XIIe Congrès forestier mondial XII World Forestry Congress XII Congreso Forestal Mundial

This is the original, unedited version of a paper submitted to the XII World Forestry Congress, 2003, Québec City, Canada.
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01039-A2

WOOD PRODUCTS AND SUSTAINABLE CONSTRUCTION

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Abstract

Affordable, safe and environmentally friendly housing is a basic human need and has become the social priority of most countries around the world.

Wood frame construction has been the mainstay of the North American residential housing market for some 200 years. It evolved into what we now know as "platform-frame" construction, a building system that is gaining acceptance worldwide because of its affordability, superior performance, beauty and flexibility in design and construction.

The remarkable growth of engineered wood products (EWP) in the last decade constitutes one of the success stories of the wood products industry. The sector's success has been driven by technology that has broadened the range of usable raw materials, including plantation fibre and previously underutilized species such as aspen. In addition, EWP's have driven down costs, improved performance and extended the applications of wood frame construction.

Recent developments in the design, production and building process have been the incorporation of pre-engineered roof, floor and wall systems into the conventional on-site building process and the rapid growth of manufactured, panelized and modular home construction.

In addition to affordability and quality, wood platform-frame construction offers superior performance under earthquake conditions. Recent improvements in design and materials have made wood frame structures comparable to other building systems with respect to durability and fire performance. Finally, life cycle analysis of different building materials has demonstrated unequivocally the environmental advantages of wood construction. This softer environmental footprint, coupled with wood's renewability, its ability to store sequestered carbon dioxide and its superior insulation properties, will make wood the construction material of choice in the coming decades.

This paper will review the evolution of wood construction in North America and abroad, its performance, with particular emphasis on environmental merit, and describe some of the social and technological challenges that lie ahead.

Introduction

Wood light-frame construction has been the mainstay of the North American housing market for some 200 years. It has developed into what we now know as "platform-frame" construction, a building system that is gaining acceptance worldwide because of its affordability, superior performance, and flexibility in design, construction and renovation. This flexibility has enabled the evolution of platform-frame construction through responses to the changing needs of both the construction industry and the homeowner (Karacabeyli 1996, de la Roche and Karacabeyli 2000).

The Canadian forest products and wood-frame construction industries have the opportunity to demonstrate to the world that we are flexible, adaptable, innovative, and value-centric, and that we are based on globally-accepted principles of sustainable forest management, environmental accountability, and resource conservation.

Engineered Wood Products

The remarkable growth of engineered wood products in the last decade constitutes one of the success stories of the wood products industry. In the last 15 to 20 years, Canada has seen significant changes in wood supply: reduced access to larger timber; less sound wood left on the harvest site; more complete usage of harvested wood; increased utilisation of broadleaf species; and new fibre sources from managed forests. This change in profile has resulted in a general decrease in log size, an increase in the number of trees and diversity of species harvested, and, in many instances, a decrease in wood quality. In response to these trends, wood-product manufacturing also has changed, with further emphasis on the breakdown of timber into strands, veneers and fibre constituents which have then been reconstituted into new lumber, panel, and other construction products. These engineered wood products (EWP) have several benefits: they have high uniformity and well-defined performance properties; they require less fibre to produce the same strength characteristics as dimensional lumber; they access a broader range of raw materials, such as trembling aspen and hybrid poplars; and they allow the use of lower quality fibre. Notable examples of EWPs used in structural applications include finger-joined lumber, laminated veneer lumber, glued-laminated lumber, parallel strand lumber, oriented strand lumber, plywood, and oriented strand board.

In our quest to extend wood fibre utilization and product performance, research efforts are targeting new composite products, such as bark board (based on wood residues) and strawboard (based on agricultural residues); and new high performance products from a combination of wood and non-wood materials, such as plastic and cement. EWPs are providing increasing flexibility and impetus to the evolution in the design, production and building of wooden platform-frame structures in North America (de la Roche and Gaston, 2001).

New Construction Techniques and Applications

Construction techniques have evolved to meet changing market needs. We are seeing less on-site housing construction and more factory pre-fabrication of components or complete structures. In North America, 95% of roof trusses in stick-built houses are manufactured off-site, and I-joists are now found in 40% of all houses built. Panelized and modular home construction techniques are gaining considerable popularity in Sweden and the US as cost-effective construction methods which result in a high quality end-product.

As the quality and performance of conventional platform-frame construction systems have become better understood and documented, designers have increased their confidence in using wood platform-frame systems for complex, non-traditional end-uses such as engineered multi-family residential construction. A recent development has been the growth of hybrid construction in which the wood frame system is used in combination with other systems. One example is four-storey multi-family buildings that use concrete for a below-grade garage and commercial first floor, upon which is built a multi-storey wood-frame structure.

There is also considerable potential for increasing wood product content (including EWPs) in non-residential construction inside and outside of North America (Gaston *et al*. 2001). While some non-residential buildings are precluded from using wood for code-related reasons, such as those over four storeys in height, it is estimated that 50% of the non-residential buildings constructed in the US could utilise wood as the main structural material and remain within existing codes. Further research and development are essential in order to expand the development of EWPs and provide optimal building solutions for the non-residential market.

Performance of Platform-Frame Construction Systems

Various surveys and focus groups, including architects, builders and homeowners, have suggested that there are about a dozen attributes that are deemed to be important in a home. These are: appearance and style, flexible design, healthy, durable, safe, affordable, low maintenance, adaptable, multi-functional, comfortable, energy efficient and environmentally friendly. Wood-built structures score very high with most of these attributes. Nevertheless, there have been notable concerns expressed about the issues of strength, fire safety, durability and environmental merit of wood construction. These concerns pose serious obstacles to extending or even maintaining the use of wood. While some concerns are legitimate, others are not.

Strength and Fire Safety

Wood has been used in buildings since the beginning of civilization and, because of its superior ratio of strength to weight, has proven to be an excellent material for structural applications. Tiemann (1951), in his authoritative review of wood and other structural materials, concluded that "weight for weight, dry wood without defect is stronger than steel." Data on the specific load carrying capacities of wood, steel and concrete confirm the favourable strength-to-weight ratio of wood (Bodig and Jayne, 1982).

Extensive seismic testing of wood systems and structures has demonstrated the superior performance of wood platform-frame construction. A recent survey of the impacts of seven major earthquakes between 1964 and 1995 revealed that only 34 reported fatalities could be attributed to failure of platform-frame wood buildings (Rainer and Karacabeyli, 1999). The evidence strongly supports the conclusion that platform-frame wood structures achieve life safety objectives under severe earthquake conditions.

The public generally has a negative perception about the fire safety of wood structures. Building codes have tended to show a bias against wood construction. Forintek, working with an international consortium of fire scientists, has evaluated the fire performance of different construction materials and systems. These results (Sultan *et al*., 1997) and other work are leading to ongoing revisions to building codes worldwide to improve the consideration given wood-frame construction systems.

Durability

Rot from excessive moisture and damage from termites have been perennial issues with wood structures. We continue to have problems worldwide with building envelope failures because design and construction practices have not adequately protected wood in wall and roof assemblies from becoming wet. If one examines the situation more closely, the problem is invariably a question of poor design, poor construction, poor maintenance, or a combination thereof. When these issues are addressed, wood structures can last indefinitely. There is a need for further research around the moisture management of wood structures, as well as more aggressive technology transfer and training programs for architects and the construction industry. Where the fault does lie with the material, new innovations and alternative materials should be sought. In the end, when it comes to the choice of building material, we have to recognize that there will be circumstances where wood should not be used.

Termite damage in wood structures poses another major threat. The voracious formosan termite (*C. formosanus*) has become a major pest throughout the tropics as well as in California, the Southeastern US, Hawaii, Japan, China and Taiwan. Conventional control strategies are generally costly, can be hazardous, and have limited long-term effectiveness. Alternative controls, such as borate treatment, have proven to be very effective. Borate is non-toxic to humans, environmentally benign, cost-effective, and comparable in efficacy to treatment with CCA. It is now widely used in Hawaii, and is rapidly gaining popularity in the Southern US and Japan, where wood construction predominates.

Environmental Merit

Consumption of natural resources, ecosystem disruption, air and water pollution, and generation of waste are just some of the undesirable side effects of building design and construction. Many design decisions have an influence on a building's total environmental footprint. How can environmentally conscious designers wade through the enormous maze of sometimes confusing information on what is "green" and what is not? Construction of buildings represents 10% of the global economic activity, consumes 40% of the world's materials and energy production, accounts for 17% of global fresh water consumption, and utilises 25% of the annual global wood harvest. When we examine the environmental profile of the three main construction materials, wood systems outperform steel and concrete on an environmental basis (Fig. 1) (Canadian Wood Council, 1999).

Recycled Versus Renewed

Recycling helps reduce landfill burdens, limit resource extraction and, in some cases, save energy by recapturing a product's embodied energy. In some circles, `recycled content' has received a disproportionate degree of perceived green value as compared to `renewable content'. Assessing whether recycled content products are environmentally preferable over those made from virgin materials requires a standard life cycle analysis (LCA) for each product. For instance, LCA studies have demonstrated that steel, even with high recycled content, is not environmentally preferable to wood (Anderson *et al*. 2002, Canadian Wood Council, 1999). Although wood is a **renewable** resource, reducing the environmental footprint of wood products should still involve improvements in the other `Rs' - **reduce**, **recycle**, and **reuse**.

Standard practices for residential wood frame construction unfortunately remain somewhat inefficient. Common examples are structural members oversized for their loads, window and door openings not optimally aligned with the framing module, and unnecessary framing elements. Increased up-front investment in architectural and engineering time, along with the use of structurally efficient elements, such as trusses, result in a 15-30% reduction in wood materials required (Edminster and Yassi, 1998). Reduced consumption can be achieved also by increasing the use of EWPs, pre-fabricated systems, and innovative building strategies.

Recovery of construction and demolition waste is a challenge. Nevertheless, there has been rapid growth in the number of companies processing recovered wood in recent years. Wood waste can be re-manufactured into high-value composite materials, chipped into mulch, animal bedding, and other low-grade usage or, as is most often the case, burned as fuel.

Wood can also be reclaimed from decommissioned buildings and re-used directly, a niche activity which is increasing due to strong market interest in old-growth, large-dimension timbers (Falk, 2002). In addition, there is a large and, as yet, relatively untapped store of standard lumber in the aging North American residential housing stock. Careful deconstruction is time-consuming, however, and can involve exposures to hazardous materials such as asbestos and lead-based paints. The complexities of re-using wood are being worked out but the potential is strong.

Sustainable Forest Management in Canada

Forests embody a wide range of values and are being used in a variety of ways, by many different stakeholders. This has prompted significant change in the way Canadian forests are managed. Canada harvests less than ½ of 1% of its commercial forest annually, or less than ¼ of 1% of its total forest area (Natural Resources Canada, 2002). By law, all forests harvested on Canada's public lands must be regenerated. More than half of our harvested forests grow back naturally and within regulated timelines. Those species and landscapes that do not regenerate well on their own are assisted by planting and seeding operations.

Although half of the earth's original forest cover is gone, much of it within the past three decades, Canada has maintained over 90% of its forest cover[1] and it has done so while being one the world's largest producers of high-quality forest products. To meet the challenges of conserving natural biodiversity, Canadian forest companies and agencies are turning to scientists, academics and conservation organizations to identify key species, habitats, and ecosystems. Canada also has the largest area of protected forest in the world. In October 2002, our Prime Minister announced the creation of 10 new national parks over the next five years, which will double the area occupied by the existing 39 national parks across the country.

In Canada, there are three forestry-specific voluntary forest certification standards: Canada's National sustainable forest management standard from the Canadian Standards Association (CSA), the Sustainable Forestry Initiative (SFI) and the Forest Stewardship Council (FSC) (Abusow, 2002). The Canadian forest industry has embraced forest certification: as of February 2003, some 25 million hectares have been certified under the three systems. By 2006, it is expected that a Canadian forest area the size of Sweden, Finland and Norway combined will be certified[2].

The public, in Canada and around the world, has been led to believe that Canadian forests are diminishing, that our practices are not sustainable, and that the world needs to use less rather than more wood. The Canadian forest sector must undertake an effective global communications strategy to refute these allegations and proclaim the true status of Canadian forest and sustainable forest management, and the real benefits of utilising wood.

In 2002, FPAC became the first international industry association to require all its members to submit their forest management practices to the scrutiny of independent, 3rd party certification audits. For that strong statement and its significance for sustainable forestry, FPAC has since received the GLOBE Foundation Industry Award for Environmental Performance.

Global Climate Change

Forests hold more carbon per unit area than most other types of land cover. Over the past century, conversion of forests to farmland or other uses has produced about a third of all man-made CO_2 emissions (Watson, 1990). Current deforestation in some regions of the world still accounts for about 20% of all anthropogenic CO_2 emissions (Houghton, 2001). Clearly, the maintenance of a productive forest provides several benefits from a climate change and environmental perspective: forest management provides an economic incentive against deforestation; production of solid wood products results in the storage of a portion of the trees' carbon in another long-term storage medium (e.g., house, furniture); and forest regeneration ensures that the carbon-absorbing role of the forest is preserved. Sustainable forest management is thus regarded as a simple and highly cost-effective way to mitigate the greenhouse gas emissions of other industries, especially in countries where large scale deforestation is an issue.

The Life Cycle of Wood Products

Significant environmental issues remain related to raw material transportation, manufacturing, construction, service life and disposal. The wood industry is starting to appreciate the fact that LCA will likely become more significant for all types of products. Forintek investment in the Athena project, a North American LCA database effort, is reaping benefits as the popularity of "sustainable design" increases. We have no choice but to accelerate the documentation of our wood products' environmental pedigree, from forest, through manufacturing, construction and service life, to final disposal or reuse.

Wood Has a Great Future

Wood-frame construction has improved dramatically: faster construction, better utilisation of fibre, less waste and better quality control. New technological advances in EWPs and connections are positioning the wood products industry to successfully compete in the construction of much larger and more complex structures. Environmental scrutiny, new products, new construction techniques, new applications, and new markets are some of the trends we will see continue over the next two decades. It is significant to note that it has been new knowledge and technology which have driven these trends and will continue to do so.

The `value chain' concept (Fig. 2) is a useful strategic framework with which to demonstrate how our industries are organising their business, and how knowledge, technology and innovation are driving change. The traditional commodity supply chain is concerned with production speed and output. A value chain is more about adding value at each step or link, and extracting the potential synergies that are inherent in the interactions amongst chain components. Value-chain management recognises that knowledge and technology are the important underpinnings, and that adding value to a commodity is really about adding knowledge and innovation along the chain (de la Roche and Dangerfield, 2002).

For example, we can examine two platform technologies which will have a major impact on the wood products sector. The first is genetics. Genetics, and more specifically, biotechnology, will allow us to diversify and shorten generation cycles in tree improvements programs, and also increase the precision and efficiency with which specific genetic traits are improved (e.g., growth rates, yield, tree form, disease, cold and drought tolerance, wood quality and strength). This opens the door to more intensive and effective forest production in Canada.

The second is electronic and information technologies. The major impact will be in helping the forest sector manage its value chain. These technologies now mean that forest science researchers (e.g., geneticists), the fibre producers (e.g., woods managers), the fibre harvesters (e.g., loggers), the equipment suppliers, the necessary service industries, the fibre processors (including the construction industry) and the customers are all linked with instantaneous communications.

These platform technologies have the potential of creating enormous synergies along the value chain. Such synergies will result in an innovative, highly competitive, efficient, and accountable industry which produces high quality, safe, affordable, healthy and environmentally friendly housing - tailored to people of different cultures around the world. Wood usage will continue to grow, particularly in construction applications, as more people come to appreciate wood's environmental merit and superior structural performance. Wood-frame construction has been and will continue to be a building system of choice for many generations to come. It has the flexibility to evolve with changing societal needs and conditions.

REFERENCES

Abusow, Kathy. 2002. Unveiling Some Forestry and Certification Truths in Canada.

Anderson, J., S. Edwards, J. Mundy and P. Bonfield. 2002. Life cycle impacts of timber: a review of the environmental impacts of wood products in construction. Building Research Establishment.

Bodig, J. and Jayne, B.A. 1982. Mechanics of wood and wood composites. New York. Van Nostrand. P. 720.

Canadian Wood Council. 1999. Life cycle analysis for residential buildings. Environmental Bulletin.

de la Roche, I.A. and J.A. Dangerfield. 2002. The power of partnerships in research and development. For. Chron. 79 (1): 120-123.

de la Roche, I. and C. Gaston. 2001. The future of wood products : what is the prognosis. The Forestry Chronicle 77(6): 985-988.

de la Roche, I. and E. Karacabeyli. 2000. Wood Products and Sustainable Construction. Proc. Bilateral Workshop on Agriculture Technology between Taiwan and Canada. TFRI Extension Series No. 127. Taipei, December 12-13, 2000.

Edminster, A. and S. Yassa. 1998. Efficient wood use in residential construction: a practical guide to saving wood, money and forests. Natural Resource Defense Council.

Falk, R. 2002. Wood-framed building deconstruction. Forest Products Journal 52 (3).

Gaston, C., R. Kosak, J. O'Connor, and D. Fell. 2001. Potential for increased wood use in N.A. non-residential markets. Forintek Canada Corp.

Houghton, J. T., Y. Ding, D. J. Griggs, M. Noguer, P. J. van der Linden, x. Dai, K. Maskell, C. A. Johnson, eds. Climate Change 2001: The Scientific Basis. Contribution of Working Group 1 to the Third Assessment Report of the Intergovernmental Panel on Climate Change.

Karacabeyli, E. 1996. Platform-frame Wood Construction in Canada. Issues and Research. Prepared for a presentation at the COST E5 Workshop, Timber Frame Building Systems, Stuttgart, Germany, October 1996.

Natural Resources Canada, Canadian Forest Service, The State of Canada's Forests 2001-2002.

Rainer, H.J. and E. Karacabeyli. 1999. Performance of wood-frame building construction in earthquakes. Forintek Canada Corp. Special Publication No. SP-40.

Sultan, M.A., V.R. Kodur, L.R., Richardson and R.A. McPhee. 1997. Fire resistance of lightweight frame wall assemblies. In: Proc. 4th Japan/Canada Housing R&D Workshop. Sapporo, Japan, 17-20 November 1997. 7 p.

Tiemann, H.D. 1951. Wood technology: construction, properties and uses. London, Pitman, 1951. 3rd ed. P. 396.

Watson, R., H. Rodhe, H. Oeschger and U. Siegenthaler, Greenhouse gases and aerosols. In: Climate Change, the IPCC scientific assessment. Houghton, J.T., G.J. Jenkins and J.J. Ephraums, eds., Cambridge University Press. 1990.

Fig. 1. Environmental impact of wood, steel and concrete homes

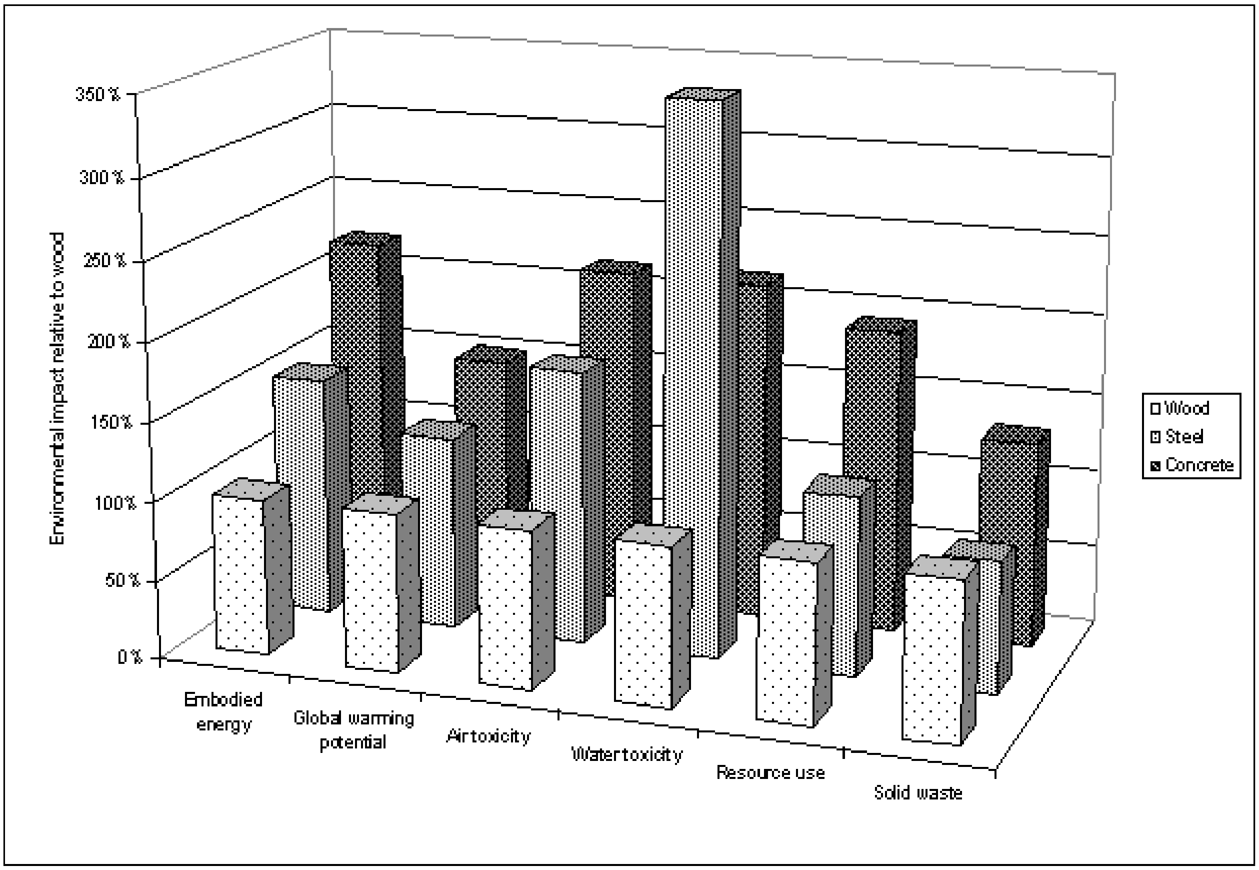
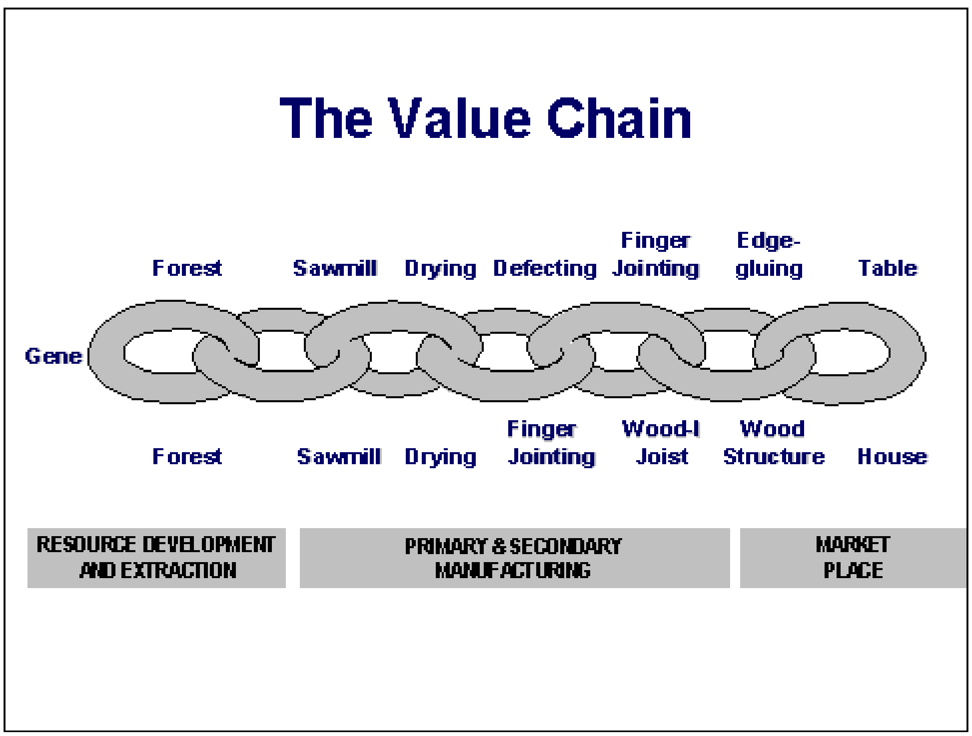
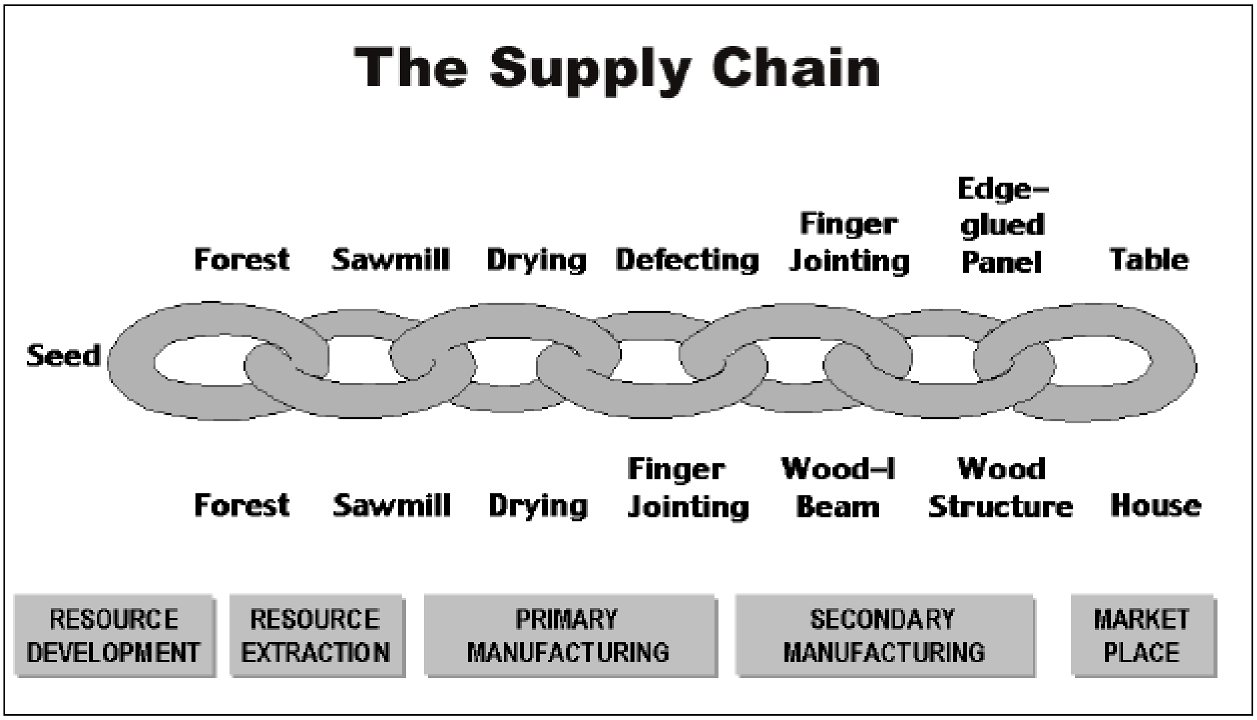
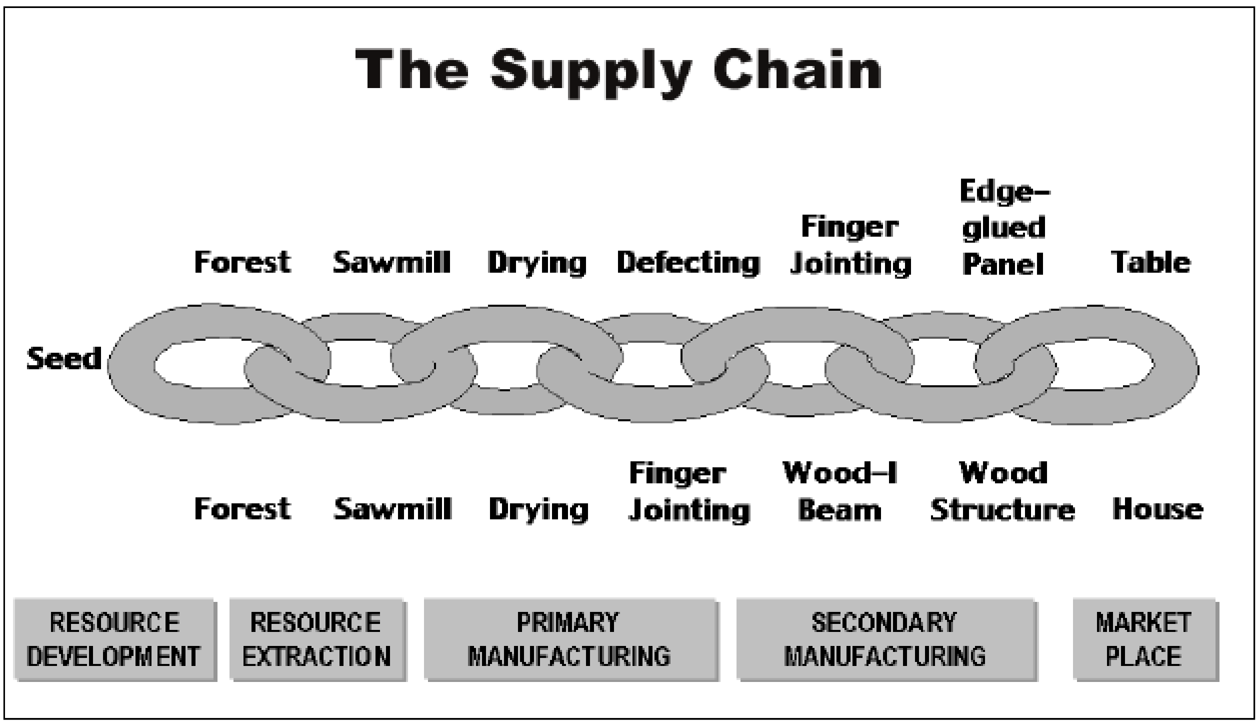


Fig. 2. Value Chain







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[1] World Resources Institute - Data Tables 2000-2001.

[2] Sustainable Forestry Bulletin, FPAC, December 3, 2002.