Wood Supply Chain Analysis
Special Market Analysis Study

2013

RISI

WSRI
Wood Supply Research Institute

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www.risi.com

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Don Taylor currently owns and operates Sustainable Resource Systems LLC that specializes in strategy and organization of all aspects of wood supply systems. Don has over 40 years in the forest industry beginning with Champion International serving in regional operations to Vice President of Forest Resources in Stamford, Connecticut. After retiring from Champion he joined PricewaterhouseCoopers in their Forest and Paper practice. He lives in Greenville, South Carolina, working in his consulting business, and has conducted WSRI research projects in two nation-wide Logging Capacity studies, Supplier-Consumer Relations, and this project. He holds a bachelor and master degree in forest science, and an MBA.

RISI Overview

RISI was founded in 1985 and quickly established itself as the premier source of independent economic analysis for the global forest products industry. RISI's products and services are used by more than 95% of the global forest products companies, financial services, buyers, and governments and associations worldwide.

RISI's team of Economists, Analysts and Engineers is the largest and only team to cover all major paper, wood, timber, nonwovens and tissue grades globally. This team consists of over 70 full time individuals producing the industry leading forecasts & analysis, news, information, price data, and mill intelligence about the North American Forest Products industry. RISI is headquartered in Boston, with locations in Atlanta, San Francisco, Brussels, Helsinki, Sao Paulo, Shanghai and Singapore.

Wood Supply Research Institute Overview

The Wood Supply Research Institute is a joint project of professional loggers, forest landowners, wood consuming mills, educators, and manufacturers that facilitates and funds research to promote and improve efficiency in the wood supply system. The WSRI identifies and documents the structure and performance of the current wood supply system and identifies opportunities for improvement. It investigates ways to operate more efficiently and cost-effectively and communicates research findings directly to WSRI members as well as the forest products industry.

Founded in 1999, the Wood Supply Research Institute brings together all parts of the wood supply chain to address wood supply issues through research, since credible research is needed to identify the primary factors that could improve the efficiency, stability, and business successes of the total wood supply system.

Table of Contents

List of Tables

Executive Summary

Appendix B: Methodology, Key Assumptions and Data Handling

Appendix C: Data Tables

List of Figures

Executive Summary

Appendix B: Methodology, Key Assumptions and Data Handling

Executive Summary

Peter Barynin, Principal Economists, RISI
Don R. Taylor, Sustainable Resource System LLC

This project is an assessment of the wood fiber production capability of the supply chain for the US forest industry's primary manufacturing. Because of the long decline in wood consumption coupled with the current economic recession, we have determined that there was a significant net divestment in harvesting capacity infrastructure in the 2007-2010 period. The focus of this study was to evaluate the current regional harvesting capacity and to quantify supply chain capabilities to meet future roundwood consumption. The focus question is, Does the wood supply system have sufficient capacity to meet the anticipated growth in harvest demand over the next five years?

The primary metric used to quantify required harvesting and trucking capacity is investment capital in harvesting and trucking equipment. The first step was to determine the various logging systems throughout the USA and their average productivity related to capital deployed. To contend with the problematic aspects of estimating industry capital stock, we performed a number of risk simulations. The projected roundwood harvest demand is based on the latest RISI forecast prepared in May 2013.

One important interpretation of this analysis is to understand that wood suppliers will need to have a reasonable investment environment to be willing to spend capital to expand operations on a timely basis. Based on our findings, we recommend that the end-user community evaluate the magnitude of change in demand within its respective procurement basins. If appropriate actions are implemented, the industry can take full advantage of the favorable business cycle.

The results show a significant infusion of capital will be required to meet forecasted demand. We see the level of invested capital within the wood supply chain needing to increase from a low of $5.9 billion in 2010 to $7.75 billion by 2017 (Table 3). WSRI also recognizes a critical need to improve the working relationships between suppliers and consuming mills in order to improve the investment environment and the overall efficiency of logging capacity.

Introduction and Background

The US forest industry has evolved through the last 50 years to rely almost totally on independent contractors to provide low-cost harvesting and delivery of raw timber. A large segment of those independent contractors purchase stumpage directly from landowners. Many of these supplier businesses are second and third generation owned and are well established. It is a fact that the industry is dependent on these wood supplier production enterprises to provide these services.

Over the last five years, the US forest sector has experienced its deepest and longest recession since the Great Depression. Roundwood production stepped down 30% between 2005 and 2009, and last year was still 21% below peak levels (Figure 1). The recent depression in the US housing and solid wood product markets has been very dramatic and will have lasting repercussions on the forest sector's ability to meet the challenges of the future. To contend with contracting markets and declining prices for wood, suppliers have reduced logging capacity by downsizing or exited the business (Figure 2). Logging capacity has declined at a slightly faster rate than manufacturing capacity according to the WSRI *Logging Capacity Survey Summary Report* in 2008.

Figure 1
United States Roundwood Harvest Demand
Million Green Short Tons, All End Uses

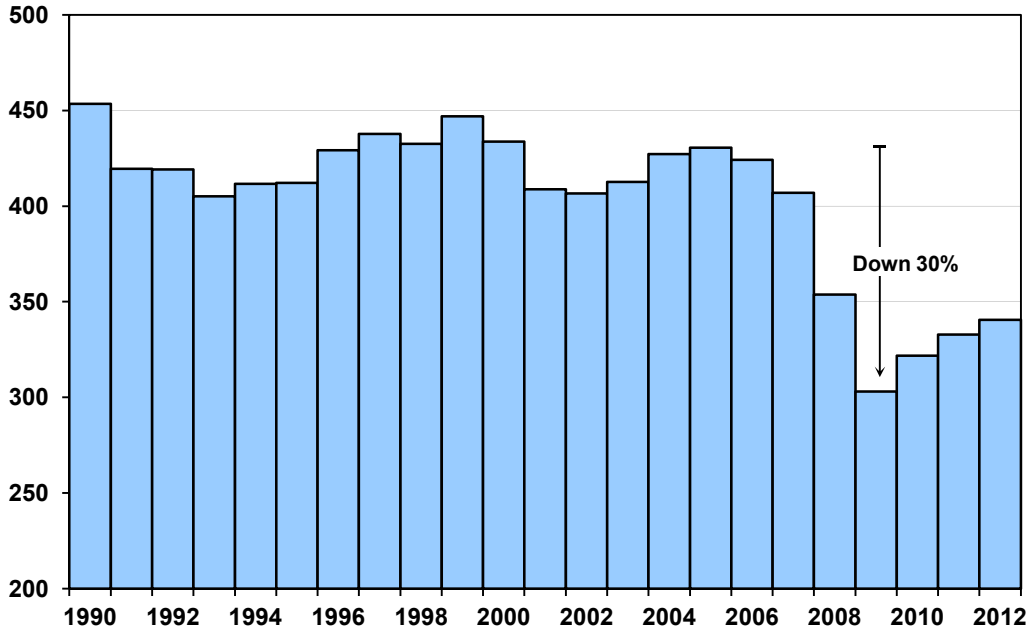
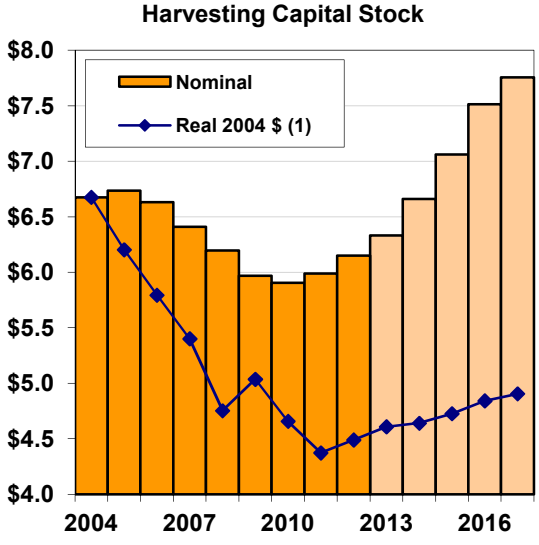
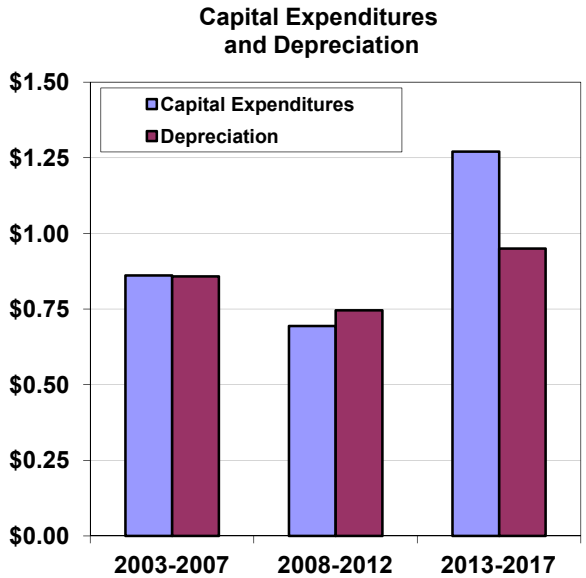


Figure 2
United States Harvesting Capital Stock
Billion Dollars





Wood Demand Forecast Drivers

The wood consumption forecast is a critical foundation for establishing logging and trucking demand and the harvesting capital stock (HCS) investment required to meet this demand. In 2012 and into 2013, the economy has shown signs of sustainable recovery, especially in the housing sector. In addition, there is an emerging energy business based on wood as fuel for both domestic power production and wood pellet exports. Pulp and paper is also expected to hold at fairly steady production levels relative to the experience of the past decade. Meanwhile, markets for lumber and panels are expected to leap forward once again starting this year. RISI forecasts the long trend of declining US roundwood consumption will reverse, and instead rise by 16% between 2012 and 2016 (peak of the next cycle). Throughout the first period, harvest demand in all scenarios remains well above the levels sustained during the last three years. Projections for forest product production and roundwood harvest demand are provided in Appendix C – Data Tables.

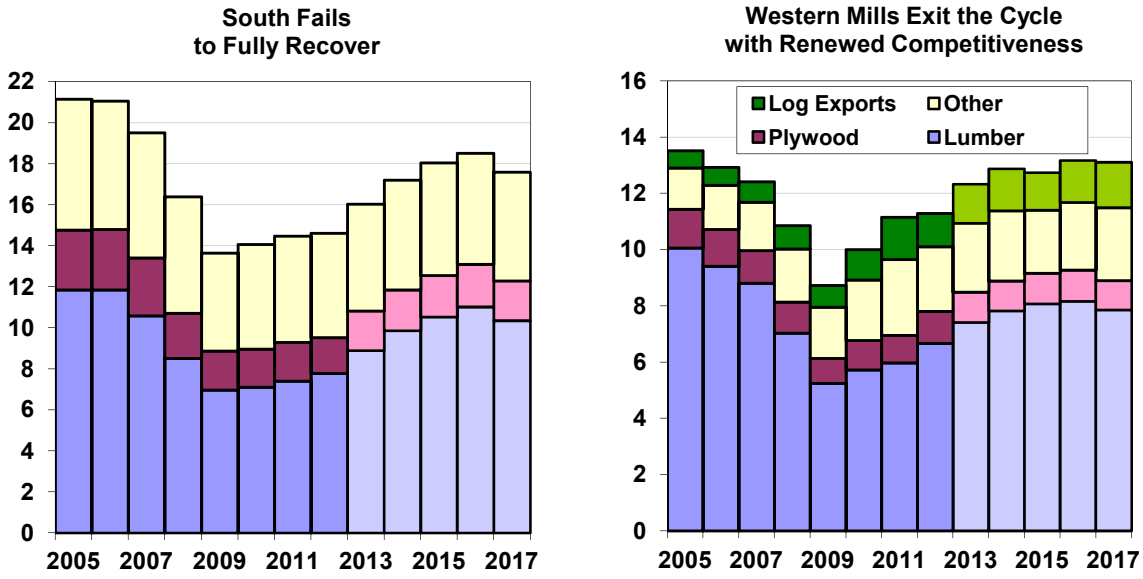
RISI's assessment is that the forest products markets are in the "foothills" of a recovery. Housing is an important driver of harvest demand and a recovery in this market is important to both the forest industry and the US economy. The collapse in housing markets that developed in 2007 was sudden, unprecedented and catastrophic. The event was so extreme, it is widely recognized as the trigger of the US financial crisis and economic recession in 2008. Indicators for housing construction show signs of permanent recovery backed by growth in the US economy and the observed correction in US housing inventories for vacant units for sale and rent. With demand for new housing expected to return to long-term sustainable levels within the next three years (on the order of 1.55-1.60 million units per year), demand on lumber mills will increase in all US regions.

RISI anticipates housing starts will rebound to 1.67 million units by 2016 of which 1.0 million units will be single-family dwellings (Table 1). Southern sawtimber demand is expected to surpass 18 BBF in 2016, up 27% from 2012 but still 12% below the peak in 2005 (Figure 3). In the South, roundwood demand will be supported by increases in both demand for sawtimber and pulpwood. In the US West, sawtimber demand is expected to nearly fully recover to pre-crisis levels, supported by increased lumber production and exports of logs and lumber to China. In the Northeast and North Central regions, harvest demand is expected to experience more modest increases. The forecast assumes a more restrained recovery in both hardwood and softwood lumber production in these two regions and the possibility for further pulp capacity shutdowns.

Table 1
Housing Dashboard

	2012	2013	2014	2015	2016	2017
US Housing Starts (Million Units)	0.78	1.03	1.34	1.55	1.67	1.49
US Single Family (Million Units)	0.53	0.67	0.82	0.93	1.00	0.91
Net US Household Formations (Millions)	0.72	1.06	1.29	1.34	1.13	1.38
US Ownership Rates (%)	65.0%	64.5%	64.0%	63.4%	63.0%	63.5%

Figure 3
Softwood Sawtimber Harvest Demand - US South and West
Billion Board Feet, Scribner



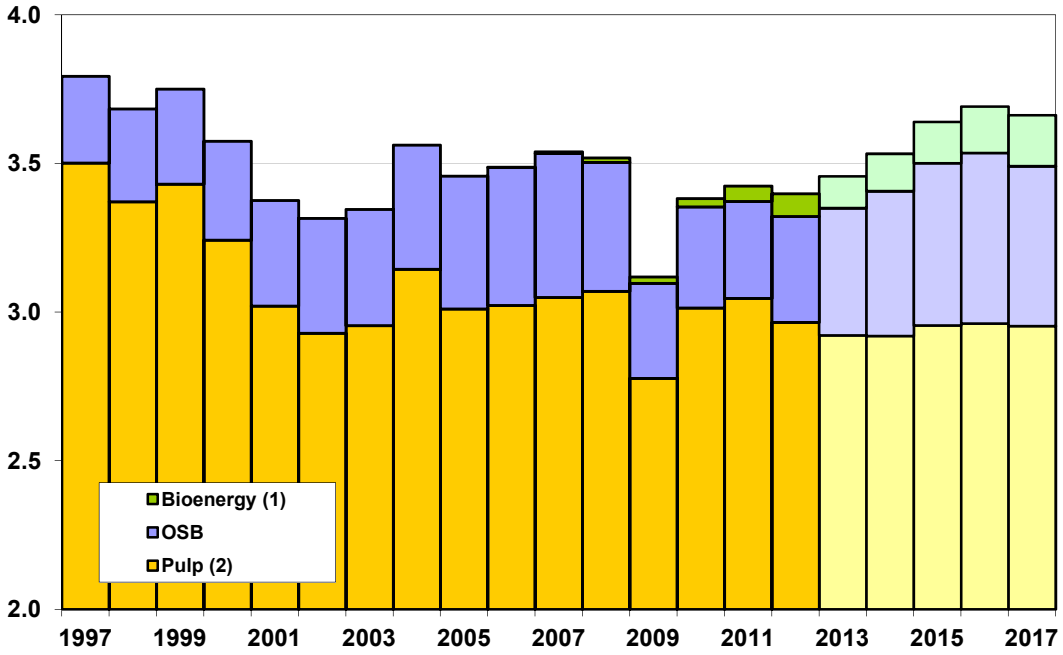
Pulpwood harvest demand has been fairly steady over the last three years but will reach record levels within the forecast period (summing roundwood consumption to produce pulp, OSB and bioenergy products). Although some announced bioenergy projects will feed on forest residuals not currently used to produce traditional forest products, this sector will also contribute to demand for roundwood that might otherwise be used to produce pulp or OSB. Wood pellet mills for export continue to be either built or planned in the US coastal areas at a rising pace.

Pulpwood roundwood demand, all species and all end uses, is expected to increase by 2% in 2013 and will continue upward through 2015 at an accelerated rate (Figure 4). OSB production will take off again and rally for the duration of the forecast period in tandem with the outlook for US housing. Throughout the next five years, the bioenergy arena will become a meaningful factor in low-grade fiber markets, adding 15 million green tons of demand for roundwood and mill residuals and 5 million tons of biomass sourced from Southern forests. The anticipated increase in pulp and pellet production over the next five years will help sop up the expanding supply of residuals.

The wood demand forecast is a base on which we apply our regional based logging capacity metrics to estimate the harvesting capital investment required to supply the market demand. Table 2 and Figure 5 depict the US roundwood harvest demand (all industrial and non-industrial uses) of 341 million tons in 2012. Demand will climb to a peak of 396 million tons in 2016. This trajectory represents an increase of 16% or an increment of 55 million tons from the 2012 level. Most of this increase will be in the South and West Coast. In the US West (Inland and Coast combined) and South, the increases will average 4% annually.

Comparing the US harvest demand to pre-collapse volumes, the analysis assumes only a partial recovery in harvest demand. The primary factors include: (1) lower overall demand for new housing than during the bubble years, (2) a larger portion of demand for new housing oriented toward multifamily units, which have lower wood usage rates than single-family units, (3) improved yields for the production of lumber, and (4) the permanent closure of pulp, plywood and lumber mills.

Figure 4
United States Pulpwood Roundwood Harvest Demand
Billion Cubic Feet

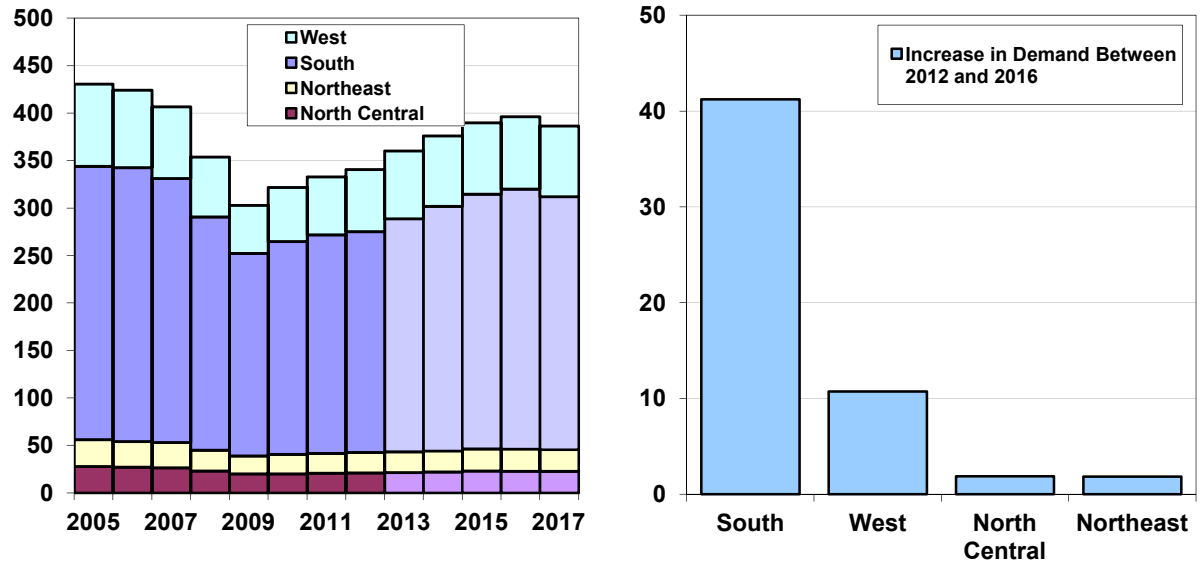


(1) Wood pellets, wood-to-electricity utilities and cellulosic ethanol.
(2) Includes chip-n-saw logs.

Table 2
United States Roundwood Harvest Demand
Million Green Short Tons, All End Uses

	2009	2010	2011	2012	2013	2014	2015	2016	2017
Volume									
United States	303	322	333	341	360	376	390	396	386
South	213	224	230	233	246	257	268	274	267
West	50.5	57.1	61.0	65.4	71.4	74.4	75.4	76.1	74.3
North Central	20.0	20.2	20.8	21.2	21.6	22.1	23.1	23.0	22.7
Northeast	19.1	20.3	21.1	21.4	21.8	22.2	23.4	23.3	22.9
Annual Percent Change									
United States	-17%	6%	3%	2%	5%	4%	4%	2%	-3%
South	-15%	5%	3%	1%	5%	5%	4%	2%	-3%
West	-25%	12%	6%	7%	8%	4%	1%	1%	-3%
North Central	-16%	1%	3%	2%	2%	2%	4%	0%	-1%
Northeast	-15%	6%	4%	1%	2%	2%	5%	0%	-2%

Figure 5
United States Roundwood Harvest Demand Forecast
Million Green Short Tons, All End Uses



Study Findings Summarized

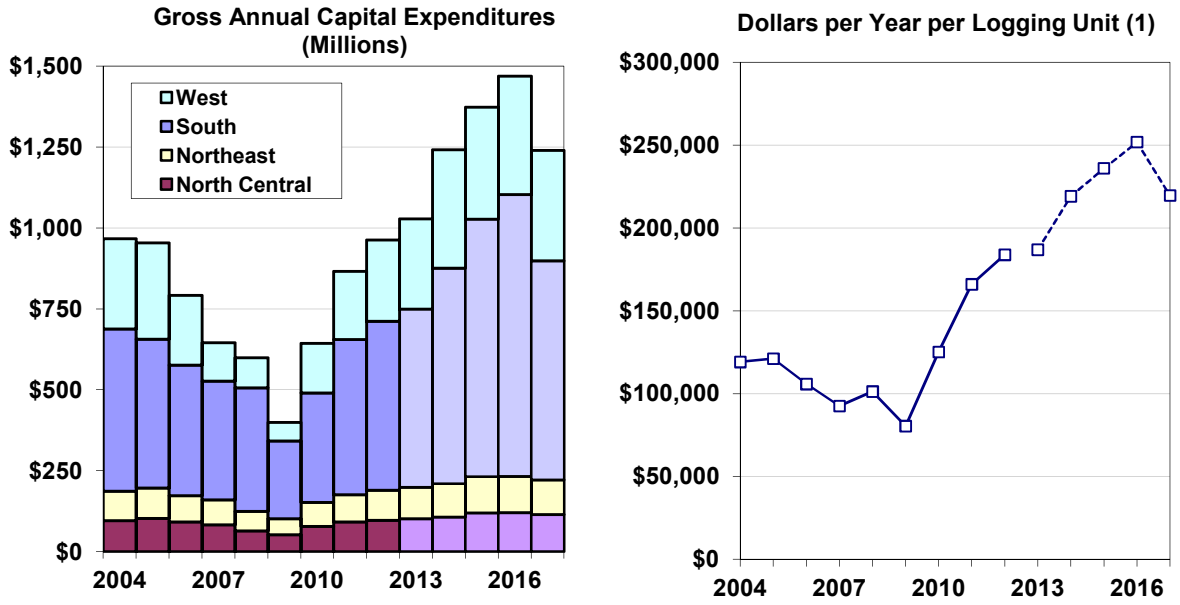
By looking five years into the past and then projecting five years into the future, we are able to provide an estimate of harvesting equipment capital investment trends over time. Whether the capital investments are made by existing harvesting and trucking businesses or new entries into the harvesting and trucking business is immaterial. The main point is that some entity will have to invest in the equipment to have sufficient logging and trucking capacity to meet the forecasted demand for roundwood. The projected HCS estimates for each US region are provided in Table 3. The capital expenditures required to sustain the HCS are presented in Figure 6.

Table 3
United States Harvesting Capital Stock
Million US Dollars

	2009	2010	2011	2012	2013	2014	2015	2016	2017
United States	5,969	5,906	5,988	6,151	6,332	6,661	7,060	7,514	7,754
South	3,196	3,139	3,184	3,272	3,362	3,529	3,790	4,099	4,224
West	1,525	1,512	1,532	1,582	1,640	1,767	1,865	1,973	2,060
North Central	610	613	622	634	650	665	687	706	720
Northeast	638	642	649	663	680	698	718	737	750

Note: Estimated book value of installed capital stock.
Harvesting Capital Stock = Capital Stock of Previous Year End + Capital Expenditures for Logging/Trucking Equipment for Current Year - Depreciation for Current Year

Figure 6
Logging Sector Annual Capital Investment by Region



(1) United States weighted average.

Procurement professionals need to understand the implications of the economic recovery in terms of increased roundwood demand and the related logging capacity that will be required to meet that demand.

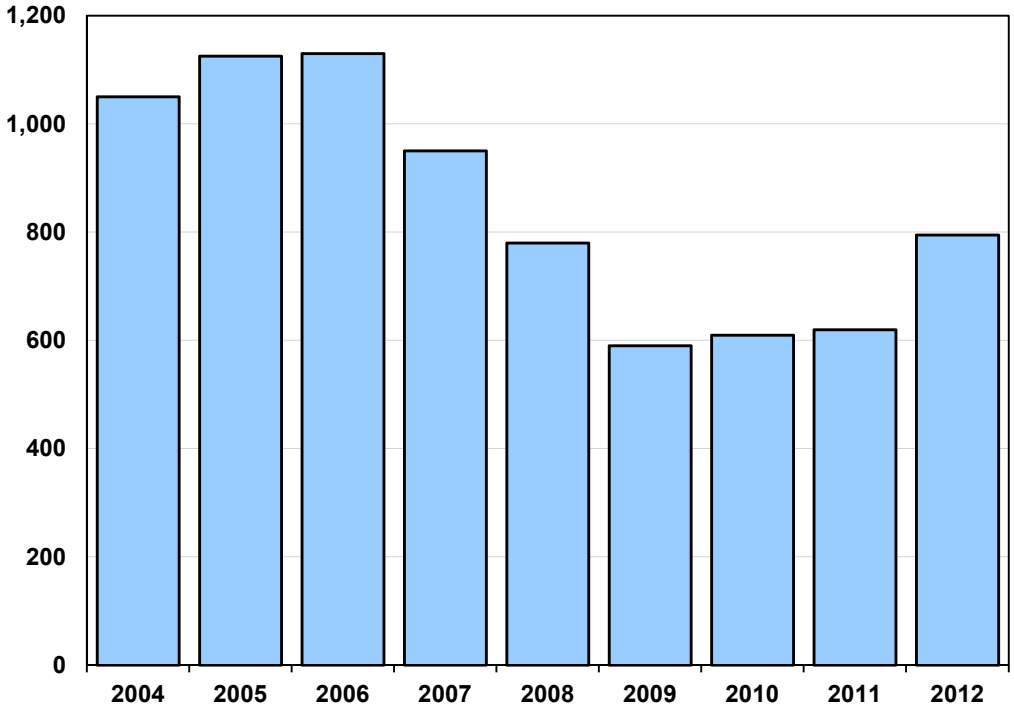
The analysis indicates a very substantial increase in logging and trucking capital expenditures over the next five years. The upward trend of capital investment is necessitated because of delayed capital spending since 2007 and the need for more logging capacity to meet future demand.

The downturn of the last five years created a massive, broad-based disinvestment situation and harvesting capital declined significantly. It is difficult to determine the depth of this decline with precision, but forestry equipment sales data support the claim that a divestment cycle was well entrenched. US log skidder sales corroborate the estimated downward trend in investment. Furthermore, this data highlights that the 2011-2012 estimates for capital expenditures may be overstated (Figures 6 & 7). If these past investments were indeed lower than we assumed, future capital expenditures may need to be higher than projected..

US logging and trucking capital stock declined to a low of $5.9 billion in 2010 (Table 3). Since then, capital stock has increased incrementally to an estimated $6.3 billion by the beginning of 2013. According to our projection, the level of invested capital will need to rise to the order of $7.75 billion cumulatively over the five-year forecast period. In the simulations, it appears that a 16% to 17% annual increase in capital invested as projected over the next four years in the base case.

On an annual basis, the annual capital investment will have to increase from $0.9 billion in 2012 to $1.4 billion in 2016 (Figure 6). This substantial increase in required capital expenditures is in part a result of having to both "catch-up" on equipment replacement and renewed demand for roundwood. If the depressed markets of the last five years had not been so long and deep, the supplier community would be in a much better place to reinvest and move forward. Instead, many suppliers are starting at a disadvantaged state, insurmountable for some. The forest industry needs to participate in laying the groundwork now in order to address this situation.

Figure 7
United States Skidder Sales
Number of Units



Source: Don Taylor, Sustainable Resource Systems LLC

Below is a list of the most important points underlying this analysis:

1. The last four years of severe recession in primary markets have significantly weakened the supplier businesses, depleting savings and worsening debt.
2. Equipment is aged and in need of replacement. The availability of labor is another important consideration, but outside of the scope of this analysis.
3. Supplier-consumer relations are strained and a sense of trust and recognition of their importance to the industry needs to be improved.
4. The markets are in the beginning stages of a robust recovery. Wood procurement organizations will need to accommodate an accelerated rise in log demand.
5. Reinvestment in harvesting equipment has begun, but in every US region investment levels are still below the levels required to maintain the capital stock.
6. Massive logging and trucking capital investments will be required to meet the projected harvest demand.
7. Due to restrictive logging equipment financing, and poor returns within this sector, new entries into the wood supply business will be spotty at best. The existing supplier businesses are the most likely to expand the capacity.
8. There is a recognized need to rebuild business relationships that minimize disruptions in the flow of wood. If business relations can be improved, the suppliers and consumers of wood-fiber and harvesting capacity will be more able to accommodate future harvest demand and support cost control for both the supplier and consumers.

Recommendations

Each company has to make its own strategy based on the local conditions. It is certain that there is a looming challenge ahead for a recovering industry. It is time for procurement organizations to examine and rethink all procurement policies and strategies. A favorable business environment must be cultured if the necessary capital investments to both hold and expand harvesting capacity are to be realized.

The recommendations include:

1. For procurement managers -- it is time to assess your wood supply system to determine the magnitude of increased demand in your procurement basin and if harvesting capacity is adequate. We think it is fair to say that the industry (whether large public or private companies) tend to think of the independent wood supply system as having the ability to react quickly to market demands. The results of this study indicate that this perception presents operational risk for the next market cycle. An assessment that indicates a deficit in logging capacity should be communicated and understood by the top levels of the consumer companies. As part of planning, the age-old "arm's length" restrictions need to be reexamined in the light of well-developed supply chain management techniques that maintain supplier independence and use tested strategies that lead to success for both suppliers and consuming mills.

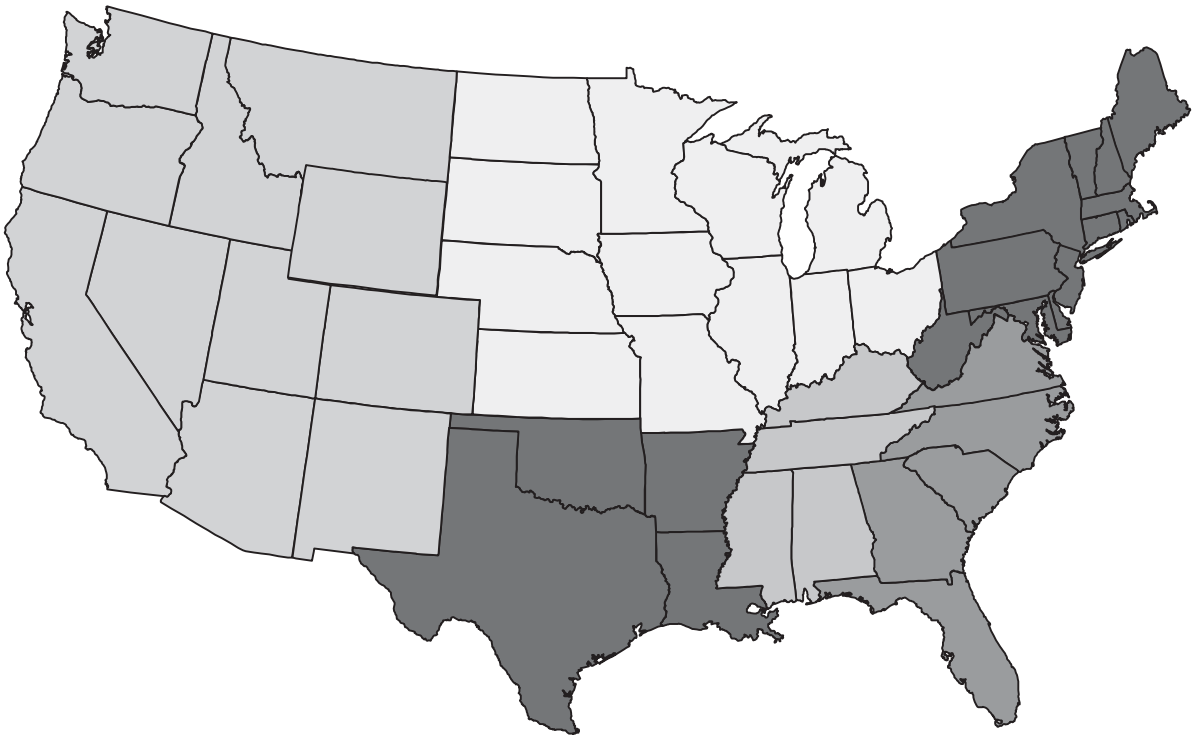
2. For procurement managers– it is time to learn as much as you can about your key suppliers, their current equipment configurations, ability to expand, purchased stumpage backlog, and financial capability for wood suppliers to obtain capital. For those willing and capable, it may be time to ask what they need to provide a business environment to start planning for expansion. Capital investment will require solid contracts, documented (take to the bank) volume commitments and steady wood orders. This is also a good time to assess the quality of the business relationship with key suppliers and address factors that may hinder productivity.

3. For wood suppliers – it is time to assess your business strategy and examine the relationship with your customer mills. This may include attention to business relationships with the mills that are core to your business and focus on organizations that demonstrate they care about building strong relationships.

In closing, the forest industry is working though a unique and unprecedented industry market cycle. A new and innovative approach is required to meet the challenges associated with capacity for harvesting and delivering wood. It is a manageable situation if the issues are intelligently approached with clear backing from the most senior levels within the company organizations. The major objective is for both suppliers and consumers to come together to make sure that the US forest industry can take full advantage of the coming economic upswing.

Appendix A: Region Map

US Regions



West

Arizona
California
Colorado
Idaho
Montana
Nevada
New Mexico
Oregon
Utah
Washington
Wyoming

North Central

Illinois
Indiana
Iowa
Kansas
Michigan
Minnesota
Missouri
Nebraska
North Dakota
Ohio
South Dakota
Wisconsin

Northeast

Connecticut
Delaware
Maine
Maryland
Massachusetts
New Hampshire
New Jersey
New York
Pennsylvania
Rhode Island
Vermont
West Virginia

South

Atlantic
Florida
Georgia
North Carolina
South Carolina
Virginia
East South Central
Alabama
Kentucky
Mississippi
Tennessee
West South Central
Arkansas
Louisiana
Oklahoma
Texas

Appendix B: Methodology, Key Assumptions and Data Handling

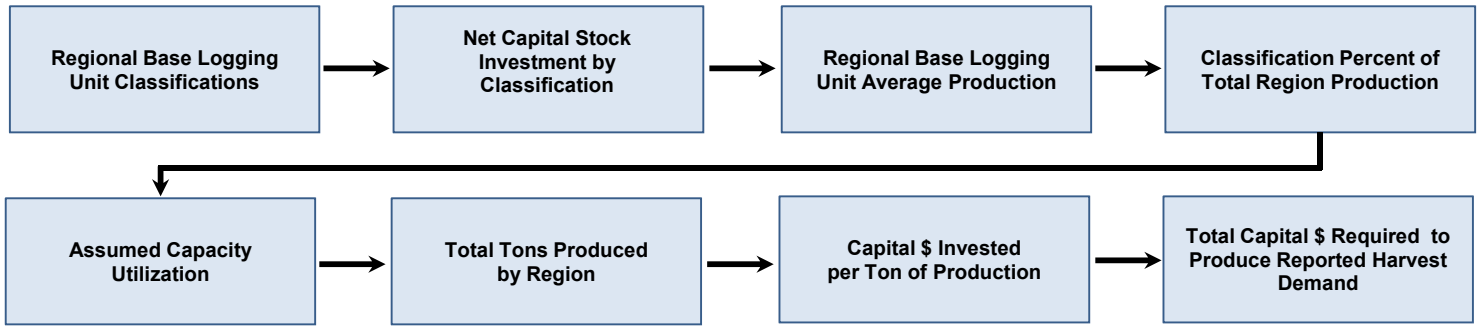
Don R. Taylor, Sustainable Resource Systems LLC and
Peter Barynin, Principal Economist, RISI

Developing metrics for the US wood supply chain is a challenge and this is the first time an attempt to do this has been made on a US aggregate and sub-regional level. This task is difficult because the precise number of logging units and various equipment configurations is poorly measured, as is the number and variety of trucks required to produce and transport logs. Adding to the complexity of this analysis, seasonality is an important variable in the northern and mountain areas of the United States where production is limited for significant portions of the year. Considering all the variables, it becomes necessary to break down logging-trucking investment on a theoretical basis by accounting for the predominant logging configurations in each region and the productivity associated with the assessed capacity and operational environment. Using the methodology stated below, we are able to estimate the magnitude of capital investment required to (1) maintain current logging-trucking productive capacity, and (2) incremental capital needed to expand logging-trucking capacity over the next five years.

Methodology Overview

The model employs a ground-up assessment of regional capital stock which is then reconciled with known regional and state harvest data (Figure 1). This method appears to be the best means to assess the total level of capital that exists in the US wood procurement sector, and provides a transparent and workable model for regional wood production systems. It also proved to be the most compatible with the data available.

Figure 1
Model Flow Chart



Data from regional research was obtained to determine the percent of total production by the various logging system configurations. Table 1 quantifies the base logging units matched with invested capital stock required to produce 1.0 ton of wood annually for each US region. This relationship between procurement capital and productivity is then used to assess the total capital stock required to meet demand. By applying operating rates (sometimes referred to as "capital utilization rates") reported in WSRI research, we then derive the invested capital stock per ton of production (Table 2). Multiplying this estimate with total regional production, we derive spot points for the total harvesting capital stock (HCS) by region. Productivity assumptions for each year are also reported in Appendix C: Data Tables.

Table 1
Capital Stock Requirements on a Crew Basis by Logging Unit Type, 2012

	Weekly Production, Tons (1)	Number of Weeks per Year	Annual Production Assumed, Tons	Percent of Total Annual Production	Average Age of Equipment, Years	Capital Deployed per Unit (2)	Capital Stock per Ton of Annual Production (3)
South							
Cut-to-Length Thin	1,500	50	75,000	2%	4.0	$850,000	$11.33
Tree Length Thin	1,629	50	81,450	60%	3.5	$950,000	$11.66
Tree Length Clear Cut	1,700	50	85,000	38%	3.5	$950,000	$11.18
West							
Ground - Shovel Operations	1,680	45	75,600	55%	5.0	$1,375,000 (5)	$18.19
Cable (4)	1,680	45	75,600	45%	5.0	$2,430,000 (6)	$32.14
North Central							
Cut-to-length	380	42	15,975	7%	3.0	$375,000	$23.47
Feller-buncher (7)	571	42	23,990	67%	3.0	$575,000	$23.97
Mixed	682	42	28,656	25%	2.0	$625,000	$21.81
Cable Skidder	68	35	2,392	1%	4.0	$200,000	$83.61
Northeast							
Tree Length	101	35	3,535	12%	7.0	$120,000	$33.95
Whole Tree	1,100	40	44,000	60%	5.0	$725,000	$16.48
Cut-to-Length	600	42	25,200	28%	4.5	$875,000	$34.72

Source notes for regional estimates

South: UGA - GA, South Carolina Study, Dr. Dale Green and Shawn Baker at the University of Georgia - Athens (Based on data for Georgia and South Carolina)

West: Associated Oregon Loggers (AOL) board member interviews (data from Oregon, Washington, Idaho, and Montana)

North Central: Statewide Surveys of Logging Business Owners Minnesota and Wisconsin, Charlie Blinn, Department of Forest Resources, University of Minnesota, University of Wisconsin-Madison, University of Wisconsin- Stevens Point

Northeast: Northern Forest Logging Industry Assessment (based on data from Maine, New York, New Hampshire, and Vermont), Dr. Jeffrey Benjamin and Bennett H. Leon, University of Maine - Orono

(1) Average production per week under normal operating conditions.

(2) Book value of surveyed operations.

(3) Capital stock "required" differs from "invested" capital stock estimates provided in Table 2.

(4) Yarder-Tower, Processor, 1 Shovel, Cat, Other Micell

(5) Deploys tractor with cutting head -- accumulates stems -- plus forwarding machine.

(6) Cut-to-length: Uses processor with cutting head -- delimb stem, measure, cut -- plus grapple skidder.

(7) Grapple skidder

Table 2
Invested Capital Stock per Ton of Annual Production

	2007	2012	2017
Total Invested Capital Stock (1)			
South	$12.20	$14.10	$15.80
West	$22.60	$24.20	$27.70
North Central	$24.40	$30.00	$31.70
Northeast	$25.00	$31.00	$32.70
Operating Rates			
South	84%	79%	78%
West	76%	76%	74%
North Central	84%	80%	84%
Northeast	76%	71%	75%
Required Capital Stock (2)			
South	$10.20	$11.20	$12.40
West	$17.10	$18.50	$20.50
North Central	$20.60	$23.90	$26.50
Northeast	$19.10	$22.10	$24.50

(1) Equivalent to harvest capital stock (HCS).

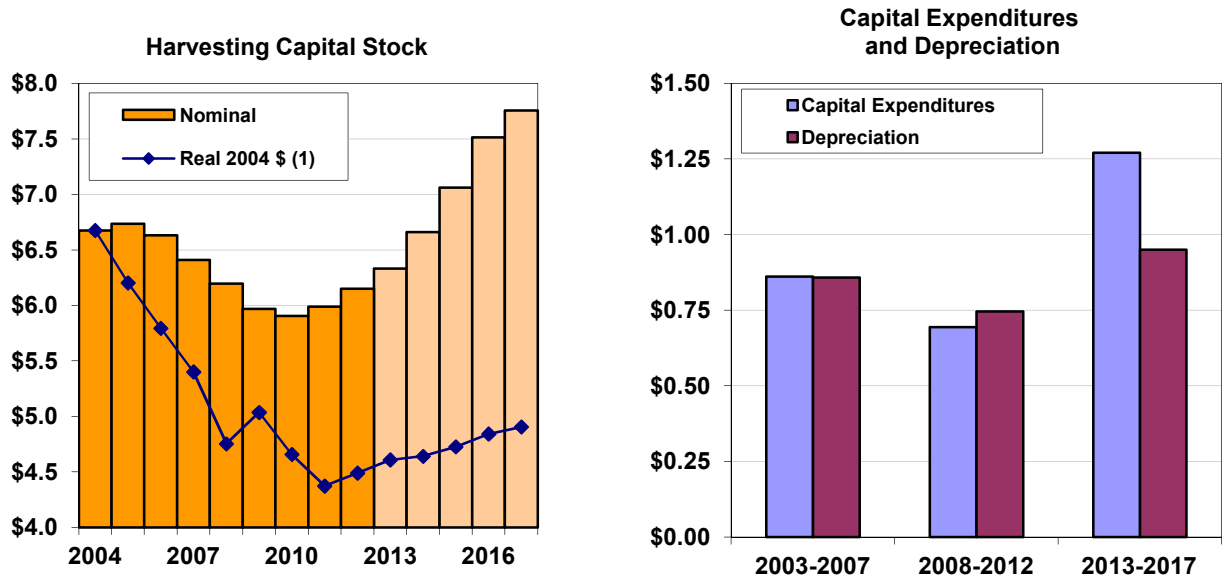
(2) Based on capital requirements to produce 1.0 ton of annual production at full potential utilization.

The greatest weakness to this model technique relates to the need to rely on small sample selections for local harvesting capital and productivity data from which we extrapolate regional aggregates (see the footnotes in Table 1 for primary data sources related to capital and productivity). Although this problem is endemic to all ground-up analyses, it is necessary when data is not systematically collected at state/regional levels. The greatest benefit of this ground-up approach is that regional estimates are reconciled to operational data that we all understand. To test and validate the models' integrity for harvesting and trucking capital, we carried the analysis back 20 years to derive historical estimates that correlate with actual harvesting data.

Implicit to the analysis, the protracted downturn of 2008-2012 created a massive, broad-based disinvestment situation. Consequently, the HCS declined in all US regions. Forestry equipment sales data support the claim that a divestment cycle was well entrenched (see Figure 7 in the "Executive Summary"). However, it is difficult to determine the depth of this decline with precision. Although reinvestment in equipment has gradually improved over the last three years, investment is still far below pre-recession years.

In the analysis, the logging-trucking capital stock was at a low level in 2011 (in real dollars) due to depressed demand for roundwood and evaporating profit margins within the overall forest product sector (Figure 2). At this time, many forest products manufacturing companies were in survival mode -- following strict cost controls, minimizing inventories and curtailing production -- until the markets stabilized. Along with this very difficult business environment, upward-spiraling diesel fuel prices further squeezed margins. In turn, logging contractors delayed normal equipment replacement, downsized or discontinued operations. Many of those who remained in business were to some extent required to "eat their equity" to survive.

Figure 2
United States Logging Capital Stock and Roundwood Production Capacity
Billion Dollars per Year



New entries into the logging-trucking business will not be sufficient to meet all incremental production required as the economic recovery develops. Barriers for new contractors to enter the business include issues related to capital, labor, SFI training and management competencies. In addition, new entries would be required to not only start up a logging business with an immediate ability to provide certifiable operations, but also have the skills required to purchase stumpage. The bottom line is that the solutions required to meet the anticipated expansion in demand must involve traditional suppliers.

It is interesting to see the wide variation among the four US regions in terms of capital required measured as dollars per ton of annual production. In comparing regions, the South has the highest productivity of capital within the four US regions (i.e., the lowest capital investment required per ton of roundwood produced.) Supporting the lower capital investment rates, Southern logging is highly productive and operations benefit from year-round production. Characteristic changes in logging efficiencies for ground operations have also been realized as a larger portion of harvesting activity has become focused on pine plantation stands. This trend will continue over the next five years and beyond.

In the West, factors such as steep terrain, log size and long hauls on forest roads all add to the capital required to produce a ton of roundwood. In addition, harvest unit locations are trending toward higher elevations and therefore require more expensive harvesting systems such as cable/tower operations versus ground skidding that is more common in other US regions.

For the Northeast and North Central regions, capital invested per ton of production is the highest. This is primarily due to high mechanization and the shortest logging season of the four US regions (around 40-42 weeks). The shorter logging season necessitates idling capital for prolonged periods during the spring break-up season, leaving capital dormant.

Harvesting Capital Stock Forecast Formula

The HCS metric is to be read as an estimate of the book value of assets for the harvesting and trucking equipment at year end. In a healthy forest economy when manufacturing is running close to full capacity, the annual capital invested tends to cover the amount of annual depreciation.

The Harvesting Capital Stock forecast is calculated as follows:

Harvesting Capital Stock Formula

= Capital Stock of Previous Year End

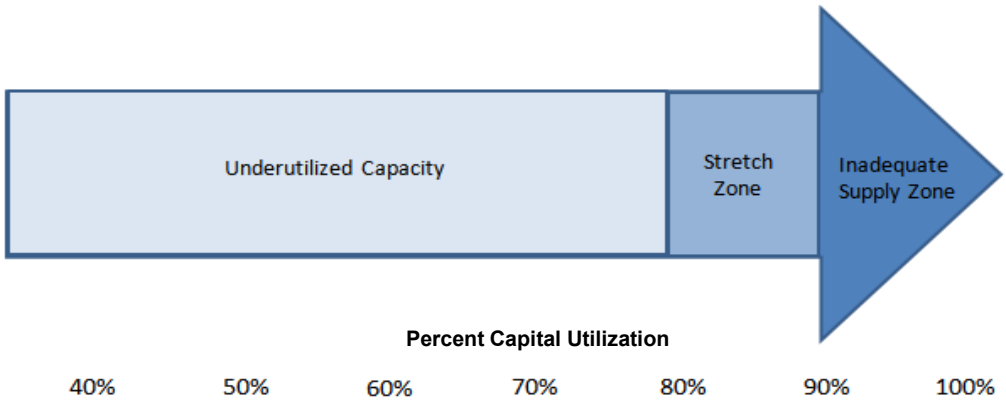
+ Capital Expenditures for Logging/Trucking Equipment for the Current Year

- Current Year Depreciation for the Current Year

The analysis incorporates variations in capital invested from year to year. Over long periods, the capital invested will equal dollar amounts depreciated in order to sustain the business. In other words, the capital stock investment-depreciation ratio equals one in order to maintain harvest capacity, assuming no productivity benefits. When this ratio declines to less than one, owners are implicitly reducing their aggregate logging capacity. It follows that to maintain production capacity, owners will eventually need to "catch-up" by investing more at a later time or cease operation as the equipment wears out. We estimate that the capital stock investment-depreciation ratio was below 1.0 throughout 2007-2011, reaching its lowest point of 0.64 in 2009. We believe this ratio may have been lower than reported for the 2011-2012 period based on model simulations.

Another important variable is the concept of logging-trucking capacity utilization. The potential production or "harvest capacity" is characterized as the "maximum annual production of raw wood or in-woods chipping, one shift, under normal weather conditions with no market restrictions and no timber supply restrictions, expressed in green tons of primary wood production." Implicit to our analysis, 100% utilization of logging capacity is not obtainable on a sustained basis (Figure 3). In logging capacity studies, if 85% to 90% production capacity utilization is obtained over a 12-month period, the logging production is at maximum after factoring in seasonal downtime and other logistical factors that impede full and perfectly efficient capital employment. When utilization nears these levels, logging fees tend to increase and capital investments in the sector become justified.

Figure 3
Harvesting Capital Utilization



On the other hand, if utilization falls below 75%, the HCS is considered underutilized. As utilization rates go down, the fixed cost percentage of total costs rises. As the percent utilization falls below this level, there is an inordinate impact on margins because of the high fixed costs associated with logging operations. Fixed costs for harvesting operations are approximately 50% of total costs. (We include labor costs in the fixed category because labor will generally not be retained on a part-time basis.)

Based on the WSRI Logging Capacity Update research, we have hard data for the period of 2004-2007. Beyond that period, utilization rates are estimated using the HCS formula in conjunction with reported harvest data. The modeling implies utilization dropped to a low of range of 60-70% during 2009-2011. In 2012, capacity adjustments and rising consumption took the slack out of the supply chain capacity and the utilization rate is now nearing 80% for the USA in aggregate. The utilization varies across regions, but most procurement professionals believed we were already near full capacity as of the end of 2012.

Productivity associated with capital stock over time is a factor we incorporate into the analysis. Analyzing current research data, we note a gradual increase in machine productivity per dollar of equipment capital as a long-term trend in all US regions. The consensus opinion is that the trend for increased productivity is due primarily to improved efficiencies achieved as machine design evolves. We assume the increase in productivity will continue at 0.5% annually for all four US regions, similar to the trend assessed over the past 20 years.

Selected Assumptions Reviewed

The key assumptions incorporated into the final results are as follows:

- Annual logging-trucking roundwood production equals annual removals.
- Historical estimates for equipment replacement/investment are estimated based on anecdotal information (e.g., skidder sales) and correlate with WSRI assessed utilization rates reported for 2004-2007. In 2013, an 85% utilization rate will produce 339 million tons for all US regions in total.
- The productivity of capital estimates represents only the capital investment qualified as book value of logging-trucking equipment and is not to be confused with total cost per ton. Total cost per ton would be a completely different calculation incorporating other costs such as labor, fuel, insurance, etc.
- Logging capacity for all US regions is capped at 80-85% utilization over extended periods. Future capital investment is estimated as required to maintain utilization rates below this threshold as well as aligned with RISI's expectations for future harvest and delivery fees.
- Depreciation is assumed to generally range from 12-14% of the total HCS in a given year. See Appendix C for specific assumptions for 2007-2017.
- All base logging units are assumed as one shift per day per crew. There are exceptions to that rule but these situations are assumed to be insignificant for a region in aggregate.
- Business relations are assumed to not be an inhibitor to wood production over the forecast period. If business relations do not address supply-chain efficiency, the required investment for logging and trucking equipment would need to be considerably higher than assumed in the base case forecast.
- Equipment productivity (tons per dollars of capital stock) increases at a trend rate of 0.5% per year over the forecast period. Table 2 depicts regional estimates of total capital dollars necessary to log and deliver 1.0 ton of wood annually in 2012.

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Appendix C: Data Tables

Table 1
United States Harvesting Capital Stock: Summary, 2012

	United States	South	West	North Central	Northeast
Harvest Demand (Million GST)	341	233	65	21	21
Machine Demand (Million Dollars)	$4,788	$2,602	$1,208	$505	$473
Capacity Utilization (Operating Rate)	78%	80%	76%	80%	71%
Capital Stock per Ton Production ($/GST)	$18.10	$14.10	$24.20	$30.00	$31.00
Machine Demand per Ton Production ($/GST)	$14.10	$11.20	$18.50	$23.90	$22.10
Annual Production per $1,000 Capital (GST)	55.4	71.1	41.4	33.4	32.3
Annual Production per $1,000 Capital Utilized (GST)	71.1	89.4	54.2	41.9	45.3

Note: GST=Green Short Ton

Table 2
United States Harvesting Capital Stock: Demand and Utilization

	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Harvest Demand (Million GST)											
United States	407	354	303	322	333	341	360	376	390	396	386
South	278	246	213	224	230	233	246	257	268	274	267
West	76	63	51	57	61	65	71	74	75	76	74
North Central	26.6	23.2	20.0	20.2	20.8	21.2	21.6	22.1	23.1	23.0	22.7
Northeast	26.6	21.9	19.1	20.3	21.1	21.4	21.8	22.2	23.4	23.3	22.9
Machine Demand (Million Dollars)											
United States	5,189	4,875	3,745	4,232	4,697	4,788	5,077	5,468	5,834	6,082	5,988
South	2,843	2,727	2,130	2,369	2,597	2,602	2,755	2,986	3,206	3,368	3,306
West	1,291	1,165	839	1,002	1,140	1,208	1,323	1,426	1,488	1,546	1,520
North Central	549	525	412	446	495	505	517	547	588	604	601
Northeast	507	458	363	415	465	473	482	509	551	565	561
Capacity Utilization (Operating Rate)											
United States	81%	79%	63%	72%	78%	78%	80%	82%	83%	81%	77%
South	84%	82%	67%	76%	82%	80%	82%	85%	85%	82%	78%
West	76%	73%	55%	66%	74%	76%	81%	81%	80%	78%	74%
North Central	84%	84%	68%	73%	80%	80%	80%	82%	86%	86%	83%
Northeast	76%	71%	57%	65%	72%	71%	71%	73%	77%	77%	75%

Note: Harvesting capital stock includes both logging and trucking equipment and is reported as assessed book value.

Table 3
United States Harvesting Capital Stock: Productivity Measures

	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Capital Stock per Ton Production ($/GST)											
United States	15.80	17.50	19.70	18.30	18.00	18.10	17.60	17.70	18.10	19.00	20.10
South	12.20	13.50	15.00	14.00	13.80	14.10	13.70	13.70	14.10	15.00	15.80
West	22.60	25.50	30.20	26.50	25.10	24.20	22.90	23.70	24.70	25.90	27.70
North Central	24.40	27.00	30.50	30.30	30.00	30.00	30.10	30.10	29.80	30.70	31.70
Northeast	25.00	29.70	33.50	31.60	30.70	31.00	31.20	31.40	30.70	31.70	32.70
Machine Demand per Ton Production ($/GST)											
United States	12.80	13.80	12.40	13.10	14.10	14.10	14.10	14.50	15.00	15.40	15.50
South	10.20	11.10	10.00	10.60	11.30	11.20	11.20	11.60	12.00	12.30	12.40
West	17.10	18.50	16.60	17.50	18.70	18.50	18.50	19.20	19.70	20.30	20.50
North Central	20.60	22.60	20.60	22.10	23.80	23.90	23.90	24.80	25.50	26.30	26.50
Northeast	19.10	20.90	19.00	20.40	22.00	22.10	22.10	22.90	23.60	24.30	24.50
Machine Demand per Ton Production ($/GST, 2012 Inflation-Adjusted)											
United States	14.70	14.50	14.30	14.20	14.10	14.10	14.00	13.90	13.70	13.60	13.40
South	11.80	11.70	11.50	11.40	11.30	11.20	11.20	11.10	11.00	10.90	10.70
West	19.70	19.50	19.20	19.00	18.70	18.50	18.50	18.30	18.10	17.90	17.70
North Central	23.80	23.80	23.80	23.80	23.90	23.90	23.90	23.60	23.40	23.20	22.90
Northeast	22.00	22.00	22.00	22.00	22.00	22.10	22.10	21.80	21.60	21.40	21.20
Roundwood Production per Crew per Week[1]											
United States	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
South	1,498	1,536	1,573	1,611	1,648	1,686	1,686	1,703	1,720	1,737	1,754
West	1,485	1,522	1,560	1,599	1,639	1,680	1,680	1,697	1,714	1,731	1,748
North Central	546	553	559	565	571	578	578	583	589	595	601
Northeast	716	725	733	741	749	757	757	765	773	780	788
Operation Weeks per Year[2]											
United States	44	44	44	44	44	44	44	44	44	44	44
South	50	50	50	50	50	50	50	50	50	50	50
West	45	45	45	45	45	45	45	45	45	45	45
North Central	42	42	42	42	42	42	42	42	42	42	42
Northeast	40	40	40	40	40	40	40	40	40	40	40

[1] Average production per week per crew during normal operations.

[2] Operation weeks calculated as a production-weighted average of logging unit types. See Appendix B Table 1 for more details.

Table 4
United States Harvesting Capital Stock: Installed Capacity
Million US Dollars

	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Capital Stock											
United States	6,410	6,195	5,969	5,906	5,988	6,151	6,332	6,661	7,060	7,514	7,754
South	3,384	3,311	3,196	3,139	3,184	3,272	3,362	3,529	3,790	4,099	4,224
West	1,710	1,608	1,525	1,512	1,532	1,582	1,640	1,767	1,865	1,973	2,060
North Central	650	626	610	613	622	634	650	665	687	706	720
Northeast	666	649	638	642	649	663	680	698	718	737	750
Depreciation											
United States	867	814	625	707	784	800	848	913	974	1,016	1,000
South	475	455	356	396	434	435	460	499	535	562	552
West	216	195	140	167	190	202	221	238	249	258	254
North Central	92	88	69	74	83	84	86	91	98	101	100
Northeast	85	76	61	69	78	79	81	85	92	94	94
Capital Expenditures											
United States	646	599	399	644	866	963	1,029	1,242	1,374	1,470	1,240
South	367	382	240	339	479	522	551	666	796	871	677
West	118	92	57	154	211	251	279	366	346	366	341
North Central	83	64	52	78	92	96	102	107	120	120	115
Northeast	78	60	49	74	84	93	98	103	112	113	107
Net Appreciation (Depreciation)											
United States	(221)	(215)	(226)	(63)	82	163	181	329	400	454	240
South	(108)	(73)	(116)	(57)	45	88	91	167	261	309	125
West	(97)	(102)	(83)	(14)	21	50	58	128	98	108	87
North Central	(9)	(24)	(17)	4	9	12	15	16	22	19	14
Northeast	(7)	(16)	(11)	5	7	14	17	18	20	18	13
Depreciation as Percent of Capital Stock											
United States	14%	13%	10%	12%	13%	13%	13%	14%	14%	14%	13%
South	14%	14%	11%	13%	14%	13%	14%	14%	14%	14%	13%
West	13%	12%	9%	11%	12%	13%	13%	13%	13%	13%	12%
North Central	14%	14%	11%	12%	13%	13%	13%	14%	14%	14%	14%
Northeast	13%	12%	10%	11%	12%	12%	12%	12%	13%	13%	12%

Note: Capital Stock = Capital Stock of Previous Year End + Capital Expenditures - Depreciation.

Table 5
United States Harvesting Capital Stock: Installed Capacity in Real Dollars
Million US Dollars, Inflation-Adusted (2012$)

	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Capital Stock											
United States	7,399	6,513	6,901	6,381	5,993	6,151	6,313	6,359	6,476	6,633	6,720
South	3,907	3,481	3,695	3,391	3,187	3,272	3,352	3,370	3,476	3,618	3,661
West	1,974	1,691	1,764	1,633	1,534	1,582	1,635	1,688	1,711	1,742	1,786
North Central	750	658	705	663	623	634	648	635	630	623	624
Northeast	768	683	738	694	650	663	678	667	659	650	650

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