Chapter 7

Forest Products

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The United States and the world have undergone immense economic, social, and economic change over the 10 years since the last Resources Planning Act (RPA) Assessment, all of which have impacts on production and consumption of forest products. This chapter describes recent trends in global and U.S. forest product consumption, production, and net trade and also explores economic projections of production, consumption, net trade, timber harvest levels, and timber prices, as influenced by four future scenarios regarding economic and population growth and changing biomass energy demand through 2070.

Key Findings

- The future of U.S. markets is shaped by strong growth in emerging economies, stable- to slightly-growing domestic demands, and by policy factors related to energy embedded in alternative scenarios. U.S. timber production and consumption are projected to remain strong with varying levels of growth across RPA scenarios, but with important changes in the product mix.
- U.S. industrial roundwood production is projected to rise faster than derived product manufacturing demand, resulting in the United States capturing a growing share of global industrial roundwood export markets.
- The U.S. South is projected to remain the dominant timber producing region in the world despite projected losses in forest area, producing around 10 percent of total industrial roundwood under all RPA scenarios.
- The U.S. paper sector has undergone a transition related to declining demand for graphics paper and the shift in global markets to overseas paper production in the last 20 years that is projected to continue into the foreseeable future.
- Overseas demand for hardwood roundwood and lumber provides a base of support for domestic U.S. production.
- Projected futures in the production and consumption of wood to generate energy depend on policy assumptions and consumer preferences and vary widely by RPA scenario.
- If current policies encouraging wood use in energy production are maintained in Europe, the United States is projected to have a durable and growing wood pellet export market through 2070. Across all RPA scenarios, future pellet production does not exceed 4.2 percent of total wood production.

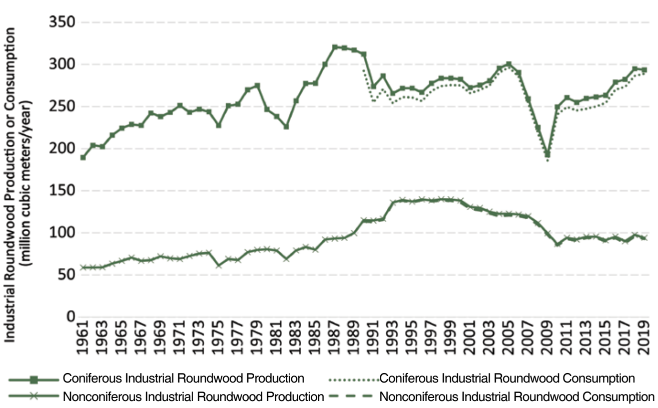
Historical Context

In 2009, the United States was emerging from a deep economic recession, the effects of which were evident in production of industrial roundwood (figure 7-1). The sharp contraction was due to substantial reductions in the demand for wood for the construction sector (Prestemon et al. 2018) and the diminished demand for paper for most end-uses (Wear et al. 2016). U.S. consumption of wood products, primarily from roundwood, rose during the recovery (Brandeis et al. 2021), while paper products consumption continued the trend of long-term decline evident since the late 1990s. The negative paper consumption trend was led by newsprint and printing and writing paper, due to substitution of electronic media (Latta et al. 2016). By 2019, total paper consumption levels still had not achieved rates observed in the late 1990s (Brandeis et al. 2021). Wear et al. (2016) attribute this weak growth to U.S. manufacturing overall, consistent with global findings (Hetemäki and Hurmekoski 2014).

From 2017 to 2020, the United States and its forest products sector were affected by increases in trade barriers, both on imports into the United States (particularly from Canada) and exports from this country to many of its major trading partners, such as Europe and China (Pan et al. 2021). Although there is uncertainty about the future evolution of trade frictions, the scenario-based approach used in this Assessment provides for a range of possible tariff environments, likely bracketing much of that uncertainty.

Today, the nation and the world are emerging from the sharpest economic contraction since the Great Depression, due to the SARS-CoV-2 global pandemic. The base year of our projection scenario falls before the pandemic and our focus is on long-run projections, so the results we present do not directly incorporate the sharp, short-term dynamics in the economy that buffeted the sector. However, a sidebar of this chapter does evaluate some of the dynamics and potential long-term implications of the pandemic on production, consumption, prices, and trade (see the sidebar A Short-Term Analysis of COVID-19 on the U.S. Forest Product Markets for more details). As the sidebar notes, the recovery from the spike-like economic contraction of mid-2020 has been sharp, in one way validating a perspective that short-run dynamics are usually subsumed in the secular trends that dominate in the long-run.

Figure 7-1. U.S. production and consumption of industrial roundwood, nationwide, 1961 to 2019.



Source: FAO 2021.

One dimension of market dynamics has been the evolving reliance on imports of forest products to meet domestic demands. The country has long been a net importer of wood products, particularly softwood lumber, softwood plywood, and oriented strand board for the construction sector (Brandeis et al. 2021). The sharp recessions observed from 2007 to 2009 and then in 2020 had little impact on U.S. import dependence in these products, with the Nation importing nearly one-third of its wood needs, particularly from Canada. In paper and paperboard, its import-dependence has receded along with demands for graphics paper (Brandeis et al. 2021).

Hardwood products also show temporal variations in production, consumption, and trade, related to the U.S. and global recessions, but secular trends in consumption and production have dominated. The United States is a net exporter of hardwood lumber, connected in part to the offshoring of furniture manufacturing in the 1990s and 2000s and corresponding growth in overseas furniture production (e.g., Grushecky et al. 2006, Schuler and Urs 2003). By 2019, consumption of hardwood lumber in the United States had declined by nearly 40 percent since its 1999 peak, a response to the disinvestment in the Nation's wood furniture manufacturing sector. U.S. hardwood industrial roundwood trends have been similarly impacted by the shifts in global wood furniture manufacture, particularly to Asia.

As Wear et al. (2016) point out, long-term trends in the U.S. forest sector are revealed not just in markets for forest products but also in its demands for inputs, including labor, capital, and wood. Employment in the wood products and paper sector has been trending downward for several decades (Wear et al. 2016). The employment trends accompany rising capital intensification and technology changes. The higher efficiencies in both labor and wood fiber use (Brandeis et al. 2021) have been enabled by innovations in manufacturing technology favoring capital over labor. The efficiency gains are further paired with the broad move away from paper as a medium for information delivery and the declining use of paper per unit of output by the U.S. manufacturing sector.

One feature of the U.S. forest product market, which can be described as an element of the sector's multiple trends but with an uncertain long-term trajectory, has been the rapid growth in the production and export of wood pellets for energy. Although pellets represent a small fraction (less than

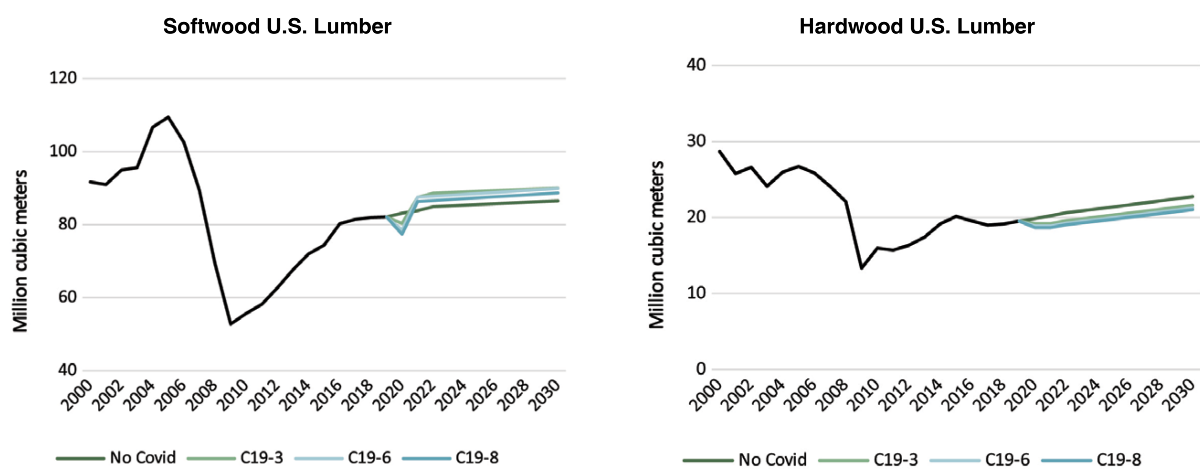
A Short-Term Analysis of COVID-19 on the U.S. Forest Product Markets

The second decade of the 21st century ended with a global pandemic caused by the SARS-CoV2 virus and the illness it produces, COVID-19. To contain the spread of the virus, governments implemented strict lockdown regulations which, along with fears of contracting the COVID-19 illness, shrank economic activity to lows not experienced in decades. Forest product markets were among those experiencing substantial disruptions early in the pandemic, ending a slow but steady rise in economic output in the United States and globally from the 2007 to 2009 global financial crisis. Despite experiencing some disruptions early on, the U.S. forest products sector rebounded quickly, yet the sector exhibited behaviors unique to the virus and differed from typical recessions. This sidebar places into context the scale of the pandemic's impacts on forest product markets and informs how such short-run market dynamics might be connected to the long-run dynamics described in the main part of the Forest Products Chapter.

To characterize the impacts of the pandemic on the sector, we applied an annualized version of the FOrest Resource Outlook Model (FOROM) model, which contains the essential features of the periodic FOROM model used in carrying out the long-run projections reported in the main body of the chapter. In carrying out what we label a COVID-19 scenario (abbreviated C19 in figure 7-2), a key modification has been made to accommodate a shorter run analysis compared to what was undertaken in the main chapter on forest products. To do this, we first updated the starting conditions of the projections to 2018 (rather than 2015, the starting point of the main chapter) and, in place of scenario-based projections, use the annual gross domestic product (GDP) forecasts of the Organization for Economic Cooperation and Development (OECD) for the world (OECD 2020) and U.S. Congressional Budget Office (CBO) for the United States (CBO 2020). The OECD and CBO forecasts for GDP envisioned a "V-shaped" recovery path. The modeling presented here also abstracts from the main chapter by not interacting (harmonizing) with the RPA Forest Dynamics Model in identifying model solutions. Variations on the scenario, C19-3, C19-6, and C19-8, quantify the effects under alternative 2020 U.S. GDP annual growth rates of -3 percent, -6 percent, and -8 percent, respectively. To identify the net effect of COVID-19 on the sector, we compared C19-3, C19-6, and C19-8 with a pre-COVID-19 projection of the U.S. and world economy made by CBO and OECD for 2020 and 2021. Assumed GDP growth from 2022 to 2030 stays the same for all the scenarios, corresponding to OECD's pre-pandemic projections (OECD 2020). Projections are to 2030, and our analysis focuses particularly on lumber markets.

According to the projections (figure 7-2), COVID-19 has time-varying impacts on lumber markets. Softwood lumber consumption, after an initial drop, quickly rebounds and exceeds what it would have been with no COVID-19. The difference increases to 2.2 to 3.5 million m^3 by 2030. Hardwood lumber consumption, in contrast, is projected to remain below the no-COVID-19 counterfactual level after its initial drop, 1.1 to 1.7 million m^3 less in 2030. The

Figure 7-2. Historic (1990 to 2019) and projected (2020 to 2030) U.S. lumber consumption, for softwood (left) and hardwood (right).



C19-3 = 2020 U.S. GDP annual growth rate of -3 percent; C19-6 = 2020 U.S. GDP annual growth rate of -6 percent; C19-8 = 2020 U.S. GDP annual growth rate of -8 percent.

combined effects of the changes in lumber consumption are to some extent consistent with Buongiorno (2021).

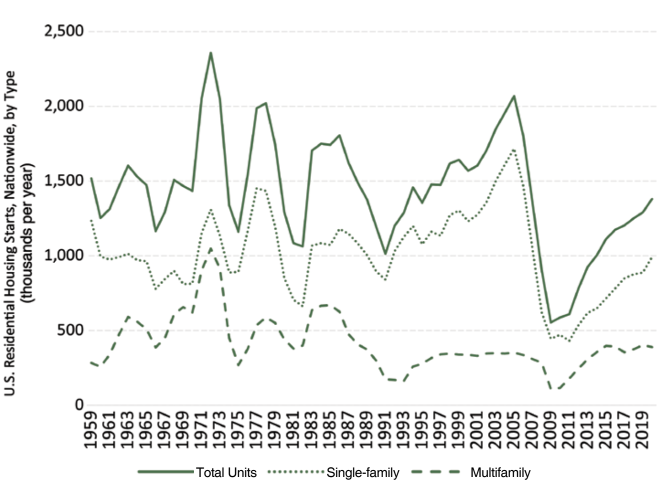
In line with the analysis in the Forest Products Chapter, the counterfactual analysis in this sidebar shows that the supply of and demand for forest products hinge on overall national economic growth. The rate of the economic growth following the 2020 nadir in consumption affects to what extent the forest product market may exhibit permanent impacts from the pandemic. A sharper but shorter "V-shaped" recovery makes up for the previous drop in growth and allows the production and consumption of forest products to return close to its long-run trend. In contrast, a longer period of U-shaped recovery reduces the production and consumption to a permanently lower level compared to the results based on the periodic FOROM.

This sidebar highlights the potential multi-year responses of forest product markets to COVID-19 disruptions. Evidence available today indicates that there were early significant disruptions in the wood products sector, but domestic U.S. production and imports slowly returned to near-normal levels 3 to 4 months after the United States first entered into a broad lock-down nationwide in March 2020 to limit virus spread (USDA FAS 2021). Despite the rapid increase in wood products demand following 3 to 4 months of subdued activity, the wood products sector has not proved immune to the multifaceted impacts of the pandemic. Producers were unable to respond to high demand promptly due to labor shortages and jumbled global supply chains (Riddle 2021), which constrained production combined with a relative abundance of standing timber volumes in much of the country—particularly in the Southern United States—and these factors combined to keep timber prices low (TimberMart-South 2021). We caution that this sidebar is not intended to be exhaustive of its effects of the pandemic on the sector; instead, it is provided to give a rough, first approximation of how it altered market conditions. Additionally, the simulation results are not intended to offer predictions of future market conditions but instead are offered to quantify how the pandemic affected markets.

2 percent) of all roundwood consumed, wood pellets have grown rapidly, destined for the European Union (EU) in support of that region's renewable energy policies.

The U.S. housing market (figure 7-3), a key component of wood products demand, has depended in part on a growing U.S. population and economy. Housing starts, in both single-family and multifamily units, have trended downward since World War II, although both categories are highly variable (U.S. Census Bureau 2021b). Prestemon et al. (2018) found a long-term trend downward in the number of housing units built, which could be connected to a slowing U.S. population (U.S. Census Bureau 2021a, Prestemon et al. 2022) and a slowing overall U.S. economy over time (e.g., Gordon 2016). To see how the projections in this chapter link to land use change, which embodies the new housing construction trends, see the sidebar The FOrest Resource Outlook Model (FOROM).

Figure 7-3. U.S. single-family and multifamily housing starts, 1959 to 2020.



Source: U.S. Bureau of the Census 2021.

A final long-term trend in the forest sector concerns climate (Tian et al. 2016). As greenhouse gases (GHGs) accumulate in the atmosphere, temperatures are rising and precipitation patterns are changing. Along with the higher GHG concentrations and higher temperatures is a general rise in net growth of forests, particularly when sufficient water is available to facilitate an acceleration in photosynthesis. Globally, forest productivity is expected to rise with altered GHG concentrations and higher temperatures. Such productivity rises could affect markets in diverse ways, including in the United States. With higher temperatures and the higher overall atmospheric water content that these higher temperatures enable, analysts expect changes in the frequency, intensity, spatial extent, and duration of natural disturbances, including from insects, diseases, tropical cyclones, wildfires, and droughts (see the Disturbance Chapter). Such disturbance changes may counter some of the climate forcing of forest productivity, and large-scale events can lead to market changes (e.g., Prestemon and Holmes 2000, 2004).

The future market outlook for forest products was projected from 2020 to 2070—based on a 2015 baseline—for the four future RPA scenarios (see the sidebar RPA Scenarios, as well as the Scenarios Chapter for more information), with the RPA climate projections incorporated through forest inputs from the Forest Dynamics Model (see the sidebar The FOrest Resource Outlook Model). These future scenarios provide a framework for describing a plausible range in the evolution of global forest product markets. When presenting the results, it is sometimes required to provide additional detail at the country/regional or product level. In these instances, the HM scenario (high warming-moderate U.S. growth) is used by default as it aligns closely with the SSP2 "middle-of-the-road" pathway, where many of the indicators broadly follow historical trends through 2070.

The future evolution of the U.S. and global forest products sector consistent with the RPA scenarios was modeled using the Forest Resource Outlook Model. FOROM incorporates various assumptions on socioeconomic developments consistent with the SSPs, and certain climatic influences on the global forest sector consistent with the RCPs. The sidebar FOrest Resource Outlook Model (FOROM) elaborates on how the four RPA scenarios were simulated within FOROM; those looking for more detailed information are encouraged to review Johnston et al. (2021).

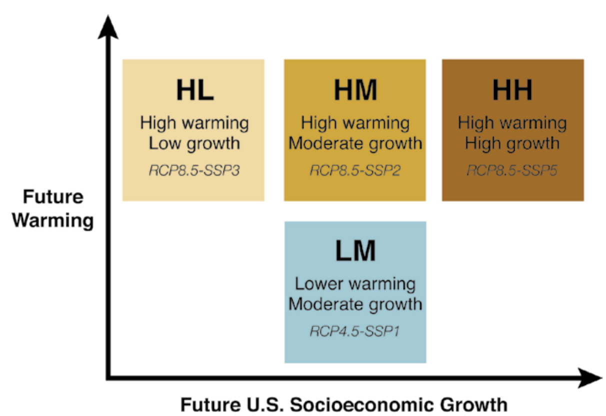
For a more in-depth overview of the state of the U.S. forest products sector, refer to other RPA products, including Status and Trends for the U.S. Forest Products Sector (Brandeis et al. 2021). Additional context about the United States as part of the global forest products sector is available from Wear et al. (2016) and Prestemon et al. (2015).

RPA Scenarios

The RPA Assessment uses a set of scenarios of coordinated future climate, population, and socioeconomic change to project resource availability and condition over the next 50 years. These scenarios provide a framework for objectively evaluating a plausible range of future resource outcomes.

The 2020 RPA Assessment draws from the global scenarios developed by the Intergovernmental Panel on Climate Change (IPCC) to examine the 2020 to 2070 time period (IPCC 2014). The RPA scenarios pair two alternative climate futures (Representative Concentration Pathways or RCPs) with four alternative socioeconomic futures (Shared Socioeconomic Pathways or SSPs) in the following combinations: RCP 4.5 and SSP1 (lower warming-moderate U.S. growth, LM), RCP 8.5 and SSP3 (high warming-low U.S. growth, HL), RCP 8.5 and SSP2 (high warming-moderate U.S. growth, HM), and RCP 8.5 and SSP5 (high warming-high U.S. growth, HH) (figure 7-4). The four 2020 RPA Assessment scenarios encompass the projected range of climate change from the RCPs and projected quantitative and qualitative range of socioeconomic change from the SSPs, resulting in four distinct futures that vary across a multitude of characteristics (figure 7-5), and providing a unifying framework that organizes the RPA Assessment natural resource sector analyses around a consistent set of possible world views. The Scenarios Chapter describes how these climate models were selected and paired; more details are provided in Langner et al. (2020).

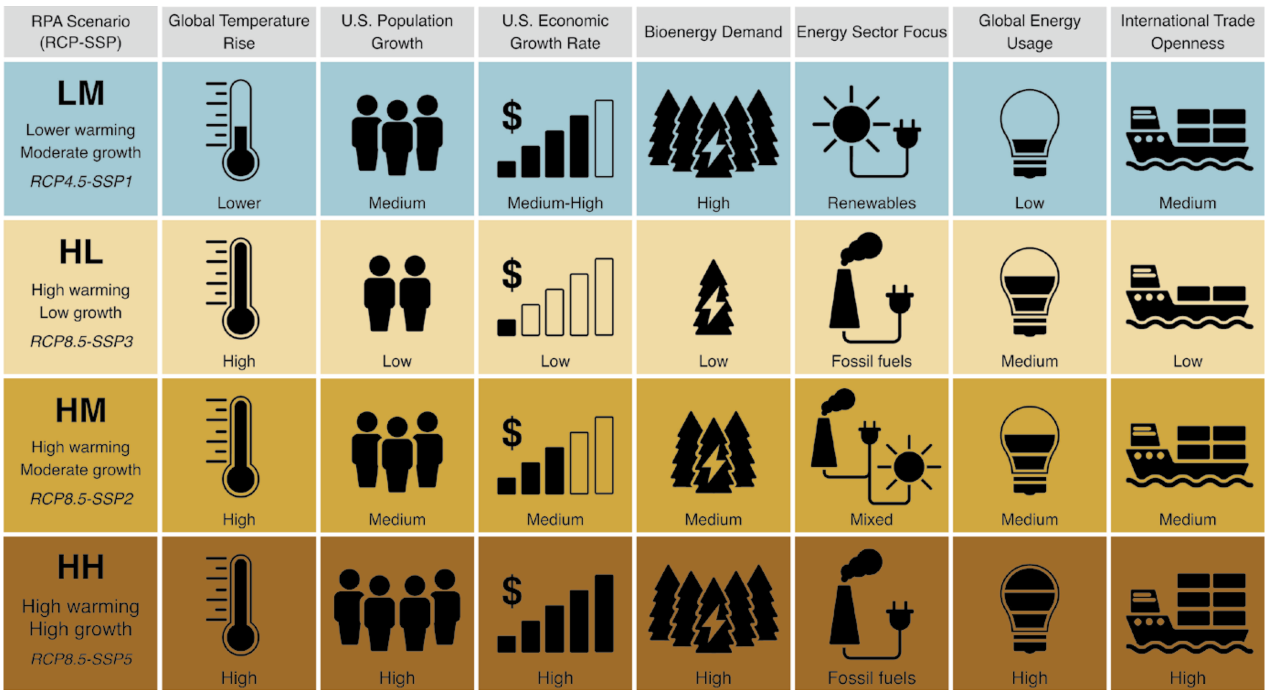
Figure 7-4. Characterization of the 2020 RPA Assessment scenarios in terms of future changes in atmospheric warming and U.S. socioeconomic growth. These characteristics are associated with the four underlying Representative Concentration Pathway (RCP) – Shared Socioeconomic Pathway (SSP) combinations.



Source: Langner et al. 2020.

The 2020 RPA Assessment pairs these four RPA scenarios with five different climate models that capture the wide range of projected future temperature and precipitation across the conterminous United States. An ensemble climate projection that averages across the multiple model projections is not used because of the importance of preserving individual model variability for resource modeling efforts. The five climate models selected by RPA represent least warm (MRI-CGCM3), hot (HadGEM2-ES), dry (IPSL-CM5A-MR), wet (CNRM-CM5), and middle-of-the-road (NorESM1-M) climate futures for the conterminous United States; however, characteristics can vary at finer spatial scales. Although the same models were selected to develop climate projections for both lower and high-warming futures, distinct climate projections for each model are associated with RCP 4.5 and RCP 8.5. The Scenarios Chapter describes how these climate models were selected. Joyce and Coulson (2020) give a more extensive explanation. An explanation of how the FOROM incorporated the effects of climate on forests globally is shown in the sidebar FOrest Resource Outlook Model (FOROM) and more extensively in Johnston et al. (2021).

Figure 7-5. Characteristics differentiating the 2020 RPA Assessment scenarios. These characteristics are associated with the four underlying Representative Concentration Pathway (RCP) – Shared Socioeconomic Pathway (SSP) combinations.



FOrest Resource Outlook Model (FOROM)

The FOrest Resource Outlook Model (FOROM) is a partial equilibrium model of the world's forest sector that includes forest resources, timber supply, demand for intermediate and final products, and international trade. The model is calibrated primarily to the FAOSTAT (FAO Stat 2021) 2015 base year information, supplemented with information from the U.S. Department of Agriculture, Forest Service's Timber Product Output (TPO) program and the United States International Trade Commission. The main function of this model is to analyze whether and to what extent production, consumption, trade, and prices of raw material, intermediates, and final products, as well as forest land area and forest standing stock, might change in response to external shocks such as economic growth, climate change, trade liberalization, or forest management.

FOROM incorporates various assumptions to help shape future conditions. The main drivers of the evolution of the global forest sector include exogenous trends in gross domestic product (GDP) and population. Market demand is assumed to change over time through exogenous shifts in GDP per capita, while changes in per capita GDP affect the marginal cost of production arising through changes in forest area and standing inventory.

Other exogenous assumptions, including technological development, provide the degree with which the global forest sector becomes efficient in transforming raw materials into finished products. Trade openness describes the frictions embedded in the model relating to the movement of goods between foreign regions of the model. In addition, the demand for bioenergy is calibrated to projections of primary and secondary biomass energy from the International Institute for Applied Systems Analysis Integrated Assessment Modeling framework, reflecting plausible differences in the future evolution of preferences (see Bauer et al. 2017).

To evaluate the forest sector impacts of climate change, exogenously projected changes in net primary productivity (NPP) were used in the FOROM to adjust the endogenous supply costs of each country/region outside the United States. Changes in NPP were simulated to 2070 at 0.5 degree-resolution globally by the dynamic global vegetation model MC2 (Kim et al. 2017), based on climate change (precipitation and temperature) and CO_2 (atmospheric forcing) change inputs. Climate and CO_2 change inputs to MC2 in Kim et al. (2017) were obtained from the MIT Integrated Global System Model-Community Atmosphere Model (IGSM-CAM) for RCP 4.5 (corresponding to the LM scenario) and RCP 8.5 (HL, HM, and HH RPA scenarios). MC2 projections under RCP 8.5 were averaged across all seven ensemble members (seven climate simulations) reported by Kim et al. (2017), while RCP 4.5 was projected with a single climate simulation from that study. NPP projections made by MC2 were aggregated to 16 global land units (countries or regions), and their average annual trends were converted to changes in forest productivity above base rates of growth for each country assigned to one of the global land units.

When solving for global forest sector solutions of the FOROM, however, climate-induced productivity change projections made by MC2 for the United States were replaced by those made by the RPA Forest Dynamics Model (FDM). FDM projections were averaged across the RPA climate projections (least warm, hot, dry, wet, middle) for each RPA scenario and each projection time-step. Projections of the U.S. forest sector made jointly with FOROM and the FDM were harmonized on inventory (volume) and removals (roundwood production) to find a roundwood price path where the inventory and removals for the United States aligned over the projection period. In each 5-year time step of FOROM, the FDM was used to calibrate inventory growth rates across the RPA regions, which were an exogenous input into FOROM. Then, FOROM projected an endogenous path of removals and roundwood prices. The roundwood prices were then used in the FDM harvest choice and timber supply models to project removals. The projected removals from FOROM and the FDM were then compared to ensure alignment.

Table 7-1 provides an overview of the defining characteristics of the RPA scenarios.

As GDP and population are key to the evolution of market projections in FOROM, they received special attention in the 2020 RPA Assessment. First, Wear and Prestemon (2019) developed a method to jointly downscale national-scale income and population projections to counties nationwide. This method was designed through statistical estimation of the relationships between historical personal income per capita at the county scale and population at the county scale. Downscaling was done such that the sum of income and the sum of population across counties matched the national level income and population projections,

Table 7-1. Key exogenous drivers of global trends in the RPA scenarios.

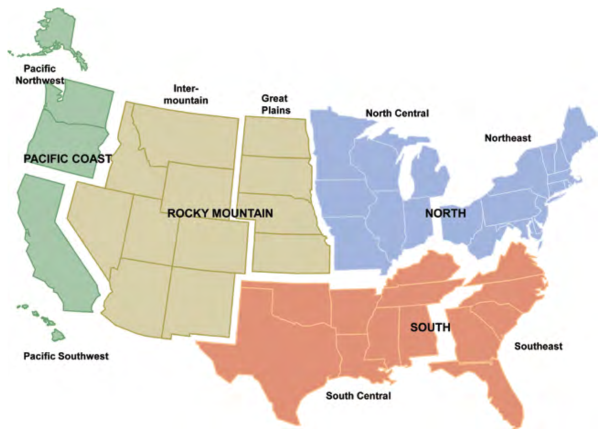
	RPA scenarios			
Exogenous driver	**LM**	**HM**	**HL**	**HH**
Socioeconomic				
GDP	High in LICs, MICs; moderate in HICs	Moderate	Low	High
Population	Relatively low	Moderate	Low in OECD, high in other countries	High in OECD, low in other countries
Technological change	High	Moderate	Low	High
Trade openness	Moderate	Moderate	Low	High
Bioenergy preferences	High	Moderate	Low	High
Climatic				
Atmospheric warming	Low	High	High	High
Motivated by the following IPCC scenarios				
SSP	SSP1	SSP2	SSP3	SSP5
RCP	RCP 4.5	RCP 8.5	RCP 8.5	RCP 8.5

GDP = gross domestic product; HIC = high income country; LIC = low income country; MIC = middle income country; OECD = Organization for Economic Cooperation and Development; RCP = Representative Concentration Pathway; SSP = Shared Socioeconomic Pathway; LM = lower warming-moderate U.S. growth; HL = high warming-low U.S. growth; HM = high warming-moderate U.S. growth; HH = high warming-high U.S. growth.

respectively, for each of the five Shared Socioeconomic Pathways; archived datasets are available from Wear and Prestemon (2019). Next, to generate projections of GDP and population at the RPA region level, a simple aggregation was done by summing projected personal income and projected population across all counties assigned to each RPA region.

FOROM explicitly recognizes the United States as six distinct RPA regions, separating the RPA North and South Regions into their component subregions for added specificity (see figure 7-6). The regional detail allows the model to directly account for changes in forest conditions and land uses and associated differences in regional production and demand conditions, including those emerging from independent projections of GDP and population from Wear and Prestemon (2019). For more detailed information on FOROM, see Johnston et al. (2021).

Figure 7-6. Resources Planning Act regions and subregions.



It is important to note that models like FOROM are calibrated to existing data, and parameterized based on historical relationships with existing product markets. Thus, as a limitation, these models cannot predict the invention of new products, or products that may be in their early stages of development (e.g., mass timber). Research on new products is ongoing, and some are considering how these new products may enter into models like FOROM (for an example, see Nepal et al. 2021 who explore various scenarios of integrating mass timber into FOROM).

Global Trends and Projections

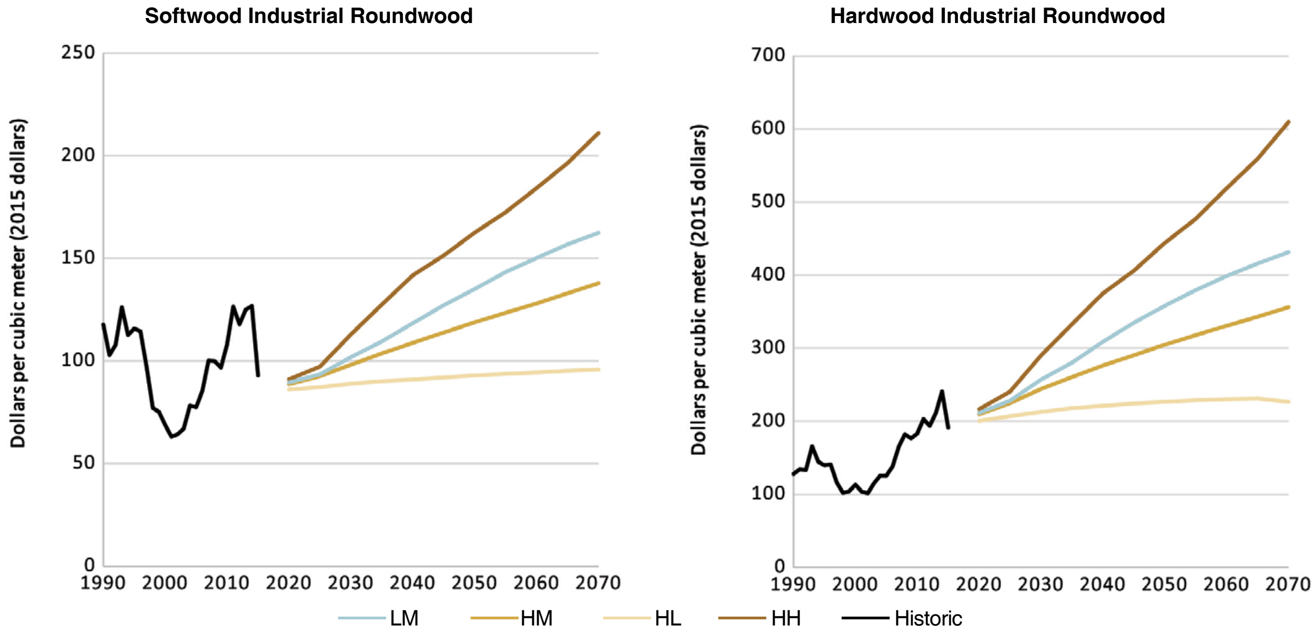
- ❖ Global forest products markets have been gradually recovering from the deep recession of 2007 to 2009. FOROM projects that global softwood roundwood consumption returns to pre-recession levels by 2020 and continues to grow thereafter. The hardwood industrial roundwood consumption trend resembles that of softwood but with a higher growth rate.
- ❖ Economic growth in emerging economies such as China and India drive much of the overall growth in demand for industrial roundwood across the scenarios.
- ❖ The consumption and production of new products such as wood pellets have the potential to increase significantly over the projection horizon under some scenarios but are contingent upon policy assumptions.
- ❖ There have been major structural changes in markets for some wood product categories since the deep recession of 2007 to 2009, including markets for newsprint and printing and writing paper which have experienced erosion in demand because of the growth in digital alternatives.

This section summarizes the market trends and FOROM-based global modeling results for major forest products (e.g., fuelwood and industrial roundwood) under the RPA scenarios. Historical data on the quantities of production, imports, exports, and unit values of products are available from Brandeis et al. (2021) for the United States and from FAO Stat (2021), which provided the input data for the global market model, FOROM. Global and U.S. projection data for this assessment are available from Johnston et al. (2022).

The real prices for softwood and hardwood industrial roundwood are projected to increase from 2020 to 2070 (figure 7-7). The prices exhibit large variations across the RPA scenarios, which are mostly driven by differences in the GDP developments. The price of softwood industrial roundwood products is expected to see the largest growth under the RPA HH scenario, rising from \$90.91 per m^3 to \$210.63 per m^3. In contrast, the HL scenario, which features a low GDP growth rate, is expected to see the lowest levels of price growth. Price elasticities of demand for hardwood are, on average, relatively smaller than that of softwood; therefore, a larger price rise is needed to satisfy the demand for hardwood industrial roundwood. Socioeconomic conditions, however, lead to the same general pattern of hardwood industrial roundwood price growth, with HH generating the highest and HL the lowest.

The demand for bioenergy in the form of fuelwood as well as wood pellets in FOROM are assumed to be driven not

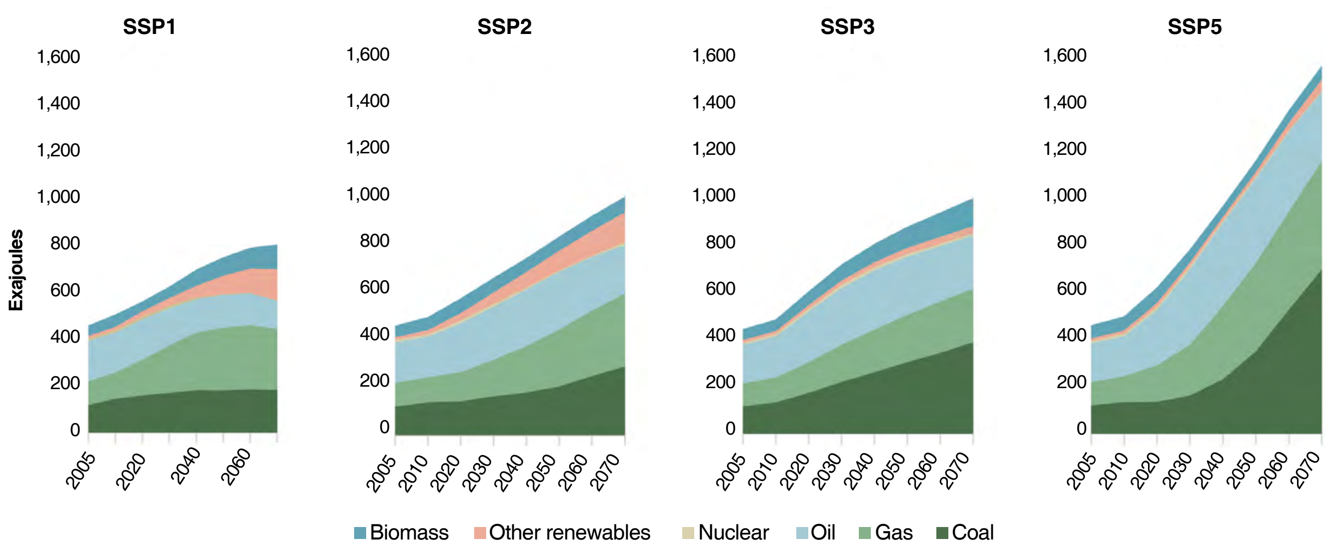
Figure 7-7. Projected average prices for global softwood industrial roundwood (left) and hardwood industrial roundwood (right) by RPA scenario, 2020 to 2070, relative to 2015 average prices.



LM = lower warming-moderate U.S. growth; HL = high warming-low U.S. growth; HM = high warming-moderate U.S. growth; HH = high warming-high U.S. growth.

only by economic development assumptions, but also by differences in consumer preference and policy assumptions underpinning the IPCC's Shared Socioeconomic Pathways (Bauer et al. 2017). For fuelwood demand, FOROM incorporates trends consistent with global primary energy from biomass from the IPCC SSP scenarios (figure 7-8). Similarly, the evolution of wood pellet consumption in FOROM is driven not only by changes in GDP per capita, but is also constrained using trends in global secondary biomass energy production to capture SSP-related preference and policy differences (figure 7-9). Global growth rates of secondary energy were used to scale recent regional growth rates. Secondary energy is energy that has been converted, and in the case of bioenergy, this could represent energy sourced from biomass including wood pellets.

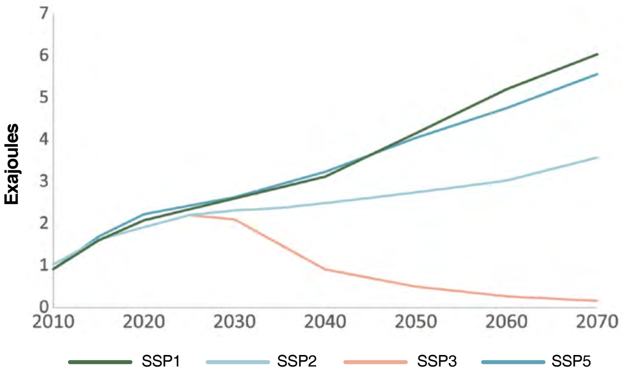
Figure 7-8. Global primary energy production for the IPCC Shared Socioeconomic Pathways used in the RPA Assessment.



IPCC = Intergovernmental Panel on Climate Change; SSP = Shared Socioeconomic Pathway.

Source: Riahi et al. 2017.

Figure 7-9. Global secondary energy production for the IPCC Shared Socioeconomic Pathways used in the RPA Assessment.



IPCC = Intergovernmental Panel on Climate Change; SSP = Shared Socioeconomic Pathway.

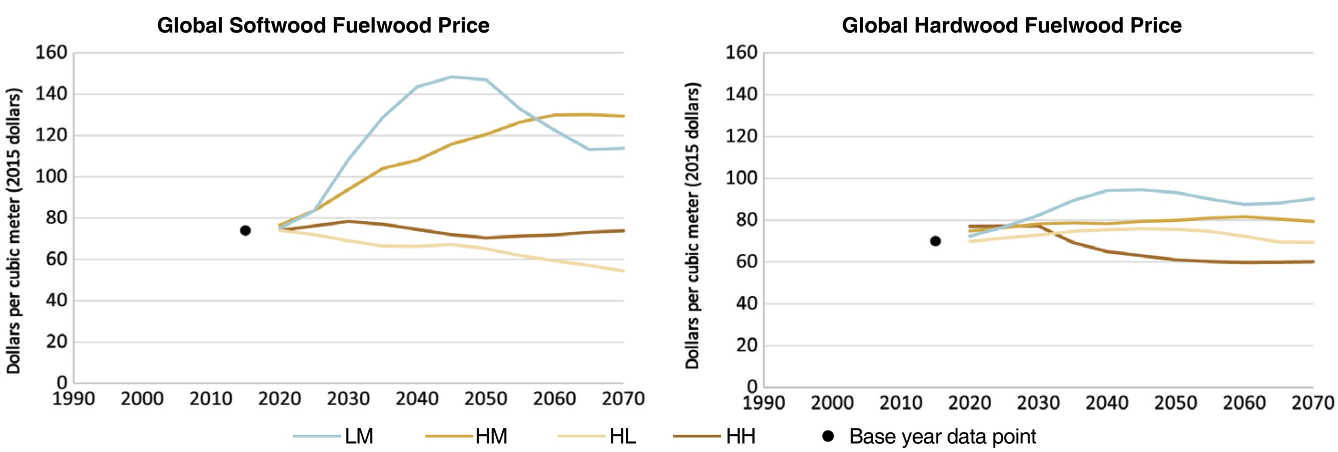
Source: Riahi et al. 2017.

To illustrate the projections of bioenergy demand under the RPA scenarios, consider the sustainability-minded SSP1 scenario that underpins the RPA LM scenario. Here, global average fuelwood consumption reaches its highest levels, driven in part by strong economic growth, but also from implied environmental and policy support. Correspondingly, we can see that in the LM scenario, the price of fuelwood rises rapidly and peaks in 2050 (figure 7-10). As preferences tend to shift more toward wood pellets, demand for fuelwood is gradually decreasing, resulting in a price drop. In contrast, the global average softwood fuelwood price in the HH scenario—a fossil fuel-dominated world—is expected to remain relatively unchanged. Even though there is a negative demand growth in the early period, the negative impact is mitigated by relatively high economic growth, leading to a relatively constant low fuelwood demand and price level throughout the simulation. The future price projection of hardwood fuelwood does not quite resemble the trends of softwood fuelwood because its positive income effect on demand is mitigated, to some extent. Thus, the growth rate of global average hardwood fuelwood price is smaller than that of softwood fuelwood price for the same scenario.

Over the past decade, the world has experienced a boom in wood pellets markets. Global wood pellet consumption reached 35.4 million metric tons (mt) in 2018, more than double its 2010 levels of 13.5 million mt. Europe is the world's largest wood pellet producer and consumer, mainly owing to EU's binding renewable energy targets for 2020 and 2030, and other environmental legislation. In 2018, the EU consumed 26.1 million mt of wood pellets but produced only 20.1 million mt. The gap between the supply and demand within the EU is contributing to the increasing importance of global wood pellet trade. In 2018, intercontinental trade in wood pellets amounted to 29 million mt, of which more than half (17 million mt) was imported from the United States by the United Kingdom.

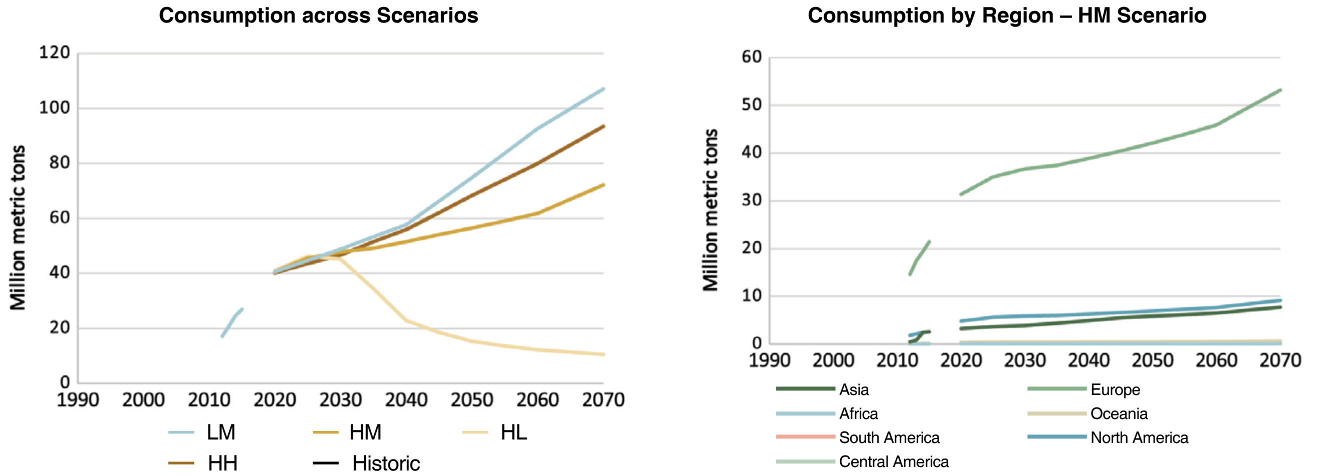
The RPA HL scenario is the only scenario in which global wood pellet consumption is projected to decrease (figure 7-11, left), which is primarily a result of projected expansion in fuelwood consumption and limited increase in industrial roundwood consumption. The other three scenarios exhibit a steady increase in the final consumption, ranging from 72 to 107 million mt across the RPA scenarios by 2070. Europe is undoubtedly the largest wood pellet consumer (figure 7-11, right), followed by North America. The growing trend continues throughout the simulation and the total consumption of wood pellets in these two regions reaches 53.2 million mt and 9.6 million mt by 2070, respectively (from 31.4 million mt and 4.8 million mt in 2020, respectively). However, it is important to note that future

Figure 7-10. Projected average prices for global softwood fuelwood (left) and hardwood fuelwood (right) by RPA scenario, 2020 to 2070, relative to 2015 average prices.



LM = lower warming-moderate U.S. growth; HL = high warming-low U.S. growth; HM = high warming-moderate U.S. growth; HH = high warming-high U.S. growth.

Figure 7-11. Historic (2012 to 2015) and projected (2020 to 2070) global wood pellet consumption across RPA scenarios (left) and by region within the RPA HM scenario (right).

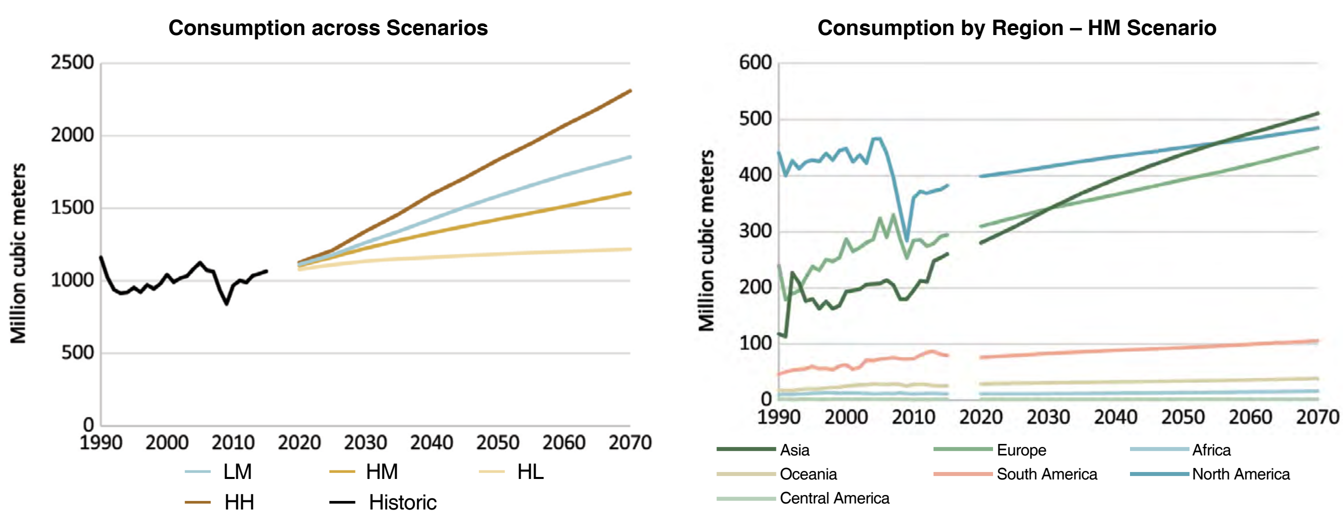


LM = lower warming-moderate U.S. growth; HL = high warming-low U.S. growth; HM = high warming-moderate U.S. growth; HH = high warming-high U.S. growth.

wood pellet markets have an additional layer of uncertainty compared to other products given the strong dependence on foreign policy and the treatment of wood in renewable energy targets.

Between 1990 and 2015, the global softwood industrial roundwood consumption fluctuated greatly, especially during the deep recession of 2007 to 2009 (sometimes referred to as the Great Financial Crisis, or GFC). After the U.S. housing bubble burst in 2008, softwood industrial roundwood consumption fell sharply. North America and Europe experienced the most severe consumption drop. With new housing construction rising since 2009, softwood lumber prices have risen, and softwood lumber and timber outputs have been gradually rising (Brandeis et al. 2021). Consumption will likely surpass the GFC level in 2020 and is projected to continue to grow by 2070 in all four RPA scenarios (figure 7-12, left). The projected global roundwood consumption trends directly hinge on assumptions about future economic growth. The consumption of softwood industrial roundwood more than doubles in the RPA HH scenario but only increases by 8 percent above its 2020 level in the RPA HL scenario. Regionally, the highest consumption growth is found in Asia, with China and India propelling the growth (figure 7-12, right). It is projected that industrial roundwood consumption in Asian markets will exceed that of the North American market in 2050 under the HM scenario and reach 511 million m^3 in 2070.

Figure 7-12. Historic (1990 to 2015) and projected (2020 to 2070) global softwood industrial roundwood consumption across RPA scenarios (left) and by region within the RPA HM scenario (right).



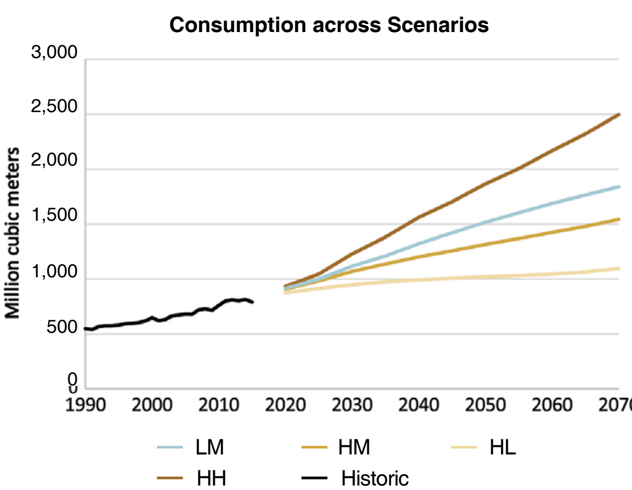
LM = lower warming-moderate U.S. growth; HL = high warming-low U.S. growth; HM = high warming-moderate U.S. growth; HH = high warming-high U.S. growth.

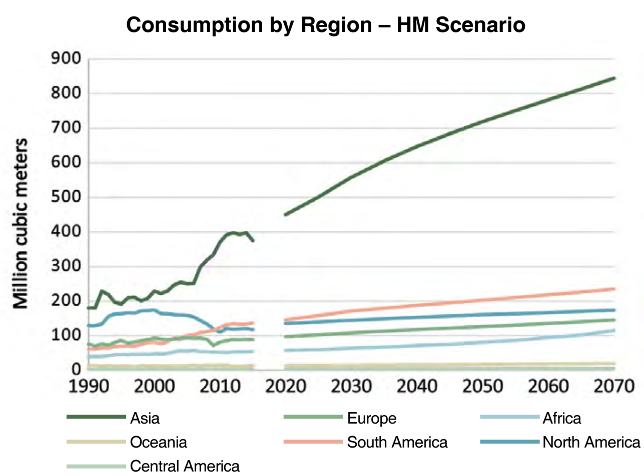
The lowest consumption growth occurs in Central America, where economic development is assumed to be slow and fragmented. North America has been, and is expected to continue to be, the highest per capita consumer of softwood roundwood with 798 m^3 per capita in 2020 and remain around this level through 2070. Asia is expected to increase its per capita consumption of softwood roundwood from 61 m^3 per capita in 2020 to 100 m^3 per capita in 2070.

Similarly, for hardwood industrial roundwood consumption, the largest increase occurs in the HH scenario and the smallest in the HL scenario (figure 7-13, left). The difference between the two scenarios reaches 1400 million m^3 in 2070. Global hardwood industrial roundwood consumption for scenarios HM and LM fall between HH and HL consumption levels throughout the projection period, largely because economic growth assumptions for these scenarios also fall between HH and HL. At the regional level, Asia is projected to continue to dominate hardwood industrial roundwood consumption (figure 7-13, right). Their share of global consumption is projected to increase from 48.2 percent in 2020 to 54.7 percent in 2070, reaching 844.5 million m^3 under the HM scenario. In contrast, other regional markets only experience minor additions to their roundwood use. South America is the highest per capita consumer of hardwood roundwood, consuming 340 and 487 m^3 per capita in 2020 and 2070 respectively. Meanwhile, Europe is projected to increase its consumption of hardwood roundwood from 97 to 165 m^3 per capita from 2020 to 2070.

The historical data indicate that a structural shift had been taking place in printing and writing paper markets since the beginning of the GFC. As the digital age matures, demand for printing and writing papers is expected to continue its trend of consumption decline throughout the projections (figure 7-14, left). In FOROM, the level of digital maturity is represented by GDP per capita. With the rapid growth in real GDP per capita, the LM scenario sees the largest reductions in the consumption of newsprint and printing and writing paper, to slightly more than one-fourth (26.12 percent) of its 2020 level by 2070. The decline is moderate in the HL scenario, where final consumption by 2070 amounts to 65 percent of 2020 global consumption levels (106.68 million mt in 2020). Figure 7-14 (right) shows a consistent negative trend in the consumption of newsprint and printing and writing paper across regions under the HM scenario. Asia accounts for the largest proportion of reduction, falling from 38 million mt to 11 million mt by 2070, followed by Europe and North America. Others have also highlighted this inverse relationship between economic growth and paper consumption, where economic development accelerates digitalization, and consumption patterns more rapidly shift away from hard print to digital alternatives (see Johnston 2016).

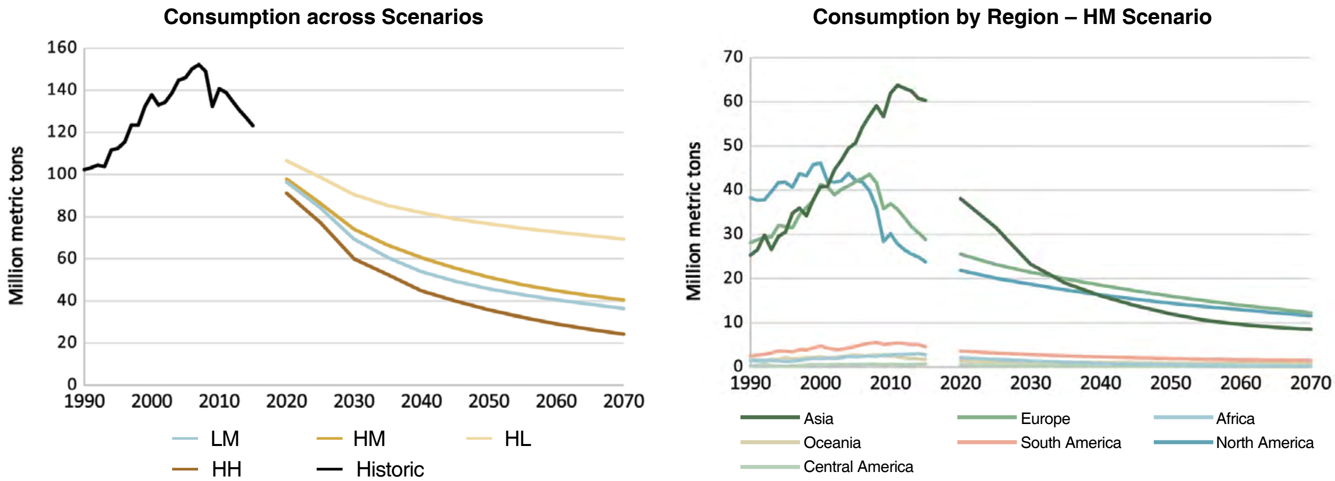
Figure 7-13. Historic (1990 to 2015) and projected (2020 to 2070) global hardwood industrial roundwood consumption across RPA scenarios (left) and by region within the RPA HM scenario (right).





LM = lower warming-moderate U.S. growth; HL = high warming-low U.S. growth; HM = high warming-moderate U.S. growth; HH = high warming-high U.S. growth.

Figure 7-14. Historic (1990 to 2015) and projected (2020 to 2070) global newsprint and printing and writing paper consumption across RPA scenarios (left) and by region within the RPA HM scenario (right).



LM = lower warming-moderate U.S. growth; HL = high warming-low U.S. growth; HM = high warming-moderate U.S. growth; HH = high warming-high U.S. growth.

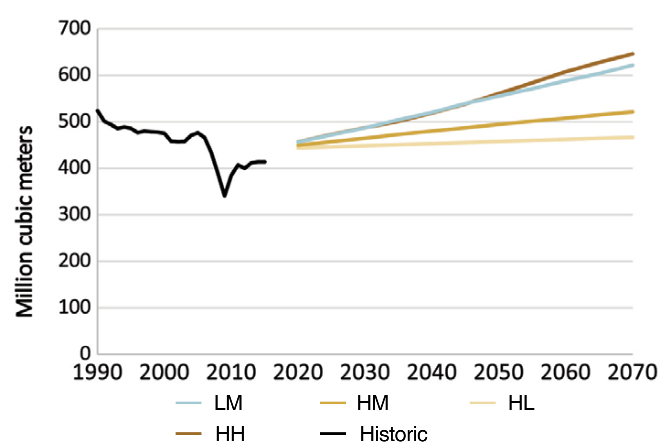
U.S. Trends and Projections

- ❖ U.S. roundwood production and prices are projected to trend upward across all scenarios, as wood product demand increases through 2070. Most projected production growth emerges from the RPA South Region, despite projected forest area shrinkage.
- ❖ Overseas markets are projected to support increasing net exports of hardwood lumber, and the United States is projected to become increasingly dependent on softwood lumber imports.
- ❖ Because of projected continued shrinkage in the demand for graphics paper and modest increases in the demand for other paper products, pulp production is projected to only increase slightly over the next 50 years. Two RPA scenarios (LM and HH) project a near doubling in the net export of non-graphics paper over this period.
- ❖ The RPA Southeast and South Central Subregions are projected to continue to supply the vast majority of wood pellets within the United States and remain the primary U.S. source of pellet exports through 2070.

Roundwood Production and Prices

Historical data and projections of U.S. roundwood production by RPA scenario are provided in figure 7-15. The production of roundwood in the United States trended downwards from the 1990s until the late 2000s. The global financial crisis in 2007 to 2009 saw a sharp reduction in roundwood production in the United States, falling from 466 million m^3 in 2007 to 341 million m^3 by 2009. A significant driver of this decline was the fall in residential housing construction, which dropped by about 75 percent between 2007 and 2009 (figure 7-3). Associated with this drop was a fall in the demand for building materials, particularly affecting softwood lumber and structural panel markets.

Figure 7-15. Historic (1990 to 2015) and projected (2020 to 2070) U.S. roundwood production by RPA scenario.



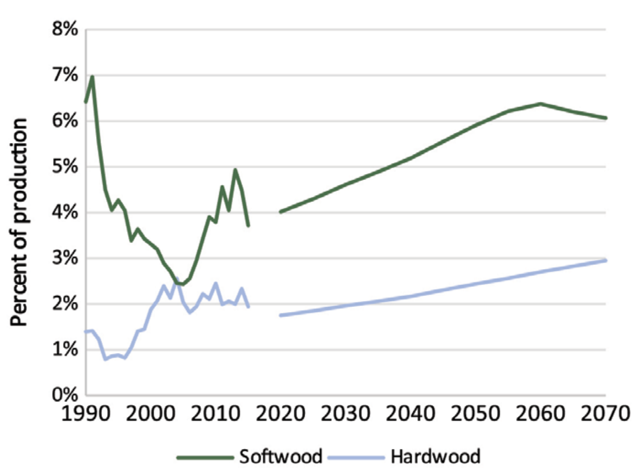
LM = lower warming-moderate U.S. growth; HL = high warming-low U.S. growth; HM = high warming-moderate U.S. growth; HH = high warming-high U.S. growth.

Since then, residential home construction and industrial roundwood production continue to rebound, with industrial roundwood production rising by roughly 20 percent between 2009 and 2015.

Projections of roundwood production across scenarios reach between an estimated 467 to 646 million m^3 by 2070 (figure 7-15). The production of roundwood is determined largely by the evolution of GDP, which varies from low under the HL scenario, to high under the HH scenario. Consumer preferences for fuelwood also impact the level of roundwood production. While the LM scenario is associated with only moderate growth in real GDP per capita, it relies on the socioeconomic developments under SSP1 which is grounded on strong sustainability preferences favoring bioenergy (see figures 7-8 and 7-9). Consequently, the LM scenario produces a similarly high level of roundwood. U.S. (and global) projection data for this assessment are available from Johnston et al. (2022).

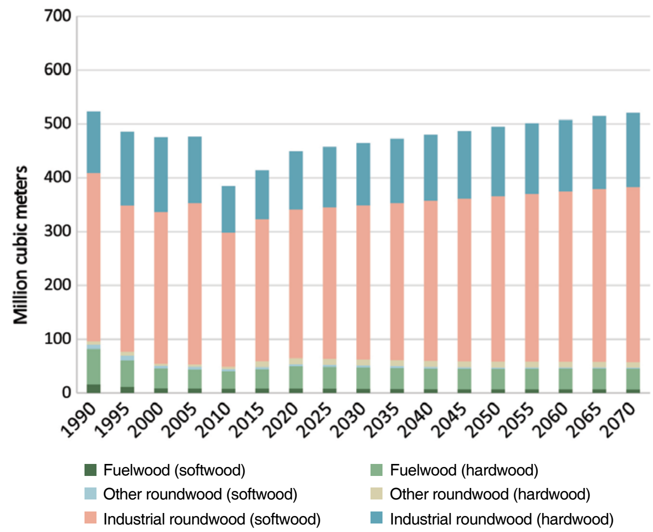
Figure 7-16 shows the export share of industrial roundwood production for softwood and hardwood roundwood. The GDP impacts of the GFC were pronounced within the United States, leading to sharp reductions in the demand for building materials. While similar effects were being felt in foreign economies, they tended to be less severe on average. As a result, this led to a reversal of the trend of a declining share of softwood roundwood production being exported observed in the 1990s for softwood roundwood, as domestic markets began to seek foreign buyers to compensate for reduced domestic demand. Markets for hardwood roundwood depend less on growth in residential housing, and export shares of production remained stable through the GFC period. Looking forward, FOROM projects an increase in the share of roundwood production exported for both hardwood and softwood under the HM scenario over the next 50 years, driven largely through the rapid consumption expansion of developing economies such as China and India.

Figure 7-16. Historic (1990 to 2015) and projected (2020 to 2070) U.S. industrial roundwood exports as share of production for the RPA HM scenario.



HM = high warming-moderate U.S. growth.

Figure 7-17. Historic (1990 to 2015) and projected (2020 to 2070) U.S. roundwood production by type for the RPA HM scenario.

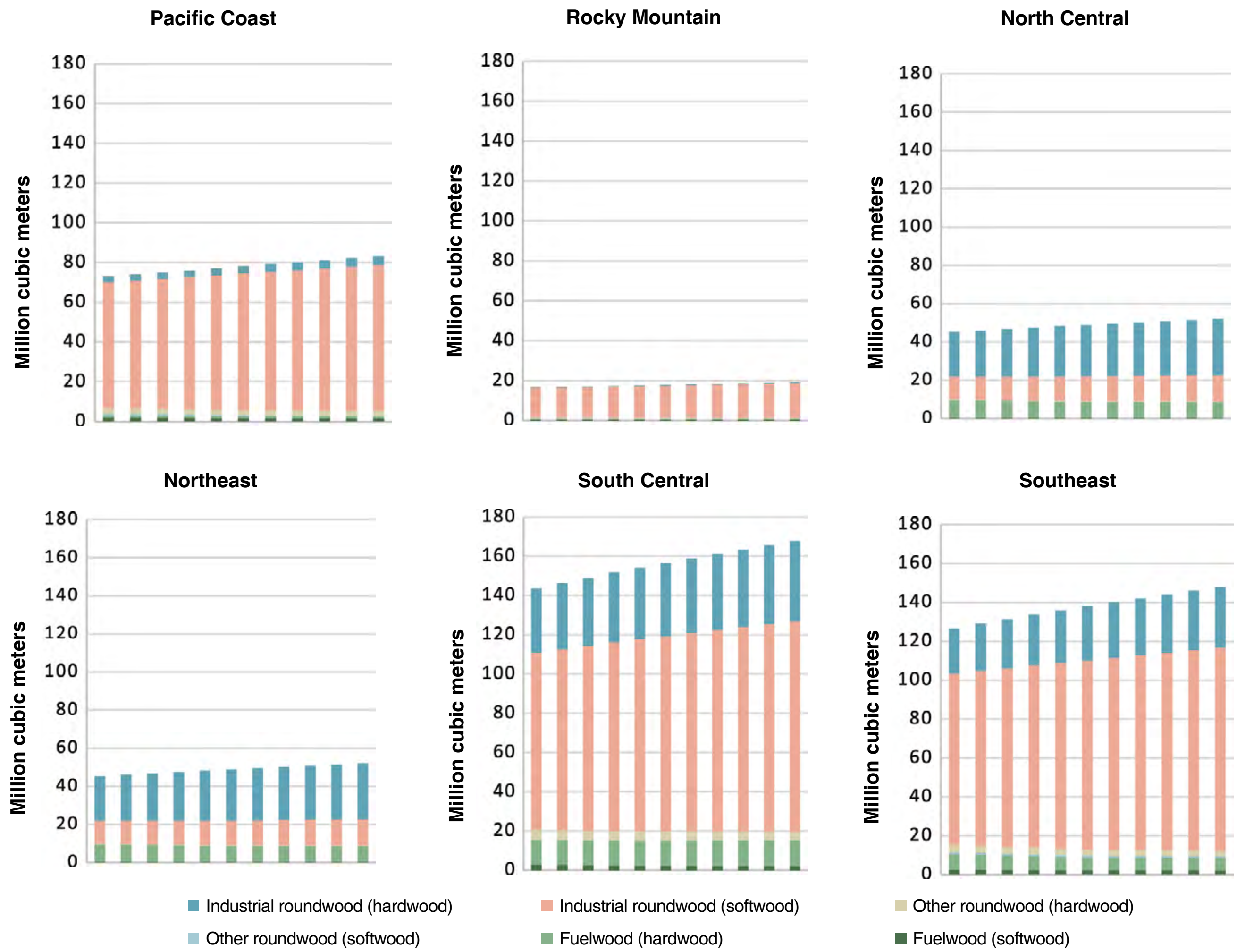


HM = high warming-moderate U.S. growth.

Since 1990, industrial roundwood from softwood and hardwood species composed over 80 percent of total roundwood production (figure 7-17). Before the GFC, the declines in roundwood production came predominantly from fuelwood and other roundwood categories, while softwood and hardwood industrial roundwood was more stable. However, during the GFC, the largest impacts were in the softwood industrial roundwood sector, driven through sharp GDP impacts affecting residential housing and other softwood-demanding sectors. FOROM projects the production of softwood industrial roundwood will return to pre-GFC levels in the coming decades, and mild growth in hardwood industrial roundwood production will materialize, driven largely through increased demand for hardwood fiber from emerging economies like India and China.

The FOROM model recognizes RPA Assessment regions as separate producing, consuming, and trading regions within a complete global market and can capture market dynamics by region across scenarios. Figure 7-18 depicts roundwood production projections by RPA region and by type, for the HM scenario. The classification of forest products used in this chapter is described in detail in Johnston et al. (2021, table A-3). Most of the growth across regions is projected to come from increased production of industrial roundwood, while other roundwood and fuelwood, regardless of species, is expected to remain constant. Most of the softwood industrial roundwood production is projected to continue to come out of the RPA South and Pacific Coast Regions, with the largest growth in softwood industrial roundwood

Figure 7-18. Projected roundwood production by RPA region for the RPA HM scenario, 2020 to 2070. The RPA North and South Regions are broken into subregions to provide additional information.



HM = high warming-moderate U.S. growth.

production coming out of the South Central and Southeast Subregions despite projected losses in forest area (see the Forest Resources Chapter). Meanwhile, the two RPA northern subregions rely more on hardwood industrial roundwood production. Despite this, the largest growth in hardwood production is projected to come out of the South Central Subregion.

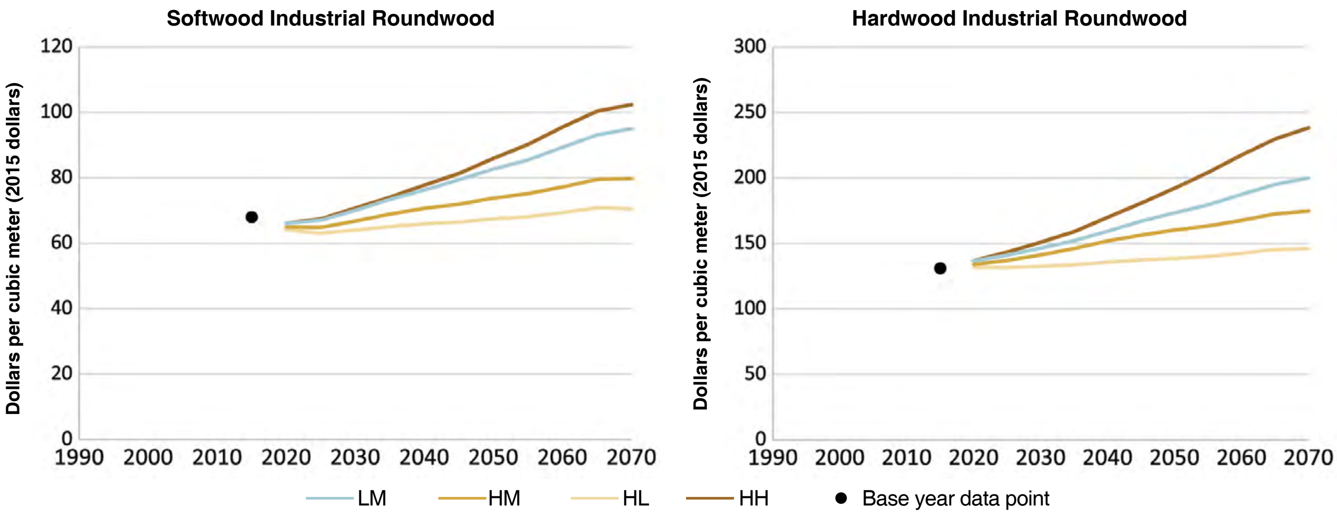
The average price of softwood industrial roundwood has been on a declining trend in recent years, which is projected to continue in the short run (figure 7-19, left). This trend could reverse quickly under a high-growth future scenario. The highest GDP scenario—the HH scenario—elicits the greatest demand for wood products, increasing the price of industrial roundwood the most relative to today's levels. Conversely, the lower growth HL scenario puts minimal pressure on the forest sector to meet demand, yielding, on average, an almost-stagnant path in the United States. Similar trends are projected for average U.S. hardwood industrial roundwood prices (figure 7-19, right).

Solid Wood Products

Lumber

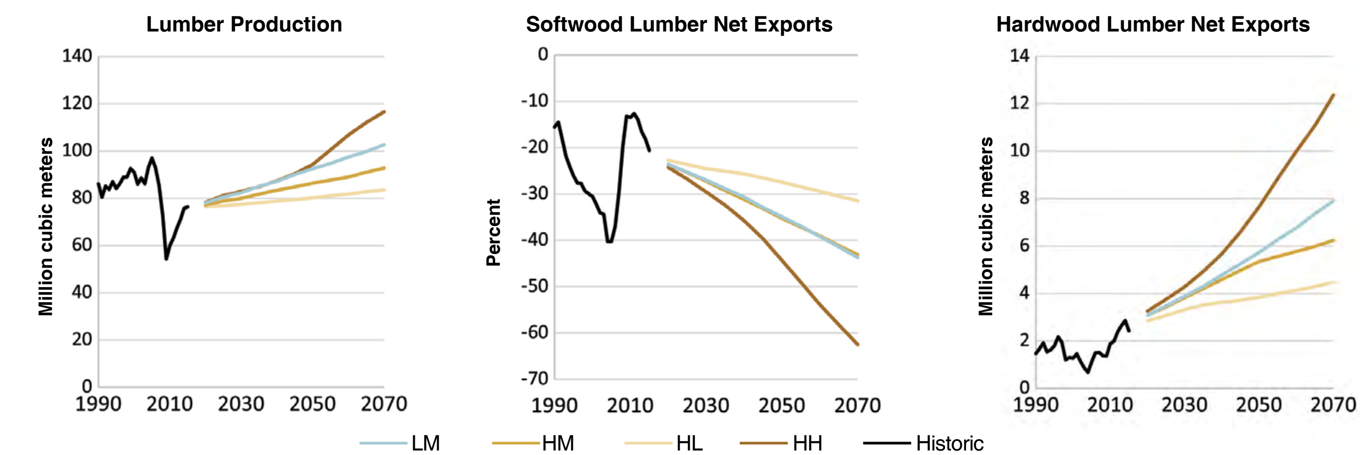
The production of lumber in the United States had been on an increasing trend before the GFC (figure 7-20, left), dominated by the production of softwood lumber—representing about 70 percent of total annual lumber production during this time.

Figure 7-19. Projected average prices for U.S. softwood industrial roundwood (left) and hardwood industrial roundwood (right) by RPA scenario, 2020 to 2070, relative to 2015 average prices.



LM = lower warming-moderate U.S. growth; HL = high warming-low U.S. growth; HM = high warming-moderate U.S. growth; HH = high warming-high U.S. growth.

Figure 7-20. Historic (1990 to 2015) and projected U.S (2020 to 2070): lumber production (left), softwood lumber net exports (middle), and hardwood lumber net exports (right), by RPA scenario.



LM = lower warming-moderate U.S. growth; HL = high warming-low U.S. growth; HM = high warming-moderate U.S. growth; HH = high warming-high U.S. growth.

The lumber sector experienced a sharp reduction in production in 2008 to 2009, brought about through reduced demand for residential home building materials. During this time, total lumber production fell from 93 million m³ in 2007 to 54 million m³ by 2009. Historically, the United States consumed more than it produced, making its net exports (exports minus imports) negative for softwood lumber, sourcing lumber primarily from Canada. During the GFC, net exports contracted towards zero (figure 7-20, middle), driven largely through a sharp reduction in the import of lumber, as the demand for this product eroded with reduced residential home construction. In contrast, the United States has historically been a positive net exporter of hardwood lumber (figure 7-20, right). Net exports of U.S. hardwood lumber were relatively unaffected by the GFC, because demand for hardwood lumber is less sensitive to fluctuations in residential construction, and being a net exporter of hardwood lumber meant this trade pattern was less sensitive to the domestic economic impacts of the GFC.

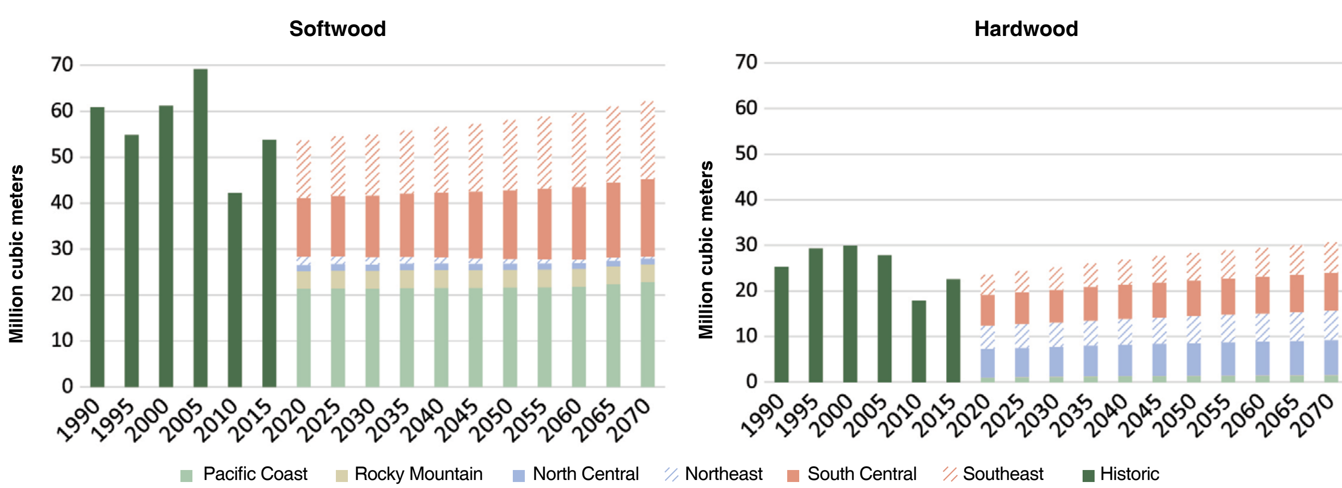
The future of lumber production in the United States is projected to be largely driven by the evolution of GDP assumed in the RPA scenarios. The high-income HH scenario sees the largest increase in the production of lumber, rising from 76 million m³ in 2015 to 117 million m³ by 2070 (figure 7-20, left). Meanwhile, the low-income HL scenario projects U.S. lumber production to reach only 84 million m³ by 2070. The scenarios project a continued trend of net softwood imports (negative net exports) under all scenarios (figure 7-20, middle). It is projected that net imports of softwood lumber in the United States will increase to 31 million m³ by 2070 under the low-income HL scenario, and as much as 62 million m³ by 2070 under the HH scenario. Meanwhile, the scenarios project a continued trend of net exports of hardwood lumber exports from the United States, ranging from at least 5 million m³ by 2070 under the HL scenario to as much as 12 million m³ by 2070 under the HH scenario (figure 7-20, right).

U.S. lumber production is projected to continue to be dominated by the production of softwood lumber, coming primarily out of the RPA South and Pacific Coast Regions (figure 7-21, left). While the Pacific Coast is currently the largest producer of softwood lumber, the model predicts only a 7-percent increase in production in the region between 2020 and 2070. Meanwhile, investments in planting and plantation forests have the South Central and Southeast Subregions increasing production by 32 and 36 percent during this period, respectively. Alternatively, production of hardwood lumber is concentrated in the four RPA South and North subregions, representing 95 percent of total hardwood lumber production combined (figure 7-21, right). Growth in production of hardwood lumber is projected to be distributed approximately evenly across these major producing subregions, driven in large part through increased foreign demand for these products from emerging markets.

Wood-Based Panels

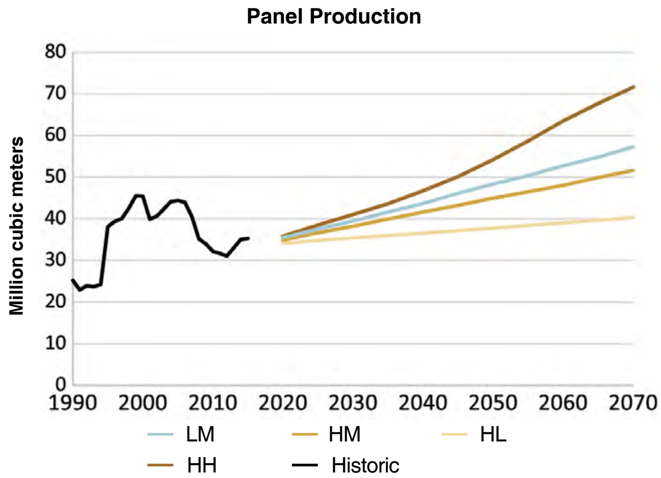
The production of wood-based panels in the United States experienced a similar adverse effect from the GFC and had yet to return to pre-GFC levels as of 2015 (figure 7-22). This is due, in part, to the slow rebound in U.S. residential home construction (figure 7-3), and the continued rise of China as the dominant wood-based panel supplier. Despite producing 35 million m³ in 2015, the United States has most recently been a net importer of wood-based panels (figure 7-22), again due in part to the low-cost alternatives coming

Figure 7-21. Historic (1990 to 2015) and projected (2020 to 2070) U.S. production of softwood lumber (left) and hardwood lumber (right) for the RPA HM scenario.



HM = high warming-moderate U.S. growth.

Figure 7-22. Historic (1990 to 2015) and projected (2020 to 2070) U.S. wood-based panels production (left) and net exports (right) by RPA scenario.



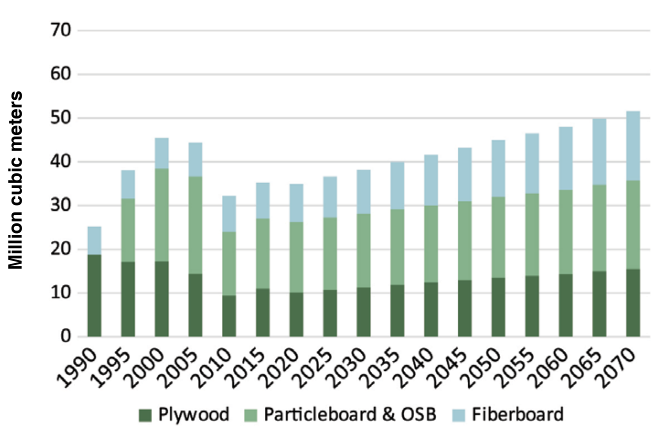
LM = lower warming-moderate U.S. growth; HL = high warming-low U.S. growth; HM = high warming-moderate U.S. growth; HH = high warming-high U.S. growth.

from foreign markets such as China. While production of panels has historically been dominated by the production of plywood and veneer (figure 7-23), the share of production from particleboard and oriented strand board (OSB) and fiberboard has been increasing since the 1990s. In 2020, about 70 percent of total wood-based panel production originated in the RPA South Region (figure 7-24).

The production of wood-based panels in the United States is projected to continue to increase under all scenarios (figure 7-22). The low-income HL scenario has production rising from 36 million m^3 in 2015 to 40 million m^3 by 2070. Production is projected to increase to as high as 72 million m^3 in 2070 under the HH scenario. The country is projected to become an even larger net importer of panels under the HL scenario, as the low-income path provides less foreign demand competing for these products (figure 7-22). Conversely, the opposite is true for the HH scenario, where high income growth around the world creates more competition for panels, raising prices and pushing the United States to reduce its imports.

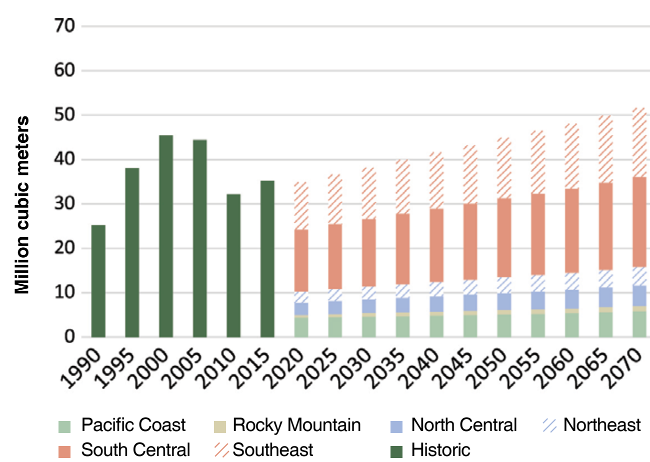
Production of panels is projected to continue to rely heavily on the South Central and Southeast Subregions through 2070 (figure 7-24). Under the HM scenario, it is projected that while plywood and veneer production will continue to rise modestly,

Figure 7-23. Historic (1990 to 2015) and projected (2020 to 2070) U.S. wood-based panels production by type for the RPA HM scenario.



HM = high warming-moderate U.S. growth; OSB = oriented strand board.

Figure 7-24. Historic (1990 to 2015) and projected (2020 to 2070) U.S. wood-based panels production by region for the RPA HM scenario.



HM = high warming-moderate U.S. growth.

much of the growth will come from fiberboard, and to a lesser extent from particleboard and OSB (figure 7-23). In 1990, plywood and veneer production comprised 74 percent of all wood-based panels production in the United States. By 2015, this number had declined to 31 percent. Fiberboard is expected to increase its relative importance in U.S. panel production, rising from 26 percent of all production in 1990 to 31 percent by 2070 in the HM scenario. The aggregate of particleboard and OSB production, meanwhile, has grown from a negligible amount in 1990 to the largest share of total panels production by volume by 2070.

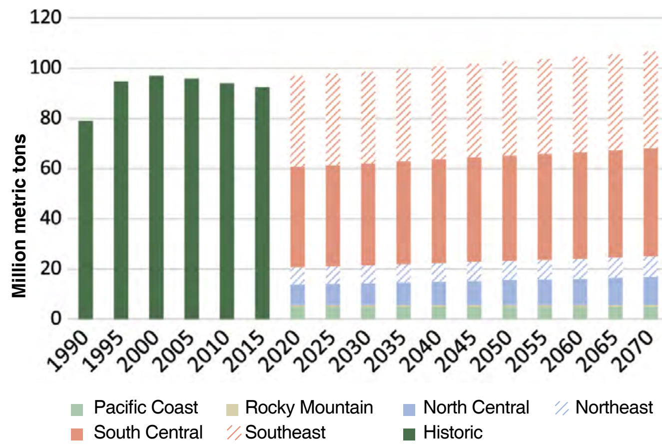
Pulp and Paper

Pulp production in the United States increased from 82 million metric tons in 1990 to 92 million metric tons by 2015 (figure 7-25). Given the projected declines in consumption of newsprint and printing and writing paper across all scenarios, it follows that only modest growth in pulp production is projected. For example, U.S. pulp production reaches an estimated 99 million metric tons in 2070 under the HL scenario, while it is projected to reach 128 million metric tons in 2070 under the HH scenario. The Southeast and South Central Subregions dominate other regions in pulp production currently, representing about 78 percent of all pulp output in 2020. It is projected that much of the growth in pulp production will come from the Southeast, South Central, and to a lesser extent, the North Central Subregions between 2020 and 2070 (figure 7-26).

Most of the pulp produced in the United States is waste (i.e., pulp made from recycled paper) and chemical forms. Mechanical pulp has historically represented a small share of total production and has been decreasing further since the 1990s. Meanwhile, waste pulp has been increasing its share of total pulp production since the 1990s, rising from 33 percent to about 50 percent of total pulp production by 2015 (figure 7-27). The U.S. production of pulp is projected to continue to be dominated by waste and chemical types.

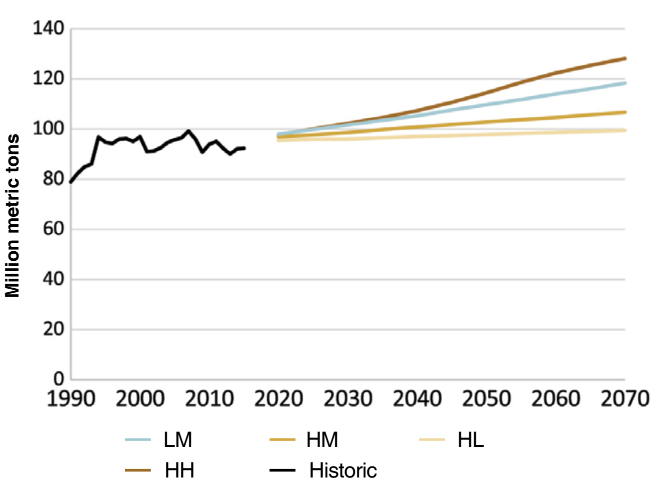
The demand for pulp is derived through the demand for final paper products (newsprint, printing and writing paper, and other paper and paperboard). As described earlier (see figure 7-14), the last decade has seen a structural break in the demand for newsprint and printing and writing paper, as consumers switch toward digital substitutes. In the United

Figure 7-26. Historic (1990 to 2015) and projected (2020 to 2070) U.S. pulp production by region for the RPA HM scenario.



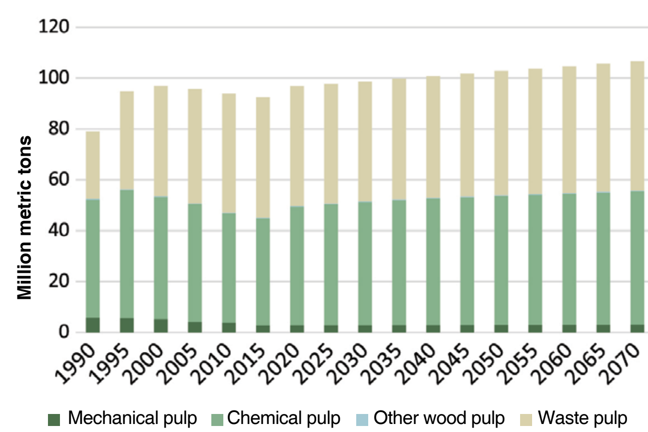
HM = high warming-moderate U.S. growth.

Figure 7-25. Historic (1990 to 2015) and projected (2020 to 2070) U.S. pulp production by RPA scenario.



LM = lower warming-moderate U.S. growth; HL = high warming-low U.S. growth; HM = high warming-moderate U.S. growth; HH = high warming-high U.S. growth.

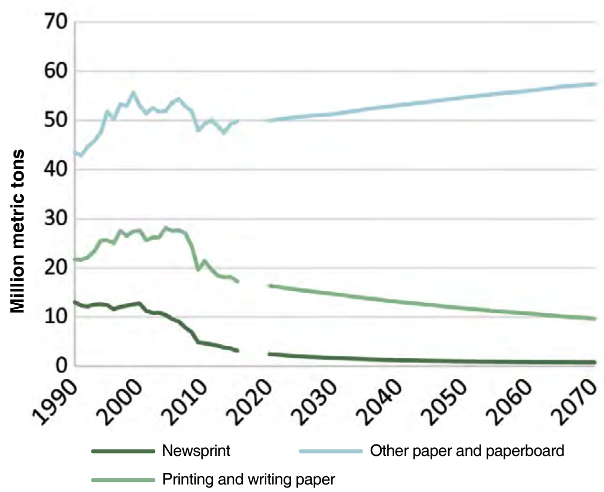
Figure 7-27. Historic (1990 to 2015) and projected (2020 to 2070) U.S. pulp production by type for the RPA HM scenario.



HM = high warming-moderate U.S. growth.

States, the consumption of these products peaked in the early 2000s and has since been on a steady decline (figure 7-28). Meanwhile, the demand for other paper and paperboard has been relatively stable in the United States during this time, driven in large part by increased demand for packaging materials to support online shopping and the robust demand for tissue papers, which rises with GDP. Consumption of newsprint and printing and writing paper were 75 and 38 percent below their 2000 levels by 2015, respectively. The consumption levels for other paper and paperboard were relatively unaffected during this period despite the impacts of the GFC. It is projected that newsprint, and printing and writing paper, will continue this trend through 2070, declining to 94 and 65 percent below their 2000 levels by 2070, respectively, under the HM scenario. Other paper and paperboard is projected to continue stable growth, growing 9 percent above its 2000 levels by 2070, under the HM scenario.

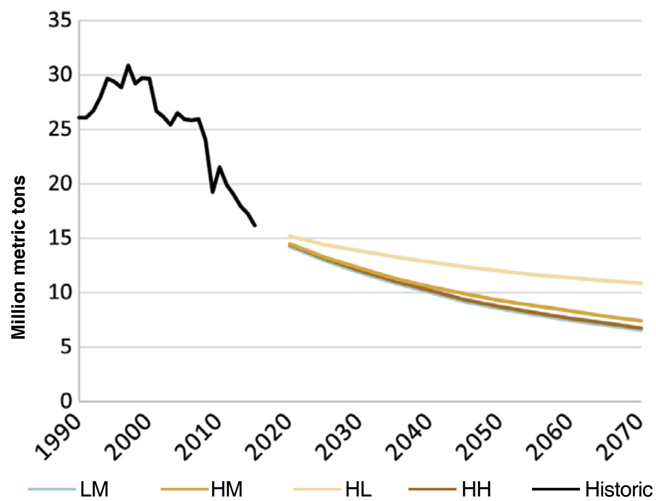
Figure 7-28. Historic (1990 to 2015) and projected (2020 to 2070) U.S. paper consumption by type for the RPA HM scenario.



HM = high warming-moderate U.S. growth.

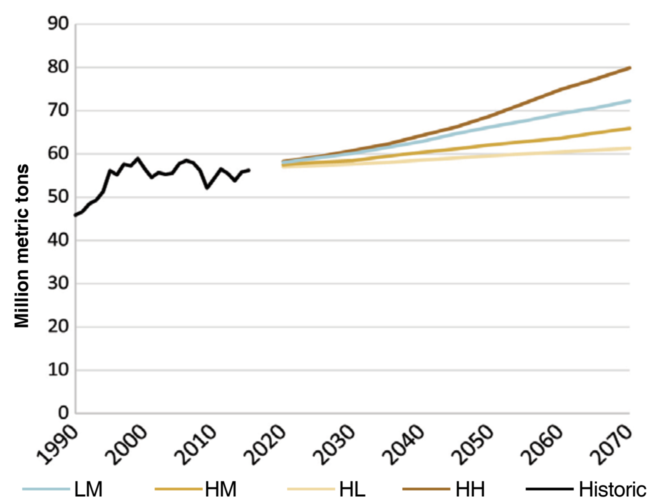
The sensitivity of these sectors to the path of GDP is highlighted in figures 7-29 and 7-30 showing diverging patterns. For newsprint and printing and writing paper, low economic growth in the HL scenario yields a slower path of digitalization, and therefore a slower path for substituting away from these paper products (figure 7-29). As a result, it is projected that production of the combined newsprint and printing and writing paper products will be 63 percent below 2000 levels by 2070 under the low-income HL scenario, and as much as 77 percent below 2000 levels under

Figure 7-29. Historic (1990 to 2015) and projected (2020 to 2070) U.S. production of newsprint and printing and writing paper by RPA scenario.



LM = lower warming-moderate U.S. growth; HL = high warming-low U.S. growth; HM = high warming-moderate U.S. growth; HH = high warming-high U.S. growth.

Figure 7-30. Historic (1990 to 2015) and projected (2020 to 2070) U.S. production of other paper and paperboard by RPA scenario.



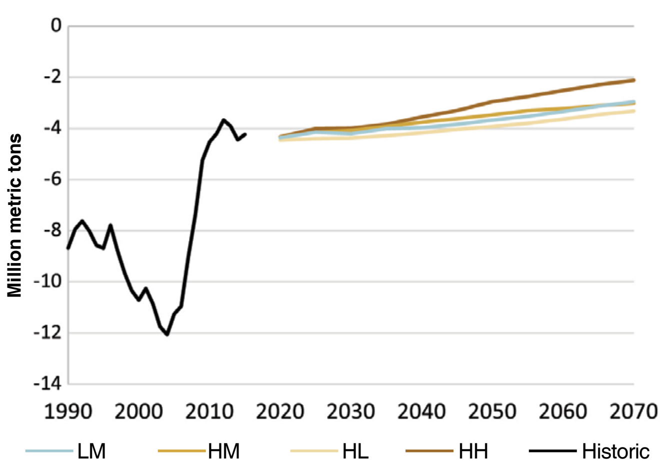
LM = lower warming-moderate U.S. growth; HL = high warming-low U.S. growth; HM = high warming-moderate U.S. growth; HH = high warming-high U.S. growth.

the higher income HH scenario. Conversely, other paper and paperboard production—which is complementary to digitalization as it supports packaging for online order shipments—yields as much as a 28-percent increase over 2000 levels by 2070 under the high-income HH scenario. The HL scenario yields a mere 8 percent growth in U.S. production of other paper and paperboard from 2000 levels by 2070, because low economic growth is related to lower manufacturing growth and connected to a slower rate of growth in online purchases and the packaging needed for deliveries to consumers.

The U.S. has historically been a net importer of newsprint and other printing and paper products (figure 7-31). The trend of decreasing demand for these products, as well as the economic impacts associated with the GFC, cut net imports to nearly 1/3 relative to pre-GFC levels. This trend is expected to continue as the U.S. and other economies continue to digitalize and is relatively insensitive to the degree of economic growth under the various scenarios. On the other hand, the United States has historically been a net exporter of other paper and paperboard products (figure 7-32), brought on by the move towards online shopping. Exports of these products are sensitive to assumptions about future economic growth, as the demand for shipping materials depends largely on the development of emerging markets like India and China. It is projected that exports of U.S. other paper and paperboard products will remain stagnant or even decline slightly under the HL scenario yet continue to increase sharply under the higher income HH scenario.

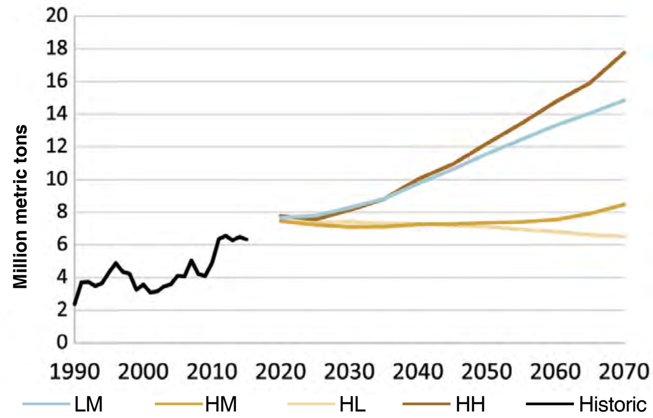
Production of newsprint is concentrated within the Southeast and South Central Subregions, representing a combined 77 percent of total U.S. production in 2020. Under the HM scenario, it is projected that these subregions will lose about 50 percent of their production of newsprint by 2070 (figure 7-33). Yet, this is lower than the proportional impact in some other U.S. regions. While the Pacific Coast is a minor player in the production of newsprint, it is expected this region will lose about 84 percent of its production during the same period.

Figure 7-31. Historic (1990 to 2015) and projected (2020 to 2070) U.S. net exports of newsprint and printing and writing paper by RPA scenario.



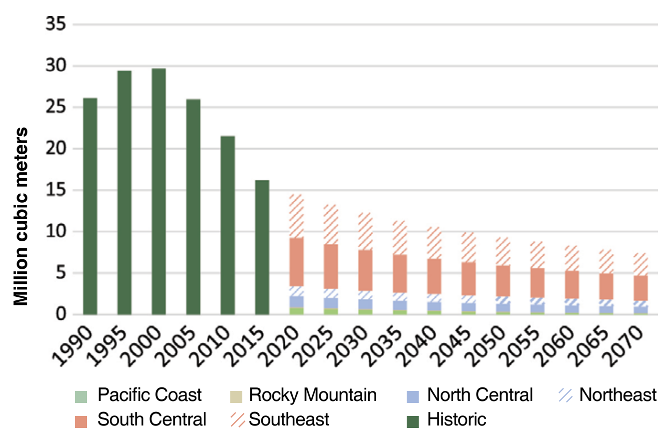
LM = lower warming-moderate U.S. growth; HL = high warming-low U.S. growth; HM = high warming-moderate U.S. growth; HH = high warming-high U.S. growth.

Figure 7-32. Historic (1990 to 2015) and projected (2020 to 2070) U.S. net exports of other paper and paperboard by RPA scenario.



LM = lower warming-moderate U.S. growth; HL = high warming-low U.S. growth; HM = high warming-moderate U.S. growth; HH = high warming-high U.S. growth.

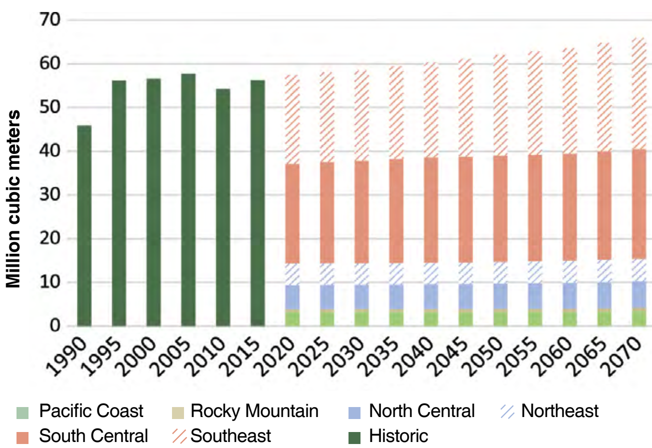
Figure 7-33. Historic (1990 to 2015) and projected (2020 to 2070) U.S. production of newsprint and printing and writing paper by region for the RPA HM scenario.



HM = high warming-moderate U.S. growth.

The U.S. production of other paper and paperboard under the HM scenario is provided in figure 7-34, where production is concentrated again in the South, and to a lesser degree in the North. Growth in the production of these products is projected to be concentrated in the South, with the Southeast and South Central growing nearly 25 and 10 percent respectively from 2020 to 2070. Other regions experience more modest gains of below 10 percent.

Figure 7-34. Historic (1990 to 2015) and projected (2020 to 2070) U.S. production of other paper and paperboard by region for the RPA HM scenario.



HM = high warming-moderate U.S. growth.

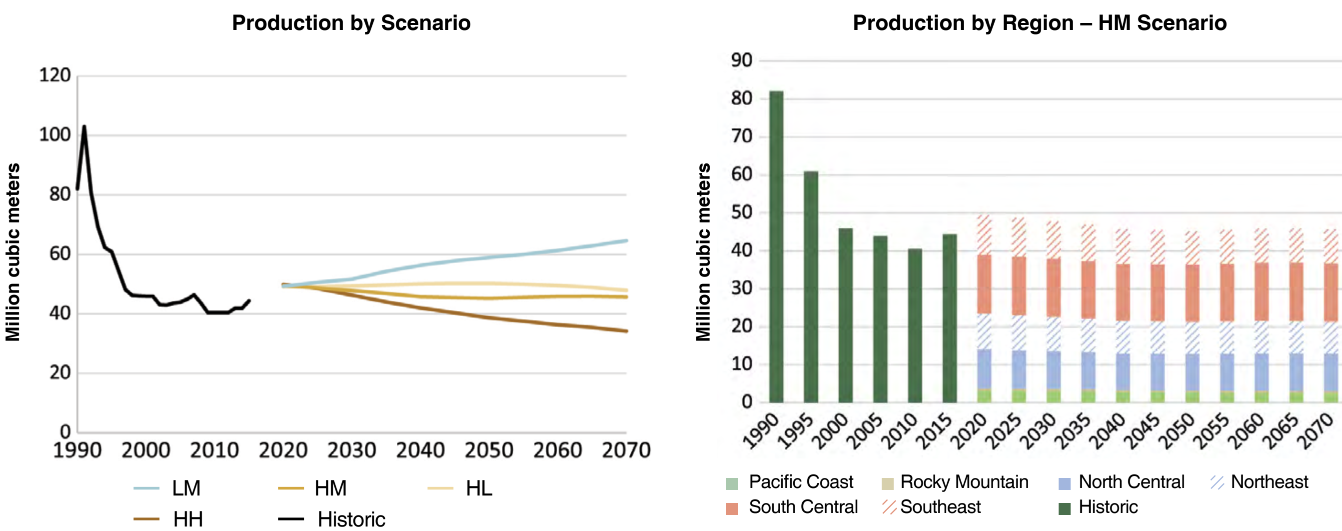
Wood Energy

The production of fuelwood within the United States has been relatively constant over the last couple decades, after a period of significant declines (figure 7-35, left). As of 2015, the U.S. produced about 44 million m³ of fuelwood. The RPA scenarios project modest variation in the production of fuelwood through 2070. Looking at the two most extreme pathways, the lowest levels are reached under the high economic growth HH scenario (34 million m³ by 2070), while the sustainably minded LM scenario yields the highest levels (65 million m³ by 2070).

The production of fuelwood is distributed across the four RPA regions, with the South Central Subregion contributing the largest share (figure 7-35, right). FOROM estimates that 31 percent of fuelwood was produced in the South Central in 2020, followed by 21 percent in both the Southeast and North Central. These shares do not change markedly throughout the HM scenario projection.

This assessment treats wood pellets as a unique product, independent from fuelwood, yet wood pellets may use industrial roundwood, fuelwood, and/or wood processing residuals as feedstock. This relationship is calibrated at the regional level to recent reported feedstock utilization outlined in the 2013 UNECE/FAO Joint Wood Energy Enquiry. As mentioned in the global section, the wood

Figure 7-35. Historic (1990 to 2015) and projected (2020 to 2070) U.S. fuelwood production by RPA scenario (left) and by region for the RPA HM scenario (right).

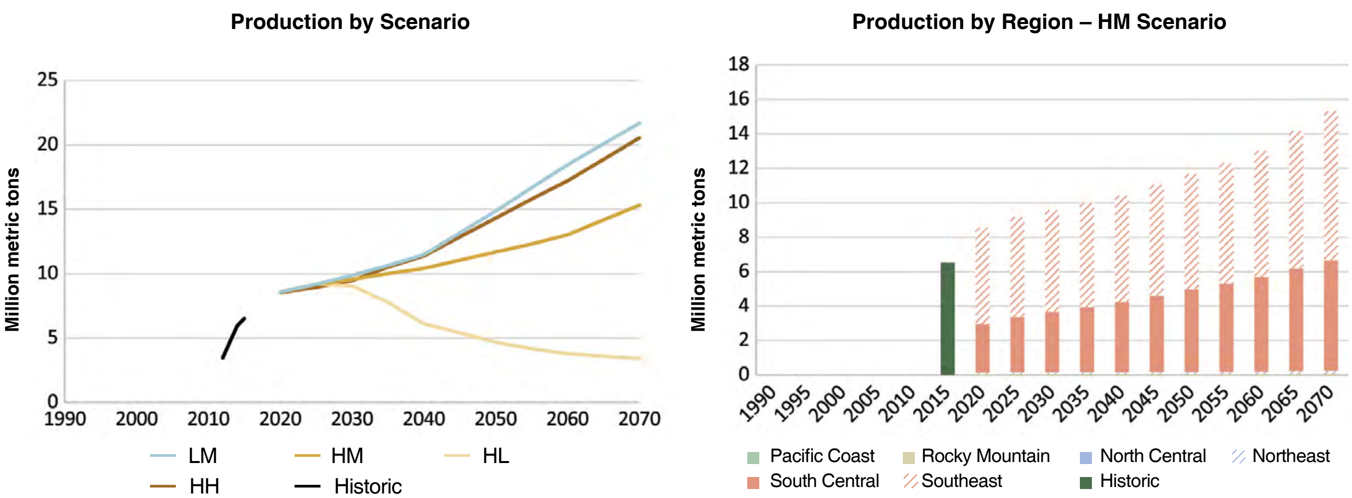


LM = lower warming-moderate U.S. growth; HL = high warming-low U.S. growth; HM = high warming-moderate U.S. growth; HH = high warming-high U.S. growth.

pellet market has experienced significant growth in the last number of years, with Europe emerging as the dominant consumer, relying significantly on the import of wood pellets from the U.S. Accordingly, the production of wood pellets in the United States has also exhibited strong growth in recent years, reaching nearly 9 million mt by 2020. Projections are highly sensitive to the RPA scenario and the underlying SSP related assumptions on preferences and policies (figure 7-36, left). The HL scenario is a low-growth scenario, where little preference is given to sustainability goals to promote the use of wood pellets in energy production. Accordingly, U.S. pellet production plateaus around current levels before shifting to a declining trend, reaching about 4 million mt by 2070. Alternatively, the more sustainability-oriented LM scenario assumes high growth in wood pellets around the world, leading to continued growth in U.S. production for export and, ultimately, a projection that wood pellet consumption increases to over 20 million mt by 2070, representing close to 4.2 percent of total annual removals.

Within the United States, wood pellet production has been overwhelmingly focused in the South (figure 7-36, right). In 2020, it is estimated that 65 percent of all wood pellets produced in the country were produced in the Southeast, followed by 33 percent in the South Central Subregion. Under the HM scenario, both subregions continue to produce the vast majority of wood pellets, with the highest growth rates observed in the South Central Subregion. Part of the South's continued dominance in wood pellet production relates not only to its high quantity of available timber, but also its relative proximity as a trading partner to supply the EU's continued demand for the product as a carbon-beneficial source of energy.

Figure 7-36. Historic (1990 to 2015) and projected (2020 to 2070) U.S. wood pellet production by RPA scenario (left) and by region for the RPA HM scenario (right).



LM = lower warming-moderate U.S. growth; HL = high warming-low U.S. growth; HM = high warming-moderate U.S. growth; HH = high warming-high U.S. growth.

Management Implications

Global production of both hardwood and softwood roundwood are projected to rise into the future, and the scenarios we report support the idea that these markets would be maintained in the coming 5 decades. For hardwood in the United States, a strong overseas market for roundwood and lumber imply likely steady to growing opportunities for exports. Such strength in hardwood markets translates into generally unchanged to rising prices in both hardwood roundwood and hardwood lumber. In contrast, the United States has long been a net importer of softwood lumber and wood-based panels, and most of the projected growth in U.S. softwood roundwood is used to produce lumber, softwood plywood, and OSB for domestic consumption. However, growth in roundwood production is projected to exceed growth in domestic consumption across most scenarios, the difference adding to U.S. net exports. Managers could therefore expect growing opportunities for exports. From this outlook, managers might expect markets to be maintained or strengthened across the United States where markets currently exist.

Although U.S. lumber production is projected to rise to 2070, projections also indicate a growing dependence on softwood lumber net imports and rising hardwood lumber net exports. Both results highlight the likely steady to strengthening markets for both kinds of lumber. Producers and consumers of lumber would therefore expect rising prices, on average, in the coming decades. Scenarios also show that the Southeast and South Central Subregions. would experience the most robust growth in softwood lumber production, with the Pacific Coast Region not increasing significantly. Growth in hardwood lumber production is more broad-based, across all regions of the country.

Although wood-based panel (plywood, OSB, fiberboard) production is projected to increase throughout the projection under most scenarios, the Nation is projected to maintain its import-dependence. Low economic growth leads to more negative net exports under the HL scenario, while high growth leads to less negative net exports under the HH scenario. Fiberboard production is projected to experience vigorous production growth to 2070 under the HM scenario, an indication of the effects of sustained U.S. economic growth and export demand.

Pulp production is expected to remain either unchanged or to grow, depending on the scenarios, and the South Central and Southeast Subregions are projected to continue to dominate the market. However, continuing a long-run trend, consumption of newsprint and printing and writing paper is projected to decline for both products, across all scenarios: in the HM scenario, newsprint declines to near zero by 2040, while printing and writing paper drops by half by 2070, compared to 2015 levels. A lesson for investors is that the trends observed in consumption since the 1990s are likely to continue, implying steady disinvestment in graphics paper manufacturing capacity. Other paper and paperboard consumption, in contrast, generally increases across all scenarios. The United States is projected to either maintain its positive net export status (HL and HM scenarios) or increase its net exports (LM and HH scenarios) in other paper and paperboard. The South Central and Southeast are projected to continue to dominate domestic paper production, highlighting likely geographic regions where steady to higher output of that aggregate category of paper would be expected.

For fuelwood, the future depends heavily on income growth, and consumption could rise or fall to 2070. For wood pellets, on the other hand, only under the HL scenario is production projected to decline after 2030, while output rises by three to five times by 2070 under the HM, HH, and LM scenarios. Nearly all production of wood pellets is expected to come from the U.S. South. Prospects for domestic production and export of wood pellets depends in large part on strong overseas markets, however, which currently are largely maintained by European Union policies fostering their consumption.

Conclusions

The U.S. forest sector has undergone wide swings in production and consumption, due to widely varying rates of economic growth over time and to secular trends in demand. High economic growth corresponds with increased residential construction and higher demand for wood-based building products, such as softwood lumber and wood-based structural panels. Therefore, vigorous economic growth raises industrial roundwood production, particularly softwood. Such vigorous growth, however, also drives demands for imports, with the United States remaining a net importer of softwood lumber and structural panels. In contrast, hardwood timber harvests are connected to not only U.S. economic growth but also to overseas economic growth and investment in furniture manufacturing. Overseas demand for hardwood roundwood and lumber provides a base of support for domestic production. All scenarios project stable export markets for hardwood industrial roundwood and lumber.

The U.S. paper sector has undergone a transition in the last 20 years that is projected to continue into the foreseeable future. In all scenarios, newsprint production and consumption decline to historically low levels by 2070, while printing and writing paper also declines, but at a slower rate. Such declines translate into lower total quantities of their imports since the United States is a net importer of both categories. The future of the remaining part of the paper sector, embodied in the aggregate category of "other paper and paperboard," however, is tied more closely to economic growth and rising overall global demand for paper for packaging and other human needs. U.S. and global consumers are projected to continue to demand those categories of paper for packaging and for sanitary purposes.

Projected futures in the production and consumption of wood to generate energy vary widely by scenario, adhering to the storylines embodied in the RPA scenarios. A future in which the United States and the world use wood to manufacture wood pellets for energy under a sustainability-oriented LM scenario leads to high growth in wood pellet demand and U.S. exports. Nevertheless, wood pellet manufacture consumes less than 2 percent of all roundwood consumption today and would not rise to much more than 4.2 percent by 2070 under LM and remain less than 1 percent under HL. Concerns about the sustainability and carbon implications of wood pellets as an energy source would therefore be most pronounced under the LM and least under the HL scenarios, but in both cases would not define substantial changes in overall production/carbon at the sector level.

The role of global markets is undeniable in the projections made not only for wood pellets but also for all other products, as the United States is among the top national producers and consumers of most broad categories of forest products. It is for that reason that U.S. projections are made in the context of a global market model. At the same time, the global market model used here allows for detailed analysis of the relative roles of the regions within the United States. Providing such regional detail in the market model allows for the full effects of global phenomena to be accounted for in regional markets and in the projected future of forest conditions. The regional detail additionally offers insights on how regions are projected to individually contribute to global markets and whether their contributions to the global position of the U.S. forest sector will endure. For example, the South (South Central plus Southeast), already the single largest producing region in the world, is projected to remain the dominant producing region for the foreseeable future, producing 10 percent of the world's total industrial roundwood by 2070 under all scenarios. The relative position of the Pacific Coast also remains steady throughout the projections, providing 3 percent of the world's total industrial roundwood by 2070.

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