the Forest Service to open the new Wood Utilization Center in Sitka, Alaska. The Center has a Southeast Alaska focus, and a statewide scope. Opened in February 1999, the Center's mission is "to identify and evaluate opportunities for variable forest products industries." Elements of the Center's charter include direction to: 1) Define and describe "value-added" activities that provide the appropriate and durable mix of employment, profits, and marketable products; 2) Identify the type and scale of harvesting operations and manufacturing facilities that are consistent with the timber resources, economic conditions, market opportunities, and economic development objectives of communities in Southeast Alaska; and 3) Clearly distinguish the roles and contributions of governments (federal, state, and local) and the private sector in promoting timber-based manufacturing for sustainable communities and forests. The Forest Service Wood Utilization Center is a component of the PNW Research Station with assistance in its development provided by the Forest Products Laboratory, Madison, WI. In the Center's first year, five professional employees were hired to undertake technology transfer and initiate studies involving wood utilization, processing, harvesting, economics, and marketing.

BOOTH 12

Juniper-Based Signs and Rangeland Restoration

James H. Muehl, Forest Products Technologist, *Andrezj Krzysik*, Scientist, *John A. Youngquist*, Project Ldr., and *Theodore L. Laufenberg*, Team Ldr., Forest Products Lab., USDA Forest Service, Madison, WI

Over the last half-century, the pinyon-juniper ecosystem in the Southwest United States has had increasing problems with the encroachment of the one-seed juniper (*Juniperus monosperma*) throughout the savanna rangelands. Natural wild fires of the past had prevented the juniper from becoming a problem. With increased fire suppression and a heavier demand on the grasslands for grazing space for cattle and sheep, juniper stands have established a strong foothold in the existing rangeland and continue to spread. It is estimated that juniper covers up to 124 million acres in the southwestern United States and that 60 to 90 million acres need restoration with only 15 percent of these acres being on public lands. Junipers are small trees, rather like a large bush, with trunks up to 10 inches in diameter but only up to 6 or 7 feet in length before they begin to branch out. Attempts to utilize this resource have been limited to firewood and fence posts. Heavy juniper stands have significantly reduced biological diversity in wildlife populations and continue to diminish grazing opportunities for deer, cattle, and sheep. Forest Service maintenance personnel have had problems with informational and route signs on southwestern National forests: for example, freeze/thaw delamination of reflective aluminum sheeting and plywood damage by porcupines. We were contacted by a private sign manufacturer in Mountainair, New Mexico, interested in developing an alternative to the traditional plywood panel substrate for his signs. He was interested in the woodfiber/plastic composites as a replacement for plywood. A juniper/plastic sign had the potential to reduce installation and lifetime costs, to be more durable in service, and to be resistant to animal damage compared with those made from aluminum or plywood. We worked with him to develop the process and produce small prototype signs from juniper and plastic. These

were installed on the Kaibab and Cibola National Forests for field evaluation to examine the effects of weathering, resistance to gunfire, and damage from animals and insects. As a demonstration project, we have worked with the sign manufacturer to identify equipment for commercial production of signs from juniper woodfiber/plastic composites. A processing plant is being built and equipment installed to start the production of sign panels. As demand increases, the manufacturer is planning to expand his business to include extruded sign substrate and wood/plastic composite signposts. He expects that this process will create a number of new jobs: up to 12 in the processing area and 8 to 10 in harvesting and restoration.

BOOTH 13

Ecological Marketing Strategies and Their Implementation in the Finish, Swedish, and North American Forest Industries: A Comparative Study of Personal Contacts

Pasi Kaskinen, Grad. Research Asst., Dept. of Wood & Paper Science, Univ. of Minnesota, St. Paul, MN

The objective of this study was to describe the logic of present ecological marketing planning and find a means of utilizing proactive ecological marketing strategies for competitive advantage. The researcher's 4 years in the field of forest industry training has shaped this project's problem area: the inconsistencies that exist between a firm's stated ecological marketing strategies and implementation. North American, Swedish and Finnish forest industries are compared in this respect. The focal point of the marketing functions examined are personal contacts, perceived as the most important single marketing function that needs development in the forest industry today. Empirical data is gathered about the North American forest firms and the results will be compared to the corresponding research in Finland and Sweden. The study utilizes multivariate analysis techniques and data was gathered by formal survey interviews, complemented by qualitative interviews.

BOOTH 14

Federal and State Income Tax Implications for Forest Landowners in the United States

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Federal and state income taxes are calculated for hypothetical forest landowners in two income brackets across all 50 states to illustrate the effects of differential state tax treatment. The income tax liability is calculated in a year in which the timber owners harvest $200,000 worth of timber. After-tax, land expectation values for a forest landowner in three sections of the country (the South, Western Oregon, and the Northern Lower Peninsula of Michigan) are calculated to illustrate the importance of tax planning on returns to timber investment over time.

BOOTH 15

Wood Material Use in the U.S. Cabinet Industry

David F. Olah, Grad. Research Asst., and *Robert L. Smith*, Assoc. Prof./Extension Specialist, Dept. of Wood Science & Forest Products, Virginia Tech, Blacksburg, VA

This project was a study of material use in the U.S. cabinet industry. The cabinet industry is an integral part of the larger entity of forest products, which is a major part of the U.S. economy. It is a substantial consumer of both hardwood lumber and wood-based panel products, yet little current quantitative information is available regarding this use. High growth within the industry during the past decade requires that current material-use data be collected. Information regarding material use is important to those involved in the industry, both suppliers and producers. It will also create a basis for comparing past research. Another goal of this study was to identify and address current managerial issues facing company executives. It is important that the industry understand where it has been and where it is going in order to promote healthy decisions for future prosperity.

BOOTH 16

Region of Origin Preferences for Hardwood Products

Stephanie Gomon, Grad. Research Asst., *Robert J. Bush*, Assoc. Dean, Research & Graduate Studies, and *Susan S. Gibson*, Marketing Research Asst., Dept. of Wood Science & Forest Products, Virginia Tech, Blacksburg, VA

Hardwood products are marketed based, in part, on their region of origin. Four or more regions of origin are typically defined: Northern, Appalachian (may be further divided), Southern, and Western. Often, manufacturers in preferred locations use region of origin in the promotion of their products. This study reported here was conducted to determine the extent and basis for region of origin preferences among selected users. The study also sought to determine the effect of preferences on purchase decisions. Data were collected from a total of 204 users in five categories. Only preferences for the Appalachian region of origin were investigated. A majority of respondents (65.2 %) specified region of origin when purchasing hardwood products. Most respondents (58.2 %) believed that Appalachian hardwoods have better characteristics for their applications than do hardwood products originating from other regions. Of the categories investigated, component manufacturers and hardwood distributors were most likely to specify the Appalachian region of origin. The most important factors in preferences for Appalachian hardwoods were color, growth rate, quality, customer preference, and texture, respectively.

BOOTH 17

Identifying Substitution Opportunities for Engineered Lumber Products in the Modular Housing Industry

Sara J. Gurney, Forest Products Marketing Specialist, Ohio State Univ. Extension, Piketon, OH; *Cynthia D. West*, Dept. Head, Forest Products Lab., Mississippi State Univ., Mississippi State, MS

The modular housing industry for the Mid-Atlantic region was evaluated in order to ascertain the current and future structural building material needs for this industry. It was felt that this industry was an important and growing segment of the industrialized housing market, but as yet, little or no information was available concerning their material usage and needs. A survey was mailed to 39 modular housing companies located in the MidAtlantic region. Following the survey, 19 of these companies participated in personal interviews. The combined response rate from the survey and interviews was 82 percent. The most important findings were that homes produced by this industry were becoming larger and more customized in order to compete with stick-built housing. Since 1992, producers have been increasing the amount of engineered lumber used per unit in order to overcome design constraints. Decreases in the quality of dimensional lumber was a high concern to companies and may prompt an increase in the use of engineered lumber over the next 3 to 5 years. The results of this study will lead to a better understanding of how structural building materials are used by this industry and create future opportunities for the use of engineered lumber products.

BOOTH 18

The Impacts of Product Mix and Distribution Channels on Pacific Northwest Exporters During the Asian Downturn

Kyle Cunningham, Grad. Research Asst., and *Ivan L. Eastin*, Assoc. Dir., Center for International Trade in Forest Products, Univ. of Washington, Seattle, WA

During the Asian downturn, housing starts in Japan fell from 1.6 million to 1.2 million. This caused a decline in the export of wood building materials from the Pacific Northwest. In spite of this, some firms reported record export levels. The purpose of this study was to better understand the various factors influencing export performance during the Asian downturn. A fax and mail survey was conducted to collect the data. The sampling frame consisted of 119 U.S. and 56 Canadian firms. These firms were composed of export consolidators and manufacturers that export their products. The choice of export products and distribution channels used had major impacts on the success of exporting firms during the Asian downturn.

BOOTH 19

Fund for Rural America Small-Diameter Timber Project: An Update

James W. Funck and *Charles C. Brunner*, Assoc. Profs., and *Johannes B. Forrer*, Research Assoc., Dept. of Forest Products, Oregon State Univ., Corvallis, OR; *John W. Punches*, Asst. Prof./Extension Agent, Dept. of Forest Products, Oregon State Univ. Extension Service, Roseburg, OR

In many areas of the United States, past management practices have created thousands of acres of densely stocked stands containing small-diameter trees. Increased management emphasis on forest health and biodiversity has forced land managers to seek economically viable stand treatments. Substantial opportunities exist to foster environmental stewardship and rural employment by defining the relationships between the resource and value-added manufacturing. However, the traditional log-to-product manufacturing process fails to recognize a tree's full value, because the process occurs in a series of steps (i.e. trees, logs, lumber, parts, etc.), each optimized for it own outputs. The ultimate end-use is rarely a consideration during intermediate processing stages. This project investigated the hypothesis of identification of the final product's potential before timber harvest and could enhance resource utilization, increase economic viability for secondary manufacturers looking to utilize small-diameter timber, and facilitate stand management activities by identifying small-diameter timber value. Therefore, stand- and tree-characteristics have been collected for 48 trees (112 logs) ranging from 5 to 10 inches DBH. Work has focused on creating computer images of the complete stems, including internal features. These computerized stems are then sawn using a true-shape and internal feature log breakdown model with the option to produce cut-stock parts rather than graded lumber. The status of the log modeling and breakdown portions of the project will be presented in this poster. Cooperators on the project include Oregon State University, USDA Forest Service PNW Station, Forest Products Laboratory, and Applegate Ranger District on the Rogue River National Forest.

MILLING & MACHINING

BOOTH 20

Veneer Slicing of Serpentine-End-Matched Flitches

James E. Reeb, Asst. Prof., *Charles C. Brunner* and *James W. Funck*, Assoc. Profs., and *Y. Liu*, Research Asst., Dept. of Forest Products, Oregon State Univ., Corvallis, OR

Appearance grade moulding and millwork require clear high-quality lumber that has become increasingly scarce and expensive. Ponderosa pine is preferred by the door and window manufacturers in the Pacific Northwest where clear pieces are sliced into veneer for overlaying wood or nonwood substrates. If defects can be removed by crosscutting and the clear pieces aesthetically joined, the longer length pieces could be sliced into valuable veneer. This would permit a more abundant material to be converted into high value-added products. Eighteen ponderosa pine flitches were crosscut into two equal lengths. A serpentine-end-matched joint was machined into each half (one with joint amplitude equal to the width of the flitch and one equal to 2/3 width). Half flitches were joined using a cross-linking PVA adhesive and sliced using standard industry methods. Of 468 veneers produced, only 20 exhibited poor bonds. Joint width averaged 0.0017 inch with a minimum width of 0.0006 inch and a maximum of 0.007 inch. Of 155 veneers tested in tension, 55 percent failed with some wood failure. Most wood failure occurred along the entire length of the glue-line except at the apex (end-grain glued to end-grain). The mean stress value for veneer 4-1/8 inch wide was 2,140 psi. The amount of wood failure observed indicated that the joints were sufficiently strong enough for veneer overlays.

BOOTH 21

Wood Machining and Tooling Research Program

Richard L. Lemaster, Dir., Wood Machining & Tooling Research Program, North Carolina State Univ., Raleigh, NC

The Wood Machining & Tooling Research Program (WMTRP) is a multidisciplinary program involving Mechanical Engineering, Industrial Engineering, Manufacturing Engineering, Material Science, and Wood Science fields. It's mission is to provide the woodworking industry with personnel educated in machining and tooling technology, and provide applied research results aimed at improving efficiency and wood utilization. Major program support is provided by the U.S. Department of Agriculture. The WMTRP is a member of the Center for Wood Utilization Research. In a response from an Office of Technology Assessment recommendation, the Center for Wood Utilization Research was established to generate the new knowledge and technologies needed to maintain a vigorous, competitive, domestic forest products industry based on sustainable use of our nation's forest resources. Main areas of WMTRP research include: high-speed machining, spindle performance, tool design, tool materials/wear, surface-quality evaluation, process monitoring/control, abrasive machining, tool grinding, and drilling.

WOOD & THE ENVIRONMENT

BOOTH 22

The Forest Industry and Earth Day 2000

Jean Mater, Vice Pres., Forest Products Marketing Services Div., Mater Engineering, Corvallis, OR

Earth Day, the environmental community's effective organized effort to develop support for the Environmental agenda, was initiated in 1970. The forest industry has not fared well in the annual Earth Day commemorations. Earth Day 2000, billed by the Earth Day Network as "the largest environmental event in

human history" is adopting "Clean Energy Now!" as the slogan for Earth Day 2000, emphasizing clean power, clean air, clean cars, and clean investments. Forest management plays a significant role in achieving all these objectives. The Willamette Valley Chapter of the Forest Products Society, in conjunction with the local chapter of the Society of American Foresters; participated in the global Earth Day 2000 network with a program that demonstrated the role of forest management in achieving the clean energy goal. The forest program emphasized forest management as one of the solutions to achieve the objective of clean energy. Forest management in this context includes both using and protecting forests and managing for environmental and industry requirements. The objective of participating in Earth Day 2000 was using the international Earth Day network to present the positive contributions of forest management. The decision to participate in Earth Day 2000 reflected the interest and determination of the two Chapters to enhance the public perception of both forest management and production of forest products. It is a marketing project for the entire forest industry. The Earth Day meeting included an interactive session between speakers and the audience to develop appropriate "Sound Bites"" messages on forest management that counter popular antiforest management assertions.

BOOTH 23

Certifying Forestland: One Landowner's Experience in the Southern Appalachians

Kaarsten Turner, Forest Information Analyst, The Forestland Group, LLC, Chapel Hill, NC

The Forestland Group, LLC (TFG) is an institutional timberland investment management organization (TIMO) established in 1995 with an emphasis on naturally regenerating hardwood and pine forests in the eastern United States. The overall goal of TFG is to acquire and manage forestlands on behalf of institutional investors and will be managed in a manner that will provide the highest rate of return for the investors while being consistent with the maintenance and enhancement of the overall biological productivity of the tract. In October 1999, TFG was the first TIMO to have qualified for and executed a contract with SmartWood for certification under the FSC, the leading third party certifier of "green" forest management practices. TFG's pursuit of certification was largely market driven and predicated on a timber-supply agreement with a leading exporter seeking a source of certified wood products. TFG expects certification to increase market accessibility for wood products, particularly to certain European export markets where demand for certified wood products is growing rapidly. This poster outlines one landowners experience with certification in the southern Appalachian Cumberland Mountains.

BOOTH 24

Design and Testing of an Environmentally-Friendly Wood Bookshelf and Cabinet for Developing Countries

Ali Naci Tankut and *Nurgul Denizli*, Ph.D. Students, and *Carl A. Eckelman*, Prof., Dept. of Forestry, Purdue Univ., W. Lafayette, IN

Household furniture in many underdeveloped countries tends to be expensive, low quality, and both structurally and poorly designed. However, well-designed, attractive, cost effective, durable furniture can be produced, using low-technology production processes,and from locally available small-diameter tree species. In this study, various solid wood frames for bookshelves and kitchen cabinets are to be designed and evaluated. These frames are to be constructed with round mortise and tenon joints. The shrinking and swelling behavior, bending strength, and withdrawal strength of this particular joint will be studied. Panels are then to be added to the frames and the resulting panel-on-frame construction analyzed. Methods will be developed for the structural analysis of panel on frame construction. Finally, frameless cabinets will be constructed, and their performance compared to that of the panel-on-frame construction.

BOOTH 25

Green Advertising of Forest Products in the United States: A Content Analysis

Ernesto R. Wagner, Grad. Research Asst., and *Eric N. Hansen*, Asst. Prof., Dept. of Forest Products, Oregon State Univ., Corvallis, OR

Green advertising expresses a relationship of a product or service to the environment, promotes a green lifestyle or presents a corporate image of environmental responsibility. Many forest-industry advertisements fall into this new category. This research took a sample of green advertisements from magazines and trade journals and performed a content analysis. This technique, proven useful in advertising research, allows valid inferences to be made from data in their context. The present investigation gives suggestions for improving green advertisements.

BOOTH 26

The Status of Wood Pallet Disposal and Recovery at U.S. Landfills

Daryl T. Corr, Grad. Research Asst., and *Robert J. Bush*, Assoc. Dean, Research & Graduate Studies, Dept. of Wood Science & Forest Products, Virginia Tech, Blacksburg, VA

Yearly, a large volume of wood pallets are deposited in U.S. landfills. It is believed that these pallets still have value when they are disposed of. The purpose of this study was to determine how many used wood pallets reached landfills in 1998 and how they were handled. A survey was sent to every state registered Municipal Solid Waste (MSW) and Construction and Demolition (C&D) landfill in the United States, excluding Alaska. The survey asked various questions to determine the size of the landfill and the cost for depositing waste there. The survey asked how much woodwaste, and more specifically how much palletwaste the landfill received. The response rate for the survey was approximately 35 percent. The average MSW landfill received 160,000 tons of waste in 1998 and charged 30 dollars a ton to deposit it. Woodwaste represented 20 percent of the waste received at landfills. Wood pallets represented two percent of waste received at landfills, translating to approximately 200 million pallets. Approximately 40 million pallets were recovered by landfills. Recovered pallets were typically ground and sold, or given away for animal bedding, fuel, or mulch.

WOOD DETERIORATION/PRESERVATION

BOOTH 27

The Leachability and the Biological Resistance of Wood Treated with Tetraphenylborate Salts

Liang Lin and *Takeshi Furuno*, Faculty of Agriculture, Shimane Univ., Matsue, Shimane, Japan

Although boron wood preservatives have many advantages such as being colorless, odorless, noncorrosive, and nonflammable, boron by itself does not adequately protect wood that is in ground contact because of the chemical's susceptibility to leaching. Tetraphenylborate salts (TPBM) were tested in terms of boron leachability from treated wood. In addition, the biological resistance of TPBM-treated sugi (*Cryptomeria japonica* D. Don) was evaluated and compared. After the leaching procedure, tetraphenylborate potassium and tetraphenylborate tetramethylammonium salts showed generally excellent leaching resistance. Also, the TPBM was found to greatly enhance the decay resistance even after leaching by running water.

BOOTH 28

Weathering of Painted Wood Construction

Michael O. Hunt, Dir., *Daniel L. Cassens*, Prof., and *J.W. Evans*, Former Grad. Student (currently Analyst, Dept. of Mathematics, Univ. of Louisville), Wood Research Lab., *George P. McCabe*, Prof., and *A.J. O'Malley*, Former Grad. Student (currently Post-Doctoral Fellow in Statistics, Harvard Medical School), Dept. of Statistics, Purdue Univ., W. Lafayette, IN; *William C. Feist*, Information Specialist, Exterior Wood Finishing, Middleton, WI

Premature failure of restored street facades of historic commercial buildings, where the facades are constructed primarily of wood, is widespread. Such failure occurs even for restoration projects done according to the Secretary of the Interior Standards. These highly-visible construction failures have at least three practical, negative consequences: 1) they reflect poorly on the business housed within; 2) they create a negative image of wood in the construction market; and 3) they provide a convincing deterrent to appropriate restoration of historic buildings. A novel research program involving weathering of small facade-like panels will be presented. Each panel is a combination of controlled research variables. The expected outcome is the identification of cost-effective, durable combinations of panel design, materials, and treatments. Reported are tentative recommendations based on 3 years of weathering exposure. Results are applicable to all types of new wood construction.

BOOTH 29

Importation of Solid-Wood Packing Material: A Case Study of the Asian Longhorned Beetle

Stephen M. Bratkovich, Forest Products Specialist, and *Dennis Haugen*, Forest Entomologist, State & Private Forestry, USDA Forest Service, St. Paul, MN

Logs, lumber, and untreated-wood products imported into the United States have the potential of introducing plant pests detrimental to agriculture and to natural, plantation, and urban forests. One class of wood products subject to import restrictions is solid-wood packing material (SWPM) that includes crates, pallets, wood spools, dunnage, and packing blocks. Introduction of exotics such as the Asian Longhorned Beetle (*Anoplophora glabripennis*) has been directly linked to the importation of SWPM from China. The recent discovery of the Asian Longhorned Beetle in urban trees in New York City and Chicago has prompted regulatory restrictions on the importation of untreated SWPM from China. USDA regulations currently being considered include: 1) requiring all imported SWPM to be heat-treated, fumigated, or preservative-treated prior to arrival in the United States; 2) imposing restrictions on a country-by-country basis; 3) prohibiting the importation of SWPM in any form; 4) prohibiting the importation of SWPM with exceptions for extended multiple shipment use; and 5) taking no additional regulatory action. Subsequent analyses to support proposed alternatives will include a risk-reduction analyses, environmental-impact statement, and economic analyses.

BOOTH 30

Bioremediation of Wood Treated with Chromated Copper Arsenate

Carol A. Clausen, Microbiologist, Forest Products Lab., USDA Forest Service, Madison, WI

An estimated 60 BBF of chromated copper arsenate (CCA)-treated products have been placed in service since CCA gained popularity in the early 1970s. Much of this wood will be removed from service in the near future. Because CCA-treated wood is recognized by the EPA as a nonhazardous material, nearly all of it is currently placed in approved landfills upon removal from service. Bioremediation, with the metal tolerant bacterium, *Bacillus licheniformis* CC01, is a novel, environmentally-benign method of recovering CCA-treated woodfiber for recycling. Extraction of chipped CCA wood with oxalic acid combined with exposure to the bacterium, removed more metals from the wood than either acid extraction or the bacterium alone, essentially cleaning the woodfiber so that it can be recycled into composite products. Cleaned fiber (70% copper, 81% chromium, and 100% arsenic removed) was reassembled into particleboard.

BOOTH 31

The Wicking of Water in Wood-Based Sidings

Perry N. Peralta, Asst. Prof., and *Joseph Judge, Jr.*, Student, Dept. of Wood & Paper Science, North Carolina State Univ., Raleigh, NC

Premature failure of wood-based sidings has been attributed to the penetration of water into the siding by mass flow in the liquid state through exposed edges. This paper presents the results of a study to compare the rate of wicking of water in three wood-based sidings: hardboard, wood-cement board, and solid wood. The moisture content profile at various times during the wicking process will be shown. The data, together with contact angle measurement results, was employed in modeling the wicking process by the Lucas-Washburn equation.

BOOTH 32

Use of Anti-Stain Chemical Treatments by the Western U.S. Softwood Lumber Industry, 2000

Eric N. Hansen, Asst. Prof., *Jeffrey J. Morrell*, Prof., and *Roy C. Anderson*, Ph.D. Grad. Student, Dept. of Forest Products, Oregon State Univ., Corvallis, OR

In the spring of 2000, a questionnaire designed to assess the use of anti-stain chemicals was mailed to all producing members of the Western Wood Products Association. Data was gathered from the survey and will be presented. It includes: total volume of lumber treated by respondents, percentage of lumber treated from that produced in the whole western region, species treated, chemicals used, treatment methods used, and the acceptability of stain in specific market segments.

BOOTH 33

Chemical Characterization of Copper Naphthenate-Treated Pole Stubs After Field Exposure

H. Michael Barnes, Prof., Forest Products Lab., Mississippi State Univ., Mississippi State, MS; *D. Pascal Kamdem*, Assoc. Prof., Dept. of Forestry, Michigan State Univ., E. Lansing, MI; *Michael H. Freeman*, Consultant, Memphis, TN

This work was the continuation of the two projects which both began almost a decade ago. Previously, it had been reported that certain morphological changes may occur in small laboratory steamed samples of copper naphthenate treated southern pine. In earlier studies, it was specifically noted that in small laboratory treated and post-treatment steamed samples, as much as 50 percent of the copper present in amorphous copper naphthenate was converted to crystalline cuprous oxide. This study examined the influence of pre- and post-treatment steaming on the character and physio-chemical nature of copper naphthenate in hydrocarbon solvent treated pine in larger, pole diameter, pole stub-length samples. Toluene-methanol extraction, UV-Vis spectroscopy, x-ray diffraction (XRD), and environmental scanning electron microscopy (ESEM) were used to investigate the nature and properties of the copper naphthenate present in the wood after 12 years of exposure and possibly reveal the formation of solid cuprous oxide.

BOOTH 34

Innovations in the Treatment of Southern Pine Heartwood

Michael G. Sanders, Research Asst., and *Terry L. Amburgey* and *H. Michael Barnes*, Profs., Forest Products Lab., Mississippi State Univ., Mississippi State, MS

Whereas the sapwood of southern yellow pine (*Pinus spp.*) is readily treatable, the heartwood is essentially impermeable to preservatives such as chromated copper arsenate (CCA). Preliminary studies at the Mississippi Forest Products Laboratory indicate that increases in penetration and retention of preservative in pine heartwood can be obtained by subjecting kiln-dried dimension stock to varying mechanical stresses using the patented TASK Process machine. The TASK Process machine incorporates varying levels of compression and/or vibration to mechanically stress lumber.

BOOTH 35

Performance of Copper Naphthenate-Treated Poles in Service

H. Michael Barnes, Prof., Forest Products Lab., Mississippi State Univ., Mississippi State, MS; *Michael H. Freeman*, Consultant, Memphis, TN; *J.A. Brient*, Mgr., Naphthenic Acid Research, Merichem Co., Houston, TX; *C.N. Kerr, Jr.*, Vice Pres., Southwest Timber Laboratories, Houston, TX

A series of copper naphthenate-treated poles in service were inspected for deterioration, penetration, retention, and serviceability. The study to date has included poles in all hazard zones in the United States. Poles installed by 12 different utilities representing eight different treating companies are included in the survey. Both southern pine and Douglas-fir poles and distribution and transmission poles are included in the survey. Only two of the surveyed poles were considered failures indicating that properly treated copper naphthenate poles are serviceable and performing satisfactorily.

BOOTH 36

The Performance of Copper Naphthenate-Treated Wood Pole Stubs after 12 Years of Field Exposure

H. Michael Barnes, Prof., Forest Products Lab., Mississippi State Univ., Mississippi State, MS; *Michael H. Freeman*, Consultant, Memphis, TN

Naphthenates have been used for the preservation of timber and cellulose since its original introduction in Russia in the early 1880s as part of a series of petroleum characterizations. Later work in the development of copper naphthenate as a heavy-duty preservative for poles led to the development of various treating cycles similar to other oilborne systems. Recent work concerning the post-treatment steam-conditioning of copper naphthenate-treated southern pine has determined that some amorphous copper naphthenate is converted to a crystalline cuprous oxide and this was later determined to be less efficacious than copper naphthenate in small laboratory tests. This gave cause to the American Wood Preservers' Association to issue the instruction to the copper naphthenate task force to review, with particular emphasis on the effect of pre- and/or post- steaming on the efficacy of copper naphthenate preservative systems, including degradation of copper naphthenate. This presentation reviews the performance of actual pole diameter stubs placed in a high-hazard location containing both termites and potential for early decay attack. Various treating cycles were used to treat the pole stubs in this test including various post-treatment conditioning methods.

BOOTH 37

Molecular Methods for the Detection of Decay Fungi in Wood and Wood Products

Jody Jellison, Assoc Prof., and *Claudia Jasalavich* and *Andrea Ostofsky*, Post-Doctoral Associates, Univ. of Maine, Orono, ME

Decay is one of the most significant problems facing the wood products industry, limiting wood-product utilization in adverse environments and costing millions annually for decay prevention and replacement of wooden structural elements. Detecting and monitoring decay in wood remains a problem. The development of a reliable assay for the early detection of decay in wood is underway and our work has established that molecular methods such as PCR and RFLP analysis of the amplified products can potentially be used to both detect decay fungi in wood and identify the causal organism. Data will be presented confirming the reliable detection of multiple species of decay fungi at relatively early stages of wood colonization. Nondecay wood-inhabiting fungi were not detected. Identification of specific decay organisms can be obtained through RFLP analysis of the ITS region of the fungal DNA.

BOOTH 38

Influence of Free Copper on Fungal Growth

Rebecca F. Jennings, Research Asst., and *D. Pascal Kamdem*, Assoc. Prof., Dept. of Forestry, Michigan State Univ., E. Lansing, MI

Copper has been shown to be an affective component in many wood preservatives. The mode of toxicity is not fully understood. The objective of this study was to determine if copper must be free in solution to prohibit fungal growth. White-rot fungal species, *Poria placenta* (Pp) and *Gleophyllum trabeum* (Gt), were used to determine the copper toxicity thresholds. Under the experimental conditions used, a copper concentration of 250 ppm inhibited growth of Pp and 50 ppm inhibited Gt. Various organic acids were used to chelate copper in media and fungal growth rate was determined. By adding EDTA in 1:1 mole ratio with copper at toxicity threshold concentrations, fungal growth rate was restored to control levels. The effect of other organic acids will be discussed.

NOTES

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