Small-Diameter Utilization Issues and Opportunities

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Introduction

This presentation provides a thought-provoking look at options for utilizing small-diameter wood to help reduce the widespread risk of catastrophic wildfire throughout the West while providing economic recovery of timber-depressed communities and sustaining viable forest products industry. Potentially viable utilization and marketing options are explored and current Forest Service small-diameter utilization research and technology transfer efforts are discussed. Specific points include effective utilization and marketing of underutilized and small-diameter material and evaluating potential investments in small-diameter utilization. Several critical factors are considered for successful business ventures for using small-diameter material. The scope of this work is applicable to a wide range of options — from traditional wood products to small niche markets and value-added opportunities.

Too Many Little Trees–Too Many Wildfires–Too Few Jobs

Throughout the western United States, there are tens of millions of acres of small-diameter, dense, overstocked stands of softwoods as a result of decades of fire suppression efforts. Consequently, forest inventories show disproportionately high volumes of small-diameter material (4 to 12 in.). This represents a dramatic increase. in forest fuel buildup and an increasing risk and frequency of catastrophic wildfire throughout the West. The USDA Forest Service alone is faced with some 40 million acres that are at risk of wildfire. In addition, an estimated 50 million acres on other Federal and Indian Trust lands are at risk. These numbers do not include State, industrial, or private lands. In 1994, the United States spent $1.4 billion fighting wildfire. Losses from catastrophic wildfire have been great–loss of natural resources, homes, livelihoods, and human lives.

There is an urgent need to manage fuel loading in our western forests to help control catastrophic wildfires. In the majority of these stands, there is a need to reduce biomass and fuel loading with mechanical treatments (removals) prior to prescribed burning. The only real cost-effective alternative is to provide economically viable wood utilization options for using this small-diameter material. The cost of removing small-diameter material is extremely high and an economical outlet (market) for biomass is needed. Finding economical uses for small-diameter material (living, dying, and dead) will help offset fuel reduction and restoration costs. This is not an easy task. Effective alternatives will be needed to attract business investment in small-diameter material utilization.

At the same time, timber-dependent rural communities have been hard hit as a result of reductions in timber supply and the changing mix and quality of the timber resource available to the forest products industry. Many large wood-using firms throughout the West have closed their doors and rural communities are struggling with social and economic hardships. In some parts of the West, the forest products manufacturing infrastructure has vanished. Many questions and uncertainties that need to be addressed

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relate to how to achieve sustainable forest-based communities with strong economic engines provided by the forest products industry and simultaneously ensure healthy, productive, and sustainable forests.

Forest-based communities have traditionally relied on a forest products industry based on large-diameter timber processing. The current mix and grade of species is typically different from that used in the past. The reduction in size and quality of small-diameter material has increased manufacturing costs per unit, with decreased wood product market values relative to products from large-diameter trees. Many forest-based rural communities lack the appropriate industrial infrastructure to fully utilize small-diameter material.

Therefore, we need to build markets for small-diameter utilization and investigate value-added opportunities to increase production capacity. Industrial capacity and markets are needed to handle large quantities of small-diameter material. Unfortunately, much of the former forest products manufacturing infrastructure that could have utilized this material is gone. In addition, this change in raw material requires existing industry to retool their operations to handle small-diameter material. Reestablishing lost industrial capacity and retooling existing industry to process small-diameter trees economically are critical needs.

Small-Diameter Issues and Needs

Over the past several years, the Forest Products Laboratory has conducted a series of technical assistance visits to various locations throughout the western United States and southeast Alaska (Forest Service Regions 1, 2, 3, 4, 5, 6, and 10). The primary purpose of these visits has been to learn about the issues affecting the National Forests and associated forest-dependent rural communities and industry.

Interdependence of Ecosystems, Rural Communities, and Forest Products Industry

A number of interrelated and profound issues surround the interdependence of ecosystems, rural communities, and the forest products industry:

(1) Biomass removal is key to accomplishing ecosystem management and forest health objectives on public lands.
(2) The Forest Service needs an outlet (i.e., market) for handling the by products of ecosystem management (e.g., biomass fiber, small-diameter trees, and underutilized species).
(3) Forest products industrial capacity provides a necessary outlet for small-diameter material, thereby assisting in reducing fuel loading and facilitating ecosystem recovery.
(4) Industrial capacity also provides primary manufacturing jobs, an important economic engine for rural communities in the West.
(5) Industry and local economies need wood from Federal lands to contribute to a diversified, sustainable rural economy.
(6) A long-term, economically viable industrial base is essential to economical forest management, ecosystem restoration, and improved forest health on public lands.
(7) The economics and infrastructure associated with current and future potential timber supplies will require changes in timber marketing processes; while small-diameter material can yield some higher value products, it is expensive to process and market and consequently has much less value than traditional timber supplies.
(8) A critical issue is matching utilization capacity with timber supply assurances.
(9) Consistent timber supply from year to year is critical for establishing and maintaining appropriate industrial capacity.

Specific Issues

Management of National Forests — The Forest Service is shifting its emphasis in forest management to focus on what the forest should look like after treatment rather than what timber should be harvested. The Forest Service is leaving timber that used to be harvested (i.e., large-diameter trees) and harvesting material that used to be left in the forest (i.e., small-diameter trees). Timber production is considered to be only one of many by products of implementing ecosystem management on the National Forests. Changing Forest Service land management strategies propose that timber and biomass removals will result in sales of smaller-diameter mixed species in contrast to the larger diameter single-species supplies of past removals.

Timber Supply–Guarantee of a consistent timber supply is the long-term major overriding issue for establishing and maintaining a sustainable forest products industry. Changes in Forest Service timber sale policy and restricted timber harvesting have resulted in a proportional reduction in the forest products industrial infrastructure. The current timber supply situation is causing a rapid shift to fewer, smaller, and less permanent firms. At greatest risk are medium to small firms without an industrial forestland base. Such firms are typical of the forest products industries in the Intermountain West.

Cost-Efficient Harvesting Systems–Cost-efficient harvesting systems adaptable to small acreage and small-diameter material are needed. This need goes beyond harvesting timber for wood and fiber products, and it could be generally categorized as forest management operations and ecosystem restoration. A primary need for these operations is to reduce fuel loading in previously untreated stands. Finding value-added uses for small-diameter material and forest residues could help cover the cost of removal. Such removals might include full utilization of tops and limbs (e.g., whole-tree chipping for use as feedstock for particleboard manufacture). Small-diameter harvesting systems (e.g., cut-to-length and commercial thinning equipment/systems) from Canada, Scandinavia, and the Lake States are potentially adaptable to processing small-diameter trees in our Western forests.

Forest Products Manufacturing Infrastructure–A healthy timber industry, with the ability to utilize and market a variety of species and size classes, is a key component of ecosystem management. Industrial capacity is necessary to help resolve some of the economics associated with forest health. The lack of forest products manufacturing infrastructure with inconsistent timber sales volume is a difficult challenge. The current need is to focus on existing industries so that they remain viable. Heavy capital investment is needed to establish new mills in today's competitive forest products industry. For existing sawmills, capital investment and improved log conversion efficiency are needed to remain competitive. However, it is unlikely that the sawmill industry will make further heavy capital investment until there is a more secure and stable timber supply. The uncertainty of the timber supply creates difficulties in obtaining financial backing for new investments.

Transportation Infrastructure–High transportation costs and the lack of transportation infrastructure in the Intermountain West are critical issues alongside the decline in the forest products industry. Poor transportation infrastructure limits options to move products to market. Proper industrial siting is vital to successfully establishing and maintaining a forest products industry, and the transportation infrastructure is a crucial consideration. Terminal facilities (e.g., railroad log and lumber reload facilities) need to be identified and established to improve the transportation of logs, primary wood products, and mill residues to market. Underutilized species and small-diameter material should first be made available in areas as close as possible to potential manufacturing facilities to help minimize transportation costs.

Sawmilling –Processing logs into higher valued sawn products, improving product mix, and increasing lumber recovery are essential for surviving sawmills to remain competitive. With today's high log costs it is difficult to compete in commodity lumber markets (e.g., studs, dimension lumber). This is especially true in the Intermountain West where there are substantial distances to primary markets, and lack of adequate transportation infrastructure. With limited capital to invest in sawmill optimization equipment, it is especially difficult for the small producer to compete. Where applicable, the product mix should include higher valued lumber (e.g., kiln-dried boards, factory grades, and molding) and other niche market

products. Successful sawmills are already focusing on these products. Opportunities to improve log conversion efficiency are just as important in squeezing the most value from small-diameter material. Improved conversion efficiency involves increasing lumber recovery with computer optimization and quality control programs with an emphasis on lumber size control. Mill automation and minimization of material handling are also important in reducing manufacturing costs.

Kiln Drying–Drying lumber is the critical link between primary manufacturing (e.g., sawmilling) and secondary value-added processing (e.g., furniture, flooring, and cabinetry). Lumber drying and remanufacturing capability are essential to the pursuit of value-added opportunities in the West. It is difficult to capture any higher value opportunities without dry kiln capacity. Drying capacity for factory lumber, especially in the Intermountain West is lacking. One potential opportunity in the Intermountain West is to establish shared dry kiln capacity, such as through a custom drying operation. Such an operation could service the needs for a number of different value-added businesses.

Mill Residue Utilization and Marketing–Of great concern to a number of forest products firms is the issue of mill residue disposal. Good markets and cost-efficient transportation are needed for mill residue (e.g., chips, bark, sawdust, slabs, edging strips, and trim). Mill residue can be marketed as feedstock for fiber-based panel products and other composite materials, as well as pulp for paper. Likewise, small-diameter material from the forest can be used as feedstock for manufacturing these products. A commercial mulch operation might be a viable alternative for mill residue for producing products such as mulch and organic fertilizer. There is also interest in investigating the production of ethanol from forest and mill residue. Ethanol research is being pursued with the Department of Energy's National Renewable Energy Laboratory in Colorado.

Market Development–In addition to markets for small-diameter material, there is a critical need to develop markets for mill residues, and value-added products like cabinets, flooring, panels and other specialty products. Many forest-dependent rural communities in the West no longer have any medium to large forest products industries to support their economic base. Market development needs to focus on finding niche markets for the surviving firms. The distance to markets and lack of transportation infrastructure are barriers to effective market development. Marketing cooperatives (e.g., Woodnet) for smaller wood products firms, especially secondary manufacturers, are of interest. Related to this is a growing interest in new markets for small-diameter trees, dead timber, and underutilized species. Remanufacturing capacity that could help integrate value-added operations is important for developing these markets.

Summary of Key Needs

Consideration of the issues identified by the Forest Products Laboratory in its outreach effort has identified many needs. These needs in turn suggest potential opportunities for small-diameter utilization and marketing development, and where research is needed. The key needs are as follows:

(1) Fuel reduction in forested areas at high risk of catastrophic wildfire.
(2) Sustainable forest products industry to provide economic engines for rural communities.
(3) Markets for mill residues and economical uses for forest biomass.
(4) Improved industrial and transportation infrastructure to process small-diameter material.
(5) Stable timber supply.
(6) Long-term timber sale contracts to encourage business investment in small-diameter utilization.
(7) Alternative methods to timber sales, such as log-sort yard sales.
(8) Value-added options for small-diameter material.
(9) Economical harvesting systems, including equipment, design, and layout
(10) Implementation of ecosystem management with economically viable stand treatments.
(11) Opportunities for economical marketing and utilization of small-diameter timber to help defray cost of ecosystem management treatments.
(12) Economic and market feasibility tools and analysis for small-diameter utilization options.

Opportunities for Utilization of Small-Diameter Wood

Figure 1 shows a variety of potential opportunities for using small-diameter material, including most of the major forest products and related business sectors (i.e., Standard Industrial Classification codes). These potential opportunities include both primary and value-added manufacturing sectors using a full range of high to low quality small-diameter material.

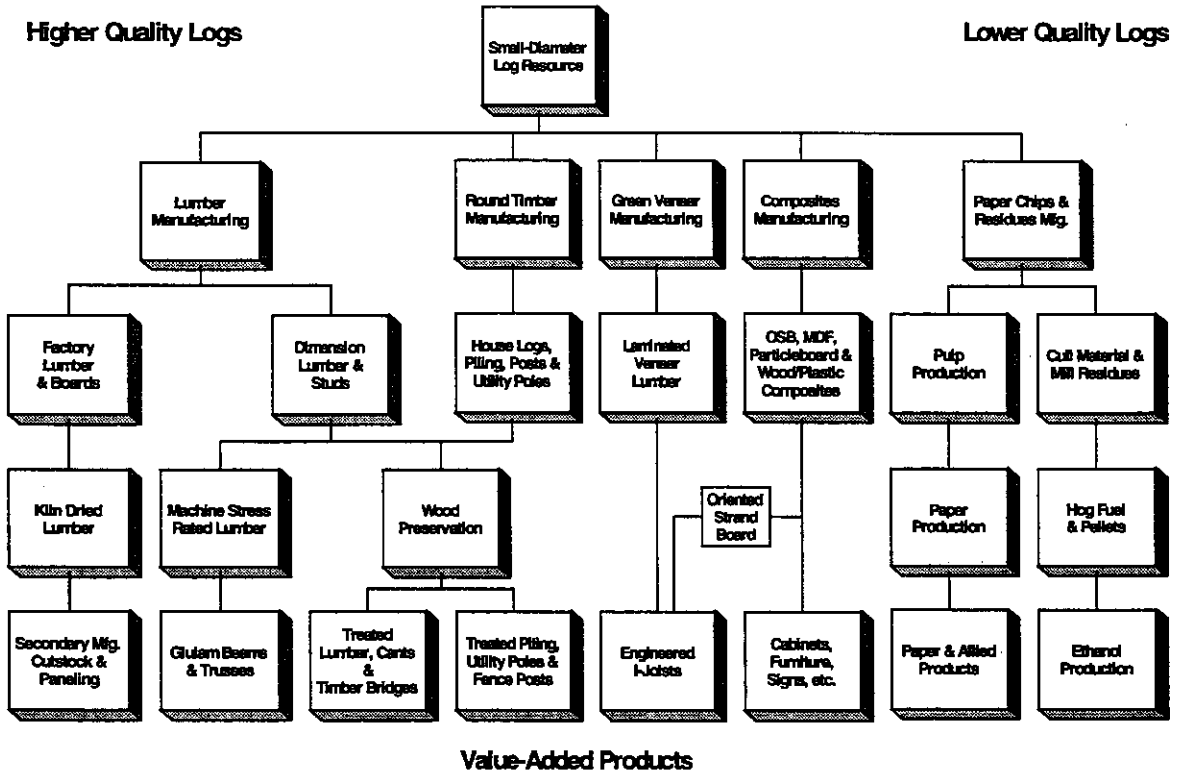

Figure 1—Potential utilization and market opportunities for small-diameter timber in the Western U.S.

Technically, there are many potentially viable options for producing products from small-diameter material. The real questions are—Is there a market and is it economically feasible to produce and sell? Also of interest are the material properties of small-diameter material–are they suitable for use? The answers to these and other questions are not well known. The next section of this paper summarizes efforts by the Forest Service to investigate these questions through research and technology transfer efforts.

Small-Diameter Utilization Research and Technology Transfer

For the last several years, a significant part of the research program at the USDA Forest Service, Forest Products Laboratory (FPL) has been refocused on the use of small-diameter material. Economical and value-added uses for this resource can help offset forest management costs and at the same time provide economic opportunities for many small, forest-based communities. The FPL research program is aimed at overcoming some of the technical and economic barriers associated with biomass removal. Since 1993, FPL has shifted some of its research effort to characterizing the small-diameter material and underutilized species, identifying potential uses for this material, and providing the technology that can help create successful businesses that utilize small-diameter material. Selected Forest Service utilization research and technology transfer efforts are summarized here.

Timber Management and Utilization

A series of Forest Service Research studies by FPL, the Pacific Northwest Research Station, and other Forest Service units were conducted on the Colville National Forest. The aim of the Colville Study was to identify and evaluate forest management options for dense, overstocked stands of small-diameter timber, which are common in forests east of the Cascade Mountains. Various forest management treatments were investigated to (1) decrease risk of insect attack, disease, and catastrophic wildfire; (2) improve wildlife habitat; and (3) improve forest stand structure and aesthetics. Results of Silvicultural simulations confirmed that stands are unlikely to meet desired conditions without mechanical treatment (i.e., removal of small-diameter material). This study also evaluated the suitability of producing various wood and fiber products from small-diameter material. Study trees were processed into mechanical and chemical pulp, lumber, veneer, composites, and other products. The results showed that in general the small-diameter trees were suitable for various products with few exceptions. Harvesting costs were found to be very sensitive to average stem diameter and represented a key influence on overall economic return from the manufacture of products from small-diameter timber. Software was developed for evaluating potential economic returns for given small-diameter stand treatments.

Economic Feasibility

An economic analysis of various potential products from small-diameter timber was conducted at FPL. Potential products included pulp, oriented strandboard (OSB), dimension lumber, stud lumber, machine stress rated (MSR) lumber, and laminated veneer lumber (LVL). Each technology was analyzed in terms of typical industrial-scale operations and per unit operating and capital costs, along with unit operating revenues at prevailing product prices. The wood supply required for typical operations and a return-to-wood figure for each operation were calculated as the difference between gross operating revenues and costs divided by timber requirements. The researchers concluded that pulping followed by LVL and OSB provide the highest economic returns. Various lumber options provide somewhat lower returns. For each manufacturing option, considerable economies of scale and capital investments are required to achieve acceptable rates of return on investments. Assurance of dependable wood supplies would be needed before industry would invest in small-diameter manufacturing opportunities.

Machine Stress Rated Lumber

This study is helping to define utilization options for wood from small-diameter trees for structural lumber. Studies are in progress at FPL to evaluate the yield of structurally graded 2 by 4's from several locations in the Intermountain West. Species under investigation include ponderosa pine, lodgepole pine, white fir, grand fir, and Douglas-fir. At each location, small-diameter trees are sawn into 2 by 4's and then visually and mechanically graded. Mechanical properties for each species from each location are being evaluated for suitability of small-diameter material for machine stress rated (MSR) lumber. Preliminary results indicate that excellent yields of visually graded structural lumber can be obtained with lodgepole pine and grand fir. Mechanical grading of lodgepole pine and grand fir offered even better grade yield of structural products than did visual grading. Small-diameter ponderosa pine shows little potential for direct use as structural lumber. In addition, ponderosa pine lumber from small-diameter material is prone to severe warping during kiln drying. Production of MSR lumber is estimated to realize a $27/thousand board foot (MBF) premium over the value of visually graded lumber for lodgepole pine and a $15/MBF premium for grand fir. Production of structural lumber for wooden trusses is a potential option for utilizing this type of small-diameter material.

Timber Bridge Designs

The FPL has been involved in developing timber bridge systems for underutilized wood species. A number of timber bridges have been made with glued-laminated (glulam) stress-laminated decks or deck panels. In the case of stress-laminated decks, bridges are constructed with a series of small glulam beams manufactured from nominal 2- by 4-in. lumber. By placing the beams side-by-side and connecting them

with tensioned steel bars, bridges with spans up to 50 feet can be built. Glulam deck panels are typically placed on top of glulam or steel beams to form a bridge deck. New designs using glulam deck panels have also been developed, and several bridges will be built. Basic research for glulam bridge designs can be adapted to small-diameter species. Future work will include the construction of demonstration bridges that can be evaluated to improve the structural efficiency and economics of standardized designs using small-diameter species.

Veneer for Laminated Veneer Lumber

The Applegate watershed (southwest Oregon) consists of suppressed, dense, overstocked stands composed of ponderosa pine, Douglas-fir, white fir, and Shasta red fir. The Pacific Northwest Research Station, in cooperation with FPL and State & Private Forestry, examined the relationship between certain properties measured in standing trees and logs and wood product quality for the potential of producing veneer from small-diameter timber. Study logs were measured and evaluated nondestructively and then processed at a cooperating mill, where they were cut into veneer and manufactured into laminated veneer lumber (LVL). Preliminary results show that small-diameter material is suitable for the manufacture of engineered wood products, such as LVL. Information to date indicates that the quality of the veneer produced from small-diameter trees is similar to the quality of veneer produced from old-growth timber.

Woodfiber–Plastic Composites

Current composites research at FPL is focusing on developing woodfiber–plastic composites from the combination of wood fibers (pinyon pine, juniper, and insect-killed white fir) and thermoplastics. FPL researchers are using underutilized wood fiber to act as a filler to improve strength, stiffness, and dimensional stability of thermoplastics at substantially lower cost. Benefits to using this technology also include reducing overall material use through better engineering, increasing the life of the product, and reducing its weight. Comparisons to commercially available wood flour fillers indicate that fibers from insect-killed white fir have slightly better notched impact, tensile, and flexural properties.

Another project is focusing on expanding the potential uses of juniper and the development of technology for industrial application of juniper fiber materials for composites. This project is developing and demonstrating the technical and market feasibility of using juniper composites for highway signs. Mixing juniper fiber with a controlled blend of recycled waste plastics has allowed FPL scientists to create a material with the needed mechanical properties and weather resistance for signs. This research and development should also open many other markets that require durable exterior materials.

Pulp Quality

Another research study is investigating the suitability of chemical and mechanical pulps from small-diameter material. Material under investigation includes Douglas-fir, western larch, and lodgepole pine sawmill residue chip mixtures, submerchantable material, and small-diameter trees. The roundwood used in the study was taken from the Colville National Forest and the sawmill residue chips and sub-merchantable logs were obtained from Vaagen Bros. Lumber, Colville, WA. Testing was conducted at the FPL and University of Washington. The results showed that this small-diameter material could be used for kraft pulp except in two cases: (1) mixing Douglas-fir submerchantable logs in large quantities with sawmill residue chips produces a nonuniform pulp and (2) pulping small trees with sawmill residue is problematic in producing linerboard-quality pulp. Lodgepole pine and Douglas-fir small-diameter trees yielded high-quality thermomechanical pulp (TMP), whereas lodgepole pine submerchantable logs and western larch small trees yielded low quality TMP.

Structural Use of Round Timbers

Researchers at FPL are initiating work on the suitability of small-diameter round timber for structural applications. Small-diameter material has several advantages for structural use compared to lumber and

sawn timbers. The strength of small-diameter roundwood has been shown to be less variable than that of sawn timber, giving a potential advantage in allowable design stresses. With respect to the presence of juvenile and mature wood, the symmetry of round timber makes the wood less susceptible to warp, more dimensionally stable, and stronger than most of the lumber that would be sawn from it. Development of value-added structural uses for round timber might significantly improve the efficient use of forest resources. Such uses include space frames, trusses, and segmental arches for roof assemblies, beam/column elements for post–framebuilding systems, and pile foundations for residential structures in flood-prone areas.

Log-Concentration-Sort Yards

Log-concentration-sort yards have potential application for effective marketing of underutilized small-diameter material. The log-concentration-sort yard concept may also provide an alternative wood and fiber supply. Specifically, these log-yard operations (1) manufacture, merchandise, and sort logs into higher value products; (2) provide a market for multiple log products for both large and small timber producers; and (3) supply forest product firms with desired raw materials. The goal for this project is to improve economic and ecosystem recovery by providing small-diameter utilization options and identifying potential market opportunities for forest products. A comprehensive guidebook for business planning, developing, and operating successful log-concentration-sort yard operations is under development. Successful log yards are self sufficient and have a good business plan, well-established markets, a steady supply of wood, and sufficient capital.

Econometric Models

Computerized econometric modeling tools are currently under development for evaluating potential uses of small-diameter material in various potential markets and the economic feasibility of these markets. The goal of the project is to provide tools and information for developing a business prospectus to attract forest products investment. The models estimate capitalization, labor, and raw material requirements for appropriate combinations of harvesting and processing systems and associated product markets. The software also allows assessment of the economic feasibility of new investments and detailed development of financial *pro forma* for prospectus and business plans. The econometric computer models will provide pre-business planning analysis in defining potentially viable business ventures for processing small-diameter trees.

Critical Factors for Successful Forest Products Business Ventures

Establishing a successful small-diameter venture implies a well-conceived and researched business plan. To be successful, business plans need to include detailed market and financial (*pro forma*) feasibility analysis and to carefully consider a number of critical factors. First, a feasibility study is conducted on potential viable business opportunities. The feasibility study also looks at the opportunities for economic/business development within the community. Then, a prospectus (i.e., a summary of any number of potential opportunities) is developed to attract business and investors in economic development. Both the prospectus and business plan need to addresses the following critical factors:

Raw material/resource– Of primary interest to forest industry is the raw material. Such things as the resource inventory, stumpage price, location in relation to manufacturing facilities, transportation infrastructure, sufficient and consistent quality and quantity of raw material, and physical properties of material as well as any unique attributes can influence the product and its markets.

Processing technologies–Material processing is also a critical consideration for successful ventures. This includes available technology and equipment, the physical plant, and automation with high piece counts. In many cases, different processing technologies have different raw material requirements. In addition, appropriately scaled technologies for a particular product and application will be important

for economic considerations. Some cases may require application of entirely new technologies, such as composite products that consist of a mixture of wood with other materials to enhance performance properties.

Products—Materialproperties and processing/technologies can provide ideas for potential products. However, such factors as trends in the marketplace for various products, existing product shortages, and new technological developments can also provide options for potential products. An important consideration is the ability of the product to meet end-use performance requirements. Careful consideration of product mix and differentiation (e.g., competitively priced/quality) is crucial in today's markets.

Markets — Market feasibility is the first consideration in exploring business investment opportunities. Such factors as size and market segmentation, market trends, competition, potential customers, potential market share, projected growth, niche vs. commodity market, transportation infrastructure, distance to markets, and pricing all need to be carefully analyzed and evaluated. Market considerations also include a critical look at the industry itself–type of industry, competitors, wages, number of jobs, growth, and stability.

Community/Workforce– The community and workforce also need careful consideration when siting a plant. Issues related to community include quality of life, zoning regulations, taxes, tax breaks, "business friendly" environment, and licensing. Workforce issues include skills, school system/training, and work ethic.

Financial — After market feasibility has been established, financial analysis is used to assess the potential profitability of the potential business investment. Financial feasibility involves the preparation of a *pro forma* statement that covers all aspects of potential financing such as working capital requirements and cash flow. Securing investment capital for potential ventures depends on good financials.

Environment, Health, and Safety — Environmental health, or safety issues and related regulations and permits are important considerations that can become a limiting consideration in an otherwise successful venture.

All of these factors are critical to the development of a successful business venture using small-diameter material. Weakness in or the lack of one or more of these factors often leads to business failure. The business plan must address all of these issues before a venture capitalist will even consider investing in a business. Likewise, the business plan points out weaknesses and deficiencies and warns of the pitfalls. The business plan also provides the community with a basis to evaluate a new potential employer in town.

Concluding Remarks

We cannot have healthy ecosystems without healthy communities and vice versa—healthy forests and healthy communities are interdependent. This interdependency is the cornerstone to building a foundation for sustainable forest management. The recurring question asked by timber-dependent communities is, *How can we develop viable forest products businesses that will help diversify our economy and use local forest resources in a manner that will help restore healthy, productive, and sustainable forests?* With declining budgets for forest management, the Forest Service must be able to deliver products (i.e., wood and fiber) to forest products firms to utilize small-diameter material. Industry plays a vital role by providing an economic engine for forest-dependent communities and an outlet for small-diameter material from our western forests.

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