FORESTRY & ECONOMICS

Uses for Small-Diameter and Low-Value Forest Thinnings

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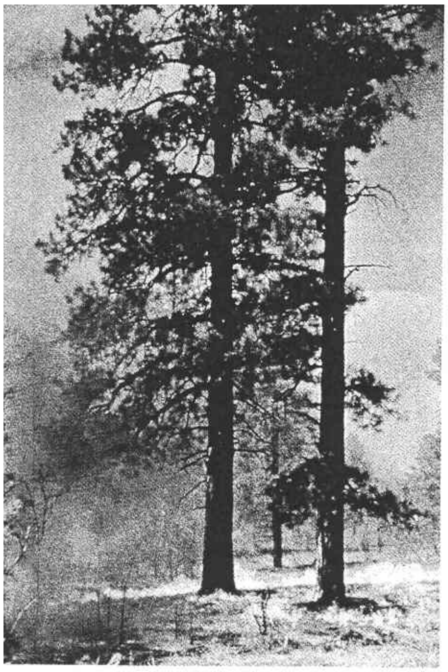

Many people believe that Native Americans lived in untouched wilderness among large old-growth forests. However, various fire history studies show that Native Americans burned land to manage natural resources, although they did so in uneven geographic distributions and with varying effects (Swanson 2002). As a result, fire was an important element in the natural cycle of many forests when European settlers arrived in this country. By the 1920s, however, catastrophic fires had generated national policies of fire suppression and prevention. A new breed of firefighters emerged using increasingly sophisticated technologies and fire-fighting procedures. They were very successful at their jobs—perhaps too successful. After 80 years of fire suppression, forests in the United States now contain enormous quantities of small trees and brush that have grown up in places where fire had once been a frequent visitor.

Background

Recent surveys of the 500 million acres of productive forest land in the United States indicate that the biomass of small trees and shrubs is increasing at an average rate of 237 cubic feet every second (Sebelius 2002). This increase in small trees and brush, in turn, creates a ladder-type fuel structure that can lead to high-intensity fires. For example, in 2000 and 2002, dense, overstocked forest stands contributed to fires that burned more than 7 million acres. This excessive growth has led to a crowded forest structure, insect infestation, and fire. Periodic forest thinning can keep these stands healthy, thereby reducing the threat from wildfires, maintaining wildlife diversity, improving forest resiliency, and protecting our nation's primary watersheds.

The U.S. Department of Agriculture's Forest Service and the U.S. Department of Interior have targeted more than $30 billion over the next decade to reduce hazardous fuels, restore damaged ecosystems, and help communities better protect themselves from catastrophic forest fires. A sizable part of this effort includes finding markets for the removed material to help offset the costs of thinning. In this article, we discuss some of the potential uses for small-diameter (9-inch dbh or less) and low-valued forest thinnings (SDT).

Potential Uses

There is a perception that small-diameter trees produce inferior wood. However, preliminary research at the Forest Products Laboratory indicates that much of the Douglas fir (*Psuedotsuga menziesii*) that occurs as understory is a high-quality material because of its suppressed growth. The same may be true for other tree species.

Considerable activity has been and is currently dedicated to improving the economics of using SDT material. Several institutions and organizations, including the Forest Products Laboratory, University of Idaho, Colorado State University and Washington State University, have

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programs that are examining the economics of existing and new technologies.

Material from SDT is being investigated for a hierarchy of uses, including 1) value-added uses by local community operators, 2) traditional uses by existing mills, and 3) residue uses (Figure 1). The resulting products include:

- Dimension and non-dimension lumber
- Engineered wood products
- Glued-laminated timber
- Structural roundwood
- Wood composites
- Wood fiber products
- Wood fiber/plastic composites
- Pulp chips
- Compost, mulch
- Energy
- Bio-fuel

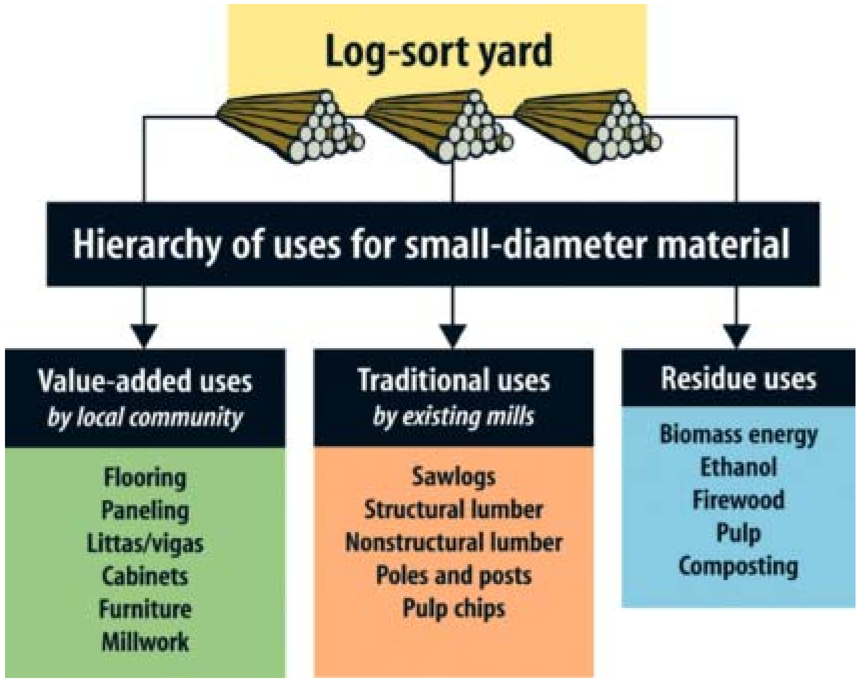

Figure 1. Thinnings of small-diameter trees provide materials for furnishings and millwork, structural materials, and energy and heat production. *Courtesy of U.S. Forest Products Laboratory*

Dimension and Non-Dimension Lumber

Lumber has three use categories: I) yard lumber, which is primarily dependent on appearance with the higher grades used for trim, siding, flooring, and paneling and the lower grades used for shelving, subflooring, and concrete forms; 2) structural lumber, which is evaluated for its relative strength and stiffness (for example, 2-by-4s, joists, I-beams, timbers, glued-laminated timber); and 3) factory and shop lumber, which is usually cut into smaller pieces for manufacturing into secondary products.

Utilizing SDT for dimension and non-dimension lumber requires efficient, economical operations and often modified or new types of machinery to handle the smaller-dimensioned material. Studies by Barbour (1999) and Wagner and colleagues (2000) indicate that small-log processors are better suited to achieve the recovery and economic gain necessary to make small-log processing a viable option. Many of them are being aided by the new equipment that is now available for processing SDT.

Since SDT is a nontraditional resource, its appropriate uses as lumber cannot be determined until its properties and characteristics are understood. Several research institutions have conducted grade yield and recovery studies to determine the best appropriate grades for SDT based on a particular species. Studies by Lowell and Green (in press), Lowell and colleagues (2000), Gorman and Green (2000), and D.W. Green (personal communication) indicate that high-quality material can be found within SDT. Some of the material is suitable for high-valued engineered wood products, such as trusses and glued-laminated timber. Other material is suitable for flooring, paneling, and furniture—all high-valued uses.

Much SDT is not of high quality, however. For example, fast-grown ponderosa pine (*Pinus ponderosa*), with its large growth rings, whorls of knots, and tendency to twist when dried, is not suitable for structural and nonstructural lumber. New technologies that cut out the knots and twisted sections and then finger-joint the good material together could add quality and improve the value of this otherwise low-quality lumber.

Structural Roundwood

Besides the traditional post-and-pole market, another potential use of small-diameter logs in the range of 4- to 6-inch dbh is for structural applications. Examples of such products are roundwood trusses, beam-column elements for post-and-frame building systems, pile foundations for residential structures, space-frame building systems, and a variety of other structures.

Researchers are addressing some technical issues regarding the structural use of roundwood. For example, they have built a mobile test machine to evaluate the material properties of ponderosa pine roundwood logs (R. Wolfe personal communication). Thus far, three field studies have been completed in South Dakota, New Mexico, and Arizona using this machine. Preliminary results indicate that while geographic location made no difference in the strength of the logs, there was a slight reduction in strength between peeled roundwood logs and debarked logs. Researchers also determined that design stress standards for peeled SDT logs should be adjusted because current design standards are derived from tests of logs from mature trees, not SDT logs with their preponderance of juvenile wood (the wood a tree produces during the first years of its growth). Wolfe and Moseley (2000) tested and evaluated several connection systems using small-diameter

Figure 2. Several demonstration structures using small-diameter roundwood trusses have been built in the United States. This visitor information center in the Wasatch Mountains near Ogden, Utah uses an innovative cupola design (see insert) that ties the roundwood rafters together through the use a ring-like structure below the cupola. *Photo courtesy of the U.S. Forest Products Laboratory*

logs. They concluded that small-diameter logs could function as structural elements with limited revisions to current roundwood specifications and design standards. In addition to research about structural properties, five field studies in Arizona, New Mexico, and California have tested the effectiveness of air-drying round logs (W. Simpson personal communication).

Demonstration structures using roundwood trusses have been constructed at the Forest Products Laboratory in Madison, Wisconsin, at the mouth of the Ogden Canyon in Ogden, Utah, and at the Soldier Hollow State Park, near Heber, Utah (Figure 2). A greenhouse for the high school in Catron County, New Mexico also uses SDT roundwood for part of its structure. Other roundwood designs include a snow equipment and recreation structure for the Wallowa Whitman National Forest in LaGrange, Oregon, a pedestrian bridge for Weaverville, California, and a library in Darby, Montana.

Results from a market survey (Paun and Jackson 2000) suggest that there is a favorable potential for the use of roundwood in highway structures such as guardrails, posts, and poles. Researchers are now studying whether the engineering design properties of small-diameter roundwood are sufficient to use for guardrails and signposts. If they are suited for this use, there would be another significant new market for small-diameter thinnings.

Wood Composites

Wood composites, such as particle board, medium-density fiberboard, oriented strand board and oriented strand lumber, are assembled from small pieces of wood glued together under pressure and heat. This technology is well suited to SDT because of the small size of the materials needed and because many species can be used. Typically, manufacturing plants that make wood composites are fairly large, requiring substantial capital investment and long-term assurance of supply (Maloney 1996). These plants are potential customers for supplies of clean wood chips and represent a sizable outlet for small-diameter thinnings.

Wood Fiber Products

Among their many uses, small-diameter thinnings can be made into wood fiber. Researchers at the Forest Products Laboratory have developed wood fiber filters to remove water pollutants and control erosion. Such products are adaptable to small, rural enterprises for local pollution sites and erosion control problems (Han 1999).

Wood fibers from SDT can also be combined with other materials to make useful products. A recent technological development involves composites of wood fiber and plastic that use low-valued species, such as juniper (*Juniperus* spp.) and insect-killed white fir (*Abies concolor*). As a result of research and development efforts, P&M Signs in Mountainair, New Mexico is successfully producing commercial highway signs from juniper fiber mixed with plastic (Figure 3) (Forest Products Laboratory 2000).

Pulp Chips

Although the pulp market is subject to wide fluctuations, chips for pulp have always been and will always be a use for SDT material. Nevertheless, recent clo-

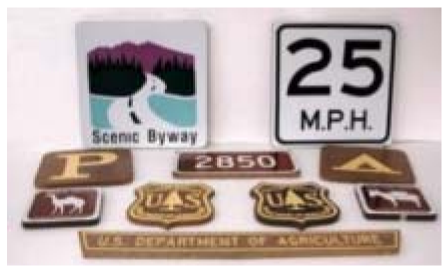

Figure 3. Research and development work by the U.S. Forest Products Laboratory has helped P&M Signs (202 E. Broadway, PO Box 567, Mountainair, New Mexico; www.pmsignsinc.com) begin production of small highway signs made from juniper or pine wood fibers and recycled plastic milk containers. The material, known as Altree™, can be routed, painted or used with reflective sheeting, and is cost competitive with high-density plywood. *Photo courtesy of the U.S. Forestry Products Laboratory*

sures of pulp mills in the United States may mean that this potential outlet for SDT may not be as readily available in the future as it has been in the past. Because pulp mills require large amounts of water to operate, geographical location also plays a role in the viability of the pulp chip market. Researchers have shown that the connection between SDT in arid locations in the United States and pulp mills is typically very weak because the cost of producing chips and transporting them to distant pulp mills is not economical (Barbour and Skog 1997, Myers and others 1999, Forest Products Laboratory 2000).

Figure 4. The BioMax 15 is a transportable and fully automated biopower unit that uses wood residues to produce electricity and heat for small enterprises, rural homes, and schools. Still in a pre-commercial development stage, units are now being tested at seven sites around the United States, including White Spruce Enterprises in Salcha, Alaska; Mount Wachusett Community College in Gardner, Massachusetts; and SBS Wood Shavings in Glencoe, New Mexico. *Photo courtesy of Community Power Corporation, Littleton, Colorado*

Compost and Mulch

There is always a certain amount of "waste" material after processing SDT into other uses. These materials are called residues. Many forest products industries burn residue as fuel. Some accumulate the material in large piles in their log yards. However, tighter environmental regulations are increasing the disposal and handling costs of residue and leading industries to look for other ways to use this material. Some of the major categories of potential use include turning residue into compost, mulch, and energy.

Composting transforms residue into a value-added product that can be sold to customers who want to increase soil fertility. Large-scale commercial composting operations are expensive, but small-scale alternatives can provide an economic option for a small business. The primary technical problem is how to incorporate a nitrogen source, such as manure, to improve the plant nutrient value. Mulch is another viable option, but local entrepreneurs must conduct careful market research and evaluation to ensure its economic viability.

Energy

Requirements for using wood as fuel are less demanding than for most other uses. Some residues of SDT and wastes generated in manufacturing various products are suitable for fuel with minimal processing, such as chipping. Fuels may be further refined through drying, pelletizing, or manufacturing into charcoal. Possible pathways for using more wood for energy include power-generating plants, industrial applications of cogenerating systems to produce heat and electricity, institutional heating facilities, and home heating.

Interest in cogeneration for electricity is high, but the price of wood for use as fuel is extremely variable. When there are surplus supplies of wood residues at forest products manufacturing plants or municipal solid-waste facilities, the cost can be very low or even negative. In these situations, the cost is mainly for transportation from the supply site to the wood combustion or wood-processing unit. At other times, wood fuel may be costly because large volumes of fuel are needed for a dependable and consistent supply, and other operations (for example, paper mills) may be competing for the same wood supply. However, wood power plants usually maintain a relatively low price and consistent fuel supply when adequate quantities are available.

New portable, small-scale wood-to-energy technologies are on the horizon. One system uses advanced downdraft gasification technology to convert the energy in wood chips to a clean, gaseous fuel suitable for use by a variety of generators, including automotive and industrial engines. The current prototype of this biopower unit can produce 15 kW of electricity and up to 50 kW of useful heat (Figure 4). However, these technologies are not yet commercially available. When biopower technology is on the market it will help improve forest health, increase sustainable domestic energy production, and help form new businesses along with its accompanying jobs.

Bio-Fuel

Residues from SDT can also be converted into fuels and chemicals through several different processes. Saccharification and fermentation, for instance, can convert wood sugars into ethanol. These products are useful in that they provide an alternative outlet for the use of low-grade wood feedstock, they displace petroleum, and they add value to the total mixture of products that can be made from SDT material (Jeffries 2000). However, the economics of making ethanol from wood are marginal. With improvements in conversion rates and new technologies that lower the cost, the economics could improve.

A process known as fast pyrolysis (rapid heating rates in the absence of oxygen) can convert woody residues into pyrolysis oil (sometimes called bio-oil). Bio-oil has a high energy density and could be a substitute for petroleum-based oil. Bio-oil can fire gas turbines and other engines that are modified to use this type of fuel. Bio-oil burns clean with low emissions of sulfur and nitrous oxides. There are a few processing plants in North America and several in Europe. A substantial amount of research is underway to improve the technology and improve the economics of this SDT product.

Conclusions

There are many potential uses for small-diameter and low-valued forest thinnings. The trick is finding the right use within the economics of the location, manufacturing process, and potential market. The first step in the process is the market evaluation. One needs to consider several product options and then conduct a thorough market assessment and feasibility study to determine if and where those markets exist. After the marketing studies are completed and product options are narrowed, the process involves the financial examination of each option. Sometimes good ideas are technically possible but not economically feasible.

There are no quick fixes that will convert low-valued forest thinnings into high-valued products. However, there are ways to improve the value-added uses, and these ways should be explored to obtain the highest and best use of small-diameter thinnings. The evaluation process has begun in many local communities, where people are working side-by-side with forestry agencies and others to create effective partnerships (see interview with Brett KenCairn in this issue). Technological advances and new research into potential product options are helping to open the doors for communities to develop rural enterprises that add value to small-diameter thinnings. New jobs will be created, and the economic diversity of forest-based rural communities will be improved. Researchers and others will continue their efforts to find value-added uses for SDT, while forest restoration is taking place. In the end, everyone will benefit.

DISCLAIMER

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