

**Trends in Utilization of Small Diameter and Low-grade Timber –  
A Review of the Literature**

Prepared for the Pennsylvania Small Diameter Task Force  
Pennsylvania Hardwoods Development Council

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## *Executive Summary*

### General

- The additional variability inherent in small-diameter timber adds cost to processing while reducing the value of the end product, and must be either overcome through technology or fiber reduction. [1]
- Spreadsheet models have been developed and successfully used to demonstrate break-even for small diameter processing. [3]
- In 2000, USFS economists identified engineered wood products and rustic rail fencing as two potentially significant markets for small-diameter hardwood; and green dimensioning, curve sawing, and standardized blanks as technologies with the most opportunity to improve utilization of small diameter by existing operations. [18]
- The 1990 Mater Report, commissioned by the Hardwoods Development Council, placed an emphasis on nine (9) specific research opportunities that could be initiated and/or supported by the council. Of these, ??? have been funded in one way or another by the Council in the fifteen years since the report was submitted.
- The Mater Report also included an “action plan” which focused on building and maintaining a communication network around the issue of small diameter/ low grade resource. To the best of our determination, this action plan was not implemented. [21]
- Review of 23 case studies submitted as ideas for “Utilization of Low-Grade Southern Hardwoods” and their proposed technologies makes an interesting exercise for brainstorming various uses of low-grade hardwood timber. Many novel and potentially valuable ideas are presented. All meet the pre-condition of a 30% pre-tax ROI, at least as determined by the researcher.
- However, the general impact upon the reviewer is, “If these technology models all provided a 30% pre-tax ROI as indicated by the requirements of the symposium, why aren’t they out there today?”
- 23 of the 36 papers are summarized here. The other 13 were deemed as too impractical given current wood product and energy markets. While the symposium called for application to southern hardwoods, there is very little material difference in the successful application of the technologies as dictated by the differing species mix. [100]

### Resource Availability and Consumption

- A 2003 Penn State study concluded that the hardwood lumber industry actually produces 11 percent more lumber (1.3 billion board feet total) than Census Bureau estimates, and that there are actually 60 percent more sawmills (556 total) than Census Bureau estimates. They note that the Census Bureau figures greatly underestimated (by 73%) the number of mills with fewer than 20 employees. [23]

- A 1990 Penn State study estimated the number of pallet producers in Pennsylvania at greater than 200. These products were valued at more than \$130 million and consumed 377 million board feet of [low-grade] lumber, valued at \$63.7 million. The companies employed 2,725 people and paid 26.5 million in wages. [26]

### Solid Wood

- Hardwood lumber production appears to be economically infeasible below 8" log diameter. [2]
- Technologies and markets exist for the economic value-added utilization of "character-marked" lumber typically produced from low-grade hardwood lumber. [4]
- The hardwood flooring industry has been a successful user of domestic low-grade hardwood lumber in recent years, but data suggests that this trend may be nearing its end due to imports, and that the pallet industry stands to benefit from the resulting decreasing pressure on low-grade lumber prices. [5]
- The changing species composition from red oak to red maple inherently contains a lowering of average log grade into the low-grade categories, thus making technological innovations such as green dimensioning and character-marked component production an essential part of the state's wood product strategy. [6, 93]
- Optimal processing of hardwood component parts from 3AC lumber [a major portion of the lumber produced from small-diameter and low-grade logs] is obtained while producing narrow, short parts from short (< 8 ft.) lumber. [7]
- A 1999 Penn State study showed that even though 60% of current log purchases consisted of desirable species and log grades, 57% of the lumber produced was 2 common or lower in grade. While it is presumed that this percentage of low grade lumber will rise as smaller diameter timber increases as the percentage of log purchases, the authors pointed out that computer-aided processing technology was still not common in Pennsylvania sawmills, hinting that technology upgrades might enable the industry to offset the coming decline in average log grade. [22]
- A 2003 USFS-Penn State joint study raises the issue that although green lumber recovery from small diameter logs appears "acceptable", grade yield of dry lumber may not be. "Initial study results indicate that the yield of grade 1 Common and Better (dry) lumber from small-diameter cherry logs is less than 10 percent." [24]

### Engineered Wood

- A 1999 USFS study concluded that although solid wood options for small-diameter hardwood use appeared to offer the highest revenue opportunities, composite [engineered wood] products probably offered the opportunities with the highest potential margin, due to production efficiencies and the ability to utilized more of the log. [19]

- “To date, the Pennsylvania hardwood resource has not been strongly impacted by the growth in fiber demand associated with OSB hardwood round wood requirements.”[25]
- A 2001 USFS study indicated that by 2006, hardwood will comprise 2/3 of the fiber utilized for OSB in North America, and that these OSB operations generally are able to out-compete most other potential users of the small diameter timber resource, with the exception of pulp mills. [16]
- However, record production increases by the Russian wood panel industry, combined with new panel capacity in the EU and a weakening demand:capacity ratio of wood panels in North America, makes it unlikely that new OSB plants will be built here in the near future. [96]
- In support of this, CANFOR reported in its Q205 results that OSB prices had fallen 29% from the same period in 2004, even though demand and shipments are up. [97] LP Corporation, the leader in market share of North American OSB, reported similar results. At the same time, LP reported that they experienced strong growth in sales, volumes, and profits from their Engineered Wood business [98].

### Wood Energy

- A supply-driven small-diameter study done in New Hampshire in 2002 concluded that “In the foreseeable future, no other market exists to replace wood-fired electricity as an outlet to consume significant volumes of low-grade wood in New Hampshire.”
- New Hampshire’s high electricity costs, due in part to its mandated usage of biomass-based power generation, have hindered the state in its attempts to attract other energy-intensive industry, including potential MDF producers.
- Without significant state assistance, 3 of the 8 wood-fired energy plants have closed, and the fate of the remaining 5 is unclear beyond 2008, when the last of the 20-year energy contracts that have sustained them at above-market prices have expired.
- However, the benefit to cost ratio of the wood energy plants from direct economic benefits is estimated to be 3.6 to 1, and nearly 9 to 1 when indirect benefits are included. This rationale has been used (unsuccessfully thus far) to promote the investment of \$10.8 million in annual incentives for the remaining wood energy facilities. It does not appear that the higher cost of electricity to New Hampshire customers is included as a cost in these calculations; thus, the actual benefit to cost ratio may be much lower. [13,48]
- A small diameter initiative in Scotland in 2001 concluded that much of the timber was held in small private woodlots, dispersed and unable to support significant ongoing investment in new wood enterprises, due to much cheaper foreign competition in cladding, flooring, and furniture. The most realistic option was to encourage a locally-branded charcoal industry, which operated as side-businesses to existing wood production businesses. However, foreign competition exists even for this low-margin product, and UK consumers show no inclination to pay a premium for the environmentally-friendly local product. [17]

- Pennsylvania's answer to Scotland's charcoal option appears to be wood pellets for fuel. Four new wood pellet operations started up in the 1990's, all as add-on's to existing wood product operations.[25]
- A series of Penn State studies into the potential use of wood biomass as a fuel for power generation demonstrated that although positive net energy values could be obtained under ideal circumstances, the dollar cost of the technologies tended to be higher than conventional coal power generation of electricity.
- They also demonstrated that the use of wood for heat and steam generation is a different matter, and in fact, much more feasible under a wider range of conditions.
- The work migrated from natural supply sources to the concept of short rotation intensive culture plantations, as the higher biomass/area seemed to offer better economic results. However, in the final reports of the series, the economics of even these "best case" scenarios seemed to fall short, as the fiber's use for energy was shown to be considerably lower than its value in pulp and paper manufacture.
- Lacking competing alternatives, however, it was demonstrated under several different conditions that positive energy cost ratios can be achieved. Actual profitability from positive cost ratios, however, is not demonstrated. [27,28,30,32,33,34]

### Wood Chemicals

- Pennsylvania has a rich history in the production of chemicals from wood, explicitly because of the availability of the resource. [36]
- Forest, energy, and chemical industry experts all foresee a significant increase in the use of bio-based materials as feedstock for the production of a wide range of chemical products, including but not exclusive to transportation fuels and energy production. Material from forest thinnings and low-grade harvests are an environmentally-conscious source of these feedstocks. Most pulp and paper operations have the basic infrastructure to produce these products. [94]
- Wisconsin's governor has budgeted \$5 million in 2006 funds for development of agricultural and forest-industry based bioenergy development. Even though he likens this investment to a Silicon Valley vision, \$5 million is probably a drop in the bucket for real progress in this area, as the New Hampshire experience shows. [37]

## *References*

**1. High value products from low value wood.** Alan A. Marra, 2003. The Forest Products Journal 53(2):6-13.

“In a way, many of our forests have been treated like the gardener who would not weed his garden because there was no market for the weeds. Converting “weed” trees to useful products efficiently enough to produce profits would make forest improvement (low grading for timber) a pay-as-you-go proposition.

Throughout the forest enterprise some type of waste or unwanted wood is created at every operation, from growing timber to harvesting, manufacturing, and use. This unwanted wood can be characterized by one or more of the following qualities, all of which have a strong bearing on its utilization: 1) poor shape or form; 2) small size; 3) undesirable species; and 4) insufficient or undependable supply. Small size timber and certain species can sometimes be utilized if in sufficient amount to create a market. However, when wood with these combined characteristics is the input to a mill, the variability from piece to piece is so great that it cannot be processed efficiently. Much of the low-value wood that is available for utilization carries these characteristics and is scattered throughout our forests, in small pockets around local industries, or in landfills and demolition centers.

This variability is central to the utilization of low-grade wood...Two complementary approaches are taken:

1. Develop a utilization system that is more accepting of variability.
2. Reduce variability.”

**2. Value analysis of lumber produced from small-diameter timber.** Dan W. Cumbo, Robert L. Smith, and Charles W. Becker III, 2004. The Forest Products Journal 54(10):29-34.

“As expected, lower grade logs yield primarily lower grade lumber...Study results revealed that the percentage of wider boards (6 in. to 8 in.) and higher-grade boards (grades 1 and 2) began to increase at a log diameter of approximately 8 inches. Lumber value produced increased substantially with increasing log diameter and the relationship appears to be linear.”

**3. Small diameter wood processing in the southwestern United States: An economic case study and decision analysis tool.** Roger D. Fight, Guy L. Pinjuv, and Peter J. Daugherty, 2004. The Forest Products Journal 54(5):85-89.

“A flow diagram was created that showed the products and by-products that resulted when a log was allocated to production of a primary product. This was converted to a spreadsheet model that included product yields, processing rates, processing costs, and sales revenue... [This model] can be used in many ways, such as a tool for look-ahead scenarios for different production schedules and the design and

analysis of alternative production systems. It was used to demonstrate break-even costs and net revenues for a processor of small-diameter material, pointing out the strengths and weaknesses of [a specific] production process.”

#### **4. Market potential for fine furniture manufactured from low-grade hardwood.**

Qingbin Wang, Guanming Shi, and Catherine Chan-Halbrendt, 2004. *The Forest Products Journal* 54(5):19-25.

“Adding value to low-grade hardwood through high-value products will directly benefit landowners and wood products enterprises as well as many rural communities. It may also meet the demand of an increasing number of consumers who want to protect our forest and environment through their purchase of environmentally-friendly products (Ozanne and Vlosky 1997).

Findings from this study suggest three major conclusions that are likely to be useful. First, about 48 percent of the respondents indicated that they were interested in purchasing wood chairs made from hardwood with character marks...Second, the most important attribute of the hardwood chairs evaluated in this study was design...Third, we found that character mark density had a ... practically insignificant effect on consumer preference rating of the chairs...

While it is technically feasible to produce fine furniture using low-grade hardwood with character marks, it will be a challenge for the industry to supply character-marked wood furniture that is attractive in design and competitive in both price and guarantee policy... [however] the cost of processing and using low-grade hardwood is likely to decrease as the production scale increases and new technologies become available.”

**5. Flooring's Impact on the Hardwood Market.** TimberLine Magazine, July, 2004.  
<http://www.timberlinemag.com/articledatabase/view.asp?articleID=1151>.

“Keep in mind that a major portion of the supply of low-grade pallet hardwood is what economists call a split product. Generally, you don’t cut down trees for just the low-grade material. Flooring, paneling, furniture and other higher priced items are the driving factors. While all products help cover the costs and contribute to the industry financial picture, the lower valued products are not the drivers. Low-grade hardwoods are important to sawmills, but the higher grades generate the majority of the income for the larger grade-sawmills.

One big question is whether or not we are seeing the start of a new trend — a major increase in imported hardwood flooring. If so, the numbers and circumstances might suggest that we could be coming to the end of our fourth growth trend for domestic hardwood flooring in the last hundred years. If that were to happen, it could reduce some

of the pressure that flooring has put on the low-grade supplies on which the pallet industry depends.”

**6. What is low-value and/or low-grade hardwood?** William Luppold and Matthew Bumgardner, 2003. *The Forest Products Journal* 53(3):54-59.

“At the beginning of the market chain, low-value and low-grade material consists of trees not considered growing stock and sawtimber trees of Grades 4 and 5. These trees have been utilized historically for industrial products such as pallets and pulpwood. More recently, they have been used increasingly in the manufacture of engineered wood products. Grade 3 trees and their subsequent logs are by far the most plentiful and expanding portion of the hardwood resource and yield proportionally large volumes of lower grade lumber. Since it is economically inefficient to process such logs at mills designed to gain maximum grade yield from high-grade logs, a process that directly transforms them into dimension parts might be an option.

Examination of growing stock volumes for Pennsylvania reveals that red maple volume in trees less than 15 inches is considerably greater than for red oak...What this indicates is a transition from red oak to red maple that is occurring in many areas of the central and northern Appalachian region.

The potential dilemma with this change is not the transition from red oak to red maple per se...The potential dilemma concerns the lower quality of red maple versus red oak stems. In Pennsylvania for instance, 4.6 percent of the red maple 15 inches and larger in diameter is in tree Grade 1 compared to 24.8 percent of the northern red oak...This indicates that even if the smaller diameter red maple is allowed to mature into a large tree, only a relatively small proportion of the tree will be of Grades 1 or 2.

Low prices for low-grade lumber coupled with the cost of extracting such lumber from Grade 3 logs have made processing of such logs at conventional modern sawmills marginal in economic terms. Development of processes, such as green dimensioning (Bratkovich et al. 2000, Lin et al. 1995), and markets, such as character-marked products (Bumgardner et al. 2000), which can utilize this material will remain a major part of wood products research.”

**7. Opportunities for expanded and higher-value utilization of 3A Common hardwood lumber.** Brian P. Shepley, Jan Wiedenbeck, and Robert L. Smith. 2004. *The Forest Products Journal* 54(9):77-85.

“There are several methods that have been, and are currently being studied as possible alternatives for efficiently manufacturing products from today’s low-grade lumber supply. Some of these include green dimensioning, different composite materials, modified sawmilling operations, finger-jointing, and structural hardwood lumber [citations].

Results of the simulations [in this study] indicated that cutting bills with narrow part widths and short part lengths are the most conducive to obtaining optimal part yield while processing 3AC lumber. Further, the results indicated that higher part yields can be obtained when processing short-length 3AC lumber (between 6 and 8 ft.) as opposed to longer length 3AC lumber.”

**13. New Hampshire Timber Owners Associations addresses low-grade wood markets crisis.** Newsletter of the New Hampshire Timberland Owners Association, Fall, 2001. <http://www.nhtoa.org/memberonly/timbercrier9-01.pdf>

“New Hampshire’s low-grade wood markets are in a state of crisis following the closure of the Berlin pulp mill, the slowdown in paper making at several other regional paper mills and the looming threat of the closure of half the state’s wood energy facilities... NHTOA is working with some of its most impacted members on several fronts (i.e., legislative, regulatory, and public opinion) to preserve this critical market.

In the General Court, NHTOA is working with key members and committees to craft legislation that will enable wood energy facilities to remain financially viable in a deregulated power market. The legislation under consideration, HB 718, would require a power distributor in New Hampshire to include, as a percentage of the total power sold, renewable power from New Hampshire’s existing biomass and hydroelectric generators.

...NHTOA is [also] intervening before the Public Utilities Commission (PUC) regarding Public Service of New Hampshire’s (PSNH) proposed buyout of the electricity rate orders for the Whitefield, Hemphill and Bioenergy power plants. These plants account for one-third of the state’s low-grade wood market. As an intervenor, NHTOA’s role is to [ensure] the PUC considers the impacts the sale of these rate orders (and anticipated closure of these facilities resulting from the loss of the rate orders) will have on New Hampshire’s rural economy, timber industry, and forest health.

The interconnection of low-grade wood markets to the rest of the state’s forest industry runs well beyond the price of electricity and pulp and paper mill layoffs. The interconnection of low-grade wood markets extends to the entire state including:

- **Landowners** who, faced with an estimated 60% of the state’s standing timber as low-grade, will now find it increasingly difficult to economically justify the practice of sustainable forestry and conduct stewardship harvests;
- **Foresters and loggers** who will struggle to find a market for pulp wood and biomass chips and find it increasingly difficult to resist the temptation to cut only saw logs while leaving low-grade timber, thereby degrading the overall health of the state’s forests;
- **Sawmill owners** who, as markets for pulpwood and biomass chips disappear and further shrink the profit margin for timber harvesters, may see loggers moving out

of certain stands of timber making it more difficult for the sawmills to procure logs;

- **Banks** who struggle with the decision on whether to repossess logging equipment and foreclose on timber harvesters' homes; and
- **Rural cities and towns** who, met with plummeting tax payments, are forced to cut services, eliminate school sports and lay off teachers.

Because the low-grade wood markets have an interconnection to all our members and the entire state's economy, NHTOA has made protecting the existing low-grade wood markets and future development of new low-grade markets a top priority."

Update, March 2002.

"A proposed amendment to HB 1447 (a bill establishing a committee to study methods of supporting the continued operation of wood-fired electricity generating facilities) would have established a short-term incentive payment to enable the wood energy facilities off rate order to operate.

On March 21, HB 1447 passed as a study bill...but without the amendment mentioned above. The fallout expected from the amendment's failure is the near-term closure (within one month) of the BioEnergy facility in Hopkinton and the eventual (within 16 months) closure of the Whitefield plant."

Update, July 2005.

*From Jasen Stock, Executive Director, New Hampshire Land Owners Association*

"New Hampshire still has five wood energy plants. BioEnergy closed, but the Whitefield plant was bought by a venture capitalist, significant capital upgrades were made; now selling energy into the open market, not on old contract; selling green energy credits to Connecticut and Massachusetts help keep them in business."

"State energy policy must be aligned with environmental policy. Unfortunately, energy industry providers lobby to control or exclude all independent sources of energy, therefore, it is difficult to pass legislation that supports independent energy providers like the wood energy plants."

"The remaining long-term energy contracts [under which the wood energy buyers are selling energy to the utilities at considerably higher than market value] all expire in the next three to four years. The small diameter market could be very different in five years."

"Rural economic activity is the key selling point against energy industry lobbyists."

**48. Alternatives to Sustain the Wood-Fired Electricity Industry in New Hampshire.** New Hampshire Department of Resources and Economic Development. January, 2002.

“Markets for low-grade wood are a critical cornerstone to New Hampshire’s forest products industry, and of its efforts to conserve open space and assure the vibrancy of rural economies. For the past two decades, wood-fired electricity has been a major market for low-grade wood.

But this market may disappear. Of the eight wood-fired generators that have been developed in New Hampshire, two are shuttered, and two have recently negotiated the termination of their guaranteed power purchase contracts, leaving them with an extremely uncertain future attempting to sell power into unregulated electricity markets. Power purchase contracts for the four remaining plants will expire between 2006 and 2008.

This report documents the third phase of a study initiated by the NH Department of Resources and Economic Development to identify and begin to develop alternative markets for low-grade wood. Phases 1 and 2 of the study evaluated the technical and economic feasibility of over a dozen possible markets, and reached the following conclusion:

*In the foreseeable future, no other market exists to replace wood-fired electricity as an outlet to consume significant volumes of low-grade wood in New Hampshire.”*

From the Table ES-1 of this report, the total wood consumption of these eight plants when they were all operating was 1,563,000 tons per year, with which they generated 107.6 MW of electricity.

“As electricity prices declined during the 1990’s...these plants became expensive sources of electricity. The prices reflected in their ‘rate orders’...are now two to three times higher than the market rate for electric power in the Northeast, and have contributed in part to the very high rates paid by electricity consumers in New Hampshire.”

#### **“Alternative Markets for Low-Grade Wood**

Phase 1 of the study assessed a total of thirteen alternative markets for low-grade wood, evaluating them against criteria related to their technical and economic feasibility, and their capability to absorb a large fraction of the low-grade wood that can be expected to come onto the market with closure of the wood-fired power plants. This work was documented in the *Phase 1 Final Report: Use of Low-grade and Underutilized Wood Resources in New Hampshire* ... Phase 1 concluded that of all alternative markets identified, Medium Density Fiberboard...represented the best and economically most feasible option to replace wood-fired electricity as a major market for low-grade wood in New Hampshire.

Phase 2 of the study comprised a detailed feasibility assessment for Medium Density Fiberboard (MDF). Its goal was to provide economic and technical analysis in sufficient detail to support efforts to attract an MDF manufacturer to locate in New Hampshire. This work is documented in *Phase II of a Project: Feasibility Analysis of Medium Density Fiberboard Manufacturing in New Hampshire ...* Phase 2 concluded that while MDF will continue to enjoy rapid growth in the U.S. and Canada, and while New Hampshire's forest resources are clearly capable of supporting MDF production, New Hampshire is unlikely to attract an MDF manufacturer to locate in the state. There are three major, and ultimately insurmountable, barriers:

- 1) Raw material costs, which in New Hampshire are about 20% higher than whole-tree chip and residue costs elsewhere in the U.S. and Canada;
- 2) High electricity costs; and
- 3) Excessive distance to MDF markets.”

#### **“BENEFIT AND COST ANALYSIS OF WOOD-FIRED POWER**

The financial projections presented in Figure ES-1 imply that in an entirely unregulated market, a single wood-fired plant typical of those in New Hampshire would operate at an annual deficit of approximately \$1.8 million. As a first order approximation, therefore, the “above market” financial assistance required to keep this industry alive in New Hampshire is approximately \$10.8 million per year - \$1.8 million/year for each of the six plants.

The benefits of this assistance far outweigh the cost. The direct economic benefits of wood-fired power in New Hampshire are approximately \$38, 550,000 per year, yielding a benefit:cost ratio of 3.6:1. The total benefits of the industry, conservatively estimated, are approximately \$95,000,000 per year, yielding a benefit:cost ratio of 8.9:1. The number of jobs directly supported by the industry is approximately 500 – about 125 directly employed by the plants, and some 375 employed in New Hampshire's logging industry to provide the 1.3 million tons of raw materials consumed by the plants.”

**17. Sustainable development of the Scottish wood products industry.** The Scottish Executive (government), 2001.

“8.12 Another problem is that the overall quality of much of the hardwood timber currently available in Scotland is of mid- to low-grade. One area identified by the Scottish Hardwood Timber Market Development Group (SHTMDG) as a priority for development is moving a greater proportion of this mid- to low-grade timber into higher-value and higher-volume markets, preferably in Scotland.

8.13 Research conducted by Highland Birchwoods (in press.) has highlighted the fact that much of the native woodland resource in northern Scotland is in a fragile and fragmented state. With the exception of Scots pine, the current capacity for native woodlands to sustain anything beyond small-scale timber utilisation is extremely variable and often poor. In Argyll, for example, the research concluded that for the foreseeable future the main native timber manufacturing options will be limited to small-scale processing of low- to mid-grade logs for a variety of end uses including craft use, occasional use in buildings, outdoor landscaping products and fuelwood. Future opportunities for enhancing timber utilisation do exist, but these depend upon improvement of woodland management and increasing the capacity to convert low-grade timber to higher-value products.

8.15 Increasing the value of low grade timber is only possible by increasing local capacity to add value, i.e. to provide such goods as cladding, flooring and furniture rather than sawn logs, and the SHTMDG are encouraging this. However, according to Ivor Davies of Highland Birchwoods, the availability of cheap but nonetheless high quality foreign imports hinders development in this area. Scottish birch, for example, is competing with a massive Eastern European/ Russian birch resource with higher-quality timber and lower labour costs. To produce a square metre of birch flooring in Scotland costs approximately £15, whilst higher quality imports can be purchased for as little as £5/m<sup>2</sup>. A similar situation exists for Scots pine.”

“8.17 In recent years there has been a resurgence in charcoal-burning in Britain as a whole, principally using coppiced woodlands. A number of charcoal-burners now operate in Scotland including (for example) Cookson Tree Services (Forteviot), Argyll Green Woodworkers Association (Taynuilt), Corrimony Charcoal (Glen Urquhart), Highland Wood Colliers (Drumnadrochit), Glengairn Charcoal (Ballater), Brechin Castle Charcoal (Angus), Lockerbie Charcoal (Dumfriesshire), Green Tree Charcoal (Galashiels) and Deeside Charcoal (Tarland).

8.18 Charcoal is made by heating wood under conditions where there is insufficient air for complete combustion. Popular modern kilns include the portable metal ‘ring’ kiln and the retort kiln. The ratio of weight of timber to the weight of charcoal produced is on average about 6:1, depending on a number of factors including the method of carbonisation, the moisture content of the timber, the species used and the percentage of bark. Charcoal can be made from any hardwood, but the best species are reputedly ash, birch, rowan, alder and oak. The best sources are branchwood from the felling of mature trees, or coppice regrowth and hardwood thinnings. Slabwood from sawmilling operations is not well suited on account of its high bark content and shape. Obtaining suitable materials is not generally a problem (charcoal-burning operations are often run as sidelines to other timber-based businesses), but prices are determined by competing markets for fuelwood and chipwood.

8.19 The demand for charcoal is relatively low in Scotland, the climate not being suitable for barbecues (which provide one of the main uses of this material). In addition to fuel, charcoal can be used as an absorptive material for poisonous gases, as a soil additive, as

an ingredient in the pharmaceutical and chemical industries and in artwork. In the UK the barbecue charcoal industry provides the biggest demand and accounts for some 40-50,000 tonnes per annum, growing annually by 5%. Of this, 95% is imported (*Tayside Native Woodlands; Woodnote Number 7; November 1997*).

8.20 The primary constraint to developing the charcoal industry in Scotland is providing this resource at a competitive price, and at present it appears unlikely that there can be a sizeable and viable charcoal industry in Scotland...Charcoal is imported from a range of countries where labour costs are low, including South Africa, Latvia, Singapore, Argentina, Indonesia and Spain (E. Croxson, Bioregional Charcoal Company, pers. comm.). In Scotland there are no full-time charcoal burners and production is usually a sideline to an existing business such as sawmilling, tree-surgery and wood-cutting. For many, charcoal-burning has more to do with lifestyle choice than viable income generation, and in some cases training workshops and demonstrations bring in more income than the product. Ben Geyer (Shiresmill Woodlands, Fife) recently abandoned charcoal burning after calculating that it was paying him £4 per day.

8.21 The wholesale selling price of charcoal is about £0.80/kg, and is usually sold in 3 or 5kg bags. In the shops (e.g. B&Q), a 3kg bag retails for between £3.95 and £4.25. Profitability of the business is largely determined by production efficiencies of the set-up, burning, grading and bagging processes. The Millennium Forest for Scotland recently funded a small project on Loch Lomondside, undertaken by John Sinclair, to raise awareness of the charcoal-making industry and of its potential benefits for the environment. In some situations, for example, charcoal derived from woodland thinnings does represent a potential way of subsidising improvement of woodland management (D. Cowan, Tayside Native Woodlands, pers. comm.).

8.22 Locally made charcoal is sometimes labelled as 'made from Scottish native wood' as a marketing strategy to help it to compete with imported charcoal. Although there may be potential for development of 'sustainably managed' charcoal, at present there is no real demand for such products and there is no indication that the public is willing to pay any environmental premium. Again, price and quality are the deciding factors. Nevertheless the Bioregional Charcoal Company now co-ordinates a supply of UK-produced charcoal to B&Q from a number of burners throughout the UK, including 1 in Scotland (Lothian Fuels). “

**18. Options for small-diameter hardwood utilization: past and present.** Matthew S. Bumgardner, Bruce G. Hansen, Albert T. Schuler, and Philip A. Araman, 2000. Proceedings, Southern Forest Economics Workers Annual Meeting. Edited by Matthew Pelki. Lexington, KY.

“The use of hardwoods in EWP is increasing, and, where EWP mills are available, can offer markets for small-diameter hardwoods and non-sawlog portions of sawlog trees. Such opportunities can help make intermediate silvicultural treatments more financially attractive. Additional research is needed to better understand the impact of EWP on the

hardwood resource in the East, where they are becoming a major component of many species' utilization.

Other promising research areas for utilization of small-diameter hardwoods include green dimension ... and curve sawing of hardwood logs and lumber. Research into "value-added" processing of small-diameter hardwoods similar to the concepts of System 6 also continues. Also, there may be regional opportunities for specialty products such as rustic rail fencing, which accounts for about 20 manufacturers in West Virginia alone..."

**19. Hardwood timber product markets: a focus on small-diameter.** Bruce Hansen, Philip A. Araman, Cindi West, and Al Shuler, 1999. Proceedings of the Society of American Foresters National Convention, Portland, OR.

"Both composite products and solid wood seem to provide alternatives for use of low-grade, small-diameter hardwood use. How a particular resource might be directed – composite products, solid products, or both – will depend on who is able to offer the best price (return to log). Although solid wood, value-added products might seem to offer the highest sales revenue, conversion costs and yield losses will likely be greater also. Composites have the advantage of using all the log in a highly efficient [manner]. Thus, lower product prices may be more than offset by lower processing costs and higher yields."

"In the United States, technological advances still to come, may well provide the needed efficiencies to make low-grade, small-diameter hardwood utilization and economic reality."

**22. A profile of Pennsylvania's hardwood sawmill industry.** Paul M. Smith, Sudiptra Dasmohapatra, and William G. Luppold. 2004. The Forest Products Journal 54(5):43-49.

"The majority of the logs purchased [by Pennsylvania sawmills] (60%) consisted of highly desirable hardwood species, such as red and white oak, cherry and hard maple and 79 percent of the logs were sourced from private non-industrial forests...."

Fifty-seven percent of the lumber produced by Pennsylvania's hardwood sawmill respondents is No. 2 common, No. 3A and 3B Common, pallet, and tie grade. This underscores the importance of successfully developing and maintaining markets for lower-grade hardwood lumber, including value-added processes such as custom sorting and grading, dimension manufacturing, and finger-jointing."

"Our study of Pennsylvania's hardwood sawmills...found [only] 35, 12, and 9 percent of respondents using computer-aided headrig, edger, and trimmer equipment, respectively, in 1999."

**23. Estimating the size of the hardwood sawmill industry in Pennsylvania.** Paul M. Smith, William G. Luppold, and Sudiptra Dasmohapatra. 2003. *The Forest Products Journal*, 53(6):19-22.

“Pennsylvania contains the largest volume of hardwood sawtimber of any state in the United States, and by all estimates, produces more hardwood lumber than any other state. The sawmill industry is also quite diverse in that it contains a large number of mills of virtually every size, with an unusually large number of small mills.”

“The size of the hardwood sawmill industry in Pennsylvania in 1999 is estimated at 1.311 BBF by 556 mills. Study results show an 11 percent higher estimate of the volume of hardwood lumber produced and a 60 percent greater number of Pennsylvania sawmills in 1999...[than] estimated by the Census Bureau for the same year...the 217 mills missed by the Census Bureau had an average capacity of less than 600 MMBF that year.

Most economic and development studies for Pennsylvania are based on Census Bureau estimates, and therefore, tend to underestimate the size of the industry, particularly the number of sawmills with <20 employees...This study provides a caution to researchers and analysts who use the Census Bureau data as a benchmark for their studies..”

**24. Small Diameter Hardwood Utilization with Emphasis on Higher Value.** Janice K. Weidenbeck, Paul R. Blankenhorn, Matthew Scholl, and Lee R. Stover. 2003. USDA Forest Service.  
[http://www.ces.ncsu.edu/nreos/forest/feop/symposium/proceedings\\_2003/PDFs/Wiedenbeck.pdf](http://www.ces.ncsu.edu/nreos/forest/feop/symposium/proceedings_2003/PDFs/Wiedenbeck.pdf)

“Facing periodic log shortages that may become more severe in coming years due to continued forest fragmentation, many sawmill owners are beginning to consider small-diameter log processing. Small “sawlogs” that may be allocated to lumber mills often contain a relatively high proportion of juvenile wood that usually is of lower intrinsic wood quality. Optimizing the potential quality of lumber sawn from small-diameter trees and the upper bole sections of larger diameter trees has become an important concern. In studies of lumber recovery from small-diameter hardwood logs, the volume of green lumber recovered has been acceptable. The quality (grade) of the lumber recovered ... is the larger issue, particularly with respect to the grade yield of dry lumber. Initial study results indicate that the yield of grade 1 Common and Better (dry) lumber from small-diameter cherry logs is less than 10 percent.”

**25. Trends in the Forest Products Industry.** John Pletcher, 2001. PENNTAP, for the PA Hardwoods Development Council, Internal Report, February.

“One of the biggest changes is how the industry now perceives waste. In many cases, it is now viewed as feedstock for other operations rather than a liability.

An excellent example of this new thinking is wood pellets made from hardwood residue. During the past decade, Pennsylvania saw four pellet fuel plants start operation. In most cases these facilities are add-on businesses within existing wood products industries in both the primary and secondary sector. Combined these four facilities have the ability to transform between 150 to 200 tons of residue into fuel pellets per eight-hour shift... During the last decade we also saw a few facilities set up shop to transform low value timber into engineered wood products such as particleboard and medium density fiberboard (MDF)...To date, the Pennsylvania hardwood resource has not been strongly impacted by the growth in fiber demand associated with OSB hardwood round wood requirements.”

**26. A description of the 1986 pallet manufacturing industry in Pennsylvania.** Rory F. Fraser, Walter W. Johnson, and Paul R. Blankenhorn. 1990. *The Forest Products Journal* 40(6):43-47.

“A survey was used to determine the size, structure, and characteristics of the pallet industry in Pennsylvania during 1986. Mail and telephone responses from 85 percent of the 411 surveyed firms indicated that there were 254 firms directly involved with the industry. Other firms were either suppliers, out of business, or listed more than once. Of the 254 firms involved in the pallet industry: 208 manufactured pallets, 18 brokered pallets, 18 recycled pallets, and 10 manufactured pallet components. Based on the responses received from 42 percent of the pallet manufacturers, it was estimated that in 1986, 23.4 million pallets, valued at \$132 million, were produced; 377 million board feet of lumber, valued at \$63.7 million, was used; a labor force of 2,725 people was employed, and \$26.5 million was paid in wages. Comparing these results with the results of a national study, it was found that the national study provided a good estimate of the gross size of the pallet industry in Pennsylvania, but underestimated the number and average size of the pallet firms in Pennsylvania.”

**16. Species Shift: Implications of the rising use of hardwoods in OSB.** Al Shuler, Matt Bumgardner, Bruce Hansen, and Bill Luppold. 2001. *Engineered Wood Journal*.

“Future trends in hardwood consumption were estimated using APA’s latest OSB production forecast (APA Economics Report E67, March 2001)...fiber demand will reach almost 900 million CF by 2006, and hardwood demand will be almost 600 CF, or 66 percent of the total...”

The trends...suggest the OSB industry will rely increasingly on hardwoods in the years ahead....

OSB enjoyed higher margins – were more profitable than pulp mills, plywood mills, and saw mills for most of the 90's. OSB mills have an additional advantage in that they have more flexibility in the mixture of hardwood/softwood fiber they can use as long as the hardwoods are “soft hardwoods”. And OSB mills generally accept a smaller top diameter than most pulp mills...

OSB mills should remain healthy as long as they stay out of direct competition with the pulp mills.”

**21. Utilization of Low-Grade Hardwoods in Pennsylvania.** Mater Engineering, 1990. Prepared for the Pennsylvania Hardwoods Development Council. 156 pp. plus appendices.

“Additional research is necessary to provide further information to encourage the application of past research. Some suggested projects are:

1. Make further log studies of the low grade and factory grade logs to determine how their configurations best lend them to conversion to useful products. A species analysis is essential to these studies; for instance, short wide clears of one species is more valuable than those of another.
2. Continue studies of sub-grade logs to determine how these should be classified and the approximate quantities of the various types and their characteristics...A quantity estimate of this type of sub-grade log by species could determine the amount of capital which could be spent to build a logging system and converting plant to utilize these low-grade and sub-grade logs.
3. Logging and Conversion Plant Study: Sawmill and rough mills are generally not designed to utilize the low grade and sub-grade logs in their operations, nor is logging and truck equipment...To encourage the industry to utilize low grade and sub-grade logs requires additional in-depth, site specific economic and technical feasibility studies to determine how the equipment that is available can be converted or utilized to make a reasonable profit by converting low grade and sub-grade logs to pieces that the rough mill or the furniture and cabinet factories need.
4. A machine to satisfactorily delimb hardwoods warrants engineering research. A delimber could greatly improve logging efficiency with small hardwood trees.
5. New ways to combine hardwoods with plastics to reap the advantages of both materials would greatly enhance the marketability and competitiveness of low grade hardwoods.
6. Additional research is needed on methods of informing and helping small private landowners improve hardwood stand management and utilize new harvesting and processing techniques.
7. Additional research is needed on applying new drying techniques to drying short pieces.

8. ... A Technology transfer study should be undertaken on the comparative effectiveness of various techniques, such as workshops, short courses, pamphlets, videotapes, television, newsletters, conferences, etc...
9. Further economic studies are needed on the conversion of hardwoods to conifers on specific Pennsylvania sites. In much of the South hardwood harvests are prompted more by the desire to remove hardwoods and allow conversion to conifers rather than for the intrinsic value of the hardwoods.”

“RECOMMENDED ACTION PLAN

1. Determine target audience...
2. Select topics of greatest utility to the target audience...
3. Design a series of hands-on workshops...
4. Institute a regularly published newsletter or bulletin...
5. Hold producer-user conferences or workshops...
6. Hold workshops with the objective of voluntarily instituting a standard of grading, packaging, and pricing system...”

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**100. Utilization of Low-Grade Southern Hardwoods.** Edited by Donald A. Stumbo, 1980. Proceedings of a symposium sponsored by the Forest Products Society, Nashville, TN. 289 pp.

“Three introductory papers on the resource and its availability and 34 papers on different enterprises were presented at the symposium...The enterprises presented range in capital investment and are divided into 5 [categories by size]...The targeted return on investment before income taxes was 30%. While this target was not reached in every case, most of the enterprises met or surpassed the 30% ROI level desired.”

*Chapter I. The Resource and Its Availability*

The Complete Forest Concept – A Fifteen Year Progress Report . Harold E. Young, University of Maine.

“There seems to be a general impression by engineers and chemists that there is a vast amount of biomass ‘out there readily available at almost no cost at all. This is...erroneous...”

The Southern Hardwood Resource: A Review, 1980. Willem van Hees and Roy C. Beltz, USDA Southern Forest Experiment Station, New Orleans, LA.

“Effective management to ensure future supplies lies largely in the hands of non-industrial private owners. Motivating these owners to achieve timber production goals will be difficult.”

Defects and Grades of Hardwood Logs and Trees . James G. Shroeder, USDA Southeastern Forest Experiment Station, Asheville, North Carolina.

“...among hardwoods...small size is the characteristic that most often makes tree quality low. Before prescribing the removal of these low-quality hardwoods, a forester should be certain that the trees will not increase sufficiently in size to become good quality trees in a reasonable period of time.”

### *Chapter II. The Feasibility of Small Enterprises*

An 80-Acre Solution. Peter Koch, USDA Southern Forest Experiment Station, Pineville, LA.

“The annual harvest of bark-free green oak and hickory wood from the 80 acres should be about 200,000 pounds: 5000 pounds per cord x ½ cord per acre x 80 acres. This bark-free wood should have an oven-dry weight of about 124,000 pounds. My solution calls for annual shipment of 600 pieces of furniture, of which the wood portion will weigh about 5,400 pounds. This amounts to a little less than 5 percent recovery of the final product from the 124,000 pounds of wood harvested...”

“Key statistics for the enterprise are as follows:

Capital investment	\$120,000
Operating cost – annual	\$158,000
Sales – annual	\$194,000
Net profit – annual	
(before income taxes)	\$ 36,000
Return on sales	19 percent
Return on investment	30 percent
Employees....	2
Energy requirement – annual	
Electrical	60,000 kWhr
Gasoline	700 gal
Wood residues	10 cords...”

Economics of a Small-Scale Pallet Manufacturing Plant Using Low-Grade Southern Hardwood . Marshall S. White, Virginia Tech, and Edward C. Brindley, Jr., Virginia Commonwealth University.

“Entering a pallet business can be successful when starting on a small scale. The example pallet operation...has a rate of return of 14.2%...The owner/manager must be unusually conscientious in maintaining a market in which his finished goods are priced

higher than his competition...Specialized markets in which service is more important than price must be available. Also, the cost of lumber constitutes 2/3 of the cost of the average finished pallet. The financial statement of the firm is very sensitive to the cost of the raw material.”

Economic Feasibility of Producing Short Hardwood Lumber for Upholstered Furniture with a Bolter Mill. Walton R. Smith, Franklin, NC.

“The two year test of a bolter saw at Marimont Furniture Company has certainly shown that this type of operation is very attractive for a plant making frame stock for upholstered furniture...Drying of short lumber created no problems; in fact, the kiln operator believes that the short lumber dried better and with less degrade than the long lumber...The greatest obstacle to the use of bolter sawn lumber at present is the lack of a grading and marketing system for short lumber...”

Economic Feasibility of Modifying Conventional Harvesting Systems to Recover Residue in Bale Form. William B. Stuart, et al., Virginia Tech.

“Our goal was to develop a method which would be compatible with the systems normally used by the small to medium sized longwood logger...Baling appeared to be a promising alternative. Bales could be transported with minimum modifications to conventional hauling equipment. They are compatible with rail and other secondary transportation forms. Baling technology had been well advanced as a result of both primary products and residues. But, most importantly, a baler is a simple, straight-forward machine requiring moderate horsepower, few moving parts, and promising great durability...It is our belief...that baling does offer the potential of meshing well with small to medium sized conventional independent contractor operations, and allows...the opportunity to produce logging residues which may find a market as an industrial fuel, fiber, or even as fuel for farm and home heating.”

Feasibility Projection for a Small Furniture Dimension Plant Using Low Grade Hardwoods. Henry A Huber, et al., Michigan State University.

“A great many papers have been published on using low-grade hardwoods...for different products including dimension stock. However, without economic justification, many wood processing companies in actual production find that higher grades will often produce the same product only more economically. It would therefore be a spurious proposal to force low grade lumber use on any plant without very careful economic consideration.”

“In all of the diagrams, tables, and figures submitted for this report, the [low-grade] furniture dimension plant looks to be an extremely profitable enterprise. Since the investment is relatively small in comparison with other enterprises and since the skills required are less than many good wood processing systems one is always plagued with the question, “If it is that good, why aren’t there more getting into the business?” and “Why are those that are already in the dimension business not doing so well?” The

answer to this question, of course, is the key to any business venture and could be answered very superficially, 'Marketing is the Key'. However, the resolution of these questions may be a combination of complicated factors. When the demand is high everyone could probably operate at this suggested profitable rate. There are periods, sometimes rather long, where the markets are simply not available and the picture then becomes one of reduced production with subsequent loss of income, and very competitive bidding by too many suppliers with needs for large sales to support the fixed costs...One dimension plant has indicated that when business is good he can't get the raw material and when business is not so good he cannot sell the product. In either case the whole picture is not sufficiently good to recommend that large numbers of plants go into this type of operation..."

### *Chapter III. The Feasibility of Medium Enterprises*

The Short-Log Process for Producing Pallet Parts and Pulpwood Chips from Southern Hardwoods. Bruce G. Hansen and Hugh W. Reynolds. USDA Forest Service, Princeton, WV.

"Our analysis suggests that a daily production rate of 20 Mbf of pallet parts from short logs between 5.5 and 11.5 inches in diameter can achieve a before-tax return on investment of nearly 38 percent...We believe that short-log processing offers a unique opportunity to increase the utilization of low-grade southern hardwoods. The increasing demand expected for wood pallets, coupled with pallet manufacturers' increasing difficulty in procuring raw material should make log processing more and more attractive."

Conversion of Low-Grade, Small Hardwoods to a New Raw Material for the Furniture Industry With System 6. Charles J. Gatchell and Hugh W. Reynolds, US Forest Service, Princeton, WV

"Low-grade, small diameter (7 ½ to 12 ½ inches) hardwood trees can be converted into a new, high-valued intermediate product called standard sized blanks. Used in place of high grade lumber, these blanks serve as a raw material for the furniture and kitchen cabinet industries. The process of turning logs to cants, cants to boards, and boards to blanks is called System 6. A System 6 mini-mill which contracts for kiln drying and uses the sales and administrative staff of a parent company can show a return on a \$937,000 investment of 32.8%."

Parallel-Laminated Hardwood Veneer for Furniture Frame Stock. William L. Hoover and Carl A. Eckelman, Purdue University, and John A. Youngquist, USDA Forest Products Laboratory, Madison, WI.

"A mix of red oak panels for exposed and unexposed applications appears to offer an LVL manufacturer the best opportunity to maximize the value added to the mix of high and low quality log input. The LVL plant would need to be located in an area capable of

supplying about 4.2 million board feet of veneer quality and 9.7 million board feet of sawlog quality red oak logs per year.”

Molded Pallets from Hardwood Flakes. Bruce A. Haataja, Michigan Technological University.

“Molded wood flake pallets...may be made in a process similar to waferboard. They consist of a flat deck with support posts or legs molded as integral parts of the deck...Molded pallet plants may be located in virtually any forested area.”

“The basic advantages to molding any material are the elimination or reduction of machining, forming and fabrication costs, and improvements in strength and aesthetic appeal...Rather than lumber, which is scarce during periods of peak demands, the flakes for the molded pallet can be obtained from many plentiful sources such as pulpwood, logging, mill and municipal residues, and possibly reclaimed molded pallets. The process lends itself to mechanization and is less labor intensive than lumber pallet manufacture. These cost savings more than offset the higher cost of resins, energy and mechanization for the molded pallets.”

Wood Foam Composites for Building Materials. Alan A Marra, University of Massachusetts-Amherst.

“Wood-foam composites, Xylofoam, are mixtures of specially comminuted wood particles and foams in which the foam acts as a bonding agent and a filler. In a sense, they may be considered wood-fiber reinforced foams. The uniqueness of the process lies in the production of a loose cohesive mat of fiber as a first step in reconstitution. The mat is then dosed with a room temperature, fast-setting foaming resin and subjected immediately to forming treatments producing either flat or molded products.”

*For current reference on this technology, see <http://www.fpdlab.com/prodproc.html>*

Dowel-Laminated Crossties. Paul D. Ladd, Koppers Company, Inc., Memphis, TN

“Only dowel-laminated wooden and pre-stressed concrete crossties have remained viable enough to warrant serious consideration as a possible solution to the shortage of mainline cross-ties...Dowel-laminated crossties have proven to be superior to concrete throughout the nineteen years of testing and also has provided the least expensive means to meet increased demands for mainline production.”

“Minitie production lends itself to the available hardwood resource by offering a readily marketable product for the smaller (8.3 inches in diameter) low grade logs.”

*Chapter IV. The Feasibility of Large Enterprises*

A System for Converting Short Hardwood Bolts to Laminated Structural Wood. George E. Woodson, Louisiana Tech University, Ruston, LA.

“An outline is given for a hypothetical system that would annually convert 16,750 cords of hickory into 11,880,000 lineal feet of structural joists with laminated veneer flanges and mixed hardwood webs. Equipment for the system includes a merchandising deck for tree-length logs; debarker; chipper; round-up shaping-lathe; veneer lathe; veneer dryer; facility to laminate short, butt-jointed veneer; cut-ups saws; facility to connect laminated flanges to hardwood flakeboard webs in an I-beam configuration; and a chipping canter facility to process veneer cores into pallet cants.”

Economics of Manufacturing Straight Structural Lumber from Hardwoods. George B. Harpole, Robert R. Maeglin, and R. Sidney Boone. USDA Forest Service, Forest Products Laboratory, Madison, WI.

“Forest Service research has demonstrated that straight structural lumber can be manufactured from low- to medium-density hardwoods such as red maple, yellow-poplar, and sweetgum. The technique is referred to as an SDR system – to saw to full width flitches, dry the flitches and then rip to desired dimensional lumber width...Analysis indicates that about 42 percent of a sawmill’s throughput can be recovered as structural lumber..”

Economic Feasibility of Converting Whole Stems of Southern Hardwoods into Composite Panels and Pallet Parts of Solid Lumber, Using Shaping Lathes. Theodore T. Roubicek, Vancouver, BC, and Peter Koch, Southern Forest Experiment Station, USDA Forest Service, Pineville, LA.

“...we have selected two commodities for manufacture; markets for both have shown steady growth for the past two decades...Oak is a favored species for one of the commodities – pallet parts...The other commodity – composite structural panels – is less well suited for manufacture from oak...but...can be used if panels are made with oriented-strand cores...”

Economic Feasibility of Manufacturing Com-Ply Joists Using Hardwoods. Gerald A. Koenigshof, USDA Forest Service, Athens, GA.

“COM-PLY joists are a structural sandwich construction with a 1.5 inch thick flakeboard core placed between 0.25 inch thick layers of solid veneers....The report shows that hardwood used for manufacturing will cost about half that required of southern pine logs were used.”

#### *Chapter V. The Feasibility of Energy Related Enterprises*

Case Study of a Wood Gasifier Using Low-Grade Hardwoods as Fuel. William S. Bulpitt, Wood Energy Systems Branch, Georgia Institute of Technology, Atlanta, GA; James Jackson, Applied Engineering Co., Orangeburg, SC; and John Mixon, Georgia Forestry Commission, Macon, GA.

“A 19,000 lb/hr gas/oil boiler at the Northwest Georgia Hospital in Rome, Georgia, is being retrofitted with a 25 million Btu/hr updraft wood gasification system. This unit...will lower the hospital’s dependence on oil and natural gas while helping to provide a new market for low-grade hardwood chips in North Georgia.”

*[The payback on this system was estimated at 1.29 years. However, according to a conversation with project engineer Wayne Kirsner, the project ran over budget and was never built.]*

Alcohol and Furfural from Southern Hardwoods – An Analysis of Methods, Equipment, and Economics, for a Small Farm Operation. Joseph J. Karchesy, Oregon State University, Corvallis, OR.

“The enterprise considered is owner-operated and consumes about 780 tons (oven-dry basis) annually to yield 19,500 gallons of 95% ethanol, 27,000 pounds of yeast and 63,500 pounds of furfural.”

“There is currently widespread interest in the production of fuel alcohol from biomass to reduce the United States’ dependence on foreign oil. Although most fuel alcohol will initially come from grain, production may shift to wood and agricultural wastes because corn and other grains are more valuable as food.”

“To obtain a 30% pre-tax return on investment...the selling price [of wood alcohol] would have to be \$6.87/gal...”

An Economic Comparison of Three Systems for Harvesting Low-Grade Hardwood Chips. J. Michael Vasievich, Southeastern Forest Experiment Station, USDA Forest Service, Durham, NC; and Philip M. Croll, Duke University, Durham, NC.

“Costs of producing whole-tree chips from low-grade hardwood stands range from \$9.42 to \$22.75 [1980 dollars] per ton with a 15 percent cost of capital. Costs are \$12.01 to \$29.12 per ton if a 30 percent return on investment is included...The cable yarding chipper is best adapted to steep slopes and yields from 20 to 25 tons per operating hour. The swathe-felling mobile chipper operates best on stone-free level ground and produce 12.5 to 20 tons per hour. The conventional system averages 25 to 30 tons per hour on moderate slopes. Whole-tree chipping leaves the site very clean and substantial site preparation savings can result.”

Portable Wood Pyrolysis of Low-Grade Southern Hardwoods. E. Lawrence Klein, Tennessee Valley Authority, Norris, TN.

“Pyrolysis is one means by which low-grade southern hardwoods can be used for energy. By converting this low-grade material into charcoal, oil, and gas, it can be utilized as a fuel by many industries and institutions that have existing oil- and gas-fired heating systems...The economics are such that one could expect at least a 33 percent return on investment. The system as described in this paper will require 21,000 oven-dry tons of

wood per year to produce 7,000 tons charcoal and 100 billion BTU's of gas and oil per year.”

The Production and Distribution of Hardwood Residual Fuel Pellets for Industrial Use.  
Ted Carpentier, Bio-Solar Research and Development Corporation, Eugene, OR.

“WOODEX is a palletized solid fuel...not just compressed biomass. The change in cell structure due to the kinetic energy of compression of the prepared biomass in the extrusion process and the resulting thermal energy sufficient to flow lignins and to change the correct moisture content of the biomass to steam, produces the cell wall changes which allow the rapid transfer of heat through the pellet when burning.”

“A typical WOODEX pellet plant is designed to produce 300 TPD of finished product, but can be sized in terms of biomass availability and market potential within viable transportation distances.”

“In terms of thermal energy produced as a realistic alternative...the bio-conversion represented by refining biomass in a palletizing process, is the lowest in capital cost of any usable energy and the least in life cycle cost, resulting in the lowest thermal energy cost for a user to buy.”

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**27. Developing Financial and Energy Accounting Models for Woody Biomass Systems** . 1989. Charles H. Strauss, Stephen C. Grado, Paul R. Blankenhorn, and Todd W. Bowersox. Solar Energy 42(5):379-386.

“A basic question concerning [short rotation intensive culture] plantations is their ability to produce biomass in a cost efficient manner...In terms of a least cost system...this cost would be 30% higher than the current market value of domestic wood used by the pulp and paper industry...”

**28. A Cost Analysis of Alternate Biomass Supply Systems**. 1988. Charles H. Strauss, Paul R. Blankenhorn, Todd W. Bowersox, and Stephen C. Grado. Forest Products Journal 38(1):47-51.

“Forest biomass represents a viable supplement for our nation's future energy needs. The intensive culture of Populus hybrid was financially evaluated under a rotation length of 4 years and a tree spacing of 0.6 m by 0.8 m. Four plantation strategies (control, fertilization, irrigation, and fertilization-irrigation) were employed on favorable and unfavorable growing sites. The various strategy/site combinations produced average annual yields ranging from 7.9 to 10.8 oven-dry tonnes (ODt) per hectare. Production costs ranged from \$28.71/ODt for control on the better site to \$103.62/ODt for irrigation on the unfavorable site. Alternate harvesting and storage strategies were linked to the plantation strategies to determine the least-cost approach for supplying biomass to a

conversion center. These additional strategy requirements more than doubled the final delivered costs of biomass from the control strategy.”

**32. Moisture Effects on an Energy Balance Developed for Using Forest Biomass as a Fuel.** 1980. Paul R. Blankenhorn and Richard E. Weyers. Forest Products Journal 30(11):41-46.

“Energy-out to energy-in ratios were greater than 1 when burning wet wood at various MC’s...As drying efficiency increases, the energy-out to energy-in ratio increases curvilinearly, but for electrical energy production, the ratio is less than 1 up to 45 percent drying efficiency...The energy-out to energy-in ratios and percent overall energy balance efficiencies versus stack gas recovery efficiencies...show that energy-out to energy-in ratios and percent overall energy balance efficiencies can be improved over burning wet wood.”

**30. The characterization of hybrid poplar as a potential feedstock for fermentation to ethanol.** 1984. P.R. Blankenhorn, C. H. Strauss, C.A. Hornicsar, T.W. Bowersox, G.L. Stimely, and M.L. DiCola. Proceedings of the 1984 Tappi Research and Development Conference, pages 43-49.

“More than 9,160 liters of ethanol per hectare may be obtained from 4 year old [hybrid poplar].”

**33. Recoverable energy from the forests.** 1978. P.R. Blankenhorn, T.W. Bowersox, and W.K. Murphey. Tappi Journal 61(4):57-60.

“A fact that is sometimes overlooked by energy planners in considering the various fuels is that energy must be expended to obtain energy...The concept that wood wastes generated by the forest products industry are cost free is erroneous when considered on an energy basis.”

“A net energy was performed by balancing production, harvesting, transportation, and processing energies against recoverable energy from forest biomass. Net energy can be realized if truck round-trip haul distances are kept within 2903-, 2483-, and 173-km radii for production of heat, process steam, and electricity, respectively.”

**34. Evaluation procedure for consideration of forest biomass as a fuel source for a 100 megawatt electric generating facility.** 1978. Paul R. Blankenhorn, Todd W. Bowersox, James J. Hildebrand, Wayne K. Murphey. Penn State Agricultural Experiment Station Bulletin 820, 16 pp.

“This bulletin establishes a method for evaluating the feasibility of using wood as a fuel source for an electric generating plant...energy inputs were balanced against the potentially recoverable energy to obtain net energy values. To illustrate the evaluation procedures, an example site at Renovo, Pennsylvania, was analyzed...There is sufficient wood within a 56.3 km radius of Renovo to continuously fire a 100 MW steam-electric generating plant.”

“At this site, the electrical energy produced would be about 8% greater than the sum of all input energy.”

### **36. A history of wood chemical plants in Pennsylvania.**

<http://www.smethporthistory.org/crosby/wood.htm>

“Along the northern border of Pennsylvania between the 1800s and 1950s, there was once more than 70 wood chemical plants. But how many people actually know what a wood chemical plant is and why is it important to us? Well, at one time McKean County was the center of the industry. It was centered here because of the cheap natural gas.

These factories converted logs into charcoal, methanol (wood alcohol), and acetate of lime or acetic acid. They took the smaller hardwood that lumber mills wouldn't use.

The basic process was to heat , in the absence of oxygen, the wood to a very high temperature which would drive off its chemicals and turn the remaining wood to charcoal. The chemicals were treated so as to produce methanol and acetate of lime. The charcoal was cooled, and most of it subsequently sold to iron producers.”

“Production varied at different plants. Hard maple and beach made the best chemical wood. Oak gave high charcoal yield, but was low on methanol and acid, which were the more valuable products. Compared to the central and southern portions of Pennsylvania, the northern third of the state had relatively little oak mixed in with the other, more valuable hardwoods. This factor plus the abundance of cheap natural gas in the McKean County area caused the industry to locate along the northern border of Pennsylvania with the greatest number of plants in McKean County. In 1913 there were 41 plant in Elk and McKean Counties.

The newer plants also were more efficient than older ones. The Keystone plant of the Quinns was the last new chemical plant built in Pennsylvania, and the most efficient. Pyrometers controlled retort temperatures, vinegar hydrometers tested the liquor, and color charts controlled the liming process. by keeping down retort temperatures, alcohol and acid production was increased and the charcoal was denser. The vinegar hydrometers saved acid that had been dumped with the tar. Instead of the usual ten gallons of methanol, they got 10 1/2 gallons; instead of 50 bushels of charcoal they got 55; and instead of 200 pounds of acetate, they got 265 pounds.

The products of the chemical plants were sold through three sales companies. Charcoal was sold by the Manufacturers Charcoal Company of Bradford. This company was organized by the charcoal producers with one share of stock being given for each cord of capacity of a producer. Each chemical company told manufacturers their production, and as orders were received, the different chemical companies would be notified to ship so many carloads to designated locations.

Charcoal was important because it contained no sulphur. Sulphur is poisonous to nickel and chromium so that high grade steels and stainless steel had to be smelted by charcoal. Huge amounts went to the International Nickel Company. Premium iron, such as required for boiler tubes, required charcoal until World War I. Charcoal after charcoal went to the Lukens Steel Company at Coatesville, Pennsylvania. It was also used in making black gun powder. Dupont, Hercules, and Atlas bought large quantities. Charcoal was also ground to a fine powder for use in filter beds, gas masks, and whiskey distilleries.

The Wood Products Company of Buffalo had the monopoly on selling methanol. All wood alcohol was sold to them. About 1910 several of the manufacturers were unhappy with prices, and so Quinn and several others organized the Manufacturers Distillers Company at Olean. They built a large plant, but never had to use it. Wood Products raised the price and leased the empty building.

Prices for acetate of lime were established by the National wood Chemical Manufacturers Association to which Martin Quinn was an officer. They met monthly in New York or Buffalo. These meetings were not always harmonious, and Evan Quinn remembers the wrangling that went on whenever one of the members tried to make a fast dollar by selling outside the organization. Users were always trying to break up the combine by offering to buy from a single company at a higher price when supplies were tight.

But like most good things, there had to be an end sometime. During the 1920s and 1930s other methods were developed for smelting alloy steel, such as electric furnaces. Black powder usage declined rapidly. Desulphurizing of petroleum products was developed. Other methods for making acetic acid and methanol became cheaper. With reduced needs caused by competing processes and the Depression, the wood chemical industry fared badly. In Pennsylvania the last large plant, the Mayburg operation, closed in 1942 when the Sheffield and Tionesta Railroad, which served it, was torn up and the rails used elsewhere for the war effort. Smaller plants continued through the war and into the early 1950s before giving up. Today, near Bradford at Custer City, the last of the former chemical plants still operates making distillery charcoal.”

**37. Wisconsin Governor Doyle Announces \$5 Million in State Budget for Bio-Based Industry Development.** July 21, 2005.

[http://www.wisgov.state.wi.us/journal\\_media\\_detail.asp?prid=1235](http://www.wisgov.state.wi.us/journal_media_detail.asp?prid=1235)

“The Governor announced that his budget will include:

- A \$1 million grant program for agricultural businesses. These grants will help entrepreneurs develop ways to use plant and animal resources for no-waste, bio-based energy, fuels or products.
- Up to \$4 million grant program for the forestry industry. These grants will leverage federal dollars for the research, development, and implementation of

forestry biomass technology in Wisconsin – encouraging the use of forestry biomass as an energy source.

The budgeted funds underscore Governor Doyle's strategy to make Wisconsin the best place to invest in zero-waste, bio-based businesses. Bio-based industries take simple and safe raw materials – the carbohydrates in plants – and convert them into fuels, polymers, fabrics, and other chemicals. Every function now served by petro-chemicals can also be served by bio-chemicals, more simply, safely, and sustainably.

"When you hear Silicon Valley, you think of California and its high tech start-ups," Governor Doyle said. "When people think about Wisconsin, I want them to think of it as the number one place to invest their time and money in biobased industry development."

**94. The U.S. Pulp and Paper Industry: A Key Player in the Coming Bio-revolution.**

July, 2005. Dovetail Partners, Inc.

<http://www.dovetailinc.org/DovetailPulpPaper0705.html>

“In response to the challenge posed by global competition, the domestic paper industry has identified a new strategic direction and embarked on an aggressive research initiative in cooperation with the U.S. Department of Energy and a number of universities. The strategy is to convert existing pulp and paper mills to full bio-refineries, capable of producing not only pulp and paper, but bio-fuels, bio-chemicals, and bio-feedstocks as well.”

**96. Panel production rising despite falling prices and current overcapacity: Wood-based panels markets, 2002-2004.**

In the United Nations Annual Forest Products Market Analysis, 2002-2004.

<http://www.unece.org/trade/timber/docs/fpama/2003/2003FPAMA-whole-doc-webversion.pdf>

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- Russian wood based panels industry beating all growth records on the back of vigorous domestic demand.
- Other Europe subregion boosting the European medium density fiberboard (MDF) industry with massive growth in production.
- Other European subregion and the Russian Federation are rapidly expanding their export markets.
- North American panel industry picked up well after serious distress, but particle board overcapacity continues to overload the weak markets.
- A recent development in the North American structural panel sector is the rapid market share growth of newcomers, in part due to current exchange rates.
- Oriented strand board (OSB) exports from the EU/EFTA climbed steeply as the fledgling industry found offshore markets.

- Low prices in Europe and North America cast a chill on the wood-based panels industry in 2002 and early 2003, however in late 2003 structural panel prices were rising rapidly in North America, achieving record highs for some panels.
- Plywood exports from outside the UNECE region continue to expand rapidly in Europe and North America.
- European wood-based panels industry anticipates competition with energy sector on raw wood supply, affecting primarily the particle board industry.
- During 2003 and 2004, with stagnating demand in Europe and North America, panel manufacturers will seek outlets abroad, as the home markets continue to deteriorate.
- In Europe, MDF and OSB are expected to offset partly the deferred recovery of the particle board industry.”