Article

Two Manifestations of Market Premium in the Capitalization of Carbon-Forest Estates

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Abstract: The effect of capitalization premium in forest estate markets on forest management and climate change mitigation economics is investigated. It is shown that proportional goodwill in capitalization induces linear scaling of the financial return, without any contribution to sound management practices. However, there is a financial discontinuity as harvesting deteriorates goodwill. On the contrary, capitalization premium set on bare land as a tangible asset would increase timber storage and carbon sequestration. Observations indicate that the proportional goodwill is closer to reality within the Nordic Region, resulting in continuity problems but a reduced capital expense for carbon storage.

Keywords: capital return rate; expected value; carbon storage; carbon rent

1. Introduction

During the third millennium, forest estates have been lucrative investments [1,2,3,4,5,6,7,8,9]. Proceedings from timber sales have developed conservatively or declined [10,11,12,13], but there has been a significant development in the valuation of estates [2,5,8,9]. The popularity of forests as investments probably has been related to declining market interest rates, impairing yields from interest-bearing instruments [14,15]. In other words, it is suspected that the inflated capitalizations are due to factors external to the forestry business [cf. 16,17,18,19,20]. It also is worth noting that vertical integration within the forestry sector might, at least in principle, induce a valuation premium for forest estates [25,2]. A third factor is that private-equity timberland often appears as a favorable component in diversified portfolios [21,2,22,23].

The positive development of the valuation of forest estates obviously has been related to an ownership change. In North America and in the Nordic Countries, forest products companies have divested forest land to institutions concentrating within the business of investing [24,25,1,2]. Recently, forestry institutions have dominated the estate market in comparison to private individuals [26,9,7]. For climate change mitigation purposes, some institutions include carbon sequestration in their business strategies [27,28]. However, enhanced carbon sequestration generally induces a deficiency in the gained financial benefit [29,30,31,32,33].

Computational methods of financial economics have recently been applied in the analysis of forestry investments. Capital Asset Pricing Model (CAPM), as well as Arbitrage Pricing Theory (APT) have been applied [24,2]. However, private-equity timberland returns are poorly explained by CAPM [24,2], even if stumpage prices appear to support timberland returns [34]. Improving investor sentiment impairs timberland returns [35]. The APT is a very complicated approach, including an intuitive selection of explaining factors. It appears to be able to reproduce differences between geographic areas, as well as temporal effects, provide the timberland returns are used to explain themselves [24].

The increased and possibly increasing capitalizations contribute to the financial return in operative forestry. Greater valuation inevitably reduces the return of capital invested. The greater valuations may or may not contribute to the economically feasible management practices. However, change of valuations necessarily contributes to the financial burden induced by economically suboptimal actions like enhanced carbon sequestration, biodiversity advancement, or recreational modifications.

Instead of merely referring to average market prices of forest estates, we will discuss valuations in terms of tangible and intangible value components appearing on forest stands and estates: trees, land, amortized investments, and eventual goodwill values. Such an insight will enable considerations of the eventual effect of economically feasible management practices on stand level and on estate level.

Two manifestations of inflated capitalization in forest estates are discussed. One manifestation contributes to the economically feasible management procedures, as the other one does not. Any of the two manifestations contribute to the financial return of operations, as well as to the expense of enhanced carbon sequestration. Interestingly, one of the manifestations results in a financial discontinuity, severely problematizing operative forestry.

In the remaining part of this paper, we will first review the financial theory, and develop it further for the discussion of inflated capitalization. Then, experimental materials are described. Third, the effect of inflated capitalization on capital return rate, capitalization per hectare, and the expense of enhanced timber storage is discussed. The enhanced timber storage is introduced in terms of restrictions to thinning practices. Finally, the observations are arranged in relation to a common reference, resulting as the financial feasibility of different management actions on enhanced carbon sequestration under the two manifestations of inflated capitalization.

2. Materials and Methods

2.1. Financial considerations

We apply a procedure first mentioned in the literature in 1967, but applied only recently [36,37,38,39,40,41,42,32,33]. Instead of discounting revenues, the capital return rate achieved as relative value increment at different stages of forest stand development is weighed by current capitalization, and integrated.

The capital return rate is the relative time change rate of value. We choose to write

$$r(t) = \frac{d\kappa}{K(t)dt} \tag{1}$$

where κ in the numerator considers value growth, operative expenses, interests, and amortizations, but neglects investments and withdrawals. In other words, it is the change of capitalization on an economic profit/loss basis. K in the denominator gives capitalization on a balance sheet basis, being directly affected by any investment or withdrawal. Technically, K in the denominator is the sum of assets bound on the property: bare land value, the value of trees, and non-amortized value of investments. In addition, intangible assets may appear. The pricing of forest estates may include goodwill value.

The momentary definition appearing in Eq. (1) provides a highly simplified description of the capital return rate. In reality, there is variability due to a number of factors. Enterprises often contain businesses distributed to a variety of production lines, geographic areas, and markets. In addition, quantities appearing in Eq. (1) and are not necessarily completely known but may contain probabilistic scatter. Correspondingly, the expected value of capital return rate and valuation can be written, by definition,

$$\langle r(t)\rangle = \frac{\int p_{\frac{d\kappa}{dt}} \frac{d\kappa}{dt} d\frac{d\kappa}{dt}}{\int p_K K(t) dK} = \frac{\int p_{\frac{d\kappa}{dt}} r(t) K(t) d\frac{d\kappa}{dt}}{\int p_K K(t) dK} \tag{2}$$

where p_i corresponds to the probability density of quantity *i*.

Let us then discuss, the determination of capital return rate in the case of a real estate firm benefiting from the growth of multiannual plant stands of varying ages. Conducting a change of variables in Eq. (3) results as

$$\langle r(t)\rangle = \frac{\int p_a(t) \frac{d\kappa}{dt}(a,t) da}{\int p_a(t) K(a,t) da} = \frac{\int p_a(t) r(a,t) K(a,t) da}{\int p_a(t) K(a,t) da} \tag{3}.$$

where *a* refers to stand age. Eq. (3) is a significant simplification of Eq. (2) since all probability densities now discuss the variability of stand age. However, even Eq. (3) can be simplified further.

In Eq. (3), the probability density of stand age is a function of time, and correspondingly the capital return rate, as well as the estate value, evolve in time. A significant simplification would occur if the quantities appearing on the right-hand side of Eqs. (2) and (3) would not depend on time. Within forestry, such a situation would be denoted "normal forest principle", corresponding to evenly distributed stand age determining relevant stand properties [43].

$$\langle r(t)\rangle = \frac{\int \frac{d\kappa}{dt}(a) da}{\int K(a) da} = \frac{\int r(a) K(a) da}{\int K(a) da} \tag{4}.$$

The "normal forest principle" is rather useful when considering silvicultural practices, but seldom applies to the valuation of real-life real estate firms, with generally non-uniform stand age distribution. However, it has recently been shown [32] that the principle is not necessary for the simplification of Eq. (3) into (4). This happens by focusing on a single stand, instead of an entire estate or enterprise, and considering that time proceeds linearly. Then, the probability density function *p(a)* is constant within an interval [0,τ]. Correspondingly, it has vanished from Eq. (4).

Application of Eqs. (1) to (4) does require knowledge of an amortization schedule. Here, regeneration expenses are capitalized at the time of regeneration and amortized at the end of any rotation [42].

By definition, inflation of capitalization corresponds to the emergence of a surplus in the capitalization *K* appearing in the denominator of Eqs. (1) to (4). Simultaneously, the value change rate ${d\kappa}/{dt}$ in the numerator may or may not become affected.

Before discussing the details of inflated capitalization, a periodic boundary condition is given as

$$\int_a^{a+\tau} \frac{dK}{dt} dt = 0 \qquad (5),$$

where τ is rotation age. On the other hand, the value growth rate sums up as free cash flow as

$$\int_a^{a+\tau} \frac{d\kappa}{dt} dt = \int_a^{a+\tau} \frac{dC}{dt} dt \qquad (6),$$

where dC/dt refers to the rate of free cash flow.

Let us then discuss a few possible manifestations of inflated capitalization. First, one must recognize that the free cash flow is due to sales of products and services and is not directly affected by inflation of estate capitalization. Secondly, it is found from Eq. (1) to (4) that provided the capitalization K and the value change rate $d\kappa/dt$ are affected similarly, the capital return rate is invariant, and does not trigger changes in management practices. Then, however, Eq. (6) is apparently violated. It must be complemented as

$$\int_a^{a+\tau} \frac{d\kappa}{dt} dt = \int_a^{a+\tau} \frac{dC}{dt} dt + \int_a^{a+\tau} \frac{dD}{dt} dt \qquad (7),$$

where dD/dt refers to the rate of intangible market premium. The intangible market premium however can be liquidized only on the real estate market, not on the timber market. Unless the real estate market is exploited, the closed integral under periodic boundary conditions

$$\int_a^{a+\tau} \frac{dD}{dt} dt = 0 \qquad (8).$$

Further, the change rate of capitalization can be decomposed as

$$\frac{dK}{dt} = \frac{d\kappa}{dt} - \frac{(dC + dD)}{dt} + \frac{dI}{dt} \qquad (9),$$

where $\frac{dI}{dt}$ is the rate of capitalized investments. Eq. (9) shows that the intangible market premium deteriorates along with harvesting. In accordance with Eqs. (7) and (8), with periodic boundary conditions, the closed integral

$$\int_a^{a+\tau} \frac{d\kappa}{dt} dt \qquad (10),$$

cannot retain intangible market premium unless the real estate market is exploited in the creation of revenue, instead of merely harvesting. As any accumulated premium deteriorates with harvesting, negative value change rates must appear along with harvesting.

Considering a scaling factor (1+*u*) for capitalization K and the value change rate $d\kappa/dt$, the expected value of capital return rate may approach

$$\langle r' \rangle = \frac{\int_a^{a+\tau} \frac{d\kappa'}{dt} dt}{\int_a^{a+\tau} K' dt} = \frac{\int_a^{a+\tau} (1+u)\frac{d\kappa}{dt} dt}{\int_a^{a+\tau} (1+u)K dt} = \frac{\int_a^{a+\tau} \frac{d\kappa}{dt} dt}{\int_a^{a+\tau} K dt} = \langle r \rangle \qquad (11),$$

if goodwill premium on the real estate market is fully exploited. However, if the cash flow is created by timber sales only, capitalization premium deteriorates with harvesting, and the expected value of capital return rate becomes

$$\langle r'\rangle = \frac{\int_a^{a+\tau} \frac{d\kappa'}{dt} dt}{\int_a^{a+\tau} K' dt} = \frac{\int_a^{a+\tau} \frac{d\kappa}{dt} dt}{(1+u)\int_a^{a+\tau} K dt} \qquad (12).$$

It is of interest that Eq. (11) at best retains the capital return rate, which however requires effective exploitation of the real estate market. It is also worth noting that even if Eq. (11) is the same as Eq. (4), the numerical value of the capital return rate generally is not the same. Deterioration of intangible goodwill in harvesting is avoided only in the absence of thinnings, and omission of thinnings generally contributes to the capital return rate.

Eq. (12) performs a linear scaling of the capital return rate by the inverse of the capitalization scaling. Any of the two cases retain management practices in terms of optimal rotation ages and thinning schedules.

A capitalization premium does not need to be intangible. A tangible asset able to absorb a premium while timber prices and sales proceedings are retained is the bare land. Such capitalization premium does not affect the value change rate in the numerator of Eqs. (1) to (4). On the other hand, other components but the bare land in the denominator being retained, the effect on the expected value of capital return rate depends on the proportions of the capitalization components. Correspondingly, there is no linear scaling of Eqs. (1) to (4), and the feasible management practices like rotation ages and thinning schedules are not retained along with changed bare land valuation.

2.2. The two datasets applied

Two different sets of initial conditions have been described in four earlier investigations [44,41,42,32]. Firstly, seven wooded, commercially unthinned stands in Vihtari, Eastern Finland, were observed at the age of 30 to 45 years. The total stem count varied from 1655 to 2451 per hectare. A visual quality approximation was implemented. The number of stems deemed suitable for growing further varied from 1050 to 1687 per hectare. The basal area of the acceptable-quality trees varied from 28 to 40 m^2/ha, in all cases dominated by spruce (*Picea abies*) trees.

As the second set of initial conditions, a group of nine setups was created, containing three tree species and three initial sapling densities [42]. The idea was to apply the inventory-based growth model as early in stand development as it is applicable, to avoid approximations of stand development not grounded on the inventory-based growth model [45]. This approach also allowed an investigation of a wide range of stand densities, as well as a comprehensive description of the application of three tree species. The exact initial conditions here equal the ones recommended in [42], appearing there in Figures 8 and 9.

The two manifestations of inflated capitalization discussed above are applied to both datasets. Firstly, a proportional goodwill (1+u) = (1+1/2) is applied according to Eq. (12). Secondly, a bare land value inflated by a factor (1+p) = (1+3) is applied in Eqs. (1) to (4). Both inflation factors are arbitrary. However, they are based on recent observations [5,7,9], including very recent observations by the author: large, productive forest estates appear to change owners at 150% of fair forestry value determined by professionals.

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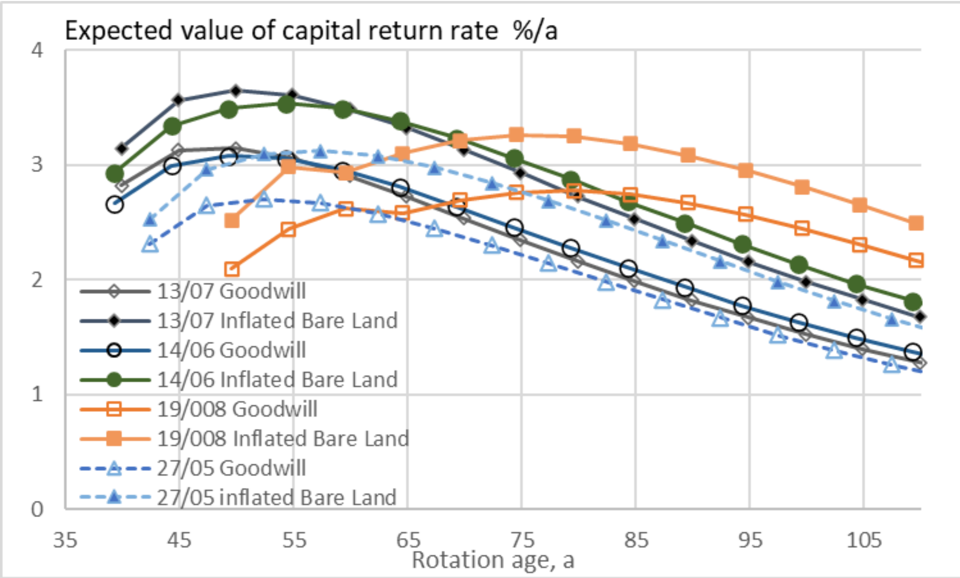
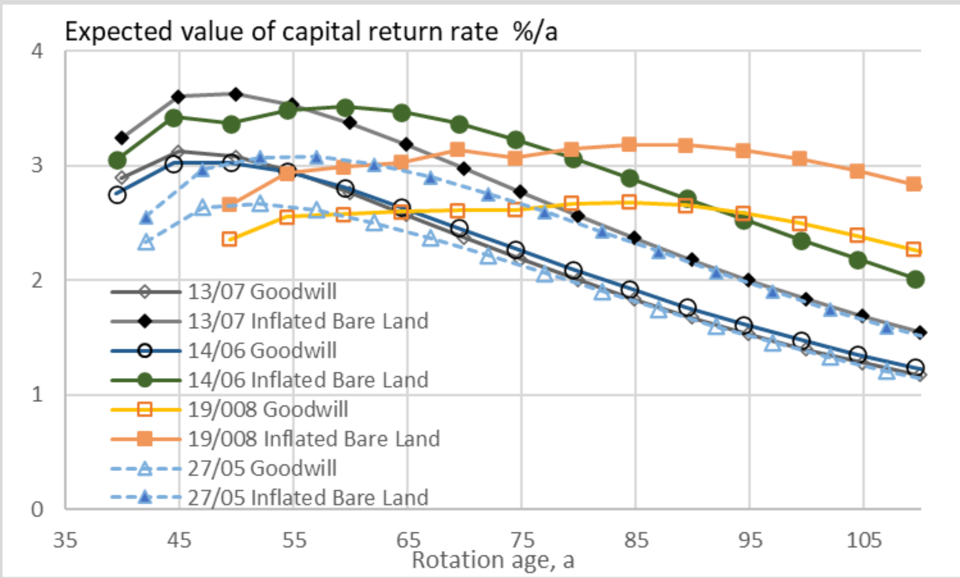
3. Results

Figs. 1 and 2 show the expected value of the capital return rate within seven stands first observed at the age of 30 to 45 years, in the presence of inflated capitalization and eventual thinning restrictions. Inflated bare land value yields greater capital return rates than proportional goodwill. The proportional goodwill retaining rotation times, inflated bare land value often increases rotation times. Thinning restrictions somewhat reduce the capital return rate and shorten rotation times. However, there are cases where thinnings restricted to the removal of large trees only increase rotation times.





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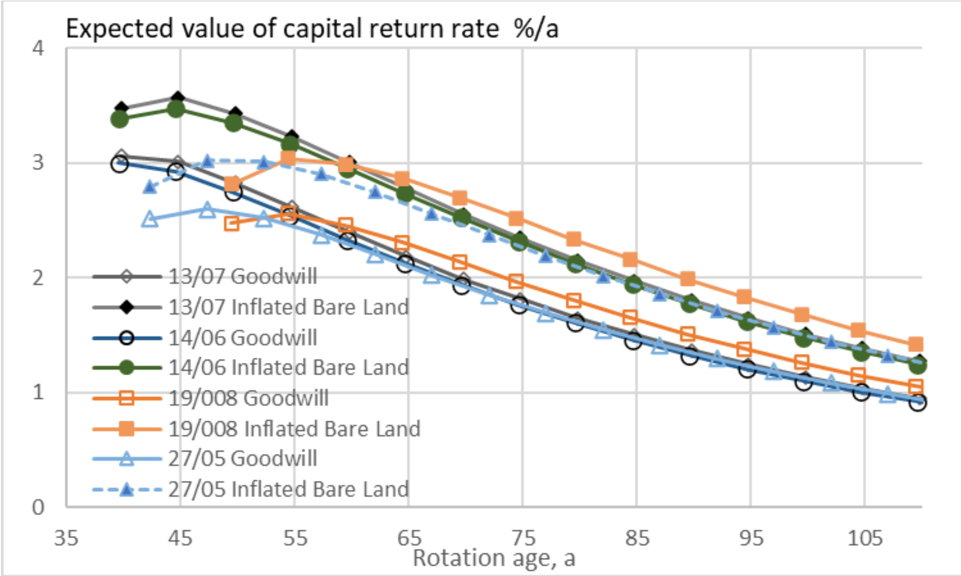

Figure 1. The expected value of capital return rate, as a function of rotation age, when the growth model is applied to four observed wooded stands, without any thinning restriction (Fig. 1a), good-quality trees of at least 238 mm of diameter only removed in thinning (1b), and without any commercial thinning (1c). Inflated capitalization is introduced either as proportional goodwill or as inflated bare land value.

Figs. 1 and 2 show the expected value of the capital return rate within seven stands first observed at the age of 30 to 45 years, in the presence of inflated capitalization and eventual thinning restrictions. Inflated bare land value yields greater capital return rates than proportional goodwill. The proportional goodwill retaining rotation times, inflated bare land value often increases rotation times. Thinning restrictions somewhat reduce the capital return rate and shorten rotation times. However, there are cases where thinnings restricted to the removal of large trees only increase rotation times.

Figs. 3, 4, and 5 show the expected value of the capital return rate within stands of three tree species where the growth model is applied as early as applicable. Again, inflated bare land value yields slightly greater capital return rates than proportional goodwill. The proportional goodwill retaining rotation times, inflated bare land value generally increases rotation times. It is found that rotation times maximizing capital return rate become the shorter the stronger are the thinning restrictions.

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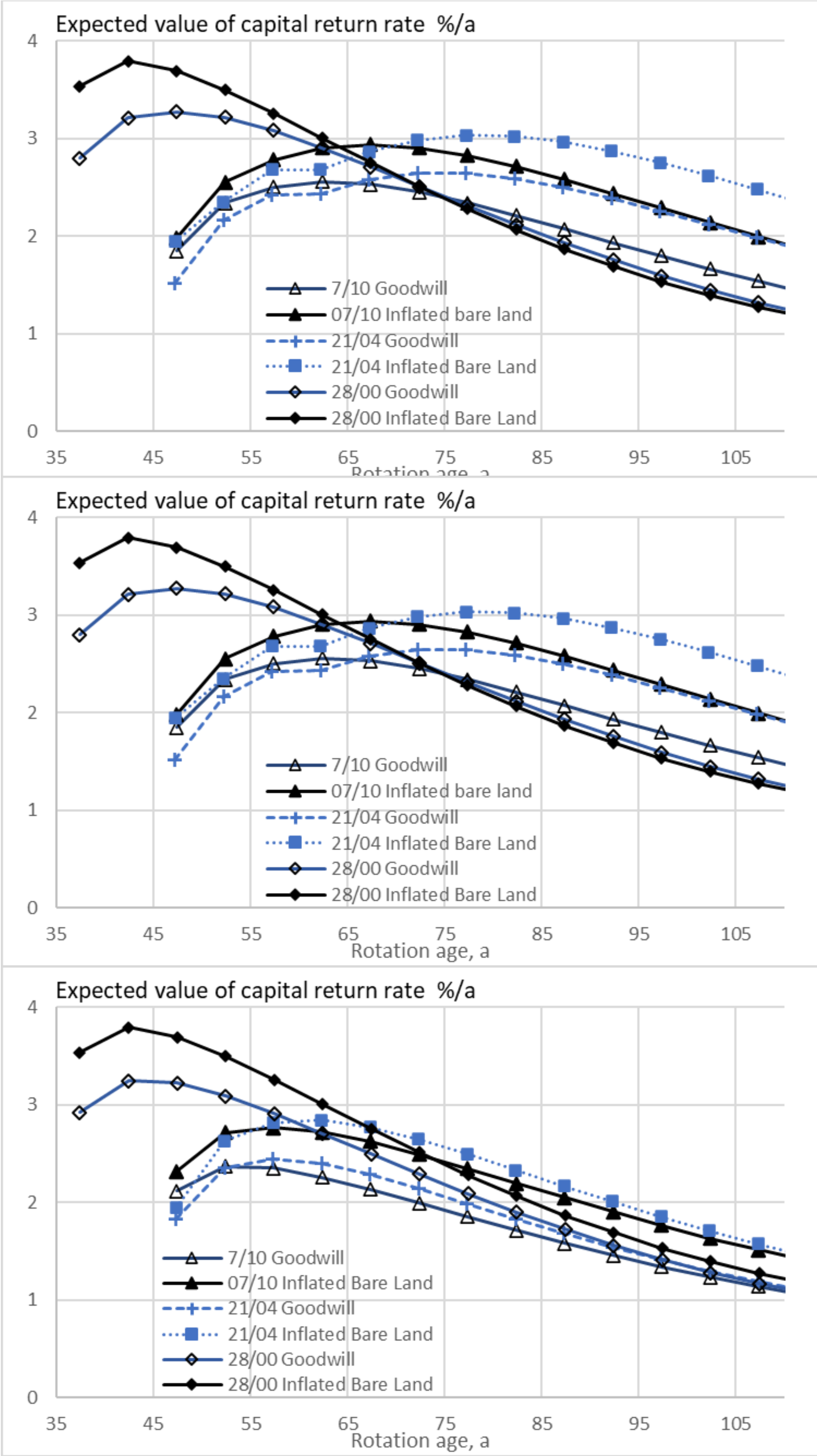
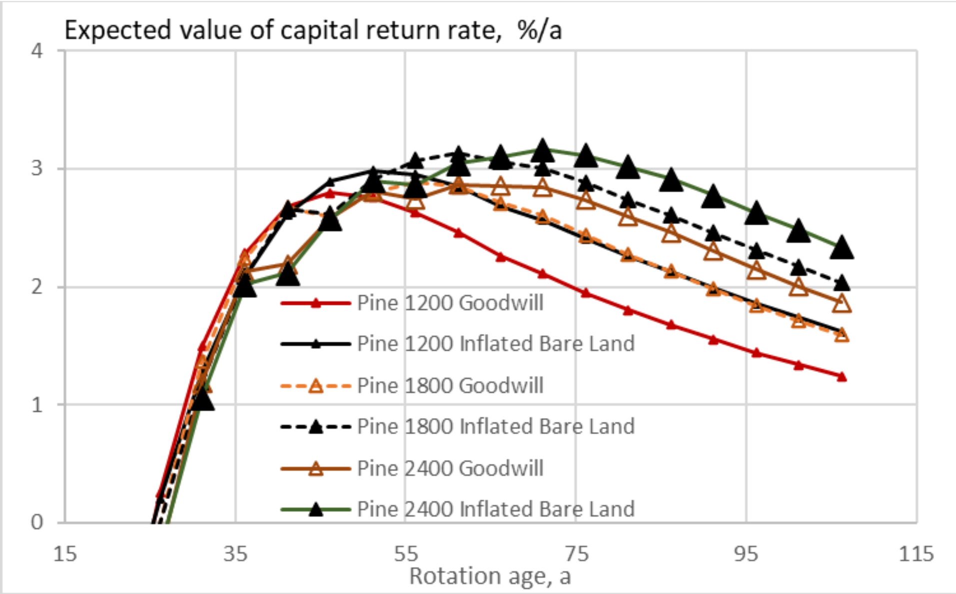
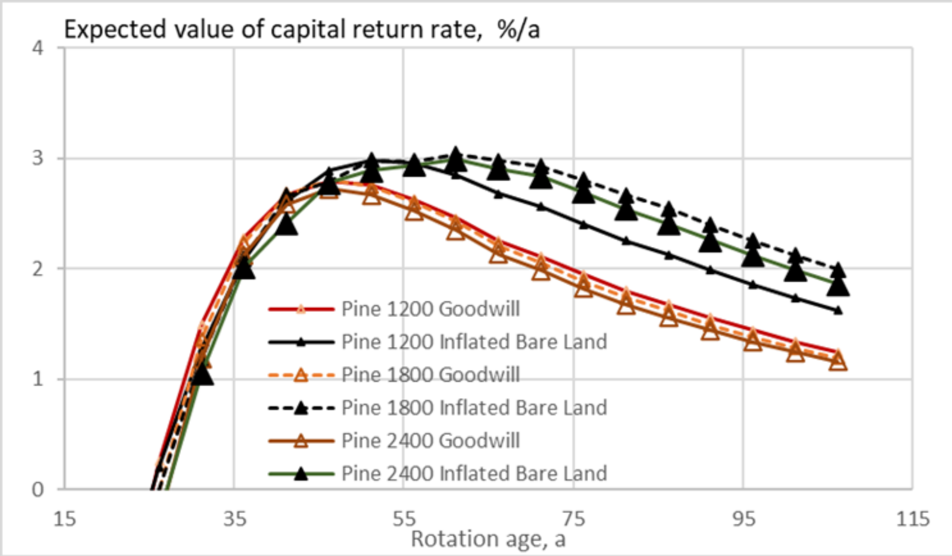


Figure 2. The expected value of capital return rate, as a function of rotation age, when the growth model is applied to three observed wooded stands, without any thinning restriction (Fig. 2a), good-quality trees of at least 238 mm of diameter only removed in

thinning (2b), and without any commercial thinning (2c). Inflated capitalization is introduced either as proportional goodwill or as inflated bare land value.





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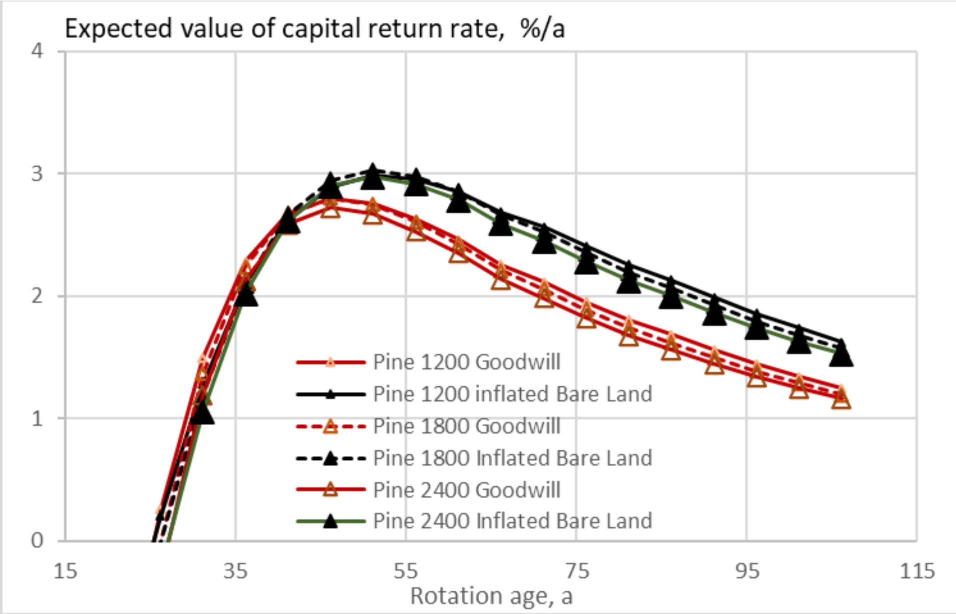
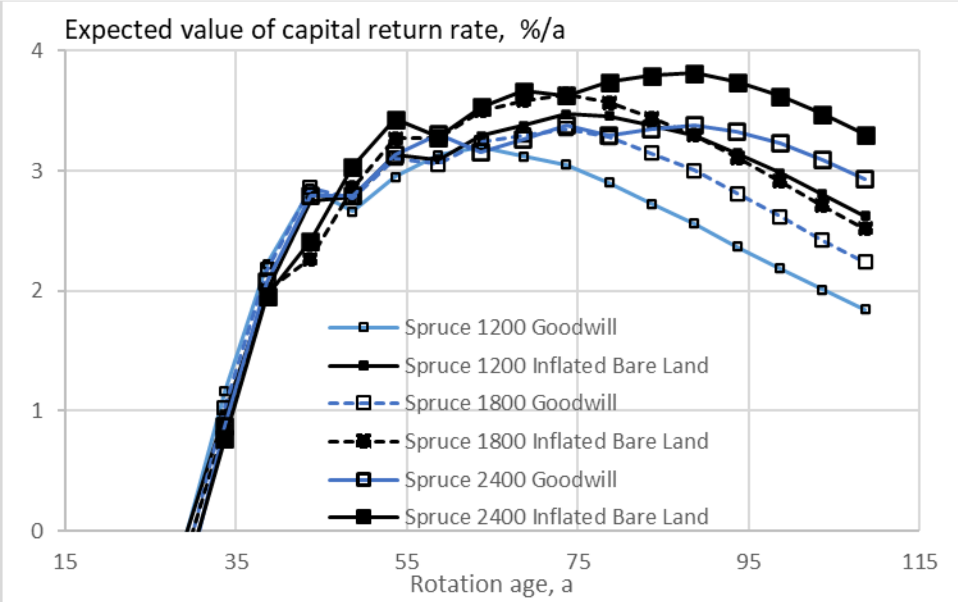
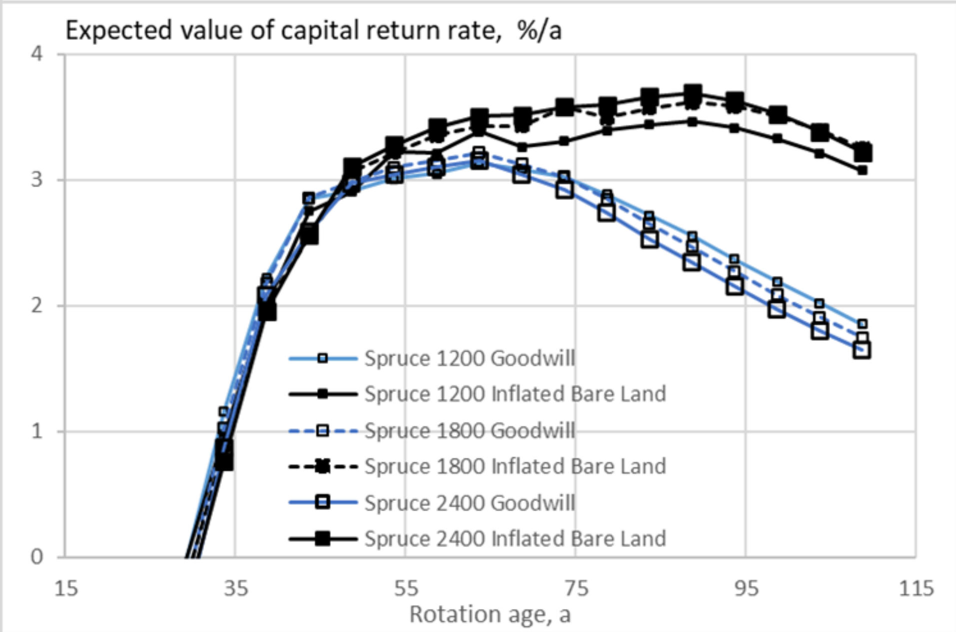


Figure 3. Figure 3. The expected value of capital return rate on pine (*Pinus sylvestris*) stands of different initial sapling densities, as a function of rotation age, when the growth model is applied as early as applicable, without any thinning restriction (Fig. 3a), good-quality trees of at least 238 mm of diameter only removed in thinning (3b), and without commercial thinning (3c). Inflated capitalization is introduced either as proportional goodwill or as inflated bare land value.


Expected value of capital return rate, %/a
4
3
2
1
0
15
35
55
75
95
115
Rotation age, a
Spruce 1200 Goodwill
Spruce 1200 Inflated Bare Land
Spruce 1800 Goodwill
Spruce 1800 Inflated Bare Land
Spruce 2400 Goodwill
Spruce 2400 Inflated Bare Land


Expected value of capital return rate, %/a
4
3
2
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0
15
35
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Rotation age, a
Spruce 1200 Goodwill
Spruce 1200 Inflated Bare Land
Spruce 1800 Goodwill
Spruce 1800 Inflated Bare Land
Spruce 2400 Goodwill
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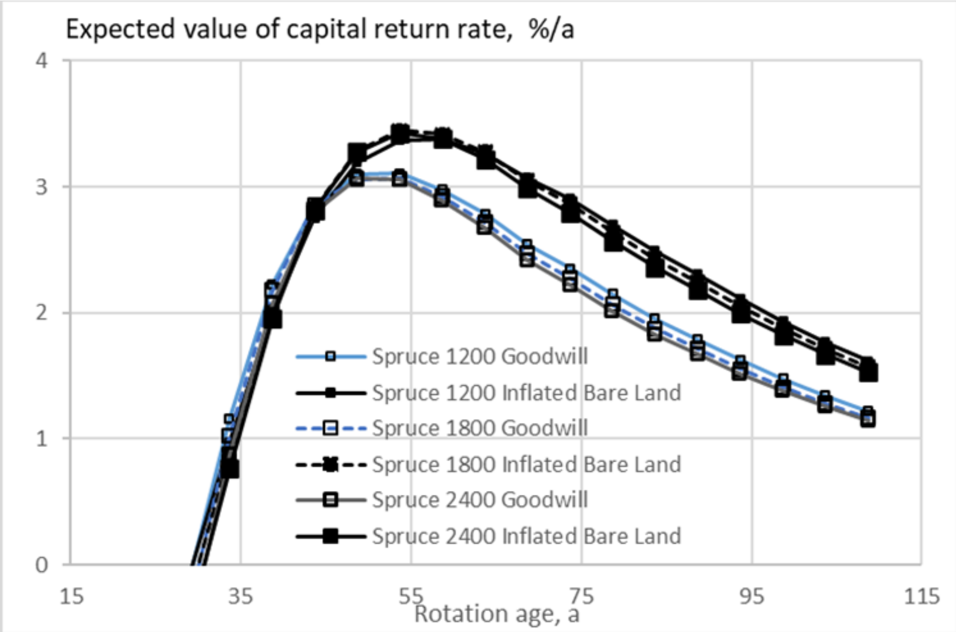

Figure 4. The expected value of capital return rate on spruce stands of different initial sapling densities, as a function of rotation age, when the growth model is applied as early as applicable, without any thinning restriction (Fig. 4a), good-quality trees of at least 238 mm of diameter only removed in thinning (4b), and without commercial thinning (4c). Inflated capitalization is introduced either as proportional goodwill or as inflated bare land value.

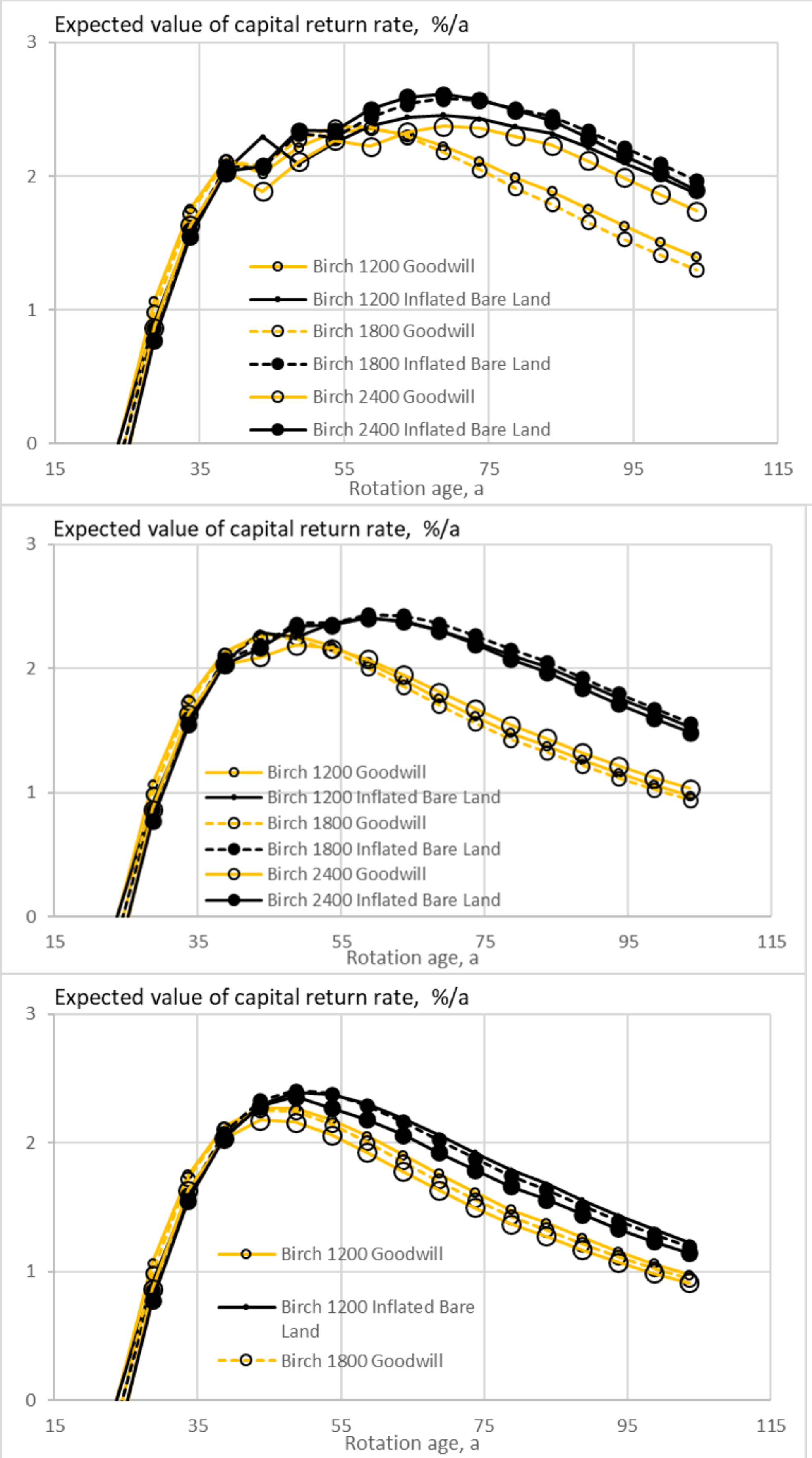

Figure 5. The expected value of capital return rate on birch (*Betula pendula*) stands of different initial sapling densities, as a function of rotation age, when the growth model is applied as early as applicable, without any thinning restriction (Fig. 5a), good-quality

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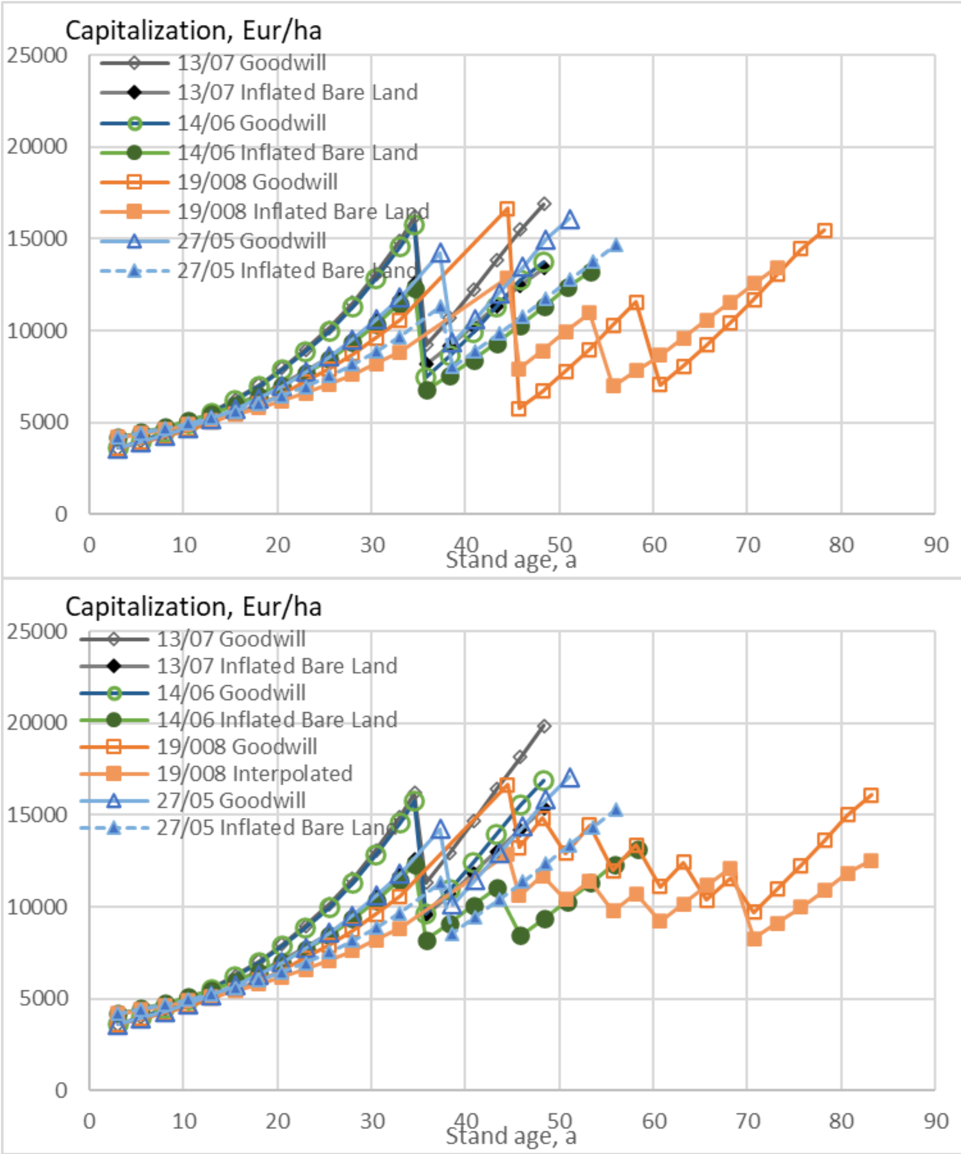
trees of at least 238 mm of diameter only removed in thinning (5b), and without commercial thinning (5c). Inflated capitalization is introduced either as proportional goodwill or as inflated bare land value.

Figs. 6 and 7 show the stand capitalization as a function of stand age within seven stands first observed at the age of 30 to 45 years, in the presence of inflated capitalization and eventual thinning restrictions. Again, the proportional goodwill retaining rotation times, inflated bare land value often increases rotation times. Thinning restrictions mostly shorten rotation times; however, there are cases where thinnings restricted to the removal of large trees only increase rotation times. Despite the generally shorter rotation times, the gentler thinnings slightly increase capitalization.



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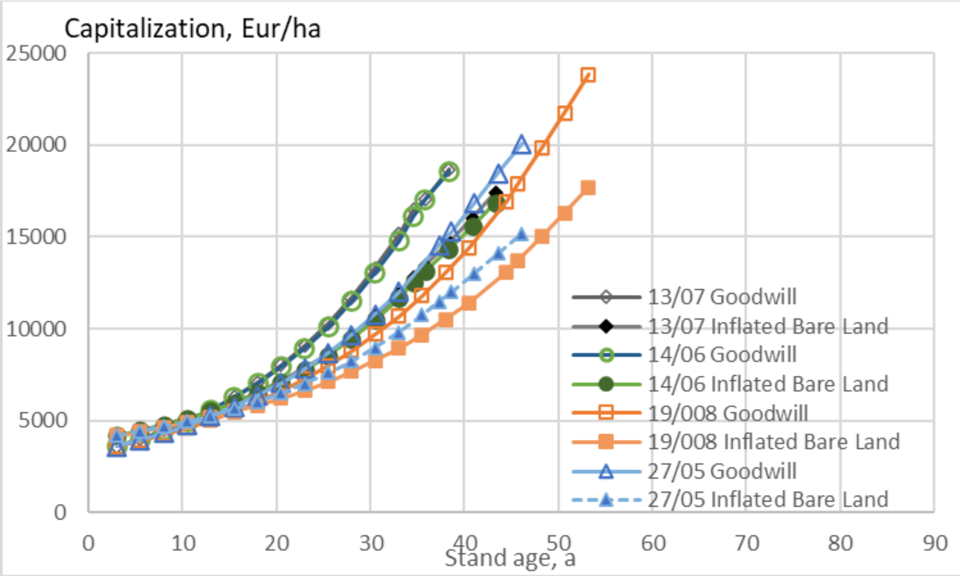

Figure 6. Stand capitalization as a function of stand age, when the growth model is applied to four observed wooded stands, without any thinning restriction (Fig. 6a), good-quality trees of at least 238 mm of diameter only removed in thinning (6b), and without any commercial thinning (6c). Inflated capitalization is introduced either as proportional goodwill or as inflated bare land value.

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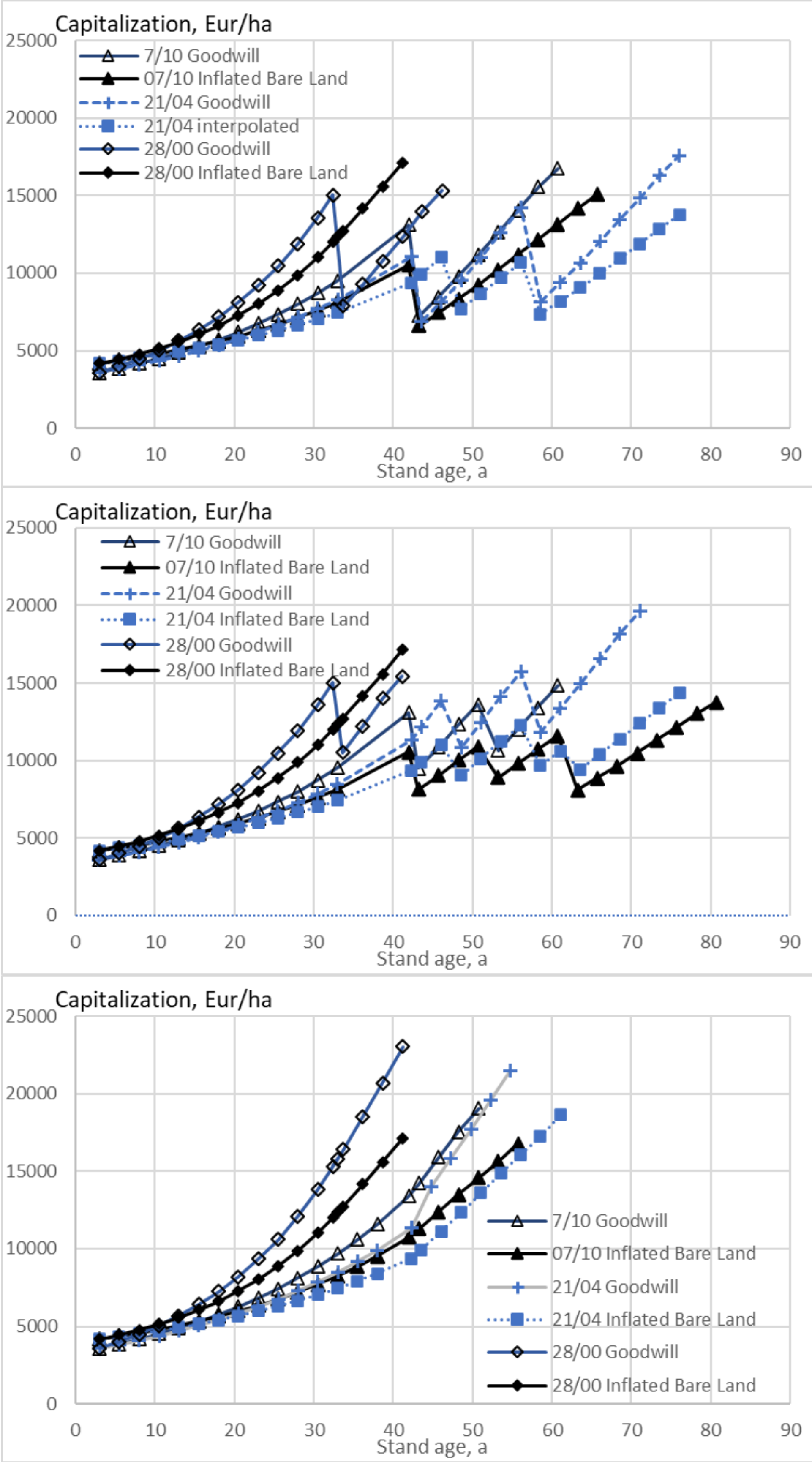
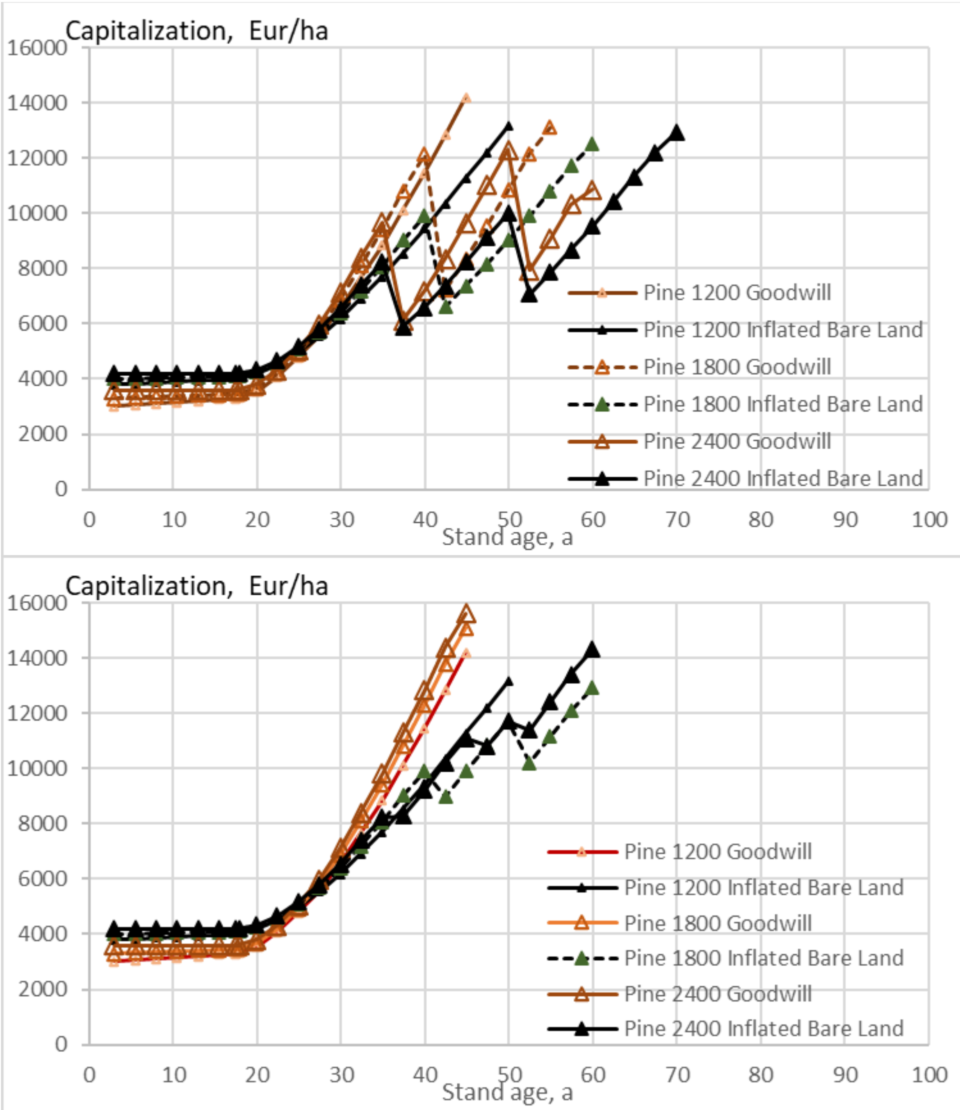


Figure 7. Stand capitalization as a function of stand age, when the growth model is applied to three observed wooded stands, without any thinning restriction (Fig. 7a), good-quality trees of at least 238 mm of diameter only removed in thinning (7b), and

without any commercial thinning (7c). Inflated capitalization is introduced either as proportional goodwill or as inflated bare land value.

Figs. 8, 9, and 10 show the stand capitalization as a function of stand age within stands of three tree species where the growth model is applied as early as applicable, in the presence of inflated capitalization and eventual thinning restrictions. Again, the proportional goodwill retaining rotation times, inflated bare land value generally increases rotation times. Within spruce stands (Fig. 9) there are cases where thinnings restricted to removal of large trees only increase rotation times. At young stand age, inflated bare land gives greater capitalization; at a mature age, the proportional goodwill yields greater capitalization. Thinning restrictions shorten rotations. It is also found that thinning restrictions increase capitalizations.



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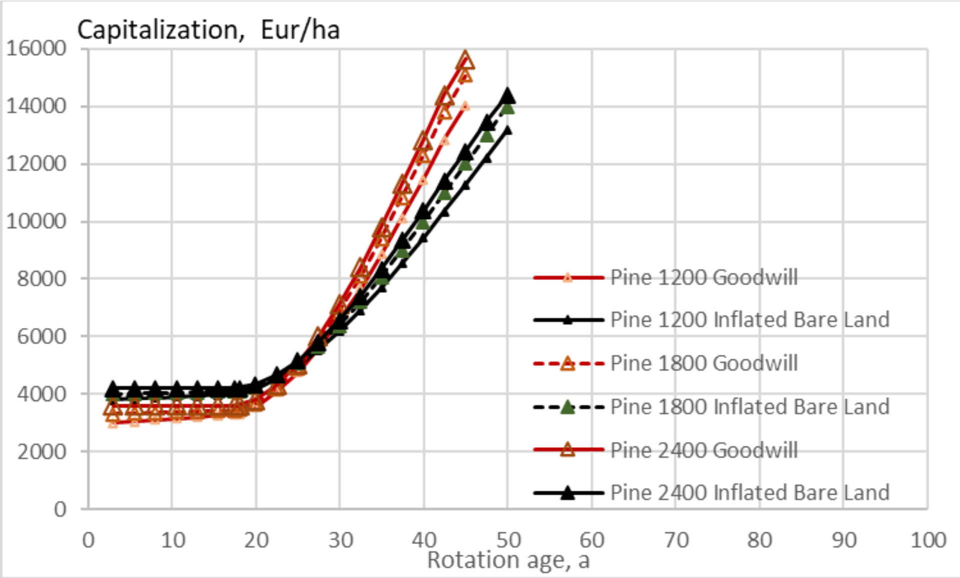

Figure 8. Capitalization on pine stands of different initial sapling densities, as a function of stand age, when the growth model is applied as early as applicable, without any thinning restriction (Fig. 8a), good-quality trees of at least 238 mm of diameter only removed in thinning (8b). Fig. 8b does not contain any commercial thinning. Inflated capitalization is introduced either as proportional goodwill or as inflated bare land value.

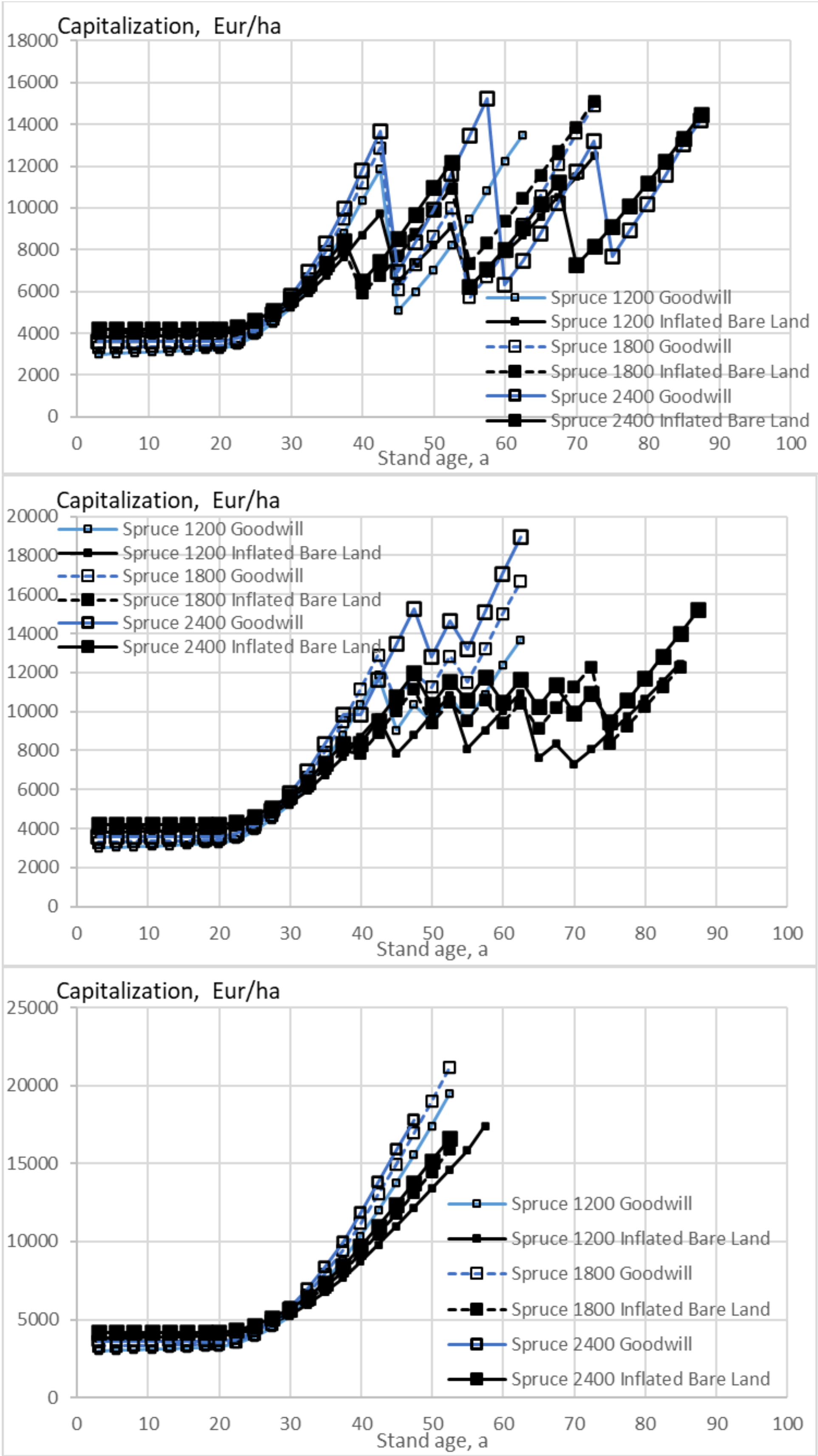

Figure 9. Capitalization on spruce stands of different initial sapling densities, as a function of stand age, when the growth model is applied as early as applicable, without any thinning restriction (Fig. 9a), good-quality trees of at least 238 mm of diameter only removed in thinning (9b), and without any commercial

thinning (9c). Inflated capitalization is introduced either as proportional goodwill or as inflated bare land value.

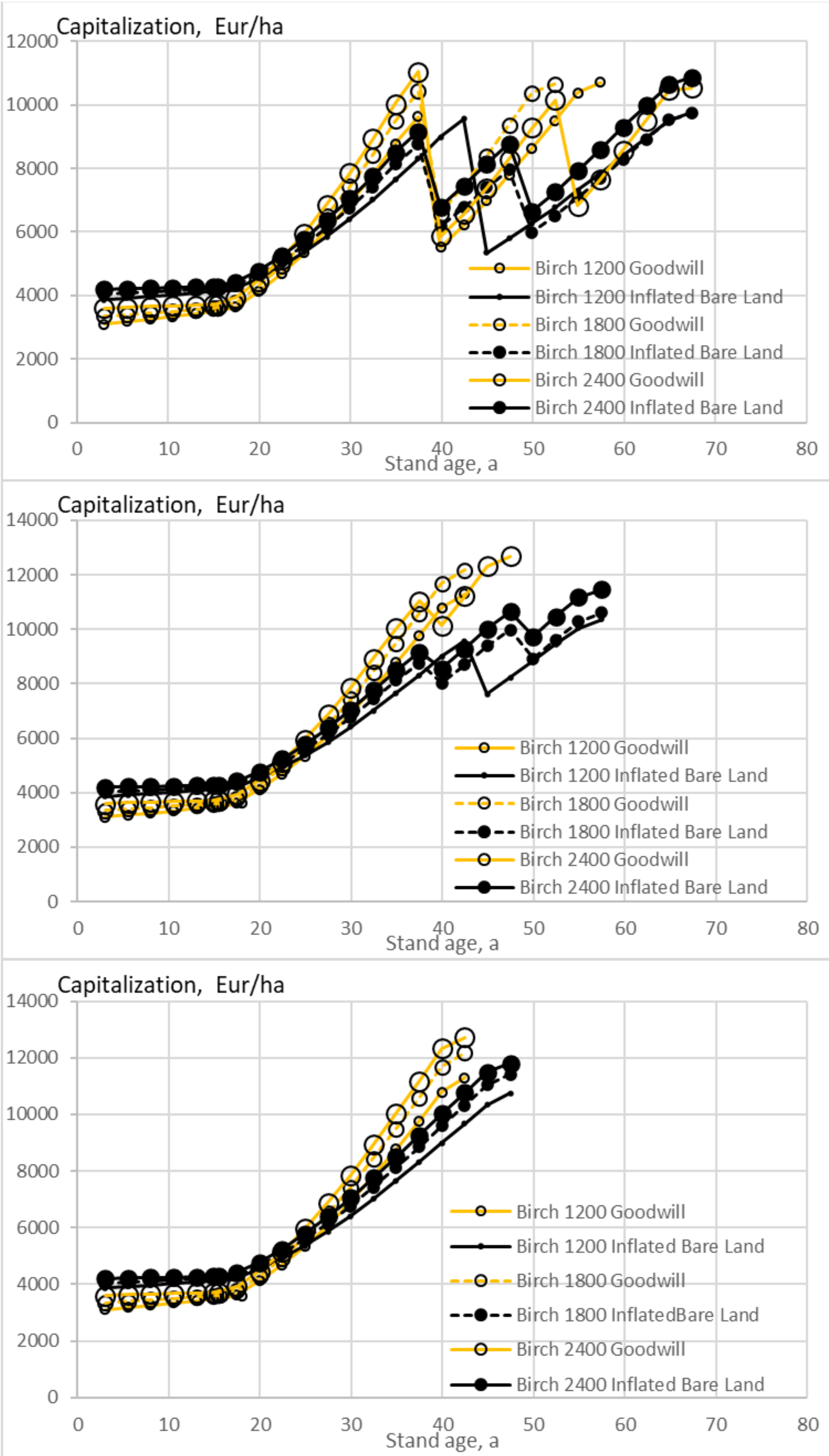

Figure 10. Capitalization on birch stands of different initial sapling densities, as a function of stand age, when the growth model is applied as early as applicable,

without any thinning restriction (Fig. 10a), good-quality trees of at least 238 mm of diameter only removed in thinning (10b), and without any commercial thinning (10c). Inflated capitalization is introduced either as proportional goodwill or as inflated bare land value.

In the absence of any thinning restrictions, management procedures maximizing the capital return rate correspond to a particular expected value of commercial timber appearing per hectare. Such average timber storage is shown in Fig. 11, for the seven stands observed at the age of 30 to 45 years, and in the case of the nine setups where the growth model is applied as early as possible. It is found that the application of inflated bare land value (vertical axis) increases the expected value of stand volume by 2% to 23%. The magnitude of the increment does depend on the magnitude of bare land value inflation, and its variability is greater in the first dataset. The greatest relative increment occurs when inflated bare land value results in the omission of a thinning. On the other hand, the application of the proportional goodwill (horizontal axis) does not contribute to the timber storage, as indicated by Eq. (12). It is, however, worth noting that if Eq. (11) would be applied, the timber storage would be affected due to the omission of thinnings.

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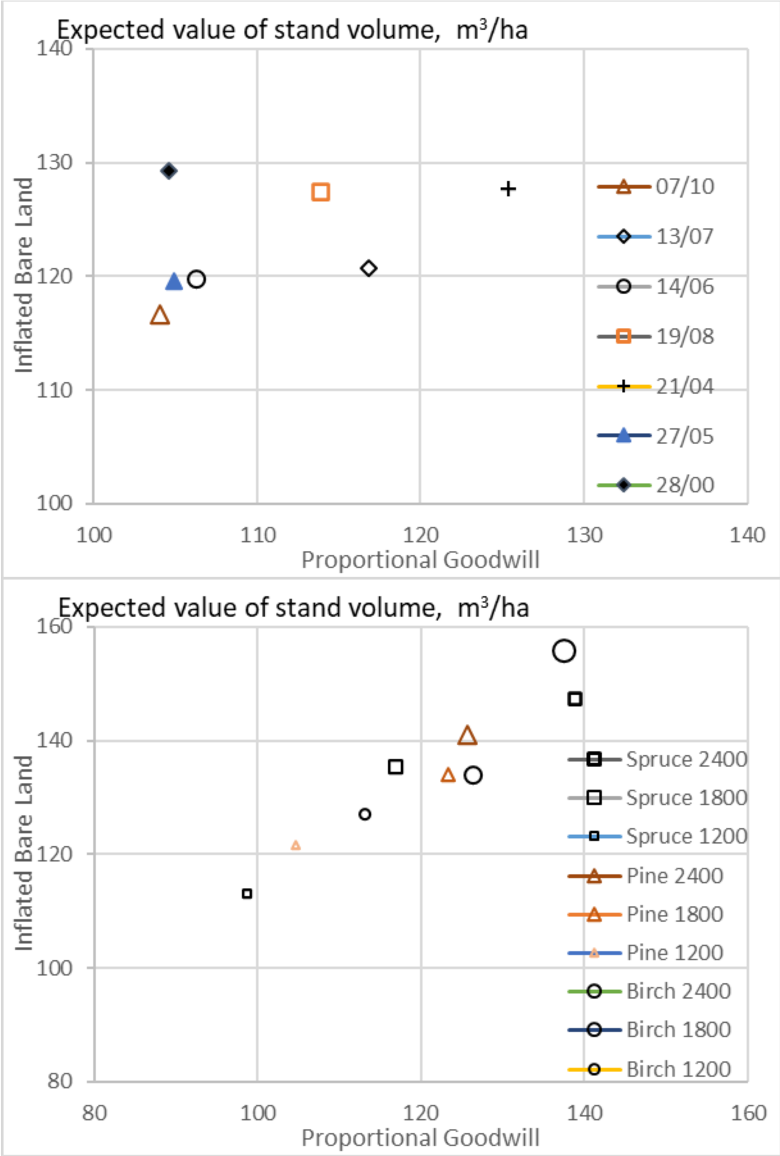
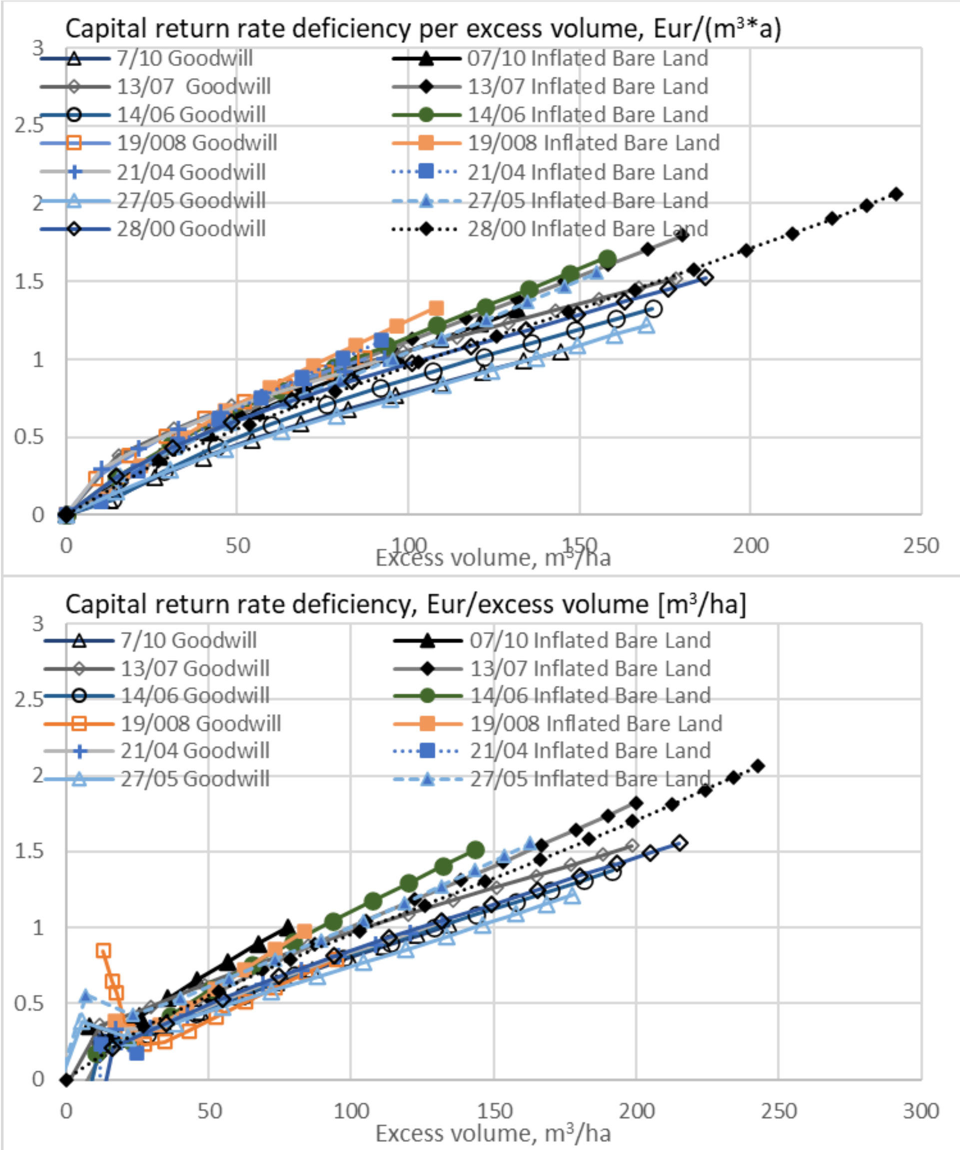


Figure 11. The expected value of commercial stand volume within the two manifestations of inflated capitalization, without any thinning restrictions, for the two datasets.

Any deviation from the procedures corresponding to the maximum capital return rate induces a deficiency in capital return rate. Annual monetary deficiency per hectare can be gained by multiplying the deficiency in percentage per annum by current capitalization per hectare. Any deviation from the procedures corresponding to the maximum capital return rate also changes the expected value of the volume of trees per hectare. In case the volume is greater than that volume corresponding to the maximum capital return rate, there is a positive expected excess volume (also a negative excess volume may appear). The annual monetary deficiency per hectare can be divided by the excess volume to yield a measure of the financial burden of increasing the timber stock.

Fig. 12 shows the expected value of the capital return rate deficiency per excess volume unit as a function of excess volume, within seven stands first observed at the age of 30 to 45 years, in the presence of inflated capitalization and eventual thinning restrictions. The proportional goodwill showing greater capitalization in Figs. 6 and 7, and correspondingly smaller capital return rate in Figs. 1 and 2, shows a smaller deficiency. It is worth noting that the deficiency is inversely proportional to the goodwill correction, as indicated in Eq. (12). Thinning restrictions reduce the deficiency and increase available excess volume. Thinnings restricted to trees larger than 237 mm diameter show the smallest deficiency with moderate excess volume, while the omission of thinnings shows the smallest deficiency at large excess volumes.



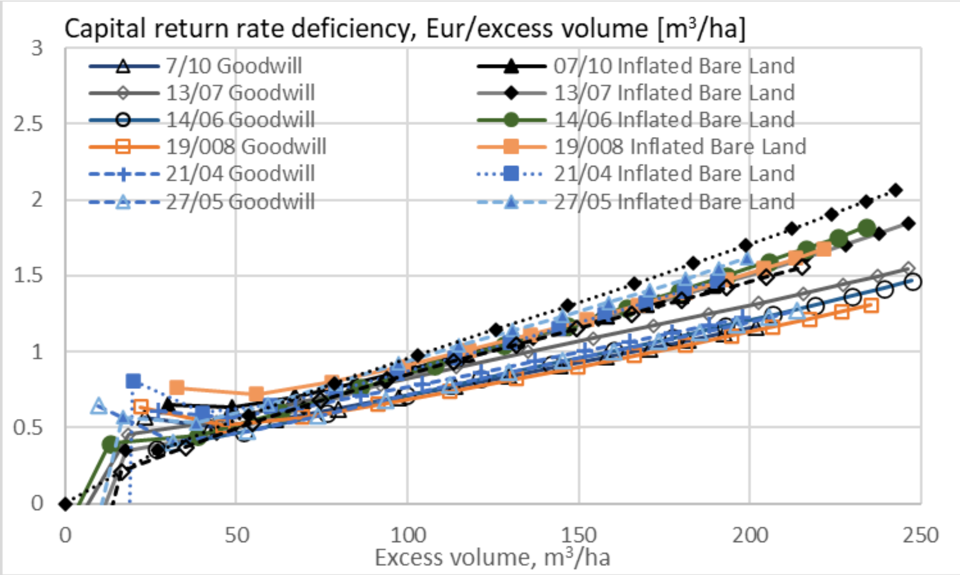
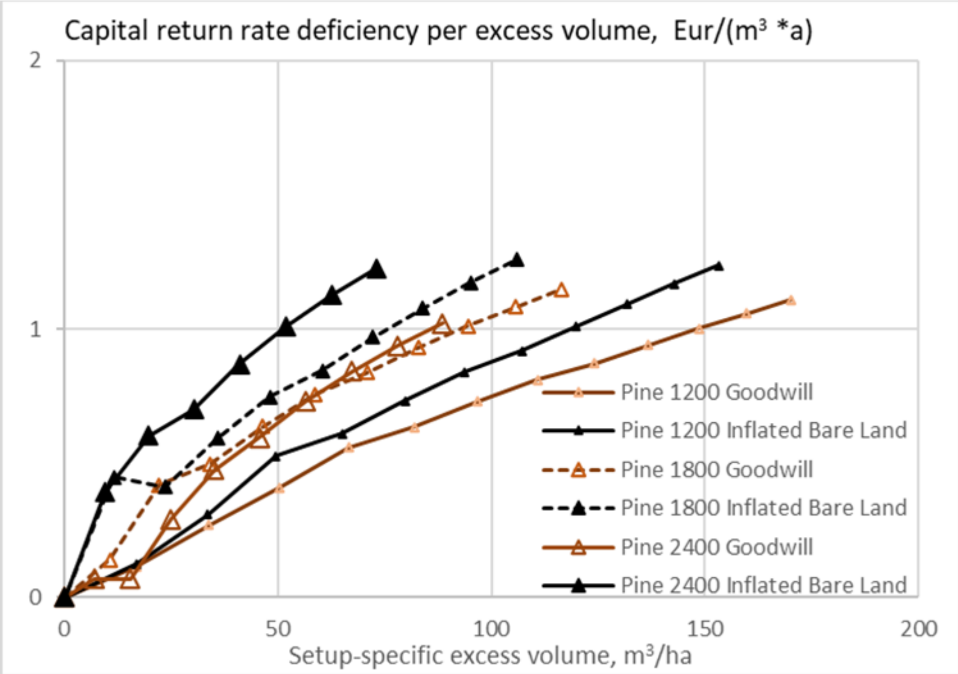
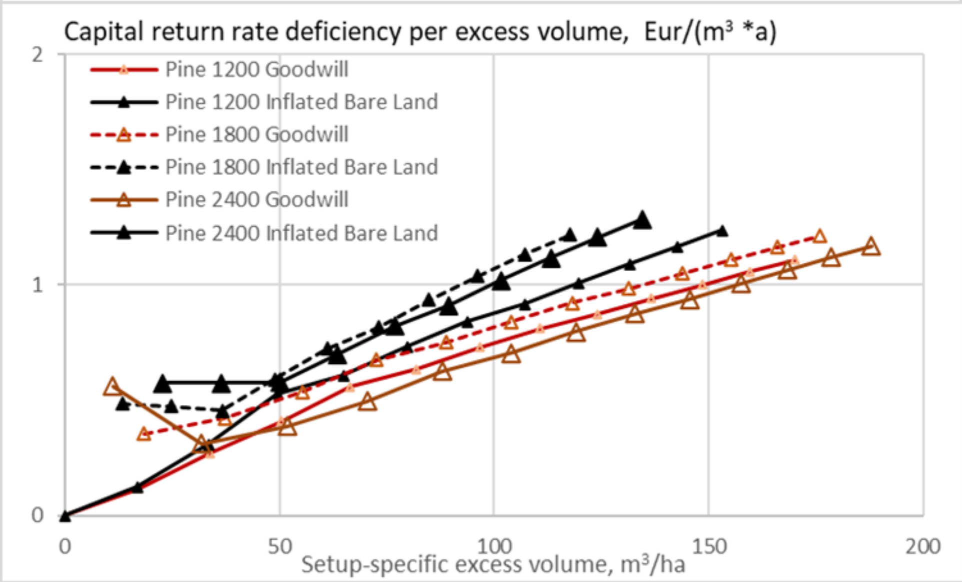


Figure 12. The expected value of capital return rate deficiency per excess volume unit, as a function of excess volume, when the growth model is applied to seven observed wooded stands, without any thinning restriction (Fig. 12a), good-quality trees of at least 238 mm of diameter only removed in thinning (12b), and without any commercial thinning (12c). Inflated capitalization is introduced either as proportional goodwill or as inflated bare land value.

Figs. 13, 14, and 15 show the expected value of the capital return rate deficiency per excess volume unit as a function of excess volume, within stands of three tree species where the growth model is applied as early as applicable, in the presence of inflated capitalization and eventual thinning restrictions. The proportional goodwill showing greater capitalization in Figs. 8, 9, and 10, and correspondingly smaller capital return rate in Figs. 3, 4, and 5, shows a smaller deficiency. It is again worth noting that the deficiency is inversely proportional to the goodwill correction, as indicated in Eq. (12). Thinning restrictions reduce the deficiency and increase available excess volume. Thinnings restricted to trees larger than 237 mm diameter show the smallest deficiency with moderate excess volume, while the omission of thinnings shows the smallest deficiency at large excess volumes.


Capital return rate deficiency per excess volume, Eur/(m³ *a)
2
1
0
0
50
100
150
200
Setup-specific excess volume, m³/ha
Pine 1200 Goodwill
Pine 1200 Inflated Bare Land
Pine 1800 Goodwill
Pine 1800 Inflated Bare Land
Pine 2400 Goodwill
Pine 2400 Inflated Bare Land


Capital return rate deficiency per excess volume, Eur/(m³ *a)
2
1
0
Pine 1200 Goodwill
Pine 1200 Inflated Bare Land
Pine 1800 Goodwill
Pine 1800 Inflated Bare Land
Pine 2400 Goodwill
Pine 2400 Inflated Bare Land
0
50
100
150
200
Setup-specific excess volume, m³/ha

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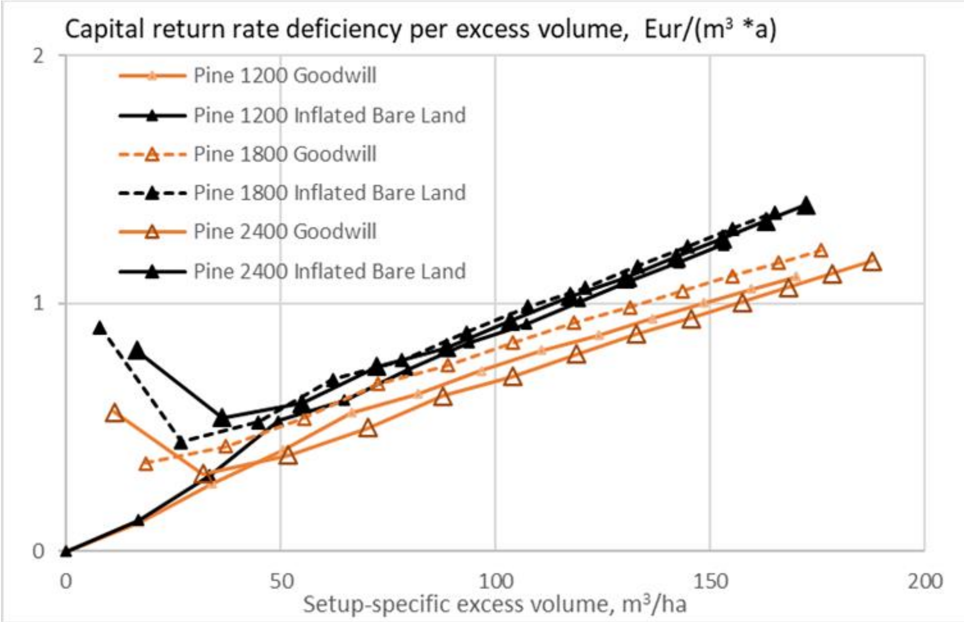

Figure 13. The expected value of capital return rate deficiency per excess volume unit on pine stands of different initial sapling densities, as a function of excess volume, when the growth model is applied as early as applicable, without any thinning restriction (Fig. 13a), good-quality trees of at least 238 mm of diameter only removed in thinning (13b). Fig. 13b does not contain any commercial thinning. Inflated capitalization is introduced either as proportional goodwill or as inflated bare land value.

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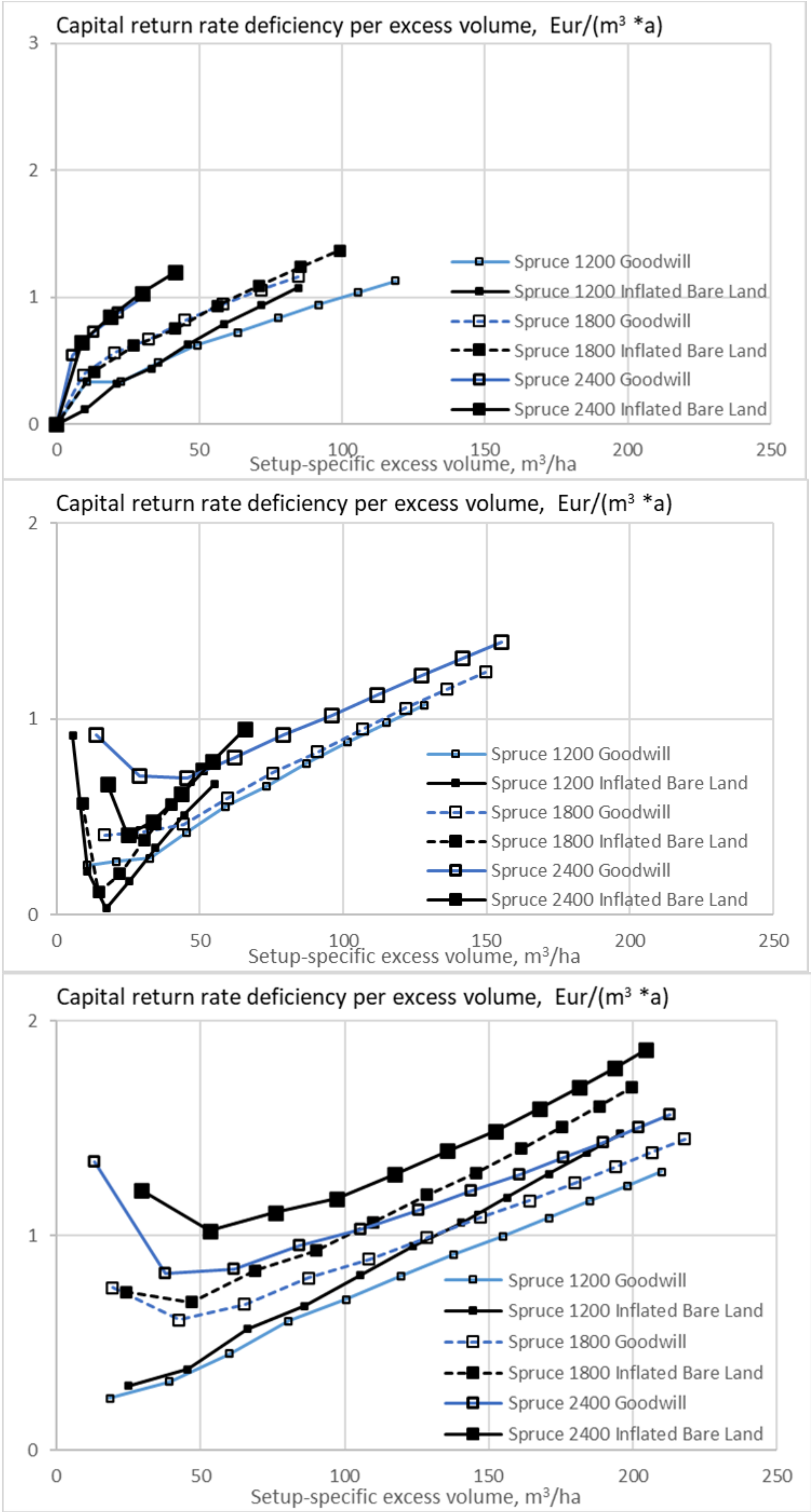

Figure 14. The expected value of capital return rate deficiency per excess volume unit on spruce stands of different initial sapling densities, as a function of excess

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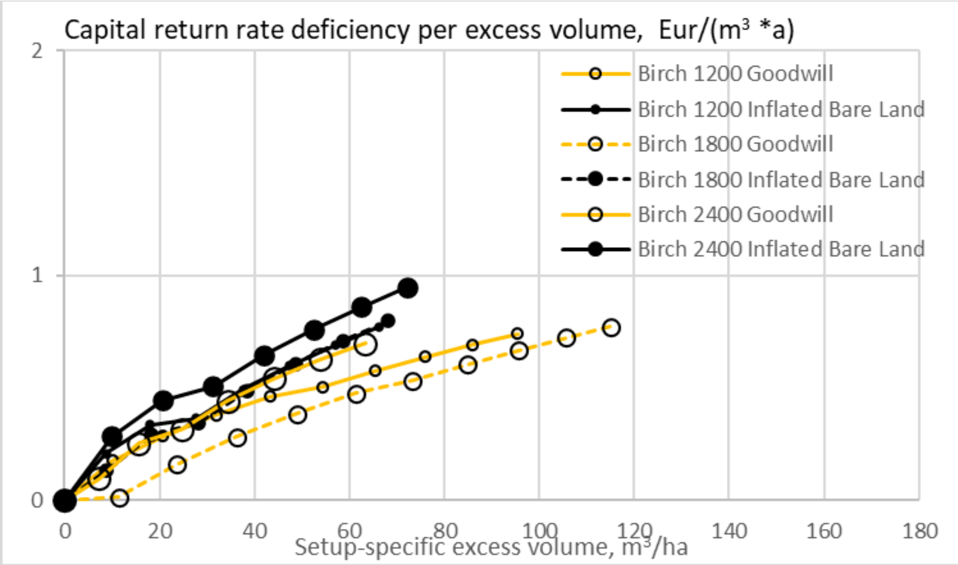
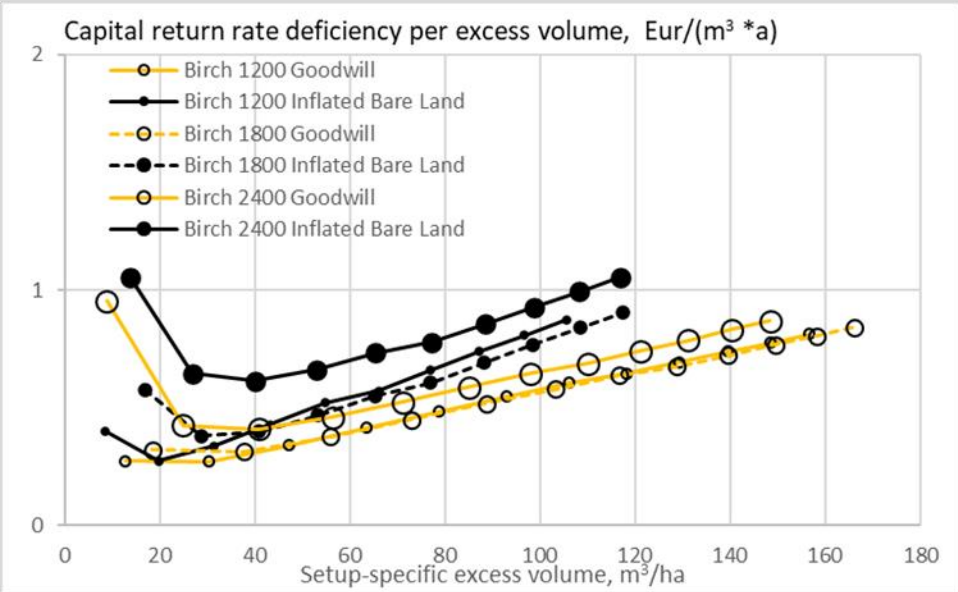
volume, when the growth model is applied as early as applicable, without any thinning restriction (Fig. 14a), good-quality trees of at least 238 mm of diameter only removed in thinning (14b), and without any commercial thinning (14c). Inflated capitalization is introduced either as proportional goodwill or as inflated bare land value.





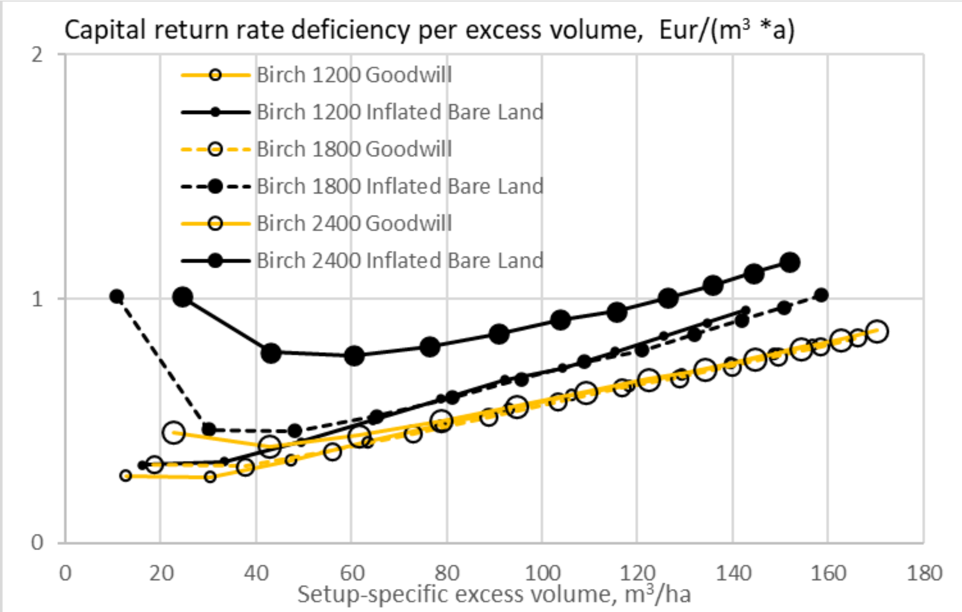


Figure 15. The expected value of capital return rate deficiency per excess volume unit on spruce stands of different initial sapling densities, as a function of excess volume, when the growth model is applied as early as applicable, without any thinning restriction (Fig. 14a), good-quality trees of at least 238 mm of diameter only removed in thinning (14b), and without any commercial thinning (14c). Inflated capitalization is introduced either as proportional goodwill or as inflated bare land value.

4. Discussion

When the growth model has been applied on growing stands as early as applicable, control parameters have included not only thinning restrictions but also the selection of tree species, as well as initial sapling densities. The capital return rate deficiencies plotted in Figs. 13 to 15 however are case-specific: financially optimized treatment for any tree species and sapling density is taken as a reference point. It is possible to replot these Figures with one common reference. We here select spruce stands with sapling density 1200/ha as the common reference. The reason for this is that the capital return rate achievable according to Fig. 4 is only slightly less than with spruce stands with greater sapling densities, but the duration risk is much less [46,47,48].

It is found from Fig. 16, applying a 50% proportional goodwill, that a small excess volume can inexpensively be gained by increasing sapling density. Greater excess volume is best achieved by restricting thinnings. A large excess volume is best achieved by omitting thinnings. These results are qualitatively the same as in recent studies omitting any goodwill [32,33]. The reason is that the proportional goodwill merely induces a linear scaling in the capital return rate according to Eqs. (11) and (12), without affecting management practices. On the other hand, as the linear scaling changes the capital return rate according to Eq. (12), it also affects the capital return rate deficiency, reducing the financial burden of enhanced carbon sequestration.

There is another important consequence of the proportional goodwill in forest estate prices. As the intangible market premium cannot be liquidized at the timber market according to Eqs. (8) and (9), the premium deteriorates with harvesting. The premium can be converted into cash by selling the estate. Considering eventual tax implications, this may or may not be microeconomically feasible. Provided the forest-owning agent desires to stay in

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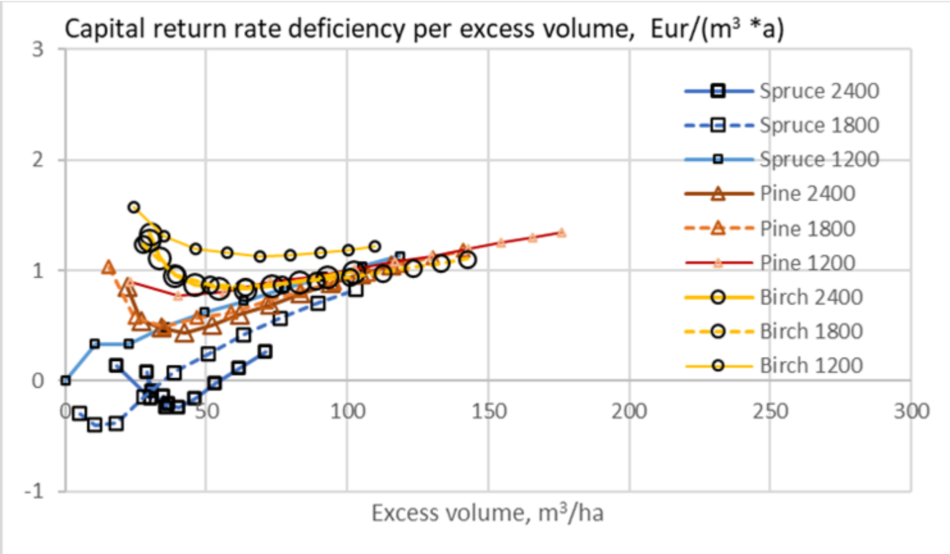
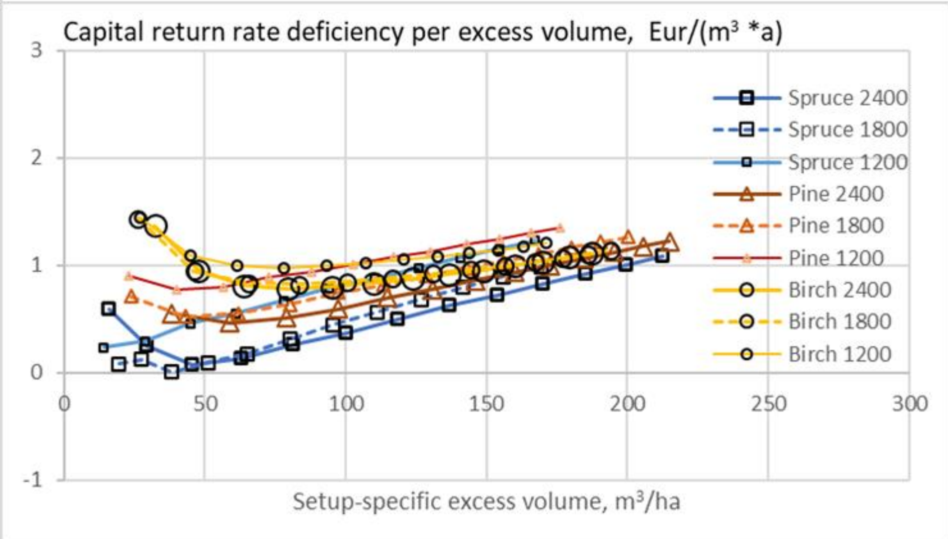
forestry, heavily wooded estates can be exchanged for young forests with a small intangible market premium. Then, a mystery is, what sense it makes to the buyer of any heavily wooded estate to purchase goodwill value which will later deteriorate in harvesting. This mystery may become partially explained by the ambitions of institutions willing to exit interest-bearing assets of negative real return [14,15].





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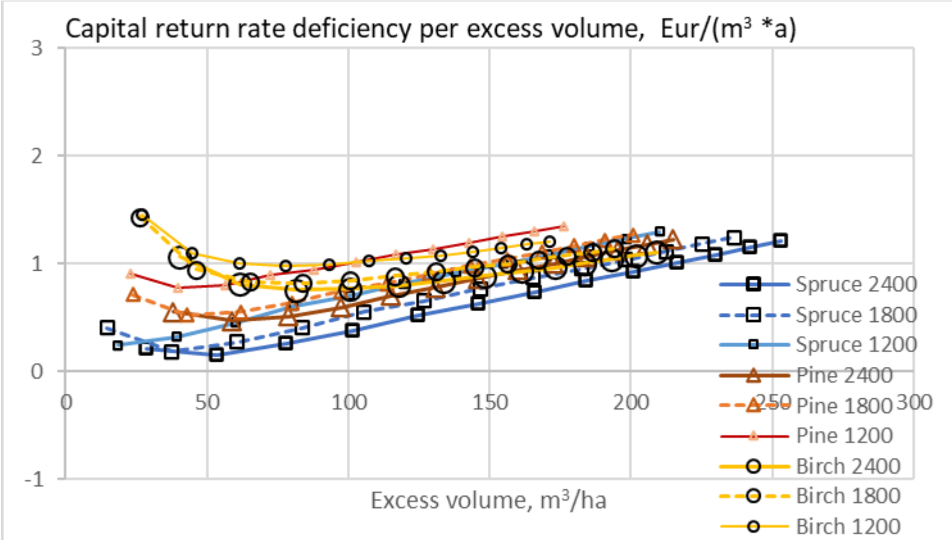
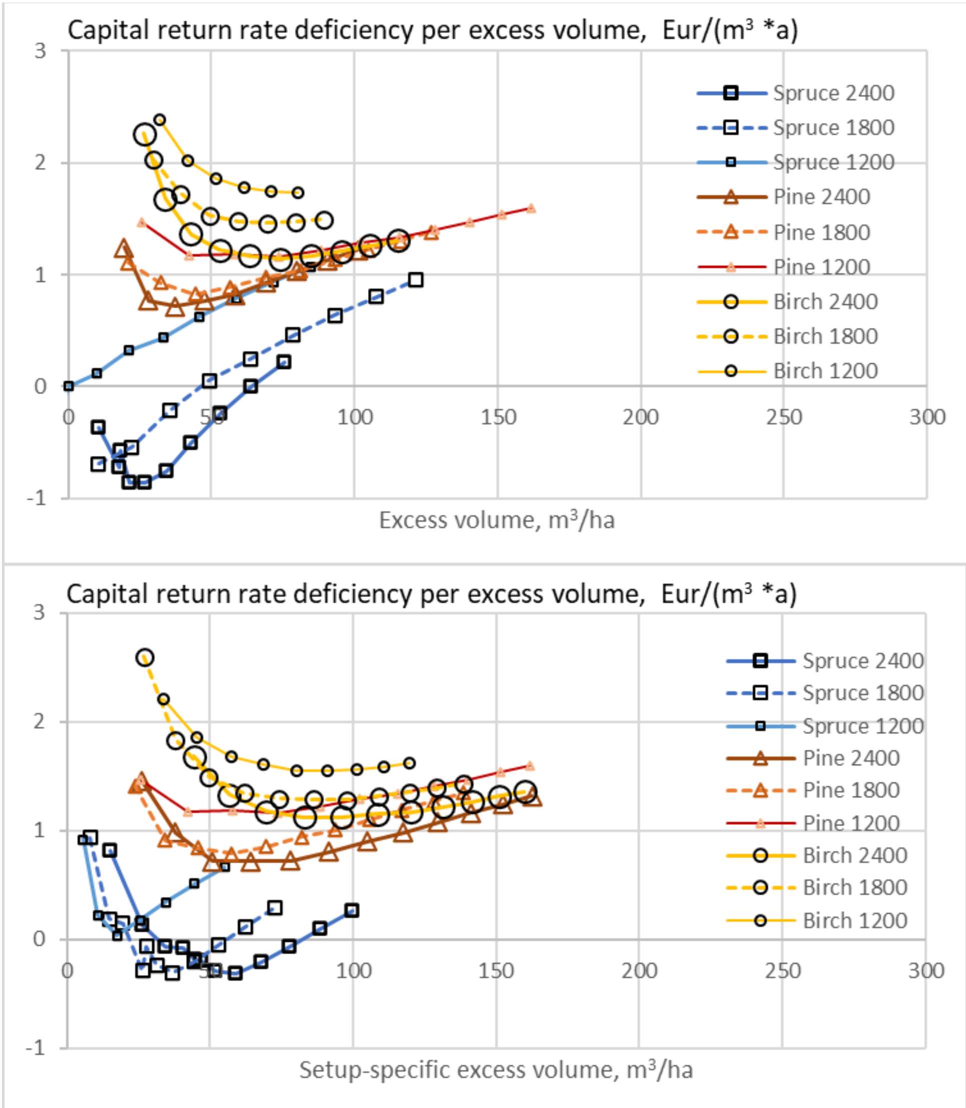


Figure 16. The expected value of capital return rate deficiency per excess volume unit on stands of different initial sapling densities, with proportional goodwill, as a function of excess volume, when the growth model is applied as early as applicable, without any thinning restriction (Fig. 16a), good-quality trees of at least 238 mm of diameter only removed in thinning (16b), and without any commercial thinning (16c). The expected value of capital return rate and stand volume from spruce stands with 1200 seedlings per hectare is taken as the common reference.

It is found from Fig. 17, applying a 300% premium in bare land value, that a small excess volume can inexpensively be gained by increasing sapling density. Greater excess volume is best achieved by restricting thinnings. A large excess volume is best achieved by omitting thinnings. These results are qualitatively the same as in recent studies omitting any goodwill [32,33]. The qualitative similarity appears even if the inflated bare land value does not induce any linear scaling in the capital return rate, and it does affect management practices as indicated in Figs. 1 to 15. The inflated bare land value changes the capital return rate according to Eqs. (1) to (4), it also affects the capital return rate deficiency, reducing the financial burden of enhanced carbon sequestration. However, as Figs. 1 to 15 indicate. the expected values of capital return rate are greater and the capitalizations lower than in the case of the proportional goodwill. This is due to the proportional goodwill is hitting large capitalizations, whereas the bare land inflated is a relatively small capitalization component. Correspondingly, the capital return rate deficiencies in Fig. 17 are larger than in Fig. 16. The relationship however depends on the magnitude of the goodwill and the inflation.

Interestingly, the two independent sets of initial conditions appear to yield similar results. As well, there are findings common for the two manifestations of inflated capitalization. The capital return rate is a weak function of rotation age, which results in variability in the optimal number of thinnings (Figures 1–6). Restricting thinnings increases timber stock but reduces rotation age (Figures 1–10). Increased timber stock induces a capital return rate deficiency (Figures 12–17). The deficiency per excess volume unit is smaller if the severity of any thinning is restricted, in comparison to extending rotations (Figures 12–17). Moderate increases in timber stock can be gained by restricting thinnings to large trees, while large increases are best achieved by omitting thinnings (Figures 12–17). Interestingly, these results align with those reported previously without inflated capitalization [32,33].

The quantitative results presented depend on the magnitude of the capitalization premia. The premia used in this study were somewhat arbitrary but based on recent observations from the Nordic Region [5,7,9], including very recent observations by the author: large, productive forest estates appear to change owners at 150% of fair forestry value determined by professionals - a recent approximation in the press has been 150 to 200% [49]. Correspondingly, the quantitative results reported are probably within a valid range, and the financial continuity problems demonstrated are real. On the other hand, vertical integration driving the inflation of estate prices in many developing countries [25], inflated bare land value may be closer to reality. In the latter case, financially optimal procedures are affected, but no financial discontinuity appears.



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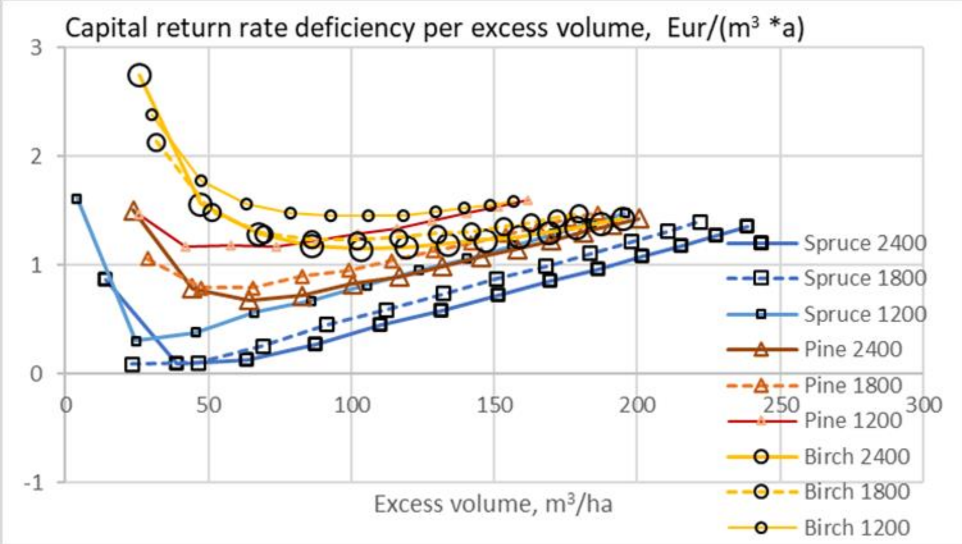

Figure 17. The expected value of capital return rate deficiency per excess volume unit on stands of different initial sapling densities, with inflated bare land value, as a function of excess volume, when the growth model is applied as early as applicable, without any thinning restriction (Fig. 17a), good-quality trees of at least 238 mm of diameter only removed in thinning (17b), and without any commercial thinning (17c). The expected value of capital return rate and stand volume from spruce stands with 1200 seedlings per hectare is taken as the common reference.

Figs. 16 and 17 indicate that a significant excess volume can be produced at the expense of a monetary capital return rate deficiency in the order of one to a Euro/excess cubic meter per annum. This can be easily compensated by a carbon rent derived from European carbon emission prices valid at the time of writing [50,32,33,40]. On the other hand, such compensation is needed to achieve a large-scale increment in carbon sequestration. It has been recently shown that the carbon stock can be increased without deteriorating the wood supply for forest-based industries [32].

5. Conclusions

It was shown that proportional goodwill in capitalization induces linear scaling of the financial return, without any contribution to sound management practices. However, there is a financial discontinuity, as harvesting deteriorates goodwill. On the contrary, capitalization premium set on bare land as a tangible asset would increase timber storage and carbon sequestration. Observations indicate that the proportional goodwill is closer to reality within the Nordic Region, resulting in continuity problems but a reduced capital expense for carbon storage.

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References

1. Viitala, E.-J. Stora Enson ja Metsäliitto-konsernin metsien omistusjärjestelyt vuosina 2001–2005. Metsätieteen aikakauskirja 3/2010, 239–260.

2. Mei, B. Timberland investments in the United States: a review and prospects. For. Policy Econ. 109, 101998. https://doi.org/10.1016/j.forpol.2019.101998.

3. Stora Enso finalises the restructuring of Bergvik Skog's forests holdings. STORA ENSO OYJ INVESTOR NEWS 31 May 2019 at 12.15 EEST. https://www.storaenso.com/en/newsroom/regulatory-and-investor-releases/2019/5/stora-enso-finalises-the-restructuring-of-bergvik-skogs-forests-holdings

4. STORA ENSO SÄLJER SKOGSINNEHAV I HALLAND OM CA 940 MLN KR (Direkt). 2020-12-18 14:23. https://www.avanza.se/placera/telegram/2020/12/18/stora-enso-saljer-skogsinnehav-i-halland-om-ca-940-mln-kr.html?fbclid=IwAR3BzZw0M4FTsM-a-aE2Fszqwj5Ms-R-iqFrcc9FF5CA6VUUzhl4hH7ClmE

5. Tilastotietoa kiinteistökaupoista. https://khr.maanmittauslaitos.fi/tilastopalvelu/rest/API/kiinteistokauppojen-tilastopalvelu.html#t443g4_x_2020_x_Maakunta

6. Myytävien metsäkiinteistöjen määrä pomppasi touko-kesäkuussa – hinnat nousevat nyt nopeammin kuin kertaakaan vuoden 2007 jälkeen. Suomen Sijoitusmetsät Oy, STT Info. https://www.sttinfo.fi/tiedote/myytavien-metsakiinteistojen-maara-pomppasi-touko-kesakuussa-hinnat-nousevat-nyt-nopeammin-kuin-kertaakaan-vuoden-2007-jalkeen?publisherId=69818737&releaseId=69918046

7. Liljeroos, H. Hannun hintaseuranta: Metsätilakaupan sesonki alkanut. Metsälehti 11.5.2021. https://www.metsalehti.fi/artikkelit/hannun-hintaseuranta-metsatilakaupan-sesonki-alkanut/#c8b05b17

8. Liljeroos, H. Hannun hintaseuranta. Hannun hintaseuranta: Metsätilamarkkinoiden yleiskatsaus 2021 – hehtaarihinnoissa voimakasta nousua. Metsälehti 12.1.2022. MAKSUMUURIN TAKANA. https://www.metsalehti.fi/artikkelit/hannun-hintaseuranta-metsatilamarkkinoiden-yleiskatsaus-2021-hehtaarihinnoissa-voimakasta-nousua/#c8b05b17

9. Kymmenen prosentin haamuraja rikki – metsäkiinteistöjen hinnat nousivat ennätyksellisen paljon vuonna 2021. Suomen Sijoitusmetsät Oy, STT Info. https://www.sttinfo.fi/tiedote/kymmenen-prosentin-haamuraja-rikki-metsakiinteistojen-hinnat-nousivat-ennatyksellisen-paljon-vuonna-2021?publisherId=69818737&releaseId=69929002

10. Cubbage, F.; Kanieski, B.; Rubilar, R.; , Bussoni, A.; Morales Olmos, V.; , Balmelli, G.; Mac Donagh, P.; Lord, R.;, Hernández, C.; Zhang, P.; Huang, J.; Korhonen, J.; Yao, R.; Peter Hall, P.; Del La Torre, R.; Diaz-Balteiro, L.; Carrero, O.; Monges, E.; Thi Thu, H.T.; Frey, G.; Howard, M.; Chavet, M.; Mochan, S.; Afonso Hoeflich, V.; Chudy, R.; Maass, D.; Chizmar, S.; Abt, R.; Global timber investments, 2005 to 2017. Forest Policy and Economics, 2020, 112, 102082, https://doi.org/10.1016/j.forpol.2019.102082.

11. Chudy, R.P.; Hagler, R.W. Dynamics of global roundwood prices – Cointegration analysis Forest Policy and Economics, 2020, 115, 102155.

12. Luke tilastopalvelu. https://www.luke.fi/avoin-tieto/tilastopalvelu/ Accessed Jul 17, 2021.

13. Pra, A.; Masiero, M.; Barreiro, S.; Tomé, M.; Martinez De Arano, I.; Orradre, G.; Onaindia, A.; Brotto, L.; Pettenella, D. Forest plantations in Southwestern Europe: A comparative trend analysis on investment returns, markets and policies. Forest Policy and Economics, 2019, 109, 102000.

14. U.S. Department of the Treasury. https://home.treasury.gov/

15. European Central Bank. https://www.ecb.europa.eu/home/html/index.en.html

16. Pearse, P.H.; DISTORTIONS IN THE MARKET FOR FOREST LAND. Forestry Chronicle, 1965, 41(4), 406-418. DOI: 10.5558/tfc41406-4

17. Vrooman, D.H. An Empirical Analysis of Determinants of Land Values in the Adirondack Park. The American Journal of Economics and Sociology, 1978, 37(2), 165-177.

18. Aronsson, T.; Carlén, O. The determinants of forest land prices: an empirical analysis. Canadian Journal of Forest Research, 2000, 30(4). https://doi.org/10.1139/x99-250.

19. Snyder, S.A.; Kilgore, M.A.; Hudson, R.; Donnay. J. Determinants of forest land prices in northern Minnesota: A hedonic pricing approach. FOR. SCI. 2007, 53(1), 25–36.

20. Zhang, D.; Meng, L.; Polyakov, M. Determinants of the Prices of Bare Forestland and Premerchantable Timber Stands: A Spatial Hedonic Study. Forest Science, 2013, 59(4), 400–406. https://doi.org/10.5849/forsci.12-014

21. Restrepo, H.; Zhang, W.; Mei, B. The time-varying role of timberland in long-term, mixed-asset portfolios under the mean conditional value-at-risk framework. Forest Policy and Economics, 2020, 113, 102136.

22. Mei, B; L.Clutter, M.L. Return and information transmission of public and private timberland markets in the United States Forest Policy and Economics 2020, 113, 102092.

23. Busby, G.M.; Binkley, C.D.; Chudy, R.P.; Constructing optimal global timberland investment portfolios. Forest Policy and Economics 2020, 111, 102083.

24. Yao, W.; Mei, B.; Clutter, M.L. Pricing Timberland Assets in the United States by the Arbitrage Pricing Theory, Forest Science 2014, 60(5), 943–952. https://doi.org/10.5849/forsci.13-02324. Yao, W.; Mei, B.; Clutter, M.L. Pricing Timberland Assets in the United States by the Arbitrage Pricing Theory, Forest Science 2014, 60(5), 943–952. https://doi.org/10.5849/forsci.13-023

25. Korhonen, J.; Zhang, Y.; Toppinen, A. Examining timberland ownership and control strategies in the global forest sector. For. Policy Econ. 2016, 70, 39–46.

26. Metsäkiinteistökauppa jäljessä edellisvuodesta – ennusteen mukaan hinnat nousevat tänä vuonna lähes yhdeksän prosenttia. Suomen Sijoitusmetsät Oy, STT Info. https://www.sttinfo.fi/tiedote/metsakiinteistokauppa-jaljessa-edellisvuodesta-ennusteen-mukaan-hinnat-nousevat-tana-vuonna-lahes-yhdeksan-prosenttia?publisherId=69818737&releaseId=69912289

27. Dasos reports on carbon impact. https://www.dasos.fi/dasos-reports-on-carbon-impact/

28. New Evli Impact Forest Fund I aims to mitigate climate change by achieving positive carbon effects. https://www.evli.com/en/news/new-evli-impact-forest-fund

29. Murray, B.C. Economics of Forest Carbon Sequestration as a Climate Change Mitigation Strategy. Reference Module in Earth Systems and Environmental Sciences, Encyclopedia of Energy, Natural Resource, and Environmental Economics Volume 1, 2013, Pages 41-47.

30. Sohngen, B. An Analysis of Forestry Carbon Sequestration as a Response to Climate Change. COPENHAGEN CONSENSUS ON CLIMATE, https://aede.osu.edu/sites/aede/files/publication_files/Analysis%20of%20Forestry%20Carbon.pdf

31. Li, R.; Sohngen, B.; Tian, X. 2021. Efficiency of forest carbon policies at intensive and extensive margins. American Journal of Agricultural Economics, 2021, 1–25. https://doi.org/10.1111/ajae.12281

32. Kärenlampi, P.P. Two Sets of Initial Conditions on Boreal Forest Carbon Storage Economics. PLOS Clim, 2022, 1(2), e0000008. https://doi.org/10.1371/journal.pclm.0000008

33. Kärenlampi, P.P. Capitalization and Capital Return in Boreal Carbon Forestry. Earth, 2022, 3, 204-227. https://doi.org/10.3390/earth3010014

34. Liao, X.; Zhang, Y.; Sun, C. Investments in timberland and softwood timber as parts of portfolio selection in the United States: a cointegration analysis and capital asset pricing model. For. Sci. 2009, 55, 471–479.

35. Yao, W.; Cheng, B.; Mei, B. Investor sentiment and timberland investment returns. For. Prod. J. 2016, 66, 147–154.

36. Speidel, G. Forstliche Betreibswirtschaftslehre, 2nd ed.; Verlag Paul Parey: Hamburg, Germany, 1967, 226p. (In German)

37. Speidel, G. Planung in Forstbetrieb, 2nd ed.; Verlag Paul Parey: Hamburg, Germany, 1972; 270p. (In German)

38. Kärenlampi, P.P. State-space approach to capital return in nonlinear growth processes. *Agric. Finance Rev.* 2019, 79, 508–518. doi:10.1108/afr-07-2018-0055.

39. Kärenlampi, P.P. Estate-Level Economics of Carbon Storage and Sequestration. *Forests* 2020, 11(6), 643; https://doi.org/10.3390/f11060643.

40. Kärenlampi, P.P. The Effect of Empirical Log Yield Observations on Carbon Storage Economics. *Forests* 2020, 11, 1312.

41. Kärenlampi, P.P. Diversity of Carbon Storage Economics in Fertile Boreal Spruce (Picea Abies) Estates. Sustainability 2021, 13, 560. https://www.mdpi.com/2071-1050/13/2/560

42. Kärenlampi, P.P. Capital return rate and carbon storage on forest estates of three boreal tree species. Sustainability 2021, 13(12), 6675. https://doi.org/10.3390/su13126675

43. Leslie, A.J. A REVIEW OF THE CONCEPT OF THE NORMAL FOREST. Aust. For. 1966, 30, 139–147, doi:10.1080/00049158.1966.10675407.

44. Kärenlampi, P.P. Harvesting Design by Capital Return. *Forests* 2019, 10, 283, doi:10.3390/f10030283.

45. Bollandsås, O.M.; Buongiorno, J.; Gobakken, T. Predicting the growth of stands of trees of mixed species and size: A matrix model for Norway. Scand. *J. For. Re*s. 2008, 23, 167–178, doi:10.1080/02827580801995315.

46. Bouchaud, J.-P.; Potters, M. Théorie des Risques Financiers (Saclay: Aléa) 1997 (Engl. transl. 2000) Theory of Financial Risks (Cambridge: Cambridge University Press)) http://web.math.ku.dk/~rolf/Klaus/bouchaud-book.ps.pdf

47. Brealey, R.A.; Myers, S.C.; Allen, F. Principles of Corporate Finance (Tenth ed. 2011), New York, NY: McGraw-Hill Irwin.

48. Fabozzi, F.J. Capital Markets: Institutions, Instruments, and Risk Management. MIT Press 2015.

49. Miten sota Ukrainassa näkyy metsätilojen kaupassa? Asiantuntijoilta kaksi erisuuntaista arviota. Forest.fi – verkkolehti 10.3.2022. https://forest.fi/fi/artikkeli/miten-sota-ukrainassa-nakyy-metsatilojen-kaupassa-asiantuntijoilta-kaksi-erisuuntaista-arviota/?fbclid=IwAR0BIUX-kLW9tWArWDeylm_46ZGt01EWRUvWBCSPqJ3GioYGV7_L5ftO9BA#9767c886

50. Lintunen, J.; Laturi, J.; Uusivuori, J. How should a forest carbon rent policy be implemented? *For. Policy Econ.* 2016, 69, 31–39. doi:10.1016/j.forpol.2016.04.005.