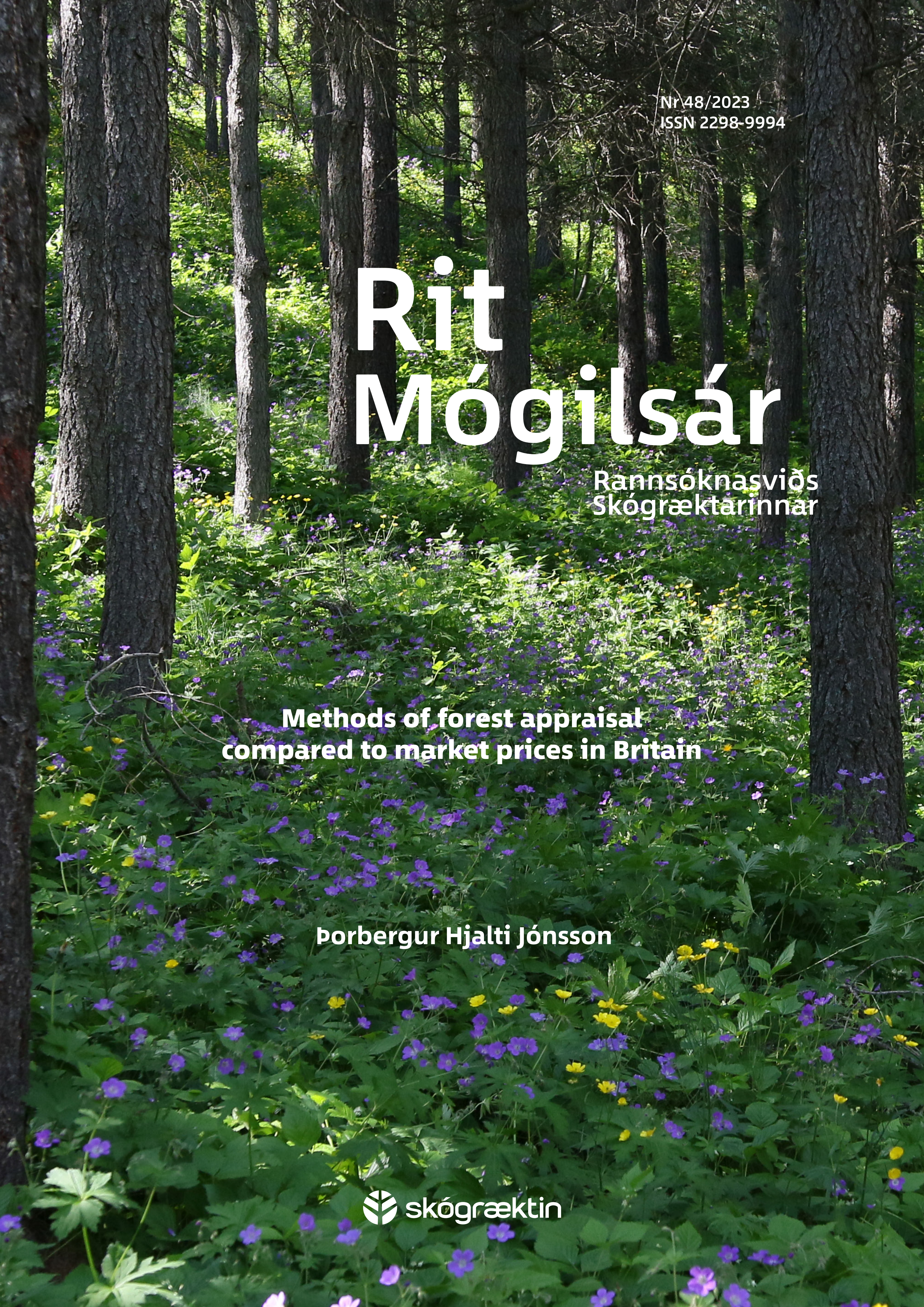

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Methods of forest appraisal compared to market prices in Britain

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Methods of forest appraisal compared to market prices in Britain

Þorbergur Hjalti Jónsson[1]

Summary

Forest appraisal is the procedure for assessing the market value of woodland parcels and is important for sale or purchase of woodlands, for accounting, distribution of inheritance amongst heirs, evaluation of assets as security against loans and for insurance or taxation purposes and in some cases evaluation for compensation. Seven methods of forest appraisals were compared to market prices in 1991 Great Britain: 1) capital invested, 2) realisation value, 3) actual value, 4) potential value estimated by Internal Rate of Return, 5) capitalised value at equal annual rate of 4.8% (continuous rate 4.7%), 6) expectation value at equal annual discount rates of 8.0% (continuous rate 7.7%) and 4.8% (continuous rate 4.7%), and 7) continuity value (time preference value), a novel method presently introduced. The appraisal methods were used to assess the average per hectare value of the total private forest estate of Great Britain partitioned by: A) Lowland broadleaves and/or mixed conifers, B) small areas of upland conifers and C) extensive areas of upland conifers (primarily Sitka spruce, YC-14, no-thinning). The three forest cover types were sectioned by age categories: 0-9 years (young plantations), 10-14 years (thicket-stage), 15-19 years (thicket-stage), 20-24 years (pole-stage), 25-29 years (thinning stage to maturity), 30-49 years (thinning stage to maturity), 50-99 years and older (thinning stage to maturity). Methods 1-6 all produced biased estimates of market value. The continuity value method produced unbiased estimates of median price as well as upper and lower price bounds for the tree forest types. The method provides appraisals for woodlands irrespective of any monetary revenue derived from the forest use and was recommended for appraisals of woodlands in Iceland. Even so, estimates of market value might not be ideal for compensations and in that case the replacement method might be more appropriate.

Key words: valuation, price, capitalisation, internal rate of return, future value, sustainability, human time preference.

Samantekt

Íslenskur titill: Aðferðir við mat á markaðsvirði skóga bornar við markaðsverð á Bretlandseyjum

Markaðsverð skógareignar getur þurft að meta vegna sölu eða kaupa á skógi, vegna eignamats í bókhaldi, skiptingar dánarbús, veðhæfni, trygginga, skattlagningar eða skaðabóta. Í þessari grein eru bornar saman sjö aðferðir til að meta markaðsverð á skógi í einkaeign á Stóra-Bretlandi. Aðferðirnar voru 1) bundið fé í skóginum, 2) verðmæti viðarforðans, 3) valið það sem hærra er, bundið fé eða verðmæti viðarforðans, 4) verðmæti skógarins metið út frá innri ávöxtun viðarnytja á ræktunarlotu, 5) núvirði miðað við jafnar árlegar tekjur af skóginum í jafnvægi nýtingar og endurnýjunar metið með ávöxtunarkröfu jafnri meðalarðsemi skógarfjárfestinga á Bretlandseyjum (4,8%), 6) væntingarvirði út frá núvirði framtíðartekna með ávöxtunarkröfu sem víða er notuð í arðskógrækt (8,0%) eða með meðalarðsemi skógarfjárfestinga á Bretlandseyjum (4,8%) og 7) sjálfbærnivirði metið út frá tímagildismati. Sjálfbærnivirðið er ný aðferð sem sett er fram í greininni og er byggt á tilgátu um tímagildismat mannsins. Skógunum var skipt í A) skóga á láglendi með lauftrjám eða blöndu af barrtrjám, B) smá svæði með barrskógi og C) víðlenda barrskóga (mest sitkagreni í Hálöndum Skotlands). Þeim var nánar skipt í aldursflokka: 0-9 ára, 10-14 ára, 15-19 ára, 20-24 ára, 25-29 ára, 30-49 ára, 50-99 ára og eldri. Vegið meðalverðmæti á hektara var metið með fyrrnefndum aðferðum fyrir alla skóga í einkaeign á Stóra-Bretlandi skipt eftir skógargerð og aldursflokki. Aðferðir 1-6 gáfu skekkt mat á markaðsverð en sjálfbærniaðferðin gaf óskekkt virðismat og fór nærri markaðsverði í öllum tilvikum. Hún mat rétt meðalverð, efri verðmörk og neðri verðmörk. Með sjálfbærniaðferðinni má meta verðmæti skóga óháð því hvort þeir skila tekjum eða ekki. Hér er mælt með sjálfbærniaðferðinni við mat á markaðsverðmæti skóga á Íslandi. Mat á skaðabótavirði er byggt á tjóni eigandans en ekki endilega markaðsvirði. Sjálfbærniaðferðin hentar því sjaldan við mat á skaðabótum.

Lykilorð: verðmat, verð, núvirði, innri ávöxtun, framtíðarvirði, sjálfbærni

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Introduction

Assessment of the capital value of woodlands and forests is important for 1) sale or purchase of woodlands, 2) for accounting, 3) distribution of inheritance amongst heirs, 4) evaluation of assets as security against loans, 5) appraisal of property for insurance or taxation purposes (Openshaw 1980) as well as 6) compensation of damages (Hart 1991).

The term valuation describes the procedure of finding a value to the owner or would be owner of an asset, whereas appraisal is the procedure for finding its market value, i.e., the price for which the asset would sell in a competitive market (Zhang & Pearse 2012).

Appraisal is the preferred approach for transactions, accountancy, and inheritance as well as collateral. Loss to the owner may deviate considerably from the market value and evaluations of damages are usually concluded by the replacement method (Hart 1991). The valuation of investments would reflect the investor's preferences rather than the perceived market value. Investments are usually assessed using the expectation value method and hurdle rates determined by the investor (e.g., Park 2007, Ross et al. 2005). The replacement method and valuation of compensations as well as assessment of investment are outside the scope of the present paper.

The trees still standing in the woods might be by far the most valuable assets of a commercial forest enterprise (Openshaw 1980). Even so, the value of immature crops of timber as well as the worth of woodlands grown for amenity, recreation, hunting, erosion control, water management or biodiversity might seem unclear. The more recent carbon value might add to the market price, whereas its impact remains uncertain. Therefore, accurate appraisals of woodlands, irrespective of objectives of present management, are highly desirable.

Land, buildings, infrastructure, machinery, and cars are items universally accounted for on the balance sheet of a woodland enterprise, whereas the woodland might be absent. In Iceland, neither unimproved land nor woodlands are assessed for taxation purposes, and hitherto appraisals of woodlands for accounting, legacy or collateral have been the exception. Since the early 1990s afforestation of farmland has created private woodland estates with diverse ownership. More recently, domestic and foreign investors have planted forests for carbon sequestration. Inevitably, these developments create the need for appraisals for inheritance, collateral and accounting.

In strict traditional accountancy, valuation of woodlands should only involve the actual net capital expenditure on the forest enterprise, ignoring growth in value (Openshaw 1980). In the 1980s, the United States Generally Accepted Accounting Principles (US GAAP) only recognised capital invested as the value of the forest growing stock, ignoring growth (Binkley 2007).

At that time, large integrated industrial timber companies owned extensive timber lands in the United States of America, from which they acquired much of their raw materials. According to the books, and in line with accepted accountancy practices, the timber lands were of low value (Binkley 2007). Furthermore, the integration of the forest resource with the utilising industries obscured the value of the wood resource as opposed to the industrial entities.

The British investor Sir James Goldsmith, saw an opportunity for leveraged buy-outs in the undervalued timber lands. During the 1980s recession, he and his business companions acquired the integrated forest companies Diamond International and Crown Zellerbach. They separated the forest estate from the timber processing entities and sold the parts separately. Their profits were high, whereas the processing industries proved unviable once departing with the previously undervalued forest estates (Binkley 2007). His leveraged buy-outs demonstrated that in a free-market economy, ignoring or underestimating the value of the trees poses an existential risk to the forest ownership.

In the International Financial Reporting Standards (IFRS) "mark to market" regime, each year the value of growth is shown on the profit and loss account and the increased value recorded on the balance sheet (Binkley 2007). For that practice an accurate method of forest appraisal is essential.

The appropriate appraisal method would be the one that accurately predicts market prices. Conclusive comparisons of forest appraisals to market prices are rarely reported. Even so, the expectation value has been advocated as the correct method of forest evaluation (Samuelson 1976), promoted in textbooks of forest economics (e.g., Williams 1981, Gregory 1987, Zhang & Pearse 2012) and prescribed for business and economic evaluations (e.g., Park 2007, Ross et al. 2005).

In most countries the asset markets for woodlands are shallow and commonly with poorly defined properties. Often, price analysis is plagued by insufficient information on forest composition and confounding of forest value to a mix of different asset values such as buildings, agricultural land, unproductive land and various infrastructure.

In Britain the woodland market is reasonably well developed and of some depth. Cyril Hart in his book Practical forestry for the agent and surveyor, provides an unusually comprehensive and detailed account of private forestry in Britain including prices, costs, yield, regulation and markets (Hart 1991). Concurrent, Forestry Commission national inventory data and yield tables enable the appraisal of the UK woodland base by different methods and comparisons to woodland prices.

Appropriate methods for forest appraisals are the subject of the present paper. First, I discuss the feasibility of using comparable sale, and then I describe six methods commonly used in forest appraisal as well as a novel appraisal method (Continuity value). Predictions derived from these methods were compared to historic prices of private woodlands in Great Britain and the most appropriate methods identified for practical applications.

Methods of appraisals

Any relevant record of comparable sales might be used to derive an estimate of the market value of woodlands (Hart 1991). In Iceland, comparable sale has been widely used for appraisals of buildings and is the basis of property taxation[1] (Council tax)[2]. Thus, comparable sales might seem the obvious basis of woodland appraisals.

Sales of woodlands usually include the land on which the trees grow. Therefore, to separate the value of the tree crop from that of the land, an accurate and preferably precise estimate of land prices is essential. In 2021 the present author proposed a model to estimate prices for parcels of land in Iceland (Jónsson 2021).

Multi variate models, commonly referred to as the hedonic pricing models, are normally employed in appraisals by comparable sales (Zhang & Pearse 2012). The data required for model construction include unambiguous prices from sales of woodlands of known characteristics and location. Prices for woodland blocks are inherently highly variable and the variance strongly heteroscedastic, thus large datasets are required for useful models.

In Iceland, woodlands are rarely offered for sale and the author is only aware of one instance where a woodland block was offered for sale separately from other asset types, forming an amalgamated property. Woodlands are usually a part of a complex asset of hay fields, pastures, waste land, houses, various infrastructure and sometimes valuable benefits, such as angling rights. The value of each component of a land property might only be approximated (Jónsson 2021) and an attempt to establish the value of woodlands from a small sample of sales would be a futile exercise. Furthermore, in Iceland prices in sales of land are not publicly disclosed (Elíasdóttir 2014, Jónsson 2021). Woodlands are composed of stands of different species, age classes and different yield potential, which might profoundly affect the valuation (c.f. Openshaw 1980, Hart 1991, Zhang & Pearse 2012) and further complicate analysis by comparable sales.

Comparable sale and hedonic pricing models are useful for economic analysis and as a reference in investment appraisals. In forestry, hedonic pricing models are rarely precise enough or with adequate resolution for practical applications such as in accountancy, inheritance or collateral. The models are empirical and thus not valid outside the temporal and spatial range of the data used in their construction. Furthermore, predictability is rarely verified and usually not verifiable on independent data. Obviously, appraisals of forests in Iceland based on compatible sales and hedonic pricing models are currently inconceivable due to scarcity of relevant transactions with sufficient information on the forest.

In accountancy forest appraisals have traditionally been conducted by one of six methods 1) capital invested, 2) realisation value (standing value), 3) actual value, 4) potential value, 5) capitalised value, and 6) expectation value (Openshaw 1980, Hart 1991).

1) Capital invested is the actual accumulated net capital expenditure on the woodland (Openshaw 1980), i.e., the cumulative cost up to the age of valuation expressed by equation 1:

$$W_{\text{inv}} = \sum c_t \qquad \textbf{(1)}$$

where W_{inv} is capital invested up to age t, $\sum c_t$ is the sum of annual net expenditure on the woodland block, i.e. $c_0+c_1+...c_{t-1}+c_t$.

2) Realisation value (standing value) is the value of timber in the woodland. The woodland is assessed as if the trees were harvested in their current state and the wood sold, less the total cost of harvesting, extraction and haulage to market, i.e., the perceived price a timber merchant might pay for the standing timber bound for harvesting (Hart 1991). The realisation value is expressed by equation 2:

$$W_{\text{stv}} = Vp_{\text{stv}} \qquad \textbf{(2)}$$

where V is standing volume of timber (m^3 per hectare), p_{stv} is the net price per m^3 estimated for trees of average size v (m^3 per average tree). The method

[1] Fasteignamat.

[2] Fasteignagjöld.

relies on good compartment records including species, tree size and total volume as well as reliable data on timber prices and costs of harvesting, extraction and haulage.

3) Actual value is the higher value of capital invested (W_{inv}) and realisation value (W_{stv}) and is expressed by equation 3:

$$W_{acv} = \max\{W_{inv}, W_{stv}\} \quad \textbf{(3)}$$

4) Potential value method uses the Internal Rate of Return to estimate values from initial cost (c_0) up to the age at valuation or the end of the rotation by equation 4:

$$W_{IRR} = \sum(w_{t-1}(1+ EAR_{IRR})+w_t \quad \textbf{(4)}$$

where w_t is annual net cash flow in year t, w_{t-1} is the corresponding cash flow a year earlier and EAR_{IRR} is Internal Rate of Return expressed as Equal Annual Rate (EAR expressed as ratio)[3]. Note the net cash flow is the annual net difference of income less costs.

5) Capitalisation value is the capitalised present value of a perpetual annual series given by equation 5:

$$W_{cv} = w/EAR \quad \textbf{(5)}$$

where W_{cv} is the capitalised value, w is annual net cash flow and EAR is Equal Annual Rate (Gregory 1987, Openshaw 1980).

6) Expectation value is the estimated Net Present Value (NPV) of future cash flow, i.e., net costs and net revenues by years to the end of the rotation, and estimated by equation 6:[4]

$$W_{NPV} = \sum w_t/(1+EAR)^t, \text{ for } t = 0 \text{ to } T \quad \textbf{(6)}$$

where w_t is net cash flow by year t up to and including rotation age T. According to Samuelson (1976) the rate should be the market rate for investment. Importantly, the method only applies to future income and expenditure ignoring any past cash flow. In that respect it is the opposite of the potential value method.

Continuity Value

A "normal" forest is a woodland with balanced age structure that generates equal annual output in perpetuity (Matthews 1991), the archetype of a sustainable system. In a "normal" forest we have equation 7 describing the yield:

$$w = W_{stv}/T \quad \textbf{(7)}$$

where w is the annual output, such as the net proceeds from annual harvesting, and W_{stv} is the realisation value (standing value,) at rotation age T.

In a sustainable system the capitalised value by equation 6 should equal the average market price P ($P = W_{cv}$). In practice, the rate of equation 6 is usually deduced from market prices and output (rent), as the ratio $r = w/P$. Rearranging the equation to isolate w, we have $Pr = w$. Thus, in a sustainable forest system $Pr = W_{stv}/T$ and $P = W_{stv}/rT$ (equation 8). Value (price P) of a sustainable forest would only equal standing value:

$$(P = W_{stv}) \text{ when } r = 1/T. \quad \textbf{(8)}$$

Piketty (2014) stated that the average rates in the economy are usually explained by human time preference. Rogers (1994) proposed that human time preference might have evolved by optimizing intergenerational transfers, i.e., sustainability. Thus, the average rate in transactions would be defined by the generation time[5]. Therefore, the rate relating price and output should be the time preference rate[6].

Both, the value (P) and rate (r) are human perceptions whereas in commercial forestry, standing value (W_{stv}) is the product of variable combinations of biological growth (tree sizes and numbers of trees), costs and timber prices, as well as the rotation T, which is usually defined to optimise output. Therefore, only exceptionally would $r = 1/T$, and usually $P \neq W_{stv}$.

I propose, humans perceive the value of any asset as the capitalised value of the perpetual value stream potentially derived from that asset, i.e., as a sustainable system. We would assess the value in its current state. In the case of accumulation such as tree crops, the perceived rotation generating the value stream becomes current age, i.e., $t = T$. Combining equation 8 and an equation I have proposed for time preference rate (Jónsson unpublished), substituting T with t (any age as opposed to rotation T), and rearranging the resulting equation to isolate price P we get equation 9:

$$P = (W_{stv}\alpha u)/t \quad \textbf{(9)}$$

W_{stv} is realisation value, α is about 9.8 (age of female puberty) and u-value represents the stage of the human life cycle. The u-value of 3.01 would define the average (generation time) and the u-values of 2.4 (onset of regeneration) and 4.06 (cessation of regeneration) might define the upper and lower limits of asset values. The corresponding rates r

[3] The internal rate of return is defined by iteratively calculating the present value of income less the present value of costs varying the discount rate until the rate of zero difference is found (present value of costs = present value of income), i.e., zero net present cash flow. Note IRR-calculations usually assume Equal Annual Rate (EAR) as opposed to continuous rate r.

[4] Presently, I used continuous discounting formulae, $\sum w_t \exp(-rt)$ as opposed to the more traditional EAR-formula $w_t/(1+r)^t$, for $t = 0$ to T (rotation age), where w_t is net cash flow by year t up to and including rotation age T.

[5] Generation time is the time between cohorts replacing previous generation (in succession).

[6] Continuous rate r and Equal Annual Rate (EAR) are easily converted one to the other. The continuous rate, $r = \text{Ln}(1+(EAR/100))$ and $EAR = \exp(r)-1$ (Zhang & Pearse 2012).

would become 3.4%, 4.3% and 2.5%, respectively. The αu-values refer to the age range of the human reproductive period.

Usually, young plantations would have no realisation value (c.f. Openshaw 1980) and forests grown for intangible services, such as amenity or biodiversity, might never produce any tangible revenue. Therefore, in these cases capitalisation of revenue or potential revenue by time preference rate would produce no asset value. Even so, forests with valuable timber reserves managed for non-timber benefits would have potential realisation value. Obviously, assets have value although only providing desirable non-marketable services. The asset value of immature timber is clearly demonstrated by market prices for young plantations in Britain as published in Hart (1991).

Anyone establishing a forest or restoring degraded land is investing current resources in anticipation of future benefits, which may or may not have monetary value. We might assume no one would willingly sell property for anything less than the initial outlay compounded at his or her time preference rate to the time of sale.

Based on the replacement model of time preference, future value of initial outlay might be given by equation 10:

$$F = c(1\text{-exp}(-\gamma t))\text{exp}(2) \qquad \textbf{(10)}$$

where, c is the initial outlay, γ is the replacement rate, $\gamma = (1+t/\alpha u)/\alpha u$ and t is time delay. As before, α is about 9.8, u-value of 3.01 would define the average value and the u-values of 2.4 and 4.06 might define the upper and lower limits of asset value (Jónsson, unpublished).

It is more important for the survival and well-being of any organism to have continuous flow of resources rather than enjoy occasional moments of plenty, interspaced with periods of deficiency. In the latter case, reserves from earlier periods must be sufficient to cover consumption until adequate resources become available. For any delayed rewards, doubling during delay period is the minimum condition maintaining parity with uninterrupted consumption. Phrased differently; if we initially had one unit which we consumed while waiting for delayed benefits, our reward must be at least two units to cover our consumption and re-establish our original reserves of one unit. If we only recovered our initial outlay, we have lost our reserves and will be unable to wait for delayed rewards the next time around.

By equation 10 we had at the outset reserves c which we invested in anticipation of later return. The value by equation 10 is the future value of the initial outlay expected by year t. By the replacement hypothesis of time preference, the minimum return for the plantation owner would be to recover both the net initial outlay and its perceived future value by time t, i.e., the continuity value would become (equation 11):

$$W_S = c+c(1\text{-exp}(-\gamma t))\text{exp}(2) \qquad \textbf{(11)}$$

Note the future value F in equation 10 is only the future value of continuous consumption during the delay period. Thus, by the end of the delay period the initial outlay has already been consumed, i.e., the costs, the expenditure invested.

In order to achieve their goals, economic actors need consent and support of their fellow citizens. Reviewing results of extensive studies of economic behaviour, Gintis (2000) concluded that economic actors are not self-regarding but seek cooperation and respond to supportive behaviour by maintaining or advancing collaboration. Human time preference is a shared evaluation system of humans and would be the common ground for different parties to negotiations.

In transaction, all parties to a deal must accept the outcome and price is the monetary value of that agreement. In dealings involving non-tangible benefits, such as immature woodlands and immaterial forest services, the aspiring buyer would recognise the seller´s ambition to recover initial outlay together with costs up to the transaction date, compounded to the time of sale, and at the time preference rate. When the current value to the buyer at least matches that of the seller, a successful deal might be done. The price point of commonly acceptable fairness might therefore be the time preference compounded establishment cost together with any subsequent costs. Thus, the expected market value of immature timber and intangible forest services might be estimated by Equation 11.

For properties generating benefit streams with monetary value or perceived accumulation of such values, e.g., immature commercial forest, current capitalised value might be seen as acceptable for both parties to a deal. The fairness rule of human engagement (c.f. Gintis 2000) would also dictate that the higher value of the two, compounded cost or capitalised benefits, might be deemed a fair deal.

In general, the acceptable price in a deal involving woodland might be estimated by equation 9 and 11, the higher price of the two might define the value of a forest property, i.e., equation 12:

$$P = \max\{c+c(1\text{-exp}(\gamma t))\text{exp}(2), (W\alpha u)/t\} \qquad \textbf{(12)}$$

where, max {Equation 11, Equation 9} selects the higher result from the two formulae. The market value resulting from many transactions should converge to that estimate by equation 12.

In general, there would be strong response to the prospect of loss, whereas only moderate reaction to possible gains. Therefore, sellers are unlikely to accept any price lower than their projected acquisition value. The lowest price will occur when sellers have low value and buyers also perceive the value low, i.e., at high rate of time preference ($u \approx 4.06$). Conversely, high value would be expected when both have high price expectations, i.e., low time preference rate ($u \approx 2.4$). A mismatch in price expectation would generally result in no sale. Therefore, sale would only be expected when both parties have similar price expectations and thus aligned time preference *u*-values.

Comparison of model predictions to market prices should conform to average prices by *u*-value of 3.4, and upper and lower price bounds to $u = 2.4$ and $u = 4.06$, respectively. The model would only be adequately supported if all three conditions are met. Thus, we have a testable hypothesis of property prices, including values of those without a market price.

Methods

Market prices

Market values (prices, £ per hectare) of stocked woodlands in Britain were acquired from Hart (1991, pages 626-627). The data comprised upper and lower bounds for market values for A) lowland broadleaves and/or mixed conifers, B) small areas of upland conifers and C) extensive areas of upland conifers, by age classes (Figure 1). Available data for upland conifers included age classes: 0-10, 10-15, 15-20, 20-25, 25-30, and 30-50 years, whereas, for lowland broadleaves and/or mixed conifers the data also included the age class 50-100 and older. Hart (1991) presented woodland prices in £ per hectare for 1) crop only, 2) land and 3) crop including land value. I used prices for the crop only excluding the land (i.e., trees only) for comparisons with calculated appraisals. The prices were current in 1991 as stated in Hart (1991). For comparisons with appraisals, I used estimated median price derived as the average of the upper and lower price bound. For comparisons to appraisals by the sustainability method I also used the upper and lower prices bound directly (see evaluation below).

Timber prices

From Hart (1991) I retrieved average standing timber prices (£ per m^3, prices for timber less cost of harvesting, extraction and hauling). Prices retrieved were for conifers in Scotland and broadleaves in the United Kingdom as well as species specific data for standing prices of oak and beech. The oak and beech prices by tree sizes were fitted to a power equation (Oak: $28.5798v^{0.4844}$, Beech: $18.0888v^{0.3104}$, where v is average tree size in m^3). The retrieved tabulated prices and estimates from the power regressions were used to produce a table of standing prices for conifers, oak and beech with the tree size range 0.01 to 10.00 m^3 and tree size steps of 0.01 m^3. Prices of broadleaves other than oak were assumed to be identical to those of beech (c.f. log prices at roadside in Hart 1991).

Costs and grants

From Hart (1991), I obtained current (in 1991) available grant aid (government subsidy) and average costs (£ per hectare) of stand establishment as well as costs of annual maintenance and management (Appendix: Table A1). The initial outlay (*c*-value) might include ground preparation, fencing (or other essential measures to protect the tree crop), plants and planting. On fertile sites with rampant ground vegetation such as those of most lowland broadleaves weeding would be necessary. It was presently assumed weeding was not a perceived necessity for upland conifers whereas essential for lowland broadleaves and/or mixed conifers.

I estimated both gross costs (ignoring any external income) and net cost to the owner with available grant aid in 1991. Planting grants for lowland broadleaves and/or mixed conifers were assessed by the assumed area band 1.0-2.9 hectares. For small areas of upland conifers, I assumed area band for less than one hectare, and for extensive areas of upland conifers I assigned area band for 10 ha and over (c.f. Hart 1991, Appendix: Table A1).

Yield

Average tree sizes (m^3 per tree) and standing volume (m^3 per hectare) was obtained, in five-year age steps, both for wood removed by thinning and tree crops after thinning, from the stand growth models of Edwards and Christie (1981).

Data were retrieved for Oak (yield classes 4, 6 and 8), Beech (yield classes 4, 6, 8 and 10), SAB (combined yield models for sycamore, ash and birch, yield classes 4, 6, 8, 10 and 12), Douglas fir (yield classes 8, 10, 12, 14, 16, 18, 20, 22 and 24), hybrid larch (yield classes 4, 6, 8, 10, 12 and 14), European larch (yield classes 4, 6, 8, 10 and 12), Norway spruce (yield classes 6, 8, 10, 12, 14, 16, 18, 20 and 22), Sitka spruce intermediate thinning (yield classes 6, 8, 10, 12, 14, 16, 18, 20, 22 and 24), Sitka spruce no thinning (yield classes 6, 8, 10, 12, 14, 16, 18, 20, 22 and 24), Lodgepole pine (yield classes 4, 6, 8, 10, 12, 14), Corsican pine (yield classes 6, 8, 10, 12, 14, 16, 18 and 20) and Scots pine (yield classes 4, 6, 8, 10, 12 and 14) (Average and range of yield classes by species see Appendix: Table A2).

Woodland composition

The woodland prices presented in Hart (1991) refer to transactions primarily of privately owned woodlands. At that time, the Forestry Commission was the single biggest forest owner in Great Britain and its forests weighed heavily in the composition of the entire national woodland area (see Anonymous 2001a, 2001b and 2001c). In the 1980s the Forestry Commission sold some minor woodland parcels (Hart 1991, Oosthoek 2013). Even so, it was a minor player on the woodland market. Thus, the composition of the Forestry Commission woodland estate might not reflect the mix of woodlands traded on the market. To avoid bias, I excluded the Forestry Commission woodland base from the current analysis of forest appraisals and market values.

From the National Inventory Reports for Scotland, Wales and England (Anonymous 2001a, 2001b and 2001c) I retrieved forest areas (hectares) of privately owned woodlands by species and age classes. Forest area data was obtained for the conifers: Scots pine, Corsican pine, Lodgepole pine, Sitka spruce, Norway spruce, European larch, Japanese and hybrid larch, and Douglas fir as well as for the categories of other conifers and mixed conifers (the latter two combined). The broadleaves retrieved were Oak, Beech, Sycamore, Ash and Birch. Areas of Poplar, Sweet chestnut and Elm were combined to the retrieved categories of other species of broadleaves and mixed broadleaves (all combined). Areas by species were retrieved for the age classes of tree crops planted in the years 1981-1990, 1971-1980, 1961-1970, 1951-1960, 1941-1950, 1931-1940, 1921-1930, 1911-1920, 1901-1910, 1861-1900 and the total area planted before 1861 as well as total planted before 1990.

For each species, woodland areas planted 1981-1990 were assigned to age class 0-9 years (young plantations). Half the area planted in 1971-1980 was assigned to the age class 10-14 years (thicket stage), the other half was assigned to age class 15-19 years (pole stage). Half the areas planted in 1961-1970 were assigned to age class 20-24 years (thinning stage) and the other half to age class 25-29 years (thinning stage). Woodland areas planted in the years 1941-1960 were assigned to the age class 30-49 years and plantations dating before 1940 were assigned to the age class 50-100 years and older.

I defined Scots pine, Lodgepole pine, Sitka spruce, Norway spruce, European larch, Japanese and hybrid larch, as upland conifers. Oak, Beech, Sycamore, Ash and Birch, Corsican pine and Douglas fir were defined as lowland broadleaves and/or mixed conifers. These species assigned to the two woodland types (lowland broadleaves and/or mixed conifers and upland conifers) accounted for 91% of the entire pre 1990 woodland base of Scotland, Wales and England combined. Other species are minor components of the private woodlands, and their value would unlikely deviate sufficiently from those of the main species to influence average prices. Therefore, I excluded other species from the estimated composition of the private woodland base involved in forest transactions.

I calculated the percentage contribution by area (hectares) of each species and age class to the respective categories of upland conifers and lowland broadleaves and/or mixed conifers. The percentage contribution was defined as the weight used to adjust calculated average values by species and age classes (Appendix: Table A3).

Appraisals

I used the data on costs (Appendix Table A1) and standing prices of timber as appropriate to estimate the average per hectare value of the entire privately owned woodland base in Great Britain (England, Scotland and Wales) subdivided by age classes and forest types of A) lowland broadleaves and/or conifers and B) small areas of upland conifers and C) extensive areas of upland conifers as classified in Hart (1991). Estimates were derived by six methods traditionally used in forest appraisals: 1) capital invested, 2) realisation value, 3) actual value, 4) potential value, 5) capitalised value 6) expectation value (at two discount rates), and 7) continuity value.

The average per hectare values by age class and forest types were weighted by the contribution of each age class and forest type to the total private woodland base of Great Britain (weight x average by forest type and age class).

Capital invested was assessed as the unadjusted cumulative cost of site preparation, fencing, plants, planting, beating up and weeding as well as maintenance and management calculated by years from establishment to the rotation age for each species and yield class based on costs in Appendix Table A2. Average annual cumulative costs by age classes were calculated across yield classes for each species. Species and yield classes were grouped by categories of A) lowland broadleaves and/or mixed conifers B) small areas of upland conifers, and C) extensive areas of upland conifers (c.f. Hart 1991). Weighted average cumulative cost for each forest category and age class was calculated by multiplying the average cumulative cost by the respective contribution of that forest category and age class to the total private forest estate of Great Britain.

Realisation value I calculated standing value per hectare (£ per hectare) in five-year steps by multiplying average standing price (£ per tree of average size), average tree size (m^3 per tree) and average standing volume (m^3 per hectare). For oak I used the standing price for oaks. For beech and the combined yield models for sycamore, ash and birch I used standing price for beech. In the cases of all conifer species, I used the standing price model for conifers. I calculated across yield class average standing price by mid points of age classes (median age of age classes). The weighted standing value by age classes was calculated by multiplying the average standing values across yield classes by species times the contribution of the species and age class to the total private woodland base of Great Britain.

Actual value per hectare for each species and age class was estimated as the higher of two values, capital invested and standing value (see above).

Potential value is the value estimated by using the internal rate of return (IRR). I estimated the internal rate of return for each species and yield class (Equal Annual Rate) by the IRR-formula in Excel. For the calculation I used costs by Appendix Table A2 and income by multiplying volume of thinning and standing crop at rotation age by standing value of corresponding tree sizes and species. The potential value was estimated by calculations in age steps during the rotation using the overall internal rate of return derived for the whole rotation and equation 4. The potential value estimates were averaged for each age class and then weighted by the contribution of that species to the woodland type.

Capitalised value was estimated for each species and yield class. The cumulative value of all current and previous thinning together with the current standing value (realisation value, above) was estimated in five-year steps up to current age. Calculations were made separately for thinning and standing stock as average tree sizes and volume were unlike for thinning and standing timber. I estimated the capitalised value by age steps by dividing the cumulative value by an Equal Annual Rate of 4.81% (continuous rate 4.7%), the concurrent risk adjusted discount rate for private sector forestry investment in Britain (McKillop and Hutchinson 1990). The average capitalised value was calculated by age classes across all yield classes. The result was multiplied by corresponding percentage weights (Appendix Table A4) to derive the contribution of that species to the national average by woodland type (lowland broadleaves and mixed conifers or upland conifers).

Expectation value was calculated by the net present value formula and discount rates. In line with Samuelson´s (1976) reasoning, I used published hurdle rate of EAR 8.0% widely used in evaluations of forest investments in Chile, Argentina, Uruguay, Brazil, Southeast United States (Cubbage et al. 2007) and New Zealand (Manley 2017, 2015) as well as the overall risk adjusted discount rate of 4.81% estimated for private sector forestry investment in Britain (McKillop and Hutchinson 1990). I converted the Equal Annual Rates of 8.0% and 4.81% to continuous discount rates r of 7.7% and 4.7% respectively, using the formula continuous rate, $r = \text{Ln}(1+(EAR/100))$, Zhang & Pearse 2011). I used the continuous present value formula, $W_{\text{NPV}} = \exp(-rt)$ to estimate the present value of future net cash flow. As before calculations for all species and age classes were adjusted and combined by woodland types.

Continuity value was estimated by first estimating the initial c-value (net cost to the owner). I retrieved from Table A2 (Appendix) data of establishment costs and available grants (State subsidy) for the initial establishment period of ten years. I used the data to calculate the present net cost by the average time preference rate of 3.41 % (continuous discounting). The resultant net cost was defined as the net establishment cost to the forest owner (discounted costs less discounted grants, Table 1).

I calculated the future value of net establishment costs by equation 11 as well as the capitalised value by equation 9 using an α value of 9.8 and u-values of 2.4, 3.01 and 4.06 and corresponding rates for capitalisation of 4.27%, 3.40% and 2.52%, respectively (upper bounds of the price range, median price and lower bounds of the price range, respectively). Together with the rates the realisation value (standing value) was used in estimates by equation 9. For each species in Britain the actual average per hectare value by age class was estimated as the higher of two values: $W_{\text{SC}} = \max\{\text{equation 11, equation 9}\}$.

Evaluations

In order to evaluate goodness of fit, I used regressions of observed values (market prices, in the y-axis) on predicted values (appraisals) (in the x-axis) as proposed by Piñeiro et al. (2008) by age classes and forest types. Prices for woodland blocks are inherently and highly variable and the variance strongly heteroscedastic, i.e., increases with higher price (Figure 1). As suggested by Jónsson and Snorrason (2018), I used log-transformation (ln, natural logarithm) of model estimates and independent data before applying linear regression to observed and predicted values.

I evaluated whether the slope and the intercept of the regression deviated significantly from 1 and 0, respectively. To distinguish between different sources of predictive error I used Theil's partial inequality coefficients of bias (U_{bias}), consistency ($U_{\text{ß-1}}$) and random error (U_{e}) as described in Smith and Rose (1995), Paruelo et al. (1998) and Piñeiro et al. (2008). Regression analyses were performed by Microsoft®-Excel®, Microsoft Corporation © 2010.

To adequately predict market prices, comparisons of prices and appraisals must pass the conformity test to woodland types. In the case of the sustainability method, appraisals predicting average prices as well as upper and lower bounds of price range must pass the conformity test to private forest types evaluated. Thus, in that case a triple pass is the minimum requirement for an acceptable model.

The selection criteria were 1) the intercept was not significantly different from zero (line passes through the origin) and 2) slope value was significant and deviates no more than 10% from one (The slope of the 1:1 line of perfect conformity, i.e., slopes value in the range 0.9 – 1.1). Furthermore, in borderline cases residual mean square error must be primarily accounted for by random error (Theil´s $U_{\text{e}} > 0.5$).

Results

Conventional methods

All conventional methods for forest appraisals (capital invested, standing value, actual value, potential value and capitalised value) failed the conformity test to average market prices (Table 1, Appendix: Table A4). These methods failed some or all comparisons either by having significant intercepts ($P \geq 0.05$), or slopes deviating more than 0.1 from the slope value of 1, indicating appreciable deviation from perfect conformity. In most cases these methods failed on both accounts.

The appraisal methods; capital invested, realisation value and the capitalised value failed in every comparison. The capital invested deviated considerably from the conformity line and overestimated the value of young plantations whereas underestimates the worth of older stands (Figure 2a, 2b, Table 1).

Initially young plantations assessed by the realisation value method have no value whereas the worth increases strongly during the later thinning stages. By maturity the method overestimated market prices (Figure 3a, 3b, Table 1).

Except for small areas of upland conifers evaluated at net establishment costs, estimates by the actual value method had little resemblance to market values. The method overestimated young plantations, underestimated the values of middle age stands and overestimated the worth of stands approaching maturity (Figure 2c, 2d, Table 1).

The potential value method passed the comparison at net establishment costs to market prices of lowland broadleaves and/or mixed conifers. In other comparisons the method overestimated the market value (Figure 2e, 2f, Table 1). It should be noted that the discrepancies are primarily explained by bias (U_{bias}) rather than by deviations from consistency ($U_{\beta\text{-}1}$, Figure 2f, Appendix: Table A4).

The capitalised value was derived from the standing value (realisation value) and similarly greatly underestimated the worth of young plantations whereas overestimated stands nearing maturity (Figure 3b, Table 1).

***Table 1**. Comparison of forest appraisal by different methods to observed market price of lowland broadleaves and/or conifers, Extensive areas of upland conifers.*

Methods of forest apraisal	Lowland Broadleaves and/ or mixed conifers	Small areas of upland conifers	Extensive areas of upland conifers*
Conventional methods (compared to median price)			
1a. Capital invested, total establishment cost	Fail	Fail	Fail
1b. Capital invested, net establishment cost	Fail	Fail	Fail
2. Standing value	Fail	Fail	Fail
3a. Actual value, total establishment cost	Fail	Fail	Fail
3b. Actual value, net establishment cost	Fail	**Pass**	Fail
4a. Potential value, total establishment cost	Fail	Fail	Fail
4b. Potential value, net establishment cost	**Pass**	Fail	Fail
5. Capitalised value, EAR 4.8% (rate 4.7%)	Fail	Fail	Fail
6a. Expectation value, EAR 8.0% (rate 7.7%)	**Pass**	Fail	Fail
6b. Expectation value, EAR 4.8% (rate 4.7%)	Fail	Fail	Fail
7. Continuity appraisal method	(c = £299)	(c = £206)	(c = £271)
Upper price limit (u-value 2.4, rate 2.52%)	**Pass**	**Pass**	**Pass**
Median price (u-value 3.4, rate 3.4%)	**Pass**	**Pass**	**Pass**
Lower price limit (u-value 4.06, rate 4.27%)	**Pass**	**Pass**	**Pass**

*Plantations containing substantial proportions of Sitka spruce and an overall weighted yield class of 14 or above (Hart 1991).

At equal annual discount rate of 4.81% (continuous rate 4.7%), the future value by expectation value method consistently overestimated the market worth (Figure 3c, 3d), and failed the conformity test involving all forest types (Table 1, Appendix: Table A4). At the higher equal annual discount rate of 8.0% (continuous rate 7.7%) the expectation value method passed the conformity test involving lowland broadleaves and/or mixed conifers. In that test the slope indicated reasonable conformity of values by age (slope 0.95, p < 0.0001, $U_{β\text{-}1}$ = 0.0064). Even so, the intercept was only marginally significant at the $p \leq 0.05$ probability level (Intercept: 0.7, p = 0.0817). The residual variance was almost entirely explained by bias (U_{bias} = 0.9661) and almost no variance was accounted for by random error (U_e = 0.0276). Although passing the hurdles, conformity was inconclusive for lowland broadleaves and/or mixed conifers. In all other comparisons the expectation value methods failed the conformity test (Table 1, Appendix: Table A4). The estimates for conifers were persistently higher or lower than the market price whereas not deviating with size (Figure 3c).

Continuity method

Estimated initial values (c-values) were £299, £206 and £271 for lowland Broadleaves and/or mixed conifers, small areas of upland conifers and extensive areas of upland conifers, respectively (Table 1).

Appraisals by the continuity method using the above c-values pass the conformity tests in all comparisons to average market prices as well as to upper and lower price bounds for the three forest types (Table 1, Appendix: Table A4). The predicted market prices as well as the upper and lower bounds of the price range had only small residual variation (Mean Square Error, MSE), mostly due to random error (U_e) and with both low U_{bias} and $U_{ß\text{-}1}$ values. Thus, the continuity method accurately predicted market prices and price range for lowland broadleaves and/or mixed conifers as well as large and small areas of upland conifers (Figure 4).

Discussion

The methods of capital invested, and realisation ignore the value of tree growth and the value of small trees, respectively. Thus, the failure of these methods was not unexpected. As opposed to orthodox accounting, actual value method combines both capital invested and the realisation value. The failure of the actual value method to predict market worth undermines the widespread use of this method in forest accounts and for forest appraisals in general (c.f. Openshaw 1980, Hart 1991).

For accurate estimates by the realisation and actual value methods detailed compartment records including tree sizes are essential. The potential value method does not involve detailed inventory of the forest estate and for convenience is commonly used in forest accountancy (Openshaw 1980, Hart 1991). The method ignores the actual condition of the forest and Samuelson (1976) dismissed internal rate of return as a method of evaluating forest investments. The current results do not support the potential value method. Thus, its merits would seem doubtful.

The capitalisation method provides quick and simple assessment of the probable value of woodland assuming unyielding output by the rotation age (Openshaw 1980). The usefulness of the method in its traditional form might be limited. Appraisals by the method were currently not supported.

The influential economist Paul Samuelson (1976) endorsed the expectation value method (Net Present Value) which has been the preferred method of forest investment appraisals (Hart 1991) and more generally in financial analyses (e.g., Park 2007, Ross et al. 2005). In line with Samuelson´s (1976) reasoning, I used published hurdle rates widely used in evaluations of forest investments in Chile, Argentina, Uruguay, Brazil, Southeast United States (Cubbage et al. 2007) and New Zealand (Manley 2017, 2015) as well as the overall risk adjusted discount rate for private sector forestry investment in Britain (McKillop and Hutchinson 1990). The risk adjusted discount rate derived by McKillop and Hutchinson (1990) was concurrent with the present analysis. In theory, that rate should be the bases of forest appraisals in Britain. Even so, forest appraisals by that rate and the expectation value method in general failed the conformity test.

Importantly, I refrained from fishing in murky water for discount rates that might produce an optimum fit for expectation value estimates. Almost inevitably, a unique rate might be found for each comparison. However, the rates derived would neither leave us any wiser as to the causal relationship nor support the use of any of the rates under different conditions.

The continuity appraisal method involves present and past income and expenditure, whereas the expectation value only involves present and future income and expenditure. We may know what we have and what the woodland has provided, whereas the future is unknown and only speculative. It would be rational to base our appraisals primarily on our current and past experiences rather than projections far into an uncertain future. The current results support the continuity value method and challenge the rationale for the expectation value and its widespread use in forest evaluations.

Appraisals by the time continuity value past and present costs and revenues must be known as well as standing value at the time of assessment. Ideally, data on costs and revenues should be from carefully kept accounts. Even so, estimates based on generally accepted costs and prices should provide reasonable estimates.

The continuity value method provides appraisals for woodlands irrespective of any monetary revenue. Some broadleaved woodlands in Britain have primarily amenity and recreation values. The lower price bound provided by Hart (1991) might reflect the value of these woodlands grown or maintained for non-market benefits such as amenity, recreation, watershed protection and biodiversity (Figure 1). The continuity value method predicted the lower price limit for lowland broadleaved woodlands thus the method might adequately assess the value of non-commercial woodlands.

In 1988 the British government removed tax concessions for afforestation. Subsequently the rate of new planting collapsed and land prices in the Scottish Highlands fell by half (Hart 1991). Even so, demand and prices of woodland parcels remained stable (Hart 1991). The policy change affected the willingness of investors to commit money to new planting without altering their perceived value or inclination to acquire existing woodlands. Thus, the markets for bare land and stocked woodlands were apparently unconnected.

The 1988 policy change replaced tax breaks by higher grants with minor effect on the monetary level of support (Hart 1991). Timber prices or costs incurred in forest management were unaffected. That outcome was in line with the continuity value method, i.e., the value of woodlands with immature timber would reflect the net establishment cost to the owner. Higher external support such as tax concessions or grant aid should suppress prices of young plantations, whereas less support might elevate prices of young plantations.

During recent decades, in Iceland the government support for afforestation of farmland has amounted to 97% of total cost of plantation establishment, maintenance and necessary operations during the contract period of 40 years (e.g., Jónsson, 2021). Thus, the net cost to the owner has been low and we might expect low value of young plantations. The value might rise as the trees reach marketable sizes or earlier if revenue from carbon sequestration materialise.

Conclusions

All traditional methods of forest appraisal compared to market prices failed the conformity test whereas the results endorse the continuity method for forest appraisals. That method might prove useful for capital valuation in forest accounting, appraisals for inheritance or collateral as well as assessments by vendors or would be buyers of woodlands. In Iceland, and more generally where woodland markets are absent or poorly developed, the continuity method might provide educated guesses for appraisals of woodlands and forests. It should be noted that loss to the owner may deviate considerably from the market value and compensation for damage to plantations are generally based on the replacement value method (Hart 1991) as opposed to market value.

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Figures

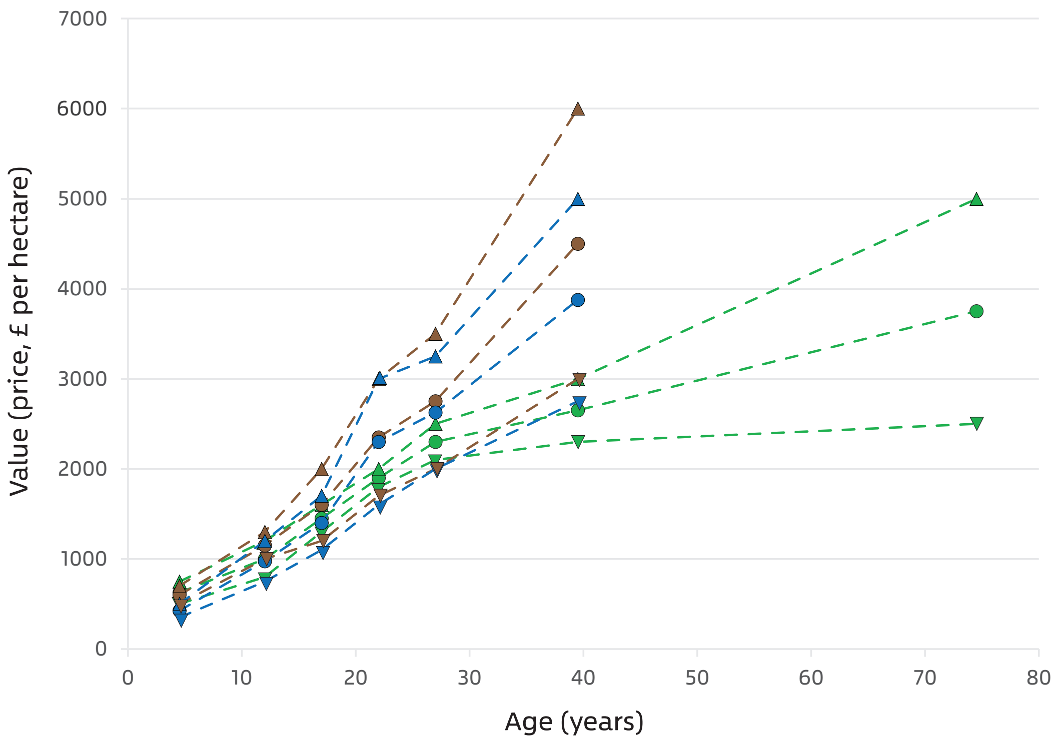

Figure 1. *Median (circles), upper bound (triangles pointing up) and lower bound (triangles pointing down) of market values (price, £ per hectare) for a) lowland broadleaves and/or mixed conifers (green), b) extensive areas of upland conifers (brown) and c) small areas of upland conifers (blue), by stand age classes (median age for age class, years). Broken line connects points in age class series. Data from Hart (1991).*

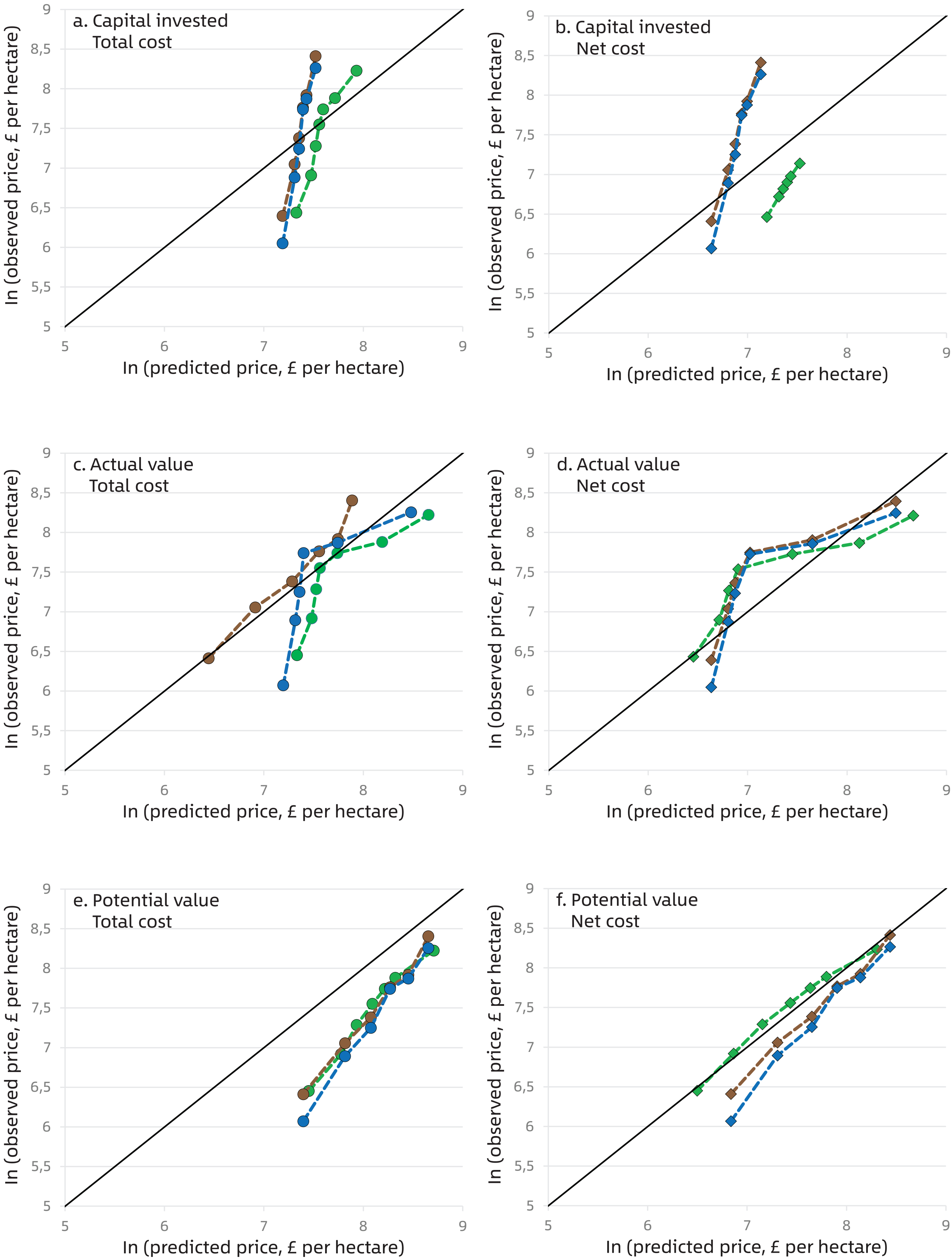

Figure 2*. Observed price (log-value per hectare) by predicted price (log-value per hectare) for Capital invested based on total establishment cost (2a) and net establishment cost (2b), Actual value, based on total establishment cost (2c) and net establishment cost (2d) and Potential value based on total establishment cost (2e) and net establishment cost (2f). Total establishment cost (circles) and net establishment cost (diamonds) for a) lowland broadleaves and/or mixed conifers (green), b) extensive areas of upland conifers (brown) and c) small areas of upland conifers (blue).*

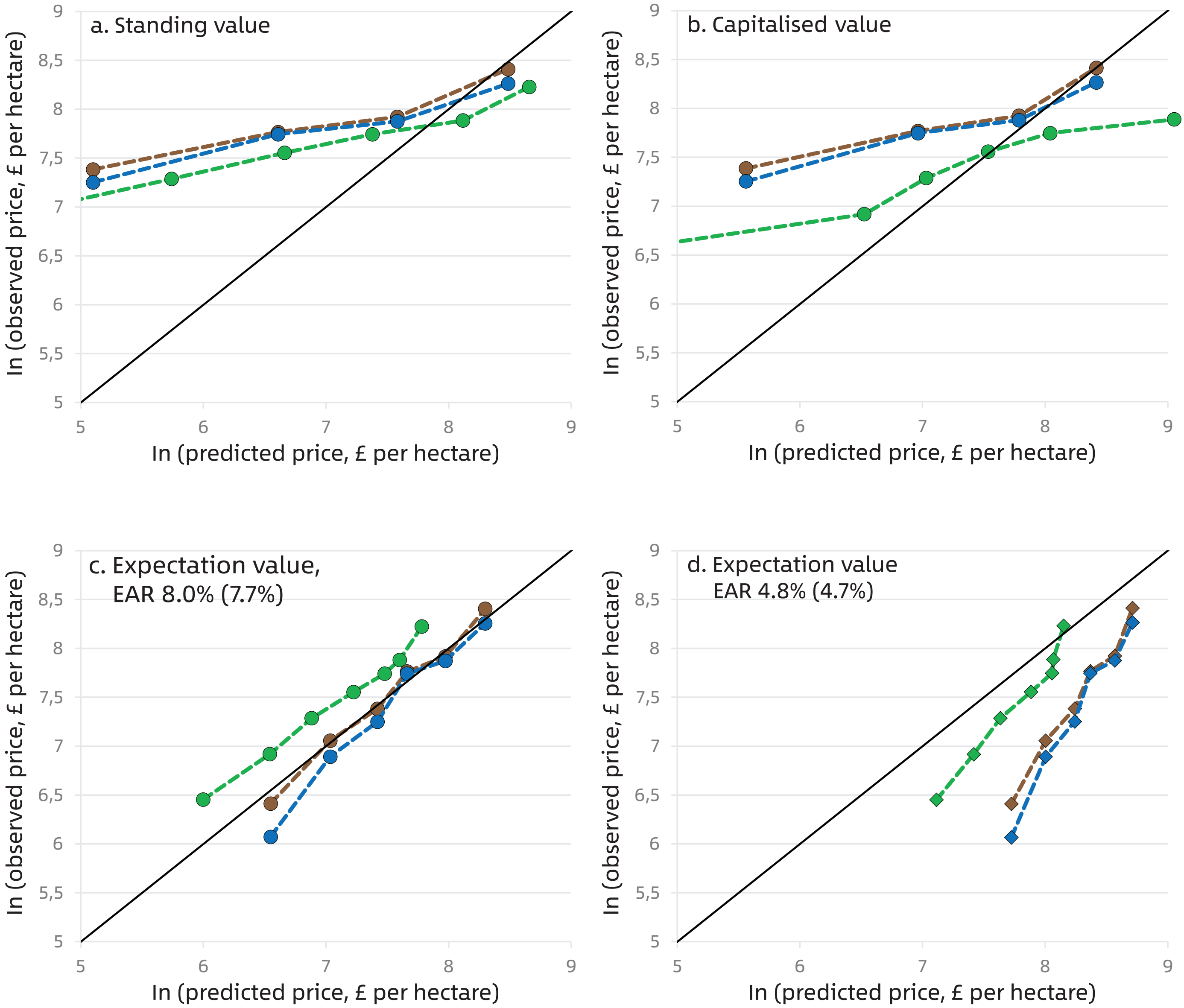

Figure 3*. Observed price (log-value per hectare) by predicted price (log-value per hectare) for Realisation value (standing value, 3a), Capitalised value (3b), for total establishment cost (circles) and net establishment cost (diamonds), as well as Expectation value at 8% EAR (continuous rate 7.7%, 3c, circles) and 4.81 EAR (continuous rate 4.7%, 3d, diamonds) for A) low-land broadleaves and/or mixed conifers (green), B) extensive areas of upland conifers (brown) and C) small areas of upland conifers (blue).*

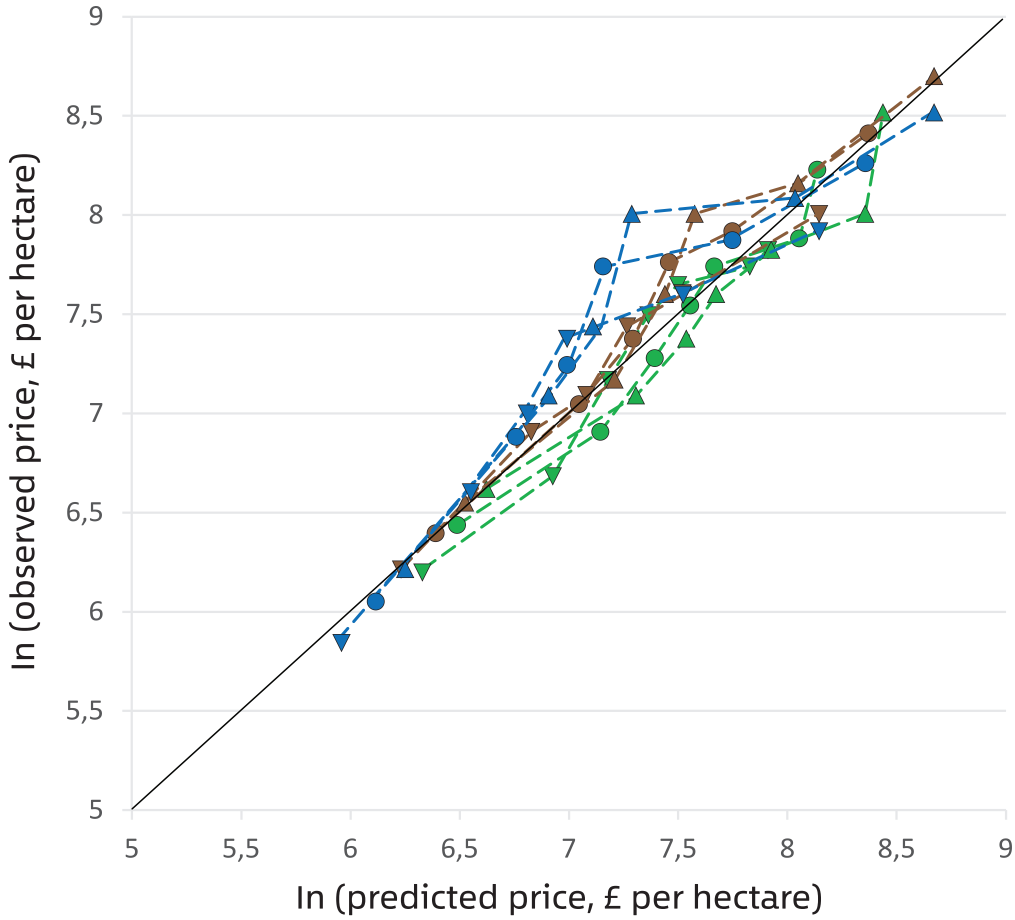

Figure 4. *Observed price (log-value per hectare) by predicted price (log-value per hectare) derived by the Continuity value method for average price (circles), upper price bound (triangles pointing up) and lower price bound (triangles pointing down) for A) lowland broadleaves and/or mixed conifers (green), B) extensive areas of upland conifers (brown) and C) small areas of upland conifers (blue).*

Appendix

Table A1. *Planting grants (£ per hectare, positive values) and costs (£ per hectare, negative values) for establishment, maintenance and management of forest plantations in 1991 Great Britain (Source: Hart 1991).*

Year	Classification of cost or income	Lowland broad-leaves and/or mixed conifers	Extensive areas of upland conifers	Small areas of upland conifers
		£ per ha	**£ per ha**	**£ per ha**
0	Site preparation	-200	-200	-200
0	Fencing (variable)*1	-500	-300	-500
0	Plants and planting*2	-594	-386	-386
0	Planting grant	963	431	616
1	Weeding, beating up and management	-200	-110	-110
2	Weeding, maintenance and management	-100	-90	-90
3	Weeding, maintenance and management	-80	-70	-70
4	Maintenance and management	-60	-40	-40
5	Maintenance and management	-50	-30	-30
5	Planting grant	275	123	176
6	Maintenance and management	-20	-12	-12
7	Maintenance and management	-20	-12	-12
8	Maintenance and management	-20	-12	-12
9	Maintenance and management	-20	-12	-12
9	Planting grant	137	61	88
10	Maintenance and management	-20	-12	-12
Annual cost	Maintenance and management	-20	-12	-12
Year 0-10	Total cost	1.884	1.286	1.486
Year 0-10	Planting grant (total)	1.375	615	880
Year 0-10	Net cost (less grant)	509	671	606
Year 0 (0-3)	Net establishment cost (c-value)	-299	-271	-206

Table A2. *Average yield class (range within brackets) and average rotations (range within brackets) by species in Britain. Source: Hart (1991).*

Species	Yield class (YC)	Rotation
	m^3 ha^{-1} $year^{-1}$	years
Oak (Oa)	4 (2-8)	150 (120-160)
Beech (Be)	6 (4-10)	115 (100-130)
Sycamore (SAB)	5 (4-12)	70 (60-80)
Ash (SAB)	5 (4-10)	70 (60-80)
Birch (SAB)	6 (4-10)	45 (30-60)
Douglas fir (DF)	14 (8-24)	58 (45-70)
Hybrid larch (HL)	8 (4-16)	48 (40-55)
European larch (EL)	8 (4-16)	53 (45-60)
Norway spruce (NS)	12 (6-22)	73 (55-90)
Sitka spruce (SS)	12 (6-24)	58 (45-70)
Lodgepole pine (LP)	7 (4-14)	70 (50-90)
Corsican pine (CP)	11 (6-20)	63 (45-80)
Scots pine (SP)	8 (4-14)	78 (55-100)

Table A3. *Median age (age range within bracket) and area weights in %, percentage for Oak (Oa), Beech (Be), Sycamore, Ash and Birch combined (SAB), Douglas fir (DF), Hybrid larch (HL), European larch (EL), Norway spruce (NS), Sitka spruce (SS), Lodgepole pine (LP), Corsican pine (CP) and Scots pine (SP) by stage of stand development.*

Stand development	Age years	Oa	Be	SAB	DF	HL	EL	NS	SS	LP	CP	SP
Young plantations	5 (0 - 9)	17,6%	5,1%	52,2%	18,3%	5,5%	0,5%	2,0%	75,4%	11,0%	6,8%	5,6%
Thicket-stage	12 (10 - 14)	9,2%	7,6%	59,9%	10,8%	6,5%	1,3%	5,6%	64,3%	10,9%	12,5%	11,4%
Thicket-stage	17 (15 - 19)	9,2%	7,6%	59,9%	10,8%	6,5%	1,3%	5,6%	64,3%	10,9%	12,5%	11,4%
Pole-stage	22 (20 - 24)	7,4%	10,3%	56,2%	16,2%	9,1%	1,7%	11,2%	46,7%	7,2%	10,0%	24,0%
Thinning stages to maturity	27 (25 - 29)	7,4%	10,3%	56,2%	16,2%	9,1%	1,7%	11,2%	46,7%	7,2%	10,0%	24,0%
Thinning stages to maturity	39,5 (30 - 49)	16,1%	9,1%	62,3%	8,7%	18,3%	5,9%	11,2%	18,0%	3,1%	3,8%	43,5%
Thinning stages to maturity	74,5 (50 - 99)	48,2%	16,2%	33,7%	1,1%	11,4%	9,1%	4,5%	4,2%	0,4%	0,8%	70,4%

__Table A4__. Conformity test results for appraisal methods compared to market prices of private forests. by lowland broad-leaves and/or mixed conifers (LBMC), extensive areas of upland conifers (EAUC) and small areas of upland conifers (SAUC). Comparisons to median price (Med), upper price limit (High) or lower price limit (Low) of price range. Number of age classes in comparisons. Values indicating pass of conformity test are in bold print.

Forest appraisal method	Forest type	Price		Linear model	Linear model	Model	Model	Inter-cept	Inter-cept	Slope	Slope	Teil´s U-value		
			N	**Adj.R²**	**SE**	**MSE**	**P-value**	**Inter-cept**	**P-value**	**Slope**	**P-value**	**Ubias**	**Uβ-1**	**Ue**
1a. Capital invested	LBMC	Med	7	0,8569	0,231	0,0533	0,0017	-15,2	0,0095	2,98	0,0017	0,1325	0,6640	0,2035
1b. Capital invested	LBMC	Med	7	0,9103	0,183	0,0334	0,0005	-4,8	0,0278	1,77	0,0005	0,7818	0,1527	0,0654
2. Standing value	LBMC	Med	6	0,9788	0,068	0,0046	0,0001	5,6	0,0000	0,29	0,0001	0,3692	0,6289	0,0019
3a. Actual value	LBMC	Med	7	0,6849	0,343	0,1174	0,0133	-1,2	0,6298	1,11	0,0133	0,5833	0,0107	0,4060
3b. Actual value	LBMC	Med	7	0,7685	0,294	0,0862	0,0060	2,6	0,0580	0,66	0,0060	0,1472	0,4425	0,4103
4a. Potential value	LBMC	Med	7	0,9678	0,110	0,0120	0,0000	-4,6	0,0037	1,49	0,0000	0,9044	0,0762	0,0194
4b. Potential value	LBMC	Med	7	0,9760	0,095	0,0089	0,0000	0,2	0,6165	0,98	0,0000	0,4602	0,0146	0,5253
5. Capitalised value	LBMC	Med	7	0,7975	0,275	0,0754	0,0042	6,4	0,0000	0,17	0,0042	0,2891	0,7045	0,0064
6a. Expectation value	LBMC	Med	7	0,9858	0,073	0,0053	0,0000	0,7	0,0817	0,95	0,0000	0,9661	0,0064	0,0276
6b. Expectation value	LBMC	Med	7	0,9639	0,116	0,0135	0,0001	-4,6	0,0046	1,55	0,0001	0,6791	0,2579	0,0630
7a. Sustainability value	LBMC	Med	7	0,9530	0,132	0,0175	0,0001	-0,3	0,7053	1,03	0,0001	0,0627	0,0236	0,9137
7b. 23.4 years/2.52%	LBMC	Low	7	0,9407	0,151	0,0229	0,0002	0,4	0,6275	0,94	0,0002	0,3321	0,0515	0,6165
7c. 39.7 years/4.27%	LBMC	High	7	0,9311	0,158	0,0251	0,0003	-0,3	0,7082	1,04	0,0003	0,0027	0,0293	0,9680
1a. Capital invested	EAUC	Med	6	0,9886	0,076	0,0057	0,0000	-38,7	0,0001	6,28	0,0000	0,0461	0,9417	0,0122
1b. Capital invested	EAUC	Med	6	0,9922	0,063	0,0039	0,0000	-18,7	0,0001	3,85	0,0000	0,6608	0,3354	0,0039
2. Standing value	EAUC	Med	4	0,9203	0,121	0,0146	0,0269	5,9	0,0033	0,29	0,0269	0,5181	0,4775	0,0044
3a. Actual value	EAUC	Med	6	0,6245	0,434	0,1886	0,0379	-1,9	0,5691	1,24	0,0379	0,0575	0,0757	0,8668
3b. Actual value	EAUC	Med	6	0,7168	0,377	0,1422	0,0209	1,4	0,4442	0,85	0,0209	0,4537	0,0554	0,4909
4a. Potential value	EAUC	Med	6	0,9896	0,072	0,0052	0,0000	-5,1	0,0009	1,55	0,0000	0,8716	0,1205	0,0079
4b. Potential value	EAUC	Med	6	0,9907	0,069	0,0047	0,0000	-1,3	0,0253	1,16	0,0000	0,5766	0,3030	0,1204
5. Capitalised value	EAUC	Med	4	0,8808	0,148	0,0218	0,0405	5,5	0,0085	0,34	0,0405	0,5063	0,4830	0,0107
6a. Expectation value	EAUC	Med	6	0,9871	0,081	0,0065	0,0000	-0,8	0,1281	1,11	0,0000	0,0000	0,4797	0,5203
6b. Expectation value	EAUC	Med	6	0,9789	0,103	0,0106	0,0001	-8,5	0,0013	1,93	0,0001	0,8543	0,1357	0,0100
7a. Sustainability value	EAUC	Med	6	0,9711	0,121	0,0145	0,0002	-0,6	0,4019	1,09	0,0002	0,2473	0,1607	0,5920
7b. 23.4 years/2.52%	EAUC	Low	6	0,9698	0,108	0,0117	0,0002	0,1	0,8700	0,99	0,0002	0,0059	0,0086	0,9855
7c. 39.7 years/4.27%	EAUC	High	6	0,9459	0,178	0,0316	0,0007	-0,3	0,7240	1,05	0,0007	0,2336	0,0412	0,7252
1a. Capital invested	SAUC	Med	6	0,9674	0,144	0,0207	0,0003	-44,2	0,0005	6,99	0,0003	0,0014	0,9634	0,0352
1b. Capital invested	SAUC	Med	6	0,9690	0,140	0,0197	0,0002	-21,8	0,0007	4,28	0,0002	0,4671	0,5107	0,0221
2. Standing value	SAUC	Med	4	0,9632	0,081	0,0065	0,0123	5,8	0,0015	0,29	0,0123	0,4691	0,5288	0,0022
3a. Actual value	SAUC	Med	6	0,5119	0,557	0,3097	0,0669	-2,5	0,5592	1,30	0,0669	0,1977	0,0618	0,7404
3b. Actual value	SAUC	Med	6	0,6180	0,492	0,2424	0,0394	0,9	0,7095	0,90	0,0394	0,1229	0,0234	0,8537
4a. Potential value	SAUC	Med	6	0,9895	0,082	0,0067	0,0000	-6,8	0,0005	1,75	0,0000	0,8525	0,1409	0,0065
4b. Potential value	SAUC	Med	6	0,9776	0,119	0,0142	0,0001	-2,5	0,0195	1,30	0,0001	0,6588	0,2530	0,0882
5. Capitalised value	SAUC	Med	4	0,9491	0,095	0,0090	0,0171	5,4	0,0036	0,34	0,0171	0,4459	0,5491	0,0050
6a. Expectation value	SAUC	Med	6	0,9717	0,134	0,0180	0,0002	-1,9	0,0527	1,24	0,0002	0,3974	0,3709	0,2317
6b. Expectation value	SAUC	Med	6	0,9704	0,137	0,0188	0,0002	-10,5	0,0016	2,16	0,0002	0,8395	0,1481	0,0124
7a. Sustainability value	SAUC	Med	6	0,9331	0,206	0,0425	0,0011	-1,6	0,2108	1,20	0,0011	0,1305	0,2909	0,5787
7b. 23.4 years/2.52%	SAUC	Low	6	0,9365	0,188	0,0352	0,0010	-1,3	0,2430	1,16	0,0010	0,4224	0,1557	0,4220
7c. 39.7 years/4.27%	SAUC	High	6	0,8995	0,263	0,0691	0,0025	-1,0	0,4814	1,12	0,0025	0,0584	0,1116	0,8301

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