An Introduction to the Circular Economy

Opportunities for Natural Resources and the Forest Sector

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Published by Dovetail Partners March 2020

Executive Summary

Sustainability concepts, including associated economic models, continue to emerge as urgency to address environmental challenges grows. From basic concepts of recycling to zero waste, these models address opportunities within business and policy arenas to reduce negative environmental impacts. The latest discussions around the "circular economy" represent a next step in these efforts by bringing together many of the prior existing ideas into a system for production and consumption that addresses environmental and economic opportunities holistically and strategically.

This report introduces the circular economy concept, provides examples of how it is being applied, and explores opportunities for the *circular bioeconomy* in the natural resources arena and forest sector. In many ways, natural resources, including forest products, have well-established circular economy practices that include utilization of byproducts, material recovery, renewable energy systems, and minimized waste production. But more needs to be done. For instance, there is a need for greater post-consumer recovery of solid wood products and continued product innovation to support keeping forests as an economically competitive land use.

A problem regarding rational development of a circular economy is that major natural resource interests, including the forest sector, are often not well represented in many circular economy discussions and initiatives. There is an opportunity for the forest sector to engage and lead in these efforts to ensure the role of forests is articulated, and that the benefits and impacts resulting from proposed innovations lead to more vibrant forests and forest-based economies.

Background

A variety of terms can be applied to designs for economic systems that increase sustainability and reduce waste production. These terms include Cradle to Cradle[1], Zero Waste[2] and Closed-Loop Supply Chain.[3] Recently, the term *Circular Economy* has re-emerged as a broadly encompassing concept that integrates many prior ideas and addresses a more extensive set of environmental issues and sustainability solutions.

> **Circular Economy** is defined as: *a system of production and consumption, which minimizes waste, optimizes the resources used with minimal pollution, regenerates natural capital, creates opportunities for jobs and entrepreneurship, and reshapes production and consumption from a life-cycle and recycling perspective.*[4]

[1] https://sustainabilitydictionary.com/2005/12/03/cradle-to-cradle/
[2] https://sustainabilitydictionary.com/2005/12/04/zero-waste/
[3] https://sustainabilitydictionary.com/2005/12/03/closed-loop-supply-chain/
[4] Author derived from: https://www.unece.org/hlpf2019-circulareconomy.html. In 2015, the EU defined circular economy as the aim to use materials and services efficiently to ensure that "the value of products, materials and

The circular economy has much in common with long-standing efforts to address waste and pollution and includes a strong focus on recycling and reuse of materials. However, it goes further to consider significant re-design and "de-coupling" within linear production and use systems. These system modifications lead to changes in multiple considerations and the associated impacts from the very beginning to the very end of production and use cycles. Figure 1 illustrates the differences in materials flows between linear, reuse, and circular economic models.

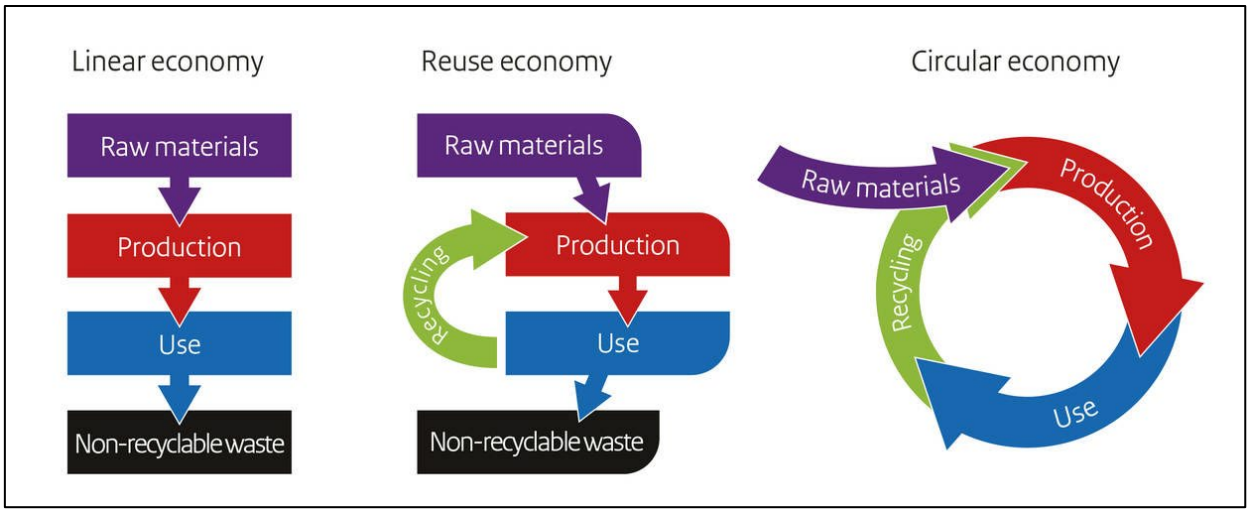

Figure 1. Linear, Reuse, and Circular Economic Models (Source: Government of the Netherlands, https://www.government.nl/topics/circular-economy/from-a-linear-to-a-circular-economy)

Proponents of the circular economy recognize the difficulties associated with trying to fully eliminate waste. There are many practical barriers to establishing a closed-loop economy. However, changes toward closed-loop operations are achievable within specific sectors, companies, or product categories. It is estimated that the world economy is currently approximately 9% circular.[5]

Common examples of business strategies for closing the production/use/disposal loop include shifting from selling products (that the consumer then owns and is responsible for disposing of) to providing a service with an agreement wherein products remain the responsibility of the manufacturer (to repair, replace, refurbish, or repurpose). Examples are cell phone companies that commit to taking back phones at the end of life, or other types of manufacturers that design products for material recovery and reuse. From a policy perspective, circular economy strategies include modifying incentive structures to support desired behaviors by organizations and individuals. Responsible consumerism by households, businesses, and other decision-makers is key to expanding the circular economy.

resources is maintained in the economy for as long as possible, and the generation of waste is minimized"
[4](http://www.fao.org/about/meetings/european-forest-week/en/) The EU action plan for the Circular Economy (2015) stated, "An economy, where the value of products, materials and resources is maintained in the economy for as long as possible, and the generation of waste minimized, is an essential contribution to the EU's efforts to develop a sustainable, low carbon, resource efficient and competitive economy'.'

[5] https://pacecircular.org/sites/default/files/2020-01/Circularity%20Gap%20Report%202018_0.pdf

There are seven identified elements of the circular economy:[6]

1. Prioritize regenerative resources
2. Preserve and extend what is already made
3. Use waste as a resource
4. Rethink the business model
5. Design for the future
6. Incorporate digital technology
7. Collaborate to create joint value

Adoption of each of these elements can lead to direct action and strategic change within public and private organizations, companies and corporations, and governments. These elements can also change material design and use and production systems. Careful examination of these elements reveals that the well-established ideas of reduce, reuse, and recycle are reflected within them.

Current efforts to address the circular economy, such as the leadership work of the Platform for Accelerating the Circular Economy (PACE), include a focus on transitions that are needed within consumer electronics, plastics packaging, and food systems.[7]

How Natural Resources and the Forest Sector Lead the Circular Economy

One of the arguments supporting movement toward a circular economy is the rise in global material resource use (Figure 2). During the 20th century, global material use rose at about twice the rate of population growth.[8] In some cases, rates of increase in resource extraction were many times greater than population growth.

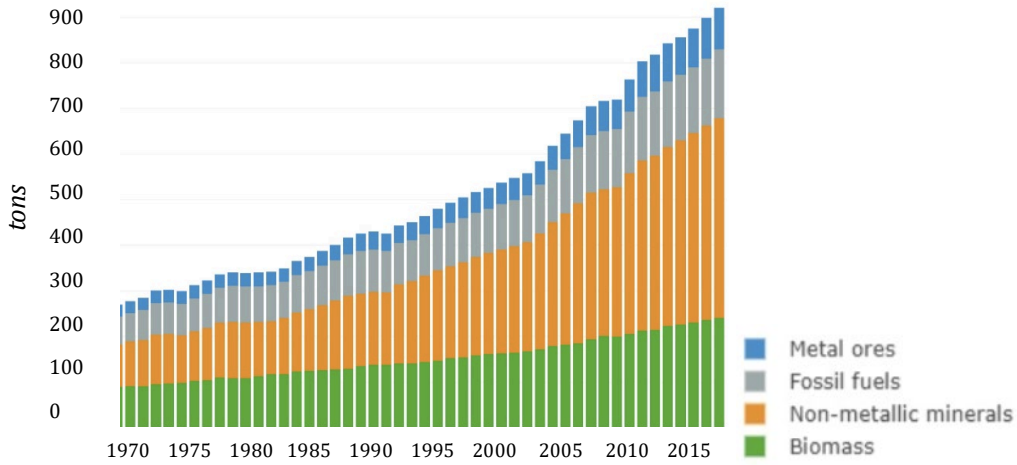

Figure 2. Global domestic material extraction, 1970-2017 (Source: WU Vienna, 2019)

During the time period 1961-2017, global population grew 2.45 times. During this same period the consumption of steel increased 4.9 times; cement and aluminum 12.7 times, and plastics 25.8 times (Table 1). These increases in consumption greatly exceeded the rate of population growth. However, consumption of wood during this time period only increased 1.6 times and at a rate *less* than population growth.

[6] https://www.circle-economy.com/circular-economy/7-key-elements
[7] https://pacecircular.org/
[8] https://www.acceleratecirculareconomy.org/s/PACE-Public-Overview.pdf

Table 1. World growth in consumption of principle raw materials, 1961-2017

Steel	Cement	Aluminum	Plastics	Wood
4.9 times	12.7 times	12.7 times	25.8 times	1.6 times

(Population growth during this period: 2.45 times)

Source: Data for wood from FAO (2018); for cement, steel, and aluminum from the U.S. Geological Survey (2018); and for plastics from the Association of Plastics Manufacturers in Europe (2018). Wood and plastics data are for 1961-2016.

To some degree, the lower rate of increase in wood consumption in recent decades reflects a shift to increased use of other materials, especially plastics. However, since the mid-1900s there has also been fundamental change in how wood is utilized within forest product manufacturing processes (Figure 3). These changes represent a partial transition toward a circular bioeconomy.

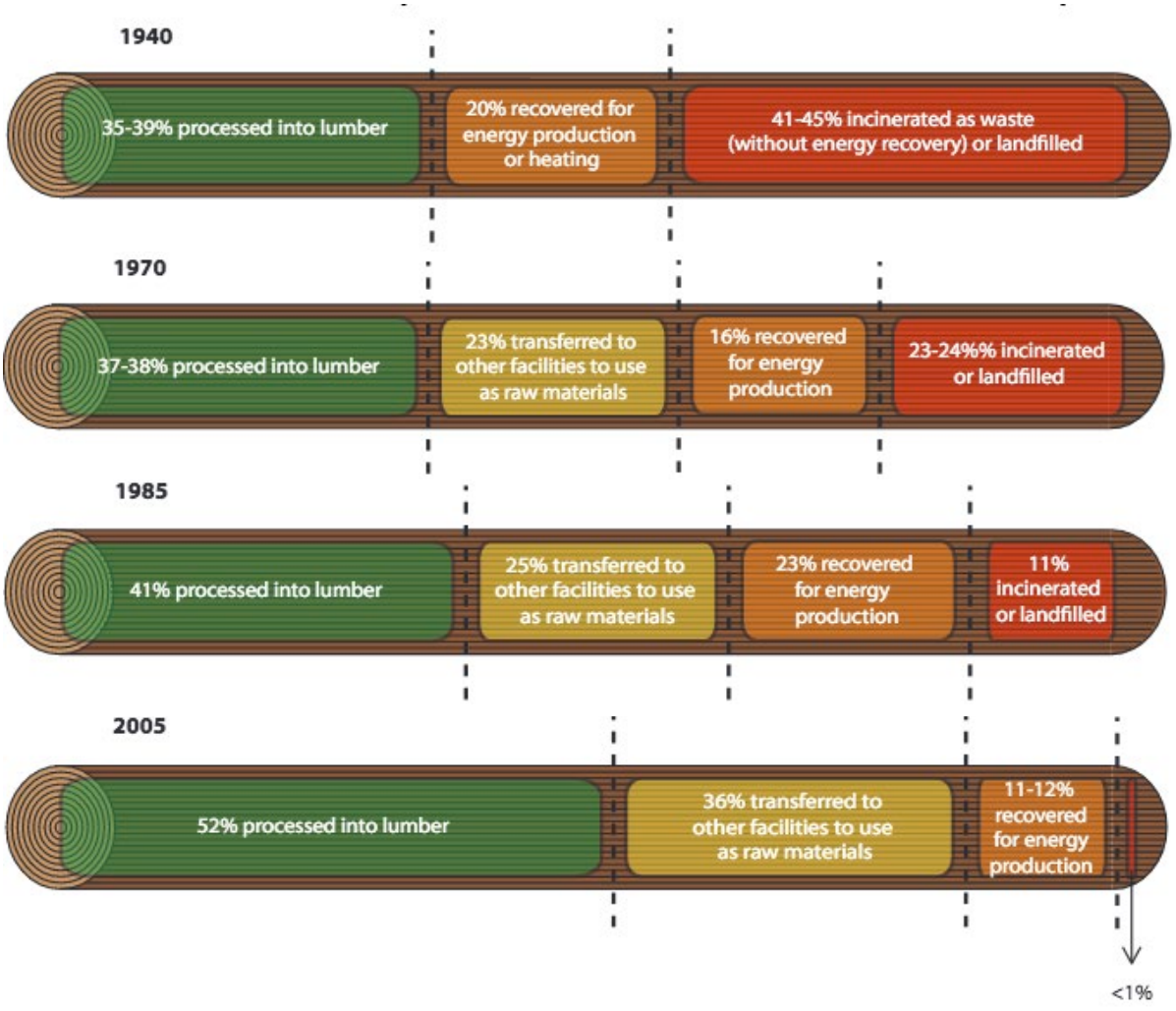

Figure 3. Changes in roundwood utilization in the forest sector, 1940-2005 (Source: Dovetail Partners, 2012 https://www.dovetailinc.org/upload/tmp/1581627196.pdf)

As recently as the 1940s, up to 45% of harvested roundwood (i.e., logs) could not be processed into lumber or other useable products due to limitations in technology and other factors (i.e., sawmill design, lack of composite product manufacturing technologies, limits in chip and byproduct utilization). Through product innovation in the subsequent decades, including the development of fiberboards and diverse laminated products, forest product companies were able to find uses for the byproducts of lumber production, resulting in potential for greater utilization of the harvested wood. The energy embargo and oil supply disruptions in the 1970s pushed the industry further, as byproducts from forest product manufacturing became an important source of renewable energy generation (heat and power). Rising fossil fuel prices and the drive for renewable sources of affordable energy led to wider use of wood-based energy, both internal and external to forest products manufacturing industries. Continued innovation in fiber recovery, energy efficiency and manufacturing technology resulted in a forest sector that by 2005 had largely eliminated waste within primary processing facilities.[9] Similarly, progress toward a circular bioeconomy within pulp and paper manufacturing has occurred through development of pre- and post-consumer recycling capacity and end-of-life alternatives that include composting and bioenergy.

These changes which have occurred in the forest sector provide an example of the types of technology innovations, market diversifications, and systems change that are needed to transition toward a circular economy. The forest sector has made significant progress, and a goal of a more complete transition is within sight. Improvements in construction/deconstruction debris recovery and recycling of solid wood products are currently areas of focus for the forest sector. Within the circular bioeconomy of wood, new raw materials in the form of additional wood harvests are added to the system, but at a lower rate than would have occurred in the absence of the improvements in utilization technology that have occurred. These changes have directly contributed to a global wood consumption rate that has increased at a lower rate than that of population growth. There are examples of manufacturing and material utilization systems as they exist today within the forest sector that address all seven elements of a circular economy (Table 2).

[9] http://www.dovetailinc.org/report_pdfs/2012/dovetailwoodutilization1012.pdf

Table 2. Elements of the circular economy represented in the forest sector (Source: Author derived examples)

Element of a Circular Economy	Examples of Forest Sector Condition or Practice
1) **Prioritize regenerative resources**	Use of wood, a renewable natural resource
2) **Preserve and extend what is already made**	Technologies and innovations that extend the useful life of products (forest product development, design and engineering)
3) **Use waste as a resource**	Byproducts from one manufacturing process (e.g., sawdust and chips) are utilized as a resource for other products (e.g., fiberboard). Material from deconstruction of wood structures are collected and processed for further use as construction materials or repurposed. Technology developments (perhaps including application of nanotechnology) allow a greater portion of fiber from recycled high-grade papers to be used in producing additional quantities of high-grade papers. Generation of renewable energy from wood materials.
4) **Rethink the business model**	Companies that provide pre-fabrication to reduce waste generation and improve efficiencies (a design and construction service model vs. a building material supplier model)
5) **Design for the future**	Research, innovation, and code changes to support tall wood buildings (i.e., Cross Laminated Timber (CLT) design and construction), bioenergy, nanotechnology, and other circular bioeconomy developments
6) **Incorporate digital technology**	Use of technology in forest management and conservation and in optimization of manufacturing processes
7) **Collaborate to create joint value**	Public and private partnerships and initiatives to support innovations in the forest sector, including ENGO engagement

Impacts on Forest Resources

An important consideration in the promotion of an economy based upon enhanced use of forest products is the potential impact on forest resources. A common misconception is that growth in demand for forest products has an inherently negative impact on forest resources. History and research demonstrate that this assumption is not entirely accurate. For example, in the US, the period of forest industry expansion and innovation shown in Figure 3 corresponds to a period of increasing net forest growth (Figure 4). One of

the major trends during this period was the reforestation of former agricultural production areas in the eastern U.S. Even since 1997, U.S. forestland has further increased by 3% to reach 765 million acres, which is 10 million acres more than the same geographic region had in 1900.[10]

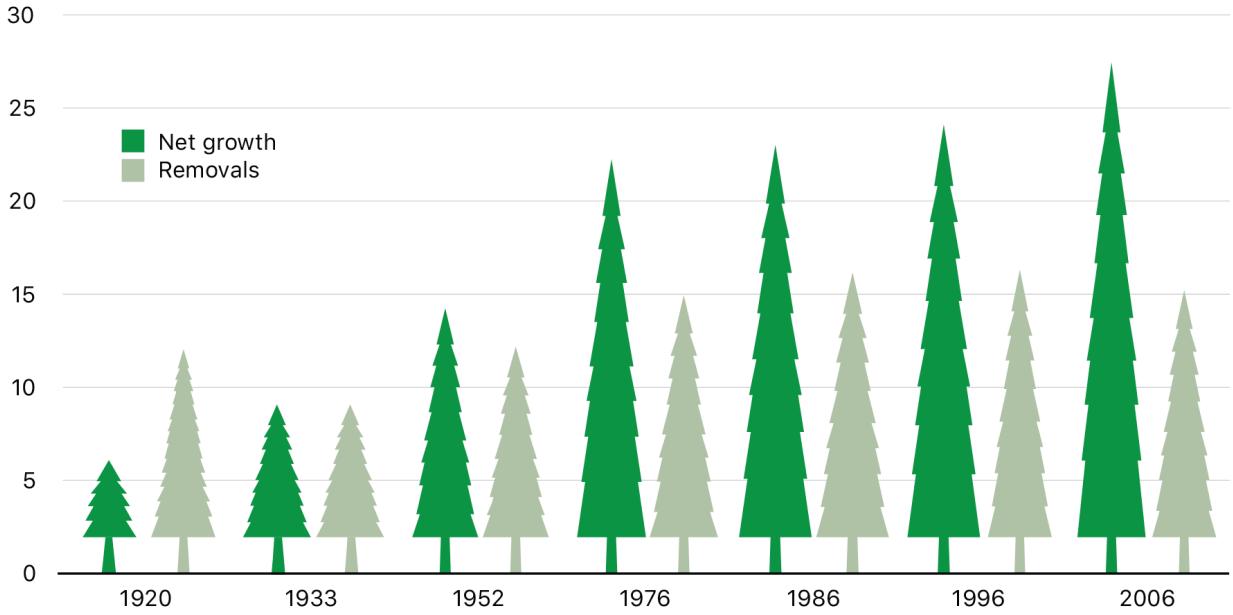

Figure 4. U.S. Timber growth and removals, 1920-2006 in billions of cubic feet per year (Source: https://www.lumi.com/blog/managed-forests)

Research has consistently demonstrated that agricultural expansion is the primary contributor to deforestation globally.[11] A key strategy for maintaining global forest resources lies in addressing stabilization in our food production and consumption trends.[12] Unsustainable logging and other land use practices can contribute to forest degradation and must be addressed through policy actions and market-based mechanisms. At the same time, the role of forest plantations and other forms of intensive forest management in contributing to greater land use efficiencies can also be recognized. For example, forest plantations comprise only about 7% of the forested area globally but provide more than a third of industrial wood supplies. Risks to forest sustainability are further mitigated in the forest sector through voluntary forest certification programs and implementation of trade policies that combat illegal logging. With these considerations in mind, strong markets for diverse forest products can support an improved circular bioeconomy as well as vibrant forest resources and forest-based economies.

[10] For more information about U.S forests, current conditions, trends, and history, see: https://usaforests.org/ and https://www.fia.fs.fed.us/program-features/rpa/

[11] WWF. 2015. Living Forests Report Chapter 5: Saving Forests at Risk https://www.worldwildlife.org/publications/living-forests-report-chapter-5-saving-forests-at-risk

[12] Public Library of Science. "Historic trends predict future global reforestation unlikely." ScienceDaily. ScienceDaily, 9 October 2013. www.sciencedaily.com/releases/2013/10/131009100221.htm

Circular bioeconomy in the European forest sector

The European Commission (EC) adopted an action plan in 2015 to accelerate Europe's transition to a circular economy, boost global competitiveness, promote sustainable economic growth and generate new employment.[13] The plan has 54 measures designed to "close the loop" of product lifecycles, encompassing production, consumption, waste management and the market for secondary raw materials, and everything in between. A 2019 report evaluated progress on the EC's 2015 Action Plan and documented substantial progress thanks to EC and European Union (EU) Member State governments' support along with strong stakeholder engagement.[14] Most EU Member States have adopted or are adopting national strategies for a transition to a circular economy. The circular economy concept is a cornerstone of the EU industrial policy and for developing Europe's future economic model. It has been promoted in Europe as a new economic model that can support growth, competitiveness and create new jobs for Europe.[15]

The circular economy concept provides a business model for many multinational corporations in Europe. The World Business Council for Sustainable Development (WBCSD) has published a "CEO guide to the circular bioeconomy"[16] and a "practitioner's guide to the circular bioeconomy".[17] The WBCSD considers the circular bioeconomy a solution to today's greatest environmental challenges. It sees it as an $8 trillion per year business opportunity throughout the next decade. According to the WBCSD, circular economies foster new markets, improve competitive advantages, and help to mitigate risks.

There are several recognized barriers to implementation of a circular economy. According to the Center for European Policy Studies (CEPS) these barriers include:

1. Lack of support in supply and demand networks
2. Lack of capital
3. Lack of government support
4. Administration burden
5. Lack of technical skills
6. Lack of information
7. Company environment culture

There are also practical and operational challenges according to the CEPS:

1. Shipment of waste for recovery: its cost and infrastructure
2. Uncertainty about substances included in products. Lack of adequate labeling and tracking
3. Low progress in setting eco-design requirements
4. Need for more evidence on the merits and demerits of different circular options
5. Wide difference in waste management performance across EU Member States. A lack of waste collection and infrastructure.

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[13] Towards a circular economy. EC. https://ec.europa.eu/commission/priorities/jobs-growth-and-investment/towards-circular-economy_en

[14] Report from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions on the implementation of the Circular Economy Action Plan. 2019. https://ec.europa.eu/commission/sites/beta-political/files/report_implementation_circular_economy_action_plan.pdf.

[15] Moving towards a circular economy: EU policy framework and current challenges. By V. Rizos, Center for European Policy Studies. Keynote presentation at UNECE/FAO, 4 November 2019. http://www.unece.org/fileadmin/DAM/timber/meetings/2019/20191104/2-Circular_Economy-V._Rizos_CEPS.pdf

[16] https://www.wbcsd.org/Programs/Circular-Economy/Factor-10/Resources/CEO-Guide-to-the-Circular-Economy.

[17] https://www.ceguide.org/

Based upon these insights and identified needs, the priorities of the forthcoming 5-year policy cycle according to the CEPS are:

1. Assess ways to facilitate the movement of waste for safe recovery of resources within the EU
2. Expand eco-design rules to non-energy-related products
3. Facilitate the trade and sale of remanufactured/refurbished goods in a global market
4. Boost demand for circular, bio-based products, e.g., by public procurement
5. Need for evidence base/scientific knowledge on the advantages and disadvantages of different circular bio-based options
6. Focus on implementation of new waste rules

The widespread and well-established interest in growing the circular economy in Europe provides policy models, business examples, and research priorities that can inform greater engagement in other regions.

Challenges and Opportunities Ahead

While the forest sector today provides a compelling example of substantial progress toward a circular economy, progress has not been without challenges. Most notably, as markets for individual forest products have changed (grown or shrunk), the connected circular economy partners are significantly affected. For example, when demand for lumber increases, one result is greater production of sawdust and other byproducts, but associated markets for fiberboard and other materials that use these byproducts may not experience corresponding growth, thus creating gaps in the circular economy.[18] To address these gaps and maintain circularity, it is important to have sufficient uses and markets for the full range of materials generated in the forest sector.

In recent years, as traditional uses of paper and other products have declined, circularity challenges have emerged in the forest sector. Like the previous example, lumber manufacturing is highly competitive today and if a sawmill loses markets for its byproducts, such as chips typically used in making paper, the entire mill operation may lose economic viability. To support continued progress toward a circular economy in the forest sector, it is necessary to continue to develop new and innovative uses for the various byproducts and waste streams generated throughout the production and use cycle of forest products.

In the U.S., approximately 90% of harvested wood utilized by the forest products industry comes from privately owned lands. Models of circularity in which current areas of forest are retained, will require new and innovative uses for not only byproducts and wastes, but for harvested wood and wood fiber as well. Should markets for harvested wood shrink over time, it is highly likely that currently forested land, especially privately-owned lands, will be converted to other types of land uses which offer greater economic value.[19] Strong and diversified markets for harvested wood are the most economically efficient way to incentivize private land owners to keep forests as forests.

While many circular economy efforts are appropriately focused on radically reinventing major raw material consumption flows such as steel, plastic, and food systems that face significant challenges in their transition, it would be a mistake to not include prioritization of strengthening circular economies where

[18] Similar challenges arise when conditions change in markets for recycled materials.

[19] For further discussion, see: Ince, Peter J. 2010. Global sustainable timber supply and demand. Sustainable development in the forest products industry, Chapter 2. Porto, Portugal: Universidade Fernando Pessoa, 2010: p. 29-41. ISBN: 9789896430528. https://www.fs.usda.gov/treesearch/pubs/37326

they already exist. Natural resources and the forest sector are cases in point. Supporting demand for traditional forest products and materials like cross-laminated timber for tall wood buildings can be strategically coupled with the development of opportunities for biomass energy, biofuels, pellet production, bio-based chemicals, bio-based plastics, and even human and animal nutrition derived from forest resources. Adding innovations in material recovery for solid wood products and deconstruction activities will further enhance these systems. Strong and diverse markets for a full range of forest products are essential to maintaining and building upon the existing circularity in the forest sector.

The forest sector also offers an opportunity to aid in the transformation of other value chains through collaboration (#7, Table 2) within the circular economy. For proponents of the circular economy, one of the core concepts is moving from addressing sectors (linear and insular) to creating transitions across value chains, and this is where the forest sector can play a significant role. Global concerns about pollution, including plastic waste in our oceans and the need to cut CO_2 emissions call for alternative materials and products that are renewable, biodegradable, easily recyclable and that *store* rather than release carbon.

A key role for the forest sector in a circular economy is in its ability to provide renewable, biodegradable raw materials – a strategic resource that can be used for creation of many advanced, reusable and recyclable biomaterials. These materials can support various value chains and prompt transformation in a number of strategic sectors of the economy such as construction and manufacturing. The most illustrative examples of the emerging forest-based value chains include wood-based construction, textiles production, packaging innovations, and bioplastics.[20] There are also diverse opportunities related to bio-based chemicals, pharmaceuticals, and cosmetics.

The Bottom Line

Sustainability concepts, including associated economic models, continue to emerge and the latest discussions around the "circular economy" bring together many of the prior existing ideas into a system for production and consumption that addresses environmental and economic opportunities holistically and strategically.

In many ways, natural resources, including forest products, have well-established circular economy practices that include utilization of byproducts, material recovery, renewable energy systems, and minimized waste production. However, major natural resource interests, including the forest sector, are not well represented in many circular economy discussions and initiatives. There is an opportunity for the forest sector, including diverse public and private organizations, to engage and lead in the support of circular economy efforts to ensure the role of forests and their multiple products is articulated, and that the benefits and impacts resulting from the proposed innovations lead to more vibrant forests and forest-based economies.

While the circular economy movement is appropriately focused on radically reinventing major raw material consumption flows such as steel, plastic, and food systems that face significant challenges in their transition, it would be a mistake to not include the prioritization of shoring up and strengthening a circular bioeconomy where it already exists in natural resources and the forest sector. Supporting demand for traditional forest products and materials like cross-laminated timber for tall wood buildings, can be strategically coupled with the development of opportunities for biomass energy, biofuels, pellet

[20] For further discussion, see: http://www.unece.org/info/media/news/forestry-and-timber/2019/european-forest-week-2019-to-highlight-the-role-of-forests-in-the-circular-economy/doc.html

production, bio-based chemicals, bio-based plastics, and even human and animal nutrition derived from forest resources if we are to strengthen the circular economy in the forest sector. A key role for the forest sector in a circular bioeconomy is in its ability to provide biodegradable raw materials – a strategic resource that can be used for creation of many advanced, reusable and recyclable biomaterials.

Additional Resources

- **PACE** is the platform for global leaders and their organizations to accelerate the transition to a circular economy. PACE provides leaders in the circular economy with the connections, learning, and opportunities to pilot and rapidly scale best practices - https://pacecircular.org.
- The mission of **Circular Economy** is to empower a global community of businesses, cities and governments to accelerate the transition to the circular economy through practical and scalable insights and solutions that address humanity's greatest challenges - https://www.circle-economy.com.
- Report from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions on the implementation of the Circular Economy Action Plan. 2019. https://ec.europa.eu/commission/sites/beta-political/files/report_implementation_circular_economy_action_plan.pdf

Report published by:

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