

Future developments in the forest sector¹

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Introduction

The start of a new decade – the 2020s – provides an opportunity to forecast future developments in the forest sector. We predict these developments of wood and paper products will bring increased demand for wood fiber. Sustainable production of wood and wood fiber is essential and must be ensured by sustainable forest management that protects biodiversity and other forest ecosystem services. Continued market development is critical, especially for new products and applications. Efficient manufacturing is needed for traditional and new products. A revitalization of the forest industry via viable products and processes is especially necessary in the United States. Strong, ongoing support is important for university-level education and research in all aspects of the forest sector. International cooperation is and always will be a key for continued forest sector development. Communication of the benefits of current and new wood and paper products and processes is essential to all target audiences. This report is intended to share creative and forward-looking thoughts from experts throughout the forest products sector with a goal to inspire additional insight and inspiration.

Background

Information for this report came from personal interviews conducted at the Society of Wood Science and Technology² (SWST) Convention in October 2019 and a pre-convention survey. The annual SWST conventions bring together some of the brightest minds in the forest sector. The convention was organized into eight topical sessions:

1. Wood Physics and Mechanics
2. Wood Chemistry
3. Advances in Cell Biology
4. Biodegradation and Preservation
5. Timber Engineering and Mass Timber
6. Composites and Adhesives
7. Business, Marketing and Regulations
8. International Innovation, Trends and Education in Wood Science

Session leaders were the primary interviewees. For this report, Dovetail Partners tapped the knowledge of these experts with a focus on their expectations and forecasts for future developments (positive and negative) in their respective fields. Informed by their forecasts, Dovetail produced this forward-looking report about the forest sector in 2020 and beyond.

¹ A preliminary version of this report was written for and presented at the 2019 Society of Wood Sciences Convention and was published at: <http://www.swst.org/wp/wp-content/uploads/2019/11/2019-Final-final-Proceedings.pdf>. This report is based on follow-up interviews at the SWST Convention and updates and insights from Dovetail Partners associates.

² The SWST is an international organization with approximately 500 members in academia, industry and government. Its mission is “to provide service to SWST members; to develop, maintain, and promulgate the educational, scientific and ethical standards that define the profession; and to advocate the socially responsive production and use of wood and lignocellulosic materials.”

The key questions upon which this report is organized were:

1. What will be the most important topic in the 2020s?
2. How does your topic address a broader, umbrella issue such as sustainable development or sustainable forest management or climate change?
3. What are the potential risks associated with this development? How could those risks limit or preclude the development?
4. What new products or product applications will become available?
5. Are these new products and applications likely to substitute for other current products or raw materials (wood- or non-wood-based products/materials)?
6. Are developments likely to increase or decrease demand for wood or wood fiber?
7. Could developments lead to reductions in the environmental impacts of wood-based products production and use, and if so, what indicators are most likely to show improvement?

The responses to the interview and survey questions are summarized in the following sections. Readers are cautioned that statements from interviewees are recorded and presented as they were provided, without modification beyond formatting or other changes that would not impact the content or substance. Explanations, interpretations, or speculation about individual comments are not provided.

Results and Discussion

Overarching developments. Despite differences in their fields of expertise, the respondents were all positive about future developments in the forest sector. Repeatedly the word “sustainable” was used in conjunction with the production of forest products and their markets. Sustainable production of wood and wood fiber is essential and is ensured by sustainable forest management (SFM) that protects biodiversity. Widespread development of forest plantations of fast-growing, often exotic species to achieve higher growth rates was mentioned, with the caveat that these species’ physical properties are known and are suitable to end uses. SFM will improve when less-utilized species and smaller-diameter trees are processed into value-added products.

Market development continues to be needed, especially for new products and their applications. Then, continued improvement in manufacturing efficiency will be necessary for traditional products, e.g., lumber (sawnwood) and panel products, and for new products as well. SFM requires sustainable forest products markets to have a balance between supply and demand.

A revitalization of the global forest industry was called for, especially in the United States. Some of the products and processes mentioned below directly address this need. For many products and processes, a systems approach is necessary to structure innovation and coordinate efficiencies. Product design can begin with the product’s end-of-life and then “up-cycling” to the product and its production. At the end-of-life, wood and paper products can be consumed for energy or incorporated as filler into other products such as 3D printing or light-weight concrete.

Respondents, many of whom were from academia, supported university-level education and research in all aspects of the forest sector. International cooperation, one of the tenants of the SWST, is and always will be important for continued forest sector development.

Question 1. What will be the most important topic in the 2020s?

New products and processes. Cross-laminated timber (CLT) was the leading important topic. Its current production is most-often from softwood species, but with additional research and testing it could be made from suitable hardwood species and small-diameter timber as well. Mass timber construction will be enabled through improvements in connections (mechanical and chemical, e.g., waterborne and lignin-based adhesives) of the panels. These buildings will show more advantages as improvements come in seismic design and long-term durability. Research will discover how to manufacture panels and construct CLT buildings for different climates, e.g., humid regions. Another area of improvement will be in reducing sound transmission in CLT buildings.³



The pulp and paper sector is evolving from traditional products which are declining in demand, e.g., newsprint, into bio-refineries.⁴ These new factories can produce a variety of traditional products, and in addition, new fiber-based bio-products and wood-based energy. Some of these products are either primary outputs or are byproducts. Heretofore byproducts, e.g., lignin, are elevated to primary- or secondary-products. Refineries will need to produce cellulose and lignin for their increasing applications of nano-fibers.⁵

Ingenuity in breaking down wood into constituent fibers and chemical components and then reforming them into composite products is forecast to continue. Biomolecular engineering of wood structure and its chemical composition will lead to enhanced materials. New applications of lignin and cellulose will produce the components for nanotechnology. Improvements in bonding of wood-to-wood composites and wood-to-other materials composites will facilitate new structural products.

Adhesives derived from natural products, as opposed to synthetic chemical sources, will provide significant environmental benefit. Science will continue to achieve greater wood stability in composite products. Research is underway to exploit biological pathways via organisms such as algae to produce new products.

Another avenue for more environmentally friendly processes is in preservation of wood. Continued research in the wood preservation field will lead to more durable, lower impact products. Biodegradation and biodeterioration are natural processes which have been

³ For more information, see the Dovetail Report, *Modern Tall Wood Buildings: Opportunities for Innovation* available at:

http://www.dovetailinc.org/report_pdfs/2016/dovetailtallwoodbuildings0116.pdf

⁴ For further discussion of the potential for biorefineries, see the Dovetail Report examining the U.S. Pulp and Paper Industry, available at:

http://www.dovetailinc.org/report_pdfs/2005/dovetailpulppaper0705new.pdf

⁵ For background information about nanotechnology, see *Nanotechnology and the Forest Products Industry: Commercial Opportunities*, available at:

http://www.dovetailinc.org/report_pdfs/2016/dovetailnanotech1016.pdf

traditionally reduced by chemical and heat treatments. New treatments will be developed that have lower environmental impacts than treatments commonly employed today. Thermally modified wood products will provide a variety of advantages in addition to resistance to decay.

Question 2. How does your topic address a broader, umbrella issue such as sustainable development or sustainable forest management or climate change?

Effects on sustainable forest management, sustainable development and climate change. The identified future developments all occur within the context of these three broad, interconnected issues: sustainability, renewability and carbon sequestration. Wood is recognized as a sustainable and renewable material that sequesters carbon and thereby helps to mitigate climate change⁶. Carbon is sequestered in standing trees and is retained in long lasting end-products of wood and paper. SFM will be enhanced through use of small-diameter timber in products such as CLT. Pre-commercial thinnings will become profitable when end-products use this low-value fiber source. Thinning forests will reduce fire hazard and provide raw material for wood and paper products or for wood-based energy. When using wood in construction, it has a much smaller carbon footprint than concrete or steel buildings.⁷ As the long-cycle CO₂ footprint decreases, the short cycle will increase, providing a more sustainable balance.

Recognizing wood's positive attributes as a building material, it needs to be used for the right applications. It is a biological material subject to degradation by insects and diseases. In addition, it can be damaged by non-biological agents such as fire, heat and weather. Protection of wood in its various uses is essential not only to extend its lifespan, and thus long-term carbon storage potential, but also to enhance its market acceptance and its ability to reduce depletion of non-



renewable resources. Research must continue to develop environmentally better protection strategies to extend the service life of wood products.

Question 3. What are the potential risks associated with this development? How could those risks limit or preclude the development?

Risks associated with the developments. A positive perception of wood and paper products and the management of forests from which they flow is critical to its current and future use. Promotion of all the advantages of living with wood and using wood and paper products is essential. Communication is necessary to counter arguments against wood which hinder its wider use. For some exterior applications, wood needs to be treated which makes some

⁶ For further discussion, *Managing Forests for Carbon Mitigation*

http://www.dovetailinc.org/report_pdfs/2011/dovetailmanagingforestcarbon1011.pdf

⁷ http://www.dovetailinc.org/report_pdfs/2015/building_with_wood.pdf

consumers doubt its sustainability – again, communication at the market level is necessary. Communication must target key audiences, e.g., civil engineers and architects. The durability of wood in service is essential to its reputation and risks can be limited through sound, applied scientific research.⁸ Ongoing education in schools is required to sensitize students on the concepts of sustainability and the life cycle of wood-based products. Communication within education begins at lower levels and continues through universities and vocational education. Public relations aimed at producers and consumers must be continued too. Effective channels of communication are needed to reach target audiences outside the forest sector itself. However, communication within the sector is a constant requirement.

Lack of investment and support for research and development is a major risk for the forest sector. Likewise, support is critical to preserve the remaining university-level wood science and technology degree programs and the precious knowledge they have generated over time. Politicians, and the populations they serve, must be convinced that the forest sector delivers sustainable products. The forest products industry itself must support R & D and university-level education.

The products with the greatest potential are those that offer superior performance and low environmental impact at an affordable price.

Products lacking those standards are unlikely to succeed in the marketplace. Going forward, products that cannot demonstrate low environmental impact or sustainability in production and use pose risks to the industries that produce them. Depending upon how society responds to signs of climate change, products that significantly



contribute, either in production, use, or disposal, to climate risks pose particular hazards to the industries that produce them. The same is true of societal response to non-renewable resource depletion. For instance, in the forest products sector, some of the best and least-expensive adhesives currently in use are petroleum-based, characterized by high environmental impacts and non-renewable resource depletion. Given the ubiquitous use of these adhesives in wood products manufacture, these adhesives pose mid- to long-term risks to the forest products sector. Development of new adhesives from chemical derivatives of wood itself offer great potential for creation of new wood products with extremely low environmental impact. Some byproducts can have a negative effect on main products' entire life cycle. Some new products production could involve high uses of water and energy which could negatively affect their life cycle analysis (LCA).

Any changes to current economies and markets carry risks of some loss of employment and increased prices. Whether society supports such negative effects is dependent on how it responds to signs of climate change and depleting resources.

⁸ Wood Science Research - Not Trendy, But Necessary, available at:

http://www.dovetailinc.org/report_pdfs/2006/dovetailresearch0506.pdf

Achieving some developments necessitates solving the skilled labor shortage. Continued implementation of robotics in wood process will help but attracting and training workers will be a challenge.

The sustainable supply of wood raw materials is essential to avoid any interruptions in the supply chain, which could lead to market disruption and greater use of non-renewable resources. New products based on nanotechnology need a stable supply of nanofibers. The supply chain itself needs to conform to the entire lifecycle of wood, i.e., from trees, to products and byproducts, to recycling and final uses such as fuel.

Another risk is declining demand for solid wood and veneer products for interior applications, such as furniture. Increasing the demand will require mitigating some of the problems for reduced demand including high costs, complexity of processing and moisture movement. Lacking solutions, solid wood will only be used for custom-made wood products. Some solutions include use of composite materials for their uniformity and workability; and simplifying and economizing in manufacturing via computer numerically controlled technology.

Excessive demand for highly fashionable species has always been a challenge for the forest sector. Since trees grow slowly to the size needed for solid wood products, overharvesting of desirable species occurs. Substitution of species and promotion of alternative species is needed.

Plantations are important in maintaining a stable, affordable source of wood fiber. Knowledge of plantation-wood's characteristics, qualities and variabilities are important to mitigate the risks sometimes associated with these fast-growing species. Some plantation species and some manufacturing processes consume inordinate quantities of water and energy, which can hinder the advancement and economic viability of new materials.⁹

A risk that exists with all new products is that they have not been thoroughly tested in use. Significant time is necessary to prove the effectiveness, durability and economic viability of new products and processes. Acceptance of new products often begins at the regulatory level to ensure that they conform to codes – or that codes are modified to enable their uses. More extensive testing prior to product introduction, combined with systematic life cycle evaluation at each step-in product and process design can reduce risks associated with market



⁹ Fast-Growth Tree Plantations for Wood Production, available at: http://www.dovetailinc.org/report_pdfs/2005/dovetailplant1005b.pdf

introduction of new products.

Question 4. What new products or product applications will become available?

New products Respondents identified a multitude of exciting new products and their applications. New products will come about by modifying wood, for example, through thermal treatments or chemical treatments or combinations of both. Acetylated¹⁰- and furfurylated¹¹ and polymeric¹²-based wood products are all in development. Nano technology will continue to evolve with a variety of end products commercialized based on wood's chemical components. Chemicals extracted from wood will be turned into organic textiles, pharmaceutical and other consumer products. Producing textiles from wood is not new, but expansion of their use to replace or supplement other non-wood fibers is increasing due to their naturalness, availability, affordability, comfort, and as an alternative to plastics (including synthetic fibers) and other materials with greater negative environmental impact.

Wood-based chemicals have uses in pharmaceuticals and cosmetics. Incorporation into drugs to reduce or eliminate dependency on opioids is being researched with promising results. Lignocellulosic materials are being tested to regulate drug release for opioid addiction treatment. Nanocellulose coatings for drugs are in the research stage. Cellulose materials are being tested for bone replacement. To bring such products to market synergies must be established between research, industry and government.

Because humans cannot digest cellulose, research is ongoing for adding it to foods for its weight-loss potential. Cellulosic fiber has long been added to foods in order to increase fiber and provide dietary features, but enhancement of performance could broaden potential applications.

Mixes of wood and plastics is commonly known for some products such as outdoor furniture and decking.¹³ Wood fibers can enhance the characteristics of other materials, for example, recycled glass fiber (rock wool, fiberglass insulation). Combinations of wood fiber and recycled carbon fibers offer some potential products with valuable strength properties. Mixes of wood with agricultural residues will yield new composite products.

New applications. Mass timber is in fashion. While CLT is not new, the applications for CLT are growing. It had been in use for many years in Europe prior its introduction in North America. In the future, new species will be incorporated into CLT, including hardwoods as mentioned above. "Hybrid panel" construction in CLT will incorporate well-known, commonly used species for the main structural elements with other parts of the panel constructed from

¹⁰ Acetylation alters the cellular structure of wood in a process involving heat, pressure and acetic anhydride. The wood becomes more durable and dimensionally stable.

https://www.deckmagazine.com/products/acetylated-decking_o

¹¹ Furfurylated wood is treated with furfuryl alcohol to improve hardness, resist microbial and insect attack, increase the modulus of rupture, increase the modulus of elasticity and to improve dimensional stability. <https://www.tandfonline.com/doi/full/10.1080/0282758041001915?src=recsys>

¹² Polymeric woods have advantages of corrosion-resistance and thermal insulation. They can be coatings or mixed with wood fibers and/or other materials such as plastic.

<https://advances.sciencemag.org/content/4/8/eaat7223.full>

¹³ Wood-Plastic Composite Lumber vs. Wood Decking, available at:

http://www.dovetailinc.org/report_pdfs/2010/dovetailplasticdeck0710.pdf

fast growing and/or naturally durable species. Hybrid panels will incorporate structural composite lumber and panels. Advances in adhesives, with higher concentrations of natural products, will enable better bonding in structural applications.

Advances in structural panels, such as CLT, along with other structural wood components, such as glulam, will result in growing height of wooden buildings. However, for the foreseeable future, four-story CLT buildings will be most economical and efficient to construct.

For some applications wood's ability to biodegrade naturally is a positive attribute when products reach their end of useful life; biodegradability can be enhanced in conjunction with certain polymers. Decomposition has always been important in forests and for products at the end of their useful life. Biodegradability and decomposition properties will be further improved and promoted.



Labor shortages can be alleviated in wood processing with advances in scanning technologies. Robotic utilization for repetitive, hazardous and dirty jobs can allow labor to be allocated to more meaningful and healthful tasks.

Internet shopping has spurred the need for packaging, especially wrapping paper and cardboard boxes. Wood-based packaging will replace some fossil-fuel based packaging. For

instance, bio-based, biodegradable plastics will increase in use and replace petroleum-based plastics in food packaging.

Question 5. Are these new products and application likely to substitute for other current products or raw materials (wood- or non-wood-based products/materials)?

Many, if not most, of the future products under development will substitute for currently used wood, or non-wood, materials. In a successful circular economy, the use of bio-based resources will replace petroleum- and cement-based materials. Naturally durable temperate species, and heat- and chemical-treated temperate species, will continue to substitute for naturally durable tropical timber.¹⁴ Composites, be they from fine particles or large pieces of wood, will continue substituting for solid wood products, but will also permit substitution for high environmental impact materials such as structural steel and concrete.

Respondents were almost universal in saying that wood-based materials will substitute petroleum-based products, e.g., plastics. Substitution will continue for other competitors of wood, e.g., concrete and metals. Biodegradable, wood-based plastics or fibrous materials will directly replace low- and medium-quality petroleum-based thermoplastics with long lives, such as LDPE, HDPE and PVC. To accomplish this replacement, biomolecular engineering of wood's structure and its chemical composition are necessary. However, the petrochemical other materials will continue to be needed when they are more advantageous in their applications than wood-based substitutes.

¹⁴ Impact of market forces and government policies on the tropical timber trade, available at: http://www.dovetailinc.org/report_pdfs/2018/dovetailtroptimber0118.pdf

Improved treatment methods for biological damage, i.e., disease and decay, will replace older treatment methods. Treatment techniques which are more environmentally safe will continue to be developed and employed. Surface treatments will enhance wood products usages in some applications.

Question 6. Are developments likely to increase or decrease demand for wood or wood fiber?

Respondents were unanimous in saying that future developments will increase the demand for wood and wood fiber. First, because with increasing populations and standards of living, demand for wood and paper products will increase. Secondly, as wood-based products substitute for less environmentally friendly materials, demand for wood will rise. And third, as we continue to address climate change, the need increases for materials that store and emit less carbon in their manufacturing, lifespan and disposal.



CLT and other engineered wood products will certainly increase the demand for wood. The advantage of developments, such as mass-timber buildings, is that they will offset decreases in demand for wood and fiber for products such as newsprint and some paper grades where demand is declining.

As knowledge rises about the attributes of wood by students, architects and designers, applications of wood will increase accordingly. The growing need for efficient and comfortable living and working spaces, for example by Millennials, will increase the demand for wood-based construction and products. Modern wooden buildings offer the desired combination of comfortable and healthy living environments as well as high-tech, stylish designs.

One of the respondents raised a question about the future increase in wood-based energy. Wood has been used as a source of energy for thousands of years. The extent to which wood will remain an important energy source depends a great deal on developments in the oil and gas industry. Wood can, for instance, be converted to a variety of liquid fuels, including ethanol, biobutanol, and even gasoline. However, at current low prices of petroleum and natural gas, production is not economical without subsidy. Similarly, a wide spectrum of chemicals and chemical feedstocks, many of which are now obtained from petroleum can also be derived from wood. But again, potential depends upon the future relative abundance of fossil fuels. Obviously, wood is first directed into its higher value uses. But will wood energy expand broadly, or will it continue to remain confined to regional uses? Will wood-based ethanol, pellets and pyrolysis become cost competitive without government subsidies? Respondents raised these questions for continued research.

Question 7. Could developments lead to reductions in the environmental impacts of wood-based products production and use, and if so, what indicators are most likely to show improvement?

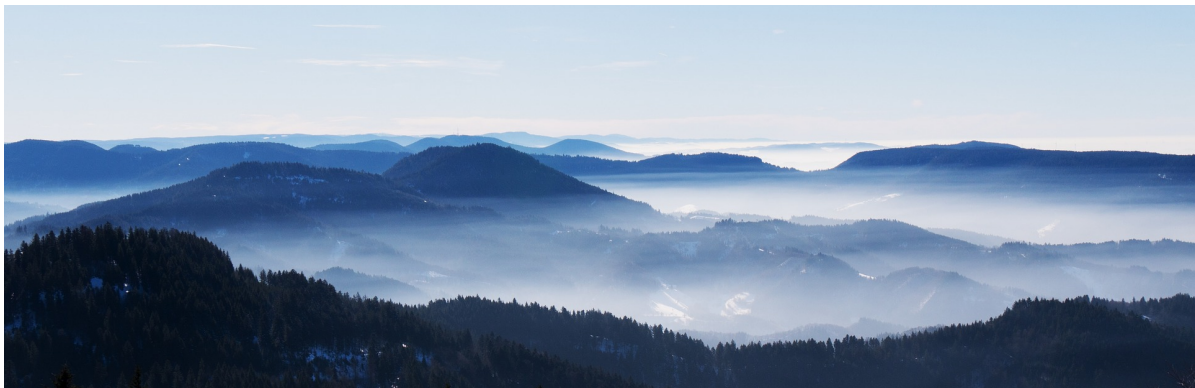
Almost all respondents said that wood products production and use will reduce impacts on the environment when considered in the context of potential substitute products. One example is in wooden construction which has a lower environmental impact than construction with competitive materials such as concrete, metal and plastic.¹⁵ Wood is a much better energy and sound insulator than the competitors.

The benefits of carbon sequestration were often cited. These span from forest environments to end-use wood-based products. Forest productivity and sustainability will continue to improve through applied genetic research.

Increasing the service life of wood through various non-toxic treatments will reduce the environmental impact of earlier replacement. The recyclability of wood and paper products is a distinct advantage for the forest sector. However, recycling requires energy. With “Down cycling”, which is the use of recovered fiber in lower and lower value products, each cycle of reuse presents an opportunity to further extend the forest resource through efficient utilization.

With a market approach by researchers, new products will meet evolving consumer needs. Proactive and life-cycle-based product and process design will ensure that these products deliver superior environmental performance to those they replace.

The best indicator to show improvement is by LCA.¹⁶ The measurements could be in kilograms of CO₂ equivalent or other measures of health and energy. A holistic approach is necessary to measure the impacts of products and processes on people’s lives, resource balances, and ecosystems. When evaluating the forest sector as a circular economy, decisions should not only be economic, but also eco-based.



¹⁵ Life Cycle Cost Analysis of Non-Residential Buildings, http://www.dovetailinc.org/report_pdfs/2013/dovetailccareport1013.pdf

¹⁶ A Review of Life Cycle Assessment Tools, <http://www.dovetailinc.org/dovetailcatools0217.pdf>

The Bottom Line

The session chairs' responses about future developments in the forest sector were all positive. They made forecasts of product and process developments in their sectors which could have far reaching advantages for the forest sector and consumers of forest products. At a macro-level CLT was most often mentioned for its multiple attributes such as carbon sequestration, sustainable development, healthy living, etc. On a micro-level, nanotechnology was often cited for its increasing applications.

To achieve these developments, synergies are necessary throughout the industry together with research and government. Government policies are necessary to enable research to be applied. In the new decade beginning in 2020, timing is perfect for wood-based construction which fits into the "new green economy".

All other new uses and applications of wood will increase wood consumption as well. On the other hand, increases in wood durability and long-term performance and product conversion efficiency could have the effect of reducing wood consumption. Whether demand for wood overall will increase or decrease in the future is an open question dependent upon trends in pulp and paper, plywood, decking, housing, energy, and other markets.

At the heart of SWST, the need for continued higher education reform was called for. Forestry and wood science education must be modernized to meet current and future industry and consumer demands while taking into account future environmental considerations.

Communication by everyone in the wood chain, from foresters to scientists to architects and builders, must support the attributes of wood. The forest sector must continue to modernize along with new needs and demands.

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- Business, Marketing and Regulations, Dr. Henry Quesada, Virginia Tech
- Innovation, Trends and Education in Wood Science, Dr. Rupert Wimmer, Boku University and Dr. Mike Burnard, InnoRenew
- Impact of Forest Disturbances on Wood Quality, Dr. Scott Leavengood, Oregon State University
- Early Stage Researchers Session, Dr. Hui Li, Washington State University
- Poster Session, Dr. Gloria Oporto, West Virginia University
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