United States
Department of
Agriculture

Forest Service

Forest
Products
Laboratory

General
Technical
Report
FPL–GTR–219

Effects on U.S. Timber Outlook of Recent Economic Recession, Collapse in Housing Construction, and Wood Energy Trends

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Abstract

This paper reviews recent trends and structural changes in U.S. forest product markets and projects their effects on the long-range U.S. timber market outlook. The analysis derives from the same U.S. and global economic model that produced 50-year projections for the 2010 RPA nationwide forest assessment, but analysis is revised to more accurately include the economic recession of 2007–2009, the collapse in U.S. housing construction since 2005, and expected growth in wood energy consumption. The analysis uses the 2012 USDA Baseline global macroeconomic and currency exchange rate outlook, along with a revised U.S. housing projection. Results provide a coherent 2012 baseline outlook to 2060 that takes into account recent market trends and includes a rebound in U.S. timber harvest and higher net exports but only modest expansion in timber harvest over the long run, resulting in only modest increases in real timber stumpage prices and expanding U.S. timber growing stock inventories.

Keywords: economic outlook, timber trends, forest product demands, recession, housing construction, wood energy

Acknowledgments

The authors acknowledge the work of former FPL and University of Wisconsin research associate, Andrew D. Kramp, who programmed the USFPM/GFPM model with the 2012 USDA Baseline projections of growth in real GDP, population, and exchange rate shifts for all countries; the work of Professor Joseph Buongiorno and his colleagues at University of Wisconsin, who developed the Global Forest Products Model; and funding support for this study from the Forest Service RPA Assessment.

December 2012

Ince, Peter J.; Nepal, Prakash. 2012. Effects on U.S. timber outlook of recent economic recession, collapse in housing construction, and wood energy trends. General Technical Report FPL-GTR-219. Madison, WI: U.S. Department of Agriculture, Forest Service, Forest Products Laboratory. 18 p.

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Introduction

In this paper we describe effects on the long-range U.S. timber outlook of the economic recession and global financial crisis of 2007–2009, the related collapse of U.S. housing construction since 2005, and other structural changes in U.S. timber demands and trade. We derive market projections from the same economic model used to produce projections for the Forest Service 2010 RPA assessment (Forest Service 2012, Ince and others 2011a). However, analysis is updated using the more recent 2012 USDA Baseline global economic outlook (ERS 2012) and a revised U.S. housing projection that includes the recent collapse in housing construction since 2005 and expected gradual rebound to the long-term historical trendline by 2020.

We begin by discussing recent trends in wood product production, consumption, and trade, describing effects of the global economic recession and collapse in U.S. housing construction, and highlighting structural changes in the economy that affect wood use. Next, we explain the objective and rationale for our analysis and explain methods for projecting future trends, including the use of the 2010 RPA forest sector market model along with economic assumptions from the 2012 USDA Baseline global economic outlook and a revised U.S. housing projection. Finally, we discuss forest management and policy implications of the 2012 baseline outlook in terms of projected timber harvest, timber growing stock inventory, timber prices and roundwood trade.

Recent Trends and Structural Changes

Figure 1 shows recent trends since 1980 in real (inflation-adjusted) U.S. Gross Domestic Product (GDP) (broadest measure of overall U.S. economic activity from U.S. Bureau of Economic Analysis) and several indexes of industrial production from the U.S. Federal Reserve, including total U.S. industrial production and production of wood products (NAICS 321) and paper manufacturing (NAICS 322), which are the leading forest-based industries of the United States. Until the mid-1990s, trends in real GDP, overall industrial production, and production of forest-based industries were

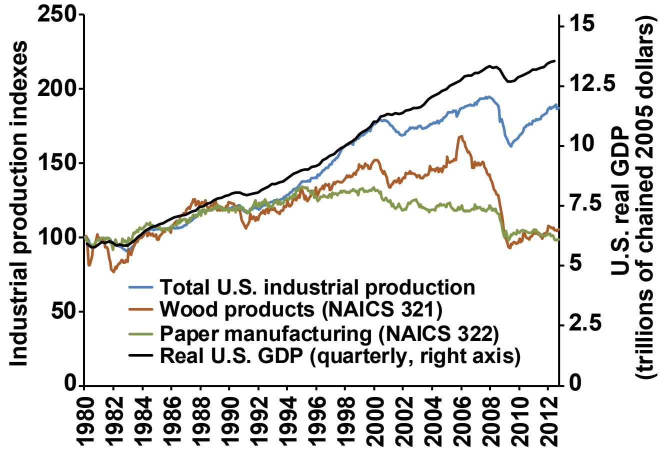

Figure 1. Trends since 1980 in U.S. real GDP and monthly industrial production indexes (Jan. 1980 = 100). (Data from Bureau of Economic Analysis and Federal Reserve on-line databases, 2012.)

somewhat parallel, but since then the trends have diverged substantially, a sign of structural changes in the economy. Growth in overall U.S. industrial production fell behind real GDP growth since the 1990s largely because of economic globalization, as consumer goods manufacturing was increasingly outsourced for a variety of reasons to countries with lower labor costs (Ince and others 2007). Forest-based industry output fell further behind as a result of economic globalization (Ince and others 2007) and also deeper structural changes, including declining U.S. consumption of paper and paperboard since the late 1990s and a collapse in housing construction activity since 2005.

Following the severe 2007–2009 economic recession, U.S. GDP growth resumed but at a slower pace, while industrial production was rebounding but lagging behind, and forest product output remained depressed. For wood products (NAICS 321), the decline in output is attributable to an unprecedented collapse in U.S. housing construction activity since 2005, which accounts for most of the recent divergence between growth in U.S. wood product output and overall GDP growth (Fig. 1). Additional structural changes that have influenced wood product output include displacement of construction lumber by engineered wood products such as structural I-joists, displacement of softwood plywood by oriented strandboard (OSB), and outsourcing of wood furniture manufacture to foreign countries with expanded furniture imports (Ince and others 2007). U.S. output of paper products (NAICS 322) also diverged from real GDP growth since the 1990s (Fig. 1) because of other long-term structural changes, including displacement of growth in (a) print paper demands and print advertising by electronic media and new information and communication technologies and (b) demands for paper and paperboard in packaging by more efficient packaging systems and rising imports of consumer goods packaged and shipped to the United States from foreign countries (Ince and others 2007).

Traditionally, the long-range U.S. housing construction outlook was supported by the theory of an “underlying” long-term housing demand driven by demographics of housing needs, with housing starts related to data on household formation and headship rates (Ince and others 2011a). According to this demographic theory, average annual U.S. single-family housing starts should be upwards of 1.4 to 1.5 million or more based on demographic data and trendline population growth. However, actual U.S. single-family housing starts have averaged less than 1.1 million over the past 50 years and exceeded 1.5 million in just two of those years (2004 and 2005), at levels that are now regarded in hindsight as abnormally high.

As measured by single-family housing starts (reported by U.S. Census Bureau), new home construction dropped to just 0.45 million in 2009, 74% below the record 1.72 million starts of 2005. Moreover, single-family housing starts did not recover after the recession ended, remaining at 0.47 million in 2010, 0.43 million in 2011, and 0.54 million by August 2012, even though real U.S. GDP had fully recovered to pre-recession levels by 2011 (Fig. 1). For almost five years now, U.S. housing starts have languished at levels lower than every previous year since 1959 when the modern Census Bureau housing data series begins. Thus, the magnitude and duration of the recent housing collapse set the current downturn apart from the more transitory or cyclical housing downturns of the post–World War II era, marking a structural change in housing demand with deeper and likely more lasting consequence.

Important indicators of structural change in the housing market include a dramatic correction in median wealth of U.S. households as home values declined and also declining home ownership rates. The latest Federal Reserve Survey of Consumer Finances showed that from 2007 to 2010, median inflation-adjusted net worth (or wealth) of U.S. families—the difference between their gross assets and liabilities—fell by 38.8%, from $126,400 in 2007 to $77,300 in 2010 (in 2010 dollars), largely because of declining home values (Bricker and others 2012). During the peak of the housing boom in 2004–2005, hundreds of billions of dollars were

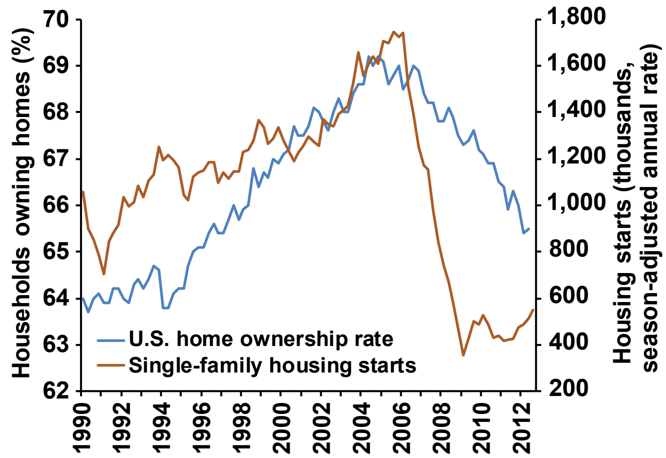

Figure 2. U.S. single-family housing starts and home ownership rates (quarterly). (Data from U.S. Census Bureau online databases.)

entering the U.S. economy annually from foreign investors via purchases of U.S. agency bonds and collateralized debt obligations (Ince and others 2007), funding a mortgage industry that adopted liberal lending practices, pushing up the U.S. home ownership rate to its all-time historical peak above 69%, and pushing up home prices and wood product demands as well. Those phenomena ultimately proved to be both abnormal and economically unsustainable, as U.S. home values began to decline and as the global financial crisis of 2008 led to a collapse of foreign investment, tightening of mortgage lending practices, widespread foreclosures, and persistently high unemployment.

By 2012, the U.S. home ownership rate (as reported by U.S. Census Bureau) was retreating toward levels that were the norm from the late 1960s to mid-1990s, around 64% to 65% (Fig. 2), which supports a view that housing demands are reverting toward historical norms and unlikely to return to recent historical peaks, as average home values have declined. Housing construction is just beginning to rebound (Fig. 2), and U.S. single-family housing starts are forecast by industry experts to average from 0.8 to 1.2 million annually over the next 15 years, but with no foreseeable return to 2004–2005 peak levels. Such forecasts bracket the historical average of single-family housing starts from 1959 to 2011 (1.08 million) and are close to the logarithmic historical trendline at around 1.1 million. Thus, in our 2012 baseline outlook we project a gradual rebound in single-family housing starts, reaching the logarithmic trendline by 2020 at around 1.1 million, which is close to the long-run historical norm and within the range of current housing expectations but much lower than recent RPA scenarios with similar or higher population growth. (Three alternative housing scenarios in the 2010 RPA Assessment (Ince and others 2011) showed single-family housing starts ranging from 0.9 million by 2060 in the B2 (population growth much lower than USDA Baseline), to 1.4 million in the A1B (population growth similar to USDA baseline), and 2.3 million in the A2 (much higher population growth).)

Meanwhile, prospects for growth in wood energy demand were affected by a different sort of structural change, one that is transforming the energy sector, namely expansion of unconventional oil and gas production via hydraulic fracturing and horizontal drilling. These revolutionary technologies have already produced abundant and cheaper natural gas supply, and also diminished the likelihood that oil production will peak in the near future (Maugeri 2012). This structural change diminishes the near-term likelihood of large-scale expansion in biomass energy production in response to peaking of oil output. Thus, in our updated forest sector outlook, we assume that U.S. and global wood energy demands will expand modestly, as determined by historical relationships of wood energy demand to GDP growth. (We project roughly a doubling in future U.S. wood fuel feedstock production, similar to the doubling of U.S. biomass energy production projected in the 2012 U.S. Annual Energy Outlook, U.S. Department of Energy.)

Other ongoing structural changes that were already taken into account in the 2010 RPA market model include (a) continued displacement of growth in U.S. print advertising expenditures and print paper demands by growth in electronic media and (b) modest growth in paperboard packaging demands with high levels of consumer goods imports (Ince and others 2011a). Thus, we expect U.S. demands for newsprint and printing and writing paper to continue receding in line with recent historical trends, while relatively stable demand levels are expected for other paper and paperboard products.

On a more positive note, a weaker U.S. dollar coupled with foreign economic growth has led in recent years to historic shifts in U.S. trade balances for commodity forest products. After many decades as a net importer of pulp and paper products (mainly from Canada but also other countries), the United States emerged in just the past few years as a global net exporter of pulp, paper, and paperboard products, with U.S. net exports of those products exceeding $3 billion in 2011 (ITA 2012). The trade balance also improved dramatically for lumber and wood panel products, although the United States is still a net importer of those products. As shown in Figure 3, these historic shifts in U.S. forest product trade balances began before the recent recession, linked to a decline in the exchange value of the U.S. dollar that favors higher net exports. Shifts in currency exchange rates reflect macroeconomic changes in the global pattern of economic growth, with notably higher economic growth in some global regions, such as Asia, than in the United States. However, trade impacts of historical and projected shifts in currency exchange rates were not included in the 2010 RPA assessment or other recent forest assessment studies. Thus, we incorporated in our 2012 baseline outlook the USDA Baseline projection of global currency exchange rate trends,

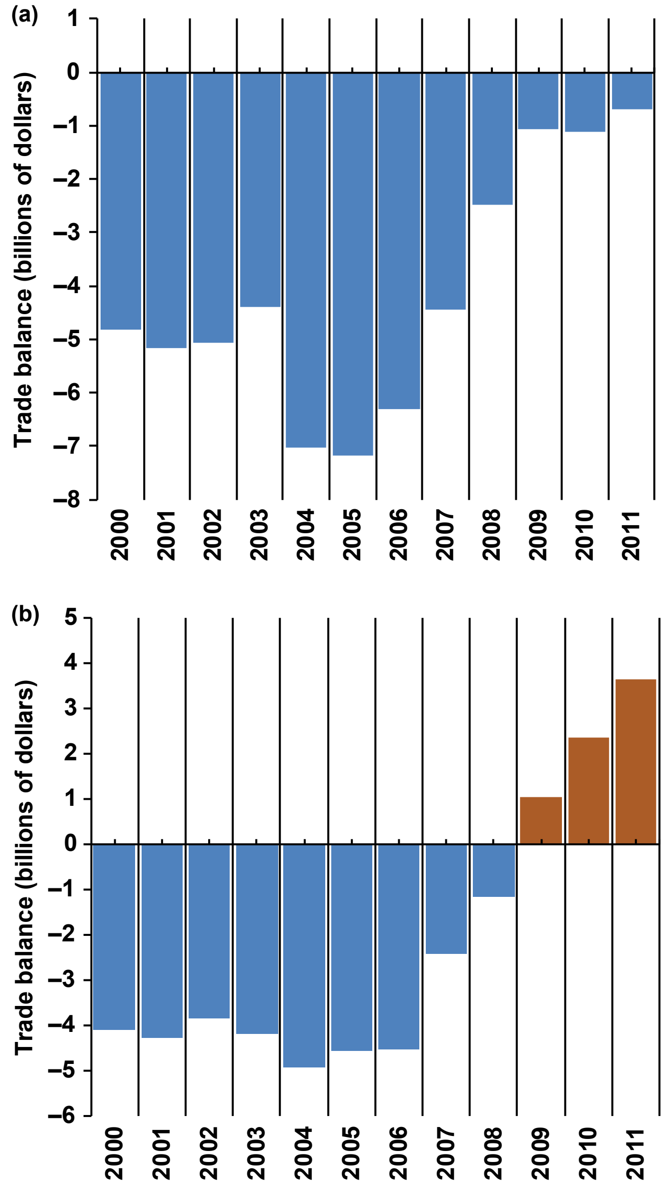

Figure 3. U.S. annual trade balances (value of exports minus imports) for (a) sawmill and wood products, NAICS 3211, and (b) pulp, paper, and paperboard mill products , NAICS 3221 (ITA 2012).

because shifts in currency exchange rates appear to be influencing the U.S. forest product trade situation.

In addition to improvement in the trade balance, another potentially positive factor could be technology developments that offer prospects of expanding future utility of wood resources. Two leading examples are cellulosic nanotechnology and forest biorefining, both aimed at obtaining new and higher value materials from wood, such as nanocrystalline cellulose, advanced biofuels, or biochemicals (Peng and others 2011, Zhu 2011). Widespread commercial application of such technologies is yet to appear but might emerge sometime in the decades ahead (Näyhä and Pesonen 2012).

Nevertheless, the scale of such technologies and their applications remain highly uncertain, so we do not include projected timber demands for such technologies in this analysis. This is not to discount the importance or potential of such technologies, however, because they could become vital to sustaining future economic development of the forest sector in the long run.

Objective and Rationale for Updated Economic Outlook

Our objective is to provide an updated 2012 baseline forest sector outlook to 2060 that includes market effects of the recent recession, collapse in housing construction, and shifts in currency exchange rates. The rationale is that these changes have had major impacts on the U.S. timber market outlook, impacts that are now more starkly evident than several years ago when the 2010 RPA analysis was developed. For example, U.S. timber harvest has declined in all regions, along with key timber market indicators, such as average price of Southern Pine sawtimber stumpage, which declined by around 40% in nominal terms from 2005 to 2011 (Timber Mart–South 1980–2011). Timber prices in the U.S. West did not decline as much, largely because of growing log exports to Asia.

Recent forest assessment studies, such as the nationwide 2010 RPA Assessment (Forest Service 2012) and Southern Forest Futures Project (Wear and Greis 2011) were focused on scenarios developed years earlier for the Intergovernmental Panel on Climate Change (IPCC). The IPCC scenarios provided a coherent view of global change but did not specifically evaluate timber market implications of the recent recession, the collapse in housing construction, or major shifts in currency exchange rates. The RPA Assessment did indicate that climate change would be an important factor for some renewable resources in certain regions, such as for water resources in the arid U.S. West, but climate change would have fairly minor effects on projected timber supply and demand, at least within the next 50 years (Forest Service 2012). By comparison, the economic recession and structural changes in demand have had far greater effects on timber market conditions.

For example, one crucial implication of the collapse in housing construction is its implication for lumber and wood panel demands. In the U.S. economy, such products have been used mainly in new housing construction (primarily in wood-framed single-family home construction) or in end uses related to housing demands, such as new household furniture, cabinetry, and flooring. Thus, nationwide demand functions for wood products (such as lumber and wood panels in the RPA market model) included housing starts as an independent variable, along with real GDP as the indicator of demands for forest products in the broader economy, such as wood use in manufacturing (Ince and others 2011a). With updated historical data and revised projections of GDP and housing starts, the RPA model can simulate accurately the recession, the collapse in housing, and anticipated future trends. The RPA market model is also a global model, covering more than 180 countries worldwide, so updated projections are required for GDP, population, and exchange rates among all countries represented in the model.

Methods

To provide a coherent long-range U.S. forest sector economic outlook, we applied the same economic model (USFPM/GFPM) that was applied in the Forest Service 2010 RPA Assessment (Forest Service 2012, Ince and others 2011a, Ince and others 2012), except we updated basic assumptions about economic growth, housing starts, and wood demands to reflect current economic trends, and we produced revised projections of timber inventory based on the updated timber harvest outlook. The 2012 USDA Baseline provides our updated global economic and population growth assumptions (ERS 2012). The USDA Economic Research Service (ERS) produces the USDA Baseline each year, and the 2012 USDA Baseline includes data from 1969 through 2011 and projections to 2030 for real GDP, population, and real exchange rates for 190 countries (ERS 2012), including all countries that are important for U.S. forest product trade. According to the ERS, the USDA Baseline is designed specifically to be used as a benchmark for analyzing impacts of U.S. and global macroeconomic trends.

Our 2012 baseline forest sector outlook uses USDA Baseline projections that were available in January 2012, including global projections of GDP, population, and currency exchange rates for all countries to 2030 (ERS 2012). We extended the USDA projections of GDP and population growth to 2060 by continuation of projected average growth rates. We applied USDA projections of currency exchange rates to 2030, and then we held exchange rates constant from 2030 to 2060. The USDA Baseline outlook generally indicates that the exchange value of the U.S. dollar will remain fairly subdued in future decades, while foreign economic growth will be fairly robust, supporting favorable prospects for U.S. net exports of commodity forest products (although not necessarily more labor-intensive secondary wood products). (As an example, China's currency is projected by the 2012 USDA Baseline to more than double in exchange value relative to the U.S. dollar from 2006 to 2030.) The USDA Baseline exchange rate outlook was not used previously in any of the 2010 RPA assessment scenarios or other recent forest assessment studies such as the Southern Forest Futures Project.

The USFPM/GFPM model includes the detailed U.S. Forest Products Module, USFPM (Ince and others 2011a), within the Global Forest Products Model, GFPM (Buongiorno and others 2003). USFPM/GFPM provides a partial market equilibrium analysis of the U.S. and global forest product sector, using maximization of consumer and pro-

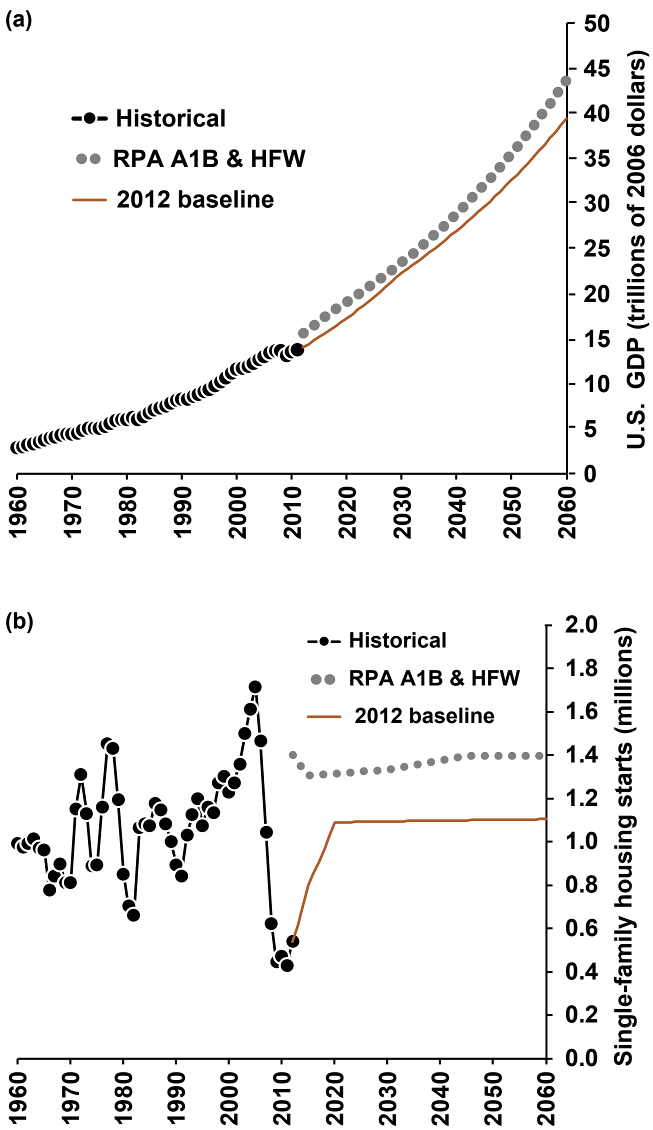

Figure 4. (a) Annual U.S. real GDP, and (b) annual U.S. single-family housing starts, along with 2012 baseline and 2010 RPA A1B and HFW scenario projections.

ducer surplus to solve annual market equilibria, including consumption, production, prices, and net trade for all primary forest products, industrial roundwood, and fuelwood in all countries worldwide (Ince and others 2011a,b; 2012). The model was designed with a capability to take into account projected shifts in currency exchange rates among all countries, a feature that was not utilized in the 2010 RPA Assessment but that we employ in this study along with the USDA Baseline outlook for currency exchange rates. The USFPM analysis extends to U.S. timber stumpage market equilibria, including timber harvest quantities and prices by major U.S. region (North, South, and West). The 2012 version of USFPM/GFPM includes also an endogenous timber growing stock growth and inventory model to keep track of regional hardwood and softwood timber growing stock inventories in response to U.S. timber harvests as projected by USFPM (see Appendix for details). Changes in regional timber growth are modeled as nonlinear functions of regional growing-stock density (Nepal and others 2012). Projected shifts in timber inventory from the growth and inventory model are used also to shift regional timber supply curves in USFPM, with an inventory elasticity of 1.0 in all regions.

In the USFPM/GFPM model, U.S. demands for forest products are shifted over time in relation to projected trends in U.S. real GDP and other independent variables, such as recent historical growth rates for advertising expenditures in print media and electronic media that shift demands for newsprint and printing and writing paper (Ince and others 2011a). Demands for structural lumber and wood panels are driven by projected trends in U.S. real GDP and single-family housing starts (Ince and others 2011a). In addition to using the 2012 USDA Baseline macroeconomic outlook, we introduced an updated projection of average U.S. single-family housing starts along with actual historical housing starts data since 2006. Figure 4 shows that our baseline projections of real U.S. GDP and housing starts are permanently lower than projections of the 2010 RPA A1B and HFW scenarios (which shared the same higher GDP and housing assumptions). Our baseline housing outlook projects a rebound in housing, with average single-family housing starts climbing back to the long-run historical trendline at around 1.1 million per year by 2020, and then following the slowly increasing trendline to 2060. The logarithmic trendline is based on historical U.S. single-family housing starts data from 1959 to 2011. (The logarithmic trendline equation for housing starts is $y = 30.576 \ln(x) + 963.29$, where y is single-family housing starts and x is the year, starting with 1959 = 1; based on Census Bureau annual housing starts data, 1959–2011.) By 2020, projected average housing starts are more than double the level of the past several years but remain well below the 2005 peak (Fig. 4). Although the 2010 RPA scenarios did not take into account the recent recession or collapse in housing construction, our 2012 baseline GDP growth outlook is fairly close to the RPA A1B & HFW in the long run, but our 2012 baseline housing projection is considerably lower than the RPA A1B & HFW housing projection. (Among alternative 2010 RPA scenarios, the RPA A1B and HFW were closest to our 2012 baseline outlook in terms of projected U.S. GDP and population growth, but RPA housing projections were based primarily on demographic analysis (Ince and others 2011a) and did not take into account the recent collapse in housing or structural changes in housing demands. By adopting the logarithmic trendline for future housing starts, we recognize structural change in the housing market with an implicit reversion of housing starts to the long-run historical norm rather than historical peaks.)

Finally, recognizing that the likelihood of large-scale expansion in wood energy has been dampened by the revolution in gas and oil supply (Maugeri 2012), our baseline analysis adopts the "Historical Fuelwood" (HFW) technique for modeling wood energy demand that was developed for the 2010 RPA assessment. In that approach, future U.S. wood fuel feedstock demand and global demands for fuelwood in all other countries are projected to follow GDP growth in each country, using price elasticities of demand and GDP elasticities derived from analysis of historical demand relationships (Ince and others 2011a, 2012; Buongiorno and others 2012). Using the USDA Baseline projections of U.S. and global GDP growth, this approach leads to fairly modest projected growth in U.S. and global wood energy consumption from 2010 to 2060 as compared to other RPA scenarios that featured much larger-scale expansion of global biomass energy production (based on IPCC projections). Nevertheless, annual U.S. production of wood fuel feedstock is still projected to approximately double from 2010 to 2060, increasing by around 100 million cubic meters from 2010 to 2060. (For perspective, that projected increase is at least 10 times greater than current annual consumption of wood feedstock for wood fuel pellet production in the United States.)

The USFPM/GFPM model has a base year of 2006, and in this analysis the model is run to the year 2060. With accurate historical data on GDP, exchange rates, and housing starts, and with U.S. demands calibrated to actual demand growth, the model produced accurate market equilibrium solutions for U.S. consumption, production, and net trade in major categories of forest products over the historical period from 2006 to 2010. The model projects future U.S. and global forest sector market equilibria at five-year intervals, for 2015, 2020, 2025 and so forth, to 2060, driven by the USDA Baseline outlook (ERS projections of global GDP, population and exchange rates for all countries) and the U.S. housing starts trendline.

Results

We illustrate results in charts that show historical trends and our overlapping projections from 2006 to 2060 for consumption, production, and net trade in major categories of forest products, and other charts showing corresponding projections of U.S. timber harvest, timber prices, and timber inventory. For these charts, we obtained historical data on apparent consumption, production, and net exports of forest products from the on-line United Nations FAOSTAT forestry database (FAO 2012). All the historical data trends reported by FAOSTAT are generally consistent with trade data reported by U.S. Commerce Department and with production data reported by leading U.S. forest product trade associations. All the projections derive from the USFPM/GFPM economic model (Ince and others 2011a), programmed with the 2012 USDA Baseline global macroeconomic outlook, the logarithmic trendline projection for average U.S. single-family housing starts (reaching nearly 1.1 million annually by 2020), and the "Historical Fuelwood" (or "low fuelwood") relationships for U.S. and global wood energy demands (Ince and others 2011a, 2012; Buongiorno and others 2012).

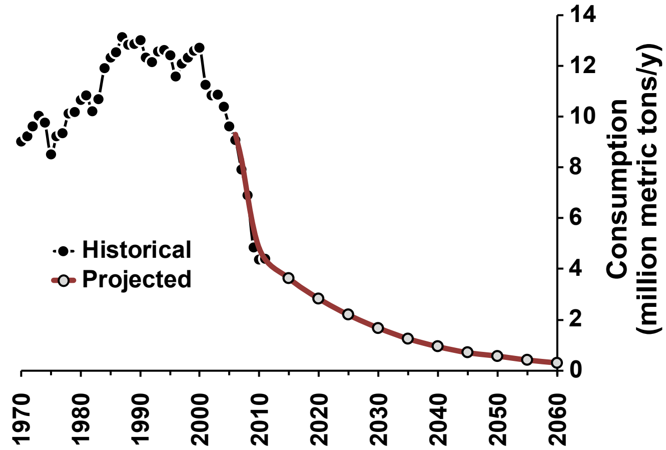

Figure 5. U.S. newsprint historical apparent consumption from 1970 to 2011 (FAO 2012) and baseline projection of annual consumption to 2060.

Paper, Paperboard, and Wood Pulp

The USFPM/GFPM model projects demands for paper and paperboard in three major categories: newsprint, printing and writing paper, and all other paper and paperboard. Among these categories, newsprint demand has experienced in recent years by far the most significant structural change. U.S. newsprint consumption has declined by more than two-thirds since peaking in the late 1980s (Fig. 5). Most of that decline occurred in just the past decade, as growth in advertising expenditures shifted from print media such as newspapers to electronic media, and as newspaper circulation declined. (Trends in U.S. newspaper circulation and print advertising expenditures are reported by the Newspaper Association of American (NAA), www.naa.org.) The severe recession of 2007–2009 also accelerated the decline in newsprint demand. Our baseline projections, which take into account recovery from the recession but also ongoing and continued structural change in advertising expenditures, indicate that roughly half of remaining U.S. newsprint consumption will be lost by 2030, and only a small residual volume of newsprint consumption is projected by 2060.

Meanwhile, U.S. printing and writing paper consumption has also begun to decline, as electronic media and technologies have contributed to structural changes in information and communication technology, offsetting growth for paper grades ranging from magazine and catalog paper to office paper and book paper. The recession of 2007–2009 also deeply affected U.S. consumption of printing and writing paper, with only a slight rebound in demand following the recession. Although not as precipitous as the decline for

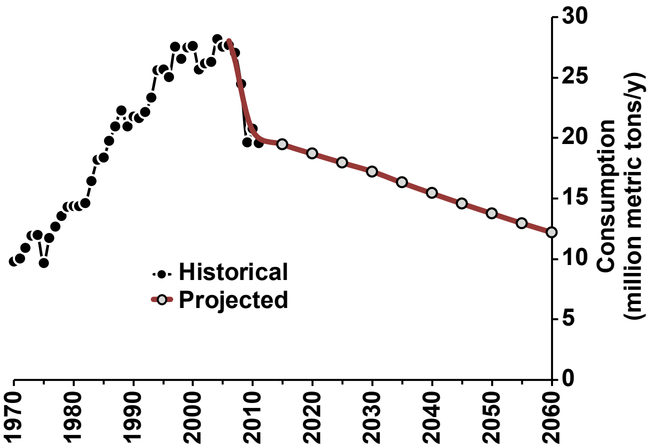

Figure 6. U.S. printing and writing paper historical apparent consumption from 1970 to 2011 (FAO 2012) and baseline projection of annual consumption to 2060.

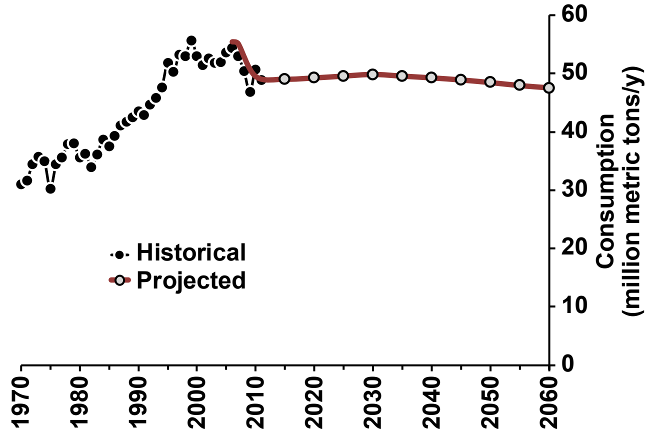

Figure 7. U.S. other paper and paperboard historical apparent consumption from 1970 to 2011 (FAO 2012) and baseline projections of annual consumption to 2060.

newsprint, U.S. consumption of printing and writing paper is projected to continue gradually declining and to be at levels that are only about half of recent historical peak levels by the end of the projection period in 2060 (Fig. 6).

Other paper and paperboard products, which include mostly packaging paper and paperboard, tissue and sanitary paper products, and specialty paper and paperboard products, have experienced proportionately less decline in consumption (Fig. 7) than newsprint (Fig. 5) or printing and writing paper (Fig 6.). However, some structural changes have affected U.S. demands for paper and paperboard packaging. Growth in U.S. demand for packaging materials has slowed as a result of slower growth in U.S. industrial production and increased U.S. imports of consumer goods that are prepackaged in other countries. Plastics too have made inroads to traditional paper packaging markets, such as plastic bags in traditional paper bag and sack markets. Overall consumption of paper and paperboard for packaging also experienced a decline during the 2007–2009 economic recession, but paper and paperboard are still by far the leading materials used for packaging and shipping containers in the U.S. economy. In addition, demands for tissue and sanitary paper products have continued to grow steadily in line with population growth. Therefore, overall U.S. consumption of other paper and paperboard is projected to remain relatively stable over the projection period (Fig. 7). In aggregate, total U.S. consumption of paper and paperboard is projected to decline in the decades ahead (Fig. 8), with newsprint and printing and writing paper accounting for most of the decline.

While U.S. consumption of paper and paperboard is declining (Fig. 8), slight gains in U.S. production of paper and paperboard are projected to be sustained because of projected continued growth in U.S. net exports. Although U.S. consumption of paper and paperboard has peaked, global demands for paper and paperboard are increasing, according

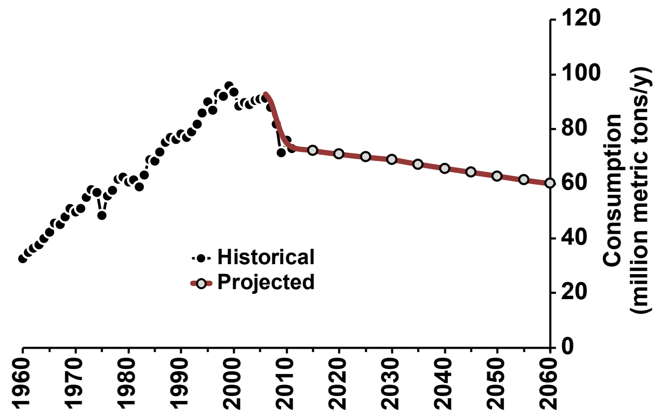

Figure 8. Total U.S. paper and paperboard historical apparent consumption from 1960 to 2011 (FAO 2012) and baseline projections of annual consumption to 2060.

to the GFPM. In addition, the USDA Baseline outlook for currency exchange rates remain favorable toward expanded U.S. net exports. Thus, U.S. production of paper and paperboard is projected to increase slightly (Fig. 9), but projected growth in production is nevertheless much slower than the rapid historical growth in production of the late 20th century, when U.S. production of paper and paperboard tripled from the early 1960s to late 1990s. Such rapid historical growth in U.S. paper and paperboard production and correlated growth in U.S. wood pulp production and pulpwood consumption are not expected to be seen again in the decades ahead.

The baseline projection of total U.S. paper and paperboard net trade volume (exports minus imports, excluding recovered paper) continues the historic reversal of the trade balance observed over the past several years (Fig. 10). The historical reversal from negative to positive net exports is attributable to gains in competitiveness for U.S.

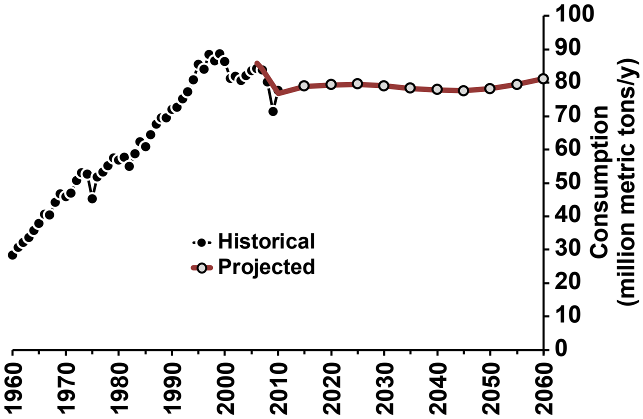

Figure 9. Total U.S. paper and paperboard historical production from 1960 to 2011 (FAO 2012) and baseline projection of annual production to 2060.

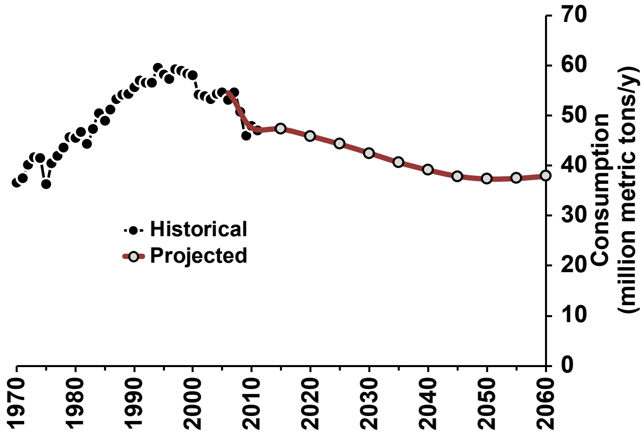

Figure 11. U.S. historical apparent consumption of wood pulp from 1970 to 2011 (FAO 2012) and baseline projection of annual consumption to 2060.

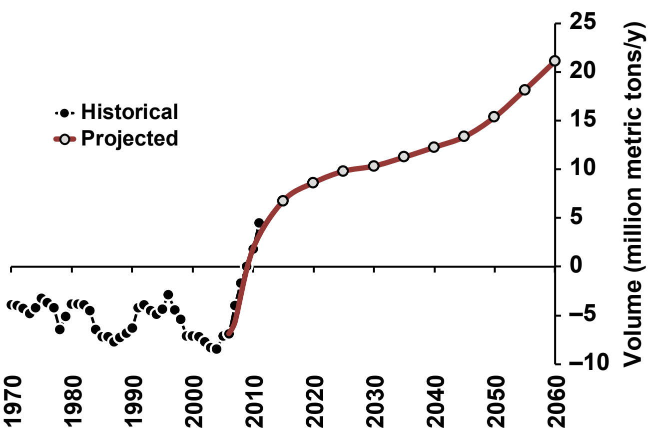

Figure 10. Total U.S. paper and paperboard historical net trade from 1970 to 2011 (FAO 2012) and baseline projection of annual net trade volumes to 2060.

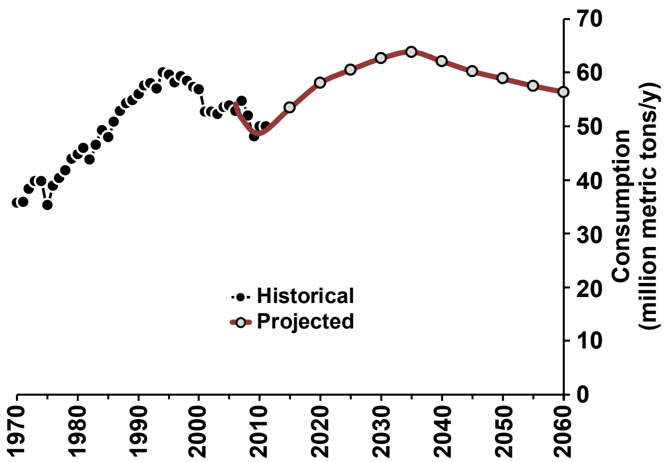

Figure 12. U.S. wood pulp production from 1970 to 2011 (FAO 2012) and baseline projection of annual consumption to 2060.

producers, with closures of less efficient mills, and also to global economic growth and a lower U.S. dollar exchange value, which favor higher U.S. net exports. Global economic growth and the favorable exchange rate condition continue into the future according to the USDA Baseline global outlook. Of course, a less optimistic outlook for global growth or exchange rates would dampen the outlook for U.S. net exports. Projected expansion of U.S. production and net exports consists mostly of other paper and paperboard products (packaging paper and paperboard products, tissue and sanitary paper products, and specialty paper products). (To explore the effect of exchange rate assumptions, we ran the analysis without the USDA Baseline global exchange rate projections, by assuming constant 2006 global exchange rates in the USFPM/GFPM model, and the result was lower projected U.S. net exports and production of forest products; for example, with constant exchange rates, U.S. production of wood pulp and sawnwood were both around 10% lower by 2030.)

U.S. consumption of wood pulp is projected to continue gradually receding as it has since U.S. wood pulp consumption peaked in the mid-1990s (Fig. 11). The decline for wood pulp consumption is a result of weak growth in paper and paperboard output, expansion in use of recycled fiber, and shifts in production of paper and paperboard products. For example, printing and writing paper uses high proportions of virgin wood pulp fiber and low proportions of recycled fiber, but U.S. output of printing and writing paper is declining. Among other paper and paperboard products that are projected to increase in output, there is potential to use higher proportions of recycled fiber, and foreign producers typically use higher proportions of recycled fiber in producing packaging paper and paperboard products and tissue paper products.

U.S. production of wood pulp is also projected to wane in the latter decades of the projection period (Fig. 12), but

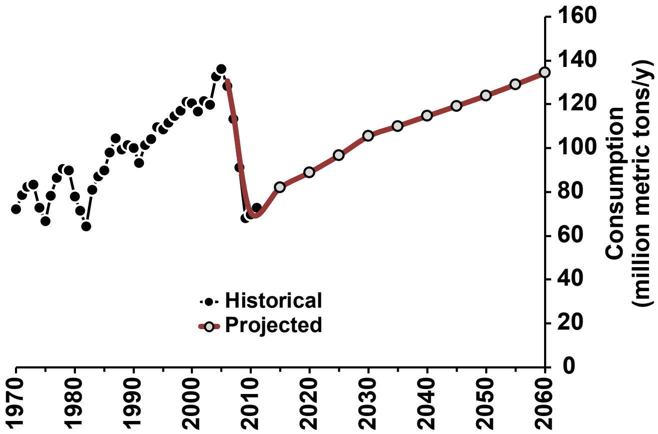

Figure 13. U.S. historical apparent consumption of sawnwood from 1970 to 2011 (FAO 2012) and baseline projection to 2060.

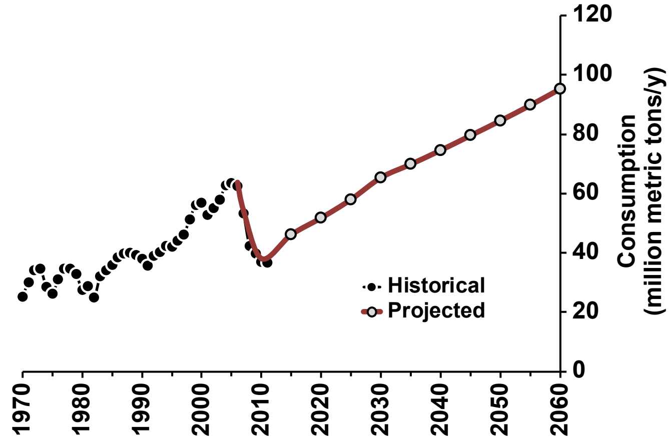

Figure 14. U.S. historical apparent consumption of wood panels and veneer products from 1970 to 2011 (FAO 2012) and baseline projection to 2060.

over the next couple of decades wood pulp production is buoyed by projected gains in U.S. net exports. Thus, U.S. wood pulp production and pulpwood consumption at wood pulp mills are projected to remain relatively buoyant over the projection period, although barely exceeding historical peak production levels and not increasing nearly as much as in the 1970s or 1980s. In the context of overall wood pulp production, chemical pulp production is projected to remain fairly stable while mechanical pulp production is projected to recede as primary uses of mechanical pulp (in newsprint and magazine paper production) are projected to recede.

USFPM/GFPM incorporates a kind of technology change assumption developed originally for the GFPM model; specifically that production technology in the global economy will become more similar across different countries because of global technology diffusion, although projected rates of technology change vary from country to country. The projected technological changes generally imply that U.S. and global technologies become more similar over the projection period, converging toward high efficiency levels in terms of paper recycling and wood use per unit of product output (Buongiorno and others 2012). (In this analysis, we used the same rates of technology change programmed originally into the GFPM model for wood products (Buongiorno and others 2012), but we reduced by half the rate of change in use of recycled fiber in U.S. paper and paperboard production because of very little projected industry growth and very limited increases in recycling at U.S. mills in the past decade. Nevertheless, there is still a substantial increase in U.S. paper recycling in our baseline outlook; the U.S. recovered paper utilization rate increases from around 39% in 2010 to around 54% by 2060.)

Wood Products

Primary wood products include sawnwood (hardwood and softwood lumber and sawn timbers) and wood panels and veneer products, including oriented strandboard (OSB), hardwood and softwood plywood and veneer, particleboard, and fiberboard, all of which are modeled in USFPM. Some of these primary wood products are also remanufactured into secondary engineered wood products, such as laminated veneer lumber (LVL) made from veneer, glue-laminated (glulam) beams made from lumber, structural I-joists made typically from laminated veneer lumber and OSB, and wood trusses for housing construction made from softwood lumber.

Figure 13 shows historical U.S. consumption of sawnwood (lumber and sawn timber products) since 1970 and our baseline projection of sawnwood consumption to 2060. Our baseline outlook indicates that U.S. lumber consumption will rebound gradually with the projected rebound in U.S. housing construction, but not fully recover to 2005 peak levels until the end of the projection period.

Figure 14 shows historical U.S. consumption of wood panels and veneer since 1970, and our baseline projection to 2060. Projected growth in wood panel and veneer consumption is a little more robust than for sawnwood because of expected continued substitution of engineered wood products for conventional lumber. In particular, U.S. consumption and production of OSB is projected to increase significantly following the projected rebound in U.S. housing construction, although recent historical peak levels of U.S. wood panel consumption (in 2005) are not projected to be reached again until around 2030 in the baseline outlook.

Of course, projections of U.S. wood product consumption hinge on the anticipated housing rebound over the next decade, without which wood product consumption would experience a much smaller rebound. Single-family housing starts are projected to more than double by 2020 to nearly 1.1 million per year, and then average starts are projected to follow the gradually increasing historical trendline to just over 1.1 million by 2060 (Fig. 4b). Projected growth in wood product demand is driven also by GDP growth and

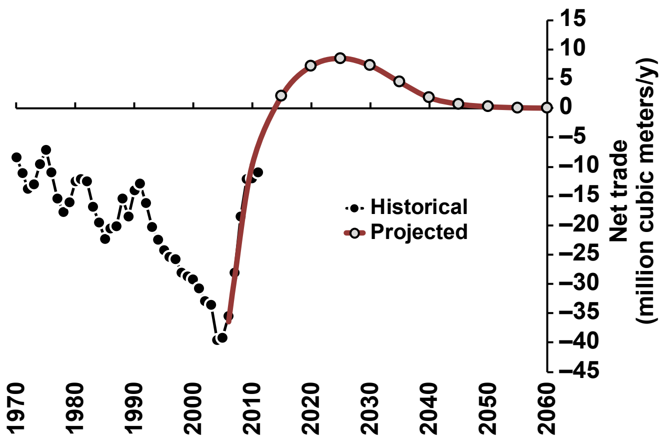

Figure 15. U.S. historical net trade of sawnwood from 1970 to 2011 (FAO 2012) and baseline projection of net trade to 2060.

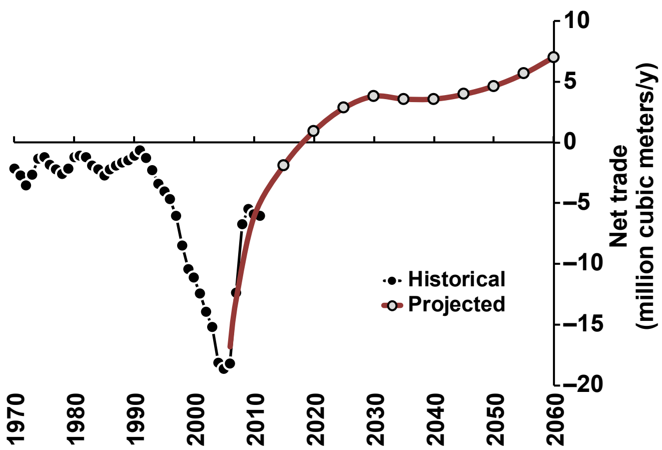

Figure 16. U.S. historical net trade of wood panels and veneer products from 1970 to 2011 (FAO 2012) and baseline projection of net trade to 2060.

use of wood products in applications other than new home construction, such as wood use in repair and remodeling, other construction, manufacturing, and transportation.

As is the case for paper and paperboard, trends in U.S. production of wood products are influenced by net trade (export minus import) as well as domestic consumption. Figure 15 shows historical net trade volumes for sawnwood along with baseline projections. U.S. net trade in sawnwood was decreasing historically, with high levels of softwood lumber imports primarily from Canada leading to a large U.S. sawnwood trade deficit up until the onset of the collapse in U.S. housing construction around 2005. The housing collapse, declining U.S. lumber consumption and a shift in currency exchange rates sharply reduced sawnwood imports after 2005, with the Canadian dollar and other currencies becoming generally more expensive relative to the U.S. dollar.

An earlier boom in Canadian lumber exports to the United States from the early 1990s to 2005 was facilitated by a strong U.S. dollar and also by higher allowable sawtimber harvests in Canada as large-scale bark-beetle infestations in Western Canada prompted increased removals of beetle-threatened sawtimber; but as that phenomenon runs its course, the allowable harvest of softwood sawtimber in Canada is expected to recede. Furthermore, the U.S. net trade outlook for sawnwood is influenced by the USDA Baseline currency exchange rate outlook, with a relatively weak U.S. dollar and strong foreign currencies, which favor a sustained improvement in the U.S. sawnwood trade balance. (The 2012 USDA Baseline macroeconomic outlook (ERS 2012) indicates, for example, that the Canadian dollar will remain above parity with the U.S. dollar over the entire projection period, whereas historically for decades prior to 2010 the exchange value of the Canadian dollar was much less than parity with the U.S. dollar, favoring U.S. imports of lumber from Canada in earlier decades.) The baseline projections indicate that the net trade balance for sawnwood will remain favorable to U.S. producers for several decades, until only later in the projection period when surging supplies of sawnwood from foreign producers are again projected to dampen U.S. net exports. Projected technological gains, with technology of developing countries becoming more similar to technology of advanced countries, tend to improve the relative efficiency of some foreign producers over time (Buongiorno and others 2012).

The recent trend in U.S. net trade for wood panels and veneer products was generally similar to that for sawnwood, and the trade outlook is also similar (Fig. 16). From the early 1990s to 2005, there was a mushrooming trade deficit as measured by the net trade volume for all wood panels and veneer products (much of it due to OSB imports from Canada), but after 2005 the trade deficit declined, largely because of the collapse in U.S. housing construction and related wood product demands but also because of sustained shifts in currency exchange rates with a weaker U.S. dollar. The baseline projections indicate continued improvement in the U.S. trade balance for wood panels and veneer products, owing in part to the weak dollar exchange rate outlook of the USDA Baseline.

Figure 17 shows historical trends and projections of U.S. sawnwood production, and Figure 18 shows historical trends and projections of U.S. wood panel and veneer production. Wood product output was severely depressed as a result of the collapse in housing construction and decline in wood product demand after 2005. U.S. sawnwood output declined by about 40%, and output of wood panels and veneer declined by about one-third. The declines in production contributed to significant declines in employment at wood product mills and in the logging sector, but production has begun to recover in the past couple years. U.S. output is projected to continue increasing for sawnwood (Fig. 17) and for

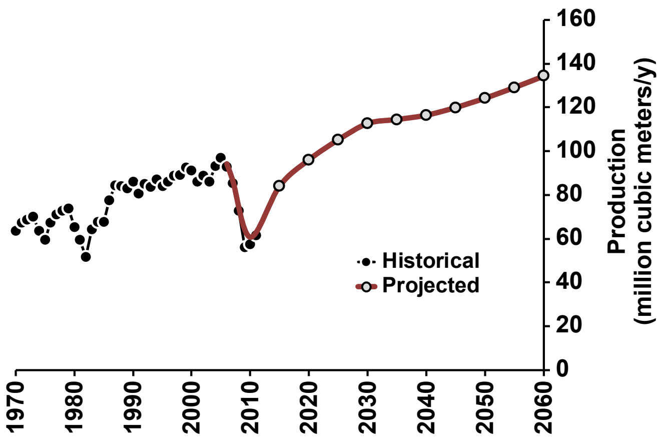

Figure 17. U.S. historical production of sawnwood from 1970 to 2011 (FAO 2012) and baseline projection to 2060.

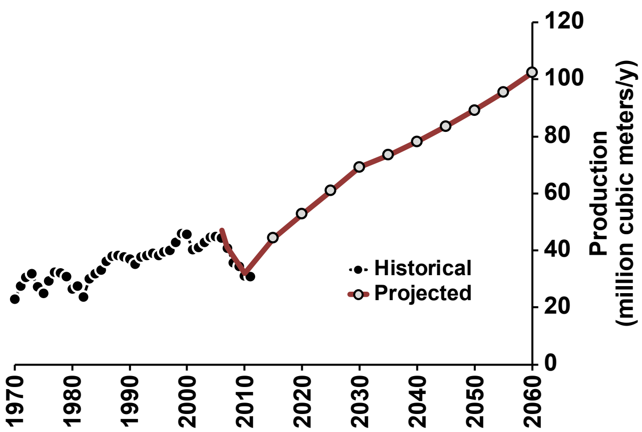

Figure 18. U.S. historical production of wood panels and veneer products from 1970 to 2011 (FAO 2012) and baseline projection to 2060.

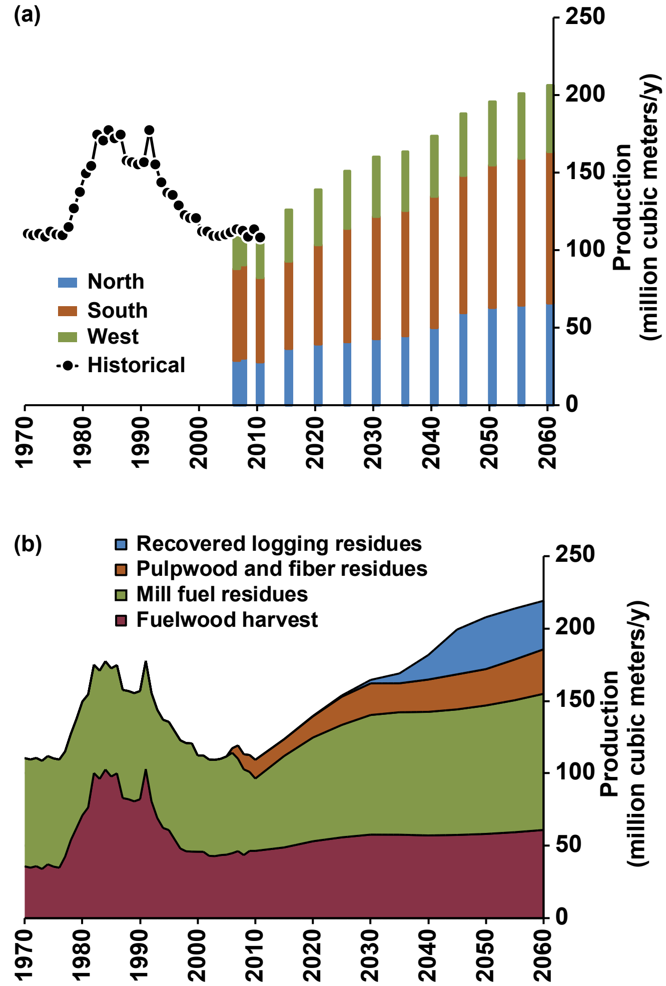

Figure 19. Historical and projected U.S. production of wood fuel feedstock (a) by region and (b) by source of feedstock.

wood panels and veneer products (Fig. 18) as a result of the projected rebound in housing and positive GDP growth (Fig. 4) and the improved trade balance for wood products (Figs. 15 and 16).

Wood Fuel Feedstock

In the USFPM analysis, U.S. wood fuel feedstock production includes all fuelwood and other wood feedstocks and wood residues used for energy, with the exception of pulp black liquor, a wood residue of the kraft pulping process that is burned for energy but counted as part of pulpwood consumption (Ince and others 2011a). Wood fuel feedstock includes residential fuelwood, wood and wood residues used in production of biofuels such as wood fuel pellets, and wood fuels used for industrial processes, such as wood or bark that are burned for energy at forest product mills or wood that is co-fired with coal at power plants. On the whole, U.S. production of wood fuel feedstock declined since the 1980s, after having increased significantly following the energy crisis of the early 1970s, but in the past decade U.S. production of wood fuel feedstock leveled out, and some uses such as commercial wood fuel pellets have increased with higher energy prices and increased export demands. It is noteworthy that U.S. output of wood fuel feedstock did not decline significantly during the recent recession.

U.S. wood fuel feedstock production is projected to nearly double by 2060, with output projected to increase in all U.S. regions (Fig. 19a). Our projected increase for U.S. wood energy output is similar but somewhat lower than the projected doubling in U.S. biomass energy production by 2030 in the reference case of the 2012 U.S. Annual Energy Outlook (U.S. Department of Energy). According to our economic model, the projected expansion in U.S. wood fuel feedstock output consists of increases in conventional fuelwood harvest, increased supplies of fuel residues from mills, increased use of pulpwood for energy (pulpwood is already being used as feedstock for producing wood pellets,

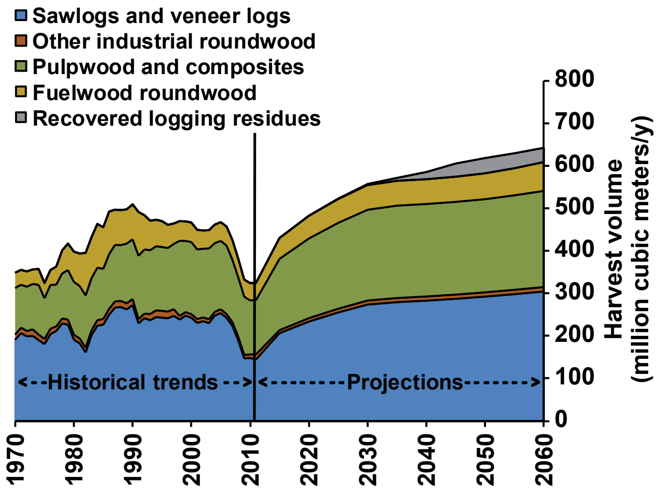

Figure 20. U.S. historical annual timber harvest volumes, 1970 to 2011 (FAO 2012) and baseline projections of timber harvests plus recovered logging residues to 2060.

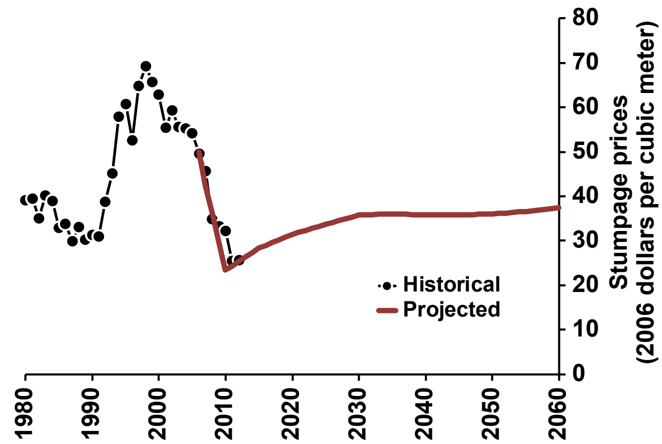

Figure 21. Average real historical stumpage prices for Southern pine (softwood) sawtimber (Timber Mart–South 1980–2011) adjusted by PPI and baseline projections to 2060.

including pellets for export), and an expansion in recovery of logging residues for energy in the latter decades of the projection as demand increases (Fig. 19b).

U.S. Timber Harvest, Prices, Inventory, and Roundwood Trade

U.S. timber harvest consists of all roundwood products such as saw logs, veneer logs, pulpwood used for wood pulp and composite wood products such as OSB, fuelwood, and other industrial roundwood including posts, poles, pilings, and miscellaneous products. U.S. roundwood product output including exports amounted to 457 million cubic meters in 2006 according to FAOSTAT (FAO 2012). This volume does not include logging residue volumes left in the forest, nor does it include other removals such as precommercial thinnings or land clearing. Total removals, including roundwood products, logging residues, and other removals, were over 600 million cubic meters in 2006 (Smith and others 2009).

Figure 20 shows historical data on annual U.S. timber harvest volumes (based on roundwood product output as reported by FAOSTAT (FAO 2012)) and our baseline projections to 2060 of U.S. timber harvest plus projected recovery of logging residue volumes used for energy. Logging residues consist of felled woody debris that has not been recovered or utilized conventionally and was historically left to decay in the forest, but an increasing share of logging residues are projected to be recovered and used economically for energy as a result of projected growth in wood energy demand according to the USFPM analysis. (We recognize that the extent of future recovery of logging residue for energy is likely to be limited for reasons that are both economical (higher costs with increased recovery) and prudent in terms of forest management (the need to leave some residues in the forest for soil nutrient cycling, wildlife habitat protection, and other reasons). The precise future extent of residue recovery is unknown at present, so USFPM logging residue recovery is conservatively limited to not more than 60% of projected volumes of residues generated by logging activities (Ince and others 2011a).) Projected U.S. timber harvest reflects the baseline projections of forest product and wood energy output shown previously, and as such the timber harvest outlook is influenced by the recent economic recession, structural changes in product demands, and the net trade outlook. The recession and collapse in housing cause a large but transitory dip in U.S. timber harvest volume, especially notable between the years 2005 and 2015. Conventional U.S. timber harvest (excluding recovered logging residues) is projected to rebound from current depressed levels and by 2030 climbs back above historical peak levels reached previously during the late 1980s. Moreover, projected U.S. timber harvest volumes by 2030 are higher than the most recent peak harvest volumes just before the collapse in housing construction in 2004 and 2005 (462 million and 467 million cubic meters, respectively), reaching 555 million cubic meters in 2030. However, U.S. timber harvest is projected to increase only modestly beyond 2030, partly because of declining projected output of wood pulp, with projected timber harvest in 2060 at 607 million cubic meters, or about 30% above the 2005 timber harvest volume (an average expansion rate of only about 0.5% per year from 2005 to 2060).

We project timber prices to rebound in the near term with the projected rebound in timber harvest, but modest growth in demand for sawnwood and expanding timber inventories result in a subdued long-run outlook for U.S. sawtimber stumpage prices. For example, real Southern Pine sawtimber stumpage prices were depressed in recent years (Fig. 21) as a result of the recession and the collapse in housing construction since 2005. The average real (inflation-adjusted)

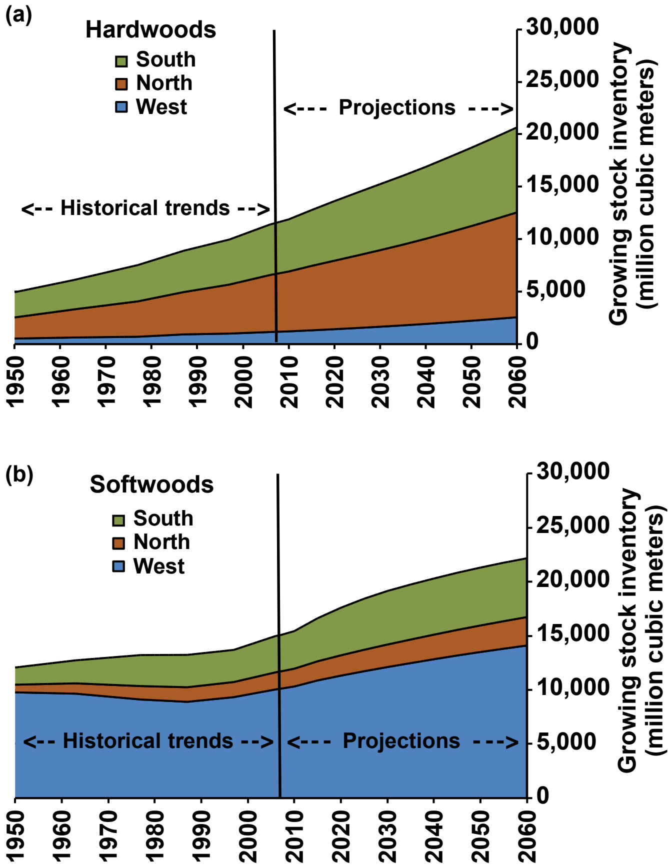

Figure 22. U.S. historical timber growing stock inventories on timberland by region for (a) hardwoods and (b) softwoods (Smith and others 2009), with baseline projections to 2060.

price of Southern Pine sawtimber collapsed by 50% from 2005 to 2011, according to South-wide average stumpage prices reported by Timber Mart–South (1980–2011), which we adjusted for inflation using the all-commodity Producer Price Index (PPI, Bureau of Labor Statistics). We project Southern Pine sawtimber stumpage prices to rebound somewhat but by no means fully recover to historical peak levels (Fig. 21). After 2030, timber stumpage prices level out over the projection period with increasing timber growing stock inventories. Similar real timber price trends are projected for other U.S. regions.

In our 2012 baseline outlook, U.S. timber growing stock inventories are projected to expand on U.S. timberland, mainly because of the large dip in U.S. timber harvest between 2005 and 2015 and the modest projected expansion in future timber harvest coupled with continued timber growth. Figure 22 shows historical trends in timber growing stock inventories on timberlands by U.S. region and species group, based on Forest Service nationwide timber inventory data for the years 1953, 1963, 1977, 1987, 1997, and 2007 (Smith and others 2009), and our baseline projections of U.S. timber inventories to 2060. Our timber inventory outlook is calibrated to historical relationships between regional average net annual growth rates and mean timber stocking density on timberland (Nepal and others 2012), and for this analysis we did not assume any expansion of Southern Pine timber plantation area in the U.S. South, because of the relatively low projections of Southern Pine stumpage prices (see Appendix for specifications of the inventory model).

Assumed future U.S. forest land area changes in our 2012 baseline scenario are the same as those developed for the A1B scenario in the 2010 RPA Assessment, where a nationwide decline of 12.4 million hectares of non-federal forestland area was projected from 2010 to 2060 in the conterminous United States (Wear 2011). This projected loss of forest land area is equivalent to 4.8% of the total forest land area and 6.1% of the timberland area of the conterminous United States in 2007 (Smith and others 2009). Loss of private forest land to urbanization accounts for most of this projected future forest land area loss according to the RPA land area analysis, primarily in the Eastern United States (Wear 2011). Losses of forest land area are highest in the South, accounting for just over half of projected nationwide losses, while federal forest land area was assumed to remain unchanged (Wear 2011). We used the RPA A1B forest land area projections in our 2012 baseline outlook because the RPA projections of urbanization were driven primarily by population and personal income growth and the USDA Baseline projections of U.S. economic growth are closest to those of the A1B scenario among RPA scenarios. In addition, we project little change in timber stumpage prices over the projection period, and the RPA land area analysis similarly assumed that relative returns to agricultural and forest land would remain constant through the forecast period (Wear 2011).

As shown in Figure 22, the projected expansion of U.S. timber inventories in our baseline outlook generally follows historical patterns of expansion in U.S. timber inventories over the past 60 years or so despite a projected decline in total U.S. forest land area and despite our assumption that pine plantation area in the South will not increase. Projected expansion of hardwood timber inventory is concentrated in the North and South, where hardwood inventories more than doubled over the historical period from 1953 to 2007 (Smith and others 2009). Projected expansion in softwood timber inventory is concentrated in the U.S. West, where softwood inventory has been expanding historically since timber harvests were scaled back on federal lands during the late 1980s (Smith and others 2009). U.S. nationwide timber growing stock inventories are projected to increase from 2007 to 2060 by 48% for softwoods, 81% for hardwoods, and 62% for total softwoods and hardwoods, while carbon in tree biomass on U.S. timberland is projected to increase by about 66%.

Although our baseline projections of U.S. timber inventories line up with historical trends (Fig. 22), they differ from the generally lower timber inventory projections of the 2010 RPA Assessment (Forest Service 2012) and Southern Forest Futures Project (Wear and Greis 2011). Among 2010 RPA scenarios, the Historical Fuelwood scenario had highest projected U.S. timber inventory by 2060, but only slightly higher than 2007 timber inventory. One reason for the much higher timber inventory projection of our 2012 baseline outlook is that projected housing starts and U.S. demands for sawnwood and wood panels are generally lower than most RPA scenarios, particularly the RPA A1B and Historical Fuelwood scenarios, which shared a much higher housing demand projection based on demographic trends (Fig. 4b). Furthermore, none of the RPA scenarios or Southern Forest Futures Project took into account reduced timber drain resulting from the recession and collapse in housing, which resulted in a significant decline in U.S. timber harvest since 2005. Also, our 2012 baseline outlook projects much less drain of timber for wood energy than most RPA scenarios (except for the Historical Fuelwood scenario). Thus, the departure of our baseline U.S. timber inventory projections from other recent forest assessments can be understood largely to be a result of a more subdued U.S. timber demand outlook, recognizing impacts of the recession, housing downturn, and structural change in wood demands, with modest growth in wood energy consumption. (In addition, the forest plot transition model used to project inventory in the 2010 RPA and Southern Forest Futures Project was a stochastic model that cannot precisely match USFPM/GFPM harvest projections. Our baseline inventory outlook is calibrated to a more precisely matched growth and inventory model (Nepal and others 2012).)

U.S. net exports of roundwood are favored by receding real timber prices over the long run and by the favorable USDA Baseline currency exchange rate outlook, so the baseline global timber trade analysis resulted in projected expansion of U.S. net exports of industrial roundwood (Fig. 23). Softwood and hardwood sawlog exports in particular from the U.S. West and North regions account for the largest shares of projected U.S. industrial roundwood exports by 2060 (42% and 37%, respectively), with Asian countries (primarily China and India) greatly expanding imports of industrial roundwood according to the baseline analysis, which is also similar to previous GFPM projections (Buongiorno 2012).

Summary and Implications for Forest Management and Policy

Our 2012 baseline outlook accounts for the recent economic recession and collapse in U.S. housing construction, structural changes in U.S. wood product demands, net trade responses to shifts in currency exchange rates, and shifts in U.S. timber stumpage markets. Our baseline outlook includes a rebound in housing construction by 2020, with

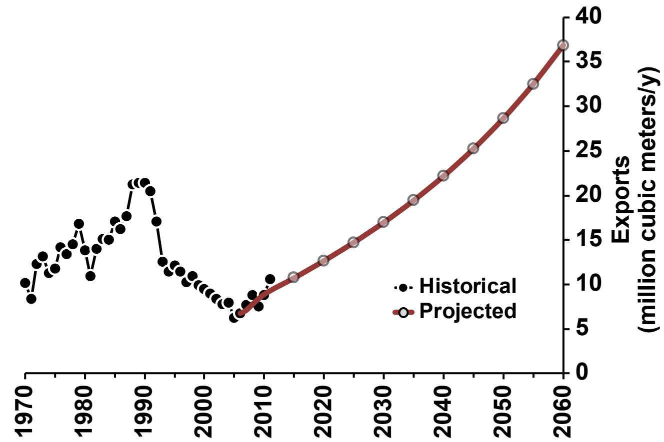

Figure 23. U.S. historical net exports of industrial roundwood from 1970 to 2011 (FAO 2012) and baseline projection of annual net exports to 2060.

long-run average single-family housing starts after 2020 following the long-term historical trendline at around 1.1 million per year over the projection period to 2060. U.S. timber harvest is likewise projected to rebound from recently depressed levels, but timber harvest levels out after 2030, largely because of declining wood pulp production, with projected U.S. timber harvest in 2060 only about 30% higher than it was in 2005, not counting increased recovery of logging residues (Fig. 20). Projections include a doubling over the next 50 years in U.S. production of wood fuel feedstock, with some expansion in use of unconventional sources of wood for energy such as harvested pulpwood and recovered logging residues. The analysis incorporates the favorable global exchange rate outlook of the USDA Baseline, which contributes to projected improvements in U.S. net exports of wood products, paper and paperboard, and sawlogs.

Projections of modest increases in U.S. timber harvests (Fig. 20), a modest rebound in real timber stumpage prices (Fig. 21), and continued expansion in U.S. timber growing stock inventories (Fig. 22) have some implications for forest management and policy. One implication is an expectation of a rebound in timber revenues, which have traditionally helped support public and private forestry activities, but the rebound in timber revenues will likely be fairly modest, with only modest increases in real stumpage prices because of expanding timber inventories and modest growth in timber demand. U.S. timber harvest is projected to exceed 2005 levels again in the decade after 2020, but then increase only gradually to 2060. Our baseline timber stumpage price outlook is closest to that of the RPA B2 or HFW scenarios, with little increase in timber prices beyond 2030. Thus, as pointed out previously in the 2010 RPA Assessment in reference to scenarios with low timber price projections (Forest Service 2012), the nation faces a challenge of sustainability in enhancing the market value of wood resources. That challenge is shared both by forest landowners and forest managers who seek to improve forest conditions and must cope with limited growth in timber revenues and by forest product researchers and industry developers who strive to design future technologies that will make forest enterprises economically sustainable.

A corollary social sustainability challenge is the need to sustain employment and community stability in a sector that has suffered significant job losses (Woodall and other 2012). Recent declines in forest sector employment reflect the economic recession and collapse in U.S. housing construction but also stem from such structural changes as industry consolidation and labor-saving productivity gains. Figure 24 shows U.S. employment trends in the primary wood products and paper manufacturing industries (NAICS 321 and 322) (U.S. Bureau of Labor Statistics), along with projected employment derived from our baseline projections of production volumes and historical trends in labor productivity. (We used USFPM/GFPM projections of U.S. production of sawnwood, wood panels and veneer as the basis for employment projections in wood products (NAICS 321), and USFPM/GFPM projections of U.S. paper and paperboard production as the basis for employment projections in paper manufacturing (NAICS 322). We adjusted employment projections in both cases for expected future productivity gains based on labor productivity trends from 1990 to 2011, which show labor productivity increasing more rapidly for NAICS 322 than for NAICS 321.) Wood product industry employment (NAICS 321) is projected to rebound in the near term, given the projected rebound in housing along with gains in lumber and wood panel output and modest labor productivity gains, while paper industry employment (NAICS 322) is projected to decline because of larger productivity gains and only modest increases in industry output. However, by 2030, total employment in these primary industries is projected to peak and then level out at around 0.9 million, which is almost 25% higher than depressed 2011 employment levels but still about 25% lower than peak employment levels of the late 1990s.

Our analysis does not project employment in secondary wood product manufacturing, but declining historical employment trends have resulted from outsourcing of secondary manufacturing such as wood furniture production to countries with lower labor costs (Ince and others 2007, Woodall and others 2012). The projected trend in U.S. net exports of industrial roundwood (Fig. 23) also reflects the growth in global demands for wood raw materials and cost competitiveness of foreign producers of wood products as represented in the USFPM/GFPM model. Projected expansion of roundwood exports portends a forfeiture of future U.S. employment opportunities that might otherwise exist if exports of industrial roundwood were instead converted by U.S. manufacturers to higher value products and then

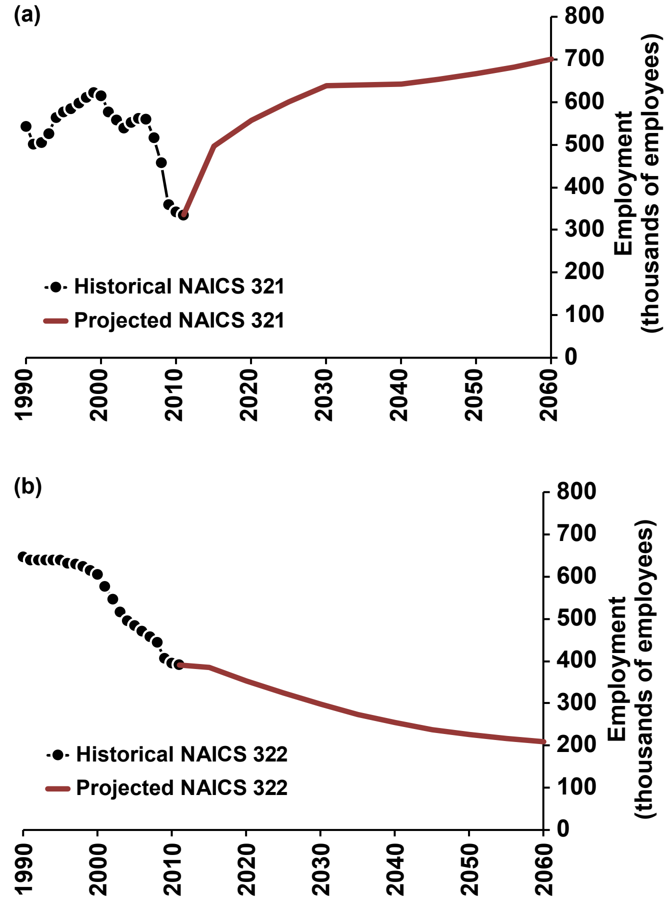

Figure 24. U.S. historical employment in (a) wood products, NAICS 321, and (b) paper products, NAICS 322, 1990 to 2011, with baseline projections to 2060.

exported. Thus, according to our baseline outlook, the challenge of social and economic sustainability extends also to the challenge of enhancing U.S. competitiveness in value-added manufacturing and secondary wood product manufacturing to improve the long-term future outlook for forest-based employment opportunities.

Another important implication of our baseline timber outlook is that timber growing stock in the United States will continue to be a net carbon sink for decades to come, absorbing atmospheric carbon as net annual growth continues to exceed annual harvest volume by a wide margin, as was the case in recent past decades. This implication that U.S. forests will continue accumulating carbon with expanding timber inventory over the next 50 years is distinctly different from scenarios of the 2010 RPA Assessment (Forest Service 2012), which had projected relatively flat to declining trends in forest carbon stocks, largely attributable to much higher projected wood use for energy and higher timber harvests for wood products because the RPA scenarios did not include the recent recession or collapse in housing construction.

Finally, our baseline analysis shows that sustaining future timber markets and timber revenues depends on sustaining the global competitiveness of the forest sector. Without projected gains in net exports or with a reversion to historically high levels of imports, there would be no projected increase in U.S. output of pulp, paper, and paperboard and much smaller gains in output of lumber and wood panel products. In this analysis, the 2012 USDA Baseline projections of U.S. and global currency exchange rates have a positive influence on projected U.S. industry competitiveness (and alternatively a reversion to historically high U.S. dollar exchange values would dampen the outlook for U.S. net exports).

Our 2012 baseline timber outlook provides a coherent reference case from which to evaluate more precisely the forest sector implications of current market conditions and trends, and future implications of forest policy alternatives. For example, our baseline outlook implies that climate change mitigation policies focused on additional carbon accumulation in forests should recognize a higher baseline outlook for U.S. forest carbon stocks because of structural changes in timber demands, with higher thresholds for consideration of forest carbon credits, additionality, and leakage effects. Similarly, the new baseline outlook points to a clear linkage between sustaining the global competitiveness of the forest product sector and sustaining future forest sector employment, timber revenues, and forestry activities.

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Appendix—Regional Timber Growth and Inventory Models

To endogenously model regional U.S. timber growth and timber growing stock inventory in the 2012 version of the USFPM/GFPM model, we employed the same technique that was developed previously for the GFPM to project growth in forest stock for all countries worldwide (Turner and others 2006). That technique projects changes in forest stock in relation to projected harvest levels, projected net growth rates (before harvest), and projected changes in forest land area (which is projected endogenously for other countries in the GFPM but which we specify exogenously for the U.S. regions based on the land area projections developed for the RPA A1B scenario (Wear 2011)). In the GFPM framework, initial stocking levels and growth rates for forest stock are specified for each country (based on global forest inventory and growth data), and stocking levels are adjusted over time based on projected growth and harvest. Furthermore, change in the growth rates are modeled as a function of projected changes in stocking density, using a negative elasticity of growth with respect to stocking density (Turner and others 2006). We found previously that we could produce accurate projections (in comparison to historical data) of U.S. regional timber inventory for hardwood and softwood timber growing stock using this modeling framework, so long as we used growth model parameters estimated appropriately for the U.S. subregions and species groups (Nepal and others 2012).

The complete specification of our endogenous timber growth and inventory model for hardwood and softwood timber growing stock in each U.S. subregion (North, South, and West) includes initial timber growing stock inventory volume, net annual growth rate as a percentage of timber inventory, forest land area, assumed annual change (loss) of forest land area to other land uses (which causes proportionate loss in available timber inventory), elasticity of timber growth with respect to stocking density, and ratio of growing stock removals to timber harvest. The model recognizes that annual growing stock removals differ from timber harvest because removals include the growing stock portion of logging residues and also other removals, whereas timber harvest volume includes both growing stock and non-growing stock timber (Smith and others 2009). Stocking density is computed by the model as the regional volume of timber growing stock per hectare of timberland. Table A1 summarizes the specifications of the endogenous timber growth and inventory model as employed in the 2012 baseline version of the USFPM/GFPM model. The elasticities of growth with respect to stocking density were set at values that produced accurate projections of timber inventory in comparison to our more detailed models of regional timber growth and inventory (Nepal and others 2012). It can be noted also that in our more detailed inventory model we can specify assumed changes in the area of pine plantations in the U.S. South (the effect is to change softwood timber growth rates in that region), and such adjustments of growth can also be entered for our endogenous timber inventory model, but in this analysis we did not assume any change in pine plantation area in the South. Also, we did not assume any changes in timber growth rates in response to climate change in the baseline analysis.Thus, the only projected changes of timber growth rates in U.S. regions are those that arise from projected changes in stocking density (according to the growth elasticity parameter), and thus the timber growth rates as a percentage of timber inventories are declining gradually in all cases because stocking densities are increasing for all regions and species groups. However, despite the assumed declines in timberland area and projected declines in net annual growth rates, U.S. regional timber inventories are still projected to increase (Fig. 22).

Table A1—Specifications for endogenous timber growth and inventory model for timber growing stock inventory in U.S. regions[a]

	Regions and timber species groups					
	North		South		West	
Model parameters	Softwood	Hardwood	Softwood	Hardwood	Softwood	Hardwood
Timber inventory (10^6 m^3)	1,582	5,441	3,355	4,815	10,049	1,152
Net annual growth rate	0.0266	0.0265	0.0644	0.0332	0.0172	0.0191
Timberland area (10^3 ha)	66,376		82,568		59,151	
Annual timberland area change (%)	–0.15		–0.24		–0.12	
Growth/stock density elasticity	–0.500	–0.505	–0.550	–0.450	–0.700	–0.130
Removals/harvest ratio	0.943	0.921	1.043	1.326	0.912	0.646

[a] Timber inventory and timberland area are based on timber growing stock volume and timberland area as reported for beginning of 2007 (or the end of our model base year, 2006); net annual growth rate relative to inventory and removals/harvest ratio are based on timber data as reported for 2006 (Smith and others 2009). Timberland area change is annual average rate of change based on projected changes in forest land area by region for the RPA A1B scenario (Wear 2011), which we applied to timberland area in this analysis. Timber growth to stocking density elasticity parameters were set at values that produced timber growth and inventory projections matching our more detailed regional growth and inventory models (Nepal and others 2012). For comparison, a stocking density elasticity of –0.48 was employed in the GFPM for all other countries, although different parameter estimates have been reported in the literature (Turner and others 2006).