Tampere University of Applied Sciences

Possible forestry investment returns in emerging Europe

– comparing theoretical 'generic forests' representative of selected countries

Peter Chappell

MASTER'S THESIS

December 2019

International Forestry

ABSTRACT

Tampereen ammattikorkeakoulu
Tampere University of Applied Sciences
MSc. International Forestry

Peter Chappell:

Possible forestry investment returns in emerging Europe

– *comparing theoretical 'generic forests' representative of selected countries*

Bachelor's thesis 134 pages, appendices 64 pages
December 2019

The merits of forestry investment in different countries depends not just on the local silvicultural forestry credentials, but also local costs of capital or discount rate, inflation, risk, and land acquisition costs. The objective of this thesis was to analyse which nations in the 'emerging Europe' region would be the best places to consider for forestry investment. The study area was defined as Estonia, Latvia, Lithuania, Poland, Hungary, Slovenia and Romania. Finland was also included as the base of the study.

A Discounted Cash flow (DCF) approach was used. Internal Rate of Return (IRR), Net Present Value (NPV) and Land Expectation Value (LEV) metrics were calculated. The DCF was built on assumptions of a theoretical private forest property featuring representative attributes of that country. Critical characteristics such as area, tree species, crop development stage, land acquisition costs, timber prices and so on, were obtained using open source data or by reference to literature. The IRR, NPV and LEV metrics were collected for three scenarios considering country's owns costs of capital and inflation (scenario 1), standard costs of capital and country's own inflation (scenario 2), and finally standard costs of capital and standard inflation (scenario 3).

From an NPV standpoint, Hungary was found to be the most desirable location for investment offering the greatest wealth return. Hungary also had the greatest LEV, but this did not consider land acquisition cost. However, IRR was deemed the most meaningful metric to compare rates of return, and the result under all scenarios was that Latvia was found to exhibit the greatest IRR.

In the future the results could be enhanced through: consideration of different forest types, such as exotic species plantations, incorporation of better DCF assumptions through availability of more open source data or research cooperation, incorporation of taxation into the DCF, account taken of risk variance between nation's contingency costs, valuation amendment to account for management flexibility and sensitivity analysis of possible future inflationary and capital cost variance.

Key words: forestry, investment, IRR, NPV, LEV, emerging Europe

CONTENTS

ABBREVIATIONS

TAMK	Tampere University of Applied Sciences
cr	credit
TIMOs	Timberland Investment Management Organisations
FBA	Forestry Business Analytics
NPV	Net Present Value
IRR	Internal Rate of Return
LEV	Land Expectation Value
DCF	Discounted Cash flow
TV	Terminal Value
UNECE	United Nations Economic Commission for Europe
HBU	Higher and Better Use
CAPM	Capital Asset Pricing Model
WACC	Weighted Average Cost of Capital
ROA	Real Options Analysis
LVD	Land Value Differential
FAO	Food and Agriculture Organisation
CEPF	Confederation European des Propriataires Forestiers
LUKE	The Natural Resources Institute of Finland
RMK	Estonian State Forest Service
ZGS	Slovenian State Forest Service
REIT	Real Estate Investment Trust

TERMS

In this thesis, ‘forestry’ and ‘timberland’ as terms shall be interpreted to have the same meaning. In the interests of consistency, ‘forestry’ shall be the preferred term, unless in relation to discussion of a specific author’s research, where the author has favoured the use of ‘timberland’. In this case ‘timberland shall be retained as a term so as to be consistent with the author’s intent of meaning.

1 INTRODUCTION

1.1 Background and rationale of thesis question

In the US, timberland investment has been recognised as an area where long term, low risk investments can be made (Mei 2017, 1). However, ’emerging Europe’ has been cited by a number of commentators as a region where investment into forestry or timberland by institutions and / or Timberland Investment Management Organisations (TIMOs) is also possible, and has been expanding in recent years (Dasos 2010, 2; Fu 2014, 80).

What is meant by the term ’emerging Europe’? The area first encompasses the eastern European counties that joined the EU in 2004. Then, to a lesser extent, countries that are considering future assertion to the EU. Least of all they include countries that could potentially in the future consider assention. Emerging Europe thus includes Bulgaria, Estonia, Czech, Hungary, Latvia, Lithuania, Poland, Romania, Slovakia, and Slovenia initially, as 2004 entrants. Then, Croatia, FYR Macedonia and Turkey as considering assertion (Croatia did go on to join in 2013). Finally, Albania, Montenegro, Bosnia-Hertzgovenia and Serbia as possible future candidates. (Herrmann and Winkler 2008, 3)

Emerging Europe was illustrated geographically by Forestry Consultants ’Forestry Business Analytics’ (FBA) in a blog in 2018 (Forest Analytics, 2018). FBA characterised emerging Europe as a frontier market based on Eastern Europe and with the Baltic countries as a ’developed growing’ market as illustrated in figure 1.

It seems that the term ’emerging Europe’ can be applied loosely to various countries within eastern Europe, depending on the author in questions context.

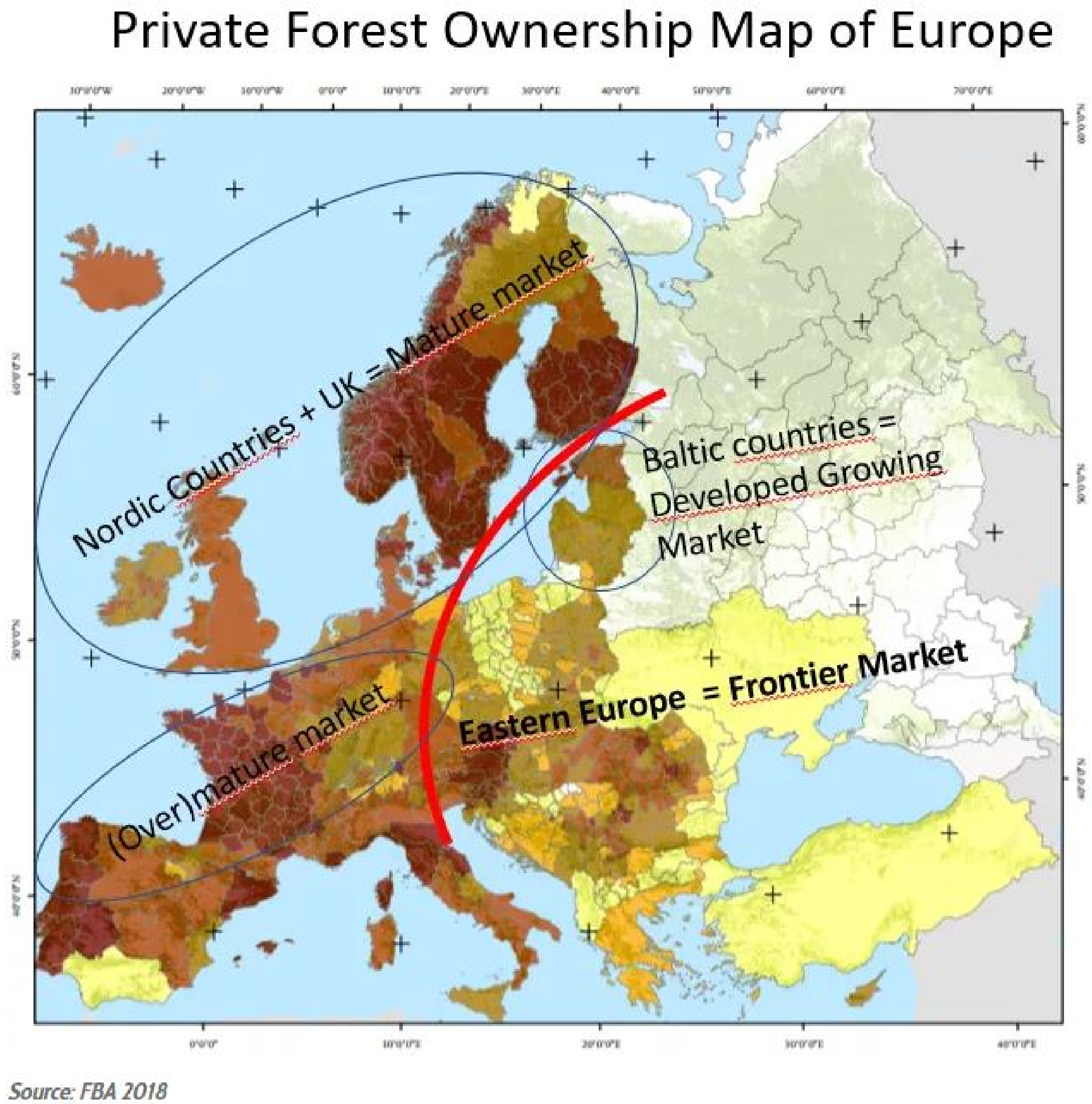

Figure 1: Forestry Investment Zone of Eastern Europe (after FBA, 2018)

Fu (2014, 101) notes that TIMOs should consider the business and regulatory environment of the country in which deals are located to ascertain suitable investment hurdle rates. Vicary (2006, 5) considers the issue of TIMOs investing in new emerging economies and asserts that a thorough country risk assessment when entering into a long term forestry investment is critical. However, investing in forestry in emerging Europe involves considering or comparing a significant number of nations with different business environments.

The nature of forestry investments between different nations will have different forestry environments, such as tree species present, growing conditions, rotation length, management costs, stumpage values and timber markets. These technical factors will strongly influence the investment merits between nations (Fu

2014, 99). Chudy *et al*. (2020, 8) compared Internal Rates of Return (IRRs) from a number of nations globally including Poland. They found that Polish pine plantations delivered a low IRR of 1.85-2.96 %, but that the risk profile was also correspondingly low, especially compared to Chilean or Brazilian eucalyptus.

Emerging Europe features diversity of nations and political administration. Within the literature there is no existing study comparing potential forestry investment returns between the different nations within the emerging Europe area. Therefore, the ambition of this thesis is to start to address this problem through evaluation of potential forestry investment returns within the region of emerging Europe.

The objective will be to determine the relative potential merits of forestry investment between the nations of emerging Europe, and to make conclusions as to which nations are the most attractive as locations for forestry investors to consider as potential target areas for investments.

1.2 Approach to compare potential forestry investment returns

How should such an evaluation of forestry investment, from an investment perspective be undertaken? This question is forward looking, it considers where should forestry investment be considered for future investment returns, rather than what have forestry investment returns been in the past. Therefore, the approach used is based on the field of forestry investment appraisal, considering an investment to be made now of a forest property asset in each of our target nations.

In chapter 2, a literature review is undertaken considering forestry property investment appraisal techniques. This review will aim to identify what are the most appropriate techniques to use to evaluate possible forestry properties for investment acquisition, such as Net Present Value (NPV), Internal Rate of Return (IRR) and Land Expectation Value (LEV).

LEV can provide useful context as it equates to what forests are inherrantly the best as investments. However, it does not include land acquisition cost and so cannot be used to form conclusions from the perspective of a new investor considering acquisition.

One important tool in forestry investment appraisal is Discounted Cash Flow (DCF), which requires use of a particular discount rate, and can be used to calculate NPV. There are a number of approaches that can be used to approximate what an appropriate discount rate is. These techniques are further explored in the literature review and based on these findings, an appropriate methodology to select discount rates is recommended.

DCFs require a Terminal Value (TV), to represent the value of the business in the cash flow into the future beyond the end of the cash flow period. TV calculation typically includes the annual net income (free cash flow), the discount rate, and can be based on a presumption of steady annual free cash flow in perpetuity. However, the TV in forestry investment is different than other types of investments with steady annual free cash flow, due to the irregular nature of costs and incomes that are a feature of forestry investments. This cash flow irregularity can be accommodated through calculation of a Land Expectation Value (LEV) along with a valuation of residual timber crops in the final cash flow year, in order to arrive at a total TV. How the LEV and intermediate crop value calculation should be accomplished is investigated in the literature review.

One weakness with the DCF approach is that assumptions of future incomes and costs are static, whereas in the real world forestry investors enjoy management flexibility, for example to choose when to realise timber income, alongside fluctuation in costs and income rates. Management flexibility is pertinent to the factors of timber price change and land value appreciation, which are important drivers in forestry investments. In the literature review, a variety of more complex techniques are identified as appropriate ways to place value on this management flexibility.

Another problem with the NPV approach when comparing forestry investments is that it does not consider the amount of capital that is required. For example, the

NPV from a large forestry acquisition may have a superior NPV, but a lower return per unit of capital invested compared to a smaller investment. This issue can be dealt with through using an Internal Rate of Return (IRR), instead of using of an NPV to compare different investments (MacLaney and Atril 2016, 572). The merits of use of IRR in our investigation is explored in the literature review.

The next question is how can one compare the possible forestry acquisitions of an entire country against another country? A DCF financial appraisal created to calculate a NPV or IRR can evaluate a proposed investment of an individual forest property through acquisition, but within any one nation there are thousands of differing forest properties. Furthermore, the differential in investment merits between these properties may be far greater than the differences between individual nations.

The problem has been approached in this thesis by use of 'generic forests' as acquisition targets for evaluation. Each generic forest is a theoretical forest property featuring forestry and economic characteristics deemed to be representative of each nation. The generic characteristics have been generated from open source data available from the United Nations Economic Commission for Europe (UNECE), and various other sources, such as published research and statistics offices of the respective countries. The most recent data available has always been used and where the best information available is more than 2 years old it has been inflated using appropriate rates local to the country in question.

Another matter is what kind of investment scenario, in terms of discount rates and inflation rates, is most appropriate? If we presume that the prospective investor is a TIMO, are they domestically based or international? If they are domestic, then the cost of capital, or discount rate, would be most appropriately obtained from the country in question. On the other hand for an international TIMO, the cost of capital may be less linked to the country where the investment is located and a standard cost of capital rate used across different countries may be more appropriate. Overall, the international TIMO route is more reflective of the idea of comparing nations, and so this scenario will be selected to produce final conclusions. However, the domestic TIMO result can provide useful context.

The other question is that of inflation. Whether or not the TIMO is domestic or international, the forestry investment will be located within a countries own inflationary environment. Therefore, a countries own rate of inflation is applicable. However, investors may be considering investment over long time periods, in which case use of current inflation rates in DCFs may be inappropriate as the actual inflation rate may change over time relative to the expected rate (Hoyt 2015, 1). Therefore, for the case of the international TIMO, an additional scenario will be considered using a standard inflation rate projection for all target nations.

1.3 Summary of objectives

The objective will be to determine the relative merits of forestry investment between the nations of emerging Europe, and to make conclusions as to which nations are the most attractive as locations for forestry investors to consider. The tool used will be a DCF generated for each nation from mean data representative of a 'generic private forest' in the respective country. NPV, IRR and LEV metrics will be generated from the generic forest assets, compared, and discussed.

The DCFs will be run considering 3 scenarios:

1. Domestic TIMO: countries own discount and inflation rates
2. International TIMO: standard discount rate but countries own inflation rate
3. International TIMO: standard discount and inflation rate.

A summary of the output metrics is displayed in table 1.

Table 1: Summary of output metrics

	Scenario 1: Domestic TIMO	Scenario 2: International TIMO	Scenario 3: International TIMO
Output metric	Own country discount rate and inflation rate	Standard discount rate and own country inflation rate	Standard discount rate and inflation rate
NPV	NPV_1	NPV_2	NPV_3
IRR	IRR_1	IRR_2	IRR_3
LEV	LEV_1	LEV_2	LEV_3

Finally, conclusions will be drawn as to where are the best places in emerging Europe to consider for forestry investment by TIMOs or other international forestry investors.

1.4 Structural weaknesses of the approach

The largest structural weakness of the approach is that the results will not address the question of whether or not in a real world situation a forest property from one country would be a better investment that a forest property from another country – this would require a bespoke evaluation considering the characteristics of those unique properties.

Also, the impact of cost of capital and inflation may be large. The approach of multiple scenario's under divergent cost of capital and inflationary environments highlights that in practice the merits of the forestry investment will be altered not just by the target countries own forestry and business environment, but also by the characteristics and investment criteria of the investing entity.

Moreover, using generic forests with generic pricing from the country as a whole will mask that in practice TIMOs may be willing to bid on forests where the underlying LEV demonstrates that the forest has sufficiently attractive investment credentials. However, in practice TIMOs are likely to benchmark their purchase price offers against a bespoke evaluation. Of course, if the market price for forests is higher than the purchase price value that any TIMO can attribute to the asset, they are unlikely to be successful in the market.

1.5 Scope of emerging Europe

In chapter 3 a justification of which nations form part of the forestry investment region of emerging Europe is built. Estonia, Hungary, Latvia, Lithuania, Poland, Slovenia and Romania are identified as the emerging Europe's forestry investment area. Finland as the base of the studies is also included for contextual reasons.

1.6 Outline of results and basis of assumptions made

In Chapters 4 & 5 the forestry property characteristics needed to order to build the generic DCF for each country are investigated and appraised. These characteristics include, forest size, tree crops (species) present, timber prices, forestry land prices, silvicultural costs and so on. These characteristics are primarily sourced from the UNECE data and where necessary supplemented by literature and other sources. The DCFs themselves are displayed in the appendices. A data hierarchy approach has been used with the UNECE data being the preferred source for forest characteristics. Where available, this has been supplemented by the statistical offices of the respective nations for generic country averages for information such as property purchase costs, timber values and so on. Where national statistics offices are not available, literature has been sourced that considers national averages within it and referenced as such. Finally, where no other source has been available, unpublished internet research has been used.

In Chapter 6 the IRRs, NPVs and LEVs produced from the DCFs are described and noteworthy elements are highlighted. In chapter 7 from the summarised results conclusions are drawn.

2 Literature Review

2.1 The context of Forestry as an investment

There are a number of general attractions of forestry as an investment. Firstly, timberland, as the producer of a commodity (timber), has been identified by many as an asset class with characteristics attractive to investors seeking to hedge inflation (Wan, Mei, Clutter and Siry 2013, 93; Hoyt 2015, 1). On the other hand, Roach and Attie (2009, 27) found that the effectiveness of commodity producing real assets', such as forestry's, effectiveness at reducing the impact of unexpected inflation varied depending on time scale. Also, non-direct ownership vehicles such as public equity timberland investments may not have the same inflation hedging attributes as direct ownership vehicles (Hoyt 2015, 1) However, forestry undoubtedly has a strong reputation as an inflation hedging asset class backed by its credentials as producing its commodity for sale, timber, over a long holding period (Parajuli and Chang 2015, 3).

Another attractive feature of forestry is that investment portfolios which diversify into forestry have a high probability of success in improving portfolio risk adjusted returns, due to the low correlation between timberland returns and equity returns (Carroll 2003, 1). Diversifying investments into forestry benefits the risk adjusted returns of investment funds by the fact that forestry enjoys the characteristic of biological growth (of timber) independent of market conditions, the ability to hedge inflation, and low systemic risk with weak correlation to financial markets (Sun & Zhang 2001, 617; Yao & Mei 2015, 192).

However, it is also often the case that forestry performs well as an investment compared to other asset classes such as equites, not taking into account risk adjusted returns. For timberland in the USA, average returns were 8.5% from 1994 to 2013 against 8.7% for equities (Fu 2014, 81). Meanwhile the UK, 25 year annualised returns from 1992 to 2017 were 9.2% for forestry, against 7.6% for equities (MSCI IPD 2017, 1).

The underlying factors driving forestry investment returns are similar to the drivers that improve risk adjusted returns in funds:

- Biological growth
- Timber price change
- Land value appreciation
  (Dasos 2010, 6; Yao, Mei and Clutter 2014, 943; International Woodland Company 2019; Chudy *et al.* 2020, 7).

Biological growth, timber price change and land value appreciation will be explored in further detail later, but first it is necessary to introduce the context of the field of forestry valuation.

2.2 Forestry valuation

The International Valuations standard (IVS 2017, 8), internationally accepted as the primary standard for valuation of property / real estate, outlines that valuation approaches can be classified into one of three categories: the market approach, the cost approach and the income approach.

2.2.1 The market approach

The market, or ‘comparable sales’ approach, uses evidence of previous transactions in order to form a basis of value. There are a number of major drawbacks to this method considering forestry property.

Firstly, forestry asset transactions tend to be relatively few in number and so the evidence base may be slim. This characteristic has been noted in New Zealand (Cheung and Marsden 2002, 9), in the UK (RICS 2010, 8) and in the USA (Harris, Singleton, Mai, and Straka 2018, 193).

Secondly, forestry assets inherently are heterogeneous in nature, and the assets featured in previous transactions are unlikely to exactly replicate the subject property (RICS 2010, 8). For example, a crucial factor in forestry asset value is a forecast of log prices, which will vary (Cheung and Marsden 2002, 10). Furthermore, site factors such as species composition, productivity, maturity, past silviculture and other factors may influence value and make past market comparable transactions inaccurate (Phillips, McDonald, Little and Phelan 2013).

Thirdly, the evidence base of previous transactions is backward looking. Whilst previous transactions are of interest, the inherent value of forestry assets is derived from their capability to generate income in the future from timber sales. Therefore, what is critical is prospective buyers' views on the future value of the commodity (i.e. timber) at the point in time at which it is likely to be harvested. The harvest could be decades into the future, and so an opinion on value requires a speculative view of future market conditions for timber. Backward looking sales data may not therefore reflect the future value outlook of the subject asset (Fu 2014, 98).

2.2.2 The cost approach

Leech and Ferguson (2012, 28) suggest the reason that a cost approach may be used could be a preference to value young stands *'on the basis of replacement cost, for the purpose of harmony with accounting practice and maintaining objectivity*'. The cost approach is based on the principle that '*a purchaser will pay no more for an asset than the cost to obtain one of equal utility whether by purchase or construction*' (IVS 2017, 51). The case of equal utility by purchase can be broadly equated to the market approach. However, the cost approach of an asset of equal utility via 'construction' in a forestry asset poses difficult questions. What is the cost of 'constructing' a forestry asset?

In most cases, forestry assets contain trees that may be aged in years or decades. Since it is not possible to 'construct' stands trees of particular ages, it follows that these trees would need to be grown from seedlings in order to 'construct' the asset; a process it then follows that could take years or decades. This long construction timescale would mean that the cost to a prospective buyer should incorporate the opportunity cost of the equity invested in the construction. The opportunity cost of the capital invested could significantly inflate the invested capital required, depending on the costs of capital and the time requirement. Furthermore, this long term construction approach is theoretical only, as in practice a purchaser would not be willing to wait for decades in order to construct a forest asset from scratch. Exceptionally, it could be a realistic option, if the investor required a young forest, the market cost of a young forest was significantly greater than the cost of creating a young forest from scratch, and the investor was willing to accept a construction timescale of a small number of years. However, in practice due to difficulties of 'constructing' trees in a timely manner, the cost approach probably has very limited application to forestry investment relative to other types of property investments (IVSC 2012, 58) and is most applicable only to stands of young trees (Leech and Ferguson 2012, 28).

2.2.3 The income approach

The most applicable valuation method for forestry investments is the income approach (Cheung and Marsden 2002, 9; IVSC 2012, 9; Leech and Ferguson 2012, 23; Phillips *et al.* 2013, 18; Fu 2014, 98; Harris *et al.* 2015, 193). The income approach capitalises future net income streams derivable from the asset into a 'present value'.

<u>Net Present Value and Internal Rate of Return</u>

The technique required in order to calculate present value of future net cash flows is discounting, and the value derived from the sum of future net cash flows is the Net Present Value or NPV. Discounting ensures that the time value of money is accounted for. Future costs and incomes are discounted in a compound manner back to the present at a selected discount rate representing the time value of money and summed to derive an NPV via a Discounted Cash Flow (DCF). In investment, a DCF that generates a positive NPV suggests that the investment is desirable and a DCF that generates a negative NPV is undesirable (MacLaney and Atrill 2016, 564).

Another metric ancillary to NPV is the Internal Rate of Return or IRR, which is equivalent to the discount rate at which the summed future costs and incomes or NPV equals 0. IRR can be used to determine value by deciding an appropriate hurdle IRR and setting the property value (or acquisition cost) within the costs and incomes in the DCF to achieve this desired threshold IRR. IRR can also be used as comparison metric to evaluate which in a series of options is the optimal from the point of view of return on capital, but not necessarily overall wealth, as the IRR does not consider investment scale (MacLanely and Atrill 2016, 568).

Discount Rate

Due to the long-time scales inherent in many forestry investments, discount rate is an important factor in determining valuation (IVSC 2012, 11). Discount rate should take account of three factors which together can be described as the opportunity costs of finance, or the time value of money. Firstly, there is inflation. If an investor placed funds into an asset and in the future received the same amount back in cash, then the actual buying power of the funds would have diminished due to the impact of inflation. The second factor is the interest lost. By placing cash into a forestry asset, then we are deprived the value of the interest that could be earned from the cash in the bank or in low risk investments whilst we are owning the asset. Finally, there is the ’risk premium’, or non-systemic risk pertinent to the individual investment to consider (MacLanely and Atrill 2016, 560).

If we applied a discount rate to the forestry investment equivalent to the interest foregone and taking account of the inflation effect, then the value of the forestry asset as an investment would be the same as placing the funds into the bank or other virtually risk free investment. However, forestry investment entails more risk than virtually risk free investments, such as cash in the bank. The forestry asset could be exposed to systemic risk affecting the entire market such as economic cycles, and non-systemic risks specific to the asset in question such as fire, pests, diseases, fluctuation in forestry costs and fluctuation in timber values (Phillips *et al.* 2013, 48; Bartosova 2015, 70; Chudy *et al.* 2020, 2).

Risk could be expressed as:

$$R_{for} = R_f + R_m + R_a$$

Where:

R_{for} = Risk of forestry investment

R_f = Risk free rate such as cash at bank, or bonds

R_m = The systemic risk that affects the whole economy such as economic cycles

R_a = The non-systemic risk attributable specifically to the asset

This framework to consider risk will be the approach used in the generic forest evaluation and will be further explained in the methodology.

2.2.4 Use of Net Present Value

The NPV is the sum of future cash flows from the investment, adjusted to take account of the time value of money by discounting. To compare which investments are the most lucrative for the owners of a business using the NPV approach, it is simply a case of seeing which of the NPVs available is the greatest. A positive NPV represents a desirable investment, and when comparing investments, the greatest NPV should provide the greatest wealth to the owners of the business (MacLaney and Atrill 2013, 564).

Discounting the value of money in a future year to the present can be expressed as:

$$PV = \frac{FV_r}{(1 + Cf\%)^i}$$

Where:

- *PV = The value of the net cash flow discounted to the present*
- *FV_r = The value of the net cash flow in the future year 'r'*
- *Cf% = The opportunity cost of finance - the rate of discounting of future cash flows which translates them into a present value*
- *'i' = The number of years into the future in which the net cash flow is obtained*

(Straka and Bullard 1996, 2)

In order to calculate NPV, the discounted net cash flow from all future years must be summed.

Thus:

$$NPV = \sum_{\mathrm{i}=1}^{\mathrm{r}} \left(PV_{i_1}\right) + \left(PV_{i_2}\right) + \left(PV_{i_3}\right) + \left(PV_{i_4}\right) + \cdots + \left(PV_r\right)$$

Where:

'r' = the final year of the net cash flows to be summed.

This expression is straightforward apart from two variables; quantifying what is the opportunity cost of finance, or discount rate (*Cf*), and how to determine the value of the final of the final year ('r') in the sequence.

2.2.5 Discount rate determination

Determining what an appropriate discount rate should be considering the risk on the costs of capital in forestry investment can be approached in various ways. Discount rate could be based on:

- Asset transaction evidence
- An implied discount rate derived from the share price of forest companies
- Minimum market acceptable IRR observed in a range of forestry projects
- Use of the Capital Asset Pricing Model (CAPM) or Weighted Average Cost of Capital (WACC)

Cheung and Marsden (2002, 10)

Cheung and Marsden (2002, 10) also note that although it may be possible to obtain market prices paid for forest properties, the discount rates used by investors tend to be commercially sensitive and not readily available. The IVSC 'valuation of forests' (2012, 11) suggests that using the CAPM or WACC is appropriate to determine what the returns required by a market participant could be. Also, that analysis of previous transactions by estimated NPV cash flows, could be a method to determine implied discount rates used by the market.

Vicary (2006, 1) along with Phillips *et al*. (2013, 42), in a different format, outlines some of the pros and cons of various methods for obtaining an appropriate rates for timberland investments as displayed in table 2.

Table 2: Common approaches to obtaining appropriate discount rates for timberland investments, after Vicary (2006, 1)

Approach	Key Assumptions	Data Required
Estimate with Capital Asset Pricing Model (CAPM)	Market rewards investors for risk, not for failures to diversify	Risk free rate; historical returns of a suitable market index and of the specific asset being considered.
Calculate Weighted Average Cost of Capital (WACC)	Firm/project maintain same debt level over time; firm/project have similar risk profiles; capital cost reflects the marginal cost of capital.	Firm market value of debt and equity, historic returns on equity, marginal cost of debt, and applicable tax rate.
Survey active investors	Honest responses; rates estimated independently; they know the market.	Discount rates; specify whether real/nominal, before/after tax, benchmark risk free rate.
Derive from comparable timberland transactions	Buyers seek to maximize profits; winning bid represents market; required data are available	Timberland prices; deal characteristics (such as debt, species, acres, volumes); assumptions regarding forest growth, revenue, mgt. costs.

Cheung and Marsden (2002, 10) refer to New Zealand Forestry Valuation Standards when considering the above methods, which proposes an order of relevance for methodologies of determining discount rate:

1. Use of an implied discount rate from asset transaction evidence
2. Use of an implied discount rate derived from the share price of forest companies
3. The minimum market acceptable IRR observed in a range of alternative forest projects
4. Use of the CAPM or WACC

Although the second most useful method of determining discount rate according to Cheung and Marsden (2002, 10) is use of a share price of forestry companies, this approach entails difficulties. The discount rate typically applicable to forestry investment is the business of growing timber as a forest owner. However, most public traded forestry companies tend not to be exclusively forest ownership / investment companies / entities. They may have operations in the timber industry or be a service provider to forestry ownership companies. On the other hand, overserving the minimum acceptable IRR market in range of alternative forestry projects similarly could be estimated by either surveying investors or use of an implied NPV from market evidence, since the IRR is simply the discount rate at the NPV = 0.

Previous transaction evidence

Using previous transaction evidence is the highest weighted method suggested by Cheug and Marsden (2002, 10) in order to determine discount rate. However, as is highlighted by Vicary (2006, 3), there are various assumptions inherent in the approach. For example, referring to Table 2, a prerequisite is that the correct data is available and that the winning bid is market representative. It may be the case that the winning bid is not market representative if the buyer is a special purchaser buying for other non-investment related reasons such as taxation or property amenity value.

Also, the correct data may not be available or may be incomplete, which could lead to incorrect conclusions. For example, it may be the case that the buyer has recognised a Higher and Better Use (HBU) interest, which the rest of the market has not (Mei, Clutter, and Harris, 2013, 25). In this case, without this knowledge then false conclusions of a depressed discount rate could be inferenced (Leech and Ferguson 2012, 29).

The other problem noted form Table 2 is the significant quantity of input data needed. Timber prices, costs and technical information on the subject asset are required. Fu (2014, 99) outlines that a harvest schedule, a projection of timber prices, discount rate, management fees and operating costs, land sale schedule, forecast of land prices and acquisition costs, alternative income and other modelling variables are required in order to construct an NPV. Herein difficulties may arise as variances in these variables, such as projections of future quantities of timber grown, can have a significant impact on the final NPV outcome (IVSC 2012, 11) and the assumptions made on these numerous variables by previous property buyers tend to be unknown.

Survey of active investors

Harris *et al.* (2018, 192) investigated why in the forestry market land values differ from calculated values, and used surveys of market participants in order to derive a discount rate. They eschewed the approach of deriving a discount rate from estimated NPV on known market transactions due to the complexity of timberland NPV cash flows, and the unwillingness of market participants to share their assumptions.

There is limited information on surveys of forestry investor's discount rates. Chueng and Marsden (2002, 11) in New Zealand suggested that forestry discount rate in real terms and unlevered was 6.75- 9.12%. Phillips *et al.* (2013, 45) reference a survey of New Zealand investors and found discount rate expectation of 6-8%. Dasos (2010, 24) report that in Eastern Europe discount rates range from 7.5 - 15%, although the source of the data is not explicit. Chudy *et al*. (2020, 6) found IRRs of 2.4% in Poland and up to 13% in Chile, although land acquisition costs were not included in the study.

Capital Asset Pricing Model

The need to determine an appropriate discount rate led to the development of the Capital Asset Pricing Model (CAPM), whose origins can be traced back to the 1960s (Jagannathan and Meier 2002, 7).

The CAPM is expressed as:

$$Cf = R_f + \beta\left(R_m - R_f\right)$$

Where:

Cf = the opportunity costs of finance or discount rate

R_f *= the rate of return from 'risk free' investments'*

R_m *= the rate of return from standard market risk investments.*

β *= 'Beta'.*

This model in the context of the income approach to forestry valuation is described by Sun and Zhang (2001, 617); the IVSC (2012, 11); Leech *et al.* (2012); and Phillips *et al.* (2013, 55) among others.

The R_f or return from risk free investments, can be considered the return that should be required from an investment where there is no or negligible risk. For example, cash at bank or US government bonds would be a good representation of R_f (Leech *et al.* 2012, 56).

The R_m on the other hand considers the expected return of a market portfolio exposed to the risks of the wider market, such as the stocks or equities (Yao, Mei and Clutter 2014, 944) and a key metric in the CAPM is the excess return of the market over the risk free rate, the so called 'risk premium' (Jagannathan & Meier 2002, 8).

Considering the CAPM equation, the discount rate can be observed to be constructed from starting with the R_f and then adding the difference between R_m and R_f, which on the face of it appears to be equivalent to the R_m. However, the other key element to the CAPM equation is the function β, which is applied to the 'risk premium', or the difference between the R_m and the R_f.

β is a measure of volatility of the asset class in question relative to the market as a whole and can be expressed as:

$$\beta = \frac{Cov\ (In_f In_m)}{Var\ (In_m)}$$

Where:
Cov = Co Variance
Var = Variance
In_f *= An index tracking changes in returns in forestry investments over time*
In_m *= An index tracking changes in returns on market investments over time*

A β of exactly 1 means that the asset class in question is exactly as volatile as the wider market. A β greater than 1 indicates that the asset class in question is more volatile that the wider market. A β less than 1 indicates that the asset class in question is less volatile the wider market. A negative β indicates that the asset class tends to move in an opposite direction to the wider market as whole.

Assuming that the R_f rate of return is low, a β less than 1 will generate a low opportunity cost of capital and similarly a β greater than 1 will generate a greater opportunity cost of capital. Herein lies a critical point about CAPM; it is applicable only to funds or portfolios where the risk-return of the whole fund is being considered (Vicary 2006, 2). Thus, where β is less than 1 for the asset in question, a fund or portfolio may be able to consider a lower discount rate than other non-portfolio market participants. Similarly, where an asset's β is greater than 1, then a portfolio or fund is likely to require a higher discount rate than other non-portfolio market participants.

Therefore, CAPM is only appropriate as a valuation tool where the market rate is set largely by the actively of large institutional investors for whom forestry is an investment diversification. In markets where this is not the case, CAPM may not be appropriate for valuation purposes, but it may be useful to identify opportunities based on low β for funds entering into new emerging markets.

Weighted Average Cost of Capital

In practice, when businesses make significant investment decisions, the source of funds may not be entirely available from owners' equity. Borrowing may be a required or favoured source of capital. In this case, the cost of capital consists of both the 'cost' of using owners' capital equity and the cost, in terms of loan interest to the bank depending on the source of funds. In this situation, a better overall approximation of an appropriate discount rate would be to use the Weighted Average Cost of Capital (WACC).

The WACC calculates the discount rate required through use of the businesses own cost of equity and the cost of finance. The rate is calculated in a weighted manner, so if 50% of funds are to come from own equity and 50% from own finance then the WACC is equal to the mean of the two rates.

A firm's own cost of equity regarding its business is a method that can be used to determine discount rate. However, the cost of equity that the firm uses may not be related to the risk level that will be incurred by the forestry investment. The exception may be a forestry investment firm who is making a similar investment to its current portfolio.

Since banks make large numbers of loan decisions, they are likely to have a relatively superior basis on which to assess to the level of risk to their capital and an appropriate level of return.

2.2.5 The Terminal Value in the Discounted Cash Flow

The duration of a DCF to calculate an NPV for a forestry investment does not necessarily need to be linked to harvesting age (Fu 2014, 99). Leech and Ferguson (2012, 40) suggest that the length of DCF should be related to the length of time that the timber growing business is deemed to be a sustainable concern. When the final year is chosen is important, since at that time a Terminal Value (TV) must be included in the DCF to account for the potential future income that could be derived from the asset after the final DCF year.

Leech and Ferguson (2012, 40) outline that there are two methods that may be employed in order to determine TV in the NPV cash flow, previously noted as $\left(PVr\right)$. The first method is to employ the initial land value, or forecast of future land value. This method is appropriate where it is presumed that the forestry asset will be sold in the final year of the DCF.

The second method is to estimate TV using a 'Faustmann' approach, presuming the value of an infinite series of future rotations as at year $\left(PVr\right)$. This formula deals with the value of the underlying land into perpetuity and is often referred to as the Land Expectation value (LEV). The LEV is a calculation of the value of land based on its potential to grow timber over an infinite series of rotations. It is sometimes known by the Faustmann formula, or the Soil Expectation Value (SEV), (Phillips *et al.* 2013, 26).

The formula can be expressed as:

$$LEV = \frac{FV_r}{\left(\left((1 + C_f)^r\right) - 1\right)}$$

(Straka and Bullard 1996, 3)

The LEV as part of the TV is a more appropriate valuation method whereby sale of asset is not presumed as part of the investment strategy. However, there is also the question of the existing tree crops to consider. Whilst in some cases it may be possible that the TV represents underlying land only, in many cases the forestry asset in the final year of the DCF will include tree crops in various stages of intermediate growth.

Harris *et al.* (2018, 192) provides a useful framework to consider this question. They liken underlying forestry land as a 'factory'. The capital expenditure required to buy the underlying forest land being similar to the purchase of a machine, as it similarly facilitates production of the commodity, in this case timber. The value of the 'machine' to an investor is the LEV.

The other element of the forestry investment is the tree crop, which can be considered stock, or work in progress, using the factory analogy. The tree crops can be valued based using either a liquidation, expectation or cost approach depending on their development stage (RICS 2010, 10). Mature crops can be valued using a timber commodity price and assuming their liquidation (Leech and Ferguson 2012, 25). Where crops are immature, then the liquidation value can be considered equivalent to an FV, and the current value a PV, with 'i' years until the timber is mature following:

$$PV = \frac{FV_i}{(1 + Cf\%)^i}$$

(Straka and Bullard 1996, 2)

Finally, where the tree crops are deemed to be very young then projection over long time periods into the future may be inappropriate and in such cases a 'replacement cost' based approach may be the best manner to attribute a value (RICS 2010, 10; Leech and Ferguson 2012, 27).

When using LEV in concert with calculations of immature crop value, Straka and Bullard (1996, 3) provides a methodology for attributing value following:

$$PV = \left(\frac{FV_r + LEV}{(1 + Cf)^{r-i}}\right) - LEV$$

Where:

PV = the value of the immature crop

FV_r = the future value of the mature stand

r = denotes the full rotation length

i = denotes the current age of the immature timber

LEV = the land expectation value

In the above equation one may question the presence of the LEV within the formula. The reason for inclusion of LEV within the TV is that since the land has immature crop upon it, rather than being bare, the land is not available at year of the TV. Rather, the land will become available at a point in the future once the immature crop may be expected to be removed. As this is beyond the final year of the DCF, depending upon the stage of growth of the immature crop, presuming availability of full LEV value with an immature crop will ‘over value’ the TV. By adding the LEV to the FV_r, the LEV is discounted by an amount appropriate depending upon the amount of the rotation remaining beyond the end of the DCF. Then, the LEV value is removed such that crop value only is left again.

In the situation of an uneven aged crop then the formula requires adjustment as it is impossible under uneven aged management to separate the land and the immature crops. The LEV equation can altered to reflect the value of the unharvestable crops which are retained, following the approach of Straka and Bullard (1996, 9).

$$LEV = NTR - \left[\!\left[\frac{\frac{C_{AM} \times \left(1 + C_f\right)^c - 1}{C_f}}{\left(1 + C_f\right)^c - 1}\right]\!\right]$$

Where:

NTR = net timber revenue received every ‘c’ years.

c = cutting cycle.

2.2.6 Use of the Internal Rate of Return

An IRR is similar to an NPV in that it uses a discounting approach to take account of the time value of money. However, unlike an NPV, where the output is a valuation of the investment, an IRR delivers a % return rate metric. To calculate an IRR the formula is:

IRR = Interest rate at which the sum of the future discounted cash flows = €0

Or in other words, the IRR is the discount rate that would need to be applied in order to gain an NPV of €0. IRRs do not calculate the potential wealth that may be generated and do not consider the scale of the investment. They only compare the relative rate of returns from competing projects (MacLaney and Atrill 2016, 588). Therefore, if the objective of the business owners is wealth generation, careful attention should be paid. Selecting the projects with the highest IRRs may not always result in the highest amount of wealth generation, depending on the scale of the opportunities. The other important matter is that an IRR on its own does not consider risk and so use of an IRR should be combined with a study of what an appropriate hurdle rate to justify any investment.

2.2.7 Summary of forest approaches valuation

In summary, although investment forestry should generally be valued using an NPV approach, in order to *compare* returns from different countries an IRR approach should be used. Key to the calculation is the manner in which discount rate is determined, which will depend on the nature of information available. Since different market participants may use different techniques to determine bid level, and those that use an NPV approach may arrive at different discount rates, the value of forestry assets to investors will vary.

For the purposes of our comparison in scenario 1 with the domestic TIMO, use of commercial bank lending rates as discount rates in the different target nations is one way in which a standard approach to sourcing of discount rate may be made. This equates to a WACC approach whereby all the equity is sourced from outside the business, but within the country in question. This approach applies the business environment within our target countries against our generic forest properties.

For scenario 2 with an international TIMO, a standard nominal WACC will be used. This scenario recognises that investors may not source capital from within the target country. However, in this scenario the inflation environment incumbent on the target country is combined with the standard nominal WACC to produce a unique real discount rate for each country.

In scenario 3, the standard nominal WACC will be combined with a standardised inflation rate for the emerging Europe zone. This scenario considers that TIMOs may take a view if their investment horizon is long term that application of current inflation rates may not be appropriate. With a standard WACC and a standard inflation rate, all the nations use the same real rate. Therefore, differences in the results can be considered striped back purely to the forest characteristics of the generic forests in each country. Finally, asset specific risk will be accounted for through use of contingency costs in the cash flow. Thus, the projected return metrics can be considered to be reflective of a very low risk environment.

Also, timber price change, land value appreciation and biological growth are all drivers of forestry investment and should be adequately considered. These themes will be picked up in the discussion of the results. TV in timberland valuation should consider the future value of forestry as an investment and so an LEV in conjunction with an immature crop calculation using the techniques of Straka and Bulland (1996, 3) will be used.

2.3 Drivers of forestry investment returns

2.3.1 Biological growth

Biological growth refers to the fact that under normal conditions the trees within forestry assets will grow increasing the volume of timber, the commodity for sale, held within the asset. Following the analogy of Harris *et al.* (2018, 192), then the underlying land within the forest constitutes the factory machinery, whilst the standing trees constitute the stock and work in progress.

Yao *et al.* (2014, 943) suggest that more than 50% of timberland returns can be attributable to biological growth, with the secondary driver being timber price change and finally land value appreciation. Also, Mei *et al*. (2013, 18) investigated timberland return drivers in southern United States and found that 61% of the return could be attributed to biological growth. They highlight that biological growth of timber constitutes two dynamic components; firstly the physical increase in the volume of timber within the trees, and secondly the incremental transference of timber volume proportion from lower value to higher value products as the size of the tree increases.

Fu (2014, 97) describes this effect in Loblolly pine in the United States. He asserts that during the point in the rotation when trees are converting pulpwood, worth $8 a ton, to chip and sawn at $16 a ton, over 5 years a tree would double its volume and increase in value by 300%. This is illustrated in figure 2.

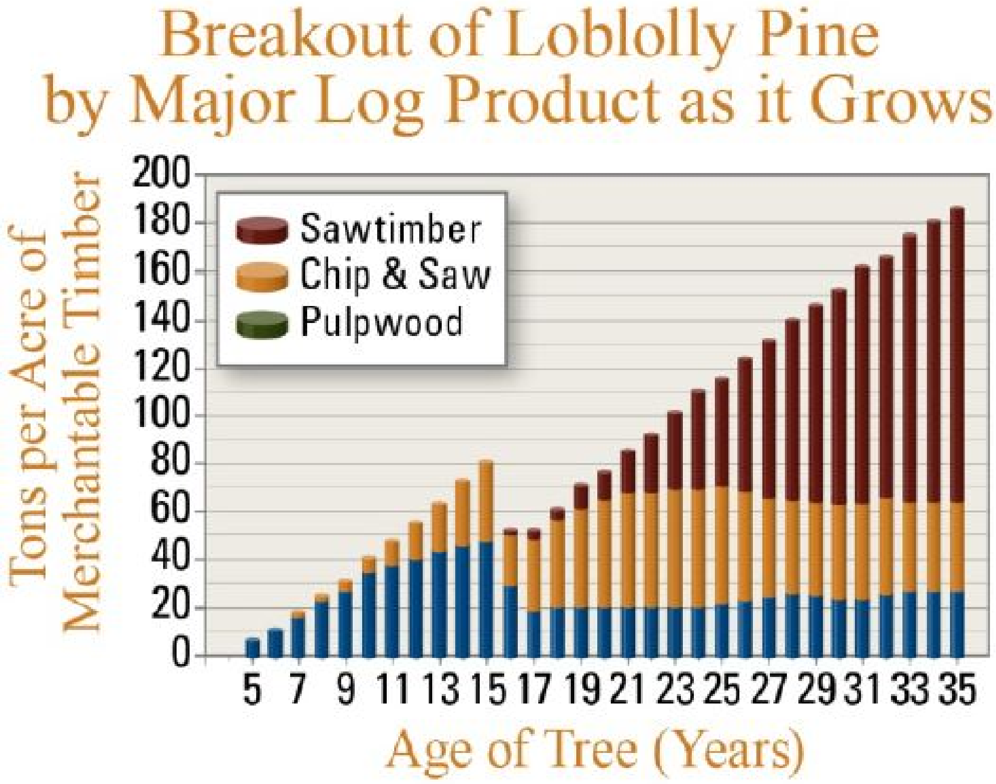

Figure 2: Increasing tonnes of timber in loblolly pine showing product proportion evolution over a rotation (after Fu 2014).

Also, Danish TIMO the International Woodland Company, highlights biological growth as the greatest driver of returns in timberland investment, along with timber price change and land value appreciation in their web material (IWC, 2019)

The International Woodland Company illustrate the process of timber increment along with product evolution over time in figure 3.

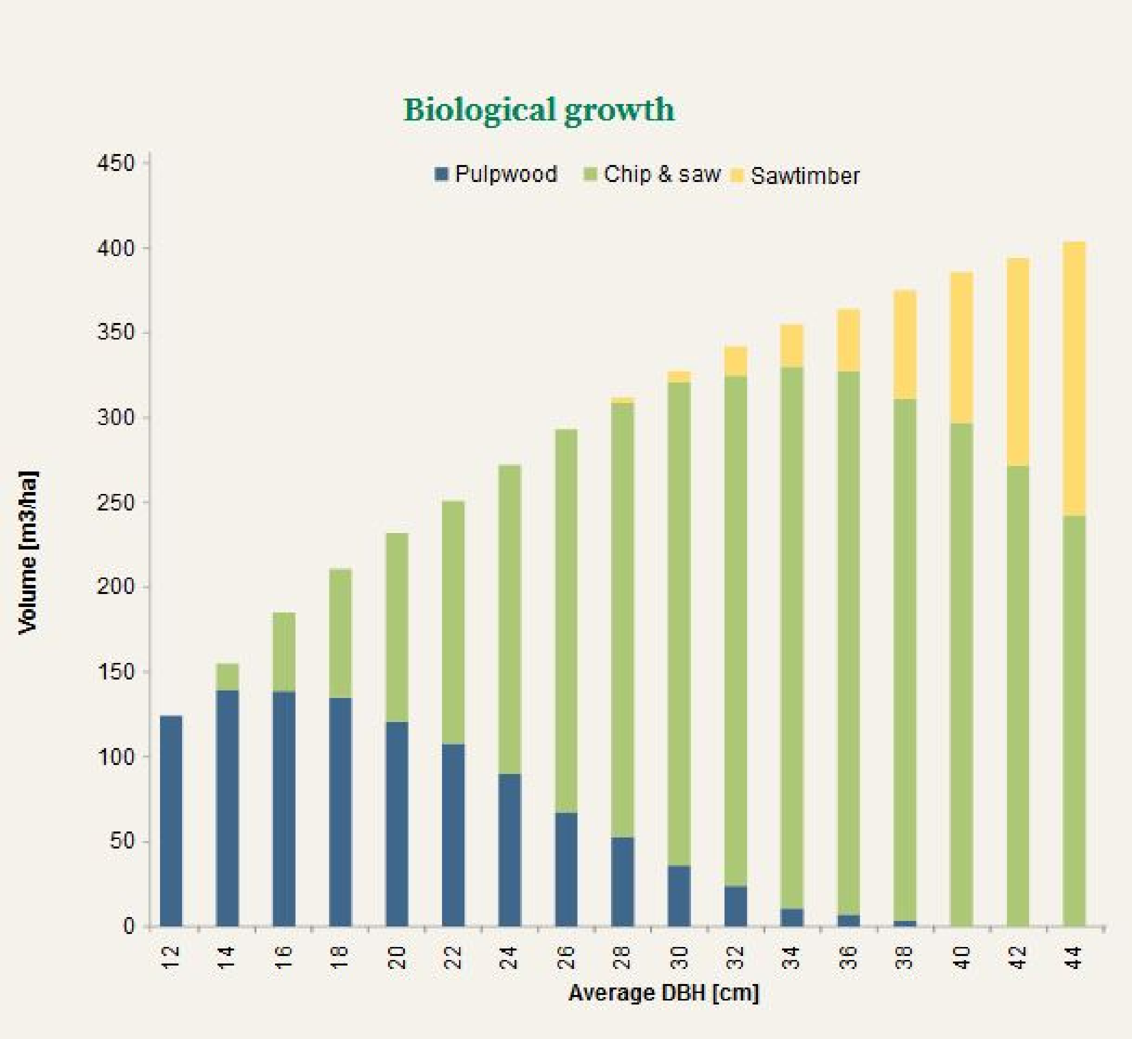

Figure 3: Biological growth and product volume evolution over time, after the International Woodland Company.

A key feature of biological growth is that it occurs independent of business cycles and market movements (Mei *et al.* 2013; Hoyt 2015, 3). Thus, especially for investors or funds diversifying into forestry, biological growth is not just a steady predictable element of investment return, it can actually improve the risk adjusted returns of the portfolio. For example, the impact on a fund of falls in the stock market will be dampened by the forestry constituent of the fund, since the quantity of the timber commodity produced by the forestry asset for future sale will continue to increase irrespective of the market deterioration (Mei *et al*. 2013, 25).

Another way to consider biological growth is as a product storage. Storage of growing products in trees gives forestry as a business a higher degree of management flexibility in the timing of when its goods may be sold, relative to many other industries. For example, if a traditional factory makes product, and due to market conditions the sale of the good at that time is undesirable, then the finished products must either be sold at a loss, or stored for future sale. Storage could be expensive for large quantities of product and there is a risk of the product losing value over time depending on the nature of the industry.

Conversely, during times of negative timber price fluctuation, owners of forestry investments generally can retain standing timber on the stump without compulsion to sell into poor market conditions. When forestry assets produce goods in the form of timber, in most cases, the forest can store the commodity if desired without significant cost (Mei and Clutter 2015, 329), or incurring loss of value of the timber. Indeed, as illustrated in figure 2 and 3, when trees are grown on longer into their rotation, there is the opportunity of transference from lower value to higher value products (Mei *et al.* 2013, 25; Fu 2014, 97).

If a significant proportion of forestry owners pursue this strategy, then when timber prices drop the supply of timber reduces as forest owners retain their timber commodity on stump. Equally, during times when timber demand increases, forest owners can bring more timber to market and increase the supply. The impact of forest owners' prerogative on whether or not they decide to sell their commodity, timber, to market therefore may dampen systemic fluctuation in timber prices.

However, management flexibility of timber harvest and product sale is not unlimited, and depending on the nature of the forestry asset, there are opportunity costs to consider. For example, by exerting flexibility of the harvest year divergence from any 'financially optimal' harvest time would be required.

<u>Financially optimal harvest time</u>

Extensive research has been undertaken on calculation of the optimal financial length of rotation of a growing crops of trees. The initial solution of this problem was the formula from the highly cited Faustmann paper of 1849 (Kant 2013, 1) and the history of surrounding work on the formula to take account of various forestry situations is described by Harou, Zheng and Zhang (2013, 46). Faustmann's formula is in effect an LEV. LEV can be used to find what, in theory, is the optimal financial rotation length. The rotation length which generates the highest LEV is the optimal financially.

Divergence from optimal financial rotations, whilst sometimes desirable, will have an impact on long term financial performance of the asset, or delay opportunities to switch to more productive land uses (Abdallach and Lasserre 2016, 3). Therefore, the financially optimal harvest date should be considered in a context of managerial flexibility. Forestry investment managers may wish to consider the utility of accepting a harvest timing decision not at the moment of the optimal financial harvest due to timber price change.

2.3.2 Timber price change

Timber price change is another key variable driving timberland investment and valuation (Dasos 2010, 6; Yao, Mei and Clutter 2014, 943; International Woodland Company 2019). However, interestingly there is not always a direct relationship between forestry property values and timber price. Mei and Clutter (2015, 333) in the United States found that in the year prior to the 2015 timberland property value was increasing at the same time as timber price was declining. To illustrate why timber price is a key factor in forestry investment it is necessary to introduce the context of timber price in the field of forest valuation.

Biological growth will determine the *quantity* of timber produced that the forestry asset can bring to market. However, forest owner's actual gross income that can be obtained is a function of both the quantity of timber, *and the timber price* that can obtained at market. Timber price is therefore a critical uncertainty and risk factor for forestry investors to consider (Chudy *et al.* 2020, 7). The longer the time horizon of the investment, the greater the investors risk associated with timber price (Mei *et al.* 2013, 25).

Timber price uncertainty raises an interesting problem; the fact that timber price is an inexorably critical determining factor in timber income to forestry investors surely undermines forestry credentials as an investment unaffected by systemic risk and market fluctuation? After all, timber is a commodity with a value likely to be volatile and susceptible to change depending on the prevailing market conditions. Therefore, timber price volatility, in conjunction with forestry management flexibility in terms of timber harvesting, are key factors in timber price change being a driver, or not, for forestry investment returns. On the assumption that forest investors *can* be flexible in timing their timber harvests to take advantage of timber price volatility, then a DCF (NPV) value may significantly understate the value of a forest (Cheung and Marsden 2002, 12; Mei *et al.* 2013 25). Both Duku-Kaakyire & Nanang (2004, 540) and Hildebrandt & Knocke (2011, 1), also highlight the fact that DCFs used to generate NPVs suffer from the weakness that the value of management flexibility is not captured.

Considering management flexibility in valuation requires use of different techniques such as Stochastic Dominance, Options Analysis or Mean Variance (Hildebrandt & Knocke 2011, 8). The various techniques fall under the umbrella terms of ‘Real Options Analysis’ (ROA) which refers to various stochastic techniques to attempt to deal with the inconsistency of management flexibility (Mei and Clutter 2015, 328) .

2.3.3 Real options analysis

Chaudhari, Kane and Wetzstein (2016, 151) describe the range of methods that can be employed and refer to Rigapoulos (2015). The nature of the different methods and the relationship between the methods is displayed in figure 4 from Chaudhari *et al.* (2016, 151).

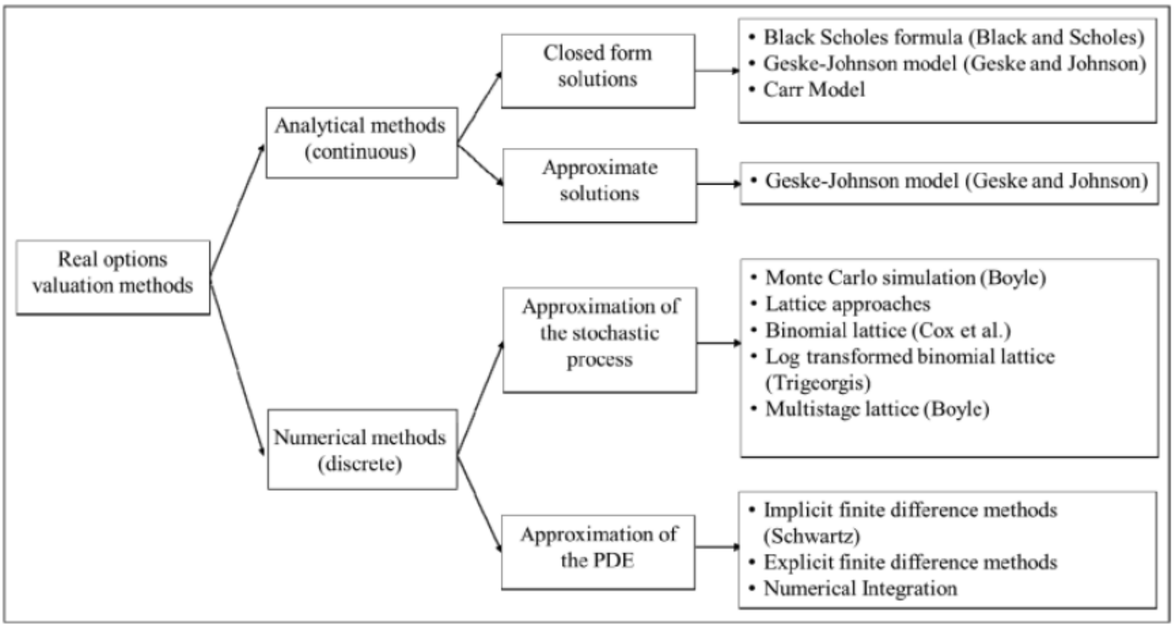

Figure 4: Real Options Analysis tree illustrating methods (after Chaudhari *et al.* (2016, 151)

The ROA methodologies shown in figure 4 are far ranging and include using continuous variables or discrete numerical methods. Choudhari *et al*. (2016, 152) assert that most forestry investment decision making problems addressing uncertainty have been formulated using stochastic dynamic programming. This technique involves cumulatively assessing a range of a particular outputs using the full range of particular outcomes possible. Other methods such as dynamic programming or Monte Carlo simulation, which use many different calculations require considerable computational power, are expensive and time consuming (Leech *et al.* 2012, 43), although have been used by Chudy *et al.* (2020, 1). For this reason, the relatively simpler binomial method was suggested by Duku-Kaakyire & Nanang (2004, 543) to assess different management options during the management of a forest asset.

Zhang & Chang (2018, 425) used a function of investor risk preference and link the impact of risk preference in management flexibility of harvesting decisions to forest land value. They analysed 34 different scenarios of varying risk tolerances. They found that LEV increased as risk tolerance increased until a critical point whereby land value decreased quickly. Zhang & Chang (2018, 435) suggest that this effect reflects the fact that risk tolerant owners tend to gain a higher LEV. This is because as timber price varies, risk tolerant investors only need one chance in which to secure the best price, and may have many opportunities whilst timber is growing on the stump and harvestable. Conversely, more risk averse owners may sell their timber more readily, and thus have less opportunities to take advantage of market upswings. Forestry investors who are stoically risk tolerant may 'hold out' too long for the very best price and miss the opportunity to harvest close to the financially optimal rotation. Hence, these owners see the impact of quickly decreasing LEV (Zhang & Chang 2018, 431).

Milanesi, Tohme, Broz and Rossit (2014, 33) present the 'fuzzy pay off model' as a variation of ROA to calculate the impact/value of management flexibility, or uncertainty in the future to find a Real Option Value or ROV. However, key to implementation of this kind of approach is definition of what is the best and worst case scenarios, which can entail subjectivity.

Ferguson (2017, 1) presents a stochastic solution for the problem of economic analysis of forestry investment. He asserts that deterministic models of NPV based on fixed assumptions are flawed. Therein, it is asserted that not enough account is taken of uncertainty in variables. Rather, a Monte Carlo simulations approach is advocated, but taking account of the non-normal distribution of probabilities of some variables, along with the conditional nature of some variables upon other variables. For example, the fact that saw log proportion increases with age of the stand means that timber income is not a normally distributed value.

There are a number of methods that can be employed to undertake real options analysis on forest investment decisions, such as when to harvest timber, within the literature. However, the problem of assessing what is the value of management flexibility, in terms of an NPV, LEV or appropriate discount rate, is not addressed in the literature in a manner which is accessible to most practitioners without significant modelling. For that reason the value of management flexibility has not attempted to be quantitatively calculated in the DCFs undertaken.

2.3.4 Land value appreciation

Land value appreciation is cited as a constituent of forestry investment returns (Mei and Clutter 2015, 328; IWC, 2019). However, Dasos (2010, 6) notes that although land value appreciation is a return source, that changes in land prices tend to form only 2-5% of forestry investment returns.

How land value appreciation delivers investment returns could be broken down into either those returns derived from the land becoming more productive, or from the value of the land, having appreciated, being sold. The value of the former being a value that can be calculated using an LEV approach, and the latter being a market value using a comparable sales approach.

It could be argued that improvements in LEV due to technical improvements of the site, actually tend to be reflected either in enhanced biological growth or as a result of timber price change, since timber income is generally a function of both quantity and value of the commodity, timber, which is sold. Therefore, land value enhancement may be under reported as a driver of forestry investment returns.

Harris *et al*. (2018, 192) in the United States presents an interesting analysis of the so called 'land value differential' (LVD). The LVD is equal to the difference in value between the LEV and the 'allocated land value' (ALV) where:

ALV = (Forest market value – Timber value)

And:

LVD = (ALV – LEV)

It was found that generally LVD >$0 and that a reduction in discount rate to 3.35% or stumpage price appreciation by 3.2% annually was required in order to bring about an LVD of $0.

The existence of LVD highlights the same problem which is associated with LEV as is associated with NPV forestry valuation methodologies: the assumptions of future uncertainties tend to be fixed and do not take account of managerial flexibility. Therefore, much of the discussion on the difficulty of valuing managerial flexibility in an environment of future variable and uncertain timber prices are applicable to the LEV also. Moreover, many other factors can influence the LEV calculation, such as annual costs, rotation length and so on.

It should also be noted that the only way to derive income directly from land value appreciation, rather than value which could be attributable to the category of the biological growth or timber price change, is through a market sale. This may explain why in practice it has been suggested that only a small proportion of forestry investment returns can be attributed to land value appreciation, since in order to actually derive the final return from this source would require sale of the whole asset, which may not occur in many cases.

3 Emerging Europe as a forestry investment zone

3.1 Historical locations for forestry investment

Forestry investment started in the in the USA and has been undertaken traditionally on behalf of institutions, such as pension funds and led by TIMOs. Fu (2014, 79) notes that the first institutional investment in forestry in the USA was in 1982 and that since then, funds have expanded around the world with the first institutional investment outside the USA in 1992 in New Zealand. By 2010 TIMO investment internationally was developing fast in South America and South East Asia alongside traditional markets in the USA and starting up in Scandinavia, Eastern Europe and in parts of Africa (Dasos 2010, 2). In recent years, timberland investment has continued to develop globally into new regions (Cubbage *et al.* 2014, 11)

3.2 The nature of investment forestry: The world and Europe

Globally, forestry investment is generally undertaken in plantations rather than semi natural forests due to the substantially better returns that can be achieved. Plantations can either use native of exotic tree species. In Europe, most plantation forestry is undertaken with native tree species. Payn *et al.* (2015, 60) highlight that Europe had 70.4 Mha, or around a quarter of the world's 277.9M ha of planted (plantation) forest in 2015. Also, that over 80% of the worlds planted forests consist of native species. Almost all plantation forests in Europe use native tree species.

Cubbage *et al*. (2006, 237) undertook an aggregate review of plantation forestry in North and South America. They compared IRRs between plantations of exotic species, plantations of native species and natural forests. Exotic plantations were generally found to offer the highest IRRs, with native species plantations second and management of natural forests third. However, when land acquisition was included in the calculation then the differential was significantly reduced and opportunities became highly dependent on local land acquisition opportunities.

Therefore, potential investors in emerging Europe should not exclude the potential for investment due to the lack of exotic species plantations, but rather local land acquisition opportunities must form an integral part of the investment calculation.

Zhang (2018, 20) found that planted forests emerge because of scarcity in timber and environmental services and develop in response to economic and policy and institutional instruments, including:

- Secure property rights.
- Stable or rising stumpage prices.
- Efficient forestry governance and administration.

Moreover, Fu (2014, 101) suggests that any timberland investment moving into new geographical markets must meet the criteria of:

- Deep competitive markets for timber and land
- Developed infrastructure
- Legal transparency
- Strong enforcement of property rights
- Owner latitude to manage land optimally
- Stable taxation

Both Zhang (2018, 20) and Fu (2014, 101) essentially highlight the same factors couched in different terms; assuredness of property rights, functional timber markets and unrestrictive and stable governance. These three areas will thus also be considered as *prerequisites* for our question of where to invest in emerging Europe.

Rickman (2015, 14) argued that although Europe features many prerequisite factors required for forestry investment, that its lack of homogeneity in business conditions presents a challenge to investors. It was posed that risks to forestry businesses are similar to many other business, and that the politically fragmented nature of Europe into a large number of nations gives rise to risks: politically, from regulation, technologically, from currency, taxation, and from management costs and markets.

Therefore, investors should not be lured by biological growth or the technical forestry characteristics of forests in different nations. Rather, these wider business factors must all be considered, which echoes the sentiment of Cubbage *et al*. (2006, 237) who highlighted the need to consider all aspects of the business and forestry environment when making any investment calculation.

In summary, our investigation must consider both the forestry characteristics of the nations within emerging Europe and the business environment. Next, we will use the three prerequisite factors posed by Zhang (2018, 20) as a barometer to outline a rationale of how to define the geographical scope of the nations which warrant inclusions within the investigation.

3.3 Prerequisite factors for forestry investment

3.3.1 Assurdedness of property rights

One way to consider in broad terms that the first of the prerequisite factors required posed by Zhang (2018, 20) are in situ, namely secure property rights, could be to consider European Union membership. The EU ‘acquis’, is a 35 chapter detailed specification of the standards that are required by prospective EU member states covering all areas of a state’s economy and governance. There is a considerable focus in the acquis on the opening of land markets to land investors throughout the EU. The rule of law, a functioning market economy and commitment to the principles of the EU are required in order to meet the acquis standards. These principles are illustrated by Bogaerts, Williamson and Fendel (2002, 42) in figure 5 and direct reference is made to secure property rights.

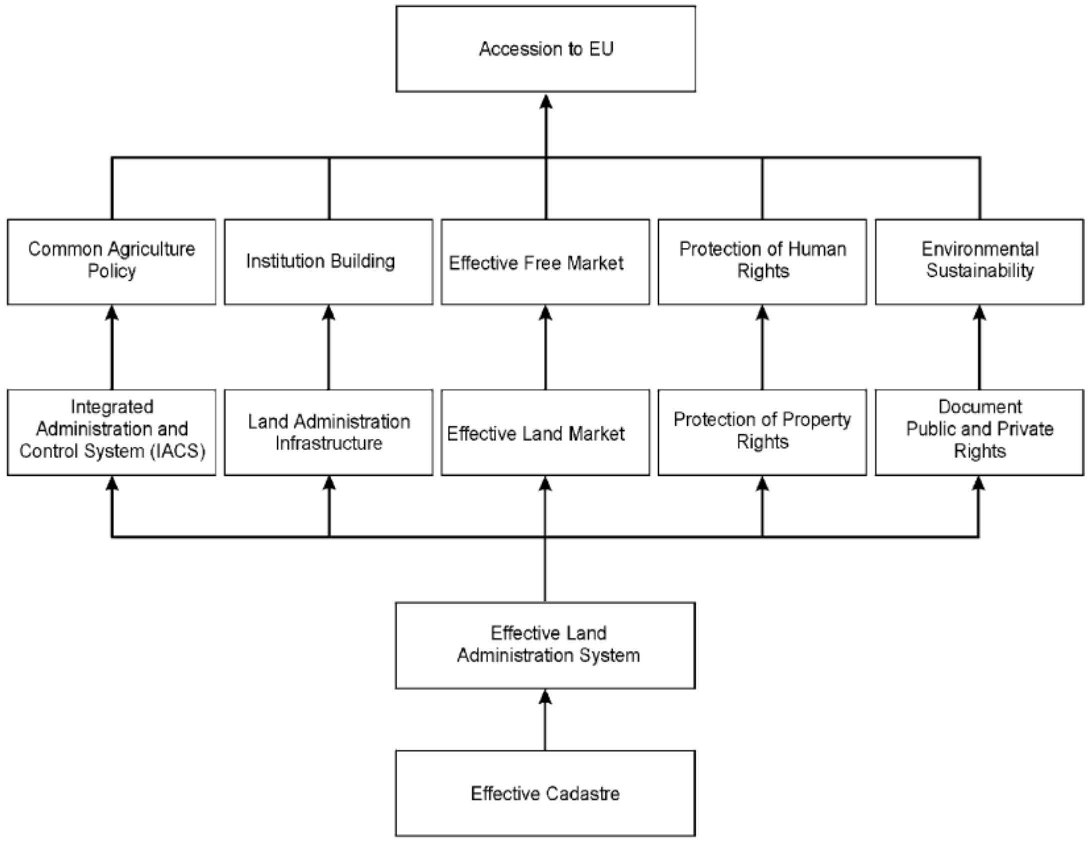

Figure 5: Accession to EU process regarding land tenure and markets (after Bogaerts *et al.* (2002, 42)

The largest intake of new EU member states was in 2004, when Czech Republic, Estonia, Cyprus, Latvia, Lithuania, Hungary, Malta, Poland, Slovakia and Slovenia joined. In 2007, Romania and Bulgaria joined. In 2013 Croatia joined. This enlargement of emerging nations is shown in figure 6, after Hahn (2015, 3). Studying the EU enlargement map in figure 6, we can broadly exclude countries which joined prior to the 2004 enlargement as ‘western European’, and therefore not ‘emerging Europe’.

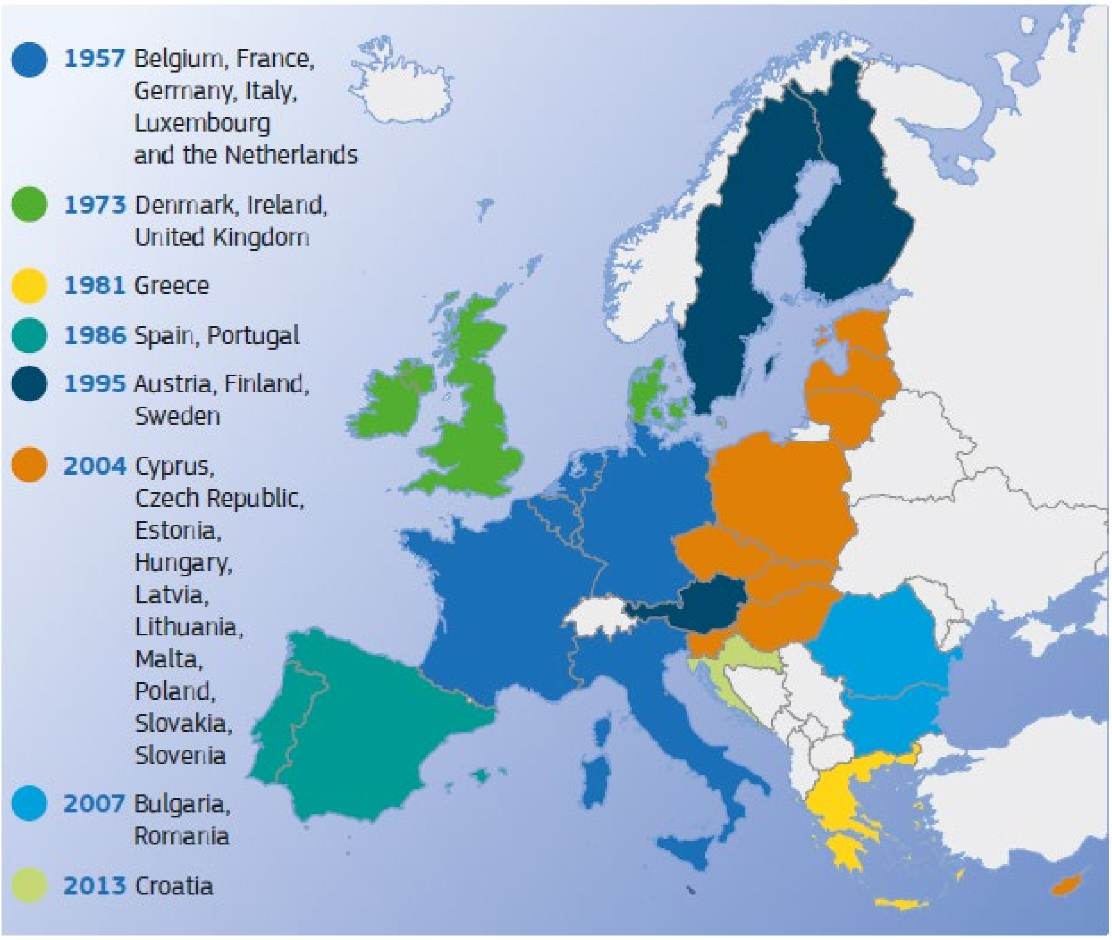

Figure 6: EU enlargement map after Hahn (2015, 3)

Therefore, our set of potential target nations, limited to those in emerging Europe and within the EU is reduced to the 13 shown in table 3 having joined the EU from 2004 onwards.

3.3.2 Functional timber markets

Some of the 13 nations listed in table 3 may not meet the remaining prerequisite standards as suggested by Fu (2014, 101; Zhang 2018, 20) regarding functional timber markets and unrestrictive and stable governance. Moreover, some of the nations may not include sufficient private, and therefore investible, forestry property to be of interest.

To determine which of the remaining 13 emerging Europe EU member states were of potential interest, as having area of investible private forestry and functional timber markets, it was decided to narrow the emerging European geographical area to the nations that have got existing TIMO interest or activity. The method was used as it is a simple proxy to narrow the scope of the investigation to the most meaningful area. Thus, TIMO activity could be used as a proxy to demonstrate that investible private forestry was present. Also, forestry investment within that country would be desirable on the presumption that TIMO investment would only occur with functional timber markets being present.

In order to find out where TIMO activity in emerging Europe is known, a telephone interview was undertaken with major international forestry advisors, Indufor. This was supplemented by internet research to identify in which of the 13 potential target countries there was existing TIMO activity.

The outcome of this survey is displayed in table 3:

Table 3: TIMO activity in EU-emerging Europe

Country	Date joined EU	TIMO activity referenced	Known players
Cyprus	2004	No	
Czech republic	2004	No	
Estonia	2004	Yes	BTG Pactual, HD Forest, Tornator, Dasos, SCA
Hungary	2004	Yes	BTG Pactual
Latvia	2004	Yes	HD Forest,
Lithuania	2004	Yes	HD Forest
Malta	2004	No	
Poland	2004	Yes	Greenwood resources
Slovakia	2004	No	
Slovenia	2004	Yes	Anon.
Bulgaria	2007	No	
Romania	2007	Yes	Tornator, Greenwood resources
Croatia	2013	No	
Finland	1995	Yes	Dasos, other institutional investors (added for context)

Although Finland is not an emerging European nation, it has been added for context as the base of the studies. Therefore, of the thirteen nations identified within the emerging – EU area plus Finland, eight are of potential interest for forestry investment.

- Estonia
- Hungary
- Latvia
- Lithuania
- Poland
- Slovenia
- Romania
- Finland

3.3.3 Unrestrictive and stable governance

The finding of the literature review was that timber price change is a major driver of forestry investment. However, the capability of TIMOs to use timber price change as driver of forestry investment depends also on land rights and forestry governance within the respective jurisdictions. If government regulation does not give forest owners freedom to manage the forest as an investment or be flexible in timber harvesting decisions, then the noted prerequisite criteria of unrestrictive and stable governance suggested by Fu (2014, 101); Zhang (2018, 20) for forestry investment could be argued not to be in place.

Nichiforel *et al*. (2018, 5) made a study of the land rights enjoyed by owners in different countries in Europe. From this study information the information in table 4 has been elicited focusing on the eight nations selected as targets for our investigation.

Table 4: Comparison of rights available to forest owners – after Nichiforel *et al.* (2019, 5)

Area	Indicator of management flexibility	Countries
Freedom of owner to determine timber harvesting quantity	Owner can decide quantity	Finland
	Owner can decide quantity in silvicultural framework	Latvia
	Owner is limited by legislation	Estonia, Lithuania, Romania
	Owner has no flexibility	Hungary, Poland , Slovenia
Freedom of owners to choose management goals	Owner can decide management goals	Finland
	Owner can decide management goals with technical limits	Estonia, Latvia, Lithuania
	Owner can help decide management goals	Hungary, Slovenia
	Owner has minimal input into management goals	Poland
	Owner has no input into management goals	

Studying table 4, it is interesting to note that in many of the countries in which TIMO activity has been observed there are restrictions on forestry governance. Therefore, in countries such as Poland, Hungary and Slovenia, there is some question over their meeting the pre requisite factors for forestry investment. However, given that there is TIMO presence in these countries, on balance they should be included in order to provide as full as result as possible. However, their investment return metrics should be viewed in a context where the governance limitations, and the potential impact on forestry investment, in these nations are understood.

Another reason why it may be appropriate to consider inclusion of countries with restrictive governance in terms of timing of harvesting, is that management flexibility is not planned to be taken account of within the investment evaluation. As was described in the literature review, techniques which take account of management flexibility, like ROA, require considerable computational power and are not available to most practitioners.

However, it must be remembered that simple DCF valuation techniques which rely on biological growth only, may not reflect the opportunity of timber price change on the value of the asset. Therefore, nations such as Finland, with high management flexibility may through 'static' DCF based evaluation be undervalued. Conversely, Hungary, Poland and Slovenia have more restrictive forestry administrative environments. In these countries, DCFs which rely on biological growth only to quantify returns are more likely to correctly value the opportunity for investors.

3.4 Investible forest area of the target nations in emerging Europe

The presence of privately owned plantation forest is a key metric for prospective TIMO forestry investors. The greater the supply of privately owned forest that is available for wood supply, the greater the opportunity. Through interrogation of the EU Eurostat, which publishes national data on forestry, an initial ranking of the nations identified in the forestry investment zone of emerging Europe was undertaken, based on the quantity of private forest used for forestry.

From the most recent 2015 data the proportion of a countries forest that is privately owned is quoted. In table 5, our eight nations of interest are ranked according the quantity of private forestry available for wood supply, and through the proportion of quoted private forestry present the 'inferred theoretical investible area' is determined. There is a significant assumption made in the theoretical investible area that the forest available for wood supply includes private sector woodland in the same proportion as the country as whole. This may not always hold true, but for the purpose of this part of the investigation is sufficient.

Table 5: Ranking of countries according to theoretical quantity of forest available for investment (after UNECE data 20160120 13:48)

Country	Forest Area (ha)	Forest available for wood supply	% private forest ownership	Inferred theoretical investible area (ha)
Finland	23,019,000	19,465,000	69.6	13,547,000
Romania	6,951,000	4,627,000	33.0	1,526,000
Latvia	3,468,000	3,151,000	47.7	1,503,027
Poland	9,435,000	8,234,000	18.1	1,498,000
Estonia	2,456,000	1,994,000	58.7	1,170,000
Slovenia	1,271,000	1,139,000	74.7	850,000
Hungary	2,190,000	1,779,000	42.4	754,296
Lithuania	2,284,000	1,924,000	38.6	742,000

Clearly Finland has by far the largest theoretical area of private forestry available with over 13.5m ha of private forest available for wood supply. The remaining countries interestingly exhibit a much narrower range of investible area. Romania, the second ranked country, at around 1.5m ha, has only around double the lowest ranked country, Lithuania at around 750,000 ha, of theoretical investible area.

4 Methodology

In order to undertake the comparison of the relative forestry investment potential of the eight selected countries, DCF valuation methodologies will be employed and applied to a generic forest asset deemed to be representative of each nation.

4.1 Forest valuation methodology

During the literature review it was found that the most appropriate method to determine the value of a forestry investment was a DCF to calculate its NPV. Fu (2014, 99) describes the information that is required in order to build a DCF;

- harvest schedule,
- timber price projection,
- discount rate,
- management fees / operating costs,
- land sales schedule,
- forecast of land prices and acquisition costs.

A ’generic forest’, deemed to be representative of a forest from each nation will be used as the ’acquisition target’ of the DCF appraisal. NPV, IRR and LEV will then be compared. Terminal Value (TV) will be generated using a Land Expectation Value (LEV) plus immature crop valuation approach. Returns will be derived from biological growth of timber only and costs and incomes projected along with the final TV in order to derive the various return metrics.

Although timber price change and land value appreciation may in practice have an influence, by its nature the DCF will project static costs and incomes. As previously described, to quantify the value of timber price change would require a complex ROA, which is beyond the scope of this investigation.

4.2 Building the generic forest

Along with the information described by Fu (2014, 99) required in order to build a DCF, the holding size must be considered. Then, the tree crop contents of the holding must be evaluated in terms of their capacity to derive timber income alongside the costs of management / operations or silvicultural expenses. Finally, the constituent elements of land and immature crops required to build the TV should be built up.

4.2.1 Holding size

The United Nations Economic Commission for Europe (UNECE) works in partnership with the FAO (Food and Agricultural Organisation) of the United Nations in order to produce forestry statistics in Europe on a wide range of forestry data. This UNECE data includes information on the typical size of forestry holdings as well as typical tree species growing and typical crop development phases. In some cases, the UNECE data is missing and then data has been sourced from the best data available as indicated. In Table 6 mean private forest holding sizes are inferred from the data for our target countries:

Table 6: Mean private forest size (after UNECE data)

Country	Mean private holding (ha)
Finland	35.0
Romania	2.7[2]
Latvia	10.8
Poland	1.5
Estonia	10.4[1]
Slovenia	3.0
Lithuania	3.0
Hungary	2.0[3]

[1] Teder *et al*. (2015, 8)

[2] European Bank for reconstruction and development (2011, 8)

[3] Jager *et al*. (2015, 5)

Studying the mean holding size it is clear that some of the nation's feature very small mean ownership sizes. This raises the question of the minimum economic ownership size, since the purpose of the investigation is an evaluation of investment potential, so the holding size must be economically viable as forestry land. Kumer and Pezdevsek-Malovrh (2018, 16) investigated the factors that hinder forest management in Slovenia among private forest owners, and found that small ownership units hindered the economic use of forest assets due to a lack of economies of scale. They cite earlier research which suggested that a minimum size of 10 ha was required for economic management.

If we presume to apply a 10 ha minimum area size threshold across emerging Europe, then it suggests that the generic forests of Poland, Slovenia and Lithuania, which feature a mean size under 10 ha, are uneconomic. However, although the mean may be under 10ha, this is not the same as there being forests over 10 ha unavailable to invest in. The UNECE data includes area and count of forests sized 11-500 ha and >500ha. The results of these data are displayed in table 7

.

Table 7: Breakdown of property sizes in countries with average property <10ha (after UNECE data)

Country	Area in holdings 11-500ha	Count of holdings 11-500ha	Area in holdings >500ha	Count of holdings >500ha
Romania	*Unknown – restitution complexities*			
Poland	263,000	13,355	137,000	29
Slovenia	394,000	17,422	11,000	20
Lithuania	297,000	13,594	21,000	20
Hungary	*Limited availability of larger ownerships.*			

The situation in Romania is not clear due to large areas with disputed tenure and a complex and contentious restoration process, which has been ongoing for many years (European Bank 2011, 8). In Hungary, whilst there are many hundreds of thousands of smaller owners' larger ownerships tend to limited to complex joint ownership arrangements (Mesaros *et al.* 2005, 306). Jager *et al.* (2015, 16) describe private forest ownership in Hungary. They highlight that it is not possible for corporations to own forest in Hungary, but that much Hungarian forest is not manageable as private units without some form of collective management intervention due to the exceptionally small areas of private ownership. In Poland, Slovenia and Lithuania, there are more significant numbers of greater than 10ha forest holdings.

From the forestry investor's perspective, it is unlikely that forest properties under 10 ha would be considered viable acquisition targets. However, apart from Romania, it is clear that despite the mean holding in Poland, Slovenia, Lithuania and Hungary being under 10ha, that other opportunities over 10 ha do exist in these countries. Although prospective difficulties in finding properties over 10 ha to invest in is a problem, and a possible rationale for exclusion of those countries from the study, it must be remembered that all of the 8 selected nations have existing TIMO players. Therefore, for completeness, it is assumed that in Poland, Slovenia, Lithuania, Hungary and Romania the acquisition holding size is 10ha. Properties under that size level are disregarded. However, it must be remembered that in these countries sourcing opportunities above the minimum size threshold may pose relatively greater challenges. On that basis, our ranking of opportunity can be reevaluated, removing sub 10ha sized properties from the inferred theoretical investible area, and the holding size finalised for the DCFs, as displayed in table 8.

Table 8: Ranking of countries according to opportunity level

Country	Private holding size used for (ha)	Inferred theoretical investible area ('000 ha)
Finland	35.0	13,547
Latvia	10.8	1,503
Estonia	10.4	1,170
Slovenia	10.0	405
Poland	10.0	400
Lithuania	10.0	318
Romania	10.0	Unknown
Hungary	10.0	Unknown

Since the difference between the minimum target size of 10.0 ha and the averages of Latvia and Estonia of 10.8 and 10.4 ha respectively is so small, all the DCF evaluations apart from Finland have used a holding size of 10 ha, so that the comparison can be as equitable as possible.

4.2.2 Modelling timber income in the DCF

The first two items of Fu’s (2014, 99) list of information requirements to build a DCF; a harvest schedule and timber price projection, can be used to determine future timber income. In order to derive this timber income for each generic forest, basic forest inventory information is required to work out timber quantity. The approach to defining the inventory characteristics of each forest will be use of the UNECE data. Where deficiencies in the data exist these will be supplemented by reference to literature.

There are two main datasets that have been utilised in order to build up the inventory and hence timber quantity position of each generic forest. Firstly is the tree species composition. This data presents the mean proportions of various species present in each of our target countries. In general, species with greater than 5% area have presumed to be main ’timber growing’ species. Species with less than 5% proportion are presumed to be minor elements, used for non-timber growth based functions.

Secondly, there is the growth development phase. This divides the tree crops within the forests into three broad stages of development; regeneration, intermediate and mature. The breakout by country of the species composition within each distinct growth development phase is not known. Therefore, it has been assumed that the species composition proportions in each growth development phase is equal. For example, if the species distribution is 50% pine, then 50% of the tree crops in the regeneration, intermediate and mature categories are presumed to be pine. The exception is Slovenia, which uses an uneven aged management system and where the forest is presumed to be mixed age.

The average of tree species present and crop development phases in the entire country could not be said to represent the species composition precisely of any particular forest property in that country. However, in order to enable a comparison on a country basis of a generic forest property, the mean species composition and mean crop development phase is deemed to representative of a 'generic forest'.

Finally, assumptions have been made on silvicultural strategies used, which is required for the DCF projection. For example, when and how often to thin, or rotation lengths. Where the literature suggests this is appropriate, clear fell silvicultural strategies have been favoured. Mature crops have presumed to be harvested at this rotation length in the second year of each cash flow.

A generic rotation length has been determined for each country by reference to literature, and the age of the crops determined in reference to this rotation length and the standard three crop development stages. For example, in Finland a generic rotation of 90 years old has been used. The first third of the rotation, or years 0-30 for Finland, is presumed to represent the 'regeneration' stage. The second third of the rotation, or years 31-60 for Finland, is presumed to represent the 'intermediate' phase. Regeneration and intermediate crops have all been presumed to be in the 'centre' of their development phase, so age 15 or 45 respectively at the start of the DCF. Mature crops are always presumed to be at the end of their growth stage i.e. 90 years old for Finland, such that harvesting can feature immediately in the DCF.

It is important that the length of the cash flow is sufficient for the crops to advance from one crop development phase to the next. This is because we need to model the effect of biological growth of timber in the TV and we are only using 3 crop development stages. So, the cash flow needs to be of a duration such that the crops 'grow' onwards from one development stage to the next. Therefore, in the case of Finland with 30 year length development stages, and crops presumed to be aged in the centre of the stage, a duration of 15 years is required for regeneration crops to be reclassified as intermediate, and intermediate crops classified as mature. Thus, the overall rotation length and crop development stages can be used to determine an appropriate DCF duration.

Mature timber that is harvested will be projected to generate income, then costs of regeneration will be estimated to be incurred in the following year, by reference to literature. Finally, a regeneration crop post-harvest is modelled for inclusion in the TV.

A harvest schedule of crops available for clear fell based on the ‘mature’ areas is a good basis for timber income. However, this would be a simplification, as in addition to timber sourced from clear-felled areas, there would be harvesting in the form of thinnings taken from ‘intermediate’ crop development areas. Moreover, in some countries use of clear fell silviculture is not predominant.

As we are considering a generic forest from each country, it is not possible to undertake in depth analysis of timber quantities present that would probably be undertaken in a real world appraisal of a specific property. However, there are meaningful differences in the generic silvicultural prescriptions that are applied between the various nations that should be considered in a projection of timber income.

Pach *et al.* (2018, 215) present a summary of harvesting systems for various typical mixtures including rotation lengths, thinning intensity and thinning frequency. The data from Pach *et al.* (2018, 215), replicated in table 9, in conjunction with other published statistics from missing nations, has been used as the basis for thinning regimes and rotations lengths. Thinning in general has been applied in year 10 of each cash flow, or at a frequency appropriate as demanded by literature and DCF duration.

Table 9: Harvesting and thinning regimes applicable to a selection of the target nations according to Pach *et al.* (2018, 215)

Country	Species	Harvest system	Rotation	Thinning intensity	Thinning frequency (yrs)
Latvia	Scots pine, Norway spruce	Clearfell	101 (SP), 81 (NS)	Variable	Various
Latvia	Norway spruce / Birch	Clearfell	81 (NS), 71 (Bir)	Variable	Various
Poland	Beech / oak	Shelterwood	100-120 (BE), 140-160 (OK)	20-25	5-7 up to 40 (3-4 interventions), then 8-10 years (in oak)
Poland	Scots pine, oak	Cleafell – shelterwood	90-110 (SP), 140-160 (OK)	20%	5-7 up to 40 (3-4 interventions) then 8-10 years (in oak)
Estonia	Scots pine, birch	Clearfell	90 (SP), 60 (Bir)	20%	15
Estonia	Norway spruce, birch	Clearfell	90 (NS), 60 (Bir)	20%	12
Lithuania	Scots pine, Norway spruce	Clearfell	101 (SP) / 71 (NS)	10-25%	5-15
Lithuania	Norway spruce, Silver birch	Clearfell	71 (NS), 61 (Bir)	10-25%	5-10

To derive income estimates from areas of different tree species timber volumes for the mature crops and timber prices from open source statistics have been found and income calculated using the simple approach of timber volume (m^3) × timber price (€/m^3) .

4.2.3 Discount rate – choice of method

In the literature review, the various generally accepted methods that can be employed to deduce an appropriate discount rate were explored. Asset transaction evidence, survey of active investors, CAPM and WACC were all recognised as appropriate techniques. However, in practice for the purposes of our investigation there are significant problems with the adoption some of these approaches.

Use of CAPM was described as being most applicable where the market value is set by investors for whom forestry is a diversification from their portfolios. This is because the risk - adjusted return, as directed by β, is a critical component of the calculation. Since the market is 'emerging' and unlikely to be dominated by investors diversifying their portfolios, use of the CAPM is probably inappropriate in terms of identifying where market participants may pitch their discount rates. Evidence from the survey of existing TIMO activity suggested that the firms making investments in emerging Europe were forestry investment specialists (TIMOs) rather than generalist investment firms. This again supports the idea that CAPM is an inappropriate metric to use.

The most effective way to determine the discount rates used in the market is to use evidence from the previous transactions. This was the highest valued method suggested by Cheung and Marsden (2002, 10). However, in practice the approach is very difficult due to the unavailability of commercially sensitive data relating to recent transactions. In order to accurately derive the discount rate from transaction evidence, all the other assumptions used by the purchasers in constructing their DCF would need to be known. In practice this information is not obtainable and even where some information on assumptions used can be inferred, partial variances from actual assumptions used could result in incorrectly calculating the discount rate (Harris *et al.* 2018, 202). Moreover, to undertake this kind of detailed work on inferring discount rate is significant, and probably warrants its own study.

Another method following the findings of the literature review is to use discount rates as determined by survey of active investors. Active investors currently constitute TIMOs as well as local players. It is important that active investors are surveyed rather than existing owners so that acquisition costs are taken into account. For example, Brukas *et al.* (2001, 143) suggested that discount rates for existing owners in Lithuania could be as low as 2% based on biological growth alone, which seems out of alignment with TIMOs expectations. Also, Chudy *et al.* in Poland found that IRRs excluding land purchase costs were just over 2%. Dasos (2010, 24) suggested discount rates in emerging Europe could be 7.5-15%, which seems more appropriate given that for investors biological growth should be considered along with timber price change and land value appreciation as sources of returns (Yao *et al.* 2014, 943). However, given 'biological growth only' rates appear significantly lower than the return range suggested by Dasos, it could be argued that for a static DCF appraisal, to focus on the lower end of this range would be more appropriate.

WACC is a method that could be used, but investors or TIMO's own cost of equity is not known. However, if one presumes that the investments are made using entirely money borrowed at commercial rates then a rationale for use of WACC as a discount rate can be made. So, by collecting data on commercial lending rates in the target nations, one can form a reasoned basis for choice of WACC,

At this point there are options as to how to decide which commercial lending rates are most appropriate. In theory, it is not desirable that all the countries within the evaluation use the same discount rate due to risk variation that occurs between countries (Vicary 2006, 6). Therefore, for scenario 1, that of the domestic TIMO, each country will use a different WACC, depending on commercial lending rates in that country. However, in practice, in scenarios 2 & 3, which involve an international TIMO buyer, then a standard WACC will be more appropriate.

4.2.4 Discount rate – ensuring risk is considered

Following Phillips *et al.* (2013, 48); Bartosova (2015, 70), discount rate can be built up from a 'bottom up' basis considering the factors; R_f, R_m and R_a.

$$R_{for} = R_f + R_m + R_a$$

Where:
R_{for} = *Risk of forestry investment*
R_f = *Risk free rate such as cash at bank, or bonds*
R_m = *The systemic risk that affects the whole economy such as economic cycles*
R_a = *The non-systemic risk attributable specifically to the asset*

In order to consider the matter of risk variance and potential basis for differences in discount rate, R_f, R_m and R_a need to be considered.

Use of WACC backed by commercial lending rates deals with the $R_f + R_m$ element of R_{for}. However, in order to deal with R_a, or the non-systemic risks attributable to specific assets, it is arguably inappropriate to simply further increase the discount rate. This is because non systemic risks, represented by R_a may be very specific to certain elements of the forestry asset DCF. For example, the most significant non systemic risk in connection with a forest investment could be a particular pest that could damage young trees and thus increase silvicultural costs. To account for the risk of the pest by increasing discount rate is a blunt tool, as in addition to silvicultural costs, all other costs and incomes would be affected. Phillips *et al.* (2013, 47) suggest that the most appropriate way to consider this issue, is to identify areas where non systemic risk may exist and account for it through assumption of conservative outcomes in the DCF, or factor in contingency costs.

As we are dealing with a theoretical forest representative of each nation, specific non systemic risk may be hard to identify. However, where specific issues that are particular to that nation as a whole are highlighted by the literature then, following the approach of Phillips *et al.* (2013, 47), these will be considered through 'contingency costs' within the relevant DCF. The contingency costs are displayed in the assumptions of the annual costs within DCF models shown in the appendix.

The most nuanced method to elicit the R_a using the contingency costs method would be to match the level of contingency to actual perceived risks within the location. To attempt to do this using a reasoned quantitative method for each generic forest is beyond the scope of this investigation. Therefore, a standard contingency cost allowance has been made using rough estimate of €50/ha/year. This approach is sub optimal, but to quantitatively analyse what an appropriate contingency could be by country probably warrants its own study.

Finally, Leech and Ferguson (2012, 36); Fu (2014, 100); Harrison and Herbohn (2016, 467) note that standard timberland DCFs are expressed in real terms ('constant pricing'). In order to adjust the nominal costs of capital to a rate that can be used to express the cost of capital in real terms, the relative rate of inflation must be considered. Leech and Ferguson (2012, 53); Harrison and Herbohn (2016, 475), describe the approach following the 'Fisher equation' that should be followed to convert nominal discount rates to real:

$$C_{f_{REAL}} = \left(\frac{1 + C_{f_{NOM}}}{1 + Inf}\right) - 1$$

Where:
$C_{f\,REAL}$ – Fisher adjusted cost of finance discount rate in real terms
$C_{f\,NOM}$ – Basic nominal costs of finance discount rate
Inf – Inflation rate

Therefore, the nominal WACC based discount rate will be adjusted by the fisher equation to ensure returns are presented in real terms. The $C_{f\,NOM}$ will equate to the WACC or the typical commercial bank lending rate for the country in question. *Inf* will be sourced from the EU Eurostat for the country in question. The final 'Fisher adjusted' rate will then be used within each countries DCF to calculate real NPV and real IRR. The final adjusted discount rates used are summarised in table 10:

Table 10: Scenario 1 conversion of nominal WACC to a real discount rate

Country	Commercial lending rate (%)	Fisher adjusted (%)	Year of data (most recent available)	Source
Finland	2.80	1.50	2018	https://www.economy.com/finland/lending-rate
Latvia	2.65	2.65	2018	https://www.economy.com/latvia/business-lending-rate
Estonia	3.19	0.60	2017	https://www.economy.com/estonia/business-lending-rate
Slovenia	2.17	0.60	2019	World bank
Poland	3.65	1.60	2019	World bank
Lithuania	0.31	Negative	2019	World bank
Romania	5.56%	1.5	2017	World bank
Hungary	0.90%	Negative	2019	https://www.economy.com/hungary/lending-rate

Looking at table 10, Lithuania and Hungary's real discount rates are negative. In these cases, to avoid illogical results, the countries own nominal commercial lending rate has been used unadjusted.

4.2.5 Management fees / operating costs

Management fees / operating costs relate to the costs of employing local property managers to undertake management, planning, works supervision or other necessary roles required to ensure that the active management of the asset is correctly implemented. The EU Eurostat publishes statistics on the main employee based indicators for the EU 27 nations. From this data published in 2008 the information in table 11 was elicited.

Table 11: Inferred €/ha forest management costs according to the EU Eurostat 2008

Country	Number of persons employed (‘000)	Av personnel cost (€’000)	Apparent productivity (€’000)	Wage adjusted labour productivity %	€/ha
Finland	72.9	43.4	68.7	158	20.0
Latvia	39.6	3.8	9.6	256	12.4
Estonia	23.6	7.4	12.4	166	19.0
Slovenia	23.5	15.3	20.2	132	23.8
Poland	228.7	6.5	14.0	216	14.6
Lithuania	37.7	4.0	6.5	163	19.2
Romania	122.0	2.5	5.0	197	16.0
Hungary	69.7	7.5	11.2	149	10.6

By cross indexing the number of personnel working in each country’s forest with the quantity of forest, we can infer an estimate of personnel requirement on a per ha basis. This estimate includes persons working in forestry processing industries rather than just simply the workers that would be required by a forestry investor to manage and maintain the forest property. However, if we presume that the personnel costs and the productivity rates can be extrapolated over the specific area of forestry management costs then we can build a picture of annual management costs. The approach used is a €/ha metric in each model. A base price for Finland was chosen of 20 €/ha based on an estimate. Then, using the wage adjusted labour productivity % benchmarked against the Finland rate, relative rates per ha of forest management and operating costs could be elicited and are displayed in table 11.

4.2.6 Acquisition costs

Since for our assessment we are considering a new forest investment, property acquisition costs must be considered. (These vary by nation due to the prevailing market conditions. Where whole country data on the forestry property market is available this has been the preferred basis of forestry property cost. Where such whole country data has not been found to be readily available, a search of forests for sale in the open market has been conducted to find a basis for acquisition costs. In the interests of maintaining simplicity, the inclusion of the acquisition cost has been set to a negative cost item in year 1 of the DCF and associated costs of acquisition, including taxes, have been excluded.

4.2.7 Terminal values

The TV calculation, along with the acquisition cost is often one of the most significant figures present in the DCF calculation. In the literature review, LEV added to timber crop PV was found to be the most appropriate method to estimate the TV. This approach captures the value of the forest as an investment, since the time value of money and irregular nature of income in the DCF is fully considered. The LEV and crop PV have been based on a 'generic rotation' cost and income projection. These are displayed for each country in the respective appendix.

5 Methodology: construction of generic forests

The development class of tree crops within each country has been sourced from the UNECE data, apart from Slovenia and Romania. The tree development class stages for each of the target nations is displayed in figure 7.

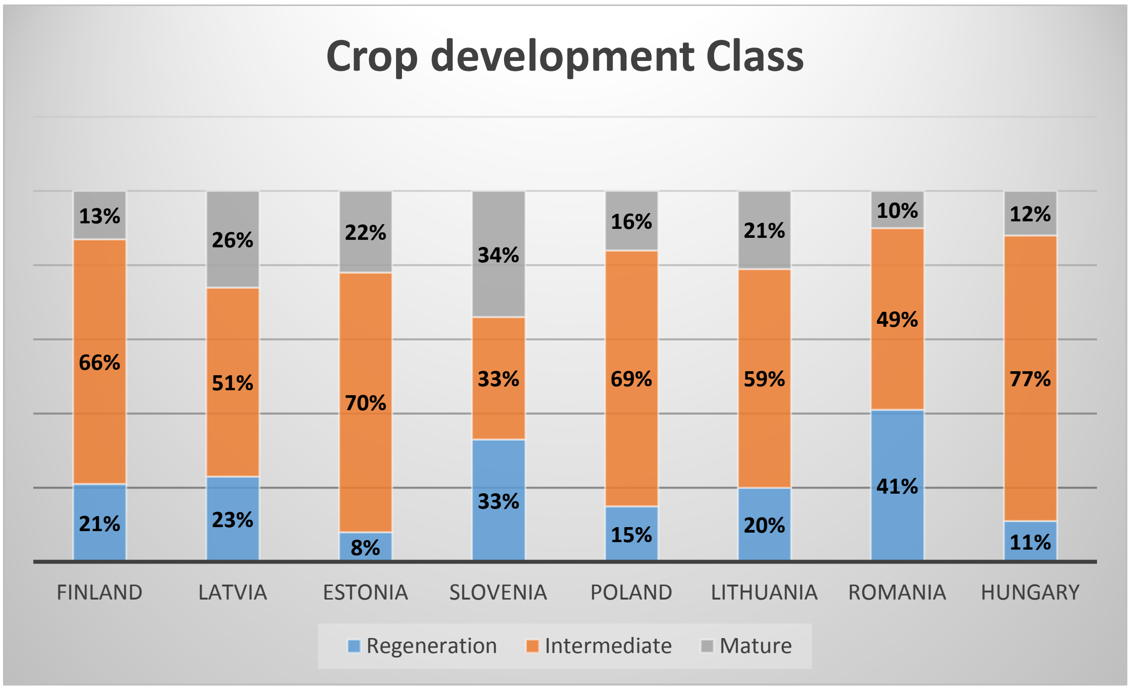

Figure 7: Crop development classes by country (after UNECE data)

The UNECE data in terms of species and other factors are discussed on a country by country basis on the following sections.

5.1 Generic investment valuation model: Finland

In Finland, there is plentiful open source data to be found supplied by LUKE the national resources institute of Finland, regarding whole country averages for timber prices, timber quantities, property prices and other factors.

5.1.1 Finland forest tree species

The UNECE data for Finland is complete both for tree species present and their respective development stage. A species breakdown is diaplyed in figure 8.

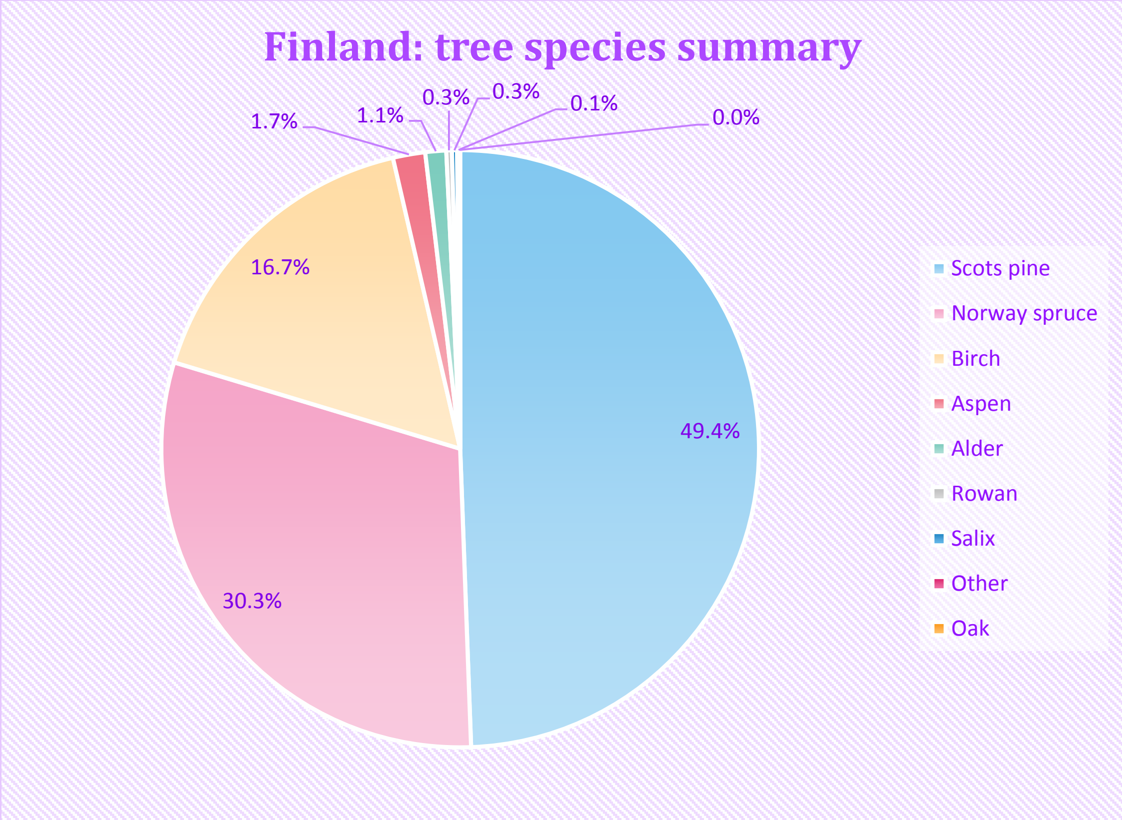

Figure 8: Finland tree species summary (after UNECE data)

In Finland, the primary species present is Scots pine, covering around half the area. The secondary species is Norway spruce with just under a third of coverage and birch comes in third with 16.7%. There are then a variety of minor species. These small areas of minor species are presumed collectively not to form part of the timber value of the generic Finnish forest.

In Finland, the dominant crop development phase, as displayed in figure 7, is ‘intermediate’ at 66%, with smaller portion of regeneration crop at 21% and mature crop at 13%. A presumption has been made that ‘mature crops’ are ready for immediate harvest and that there is no impediment to their liquidation in year 2 of the DCF. Intermediate crops are presumed to require another 10 years growth prior to a thinning. Applying the UNECE data for tree species and growth phase to the mean holding size in Finland of 35ha the ‘generic forest can be built as displayed in appendix 1.

5.1.2 Finland timber income forecast

In the generic Finnish forest, there are 4.6 ha of mature timber crops for harvest featuring Scots pine, Norway spruce and birch. Small areas of other species have been disregarded as uneconomic. Average country data has been sourced for timber volumes from mature stands, timber product (stumpage) prices for logs and pulp for each of the three species, and the generic proportion of logs and pulp that each species generates at harvest. This information is displayed in the assumptions summary for the Finland DCF in appendix 2. These data have been combined to generate a timber income projection. Mature timber has been projected to be clear felled in year 2, 2020, and a thinning of intermediate areas scheduled for 10 years later in 2030.

5.1.3 Finland generic forest assumptions

In addition to annual management costs, an element of silvicultural costs have been included in the Finland DCF. The LUKE data lists typical silvicultural operations and average costs in Finnish forests. Operations that relate to replanting costs have been summed and inserted into the DCF as a capital cost in the year following harvesting operations to re-establish to new crop, although it has been presumed that operations that may be required to establish younger crops, such as pruning, are not required with the DCF period.

The other main relevant cost that has however been included is that of ditch maintenance. Hökkä et *al.* (2017, 234) assert that in Finland ditches tend to be maintained only once or twice every 100 years. However, on presumption that our investor, like many TIMOs, will be an active manager, a ditch maintenance intervention is factored into the silvicultural expenditure.

The national land survey of Finland 2018 asserts that the average price paid per hectare for forest property was €3,026 / ha. This figure has been used as the basis of the overall property cost using the holding size of 35.0ha.

5.2 Generic investment valuation model: Latvia

Latvia gained its independence in the early 1990s and since then around half of the nation's forest has transferred from the state into private ownership (Lelde and Zinta 2015, 1). Today, private forest owners generally feature relatively small holdings at around 10.8 ha (Table 6), live nearby their holdings and are primarily motivated by capability to provide firewood and leave an asset of value to their successors (Lelde and Zinta 2015, 1).

5.2.1 Latvia forest tree species

Looking at figure 9, in Latvia, like Finland Scots pine retains its dominace, but now covers just over a third of forest land at 37%. There are five primary species significant for timber production: Scots pine, birch, Norway spruce, grey alder and aspen. Birch forms a greater proportion of forest land than Finland at around a quarter, whilst the amount of Norway spruce is reduced at 16.2%.

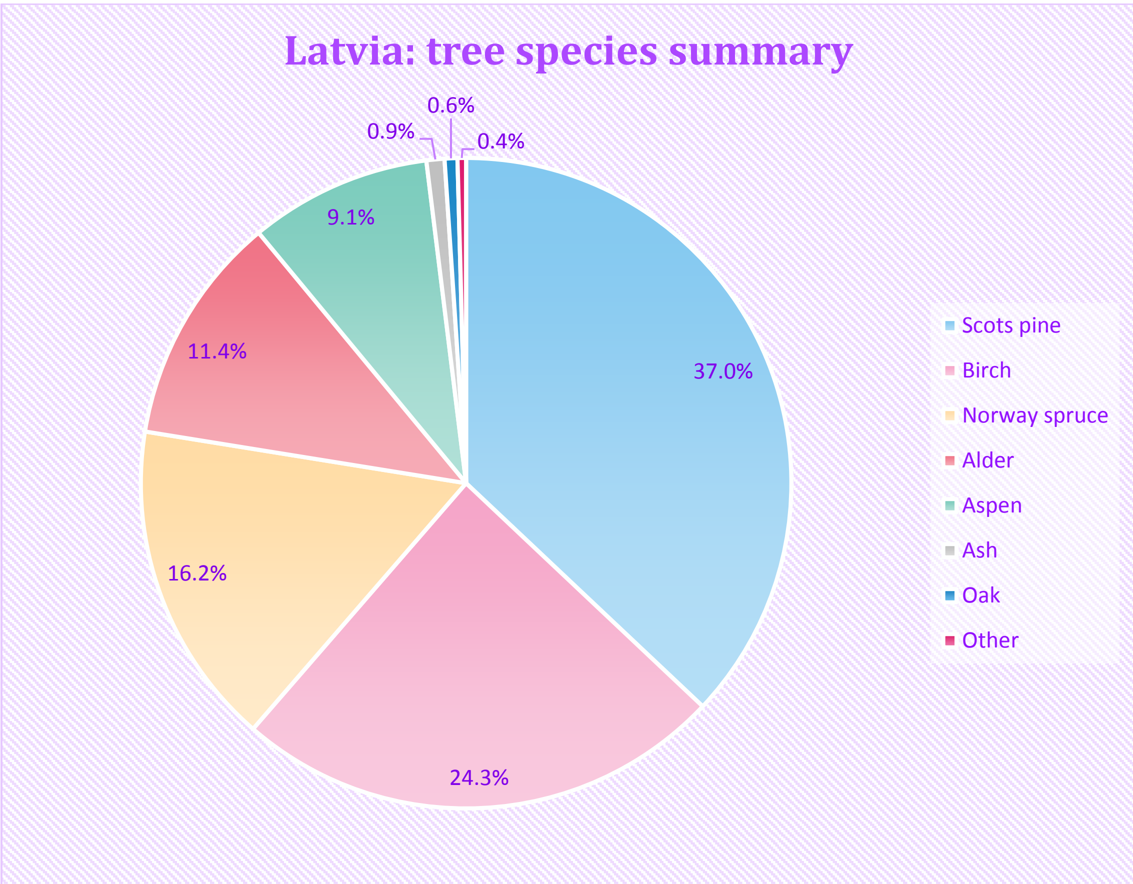

Figure 9: Latvia tree species summary (after UNECE data)

New species forming significant areas are alder at 11.4% and aspen at 9.1%. Both of these species are commercial according to Mark, Newton, Oldfield and Rivers (2014, 16), although are lower value than the primary conifers Scots pine and Norway spruce (Central statistical beaureau of Latvia, 2018). Other species form very small components and have been considered as the non commercial elements of the forest.

In terms of crop development stage as displayed in table 7, Latvia features an increased proportion of mature forest relative to Finland. This is probably due to a greater proportion of small and relatively inactive forest owners (Lelde and Zinta 2015, 18).

5.2.2 Latvia timber income forecast

The Latvian central statistical Bureau produces detailed statistics on timber harvesting in Latvia. This includes the timber volumes that can be expected to be harvested from mature stands and thinning for each of the five principle species. Also, timber prices for logs and smaller products for each species are available for 2018.

Kons (2011, 13) describes the product assortments that are typically cut from clear-felling in Latvia and these proportions have been used in the timber income projection for the year 2 clear-fell of the mature timber. For the thinning timber income projection, log proportion derived has been reduced to 30% of the clear-fell proportion, so as to be approximately in alignment with the Finland DCF since the Latvian Statistical Bureau does not produce data on that element.

5.2.3 Latvia generic forest assumptions

The Latvian generic rotation has been projected at 83 years old. This has been produced by using the weighted proportions of pine having a rotation age of 101, spruce 83 and birch/others at 71. Officially pine has a rotation of 100 and birch 70 years old (Bekeris 2016, 24). It is noted by Berkeris (2016, 24) that the official rotations of the primary species in Latvia may be an over estimate as a result of historical sub optimal management, and that with active management, rotation lengths may have the capability to be significantly shortened. Silvicultural costs are listed by the Latvian central statistical bureau and an assumption has been made that one operation of each of the listed options will be required to establish a new crop.

5.3 Generic investment valuation model: Estonia

In recent years, Estonia of the three Baltic States is the nation which has had the most active forest property market. This is reflected in the prices paid for Estonian forests which are greater per ha than both Lithuania and Latvia (The Baltic review 2017, 8). Also, there are more TIMOs invested into Estonia than Latvia or Lithuania according to table 3.

Teder *et al.* (2015, 6) note that like in Latvia, in Estonia a process of forest ownership restitution has been ongoing since 1991. Now, recent trends have been growth of corporate and foreign ownership of forests led by a market of private advisors. Pollumae and Korjus (2017, 725) furthermore note that average holding size has in recent years been decreasing, and that corporate ownership has been increasing.

5.3.1 Estonia forest tree species

In Estonia, as displayed in figure 10, the tree species breakout is very similar to its Baltic neighbour Latvia. Scots pine again is the primary species at just under 30% but is closely followed by Norway spruce, which together form just over half of the forest area. Birch is the third species at 22.6%. Like Latvia, alder and aspen form notable components, with the remainder of the tree species forming insignificant areas.

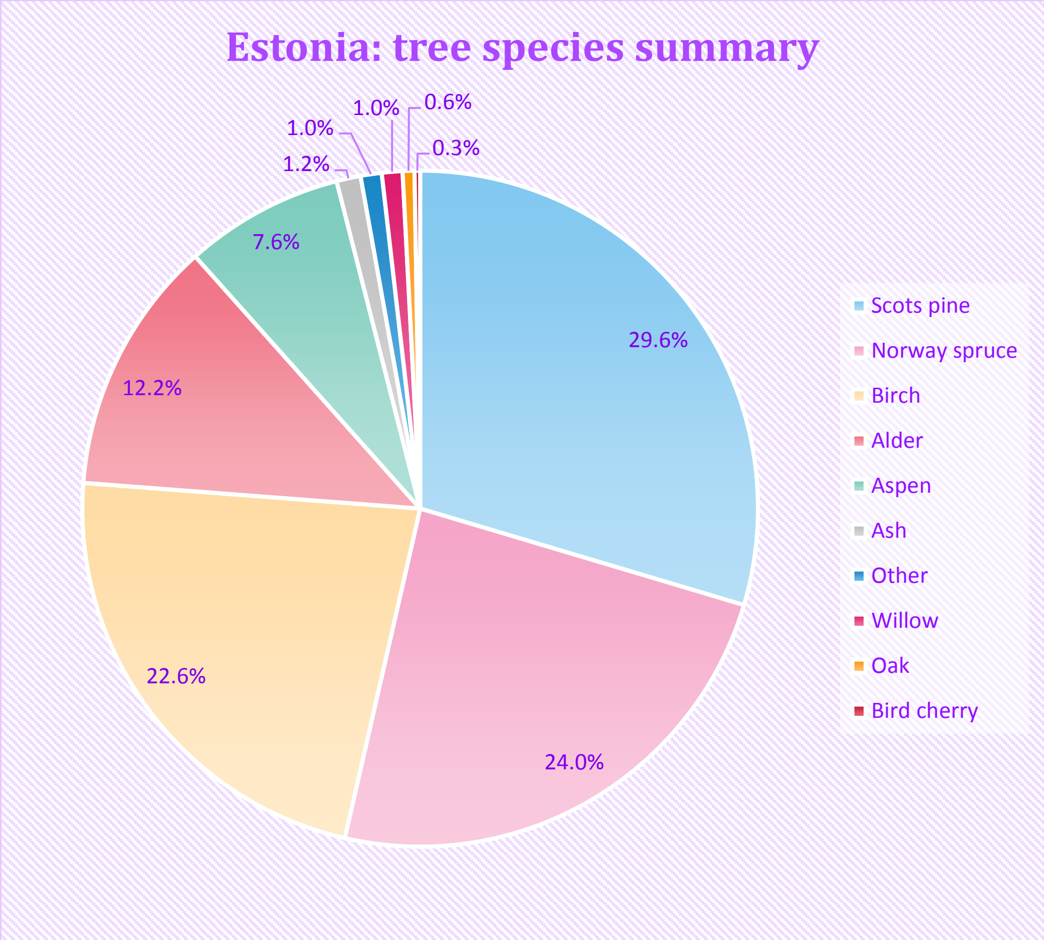

Figure 10: Estonia tree species summary (after UNECE data)

Regarding crop developments phases, as displayed in figure 7, the greatest proportion of the forest, some 70% of area, is in the intermediate growth phase. Only 8% is in regeneration and like Latvia there is an increased proportion relative to Finland of mature forest at 22%. Applying the UNECE data for tree species and growth phase to the mean holding size in Estonia the 'generic forest' can be built as displayed in appendix 1.

5.3.2 Estonia timber income forecast

In Estonia there is no central statistical service that produces wide ranging specific information on timber prices, costs of timber extraction, and timber volumes in mature stands and so on, although some roadside timber price information is published by RMK, the state forest service. In terms of average timber volumes, due to the geographical proximity and similar species structure, the Latvian data has been used by species. The RMK timber price data is of interest, but because it is roadside prices, without published data on costs of extraction and harvesting is difficult to use.

A private management company HD Forest fest publishes stumpage price data, (i.e. income per m^3 of timber after costs of felling and extraction are considered by species). This may not be fully representative of the country as a whole, although as it is published, one would presume that the data is not significantly out of alignment with the market. Therefore, as the best available information, the HD Forest fest data has been used. Thinning volume has been derived from using the thinning % as suggested by Pach *et al.* (2018, 215) in table 9.

5.3.3 Estonia generic forest assumptions

The Estonian generic rotation has been projected at 76 years old. This has been estimated by using the weighted proportions of pine and spruce having a rotation age of 90 years old and other species having a rotation age of 60 years old (Pach *et al.* 2018, 215). Based on the generic rotation and described rationale to determine DCF duration, a DCF period for Estonia has been generated of 13 years.

Regarding silvicultural costs, Virkkunen (2017, annex 4 X) noted regeneration costs in Estonia and included scarification, planting, seeding, grass suppression, cleaning and tending seedlings stands. Although the timing of these operations is staggered over the first few years of regeneration, in the interests of simplicity these operations have been capitalised into a single year with the DCF.

5.4 Generic investment valuation model: Slovenia

Slovenia is highly wooded country with 58% land area covered by forest, much of which is owned by farmers in very small units of tenure. Around 75% of the forest is in private hands, but this is divided among 320,000 owners. 40% of forest properties are less than 6 ha Krč *et al.* (2015, 7). Most ownerships are below the 10 ha threshold whereby it is deemed that there are sufficient economies of scale for efficient forest management (Kumar & Malovrh 2018, 2).

Slovenian forests are managed on a ‘close to nature’ basis. These mixed structure forests are located within beech, fir - beech and beech - oak sites. However, today many beech forest areas have been planted with Norway spruce for silvicultural reasons in the 18th and 19th centuries. The implication of close to nature management is that trees are not managed in plantations, but have irregular structures of age and size and may feature natural regeneration (Kavailiauskas *et al.* 2018, 4). Therefore, Slovenian forests cannot be simply categorised into ‘mature’, ‘intermediate’ or ‘regeneration’ groupings.

Malovrh, Leban, Krč, and Stirn (2012, 2) describe how in Slovenia growing stock and increment have been in a long process of increasing since the end of World War 2. Today, in Slovenia the annual harvest is around 70% of the allowable cut and around 40% of the increment (ZGS, 2019).

5.4.1 Slovenia forest tree species

In figure 11 is displayed the main forest tree spoecies in Slovenia. The two main tree species are beech and Norway spruce, which collectively cover around two thirds of the forest area. There are extensive differences in tree species distribution in Slovenia, due to the variation in the geographical properties of the regions. Most Slovenian forests are located within the area of beech (53,49%) and fir-beech (12,96%), with a relatively high production capacity (Malovrh *et al.* 2012, 5). Other species of note are mixed (10.2%), Fir 8%, Scots pine, and oak (5.8%).

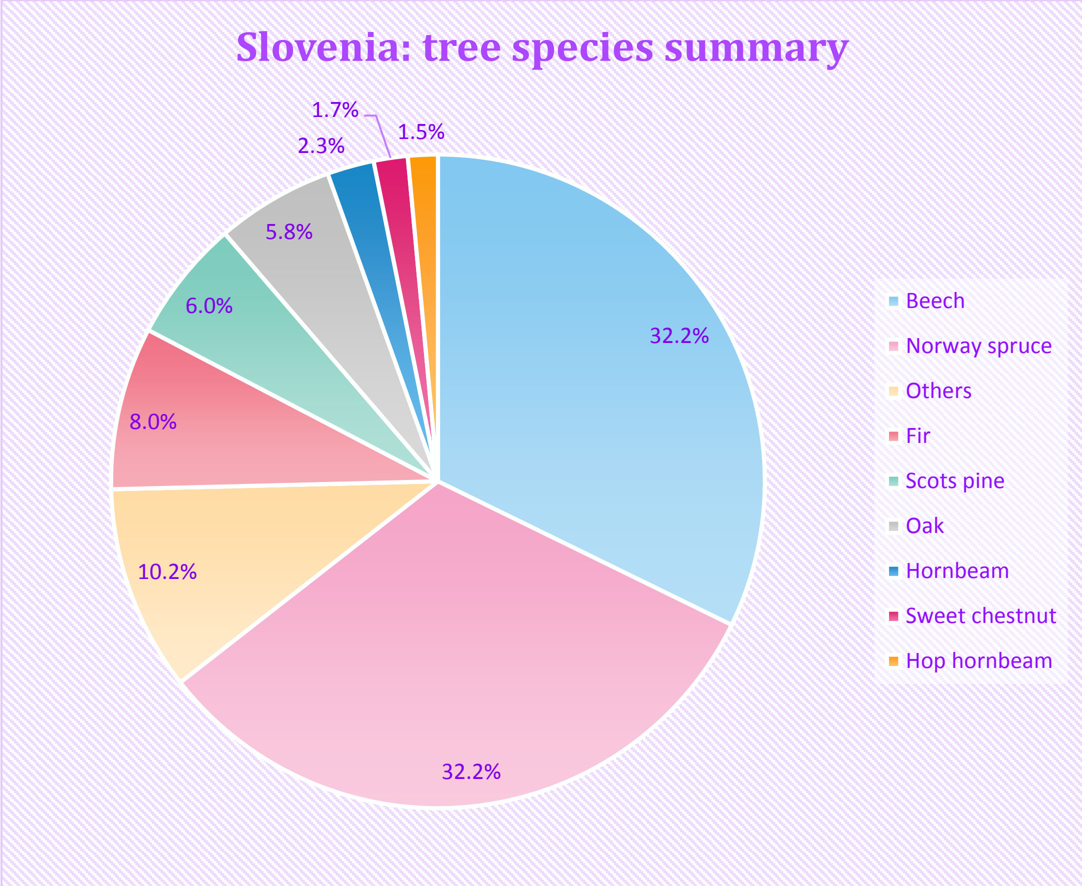

Figure 11: Slovenia tree species summary (after UNECE data)

Hornbeam, sweet chestnut and hop hornbeam are considered part of the non crop tree species area.

5.4.2 Slovenia timber income forecast

Due to the relatively high timber volume in Slovenia and history of increasing growing stock, the generic Slovenian forest has been presumed to be an equal mixture of regeneration, intermediate and mature stages in an intimate mixture. Also, as a result of the close to nature management used in the country, the assumption used for harvestable quantity is that it is limited to timber increment.

In Slovenia, timber prices are collected and published for a variety of products at roadside by the statistical office of Slovenia. Logs are graded A-D, and a conservative assumption of grade ‘C’ has been made for produce in the DCF. Malovrh *et al.* (2012, 6) outline for different tree species the proportion of volume that translates into different timber products. Therefore, through use of the harvestable timber volume, limited to increment, for the country as a whole, a quantity of different timber products along with known prices has been derived.

Costs of harvesting and extraction in Slovenia tend to be large due to the steep terrain. Fortunately, plentiful open source information on timber harvesting and extraction costs are available from the Slovenian Forestry Research Institutes ‘wood chain manager’ website. Information on extraction costs from this system has been used to convert roadside timber product prices into a stumpage appropriate for inclusion in the timber income forecast.

5.4.3 Slovenia generic forest assumptions

The Slovenian generic rotation used in the terminal value has been approached in a different manner due to the close to nature management system employed in this country. Realisable timber income is less related to any forest ‘rotation length’, but to harvestable increment. In other words, even if the whole forest was at rotation end, realisable income is limited to increment using the close to nature management approach. Therefore, a ‘rotation length’ of 10 years has been used, which is in alignment with the Slovenian state forest service’s planning duration in which felling permission is authorised (ZGS, 2019). Based on this felling authorisation window, a DCF duration for Slovenia has been generated of 10 years.

Also, since natural regeneration is the prefered method of regeneration, no allowance for ’restock costs’ has been made in the model post harvest. All forest restocking is preumed to occur using natural regeneration. All harvesting has been presumed to be alternitives to clearfell. Silvicultural works, are presumed to be implemented through the various harvesting interventions, so there is no direct allowance for silvicultural costs.

5.5 Generic investment valuation model: Poland

According to forest inventory carried out by the Forest Research Institute of Poland, the forest area of Poland has hovered at around 32.8%-33% of the countries land area. This is a higher figure than some previous estimates due to expansion of the forest onto abandoned agricultural lands (Jabłoński, Mionskowski and Budniak 2018, 365).

Today there are silvicultural expectations on private forest owners, but a legacy still exists of under management in private forests due to the agricultural system employed from 1944 to 1991 (Jaszczak, Krzysztof Adamowicz, Wajchman-Świtalska, Miotke 2018, 795). Generally, the clear-cut system is predominately used in Poland, although there is an increasing preponderance towards attempting natural regeneration following harvesting (Banach, Kinga Skrzyszewska and Skrzyszewski 2017, 185).

5.5.1 Poland forest tree species

In Figure 12 is displayed the forest tree species in Poland. The primary tree species is Scots pine with 57% of forest area. Other species with proportions over 5% include oak, Norway spruce, beech and birch.

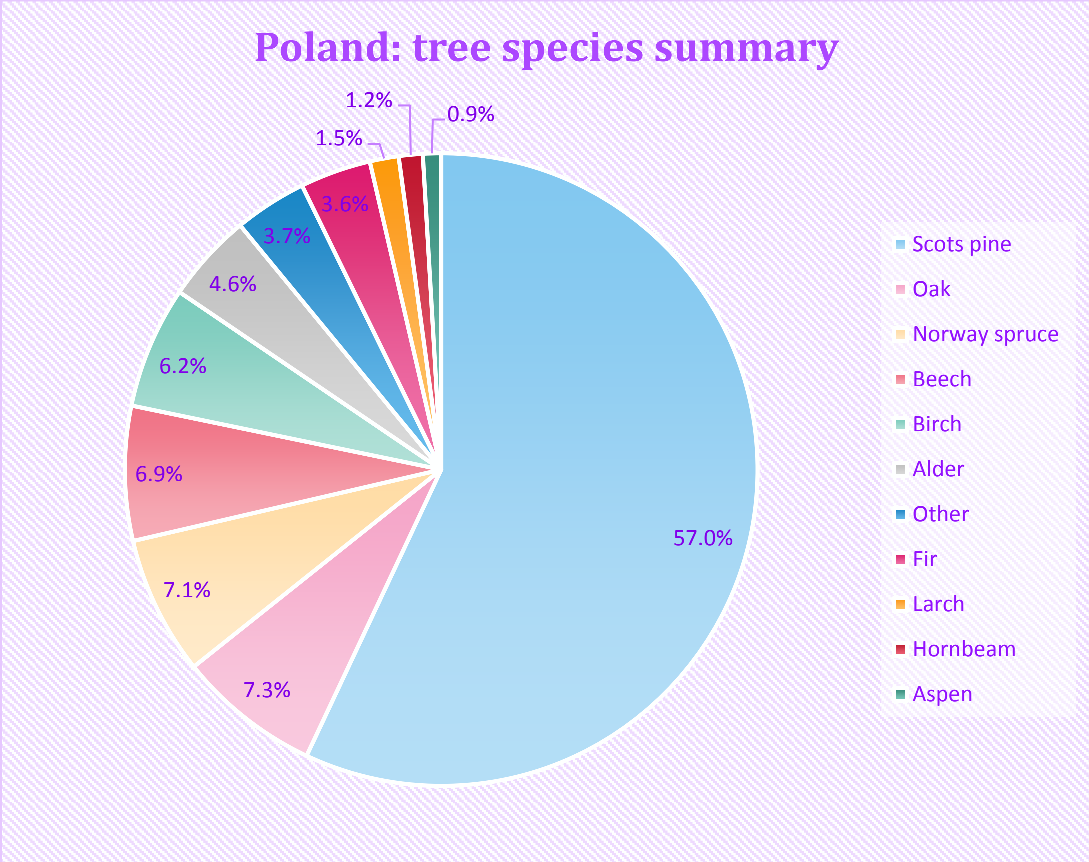

Figure 12: Forest tree species in Poland (after UNECE data)

Along with the species domination of Scots pine highlighted in figure 12, in figure 7 is shown that the intermediate development phase dominates. Around 15% of the area can be attributable to regeneration forest and a similar proportion to mature forest awaiting harvest.

5.5.2 Poland timber income forecast

Timber income has been based on the presumption that conifers are clear-felled but broadleaves are managed on a close to nature system. In terms of volumes of timber at clear fell, Jabłoński and Neroj (2019, 1) found in Poland average standing timber volume to be 280m^3/ha. This however related to the average stand, rather than mature stands. Bis (2009, 79) on the other hand did consider mature stands of timber from various regions in Poland of different levels of quality. From this data an inferred average of mature Scots pine stands averaged at 489m^3 / ha has been used as the basis of timber quantity in the DCF.

The most notable characteristic of the Polish timber income projection is the large number of thinnings. Following the typical rotation suggested by Bis (2009, 89), 7 thinnings have been projected in a typical rotation. Thinning volumes have been determined using the proportions suggested by Pach *et al.* (2018, 215) as noted in table 9.

Timber prices have been sourced for both conifer logs and pulpwood, but were not able to be found on an open source basis for hardwoods. Therefore, in the interests of conservatism hardwood product value has been equated to conifer pulpwood value. Bis (2009 76) suggests a product breakout between log and pulp of 85% to 15% for clear-fell, and 15% to 85% for thinnings, which has been applied to the timber income forecast in the DCF.

5.5.3 Poland generic forest assumptions

A rotation length of 102 years in Poland has been generated from a weighted average of the productive species with more than 5% proportion: Scots pine, oak, Norway spruce, beech and birch, as shown in figure 12. Post harvesting, a presumption has been made that all regeneration would consist of Scots pine, the primary commercial species. In Poland, the silvicultural system for regeneration of Scots pine crops is described by Bis (2009, 40). Scots pine are planted at high density and then gradually removed in a serious of early and later cleaning operations. The costs of these operations have been inflated from those suggested by Bis (2009, 42) to present day using the current inflation rate and capitalised into the silvicultural costs column in the year following clear fell harvest within the DCF model.

5.6 Generic investment valuation model: Lithuania

Since 2010, forest cover in Lithuania has remained steady at around 33% of land area (Rutkuaskas 2017, 12). Today forests are classified into 4 groupings based on primary function: group 1 – Forest Reserves, group 2 – protected forests, group 3 – protective forests and group 4 commercial forests (Brukas, Mizaras, and Mizaraitė 2015, 57). Therefore, it is presumed that the target generic forest is from group 4.

Lithuania, like many countries in emerging Europe features a legacy of central government control, but now gradually increasing private forest ownership. The main obstacles to efficient use of the forest resource in Lithuania are small land ownerships, a lack of capital available from private owners for silvicultural activities and bureaucratic governance. For these reasons for most forest owners, firewood consumption, (modest) timber sales and nature conservation are the primary objective of ownership (Mizarite & Mizaras 2005, 483).

5.6.1 Lithuania forest tree species

In Figure 13 is shown the forestry tree species breakdown in Lithuania. The general pattern of species distribution is similar to the other Baltic States. Scots pine (37%) is the main species followed by Norway spruce (20%), birch (16%), alder (12%) and aspen (6%). Other minor species constituting less than 5% of the countries forest each have been considered unproductive.

Referring to figure 7, over 20% of the forest can be considered mature, which in the Lithuanian context means a technical maturity where optimal log breakout has been reached (Brukas *et al.* 2015, 57). A similar proportion is under regeneration with a relatively smaller proportion at 59% in the intermediate category.

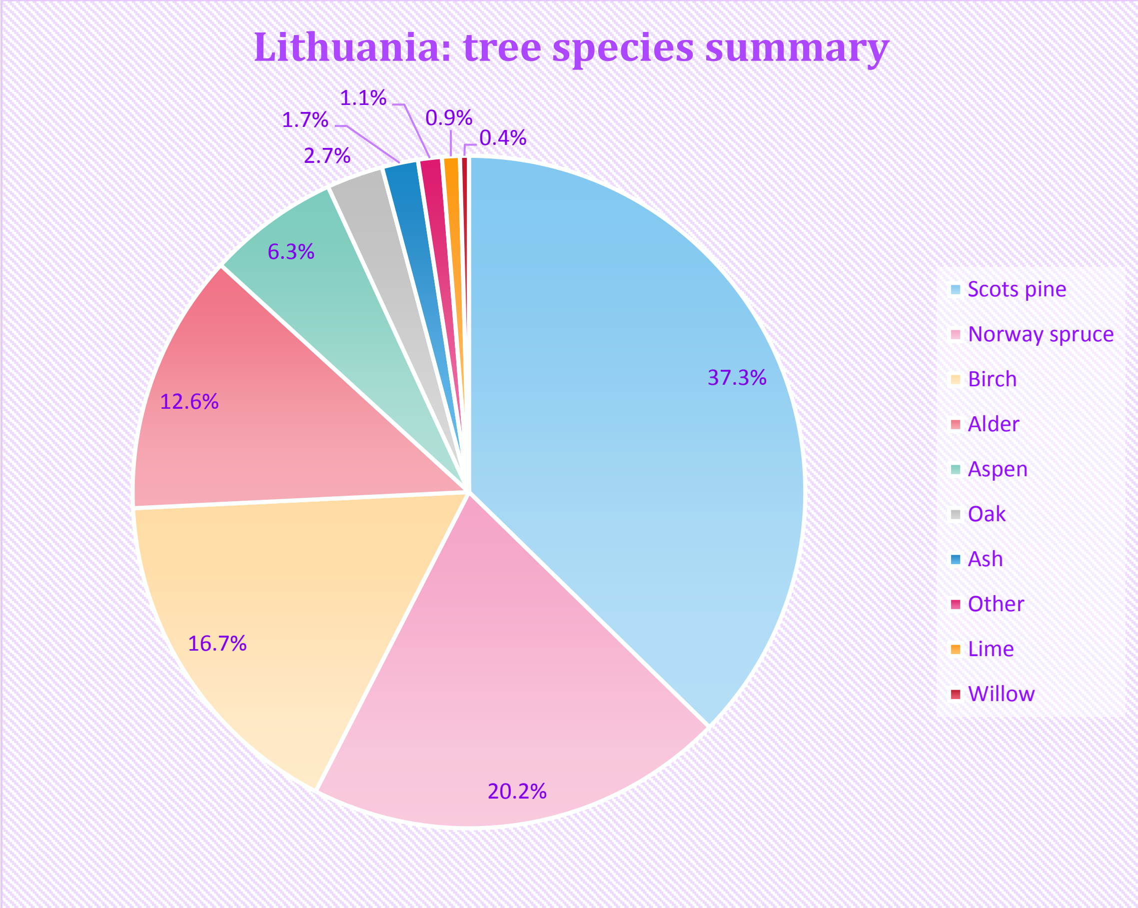

Figure 13: Forest tree species in Lithuania (after UNECE data)

5.6.2 Lithuania timber income forecast

In Lithuania, detailed information on quantities of timber growing and cut are published in the Lithuanian State Forest Service Statistical Yearbook. This data provides national averages on timber volume for mature stands in each of the principle species, which has formed the basis of timber quantity in the DCF for Lithuania.

Thinning volume has been derived using the thinning % as suggested by Pach *et al.* (2018, 215) in table 9. No Lithuanian timber price data could be sourced from published statistics and so timber prices have been obtained by species using the HD forest fest information for the three Baltic States described for Estonia/Latvia.

5.6.3 Lithuania generic forest assumptions

The Lithuania generic rotation has been projected at 74 years old. This has been estimated by using the weighted proportions of pine with 101 year rotation, spruce having a rotation age of 71 years old and other species having a rotation age of 61 years old (Pach *et al.* 2018, 215). Based on the generic rotation length, a DCF duration for Estonia has been generated of 12 years.

The real discount rate for scenario 1 (the domestic TIMO using own country costs of capital) caused difficulty in the case of Lithuania. According to the World Bank data on country interest rates, Lithuania features a rate of 0.31%. However, inflation according to the Eurostat is 2.3%. After application of the Fisher equation to derive the real interest rate, the result is a negative discount rate. To avoid the counter intuitive results that application of a negative interest rate has on the DCF, the interest rate has not adjusted to be real in scenario 1.

Brukas *et al.* (2015, 58) describe a typical schedule of regeneration operations with costs that could be expected for both pine and spruce, the primary commercial species. Spruce is the more expensive species to regenerate costing €1,124 / ha including ground prep, planting and 3 pre commercial thinnings. Pine was a somewhat cheaper option, but, there was some uncertainty due to the price data being somewhat out of date. Therefore, in the interests of conservatism the more expensive spruce regeneration option has been used in the DCF.

5.7 Generic investment valuation model: Romania

According to Nita (2015, 796), Romania contains some 6,519,000 ha of forest (27.3% of land area). This approximately agrees with the EU Eurostat, who place Romania second only to Finland in table 5 illustrating the emerging EU countries with the greatest area of forest.

In Romania, the implementation of centralised control over forest resources during the communist era was total, and even in recent times there is only a limited functional land acquisition market. Most land is acquired through a process of court restitution (Nichiforel *et al.* 2015, 12). Also, although since 2014 it is possible for foreign owners to buy forest in Romania (Nichiforel *et al.* 2015, 11), a pre-emption right also applies pre-sale to the authority and neighbours (Nichiforel *et al.* 2018, 12).

The most common forest management system, used in 66% of forests, is even aged plantation management (O'Hara 2018, 135). However, for investors the greatest barriers to the country are highly inflexible and prescriptive management regulations, low road density, and insecure land tenure as a result of the court restitution process (Nichiforel *et al.* 2015, 18).

5.7.1 Romania forest tree species

Looking at figure 14, in Romania, the primary species are beech at 35% and Norway spruce at 29%. Bouriaud *et al.* (2016, 1) in their study recognise beech and Norway spruce to be the most economically relevant elements of Romanian forests. In the context of the low efficiency of management that prevails in Romania due to the inappropriate and outdated reforestation regime (Palaghianu 2018, 46), low density of roads (Nichiforel *et al.* 2015, 19) and historical over exploitation (Bouriaud *et al.* 2016, 2), no species beyond beech and Norway spruce have been considered productive within the DCF timber income forecast.

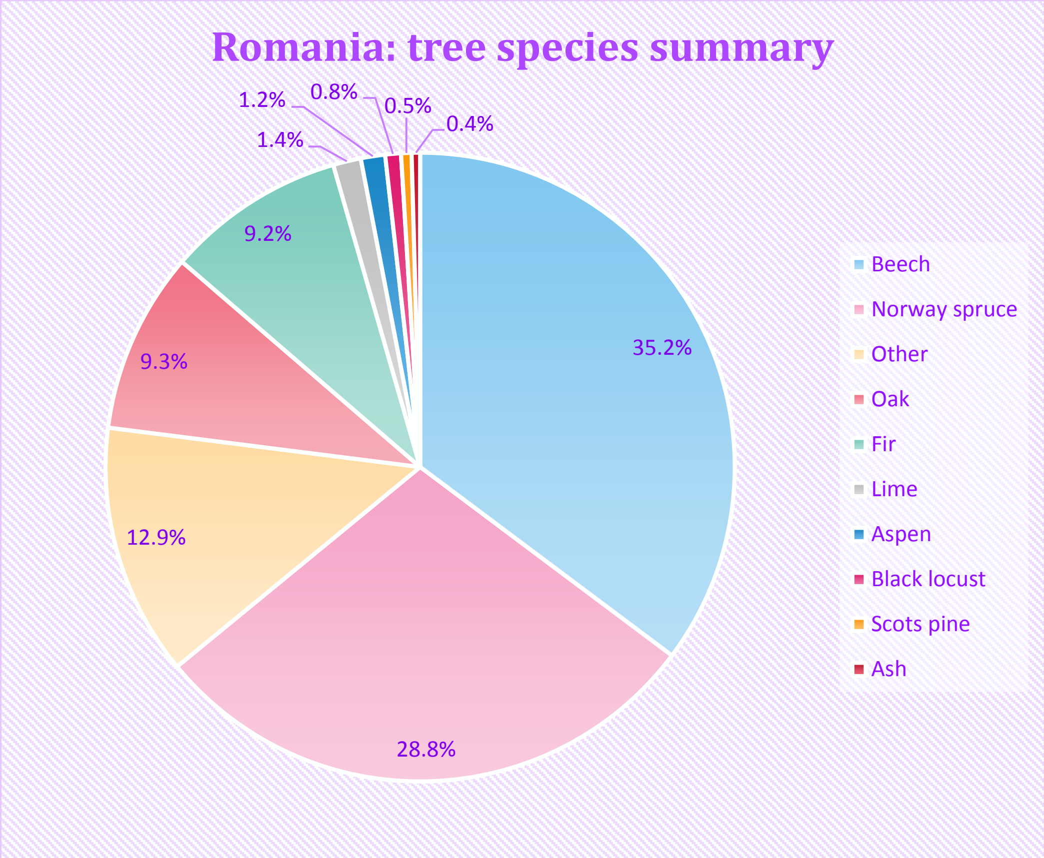

Figure 14: Forest tree species in Lithuania (after UNECE data)

No development class data for Romania has been provided by the UNECE. However, Munteanu, Nita, Abrudan and Radeloff (2016, 189) investigated the age class structure of Romanian forests over time and found a distribution in 2014 as detailed in figure 15:

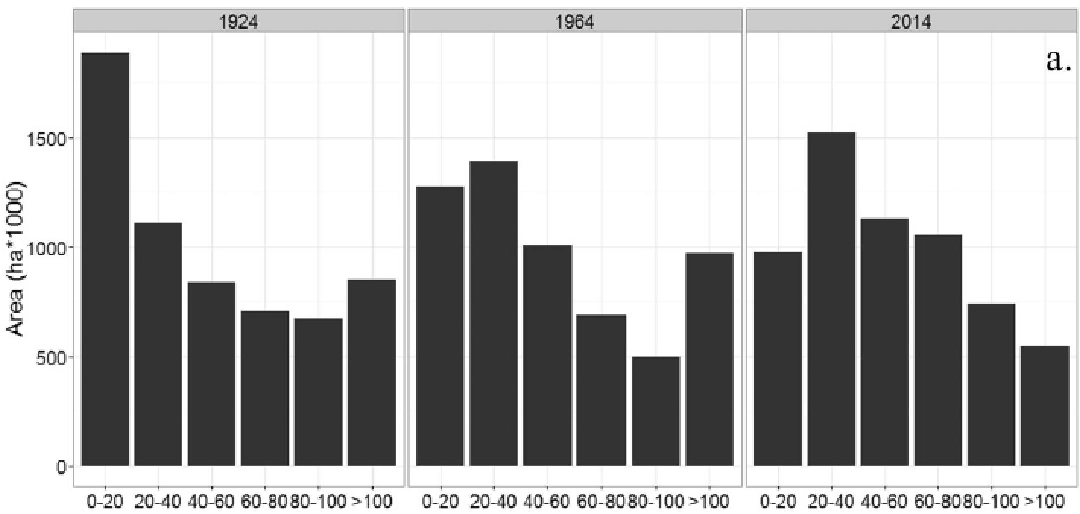

Figure 15: Romania forest age class distribution After Munteau *et al.* (2016)

Conversion of the 2014 data in figure 15 from age classes in 20 year bands, to the UNECE classes of ‘regeneration’, ‘intermediate’ or mature was undertaken by equating the development classes as per break down in table 12. Then, by applying the development phase proportions inferred from Munteanu *et al.* (2016, 189) and applying the UNECE species data breakdown one can formulate productive area summary as per the table in appendix 1.

Table 12: Inferred crop development classes in Romania.

Age class	Area (‘000 ha)	Development class	Development phase proportion
0-20	950	Regeneration	41%
20-40	1,500	Regeneration	
40-60	1,100	Intermediate	49%
60-80	1,050	Intermediate	
80-100	750	Intermediate	
100 +	600	Mature	10%

5.7.2 Romania timber income forecast

Bouriaud *et al*. (2016, 7) summaries the key silvicultural aspects of beech and Norway spruce in Romania, which is determined in the main by regulatory aspects. Information on timber prices and average timber volumes is difficult to come by in Romania. One could infer that the strict regulatory regimes in place described by Bouriaud *et al.* (2016, 7) have conjured a state whereby information is not willingly shared by forest market participants, due to the risk harsh penalties (Ilie 2013, 174) incurred as a result of regulatory infringements.

5.7.3 Romania generic forest assumptions

Sculze *et al.* (2014) describe that Romanian silviculture could be described as ‘cut and leave’. They assert that this is not suggesting resource depletion, but that regeneration is undertaken over a longer period using natural succession.

Thinning is permitted, but only every 10 years once the canopy is closed and is limited to 17-18% (Bouriaud *et al.* 2016, 7). From age 100, clear-fell is allowed, but only using patch cuts up to 3 ha in spruce and shelter wood systems in beech (Schulze 2014, 5). Therefore, the Romanian generic forest has been projected to be thinned three times during the inferred 'intermediate phase', from age 40-100, and with a staggered clear-fell from age 100-130 (spruce) and 100-160 (beech). This gives rise to a generic rotation length of 145 years and a DCF duration of 24 years.

Since in Romania the 'cut and leave' approach is used, no 'restocking costs' have been projected in the DCF. Also, due to the lack of infrastructure described by Nichiforel *et al.* (2015, 19) an allowance for capital expenditure in infrastructure to facilitate timber harvesting has been projected.

5.8 Generic investment valuation model: Hungary

In 2017 the Hungarian Forestry Authority published Forestry statistics on Hungarian forests. It states that:

- 20.9% of Hungarian land is forest.
- Clear-fell is by far the most common silvicultural practice and growing stock has been steadily accumulating.
- The forest is diverse in type, with native hardwoods such as oak and beech being present, alongside exotic species plantations of popular and notably black locust. The country contains the largest area of black locust anywhere in Europe.

Jager *et al.* (2015, 16) report on forest ownership change in Hungary. They assert that 'only private persons' may obtain forest land. Also, recent changes limit forest purchases further to only 'farmers or foresters', which has spawned various companies offering forestry courses to those looking to acquire land (Aranykalaszos, 2019). These findings agree with our ranking of Hungary within emerging Europe as the lowest on the scale of opportunity due to uncertainty over the investible area of private forest blended with the legal and regulatory restrictions.

5.8.1 Hungary forest tree species

The diversity of Hungarian forests is illustrated in figure 16. Oak is the dominant native hardwood at 40.8%, then the exotic species black locust follows at 15.9%. Black locust is of note as it is the largest element of exotic species forestry tree planted in our target nations. It is normally grown in single species plantation (Nicholescu *et al.* 2018, 4). The presence of black locust is significant as it features a differing regulatory regime to native woodland, for example, there is grant available for afforestation of some exotics (Jager *et al.* 2015, 19).

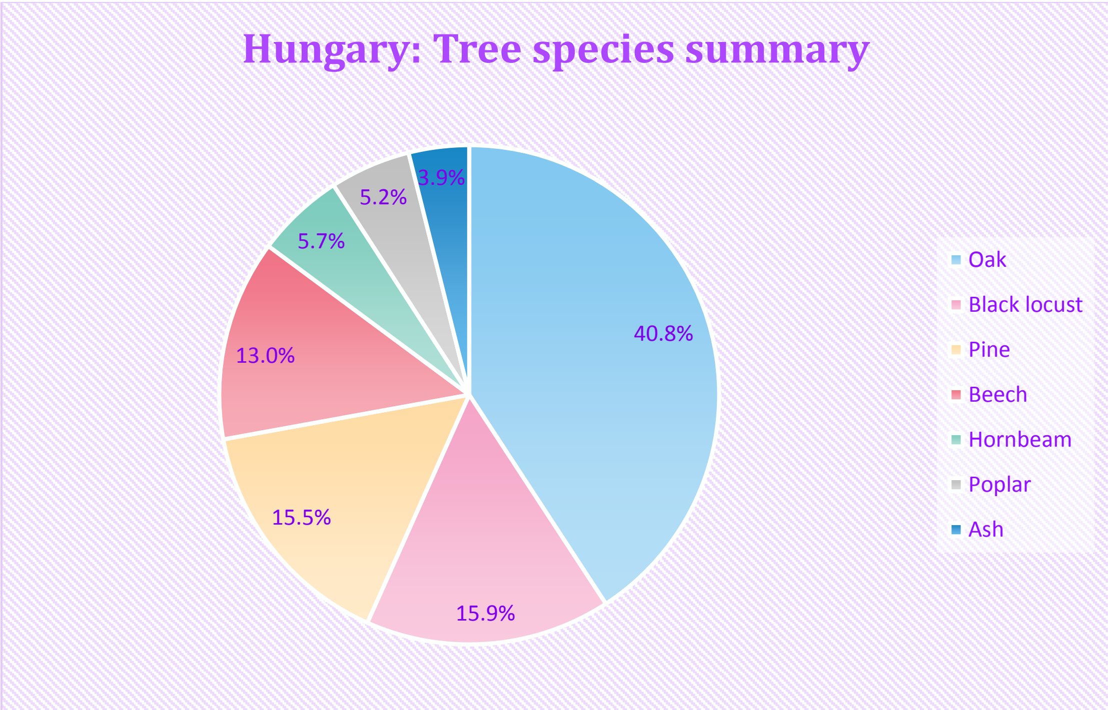

Figure 16: Forest tree species in Hungary (after UNECE data)

Pine occupies a similar area at 15.5%. Beech covers 13%. Hornbeam and poplar form minor elements but are treated as commercial as they form over 5%. The Hungarian forest is dominated by stands in the intermediate development class category at 76%, as displayed in figure 7. The balance is split approximately equally between regeneration and mature areas.

5.8.2 Hungary timber income forecast

The Confederation European des Propriataires Forestiers or CEPF in 2010 reported on forestry in Hungary. CEPF (2010, 10) assert that annual increment across Hungarian forests is 6.8m^3/ha/year, and this has been used as the basis for the timber production forecast. Final felling volume data from Hungary was not found in the literature and so felling volume was equated to average annual increment multiplied by weighted rotation length. The CEPF report includes detailed information of stumpage prices by species, and so these data have been used in concert with volume breakouts by species following the proportions suggested by the UNECE data.

5.8.3 Hungary generic forest assumptions

The CEPF (2010, 10) report details average rotation lengths for the various species of interest in Hungarian forestry. There is a wide variation, with oak and beech on one hand at 110 years, whereas black locust is only 30 years. The weighted average is 68 which suggests a DCF duration of 11 years is appropriate using the rationale of 'growing' the various crops from the centre of one development phase until the point at which they cross over into the next development phase.

According Jáger, Schiberna, Ali, and Horváth (2015, 13), forest management in Hungary is highly regulated and conforms to principles of sustainable production on a 10 year planning cycle. Therefore, a rationale of production on an intervention cycle of 10 years has been used in projection of the generic rotation.

6 Results and discussion

The three result metrics: IRR, NPV and LEV, find differences in which nations are most desirable for forestry investment. From the literature review, it was established that the IRR is the most useful for *comparing* which investment generates the highest rate of return. The NPV on the other hand measures which investment delivers the *greatest* wealth back to the owners of the business. Finally, the LEV considers which land is inherently most valuable in generating investment returns from forestry in perpetuity, but *excludes* costs of property acquisition.

In the results figures, the order of the presentation of the countries has been retained in the order of those with the theoretically highest investible area at to the left (i.e. Finland being the nation with the highest investable area, and Hungary with the lowest). For each metric, results are displayed for the three scenarios as described in table 13, repeated below from the objectives.

Table 13: Output metrics summary

	Scenario 1: Domestic TIMO	Scenario 2: International TIMO	Scenario 3: International TIMO
Output metric	Own country discount rate and inflation rate	Standard discount rate and own country inflation rate	Standard discount rate and inflation rate
IRR	IRR_1	IRR_2	IRR_3
NPV	NPV_1	NPV_2	NPV_3
LEV	LEV_1	LEV_2	LEV_3

6.1 Internal Rate of Return

The IRRs for scenarios 1-3 are found displayed in Table 14. Since costs of capital, or real interest rate used is such as crucial factor, the real interest rates are also displayed in table 15 for context. Latvia is the strongest performing country in all scenarios. Further discussion of the dynamic in each scenario will now be explored further.

Table 14: IRRs generated from countries own generic forests

Country	IRR_1 (%)	IRR_2 (%)	IRR_3 (%)
Finland	7.6	2.5	4.8
Latvia	39.3	40.5	39.5
Estonia	13.3	3.5	3.2
Slovenia	3.3	3.1	-3.5
Poland	5.1	2.9	2.6
Lithuania	32.4	12.9	13.5
Romania	1.1	2.6	-0.6
Hungary	28.6	23.4	15.1

Table 15: Real interest rates used in scenario's 1-3

Country	Scenario 1 Interest Rate (%)	Scenario 2 Interest Rate (%)	Scenario 3 Interest Rate (%)
Finland	1.50	3.70	2.4
Latvia	2.60*	1.84	2.4
Estonia	0.60	2.30	2.4
Slovenia	0.60	3.30	2.4
Poland	1.60	2.30	2.4
Lithuania	0.30*	2.60	2.4
Romania	1.50	1.00	2.4
Hungary	0.90*	1.40	2.4

**Unadjusted by inflation due to negative result.*

6.1.1 Internal Rate of Return: Scenario 1

Studying figure 17, it is interesting to note that Latvia, Lithuania and Hungary, are performing exceptionally strongly using the generic forest model. Estonia and Finland are within the IRR range originally suggested by Dasos back in in 2010, whilst other nations have a more modest return profile. However, with the exception of Finland, there are no recent published open source data on generic investment returns generated from forestry property in our target countries that could be sourced in order to compare our results with the findings of others.

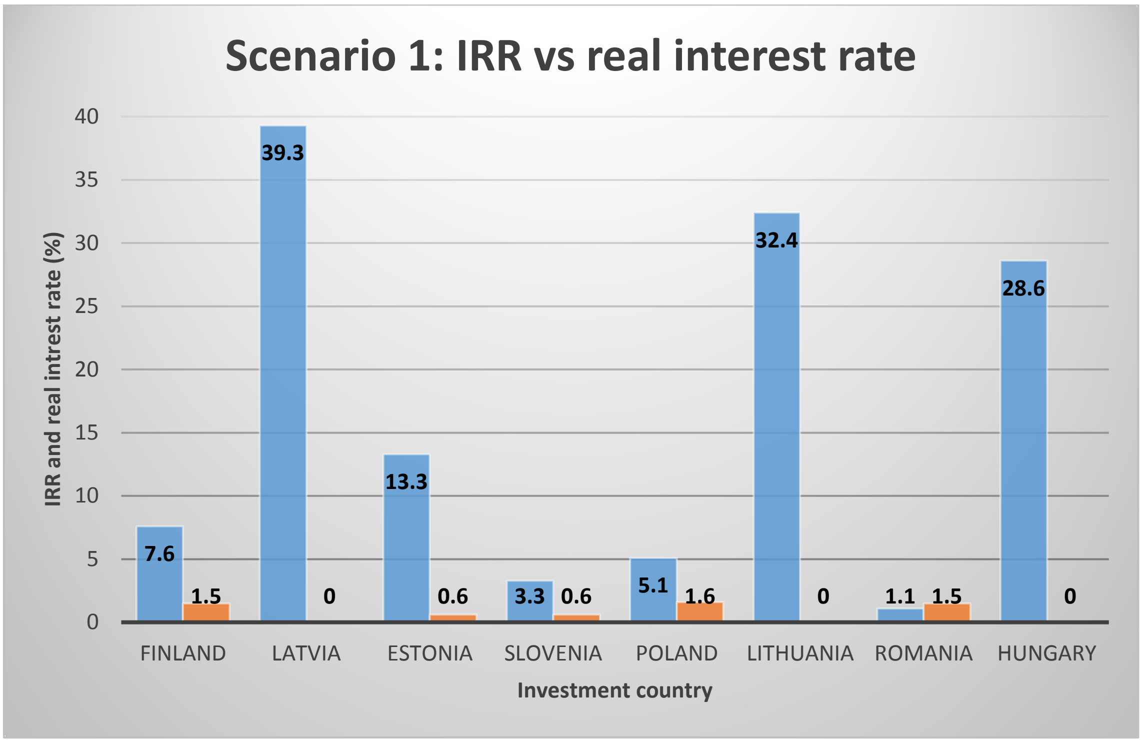

Figure 17: IRR and real interest rates from Scenario 1.

In Finland, LUKE in 2019 published results that suggested returns for the whole of Finland average 12.98% in real terms over 2018. This is displayed in figure 18. Just over two thirds of this return were generated from changes in stumpage value, and the balance from biological growth of timber.

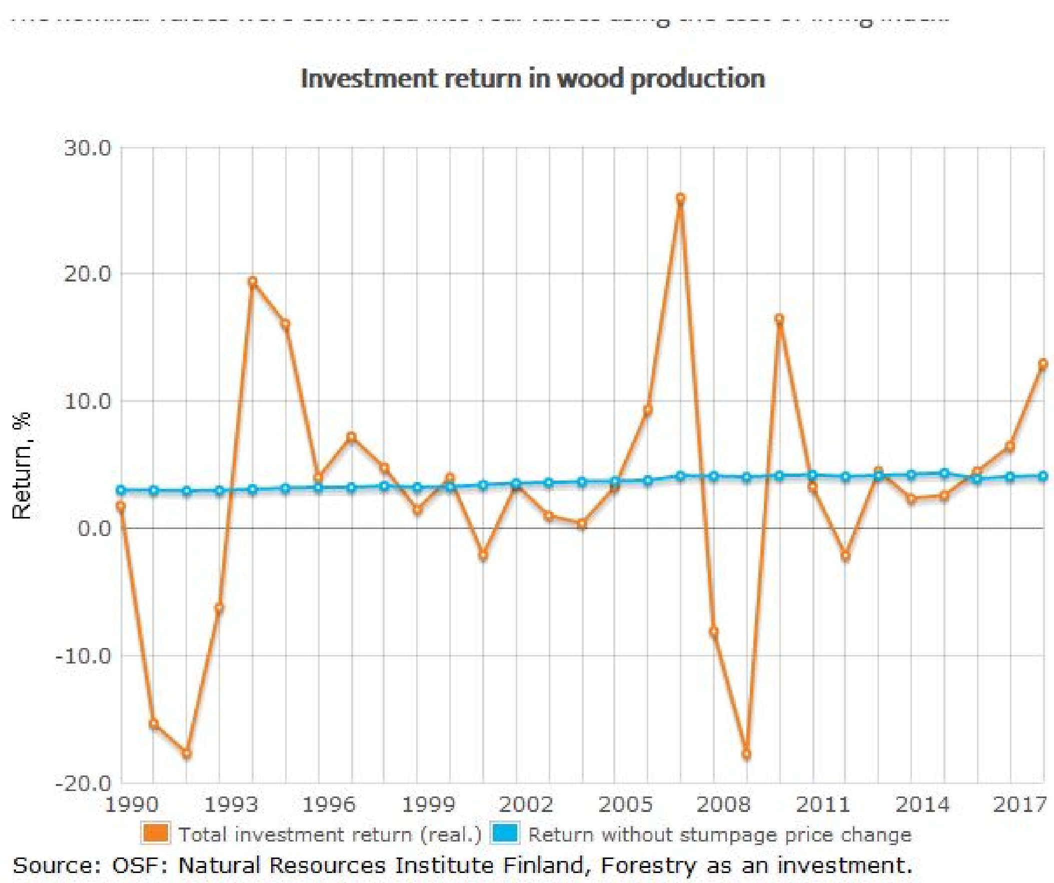

Figure 17: Forestry investment returns in Finland by source (after LUKE Finland)

Back in 2010, Dasos suggested that an appropriate level of return in Eastern Europe should be 7-15%. However, this assertion should now be treated with caution given the movement in the investment environment outlook, especially in relation to interest rates. Through flexing interest rate levels in the scenario 1 models, it was observed that higher interest rates reduce forestry returns / values and that lower interest rates increase them. This characteristic can be found in table 14 and 15. Where the standard 5% WACC is used in scenario 2, which generally results in a greater real interest rate, IRR tends to decrease. Therefore, given that in current times Europe is experiencing a period of prolonged extremely low interest rates, one would expect the rate of return possible from forestry to have increased from 2009 levels.

In Latvia, Lithuania and Hungary this is indeed the case with IRRs found of 39.3, 32.4 and 28.6% respectively for scenario 1. However, the results from these three countries displaying exceptionally high IRRs must be treated with caution. These nations real adjusted interest rates were negative, so commercial lending rates were used instead of a real interest rate adjusted by the Fisher equation, which will have significantly impacted the result.

It could be argued that the approach of scenario 1, use of individual interest rates for each nation, whilst being representative of the financial environment in the country, is not appropriate for an IRR comparison between countries. This is because if we are undertaking the study from the perspective of an international TIMO evaluating where to place funds, then the source of credit is unlikely to be the country in question. Rather, the WACC is much more likely to reflect the TIMOs own capital return requirements or owners' equity return requirements. This brings us to consideration of scenario 2, whereby a standard WACC is applied.

6.1.2 Internal Rate of Return: Scenario 2

Since three of the nations had to use costs of capital unadjusted for inflation in scenario 1, and those three have produced what intuitively appear to be very (too) high IRRs, It could be asserted that the scenario 1 approach of individual country interest rates may be impacting the quality of the results. In order to strip out the potential impact of the variance in cost of capital impact on the IRRs, a presumption of the same WACC originating from a single international TIMO purchaser was made for scenario 2. Then, IRRs were generated with a standard nominal interest rate, is displayed in table 14 and table 15.

<u>Selection of the standard Weighted Average Cost of Capital for scenario 2</u>
The question therefore arises again of what an appropriate standard interest rate to use would be? One option on the interest rate is to use the Finnish LUKE results on forestry investment returns as a benchmark. In other words, select the WACC that would in the DCF for Finland, arrive at the investment returns as projected by LUKE, and then apply the same rate as a standard WACC to all the other countries.

Using this approach the rate to choose is 1.92%, which is the rate required to obtain the 12.9% real return in Finland according to our generic Finland forest model. However, there is a major problem with this approach. Much of the 12.9%

return has been generated through *change in stumpage values*, rather than biological growth whereas our evaluation has been undertaken presuming static assumptions, i.e. no change in stumpage values.

The problem of static assumptions failing to take account of the opportunity forestry investors have of making additional return from increases in stumpage was underlined by Cheung and Marsden (2002, 9). Cheung and Marsden (2002, 12) asserted that for this reason, static assumption based NPV cash flows tend to under value forest assets. Also, if we are to move to a standard nominal cost of capital, it is desirable to eliminate the result of negative real rates on the results caused by inflation exceeding WACC in Latvia, Lithuania and Hungary - 1.95% is still too low a WACC to achieve this elimination.

Another pragmatic point is that, although the models presume static interest rates and inflation rates, which are currently at very low levels, forestry investors may be taking a longer term outlook presuming some movement in rates. As forestry is inherently a long term enterprise, investors may weigh up that the current exceptionally low interest rate environment will not persist over the longer term, or over the terms of the expected hold of the forest property investment. On that basis, investors may conclude that it is not appropriate to buy forest assets now based on valuations of forests at ‘high levels’ underpinned by low interest rates – since if interest rates rise in the longer term, the value outlook of their asset from an income perspective will have diminished (Hoyt 2015, 5).

Therefore, a rationale for a choice of nominal discount rate above the 1.92% level is required. The scenario 2 deemed appropriate nominal discount rate applied to the countries was 5%. This is a rounded sum, which is approximately halfway between 2.6%, whereby all negative real rates from our models could be eliminated, and 7.5%, the approximate lower end of the range suggested by Dasos in 2010. This also generates a real discount rate in Poland of 2.3% or 2.4% for scenario 2 and 3 respectively, which aligns approximately with Chudy *et al.* (2020, 8), although a different approach has been used in relation to land acquisition cost and risk contingencies.

Impact of the standard 5% Weighted Average Cost of Capital

Using a nominal 5% WACC across the countries, real rates are still obtained by taking account of inflation rates in the respective models from each country. The IRRs and respective real rates for scenario 2 are displayed in figure 18. Considering the real interest rates shown in figure 18, now all the rates used are positive after adjustment for inflation, so the comparison is fairer than in scenario 1.

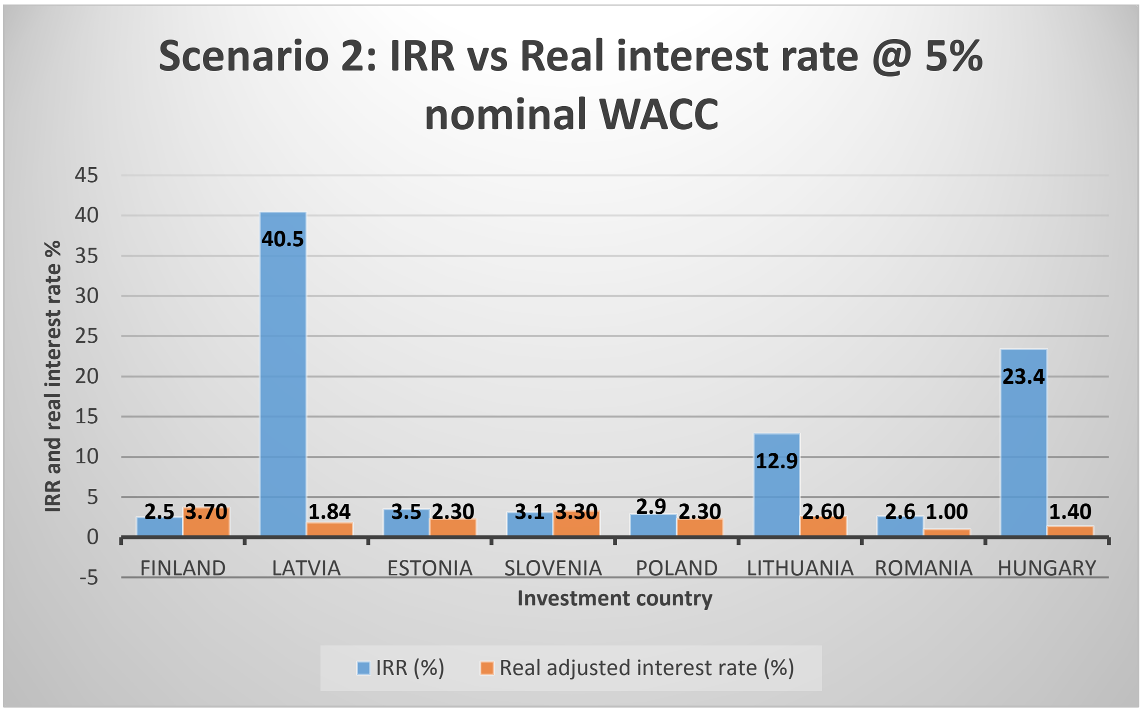

Figure 18: Scenario 2 IRRs and real interest rates

There are still three countries exhibiting very high returns: Latvia, Lithuania and Hungary. Due to our weighting of investability, the Hungary result should be treated with the most caution and greatest confidence should be attributed to Latvia. One way to display the result in a more conservative manner could be stratify countries based on groupings of hurdle rate around which countries can cluster. This stratification is displayed in table 16. Therefore, considering the IRR metric and presuming various TIMO IRR hurdle rates Latvia, Lithuania and Hungary could be considered to top grouping.

Table 16: Stratification of scenario 2 IRR results according to selected hurdle rates.

TIMO hurdle IRR	Viable targets
4%	Latvia, Lithuania, Hungary
3%	Estonia, Slovenia
2%	Finland, Romania, Poland

Interestingly using the scenario 2 5% WACC, the ‘biological growth only’ return elicited from our model in Finland of 2.5% is similar to the return ‘without stumpage price change’ suggested by LUKE in figure 17. This provides some assurance that the approach, at least in Finland, is appropriate. Notable elements of the IRR results for specific countries are explored further by country.

6.1.3 Internal Rate of Return Scenario 2 country commentary: Latvia, Lithuania and Estonia.

The Baltic States are a natural grouping as they were considered a ‘developed growing market’ by commentators Forestry Business Analytics (Forest analytics, 2018). The scenario 2 IRR result with a standard 5% WACC in the Baltic countries is especially interesting. There are significant differences in the IRRs; Latvia at 40.5%, Lithuania at 12.9% and Estonia at 3.5%. However, fundamentally there are similarities in their forest resources according to the UNECE data with Scots pine, Norway spruce, birch, alder and aspen being the commercial species. The quantities of the species are not in significantly dissimilar proportions, and the proportion of mature forest, as displayed in figure 7, which has the greatest effect on timber income, has a narrow range from 21-26%.

In order to examine the differences between the DCFs that may explain the variance in IRR, a comparison between the main elements of the three countries DCFs is illustrated in table 17. Considering the three countries DCF elements, although there are many similarities, there are two key differences evident which may explain the significant differences in IRRs. Firstly, Latvia benefits from much lower property acquisition costs that Lithuania or Estonia at only -€1,500/ha, compared to -€3,200/ha and -€3,600/ha respectively. Both Latvia and Lithuania also enjoy very strong terminal values, which are much larger than Estonia. The origin of the differences in terminal value appear to come back to the underlying credentials of the property to be able to generate timber income. In Latvia and Lithuania, clear-fell income/ha is projected at €9,457 and €9,664 respectively, whilst in Estonia it is €6,962. The difference in stumpage appears to be down to relatively lower volumes per ha in Estonia and relatively lower timber prices, according to the generic country data.

Table 17: comparison of DCF elements in Latvia, Lithuania and Estonia

Element	**Latvia**	**Lithuania**	**Estonia**
Acquisition costs /ha	-€1,500	-€3,200	-€3,600
Net timber revenue /ha	€3,783	€3,169	€2,506
Management and maintenance (ha/yr.)	-€62.40	-€69.20	-€69.00
Silvicultural expenditure	-€1,997	-€2,620	-€3,120
Terminal value	€59,800	€61,990	€37,371
DCF duration - years	14	12	13
Real interest rate at 5% WACC	1.84%	2.64%	2.30%

However, mixed data sources have formed the basis of these clear-fell income per ha projections, and so an element of caution should be applied. Also, although in Estonia and Lithuania stumpage prices were used, in Latvia timber products were available on a 'per product' basis. The sources of the product breakout proportions and the products prices were different. This meant another layer of assumptions needed to be applied to elicit the overall timber income. So, for example, it is possible variances in how timber products were defined as 'logs' or 'pulp' may have influenced estimates of product breakout and weighted overall timber price.

For these reasons it is difficult to make definitive assertions regarding which of the three Baltic countries may have the best forest investment merits. However, presuming the assumptions used are broadly correct then the most desirable location is Latvia, followed by Lithuania and then Estonia. The reasoning for the differences appear to be higher timber volumes present in Lithuania and Latvia, combined with lower forest values in Latvia.

6.1.4 Internal Rate of Return Scenario 2 country commentary: Hungary

Outwith the Baltics, the scenario 2 IRR for Hungary was found to be the greatest at 28.8%. Intuitively, this appears an unnaturally strong IRR for a forestry investment in Europe. Therefore, it is appropriate to investigate the main DCF elements and make a comparison to elicit what factors may be driving the high IRR result. Unlike the Baltic States, there are not any neighbouring nations with similar forestry characteristics and so it makes sense to compare Hungary with Finland, as our benchmark country where perhaps the best open source forestry data was available.

This comparison has been undertaken in table 18. Considering the information in table 18, there are differences between the acquisition costs and timber income in existing mature crops between Hungary and Finland. However, the most significant variances to note in table 18 are the difference real interest rates at 1.4% and 3.7%, and the highly significant variation in terminal value / ha from €21,469 (Hungry) to €3,296 (Finland).

Table 18: Comparison of DCF elements in Hungary and Finland

Element	**Hungary**	**Finland**
Acquisition costs /ha	-€4,326	-€3,026
Net timber revenue / ha	€2,539	€2,283
Management and maintenance (ha/yr.)	€60.60	€70.00
Silvicultural expenditure/ha	-€105	€478
Terminal value / ha	€21,469	€3,296
DCF duration - years	11	15
Real interest rate at 5% WACC	1.4%	3.7%

It is useful at this point just to recall the implication of the Terminal Value. The TV in this analysis sums both the value of the bare underlying land in terms of its capability to generate income in the future (i.e. LEV) and also the discounted net cash flow remaining from the immature crops. Therefore, interest rate is a critical element in the TV, considering values into perpetuity and as a figure in our DCF, also has a profound effect on our IRRs. The difference between the LEV in Hungary and Finland is the largest between any two nations in the study – over €12,000/ha using a standard WACC of 5%. The reasons for this difference are multiple. Hungary features higher inflation and so has a lower 'real' interest rate. It features shorter rotations, higher timber incomes per ha and lower silvicultural costs. The result is that crucially, within the TV, immature crops in Hungary are more valuable, which significantly affects the TV and thus the IRR.

6.1.5 Internal Rate of Return: Scenario 3

The third scenario uses the approach of an international TIMO again using a standard 5% WACC as per scenario 2. However, in scenario 3 variation in current inflation rates have been ironed out, and an average inflation figure of 2.5% has been used from across the eight nations. The rationale for scenario 3 is that it can be argued that the long term nature of forestry investment makes variation as a result of inflation inappropriate, since the future inflationary environment in each nation is unknown beyond the present. Therefore, scenario 3 is a pure 'real terms' analysis, which is probably most appropriate for long term forestry investment, not in publicly traded vehicles such as REITs, where dividends may be affected by short term inflation (Hoyt 2015, 5). With a standard nominal WACC of 5% and standard inflation assumption of 2.5%, the real interest rate, as displayed in figure 19, is 2.4% for all the potential investment nations.

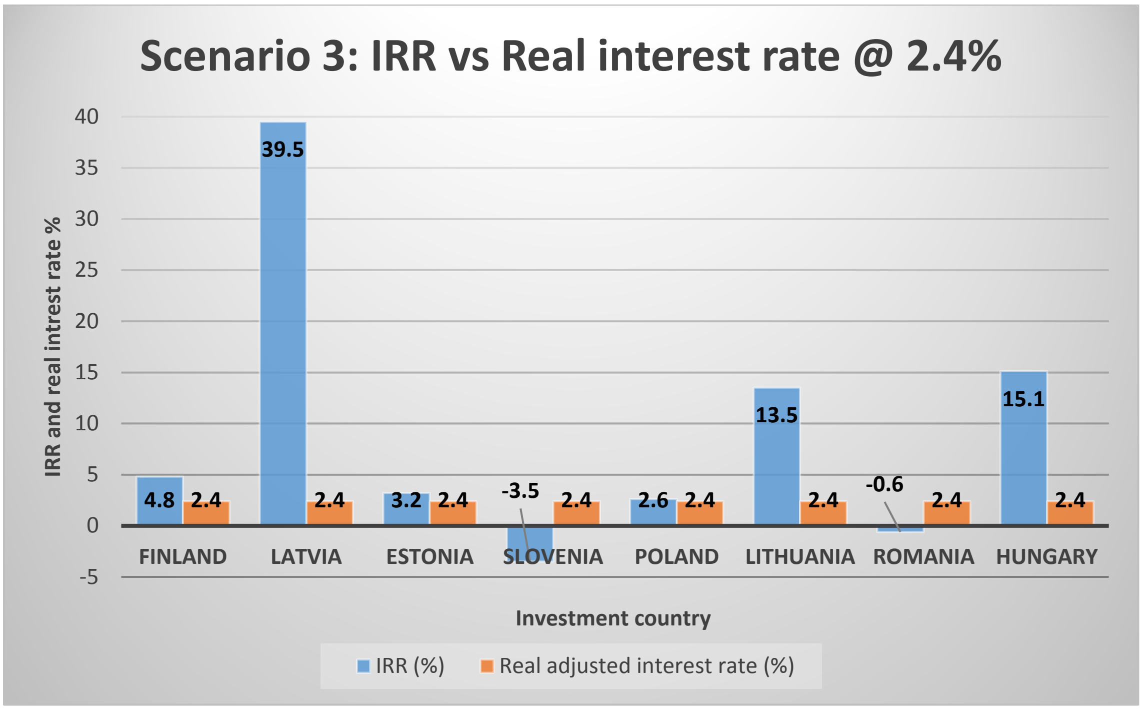

Figure 19: Scenario 3 IRRs and real interest rates

Considering the changes in IRRs in figure 19 from scenario 2, Latvia, followed by Hungary and Lithuania are still the clear top performers with real IRRs of 39.5%, 15.1% and 13.5% respectively.

6.2 Net Present Value

The NPV represents wealth that could be returned to the owners of the business further to the forest acquisition, expressing future net value today. A negative result would indicate that the acquisition is not recommended at the price available, whilst a positive result indicates that the investment is recommended at the price available.

The NPVs for scenarios 1-3 are found displayed in Table 19. Interestingly, the highest NPV varies by scenario. In scenario 1, Lithuania has the greatest NPV, whereas in scenarios 2 and 3 Hungary has the greatest.

Table 19: NPVs generated from countries own generic forests

Country	NPV_1 (€'000)	NPV_2 (€'000)	NPV_3 (€'000)
Finland	111	-13	33
Latvia	32	49	36
Estonia	89	4	3
Slovenia	12	-1	-14
Poland	42	4	2
Lithuania	402	33	38
Romania	-6	35	-36
Hungary	274	158	62

6.2.1 Net Present Value: Scenario 1

Considering figure 20, interestingly only Romania shows a negative NPV. Both Lithuania and Hungary show very high NPVs relative to the remaining countries, whilst Finland and Estonia are in a moderate position. Latvia, and especially Slovenia and Poland show quite low but still positive NPVs.

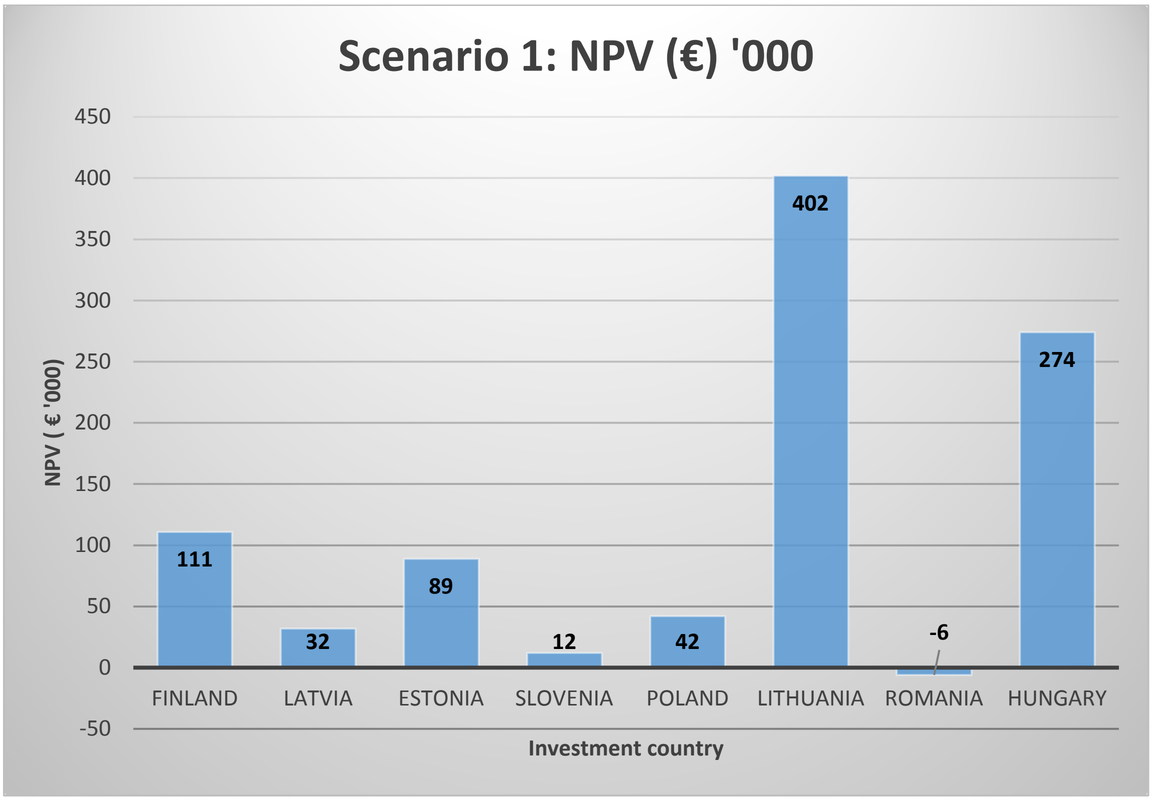

Figure 20: NPV results for scenario 1

One crucial variance is the interest rate between the countries. The interest rates from table 15 are displayed graphically in figure 21. Rates vary from 0.3% with Lithuania to 2.6% with Latvia. The mean of the rates is 1.2%. Intuitively, what is striking is how low the rates are, which will have been a significant factor in boosting NPVs.

Considering figure 20, one may question why Latvia, our highest performer on an IRR basis has such an unimpressive NPV. The potential answer becomes clearer considering figure 21, where the real interest rate for Latvia is significantly greater than the other nations and where Lithuania has a very low rate of only 0.3%.

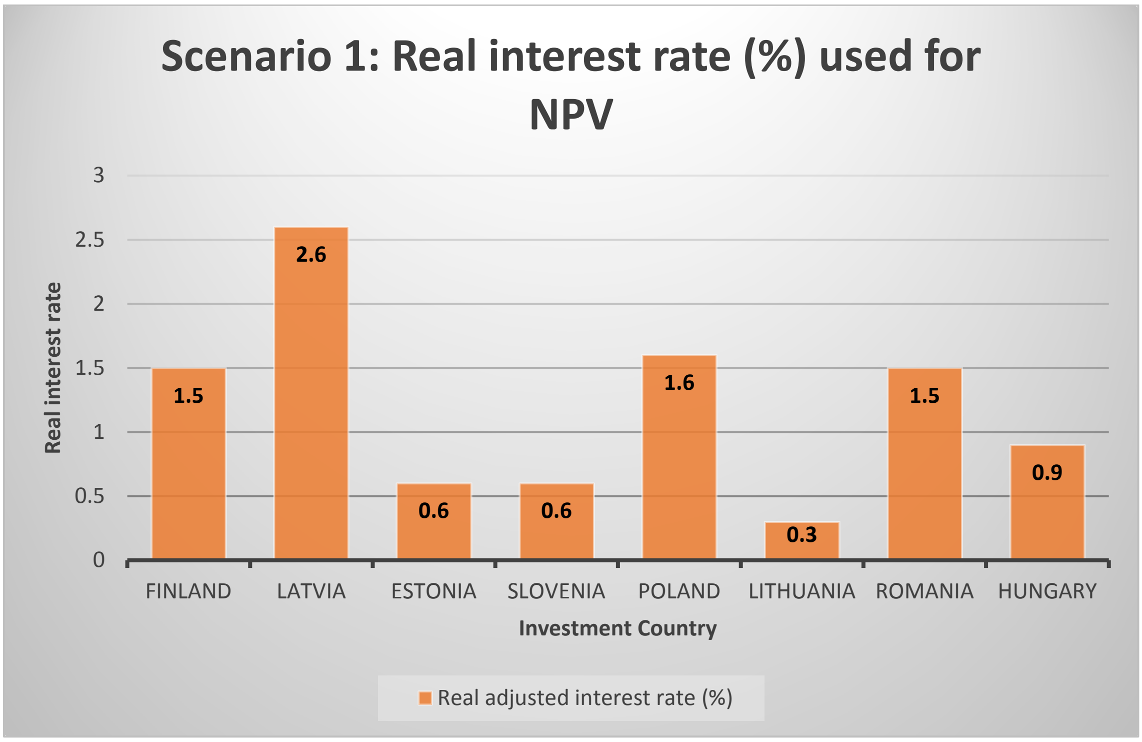

Figure 21: Interest rates used in NPV calculation for scenario 1

6.2.2 Net Present Value: Scenario 2

As with the IRRs, the NPV results have also been produced under a fixed nominal interest rate of 5% in order to:

- Remove the problems of being unable to generate positive real interest rates in Latvia, Lithuania and Hungary.
- To recognise that investors may feel that the current very low rates of commercial lending in Europe may not be representative of the longer term outlook.
- To recognise that investor's capital may originate from international sources, rather than the country where the investment is located.

At a 5% nominal WACC, the mean real rate of interest increases from 1.2% to 2.3% using averages of the figures in table 15, although there is variance in this as the countries own real rates factoring in local inflation conditions range from 1.0% - 3.7%.

As one would expect, higher interest rate results in generally lower NPVs, which are displayed in figure 22. Finland and Slovenia exhibit negative results, although the Slovenia result is marginal. Romania bucks the trend in increasing its NPV from negative to positive and joins Latvia and Lithuania in being in the +€30,000-€50,000 range. Hungary now stands alone with the greatest NPV although it significantly reduced from +€274,000 to +€158,000, from scenario 1 to scenario 2.

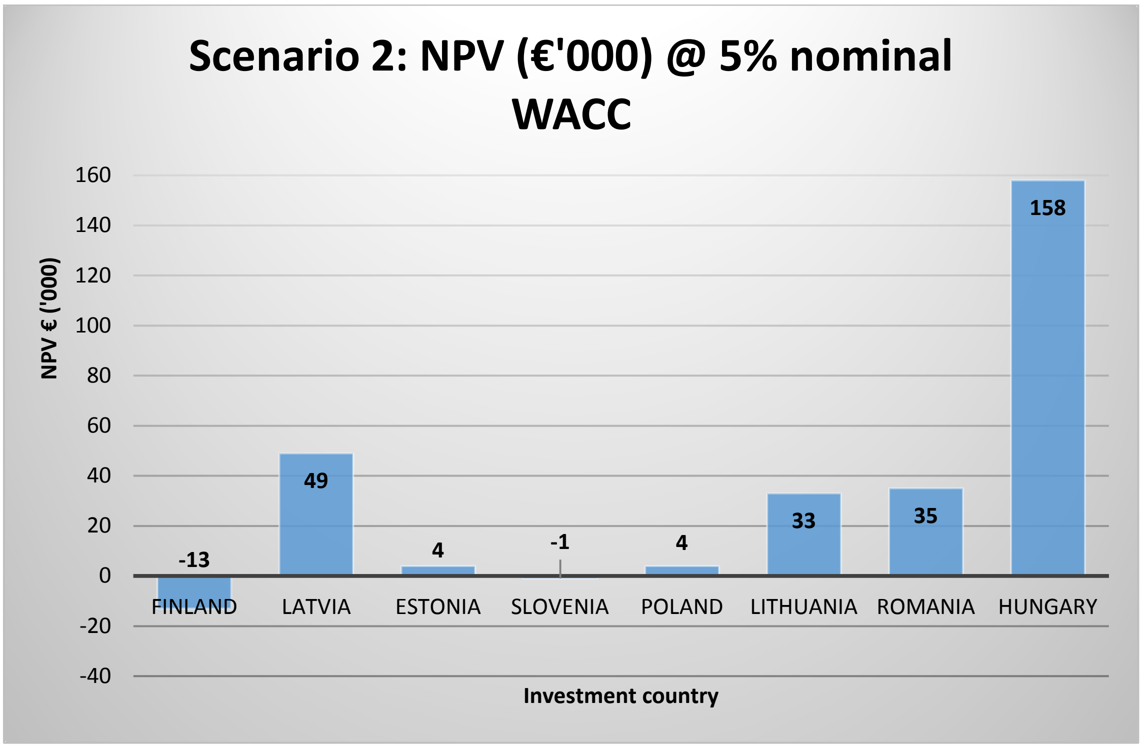

Figure 22: NPVs with standard nominal WACC of 5%

Once again as per scenario 1, the real interest rates used are critical in interpretation of the results. From table 15, the real rates for scenario 2 are illustrated graphically in figure 23. Considering figure 23, one can postulate on the impact of changing the cost of capital on the NPV. There appears to be an inversely proportional relationship in the impact on NPV of the imposition of a standard 5% nominal WACC. For example, in Lithuania the real interest rate changed from 0.3% to 2.6%, a high increase proportionally, which resulted also in a high decrease proportionally in NPV from €402,000 to €33,000. Also, of note is Estonia where the real rate with 5% WACC increased from 0.6% to 2.3%. This reduced NPV from €89,000 to €4,000.

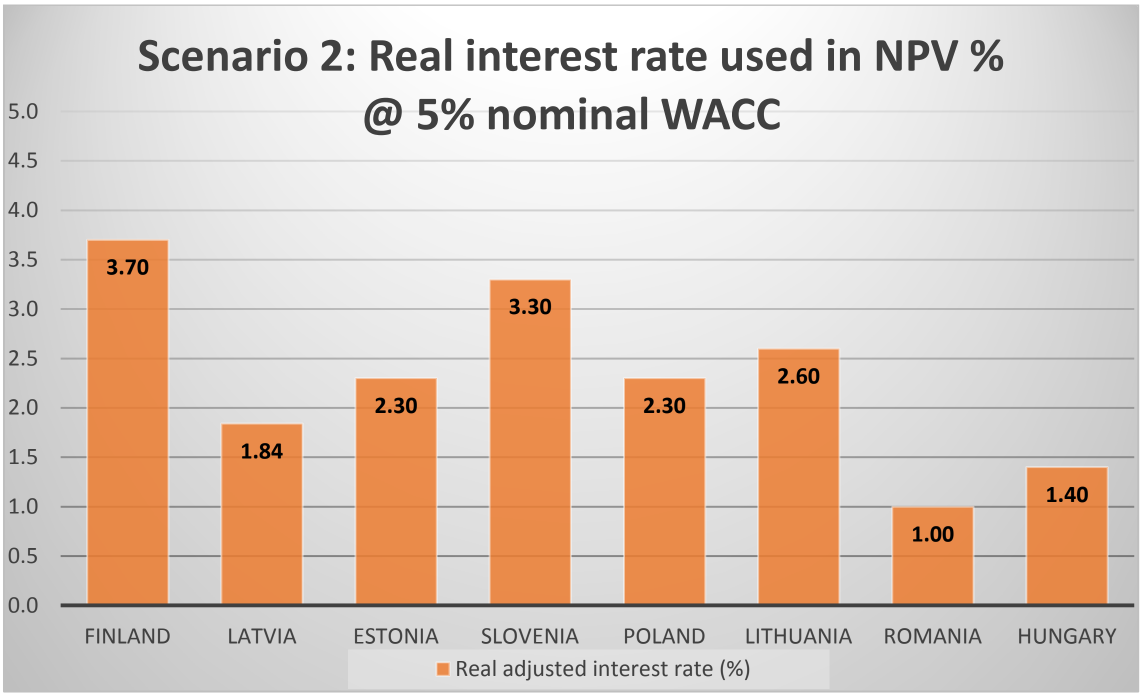

Figure 23: Real interest rates used in NPV calculation for scenario 2

The NPV result using a 5% WACC makes a different conclusion to the IRR in terms of the most attractive country from an investment perspective; Hungary.
The reason why the IRR and NPV metrics make differing conclusions is not intuitive. However, studying the DCFs of the two nations in the appendix there may be reasons that can be highlighted. The engine defining the NPV metric is the real interest rate. In Hungary, the TV is very large and this TV combined with interest rate are the main factors in the Hungary NPV as displayed in figure 22.

However, the IRR is driven somewhat less by the real interest rate – rather it is the real interest rate. Therefore, the fact that in Latvia the immediate timber income in its DCF is greater than the purchase costs is very significant relatively, even though the absolute amount of money is less. Ultimately, this difference comes down to the difference between the IRR and NPV – the IRR is only comparing relative returns and not absolute amounts of potential wealth generated.

The scenario 2 NPV results for the three Baltic counties show a similar pattern to the IRRs. All three countries suggest that they merit investment, although Latvia has the strongest NPV at €42,000, Lithuania is again in the middle position with €33,000 and Estonia is the weakest with €4,000.

Notable other elements of the NPV results for are explored further for Romania and Finland.

6.2.3 Net Present Value scenario 2 country commentary: Romania

Romania exhibits variable results, which alter the appropriateness of Romania as a target for forestry investment. A summary of the Romanian results are shown in table 20.

Table 20: Romanian NPV and IRR result

Metric	Result	Cost of capital (real)
IRR_1	1.1%	1.5%
IRR_2	2.6%	1.0%
NPV_1	-€6,000	1.5%
NPV_2	€35,000	1.0%

Romania is unique in that the nominal cost of capital in the country was over 5% at 5.66% in scenario 1, before the WACC of 5% was applied in scenario 2. This meant that the real cost of capital actually decreased when the 5% nominal WACC was applied. A lower cost of capital generally equates to higher IRR and so the IRR shifted from 1.1% to 2.6%. However, whilst both the IRRs were positive results, the NPV reveals whether or not the investment is actually desirable in a binary manner, with only a positive result indicating a desirable investment.

The first NPV with the Romanian nominal cost of capital shows that it is undesirable at a 1.1% IRR as the NPV is negative. However, with the slightly reduced nominal WACC of 5%, the NPV shifts from -€6,000 to €35,000 making the Romanian forest a desirable investment.

One question could be why in Romania, how a modest movement in nominal costs of capital from 5.66% to 5% makes such a significant difference, more than doubling the IRR and moving the NPV from negative to positive. The answer could be to down rotation length. In Romania the rotation length was the greatest of any of the countries in the investigation at up to 160 years, which is significantly greater than any of the other subject countries. Therefore, in Romania, even small changes in interest rate will have a relatively greater impact, as the time value of money will have a longer time period to have impact on the value of the investment.

6.2.4 Net Present Value scenario 2 country commentary: Finland

Finland is also deserving of discussion in the regarding the NPV results. The change in NPV from using the Finnish real interest rate of 1.5%, which gave a positive NPV of €111,000, to the negative NPV of -€13,000, using a nominal WACC of 5%, or 3.7% real interest rate, was stark.

Looking into the Finland DCF, the reason for the impact of variation in interest rate could be down to the length of the rotation inherent in Finland, and critically the duration of time that the investment in replanting must await until the income generation phase. In Finland, LUKE describes the generic operations that are inherent in establishing forest from ground preparation, through to scarification, planting, tending and pre commercial cleaning and tending. The total cost of these operations is in excess of €2,000/ha. Over a 90 year generic rotation the impact on net future value is highly significant – net future value including all establishment costs and timber income is around -€20,000. However, with the investment in restocking already made, the net future value becomes +€31,000, with around two thirds of the value originating not from clear-fell, but from the inflated value of earlier thinning income.

The Finland DCF suggests that forestry investors should look carefully at the age classes within their target investments and their costs of capital. Money invested in restocking felled areas, although necessary may not be as financially attractive as securing older but pre thinning age crops. Also, production of early thinning income is important considering the time value of money impact on the DCF.

6.2.5 Net Present Value: Scenario 3

In figure 23 is displayed the NPV result using a standard real interest rate of 2.4%. Hungary still retains its top position, although interestingly variation has been reduced relative to scenario 2 where a range of NPV of €171,000 was evident, now in scenario 3 the range is only €98,000.

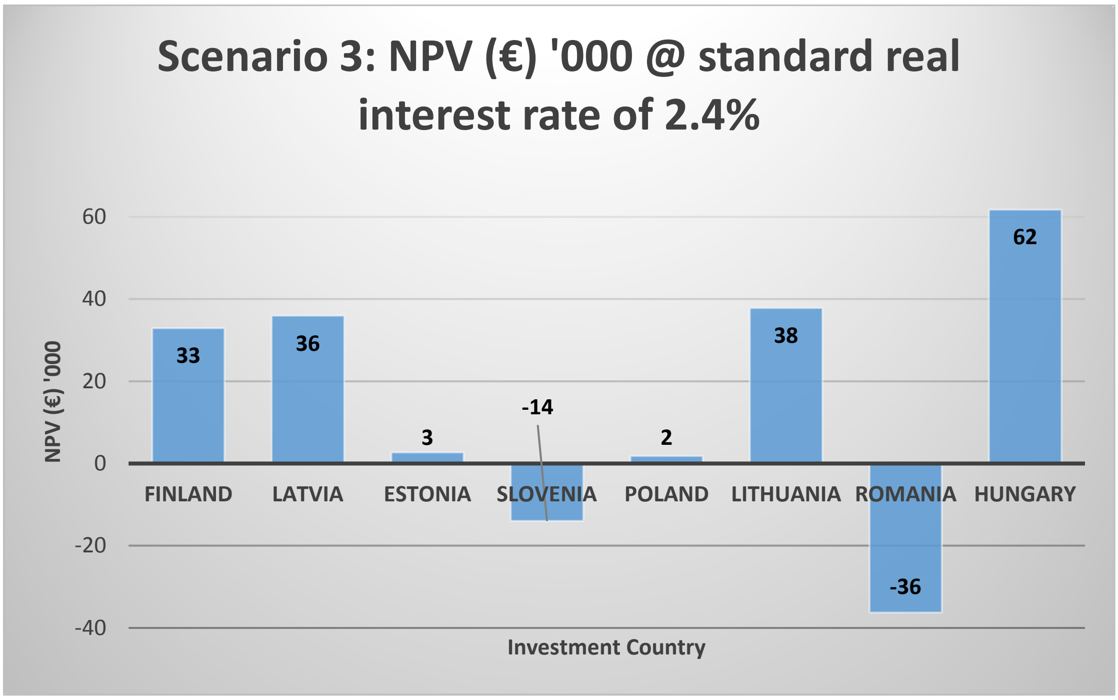

Figure 23: Scenario 3 NPV with standard real interest rate of 2.4%

Based on earlier discussion as one might expect, countries where the real interest rate has increased relative the scenario 2, such as Romania, feature decreased NPV. Conversely, countries where the real interest rate has decreased relative the scenario 2, such as Finland, feature increased NPV. Figure 23, and variance from scenario 2, highlights the fact that conclusions made regarding investments in forestry can be highly dependent on the assumptions used, especially regarding interest rate. Therefore, the approach taken to establishing these assumptions must be carefully considered, and results taken in a context of what may happen should the input assumptions change.

6.3 Land Expectation Value: Scenario 1

Straka and Bullard (1996, 5) describe the LEV as the '*theoretically correct criterion for valuing bare land in timber production, for evaluating the value of various forest management alternatives, or even for determining the age of final timber harvest'*. Therefore, it must be emphasised that the LEVs found only reflect the generic management prescriptions and interest rates used. Flexing management prescriptions or interest rates will have a significant impact on LEV. The LEV does not produce a true result to meet the question of our study of where to invest in emerging Europe, as it does not consider costs of acquisition or the merits of the investment in the existing crops. However, it is a useful indicator of the underlying credentials of the nation's forestry land in the study.

The LEVs found in scenario 1 are displayed in figure 24. Considering the range of LEVs displayed in figure 24, it is clear that the influence of very low interest rates has again had a distorting influence. Both Lithuania and Hungary have LEVs which are clearly out of alignment of what one would consider reasonable levels for forest land, and also have feature real interest rates of 0.3% and 0.9% respectively – exceptionally low interest rates.

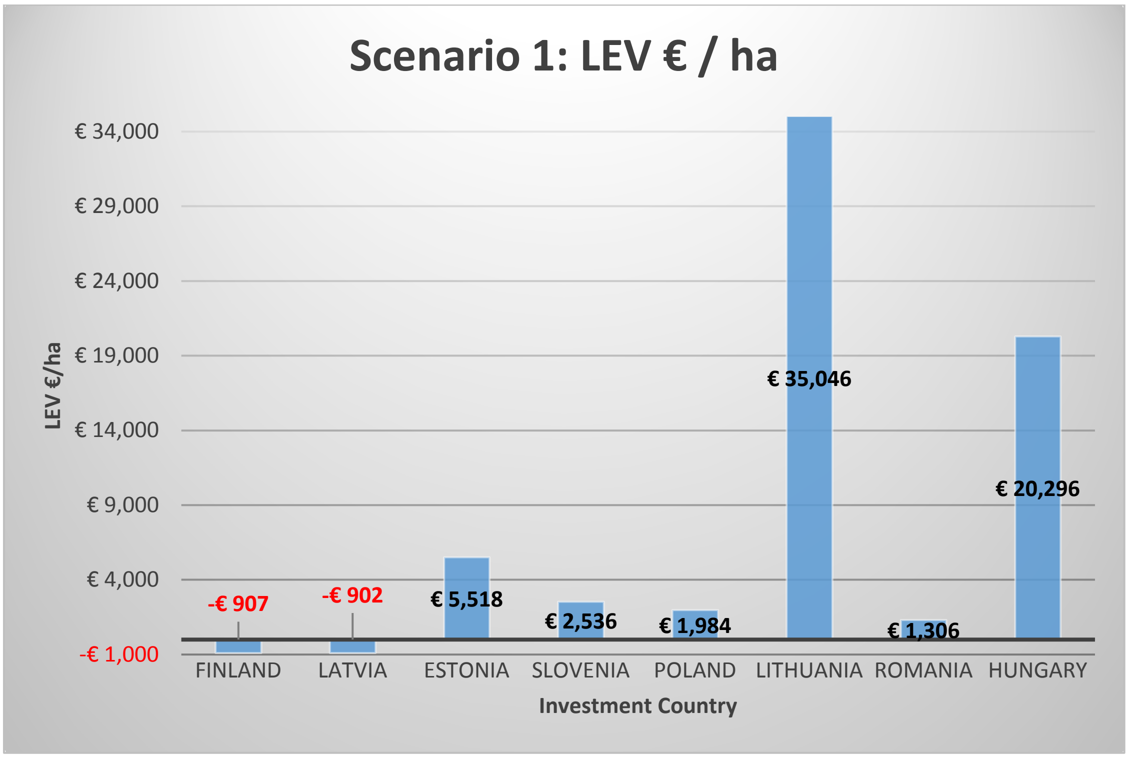

Figure 24: Scenario 1 LEV

6.4 Land Expectation Value: Scenario 2

In figure 25 is displayed the LEV results with a standard nominal WACC of 5% Finland, Estonia and Poland exhibit negative results. This indicates that considering a standard 5% nominal cost of capital, countries own inflation rate, and net future value, investment in bare land is not recommended. However, in both Latvia and Lithuania, along with Romania and Hungary to a greater extent, investment in bare forest land is justifiable since their LEVs are positive.

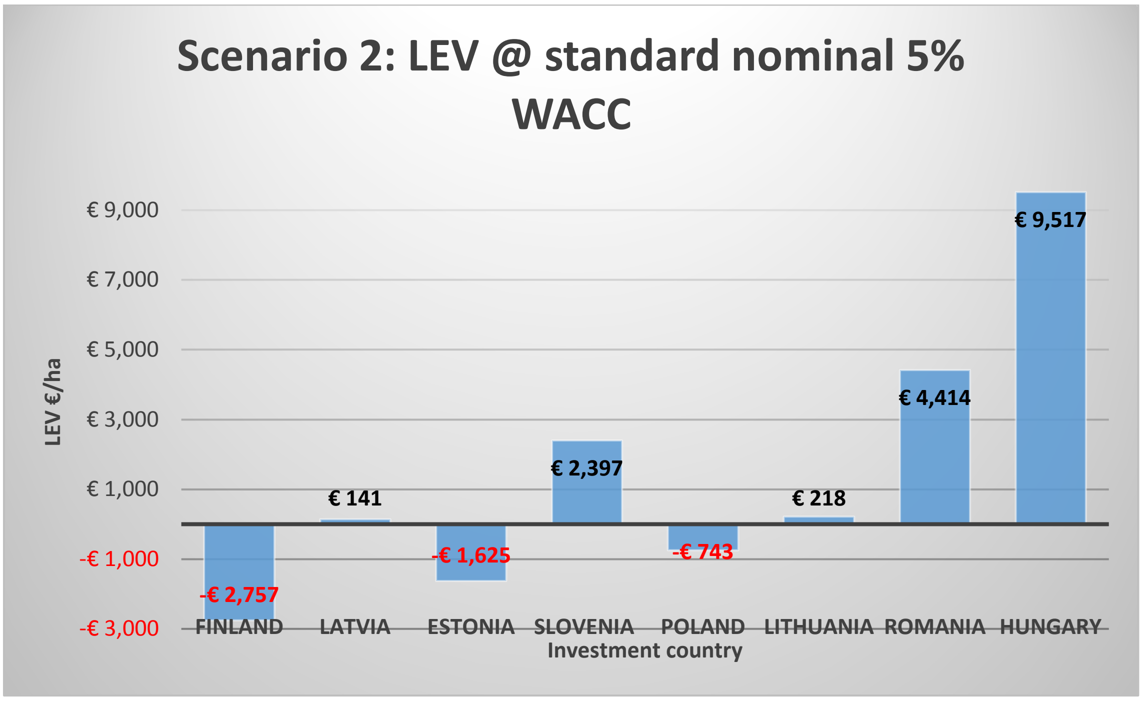

Figure 25: Scenario 2 LEV with a standard 5% nominal WACC

Hungary and Romania show the most positive LEVs at €9,517 and €4,414. Looking at the real adjusted interest rates, again the link between investment metric and costs of capital are highlighted, as Hungary and Romania both have the lowest real adjusted rates at 1.4% and 1.0% respectively.

However, as was highlighted in the discussion regarding the Romanian scenario 2 NPV and IRR result, whilst according to our LEV result Romania appears to be an inherently sound region for investment, even slight shifts in inflation or interest rate may well change this dynamic. Therefore, Romanian forestry investment must be treated with a degree of caution, NPVs and IRRs considered, as well the impact of changes in the input assumptions, such as real interest rate.

6.4.1 Land Expectation Value scenario 2 country commentary: Slovenia

Slovenia's LEV result is somewhat incomparable with the other nations as it is based on a varied LEV formula adjusted to take account of the uneven aged nature of Slovenian forestry. Under uneven aged management bare land and unharvestable timber cannot be separated as the unharvestable crop does not 'age' in the manner of plantation. This means that the Slovenian LEV also includes unquantified unharvestable elements of immature crops. Therefore, although LEV value is of interest for considering Slovenian forestry, it is not comparable with the other nations for whom the standard bare land even aged management LEV calculation has been undertaken.

6.5 Land Expectation Value: Scenario 3

In figure 26 can be seen the result for the LEV in scenario 3. Hungary clearly appears to be have the most attractive underlying forestry credentials, excluding the costs of land purchase, and where under scenario 3 the impact of relative differences in real interest are removed (Slovenia is not comparable due to the inclusion of immature crop within the LEV calculation).

At the chosen real interest rate of 2.4% Finland, Latvia, Estonia and Poland are not worthy of investment in bare forest land. It is of interest that for example Latvia, our most attractive country for investment using IRR can exhibit a negative LEV. The reason is simply that in practice the generic forest is a blend of land and timber crops at different stages of development. The income derivable from the crops during the DCF period and the impact of biological growth on TV can mean that overall the investment works.

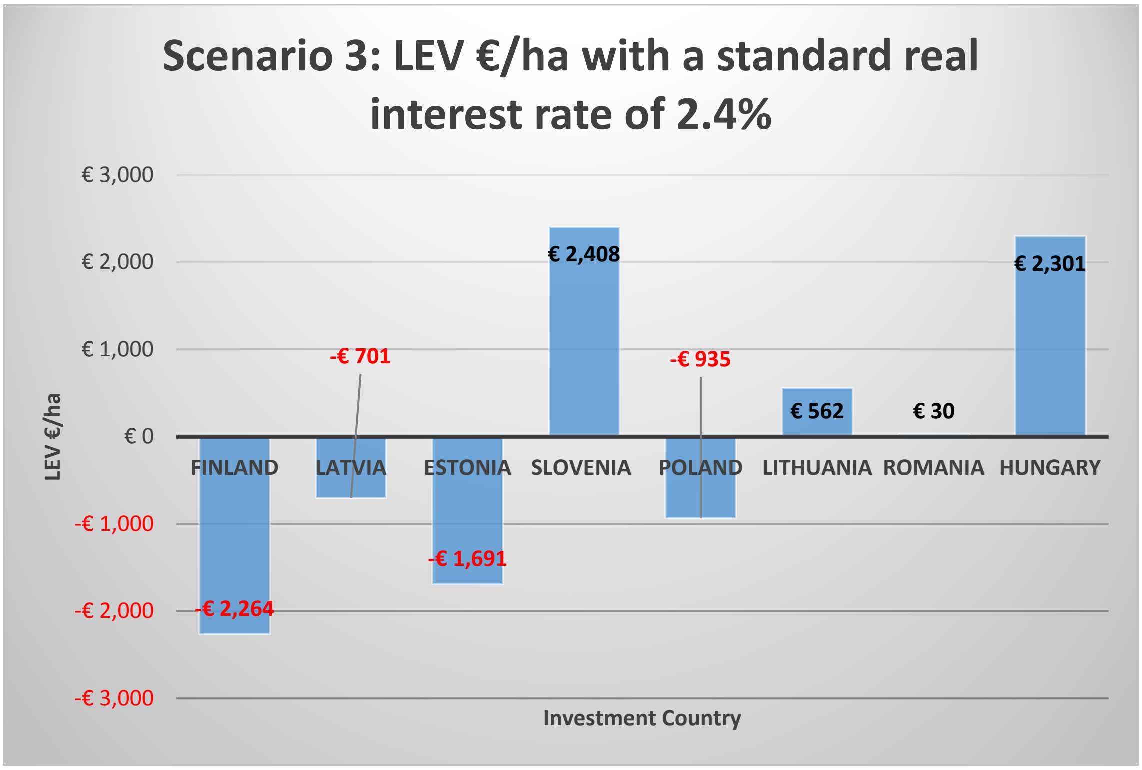

Figure 26: Scenario 3: LEV with standard real interest rate of 2.4%

6.6 Weaknesses in the analysis

6.6.1 Tax

In the interests of keeping the analysis of manageable proportion, the impact of taxation has been excluded. This is an undesirable weakness in the analysis as taxation can affect input parameters of the elements in the DCFs. For example, one common taxation is related to property purchase, and so in some jurisdictions overall purchase costs inclusive of taxes may be greater. Also, in some countries there are forms of taxation on timber income.

However, as well as complication another difficultly with the inclusion of taxation is what assumption to make regarding the nature of the purchasing entity. Taxation levels depend not just on the nature of the forest and incomes, but also on the owner, be it a TIMO, or other business / person, and crucially whether it would be based in the country or in some other jurisdiction.

This question is impacted by the legislative arrangements for property ownership in the various countries, and is a complex area as attested within the various reports on land tenure within our subject countries (Jager *et al.* 2015, Krč, *et al.* 2015, Lelde and Zinta 2015, Nichiforel *et al.* 2015, Teder *et al.* 2015). However, inclusion of taxation would present a potential enhancement of the study.

6.6.2 Asset specific risk and contingencies

One matter that must be addressed is the manner in which risk has been addressed in the analysis. It was earlier explored in the literature review that the manner in which risk has been dealt with has followed the approach of Phillips *et al.* (2013, 48).

$$R_{for} = R_f + R_m + R_a$$

Our approach earlier described considered that within our DCF scenario 2:

$$R_f + R_m = WACC = 5\%$$

And also that for all the scenarios in all the DCFs:

$$R_a = asset\ specific\ contingency\ risk = \text{€}50\ per\ ha\ per\ year$$

Thus our approach could be summarised as:

$$R_{for} = 5\% + \text{€}50\ per\ ha\ per\ year$$

In other words, the R_f and R_m have been combined to be broadly equivalent to a hurdle rate considering risk free rate and systemic risk within the economy. Whilst commercial bank lending rates and observations of TIMOs who operate in this sphere could be construed to form of a basis for this, the Ra, or asset specific contingency risk is difficult to quantify.

For a specific forest property asset purchase, specific risks might be able to be identified and appropriate levels of contingency incorporated. However, for a generic forest, quantification of what is an inherently asset specific metric is difficult.

The approach taken has been to use an approximation of €50/ha/year. However, this is somewhat crude. Ideally, risks that could be generically associated with the difference countries could have been identified and contingency levels tailored to each target nation based on their generic asset specific risk profile. However, such an analysis would have required much more detailed knowledge of the subtleties in silvicultural aspects, biotic threats and abiotic factors such as fire, storm and snow damage. To consider the thesis question regarding generic forests, this depth of investigation, although perhaps desirable, is beyond of the scope of this project.

7 Conclusions

The answer to our initial question of where is the best place to make a forestry investment in emerging Europe using the theoretical 'generic forests' approach is Latvia. However, there is variation in the findings depending on the scenario (1, 2 or 3) or metric, either IRR, NPV or LEV used. Therefore, the overall answer of Latvia needs to be put into context.

Considering the output from the results, the scenario 2 version of the metric using the standard nominal 5% interest rate and countries own inflation rate probably provides a fairer basis than scenario 1. This is because since we are undertaking a comparison of countries, it is a reasonable presumption is that the TIMO investor is international in outlook. That then follows that the TIMO is not prejudiced by being based in, and obtaining capital from, any one nation. However, scenario 1 provides a useful context for our imaginary TIMO, in that it may provide contextual information on the nature of the domestic investor market with whom they may need to compete to buy property.

Regarding the merits of scenario 3, although it may be inappropriate to assume that in the long term the inflationary environment between nations will continue express itself in the same manner as current times, the investor will need to place their investment now, and the short time has the greatest influence over the metrics compared to the long term due to the time value of money. Therefore, it can be argued that it is desirable that the current inflationary environment within the target country is considered. Like scenario 1, scenario 3 provides a useful context as all differences relating to differing real rates of interest used are removed.

Also, interestingly, it is scenario 2 which gives a result of a real IRR 2.5% in Finland, which is closest (-0.5%) to the published data on investment returns based on biological growth only supplied by LUKEs of 3-4%. Scenario 3 is also fairly close at 4.8% real IRR, but varies slightly more at +0.8%. Also, under this scenario the Poland result is 2.9% real IRR, which is in broad alignment with Chudy *et al*. (2020, 8), despite some variance in approach.

For each metric the final conclusions are theoretical as the information only relates to generic forests, which in practice, do not exist.

7.1 Theoretical conclusions

Our three investment metrics IRR, NPV and LEV provide different answers to different questions, which provide slightly different data so make conclusions on.

7.1.1 Theoretical conclusion: Internal Rate of Return

Using scenario 2, at the standard nominal 5% WACC, the highest IRR is Latvia with an exceptional high result at 40.5%. Hungary is second with 23.4% and Lithuania third at 12.9%. According to this study the issue of how we can best compare investment opportunities is dealt with through use of the IRR. Therefore, the conclusion of the question as to where the generic forests suggest are the best locations to invest is Latvia, as summarised in table 21.

7.1.2 Theoretical conclusion: Net Present Value

The NPV considers whether or not making an investment is desirable, with a positive NPV indicating that it is desirable. Using the NPV the clear best performer is Hungary. Latvia, Lithuania and Romania also have positive NPVs. Estonia is marginally positive and Slovenia is marginally negative. Finland has a truly negative NPV and so investment in a generic forest in this location is not desirable.

Using NPV we can assert that investment in the generic forest could be clearly justified in Hungary, Latvia, Lithuania and Romania and still technically recommended in Estonia and Poland. However, as it is not as technically desirable as the IRR to compare investments, it cannot be used to assert which investment will provide the greatest rate of return. However, the NPV may inform which investment will provide the greatest wealth back to the owners of the business.

Table 21: Where is the best place to undertake investment forestry in emerging Europe? A summary of the results from the generic forests.

Rank	Country	IRR (%)	NPV (‘000€)	Investment in generic forest recommended?
1	Latvia	40.5	49	Yes
2	Hungary	23.4	158	Yes
3	Lithuania	12.9	33	Yes
4	Estonia	3.5	4	Yes
5	Poland	2.9	4	Yes
6	Romania	2.6	35	Yes
7	Slovenia	3.1	-1	No
8	Finland	2.5	-13	No

7.1.3 Theoretical conclusion: Land Expectation Value

The LEV considers the locations where inherently owning bare land for regeneration may be the best investment, excluding property purchase costs. On this basis and focusing on scenario 2 Hungary is the top location, followed by Romania in second. Of course, in Hungary this result is due sound forestry credentials such as low regeneration costs, high timber production, high timber prices and short rotations. On the other hand in Romania it must be remembered that the ‘cut and leave’ silviculture means that Romania is unique in not having costs of regeneration. This means its net timber values once its regeneration costs are inflated are less adversely affected by its very long rotation.

In Lithuania and Latvia, the impact of the WACC is large and with the results considering a standard 5% WACC, then the LEV produces only a barely positive result. In Poland, the LEV result is actually negative. This is probably as a result of the additional silvicultural costs required in Poland resulting in the greatest crop establishment costs of any of the nations featured.

As previously described, the Slovenian LEV is not comparable with the other nations due to its inclusion within it of unharvestable growing timber. However, the

Slovenian result does indicate that in Slovenia the land is inherently investable, if obtained at the right price.

Finland and Estonia produce negative LEVs. In the case of Estonia this is probably a slightly worse performing version of the other Baltic States as a result of the lower timber volumes suggested by the literature compared to for example Lithuania. In Finland, there are long rotations to contend with and also the higher of real interest rates at 3.7% which is probably the reason the negative result has occurred.

The LEV provides a useful theoretical context but is somewhat weak from an investment perspective in that property purchase costs are not considered. Also, considering the results it is clear that changes in inflation or WACC would have a profound impact on some of the featured countries. Since the LEV considers bare land and the required investment period to obtain income is inherently very long, it could be argued that individual country inflation rates are unfair variables to apply on a static basis. However, the alternative, presuming a standard inflation rate is also unfair as it does not reflect the conditions in which the forest is based. Therefore, LEVs are of interest but must be treated with caution.

7.2 Cautionary notes

The conclusions regarding particular countries should be considered in the context of the following cautionary notes.

7.2.1 Latvia: Cautionary note

In Latvia there were two factors discussed driving the return. The first was very low purchase costs. The origin of the purchase costs was the Baltic Review report. Some caution should be applied here as unlike in some other countries, official government reports were not available. Therefore, it is possible that this data is reflective only of certain types of forests in Latvia, which may not be reflective of the generic forest generated by our country inventory UNECE data.

The other matter was the timber prices used. Although in Latvia there was a useful central forestry statistical bureau, the nature of the breakout of the different forest products featured was not completely clear as there were multiple types of logs in different size classes and so on. The presumption was to always select the ‘middle’ one, but it is possible that this approach was introduced some inaccuracy into the result.

7.2.2 Hungary: cautionary note

In Hungary, there are some specific considerations that should throw caution upon the results. Firstly, there is the species which make up the generic Hungarian forest. Hungary was unique in having a significant proportion of its forest land in exotic species plantations, such as black locust. Growth rates of species such as black locust are significantly greater that native woodland species, such as oak, and the regulatory regime is different.

Also, silvicultural inputs, timber extraction costs and regulatory matters will all vary between a woodland based on native tree species, compared to black locust plantations. This means there a risk in the inputs into the DCF that they may inadvertently be more reflective of exotic plantations or native woodlands depending on the source. According to our method, the inputs should be reflective of the whole of Hungary and thus reflect the proportions of the different kinds of woodland. However, this possible polarised nature of input data introduces some risk.

A more nuanced manner to approach the matter would be to separate the different kinds of woodland in Hungary and to make each a study ‘type’. However, in that case similar woodland type stratification could be advocated in other countries, such as Romania, and so the scope of the project could become too large.

Another issue in Hungary is the question of whether or not land is investible by a prospective TIMO. During the phase in the project when the scope of emerging Europe was chosen, Hungary was ranked as the least attractive due to high level of uncertainty regarding property availability of adequate size.

In conclusion therefore, whilst the Hungarian result is very attractive, there are barriers to entry and probably, the market value of land would increase substantially if these barriers to access were lifted, which may reduce return levels to more levels lower than those suggested in this study.

7.2.3 The potential impact of timber price change.

The result obtained is based on returns from DCFs presuming no timber price change and returns based on biological growth only. However, excluding land price appreciation, the other crucial factor that our ranking of best locations for investment does not consider is the impact of timber price change. Whilst it was concluded that incorporation of timber price change was beyond the scope of the project, the result should be considered in a general context.

It is of interest note from table 4 that generally the Baltic States have a good degree of flexibility, which supports the study's findings that Latvia is the optimal location to consider for forestry investment. Hungary however, clearly has limitations, crucially in having no flexibility in harvest timing, which means that the assumptions of harvesting used in the Hungary DCF could be optimistic. Unfortunately, to fully consider timber price change within the study would require full options analysis, which is beyond the scope of this project.

7.2.4 Unintuitive results.

Finally, a note should be made on unintuitive results. Generally, it was found in the literature review that IRRs for forestry investments tend to be found in single digits. Exceptionally, in some frontier markets IRRs into the 20s may be reached. However, without doubt the Latvia result of an IRR at over 40% is unintuitive. This does suggest that there is likely some inaccuracy in the build-up assumptions that have formed the DCF. This probably highlights one of the inherent difficulties of the ‘generic forest ‘approach being the availability of recent open source high quality country wide data.

7.3 Future studies

This study has found that Latvia promises the best potential returns, based on a generic forest and generic conditions reflective of Latvian forest and financial conditions. For the future it would be interesting to

- Model more closely different types of forests in our countries of interest, such as Latvia and Hungary. This could extend to including possibilities for exotic plantations.
- Consider an appropriate manner to deal with the impact of a changing inflation and interest rate environment during the long term investment period.
- Take account of variable asset specific risks in the different countries.
- Take account of the value of management flexibility in timber harvesting, where available.
- Gain greater accuracy of input data through wider collaboration with other forestry investment researchers.

8 REFERENCES

Abdallah, S., B., Lasserre, P., (2016) Forest Land Value and rotation with an alternative land use. CIRANO Scientific series 2016s-38.

Aranykalaszos Published 23/09/2019. Last read 03/12/2019. https://www.aranykalaszos.hu/erdomuvelo/

Banach, J., Skrzyszewska, K., Skrzyszewski, J., (2017) Reforestation in Poland: History, current practice and future perspectives. Reforesta 3:185-195

Bartosova, V., Majercak, P., Hraskova, D., (2015) Taking risk into account in the evaluation of economic efficiency of investment projects: traditional methods. Procedia Economics and Finance 24 68-75.

Bekeris, P., (2016) Forest Sector in the 25 years of Latvia’s independence. Balti Group Ltd

Bogaerts, T., Williamson, I., P., Fendel, E., M., (2002) The role of land administration in the accession of Central European Countries to the European Union. Land Use Policy 19:29-46

Bouriaud, O., Marin, G., Bouriaud, L., Hessenmoller, D., Schulze, E-D., (2016) Romanian legal management rules limit wood production in Norway spruce and beech forests. Forest ecosystems 3:20

Brukas, V., Jellemark Thornson, B., Helles, F., Tarp, P., (2001) Discount rate and harvest policy: Implications for Baltic Forestry. Forest Policy and Economics 2(2):143-156

Brukas, V., Mizaras, S., Mizaraite, D., (2015) Economic Forest Sustainability: Comparison between Lithuania and Sweden. Forests 6 47-64

Cantar, I., (2014) Research of the influence of operating conditions for establishing the price of timber wood in Forestry Management. Lucrari Stiintifice Seria 1: Vol 16 (2)

Carroll, B., (2003) Applying Modern Portfolio Theory to Timberland Allocation. Forest Technology Group.

Chudy, R. P., Chudy, K., A., Kaniesski da Silva, B., Cubbage, F., W., Rubilar, R., Lord, R., (2020) Profitability and risk sources in global timberland investments. Forest Policy and Economics 111 102037.

Confederation European des Propriataires Forestiers (2010) Prospects for the market supply of wood and other forest products from areas with fragmented forest ownership structures. CEPF

Cheung, J., Marsden, A., (2002) Forest valuation, capital budgeting and discount rates. NZ Journal of Forestry.

Cubbage, F., MacDonagh, P., Balmelli, G., Olmos, V., M., Bussoni, A., Rubilar, R., De la Torre, R., Lord, R., Huang, J., Hoeflich, V., A., Muara, M., Kanieski, B., Hall, P., Yao, R., Adams, P., Kotze, H., Monges, E., Hernandez Perez, C., Wikle, J., Abt, R, Gonzalez, R., Carreo, O., (2014) Global Timber Investments and Trends 2005-2011. New Zealand Journal of Forest Science 44(1) S7

Duku-Kaakyire, A., Nanang, D., M., (2004) Application of real options theory to forestry investment analysis. Forest Policy and Economics 6:539-552

Dasos Capital 2010 Current and Emerging Timberland Investment Prospects.

Does the wood market work in the Central and Eastern European Region (CEE)? Analysis of new forest business frontiers. Forest Business Analytics Blog 2018.

Forest-Analytics. Posted by FBA on May 14, (2018). Last read 03/12/2019. (http://forest-analytics.com/index.php/2018/05/14/new-forest-business-frontiers-cee/

Forestry and Forest Industry sector study in Romania (2011). European Bank for reconstruction and development.

Fu, C-H., 2014 Timberland Investments: A primer. Timberland Investment Resources LLC.

Harou, P., A., Zheng, C., Zhang, D., The Alternative test in forestry. Forest policy and economics 34:41-46

Harris, A., B., Singleton, C., N., Straka, T., J., (2018) Land differentials resulting from variability between the sales comparison and income approaches in timberland valuation. The appraisal Journal Summer 2018.

Harrison, S., Herbohn, J., (2016) Financial evaluation of forestry investments: Common pitfalls and guidelines for better analysis. Small scale forestry 15:463-479

Herrmann, S., Winkler, A., (2008) Real convergence, financial markets, and the current account – Emerging Europe vs emerging Asia. European Commission Economic papers 362.

Hildebrandt, P., Knocke, T., (2011) Investment decisions under uncertainty – A methodical review on forest science studies. Forest Policy and Economics 13: 1-15

Hoyt, A., (2015) Timberland and Inflation. Campbell Global

Hökkä, H., Salminen, H., Ahtikoski, A., Kojola, S., Launiainen, S., Lehtonen, S., (2017) Long-term impact of ditch network maintenance on timber production, profitability and environmental loads at regional level in Finland: a simulation study. Forestry 2017; 90, 234–246

Ilie, M., (2013) The judicial protection of the forest in Romania. Procedia - Social and Behavioural Sciences 81 171 – 175

International Woodland Company (2019) www.iwc.dk/timberland/#investment-process. Last read 03/12/19.

International Valuation Standards (2017) RICS Global Standards 2017.

International Valuation Standards Council (2012) The Valuation of Forests.

Jabłoński, M., Mionskowski, M., Budniak, P., (2018) Forest area in Poland based on national forest inventory. Sylwan 162 (5): 365-372

Jabłoński, M., Neroj, B., (2019) Revisiting the main attributes of Polish forests. www.ibles.pl

Jagannathan, R., Meier, I., (2002) Do we need CAPM for capital budgeting? Financial Management Winter 5-27.

Jager, L., Schiberna, I., Ali, T., Horvath, K., (2015) Forest land ownership change in Hungary. COST Action FP1201 FACESMAP Country report, European Forest Institute Central east and South East European Regional Office.

Jaszczak, R., Gołojuch, P., Wakhman-Świtalska, S., (2018) Selected aspects of private forest management in Poland. Sylwan 162 (9): 754-762

Kavailiauskas, D., Fussi, B, Westergren, M., Aravanopoulos, F., Finzgar, D., Baier, R., Alizoti, P., Bozic, G., Aramidiou, E., Konnert, M., Kraigher, H., (2018) The interplay between forest management practices, genetic monitoring and other long term monitoring systems. Forests 9:133

Keca, L., J., Marcerta, M., Bozic, G., Peric, S., Tsvetkov, I., Andreassen, K., Stijovic, A., Mandzukovski, D., Zlokapa, B., Nicolescu, V., N., (2019) Non Native tree species: strategies for sustainable ma from Clear-felling's in Latvia. Sveriges lantbruksuniversitet Institutionen för skoglig resurshushållning.

Krč, J., Pezdevšek Malovrh, S., Ficko, A., Šinko, M., Premrl, T., Bogataj, N., Udovč, A., (2015) Forest Land Ownership Change in Slovenia. COST Action FP1201 FACESMAP Country Report, European Forest Institute Central-east and South-East European Reginal Office, Vienna.

Kumer, P., Pezdevsek Malovrh (2018) Factors hindering forest management amoung engaged and detached private forest owners: Slovenian stakeholders' perceptions. Small-scale forestry; October 2018.

Leech, J., Ferguson, I., (2012) A standard for valuing commercial forests in Australia. Association of consulting foresters of Australia, Division of the Institute of Foresters of Australia, Canberra.

Lelde, V., Zinta, Z., (2015) Forest Land Ownership change in Latvia. COST Action FP1201 FACESMAP Country report.

Malovrh, S., P., Leban, V., Krc, J., Stirn, L., Z., (2012) Slovenia Country Report. COOL: Competing uses of Forest Land.

MacLanely, E., Atril, P., (2016) Accounting and Finance: An Introduction. Pearson Education Limited.

Mark, J., Newton, A., C., Oldfield, S., Rivers, M., (2014) The international timber trade: A working list of commercial timber tree species. Botanic Gardens Conservation International

Mei, B., (2017) Investment returns of US commercial timberland: insights into index construction methods and results. Can. J. For. Res. 47: 226-233

Mei, B., Clutter, M., L., (2015) Evaluating Timberland Investment Opportunities in the United States: A real options analysis. Forest Science 61(2):328-335

Mei, B., Clutter, M., L., Harris, T., G., (2013) Timberland Return Drivers and Timberland Returns and Risks: A Simulation Approach. Southern Journal of Applied Forestry 37:1

Mesaros, K., Jager, L., Hegedus, A., (2005) Hungary. Acta Silv. Hung Special Edition 297-333

Milanesi, G., S., Broz, D., Tohme, F., Rossit, D., (2014) Strategic analysis of forestry investments using real option: the Fuzzy Pay Off Model (FOPM). Fuzzy Economic Review Vol XIX: p33-44

Mizarite, D., Mizaras, S., (2005) The formation of small scale forestry in countries with economies in transition: observations from Lithuania. Small-scale Forest Economics, Management and Policy, 4(4): 437-450

Munteanu, C., Nita, M., D., Abrudan, I., V., Radeloff, V., C., (2016) Historical forest management in Romania is imposing strong legacies on contemporary forests and their management. Forest ecology and management 361:179-193

Nichiforel, L., Bouriaud, L., Dragoi, M., Dorondel, S., Mantescu, L., Terpe, H., (2015) Forest land ownership change in Romania. COST Action FP1201 FACESMAP Country Report European Forest Institute Central East and South East European Regional Office , Vienna.

Nichiforel, L., Keary, K., Deuffic, P., Weis, G., Jellesmark Thorsen, B., Winkel, G., Avdibegovic, M., Dobsinkska, Z., Feliciana, D., Gatto, P., Gorriz Mifsud, E., Hoogstra-Klein, M., Hrib, M., Hujala, T., Jager, L., Jarsky, V., Jodlowski, K., Lawrence, A., Lukmine, D., Molovrh, S., P., Nedeljkovic, J., Nonic, D., Krajter Ostoic, S., Pukall, K., Rondeux, J., Samara, T., Sarvasova, Z., Elena Sciban, R., Silingiene, R., Sinko, M., Stojanovska, M., Stojanovski, V., Stoyanov, N., Teder, M., Vennesland, B., Vilkriste, L., Wilhelmsson, E., Wilkes-Allemann, J., Bouriand, L., (2018) How private are Europe's private forests? A comparitive property rights analysis. Land use policy 2018.02.034.

Nicholescu, V., N., Hernea, C., Bakti, B., Kersaru, Z., Antal, B., Redei, K., (2018) Black locust (Robinia pseudoacacia L.) as a multi-purpose tree species in Hungary and Romania: a review. J. For. Res. https://doi.org/10.1007/s11676-018-0626-5

O'Hara, K., L., Boncina, A., Diaci, I., Anic, I., Boydak, M., Curoviv, M., Govedar, Z., Grigoriadis, N., Ivojevic, S., Keren, S., Kola, H., Kostov, G., Medarevic, M., Metaj, M., Nicolescu, N., V., Raifailov,G., Stancioiu, P., T., Velkovski, N., (2018) Culture and silviculture in south east Europe. International Forestry Review Vol 20(1)

Pach, M., Sansone, D., Corona, P., Ponette, Q., Barreiro, S., Mason, B., Bravo-Oviedo, A., (2018) Silviculture of mixed forests: A European Overview of Current Practices and Challenges. Dynamics, Silviculture and Management of Mixed Forests, Managing Forest Ecosystems 31.

Palaghianu, C., (2018) Afforestation and reforestation management in Romania – migrating to sustainability and responsibility. Proceedings of the 4th International conference on Integrated Management of Environmental resources 2017.

Parajuli, R., Chang, S., J., (2015) Real assets and Inflation: Which real assets hedge inflation? Unpublished but uploaded to ‘researchgate.net’

Payn, T., Carnus, J-M., Freer-Smith, P., Kimberly, M., Kollert, W., Liu, S., Orazio, C., Rodriguez, L., Silva, L., N., Wingfield, M., J., (2015) Changes in planted forests and global future implications. Forest Ecology and management 352: 57-67

Perko, F., Golob, A., (2006) Slovenian forests. Waldwissen.net

Pollumae, P., Korjus, H., (2017) Estonian private forestry, a review of research and developments. Baltic forestry 23:3 p724-733.

Report on the Slovenian real property market. (2017) Surveying and mapping authority of the republic of Slovenia.

RICS Valuation of woodlands 1st edition guidance note. GN 64/2010 Royal Institute of Chartered Surveyors (RICS).

Roache, S., K., Attie, A., P., (2009) Inflation hedging for long term investors. IMF working paper

Rutkauskas, A., (reviewer) (2017) Statistical yearbook of Lithuanian forestry. Lithuanian State forest service.

Schulze, E., D., Bouriaud, L., Bussler, H., Gossner, M., Walentowski, H., Hessenmoller, D., Bounriaud, O., Gadow, K., (2014) Opinion paper: Forest Management and Biodiversity. Web Ecol 14: 3-10

Straka, T., J., Bulland, S., H., (1996) The land expectation value calculated in timberland valuation. Faculty publications. Paper 49.

Sun, C., Zhang, D., (2001) Assessing the financial performance of forestry related investment vehicles: Capital Asset Pricing Model vs Arbitrage Pricing Theory. American Journal of Agricultural Economics 83(3): 617-628

Teder, M., Pollumae, P., Korjus, H., (2015) Forest land ownership change in Estonia. COST action FP1201 – FACESMAP Country Report, European Forest Institute Central east and South East European Regional office, Vienna.

The state land service of the republic of Latvia. (2018) The Baltic review.

Vicary, B., P., (2006) Discount rates and timberland investments. Timberland report Vol 8 No 3.

Virkkunen, E., (2018) Economic optimisation of harvesting schedules for main tree species in Estonia. University of Helsinki master’s thesis.

Wan, Y., Mei, B., Clutter, M., L., Siry, J., P., (2013) Assessing the inflation hedging ability of timberland in the United States. Forest Science 59 (1) 93-104

Yao, W., Mei, B., (2015) Assessing forestry-related assets with the intertemporal capital asset pricing model. Forest Policy and Economics 50 192-199.

Yao, W., Mei, B., Clutter, M., L., (2014) Pricing Timberland Assets in the United States by the Arbitrage Pricing Theory. Forest Science 60(5):943-952

Zhang, D., (2018) Planted forest development: from theory to policies and practices. Proceedings of ICPF – the 4th International Conference on Planted forests.

Yrjölä, T., (2002) Forest Management Guidelines and Practices in Finland, Sweden and Norway. European Forest Institute Internal Report no 11.

Zhang, F., Chang, S., J., (2018) Measuring the impact of risk preference on land valuation: Evidence from forest management. Land Economics 94(3):425-436

ZGS. The Slovenian State Forest Service. www.zgs.si. Read 03/12/2019.

APPENDICES

Appendix 1: Country compartment data

Finland

Mature compartments for harvest

Species	Area (ha)
SP	2.2
NS	1.4
BI	0.8
Other	0.2
Total	**4.6**

Intermediate compartments for thinning

SP	11.4
NS	7.0
BI	3.9
Other	0.8
Total	**23.1**

Regeneration

SP	3.6
NS	2.2
BI	1.2
Other	0.3
Total	**7.4**

Total forest size	**35.0**

Latvia

Mature compartments for harvest

Species	Area (ha)
SP	1.0
BI	0.6
NS	0.4
AL	0.3
ASP	0.2
Unproductive	0.1
Total	**2.5**

Intermediate compartments for thinning

SP	1.9
BI	1.2
NS	0.8
AL	0.6
ASP	0.5
Unproductive	0.1
Total	**5.1**

Regeneration

SP	0.9
BI	0.6
NS	0.4
AL	0.3
ASP	0.2
Unproductive	0.0
Total	**2.3**

Total forest size	**10.0**

Estonia

Mature compartments for harvest

Species	**Area (ha)**
SP	0.7
NS	0.5
BI	0.5
AL	0.3
ASP	0.2
Unproductive	0.1
Total	**2.2**

Intermediate compartments for thinning

SP	2.1
NS	1.7
BI	1.6
AL	0.8
ASP	0.5
Unproductive	0.3
Total	**7.0**

Regeneration

SP	0.2
NS	0.2
BI	0.2
AL	0.1
ASP	0.1
Unproductive	0.0
Total	0.8

Total forest size	**10.0**

Poland

Mature compartments for harvest

Species	Area
SP	0.9
OK	0.1
NS	0.1
BE	0.1
BI	0.1
Unproductive	0.3
Total	**1.6**

Intermediate compartments for thinning

SP	3.9
OK	0.5
NS	0.5
BE	0.5
BI	0.4
Unproductive	1.1
Total	**6.9**

Regeneration

SP	0.9
OK	0.1
NS	0.1
BE	0.1
BI	0.1
Unproductive	0.2
Total	**1.5**

Total forest size	**10.0**

Lithuania

Mature compartments for harvest

Species	**Area**
SP	0.8
NS	0.4
BI	0.4
AL	0.3
ASP	0.1
Unproductive	0.1
Total	2.1

Intermediate compartments for thinning

SP	2.2
NS	1.2
BI	1.0
AL	0.7
ASP	0.4
Unproductive	0.4
Total	5.9

Regeneration

SP	0.7
NS	0.4
BI	0.3
AL	0.3
ASP	0.1
Unproductive	0.1
Total	2.0

Total forest size	**10.0**

Romania

Mature compartments for harvest

Species	Area
Beech	0.4
Norway spruce	0.2
Unproductive	0.4
Total	1.0

Intermediate compartments for thinning

Beech	1.8
Norway spruce	1.0
Unproductive	2.1
Total	4.9

Regeneration

Beech	1.5
Norway spruce	0.8
Unproductive	1.7
Total	4.1

Total forest size	10.0

Hungary

Mature compartments for harvest

Species	Area
Beech	0.4
Norway spruce	0.2
Unproductive	0.4
Total	1.0

Intermediate compartments for thinning

Beech	1.8
Norway spruce	1.0
Unproductive	2.1
Total	4.9

Regeneration

Beech	1.5
Norway spruce	0.8
Unproductive	1.7
Total	4.1

Total forest size	10.0

Appendix 2: Finland Discounted Cash Flow

Finland	1.0

	Property purchase	Net timber revenue	Capital Expenditure	Management and maintenace	Silvicultural expenditure	Terminal value	Total
2019	-£ 105,910	€ -	€ -	-€ 2,450	€ -		-€ 108,360
2020	£ -	€ 42,646	€ -	-€ 2,450	€ -		€ 40,196
2021	£ -	€ -	€ -	-€ 2,450	-€ 9,227		-€ 11,677
2022	£ -	€ -	€ -	-€ 2,450	€ -		-€ 2,450
2023	£ -	€ -	€ -	-€ 2,450	€ -		-€ 2,450
2024	£ -	€ -	€ -	-€ 2,450	€ -		-€ 2,450
2025	£ -	€ -	€ -	-€ 2,450	€ -		-€ 2,450
2026	£ -	€ -	€ -	-€ 2,450	-€ 7,525		-€ 9,975
2027	£ -	€ -	€ -	-€ 2,450	€ -		-€ 2,450
2028	£ -	€ -	€ -	-€ 2,450	€ -		-€ 2,450
2029	£ -	€ -	€ -	-€ 2,450	€ -		-€ 2,450
2030	£ -	€ 37,283	€ -	-€ 2,450	€ -		€ 34,833
2031	£ -	€ -	€ -	-€ 2,450	€ -		-€ 2,450
2032	£ -	€ -	€ -	-€ 2,450	€ -		-€ 2,450
2033		€ -	€ -	-€ 2,450	€ -	€ 161,984	€ 159,534
Total	**-€ 105,910**	**€ 79,929**	**€ -**		**-€ 16,752**	**€ 161,984**	**€ 82,501**

Finland	1.0

	Gross timber income						
	Pine log	Spruce log	Birch log	Pine pulp	spruce pulp	Birch pulp	Total
2019	€ -	€ -	€ -	€ -	€ -	€ -	€ -
2020	€ 18,501	€ 15,407	€ 1,787	€ 3,431	€ 1,323	€ 2,197	€ 42,646
2021	€ -	€ -	€ -	€ -	€ -	€ -	€ -
2022	€ -	€ -	€ -	€ -	€ -	€ -	€ -
2023	€ -	€ -	€ -	€ -	€ -	€ -	€ -
2024	€ -	€ -	€ -	€ -	€ -	€ -	€ -
2025	€ -	€ -	€ -	€ -	€ -	€ -	€ -
2026	€ -	€ -	€ -	€ -	€ -	€ -	€ -
2027	€ -	€ -	€ -	€ -	€ -	€ -	€ -
2028	€ -	€ -	€ -	€ -	€ -	€ -	€ -
2029	€ -	€ -	€ -	€ -	€ -	€ -	€ -
2030	€ 16,174	€ 13,470	€ 1,562	€ 2,999	€ 1,157	€ 1,921	€ 37,283
2031	€ -	€ -	€ -	€ -	€ -	€ -	€ -
2032	€ -	€ -	€ -	€ -	€ -	€ -	€ -
2033	€ -	€ -	€ -	€ -	€ -	€ -	€ -
Total							**€ 79,929**

Finland	1.0

	Gross timber volume Pine log	Gross timber volume Spruce log	Gross timber volume Birch log	Gross timber volume Pine pulp	Gross timber volume spruce pulp	Gross timber volume Birch pulp	Harvest type
2019							
2020	306	240	39	195	68	130	Clearfell
2021							
2022							
2023							
2024							
2025							
2026							
2027							
2028							
2029							
2030	267	210	34	171	59	114	Thinning
2031							
2032							
2033							
Total							

Terminal value: Finland

Crop type	Area	Price per ha	Total	Age at end of DCF	Age 2019
Regeneration (new)	4.6	€ 5,350	€ 24,341	12	n/a
Regeneration - Thinning age	7.4	€ 7,017	€ 51,577	30	15
Thinning age - Maturing	23.1	€ 7,155	€ 165,292	60	45
Total Crop Value	**35.00**		**€ 241,210**		

Cashflow duration (years)	**15**

Present value		€ 547	**Bare land value of one rotation without annual costs**
Future value		€ 4,742	**Future land value of one rotation**
LEV B4 annual costs		€ 618	**Bare land value of infinite rotations without annual costs**
LEV		-€ 2,264	**Bare land value with infinite rotations with annual costs**
TOTAL land			**-€ 79,226**

Grand total	**€ 161,984**
€ 4,628	per hectare

Finland	1.0

Year	Cost	Income - clearfell	Income - thin 1	Income - thin 2	Income - thin 3		
0	-€ 2,028					€ 547	
1	-€ 2,077					€ 560	
2	-€ 2,128					€ 574	
3	-€ 2,179					€ 588	
4	-€ 2,232					€ 602	
5	-€ 2,287					€ 617	
6	-€ 2,342					€ 632	
7	-€ 2,399					€ 647	
8	-€ 2,457					€ 663	
9	-€ 2,517					€ 679	
10	-€ 2,578					€ 695	
11	-€ 2,641					€ 712	
12	-€ 2,705					€ 729	
13	-€ 2,771					€ 747	
14	-€ 2,838					€ 765	
15	-€ 2,907					€ 784	
16	-€ 2,977					€ 803	
17	-€ 3,050					€ 822	
18	-€ 3,124					€ 842	
19	-€ 3,200					€ 863	
20	-€ 3,277					€ 884	
21	-€ 3,357					€ 905	
22	-€ 3,439					€ 927	
23	-€ 3,522					€ 950	
24	-€ 3,608					€ 973	
25	-€ 3,695					€ 997	
26	-€ 3,785					€ 1,021	
27	-€ 3,877					€ 1,046	
28	-€ 3,971					€ 1,071	
29	-€ 4,068					€ 1,097	
30	-€ 4,166					€ 1,124	
31	-€ 4,268					€ 1,151	
32	-€ 4,371					€ 1,179	
33	-€ 4,477					€ 1,207	
34	-€ 4,586					€ 1,237	
35	-€ 4,698				€ 1,576	€ 1,267	
36	-€ 4,812				€ 1,614	€ 1,298	
37	-€ 4,929				€ 1,653	€ 1,329	
38	-€ 5,048				€ 1,693	€ 1,361	
39	-€ 5,171				€ 1,734	€ 1,394	
40	-€ 5,297				€ 1,777	€ 1,428	
41	-€ 5,425				€ 1,820	€ 1,463	
42	-€ 5,557				€ 1,864	€ 1,499	
43	-€ 5,692				€ 1,909	€ 1,535	
44	-€ 5,830				€ 1,956	€ 1,572	
45	-€ 5,972				€ 2,003	€ 1,610	
46	-€ 6,117				€ 2,052	€ 1,650	
47	-€ 6,265				€ 2,102	€ 1,690	
48	-€ 6,418				€ 2,153	€ 1,731	
49	-€ 6,574				€ 2,205	€ 1,773	
50	-€ 6,733			€ 1,576	€ 2,258	€ 1,816	
51	-€ 6,897			€ 1,614	€ 2,313	€ 1,860	
52	-€ 7,064			€ 1,653	€ 2,370	€ 1,905	
53	-€ 7,236			€ 1,693	€ 2,427	€ 1,951	
54	-€ 7,412			€ 1,734	€ 2,486	€ 1,999	
55	-€ 7,592			€ 1,777	€ 2,546	€ 2,047	
56	-€ 7,776			€ 1,820	€ 2,608	€ 2,097	
57	-€ 7,965			€ 1,864	€ 2,672	€ 2,148	
58	-€ 8,158			€ 1,909	€ 2,737	€ 2,200	
59	-€ 8,357			€ 1,956	€ 2,803	€ 2,254	
60	-€ 8,560			€ 2,003	€ 2,871	€ 2,308	
61	-€ 8,767			€ 2,052	€ 2,941	€ 2,364	
62	-€ 8,980			€ 2,102	€ 3,012	€ 2,422	
63	-€ 9,199			€ 2,153	€ 3,085	€ 2,481	
64	-€ 9,422			€ 2,205	€ 3,160	€ 2,541	
65	-€ 9,651		€ 1,614	€ 2,258	€ 3,237	€ 2,603	
66	-€ 9,885		€ 1,653	€ 2,313	€ 3,316	€ 2,666	
67	-€ 10,125		€ 1,693	€ 2,370	€ 3,396	€ 2,731	
68	-€ 10,371		€ 1,734	€ 2,427	€ 3,479	€ 2,797	
69	-€ 10,623		€ 1,777	€ 2,486	€ 3,563	€ 2,865	
70	-€ 10,881		€ 1,820	€ 2,546	€ 3,650	€ 2,934	
71	-€ 11,146		€ 1,864	€ 2,608	€ 3,739	€ 3,006	
72	-€ 11,416		€ 1,909	€ 2,672	€ 3,829	€ 3,079	
73	-€ 11,694		€ 1,956	€ 2,737	€ 3,922	€ 3,154	
74	-€ 11,978		€ 2,003	€ 2,803	€ 4,018	€ 3,230	
75	-€ 12,269		€ 2,052	€ 2,871	€ 4,115	€ 3,309	
76	-€ 12,567		€ 2,102	€ 2,941	€ 4,215	€ 3,389	
77	-€ 12,872		€ 2,153	€ 3,012	€ 4,318	€ 3,471	
78	-€ 13,185		€ 2,205	€ 3,085	€ 4,422	€ 3,556	
79	-€ 13,505		€ 2,258	€ 3,160	€ 4,530	€ 3,642	
80	-€ 13,833		€ 2,313	€ 3,237	€ 4,640	€ 3,730	
81	-€ 14,169		€ 2,370	€ 3,316	€ 4,753	€ 3,821	
82	-€ 14,513		€ 2,427	€ 3,396	€ 4,868	€ 3,914	
83	-€ 14,866		€ 2,486	€ 3,479	€ 4,986	€ 4,009	
84	-€ 15,227		€ 2,546	€ 3,563	€ 5,107	€ 4,106	
85	-€ 15,597		€ 2,608	€ 3,650	€ 5,232	€ 4,206	
86	-€ 15,975		€ 2,672	€ 3,739	€ 5,359	€ 4,308	
87	-€ 16,363		€ 2,737	€ 3,829	€ 5,489	€ 4,413	
88	-€ 16,761		€ 2,803	€ 3,922	€ 5,622	€ 4,520	
89	-€ 17,168		€ 2,871	€ 4,018	€ 5,759	€ 4,630	
90	-€ 17,585	€ 9,373	€ 2,941	€ 4,115	€ 5,899	**€ 4,742**	**Future value**

€ 22,327	**Future value without restock cost**
€ 12,314	**Future value with only 1 thin left**

Forest name	**Finland**
Current year	**2019**
Version	**1.0**

Assumptions

	Variable for calculation
	Calculated figure

Acquisition costs

Variable	**per ha**	**Comment / Source**
Purchase price	3,026 €	National land survey of Finland 2018
Area	35.0	Thesis assumption
Total	105,910 €	
Costs	0%	

Compartment Schedule

Variable		**Comment / Source**
Tree species makeup		UNECE data
Crop development phase		UNECE data

Cashflow duration

	Years	**Comment / Source**
	15	Half of duration of UNECE crop devlopment stage

Felling Plan

Variable	**Modelling approach**	**Comment / Source**
Approach to clearfell harvesting	Clearfell mature crops	Thesis assumption
Approach to thinning	3 thinnings 30%	https://smy.fi/en/glossary/thinning-harvennushakkuu/

Timber production

Tonnage calculations	**Modelling approach**	**Comment / Source**
Mature volume	223	Luonnonvarakeskus, Metsävarat
Advanced thinning stand	169	Luonnonvarakeskus, Metsävarat
Young thinning stand	87	Luonnonvarakeskus, Metsävarat
Generic thinning stand	128	Mean of advanced and young stand
Thinning proportion	30%	https://smy.fi/en/glossary/thinning-harvennushakkuu/

Harvest products and prices

Species	**Stumpage price**	**Comment / Source**
Pine log	€ 60.51	OSF: Natural Resources Institute Finland, Volumes and prices in industrial roundwood trade 2018
Spruce log	€ 64.25	OSF: Natural Resources Institute Finland, Volumes and prices in industrial roundwood trade 2018
Birch log	€ 45.85	OSF: Natural Resources Institute Finland, Volumes and prices in industrial roundwood trade 2018
Pine pulp	€ 17.55	OSF: Natural Resources Institute Finland, Volumes and prices in industrial roundwood trade 2018
spruce pulp	€ 19.56	OSF: Natural Resources Institute Finland, Volumes and prices in industrial roundwood trade 2018
Birch pulp	€ 16.84	OSF: Natural Resources Institute Finland, Volumes and prices in industrial roundwood trade 2018

Forest specific timber extraction costs

	Cost per tonne	**Comment / Source**
Generic harvester / forwarder cost		Not used
Generic winch/skidder cost		Not used
Skyline		Not used
Optimisation incentive		Not used
Timber merchant management / tonne		Not used
Infrastructure maintenance allowance during harvesting		Not used
Gross to net timber income reduction factor	**0%**	
% of site Harvester-Forwarder		Not used
% of site winch-skidder		Not used
% of site skyline		Not used
	100%	

Product assortments		**Comment / Source**
Pine log	61%	Luke_Met_Teollpuu_01
Spruce log	78%	Luke_Met_Teollpuu_01
Birch log	23%	Luke_Met_Teollpuu_01
Pine pulp	39%	Luke_Met_Teollpuu_01
spruce pulp	22%	Luke_Met_Teollpuu_01
Birch pulp	77%	Luke_Met_Teollpuu_01

Other revenue		

	Modelling approach	Comment / Source
None		

Terminal value assumptions		Comment / Source
Establishment costs /ha	-€ 2,028	
Timber clearfell income / ha	€ 9,373	
Timber thinning income / ha	€ 1,614	
Typical rotation length	90	*Yrjola 2002*
Nominal discount rate scenario 1	2.80%	
Nominal discount rate scenario 2&3	5.000%	https://www.economy.com/finland/lending-rate
Discount rate real	2.4%	Fisher adjusted
Inflation scenario 1&2	1.3%	2019 Eurostat
Inflation scenario 3	2.5%	Av emerging Europe

Other income		Comment / Source
none		

Capital Expenditure		Comment / Source
Ditch drain maintenance	€ 215	LUKE silvicultural costs

Restocking costs		
	Cost per ha	**Comment / Source**
	€ 2,028	Total costs to fully re-establish crop
Build up ops		
Clearing of regeneration areas	€ 206	LUKE
Patch scarification	€ 327	LUKE
Planting	€ 739	LUKE
Early cleaning of seedling stands	€ 332	LUKE
Tending of seedling stands	€ 424	LUKE

Maintenance Expenditure	Cost per ha	Comment / Source
Total Annual costs	€ 70.00	Calculated
Management costs	€ 20.00	Thesis assumption
Risk	**Cost per ha**	**Comment / Source**
Contingency costs	€ 50.00	Thesis assumption

Appendix 3: Latvia Discounted Cash Flow

Latvia	1.0

	Property purchase	Net timber revenue	Capital Expenditure	Management and maintenace	Silvicultural expenditure	Terminal value	Total
2019	-€ 15,000	€ -	€ -	-€ 624	€ -		-€ 15,624
2020	€ -	€ 24,589	€ -	-€ 624	€ -		€ 23,965
2021	€ -	€ -	€ -	-€ 624	-€ 1,997		-€ 2,621
2022	€ -	€ -	€ -	-€ 624	€ -		-€ 624
2023	€ -	€ -	€ -	-€ 624	€ -		-€ 624
2024	€ -	€ -	€ -	-€ 624	€ -		-€ 624
2025	€ -	€ -	€ -	-€ 624	€ -		-€ 624
2026	€ -	€ -	€ -	-€ 624	€ -		-€ 624
2027	€ -	€ -	€ -	-€ 624	€ -		-€ 624
2028	€ -	€ -	€ -	-€ 624	€ -		-€ 624
2029	€ -	€ -	€ -	-€ 624	€ -		-€ 624
2030	€ -	€ 6,194	€ -	-€ 624	€ -		€ 5,570
2031	€ -	€ -	€ -	-€ 624	€ -		-€ 624
2032	€ -	€ -	€ -	-€ 624	€ -		-€ 624
2033	€ -	€ -	€ -	-€ 624	€ -	€ 45,853	€ 45,229
Total	**-€ 15,000**	**€ 30,783**	**€ -**		**-€ 1,997**	**€ 45,853**	**€ 50,279**

Latvia	1.0										
	Gross timber income										
	Pine log (18cm +)	Birch log (24cm+)	Spruce log (24cm +)	Alder log (24cm +)	Aspen log (24cm +)	Pine pulp	Birch pulp	Spruce pulp	Alder pulp	Aspen pulp	Total
2019	€ -	€ -	€ -	€ -	€ -	€ -	€ -	€ -	€ -	€ -	€ -
2020	€ 9,092	€ 2,699	€ 2,647	€ 2,291	€ 654	€ 1,640	€ 2,674	€ 1,243	€ 731	€ 918	€ 24,589
2021	€ -	€ -	€ -	€ -	€ -	€ -	€ -	€ -	€ -	€ -	€ -
2022	€ -	€ -	€ -	€ -	€ -	€ -	€ -	€ -	€ -	€ -	€ -
2023	€ -	€ -	€ -	€ -	€ -	€ -	€ -	€ -	€ -	€ -	€ -
2024	€ -	€ -	€ -	€ -	€ -	€ -	€ -	€ -	€ -	€ -	€ -
2025	€ -	€ -	€ -	€ -	€ -	€ -	€ -	€ -	€ -	€ -	€ -
2026	€ -	€ -	€ -	€ -	€ -	€ -	€ -	€ -	€ -	€ -	€ -
2027	€ -	€ -	€ -	€ -	€ -	€ -	€ -	€ -	€ -	€ -	€ -
2028	€ -	€ -	€ -	€ -	€ -	€ -	€ -	€ -	€ -	€ -	€ -
2029	€ -	€ -	€ -	€ -	€ -	€ -	€ -	€ -	€ -	€ -	€ -
2030	€ 1,065	€ 227	€ 222	€ 239	€ 57	€ 1,769	€ 880	€ 1,133	€ 305	€ 297	€ 6,194
2031	€ -	€ -	€ -	€ -	€ -	€ -	€ -	€ -	€ -	€ -	€ -
2032	€ -	€ -	€ -	€ -	€ -	€ -	€ -	€ -	€ -	€ -	€ -
2033	€ -	€ -	€ -	€ -	€ -	€ -	€ -	€ -	€ -	€ -	€ -
Total											**€ 30,783**

Latvia	1.0

	Gross timber volume Pine log (18cm +)	Gross timber volume Birch log (24cm+)	Gross timber volume Spruce log (24cm +)	Gross timber volume Alder log (24cm +)	Gross timber volume Aspen log (24cm +)	Gross timber volume Pine pulp	Gross timber volume Birch pulp	Gross timber volume Spruce pulp	Gross timber volume Alder pulp	Gross timber volume Aspen pulp	Harvest type
2019											
2020	159	42	71	19	23	56	98	32	27	34	Clearfell
2021											
2022											
2023											
2024											
2025											
2026											
2027											
2028											
2029											
2030	20	4	9	2	1	71	38	33	13	13	Thinning
2031											
2032											
2033											
Total											

Terminal value: Latvia

Crop type	Area	Price per ha	Total	Age at end of DCF	Age 2019
Regeneration (new)	2.6	€ 3,731	€ 9,700	12	n/a
Regeneration - Thinning age	2.3	€ 5,137	€ 11,814	28	14
Thinning age - Maturing	5.1	€ 6,167	€ 31,450	56	42
Total Crop Value	**10.00**		**€ 52,964**		

Cashflow duration (years)	**14**

Present value		€ 1,598	**Bare land value of one rotation without annual costs**
Future value		€ 11,855	**Future land value of one rotation**
LEV B4 annual costs		€ 1,847	**Bare land value of infinite rotations without annual costs**
LEV		-€ 711	**Bare land value with infinite rotations with annual costs**
TOTAL land			**-€ 7,111**

Grand total	**€ 45,853**	
	€ 4,585	per hectare

Latvia	1.0

Year	Cost	Income - clearfell	Income - thin 3	Income - thin 2	Income - thin 1		
0	-€ 768					€ 1,598	
1	-€ 787					€ 1,637	
2	-€ 806					€ 1,677	
3	-€ 826					€ 1,718	
4	-€ 846					€ 1,760	
5	-€ 866					€ 1,803	
6	-€ 887					€ 1,847	
7	-€ 909					€ 1,892	
8	-€ 931					€ 1,938	
9	-€ 954					€ 1,985	
10	-€ 977					€ 2,034	
11	-€ 1,001					€ 2,083	
12	-€ 1,026					€ 2,134	
13	-€ 1,051					€ 2,186	
14	-€ 1,076					€ 2,240	
15	-€ 1,102					€ 2,294	
16	-€ 1,129					€ 2,350	
17	-€ 1,157					€ 2,407	
18	-€ 1,185					€ 2,466	
19	-€ 1,214					€ 2,526	
20	-€ 1,244					€ 2,588	
21	-€ 1,274					€ 2,651	
22	-€ 1,305					€ 2,716	
23	-€ 1,337					€ 2,782	
24	-€ 1,369					€ 2,850	
25	-€ 1,403					€ 2,919	
26	-€ 1,437					€ 2,991	
27	-€ 1,472					€ 3,063	
28	-€ 1,508					€ 3,138	
29	-€ 1,545					€ 3,215	
30	-€ 1,582					€ 3,293	
31	-€ 1,621					€ 3,373	
32	-€ 1,661					€ 3,456	
33	-€ 1,701					€ 3,540	
34	-€ 1,743					€ 3,626	
35	-€ 1,785					€ 3,715	
36	-€ 1,829				€ 1,186	€ 3,805	
37	-€ 1,873				€ 1,214	€ 3,898	
38	-€ 1,919				€ 1,244	€ 3,993	
39	-€ 1,966				€ 1,274	€ 4,091	
40	-€ 2,014				€ 1,306	€ 4,190	
41	-€ 2,063				€ 1,337	€ 4,293	
42	-€ 2,113				€ 1,370	€ 4,397	
43	-€ 2,165				€ 1,403	€ 4,505	
44	-€ 2,217				€ 1,438	€ 4,614	
45	-€ 2,271				€ 1,473	€ 4,727	
46	-€ 2,327				€ 1,509	€ 4,842	
47	-€ 2,384				€ 1,545	€ 4,960	
48	-€ 2,442				€ 1,583	€ 5,081	
49	-€ 2,501				€ 1,622	€ 5,205	
50	-€ 2,562				€ 1,661	€ 5,332	
51	-€ 2,625			€ 1,186	€ 1,702	€ 5,462	
52	-€ 2,689			€ 1,214	€ 1,743	€ 5,596	
53	-€ 2,754			€ 1,244	€ 1,786	€ 5,732	
54	-€ 2,822			€ 1,274	€ 1,829	€ 5,872	
55	-€ 2,890			€ 1,306	€ 1,874	€ 6,015	
56	-€ 2,961			€ 1,337	€ 1,920	€ 6,162	
57	-€ 3,033			€ 1,370	€ 1,967	€ 6,312	
58	-€ 3,107			€ 1,403	€ 2,014	€ 6,466	
59	-€ 3,183			€ 1,438	€ 2,064	€ 6,624	
60	-€ 3,261			€ 1,473	€ 2,114	€ 6,785	
61	-€ 3,340			€ 1,509	€ 2,166	€ 6,951	
62	-€ 3,422			€ 1,545	€ 2,218	€ 7,120	
63	-€ 3,505			€ 1,583	€ 2,272	€ 7,294	
64	-€ 3,590			€ 1,622	€ 2,328	€ 7,472	
65	-€ 3,678			€ 1,661	€ 2,385	€ 7,654	
66	-€ 3,768		€ 1,186	€ 1,702	€ 2,443	€ 7,841	
67	-€ 3,860		€ 1,214	€ 1,743	€ 2,502	€ 8,032	
68	-€ 3,954		€ 1,244	€ 1,786	€ 2,563	€ 8,228	
69	-€ 4,050		€ 1,274	€ 1,829	€ 2,626	€ 8,429	
70	-€ 4,149		€ 1,306	€ 1,874	€ 2,690	€ 8,634	
71	-€ 4,250		€ 1,337	€ 1,920	€ 2,756	€ 8,845	
72	-€ 4,354		€ 1,370	€ 1,967	€ 2,823	€ 9,061	
73	-€ 4,460		€ 1,403	€ 2,014	€ 2,892	€ 9,282	
74	-€ 4,569		€ 1,438	€ 2,064	€ 2,962	€ 9,508	
75	-€ 4,680		€ 1,473	€ 2,114	€ 3,034	€ 9,740	
76	-€ 4,794		€ 1,509	€ 2,166	€ 3,108	€ 9,977	
77	-€ 4,911		€ 1,545	€ 2,218	€ 3,184	€ 10,221	
78	-€ 5,031		€ 1,583	€ 2,272	€ 3,262	€ 10,470	
79	-€ 5,154		€ 1,622	€ 2,328	€ 3,341	€ 10,725	
80	-€ 5,280		€ 1,661	€ 2,385	€ 3,423	€ 10,987	
81	-€ 5,408		€ 1,702	€ 2,443	€ 3,506	€ 11,255	
82	-€ 5,540		€ 1,743	€ 2,502	€ 3,592	€ 11,530	
83	-€ 5,675	€ 9,457	€ 1,786	€ 2,563	€ 3,680	**€ 11,811**	**Future value**

€ 17,486	**Future value without restock cost**
€ 13,806	**Future value with only 2 thins left**
€ 11,243	**Future value with only 1 thin left**
€ 9,457	**Future value with only clearfell left**

Forest name	**Latvia**
Current year	**2019**
Version	**1.0**

Assumptions

(yellow)	Variable for calculation
(green)	Calculated figure

Acquisition costs

Variable	per ha	Comment / Source
Purchase price	1,500 €	Baltic review 2017
Area	10.0	Thesis assumption
Total	15,000 €	
Costs	0%	

Compartment Schedule

Variable		Comment / Source
Tree species makeup		UNECE data
Crop development phase		UNECE data

Cashflow duration

	Years	Comment / Source
	14	Half of duration of UNECE crop development stage

Felling Plan

Variable	Modelling approach	Comment / Source
Approach to clearfell harvesting	Clearfell mature crops	Thesis assumption
Approach to thinning		

Timber production

Tonnage calculations	Modelling approach	Comment / Source
Mature Scots pine	223	Central Statistical Bureau of Latvia
Mature Birch	222	Central Statistical Bureau of Latvia
Mature Norway spruce	245	Central Statistical Bureau of Latvia
Mature Alder (grey alder)	153	Central Statistical Bureau of Latvia
Mature Aspen	243	Central Statistical Bureau of Latvia
Thinning Scots pine	48	Central Statistical Bureau of Latvia
Thinning Birch	34	Central Statistical Bureau of Latvia
Thinning Norway spruce	50	Central Statistical Bureau of Latvia
Thinning Alder (grey alder)	26	Central Statistical Bureau of Latvia
Thinning Aspen	32	Central Statistical Bureau of Latvia
Thinning proportion		

Harvest products and prices

Species	Stumpage price	Comment / Source
Pine log (18cm +)	€ 73.70	Central Statistical Bureau of Latvia
Birch log (24cm+)	€ 80.53	Central Statistical Bureau of Latvia
Spruce log (24cm +)	€ 79.30	Central Statistical Bureau of Latvia
Alder log (24cm +)	€ 48.71	Central Statistical Bureau of Latvia
Aspen log (24cm +)	€ 51.48	Central Statistical Bureau of Latvia
Pine pulp	€ 45.85	Central Statistical Bureau of Latvia
Birch pulp	€ 43.68	Central Statistical Bureau of Latvia
Spruce pulp	€ 55.41	Central Statistical Bureau of Latvia
Alder pulp	€ 43.68	Central Statistical Bureau of Latvia
Aspen pulp	€ 43.68	Central Statistical Bureau of Latvia

Forest specific timber extraction costs

	Cost per tonne	Comment / Source
Cost to harvest, extract and haul to market - clearfell	€ 16.48	Central Statistical Bureau of Latvia
Cost to harvest, extract and haul to market - thinning	€ 20.77	Central Statistical Bureau of Latvia
Infrastructure maintenance allowance during harvesting		Not used
Gross to net timber income reduction factor	**0%**	
% of site Harvester-Forwarder		Not used
% of site winch-skidder		Not used
% of site skyline		Not used
	100%	

Product assortments		Comment / Source
Pine log (18cm +)	74%	Kons 2011
Birch log (24cm+)	30%	Kons 2011
Spruce log (24cm +)	69%	Kons 2011
Alder log (24cm +)	41%	Kons 2011
Aspen log (24cm +)	41%	Kons 2011
Pine pulp	26%	Kons 2011
Birch pulp	70%	Kons 2011
Spruce pulp	31%	Kons 2011
Alder pulp	59%	Kons 2011
Aspen pulp	59%	Kons 2011
Thinning log proportion reduction factor	30%	

Other revenue		

	Modelling approach	Comment / Source
None		

Terminal value assumptions		Comment / Source
Establishment costs /ha	-€ 768	
Timber clearfell income / ha	€ 9,457	
Timber thinning income / ha	€ 1,214	
Typical rotation length	83	*Weighted*
Pine	101	*Pach et al 2018*
Spruce	81	*Pach et al 2018*
Birch/other	71	*Pach et al 2018*
Nominal Discount rate scenario 1	2.66%	World bank
Nominal Discount rate scenario 2&3	5.00%	
Fisher adjusted real rate	2.44%	
Latvia inflation rate scenario 1&2	3.10%	2019 Euro stat
Latvia inflation rate scenario 3	2.50%	av emergin europe

Other income		Comment / Source

Capital Expenditure		Comment / Source

Restocking costs		

	Cost per ha	Comment / Source
	€ 768	Total costs to fully re-establish crop
Build up ops		
Soil preparation	€ 135	
Plants	€ 301	
Planting	€ 81	
Forest crop cultivation	€ 115	
Forest stock cultivation	€ 136	

Maintenance Expenditure	Cost per ha	Comment / Source
Total Annual costs	€ 62.40	Calculated
Total Annual costs	€ 12.40	Thesis assumption
Risk	**Cost per ha**	**Comment / Source**
Total Annual contingency	€ 50.00	Thesis assumption

Appendix 4: Estonia Discounted Cash Flow

Estonia 1.0

	Property purchase	Net timber revenue	Capital Expenditure	Management and maintenace	Silvicultural expenditure	Terminal value	Total
2019	-€ 36,000	€ -	€ -	-€ 690	€ -		-€ 36,690
2020	€ -	€ 15,317	€ -	-€ 690	€ -		€ 14,627
2021	€ -	€ -	€ -	-€ 690	-€ 3,102		-€ 3,792
2022	€ -	€ -	€ -	-€ 690	€ -		-€ 690
2023	€ -	€ -	€ -	-€ 690	€ -		-€ 690
2024	€ -	€ -	€ -	-€ 690	€ -		-€ 690
2025	€ -	€ -	€ -	-€ 690	€ -		-€ 690
2026	€ -	€ -	€ -	-€ 690	€ -		-€ 690
2027	€ -	€ -	€ -	-€ 690	€ -		-€ 690
2028	€ -	€ -	€ -	-€ 690	€ -		-€ 690
2029	€ -	€ -	€ -	-€ 690	€ -		-€ 690
2030	€ -	€ 9,747	€ -	-€ 690	€ -		€ 9,057
2031	€ -	€ -	€ -	-€ 690	€ -	€ 36,168	€ 35,478
Total	**-€ 36,000**	**€ 25,064**	**€ -**		**-€ 3,102**	**€ 36,168**	**€ 13,160**

Estonia	1.0

	Gross timber income					
	Pine (mixed assortment)	Spruce (mixed assortment)	Birch (mixed assortment)	Alder (mixed assortment)	Aspen (mixed assortment)	Total
2019	€ -	€ -	€ -	€ -	€ -	€ -
2020	€ 6,034	€ 4,103	€ 4,215	€ 404	€ 561	€ 15,317
2021	€ -	€ -	€ -	€ -	€ -	€ -
2022	€ -	€ -	€ -	€ -	€ -	€ -
2023	€ -	€ -	€ -	€ -	€ -	€ -
2024	€ -	€ -	€ -	€ -	€ -	€ -
2025	€ -	€ -	€ -	€ -	€ -	€ -
2026	€ -	€ -	€ -	€ -	€ -	€ -
2027	€ -	€ -	€ -	€ -	€ -	€ -
2028	€ -	€ -	€ -	€ -	€ -	€ -
2029	€ -	€ -	€ -	€ -	€ -	€ -
2030	€ 3,840	€ 2,611	€ 2,682	€ 257	€ 357	€ 9,747
2031	€ -	€ -	€ -	€ -	€ -	€ -
Total						€ -

Estonia	1.0

	Gross timber volume Pine (mixed assortment)	Gross timber volume Spruce (mixed assortment)	Gross timber volume Birch (mixed assortment)	Gross timber volume Alder (mixed assortment)	Gross timber volume Aspen (mixed assortment)	Harvest type
2019						
2020	147	117	124	40	37	Clearfell
2021						
2022						
2023						
2024						
2025						
2026						
2027						
2028						
2029						
2030	94	75	79	26	24	Thinning
2031						
Total						

Terminal value: Estonia

Crop type	Area	Price per ha	Total	Age at end of DCF	Age 2019
Regeneration (new)	2.2	€ 4,351	€ 9,571	10	n/a
Regeneration - Thinning age	0.8	€ 5,568	€ 4,454	26	13
Thinning age - Maturing	7.0	€ 5,579	€ 39,051	52	39
Total Crop Value	**10.00**		**€ 53,077**		

Cashflow duration (years)	**13**

Present value		€ 965	**Bare land value of one rotation without annual costs**
Future value		€ 6,009	**Future land value of one rotation**
LEV B4 annual costs		€ 1,150	**Bare land value of infinite rotations without annual costs**
LEV		-€ 1,691	**Bare land value with infinite rotations with annual costs**
TOTAL land			**-€ 16,909**

Grand total	**€ 36,168**	
	€ 3,617	per hectare

Estonia	1.0

Year	Cost	Income - clearfell	Income - thin 3	Income - thin 2	Income - thin 1		
0	-€ 1,410					€ 965	
1	-€ 1,444					€ 989	
2	-€ 1,479					€ 1,013	
3	-€ 1,515					€ 1,037	
4	-€ 1,552					€ 1,062	
5	-€ 1,590					€ 1,088	
6	-€ 1,629					€ 1,115	
7	-€ 1,668					€ 1,142	
8	-€ 1,709					€ 1,169	
9	-€ 1,750					€ 1,198	
10	-€ 1,793					€ 1,227	
11	-€ 1,836					€ 1,257	
12	-€ 1,881					€ 1,287	
13	-€ 1,926					€ 1,318	
14	-€ 1,973					€ 1,350	
15	-€ 2,021					€ 1,383	
16	-€ 2,070					€ 1,417	
17	-€ 2,121					€ 1,451	
18	-€ 2,172					€ 1,487	
19	-€ 2,225					€ 1,523	
20	-€ 2,279					€ 1,560	
21	-€ 2,334					€ 1,598	
22	-€ 2,391					€ 1,636	
23	-€ 2,449					€ 1,676	
24	-€ 2,508					€ 1,717	
25	-€ 2,569					€ 1,759	
26	-€ 2,632					€ 1,801	
27	-€ 2,696					€ 1,845	
28	-€ 2,761					€ 1,890	
29	-€ 2,828					€ 1,936	
30	-€ 2,897					€ 1,983	
31	-€ 2,967					€ 2,031	
32	-€ 3,039					€ 2,080	
33	-€ 3,113					€ 2,131	
34	-€ 3,189					€ 2,182	
35	-€ 3,266					€ 2,236	
36	-€ 3,346				€ 1,359	€ 2,290	
37	-€ 3,427				€ 1,392	€ 2,345	
38	-€ 3,510				€ 1,426	€ 2,402	
39	-€ 3,595				€ 1,461	€ 2,461	
40	-€ 3,683				€ 1,496	€ 2,521	
41	-€ 3,772				€ 1,533	€ 2,582	
42	-€ 3,864				€ 1,570	€ 2,644	
43	-€ 3,958				€ 1,608	€ 2,709	
44	-€ 4,054				€ 1,647	€ 2,774	
45	-€ 4,152				€ 1,687	€ 2,842	
46	-€ 4,253				€ 1,728	€ 2,911	
47	-€ 4,356				€ 1,770	€ 2,982	
48	-€ 4,462				€ 1,813	€ 3,054	
49	-€ 4,571				€ 1,857	€ 3,128	
50	-€ 4,682				€ 1,902	€ 3,204	
51	-€ 4,795			€ 1,359	€ 1,949	€ 3,282	
52	-€ 4,912			€ 1,392	€ 1,996	€ 3,362	
53	-€ 5,031			€ 1,426	€ 2,044	€ 3,443	
54	-€ 5,153			€ 1,461	€ 2,094	€ 3,527	
55	-€ 5,279			€ 1,496	€ 2,145	€ 3,613	
56	-€ 5,407			€ 1,533	€ 2,197	€ 3,700	
57	-€ 5,538			€ 1,570	€ 2,250	€ 3,790	
58	-€ 5,673			€ 1,608	€ 2,305	€ 3,882	
59	-€ 5,810			€ 1,647	€ 2,361	€ 3,977	
60	-€ 5,952			€ 1,687	€ 2,418	€ 4,073	
61	-€ 6,096			€ 1,728	€ 2,477	€ 4,172	
62	-€ 6,244			€ 1,770	€ 2,537	€ 4,274	
63	-€ 6,396			€ 1,813	€ 2,599	€ 4,377	
64	-€ 6,551			€ 1,857	€ 2,662	€ 4,484	
65	-€ 6,710			€ 1,902	€ 2,727	€ 4,593	
66	-€ 6,873		€ 1,359	€ 1,949	€ 2,793	€ 4,704	
67	-€ 7,040		€ 1,392	€ 1,996	€ 2,861	€ 4,819	
68	-€ 7,211		€ 1,426	€ 2,044	€ 2,930	€ 4,936	
69	-€ 7,387		€ 1,461	€ 2,094	€ 3,001	€ 5,055	
70	-€ 7,566		€ 1,496	€ 2,145	€ 3,074	€ 5,178	
71	-€ 7,750		€ 1,533	€ 2,197	€ 3,149	€ 5,304	
72	-€ 7,938		€ 1,570	€ 2,250	€ 3,225	€ 5,433	
73	-€ 8,131		€ 1,608	€ 2,305	€ 3,304	€ 5,565	
74	-€ 8,328		€ 1,647	€ 2,361	€ 3,384	€ 5,700	
75	-€ 8,531		€ 1,687	€ 2,418	€ 3,466	€ 5,838	
76	-€ 8,738	€ 6,962	€ 1,728	€ 2,477	€ 3,550	**€ 5,980**	**Future value**

€ 14,718	**Future value without restock cost**
€ 11,168	**Future value with only 2 thins left**
€ 8,691	**Future value with only 1 thins left**
€ 6,962	**Future value with only clearfell left**

Forest name	**Estonia**
Current year	**2019**
Version	**1.0**

Assumptions

(yellow)	Variable for calculation
(green)	Calculated figure

Acquisition costs

Variable	**per ha**	**Comment / Source**
Purchase price	3,600 €	Baltic survey 2017
Area	10.0	Thesis assumption
Total	36,000 €	
Costs	0%	

Compartment Schedule

Variable		**Comment / Source**
Tree species makeup		UNECE data
Crop development phase		UNECE data

Cashflow duration

	Years	**Comment / Source**
	13	Half of duration of UNECE crop development stage

Felling Plan

Variable	**Modelling approach**	**Comment / Source**
Approach to clearfell harvesting	Clearfell mature crops	Thesis assumption
Approach to thinning	3 thinnings	20% of mature crop vol per thin

Timber production

Tonnage calculations	**Modelling approach**	**Comment / Source**
Mature Scots pine	223	Central Statistical Bureau of Latvia
Mature Spruce	222	Central Statistical Bureau of Latvia
Mature Birch	245	Central Statistical Bureau of Latvia
Mature Alder (grey alder)	153	Central Statistical Bureau of Latvia
Mature Aspen	243	Central Statistical Bureau of Latvia
Thinning Scots pine	45	Calculated
Thinning Birch	44	Calculated
Thinning Norway spruce	49	Calculated
Thinning Alder (grey alder)	31	Calculated
Thinning Aspen	49	Calculated
Thinning proportion	20%	Pach et al 2018

Harvest products and prices

Species	**Stumpage price**	**Comment / Source**
Pine (mixed assortment)	€ 41.00	HD forest fest client timber sale June 19
Spruce (mixed assortment)	€ 35.00	HD forest fest client timber sale June 19
Birch (mixed assortment)	€ 34.00	HD forest fest client timber sale June 19
Alder (mixed assortment)	€ 10.00	HD forest fest client timber sale June 19
Aspen (mixed assortment)	€ 15.00	HD forest fest client timber sale June 19

Forest specific timber extraction costs

	Cost per tonne	**Comment / Source**
Cost to harvest, extract and haul to market - clearfell	€ -	Not used
Cost to harvest, extract and haul to market - thinning	€ -	Not used
Infrastructure maintenance allowance during harvesting		Not used
Gross to net timber income reduction factor	**0%**	
% of site Harvester-Forwarder		Not used
% of site winch-skidder		Not used
% of site skyline		Not used
	100%	

Product assortments

		Comment / Source
Pine (mixed assortment)	100%	Not used
Spruce (mixed assortment)	100%	Not used
Birch (mixed assortment)	100%	Not used
Alder (mixed assortment)	100%	Not used
Aspen (mixed assortment)	100%	Not used
Thinning log proportion reduction factor		Not used

Other revenue		

	Modelling approach	Comment / Source
None		

Terminal value assumptions		Comment / Source
Establishment costs /ha	-€ 1,410	
Timber clearfell income / ha	€ 6,962	
Timber thinning income / ha	€ 1,392	
Typical rotation length	76	*Weighted*
Pine / spruce	90	Pach et al 2018
Birch/other	60	Pach et al 2018
Nominal discount rate - scenario 1	3.19%	
Nominal discount rate - scenario 2&3	5.000%	https://www.economy.com/estonia/business-lending-rate
Discount rate	2.4%	Real fisher adjusted rate
Inflation scenario 1&2	2.6%	2019 Eurstat
Inflation scenario 3	2.5%	Av emerging europe

Other income		Comment / Source
None		

Capital Expenditure		Comment / Source
None		

Restocking costs		

	Cost per ha	Comment / Source
	€ 1,410	Total costs to fully re-establish crop
Build up ops		
Scarification	€ 109	after Vikkunen 2017
Planting	€ 592	after Vikkunen 2017
Seeding	€ 249	after Vikkunen 2017
Grass suppression	€ 100	after Vikkunen 2017
Cleaning	€ 150	after Vikkunen 2017
Tending seedling stand	€ 211	after Vikkunen 2017

Maintenance Expenditure	Cost per ha	Comment / Source
Annual costs	€ 69.00	Calculated
Annual costs	€ 19.00	Thesis assumption
Risk	**Cost per ha**	**Comment / Source**
Annual contingency costs	€ 50.00	Thesis assumption

Appendix 5: Slovenia Discounted Cash Flow

Slovenia	1.0

	Property purchase	Net timber revenue	Capital Expenditure	Management and maintenace	Silvicultural expenditure	Terminal value	Total
2019	-£ 50,000	€ -	€ -	-€ 738	€ -		-€ 50,738
2020	£ -	€ 24,507	€ -	-€ 738	€ -		€ 23,769
2021	£ -	€ -	€ -	-€ 738	€ -		-€ 738
2022	£ -	€ -	€ -	-€ 738	€ -		-€ 738
2023	£ -	€ -	€ -	-€ 738	€ -		-€ 738
2024	£ -	€ -	€ -	-€ 738	€ -		-€ 738
2025	£ -	€ -	€ -	-€ 738	€ -		-€ 738
2026	£ -	€ -	€ -	-€ 738	€ -		-€ 738
2027	£ -	€ -	€ -	-€ 738	€ -		-€ 738
2028	£ -	€ -	€ -	-€ 738	€ -		-€ 738
2029	£ -	€ -	€ -	-€ 738	€ -	£ 24,082	€ 23,344
Total	**-€ 50,000**	**€ 24,507**	**€ -**		**€ -**	**€ 24,082**	**-€ 9,529**

Slovenia	1.0

	Gross timber income										
	Mature Beech log 'C' grade Q1 2019 Bukev	Mature Norway spruce - log 'C' grade Q1 2019 Smreka	Mature European silver fir - log grade 'C' Q1 2019 Jelka	Mature Scots pine - log grade 'C' Q1 2019 Rdeči bor	Mature oak - log grade 'C' Q1 2019 (over 50cm) Hrast	Mature Beech firewood grade Q1 2019 Bukev	Mature Norway spruce - pulp grade Q1 2019 Smreka	Mature European silver fir - pulp grade Q1 2019 Jelka	Mature Scots pine - pulp grade Q1 2019 Rdeči bor	Mature oak - grade 'D' Q1 2019 (under 50cm) Hrast	Total
2019	€ -	€ -	€ -	€ -	€ -	€ -	€ -	€ -	€ -	€ -	€ -
2020	€ 3,027	€ 7,890	€ 2,122	€ 1,294	€ 1,523	€ 5,476	€ 817	€ 259	€ 203	€ 1,895	€ 24,507
2021	€ -	€ -	€ -	€ -	€ -	€ -	€ -	€ -	€ -	€ -	€ -
2022	€ -	€ -	€ -	€ -	€ -	€ -	€ -	€ -	€ -	€ -	€ -
2023	€ -	€ -	€ -	€ -	€ -	€ -	€ -	€ -	€ -	€ -	€ -
2024	€ -	€ -	€ -	€ -	€ -	€ -	€ -	€ -	€ -	€ -	€ -
2025	€ -	€ -	€ -	€ -	€ -	€ -	€ -	€ -	€ -	€ -	€ -
2026	€ -	€ -	€ -	€ -	€ -	€ -	€ -	€ -	€ -	€ -	€ -
2027	€ -	€ -	€ -	€ -	€ -	€ -	€ -	€ -	€ -	€ -	€ -
2028	€ -	€ -	€ -	€ -	€ -	€ -	€ -	€ -	€ -	€ -	€ -
2029	€ -	€ -	€ -	€ -	€ -	€ -	€ -	€ -	€ -	€ -	€ -
Total											€ -

Slovenia	1.0

	Gross timber volume Mature Beech log 'C' grade Q1 2019 Bukev	Gross timber volume Mature Norway spruce - log 'C' grade Q1 2019 Smreka	Gross timber volume Mature European silver fir - log grade 'C' Q1 2019 Jelka	Gross timber volume Mature Scots pine - log grade 'C' Q1 2019 Rdeči bor	Gross timber volume Mature oak - log grade 'C' Q1 2019 (over 50cm) Hrast	Gross timber volume Mature Beech firewood grade Q1 2019 Bukev	Gross timber volume Mature Norway spruce - pulp grade Q1 2019 Smreka	Gross timber volume Mature European silver fir - pulp grade Q1 2019 Jelka	Gross timber volume Mature Scots pine - pulp grade Q1 2019 Rdeči bor	Gross timber volume Mature oak - grade 'D' Q1 2019 (under 50cm) Hrast	
2019											
2020	61	149	47	37	11	156	68	22	17	29	select fell
2021											
2022											
2023											
2024											
2025											
2026											
2027											
2028											
2029											
Total											

Terminal value: Slovenia - Uneven aged forest

Crop type	Area	Price per ha		Total			Age 2019
LEV land and crop - production in 10 years	10.0	€	2,408	€	24,082		
Total Crop Value	**10.00**			**€**	**24,082**		
Cashflow duration (years)	**10**						
Grand total				**€**	**24,082**		
				€	**2,408**	per hectare	

Slovenia 1.0

Year	Cost	Income - select fell		
0	€ -		€ 1,928	
1	€ -		€ 1,975	
2	€ -		€ 2,023	
3	€ -		€ 2,072	
4	€ -		€ 2,122	
5	€ -		€ 2,174	
6	€ -		€ 2,226	
7	€ -		€ 2,280	
8	€ -		€ 2,336	
9	€ -		€ 2,393	
10	€ -	€ 2,451	**€ 2,451**	**Future value**
			€ 2,451	**Future value without restock cost**
			€ 2,451	**Future value with only 2 thins left**
			€ 2,451	**Future value with only 1 thins left**
			€ 2,451	**Future value with only clearfell left**

Forest name	**Slovenia**
Current year	**2019**
Version	**1.0**

Assumptions

	Variable for calculation
	Calculated figures

Acquisition costs

Variable	per ha	Comment / Source
Purchase price	5,000 €	Report on the Slovenian real property market
Area	10.0	
Total	50,000 €	
Costs	0%	

Compartment Schedule

Variable		Comment / Source
Tree species makeup		UNECE data
Crop development phase		not applicable

Cashflow duration

	Years	Comment / Source
	10	Forest plan duration

Felling Plan

Variable	Modelling approach	Comment / Source
Approach to clearfell harvesting	Select felling in line with increment	Thesis assumption
Approach to thinning	Select felling in line with increment	Thesis assumption

Timber production

Tonnage calculations	Modelling approach	Comment / Source
Mixed forest	282	Malovrh 2012
	0	Calculated
	0	Calculated
	0	Calculated
	0	Calculated
	0	Calculated
Thinning proportion		

Harvest products and prices

Species	Stumpage price	Comment / Source
Mature Beech log 'C' grade Q1 2019 Bukev	€ 65.00	http://wcm.gozdis.si/cene-okroglega-lesa
Mature Norway spruce - log 'C' grade Q1 2019 Smreka	€ 68.00	http://wcm.gozdis.si/cene-okroglega-lesa
Mature European silver fir - log grade 'C' Q1 2019 Jelka	€ 60.00	http://wcm.gozdis.si/cene-okroglega-lesa
Mature Scots pine - log grade 'C' Q1 2019 Rdeči bor	€ 50.00	http://wcm.gozdis.si/cene-okroglega-lesa
Mature oak - log grade 'C' Q1 2019 (over 50cm) Hrast	€ 150.00	http://wcm.gozdis.si/cene-okroglega-lesa
Mature Beech firewood grade Q1 2019 Bukev	€ 50.00	http://wcm.gozdis.si/cene-okroglega-lesa
Mature Norway spruce - pulp grade Q1 2019 Smreka	€ 27.00	http://wcm.gozdis.si/cene-okroglega-lesa
Mature European silver fir - pulp grade Q1 2019 Jelka	€ 27.00	http://wcm.gozdis.si/cene-okroglega-lesa
Mature Scots pine - pulp grade Q1 2019 Rdeči bor	€ 27.00	http://wcm.gozdis.si/cene-okroglega-lesa
Mature oak - grade 'D' Q1 2019 (under 50cm) Hrast	€ 80.00	http://wcm.gozdis.si/cene-okroglega-lesa

Forest specific timber extraction costs

	Cost per tonne	Comment / Source
Cost to harvest, extract and haul to market - harvester forwarder	€ 11.22	Wood chain manager 2019
Cost to harvest, extract and haul to market - motor manual skidder	€ 17.53	Wood chain manager 2019
% harvester forwarder	40%	Thesis assumption
% motor manual skidder	60%	Thesis assumption
weighted average	€ 15.01	calculated
Infrastructure maintenance allowance during harvesting		Not used
Gross to net timber income reduction factor	**0%**	
% of forest Harvester-Forwarder		Not used
% of site winch-motor manual skidder		Not used
	100%	

Product assortments		**Comment / Source**
Mature Beech log 'C' grade Q1 2019 Bukev	27.9%	Malovrh 2012
Mature Norway spruce - log 'C' grade Q1 2019 Smreka	68.6%	Malovrh 2012
Mature European silver fir - log grade 'C' Q1 2019 Jelka	68.6%	Malovrh 2012
Mature Scots pine - log grade 'C' Q1 2019 Rdeči bor	68.6%	Malovrh 2012
Mature oak - log grade 'C' Q1 2019 (over 50cm) Hrast	27.9%	Malovrh 2012
Mature Beech firewood grade Q1 2019 Bukev	72.1%	Malovrh 2012
Mature Norway spruce - pulp grade Q1 2019 Smreka	31.4%	Malovrh 2012
Mature European silver fir - pulp grade Q1 2019 Jelka	31.4%	Malovrh 2012
Mature Scots pine - pulp grade Q1 2019 Rdeči bor	31.4%	Malovrh 2012
Mature oak - grade 'D' Q1 2019 (under 50cm) Hrast	72.1%	Malovrh 2012
Thinning log proportion reduction factor		Not used

Other revenue		

	Modelling approach	Comment / Source
None		

Terminal value assumptions		Comment / Source
Establishment costs /ha	€ -	
Timber harvest income / ha	€ 2,451	
Forest plan duration	10	forest plan duration
Typical rotation length		
Typical incremnent	6.74	http://www.zgs.si/eng/slovenian_forests/forests_in_slovenia/growing_stock_increment_and_cut/index.html
Nominal discount rate scenario 1	2.2%	World bank
Nominal discount rate scenario 2&3	5.0%	
Real Discount rate	2.4%	Real fisher adjusted
Inflation scenario 1&2	1.6%	2019 Euro stat
Inflation scenario 3	2.5%	Av emergin Europe

Other income		Comment / Source

Capital Expenditure		Comment / Source
none		

Restocking costs		

	Cost per ha	Comment / Source
	€ -	Total costs to fully re-establish crop
Build up ops		
	€ -	

Maintenance Expenditure	Cost per ha	Comment / Source
Total annual costs	€ 73.80	Estimate
Annual management	€ 23.80	
Risk	**Cost per ha**	**Comment / Source**
Contingency	€ 50.00	Estimate

Appendix 6: Poland Discounted Cash Flow

Poland | 1.0

	Property purchase	Net timber revenue	Capital Expenditure	Management and maintenace	Silvicultural expenditure	Terminal value	Total
2019	-£ 81,781	€ -	€ -	-€ 646	€ -		-€ 82,427
2020	£ -	€ 27,022	€ -	-€ 646	€ -		€ 26,376
2021	£ -	€ -	€ -	-€ 646	-€ 4,674		-€ 5,320
2022	£ -	€ -	€ -	-€ 646	€ -		-€ 646
2023	£ -	€ -	€ -	-€ 646	€ -		-€ 646
2024	£ -	€ -	€ -	-€ 646	€ -		-€ 646
2025	£ -	€ 9,404	€ -	-€ 646	€ -		€ 8,758
2026	£ -	€ -	€ -	-€ 646	€ -		-€ 646
2027	£ -	€ -	€ -	-€ 646	€ -		-€ 646
2028	£ -	€ -	€ -	-€ 646	€ -		-€ 646
2029	£ -	€ -	€ -	-€ 646	€ -		-€ 646
2030	£ -	€ -	€ -	-€ 646	€ -		-€ 646
2031	£ -	€ -	€ -	-€ 646	€ -		-€ 646
2032	£ -	€ 9,404	€ -	-€ 646	€ -		€ 8,758
2033	£ -	€ -	€ -	-€ 646	€ -		-€ 646
2034	£ -	€ -	€ -	-€ 646	€ -		-€ 646
2035	£ -	€ -	€ -	-€ 646	€ -	£ 85,155	€ 84,509
Total	**-€ 81,781**	**€ 45,831**	**€ -**		**-€ 4,674**	**€ 85,155**	**€ 33,550**

Poland	1.0					
	Gross timber income					
	Pine/ spruce(log)	**Pine/ spruce(pulp)**	**Oak/Beech/Birch (pulp)**			Total
2019	€ -	€ -	€ -	€ -	€ -	€ -
2020	€ 24,422	€ 2,600	€ -	€ -	€ -	€ 27,022
2021	€ -	€ -	€ -	€ -	€ -	€ -
2022	€ -	€ -	€ -	€ -	€ -	€ -
2023	€ -	€ -	€ -	€ -	€ -	€ -
2024	€ -	€ -	€ -	€ -	€ -	€ -
2025	€ 2,128	€ 7,276	€ -	€ -	€ -	€ 9,404
2026	€ -	€ -	€ -	€ -	€ -	€ -
2027	€ -	€ -	€ -	€ -	€ -	€ -
2028	€ -	€ -	€ -	€ -	€ -	€ -
2029	€ -	€ -	€ -	€ -	€ -	€ -
2030	€ -	€ -	€ -	€ -	€ -	€ -
2031	€ -	€ -	€ -	€ -	€ -	€ -
2032	€ 2,128	€ 7,276	€ -	€ -	€ -	€ 9,404
2033	€ -	€ -	€ -	€ -	€ -	€ -
2034	€ -	€ -	€ -	€ -	€ -	€ -
2035	€ -	€ -	€ -	€ -	€ -	€ -
Total						€ -

Poland	1.0

	Gross timber volume Pine/ spruce(log)	Gross timber volume Pine/ spruce(pulp)	Gross timber volume Oak/Beech/Birch (pulp)	Gross timber volume	Gross timber volume	Harvest type
2019						
2020	426	75				Clearfell
2021						
2022						
2023						
2024						
2025	37	211	96			Thinning
2026						
2027						
2028						
2029						
2030						Thinning
2031						
2032	37	211	96			
2033						
2034						
2035						
Total						

Terminal value: Poland

Crop type	Area	Price per ha	Total	Age at end of DCF	Age 2019
Regeneration (new)	1.6	€ 6,665	€ 10,663	10	n/a
Regeneration - Thinning age	1.5	€ 7,629	€ 11,444	34	17
Thinning age - Maturing	6.9	€ 10,215	€ 70,482	68	51
Total Crop Value	**10.00**		**€ 92,589**		

Cashflow duration (years)	**17**

Present value		€ 1,827	**Bare land value of one rotation without annual costs**
Future value		€ 19,226	**Future land value of one rotation**
LEV B4 annual costs		€ 2,018	**Bare land value of infinite rotations without annual costs**
LEV		-€ 743	**Bare land value with infinite rotations with annual costs**
TOTAL land			**-€ 7,434**

Grand total	**€ 85,155**
	€ 8,516 per hectare

Poland	1.0

Year	Cost	Income - clearfell	Income - thin 7	Income - thin 6	Income - thin 5	Income - thin 4	Income - thin 3	Income - thin 2	Income - thin 1		
0	-€ 2,921									€ 1,827	
1	-€ 2,989									€ 1,869	
2	-€ 3,059									€ 1,913	
3	-€ 3,131									€ 1,958	
4	-€ 3,204									€ 2,004	
5	-€ 3,279									€ 2,050	
6	-€ 3,356									€ 2,098	
7	-€ 3,434									€ 2,147	
8	-€ 3,514									€ 2,198	
9	-€ 3,597									€ 2,249	
10	-€ 3,681									€ 2,302	
11	-€ 3,767									€ 2,356	
12	-€ 3,855									€ 2,411	
13	-€ 3,945									€ 2,467	
14	-€ 4,038									€ 2,525	
15	-€ 4,132									€ 2,584	
16	-€ 4,229									€ 2,644	
17	-€ 4,328									€ 2,706	
18	-€ 4,429									€ 2,769	
19	-€ 4,532									€ 2,834	
20	-€ 4,638									€ 2,900	
21	-€ 4,747								€ 1,363	€ 2,968	
22	-€ 4,858								€ 1,395	€ 3,038	
23	-€ 4,972								€ 1,427	€ 3,109	
24	-€ 5,088								€ 1,461	€ 3,181	
25	-€ 5,207								€ 1,495	€ 3,256	
26	-€ 5,329								€ 1,530	€ 3,332	
27	-€ 5,453								€ 1,566	€ 3,410	
28	-€ 5,581							€ 1,363	€ 1,602	€ 3,490	
29	-€ 5,711							€ 1,395	€ 1,640	€ 3,571	
30	-€ 5,845							€ 1,427	€ 1,678	€ 3,655	
31	-€ 5,982							€ 1,461	€ 1,718	€ 3,740	
32	-€ 6,122							€ 1,495	€ 1,758	€ 3,828	
33	-€ 6,265							€ 1,530	€ 1,799	€ 3,917	
34	-€ 6,411							€ 1,566	€ 1,841	€ 4,009	
35	-€ 6,561							€ 1,602	€ 1,884	€ 4,103	
36	-€ 6,715							€ 1,640	€ 1,928	€ 4,199	
37	-€ 6,872							€ 1,678	€ 1,973	€ 4,297	
38	-€ 7,033							€ 1,718	€ 2,019	€ 4,398	
39	-€ 7,197							€ 1,758	€ 2,067	€ 4,500	
40	-€ 7,366							€ 1,799	€ 2,115	€ 4,606	
41	-€ 7,538							€ 1,841	€ 2,164	€ 4,714	
42	-€ 7,714							€ 1,884	€ 2,215	€ 4,824	
43	-€ 7,895							€ 1,928	€ 2,267	€ 4,937	
44	-€ 8,079							€ 1,973	€ 2,320	€ 5,052	
45	-€ 8,268						€ 1,363	€ 2,019	€ 2,374	€ 5,170	
46	-€ 8,462						€ 1,395	€ 2,067	€ 2,430	€ 5,291	
47	-€ 8,660						€ 1,427	€ 2,115	€ 2,486	€ 5,415	
48	-€ 8,862						€ 1,461	€ 2,164	€ 2,545	€ 5,542	
49	-€ 9,069						€ 1,495	€ 2,215	€ 2,604	€ 5,671	
50	-€ 9,282						€ 1,530	€ 2,267	€ 2,665	€ 5,804	
51	-€ 9,499						€ 1,566	€ 2,320	€ 2,727	€ 5,940	
52	-€ 9,721						€ 1,602	€ 2,374	€ 2,791	€ 6,079	
53	-€ 9,948						€ 1,640	€ 2,430	€ 2,856	€ 6,221	
54	-€ 10,181						€ 1,678	€ 2,486	€ 2,923	€ 6,366	
55	-€ 10,419					€ 1,363	€ 1,718	€ 2,545	€ 2,992	€ 6,515	
56	-€ 10,663					€ 1,395	€ 1,758	€ 2,604	€ 3,062	€ 6,668	
57	-€ 10,912					€ 1,427	€ 1,799	€ 2,665	€ 3,133	€ 6,824	
58	-€ 11,168					€ 1,461	€ 1,841	€ 2,727	€ 3,207	€ 6,983	
59	-€ 11,429					€ 1,495	€ 1,884	€ 2,791	€ 3,282	€ 7,147	
60	-€ 11,696					€ 1,530	€ 1,928	€ 2,856	€ 3,358	€ 7,314	
61	-€ 11,970					€ 1,566	€ 1,973	€ 2,923	€ 3,437	€ 7,485	
62	-€ 12,250					€ 1,602	€ 2,019	€ 2,992	€ 3,517	€ 7,660	
63	-€ 12,536					€ 1,640	€ 2,067	€ 3,062	€ 3,600	€ 7,839	
64	-€ 12,830					€ 1,678	€ 2,115	€ 3,133	€ 3,684	€ 8,022	
65	-€ 13,130				€ 1,363	€ 1,718	€ 2,164	€ 3,207	€ 3,770	€ 8,210	
66	-€ 13,437				€ 1,395	€ 1,758	€ 2,215	€ 3,282	€ 3,858	€ 8,402	
67	-€ 13,751				€ 1,427	€ 1,799	€ 2,267	€ 3,358	€ 3,948	€ 8,599	
68	-€ 14,073				€ 1,461	€ 1,841	€ 2,320	€ 3,437	€ 4,041	€ 8,800	
69	-€ 14,402				€ 1,495	€ 1,884	€ 2,374	€ 3,517	€ 4,135	€ 9,006	
70	-€ 14,739				€ 1,530	€ 1,928	€ 2,430	€ 3,600	€ 4,232	€ 9,216	
71	-€ 15,084				€ 1,566	€ 1,973	€ 2,486	€ 3,684	€ 4,331	€ 9,432	
72	-€ 15,436				€ 1,602	€ 2,019	€ 2,545	€ 3,770	€ 4,432	€ 9,653	
73	-€ 15,797				€ 1,640	€ 2,067	€ 2,604	€ 3,858	€ 4,536	€ 9,878	
74	-€ 16,167				€ 1,678	€ 2,115	€ 2,665	€ 3,948	€ 4,642	€ 10,109	
75	-€ 16,545			€ 1,363	€ 1,718	€ 2,164	€ 2,727	€ 4,041	€ 4,751	€ 10,346	
76	-€ 16,932			€ 1,395	€ 1,758	€ 2,215	€ 2,791	€ 4,135	€ 4,862	€ 10,588	
77	-€ 17,328			€ 1,427	€ 1,799	€ 2,267	€ 2,856	€ 4,232	€ 4,975	€ 10,836	
78	-€ 17,734			€ 1,461	€ 1,841	€ 2,320	€ 2,923	€ 4,331	€ 5,092	€ 11,089	
79	-€ 18,148			€ 1,495	€ 1,884	€ 2,374	€ 2,992	€ 4,432	€ 5,211	€ 11,348	
80	-€ 18,573			€ 1,530	€ 1,928	€ 2,430	€ 3,062	€ 4,536	€ 5,333	€ 11,614	
81	-€ 19,007			€ 1,566	€ 1,973	€ 2,486	€ 3,133	€ 4,642	€ 5,458	€ 11,886	
82	-€ 19,452			€ 1,602	€ 2,019	€ 2,545	€ 3,207	€ 4,751	€ 5,585	€ 12,164	
83	-€ 19,907			€ 1,640	€ 2,067	€ 2,604	€ 3,282	€ 4,862	€ 5,716	€ 12,448	
84	-€ 20,373			€ 1,678	€ 2,115	€ 2,665	€ 3,358	€ 4,975	€ 5,850	€ 12,739	
85	-€ 20,849		€ 1,363	€ 1,718	€ 2,164	€ 2,727	€ 3,437	€ 5,092	€ 5,986	€ 13,037	
86	-€ 21,337		€ 1,395	€ 1,758	€ 2,215	€ 2,791	€ 3,517	€ 5,211	€ 6,126	€ 13,342	
87	-€ 21,836		€ 1,427	€ 1,799	€ 2,267	€ 2,856	€ 3,600	€ 5,333	€ 6,270	€ 13,654	
88	-€ 22,347		€ 1,461	€ 1,841	€ 2,320	€ 2,923	€ 3,684	€ 5,458	€ 6,416	€ 13,974	
89	-€ 22,870		€ 1,495	€ 1,884	€ 2,374	€ 2,992	€ 3,770	€ 5,585	€ 6,566	€ 14,301	
90	-€ 23,405		€ 1,530	€ 1,928	€ 2,430	€ 3,062	€ 3,858	€ 5,716	€ 6,720	€ 14,635	
91	-€ 23,952		€ 1,566	€ 1,973	€ 2,486	€ 3,133	€ 3,948	€ 5,850	€ 6,877	€ 14,978	
92	-€ 24,512		€ 1,602	€ 2,019	€ 2,545	€ 3,207	€ 4,041	€ 5,986	€ 7,038	€ 15,328	
93	-€ 25,086		€ 1,640	€ 2,067	€ 2,604	€ 3,282	€ 4,135	€ 6,126	€ 7,203	€ 15,686	
94	-€ 25,673		€ 1,678	€ 2,115	€ 2,665	€ 3,358	€ 4,232	€ 6,270	€ 7,371	€ 16,053	
95	-€ 26,273		€ 1,718	€ 2,164	€ 2,727	€ 3,437	€ 4,331	€ 6,416	€ 7,544	€ 16,429	
96	-€ 26,888		€ 1,758	€ 2,215	€ 2,791	€ 3,517	€ 4,432	€ 6,566	€ 7,720	€ 16,813	
97	-€ 27,517		€ 1,799	€ 2,267	€ 2,856	€ 3,600	€ 4,536	€ 6,720	€ 7,901	€ 17,207	
98	-€ 28,160		€ 1,841	€ 2,320	€ 2,923	€ 3,684	€ 4,642	€ 6,877	€ 8,086	€ 17,609	
99	-€ 28,819		€ 1,884	€ 2,374	€ 2,992	€ 3,770	€ 4,751	€ 7,038	€ 8,275	€ 18,021	
100	-€ 29,493		€ 1,928	€ 2,430	€ 3,062	€ 3,858	€ 4,862	€ 7,203	€ 8,468	€ 18,442	
101	-€ 30,183		€ 1,973	€ 2,486	€ 3,133	€ 3,948	€ 4,975	€ 7,371	€ 8,666	€ 18,874	
102	-€ 30,889	€ 16,889	€ 2,019	€ 2,545	€ 3,207	€ 4,041	€ 5,092	€ 7,544	€ 8,869	**€ 19,315**	**Future value**

€ 50,204	**Future value without restock cost**
€ 33,792	**Future value with 5 thins left**
€ 21,453	**Future value with 2 thins left**
€ 16,889	**Future value with only clearfell left**

Forest name	Poland
Current year	2019
Version	1.0

Assumptions

	Variable for calculation
	Calculated figure

Acquisition costs

Variable	per ha	Comment / Source
Purchase price	8,178 €	Comparables from https://sprzedajemy.pl/temat/cena+1+ha+lasu
Area	10.0	Thesis assumption
Total	81,781 €	
Costs	0%	

Compartment Schedule

Variable		Comment / Source
Tree species makeup		UNECE data
Crop development phase		UNECE data

Cashflow duration

	Years	Comment / Source
	17	Half of duration of UNECE crop development stage

Felling Plan

Variable	Modelling approach	Comment / Source
Approach to clearfell harvesting	Clearfell mature conifers	Thesis assumption
Approach to thinning	7 thins 20% of average stand vol	Pach et al 2018

Timber production

Tonnage calculations	Modelling approach	Comment / Source
Mature Scots pine / Norway spruce	489	Bis 2009
Oak/Beech Birch	0	Presumed no clearfelling of broadleaves
Mature Scots pine / Norway spruce	56	Calculated
Mature Oak/Beech/Birch	56	Presume same vol as conifer but thin only
Av stand vol	280	Jablonski and Neroj 2019
Thinning proportion	20%	Pach et al 2018

Harvest products and prices

Species	Stumpage price	Comment / Source
Pine/ spruce(log)	€ 57.29	http://forest-analytics.com/index.php/2018/05/14/new-forest-business-frontiers-cee/
Pine/ spruce(pulp)	€ 34.56	http://forest-analytics.com/index.php/2018/05/14/new-forest-business-frontiers-cee/
Oak/Beech/Birch (pulp)	€ 34.56	Presume same value as conifer pulp

Forest specific timber extraction costs

	Cost per tonne	Comment / Source
Cost to harvest, extract and haul to market - clearfell	€ -	Not used
Cost to harvest, extract and haul to market - thinning	€ -	Not used
Infrastructure maintenance allowance during harvesting		Not used
Gross to net timber income reduction factor	**0%**	
% of site Harvester-Forwarder		Not used
% of site winch-skidder		Not used
% of site skyline		Not used
	100%	

Product assortments		**Comment / Source**
Clearfell		
Pine/ spruce(log)	85%	Bis 2009
Pine/ spruce(pulp)	15%	Bis 2009
Thinning		
Pine/ spruce(log)	15%	Bis 2009
Pine/ spruce(pulp)	85%	Bis 2009
Oak/Beech/Birch (pulp)	100%	Not used
Thinning log proportion reduction factor		Not used

Other revenue		

	Modelling approach	Comment / Source
None		

Terminal value assumptions		Comment / Source
Establishment costs /ha	-€ 2,921	Pine Bis 2009
Timber clearfell income / ha	€ 16,889	
Timber thinning income / ha	€ 1,363	
Typical rotation length	102	Weighted
Pine	100	Bis 2009
Oak	150	pach et al 2018
Norway spruce	100	pach et al 2018
Beech	110	pach et al 2018
Birch	60	pach et al 2018 (in Lithuania)
Nominal discount rate - Scenario 1	4.228%	
Nominal discount rate - Scenario 2&3	5.000%	World bank
Discount rate	2.3%	Real fisher adjusted rate
Inflation - scenario 1&2	2.6%	2019 Eurstat
Inflation - scenario 3	2.5%	av emerging europe

Other income		Comment / Source

Capital Expenditure		Comment / Source

Restocking costs		

	Cost per ha	Comment / Source
	€ 2,921	Total costs to fully re-establish crop
Build up ops		Oak cheaper: Kaliszewski 2017 says 1638 euro artificial and cheaper by nat regen
Planting and soil prep	€ 1,700	after Bis 2009
Protection	€ 266	after Bis 2009
Protection	€ 266	after Bis 2009
Protection	€ 266	after Bis 2009
1st Early cleaning	€ 98	after Bis 2009
2nd Early cleaning	€ 98	after Bis 2009
1st late cleaning	€ 119	after Bis 2009
2nd late cleaning	€ 106	after Bis 2009

Maintenance Expenditure	Cost per ha	Comment / Source
Total Annual costs	€ 64.60	Estimate
Annual costs /ha	€ 14.60	Estimate
Risk	**Cost per ha**	**Comment / Source**
Annual contingency costs	€ 50.00	Estimate

Appendix 7: Lithuania Discounted Cash Flow

Lithuania	1.0

	Property purchase	Net timber revenue	Capital Expenditure	Management and maintenace	Silvicultural expenditure	Terminal value	Total
2019	-€ 32,000	€ -	€ -	-€ 692	€ -		-€ 32,692
2020	€ -	€ 20,293	€ -	-€ 692	€ -		€ 19,601
2021	€ -	€ -	€ -	-€ 692	-€ 2,598		-€ 3,290
2022	€ -	€ -	€ -	-€ 692	€ -		-€ 692
2023	€ -	€ -	€ -	-€ 692	€ -		-€ 692
2024	€ -	€ -	€ -	-€ 692	€ -		-€ 692
2025	€ -	€ -	€ -	-€ 692	€ -		-€ 692
2026	€ -	€ -	€ -	-€ 692	€ -		-€ 692
2027	€ -	€ 11,403	€ -	-€ 692	€ -		€ 10,711
2028	€ -	€ -	€ -	-€ 692	€ -		-€ 692
2029	€ -	€ -	€ -	-€ 692	€ -		-€ 692
2030	€ -	€ -	€ -	-€ 692	€ -	€ 66,785	€ 66,093
Total	**-€ 32,000**	**€ 31,696**	**€ -**	**-€ 8,304**	**-€ 2,598**	**€ 66,785**	**€ 55,579**

Lithuania	1.0					
	Gross timber income					
	Pine (mixed assortment)	**Spruce (mixed assortment)**	**Birch (mixed assortment)**	**Alder (mixed assortment)**	**Aspen (mixed assortment)**	Total
2019	€ -	€ -	€ -	€ -	€ -	€ -
2020	€ 10,946	€ 5,423	€ 2,651	€ 676	€ 597	€ 20,293
2021	€ -	€ -	€ -	€ -	€ -	€ -
2022	€ -	€ -	€ -	€ -	€ -	€ -
2023	€ -	€ -	€ -	€ -	€ -	€ -
2024	€ -	€ -	€ -	€ -	€ -	€ -
2025	€ -	€ -	€ -	€ -	€ -	€ -
2026	€ -	€ -	€ -	€ -	€ -	€ -
2027	€ 6,151	€ 3,047	€ 1,490	€ 380	€ 335	€ 11,403
2028	€ -	€ -	€ -	€ -	€ -	€ -
2029	€ -	€ -	€ -	€ -	€ -	€ -
2030	€ -	€ -	€ -	€ -	€ -	€ -
Total						€ -

Lithuania	1.0

	Gross timber volume Pine (mixed assortment)	Gross timber volume Spruce (mixed assortment)	Gross timber volume Birch (mixed assortment)	Gross timber volume Alder (mixed assortment)	Gross timber volume Aspen (mixed assortment)	Harvest type
2019						
2020	322	159	110	56	50	Clearfell
2021						
2022						
2023						
2024						
2025						
2026						
2027	181	90	62	32	28	Thinning
2028						
2029						
2030						
Total						

Terminal Value: Lithuania

Crop type	Area	Price per ha		Total		Age at end of DCF	Age 2019
Regeneration (new)	2.1	€	5,025	€	10,553	12	n/a
Regeneration - Thinning age	2.0	€	4,935	€	9,871	24	12
Thinning age - Maturing	5.9	€	6,905	€	40,738	49	37
Total Crop Value	**10.00**			**€**	**61,162**		

Cashflow duration (years)	**12**

Present value		€	2,830	**Bare land value of one rotation without annual costs**
Future value		€	16,606	**Future land value of one rotation**
LEV B4 annual costs		€	3,411	**Bare land value of infinite rotations without annual costs**
LEV		€	562	**Bare land value with infinite rotations with annual costs**
TOTAL land				**€ 5,623**

Grand total	**€**	**66,785**	
	€	**6,678**	per hectare

Lithuania	1.0

Year	Cost	Income - clearfell	Income - thin 3	Income - thin 2	Income - thin 1		
0	-€ 1,237					€ 2,830	
1	-€ 1,267					€ 2,899	
2	-€ 1,298					€ 2,969	
3	-€ 1,330					€ 3,041	
4	-€ 1,362					€ 3,115	
5	-€ 1,395					€ 3,191	
6	-€ 1,429					€ 3,268	
7	-€ 1,464					€ 3,348	
8	-€ 1,499					€ 3,429	
9	-€ 1,536					€ 3,512	
10	-€ 1,573					€ 3,597	
11	-€ 1,611					€ 3,685	
12	-€ 1,650					€ 3,774	
13	-€ 1,690					€ 3,866	
14	-€ 1,731					€ 3,960	
15	-€ 1,773					€ 4,056	
16	-€ 1,816					€ 4,155	
17	-€ 1,861					€ 4,256	
18	-€ 1,906					€ 4,359	
19	-€ 1,952					€ 4,465	
20	-€ 1,999					€ 4,573	
21	-€ 2,048					€ 4,684	
22	-€ 2,098				€ 1,887	€ 4,798	
23	-€ 2,149				€ 1,933	€ 4,915	
24	-€ 2,201				€ 1,980	€ 5,034	
25	-€ 2,254				€ 2,028	€ 5,156	
26	-€ 2,309				€ 2,077	€ 5,282	
27	-€ 2,365				€ 2,127	€ 5,410	
28	-€ 2,423				€ 2,179	€ 5,541	
29	-€ 2,482				€ 2,232	€ 5,676	
30	-€ 2,542				€ 2,286	€ 5,814	
31	-€ 2,604				€ 2,342	€ 5,955	
32	-€ 2,667				€ 2,399	€ 6,100	
33	-€ 2,732				€ 2,457	€ 6,248	
34	-€ 2,798				€ 2,517	€ 6,400	
35	-€ 2,866				€ 2,578	€ 6,555	
36	-€ 2,936				€ 2,640	€ 6,714	
37	-€ 3,007			€ 1,887	€ 2,705	€ 6,877	
38	-€ 3,080			€ 1,933	€ 2,770	€ 7,044	
39	-€ 3,155			€ 1,980	€ 2,837	€ 7,215	
40	-€ 3,231			€ 2,028	€ 2,906	€ 7,391	
41	-€ 3,310			€ 2,077	€ 2,977	€ 7,570	
42	-€ 3,390			€ 2,127	€ 3,049	€ 7,754	
43	-€ 3,473			€ 2,179	€ 3,123	€ 7,942	
44	-€ 3,557			€ 2,232	€ 3,199	€ 8,135	
45	-€ 3,643			€ 2,286	€ 3,277	€ 8,333	
46	-€ 3,732			€ 2,342	€ 3,357	€ 8,535	
47	-€ 3,822			€ 2,399	€ 3,438	€ 8,743	
48	-€ 3,915			€ 2,457	€ 3,522	€ 8,955	
49	-€ 4,010			€ 2,517	€ 3,607	€ 9,173	
50	-€ 4,108			€ 2,578	€ 3,695	€ 9,395	
51	-€ 4,208			€ 2,640	€ 3,785	€ 9,624	
52	-€ 4,310		€ 1,887	€ 2,705	€ 3,876	€ 9,857	
53	-€ 4,414		€ 1,933	€ 2,770	€ 3,971	€ 10,097	
54	-€ 4,522		€ 1,980	€ 2,837	€ 4,067	€ 10,342	
55	-€ 4,632		€ 2,028	€ 2,906	€ 4,166	€ 10,593	
56	-€ 4,744		€ 2,077	€ 2,977	€ 4,267	€ 10,851	
57	-€ 4,859		€ 2,127	€ 3,049	€ 4,371	€ 11,114	
58	-€ 4,977		€ 2,179	€ 3,123	€ 4,477	€ 11,384	
59	-€ 5,098		€ 2,232	€ 3,199	€ 4,586	€ 11,661	
60	-€ 5,222		€ 2,286	€ 3,277	€ 4,697	€ 11,944	
61	-€ 5,349		€ 2,342	€ 3,357	€ 4,811	€ 12,234	
62	-€ 5,479		€ 2,399	€ 3,438	€ 4,928	€ 12,531	
63	-€ 5,612		€ 2,457	€ 3,522	€ 5,048	€ 12,836	
64	-€ 5,748		€ 2,517	€ 3,607	€ 5,170	€ 13,147	
65	-€ 5,888		€ 2,578	€ 3,695	€ 5,296	€ 13,467	
66	-€ 6,031		€ 2,640	€ 3,785	€ 5,424	€ 13,794	
67	-€ 6,177		€ 2,705	€ 3,876	€ 5,556	€ 14,129	
68	-€ 6,327		€ 2,770	€ 3,971	€ 5,691	€ 14,472	
69	-€ 6,481		€ 2,837	€ 4,067	€ 5,829	€ 14,824	
70	-€ 6,639		€ 2,906	€ 4,166	€ 5,971	€ 15,184	
71	-€ 6,800		€ 2,977	€ 4,267	€ 6,116	€ 15,552	
72	-€ 6,965		€ 3,049	€ 4,371	€ 6,265	€ 15,930	
73	-€ 7,134		€ 3,123	€ 4,477	€ 6,417	€ 16,317	
74	-€ 7,307	€ 9,664	€ 3,199	€ 4,586	€ 6,573	**€ 16,714**	**Future value**

€ 24,021	**Future value without restock cost**
€ 17,448	**Future value with only 2 thins left**
€ 12,863	**Future value with only 1 thin left**
€ 9,664	**Future value with only clearfell left**

Forest name	Lithuania
Current year	2019
Version	1.0

Assumptions

	Variable for calculation
	Calculated figure

Acquisition costs

Variable	per ha	Comment / Source
Purchase price	3,200 €	Baltic survey 2017
Area	10.0	
Total	32,000 €	
Costs	0%	

Compartment Schedule

Variable		Comment / Source
Tree species makeup		UNECE data
Crop development phase		UNECE data

Cashflow duration

	Years	Comment / Source
	12	Half of duration of UNECE crop development stage

Felling Plan

Variable	Modelling approach	Comment / Source
Approach to clearfell harvesting	Clearfell mature crops	Thesis assumption
Approach to thinning	3 thinnings at 20%	Pach et al 2018

Timber production

Tonnage calculations	Modelling approach	Comment / Source
Mature Scots pine	411	2017 Lithuanian state forest service stats yearbook
Mature Spruce	376	2017 Lithuanian state forest service stats yearbook
Mature Birch	315	2017 Lithuanian state forest service stats yearbook
Mature Alder (grey alder)	213	2017 Lithuanian state forest service stats yearbook
Mature Aspen	376	2017 Lithuanian state forest service stats yearbook
Thinning Scots pine	82	Calculated
Thinning Birch	75	Calculated
Thinning Norway spruce	63	Calculated
Thinning Alder (grey alder)	43	Calculated
Thinning Aspen	75	Calculated
Thinning proportion	20%	Pach et al 2018

Harvest products and prices

Species	Stumpage price	Comment / Source
Pine (mixed assortment)	€ 34.00	HD forest fest client timber sale June 19
Spruce (mixed assortment)	€ 34.00	HD forest fest client timber sale June 19
Birch (mixed assortment)	€ 24.00	HD forest fest client timber sale June 19
Alder (mixed assortment)	€ 12.00	HD forest fest client timber sale June 19
Aspen (mixed assortment)	€ 12.00	HD forest fest client timber sale June 19

Forest specific timber extraction costs

	Cost per tonne	Comment / Source
Cost to harvest, extract and haul to market - clearfell	€ -	Not used
Cost to harvest, extract and haul to market - thinning	€ -	Not used
Infrastructure maintenance allowance during harvesting		Not used
Gross to net timber income reduction factor	**0%**	
% of site Harvester-Forwarder		Not used
% of site winch-skidder		Not used
% of site skyline		Not used
	100%	

Product assortments		**Comment / Source**
Pine (mixed assortment)	100%	Not used
Spruce (mixed assortment)	100%	Not used
Birch (mixed assortment)	100%	Not used
Alder (mixed assortment)	100%	Not used
Aspen (mixed assortment)	100%	Not used
Thinning log proportion reduction factor		Not used

Other revenue		

	Modelling approach	Comment / Source
None		

Terminal value assumptions		Comment / Source
Establishment costs /ha	-€ 1,237	
Timber clearfell income / ha	€ 9,664	
Timber thinning income / ha	€ 1,933	
Typical rotation length	74	*Weighted*
Pine	101	*Pach et al 2018*
Spruce	71	*Pach et al 2018*
Birch / braodleaves	61	*Pach et al 2018*
Nominal discount rate scenario 1	0.31%	World bank
Nominal discount rate scenario 2&3	5.000%	
Discount rate	2.43%	Real fisher adjusted rate
Inflation scenario 1&2	2.30%	2019 Euro stat
Inflation scenario 3	2.5%	av emerging europe

Other income		Comment / Source

Capital Expenditure		Comment / Source

Restocking costs		

	Cost per ha	Comment / Source
	€ 1,237	Total costs to fully re-establish crop (inflated to 2019)
Build up ops		after Brukas et al 2015
Forest regeneration	€ 941	
PCT 1	€ 87	
PCT 2	€ 72	
PCT 3	€ 24	

Maintenance Expenditure	Cost per ha	Comment / Source
Annual costs	€ 69.20	Calculated
Annual costs	€ 19.20	Thesis assumption
Risk	**Cost per ha**	**Comment / Source**
Annual contingency costs	€ 50.00	Thesis assumption

Appendix 8: Romania Discounted Cash Flow

Romania	1.0

	Property purchase	Net timber revenue	Capital Expenditure	Management and maintenace	Silvicultural expenditure	Terminal value	Total
2019	-£ 30,000	€ -	-€ 50,000	-€ 660	€ -		-€ 80,660
2020	£ -	€ 5,356	€ -	-€ 660	€ -		€ 4,696
2021	£ -	€ -	€ -	-€ 660	€ -		-€ 660
2022	£ -	€ -	€ -	-€ 660	€ -		-€ 660
2023	£ -	€ -	€ -	-€ 660	€ -		-€ 660
2024	£ -	€ -	€ -	-€ 660	€ -		-€ 660
2025	£ -	€ -	€ -	-€ 660	€ -		-€ 660
2026	£ -	€ -	€ -	-€ 660	€ -		-€ 660
2027	£ -	€ 10,498	€ -	-€ 660	€ -		€ 9,838
2028	£ -	€ -	€ -	-€ 660	€ -		-€ 660
2029	£ -	€ -	€ -	-€ 660	€ -		-€ 660
2030	£ -	€ 5,356	€ -	-€ 660	€ -		€ 4,696
2031	£ -	€ -	€ -	-€ 660	€ -		-€ 660
2032	£ -	€ -	€ -	-€ 660	€ -		-€ 660
2033	£ -	€ -	€ -	-€ 660	€ -		-€ 660
2034	£ -	€ -	€ -	-€ 660	€ -		-€ 660
2035	£ -	€ -	€ -	-€ 660	€ -		-€ 660
2036	£ -	€ -	€ -	-€ 660	€ -		-€ 660
2037	£ -	€ -	€ -	-€ 660	€ -		-€ 660
2038	£ -	€ -	€ -	-€ 660	€ -		-€ 660
2039	£ -	€ -	€ -	-€ 660	€ -		-€ 660
2040	£ -	€ 5,356	€ -	-€ 660	€ -		€ 4,696
2041	£ -	€ -	€ -	-€ 660	€ -		-€ 660
2042	£ -	€ -	€ -	-€ 660	€ -		-€ 660
2043	£ -	€ -	€ -	-€ 660	€ -	€ 60,792	€ 60,132
Total	**-€ 30,000**	**€ 26,566**	**-€ 50,000**	**-€ 16,500**	**€ -**	**€ 60,792**	**-€ 9,141**

Romania	1.0					
	Gross timber income					
	Beech (mixed assortment)	**Spruce (mixed assortment)**	**0**	**0**	**0**	Total
2019	€ -	€ -	€ -	€ -	€ -	€ -
2020	€ 10,423	€ 5,645	€ -	€ -	€ -	€ 16,068
2021	€ -	€ -	€ -	€ -	€ -	€ -
2022	€ -	€ -	€ -	€ -	€ -	€ -
2023	€ -	€ -	€ -	€ -	€ -	€ -
2024	€ -	€ -	€ -	€ -	€ -	€ -
2025	€ -	€ -	€ -	€ -	€ -	€ -
2026	€ -	€ -	€ -	€ -	€ -	€ -
2027	€ 6,810	€ 3,688	€ -	€ -	€ -	€ 10,498
2028	€ -	€ -	€ -	€ -	€ -	€ -
2029	€ -	€ -	€ -	€ -	€ -	€ -
2030	€ -	€ -	€ -	€ -	€ -	€ -
2031	€ -	€ -	€ -	€ -	€ -	€ -
2032	€ -	€ -	€ -	€ -	€ -	€ -
2033	€ -	€ -	€ -	€ -	€ -	€ -
2034	€ -	€ -	€ -	€ -	€ -	€ -
2035	€ -	€ -	€ -	€ -	€ -	€ -
2036	€ -	€ -	€ -	€ -	€ -	€ -
2037	€ -	€ -	€ -	€ -	€ -	€ -
2038	€ -	€ -	€ -	€ -	€ -	€ -
2039	€ -	€ -	€ -	€ -	€ -	€ -
2040	€ -	€ -	€ -	€ -	€ -	€ -
2041	€ -	€ -	€ -	€ -	€ -	€ -
2042	€ -	€ -	€ -	€ -	€ -	€ -
2043	€ -	€ -	€ -	€ -	€ -	€ -
Total						€ -

Romania	1.0

	Gross timber volume Beech (mixed assortment)	Gross timber volume Spruce (mixed assortment)	Gross timber volume 0	Gross timber volume 0	Gross timber volume 0	Harvest type
2019						
2020	168	91				Clearfell
2021						
2022						
2023						
2024						
2025						
2026						
2027	110	59				Thinning
2028						
2029						
2030						
2031						
2032						
2033						
2034						
2035						
2036						
2037						
2038						
2039						
2040						
2041						
2042						
2043						
Total						

Terminal Value: Romania

Crop type	Area	Price per ha	Total	Age at end of DCF	Age 2019
Regeneration (new)	1.0	€ 4,596	€ 4,596	23	n/a
Regeneration - Thinning age	4.1	€ 5,763	€ 23,627	48	24
Thinning age - Maturing	4.9	€ 6,585	€ 32,268	97	73
Total Crop Value	**10.00**		**€ 60,491**		

Cashflow duration (years)	**24**

Present value		€ 2,663	**Bare land value of one rotation without annual costs**
Future value		€ 86,427	**Future land value of one rotation**
LEV B4 annual costs		€ 2,747	**Bare land value of infinite rotations without annual costs**
LEV		€ 30	**Bare land value with infinite rotations with annual costs**
TOTAL land			**€ 301**

Grand total			**€ 60,792**
			€ 6,079 per hectare

Romania	1.0

Year	Cost	Income - clearfell 3	Income - clearfell 2	Income - clearfell 1	Income - thin 3	Income - thin 2	Income - thin 1		
0	€ -							€ 2,663	
1	€ -							€ 2,727	
2	€ -							€ 2,794	
3	€ -							€ 2,861	
4	€ -							€ 2,931	
5	€ -							€ 3,002	
6	€ -							€ 3,075	
7	€ -							€ 3,150	
8	€ -							€ 3,226	
9	€ -							€ 3,305	
10	€ -							€ 3,385	
11	€ -							€ 3,467	
12	€ -							€ 3,551	
13	€ -							€ 3,638	
14	€ -							€ 3,726	
15	€ -							€ 3,816	
16	€ -							€ 3,909	
17	€ -							€ 4,004	
18	€ -							€ 4,101	
19	€ -							€ 4,201	
20	€ -							€ 4,303	
21	€ -							€ 4,407	
22	€ -							€ 4,515	
23	€ -							€ 4,624	
24	€ -							€ 4,737	
25	€ -							€ 4,852	
26	€ -							€ 4,969	
27	€ -							€ 5,090	
28	€ -							€ 5,214	
29	€ -							€ 5,340	
30	€ -							€ 5,470	
31	€ -							€ 5,603	
32	€ -							€ 5,739	
33	€ -							€ 5,879	
34	€ -							€ 6,021	
35	€ -							€ 6,168	
36	€ -							€ 6,317	
37	€ -							€ 6,471	
38	€ -						€ 2,092	€ 6,628	
39	€ -						€ 2,142	€ 6,789	
40	€ -						€ 2,194	€ 6,954	
41	€ -						€ 2,248	€ 7,123	
42	€ -						€ 2,302	€ 7,296	
43	€ -						€ 2,358	€ 7,473	
44	€ -						€ 2,416	€ 7,655	
45	€ -						€ 2,474	€ 7,841	
46	€ -						€ 2,534	€ 8,031	
47	€ -						€ 2,596	€ 8,226	
48	€ -					€ 2,092	€ 2,659	€ 8,426	
49	€ -					€ 2,142	€ 2,724	€ 8,631	
50	€ -					€ 2,194	€ 2,790	€ 8,840	
51	€ -					€ 2,248	€ 2,858	€ 9,055	
52	€ -					€ 2,302	€ 2,927	€ 9,275	
53	€ -					€ 2,358	€ 2,998	€ 9,500	
54	€ -					€ 2,416	€ 3,071	€ 9,731	
55	€ -					€ 2,474	€ 3,145	€ 9,967	
56	€ -					€ 2,534	€ 3,222	€ 10,209	
57	€ -					€ 2,596	€ 3,300	€ 10,457	
58	€ -				€ 2,092	€ 2,659	€ 3,380	€ 10,711	
59	€ -				€ 2,142	€ 2,724	€ 3,462	€ 10,972	
60	€ -				€ 2,194	€ 2,790	€ 3,546	€ 11,238	
61	€ -				€ 2,248	€ 2,858	€ 3,633	€ 11,511	
62	€ -				€ 2,302	€ 2,927	€ 3,721	€ 11,791	
63	€ -				€ 2,358	€ 2,998	€ 3,811	€ 12,077	
64	€ -				€ 2,416	€ 3,071	€ 3,904	€ 12,370	
65	€ -				€ 2,474	€ 3,145	€ 3,999	€ 12,671	
66	€ -				€ 2,534	€ 3,222	€ 4,096	€ 12,979	
67	€ -				€ 2,596	€ 3,300	€ 4,195	€ 13,294	
68	€ -				€ 2,659	€ 3,380	€ 4,297	€ 13,617	
69	€ -				€ 2,724	€ 3,462	€ 4,402	€ 13,948	
70	€ -				€ 2,790	€ 3,546	€ 4,508	€ 14,286	
71	€ -				€ 2,858	€ 3,633	€ 4,618	€ 14,633	
72	€ -				€ 2,927	€ 3,721	€ 4,730	€ 14,989	
73	€ -				€ 2,998	€ 3,811	€ 4,845	€ 15,353	
74	€ -				€ 3,071	€ 3,904	€ 4,963	€ 15,726	
75	€ -				€ 3,145	€ 3,999	€ 5,083	€ 16,108	
76	€ -				€ 3,222	€ 4,096	€ 5,207	€ 16,499	
77	€ -				€ 3,300	€ 4,195	€ 5,333	€ 16,900	
78	€ -				€ 3,380	€ 4,297	€ 5,463	€ 17,310	
79	€ -				€ 3,462	€ 4,402	€ 5,595	€ 17,731	
80	€ -				€ 3,546	€ 4,508	€ 5,731	€ 18,161	
81	€ -				€ 3,633	€ 4,618	€ 5,871	€ 18,603	
82	€ -				€ 3,721	€ 4,730	€ 6,013	€ 19,054	
83	€ -				€ 3,811	€ 4,845	€ 6,159	€ 19,517	
84	€ -				€ 3,904	€ 4,963	€ 6,309	€ 19,991	
85	€ -				€ 3,999	€ 5,083	€ 6,462	€ 20,477	
86	€ -				€ 4,096	€ 5,207	€ 6,619	€ 20,974	
87	€ -				€ 4,195	€ 5,333	€ 6,780	€ 21,484	
88	€ -				€ 4,297	€ 5,463	€ 6,944	€ 22,006	
89	€ -				€ 4,402	€ 5,595	€ 7,113	€ 22,540	
90	€ -				€ 4,508	€ 5,731	€ 7,286	€ 23,088	
91	€ -				€ 4,618	€ 5,871	€ 7,463	€ 23,649	
92	€ -				€ 4,730	€ 6,013	€ 7,644	€ 24,223	
93	€ -				€ 4,845	€ 6,159	€ 7,830	€ 24,811	
94	€ -				€ 4,963	€ 6,309	€ 8,020	€ 25,414	
95	€ -				€ 5,083	€ 6,462	€ 8,215	€ 26,031	
96	€ -				€ 5,207	€ 6,619	€ 8,414	€ 26,664	
97	€ -				€ 5,333	€ 6,780	€ 8,619	€ 27,311	
98	€ -				€ 5,463	€ 6,944	€ 8,828	€ 27,975	
99	€ -				€ 5,595	€ 7,113	€ 9,043	€ 28,654	
100	€ -				€ 5,731	€ 7,286	€ 9,262	€ 29,350	
101	€ -				€ 5,871	€ 7,463	€ 9,487	€ 30,063	
102	€ -				€ 6,013	€ 7,644	€ 9,718	€ 30,793	
103	€ -				€ 6,159	€ 7,830	€ 9,954	€ 31,541	
104	€ -				€ 6,309	€ 8,020	€ 10,196	€ 32,308	
105	€ -				€ 6,462	€ 8,215	€ 10,443	€ 33,092	
106	€ -				€ 6,619	€ 8,414	€ 10,697	€ 33,896	
107	€ -				€ 6,780	€ 8,619	€ 10,957	€ 34,720	
108	€ -				€ 6,944	€ 8,828	€ 11,223	€ 35,563	
109	€ -				€ 7,113	€ 9,043	€ 11,495	€ 36,427	
110	€ -				€ 7,286	€ 9,262	€ 11,775	€ 37,312	
111	€ -				€ 7,463	€ 9,487	€ 12,061	€ 38,218	
112	€ -				€ 7,644	€ 9,718	€ 12,354	€ 39,146	
113	€ -				€ 7,830	€ 9,954	€ 12,654	€ 40,097	
114					€ 8,020	€ 10,196	€ 12,961	€ 41,071	
115					€ 8,215	€ 10,443	€ 13,276	€ 42,069	
116					€ 8,414	€ 10,697	€ 13,598	€ 43,091	
117					€ 8,619	€ 10,957	€ 13,929	€ 44,137	
118					€ 8,828	€ 11,223	€ 14,267	€ 45,209	
119					€ 9,043	€ 11,495	€ 14,614	€ 46,307	
120					€ 9,262	€ 11,775	€ 14,969	€ 47,432	
121					€ 9,487	€ 12,061	€ 15,332	€ 48,584	
122					€ 9,718	€ 12,354	€ 15,705	€ 49,765	
123					€ 9,954	€ 12,654	€ 16,086	€ 50,973	
124					€ 10,196	€ 12,961	€ 16,477	€ 52,211	
125				€ 5,356	€ 10,443	€ 13,276	€ 16,877	€ 53,480	
126				€ 5,486	€ 10,697	€ 13,598	€ 17,287	€ 54,779	
127				€ 5,619	€ 10,957	€ 13,929	€ 17,707	€ 56,109	
128				€ 5,756	€ 11,223	€ 14,267	€ 18,137	€ 57,472	
129				€ 5,896	€ 11,495	€ 14,614	€ 18,577	€ 58,868	
130				€ 6,039	€ 11,775	€ 14,969	€ 19,029	€ 60,298	
131				€ 6,186	€ 12,061	€ 15,332	€ 19,491	€ 61,763	
132				€ 6,336	€ 12,354	€ 15,705	€ 19,964	€ 63,263	
133				€ 6,490	€ 12,654	€ 16,086	€ 20,449	€ 64,800	
134				€ 6,647	€ 12,961	€ 16,477	€ 20,946	€ 66,374	
135			€ 5,356	€ 6,809	€ 13,276	€ 16,877	€ 21,455	€ 67,986	
136			€ 5,486	€ 6,974	€ 13,598	€ 17,287	€ 21,976	€ 69,637	
137			€ 5,619	€ 7,144	€ 13,929	€ 17,707	€ 22,510	€ 71,329	
138			€ 5,756	€ 7,317	€ 14,267	€ 18,137	€ 23,057	€ 73,062	
139			€ 5,896	€ 7,495	€ 14,614	€ 18,577	€ 23,617	€ 74,836	
140			€ 6,039	€ 7,677	€ 14,969	€ 19,029	€ 24,190	€ 76,654	
141			€ 6,186	€ 7,864	€ 15,332	€ 19,491	€ 24,778	€ 78,516	
142			€ 6,336	€ 8,055	€ 15,705	€ 19,964	€ 25,380	€ 80,423	
143			€ 6,490	€ 8,250	€ 16,086	€ 20,449	€ 25,996	€ 82,377	
144	€ -		€ 6,647	€ 8,451	€ 16,477	€ 20,946	€ 26,628	€ 84,378	
145	€ -	€ 5,356	€ 6,809	€ 8,656	€ 16,877	€ 21,455	€ 27,274	**€ 86,427**	**Future value**

€ 86,427	**Future value without restock cost**
€ 59,153	**Future value with only 2 thins left**
€ 37,698	**Future value with only 1 thins left**
€ 20,821	**Future value with only clearfells left**
€ 12,165	**Future value with only clearfells left 2 & 3 left**
€ 5,356	**Future value with only clearfell 3 left**

Forest name	Romania
Current year	2019
Version	1.0

Assumptions

	Variable for calculation
	Calculated figure

Acquisition costs

Variable	per ha	Comment / Source
Purchase price	3,000 €	Average price observed from internet advertising of properties.
Area	10.0	Thesis assumption
Total	30,000 €	
Costs	0%	

Compartment Schedule

Variable		Comment / Source
Tree species makeup		UNECE data
Crop development phase		UNECE data

Cashflow duration

	Years	Comment / Source
	24	Half of duration of UNECE crop development stage

Felling Plan

Variable	Modelling approach	Comment / Source
Approach to clearfell harvesting	Clearfell mature crops	Thesis assumption
Approach to thinning		Bis 2009

Timber production

Tonnage calculations	Modelling approach	Comment / Source
Beech (mixed assortment)	450	Legal max vol
Spruce (mixed assortment)	450	Legal max vol
Thinning Beech	60	
Thinning Spruce	60	
	0	
	0	
	0	
Annual increment times 10 years	60.00	m3

Harvest products and prices

Species	Stumpage price	Comment / Source
Beech (mixed assortment)	€ 62.10	Cantar 2014
Spruce (mixed assortment)	€ 62.10	Cantar 2014

Forest specific timber extraction costs

	Cost per tonne	Comment / Source
Cost to harvest, extract and haul to market - clearfell	€ -	Not used
Cost to harvest, extract and haul to market - thinning	€ -	Not used
Infrastructure maintenance allowance during harvesting		Not used
Gross to net timber income reduction factor	**0%**	
% of site Harvester-Forwarder		Not used
% of site winch-skidder		Not used
% of site skyline		Not used
	100%	

Product assortments		Comment / Source
Beech (mixed assortment)	100%	Not used
Spruce (mixed assortment)	100%	Not used
0	100%	Not used
0	100%	Not used
0	100%	Not used
Thinning log proportion reduction factor		Not used

Other revenue		
	Modelling approach	Comment / Source
None		

Terminal value assumptions		Comment / Source
Establishment costs /ha	€ -	Cut and leave Bouriaud et al 2016
Timber clearfell income / ha	€ 5,356	One third
Timber thinning income / ha	€ 2,142	every 10 years
Typical rotation length	145	Weighted
Beech	160	Bouriaud et al 2016
Spruce	130	Bouriaud et al 2016
Nominal discount rate scenario 1	5.566%	World bank
Nominal discount rate scenario 2&3	5.000%	
Discount rate	2.4%	Real fisher adjusted rate
Inflation scenario 1&2	4.00%	2019 Euro stat
Inflation scenario 3	2.5%	av emerging europe

Other income		Comment / Source

Capital Expenditure		Comment / Source
Cost per ha of infrastructure	€ 5,000	Thesis assumption

Restocking costs		
	Cost per ha	Comment / Source
	€ -	
Build up ops		
Forest regeneration	€ -	cut and leave '

Maintenance Expenditure	Cost per ha	Comment / Source
Annual costs	€ 66.00	Estimate
Annual costs	€ 16.00	Thesis assumption
Risk	**Cost per ha**	**Comment / Source**
Annual contingency costs	€ 50.00	Thesis assumption

Appendix 9: Hungary Discounted Cash Flow

Hungary	1.0

	Property purchase	Net timber revenue	Capital Expenditure	Management and maintenace	Silvicultural expenditure	Terminal value	Total
2019	-€ 43,260	€ -	€ -	-€ 606	€ -		-€ 43,866
2020	€ -	€ 21,987	€ -	-€ 606	€ -		€ 21,381
2021	€ -	€ -	€ -	-€ 606	-€ 1,052		-€ 1,658
2022	€ -	€ -	€ -	-€ 606	€ -		-€ 606
2023	€ -	€ -	€ -	-€ 606	€ -		-€ 606
2024	€ -	€ -	€ -	-€ 606	€ -		-€ 606
2025	€ -	€ -	€ -	-€ 606	€ -		-€ 606
2026	€ -	€ -	€ -	-€ 606	€ -		-€ 606
2027	€ -	€ -	€ -	-€ 606	€ -		-€ 606
2028	€ -	€ -	€ -	-€ 606	€ -		-€ 606
2029	€ -	€ -	€ -	-€ 606	€ -	€ 116,962	€ 116,356
Total	**-€ 43,260**	**€ 21,987**	**€ -**	**-€ 6,666**	**-€ 1,052**	**€ 116,962**	**€ 87,971**

Hungary	1.0

	Gross timber income					
	All					Total
2019	€ -	€ -	€ -	€ -	€ -	€ -
2020	€ 21,987	€ -	€ -	€ -	€ -	€ 21,987
2021	€ -	€ -	€ -	€ -	€ -	€ -
2022	€ -	€ -	€ -	€ -	€ -	€ -
2023	€ -	€ -	€ -	€ -	€ -	€ -
2024	€ -	€ -	€ -	€ -	€ -	€ -
2025	€ -	€ -	€ -	€ -	€ -	€ -
2026	€ -	€ -	€ -	€ -	€ -	€ -
2027	€ -	€ -	€ -	€ -	€ -	€ -
2028	€ -	€ -	€ -	€ -	€ -	€ -
2029	€ -	€ -	€ -	€ -	€ -	€ -
Total						€ -

Hungary	1.0

	Gross timber volume						Harvest type
2019							
2020	551						Clearfell
2021							
2022							
2023							
2024							
2025							
2026							
2027							Thinning
2028							
2029							
Total							

Terminal value: Hungary

Crop type	Area	Price per ha	Total	Age at end of DCF	Age 2019
Regeneration (new)	1.2	€ 4,198	€ 5,037	9	n/a
Regeneration - Thinning age	1.1	€ 6,684	€ 7,353	23	11
Thinning age - Maturing	7.7	€ 10,592	€ 81,559	45	34
Total Crop Value	**10.00**		**€ 93,949**		

Cashflow duration (years)	**11**

Present value		€ 3,847	**Bare land value of one rotation without annual costs**
Future value		€ 19,439	**Future land value of one rotation**
LEV B4 annual costs		€ 4,796	**Bare land value of infinite rotations without annual costs**
LEV		€ 2,301	**Bare land value with infinite rotations with annual costs**
TOTAL land			**€ 23,013**

Grand total	**€ 116,962**	
	€ 11,696	per hectare

Hungary	1.0

Year	Cost	Income - clearfell 1	Income - thin 3	Income - thin 2	Income - thin 1		
0	-€ 877					€ 3,847	
1	-€ 898					€ 3,940	
2	-€ 920					€ 4,036	
3	-€ 942					€ 4,134	
4	-€ 965					€ 4,235	
5	-€ 989					€ 4,337	
6	-€ 1,013					€ 4,443	
7	-€ 1,037					€ 4,551	
8	-€ 1,063					€ 4,661	
9	-€ 1,088					€ 4,774	
10	-€ 1,115					€ 4,890	
11	-€ 1,142					€ 5,009	
12	-€ 1,170					€ 5,131	
13	-€ 1,198					€ 5,256	
14	-€ 1,227					€ 5,383	
15	-€ 1,257					€ 5,514	
16	-€ 1,288					€ 5,648	
17	-€ 1,319					€ 5,785	
18	-€ 1,351					€ 5,926	
19	-€ 1,384					€ 6,070	
20	-€ 1,417					€ 6,217	
21	-€ 1,452					€ 6,368	
22	-€ 1,487					€ 6,523	
23	-€ 1,523					€ 6,681	
24	-€ 1,560					€ 6,843	
25	-€ 1,598					€ 7,010	
26	-€ 1,637					€ 7,180	
27	-€ 1,677					€ 7,354	
28	-€ 1,717					€ 7,533	
29	-€ 1,759					€ 7,716	
30	-€ 1,802				€ 975	€ 7,903	
31	-€ 1,846				€ 998	€ 8,095	
32	-€ 1,890				€ 1,023	€ 8,292	
33	-€ 1,936				€ 1,047	€ 8,493	
34	-€ 1,983				€ 1,073	€ 8,700	
35	-€ 2,031				€ 1,099	€ 8,911	
36	-€ 2,081				€ 1,126	€ 9,127	
37	-€ 2,131				€ 1,153	€ 9,349	
38	-€ 2,183				€ 1,181	€ 9,576	
39	-€ 2,236				€ 1,210	€ 9,809	
40	-€ 2,290			€ 975	€ 1,239	€ 10,047	
41	-€ 2,346			€ 998	€ 1,269	€ 10,291	
42	-€ 2,403			€ 1,023	€ 1,300	€ 10,541	
43	-€ 2,461			€ 1,047	€ 1,332	€ 10,797	
44	-€ 2,521			€ 1,073	€ 1,364	€ 11,059	
45	-€ 2,582			€ 1,099	€ 1,397	€ 11,328	
46	-€ 2,645			€ 1,126	€ 1,431	€ 11,603	
47	-€ 2,709			€ 1,153	€ 1,466	€ 11,885	
48	-€ 2,775			€ 1,181	€ 1,501	€ 12,174	
49	-€ 2,843			€ 1,210	€ 1,538	€ 12,469	
50	-€ 2,912		€ 975	€ 1,239	€ 1,575	€ 12,772	
51	-€ 2,982		€ 998	€ 1,269	€ 1,613	€ 13,083	
52	-€ 3,055		€ 1,023	€ 1,300	€ 1,653	€ 13,400	
53	-€ 3,129		€ 1,047	€ 1,332	€ 1,693	€ 13,726	
54	-€ 3,205		€ 1,073	€ 1,364	€ 1,734	€ 14,059	
55	-€ 3,283		€ 1,099	€ 1,397	€ 1,776	€ 14,401	
56	-€ 3,363		€ 1,126	€ 1,431	€ 1,819	€ 14,750	
57	-€ 3,444		€ 1,153	€ 1,466	€ 1,863	€ 15,109	
58	-€ 3,528		€ 1,181	€ 1,501	€ 1,909	€ 15,476	
59	-€ 3,614		€ 1,210	€ 1,538	€ 1,955	€ 15,852	
60	-€ 3,702		€ 1,239	€ 1,575	€ 2,002	€ 16,237	
61	-€ 3,791		€ 1,269	€ 1,613	€ 2,051	€ 16,631	
62	-€ 3,884		€ 1,300	€ 1,653	€ 2,101	€ 17,035	
63	-€ 3,978		€ 1,332	€ 1,693	€ 2,152	€ 17,449	
64	-€ 4,075		€ 1,364	€ 1,734	€ 2,204	€ 17,873	
65	-€ 4,173		€ 1,397	€ 1,776	€ 2,258	€ 18,307	
66	-€ 4,275		€ 1,431	€ 1,819	€ 2,313	€ 18,752	
67	-€ 4,379		€ 1,466	€ 1,863	€ 2,369	€ 19,207	
68	-€ 4,485	€ 18,323	€ 1,501	€ 1,909	€ 2,426	**€ 19,674**	**Future value**
						€ 24,159	**Future value without restock cost**
						€ 21,732	**Future value with only 2 thins left**
						€ 19,824	**Future value with only 1 thins left**
						€ 18,323	**Future value with only clearfell left**

Forest name	Hungary
Current year	2019
Version	1.0

Assumptions

(yellow)	Variable for calculation
(green)	Calculated figure

Acquisition costs

Variable	per ha	Comment / Source
Purchase price	4,326 €	https://www.agrarszektor.hu/fold/megallithatatlan-a-dragulas-ennyibe-kerulnek-most-a-foldek-az-orszagban.12985.html
Area	10.0	Thesis assumption
Total	43,260 €	
Costs	0%	

Compartment Schedule

Variable		Comment / Source
Tree species makeup		UNECE data
Crop development phase		UNECE data

Cashflow duration

	Years	Comment / Source
	11	Half of duration of UNECE crop development stage

Felling Plan

Variable	Modelling approach	Comment / Source
Approach to clearfell harvesting	Clearfell mature crops	Thesis assumption
Approach to thinning	10 year cycle	Jager et al 2015

Timber production

Tonnage calculations	Modelling approach	Comment / Source
Oak		Production set to annual increment
Black locust		Production set to annual increment
Pine		Production set to annual increment
Beech		Production set to annual increment
Hornbeam		Production set to annual increment
Poplar		Production set to annual increment
Mean	459	Calculated
Annual increment	6.8	CEPF
Annual increment times 10 years	68.00	Calculated

Harvest products and prices

Species - clearfell	Stumpage price	Comment / Source
Oak	€ 55.12	estimate based on inflated value from 2004 CEPF
Black locust	€ 30.46	estimate based on inflated value from 2004 CEPF
Pine	€ 31.91	estimate based on inflated value from 2004 CEPF
Beech	€ 36.26	estimate based on inflated value from 2004 CEPF
Hornbeam	€ 27.56	estimate based on inflated value from 2004 CEPF
Poplar	€ 26.11	estimate based on inflated value from 2004 CEPF
Weighted	€ 39.92	Calculated
Species thinning		
Oak	€ 26.11	estimate based on inflated value from 2004 CEPF
Black locust	€ 17.41	estimate based on inflated value from 2004 CEPF
Pine	€ 13.05	estimate based on inflated value from 2004 CEPF
Beech	€ 20.31	estimate based on inflated value from 2004 CEPF
Hornbeam	€ 14.50	estimate based on inflated value from 2004 CEPF
Poplar	€ 17.41	estimate based on inflated value from 2004 CEPF
Weighted	€ 19.81	Calculated

Forest specific timber extraction costs

	Cost per tonne	Comment / Source
Cost to harvest, extract and haul to market - clearfell	€ -	Not used
Cost to harvest, extract and haul to market - thinning	€ -	Not used
Infrastructure maintenance allowance during harvesting		Not used
Gross to net timber income reduction factor	**0%**	
% of site Harvester-Forwarder		Not used
% of site winch-skidder		Not used
% of site skyline		Not used
	100%	

Product assortments		**Comment / Source**
Oak	100%	Not used
Poplar	100%	Not used
Hornbeam	100%	Not used
Weighted	100%	Not used
Weighted	100%	Not used
Thinning log proportion reduction factor		Not used

Other revenue		

	Modelling approach	Comment / Source
None		

Terminal value assumptions		Comment / Source
Establishment costs /ha	-€ 877	
Timber harvesting income / ha	€ 18,323	
Timber thinning income / ha	€ 975	every 10 years
Typical rotation length	68	*Weighted*
Oak	110	*CEPF 2010*
Black locust	30	*CEPF 2010*
Pine	50	*CEPF 2010*
Beech	110	*CEPF 2010*
Hornbeam	80	*CEPF 2010*
Poplar	25	*CEPF 2010*
Nominal discount rate - scenario 1	0.90%	
Nominal discount rate - scenario 2&3	5.000%	World bank
Discount rate	2.4%	Real fisher adjusted rate
Inflation scenario 1&2	3.5%	
Inflation scenario 3	2.5%	Emerging Europe average

Other income		Comment / Source

Capital Expenditure		Comment / Source
none	€ -	Estimate

Restocking costs		

	Cost per ha	Comment / Source
	€ 877	Op ex per per year times rotation length
Build up ops		
Forest regeneration	€ -	

Maintenance Expenditure	Cost per ha	Comment / Source
Annual costs	€ 60.60	Calculated
Annual costs	€ 10.60	Thesis assumption
Risk	**Cost per ha**	**Comment / Source**
Annual contingency costs	€ 50.00	Thesis assumption