Forest Products Utilization Within a Circular Bioeconomy

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Abstract

The advent of tall wood structures in North America is heightening a public awareness that forest products, designed for higher and better uses, will lead to enhanced environmental benefits within the Circular Bioeconomy. The application of these newer wood-based processing technologies and their resulting products, in place of completive products such as concrete, steel and other non-wood construction materials, will redefine and expand the advantages that wood has as a construction material.

Further, the growing capability to use small logs, and diverse species, as raw material for the newer generation of forest products will magnify the carbon sequestration benefits from the working forest. A recipe of getting more benefits and improved utilization from the working forest is identified and described, while focusing on the means and methods of obtaining these benefits.

The introduction of tall wood structures within North America is heightening a public awareness that forest products, when designed for higher and better uses, will also lead to enhanced environmental benefits. And that these benefits are best achieved by growing trees, manufacturing products, and building with wood within the framework of a Circular Bioeconomy.

What then is a Circular Bioeconomy? How does the introduction of innovative uses of wood, such as in Tall Building, contribute to a Circular Bioeconomy? And what is the role of the tree and the forester? In addition, what changes can occur within the wood products manufacturing process that will enhance greater conversion efficiency?

And lastly, how will a forest-based Circular Bioeconomy contribute to the Environmental 'Wellness' of planet earth?

Circular Bioeconomy and the Forest Base

The renewable biological resource, trees, are the fundamental ingredient of an economic model which can be best labeled as a forest-based Circular Bioeconomy. The process is often referred to simply as "circularity." (Wikipedia, 2019) However, the over-arching term, Circular Bioeconomy, characterizes an economic model that focuses on eliminating waste (or lower value products) while advocating the continued use of the resource at its highest possible value over time.

The discrete terms Circular and Bioeconomy share much in common, and together aptly depict the sequence of share, maintain, use, reuse, remanufacture, recycle. (Circular Bioeconomy: an Uneasy Marriage of Concepts, so Far, 2018)

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"The object of these actions (in this order) is to maintain the economic value of products, materials and resources, as long as possible. And in doing so, use resources to the maximum and reduce the amount of waste to a minimum. (Melton, 2018)

A Circular Bioeconomy, often called as a regenerative approach, is in sharp contrast to the more traditional linear econometric model of take, make use, dispose, pollute model as shown in Exhibit 1.

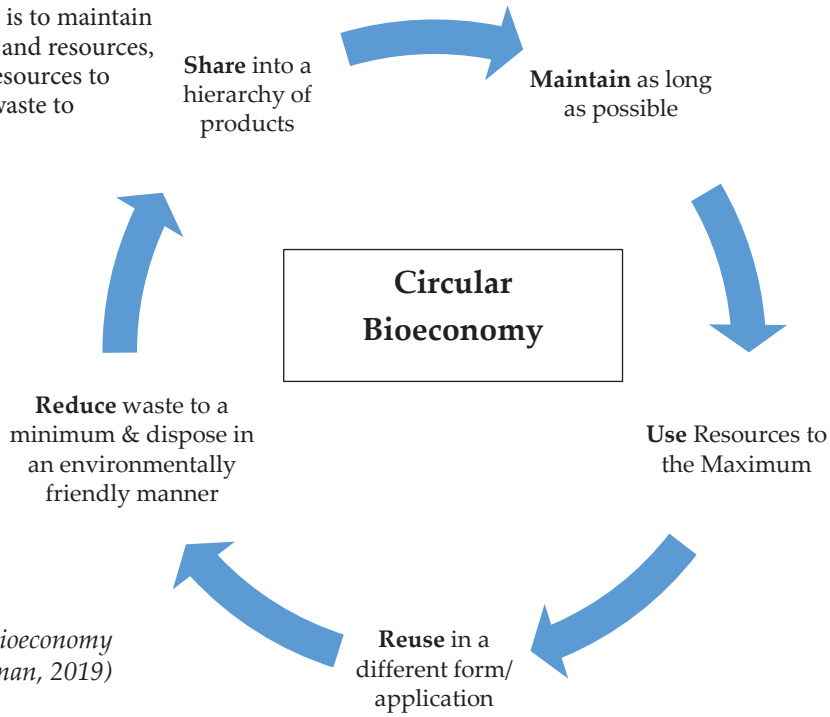

Exhibit 1 Circular Bioeconomy
Source: (Weetman, 2019)

The regenerative approach grows the trees sustainably and more abundantly; then harvests and converts the resulting timber to its highest and best use.

Consequently, the tree is converted into products of enduring value, such as long-lasting wood structures. Maintaining the embodied carbon within the wood for the longest term possible is a companion goal. When the wood outlives its original use it is repurposed, or disposed of, in a way that retains the embodied carbon as much as possible.

Lastly, it disposes of any current and future residuals in a thoughtful way to prevent, or minimize the escape of the embodied carbon back into the atmosphere.

Research and Development, and the resulting innovations are typically the means used to transform ordinary products, such as lumber and veneer, into extraordinary final outcomes. (Kutt, 2019) The overall goal is to find more and better sustainable uses for the wood products that are derived from these trees initially, then create a sequence of useful products until the wood fiber is eventually disposed.

The forest-based Circular Bioeconomy model promotes and facilitates the higher and better use of wood in products that provide improved beauty, utility and derive

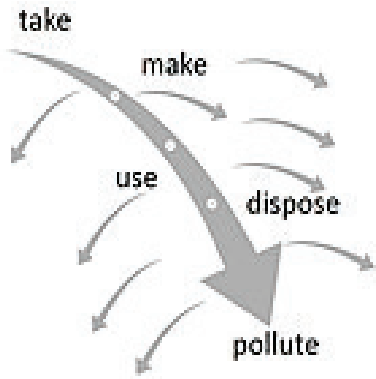

Exhibit 2 Linear Economic Model
Source: (Weetman, 2019)

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Carbon Sequestration is the process involved in carbon capture and the long-term storage of atmospheric carbon dioxide or other forms of carbon to mitigate or defer global warming. It has been proposed as a way to slow the atmospheric and marine accumulation of greenhouse gases, which are released by burning fossil fuels. (Contributors, Carbon Sequestration, 2019)

Embodied Carbon: Embodied carbon is the carbon footprint of a material. It considers how many greenhouse gases (GHGs) are released throughout the supply chain and is often measured from cradle to (factory) gate, or cradle to site (of use). (Jones, 2019)

environmental enhancements then and over the long-term. The continuing quest to convert the tree into the highest and longest serving end use governs the process.

The architect and designer play a crucial role in creating wood structures, that are not only beautiful and functional; but sequester a massive amount of CO_2 initially and over the long term as a more functional and better answer for the initial needs of the tenant.

Yet, subsequent sequestering of CO_2 will provide benefits that extend into the overall environmental friendliness of the construction project. The initial environmental benefits are magnified knowing that each wood structure, particularly those pertaining to Tall MASS Timber Construction likely replace net CO_2 emitters such as concrete and steel.

Tall MASS Timber Construction in North America

Tall Mass Timber Construction is the new catch-phase in design and construction that encompasses a wide range of solid wood, veneer, and composite based Products. Relative "Old-timer" products such as sawn lumber, plywood, laminated Veneer Lumber (LVL), and Glulam (glue laminated timber) are still basic elements of wood construction.

However, these products are often being used in conjunction with the newer wood products such as Cross Laminated Lumber (CTL) and Mass Plywood Panels (MPP). CTL and MPP can be considered a disruptive innovation (Christiansen, 2017) that is creating new markets for wood products.

Almost daily, the reader will encounter news articles in trade publications and mainstream media that describe projects that use these newer wood products, such as:

- The Future of Portland's Skyline is Made of Wood. Yes, Wood (Libby, 2017)
- Blast Testing of Loaded Mass Timber Structures Yields Positive Results. (Fabris, 2018)
- The World's tallest Wood Building was just completed in Norway (Gallaher, 2019)

These examples are just three of a hundred and more news articles and announcements that originated in trade and general news publications within the past three years; and the author has likely missed more than a few.

Tall MASS Timber Buildings
Industry term to identify mass timber buildings constructed of mass timber elements, that exceed current height limits for wood building set by the International building code (IBC) They encompass a wide range of solid wood, veneer, and composite based products. (Tall Mass Timber, 2018)(of use). (Jones, 2019)

Let's delve into the source of these articles; and gain insight in what could be described as a 'sea-change' of how the public is beginning to view wood use in construction. Also important: the role of the managed forest and the mill.

MASS Timber Construction is the new catchphrase in the design and construction of Tall Wood Buildings.

"Starting in Austria about 20 years ago… builders began using cross-laminated timber, or CLT: manufactured panels created by gluing together layers of wood, then compressing them into a packed structure as strong, pound for pound, as steel construction." (Libby, 2017)

According to the American Wood Council: (Tall Mass Timber, 2018)

- MASS timber includes any product currently permitted for use in Type IV Construction, such as,
  - Cross Laminated Timber (CLT)
  - Mass plywood panels (MPP)
  - Structural Composite Lumber (SCL)
  - Glue-laminated timber (Glulam)
  - Large Solid-Sawn Timbers (Tall Mass Timber, n.d.)

TALL Timber Wood Building

The updated International Building Code (IBC), Year 2021 edition, will contain provisions that allow for the construction of tall mass timber buildings up to 18 stories tall, rather than current up to 12 story limitations.

Architects and designers, then and now working together with focused leadership, have an enormous role to play. Working together with other key members of a project team, they can discover, test, and implement innovative designs that provide greater beauty and utility, while sequestering carbon for the long term. They also consider ways and means to minimize the offtake of CO_2 during construction as part of the task.

For example, Jason McLennan (McLennan Design) cited as one of the world's most influential individuals in wood architecture and green building movement, is an Award-winning architect and creator of the stringent green building certification, the Living Building Challenge (Contributors, Jason F. McLennan, 2019). Jason is a sought-after speaker; he delivered a keynote address at the March 2019 International MASS Timber Conference in Portland, OR.

Exhibit 3 Jason F. McLennan Source: (Edelstein, 2017)

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Jason's keynote address equated the close coupling of the forest, and the products derived from the forest.

"… he believes we are at a tipping point where wood construction will take over the commercial building industry much the way the automobile replaced the horse and buggy in the early 20th Century." (Cloughesy, 2017)

This bold statement is followed by a caveat, i.e., McLennan reasons that Tall MASS Timber Construction will make it past the "tipping point" only if the designers, architects, and yes, the consumer, are convinced that the raw material, wood, originates from sustainably managed forests that actively work to achieve a favorable CO_2 outcome for the growing, harvesting, and reestablishing of the forest.

The resulting conviction will be strengthened if the public further perceives that the wood assemblies used in MASS Tall Wood Construction, and the newer "built with wood" technologies have an important role to play in in forest-based Circular Bioeconomy sequestering carbon. Public support is strengthened by gaining a better understanding of CO_2 and the its implications to Global Warming.

Global Warming, An Alarming Phenomenon

Global warming has emerged as the latest, and seemingly the most urgent environmental issue and is an important consideration within the Circular Bioeconomy.

Let's start by creating a basis for defining Global Warming and understanding its implications; the finding of the late Dr. Thomas Kyle signifies a good place to start.

Dr. Kyle's lengthy tenure at the National Center for Atmospheric Research (NCAR) focused on the Earth's upper atmosphere. His findings, and that of his research colleagues, were published in over one hundred peer–reviewed articles.

I became a friend and acquaintance during his last years. We talked often, and about his work.

One day I asked, *"Tom, we hear so much about global warming and the CO_2 layer in the upper atmosphere, what can you tell me about that? "*

He said, *"There is a layer and it is blanketing the earth. And likely will continue to grow over time."*

Tom's reflective demeanor and the conversations that followed, converted a skeptic into a believer; and a believer that began quietly looking for answers and better understanding.

Global Warming
A definition: an increase in the earth's atmospheric and oceanic temperatures widely predicted to occur due to an increase in the greenhouse effect resulting especially from pollution.
(Global Warming, n.d.)

Tom's work, and that of his peers and predecessors, generally agree that carbon dioxide (CO_2) is a significant contributor to global warming. Its growing concentration contributes to a proportional increase in the layer blanketing the earth.

Recently, the National Oceanic and Atmospheric Administration (NOAA) cited data gathered by scientists at Mauna Los Observatory in Hawaii. This site has monitored the atmosphere and has collected data related to atmospheric change since the 1950s.

A peak atmospheric concentration of CO_2 (414.7 Parts Per Million) occurred on May 2019, as reported in June 2019. This was the highest reported level in 61 years of data gathering at Mauna Los Observatory. (Eleanor Imster, Deborah Byrd, 2019). More recent data indicates a sustained unfavorable trend; readings are continuing to trend higher.

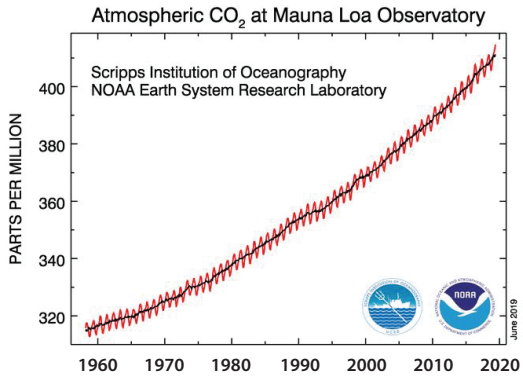

Exhibit 4 Atmospheric CO_2 at Mauna Loa Observatory
Source: (Eleanor Imster, Deborah Byrd, 2019)

Tom's work, and his findings; and that of others, is continuing to shed light on possible remedies to the continuing build-up of CO_2 in the atmosphere. Forests, forest products, and the uses of other bio-based forest resources may have an important role to play.

The facts and the developing framework for an effective forest-based Circular Bioeconomy are just starting to emerge that will aid in the development of the next generation of sustainable forest product, while materially contribute to the prevention and mitigation of CO_2 in the atmosphere.

The Forest and Wood Products Within a Circular Bioeconomy

What do we know about a tree's environmental benefits? Generally, the faster the tree grows, the more carbon is derived from the atmosphere and embedded within the tree (carbon sequestering). Carbon sequestering increases as the tree grows and matures; and declines as it ages. And at some point the tree becomes a net emitter of carbon as it ages and decays.

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The resulting wood products from the tree will sequester carbon indefinitely based on their service life. The environmental benefits of wood, are oversimplified, but fortunately there is a technical foundation for tying all this together.

Actual research results published to date by CORRIM and others are currently limited; but the continuing research and documentation results will become a measureable benefit to optimize the economic and environmental benefits of the forest-based Circular Bioeconomy model.

CORRIM has an important role to play when focused upon the benefits derived from a forest-based Circular Bioeconomy. Whole-building life-cycle assessment is focused on those benefits.

The Consortium for Research on Renewable Industrial Materials (CORRIM), is the recognized leader in pursuing and assembling comprehensive environmental performance information on wood building materials consistent with International Organization for Standardization (ISO) standards for life-cycle inventory (LVI) and life cycle assessment (LCA). Research has been conducted, data collected and analyzed, and result published periodically. Broadly summarized, the CORRIM data establishes baseline environmental assessments of forest resources and wood products.

CORRIM data indicates that managing a sustainable forest is something more than cutting fewer trees that are being grown; it involves careful planning and implementation of forest practices from planting to harvest to optimize the environmental benefits of a forest as it absorbs and sequesters carbon through its life cycle of planting, harvesting, and regeneration.

"One of the most important takeaways from whole-building life-cycle assessment almost always composes the largest source of embodied carbon in the building-up to 80%, depending on the building type." (Melton, 2018)

Whole of Life Assessment comprises the facilitation of decisions across the various project disciplines, and the subsequent compilation of documentation that captures the decisions made during the period of assessment. (Whole Life Assessment, 2018)

CORRIM and life-cycle assessment (LCA) are developing over time as useful tools to assist the project team in assessing the environmental impact of a structure. This information becomes an important tool in optimizing the economic and environmental benefits of a forest-based Circular Bioeconomy

Mass Timber Construction, A Significant Component of the Circular Bioeconomy Model

A fusion of the old and new conversion technologies is coming together to create new products that are the feedstock for MASS Timber Construction.

For example, plywood technologies are essentially being used to manufacture Cross Laminated timber (CLT). A dry lumber mat is formed by laying dry lumber side by side, adhesive applied, with the next (and every other) layer laid cross-ways to build the assembly into the desired thickness.

"The cross-laminated configuration improves rigidity, dimensional stability, and mechanical properties. Structurally, CLT offers performance comparable to concrete or steel, with panels suitable for use as walls, floors, roofs and other applications." (Cross-Laminated Timber Market - Industry Trends, Manufacturing Process, Plant Setup, Machinery, Raw Materials, Cost and Revenue, 2016)

Riddle, Oregon, is the site of the first CTL manufacturing plant in North America. The D.R. Johnson Lumber company plant, patterned after similar successful processes in Europe, is being joined by others such as in recently opened Katerra's plant in Spokane, Washington.

Another MASS product, the Mass Plywood Panel (MPP), is being manufactured by Freres Lumber Company using a specialized construction featuring nine-ply 1-inch-thick nominal 4x8 plywood panels, rather than dimension lumber. A panel up to 40 feet long (60 soon possible), 12-foot-wide, and 2-foot-thick billet is manufactured from these 4x8 panels and this larger panel is subsequently remanufactured into the desired dimension. The wood fiber required to duplicate CLT's structural properties is reputed to be substantially less when using the MPP panel.

Historic tried and true wood products such as conventional dimension lumber, solid headers and beams, glulam, LVL, plywood and other engineered wood products are also wood products used within Mass Timber Construction.

What most of these products have in common is the utilization of small logs into primary products. Large logs are no longer needed unless earmarked for specialty solid sawn beams and timbers. Increasing the yield of higher value products translates into higher primary product yield and a greater proportion of the log going into long lived products that sequester carbon.

The Forest-Based Circular Economy; the Forest, the Products, and the End Uses

The forest-based Circular Economy is an important framework for maximizing and optimizing both the economic and environmental benefits of wood. The newer wood products and subsequent applications, such as Cross Laminated Timber (CLT) and it companion engineered wood products, are paving the way for Tall MASS Timber Construction. These newer constructions will consume more environmentally friendly wood in comparison to concrete and steel.

Sufficient facts are just now developing that will provide the framework for an ever more effective forest-based Circular Bioeconomy operational Model. The newer generation of forest products, the realization that the circular Bioeconomy process begins in the forest, and circles through a series of operations and end uses that can extent over century, and the knowledge that the basic principles of are just starting to emerge that will aid in the next generation of sustainable forest products, while materially contributing to the prevention and mitigation of CO_2 in the atmosphere.

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Much research has, and is being conducted to identify the growth, harvest, and regrowth life-cycle quantitative assessment of the environmental impact of forest management activities that are required to provide logs to the mill.

The search for better answers is not without a full measure of controversy and complexity. A struggle will continue to achieve the answers acceptable to the various special-interest constituencies. Research finding and opinions often differ; and these differences, and how they are resolved, will lengthen the process. however, the facts will be developed and interpreted over time and the appropriate answers will be found and accepted.

What is becoming apparent though; we currently have the technology to create a high yield of long-life products from small log of diverse species. This yields the potential to improve forest practices; but will yield substantial environmental benefits over the life of the forest and its products.

The forest-based Circular Bioeconomy Model provides the framework for superior results.

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