

FIELDNOTES

GreenWood Resources Research Report for Timberland Investors

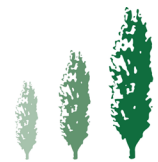
Optimal Global Timberland Investment Portfolios

Suppose you have decided that timberland is an attractive addition to your investment program. The next logical question is: “what kind of timberland and where?” This research note uses modern portfolio theory (mean-variance optimization) to help answer that question. Several researchers have addressed this question in the past but the investable universe has evolved, new markets have emerged, wood science and engineering technology has advanced, and time has passed. More and different information is now available to support prudent investment decisions. And, this new information provides some surprising results.

APPROACH. The first step in the analysis is to define the universe of investment opportunities available to an institutional investor. We do this mostly by considering where institutions have invested, with a few caveats. We omit Russia, Argentina and all of Africa on the grounds that the vast majority of investors would find those regions to carry excessive political risk. Otherwise we include North America (US, Canada), Latin America (Brazil, Chile, Uruguay, Panama, Costa Rica), Europe (Sweden, Finland, Poland, Estonia, Latvia, Lithuania, Spain, Portugal) and Asia (Indonesia, Malaysia, China). We define the investment opportunities available in each country by specifying the species/forest type and management strategy. For example, two investment opportunities included in the model are (i) eucalypt pulpwood in Chile and (ii) pine sawtimber in the US South. One of the more interesting investment opportunities we include is “conservation forestry”, an investment in US timberlands where some of the return is generated by ecosystem service payments (Binkley, 2017).

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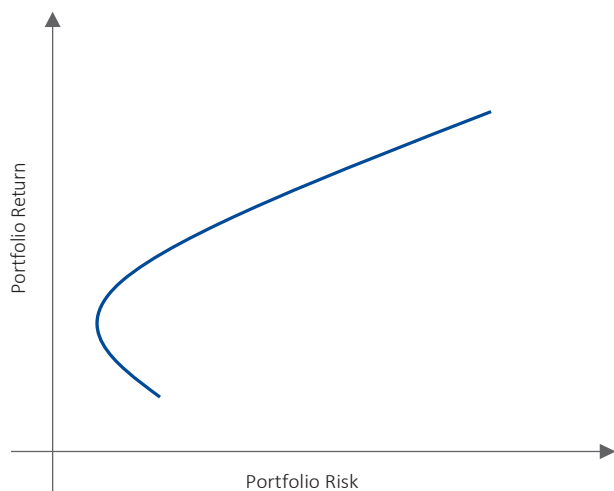
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What about the data going into the model? We estimate the expectations for forward-looking mean real returns for each investment opportunity based on investor surveys and GreenWood Resources experience. Our estimates of the variance and covariances of returns come from timber/forest products price data, denominated in USD, related to each of the investment opportunities. The price data are for the period 1995-2016, covering a range of shocks to the sector: the early-1990s price spikes associated with the sudden “spotted owl” supply restrictions; the run up to the 2005 boom in US housing; the sector-wide collapse related to the global financial crisis; the following recovery, complete in some regions (e.g. the US Pacific Northwest (PNW)) but still struggling in others (e.g. the US South). The data are all in USD so the analysis accounts for FX risks, and indeed might overstate the FX risks (Busby et al. 2018).

With estimates of mean returns and the full variance/covariance matrix, we use a mathematical optimization model to solve for the efficient frontier—the set of timberland investment portfolios that maximizes expected returns for a given risk budget (along with a few constraints related to minimum levels of diversification and maximum exposure to specific investments). Busby et al. (2017) provide the details of the analysis.

EFFICIENT FRONTIER



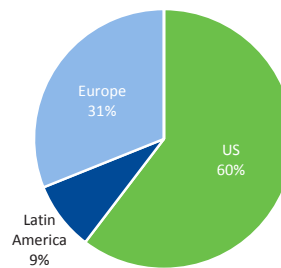
RESULTS. The analysis provides some interesting results, only a small portion of which can be reported here. The essential output from the model is the set of “best possible” timberland portfolios along the efficient frontier. The table that follows provides the highlights for four timberland investment portfolios of interest:

- one that minimizes risk (“Risk Min”);
- one that maximizes returns (“Return Max”);
- one that maximizes the risk-adjusted returns as measured by the Sharpe Ratio (“Sharpe Ratio Max”); and
- one that provides a strong expected return without much increase in risk compared to the Sharpe Ratio Max portfolio (“8.5% Real Return Hurdle Portfolio”).

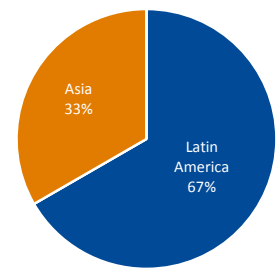
RISK-EFFICIENT TIMBERLAND INVESTMENT PORTFOLIOS

	Risk Min Portfolio	Return Max Portfolio	Sharpe Ratio Max Portfolio	8.5% Real Return Hurdle Portfolio
REGIONAL ALLOCATION				
US	60%	0%	41%	19%
Latin America	9%	67%	57%	66%
Europe	31%	0%	0%	5%
Asia	0%	33%	2%	10%
Oceania	0%	0%	0%	0%
FINANCIAL METRICS				
Expected				
Nominal Return	7.4%	11.7%	10.0%	10.9%
Variance	0.0023	0.0071	0.0016	0.0028
Sharpe Ratio	1.50	1.41	1.95	1.64

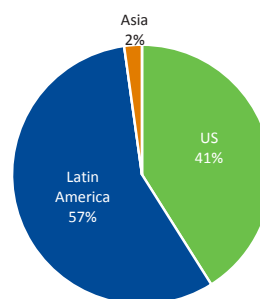
Risk Min Portfolio



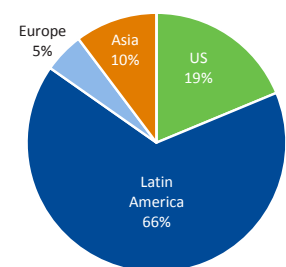
Return Max Portfolio



Sharpe Ratio Max Portfolio



8.5% Real Return Hurdle Portfolio



WHAT DOES THIS MEAN FOR INVESTORS?

- i. The lowest-risk (Risk Min) portfolio includes broad geographic diversification, with nearly 10% allocated to Latin America and 60% to the US. This is consistent with the huge growth of the forest products industry in Latin America and the continued strong demand for forest products in the US and Europe. Interestingly, this portfolio also includes the maximum permitted allocation to the conservation forestry investment opportunity.
- ii. The portfolio that maximizes risk-adjusted returns (Sharpe Ratio Max) and the 8.5% Real Return Hurdle portfolio produce similar Sharpe Ratios but with very different regional distributions. In the 8.5% Real Return Hurdle portfolio, the additional risk from greater investment in Latin America is offset by higher expected returns.
- iii. The gains from taking on additional risk of investments in Asia appear to be small. A risk-efficient investor may want to have a small fraction of her portfolio in Asia (<10%) but moving to the full return-maximizing allocation may actually reduce risk-adjusted returns.

- iv. Oceania is not included in the risk-efficient portfolios for USD-denominated investors detailed here. The incremental return assumptions for Australia and New Zealand are too low to offset the historically high volatility of USD returns. However, for most of the historical period analyzed, there were virtually no log exports from Australia. The recently observed increase in export volumes from Australia may moderate the impact of FX volatility, reducing risk and potentially supporting a positive portfolio allocation.
- v. Near maximum risk-adjusted returns can be achieved with a portfolio concentrated outside of North America. The 8.5% Real Return Hurdle portfolio offers risk-adjusted returns that are only slightly below those from the Sharpe Ratio maximizing portfolio but with nearly 100 bps of additional absolute return.

Of course, investors consider many factors when constructing their investment programs. These findings on risk efficiency comprise but one, albeit one we think is important to consider.

References on page 10.



REGIONAL MARKETS

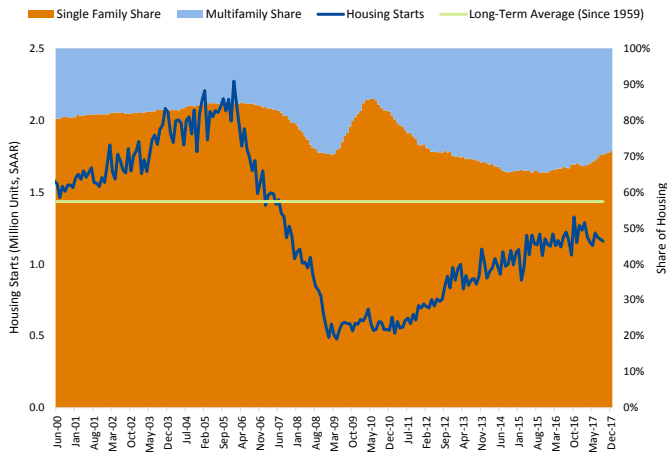
NORTH AMERICA

US HOUSING

- US housing demand continued with modest gains during Q4 2017 and reached 1.2 million total housing starts for the year. Although starts remain below the long-term average of 1.5 million, they have continued to climb steadily since 2008.
- Single-family housing gained significant momentum during 2017, with starts up 8.4% for the year representing a 71% share of residential construction. Residential improvement expenditures in 2017 reached pre-recession levels of \$150+ billion (2009 USD) on the backbone of rapid increases in home equity with modest leverage compared to the housing boom (FEA, January 2018).
- Affordability, tight credit markets, and shortages of construction labor and buildable lots remain headwinds to speedier recovery. The residential construction labor pool has not recovered since the global financial crisis (GFC), when plenty of workers exited the industry.
- US housing expectations remain positive as underlying fundamentals remain strong. US economic growth, improving labor markets, and millennial-led demographics are all supportive of housing demand. In addition, many years of underbuilding relative to income and population growth and a rapidly aging housing stock signal mounting demand for new homes and strength in repair and remodel activity.

REGIONAL MARKETS

FIGURE 1. US HOUSING STARTS



SOURCE: U.S. CENSUS; GWR RESEARCH.

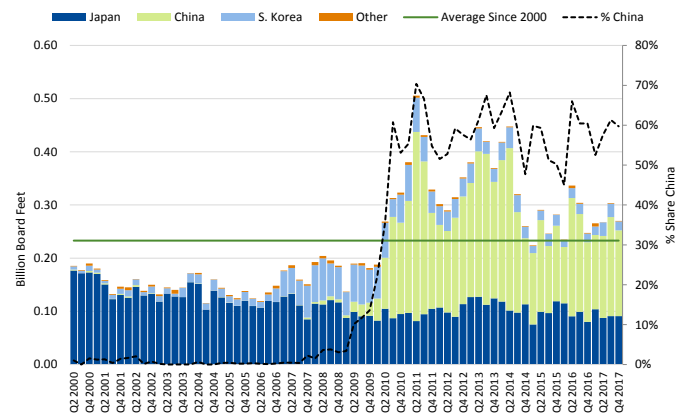
LOG MARKETS

- In North America, log prices in the PNW represented the story of the year with strong demand and pricing for all species in domestic and export markets. In domestic PNW markets, Douglas-fir and whitewoods (i.e., hemlock and true firs) sawlog prices increased 5.9% and 6.9% quarter-over-quarter, finishing the year with annual increases of 19.5% and 24.6%, respectively (RISI, 2018).
- With continued strong demand from China through the end of 2017, log export markets also experienced significant gains. West Coast Douglas-fir and hemlock sawlog prices to China were up 5.5% and 4.7% quarter-over-quarter, closing the year with impressive price increases of 22.4% and 28.0%, respectively (RISI, 2018).
- West Coast log export volumes reached 0.27 BBF during Q4 2017 for a total annual figure of 1.1 BBF, surpassing the annual average of 0.93 BBF since 2000 (Figure 2). The share of total log exports to China finished the year at 60%.
- In the US South, timber prices remain muted with flat to slightly eroding sawlog prices. During Q4 2017, southern pine log prices decreased 0.2% for an annual total decrease of 0.8% (RISI, 2018). On the bright side, however, low timber prices in the region combined, with healthy lumber consumption in the US, continue to attract mill investment to specific regions. In 2017, lumber capacity additions totaled

about 1 BBF, with another expected 1.7-2 BBF coming in 2018-19.

- The outlook for US timber markets remains positive. Price increases in the PNW may slow down but are likely to remain supported by strong export and domestic demand. In the South, region-wide timber prices will continue to be challenged from the buildup of inventory but corporate investment from large-scale manufacturers and higher market tension in some regions are likely to further differentiate micro-markets.

FIGURE 2. WEST COAST LOG EXPORTS BY DESTINATION



SOURCE: U.S. CENSUS; FEA; GWR RESEARCH.

LUMBER MARKETS

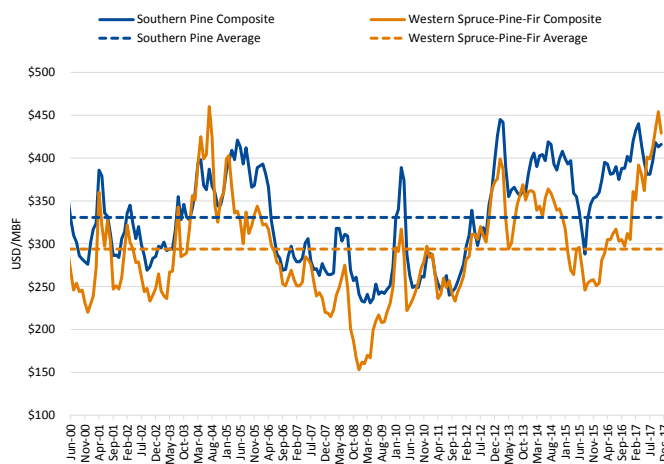
- In line with US housing upwards trends and positive long-term outlook, US lumber consumption and production finished the year strong. During Q4 2017, softwood lumber consumption reached 12.5 BBF for a total annual consumption of 50.9 BBF, the highest annual figure since 2007.
- Lumber markets posted solid gains in Q4 2017, with lumber composite prices up 7.6% and 8.6% for Southern Pine and Western SPF, respectively (Figure 3). Of the total US softwood lumber consumption during 2017, Canadian imports supplied 14.9 BBF for a 29.3% market share, down from its peak of 35.2% in early 2016.
- In December 2017, the US International Trade Commission unanimously voted that Canadian softwood lumber imports have harmed the US industry. The ruling confirms import tariffs on softwood lumber from

REGIONAL MARKETS

Canada of 6.1% and 14.2% for anti-dumping and countervailing duties, respectively, for a combined rate of 20.3%.

- Import duties on Canadian softwood lumber and a slightly strengthened Canadian dollar are expected to further decrease Canada’s market share as a supplier to the US. But remember, economics always wins! If the Canadian currency weakens (again), this trend could be reversed and the political show around duties may become less relevant.
- During Q4 2017, US softwood lumber production reached 8.9 BBF for a total annual production of 34.2 BBF, the highest annual figure since 2007. US West Coast softwood lumber production increased steadily from its bottom of 1.5 BBF in the depths of the GFC and has stabilized in the 2.0-2.2 BBF range. Lumber production in the US South, which was severely impacted during the housing crash, has recovered at a more rapid pace from its quarterly low of 2.6 BBF in 2009 to 4.6 BBF during Q4 2017 (Figure 4). Total production in the US South during 2017 equaled 18.5 BBF, the highest annual figure since the housing boom in 2006. As production in the US South continues to ramp up following a series of recently announced mill capacity investments, the region’s large share of total production (currently 54%) is likely to further increase.

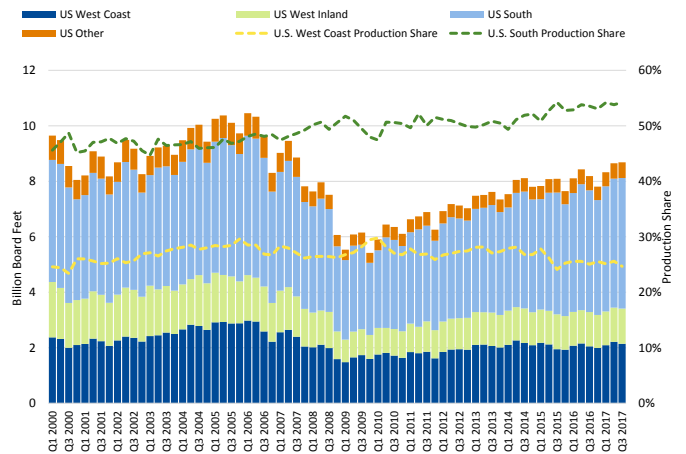
FIGURE 3. SOFTWOOD LUMBER PRICES



SOURCE: RANDOM LENGTHS; GWR RESEARCH.

NOTE: AVERAGES ARE FOR THE PERIOD Q1 2000 TO Q4 2017.

FIGURE 4. SOFTWOOD LUMBER PRODUCTION

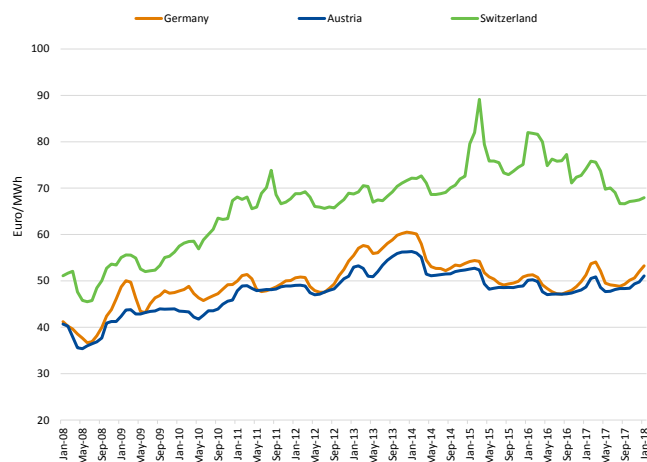


SOURCE: U.S. CENSUS; FEA; GWR RESEARCH.

EUROPE

BIOMASS MARKETS

FIGURE 5. EUROPEAN RESIDENTIAL HEATING PELLET PRICES, JAN 2008 – JAN 2018



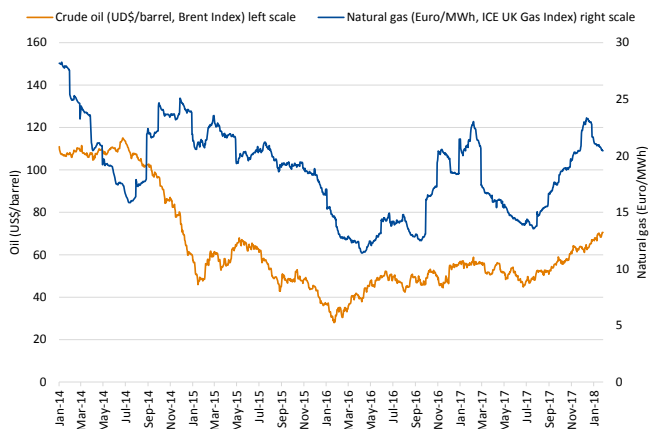
SOURCES: DEP; PROPELLETS AUSTRIA.

- Industrial and residential pellet markets began 2018 showing signs of strength. Hawkins Wright (January 2018) reports that industrial pellet prices are at a two-year high as a result of increased demand and tightening supplies in European and Asian markets. In European heating markets, cold weather is producing a strong seasonal uplift in wood pellet demand and supporting gains in prices (Figure 5).

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- European demand remains the primary driver of global wood pellet trade, though Asian markets are growing. Pellet imports to Europe totaled 14.9 million metric tons in 2017, up 5% compared to 2016. Total traded volumes are expected to continue expanding, with the UK, the Netherlands, Belgium and Denmark all planning to expand or open new power plants in coming years.
- In January, the European Parliament finalized its report on the Renewable Energy Directive II (RED II), laying out a plan to achieve a 35 percent renewable energy target by 2030, binding at the EU level. In general, the outcome was favorable to the biomass industry. Notably, the Parliament did not approve an amendment which would have prevented countries not party to the Paris Climate Change Agreement (e.g., the US) from being able to supply biomass eligible for member state support. RED II also lays out sustainability criteria for biomass produced or consumed in the EU, which focus on the net carbon footprint from forest biomass used for energy and apply to installations of 20MW (energy input basis) or above.

FIGURE 6. EUROPEAN ENERGY PRICES, JAN 2014 – JAN 2018



SOURCES: EEX; ICE; HAWKINS WRIGHT.

- Prices in global energy markets for oil and natural gas increased steadily through Q4 2017, though natural gas prices were down at the start of 2018 (Figure 6). In late-January, Brent Index oil prices topped \$70/

barrel, their highest level since December 2014, with increases driven by strong global demand and short-term supply disruptions. Continued strength in oil and natural gas markets, with Brent spot prices expected to average \$62/barrel (US EIA, March 2018) in 2018, will support demand for woody biomass, particularly where industrial and residential infrastructure already exists.

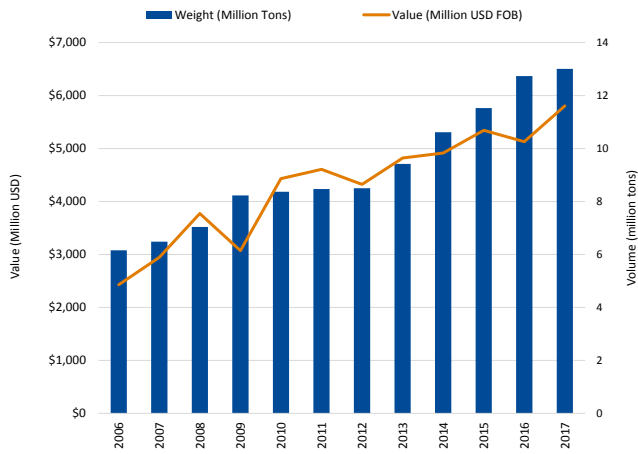
LATIN AMERICA

PULP MARKETS

- Global demand for bleached chemical pulp (BCP) increased by an estimated 2.0 million tons in 2017, up 3.6% year-over-year (Hawkins Wright, March 2018). Demand growth was concentrated in Chinese hardwood pulp markets, with bleached eucalyptus kraft pulp (BEKP) consumption up 4.7% or 1.0 million tons (Hawkins Wright, March 2018). Demand growth has been matched by BCP capacity expansion in Latin America, Europe and Asia—2018 will be the first full year of production at Fibria Tres Lagoas II and Metsa Fiber Anekoski and will bring continued operational improvements at APP OKI.
- Latin America is well-established as the low-cost producer of bleached hardwood kraft pulp (BHKP) globally and the dominant supplier to Chinese markets. Favorable growing conditions for fast-growing eucalyptus together with a well-developed plantation infrastructure and a highly efficient industry have positioned Brazil and Uruguay as the two lowest cost producers in Latin America. Figure 7 shows BHKP exports from Brazil, which more than doubled both in terms of volume and value between 2006 and 2016. In 2017, Brazilian BHKP pulp exports reached an all-time high. Growth is expected to continue and in the first two months of 2018, export volume is up 10% compared to the same period a year earlier.

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FIGURE 7. BRAZIL BHKP EXPORTS, 2006 – 2017



SOURCE: BRAZIL MINISTRY OF INDUSTRY, FOREIGN TRADE AND SERVICES.

- China’s efforts to clean up air and water pollution may increase demand for virgin pulp imports. China produces a considerable amount of packaging from imported recycled paper and container board. Contaminants arriving with these inputs end up as waste in rivers and lakes as part of the effluent stream from the production facilities consuming them. In late-2017, the Chinese government suspended import permits for such fiber as a means for upgrading the standards and perhaps ultimately eliminating this source of fiber altogether. This policy shock has contributed to increased price volatility and may increase demand for imported pulp, both chemical and mechanical. Latin American pulp producers would be the main beneficiaries of the former; Canadian bleached chemiThermoMechanical pulp (BCTMP) producers the main beneficiaries of the latter.

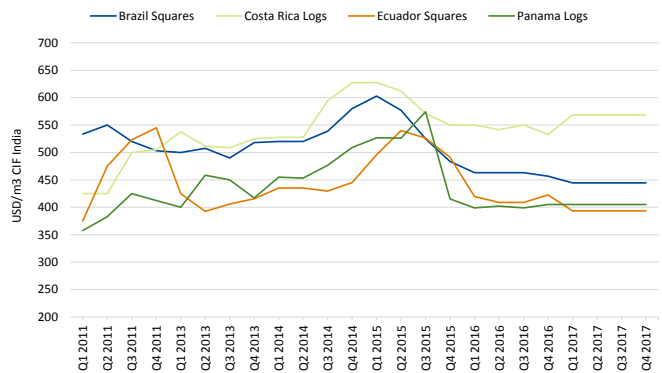
TROPICAL HARDWOODS

- Tropical hardwood plantations provide a sustainable alternative to the increasingly constrained supply of natural-grown tropical hardwoods. A prime example of this is plantation-grown teak from Latin America, which has replaced native teak from South and Southeast Asia in many global markets and currently represents the vast majority of teak log trade. However, plantation management intensity and teak wood quality is highly variable across Latin America. Variability in management can lead to vast differences in diameter class mix at final harvest and ratio of

heartwood to sapwood, critical factors in determining teak log price.

- The International Tropical Timber Organization (ITTO) reports that average plantation teak log prices held steady through Q4 2017 (Figure 8). Price differences across countries are a function of wood properties (e.g., color, ratio of sapwood to heartwood, branching), plantation management, harvest and transportation costs. However, for several years, Costa Rican teak has maintained a premium in global markets over teak from Ecuador, Panama, and Brazil. Market participants in Latin America report some volatility in pricing for small to medium diameter plantation logs, but increasing prices for large-diameter plantation logs (>40 cm diameter at breast height).

FIGURE 8. REGIONAL PLANTATION TEAK LOG PRICES, Q1 2011 – Q4 2017



SOURCE: ITTO.

ECOSYSTEM SERVICE MARKETS

- As ecosystem service markets have developed and grown, there is an increasing recognition that ecosystems and commercial timber can be jointly managed in a manner that positively impacts the environment, communities, and the investor through conservation forestry. Payments for ecosystem services (PES) monetize ecosystem benefits, providing a financial return for forest management that produces quantifiable ecosystem service values. The primary sources of PES from timberland include conservation easement and fee sales, carbon credits, water quality credits, and wetlands mitigation banking.
- In the US, the California (CA) carbon market is the

REGIONAL MARKETS

major driver of demand for forest-based carbon offset credits. In 2017, the CA state legislature approved an extension of the cap-and-trade program through 2030 (AB 398), improving market stability and policy certainty. Although the extension decreased the share of total compliance that can come from offsets, demand for offset credits is expected to increase following the January 2018 addition of Ontario to CA's cap-and-trade program.

- Well-developed regulatory carbon markets in Europe and the US provide information on pricing that can be incorporated into traditional financial analysis of investment opportunities. Figure 9 describes carbon price under the EU's Emissions Trading Scheme. In February 2018, and for the first time since 2011, European carbon prices surpassed the €10/tCO₂ mark. Prices surged following the European Parliament's approval of post-2020 reforms to the EU ETS scheme targeting the oversupply of allowances.

FIGURE 9. EU EMISSION TRADING SCHEME CARBON PRICE, 2014 - 2018 YTD



SOURCE: BLOOMBERG.

FOREST SCIENCE

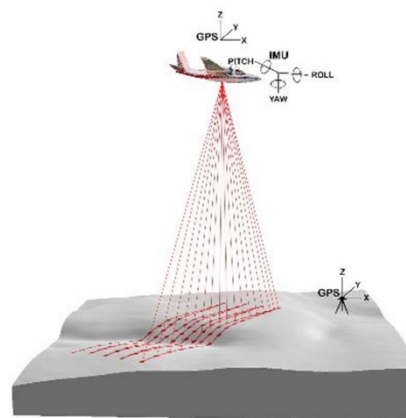
REMOTE SENSING TO IMPROVE FOREST INVENTORY SYSTEMS

- Remote sensing of timberland using light detection and ranging (LIDAR) laser technology is a source of accurate data suitable for forest inventory and assess-

ment. LIDAR is an advanced land surveying method that uses pulses of light sent from an airborne laser to the forest below where the pulse reflects off the forest canopy and is collected back at the instrument (Figure 10). LIDAR data can be used to make high-resolution inventory maps of an asset including estimates of canopy height, basal area, timber volume, and biomass. Forest health assessments using LIDAR can lead to early detection of insect infestation or disease, enabling cost-effective control.

- GreenWood Resources, in collaboration with Virginia Tech's Forest Productivity Cooperative, is using LIDAR technology to support inventory work and improve forest management efficiency in the US South.

FIGURE 10. SCHEMATIC OF LIDAR SURVEY SYSTEM



TREE IMPROVEMENT IN NORTH AMERICA

- Tree improvement through selective breeding seeks to replicate the scientific methods applied to agricultural crop improvement programs over several generations that have produced tremendous gains in the agricultural sector. Tree improvement begins with the identification of superior trees, which are then cross pollinated and their progeny tested in the field in order to select and deploy the individuals that grow the fastest, produce the highest-quality wood, and are most disease resistant. Further, current research in the field of tree improvement includes molecular techniques to accelerate the realization of genetic gains.
- GreenWood Resources participates in research cooperatives aimed at producing genetically superior

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trees. In the US South, tree improvement research is in collaboration with the North Carolina State University Cooperative Tree Improvement Program and the Western Gulf Forest Tree Improvement Programs, focusing on pine species. In the PNW, GreenWood Resources is actively involved in Oregon State University's Northwest Tree Improvement Cooperative, focusing on Douglas-fir and western hemlock.

FIGURE 11. GENETICALLY IMPROVED DOUGLAS-FIR



NOTE: IMPROVED TREES AT LEFT AND UNIMPROVED TREES AT RIGHT.

MACROECONOMICS

UPDATES

BRAZIL

- Political turmoil in Brazil continues. Though President Michel Temer remains in power—in late-2017, Brazil's lower house of Congress blocked a corruption trial against him—his ability to enact an ambitious reform agenda has diminished. Responsibility for reviving pension reform (and stabilizing the public finances more generally) will lie with the new administration that emerges from national elections in October 2018.
- In early-2018, S&P and Fitch lowered their long-term ratings for Brazil sovereign debt to BB- from BB. The ratings downgrades were largely the result of failed pension reform and post-election policy uncertainty. However, in spite of these downgrades, Brazil's recovery appears to be gathering pace and the economy is now growing by around 2% year-over-year—its fastest rate in four years.

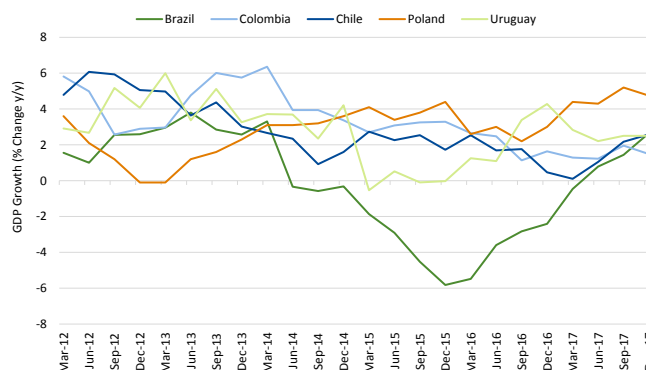
POLAND

- Poland's economy is expanding at a rapid pace, growing by an impressive annualized rate of 4.7% in Q4 2017. Wage growth coupled with the continuation of expansionary fiscal policy is creating posi-

tive inflationary pressure. Capital Economics (January 2018) reports that two widely-watched measures of price expectations in Poland hit seven-year highs in January, suggesting that core inflation is set to pick up markedly over the course of 2018.

- The European Commission remains concerned about the rule of law in Poland and that recent reforms to the Polish judicial system have compromised its independence. The European Parliament has backed a resolution supporting a December 2017 recommendation from the European Commission to invoke Article 7 against Poland. This move could result in the loss of Poland's EU voting rights and EU funding, potentially impacting medium- and long-term growth.

FIGURE 12. GDP GROWTH, 2012 - 2017



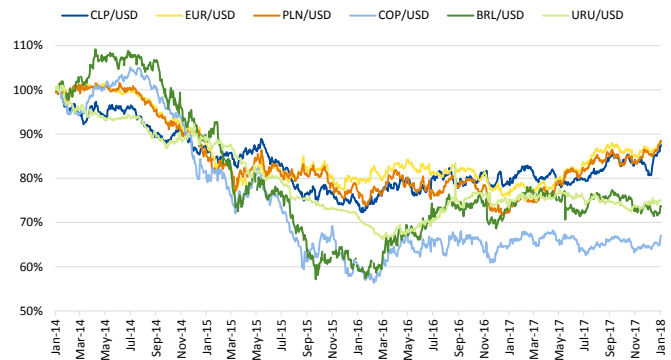
SOURCE: CAPITAL ECONOMICS.

COUNTRY STATS

FX RATES

- The USD maintained its relative strength in currency markets through Q4 2017 compared to long-term trends. In 2017, Latin American currencies—the Colombian peso, Brazilian real and Uruguayan peso—were largely flat against the dollar while the Chilean peso was up 8%. The Euro and the Polish zloty finished the year up over 18% and 13%, respectively.
- The impact of foreign currency exchange rate volatility on timberland investment will be explored in an upcoming issue of GreenWood Resources Research Report for Timberland Investors.

FIGURE 13. FOREIGN CURRENCY EXCHANGE RATES RELATIVE TO THE US DOLLAR, INDEXED FROM 2014



SOURCE: BLOOMBERG; GWR RESEARCH.

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