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Global timber investments, 2005 to 2017

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ABSTRACT

We estimated timber investment returns for 22 countries and 54 species/management regimes in 2017, for a range of global timber plantation species and countries at the stand level, using capital budgeting criteria, without land costs, at a real discount rate of 8%. Returns were estimated for the principal plantation countries in the Americas—Brazil, Argentina, Uruguay, Chile, Colombia, Venezuela, Paraguay, Mexico, and the United States—as well as New Zealand, Australia, South Africa, China, Vietnam, Laos, Spain, Finland, Poland, Scotland, and France. South American plantation growth rates and their concomitant returns were generally greater, at more than 12% Internal Rates of Return (IRRs), as were those in China, Vietnam, and Laos. These IRRs were followed by those for plantations in southern hemisphere countries of Australia and New Zealand and in Mexico, with IRRs around 8%. Temperate forest plantations in the U.S. and Europe returned less, from 4% to 8%, but those countries have less financial risk, better timber markets, and more infrastructure. Returns to most planted species in all countries except Asia have decreased from 2005 to 2017. If land costs were included in calculating the overall timberland investment returns, the IRRs would decrease from 3 three percentage points less for loblolly pine in the U.S. South to 8 percentage points less for eucalypts in Brazil.

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1. Introduction

Global timber investments are a continuing subject of interest to analysts and investors in forest policy and economics. The objective of this research was to examine the current timber investment returns in many regions throughout the world. We performed a longitudinal study of timber investment returns and trends, without the costs of land, for selected countries and species as of 2017. We compared those with prior research we have conducted back to 2005, as well as with other related forest economics literature. This research and analysis can help investors and policy makers compare timber returns among countries based on the underlying forest growth, factor costs, and timber prices; provide benchmarks for important countries in the world; and offer a template for more detailed analyses for their own investments.

The article begins with a literature review of the research on timber investments; proceeds to briefly explain our fairly standard economic analysis methods; summarizes the current global plantation and planted forest investment returns that we have found; examines trends; and draws conclusions about comparative advantages among countries and regions.

Investment returns in planted forests, as well as the risks of those returns, usually drive most of the purposeful forest harvesting and regeneration decisions throughout the world, ceteris paribus. Alternative land uses also affect forest harvesting and retention, but even these tradeoffs between forests and developed or agriculture land uses usually depend on comparative land rents or needs for subsistence and shelter. In addition, the comparative returns among countries in the world also drive their competitive advantage in global forest products manufacturing and trade. Timber investments at the stand level will not only determine the profits and competitive advantage within each country, but also the comparative advantages that countries have to gain more market share and capture increases in global forest products consumption.

Timber investment analyses also help explain the increase in forest plantation area and future projections for more planted forests (Carle and Holmgren, 2008; Payn et al., 2015; Nepal et al., 2019), the increase in forest industry investments, and the role of forest plantation timber to substitute for timber coming from natural forests (e.g., Sedjo, 1983; Binkley, 1997; Sedjo and Botkin, 1997; Buongiorno and Zhu, 2014). While planted forests have detractors as well as proponents—see balanced discussions by Cossalter and Pye-Smith (2003), Pirard et al. (2016, 2017)—their area and share of industrial wood they provide continues to increase. Since we started our studies in 2005, many new world class pulp mills have been built throughout the world, with the brunt of them in the selected developing countries we have benchmarked through the last 15 years, although new plants now exist or are planned in Asia and Finland at least.

As co-authors here and previously, we have cooperated to collect data, provide summaries, and perform analyses of timber investment returns for more than a decade (Cubbage et al., 2007, 2010, 2014). We have slowly built the cooperating research team for this work, and now we have collected data of forest returns for 22 countries and 54 species in the world. Core countries in North and South America have been represented for the duration of these analyses, and other countries in Oceania, Asia, and Europe have been added in the 2010s. We focus mostly on returns from planted forests, which are the focus for most domestic or foreign investors, but also address some common natural forest systems where they are available and relevant.

2. Literature review

Timber investments are one of many assets that investors may choose. There is varied literature on timberland investments in general, as well as some on comparisons with other asset classes. We briefly review the literature on timberland finance first, and then provide details on other studies that analyzed timberland investments in various countries.

2.1. Timberland finance

Early timber finance literature, which included both popular articles and refereed research, developed the general principles for modern forestry investments as an asset class. These included concepts that timber investments had several principal components of returns—biological growth; increase in timber values with age by product class; some timber real price increases greater than inflation; opportunities for land price appreciation; higher and better use (HBU) sales on parts of large timberland properties; and merits of timberland in a mixed portfolio. These concepts and a number of forestry sector strategic decisions led a major shift to the transition of timberland ownership in the United States and some other countries.

In the United States, in the four decades since 1980, virtually all major Vertically Integrated Forest Products Companies (VIFPCs) have sold their timberland to other institutional or individual owners. These lands are managed by Timber Investment Management Organizations (TIMOs), or were spun off their corporate lands into Real Estate Investment Trusts (REITs) (Korhonen et al., 2016). This conversion was prompted by relatively poor corporate financial performance; limits to corporate timberland price appreciation due to standard accounting principles; opportunities to cash out on significantly appreciated land values; declining incentive to own and produce their own wood supply; prohibitive federal tax treatment for C-Corporations; and the opportunity to structure forestland holdings as a pass-through tax entity and avoid corporate taxes (Hickman, 2007; Zhang et al., 2012).

In other countries, most notably New Zealand, Australia, and South Africa, government developed timberlands were sold to TIMOs or other private investors. These conversions from industry and government to TIMOs and REITs, as well as changes in U.S. pension laws regarding investments, spurred a major institutional interest in timberland assets. In addition, high wealth investors from Europe and the Middle East began investing more in forest assets. Large and small private owners in the U.S. and other countries still maintain a keen interest in forest investments as well, of course.

Various scholarly research examined returns to timber investments using modern financial and portfolio theory (e.g., Mills and Hoover, 1982; Redmond and Cubbage, 1988; Cascio and Clutter, 2008; Mei and Clutter, 2010; Martinez-Oviedo and Medda, 2017), which is examined in detail in another paper in *Forest Policy and Economics* (Mei, 2019). This research generally found that timber investments provided moderate returns, with less systematic risk than comparable stock returns. They also provided theory and evidence that helped support the merits of timberland as a viable asset class for institutional investors as part of a balanced portfolio, as did a number of annual or periodic timber investments conferences that have developed in the U.S. and elsewhere.

Timber prices and timber markets remained quite attractive until the U.S. major recession of 2008, and most literature until that time continued to find that timberland offered reasonable investment returns with less risk than stocks or bonds. However, faced with an extended ten year decrease in real timber stumpage prices since 2008 in the U.S. South (albeit not the Pacific Northwest), the viability of forest investments has been questioned or at least re-examined. As one response to this issue, we focus here on scholarly research on individual timber and timberland investments for various countries in the world.

2.2. Timber and timberland investments

Experts and popular articles have examined and discussed timberland returns for at least a century since the development of the Faustmann (1849) Formula for calculating forest land expectation values and its subsequent widespread applications (e.g., Duerr, 1993; Gregory, 1987; Klemperer, 2003; Wagner, 2012), and this increased considerably as a new forest plantation sector has developed. Scholarly

Table 1
Summary of selected articles on timber investment returns by country.

Authors	Country	Species	IRR
Sedjo (1983)	Global	16 Country/species combinations	Pulpwood: 4.6–20.5% Sawtimber: 5.6–23.5%
Siry et al. (2001)	USA	Loblolly pine	10–14%
Brukas et al. (2001)	Lithuania	Pine, spruce and birch	3–5%
Bis (2009)	Poland	Pine, spruce	2.9, 4.5%
Piotto et al. (2010)	Costa Rica	5 native mixed species 3 monoculture species	7.7–15.6% 9.2–14.3%
Ying et al. (2010)	China	Pine, fir, eucalyptus	33%, 20%, 20%, respectively
Wang (2014) Comment, ibid	China	Pine	5–8%
Keča et al. (2012)	Serbia	Poplar	4.3–6.9%
Thomas (2012)	USA South	Pine	2.8%
Wang et al. (2014)	China	Poplar	13.2–29.3%
Watt et al. (2017)	New Zealand	Pine	7.5–9%
Maraseni et al. (2017)	Vietnam	Acacia	27–33%
Maraseni et al. (2018)	Lao PDR	Teak	15–20%
Frey et al. (2018)	Vietnam	Acacia, eucalyptus, site III+	6.9–33.1%
Zhang et al., 2019	China	Eucalyptus, castanopsis, cunninghamia, pinus	24–28%, 21%, 13%, 10%, respectively
Chudy et al., 2019a	US Northwest	Poplar	0%

research that examined comparative timberland investment returns for plantations in different regions in the world was first published by Sedjo (1983, 1999, 2001), who examined plantation investment returns for in nine countries that grew 6 species. He estimated internal rates of return (IRRs) and net present values (NPVs) for both pulpwood and sawtimber.

As co-authors of this paper we have followed that line of research since 2005, estimating various capital budgeting criteria (Cubbage et al., 2007, 2010, 2014). In addition to purposeful global timber investment returns, there have been a few individual studies that have analyzed returns to forest investments in one or several countries, for various planted and natural species. To simplify this literature review, in Table 1 we summarize the major modern timber investment studies, genera, species, and rates of return, excluding ours, which are covered subsequently.

Each of the studies summarized in Table 1 performed forest investment analyses based on the costs of forest establishment and management, growth rates, rotation ages, and periodic and final harvest volumes and prices. Returns were calculated using discounted cash flow analyses and calculated with capital budgeting criteria such as net present value, land expectation value, or internal rate of return. All of them calculated returns without the cost of land. All of them used constant establishment, management, and timber prices, not including the effects of inflation. This is the standard approach to estimate base timber investment returns, which we followed as well. The studies did use different discount rates for different locations and time periods, but most also calculated internal rates of return, which are most useful to compare and avoid the requirement to find a universally agreed on discount rate.

Broadly speaking, the studies summarized here are limited by assumptions needed on the representativeness of the typical management regimes, accuracy of factor costs and timber prices, effects of inflation and foreign exchange on returns, and whether to include land costs and appreciation. We do not critique each of the studies here based on these characteristics, which could be paper in itself, but address the effect of these investment factors in our analyses. Many studies also analyze the effect of changing these assumptions as different scenarios, and indeed investors and appraisers usually do this as well.

Notably, the prior research, as well as ours, usually excluded land in the capital budgeting estimates for several reasons. These include (1) the land expectation value (LEV) calculation does provide an estimate of what buyers should pay for land based on the infinite stream of identical costs and revenues; (2) land costs are often more widely variable and less readily available than the timber management costs and timber/stumpage prices; (3) the estimation of future land prices in such calculations is extremely speculative, potentially distorting the results almost entirely based on the inflation rate assumed for the land; (4) including land (or any factor) with any real price appreciation or depreciation violates the assumption of identical cash flows in the Faustmann formula; (5) many owners already have the land, and do not intend to sell it, so it is a sunk cost; and (6) comparisons of timber returns excluding the price of land are easier to make among countries, reflecting timberland productivity, management costs, and timber prices alone, not speculative prospects or higher and better use (HBU) development.

So, this literature review of the salient studies that explicitly examined timber investment returns—not including perhaps many broad forest management studies that included a financial analysis—indicates that timber investments seem quite promising historically. Internal rates of returns for the slower growing species in northern Europe were found to be lower, at about 3% to 7% (Brukas et al. 2001; Bis 2009; Keča et al., 2012). In contrast, Sedjo (1983) reported that IRRs in Brazil and Chile in South America were quite high, ranging from 16% to 28%. His reported returns in Borneo, South Africa, and Oceania fell in the middle range, with IRRs between 10% to 19%. Watt et al. (2017) found IRRs of 7.5% to 9% for exotic *Pinus radiata* in New Zealand. In one of the few studies of tropical plantations, Piotto et al. (2010) found IRRs in plantations of mixed native species in Costa Rica ranging from 8% to 16%, and slightly lesser IRRs for pure stands of native species there, ranging from 9% to 14%.

Sedjo (1983) reported that loblolly pine (*Pinus taeda*) in the U.S. South had IRRs ranging between 12% to 14%, and Douglas-fir (*Pseudotsuga menziesii*) in the Pacific Northwest ranged between 7% and 10%. Siry et al. (2001) also found southern U.S. loblolly IRRs exceeded 10% as of 2000. A more recent analysis by Thomas (2012), however, estimated U.S. South loblolly returns with land costs of only 3% IRR. More recently, Callaghan et al. (2019a) estimated returns for southern pine forestry investments under different cost scenarios. While they did not publish IRRs, almost all of the cost/timber price scenarios yielded slightly positive net present values (NPVs) of $50 USD to $250 USD per ha at a 7% discount rate, indicating IRRs of at least 7%.

Asian timber investment returns have generally been reported to be quite high, often exceeding 20%. Maraseni et al. (2017, 2018) found high rates of return for plantations in Lao PDR and Vietnam, ranging from 15% to 33%. Studies in China found considerable variation in the results. Ying et al. (2010) founds IRRs for *Pinus massoniana* of more than 20%. A reply to that research estimated low returns as of 2010 of about 5% to 8% when accounting for land lease opportunity costs (Wang, 2014). Wang also observed that forest plantations are not a high return sector, and are incapable of having an IRR of close to 40%. Wang et al.

(2014), however, found returns for *Populus* spp. plantations with IRRs of 13%–29%. Zhang et al. (2019) found higher returns in southern China as of 2015—from 10% for *Pinus massoniana* to 28% for *Eucalyptus spp*., mostly excluding land.

3. Methods

Following our prior research methods described in Cubbage et al. (2014), we used discounted cash flow analyses and capital budgeting criteria to evaluate timber investment returns, including net present value (NPV), land expectation value (LEV), and internal rate of return (IRR), such as described in Gregory (1987), Duerr (1993), Klemperer (2003), and Wagner (2012). The methods for the financial approach methods are paraphrased here, from Cubbage et al. (2014). We have described these general approaches in English and Spanish technical reports (Cubbage et al., 2011, 2013), and a book chapter (Cubbage et al., 2016) as well. In brief, we calculated the timber investment returns for typical planted or natural stands in the selected countries, not including land costs, inflation, or corporate or institutional administrative costs. All costs, prices, and returns were converted into U.S. dollars by the co-authors for ease of comparison, and to remove any exchange rate fluctuations. Land areas and wood volumes were all converted into metric equivalents.

We used a uniform 8% real discount rate to estimate returns for all species in all countries. The exact discount rate for more than a dozen countries over a decade is not possible to determine. We did survey discount rates used in forestry investments as part of the research, and they ranged from as low as 6% in the northern hemisphere to 15% in the southern hemisphere. Thus, we selected 8% in 2005, and have kept that as the baseline for consistency for every year that the research data have been collected. This fixed discount rate allowed all investments to be compared on the same basis, without the cost of land, for the entire period.

We also calculated the IRRs for each stand investment, which are perhaps more useful for handy comparisons as demonstrated by its most frequent use in the preceding forest finance literature—despite some theoretical shortcomings (Klemperer, 2003; Wagner, 2012). IRR represents a return per unit of capital spent, whereas NPV and LEV represent the return per unit area of land at a given discount rate. Different types of investors with different land ownership contexts and investment objectives may prefer one measure over the other (Mercer et al., 2014).

We identified the most important forest genera/species in each relevant country, and collected forest productivity and cost data to estimate returns to timber investments at the stand or forest management unit level. We estimated productivities based on using a common Mean Annual Increment (MAI) for growth rates for typical or representative stands for each species in the relevant region of the country. Each analyst assumed that the site quality was for typical representative sites and the most likely timber rotation and thinning regimes for the selected species in the country, with good growth and management practices.

Costs included all those for forest regeneration, intermediate stand treatments and management, and a similar fixed cost for taxes and administration for every country and stand. Information on timber prices by product size was gathered from available literature or personal contacts with colleagues in the timber sector. Published timber price and management cost series are only available for a few countries, such as the Timber Mart-South (2018) and a Forest Landowner (Maggard and Barlow, 2017) management cost series in the USA. Consequently, most of the input costs and timber prices were obtained by each co-author in their relevant country by making personal contacts with foresters in that country. The establishment and management costs and timber prices were selected as a point estimate for 2017. This is apt to be more accurate for current costs than future timber prices, so the deterministic inputs and outputs should be considered indicative of typical stands, not absolute.

We used real (constant) input costs and timber prices, and no inflation in management costs or timber prices. All analyses were assumed to be on a before income tax basis, without any planting or other subsidies. We also collected data on forest land prices for many countries in 2017. These data allowed us to compare estimated land prices with the calculated LEVs, which in theory should provide a measure of land price. However, land prices often exceed the estimated present value of their discounted returns, because the anticipated increase in land rent for other, non-forestry uses is greater than the calculated rents for forestry. In addition, financial, political, social, export, and environmental risks affect these timberland investments, which we lack space to address here.

The data collection and entry were standardized by use of a common spreadsheet with appropriate cells for each researcher to fill in with information for their species/country. The spreadsheet was a template with cells for species, country, management costs, timber productivity, and timber returns, which were then used to calculate various capital budgeting metrics. The template is available as supplementary information (see Supplementary data section). Several researchers have adapted the template to work best in their situation, such as: modifying timber prices from a stumpage basis to a mill basis; adding more product classes; or adding more analyses of land or other factors.

In a few cases, several researchers worked in the same country, although not always with the same species. Where more than one individual was familiar with a species, a synthesis of data and inputs was used and reviewed by the relevant researchers for that country. In addition, all the spreadsheets and calculations were reviewed by the lead author and any anomalies were noted and verified or rectified through an iterative process with lead researchers in each country. The final tables of inputs, costs, yields, and investment returns were assembled and analyzed to examine trends for each year that this benchmarking exercise was performed—2005, 2008, 2011, 2014, and 2017.

The results include a summary of the input costs and the timber investment returns. However, despite having investment return data for many countries and years, a statistical cross-sectional/time series/panel data analysis was not possible, or at least not wise. The benchmarking data are still too different among years and countries for sound statistical analysis, and there are missing countries and species in each year.

In order to illustrate the effect of land costs for new timberland investments, we did estimate the timber investment returns including land costs for a few selected major timber producing countries where we had better data on purchase costs. We collected data on average bare timberland prices in 2017 for the United States ($2000 USD per ha southern to $2500 USD per ha western) per ha; Brazil ($5000 per ha for Santa Catarina to $5500 USD per ha for São Paulo); and New Zealand ($4500 USD per ha). We assumed that the timberland purchase would occur in the first year, and then the land would be sold at the end of the rotation for the same price, with no inflation. This method of buying and selling the land in the same perpetual rotation does allow one to calculate a LEV, although it now would reflect the excess price that one could pay (or would lose) at a given discount rate—greater than (or less than) the actual price of the land.

4. Results

The key inputs and outcomes for the analysis of our 54 timber investment management regimes and capital budgeting returns in 2017 are summarized in Appendix 1. The NPVs, LEVs and IRRs are summarized in Table 2.

In brief, as Table 2 indicates, these timber investment returns without land seem relatively promising for many countries. For ease of understanding, we discuss the results here by broad region. Since the co-authors here are all quite familiar with the timber sector in the countries covered, we also make a few general observations about the

Table 2
Investment analysis capital budgeting results for selected species and countries 2017.

Country	Species	Capital budgeting criteria		
		NPV	LEV	IRR
		($/Ha@8%)		(%)
Argentina	*Pinus taeda* - Misiones	−506	−678	6.5
Argentina	*Eucalyptus grandis* - Corrientes	−57	−95	7.5
Australia	*Pinus radiata* high growth	−68	−77	7.5
Australia	*Pinus radiata* low growth	−1036	−1183	5.7
Brazil	*Pinus taeda* sawtimber	2484	3099	14.3
Brazil	*Eucalyptus urophylla* pulpwod, Sao Paulo	13	34	8.1
Brazil	*Eucalyptus grandis* sawtimber	812	818	10.7
Chile	*Pinus radiata* Sawtimber - Good Site	1542	1889	13
Chile	*Pinus radiata* - Pulpwood - Poor Site	555	784	11.2
Chile	*Eucalyptus globulus* pulpwood	1553	2193	14.3
Chile	*Eucalyptus nitens* pulpwood	745	1130	12.2
China	*Pinus massoniana*	−62	−69	7.9
China	*Eucalyptus spp.*	3505	9479	31.5
Colombia	*Pinus tecunumanii*	374	499	8.7
Colombia	*Pinus patula*	−658	−878	6.63
Costa Rica	*Gmelina arborea*	4325	5818	24.5
Finland	*Picea abies*	−1185	−1195	4.3
Finland	*Pinus sylvestris*	−1431	−1439	4.3
France	*Quercus petraea*	−2922	−2922	2.0
Laos	*Eucalyptus spp.* Industry	2617	6283	21.7
Laos	*Eucalyptus spp.* Outgrower	319	998	11.8
Laos	*Tectona grandis / Teak*	2007	2383	13
Mexico	*Pinus gregii*	1248	1590	11.3
Mexico	*Eucalyptus grandis*	1693	3683	20.1
Mexico	*Gmelina*	734	2297	19.7
Mexico	*Tectona grandis* / Teak	5920	18,537	18.6
New Zealand	*Pinus radiata*	549	621	8.8
Paraguay	*Eucalyptus grandis/urograndi* clones	2650	4937	21.8
Peru	*Pinus patula*	−2336	−2838	3.6
Poland	*Quercus spp.* State Forest	−5275	−5276	2.4
Poland	*Pinus sylvestris* State Forest	−3154	−3155	2.4
Poland	*Pinus sylvestris* Private	−1515	−1516	4.5
Scotland	*Picea sitchensis* / Sitka spruce	1567	1681	13.6
South Africa	*Pinus spp.*	−898	−1051	3.06
South Africa	*Eucalyptus spp.*	2166	4112	24.8
Spain	*Populus spp.*	575	840	9.9
Spain	*Eucalyptus globulus*	1094	1598	9.6
Uruguay	*Eucalyptus globulus*	916	1603	13.2
Uruguay	*Eucalyptus grandis* pulp	341	635	10.4
Uruguay	*Eucalyptus grandis* sawtimber	963	1361	11.8
Uruguay	*Pinus taeda*	0	0	8
USA	*Pinus taeda*/Low Yield & Intensity	−216	−253	0
USA	*Pinus taeda* / Medium Yield -NC	−478	−560	5.9
USA	*Pinus taeda* / Medium Yield - South	−202	−233	7.1
USA	*Pinus taeda* / HighYield & Intensity	−97	−115	7.6
USA	Mixed Hardwoods, Even Age, Plant	−273	−276	3.2
USA	Mixed Hardwoods, Uneven Age, Selection	97	98	10
USA	*Pseudotsuga menziesii* Site I	−34	−35	7.9
USA	*Pseudotsuga menziesii* Site III	−1125	−1161	5.9
USA	Hybrid Exotic Larch, Northeast/ Central / *Larix marschlinsii*	−946	−1050	5.2
Venezuela	*Eucalyptus urophylla*	362	869	12.4
Vietnam	*Acacia spp.* Smallholder	1274	3989	22.7
Vietnam	*Acacia spp.* State Forest	−29	−69	7.7
Vietnam	*Eucalyptus urophylla* high growth	1408	3805	23.1

markets and forestry technology in each country based on our knowledge in order to help explain the investment return calculations and opportunities.

According to the estimates we have made, the highest potential timber investment returns, not including the price of land, can be achieved in Asia, followed by Latin America, Oceania, and the Northern Hemisphere. Overall, while timber planting and forest management costs do vary considerably among countries, these differences are less than timber prices for stumpage—the price of wood sold as standing in the forest. Timber growth rates do vary considerably, but in general Northern Hemisphere native temperate forests grow slower than exotic plantations in the subtropical and equatorial Southern Hemisphere forests. Temperate exotic plantation growth rates and prices in Oceania, Chile, and South Africa fall between Northern Hemisphere and subtropical regions.

This combination of modest differences in management costs; moderate differences in timber growth rates; and the highest regional demand compared to supply, leading to higher timber prices in Asia, prompted it to have the most potential for large timber investment returns. However, the scarcity of timber there exists for several reasons—land is scarce, rural infrastructure is poor, government institutions are weak, biological and political risks are higher, and achieving good forest management is challenging. Details of timber investment returns that we estimated by region and country follow.

4.1. South and Central America

South American industrial plantations are generally comprised of exotic species of pine (e.g., *P. taeda, P. radiata*) from North America and eucalypt (e.g., *E. grandis, E. urophylla, E. globulus, E. dunii,* or hybrids) from Australia. Plantations of these species are now in the second or third generation of genetic improvement, are very intensively managed, are often on relatively good sites for forests, and can grow almost all year long. As of 2017, the plantation average growth rates for Brazil were the highest in the world, at up to 40 m^3/ha/yr for pine and 50 m^3/ha/yr for eucalypt, and are reported to be higher by 2019 as well. Other Southern Cone countries also have growth rates of up to 30 m^3/ha/yr or more. These high growth rates and good forest management practices have medium to above average forest establishment costs, which makes sense in order to achieve the excellent quality and productivity of the plantations.

There are active timber markets for most of the established regions in South America, and the good timber prices there reflect this. Pulpwood stumpage prices in the Southern Cone ranged from $5 USD per m^3 to $30 USD per m^3, and larger timber sizes have prices ranging from $16 USD per m^3 for pine in Uruguay, which has weak markets, to $53 USD per m^3 for good timber markets in Chile. Sawtimber prices were about $30 USD per m^3 in Brazil and Argentina. However, prices in 2017 were less than in 2011 and 2014, and some new greenfield areas that we have not analyzed here have occasionally not realized the forest products market expansion hoped for yet, so timber prices are lower than in well developed markets.

The major forest sector Southern Cone countries of Brazil, Chile, and

Uruguay all had rates of return in 2017 that exceeded the 8% real hurdle rate, with IRRs ranging from 8% to 14%. Timber management returns in Argentina, which has fewer large forest products firms but many more medium and small sawmills, were slightly less with IRRs of about 7%, and the much smaller Colombia timber markets had returns that ranged from 7% to 9%. Venezuela had calculated IRRs of 11% for eucalypt, and Paraguay had IRRs greater than 20%.

Central America has less industrial plantation area than South America, and a more diverse set of species and calculated returns. Costa Rica and Mexico had high rates of return of at least 20% for *Gmelina*. IRRs for teak (*Tectona grandis*) and *Eucalyptus spp.* in Mexico also were around 20%, while *Pinus gregii* was about 11% in Mexico. The calculated *Pinus spp.* IRRs were only 4% in Peru, although this was an extremely limited sample.

The Land Expectation Values (LEVs) at the 8% discount rate indicate how much one could pay for land and earn that given discount rate—which is a relatively high standard for any land investments, including forestry. In the key largest markets in Brazil, the LEVs ranged from only $35 USD per ha for eucalypt pulpwood to $3100 USD per ha for *P. taeda*. Land would be cheaper in emerging markets like in Maranhão, Piauí, and Tocantins and Mato Grosso do Sul, or in less productive sites with more environmental regulations like Rio Grande do Sul. However, one must purchase more land that must be set aside in in natural forests there than in other regions of Brazil.

In the states of Santa Catarina and São Paulo, good land—which also could be used for high value agriculture products such as soy bean and sugar cane—is quite expensive. So one would expect that the actual discount rate new forestry investors would achieve is less than 8%, although existing land holders probably paid much less for land than current prices and are indeed making that return or greater not including the sunk cost for land. In states with lower land prices, returns may be better per ha of planted land, but again, not all land purchased can actually be planted.

Timberland LEVs ranged considerably, reflecting the differences in growth rates, input costs throughout the management regime, and stumpage prices that generated the extra land value in excess of the 8% discount rate. LEVs at 8% were negative in Argentina; $1000 to $2000 USD per ha in Chile; $0 to $1600 per ha in Uruguay; $4900 per ha in Paraguay; $800 per ha in Venezuela; and negative to $500 per ha in Colombia. In Central America, *Gmelina* had estimated LEV returns of $5000 per ha in Costa Rica and $2300 per ha in Mexico. In Mexico, *P. greggii* had LEV of $1600 per ha; *E. grandis* of $1680 per ha, and teak of $18,000 per ha. These LEVs usually are less than the amount one could pay for land, except in Paraguay, where land might be readily available, and Mexico, where it is not. The negative LEVs do indicate that forestry investments at current costs and timber prices would expect to receive a lower IRR than the 8% discount rate.

Based on current European Credit Group ratings (Credendo, 2019), Chile, Uruguay, Peru, Mexico, Paraguay, and Brazil, in that order, had low to moderate risks for direct investments and export transactions—with risk rankings from 1 to 5 on a 7 point scale (1 best; 7 worst) for most factors analyzed. However, Ecuador, Belize, Argentina, Nicaragua, and Venezuela ranked worse, with scores of 5 to 7 on most factors summarized. The Southern Cone countries of Brazil, Chile, and Uruguay all have international investment grade risk ratings, as does Columbia and Peru, and Paraguay has improved its business environment considerably in recent years.

4.2. Northern hemisphere

Moderately intensive timber management and silviculture in native natural and planted stands have occurred in the Northern Hemisphere for decades in the United States, or even centuries in Europe. The forest technology, management, and markets are well established, if not always robust. Native species growth rates range from 5 from 10 m^3/ha/yr, and the exotic species in Spain and Scotland exceeded 20 m^3/ha/yr. Northern hemisphere forests usually are relegated to lower sites than high quality lands in South America, and the growing season is perhaps only half as long as in subtropical areas. Furthermore, native species in the northern hemisphere do not have as much growth efficiency as exotic species in South America (Albaugh et al., 2018).

The calculated rates of return without land for the U.S. South and Pacific Northwest were moderate, with most IRRs ranging from 5.9% for *P. taeda* (loblolly pine) with medium yield and intensity to 7.9% for *Pseudotsuga menzieseii* (Douglas-fir) on the highest sites. Low intensity and site quality for loblolly in the South did not generate any positive returns at 8%; the high intensity and site quality cases had returns of 7.6%. These quite consistent IRRs of less than 8% led to negative LEVs per ha, surely indicating that investors would have to use lower discount rates to justify making timberland investments in forestry in the U.S., which they indeed do.

Timber prices in the U.S South have been in a trough for almost a decade since the major recession of 2008, with pulpwood averaging $13 USD per m^3, and standard sawtimber stumpage prices of $25 per ton, or about $33 per m^3 (Timber Mart-South, 2018). This has been caused by a major reduction in demand with the recession, and an equally large increase of timber inventories and outward shift of timber supply (Galik and Abt, 2016). The prices in the U.S. Pacific Northwest were much better, at $50 to $100 USD per m^3, driven partially by large export markets to China.

We calculated returns for other species in the U.S. as well, including a 5.2% IRR for fast growing hybrid Larch (*Larix X marschlinsii*) in the Northeast, although markets and prices for this new species are still developing. Even-aged planted mixed hardwood stands had a 3% IRR. Interestingly, we found that if one had an existing older mixed hardwood stand and made periodic thinnings (e.g. the prior years of growth was a sunk cost/"free"), they could earn an IRR of 10%. But the LEV was still quite low at $100 USD per ha, so the effective discount rate with land would be smaller.

The cases we computed in Europe had typically slower growth rates and long rotations and modest IRRs, with the exception of the exotic *Picea sitchensis* (Sitka Spruce) in Scotland and poplar and eucalypts in Spain. *Picea abies* (Norway spruce) and *Pinus sylvestris* (Scots pine) had IRRs of 4.3% in Finland. In Poland, *P. sylvestris* and *Quercus* spp. on state forests had 2.4% IRRs; better Scots pine sites and management on private lands had a 4.5% IRR. *Q. petraea* in France also had a 2% IRR. The Sitka spruce had a computed IRR of 13.6%. Exotic species of *Populus* and *Eucalyptus globulus* had greater returns in warmer Spain than species in Northern Europe, with IRRs of 9.9% and 9.6%, respectively.

Obviously, the LEVs at the 8% discount rate were negative in Northern Europe, indicating that only existing landowners were apt to achieve reasonable rates of return on forest management of native species. LEVs for exotic Sitka spruce in Scotland were $1560 USD per ha.

Despite moderate investment returns, the Northern Hemisphere has the least market risk in the world, but North America pulp mills at least still tend to close more than open, although sawmills have increased in number or production in the 2010s. In addition, the concentrated mill market structure may not always favor landowners. The Northern Hemisphere and Oceania countries all have the best ratings for business environment in every major survey, with all of them having Credendo (2019) investment and export risk ratings of 1 out of 7 on the latest rankings. South Africa has declined somewhat recently, with rankings of 2 to 4. Nonetheless, even individual temperate climate countries periodically still debate and substantially modify property rights, taxation, regulation, tariffs, imports, and exports, which can affect forest investments substantially, especially if the recent trade wars persist or expand.

Table 3
Trends in plantation investment returns for selected species and countries, 2005–2017.

Country	Species	MAI	Land expectation value (LEV)					Internal rate of return (IRR)				
		m3/ha/yr	2005	2008	2011	2014	2017	2005	2008	2011	2014	2017
			- - - - $/Ha@8% - - - -					- - - - - - - % - - - - - - -				
Argentina	*Pinus taeda* - Misiones	20–30	1462	3202	1552	1315	−678	12.9	20.0	12.5	10.8	6.5
Argentina	*Eucalyptus grandis* - Corrientes	35–40	1241	3178	4560	2843	−95	13.8	18.2	19.6	14.7	7.5
Brazil	*Pinus taeda*	30	2495	5242	6809	1588	3099	16.0	20.8	23.2	16.0	14.3
Brazil	*Eucalyptus spp.* pulpwood	40	5427		6344	1496	34	22.7		26.6	12.0	8.1
Brazil	*Eucalyptus grandis* sawtmbr	40	8311	5004	10,891	2397	812	25.5	21.4	27.9	14.9	10.7
Chile	*Pinus radiata* sawtimber	22–30	3345	2782	2161	2216	1889	16.9	15.6	14.7	13.9	13.0
Chile	*Pinus radiata* pulp	20		894	960	280	784		13.1	12.6	9.3	11.2
Chile	*Eucalyptus nitens* pulp	30			2094	1523	1130			14.4	13.1	12.3
China	*Pinus massoniana*	9.5–10.5		92	1360	2416	−69		12.1	11.5	13.8	7.9
China	*spp.*	30			16,142	12,745	9479			33.6	29.6	31.5
Costa Rica/Mexico	*Gmelina arborea*	31			5818		2298			24.5		19.7
Mexico	*Pinus gregii*	15			2137	2399	1248			13.2	12.8	11.3
Mexico	*Eucalyptus grandis*	30			1962	4395	1693			18.4	23.2	20.1
New Zealand	*P radiata,* no pruning	24			−23		621			8.0		8.8
Paraguay	*Eucalyptus spp.* clones	30			2552	3330	4937			14.2	17.6	21.8
South Africa	*Pinus patula*	14		1862			−1051		11.1			3.1
South Africa	*Eucalyptus grandis*	32		2872			4112		12.4			24.8
Uruguay	*Eucalyptus globulus*	18–22	593	2358	2563	1613	1603	12.8	22.9	17.9	13.6	13.2
Uruguay	*Pinus taeda* sawtimber	18–20	2003	1048	1224	338	0	15.1	12.8	13.7	9.2	8.0
Uruguay	*Eucalyptus grandis* sawtimber	25–30	4081	1389	2465		1361	21.9	13.9	14.5		11.8
USA	*Pinus taeda* South / Low Intens.	10–12	408	−324	−761	−1367	−560	9.5	6.9	5.3	3.2	5.9
USA	*Pinus taeda* South / High Intens.	12.75–15		171	−843	−1216	−233		8.5	5.4	4.1	7.1
USA	*Pseudotsuga menziesii* Site I	17–18		−29	−211	132	−35		8.0	7.7	8.1	7.9
USA	*Pseudotsuga menziesii* Site III	13–14		−779	−621	−392	−1125		6.5	6.9	7.4	5.9
Venezuela	*Eucalyptus urophylla*	25		2905	1343	869			22.4	10.4	12.4	

4.3. Oceania and South Africa

New Zealand, Australia, and South Africa share moderate climate characteristics, along with planting of exotic pines originating in North America. The IRRs for pines ranged from 3% in South Africa to 9% in New Zealand, and eucalypt in South Africa was almost 25%. *Pinus radiata* in New Zealand had a positive LEV, at $620 USD per ha, along with eucalypt in South Africa, at $4000 per ha. These countries all serve small domestic markets. Australia and New Zealand also provide a large amount of exports to China, which gave them high timber prices of up to $55 USD per m^3 in 2017 for large sawtimber size logs. South Africa also plants eucalypt as an exotic species; we lack timber return data for it as a native species in Australia. Reported growth rates for pine and eucalypt ranged from 16 to 25 m^3/ha/yr.

4.4. Asia

On paper, timberland investment opportunities in Asia provide the best opportunity for large investment returns, excluding land. These results are based on relatively high establishment costs, excellent prices, and *Eucalyptus* and *Acacia* species growth of about 20 m^3/ha/yr. Pulpwood prices were more than $30 USD per m^3 throughout Vietnam and Laos, driven by imports by China and Japan. In fact, China had the highest pulpwood prices reported in our the world in our surveys, at almost $80 USD per m^3.

Large landowners in China and Laos and small landowners in Vietnam all reported data that led to IRRs of more than 20%. The large IRRs translated into large LEVs as well, of $400 to $9000 USD per ha. State *Acacia* hybrid forest returns in Vietnam and slower growing *Pinus massoniana* returns in China were only equal to 8%, while outgrower *Eucalyptus spp.* returns in Lao PDR were 12%. However, assembling large land holdings of desirable land in these countries and sorting out national and community land tenure rights does present major challenges that are not represented in our narrowly defined timber management scenarios. In addition, the levels of forest management genetics and silviculture are the least well developed in Asia (other than Central Africa), so investors must develop a large amount of their own capability, at their own expense.

The Credendo (2019) risk ratings for Asia are extremely variable. China has the best ratings, with a 1 or 2 rating for the export, political, and investment risks, except for a 5 for expropriation or threat of government action. Vietnam is intermediate, with 3s or 4s; Loa PDR is poor, with all 6s or 7s.

A few authors' observations here might help augment the numerical findings. Asia has a large deficit in timber supply in China, India, and Japan, leading to very high prices for roundwood in each country, as well for the computed timber investment returns. On paper, Asia had our highest calculated timber investment returns. In reality, however, these cover the smallest in-country industrial timber plantation areas in relation to the amount of wood consumption. This indicates a potential high opportunity cost of land for agriculture and urban uses to support the vast population. In fact, most of the forest land is relegated to very poor sites such as mountain sides or distant lands, so has relatively poor growth rates even for exotic species.

In China, the national government owns and manages the forests in northern China, and the local governments and communes control most land in Southern China (Zhang et al., 2019). Southern governments have just begun to arrange 25 to 50 year land tenure rights for locals and foreign investors to plant forest, which is still difficult. Land areas are very small—a hectare or less—and there is considerable demand for good land with agriculture or developed areas. Roads are poor on the mountainous regions possible to plant commercial forests, and the quantity of professional and technical managers per unit of area are the highest in the world. Overall, the land tenure rights favor domestic landowners at best, and considerable institutional and infrastructure challenges exist for investments in each Asian country. Foreign investors would also need to establish means to make and expatriate profits.

4.5. Timber investment trends, 2005–2017

Table 3 summarizes trend data in the capital budgeting results from 2005 to 2017 for a smaller set of countries and species with more than one data point between 2005 and 2017. In general, the data indicate that timber investment returns in most countries increased from 2005 to 2008, were relatively stable from 2008 to 2011, decreased slightly in 2014, and dropped most markedly in 2017. This trend generally follows a parallel trend in timber prices during this period, which peaked in the U.S. South in 2008 at the time of the major recession, and dropped significantly after that. Other countries in the world were less affected by the U.S. recession and housing crash, but still slowly began to experience slower declines in timber prices until 2017.

For softwood timber, the U.S. was the unfortunate trend setter, dropping from an IRR for *Pinus taeda* (loblolly) without land of 9.5% in 2005 to 3% to 4% percent in 2014, and increasing slightly to 6% to 7% in 2017. Brazil IRRs for *P. taeda* were more stable, increasing from 16% in 2005 to 23% in 2011, and then declining to 14% in 2017. Radiata pine in Chile had slightly lower growth rates and returns, at 17% in 2005, decreasing slightly to 13% in 2017. China pine timber investment returns ranged from 12% in 2008 to 8% in 2017. Radiata pine in New Zealand ranged between 8% in 2011 to 8.8% in 2017, prompted by higher prices for exports to Asia. Douglas-fir (Pseudotsuga menziessi) on the U.S. West Coast had the most stable returns at about 8% for each period, since it had a mix of domestic and Asian export markets that helped maintain good timber prices.

Returns for planted exotic hardwood species, mostly various species of exotic eucalypt for pulpwood, were generally better than for pines due to the high growth rates. Eucalypt pulpwood and sawtimber IRRs without land exceeded 20% in Brazil in 2005 and 2011, but dropped to 8% for pulpwood and 11% for sawtimber in 2017. Pulpwood does dominate eucalypt production in Brazil, with perhaps 90% of the roundwood. Eucalypt pulpwood IRRs in Chile and Uruguay were about 12% to 13% for most of the period. IRRs for eucalypt energy and sawtimber purposes in Paraguay were greater than 15%, and were greater than 20% in China and Mexico.

While average investment returns in many countries outside of Asia declined somewhat until 2014, there was some improvement in 2017. This was due to slightly more stable to increasing timber prices, and some decrease in costs. For example, Callaghan et al. (2019b) examined trends in forest management costs in the U.S. South from 1982 to 2016, and found that the overall real cost of intensive silviculture fluctuated around the base level starting index of 100, although the employee wage index did increase.

4.6. Returns with land costs

The net returns without and with land costs help provide a more complete picture of timber investment opportunities in those countries and the effect on the LEV and IRR with land costs, and also provide some inferences for approximate reductions in returns that might be expected with land costs in other countries. The results for the effects of selected land cost additions are summarized in Table 4.

The returns with and without land costs follow the pattern that one would expect. Timber investments that do not include land costs have much better returns than those with. In fact, adding the cost of the land in the first year and receiving it as income in the last year of a rotation essentially reduces the LEV by about as much as the cost of the land. Less apparently, it reduces the IRRs by 3 full percentage points in the U.S. South; 5 percentage points in New Zealand; and 8 percentage points in southern Brazil, depending on the price of the land.

Table 4
Timberland investment returns with land costs for selected countries, 2017.

Country/species	Land price (USD$ / ha)	Land expectation value @8% (USD$ / ha)		Internal rate of return (IRR) (percent)	
		Without land	*With land*	*Without land*	*With land*
Brazil *Pinus taeda*	5500	3099	−2410	14.3%	6.2%
Brazil *Eucalyptus spp.* Pulpwood	5000	34	−4965	8.1%	2.6%
New Zealand *Pinus radiata*	4500	621	−3902	8.9%	4.2%
USA *Pinus taeda*	2000	−560	−2560	5.9%	3.2%

The bottom line here is that for new investors, land prices will be crucial in determining timberland present values and IRRs. Existing landowners may well have bought when land was cheap a decade or two ago, or even inherited land from their family. If they consider land as a sunk cost, timber investment returns will be much better. If they include land costs as a foregone opportunity in their analysis, timberland investments will not fare as well. However, if one compares high IRRs without land as being similar to buying that land and planting agricultural crops, forestry may look acceptable.

On the other hand, in much of the Southern Cone of South America, the sunk (and cheap) land costs are one major reasons that vertically integrated pulp and paper companies have not yet sold their timberland asset. First, they make handsome profits on just growing timber—-among the best in the world based on the excellent growth rates. Second, if they cashed out and sold their now high-priced land to agriculture interests, they would not be able to furnish their large mills. These tradeoffs between site quality, current land prices, and scarce land help early timberland investors fare better than new investors, and adversely affect IRRs and LEVs for new investors with large land costs.

Even without calculating a full set of returns for land for the additional countries, we also can examine the LEVs to make a subjective estimate of whether the country/species scenarios are apt to have a LEV greater than the cost of land for each country and species at the designated 8% discount rate. This is unfortunately quite easy for many countries. Any country/species combination that has a negative LEV clearly will not have free land, or payments to own land, so cannot earn 8% including the price of land.

The United States actually has some of the cheapest land of the major forest producing regions in the world. Almost no country in the world that we analyzed is apt to have land prices of much less than $2000 per ha; thus the LEVs would have to at least exceed this cutoff to earn 8%. In fact, most countries will need to have a LEV of $4000 per ha or more to meet an 8% or better return. This narrows the other countries that might earn 8% with land to eucalypt in China (LEV or $9479 per ha), Paraguay ($4937 per ha), South Africa ($4112 per ha), or Lao PDR ($6103 per ha). *Gmelina* in Costa Rica ($5818 per ha) and teak in Mexico ($18,537 per ha) also meet this likely standard. However, available land in most of these countries is scarce.

5. Discussion and conclusions

5.1. Methods

This research on global timber investments extends efforts that we made in the past for another period, and covers several new species and countries that we have not collected data on previously. We have cooperated among the authors as experts in each country to identify the most important species and to collect data from local foresters and scientists. We then used standard capital budgeting techniques to estimate returns mostly to plantation forest management, assuming no land costs or income taxes (but with property taxes)—essentially a discounted cash flow analysis of returns before interest, taxes, depreciation, and amortization (EBITDA). This approach also allowed us to compare the theory of LEV land price calculations with the actual market prices in countries where data were available. Financial, political, social, export, and environmental risks also affect these investments.

The research approach and the data collection spreadsheet are similar to methods we have used before (Cubbage et al., 2014), and have proven to be robust and accurate, and sensitive to changing input prices and timber stumpage prices by product classes, as the logical trend analysis differences suggest.

The results calculated the stand level returns with a moderate fixed charge for administration—roads, fire control, insect and disease, and property taxes—of $30 per ha per year. This does not include organizational overhead such as management, accounting, analytical, biometrics, harvest scheduling, research, office, or infrastructure costs, which vary considerably from firm to firm and country to country. This might seem like a major omission, but that probably is not the case.

For example, a large timber investment management organization (TIMO) might have 50 employees to cover 1 million ha of land. A generous $200,000 salary and fringes per employee would be $10 million per year, plus maybe $2 million in administrative expenses would total $12 million in costs. That would equate to only $12 per ha per year, so would not distort the results, and indeed could be covered by the $30 per ha per year charge. Smaller areas may have higher costs, but these magnitudes would be fairly similar among all species, so would not diminish the value of our comparative benchmarking estimates provided here. In some countries where state forest ownership dominates, such as Poland and Vietnam, management costs may be much more substantial and state forest returns are smaller than private returns due to excess employment and high costs largely caused by government social goals rather than efficiency goals (Bis, 2009; Chudy et al., 2016; Frey et al., 2018).

We also have extended this analysis in a few cases to examine the effects of land prices to give a more complete picture of timberland investments, which of course substantially decrease the rates of return that one could expect. One could also easily extend such analyses to include common revenues such as hunting leases, at least in the U.S. or many other payments for environmental services such as carbon sequestration, although these would alter harvest decisions as well. But on balance, new forest environmental payments would either increase rates of returns roughly in proportion to the net increase in cash flows received, or they would be eschewed.

5.2. Findings, comparisons, and caveats

This applied research summarized the returns to typical forest investments for 54 different species and country combinations throughout the world using standard capital budgeting approaches. This extends the work from our prior research and from other literature, as recapped briefly here. Sedjo (1983) led in performing this line of research, and generally found relatively high IRRs for South America and Asia; lesser returns for Oceania and the U.S. South; and the smallest returns for Europe. This relative ranking seems to hold in our analyses, although returns for South America have fallen some, and returns fell even more for the U.S. South. Siry et al. (2001) found strong returns in the U.S. South, as we did up until 2008, but those have dropped substantially according to the 2014 and 2017 data. Based on huge increases in imports from China, as well as large imports from Japan, our estimated returns in Asia, however, increased from those found by Sedjo (1983), although we collected information for a completely different set of countries. Overall these broad trends are confirmed by the 16 related articles that we reviewed initially here from the literature.

Our latest data collection from 2017 indicates that timberland returns without land costs all earned modest to excellent internal rates of return (IRRs). About half of the species analyzed (27) would have a positive land expectation value (LEV) at the selected 8% real discount rate, with the brunt of these being in the Southern Hemisphere or Asia. With the cost of land, far fewer species/countries would have IRRs that exceed an 8% discount rate, and thus have positive LEVs at that rate. The Northern Hemisphere had lower levels of returns, but is widely considered to have less risk, a better business environment, and has relatively well established timber and land markets.

We estimated returns for a key set of U.S. South, New Zealand, and Brazil species and regions that we had good land price data for, and found that these rates of return would drop by as much as 3 (U.S. South pine) to 8 percentage points (Brazil eucalypt) if land were included as a purchase and then sale cost. This would drop total returns for new investors to 2.6% to 6.2%, respectively, including the price of land.

Overall, timber investment returns in the Northern Hemisphere decreased in 2017 from those calculated in our prior surveys. Our reported returns in 2017 also were generally much less than those reported in prior studies reviewed in the preceding literature review (e.g., Sedjo, 1983, and most others). The decreased timber investment returns could be partially attributed to the major recession in the U.S in 2007, which decreased world demand for sawtimber products for at least a decade. Concurrently, the U.S. South and South America increased their forest productivity continually, growing more timber per unit of area, and contributing to a much faster increase in inventory and supply than the increase in demand. South America and Asia also increased their area of planted forests (Nepal et al., 2019). Large increases in demand in Asia continued to bolster their stumpage prices and potential investment returns, if land could be found to plant and grow industrial timber plantations.

Our approach to benchmarking forest investment returns provides useful data for assessing comparative advantages among forest countries, and helps investors, foresters, and policy makers consider the merits of the forestry sector and their economic development opportunities. The economic return results we found conform well to those found in individual studies that have been published by other researchers, although perhaps those in the literature are somewhat higher than those we estimated for the Northern Hemisphere. Many of the prior North American studies were performed a decade ago when timber prices were much better. Our discounted cash flow / capital budgeting approach and that of prior authors were basically the same, and the growth rates we used were generally equal to or greater than prior literature—before better tree improvement and silviculture were practiced. Callaghan et al. (2019a) suggest that at least in the U.S., timber planting and management practices have not had large cost increases over the last few decades. So our findings of lower average returns would seem to be most attributable to lower timber prices in 2017.

Various caveats do bear consideration in our approach, and indeed all similar studies we reviewed in the literature. We did use a deterministic, discounted cash flow, capital budgeting approach to estimate timber investment returns, excluding the cost of land, with a fixed discount rate for all species and all regions, through the entire period of analysis. We estimated establishment and management costs and timber prices as a point estimate for 2017. The timber prices were representative of the likely range of prices afforded to the seller in the future; the seller doesn't have to sell in a particular year. They will be selling in a year of their choice. So the relevant price is their estimate of the likely range of prices available in the future.

Using fixed factor costs and timber prices assumes that all variability in those prices or macroeconomic effects such as foreign exchange or political risk are constant and do not alter the results, at least at that point in time. One would expect that different factor costs or timber prices will alter these calculated investment returns, with higher costs decreasing returns, better timber prices increasing them, and vice versa. Foreign exchange rates as estimated in US Dollars affects planting and management costs most in the Southern Hemisphere and Asian countries, and especially timber prices received for export-dependent countries. Discount rates may vary by country, and perceived discount rates have declined somewhat in the 2010s. Including land costs will decrease overall timberland investment returns substantially—by at least 3 to 8 percentage points (300 to 800 basis points)—and are quite variable within and among different countries. Individual investment analyses of timberland should consider all of these factors in more detail. We provide a companion paper by Chudy et al. (2019b) in this Special Issue which does analyze the stochastic effects of variability of some of these key factors on timber investment returns.

5.3. Timber asset implications

In general, timber investments compare relatively well with other assets, but do have lower rates of return on average than U.S. stock markets in the last decade. Timberland does bring unique contributions to an investment portfolio as an asset that is not correlated with the stock market (Lutz, 2018). Furthermore the variation in returns in stocks and bonds as evidenced by U.S. markets (Damodaran, 2012) as a proxy is huge—almost two times greater than the means. Despite fluctuations, timber does not seem nearly as volatile, although investors surely hope for more upswings.

Hagler (2019) stated that the cumulative investment returns annual growth rate (CAGR) for timberland investments for institutional investors from 2008 to 2018 averaged only 4.3% in nominal terms, or 2.6% real. He compared this with a 7.9% nominal return and 6.2% real returns in equities, and a 10.0% nominal and 8.3% real return in real estate. He concluded this led to limited "net" capital coming into institutional timberland investments, with most growth occurring through separate investor accounts and direct investments.

As usual, the question is whether the trends of high returns for the stock market, low returns for bonds, and low returns for Northern Hemisphere timber will continue. If investors seek to match high stock returns, it might suggest that timberland investments in the more challenging countries in Asia or new afforestation countries in South and Central America will be more worth pursuing in the future—if the risks can overcome through careful investment selection and structure.

Land has often been considered as an inflation hedge, and land prices in most regions increased at least until 2010. With increasing population—and more arable land losses due to adverse weather under climate change—most investors believe that land prices will appreciate at a rate greater than inflation. This has attracted large amounts of capital to all land investments, and will increase returns for patient investors, such as high wealth individuals and families. For some owners, land ownership certainly brings a feeling of security as a timeless store of value, or intrinsic nonmarket values to many small and large private owners, albeit this offers far less merit to institutional investors.

5.4. Timberland investment and management implications

There are many ways to increase timberland investment returns other than buying bare land (or clearing land) and planting forests and waiting for final harvests. First, in many cases, timberland for vertically integrated forest products firms or for family owners was bought decades ago, when land prices were low, so the land cost basis is quite small. Early investors then can receive a relatively high rate of return on that smaller basis, which is a sunk cost. However, if they consider the sale of land as a foregone opportunity cost for making large windfall profits—such as the U.S. forest companies and Oceania governments did—then effective returns will be much less. Nonetheless, a small private family or high wealth investors are often willing to have the land store of value at a low cost and make moderate returns until some indefinite final sale or transfer to heirs occurs.

One can also make higher returns with a timberland purchase in various means. First, timber buyers usually buy land and timber together. They could make more money by simply paying slightly less than the "true" market value for either the land itself, or for the growing stock on the land, and then making more when any timber or land sales occur. Land prices are somewhat uncertain, and at least vary by location, site characteristics, timber markets, and landowner willingness to sell. Timber inventories for small or large tracts are uncertain. Simply taking advantage of imperfect knowledge can help timberland investors profit more. Furthermore, if a tract has a significant share of immature or young mature timber, buyers may increase returns by harvesting this timber and getting early cash flows before they begin to replant and incur those expenses. Another viable alternative would be to lease timber rights instead of acquiring the land. This strategy would reduce the initial costs as well as gain more liquidity in the investment in comparison to land ownership.

Second, timberland buyers also may sell some small parcels—say 5% to 10% of a large tract—for higher and better and uses (HBU sales)—development into other agricultural, housing, or commercial land uses. Major forest products companies, REITs, and many TIMOs make a specific practice of this. The sale of conservation easements on timberland has been a related profitable HBU practice for some timberland owners and TIMOs. These essentially sell some portion of the development rights for a tract of land, but retain the right to manage the forest for timber production or other natural resource uses. The timberland then usually must stay in timber, which can earn rates of return such as calculated here, although easements usually specify natural forest management, not plantations.

Third, managers may be able to make more money by indeed being better than average managers, with higher growth rates, lower costs, or better timber sales. Somebody of course must be below average, but this may fall to the lot of small woodland owners rather than large investors. This is still moot, however. Small owners may manage more themselves and have less costs than TIMOs and REITs, and thus greater IRRs, if not greater LEVs. In a related strategy, landowners can try to own more high site quality land and properties; this may favor small selective owners. Geographic diversity may, however, provide large owners more advantages in reducing overall timberland risk from natural disasters such as fire or hurricanes, or pathogens such as insects or disease.

Last, one can also make more money in timberland ownership by diversifying the goods and services managed beyond the timber returns analyzed here, and "stack" different types of returns. While nontimber products and services have been considered minor, their opportunities are increasing rapidly. Conservation easements are one type of nontimber payment. The common hunting leases in the U.S. South are another. Opportunities for carbon storage payments have been increasing slowly, but have more promise as climate change worsens, demands for mitigation increase, and government programs proliferate.

Other existing or potential forest income sources could include payments to protect endangered species, provide better water quality, buffer downstream communities against floods, develop wetland banks, site windmills or cell towers, or conversion to solar farms. Investments in the provision of such forest ecosystem services have been encouraged and forest companies have expressed interest in investing in the provision of those services to help with product certification, achieving their corporate social responsibility by being a good community citizen and their social license to operate (Koellner et al., 2010; Yao et al., 2017; Deal et al., 2017).

Of course, climate change also might increase risks to forestry investments, from insects and disease, fire, hurricanes, and floods. Climate change risks are not confined to forests alone, however. Damages to agricultural and urban land areas, and investment returns, also are at least as likely, and probably even much more expensive. So at least ceteris paribus, the returns we calculated here and their relative ranking with other investment classes are likely to remain valid or even favor timberland.

This plethora of opportunities for forest land can help existing forest owners earn more than just timber income, and may indeed be driving forest land sales and valuations that exceed the pure timber cash flows and returns that we have calculated here. This area of nonmarket returns and actual investor uptake can also provide a wide field for future forestland investment returns research (Matthies et al., 2015). Overall, the base timber investment returns collected and analyzed here can help investors and policy makers understand the forestry sector and opportunities better. They must of course follow up on these benchmarks with their own detailed evaluation of specific tracts or public programs to determine the merits of timberland—both for timber and for other goods and services—as an investment.

Declaration of Competing Interest

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Appendix A. Supplementary data

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