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Simulation Depending on Subsidy Scenarios for Carbon Stock and Industrial Timber Development

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Keywords: Carbon stock, forestry profits, subsidy, timber production

Abstract: This study uses simulations to investigate the effects of implementing two different Japanese forestry subsidy systems on timber production and carbon stock, and examines the consequences for harvesting strategies. An existing local yield table construction system (LYCS), a wood conversion algorithm, and a harvesting cost model were used in the simulations to test the applicability of different subsidies to the thinning of stands. Using forest inventory data collected by local government staff, forestry profits, carbon stock, subsidy, and the cost effectiveness of investing in subsidies were calculated from the simulation output. By comparing the output of simulations based on the two scenarios, it was found that both the clear cutting area and the amount of harvested timber were larger under Scenario 2, in which the rules governing subsidy allocations are more relaxed, than under Scenario 1, in which the rules are more restrictive. Because the harvested timber under Scenario 1 was mainly produced by clear-cutting, the forestry profits and the subsidy predicted in the early period of the simulation, were larger under Scenario 1 than under Scenario 2. In contrast, the carbon stock was larger under Scenario 2 than under Scenario 1.

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1. Introduction

In response to current concerns over climate change and global warming, carbon emissions need to be reduced. Managing forests sustainably and accounting for their carbon sink value in terms of the biomass of forest trees, can make an important contribution to this goal. The public benefits arising from timber production and carbon sequestration in forested areas have recently been recognized in many parts of the world including the United States (Sakata 2005, Foley *et al.*, 2009, Ehman *et al.*, 2002, Im *et al.*, 2007), Europe (Backe'us *et al.*, 2005, Sivrikaya, 2007, Kaipainen *et al.*, 2004, Seidl *et al.*, 2007, Raymer *et al.*, 2009, Pohjola and Valsta, 2007), Canada (Hennigar *et al.*, 2008, Thompson 2009, McKenney *et al.*, 2004), Oceania (Campbell, 2004) and Asia (Ravindranath and Somashekhar, 1995, Han *et al.*, 2009). Forests have not only economic value from the commercial production of timber, but are also of value to the public in other ways through their environmental roles including acting as carbon sinks, contributing to biodiversity, and protecting water resources (Pukkala, 2002). Since forest management is subsidized by the taxpayer through the national budget, it must take into consideration the public benefits of forestry by restricting the area of clear-cutting and certain other silvicultural treatments. Because profits decrease with the decreasing price of timber (Forestry Agency, 2007), almost all forest owners in Japan depend on subsidies (Komaki 2006, Nakajima *et al.*, 2007b). Previous studies have indicated that the amount of various silvicultural practices undertaken in an area, including planting, weeding, pruning, pre-commercial thinning and thinning area, can be strongly correlated with the amount of national subsidy available (Hiroshima and Nakajima, 2006). It is therefore necessary to bring forest plantations that are dependent on national subsidies, into a condition whereby they provide high levels of benefit to the public in Japan.

Under the global policy framework of the Kyoto Protocol, the carbon sink value of forests is calculated both in terms of forests which have undergone aforestation, reforestation and deforestation (ARD forests) since 1990, as described by Article 3.3, and in terms of managed forests that have been subjected to silvicultural practices since 1990 (FM forests) under Article 3.4. Japan is currently preparing to report emissions and removals of carbon from forests in accordance with the good practice guidance for land use, land-use change, and forestry (GPG-LULUCF) (Houghton *et al.*, 1997, IPCC 2000, IPCC 2007).

Based on attitudes since the Kyoto Protocol was first enforced, Japanese citizens are expected to consider that the most important function of forests is their role as carbon sinks (Forestry Agency, 2007). Consequently, some studies (Hiroshima and Nakajima, 2006, Nakajima *et al.*, 2007a) have investigated the effects of the subsidy system on the carbon stock held in the forested areas of Japan, as well as its effects on forestry profits.

The present study investigates, through simulations, the effects of the Japanese forestry subsidy system on timber production, carbon stock and other factors. Simulation output is used to assess the cost-effectiveness of investments in forestry and carbon stock.

2. Materials and methods

2.1. Study site

The study site was a forest plantation in town, in Akita Prefecture, which is located in northern part of Japan (Fig.1) and which produces the large quantity of timber products in the country. Inakawa town is located in a subarctic zone, with an average annual temperature of approximately 11.7 ℃ and rainfall of about 1166 mm.

Forests cover a total area of 3,346 ha of which 1,380 ha is plantation

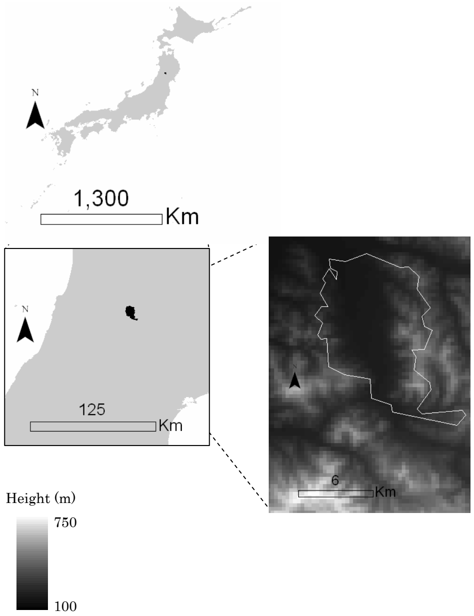

Figure 1. Location of Inakawa town, showing an elevation of the study site

(1,259 ha or 91.2% is Japanese cedar and 85 ha or 6.2% is Japanese larch (*Larix leptolepis*) (Akita Prefecture Government, 2008). A geographic information system of private forests in Inakawa town has been established. The targeted areas are forest plantations that are mainly occupied by *Cryptomeria japoinica* between 20 and 60 years old (Fig.2). In the private forest sites where the present study was conducted, thinning was undertaken by forestry workers of the forestry cooperative. A national subsidy system for the thinning of all planted tree species is commonly applied, but mainly to forest plantations less than 35 years old. The grant rates of the subsidy systems cover approximately 70% of the cost of thinning. Inventory data relating to the private forests, such as stand age, area, tree species, slope, address of forest owners and site index, were available and were also linked to each sub-compartment included in the geographic information system (GIS).

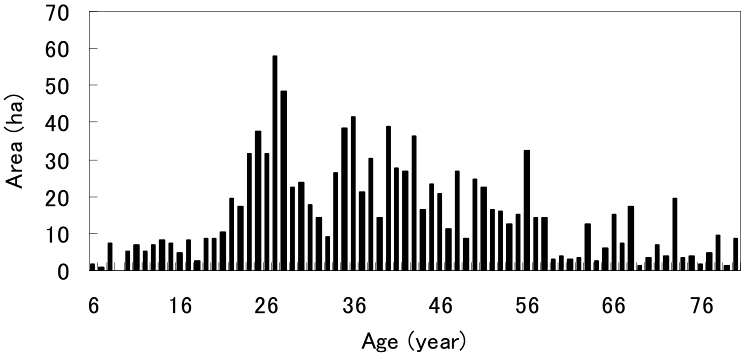

Figure 2. The age distribution of forested areas in the study site

2.2. Data analysis

The analysis tools used in this study were as follows. For estimating carbon sequestered by forests, we referred to the J-VER guidelines (Environmental Ministry, 2009), which are based on the carbon accounting system of the Kyoto Protocol. J-VER guidelines allow the use of the Local Yield Table Construction System (LYCS), which simulates timber growth and carbon stock (Environmental Ministry, 2009). This growth model is applicable to the main tree species, including sugi (*Cryptomeria japonica*), hinoki (*Chamaecyparis obtusa*), karamatsu (*Larix leptolepis*) and todomatsu (*Abies sachalinensis*), which are planted throughout Japan (Shiraishi, 1986, Nakajima *et al.*, 2009c, Nakajima *et al.*, 2010). By combining LYCS with a wood conversion algorithm and a harvesting cost model (Nakajima *et al.*, 2009a, 2009b), we can predict not only carbon stock but also harvested timber volume and forestry income.

The total cost for harvesting was calculated as follows.

[1] $$Ch_t = C_m + C_h$$

where:

Ch_t: total forestry cost derived from harvesting (yen),

C_m: marketing cost (yen),

C_h: harvesting cost (yen)

Marketing cost was calculated as follows.

[2] $$C_m = (V_{14} C_{hm14} + V_{16} C_{hm16})\, Tm$$

where:

V_{14}: timber volume of top-end diameter less than $14cm (m^3)$

V_{16}: timber volume of top-end diameter more than $16cm (m^3)$

C_{m14}: marketing charge for timber of top-end diameter less than $14cm$ (yen)

C_{m16}: marketing charge for timber of top-end diameter more than $16cm$ (yen)

T_m: timber market tax rate

Timber volume depending on the top-end diameter could be estimated by WoodMax algorithm (Nakajima *et al.*, 2009).

Harvesting cost was calculated as follows.

[3] $$C_h = (C_f + C_l + C_b + C_s)\, Ch_h$$

where:

C_f: felling cost using chainsaw (yen)

C_l: logging cost using chainsaw (yen)

C_b: bunching cost using grapple (yen)

C_s: skidding cost using forwarder (yen)

Ch_h: harvesting charge rate

The felling, logging, bunching and skidding cost was formulated as follows.

[4] $$C_f = \left({}^{V}\!/_{P_f}\right)(C_e + C_{Dc})$$

[5] $$C_l = \left({}^{V_t}\!/_{P_l}\right)(C_e + C_{Dc})$$

[6] $$C_b = \left({}^{V_t}\!/_{P_b}\right)(C_e + C_{Dg}) + C_{dg}$$

[7] $$C_s = \left({}^{V_t}\!/_{P_s}\right)(C_e + C_{Df}) + C_{df}$$

where:

P_f: felling productivity (m^3/ person day)

P_l: logging productivity (m^3/ person day)

P_b: bunching productivity (m^3/ person day)

P_s: skidding productivity (m^3/ person day)

C_e: employment cost (yen / person day),

C_{Dc}: depreciation cost of chainsaw (yen/m^3),

C_{Dg}: depreciation cost of grapple (yen/m^3),

C_{Df}: depreciation cost of forwarder (yen/m^3),

C_dg: delivery cost of grapple (yen),

C_df: delivery cost of forwarder (yen),

V: stem volume (m^3),

V_t: timber volume (m^3)

Stem volume, timber volume, number of stem and timber could be estimated from Local Yield table Construction System and Woodmax algorithm (Nakajima *et al.*, 2010, 2009). Based on these estimated variables, felling, logging, bunching and skidding productivity (m^3/ person day) were calculated by applying formulas described in Table 1 to observed historical records of harvesting.

Table 1. Formulas for estimation of felling (P_f), logging (P_l), bunching (P_b) and skidding (P_s) productivity

	RMSE	Sample number
$P_\mathrm{f} = 20.5\ V_\mathrm{a}^{\ 0.6}$	5.0	19
$(P_\mathrm{f} = 28.2\ V_\mathrm{a}^{\ 0.6})$	5.9	11
$P_\mathrm{l} = (11.19\ V_\mathrm{ta}^{\ 0.05})\ (V_\mathrm{t} / V)$	2.9	18
$P_\mathrm{b} = \nrightarrow 3.5 \log D + 30.5$	2.2	16
$(P_\mathrm{b} = \nrightarrow 4.1 \log D + 38.5)$	4.6	11
$P_\mathrm{s} = \nrightarrow 10.5 \log D + 91.6$	3.4	21

Formula in parentheses indicate felling and bunching productivity of clear cutting

D: distance from forest road (m), V_a: average stem volume (m^3), V_ta: average timber volume (m^3), V: stem volume (m^3), V_t: timber volume (m^3)

The average stem and timber volume could be calculated by dividing stem and timber volume by number of stem and timber derived from Local Yield table Construction System and WoodMax. Distance from forest road was obtained by forest inventory data established in Inakawa town by government. Other variables and silvicultural cost proposed by hearing investigation with forest association considering the historical records of silvicultural practices were set in Table 2.

The forest inventory data such as stand age, tree species, and site index can be used as input data for the LYCS.

In the present study, we investigate through simulation modeling the effects of the Japanese forestry subsidy system on timber production,

Table 2. (a)Variables and (b) silvicultural practice cost set in study site

(a)

Variable	Amount	Variable	Amount
C_{m14}	1000	C_{Dc}	1600
C_{m16}	1200	C_{Dg}	15000
T_m	0.12	C_{Df}	13000
Ch_h	0.35	C_{dg}	22000
C_e	12000	C_{df}	21000

C_{m14}: marketing charge for timber of top-end diameter less than 14 cm (yen),
C_{m16}: marketing charge for timber of top-end diameter more than 16 cm (yen),
T_m: timber market tax rate, Ch_h: harvesting charge rate
C_e: employment cost (yen / person day), C_{Dc}: depreciation cost of chainsaw (yen/m^3),
C_{Dg}: depreciation cost of grapple (yen/m^3), C_{Df}: depreciation cost of forwarder (yen/m^3),
C_{dg}: delivery cost of grapple (yen), C_{df}: delivery cost of forwarder (yen)

(b)

Silvicultural practices	Cost (yen/ha)	Stand age (year)	Labor quantity (person day / ha)
Land preparation and planting	800000	0	50
Weeding	150000	1-10*	12
Pruning	236000	15	20
Precommecial thinning	210000	20, 25	15

* Weeding is implemented every year between age 1 and 10

carbon stock holdings, and subsidy. Two subsidy system scenarios were assumed: Scenario 1 was the traditional subsidy applied to stands less than 35 years old (Nakajima *et al.*, 2007a); Scenario 2 was the subsidy applied to stands of any age. Based on the assumptions of the two scenarios, the harvesting area, amount of harvested timber, subsidy, forestry profits, and carbon stock were calculated as follows, using an existing stand growth model (Nakajima *et al.*, 2010), a wood conversion algorithm (Nakajima *et al.*, 2009b) and a forestry cost model mentioned above.

By inputting the stand condition derived from forest inventory data into these models, the future forestry profits could be estimated as a function of harvesting planning strategies. The final age at cutting was chosen to maximize the present net value of forestry profits, estimated from those valid at the most recent final cutting. The discount rate was then estimated relative to a value considered to be reasonable to society; in this case 3.0% was considered reasonable as this represents the average long-term yield of Japanese government bonds (Tokyo Stock Exchange, 2007). We varied the thinning ratios from 25% to 35% by 5%. We also varied the number of thinnings between zero and three, and the thinning age between initial stand age and final cutting age by increments of 5 years. Inputting these various thinning plans into the LYCS, we simulated forestry profits under all harvesting strategies. We then selected the cutting plan that maximized the present net value of forestry profits for each sub-compartment.

Based on previous studies (Roise, 1986, Valsta, 1987, 1992, 1993), the optimization problem was formulated as follows:

$$[8] \qquad \max PV_j = \sum_{k=j}^{T} \left\{ \frac{I\left(x_k\right) + Ch\left(x_k\right) + Sh_k + Cs_k + Ss_k}{\left(1+r\right)^{k-j}} \right\}$$

subject to:

$x_{k+1} = F\left(t_k, x_k, u_k\right)$

when $k < t, 25 < u_k < 35$

when $k = T, u_k = 100$

$t_k, x_k > 0$

where:

PV_j: present value at current stand age j
$I(x_k)$: forestry income derived from harvesting
in the stand at age k
$Ch_t(x_k)$: total forestry cost derived from harvesting
in the stand at age k
Sh_k : forestry subsidies derived from harvesting
in the stand at age k
Cs_k : forestry cost derived from silviculture in
the stand at age k
Ss_k : forestry subsidies derived from on silviculture
at age k
j: current stand age
T: clear cutting age
x_k: the stand characteristics during harvesting at stand age k
t_k: the time between harvesting $k-1$ and k
u_k: the percentage of trees removed when harvesting.
$F(t_k, x_k, u_k)$: the stand development model
(Local Yield Table Construction System: LYCS)
r: the discount rate.

The total harvesting area and quantity of harvested timber were calculated by summarizing their respective values based on the harvesting plans calculated under the two existing subsidy scenarios. We call this calculation procedure the “Stand Simulation Summation System”. The subsidies were estimated by summarizing the silviculture and thinning subsidies derived from government subsidy unit prices. The total forestry profits could then be estimated from forestry income and subsidy. The carbon stocks were also estimated by substituting stand volumes derived from LYCS into the following formula (Environmental

Ministry, 2009):

[9] $C = EDV\,(t)$

where:

C = carbon stock (ton ha^{-1})
E = a biomass expansion factor
D = wood density (ton/m^3)
$V(t)$ = stand volume (m^3 ha^{-1})

These variables including E and D could be derived from previous study (Fukuda *et al.*, 2003). The cost-effectiveness of any forestry investment was calculated by dividing the forestry profits or value of carbon stock by the annual subsidy applied.

3. Results and discussion

Figure 3 shows that the average stand age at clear-cutting was 57 years and 59 years under Scenarios 1 and 2, respectively. The age classes at clear-cutting ranged from 8 - 15, and from 8 - 20, under Scenarios 1 and 2, respectively. Under Scenario 1, profits from stands in an age class greater than 8 (36 years old) could be derived from harvest income alone, while under Scenario 2 profits could only be derived from harvesting income and subsidies. Thus, under Scenario 2 the age at clear-cutting needs to be greater than under Scenario 1 in order to increase total forestry profits, including subsidies and clear-cutting income derived from the larger timber harvested from older stands. Figure 4 shows the harvesting area under the two different scenarios. The increase in the potential harvesting area is derived from the increasing area of mature forest as the age distribution of stands in the study site changes over time. A comparison of the two scenarios clearly reveals a larger clear-cutting area under Scenario 1 than under Scenario 2, the difference ranging between 9 ha and 28 ha. After 2010, the magnitude of the difference in clear-cutting areas decreased by up to 30.9% of its maximum value. In contrast, the thinning area under Scenario 2 is clearly larger than under Scenario 1, with the difference ranging between 0 and 22 ha.

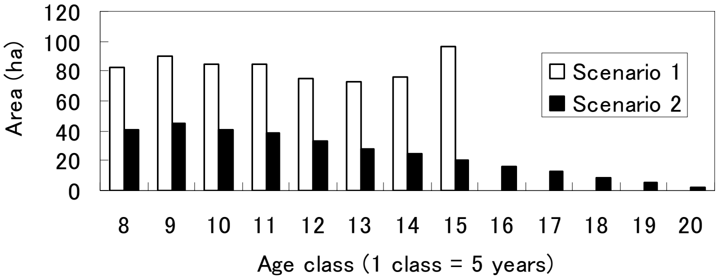

Figure 3. The age class distribution of final cutting area under different scenarios

Figure 5 shows the differences in volumes of harvested timber under the two scenarios. Under Scenario 1, the harvest of clear-cutting timber was larger than that of thinning timber, with a ratio of the clear-cutting to thinning harvested timbers ranging from 77:23 in 2010 to 65:35 in 2025.

Under Scenario 2 the clear-cut timber harvest was smaller than that of thinned timber with the ratio of the clear-cut to thinned timber ranging between 39:61 in 2010 to 53:47 in 2035. The harvested timber volume increased by up to 189.1% of its minimum value between 2010 and 2035 due to an increasing harvesting area (Fig.4b).

A comparison of the two scenarios clearly shows that the harvested volume of clear-cut timber was larger under Scenario 1 than Scenario 2, with differences ranging between 2.2 and $9.2 \times 10^3 m^3$. After 2010,

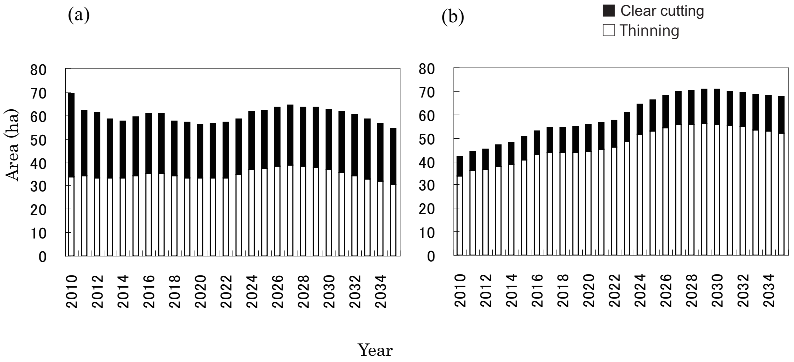

Figure 4. The clear-cutting and thinning harvesting areas under (a) Scenario 1 and (b) Scenario 2.

the difference between volumes of clear-cut timber decreased by up to 23.9% of its maximum value. In contrast, the volume of thinned timber harvested under Scenario 2 was clearly larger than under Scenario 1, with differences ranging between 0 and $2.5 \times 10^3 m^3$. These results suggest that timber production was mainly of clear-cut and thinned timber under Scenarios 1 and 2, respectively. Comparing Figures 4 and 5 shows that the ratio of clear-cut timber to total harvested timber is higher than the ratios of their respective harvested areas indicating that the volume of harvested timber per unit of harvested area was larger for clear-cut timber than thinned timber.

Figure 6 shows how subsidies vary depending on the scenario. Under Scenario 1, the maximum and minimum subsidies were 49.5 million yen (M¥) in 2017 and14.9M¥ in 2011; the maximum and minimum silviculture subsidies were 40.9 M¥ in 2018 and 6.4 M¥ in 2011; and the maximum and minimum thinning subsidies were 9.7 M¥ in 2027

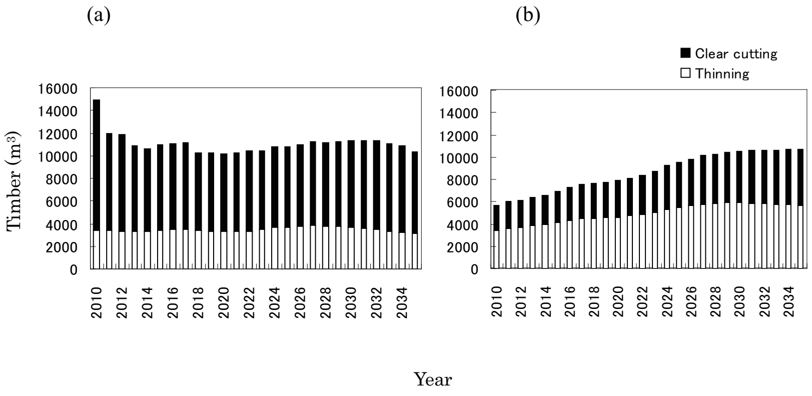

Figure 5. The clear-cutting and thinning harvested timber volume under (a) Scenario 1 and (b) Scenario 2.

and 7.6 M¥ in 2035. Under Scenario 2 the maximum and minimum subsidies were 34.1 M¥ in 2034 and 15.4 M¥ in 2011; the maximum and minimum silviculture subsidies were 20.9 M¥ in 2034 and 6.4 M¥ in 2011; and the maximum and minimum thinning subsidies were 14.0 M¥ in 2029 and 8.5 M¥ in 2010. Under Scenario 2 the silviculture subsidy was larger than thinning subsidy with ratios of silviculture and thinning subsidies ranging from 41:59 in 2011 to 65:35 in 2018. Subsidies increased by up to 221.6% of their minimum value over the period of simulated predictions due to an increase in the total harvesting area (Fig.4b). The total subsidy under Scenario 1 is larger than that under Scenario 2 throughout the prediction period.

A comparison of the two scenarios shows the silviculture subsidy in Scenario 1 to be clearly larger than that of Scenario 2, with differences ranging between 0 and 22.0 M¥. After 2017, the difference of silvicul-

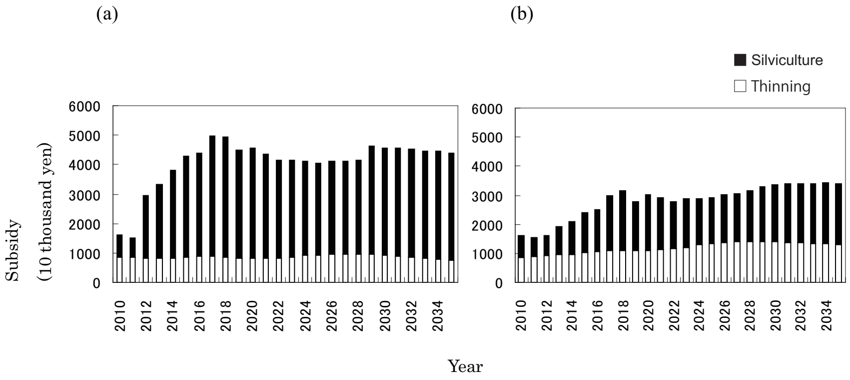

Figure 6. The silviculture and thinning subsidy under (a) Scenario 1 and (b) Scenario 2.

ture subsidy decreased by up to 70.1% of the maximum difference, while the thinning subsidy was clearly larger under Scenario 2 than Scenario 1, with differences ranging between 0 and 5.4 M¥. Subsidies under the two scenarios were thus mainly allocated for clear-cutting and thinning under Scenarios 1 and 2, respectively. These results suggest that if the clear-cutting area were to decrease, the required subsidy would not decreased immediately, because weeding continues to be required for 10 years after planting in the clear-cutting area.

Figure 7 shows the forestry profits under the two scenarios. Under Scenario 1 the maximum and minimum forestry profits were 41.0 M¥ in 2010 and 13.7 M¥ in 2035. The forestry profits in 2035 were 33.5% of those in 2010 due to a decrease of harvesting area (Fig.4a) for clear-cutting.

Under Scenario 2 the maximum and minimum forestry profits were 20.1 M¥ in 2028 and 13.2 M¥ in 2013. Between 2013 and 2028 forestry

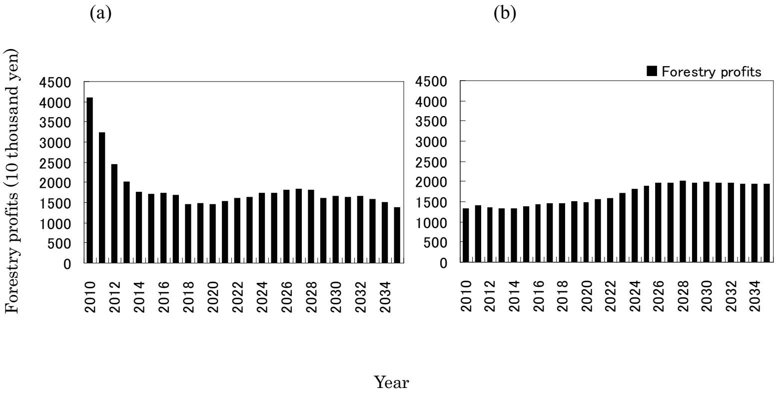

Figure 7. The forestry profits under (a) Scenario 1 and (b) Scenario 2.

profits increased by up to 152.5% of their minimum values due to the increased harvesting area (Fig.4b). Although the total forestry profits under Scenario 1 are larger than under Scenario 2 up to 2018, the pattern was reversed in 2023.

Figure 8 shows the response of carbon stock to the different scenarios. Under Scenario 1 the maximum and minimum carbon stocks were 106.7 thousand tons (Kt) in 2010 and 78.3 Kt in 2035. The carbon stock decreased by up to 73.4% of its maximum value due to the harvesting area (Fig.4a) for clear-cutting. Under Scenario 2 the maximum and minimum carbon stocks were 113.3 Kt in 2026 and 106.7 Kt in 2010. Between 2010 and 2026 carbon stock increased by up to 106.2% of its minimum value due to forest growth (Fig.4b). The total carbon stock was smaller under Scenario 1 than under Scenario 2 throughout the prediction period.

Generally, the carbon stock under Scenario 2 was relatively more stable than that under Scenario 1. A comparison of the two scenarios

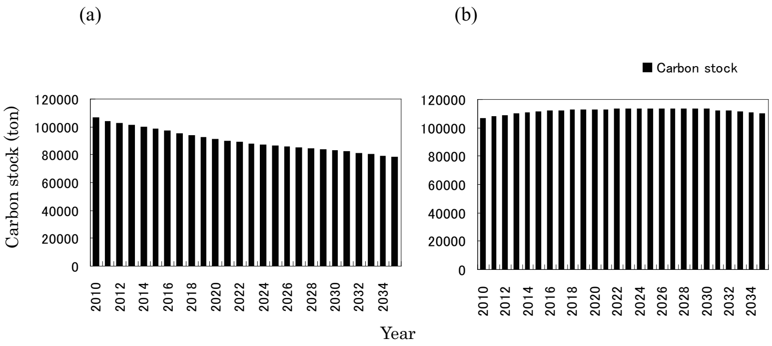

Figure 8. The carbon stock under (a) Scenario 1 and (b) Scenario 2.

clearly shows the carbon stock under Scenario 1 to be smaller than under Scenario 2 with differences ranging between 0 and 31.8 Kt suggesting that differences in carbon stock between the two scenarios were mainly due to clear-cutting.

Our approach enables the effects of different subsidy scenarios on forestry to be calculated. Although timber production is the basic function of forests, their role in storing carbon stock currently also holds a high position in the public mind, especially during the first commitment period of the Kyoto Protocol. Figures 5 and 8 enable us to consider the influence of forest management under different subsidy systems on both of these factors. Previous studies have analyzed useful variables and estimated parameters for several econometric models including the probit model (Dennis, 1990, Pattanayak *et al.*, 2003) and the logistic regression model (Royer, 1987, Zhang and Pearse, 1997), which can be used to predict the effects of forestry policies and subsidy systems. Other previous studies (e.g. Lewis and Plantinga, 2007, Kurttila *et al.*, 2006, Bolkesjo and Baardsen, 2002) have created models to estimate the effects of different amounts of subsidy. Our simulations also enable us to predict the effect of subsidy scenarios on the forest resources and timber production in targeted Japanese forest plantations.

For instance, in the present study, under Scenario 1 it is feasible to increase timber production during the early period of our predicted output (Fig.5). However, Scenario 2 is a better option if the forests' function of holding carbon stock is the more pressing and stronger requirement (Fig.8). The most suitable scenario could be selected by considering practical issues based on subsidies (Fig.6). Finally, Figure 9 shows the cost-effectiveness of investments in forestry and carbon stock. In terms of forestry profits, the maximum difference in the cost-effectiveness of Scenarios 1 and 2 was 1.7 in 2010. This relationship was reversed in 2012 and the difference in cost-effectiveness of the two scenarios increased with time. On the other hand, in terms of carbon stock, the maximum difference in the cost-effectiveness of Scenarios 1 and 2 was 33.0 in 2012. In this case the difference in cost-effectiveness decreased with time after 2013. As mentioned above, in the case of regional forest areas, the difference in the cost-effectiveness of any investment might be comparable during the period over which our predictions are made.

4. Conclusion

This study used simulation to investigate the effects on timber production and levels of carbon stock, of two scenarios describing alternative subsidy systems applied to Japanese forestry. Simulation output showed that both the harvested thinning area and the volume of harvested timber were larger under Scenario 2, in which the rules governing subsidy allocations are more relaxed, than under Scenario 1, in which the rules governing subsidy allocations are more restrictive. Because harvested timber was mainly produced by clear-cutting under Scenario 1, the forestry profits and the subsidy during the initial pre-

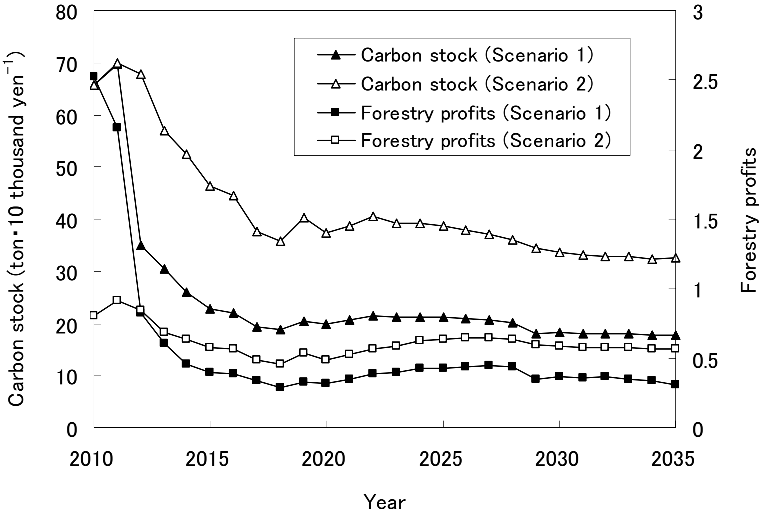

Figure 9. Cost-effectiveness of industrial timber development and carbon sequestration

diction period were larger than under Scenario 2. Silviculture subsidies and forestry profits were also larger under Scenario 1 than Scenario 2. However, carbon stocks were smaller under Scenario 1 than under Scenario 2. Reference to previous studies suggests that feasible forest management systems should consider the cost-effectiveness of any subsidy.

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炭素蓄積および木材生産における補助金シナリオに応じたシミュレーション

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要約: 本研究は、木材生産と炭素蓄積における異なる林業補助金制度の影響や、伐出施策における重要性を検討するためにシミュレーションを行った。間伐に対して適用要件の異なる補助金を検討するうえで、シミュレーションに収穫表作成システム LYCS、採材アルゴリズムおよび伐出コストモデルを使用した。行政によって収集された森林資源データをもちい、林業収支、炭素蓄積、補助金額および補助金の費用対効果をシミュレーション結果から算出した。ふたつのシナリオを基礎としたシミュレーションを比較すると、主伐面積および収穫材積の両方は、補助金の適用要件の厳格なシナリオ１にくらべて、補助金の適用用件の緩やかなシナリオ２において増加した。シナリオ１における出材量は主に主伐によって生産されたことに起因し、シミュレーションの初期において予測された林業収支および補助金額は、シナリオ２にくらべてシナリオ１の方が大きかった。逆に、炭素蓄積はシナリオ１くらべ、シナリオ２においてより増加した。

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