Changes in the Residual Wood Fiber Market, 2004 to 2017

Resources for the Future
US Endowment for Forestry & Communities, Inc.
National Wooden Pallet & Container Association

FOREST2MARKET
Global Wood & Fiber Supply Chain Experts

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1 INTRODUCTION

1.1 Objective

Wood residuals are an important source of revenue for solid wood manufacturers (sawmills, plywood mills, pallet mills, etc.). Because the sale of this material often offsets production costs at a mill, having a stable market for residuals is critical for mill profitability.

In fact, the sustainable balance between residual supply and demand is essential for the stability of forest products markets. Because both the sellers and the buyers of these materials are participants in the forest products industry, the market for wood residuals can be both dynamic and delicate. When disruptions occur in supply, a chain reaction of higher priced, raw material substitutions can ripple through the industry, resulting in higher costs and lower profitability; when disruptions occur in demand, the accrual of residuals at the mill becomes a disposal problem. To maintain efficiency, un-sold byproducts must be landfilled or burned, and both options are environmentally untenable and cost prohibitive.

The market for and price of wood residuals have strengthened and declined over economic cycles. Since 2010, the supply of wood fiber residuals has been expanding, driven by rising lumber production and improving economic conditions. And more expansion is on the horizon. In the US South, over 2.5 billion board feet (BBF) of new lumber capacity has been announced; in the Pacific Northwest (PNW) that number is smaller but still significant at 750 million board feet (MMBF). Together, new production will add 4 million tons of residuals to the supply base.

While supply is expanding, however, demand has been impacted by economic and industry developments over the last ten years as well. Structural market changes may well portend a long-term market softening for sawmill chips and wood fuel.

For solid wood manufacturing to continue expansion in the United States, outlets for wood residuals must be robust and commercially accessible.

Project sponsors—Resources for the Future (RFF), the US Endowment for Forestry & Communities, Inc. and the National Wooden Pallet & Container Association (NWPCA)—engaged Forest2Market to perform a comprehensive wood fiber residuals market analysis. The objectives of this study included:

- Uncovering the underlying market forces that impact the residual market
- Assessing the nature and implications of these impacts
- Determining whether the changes occurring in the market are:
    - Fundamental, structural changes that necessitate a systematic problem-solving approach or
    - Temporary, short-term, cyclical changes that require a corporate-level response

To accomplish these objectives, this study focuses on economic conditions, changes in consumer preferences and changes in forest products preferences and demand for two time periods—2004-2009 (the pre-recession bubble and the Great Recession) and 2007-2017 (the Great Recession and recovery)—in order to fully understand changes occurring in the market.

1.2 Geographic Scope

The geographic scope for this study was divided into two broad regions of the United States: the US South and the PNW (Figure 1-1). The pulp and paper mills found in both areas are vital to the residual wood fiber market as the primary consumers of chips, sawdust and shavings and wood fuel. Conveniently, the chief producers of residual wood fiber also exist as sawmills and other primary manufacturing facilities. In the US South, pertinent mills located within the states of Alabama, Arkansas, Florida, Georgia, Louisiana, Mississippi, North Carolina, (southeastern) Oklahoma, South Carolina, Tennessee, (eastern) Texas and Virginia were included in this study.

While it should be noted that both the production and capacity of the wood fiber market in the US South operates on a much larger scale than that of the PNW, this does not discount the importance of the residual market presence in the states of (northern) California, Idaho, (western) Montana, Oregon and Washington. Since there are currently no pulp or paper mills operating in northern California, most of the residual chips produced by the region's sawmills are consumed by mills to the north in Oregon and Washington.

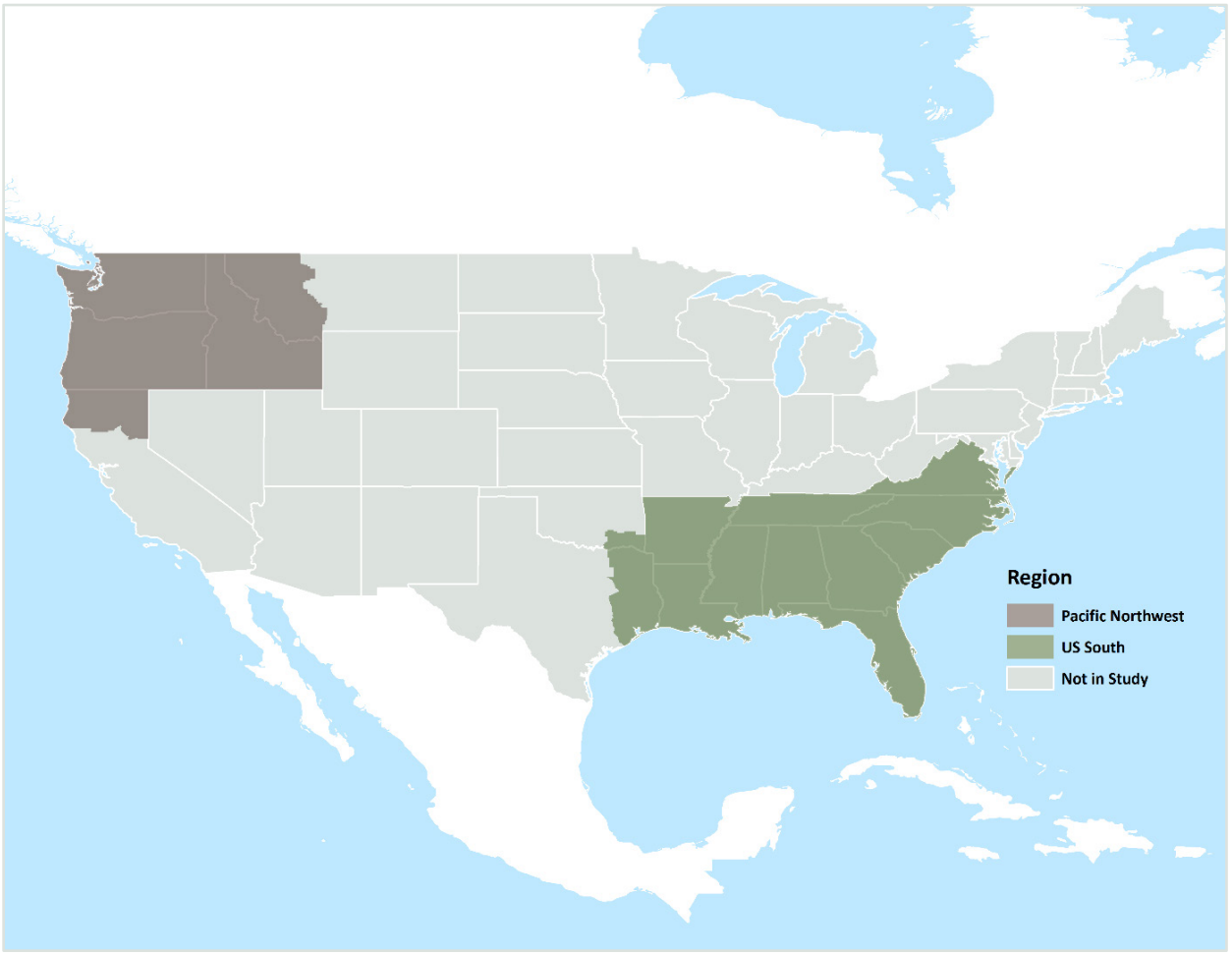


Figure 1-1 Residual Wood Fiber Study Regions

While not part of the scope of this study, it is worth noting that the residual market in the US Northeast—once a bastion of paper production due to its vast hardwood resource—continues to struggle as a number of the region's paper mills have shuttered over the last 20 years. Since the beginning of 2014, the state of Maine alone has lost over 4 million tons of low-grade market—most of which were pulps mills (that used residual chips) with some biomass market loss as well.

2 DETERMINING STRUCTURAL MARKET CHANGE

Fundamental changes to global markets often go unnoticed until the effects are blatantly obvious and painful. After an initial shock, a series of subsequent shockwaves continues to exacerbate the situation and by the time market participants realize that the market has structurally changed, it is generally too late to alter course. When asset bubbles burst, the resulting economic downturn is dramatic. Consumer confidence is eroded; as confidence wanes, so does demand. This is the tipping point in the business cycle where the peak, accompanied by irrational exuberance, tips into contraction. Once the contraction gains momentum, market panic sets in and, as a result, federal governments and central banking systems typically have to step in to mitigate the damage.

History is brimming with examples of this process at work. “Tulip mania” that shocked the Netherlands in 1637 is generally considered to be the first recorded speculative bubble in which asset prices deviated significantly from intrinsic values, but the same dynamic could be seen in the “dot-com bubble” of 2002 that resulted in a stock market downturn and loss of $5 trillion in market capitalization from its peak.

An asset bubble in US real estate formed in 2005 when demand for mortgages drove up demand for housing, which homebuilders largely met; housing starts totaled almost 2.1 million units in 2005. Home loans were cheap, and the number of subprime mortgages skyrocketed, but when the fed funds rate went from 2.25% in 2004 to over 5% just a year later, millions of homeowners were simply priced out of their homes. As a result, mortgages went unpaid, housing prices plummeted, and the entire housing market bubble popped, which created an ensuing banking crisis that spread to Wall Street and beyond in late 2008. Unlike the asset bubbles mentioned above, which were localized or industry-specific and therefore caused limited structural damage, this event (the Great Recession) had profound implications on a global scale.

To determine whether the residual market has also undergone a structural change as a direct (or indirect) result of the Great Recession, one must compare the current market to past markets. Forest2Market is uniquely qualified to understand market changes over time due to our long commercial history and our robust databases of actual wood raw material transactions (Appendix B – About Forest2Market Data).

A number of market indicators foreshadow structural change, including:

- Changes in supply and demand
- Changes in cost structure and price
- Changes in product use and consumer preferences
- Introduction of compelling product substitutes
- Consolidations and closures

Forest2Market investigated whether the United States’ residual market was subject to one or all these changes.

3 ECONOMIC CONDITIONS AND PERFORMANCE

Structural changes in markets are often caused by profound changes to the economy. Over the course of the last 15 years, the US economy has undergone stark changes:

- 2004-2007: A pre-recessionary growth phase
- 2007-2009: The Great Recession, which reverberated through every part of the US and global economies
- 2009-2017: A slow and arduous but persistent recovery

To provide context for the changes that have occurred, and are still occurring, in the wood residuals market, this section of the report highlights the economic changes that have occurred in two periods:

- 2004-2009—The Great Recession and the Pre-Recessionary Period
- 2007-2017—The Great Recession and the Recovery

3.1 Gross Domestic Product

3.1.1 2004-2009—The Great Recession and the Pre-Recessionary Period

Perhaps the simplest measurement of general economic health is gross domestic product (GDP). GDP is the measure of a nation's economic performance (i.e. total value of goods produced, and services provided, during a year). Just after the US housing market peaked in late 2005, the nation experienced a weakening in the economy that led to a freefall in the period between 2007 and 2009, an event that is now known as the Great Recession (Figure 3-1). In 2009, GDP retracted by 2.8% compared to 3.8% growth measured in 2004—a 6.6% swing in growth. This recession was the worst economic downturn in US history since the Great Depression of the 1930s.

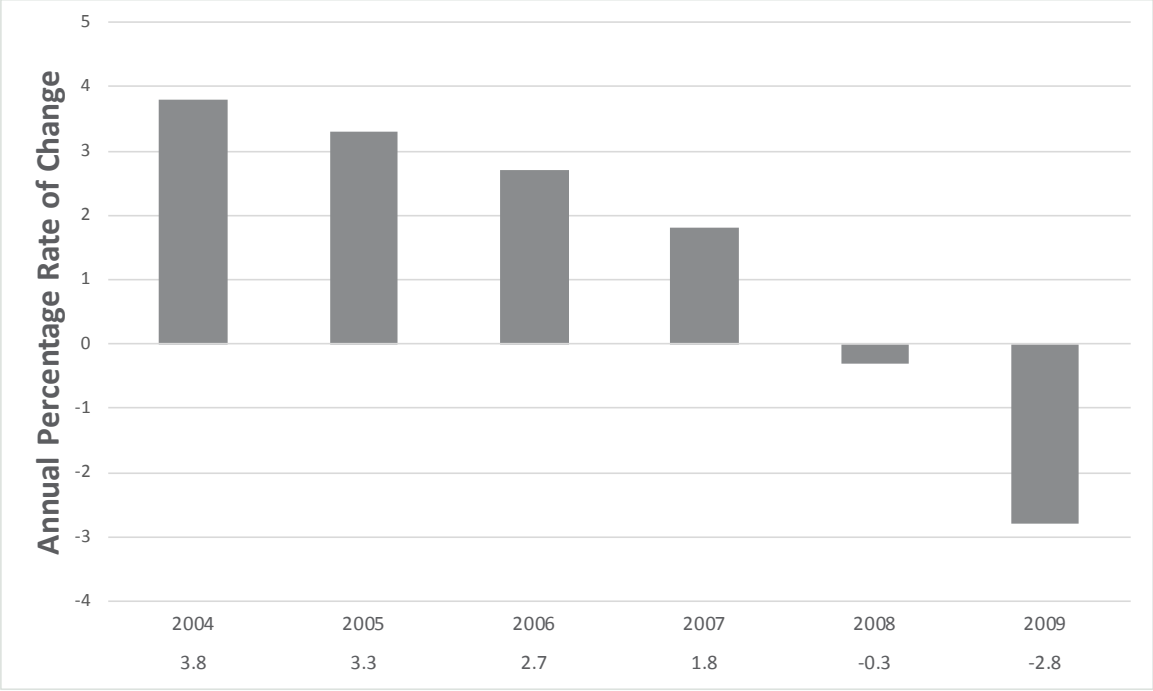


Figure 3-1 Real GDP Change from 2004 to 2009
(Source: U.S. Bureau of Economic Analysis)

3.1.2 2007-2017—The Great Recession and Recovery

Since its low point in 2009, the real GDP annual percentage rate of change has demonstrated significant improvement, showing an increase each year since returning to pre-recession levels in the third quarter of 2011 (Figure 3-2). The current outlook for the future is also hopeful. In the second quarter of 2018, GDP growth was 4.1% annualized, which is an increase from the 2.3% average in 2017. Forest2Market's GDP forecast indicates that, without major socio-political disruptions, GDP will remain in positive territory through the second quarter of 2020.

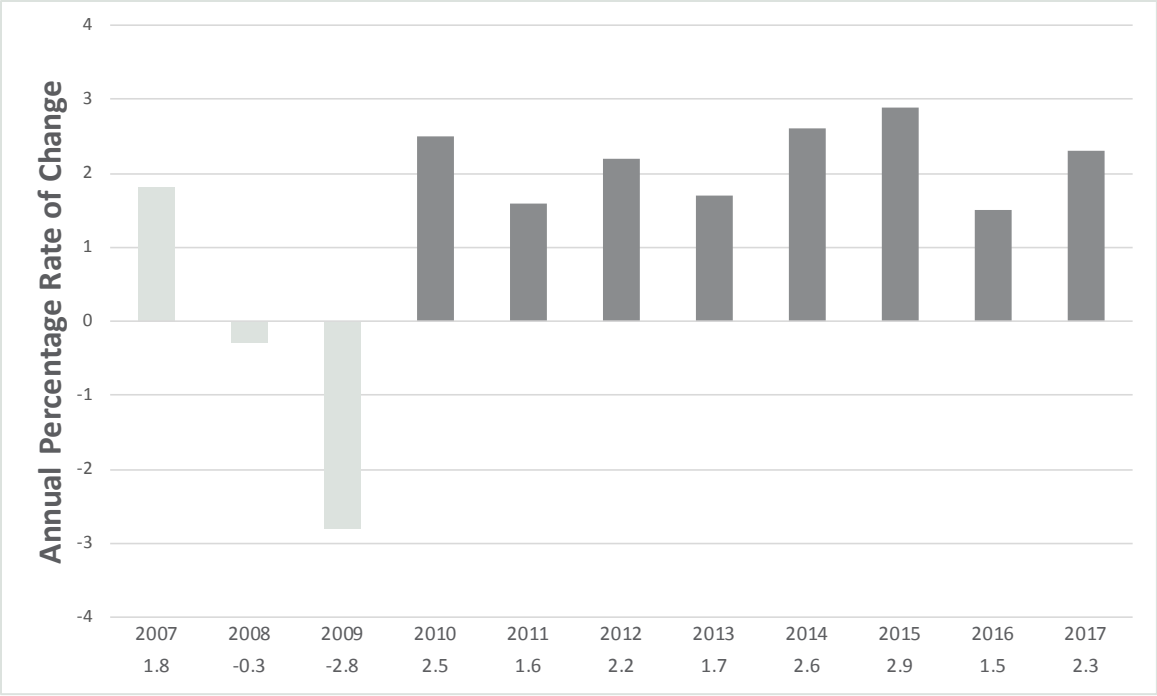


Figure 3-2 Real GDP Change from 2007 to 2017
(Source: U.S. Bureau of Economic Analysis)

3.2 Housing Starts & Home Improvement Spending

3.2.1 2004-2009—The Great Recession and the Pre-Recessionary Period

New housing construction is one of the most important indicators of general economic health. After peaking at almost 2.1 million starts in 2005, homebuilding began to drop precipitously over the course of the next several months, sinking to 1.8 million units by the end of the following year and free falling through 2009 before hitting its lowest point in the cycle at 554,000 units, a drop of 74% (Figure 3-3). Unsurprisingly, remodeling (-28%) and home improvement spending (-21%) followed suit (Figure 3-4 and Figure 3-5).

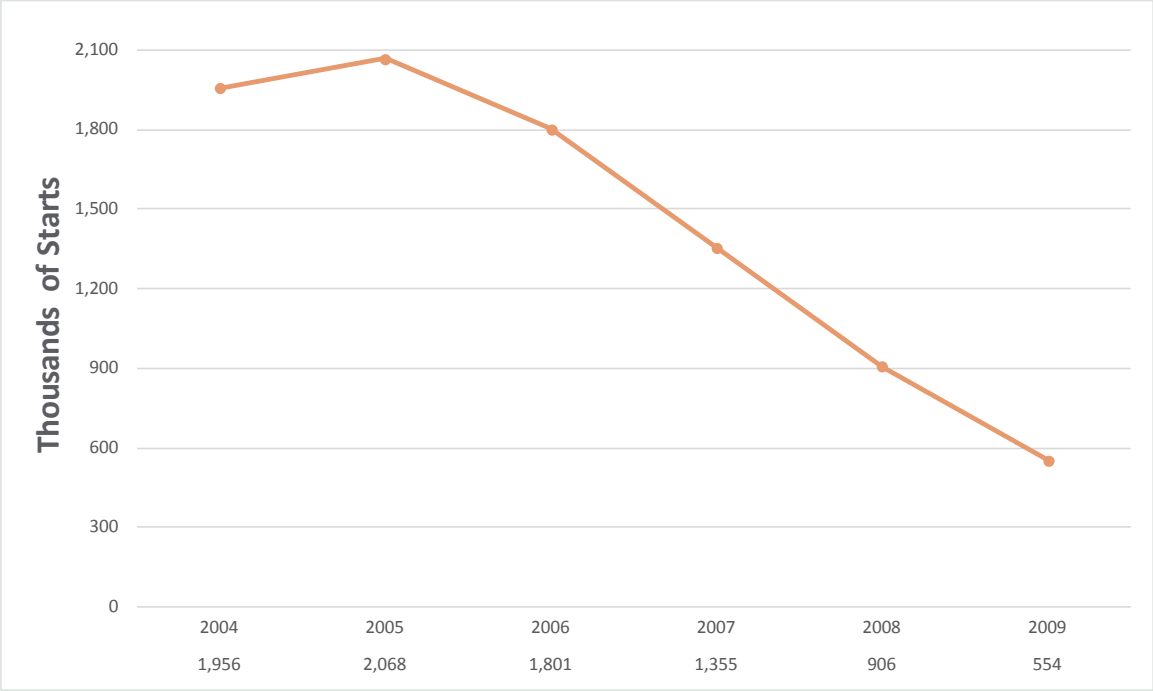


Figure 3-3 Housing Starts from 2004 to 2009
(Source: US Bureau of the Census)

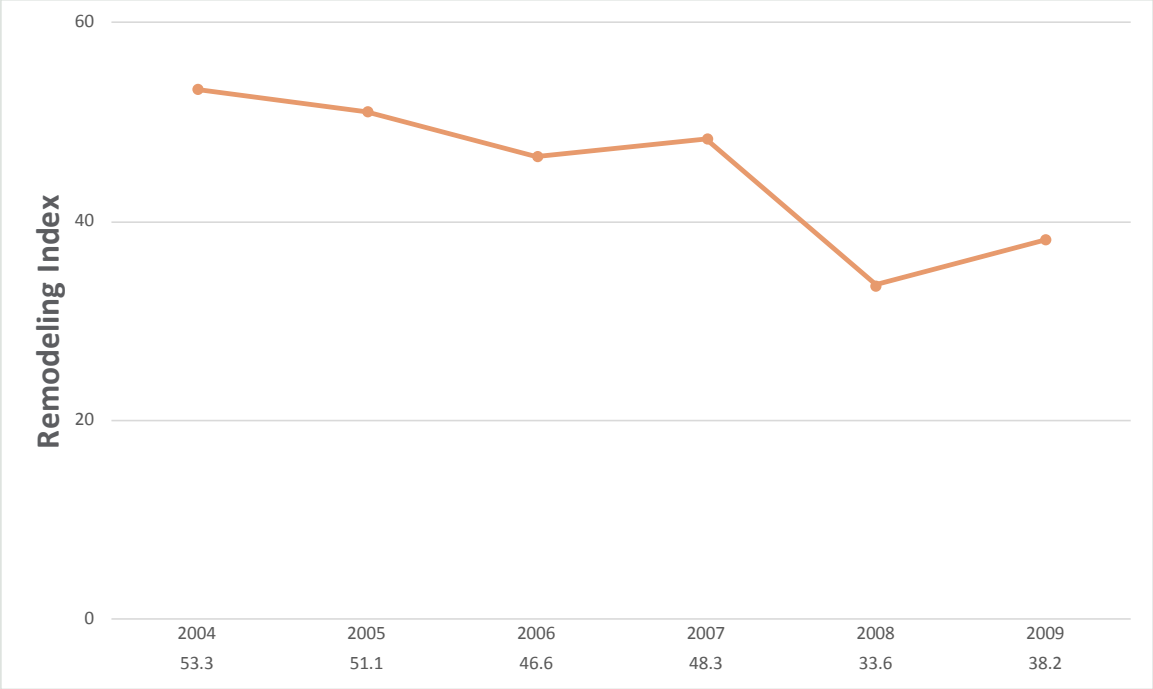


Figure 3-4 Remodeling Market Index from 2004 to 2009
(Source: National Association of Homebuilders)

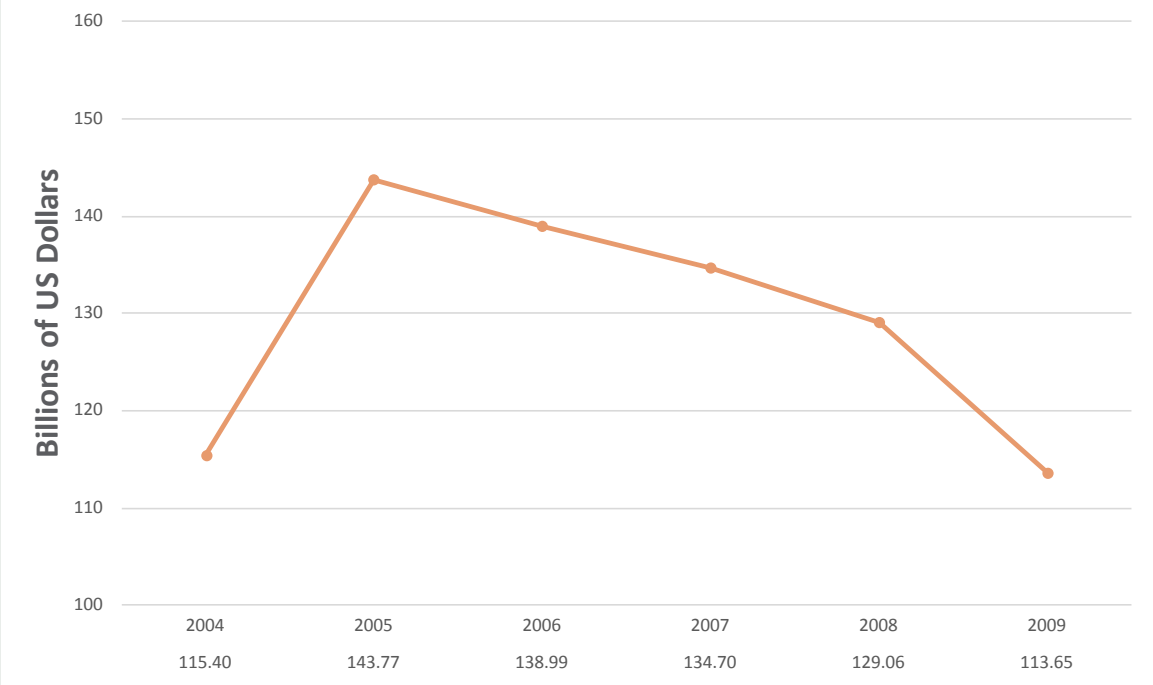


Figure 3-5 Annual Home Improvement Spending from 2004 to 2009
(Source: US Bureau of the Census)

3.2.2 2007-2017—The Great Recession and Recovery

While homebuilding and home improvement spending have demonstrated steady growth since the crash, these segments have slowed in recent months and are flattening in 2018 (Figure 3-6). Economists anticipate the market will trend toward slow growth in the coming years. While housing starts have not yet recovered to pre-recession levels, they stabilized by 2011 and staged steady growth through 2017 (+118% from 2009-2017). The remodeling index (+50%) and annual home improvement spending (+71%) showed very strong recoveries during this same period. This is due in part to the aging home inventory and the fact that Baby Boomers are choosing to modernize and remain in their homes (Figure 3-7 and Figure 3-8).

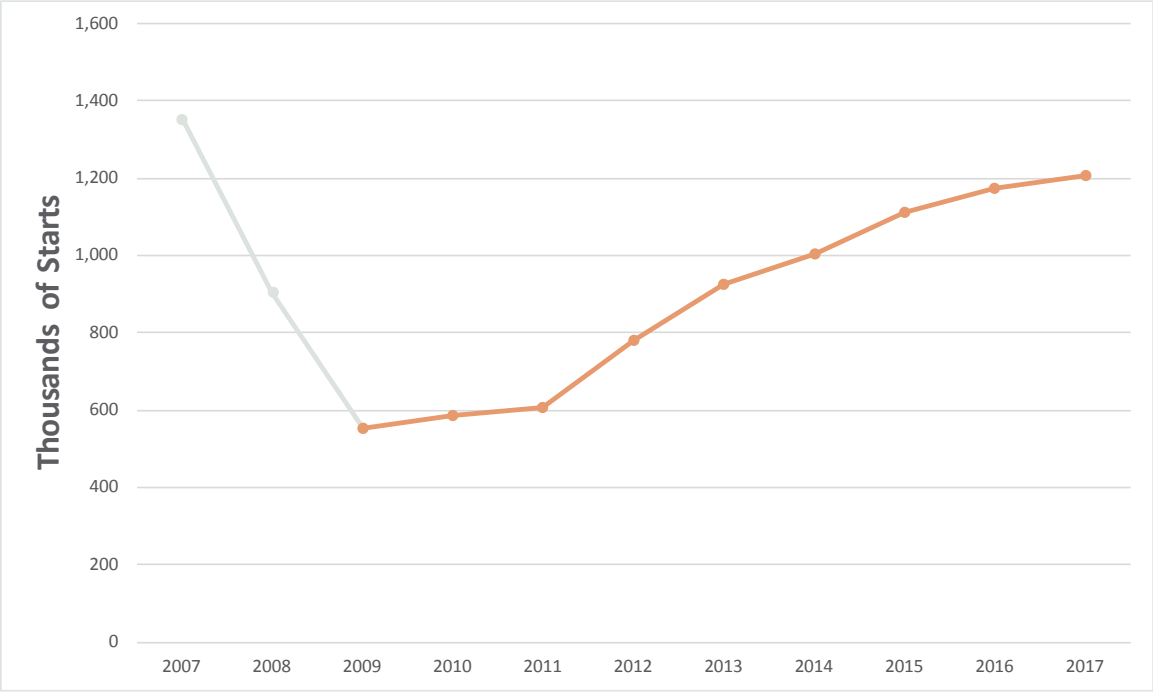


Figure 3-6 Housing Starts from 2007 to 2017
(Source: US Bureau of the Census)

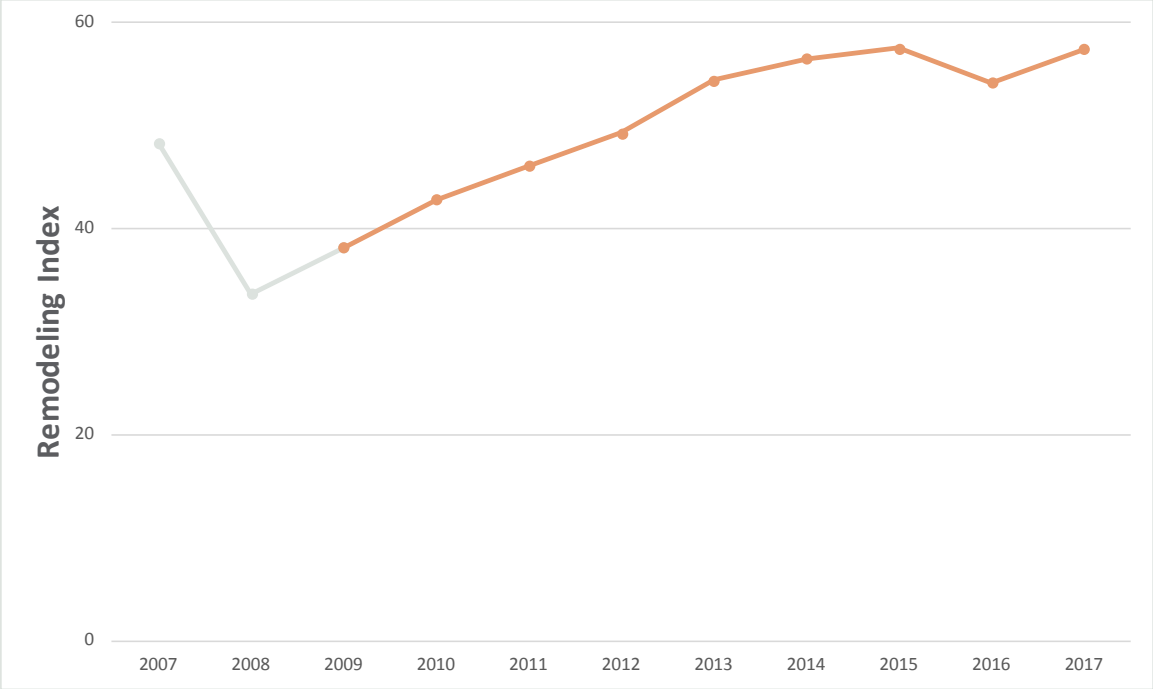


Figure 3-7 Remodeling Market Index from 2007 to 2017
(Source: National Association of Homebuilders)

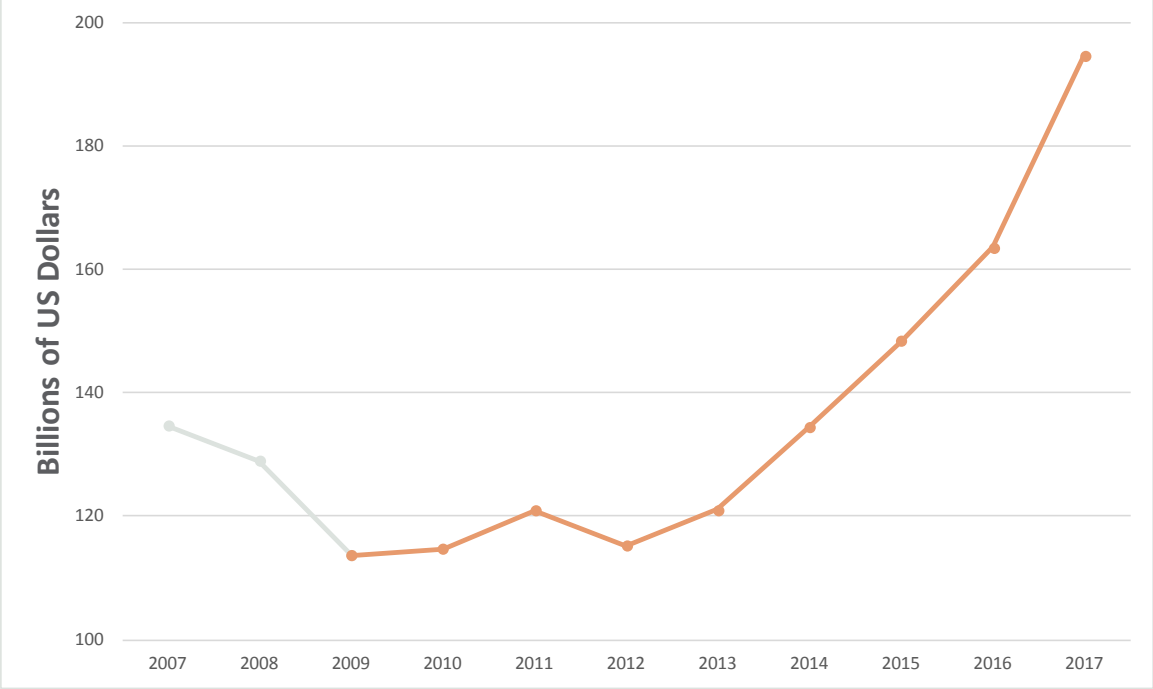


Figure 3-8 Annual Home Improvement Spending from 2007 to 2017
(Source: US Bureau of the Census)

3.3 DJIA Performance & Wage Growth

3.3.1 2004-2009—The Great Recession and the Pre-Recessionary Period

Measures of wealth also experienced enormous recessionary declines. While the Dow Jones Industrial Average (DJIA) is not a direct measure of economic health, it is highly correlated to personal wealth and consumer confidence, as is wage growth.

In 2005, a boom in the housing sector drove significant speculation and investor confidence, causing the market to rally in 2006. Over the course of the next year, the DJIA added over 16% in yearly returns and set a record high, topping out at 13,265 points by the end of 2007. In 2008, the collapse of the sub-prime mortgage market rippled through other debt markets, and the DJIA spiraled downward. The DJIA bottomed out at 6,443 points in 2008 before ending the year at 8,776—a 34% drop from its cyclical peak (Figure 3-9). Unlike the 2002 dot-com crash, which was isolated to the tech sector and experienced a quick and decisive recovery, the 2008 crash was much more dramatic and longer-lived.

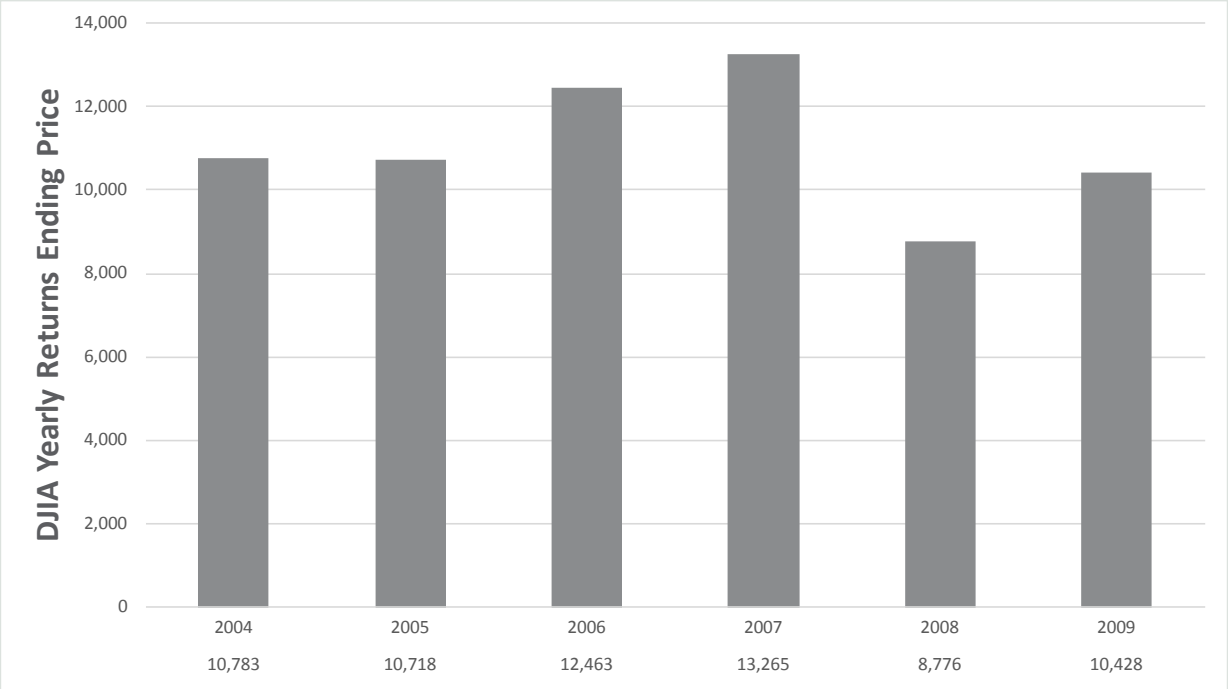


Figure 3-9 Dow Jones Industrial Average Yearly Performance from 2004 to 2009 (Source: US Bureau of Economic Analysis)

As measured by the Wage Growth Tracker, nominal wage growth peaked in 2007 and has declined since (Figure 3-10). This trend shares an inverse relationship with the unemployment rate during the study period. This metric was developed by the Federal Reserve Bank of Atlanta and is a measure of the nominal wage growth of individuals (unadjusted for inflation), which is constructed using microdata from the Current Population Survey (CPS) and is the median percent change in the hourly wage of individuals observed 12 months apart. Wage growth fell 38% from its 2007 peak to its 2009 low.

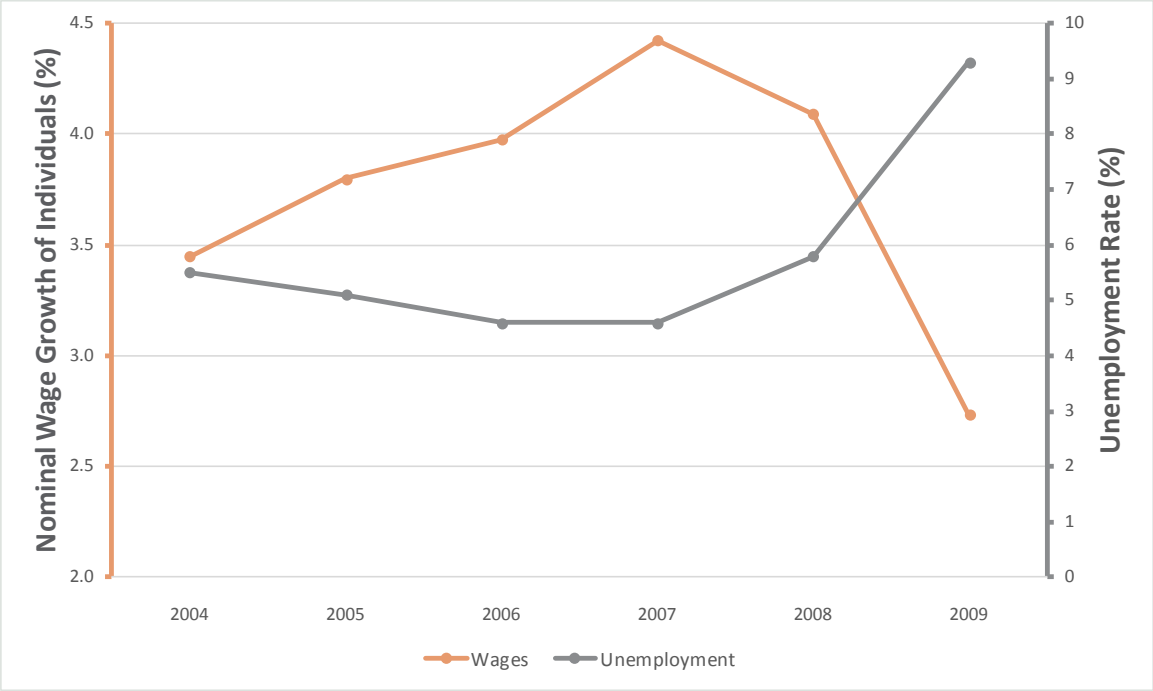


Figure 3-10 Wage Growth and Unemployment Measured from 2004 to 2009 (Source: Federal Reserve Bank of Atlanta)

3.3.2 2007-2017—The Great Recession and Recovery

The DJIA has experienced increasing returns at the end of each year since 2009, except for a negligible 2% dip in 2015. The Index reached an all-time high when the metric hit 24,719 at the end of 2017 (Figure 3-11). This is a 182% increase since the Index's 2008 low.

Steady wage growth is often used to help gauge how far the economy remains from a full recovery. Nominal wage growth since the recovery officially began in mid-2009 and started off low to flat before increasing more aggressively from 2013 to 2016, reaching 3.73% before falling back slightly in 2017 (Figure 3-11). While it has not yet made a full recovery, the nominal wage growth average at this point in 2018 has increased to 3.63% as the unemployment rate has dropped to 3.9%.

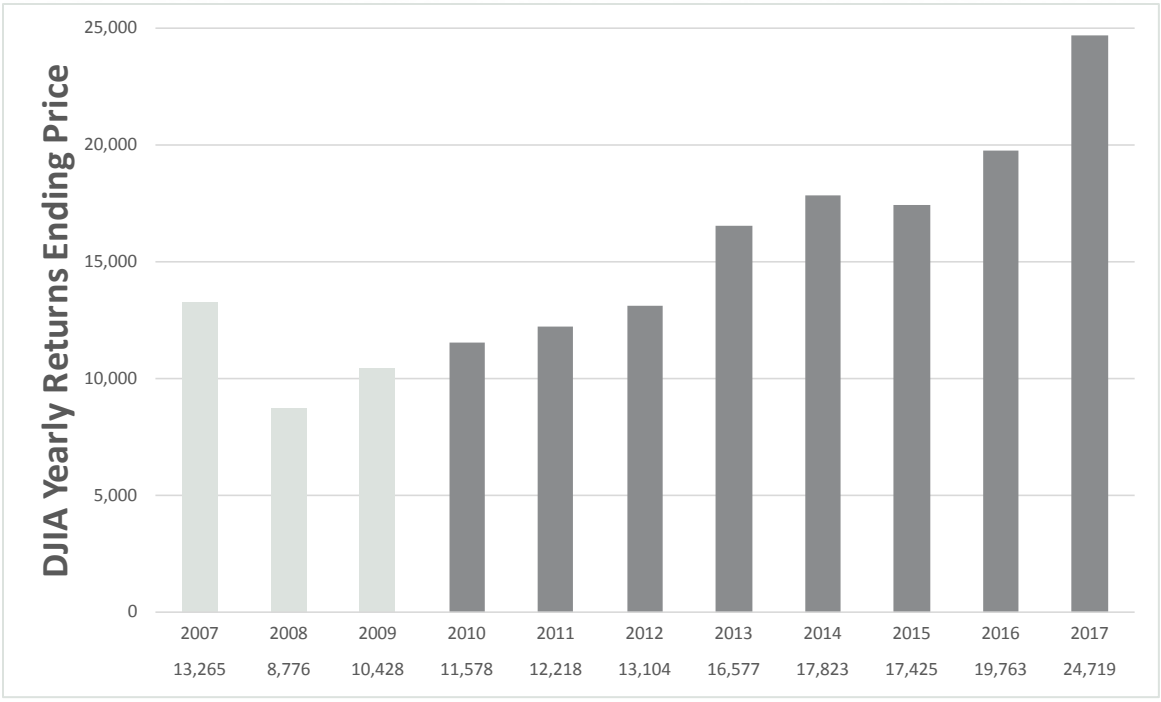


Figure 3-11 Dow Jones Industrial Average Yearly Performance from 2007 to 2017
(Source: US Bureau of Economic Analysis)

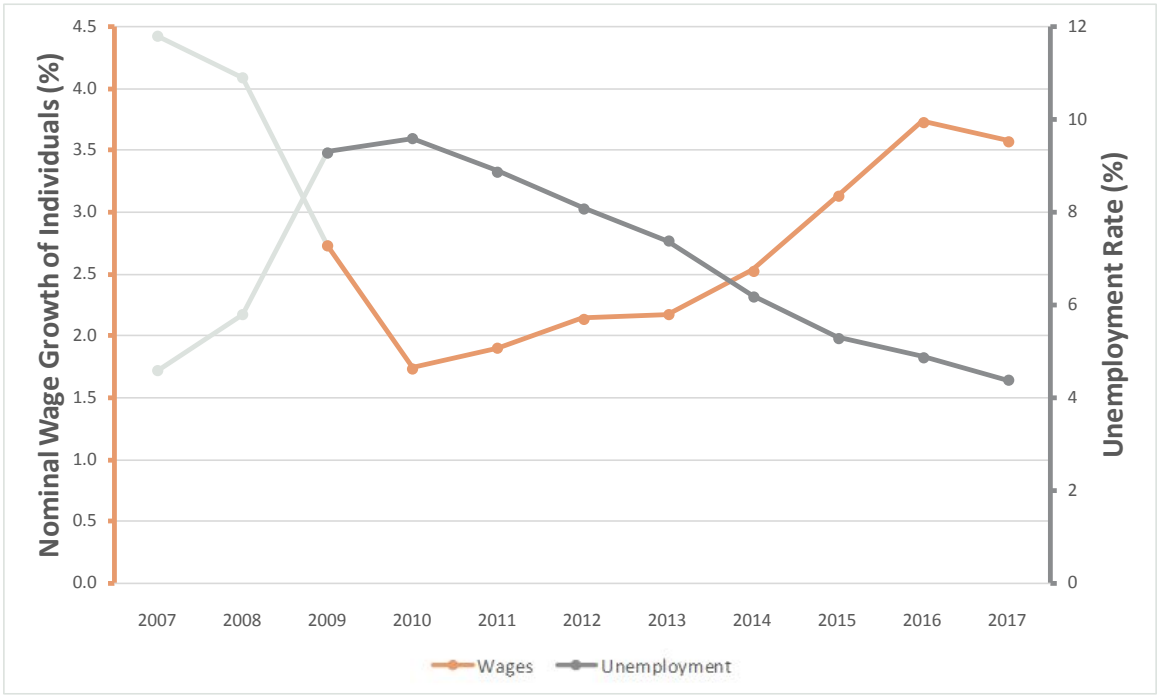


Figure 3-12 Wage Growth and Unemployment Measured from 2007 to 2017
(Source: Federal Reserve Bank of Atlanta)

3.4 Consumer Spending

3.4.1 2004-2009—The Great Recession and the Pre-Recessionary Period

Consumer spending went from 5.1% annualized growth in 2004 to -3.1% in 2009 (Figure 3-13). This is the natural market response to 8.7 million job losses, the destruction of nearly half of the stock market's value, declining wage growth, a massive number of foreclosures, the seizing up of debt markets and the most severe economic decline in the US since the Great Depression.

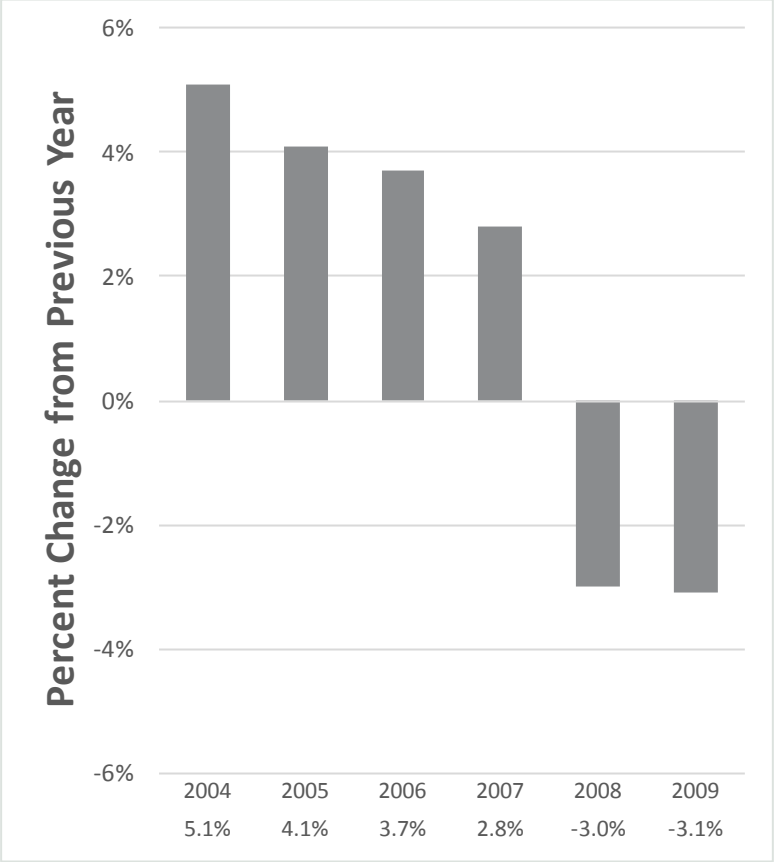


Figure 3-13 Real Personal Consumption Expenditures for Goods - Percent Change from Previous Year (2004-2009) (Source: Bureau of Economic Analysis)

3.4.2 2007-2017—The Great Recession and Recovery

Slowly-improving GDP since 2011 has stimulated an increase in discretionary spending, which has resulted in increased demand for products derived from wood (Figure 3-14).

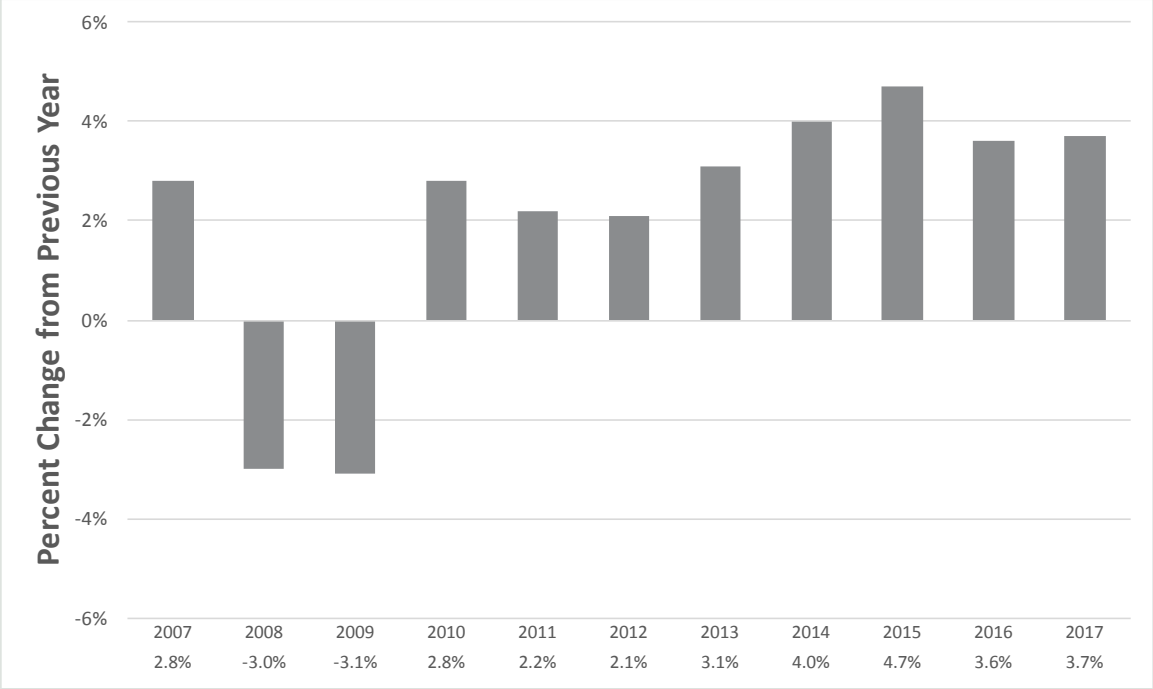


Figure 3-14 Real Personal Consumption Expenditures for Goods - Percent Change from Previous Year (2007-2017) (Source: Bureau of Economic Analysis)

3.5 Conclusion

During the Great Recession, all the major indicators of economic activity that could affect the forest products industry in general, and the wood residuals market specifically, took a stark and debilitating turn for the worse. The recovery has not, for the most part, been rapid or steep. The impact of these changes—both the recession and the slow recovery—on the forest products industry are the subject of the next section of this report.

4 CHANGES IN CONSUMER PREFERENCES

Customer preferences are constantly changing, whether it is in the forest products industry or the broader economy. Over the last two decades, several trends have driven customer preferences and changes in demand for forest and paper products. Some of these changes are fundamental and have already altered global markets; the full scope of other changes has yet to be realized.

4.1 Digital Media

Widespread access to the internet in the mid-1990s ushered in a new digital age—a profound shift in accessibility, information gathering and knowledge sharing that is still developing at an ever-quickening pace. Demand for printing and writing papers continues to decline rapidly as the digital age matures; over the last decade, production of printing and writing papers has declined by 6% annually.

4.2 E-commerce

The continued evolution in consumer buying habits suggests a structural market change toward online product fulfilment (e-commerce). In 2017, e-commerce sales accounted for 10.2% of all retail sales worldwide, and this figure is expected to reach 17.5% in 2021. Amazon, for instance, has quickly become the largest and most active online retailer in the world, shipping an average of roughly 1.7 million packages each day. The multinational e-commerce company's revenue during the study period corroborates the change in consumer purchasing preferences: In 2017, Amazon's net revenue was almost $178 billion compared to $15 billion in 2007—a nearly 1,100% increase.

4.3 Demographic Changes

By 2019, the Millennial generation—92 million people born between 1980 and 2000—will surpass Baby Boomers (those born between 1946 and 1964) as the largest US adult generation, and they differ significantly from their older counterparts in many ways. Twenty-two million millennials aged 18 to 34 are still living at home; they demonstrate prudence and thriftiness because of having lived through the Great Recession. They have also been raised in a digital environment. Millennials are inventing new ways to derive the same benefits of ownership for less money and in less time as evidenced by the tremendous growth in the modern sharing economy—an economy in which expenses, goods, and other financial responsibilities can be shared, leased and/or bartered. This economy continues to evolve at a quickening pace.

Millennials are risk averse, less wealthy, burdened by student loan debt and starting families much later in life. Since most are seeking single-adult household options, trends show growing interest in a metropolitan lifestyle. While home values in urban and developed areas tend be much higher than those located in suburbs and rural America, homeownership for this group has largely been cost-prohibitive as inventory has remained tight amid skyrocketing home prices. However, the data suggest that Millennials desire to own their own homes in the long term rather than rent. Currently, half of all homebuyers are under the age of 36.

Conversely, the Baby Boomer population (roughly 79 million) remains relatively affluent and as this cohort's oldest members reach their 70s, the future impacts on homeownership, remodeling activity and the growth in senior housing and assisted living communities are unclear. An estimated 10,000 Baby Boomers reach retirement age every single day, and downsizing "empty nesters" and retirees are being faced with a pivotal decision: is it more advantageous to rent or own?

An overwhelming number of Baby Boomers (87%) have delayed selling their homes due to post-recession market conditions, and two-thirds of this group has expressed a desire to "age in place." A continuation of this trend will affect the remodeling industry over the next decade as this demographic invests capital in home improvements and modifications for universal design features such as widening entranceways to accommodate wheelchair use. However, a continuation of this trend will also affect the growth of senior housing and assisted living facilities.

Nationwide, senior housing occupancy recently reached its lowest level in over eight years. Occupancy at senior housing communities averaged 88% in 2Q2018, down nearly 1% from the same time last year. The occupancy rate for assisted living communities averaged 85% in 2Q2018, which is the lowest level for assisted living occupancy since 2005. Construction in the sector peaked in 2016 and inventory (35,000 new units added in the last year) appears to be outpacing near-term demand. Despite the recent pullback in occupancy levels, it is important to clarify that senior communities and managed care facilities also follow natural cycles like the larger housing market. As growing numbers of Baby Boomers continue to age, this sector will grow to meet the added demand.

4.4 Renewable Energy

Over the last decade, European utilities have increasingly relied on the use of industrial wood pellets as one of the most efficient means of meeting renewable energy and carbon emissions reduction targets while displacing coal as the primary source of electricity generation. Long-range goals include the use of solar, wind and other "green" technologies to generate energy, but woody biomass is reliably filling the renewables gap especially as it relates to base load capacity (ability to dispatch on demand) something that rapidly growing solar and wind generated power cannot currently do, while some of the other technologies are in the developmental stage. This new demand—driven by a consumer preference for more renewable energy and by EU subsidies to support a renewable transition—has facilitated the development of large-scale wood pellet export mills in the US. UK-based companies, for instance, either offer US producers secure long-term contracts, or they purchase facilities in the US, vertically integrating into the region. Without the industrial wood pellets produced in the US, large scale coal-to-biomass conversions would have been impossible. Over the last ten years, wood pellet exports from the US have increased from less than 30,000 tons in 2008 to over 5 million tons in 2017 (Figure 4-1).

For decades, a latent domestic pellet market has existed in the PNW and other northern regions of the US. However, this market is highly localized to areas that necessitate alternative sources of fuel for a variety of heating applications and constitutes a small percentage of the total volume of pellets that are produced in the US South. In recent years, demand in this market has fluctuated wildly due to mild winters and low-cost competitors such as natural gas, electricity and fossil fuels. Additionally, unlike in the EU, no federal legislation facilitates pellet adoption.

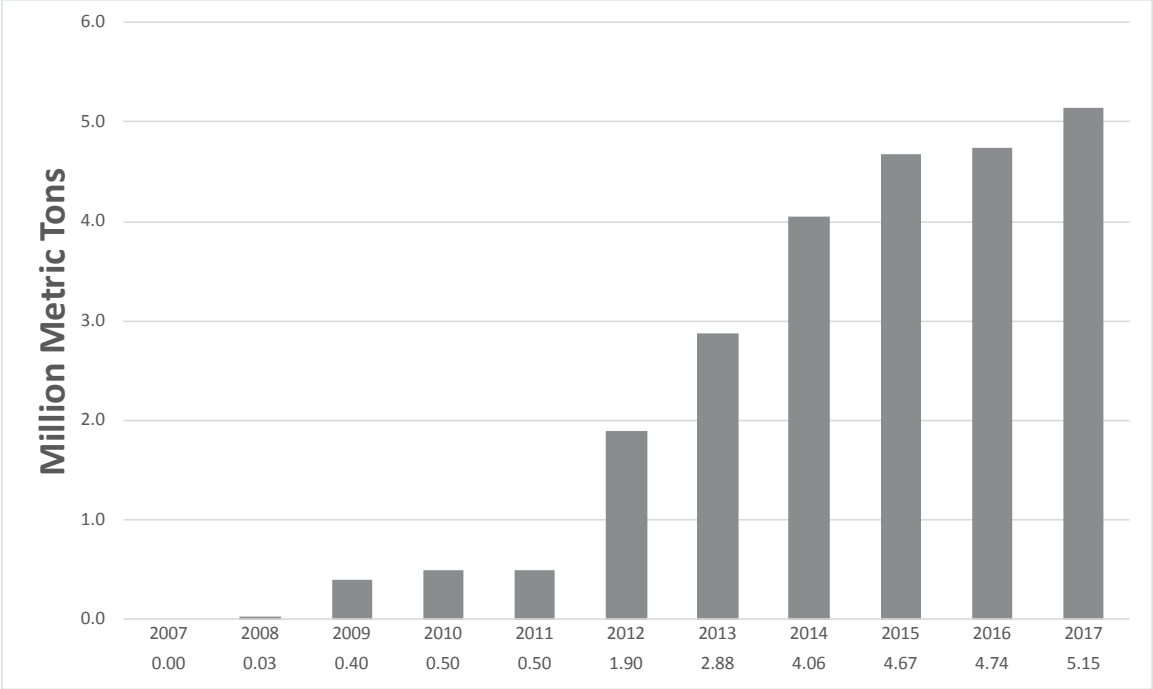


Figure 4-1 US Industrial Wood Pellet Exports from 2007 to 2017

5 CHANGES IN FOREST PRODUCT PREFERENCES & DEMAND

In addition to changes in the general economy and consumer preferences, industry-specific preferences also effect market changes. Over the course of the last decade, forest products preferences and demand have undergone significant changes.

5.1 Printing Papers, Newsprint and Fluff Pulp

Printing and writing papers are in secular decline because of the move from print to digital media. Demand for both products is declining at roughly 6% annually and shows no sign of improving. While not part of the scope, the US Northeast was once home to a large concentration of newsprint manufacturers. Demand for newsprint has continued to fall since the turn of the millennium—down almost 10% in 2017 from the previous year. Expectations are that this market will continue to evaporate. Most of the newsprint plants in the US South or PNW have been closed or converted to other machines.

Conversely, the demand for other pulp products has markedly increased. A case in point is fluff pulp. High-quality fluff pulp is an absorbent material made from bleached softwood cellulose fiber that is used globally in a variety of applications such as feminine hygiene products, baby diapers and adult incontinence products. While this is a relatively small market at only 6 million tons, worldwide demand is increasing at 4% annually. This is a clear example of a situation where a change in customer preference has not changed the total demand for raw wood material, but rather has shifted the demand from one product to another.

Printing and writing papers are made from hardwood fiber, while fluff pulp is made from softwood fiber. Newsprint, however, can be made from both. Many of the pulp mills dedicated to manufacturing printing and writing papers have been converted to produce fluff pulp. While this is a growing market for the softwood fiber resource, a shrinking printing and writing papers industry has left a void in the hardwood pulp market, and both chip and wood fuel demand continue to decrease as a result.

5.2 Containerboard

Containerboard is a specific type of paperboard that is manufactured for use in the production of both linerboard (*facing)* and corrugating medium (*fluting*), the two wood fiber components that make up cardboard boxes.

According to the American Forest & Paper Association, more than 95% of all products in the US are shipped in cardboard boxes. This product is very well-positioned in the growing e-commerce market, as online orders arrive in high-grade cardboard boxes to prevent damage during shipping. Individual product shipments use much more containerboard per delivery than bulk shipments from the manufacturer to the retailer. This underpins the demand for containerboard and related packaging. Since most containerboard is made from softwood fiber, the e-commerce phenomenon is buoying demand for softwood residual chips and pulpwood. Manufacturers of containerboard products prefer softwood fiber because of its strength characteristics. Over the last several years, this segment has increased production by nearly 2% annually.

5.3 Boxboard and Liquid Packaging Board

Boxboard is a low-density, hardwood-based, paperboard product formed from layered sheets of mechanical and chemical pulp. This material has high stiffness and is often folded to be used in a variety of packaging applications

including pharmaceuticals, frozen foods, cigarettes and beauty products. Liquid packaging board (LPB) is a laminated paperboard product manufactured to package fluids, like milk.

While only hardwood virgin fibers are used in the manufacture of LPB, the demand trend for boxboard and LPB has been flat to decreasing, adding to the already shrinking demand for hardwood fiber.

5.4 Solid Wood Manufacturing

Demand for solid wood products is driven by both housing starts and remodeling activity. As these drivers decline, demand for lumber and plywood also decline. In turn, the production of all residual wood fiber materials also declines. Manufacturers of OSB, plywood, lumber and pallets directly support the homebuilding and construction industry (pallets to a far lesser extent, as these products also serve the global transportation industry) and are therefore sensitive to demand changes in the housing market. Solid wood production dropped to just 68.5 million cubic meters in the immediate aftermath of the Great Recession—a decrease of 33% from just two years earlier in 2007 (Figure 5-1). Production has increased steadily to 96.8 million cubic meters in tandem with housing starts since bottoming in 2009. While this market has not fully recovered, it is within 95% of pre-recession levels.

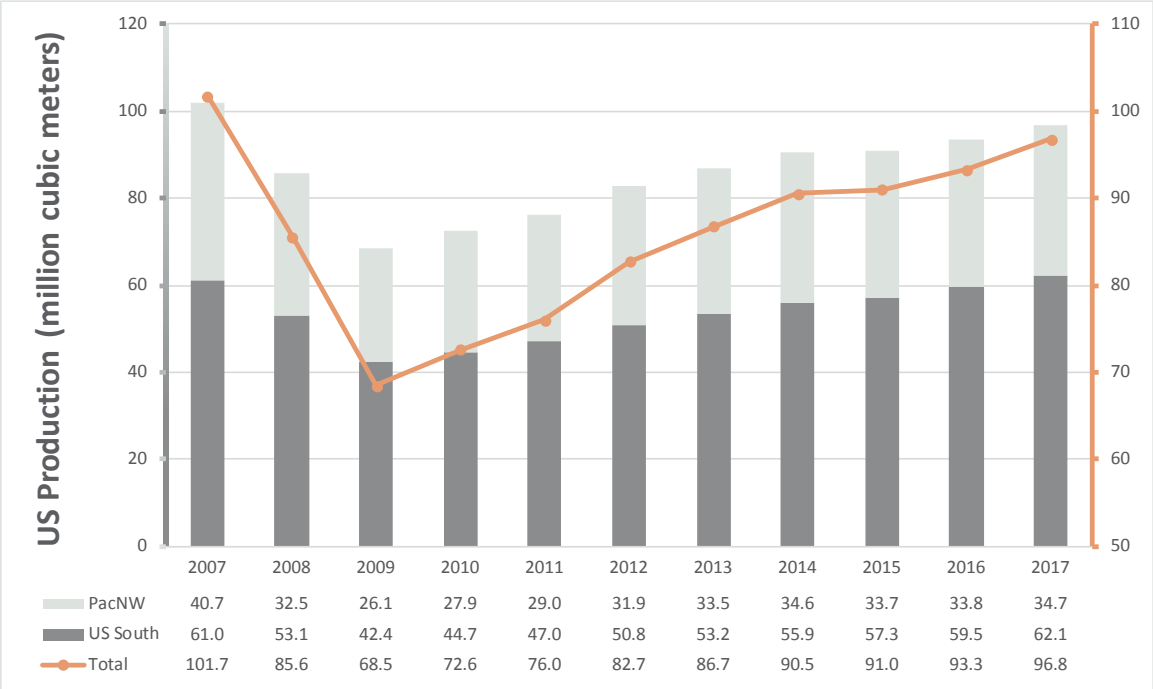


Figure 5-1 Total Volume of Solid Wood Produced in the US South and PNW from 2007 to 2017 (Source: Western Wood Products Association)

5.5 Wood Pellets

The most significant development in the forest products industry over the last decade has been the addition of industrial wood pellet mills. While industrial pellet producers consume residual chips and pulpwood, most prefer sawdust and shavings as their primary feedstock since these fine materials require less effort to process. However, the emergence of large pellet mills in many cases has made the need for pulpwood a supply necessity.

While US pellet exports have played a significant role in facilitating large-scale coal-to-biomass conversions and co-firing projects in Europe, growth in the European industrial pellet market is decelerating as fewer coal units remain to be converted to wood pellets. As a result, US wood pellet exports to Europe are starting to slow after growing at a rapid 63% compound annual growth rate (CAGR) from 2011 to 2014; pellet export growth has slowed to 6.4% CAGR from 2014-2017. New demand flattened in 2017 and minimal EU growth is forecast in the near term, but bourgeoning biomass and wood pellet opportunities exist throughout Asia. From 2012 to 2017, wood pellet imports to Japan and Korea increased from less than 200,000 tons to nearly 3 million tons. Most expect future demand in Asia to be between 10 and 20 million tons within the next ten years.

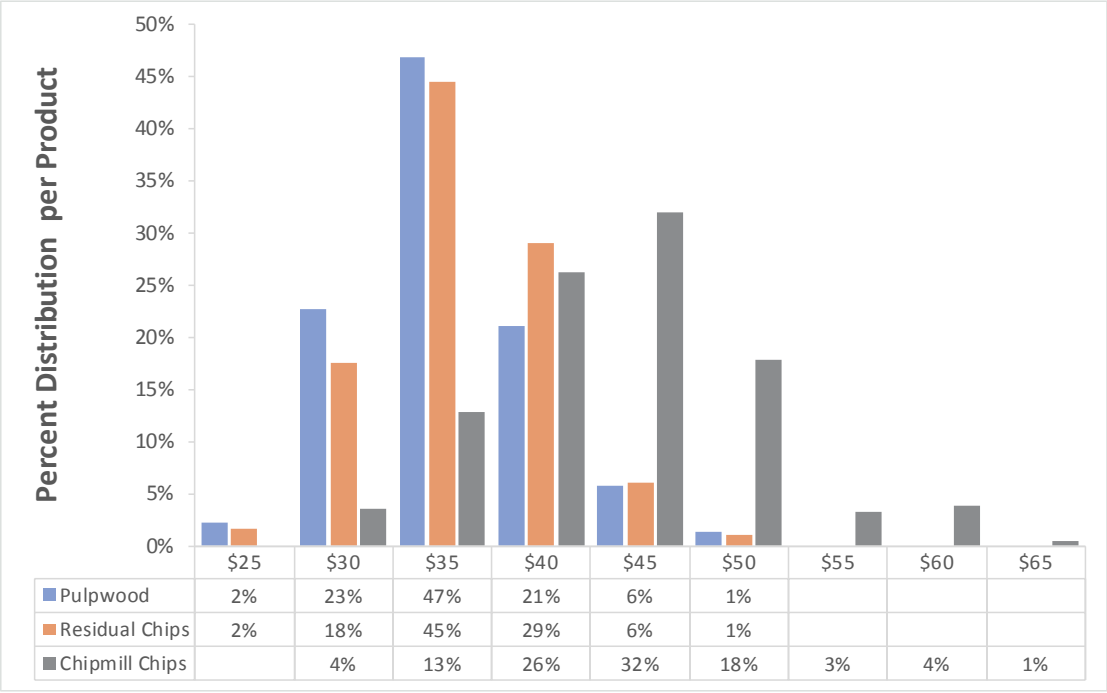
6 IMPLICATIONS FOR THE FOREST PRODUCTS INDUSTRY

The global wood products market, like many other markets, is dynamic and driven by changing consumer preferences, technological adaptations, improvements in trade and transportation, as well as catastrophic economic events such as the Great Recession. The metrics outlined in Section 3 (Economic Conditions and Performance) represent those that most influence the wood products market and, by proxy, the supply and price of residual material in the market. Consumer trends and preferences (discussed in Section 4) have the potential to change at an ever-quickening pace, but the immediate shock of the Great Recession has had rippling effects for the forest products industries in both the US South and PNW. These markets function differently at a fundamental level, and they have responded differently to the structural changes resulting from the Great Recession.

6.1 The US South Region

6.1.1 Residual Market Overview: Distribution by Product

In the US South, the primary consumers of residual wood fiber are pulp mills, engineered wood panel mills and industrial pellet facilities. For the majority, small roundwood (pulpwood) is the preferred wood raw material; however, these mills will also purchase residual chips and whole tree (chipmill) chips to meet their wood fiber demands. Currently, the pine feedstock blend consumed in this region is 67% pulpwood, 20% residual chips, and 13% whole tree, chipmill chips. While some southern pulp mills prefer the mature fiber in sawmill chips generated from older sawlogs, a clear majority of the demand is supplied with pulpwood. In general, mills consume all of the residual chips that are produced, then make up the balance with whole tree, chipmill chips as needed, since they are more expensive (Figure 6-1). The high utilization rate of pulpwood in southern mills results in abundant internal waste wood in the form of bark and screened chips that do not meet specifications, which they use as boiler fuel.



	$25	$30	$35	$40	$45	$50	$55	$60	$65
Pulpwood	2%	23%	47%	21%	6%	1%			
Residual Chips	2%	18%	45%	29%	6%	1%			
Chipmill Chips		4%	13%	26%	32%	18%	3%	4%	1%

Figure 6-1 Pulpwood and Chip Distribution per Product

While the feedstock blend percentages differ for hardwood pulp mills, on average they consume 50% pulpwood, 37% whole tree, chipmill chips, and 13% residual chips (Figure 6-2). This is a function of market limitations in this region, where the pine resource supply is more readily available, and the hardwood resource is more difficult to obtain. Hardwood pulpwood is harvested less aggressively and, since residual chip supply cannot make up the difference, a greater emphasis is placed on whole tree, chipmill chips.

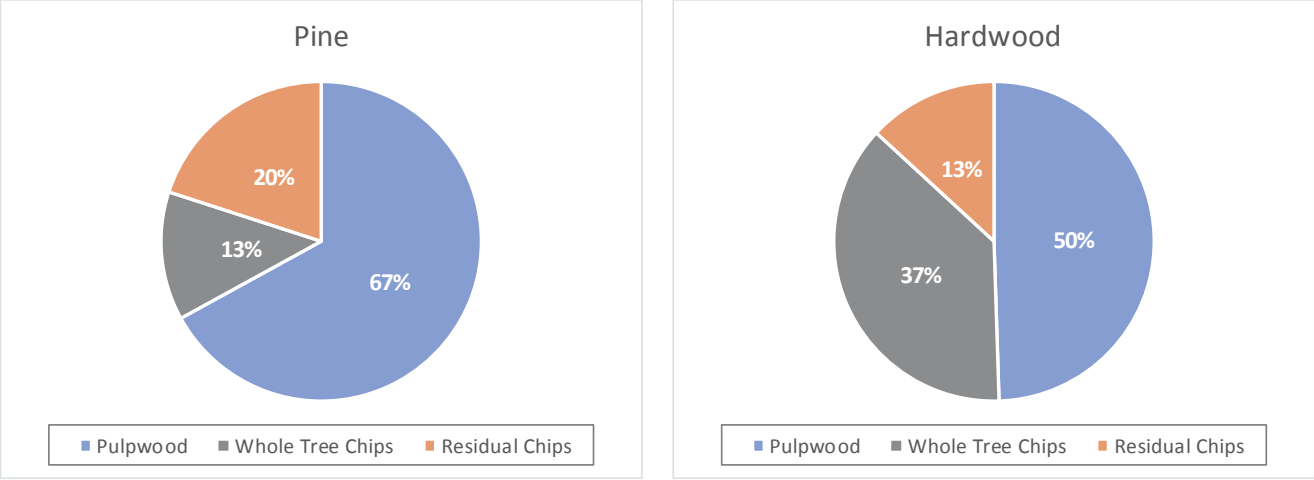


Figure 6-2 Feedstock Blend of Residual Consuming Mills in the US South

6.1.2 US South Market Profile: Closures, Conversions and Consolidations

Over the last ten years, the US South mill portfolio has been dynamic. The permanent closure of three pulp and paper mills and three particleboard plants was met with the opening of 16 new industrial pellet facilities, which led to a 10% increase in the total number of residual wood fiber consumers (Table 6-1). Conversely, 36 pine sawmills and 66 hardwood sawmills have closed during the same period, which led to a 15% decrease in the total number of residual wood fiber producers. The combined total number of residual wood fiber consumers and suppliers has decreased by 12% over the last decade.

Table 6-1 US South - Mill Count by Year - Residual Wood Fiber Suppliers & Consumers

Mill Description	Consumer Mill Count	
	2007	2017
Pulp & Paper	78	75
Engineered Wood Panels[1]	17	14
Industrial Pellets	2	18
Totals	**97**	**107**

[1]Includes MDF and Particleboard

Mill Description	Supplier Mill Count	
	2007	2017
Pine Sawmills[2]	276	240
Hardwood Sawmills	367	301
Plywood & OSB	52	49
Totals	**695**	**590**

[2]Includes Sawmill, Chip n Saw, and Pole Mills

Growing demand for absorbent and container products has incited production increases from southern kraft mills by nearly 4% per year. In some cases, this has driven machine conversions at existing mills as demand is reallocated to other products and markets. Additionally, this represents a major demand shift from hardwood (paper) to softwood (fluff pulp and containerboard). As of 2017, three facilities have already made this transition—two International Paper Company mills in Franklin, Virginia and Riegelwood, North Carolina and one Domtar Inc. mill in Ashdown, Arkansas (Figure 6-3). While the processes involved in converting a mill to manufacture a different product can be very expensive, it is far less costly than a shutdown or a new building project.

The distribution of current consuming mills is primarily concentrated where the pine timber resource is located, particularly in the coastal plain region (Figure 6-3). This remains true today despite the closures and manufacturing changes that have taken place over the last decade that most notably include:

- International Paper's closure of its paper producing and primarily hardwood consuming mills in Bastrop, Louisiana; Courtland, Alabama and Franklin, Virginia. The Franklin mill was later reopened as a pine consuming fluff pulp mill. International Paper also recently converted a machine at its Riegelwood, North Carolina mill from paper (hardwood) to fluff pulp (pine).

- Resolute Forest Products Company's newsprint machine closures in Calhoun, Tennessee and Coosa Pines, Alabama.
- Domtar Inc.'s conversion of a paper machine (hardwood) to fluff pulp (pine) in Ashdown, Arkansas.
- The reduction of three particleboard plants by Roseburg Forest Products Co. in Mississippi and North Carolina.
- The rapid increase of industrial pellet mills to satisfy growing energy demands in Europe, namely Enviva Partners, LP and Drax Biomass.

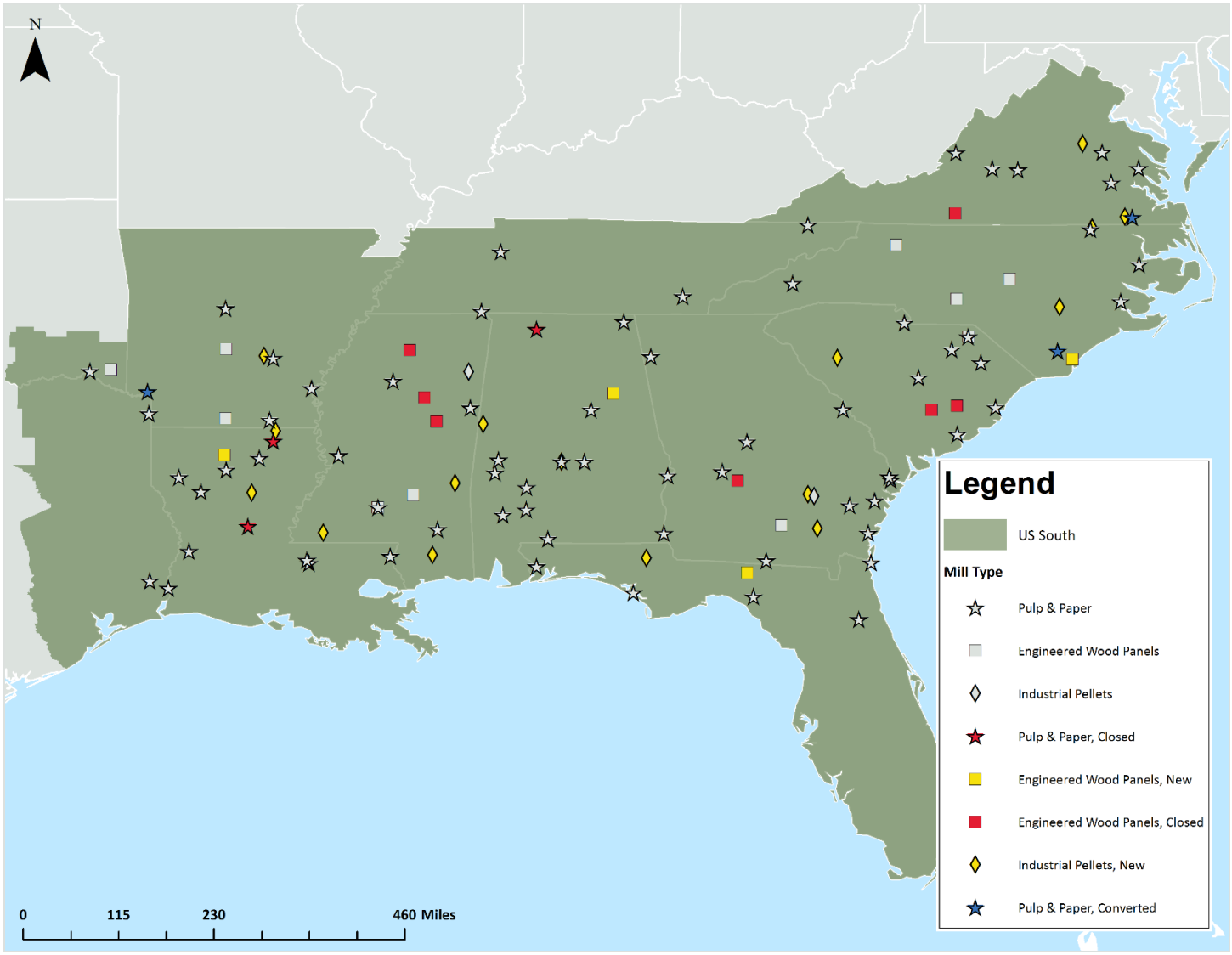


Figure 6-3 US South – 2007 to 2017 Residual Wood Fiber Consumers – New Openings, Closures and Conversions

In addition to these changes, regional industry consolidation has occurred among consumers of wood residuals:

- In 2011, Smurfit-Stone Container became a wholly-owned subsidiary of RockTenn. Then in 2015, RockTenn and MeadWestvaco agreed to a merger under the trademark WestRock, forming a $16 billion packaging giant.

- In mid-2016, Weyerhaeuser Company announced an agreement to sell all fluff pulp manufacturing facilities to IP for the purchase price of $2.2 billion in cash. This acquisition included four pulp mills in the US South and one in Canada.

- At the beginning of 2018, WestRock seized another market expansion opportunity by agreeing to buy KapStone Paper and Packaging Co. As the second largest packaging company in the world behind International Paper, this was one of the last openings for consolidation in a market that has already undergone significant reorganization. Consequently, the majority of market share in the US South pulp and paper industry belongs to three companies: International Paper, WestRock and Georgia-Pacific Corp.

- In the new pellet mill industry, Enviva acquired Green Circle BioEnergy and Colombo Energy while Drax acquired the bankrupt assets of German Pellets in Urania, Louisiana.

From the supplier standpoint, the distribution of both pine and hardwood sawmills is uniform east-to-west throughout the region, but there is not an excessive amount of overlap between the two markets. This is primarily attributed to differences in physiography, as a greater concentration of pine sawmills can be found in the southern and coastal extents of the region and hardwood sawmills to the north, towards the foothills and into the mountains. Since so many of the mills that shuttered in the wake of the Great Recession processed hardwood species, this mill type is noticeably sparser in 2017 (Figure 6-4).

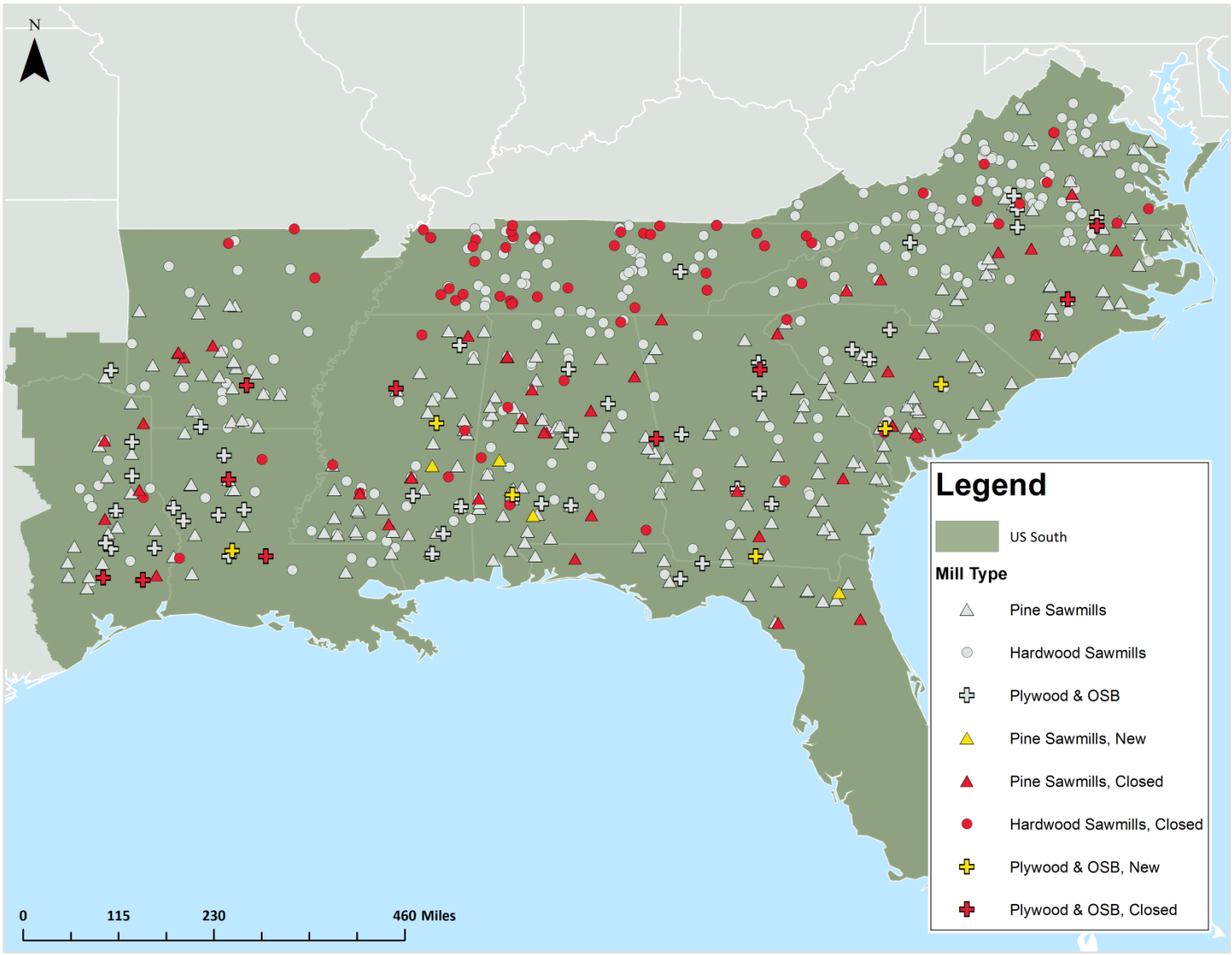


Figure 6-4 US South – 2007 to 2017 Residual Wood Fiber Suppliers – New Openings and Closures

6.1.3 Broad Market Changes

Due to the aforementioned closures, conversions, consolidations and changes in market dynamics and consumer preferences, the US South region continues to adapt to meet the needs of an evolving market. Demand for hardwood has trended down 1.5 % annually since 2007, a result of a decline in demand for printing and writing papers. At the same time, demand for pine has increased steadily at 2.1% annually to accommodate growing containerboard, fluff pulp, OSB and wood pellet demand.

Pine Sawmills

The total number of operating pine sawmills in the US South has decreased over the last decade, however, five new facilities were established in 2017 and are now fully operational. The segment is expanding, but only after a very lean, transitional period in the years following the Great Recession.

Recently, several sawmill projects have been proposed and are on track to begin construction later in 2018 and beyond (Table 6-2); most of these facilities plan for annual capacities of 250 to 350 million board feet—roughly 2 to 3 times the size of the previous generation of mills. Existing mills are also expanding—adding drying capacity, running longer hours and upgrading equipment to take advantage of the lumber market and plentiful supplies of southern yellow pine (SYP) timber. In the markets where these new facilities are breaking ground and existing facilities are adding capacity, mills that are smaller, less-efficient and unwilling to adapt to the market change may be unable to compete. When these new sawmills are operational, the supply of wood fiber residuals will increase between 0.32 and 0.44 million dry tons per year based upon the published capacity estimates.

Table 6-2 US South - Newly Established and Proposed Pine Sawmills

Recent Builds:		
Company Name	**Mill Location**	**Startup**
Weyerhauser Co.	Dierks, AR	December 2017[1]
Biewer Lumber, LLC	Newton, MS	January 2017
Conifex Timber Co.	El Dorado, AR	January, 2017[1]
Winston Plywood & Veneer, LLC	Louisville, MS	April 2017
Two Rivers Lumber Co.	Demopolis, AL	September 2017
Proposed New Builds:		
Company Name	**Mill Location**	**Anticipated Startup**
Georgia-Pacific, LLC	Talladega, AL	Q4 2018
Tolko Ind. & Hunt Forest Products	Urania, LA	Q4 2018
Rex Lumber	Pike County, AL	Q2 2019
Georgia-Pacific, LLC	Warrenton, GA	Q2 2019[1]
Georgia-Pacific, LLC	Albany, GA	Q3 2019
Canfor Co.	Washington, GA	Q3 2019
Interfor Co.	Central US South	Unannounced
Ashton Lewis Lumber Co.	Abbeville, AL	Unannounced
Westervelt Co.	Southern AL	Unannounced

[1]Rebuild or modernization of pre-existing mill site

Pine Supply

While total pine sawtimber inventory and harvested volume have increased at similar rates, growth still outpaces removals by 82% (Figure 6-5). As a measure of overall sustainability of the timber resource, this is one of the contributing factors that makes the US South an attractive investment opportunity and has led to numerous upgrades and expansions of existing sawmills. While timber supply is a major consideration for expansion projects, it is far from the only factor; labor pools/costs, competitive market dynamics, transportation conditions and haul distances are equally important concerns. As a result of the abundant pine sawtimber supply, prices have remained low and globally competitive with little volatility—all important criteria for investment decisions.

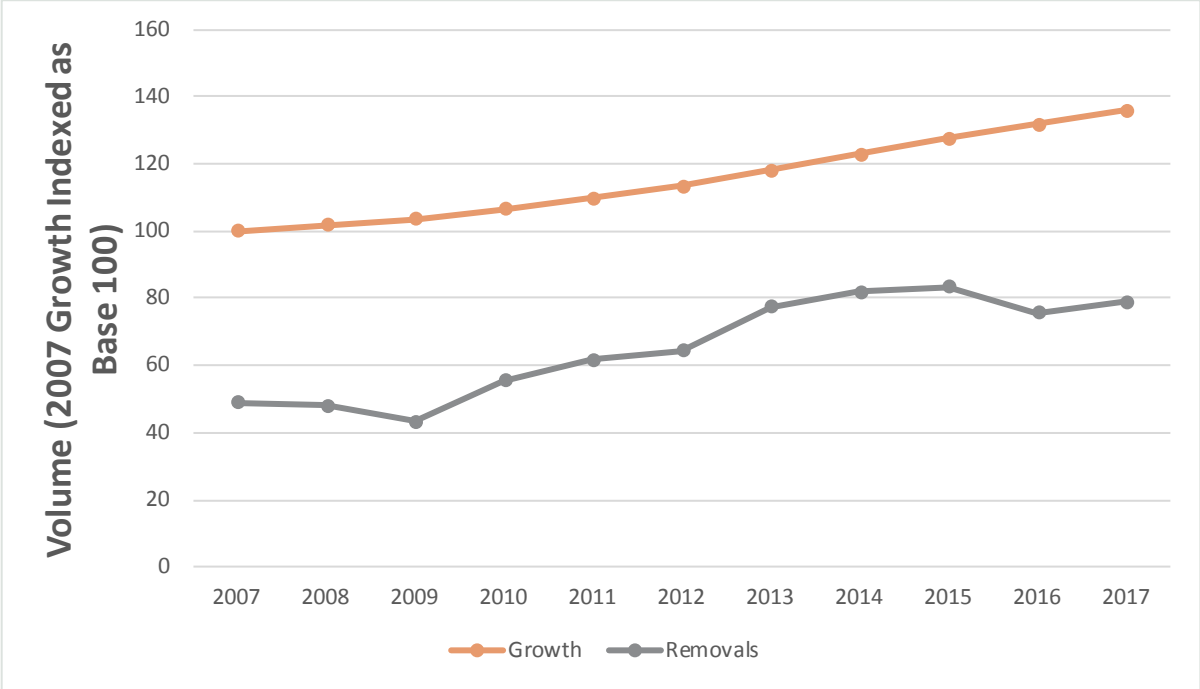
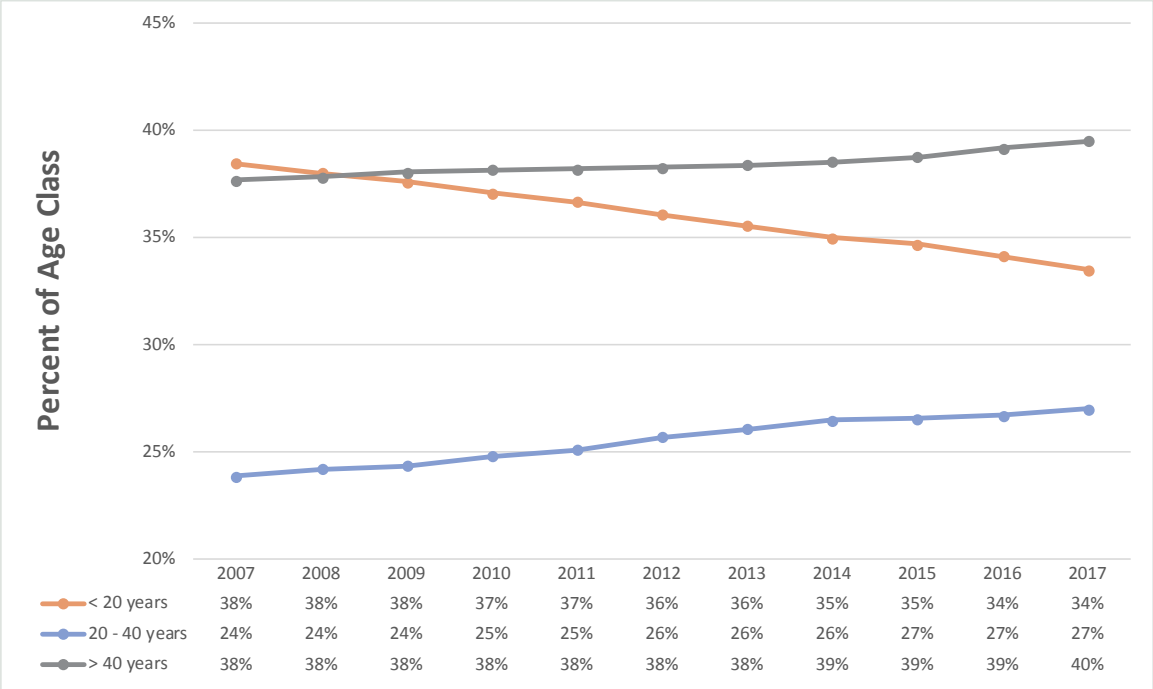


Figure 6-5 US South Pine Sawtimber Growth v. Removals
(Source: USDA Forest Service, Forest Inventory and Analysis)

Pine Prices

This trend shows no sign of abating due to two independent decisions made by opposing stakeholders in the supply chain. In the aftermath of 2008's financial collapse, sawmills were forced into survival mode. The mills that survived invested in new technology that improved efficiency and lowered costs. It is not, in fact, an overstatement to say that the industry shifted its cost structure significantly. At the same time, as log prices collapsed, landowners simply chose not to sell timber, opting instead to wait out the down cycle. A strange thing happened as a result of this confluence. As landowners waited for a recovery, trees grew larger and mills, owing to their new-found efficiency, used fewer trees. The net result after 10 years was that forests in the US South had more and larger trees, and sawtimber prices in the region are virtually unchanged since 2007.

As Figure 6-6 shows, sawtimber is getting older and larger. Older, larger sawtimber has many of the characteristics—including strength and clear wood—that are highly sought after. This, in turn, stimulated more sawmill investments in the South.



	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
< 20 years	38%	38%	38%	37%	37%	36%	36%	35%	35%	34%	34%
20 - 40 years	24%	24%	24%	25%	25%	26%	26%	26%	27%	27%	27%
> 40 years	38%	38%	38%	38%	38%	38%	38%	39%	39%	39%	40%

Figure 6-6 Percent of Age Class as a Function of Acreage – US South

Prices have reflected this change in the market. The oversupply of pine sawtimber and improved sawmill efficiencies are keeping sawlog prices low, even as demand for lumber and sawmill production increases as a result of an improving housing market. At the same time, the demand for pulpwood has remained strong, and the effect of the aging forest and decreasing acres of pine pulpwood has not been realized (Figure 6-7).

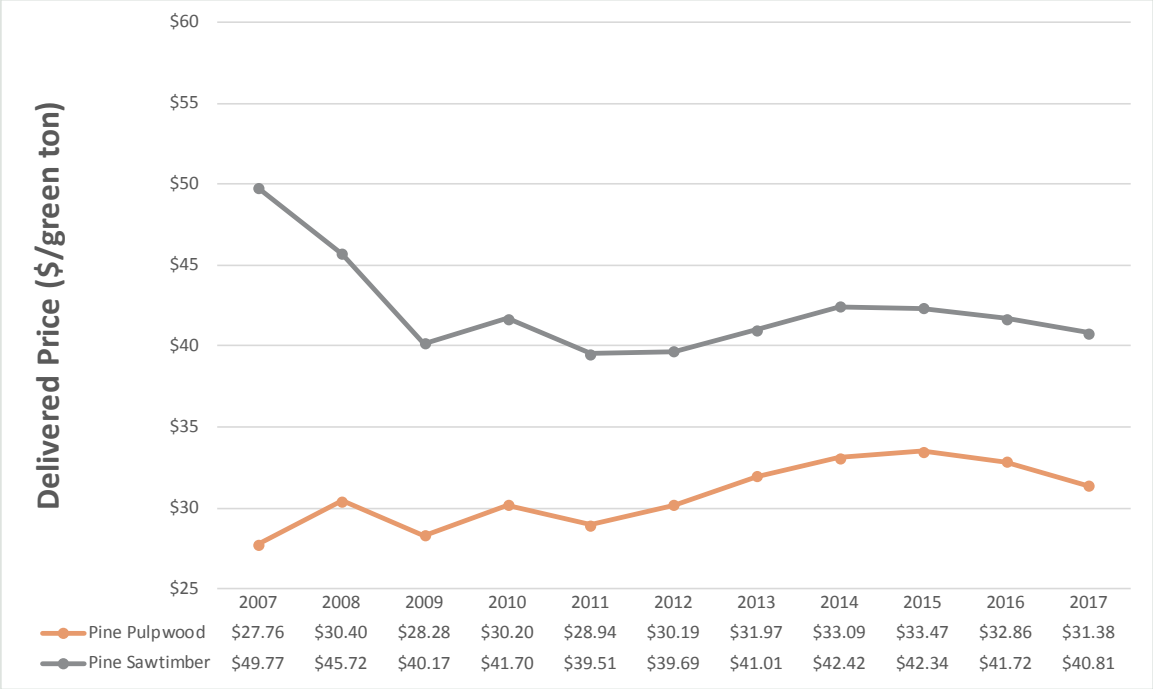


Figure 6-7 US South Delivered Pine Sawtimber and Pulpwood Prices

While sawtimber prices have been low, lumber prices skyrocketed in 1H2018, though they have decreased precipitously since peaking in June—indicative of the steady demand for solid wood products in the US (Figure 6-8). A number of factors contributed to the sudden rise in prices, including US tariffs on Canadian softwood lumber that were instituted in 2017 and a shortage in log supply in British Columbia (BC) due to mandated reductions to its annual allowable cut (AAC).

Figure 6-8 US South Lumber Prices vs. Log Prices

In 2017, SYP lumber production totaled 18 BBF, or roughly one-third of total North American production. More than 3 BBF of new SYP lumber production capacity will be installed by the end of 2020, much of which will originate from approximately 20 new mill facilities—both greenfield operations and older mills that will be significantly overhauled. The scale of these new facilities will have an impact on demand for logs produced regionally, as well as the supply of lumber and residuals in the market. While average SYP sawmill production levels in 2012 were roughly 125 MMBF, modern facility improvements will result in an average capacity of roughly 200 MMBF by 2022, and many mills will boast annual capacities of 250 to 350 MMBF. Forest2Market estimates that the capital invested in these new operations will exceed $2 billion.

Hardwood Demand and Prices

Demand for hardwood pulpwood and sawtimber has decreased by 8 million tons (20%) and 10 million tons (32%), respectively (Figure 6-9). This is no surprise considering the sheer number of hardwood mills that are no longer operational. Hardwood solid wood and pulp producers in the US South will continue to be challenged by structural market changes as demand continues to shift to softwood products.

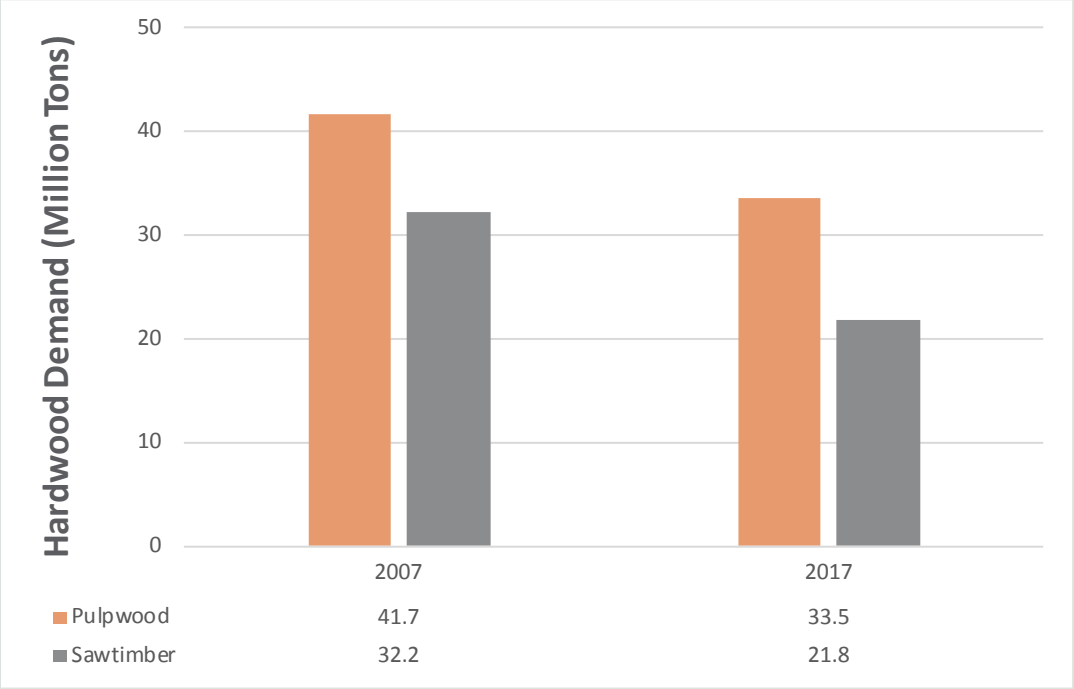


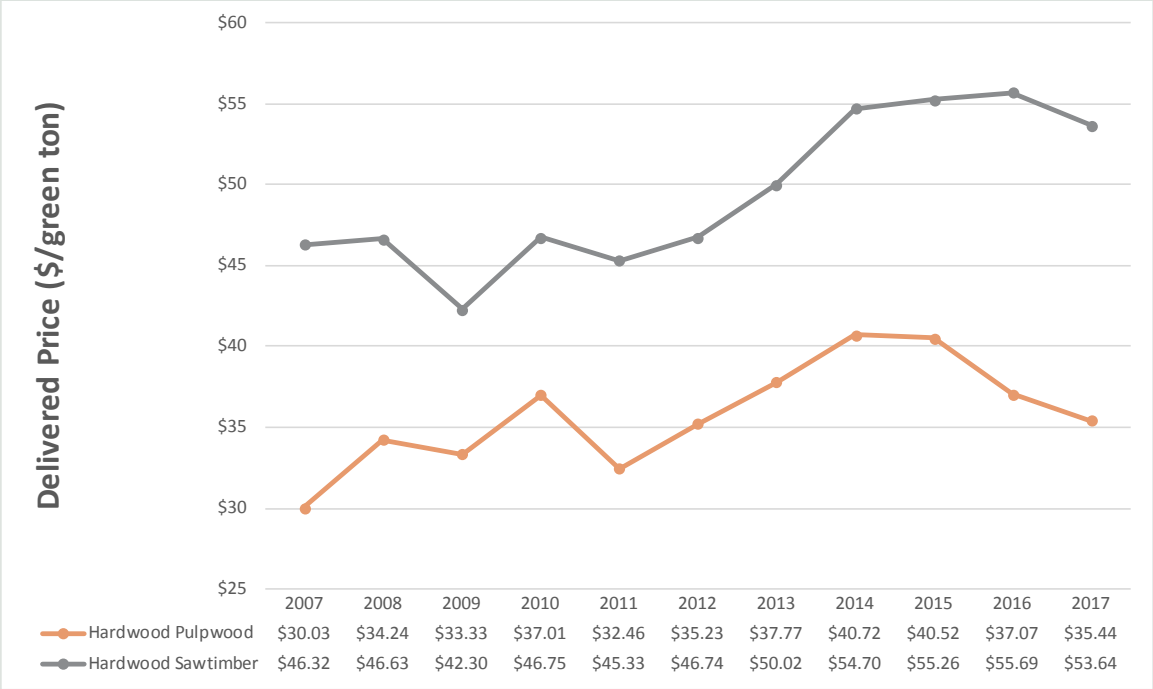
Figure 6-9 Changes in Hardwood Demand – US South

Interestingly, while the number of hardwood mills in the US South decreased, the trend for hardwood pulpwood and sawtimber delivered prices did not (Figure 6-10). Unlike pine products, prices for both sawtimber and pulpwood in this category have increased significantly over the last decade. However, the sharp rise in price after 2011 is more a function of supply than demand, as availability is driving price. In this region, merchantable tracts of hardwood timber are simply not as accessible as tracts of upland pine.

Demand for hardwood has not returned to pre-recession levels, and consumer preferences are the primary reason.

- Demand for red oak flooring has dried up as consumers have migrated toward lighter colors and composites.
- Laminated (white) cabinetry is now back in style. In 2007, dark oak and maple were consumer preferences.

The expansion of Eastern European hardwood lumber markets, plus growth in composite manufacturing in Europe, has encroached on traditional North American lumber markets.



	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Hardwood Pulpwood	$30.03	$34.24	$33.33	$37.01	$32.46	$35.23	$37.77	$40.72	$40.52	$37.07	$35.44
Hardwood Sawtimber	$46.32	$46.63	$42.30	$46.75	$45.33	$46.74	$50.02	$54.70	$55.26	$55.69	$53.64

Figure 6-10 US South Delivered Hardwood Sawtimber and Pulpwood Prices

Note: W*eight scale is the preferred measure when purchasing wood fiber in the US South. Moisture content of logs is reasonably consistent between 48%-55%. Wood fiber—pulpwood and chips—are purchased and priced in tons regardless of moisture content. For this report and for the sake of consistency, we have converted green short tons to bone-dry short tons using a ratio of 0.52 bone-dry tons per green ton; please note that all tons in this report are short tons. A bone-dry short ton (BDT) is wood or wood residue weighing 2,000 pounds at zero percent moisture content.*

6.1.4 Residual Market Changes

Up to this point, much discussion has focused on changes in mill demand, mill numbers, and consumer and product preferences between pre-recession and post-recession markets. Residual markets, by definition, must and will follow the same patterns—and by and large they have.

Where demand for softwood lumber has returned, so has supply of residuals in the form of chips, sawdust, shavings and wood fuel. Conversely, where solid wood demand has not returned—hardwood lumber in particular—residual supply has followed suit.

As will become evident, the price dynamics of residual materials—whether pine or hardwood—are not necessarily inversely related to available supply. This is because of the availability of substitute products such as standing pulpwood and in-woods clean and dirty (bark on) chips. Other confounding factors that have an effect similar to substitutions are changing procurement patterns and new supply lines. For example, a composite mill may buy sawdust from a dozen vendors. If one of the vendor sawmills shuts down, the composite mill has many choices to replace that supply, including purchasing incrementally more material from its other vendors, purchasing more in-woods chipped materials or purchasing more sawmill chips or roundwood pulpwood.

This shift in procurement patterns may (or may not) incrementally raise the composite mill's fiber costs. Subtle changes in residual supply may or may not be evident in residual raw material prices immediately as a result. Over time, however, prices react to longer-term trends in supply.

Figure 6-11 and Figure 6-12 speak to and describe the results of the changing end-product markets. Figure 6-11 depicts the increasing demand for pine residuals because of consumer trends, which are more heavily weighted toward fluff pulp, container board and pellet production. Conversely, the decline in demand for hardwood residuals is due to eroding markets for paper products made from hardwood species, such as printing, writing and copy paper (commercially known as uncoated freesheet).

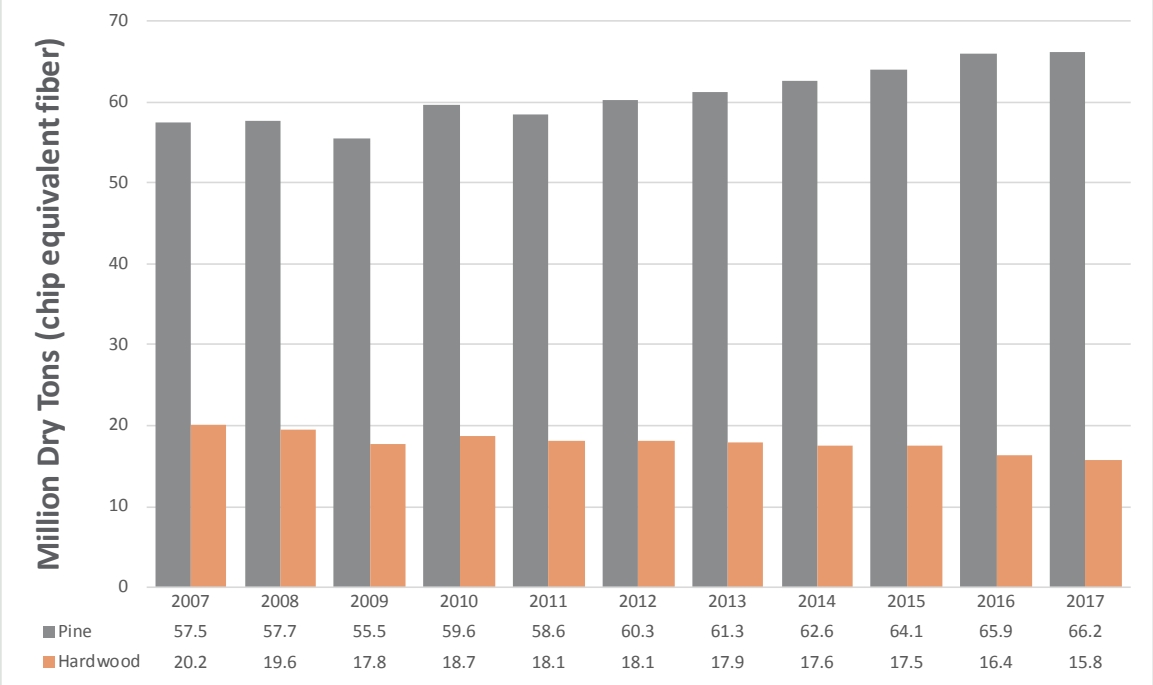
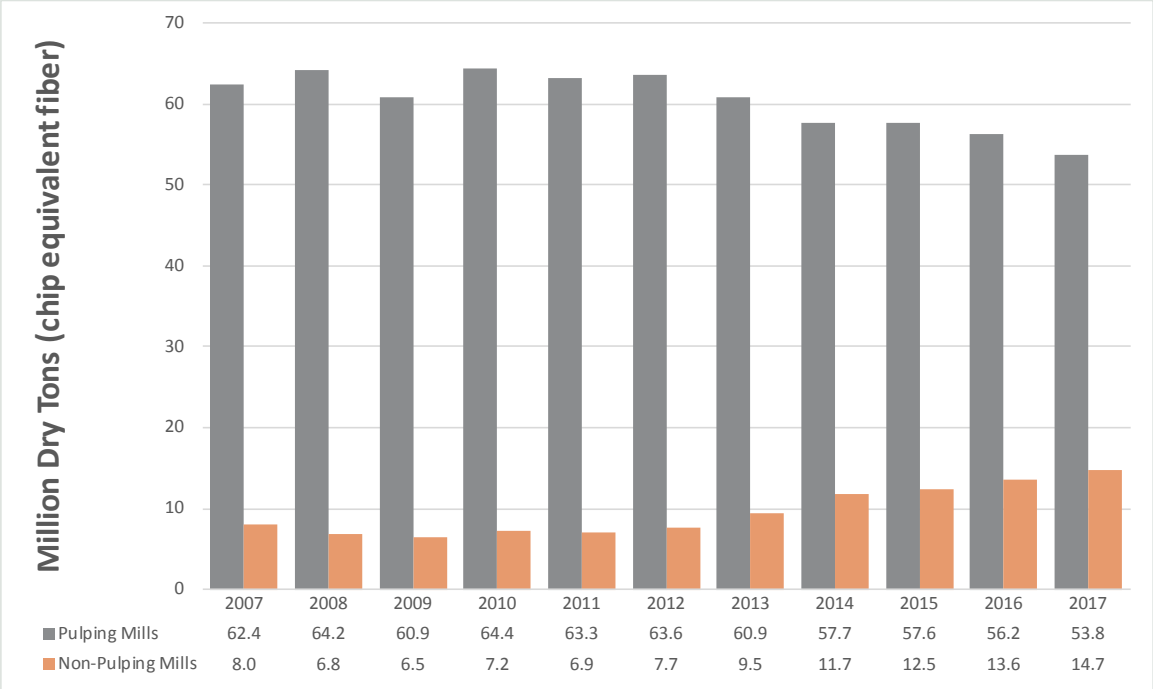


Figure 6-11 Demand for Residuals – Pine vs. Hardwood

Figure 6-12 demonstrates that much of the new demand has come from non-pulp sources, including pellet mills and OSB manufacturers, which has shown an upward trend of 12.7% annually since 2009. Conversely, the combined demand for all pulp mills has trended down 1.9% annually at the same time, primarily the result of decreased demand for hardwood pulp. This chart confirms that the pulp market is being driven by a couple of rapidly-growing sectors.

It is also important to note that these volumes include both hardwood and softwood demand, meaning that the greater pulp market would be in steady decline if it were not for significant wood pellet and OSB developments that have taken place in recent years.



	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Pulping Mills	62.4	64.2	60.9	64.4	63.3	63.6	60.9	57.7	57.6	56.2	53.8
Non-Pulping Mills	8.0	6.8	6.5	7.2	6.9	7.7	9.5	11.7	12.5	13.6	14.7

Figure 6-12 Demand for Residuals – Pulp vs. Non-Pulp Mills

The 2008 recession had a devastating effect on sawmill production in the US South. Thirty-six southern yellow pine mills went under, and capacity was reduced by 30%. Consequently, nearly 4 million tons of residual chip supply evaporated from the market between 2007 and 2009 (Figure 6-13).

With improved new housing and strong remodeling demand, however, lumber and chip production recovered by 2015, surpassing 2007 levels in the next 2 years—making a slow but full recovery.

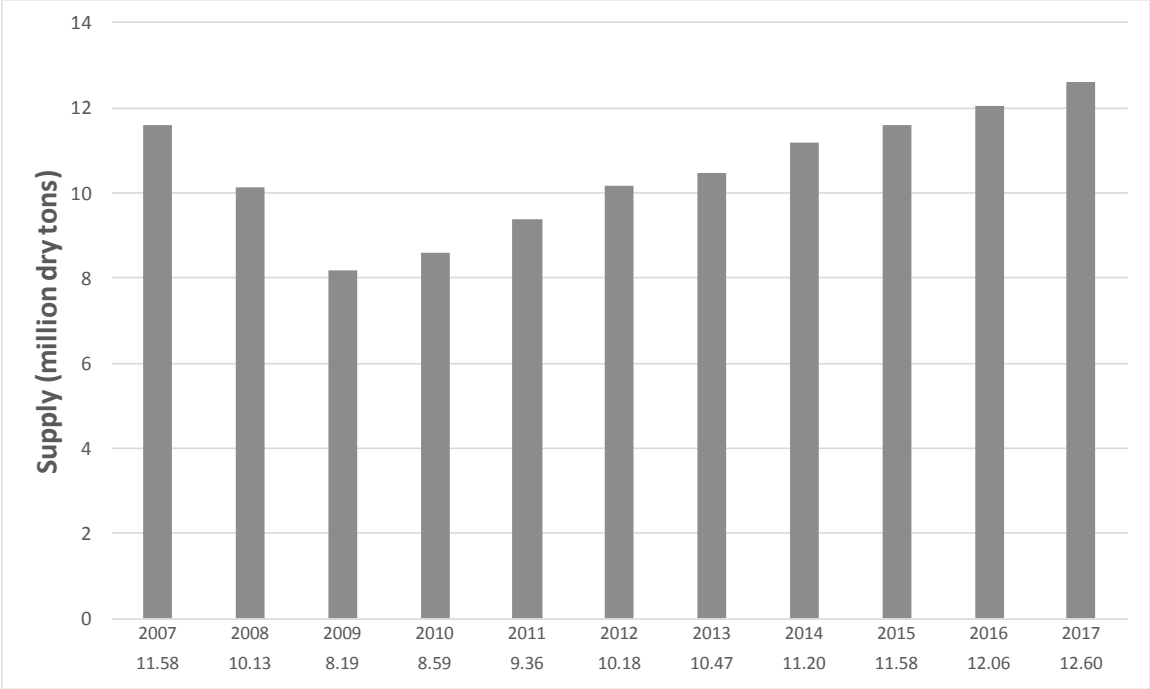


Figure 6-13 Residual Chip Supply Delivered to Consumer - US South - Pine Species

Prices for residual chips—both pine and hardwood—have increased modestly over the past 10 years, even though each has dramatically different supply and demand trends. The supply and demand for hardwood residuals has trended down, while pine has followed an exact opposite trend.

Figure 6-14 demonstrates that, as pine residual chip supply increased, both delivered and FOB chip price (the price that sawmills get paid, excluding freight) also increased. The increase has been modest, however, below the rate of general inflation.

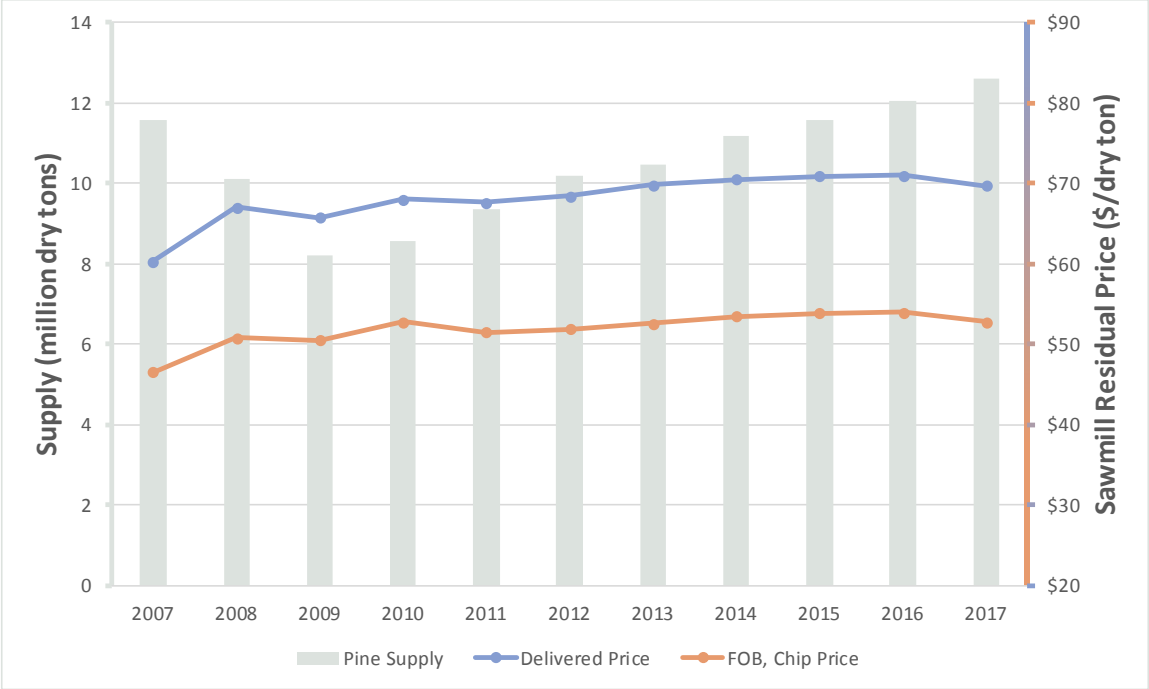


Figure 6-14 Residual Chip Supply Delivered to Consumer and Price - US South - Pine Species

Hardwood sawmill production—thus residual production and supply—has not recovered to pre-recession levels. Since 2010, supply has hovered just below 2 million bone dry tons and shows no indication of returning to pre-recession levels (Figure 6-15).

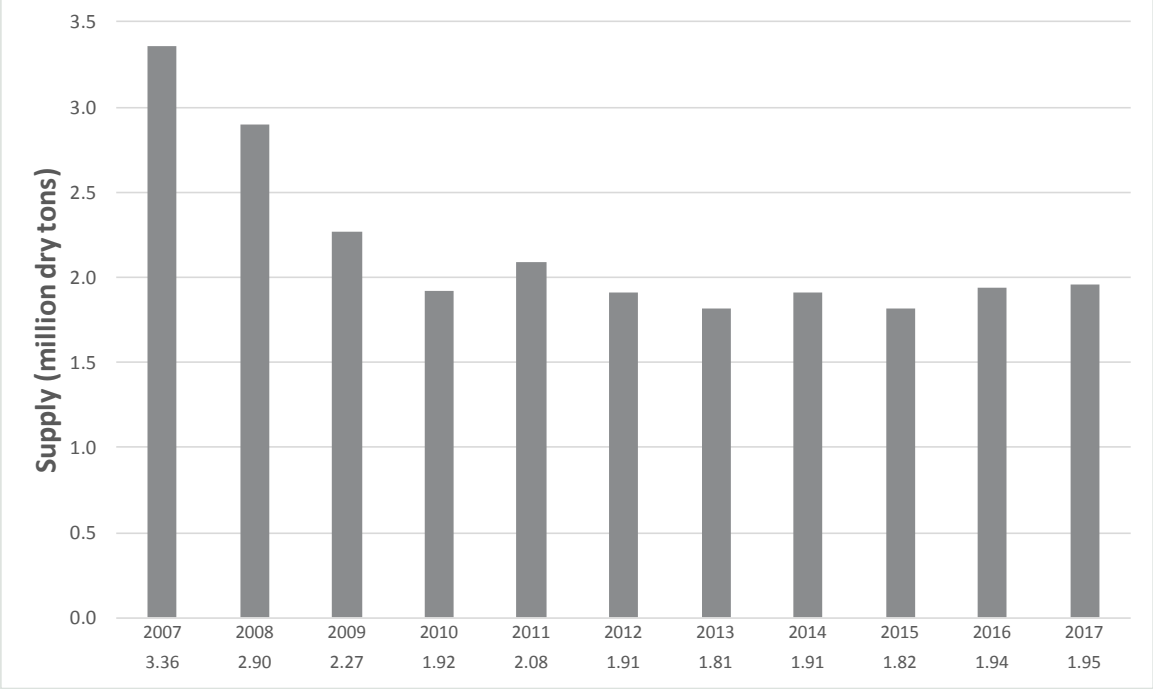


Figure 6-15 Residual Chip Supply Delivered to Consumer - US South - Hardwood Species

Prices for hardwood residual chips have increased by roughly $10/dry ton over the past 10 years. This is a modest increase that essentially mimics general inflation trends in the US, but with different drivers (Figure 6-16). Compared to pine where supply increased over the last decade, we would have expected stronger price reaction in the hardwood residual market. The underlying reason is that demand decreased by 4.4 million bone dry tons (Figure 6-11). This more than offset the decrease in supply, having only a marginal effect on price.

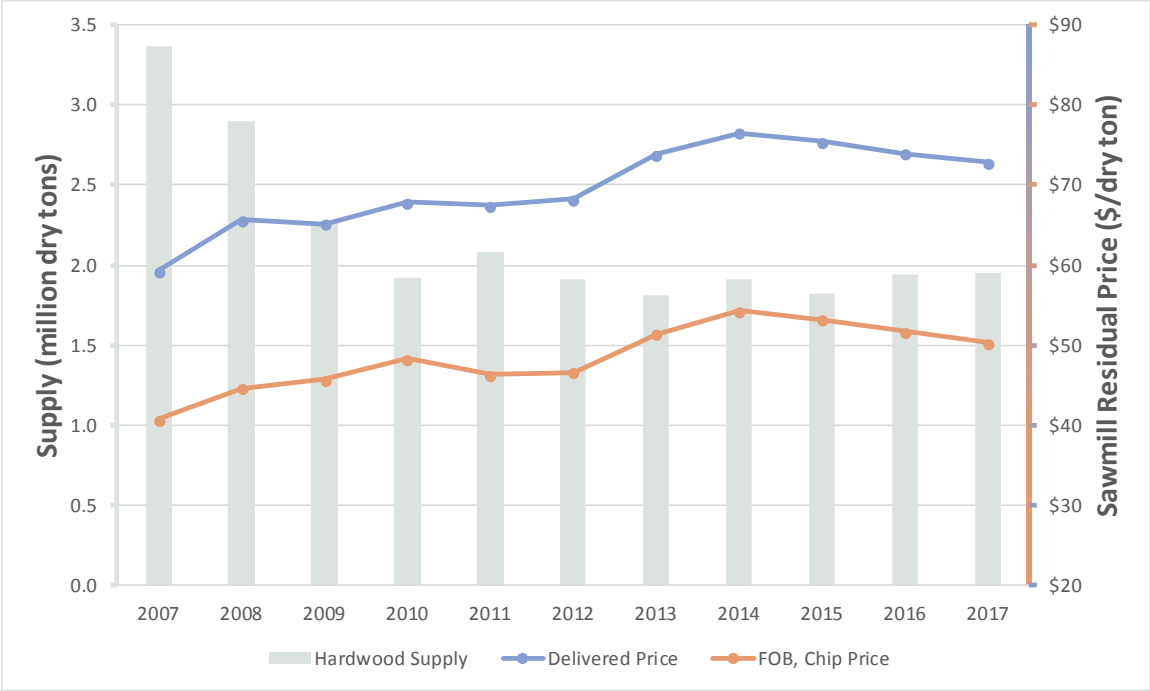


Figure 6-16 Residual Chip Supply Delivered to the Consumer and Price - US South - Hardwood Species

Sawdust, Shavings and Wood Fuel

For sawdust, shavings and wood fuel, the market does not always draw clear lines between species. However, most of the supply originates from SYP mills. As such, the trend for these residuals mirrors the pine residual chip trend. Supply dwindled through 2009 to 3.07 million bone dry tons before starting a slow and arduous rebound in 2010 (Figure 6-17). Since this time, supply has increased 54% to 4.71 million bone dry tons in 2017, surpassing 2007 levels.

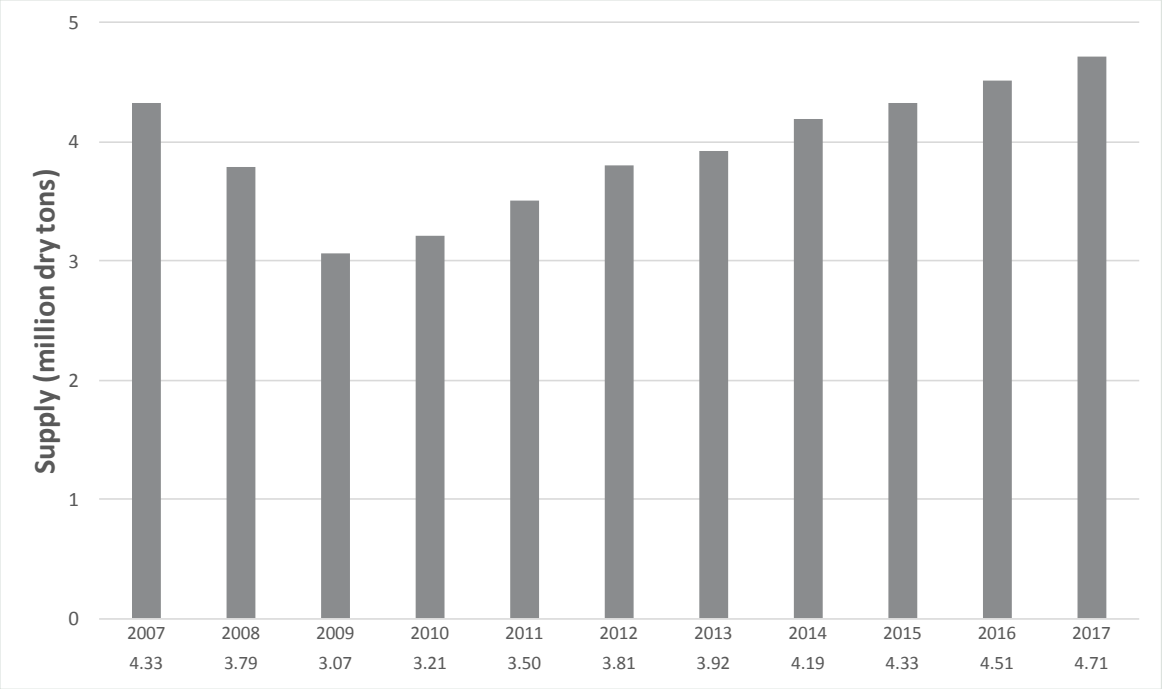


Figure 6-17 Sawdust and Shavings Supply Delivered to the Consumer - US South

Price trends for sawdust and shavings mirror residual chip prices for 2007-2017 (Figure 6-18). However, the spread between delivered price and net FOB price (the price the producing mill receives) has widened, indicating underlying healthy demand for sawdust and shavings. This is no surprise after considering that 16 new pellet mills were constructed between 2007 and 2017, many of which consume sawdust and shavings (Table 6-1).

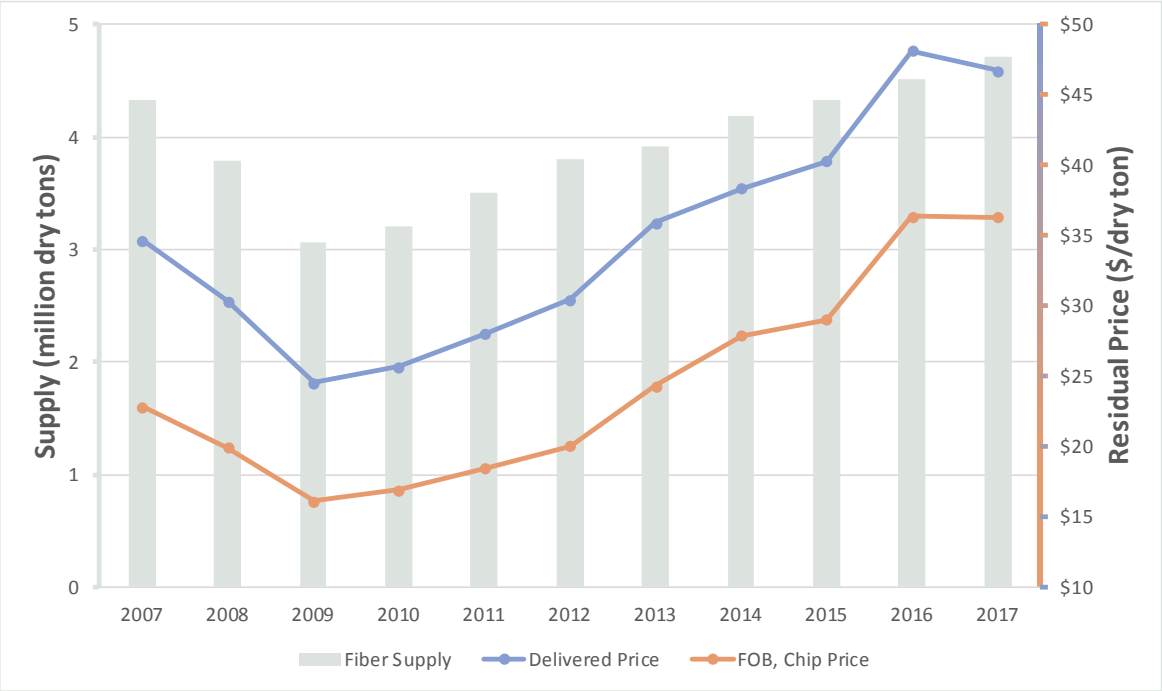


Figure 6-18 Sawdust and Shavings Supply Delivered to the Consumer and Price - US South

The supply of wood fuel also declined during the Great Recession as mill residue output and harvest activity slowed (Figure 6-19). (Final sawtimber harvests typically generate post-harvest residue from logging slash.) While supply increased from its low in 2009, it plateaued in 2015 and 2016 and decreased in 2017.

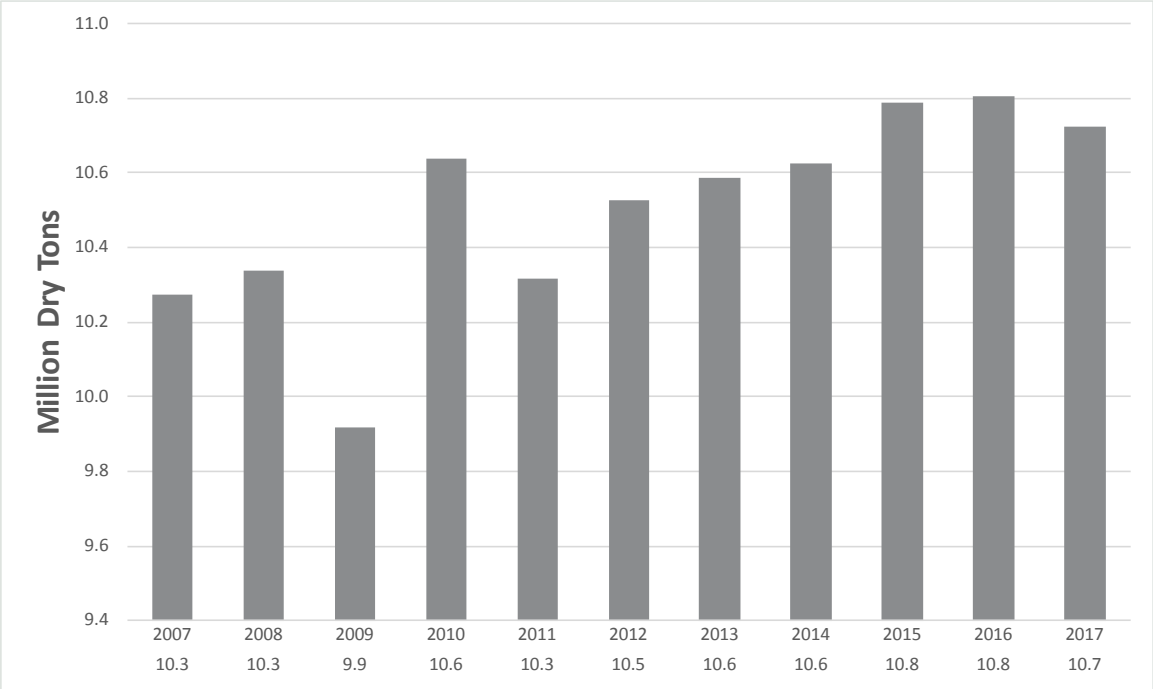


Figure 6-19 Internal Wood Fuel Supply Generated by Debarking and Chipping of Pulpwood

Notice too that the supply recovery has been uneven and choppy, especially from 2009-2011. This unevenness is illustrative of the dynamic, self-correcting nature of the wood residual market.

In 2009, when sawmill production was off cyclical highs by 30%, so too were the production of residual sawmill chips. Since chips were scarce, pulp mills began harvesting more roundwood pulpwood to make up the difference (2010). Roundwood pulpwood comes with 12% bark by weight. As deliveries of roundwood increased, so did the production of bark and wood fuel.

In 2010, several large, integrated pulp mills sponsored in-woods whole tree wood fuel chipping contractors to guarantee a fuel source supply for inside-the-fence boilers. The pull back in 2011 was a reaction to the overreach in 2010. The plateau in 2015/2016 and subsequent softening is a response by pulp mills to the new supply of pine sawmill chips, as they reduced roundwood and in-woods chip purchases and increased pine sawmill chip purchases.

Supply of wood fuel delivered to the consumer has been far more consistent, apart from a marginal decrease that took place in 2010 and persisted into 2013 (Figure 6-20). Supply recovered to near pre-2010 levels in 2014 and has remained in pre-recession territory since.

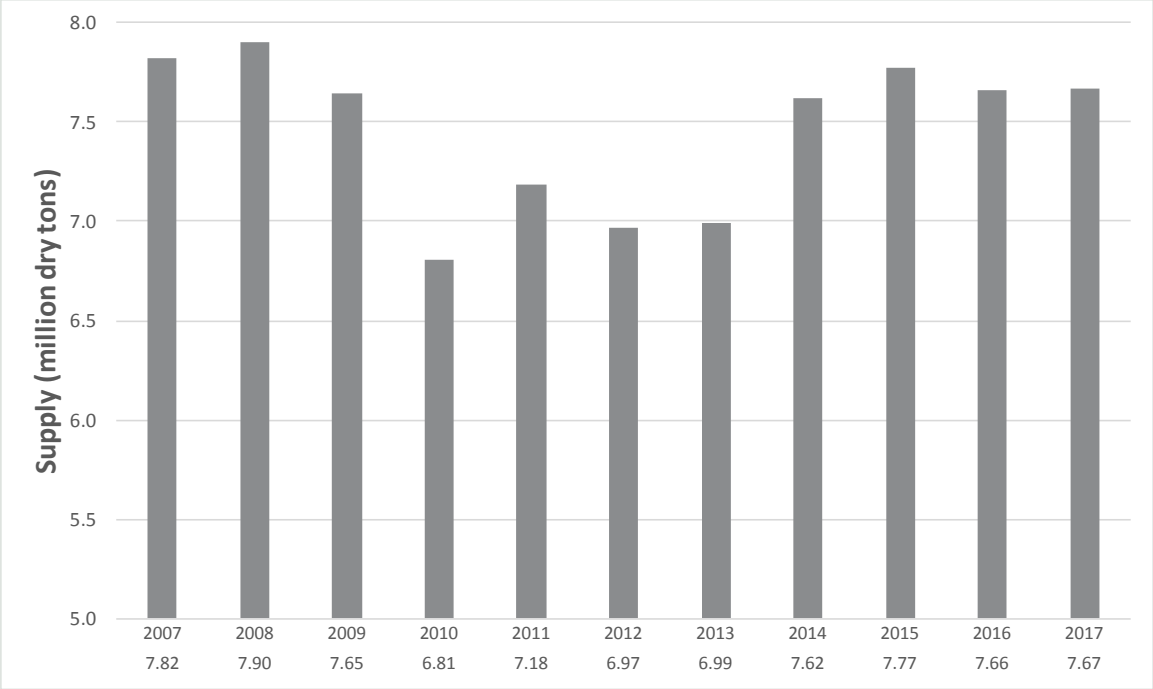


Figure 6-20 Wood Fuel Supply Delivered to the Consumer - US South

Despite some positive price runs from 2007-2009 and again between 2013-2014, wood fuel prices are essentially the same today as in 2007 (Figure 6-21). This is clearly a different pattern than wood chips or shavings and sawdust. Because wood fuel substitutions are readily available, wood fuel can be sourced many ways; it is a low-value energy product influenced by the natural gas and fuel oil markets.

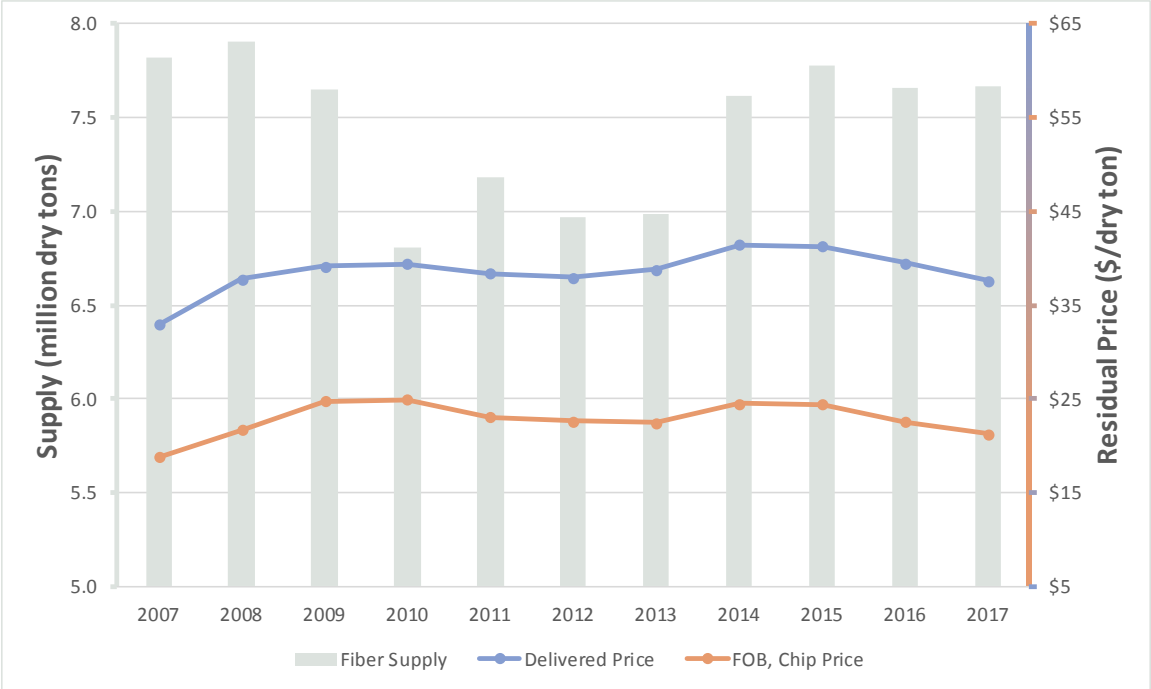
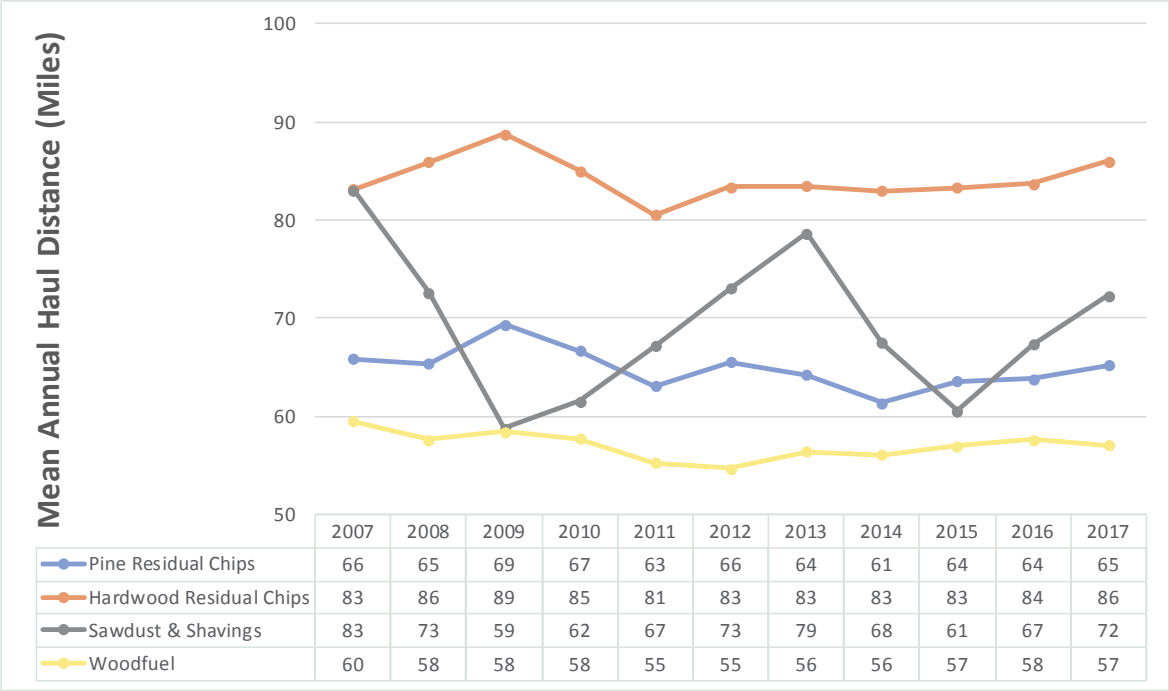


Figure 6-21 Wood Fuel Supply and Price - US South

Mill Dispersion

It is commonly perceived that haul distances between producers of residuals and consumers of residuals are lengthening. This theory is based on the logical assumption that in an oversupplied market, producers would be disadvantaged by being forced to absorb the higher haul cost and netting less revenue. The data shows that this is a misconception, however. Haul distances have remained stable over the last 10 years (Figure 6-22). While it is true that both consumers and producers have grown and consolidated, the net effect on haul distance and net price received by the producer have been unaffected.



	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Pine Residual Chips	66	65	69	67	63	66	64	61	64	64	65
Hardwood Residual Chips	83	86	89	85	81	83	83	83	83	84	86
Sawdust & Shavings	83	73	59	62	67	73	79	68	61	67	72
Woodfuel	60	58	58	58	55	55	56	56	57	58	57

Figure 6-22 Mean Annual Haul Distance for Residuals Delivered to Consumer – US South

6.1.5 Regional Takeaways

The US South's forest products industry is a tale of two worlds: one has seen a robust recovery, capital inflows and high profitability; the other has never recovered to pre-recession highs, endured a significant number of mill closures and suffered at the hands of changing consumer preferences.

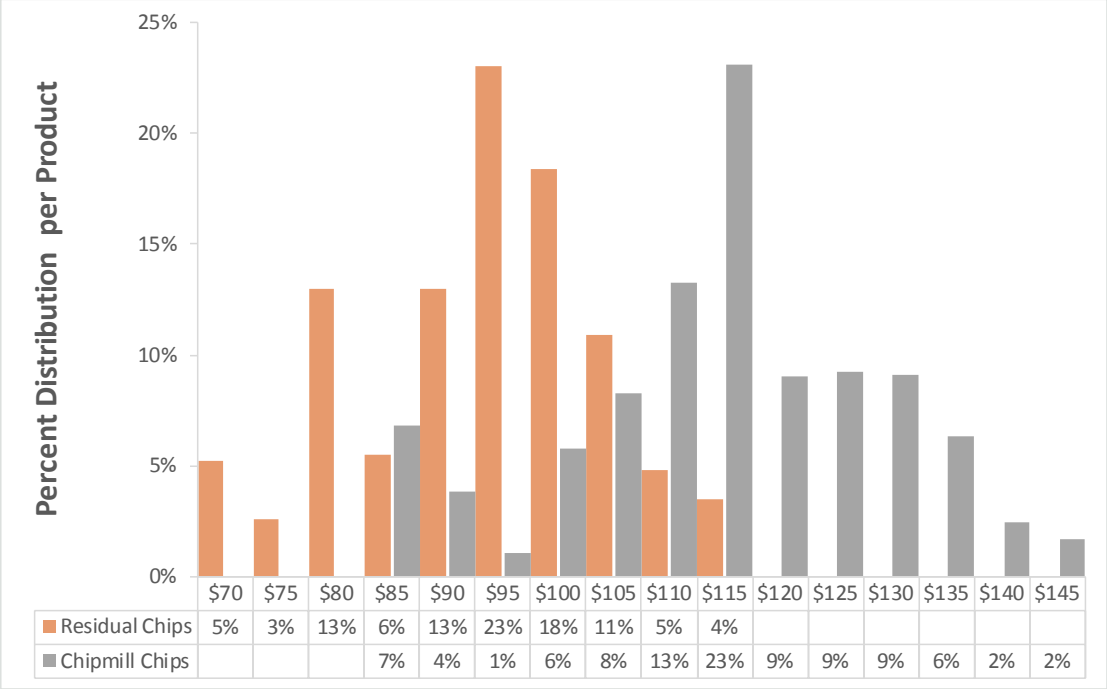
- **Pine Consumers/Pine Market:** The consumers of pine fiber and logs, including pulp mills, pellet mills, OSB mills, sawmills and plywood plants are the winners over the study period. While the total number of pulp mills decreased by three, two of them were hardwood purchasers. Additionally, three other mills were converted to pine for a net gain of two softwood purchasing pulp mills. The number of mills producing pellets increased from two in 2007 to 18 in 2017. The number of softwood producing lumber mills declined, but production has rebounded to pre-recession levels because of steady new home construction and excellent remodeling demand.
    - The market looks strikingly like the pre-recession period, except for these important differences:
        - Fiber prices have remained low with very little volatility.
        - Mill profitability has been at or near record levels for a sustained period.
        - Capital is flowing to new sawmill and pellet mill development as well as new fluff pulp conversions.
    - The supply and demand and volume flows of all pine residual products surpassed 2007 levels by 2017, indicating a full recovery from—and adjustment to—the malaise of the Great Recession.
- **Hardwood Consumers/Hardwood Market:** Hardwood solid lumber and pulpwood markets declined tremendously over the past 10 years. The pulpwood market faced many headwinds including changing consumer preferences and structural changes in how news and information are delivered in the digital age. Primary production of hardwood lumber has never recovered to 2007 levels for a number of reasons, including changing preferences for hardwood flooring (particularly red oak), loss of remanufacturing profitability, Europe's focus on engineered wood substitutes and the rise of the Eastern European hardwood market.
    - The number of hardwood sawmills declined by 66 between 2007 and 2017, while lumber production declined by one-third, along with production of hardwood residuals.
    - The hardwood pulp fiber market has also declined precipitously over the study period. By any measure, whether number of mills and machines running, production or fiber demand, the hardwood market in the US South is in trouble.
    - While hardwood fiber prices for pulpwood, chips and other residuals have increased over the period, volumes have declined by about one-third and show all signs of continued decline. Structural changes have affected the hardwood market in the South in ways that cannot be reversed.

6.2 Pacific Northwest

6.2.1 Residual Market Overview: Distribution by Product

The market structure and supply dynamics for residual material are considerably different in the Pacific Northwest than they are in the US South. Since the early 1900s, this market has focused on lumber production and sawlog harvests. As a result, pulp mills were designed to consume only conifer sawmill chips, with no log handling equipment. Landowners are not accustomed to growing pulpwood, and thinnings for pulpwood are not common. This is the result of mill consumption needs and the fact that logging conditions (steep terrain and high logging costs) make thinnings only marginally commercially feasible. Hardwood, in the form of Red Alder logs, is the main commercial species and there are a handful of mills that process alder logs in the region. However, no meaningful residual market exists for hardwood species and they are not considered in this analysis as a result.

In the aftermath of the spotted owl crisis which led to harvest restrictions in national forests in the 1990s, nearly half of the lumber capacity in the PNW evaporated. Since then, the demand from pulp mills for sawmill residuals has far outstripped available supply. The balance is made up by pulp logs or sawlog tops that are chipped in stand-alone chip mills. As a consequence, supply factors are the weighting influence on residual chip pricing, not demand. As evidenced by Figure 6-23, sawmill residual chips are priced lower than chip mill chips and are always in high demand in the market.



	$70	$75	$80	$85	$90	$95	$100	$105	$110	$115	$120	$125	$130	$135	$140	$145
Residual Chips	5%	3%	13%	6%	13%	23%	18%	11%	5%	4%						
Chipmill Chips				7%	4%	1%	6%	8%	13%	23%	9%	9%	9%	6%	2%	2%

Figure 6-23 Chip Distribution Per Product

Pulp mills in the PNW are much smaller (less than half) than their counterparts in the South. The average mill consumes 500,000 bone dry tons (BDT) annually (vs. 1.1 million in the South), and the PNW market is just 15% of the size of the US South market. Pulp mills do play a vital role in the health of the entire forestry industry in the PNW, however; no other outlets for residuals exist, as neither the wood energy nor pellet markets have developed in any substantial way in the region.

Historically traded on a bone-dry basis, the current feedstock blend consumed by conifer pulp mills in the PNW is 41% whole tree, chipmill chips and 59% residual chips (Figure 6-24).

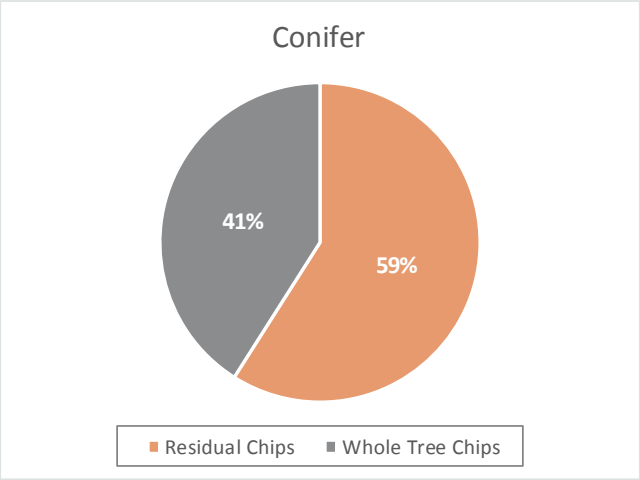


Figure 6-24 Feedstock Blend of Pulp Mills in the PNW

6.2.2 PNW Market Profile: Resource Constraints, Mill Closures and Added Demand

The forest industry in the PNW faces a unique set of challenges that are principally supply driven. Constrained supply for all wood products limits growth opportunities in the region, keeps log and fiber prices elevated and has led to mill closures and capacity reductions. The domestic PNW industry is resource constrained due to the combined effects of four factors:

- **Loss of available timberland:** The timber market in the PNW was fundamentally altered after the listing of the spotted owl as a threatened species over 30 years ago. The listing severely restricted timber sales on approximately 10 million federal acres scattered across 17 national forests in Washington, Oregon and Northern California. As log supply from national forests dried up, the mills that relied on this resource curtailed production or failed. Dimensional lumber production dropped from 21.8 BBF in 1989 to an average of 16.9 BBF during the 1990s. Current production is even lower, at only 14.6 BBF. When residual chip production from the curtailed or closed mills disappeared, chipmills that could produce a high-quality paper mill chip stepped in—albeit at a much higher cost. Pulp mills were forced to endure a cost increase, which weakened their profitability and their global cost position.

- **Loss of marketable timber:** Catastrophic wildfires and the Mountain Pine Beetle (MPB) infestation have destroyed millions of acres of both public and private timberland in the region in recent years, further limiting access to available timber. Per recent data from the US Forest Service, forest growth was 48% of mortality in western national forests, while timber harvests are a mere 11% of what is dying annually. The agency estimates that 6.3 billion dead trees were standing in 11 western states in 2015, up from 5.8 billion in 2010—so the trend continues.

- **Increased demand shift to PNW due to supply constraints in Canada:** The devastating Mountain Pine Beetle infestation in British Columbia has been well documented. Annual allowable cuts (AAC) have been reduced by about 20% from historical norms and are not expected to recover until 2080. In addition, wildfires have resulted in a loss of 25 million cubic meters in the mid-term supply, and 12 million cubic meters of previously-available insect-killed pine. These supply constraints are starting to show up in BC lumber production losses; current lumber production in BC is down nearly 6%, shipments are down nearly 10%, and the region's supply continues to dwindle. As a result of these catastrophic events, the geographic shift in demand has placed pressure on available resources in the PNW.

- **Export Demand:** The PNW has a robust export sawlog market. Landowners have access to no fewer than five ports that source the Pacific Rim log trade. Nearly 2.4 million cubic meters of Doug fir logs were exported in 2017.

Demand for PNW sawlogs has remained strong but, unlike the US South, timber supply is constrained. Unlike markets where the timber supply is expanding and prices can adjust downward as supply outpaces demand, the PNW timber supply is tightly matched to lumber and panel production requirements. This limits sawmill expansions and caps residual production to a finite volume. The PNW lost seven major pulp and paper operations in the wake of the Great Recession (Table 6-3). Three plywood and veneer mills and 15 conifer sawmills also closed. This represents 10% of the PNW's mill portfolio.

Table 6-3 PNW - Mill Count by Year - Residual Wood Fiber Suppliers & Consumers

Mill Description	Consumer Mill Count	
	2007	2017
Pulp & Paper	21	14
Engineered Wood Panels[1]	10	10
Totals	**31**	**24**

[1]Includes MDF and Particleboard

Mill Description	Supplier Mill Count	
	2007	2017
Conifer Sawmills[2]	155	140
Plywood & Veneer	25	22
Totals	**180**	**162**

[2]Includes Sawmill, Specialty Timber, and Pole Mills

The primary consumers of residual wood fiber are manufacturers of pulp and paper and engineered wood panels (Figure 6-25). In 2007, most mills were located west of the Cascade Mountains and were centered among clusters of sawmills in western Washington or northwestern Oregon.

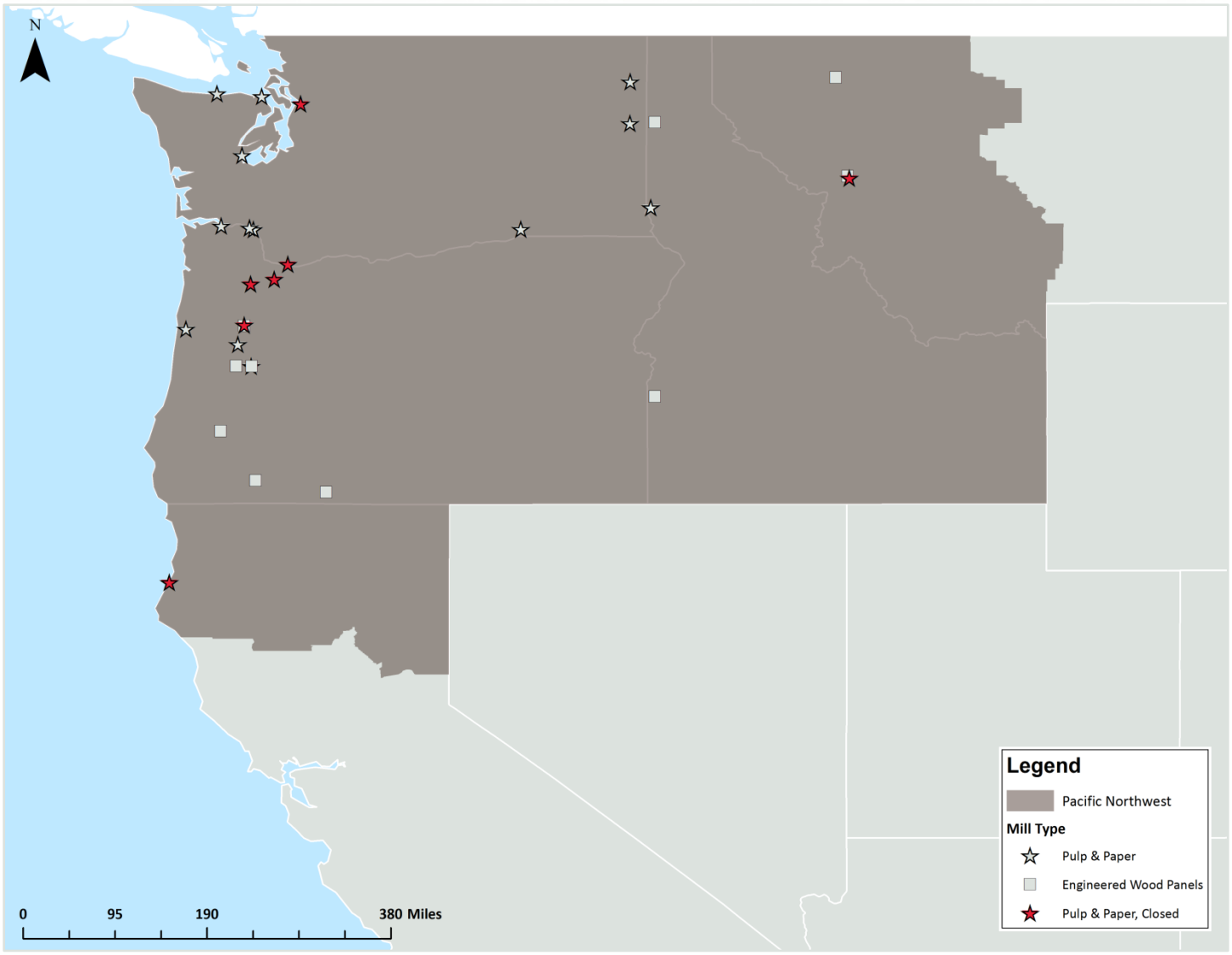


Figure 6-25 PNW – 2007 to 2017 Residual Wood Fiber Consumers – Active and Closures

Some notable changes at the mill level reflect the larger structural changes within the market over the study period:

- In 2009, IP closed its pulp mill near Albany, Oregon. This shutdown was attributed to fluctuating demand for packaging materials that resulted from the Great Recession.

- In late 2010, Freshwater Tissue Company closed its pulp mill in Samoa, California.

- In 2014, Smurfit-Stone Container Co. (now WestRock) announced the permanent closure of its pulp mill near Missoula, Montana, ending the annual production of approximately 620,000 tons of linerboard. This decision was a result of declining lumber demand in Montana that had placed insurmountable pressures on consumers of residual material. This was further evidenced by the closure of two other Montana mills—one belonging to Plum Creek Timber (now Weyerhaeuser) and the other to Stimson Lumber—that occurred within months of the

Missoula shutdown.

- At the beginning of 2018, this trend continued as Georgia-Pacific, LLC announced its decision to end most of the production at its Camas, Washington, pulp and paper mill by mid-2019.

In the PNW, the primary suppliers of residual wood fiber are manufacturers of conifer lumber, plywood and veneer (Figure 6-26). The highest concentration of mills is located on the western side of Washington and Oregon. A noticeable gap occurs in the middle of the two states where the Cascade Mountains divide the mills. Mills are spread further apart east of the Cascades, but clusters appear in Northern Idaho and western Montana.

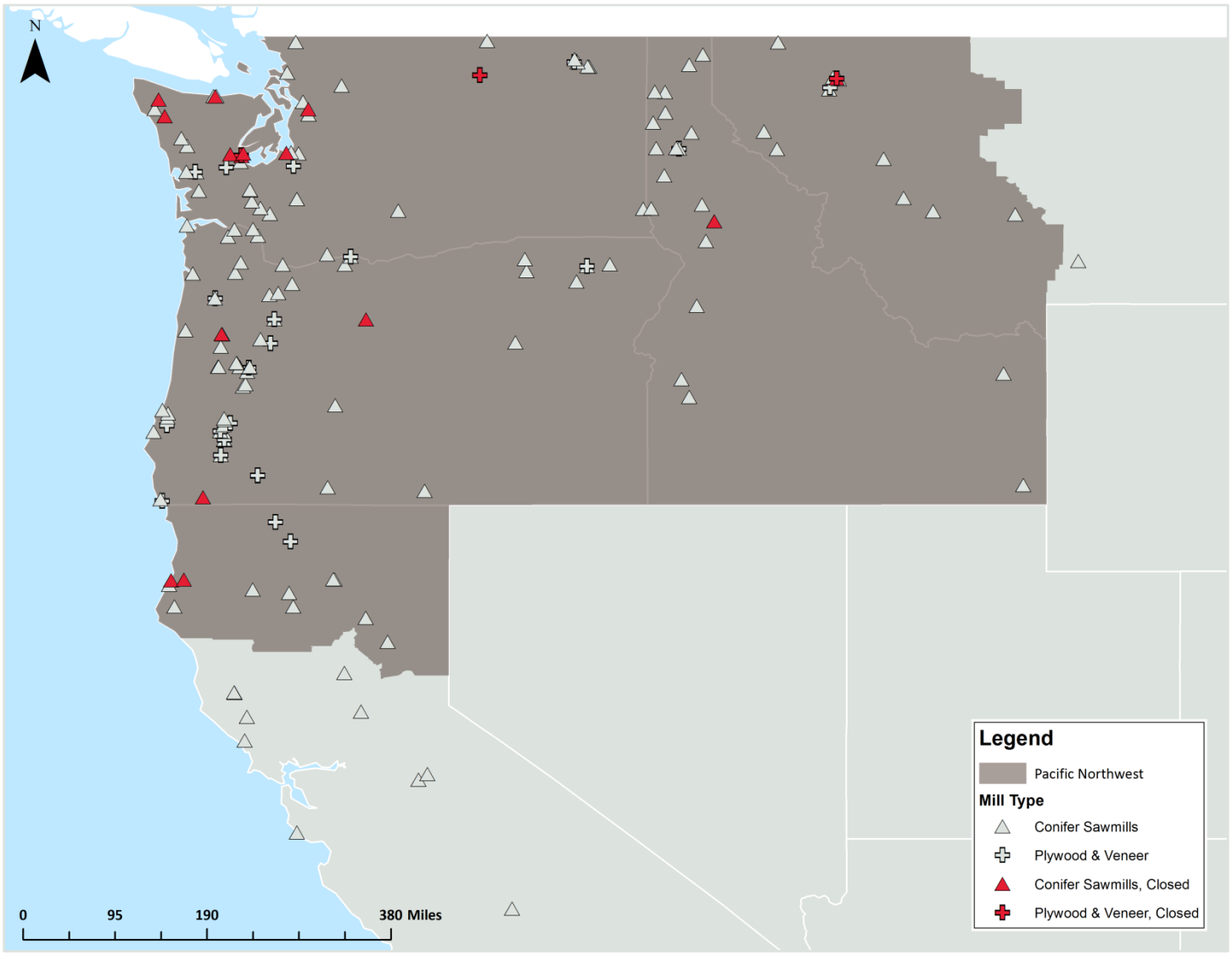


Figure 6-26 PNW – 2007 to 2017 Residual Wood Fiber Suppliers – Active and Closures

6.2.3 Broad Market Changes

Timber inventories in the PNW have been strained throughout the study period as evidenced by the elevated sawlog price levels throughout most of the last ten years. Again, due to limited timber supply, sawlog prices recovered quickly after the lows of 2009 (Figure 6-27). By 2013, sawlog prices had recovered to 2007 levels. The elevated price levels limit additional lumber and panel production and reinforce the notion that timber supply limits upside potential.

	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Domestic	$560	$444	$350	$444	$517	$513	$599	$641	$596	$587	$674
Export	$659	$543	$484	$510	$613	$548	$686	$697	$581	$599	$694

Figure 6-27 Domestic vs. Export Delivered Price in the PNW

6.2.4 Residual Market Changes

Demand for sawlogs has been robust. At the same time, domestic demand for wood chips has decreased because of pulp mill closures. On the surface, one would think that the wood chip demand decrease—just as wood chip production was increasing—would be damaging to the market price of wood chips and create chip backlogs for sawmills. This is not the case, however. Since sawmill chips get consumed first—because of their lower price and availability—pulp mills will increase purchases of lower cost sawmill chips to replace higher cost chip mill chips, a substitution that is certainly beneficial to the economics of the pulp mill and sawmill alike.

Export demand has increased over the study period (Figure 6-28). Wood chip exports to Asia, in particular, have shown some growth. There is also a growing demand for wood pellets in Asia. Unlike the US South, however, industrial wood pellet production in the PNW is virtually non-existent. Despite the forecasted growth in pellet demand for the Asian market, the PNW is simply not in a position to capitalize on the opportunity.

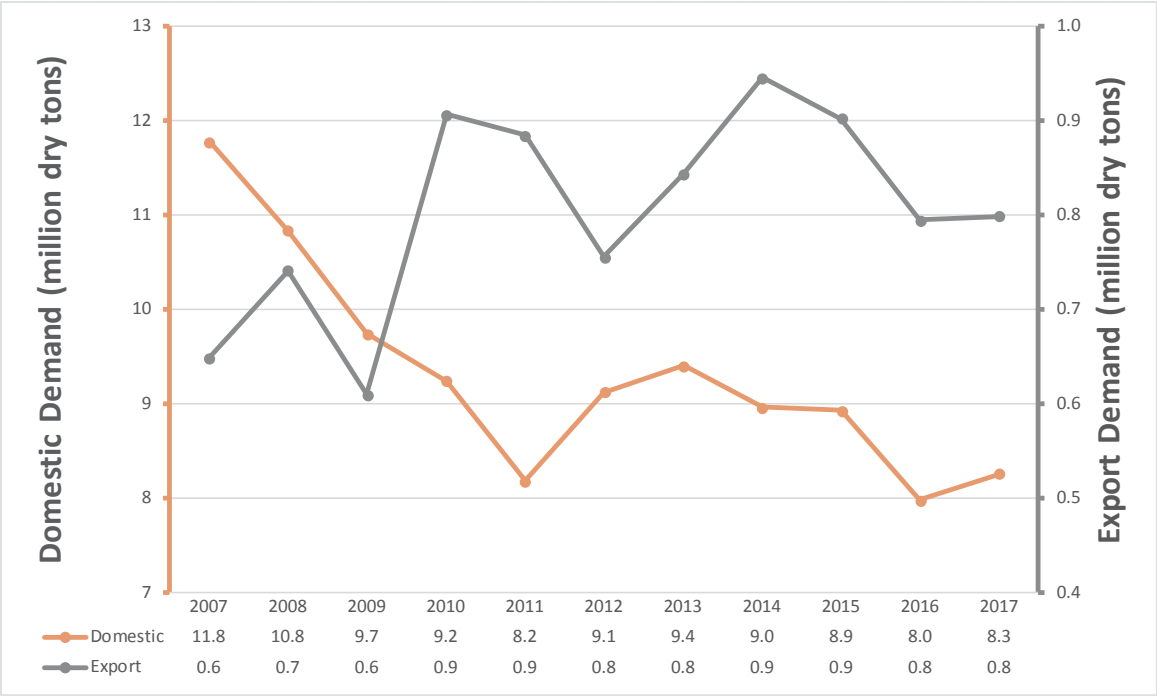


Figure 6-28 Domestic and Export Chip Demand in the PNW

Both residual and chipmill chip prices have trended down over the study period, although they have leveled out somewhat since 2015. Figure 6-29 illustrates the relative value between residual chips and chipmill chips; the widening gap is mostly attributable to the expanding availability of sawmill chips.

Figure 6-29 Delivered Chip Price in the PNW

Over the last decade, the trend of conifer residual chip supply in the PNW has mirrored the lumber production trend. Supply is still below 2007 levels, but supplies recovered and stabilized by 2013, just like lumber. Since 2012, annual supply has remained above 5 million bone dry tons (Figure 6-30). Again, these supply trends show how inextricably linked the restrained sawlog supply, lumber production and eventual chip supply are. Perhaps most importantly, Figure 6-30 displays the limits of the market.

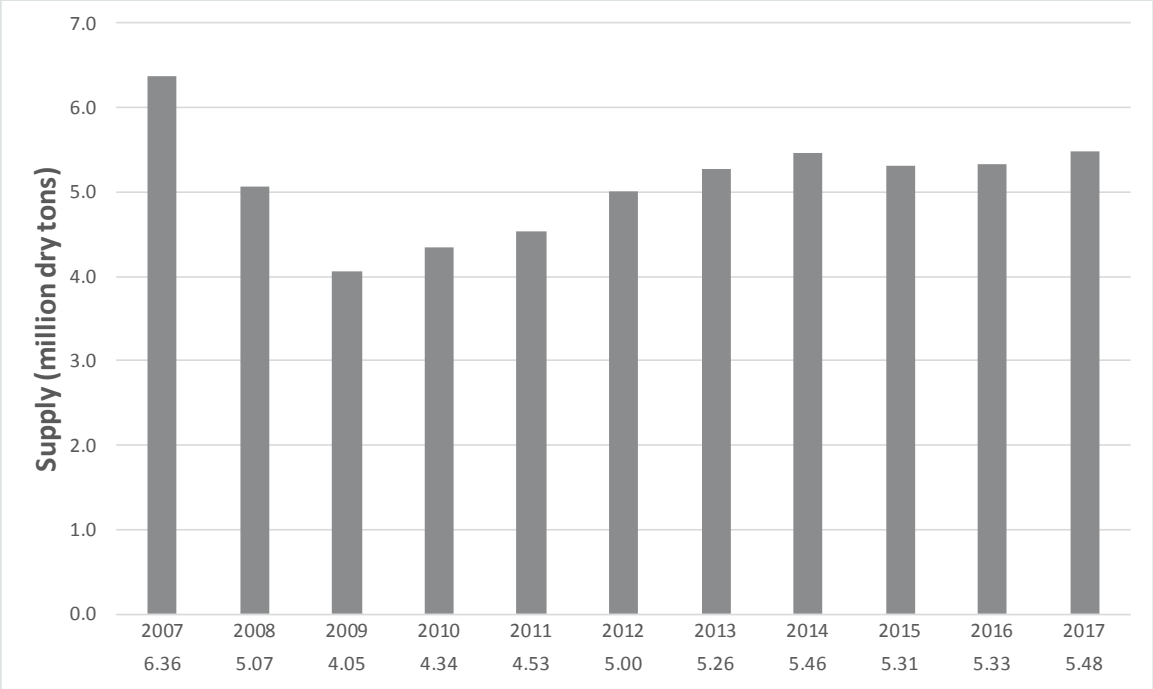


Figure 6-30 Residual Chip Supply - PNW - Conifer Species

Chip prices in the PNW are volatile, and the volatility is supply driven. Sawmill residual chip prices declined rapidly between 2007 and 2009 as demand dwindled. Prices for residuals were at a high between 2005 and the beginning of 2007 before sawmill production started to decline rapidly in response to the housing market crash. Pulp mills began to lean on whole tree chips to make up the deficit. This continued through 2009.

In 2010 and 2011, a spike in the market occurred as demand for export chips increased and pulp mill profitability returned. From this point, residue supply began to outweigh demand as lumber production increased. Supply has flattened in recent years, as have volatility and price (Figure 6-31).

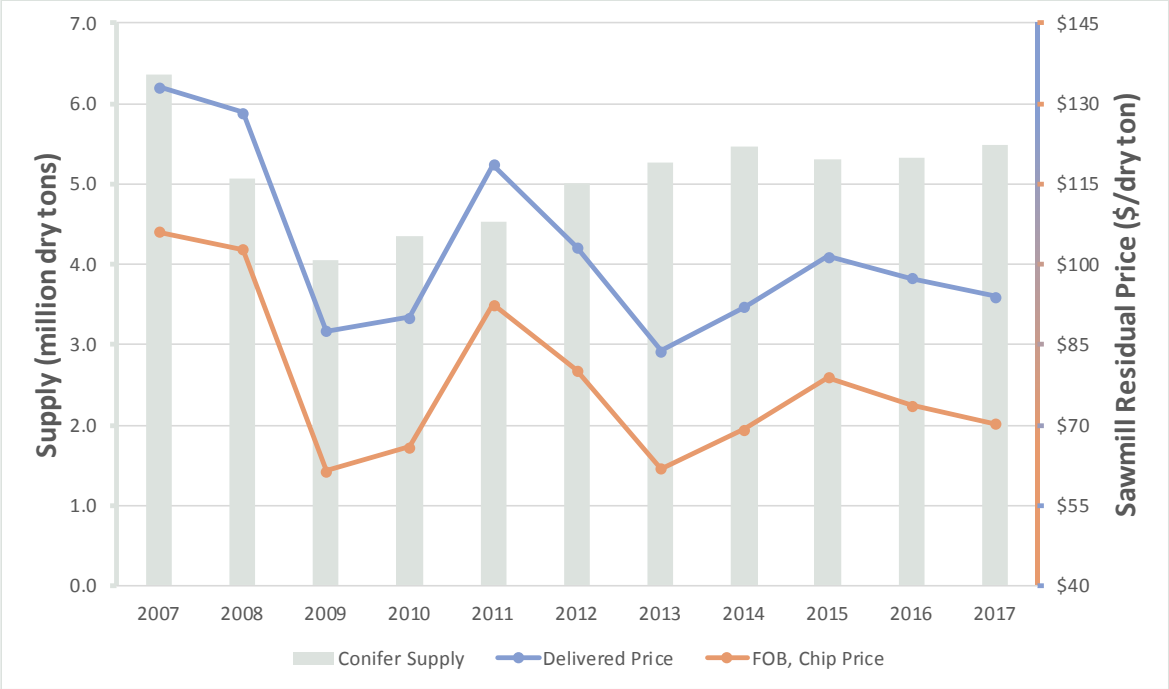


Figure 6-31 Residual Chip Supply and Price - PNW - Conifer Species

Sawdust, Shavings and Wood Fuel

As expected, trends in sawdust, shavings and wood fuel, predominantly produced by sawmills, resemble residual chip supply patterns. Sawdust and shavings reached their low point in 2009 at 2.29 million bone dry tons (Figure 6-32). Since this point, supply has increased 35% to a total of 3.09 million bone dry tons in 2017. Wood fuel supply has increased 31% since 2009 (Figure 6-33). The supply of these three residuals has been remarkably stable over the past five years as lumber production is maxed out due to restrained log supply.

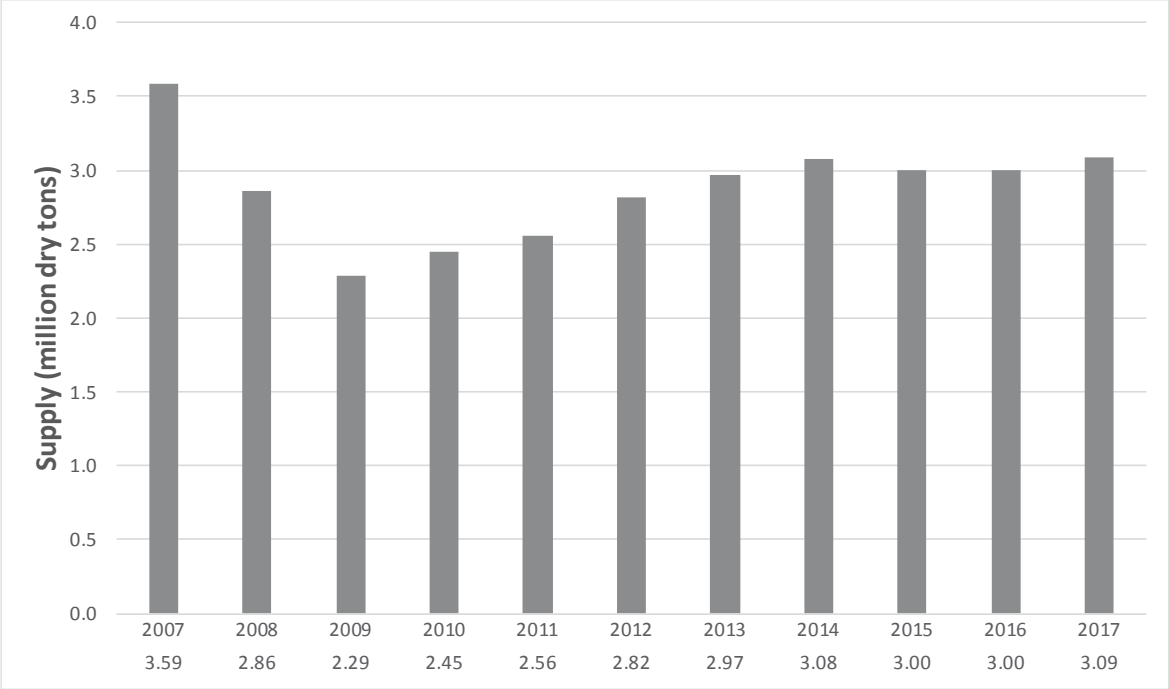


Figure 6-32 Sawdust and Shavings Supply - PNW

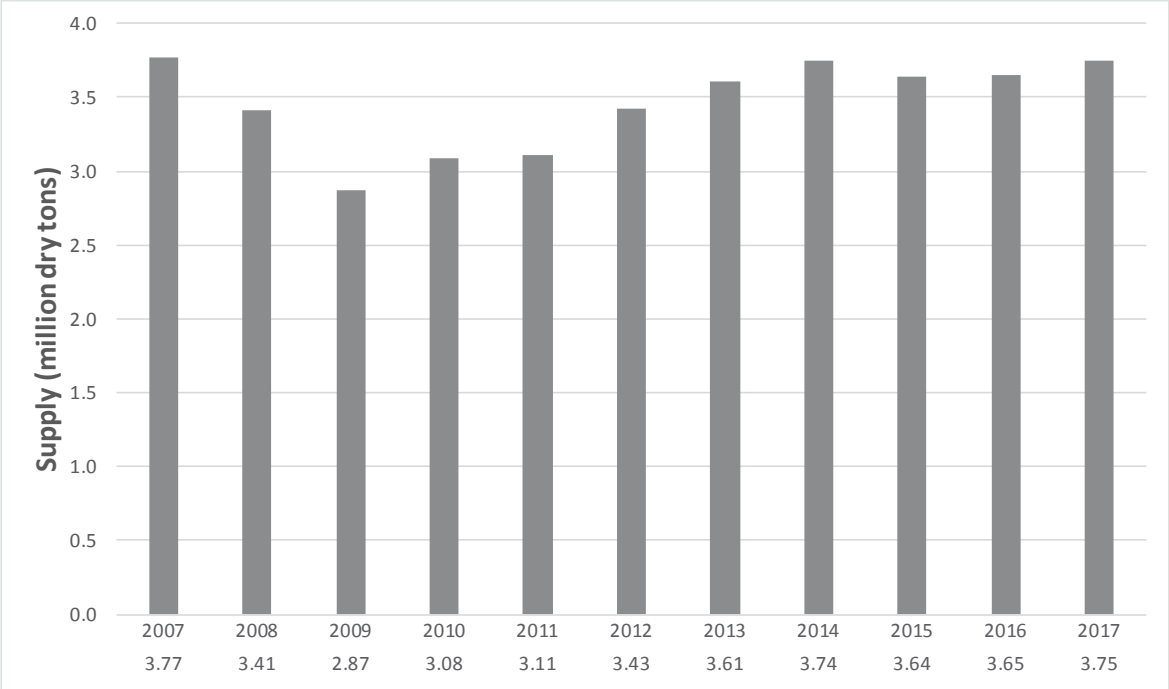


Figure 6-33 Wood fuel Supply - PNW

Prices for sawdust, shavings and wood fuel have also been stable over the past five years, with some noticeable softening in wood fuel prices (Figure 6-34 and Figure 6-35).

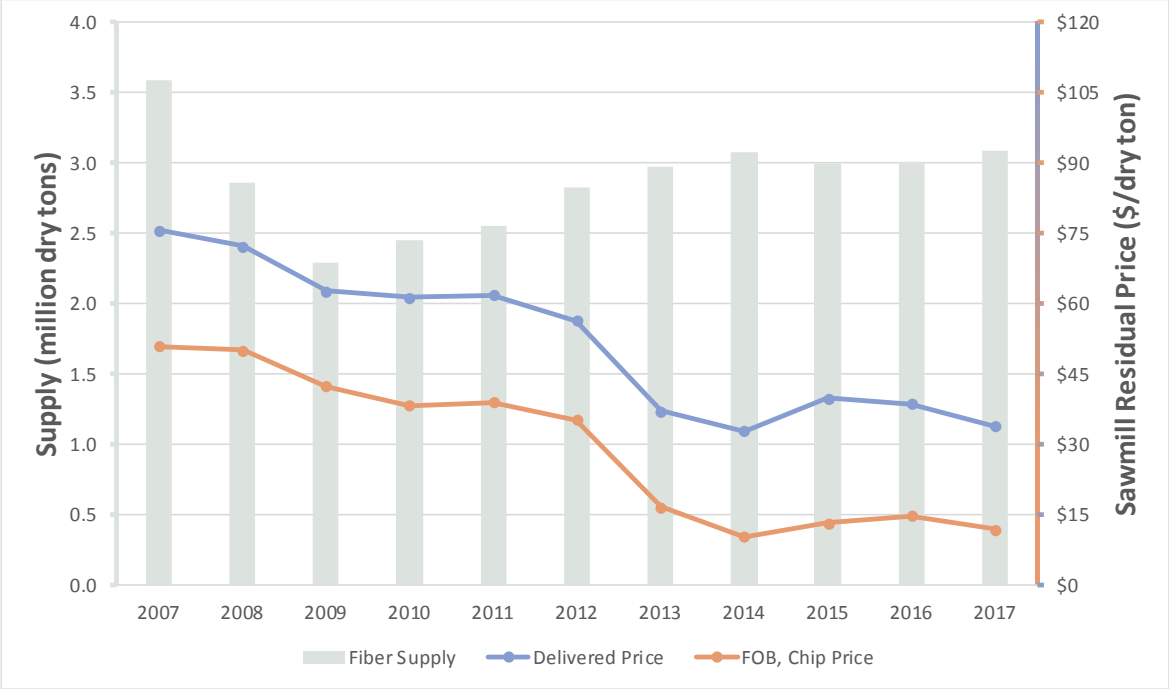


Figure 6-34 Sawdust and Shavings Supply – PNW

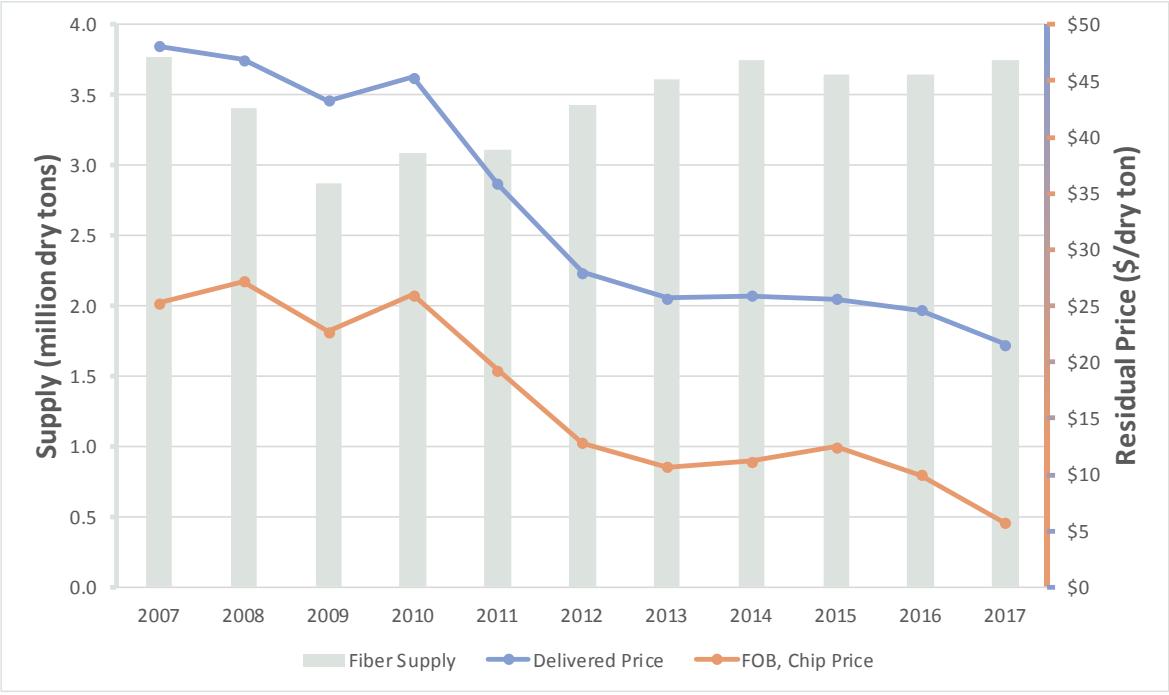
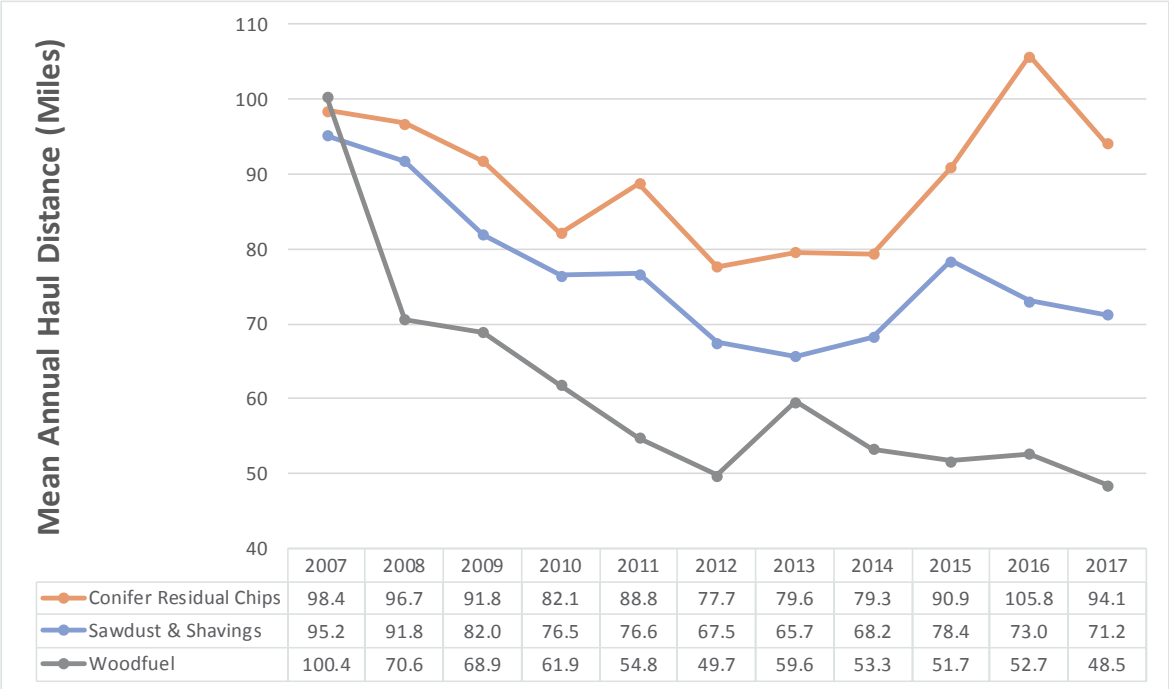


Figure 6-35 Wood fuel Supply - PNW

Mill Dispersion

In the corresponding section focused on the US South (the end of section 6.1.4), we debunked the theory that as mill ranks thin, suppliers of chips will be further away from buyers of chips. If the assumption were true, this would drive up freight costs and decrease net realization from chip sales for the supplying mill. Forest2Market's data shows that this theory is simply false. In fact, the data suggests exactly the opposite in the PNW (Figure 6-36).



	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Conifer Residual Chips	98.4	96.7	91.8	82.1	88.8	77.7	79.6	79.3	90.9	105.8	94.1
Sawdust & Shavings	95.2	91.8	82.0	76.5	76.6	67.5	65.7	68.2	78.4	73.0	71.2
Woodfuel	100.4	70.6	68.9	61.9	54.8	49.7	59.6	53.3	51.7	52.7	48.5

Figure 6-36 Mean Annual Haul Distance for Residuals Delivered to Consumer – PNW

6.2.5 Regional Takeaways

- **Market equilibrium:** In most aspects and by any measure, the PNW forest industry is in a state of equilibrium. Domestic sawlog, lumber and residual production have been stable for the past 3-5 years. These have largely, but not totally, recovered following the Great Recession.

- **Timber resource constraints:** Resource constraints are palpable and restrict production levels for all products. The reason that sawmill output has been steady for the past several years is that the available supply of sawlogs is constrained. Unlike oversupplied timber markets (US South) that can absorb additional log demand without moving log prices higher, log prices in the PNW are very sensitive to additional demand. Additional demand does not stimulate additional harvests; it only stimulates higher prices. Sawlog prices in the PNW are twice as high as those in the US South and on par with traditional high cost markets in Sweden and Germany. All of the data points to a very constrained market that has limited upside before pricing itself out of the global market.

- **Limited upside:** The implications of the resource constraints are far reaching. For the landowner, it means elevated timber prices for the foreseeable future. For plywood and lumber manufacturers, it means the PNW is at peak production. For consumers of residuals, it means that expansion is out of the question unless they are willing to absorb raw material price increases via a product mix change.

- **Mill closures between 2007 and 2017 had a marginal impact on residual markets:** Residuals are the fiber of choice for PNW pulp mills. To be sure, the PNW has lost both residual production as well as residual consumption over the years. However, additional chipmill chip production made up for the residual supply reductions from 2007-2009. Conversely, the supply additions that occurred in 2010 and beyond have eroded chipmill market share, leaving the price and the free flow of residual chips reasonably unaffected.

7 COMPELLING ENERGY SUBSTITUTES

The Great Recession also had far-reaching impacts on global energy markets, energy pricing and bioenergy. Wholesale electricity prices have remained relatively stable since 2008 while natural gas prices have dropped 57% over the same time period (Figure 7-1 and Figure 7-2). Several EU countries pursued large scale coal-to-biomass conversions at the beginning of the study period, but the trend did not extend to the US. There was considerable interest in renewable feedstocks to support individual state Renewable Portfolio Standard (RPS) goals in the beginning of the study period, but the availability of cheap natural gas and electricity has since stifled new bioenergy project development in the US.

The existing biopower industry has also been impacted as evidenced by the active legacy biomass power plants (six) in New Hampshire that are struggling to remain open. With low wholesale electricity prices, the revenue from selling power is not enough to offset the cost of wood fuel and operations. Recognizing how important these markets are to landowners, loggers and the entire forest industry value chain, the New Hampshire legislature recently passed two bills to support continued operations of these power plants.

Currently, no viable substitutes for the pulp fiber used in the manufacture of paper and paperboard products exists. The only true substitutes are the competitive supply of pulpwood and whole tree, chipmill chips. However, there are two compelling substitutes for wood fuel.

Since the early 1960s, pulp mills have utilized solid wood residues to fuel recovery boilers. The bark and fiber generated during the debarking of roundwood is an efficient source of fuel to produce the steam required to run pulp and paper operations. However, the low price of natural gas has made an attractive substitute. As a result, some pulp mills are considering converting their boilers to co-fire natural gas. New continuous kilns at sawmills are heated with a combination of wood fuel and a natural gas back-up.

Of course, this choice is often dependent upon the availability of natural gas and the mill's proximity to a natural gas line. In the PNW, most of the mills that could potentially benefit from using this alternative fuel source are simply too remote for conversion to be feasible. In the US South, natural gas appears to be a much more compelling substitute for wood fuel. Louisiana, Oklahoma and Texas are the top three producers of natural gas in the nation, so it is much more readily available for use by mills in this region.

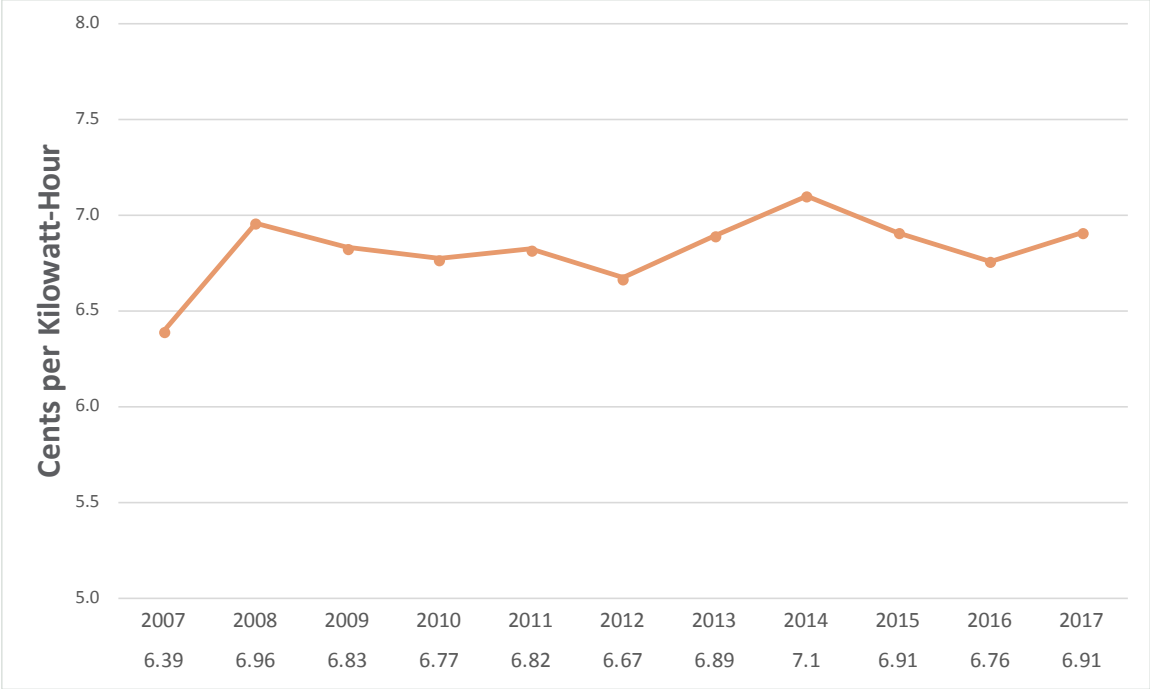


Figure 7-1 Wholesale Electricity Prices, 2007-2017

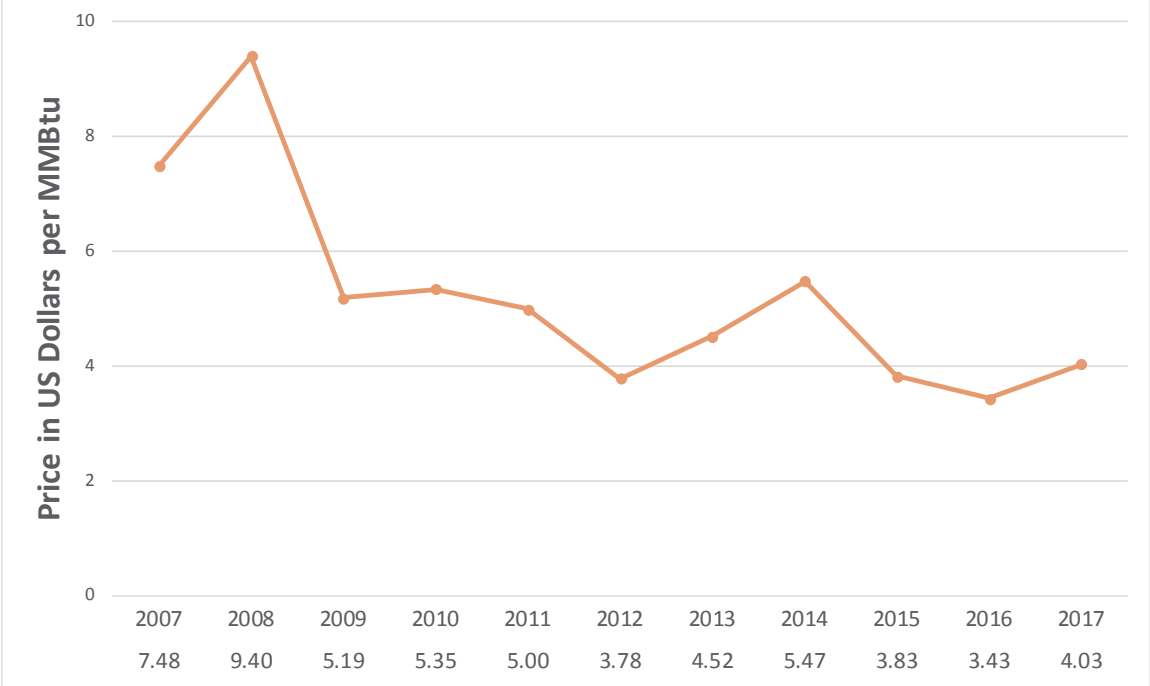


Figure 7-2 Wholesale Natural Gas Prices, 2007-2017

8 CONCLUSIONS

The objective of this study was narrowly focused, but the implications have far-reaching effects on the health of the US forest products industry. The first two goals of uncovering market forces that impact the residual market and follow-on implications shine a light on how different the recovery between the pine and hardwood market has been. The PNW markets have shown resiliency, but limited growth and supply chain links that bind one sector (lumber) to another (pulp).

8.1 US South

Based on any measure of manufacturing output, the US South solid wood (lumber and panels) and softwood pulp markets have returned and surpassed pre-recession levels. Their cost structure ranges from globally competitive (pulp) to the envy of the world (lumber). New capital investment is pouring in from around the globe, and profitability is at record highs.

The high flying economic times are very much supply driven. There is an abundance of conifer/softwood wood fiber from surpluses that accumulated during the Great Recession and its aftermath. The sale of pine sawtimber drives forestland owner returns, and these prices are stuck at all-time lows; even with new lumber demand, excess inventory will limit an upside price correction for years.

The softwood pulp industry has benefited from positive consumer trends such as growth in packaging and container demand and new-found demand for absorbent products. The demand for these products is growing between 2-4% annually, and the US South is well positioned to take advantage of these trends.

The softwood/pine wood residual market has been soft, but stable for some time. With expanding southern lumber production and associated residual production, we expect the softening to continue. But we don't expect the excess supply of chips and wood fuel to inhibit growth in the sector. The counterbalance to the new supply of chips is the growth in the softwood pulp industry, composite panels and wood pellets. Ultimately, pulp mills have a lot of supply chain flexibility to substitute pine pulpwood stumpage for residual sawmill chips. On balance, pulp mills would rather source wood fiber from already processed chips. We are seeing early signs of the southern pulp industry preparing for the onslaught of pine chips by deploying capital to build new truck dumps and woodyard chip pads.

The southern hardwood markets have been in a state of structural decline for many years. Consumer trends and preferences are moving away from products made from hardwood fiber. Printing and writing papers, carton board and liquid packaging are all in a state of global structural decline to the tune of 4-5% per year. Additionally, low cost pulp production in Brazil and Indonesia has stymied any new capital inputs in the US South hardwood business. At least three pulp mills have been converted away from hardwood production in the past 5 years. Hardwood pulpwood turned out not to be the fiber of choice for European energy pellets. Currently, there are no demand trends that indicate future growth for the hardwood pulp market.

The same holds true for hardwood lumber markets, which have not returned to pre-recession levels. Mill numbers and hardwood lumber and resulting residual production have declined precipitously. Consumer preferences have moved away from traditional southern and Appalachian hardwood lumber, and product substitutions such as laminate flooring, high quality MDF and particle board (for cabinetry) have taken their toll. While demand for hardwood lumber has plummeted, the price of raw materials—logs and residuals—has stayed elevated.

8.2 Pacific Northwest

If nothing else, the study demonstrates the inextricable link between PNW log supply, lumber production and pulp capacity. The Northwest US market is severely hobbled due to the tight log supply. The added demand of export markets further complicates the supply situation. PNW lumber capacity has never recovered from the spotted owl crises, let alone the aftermath of the Great Recession. Strangely, the PNW residual chip market is very much insulated from the production declines, as pulp mills make up residual chip deficits with primary chip mill chips. To be sure, this is a cost issue, but not a supply issue. Also notable is the fact that very little capital is flowing to the PNW industry, owing in large part to the restricted log supply and pernicious high log costs, which are some of the highest in the world. Pulp mill numbers and production have declined dramatically. On the surface, this should be alarming; however, the supply of residual chips is only about one-half the amount demanded by pulp mills.

8.3 Temporary or Permanent Structural Shifts

The southern pine lumber and pulp markets are fully recovered from pre-recession lows, investment capital is building new mills and consumer preferences favor pulp fiber production. The industry is solidly profitable with globally-low cost structures. The one challenge and possible inhibitor to growth is the oversupply of wood residues. Forest2Market believes that the negative result of this—if it occurs at all—will be borne by the forestland owner as mills choose to weight their pine fiber mix toward wood residuals and away from pulpwood. In addition, since pine sawtimber growth widely outpaces demand (and will continue to do so even after new lumber production capacity is brought on line), the forestland owner will suffer through many more years of historically low sawtimber prices.

The hardwood lumber and hardwood pulp markets have been in a state of structural decline for a couple of decades. Mill numbers and production have declined over 30% since pre-recession highs. Consumer preferences run countercurrent to products made by hardwood saw and pulp mills, and new market entrants are not choosing hardwood as the feedstock of preference. Instead of fighting the inevitable decline, hardwood pulp mill operators have switched to pine pulp or taken mills out of production. The hardwood lumber industry has not adapted to new market realities as evidenced by declining mill numbers, as well as lumber and residual production.

The market in the PNW might be best described as structurally stagnant. It is reasonably healthy despite its stagnation, the high cost of fiber and lack of capital inflows. Sawmills are profitable, and forestland owners are enjoying near record prices for logs. However, the upside potential of the PNW industry is severely limited due to the structural changes in lumber supply. The lack of supply will haunt the industry for years to come. With no additional log supply, there can be no additional lumber production or residual production and, of course, no new pulp capacity. The PNW market is very likely the same size it will be for the foreseeable future.

APPENDIX A – PRODUCT DEFINITIONS

On average, slightly more than half of the raw material processed by solid wood manufacturers is transformed into an end product—the remainder of which is sold as a byproduct (or *residual*). Consequently, if the residual market did not exist, the remaining wood volume could not be merchandized, substantially reducing revenue to the facility.

The residual wood fiber market largely involves three byproducts:

- Residual chips
- Sawdust and Shavings
- Wood fuel

Residual Chips

The main residual material produced in both regions is residual chips from sawmills. These chips are a byproduct from the production of solid wood when round stemwood (or *roundwood*) is being squared or trimmed. Since the wood fiber is generated from the edge cuts necessary to turn logs into lumber, the material size is generally consistent and free from contaminants (pictured below and left). Most of these chips are purchased by pulp mills and facilities that produce industrial pellets and medium-density fiberboard (MDF).

A residual chip is generally a clean chip with less than 0.5% bark. Also, since it is in chip form and does not require further processing, it is an alternative to higher marginal cost pulpwood and chipmill chips. When compared to juvenile pulpwood stems, this resource may also be favored for its fiber maturity. As a result, there is a correlation between residual chip supply and pulpwood demand; as residual supply increases, demand for pulpwood will decline, and vice versa. The market will consume all of the residual chips that are produced and make up the balance through pulpwood or chipmill chips.

Sawdust and Shavings

An additional source of supply in both regions is wood shavings and sawdust. Sawdust (pictured below and left) is the fine waste material that is created mostly during the cutting and sawing of the roundwood. Shavings are created during the edging and planing of kiln-dried lumber (pictured below and right).

These materials play a smaller role in the residual wood fiber. The consumers are specialized, niche markets such as wood pellets, particleboard and animal bedding producers.

Wood Fuel

Sometimes referred to as “waste wood,” “boiler fuel” or “hog fuel,” wood fuel has a heavy bark content and originates from two sources: in-woods harvest residue and mill-produced residue. Depending on soil types, weather at harvest, logging practices, etc., this material can contain significant contaminants – typically sand and mud (pictured right). The moisture content is also variable.

- In-woods harvest residue includes chipped limbs, tree tops and other woody material collected during or immediately after thinning or harvest.
- Mill-produced residue generally consists of bark and wood material unsuited to meet a chip specification. It is a byproduct of debarking stemwood and the sawing or chipping process.

The bark and fiber that is lost is accumulated and sold to pulp mills and biopower producers as fuel to efficiently power their recovery boilers and generate steam to run the facility. In some markets, especially those adjacent to metropolitan areas, bark and waste wood is also utilized in landscaping applications such as soil conditioner or mulching material.

APPENDIX B – ABOUT FOREST2MARKET DATA

Forest2Market's data is unique within the forest products industry, as it is the only comprehensive set of data that is collected at the transaction level; no survey data is incorporated. This transactional data provides a full-spectrum view of market dynamics and includes information supplied by forest products companies, wood dealers, loggers, consultants and landowners.

Every piece of data collected by **Forest2Market** goes through a rigorous validation and standardization process before being entered into one of our unique databases. **Forest2Market's** staff of foresters carefully reviews and validates each transaction, along with its attributes and price components, before it is entered into one of our databases. Our comprehensive suite of data-driven products is derived from these databases.

The depth and breadth of this data allows for unparalleled insight into wood supply chains, from the source to final consumption. The data we collect represent:

- 42 million wood raw material transactions per year
- 65 – 90% market share in North American markets
- Rapidly growing market share in international markets

For each transaction, our data also includes:

- Source (stumpage) cost
- Commission cost
- Freight cost and distance
- Harvest cost
- Total delivered price per ton
- Seller type
- Geographic origin
- Total tons

Critical data verification processes converge to form the most secure, accurate and unbiased databases in the forest products industry. They are powerful resources for analyzing trends and markets, forecasting, and providing a high level of insight into wood raw materials markets. Using Forest2Market data-driven project support services throughout the life of a project provides financiers, policy makers, developers and operators with the most credible source of supply and cost information available in the industry.

APPENDIX C – GLOSSARY

Annual growth and annual removals – A comparison of the rate at which wood is produced in the forest and the rates at which it is destroyed by natural causes and removed by man should be the most important feature of any forest inventory. It may show that the forests are being felled too heavily or that the wood they grow is not being fully utilized. If overexploitation persists, destruction of the forest and loss of future production will follow. On the other hand, under exploitation indicates failure to make full use of the productive power of the forest soil. (See Growth-to-removal ratio.)

Bark – see Wood fuel. The tough exterior covering of a woody stem that is removed prior to manufacturing the solid wood that remains into a product such as wood fiber, lumber or plywood.

Chipmill chips – Wood chips from a chipmill are produced by whole, de-barked trees. Chipmill chips are consistent in size and specification. Most chipmills can offer a consistent product relative to size, specific gravity, etc. Chipmill chips are primarily used by pulp and paper mills to make pulp and paper.

DBH – Diameter at breast height is used to determine a log's classification as pulpwood or sawtimber. The DBH of a standing tree is measured $4\text{-}^{1}/_{2}$ feet off of the ground (the breast height of a forester taking a forest inventory).

Dry sawdust – Sawdust that is created during the sanding, edging and planing of kiln-dried lumber.

Dry shavings – Wood material that is created during the edging and planing of kiln-dried lumber.

FOB – Free on Board – A contract term that means that the buyer takes delivery of goods being shipped to it by a supplier once the goods arrive at the buyer's receiving dock.

Green sawdust – Sawdust that is created during the sawing of a sawtimber log and prior to drying, sanding, edging and planing of lumber.

Green short tons (GST) – Green short tons. See Ton.

Growth-to-removal ratio (GRR) – The annual growth in forest inventory divided by the annual tons removed is the growth-to-removal ratio. A ratio above 1.0 may indicate opportunities for additional harvests. When below 1.0, it indicates timber is removed from production faster than it is replaced by growth.

Hardwood – See Timberland type.

Lowland hardwood – See Timberland type.

Metric ton - Commonly used unit of measure of weight of wood fiber outside the United States. A metric ton 2,204.62 pounds or 1,000 kilograms.

Mixed pine/hardwood – See Timberland type.

Natural pine – See Timberland type.

Nominal price – Nominal prices reflect the present value of goods and services exchanged in the marketplace. Prices in real dollars communicate the value of goods and services exchanged without the effect of inflation.

OSB – see Oriented strand board.

Oriented strand board - A type of engineered lumber similar to particle board formed by adding adhesives and then compressing layers of wood strands (flakes) in specific orientations.

Planted pine – See Timberland type.

Pulpwood – Any stemwood that is generally 5" to 9" in DBH; also, low quality trees and topwood stemwood, not suitable for veneer or lumber. Pulpwood is used by chipmills, OSB mills and pulp and paper mills and requires debarking and chipping.

Real price – See Nominal price.

Residual byproduct – Byproducts generated from the manufacturing process of turning round logs into lumber. Includes residual chips, bark, green sawdust, dry sawdust and dry shavings.

Roundwood – A length of cut stemwood generally having a round cross- section, such as a log. Logs and other round timber generated from harvesting trees for industrial or consumer use.

Sawmill (or plymill) residual chips – These chips are wood fiber generated from the edge cuts necessary to turn round logs into lumber. The material size is generally consistent and free from contaminants.

Sawtimber – Large stemwood trees harvested to produce lumber. The term can also be generically used for stemwood trees harvested to produce plywood.

Southern Yellow Pine – Trees of the *Pinus* genus in the US South primarily including the species of: loblolly (*Pinus taeda*), longleaf (*Pinus palustris*), shortleaf (*Pinus echinata*) and slash (*Pinus elliottii*). The wood has a yellow tint.

Stemwood – Wood from the main part of a tree and not including the branches, stump or roots.

Timberland Investment Management Organization – A TIMO acts as a broker for institutional clients. TIMOs find, evaluate and purchase timberland properties that would best suit their clients' investment objectives. The TIMO actively manages the timberland to achieve adequate returns for the investors.

Timberland type – A classification of timberland based on the species forming a plurality of live-tree inventory (stock).

- **Hardwood** – Usually a natural stand of predominately deciduous broad-leaved species of trees without a predominate species.
    - **Lowland hardwood** – Are found in areas that hold water at least some part of the year. Lowland hardwood tracts are not easily logged and the land not suited to conversion to plantation or cropland.
    - **Upland hardwood** – Timberland containing well-developed, closed-canopied trees dominated by deciduous hardwood species.
- **Mixed pine/hardwood** – A forest composed of a mix of hardwood and pine.
- **Natural pine** – A forest of predominately pine that grew from a natural re-seeding process.
- **Planted pine** – A man-made forest stand that was regenerated artificially either by sowing or planting.

Ton (green short ton) – Commonly used unit of measure of weight of wood fiber in the United States. A ton is frequently referred to as a short ton when compared to a metric ton because it is equivalent to 2,000 pounds compared to 2,204.62 pounds. Green refers to the content of wood including moisture.

Topwood – The upper portion of a sawtimber tree that is unsuitable for the sawing of lumber, but can be salvaged and delivered to market. Generally, the salvaged stem is not as long as pulpwood and will be stacked in two different directions on a log trailer. For this reason, topwood may also be referred to as "double-bunk". Like pulpwood, topwood requires debarking and chipping.

Upland hardwood – See Timberland type.

Wood fuel – Sometimes referred to as "waste wood", "boiler fuel" or "hog fuel," wood fuel comes from two sources: in-woods harvest residue and mill-produced residue. Depending on soil types, weather at harvest, logging practices and so on, this material can contain significant contaminants – typically sand and mud. The moisture content is also variable.

- **In-woods harvest residue** – Chipped limbs, tree tops and other woody material collected during or immediately after thinning or harvest.

- **Mill-produced residue** – Generally consists of bark and green sawdust. It is a by-product of debarking stemwood and the lumber manufacturing process.

Wood fiber – Term used for the cellulosic content of wood that is used in the OSB, pellet, pulp and paper manufacturing process. Inclusive of pulpwood, chipmill chips and sawmill residual chips.