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The impact of a short-term carbon payment scheme on forest management

Artti Juutinen[a,b,*], Anssi Ahtikoski[a], Mika Lehtonen[c], Raisa Mäkipää[d], Markku Ollikainen[e]

[a] Natural Resources Institute Finland, P.O. Box 413, University of Oulu, FI-90014, Finland
[b] Department of Economics, P.O. Box 4600, University of Oulu, 90014 FI, Finland
[c] Natural Resources Institute Finland, P.O. Box 18, Vantaa FI-01371, Finland
[d] Natural Resources Institute Finland, Latokartanonkaari 9, FI-00790 Helsinki, Finland
[e] Department of Economics and Management, P.O. Box 27, FI-00014, University of Helsinki, Finland

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ABSTRACT

We examine the feasibility and impacts of a short-term carbon payment mechanism on forest management in boreal forests. Unlike under long-term carbon sequestration commitments over a rotation period, landowners are allowed in this scheme to sell temporal carbon credits based on stored carbon for one year and reissue them annually. Using numeric optimization we show that the short-term carbon payment mechanism has a profound effect on the timing and intensity of thinning, and the optimal rotation length showing up in higher timber yield and improved profitability. A comparison of the case where all carbon or only additional carbon above that in timber management benchmark is accounted for by the short-term payment scheme shows that the optimal forest management remains roughly the same. However, the increase in the profitability of forestry introduced by carbon credits is relatively small, if only additional carbon is credited. Hence the short-term mechanism may be feasible only under high carbon prices and it would most likely increase rotation length of mature stands with additionality requirement in boreal forests.

1. Introduction

Climate change is perhaps the greatest challenge the humankind faces. Article 2 of the Paris Climate Agreement 2015 sets the global climate goal, which requires: "Holding the increase in the global average temperature to well below 2 °C above pre-industrial levels and to pursue efforts to limit the temperature increase to 1.5 °C above pre-industrial levels, recognizing that this would significantly reduce the risks and impacts of climate change." Both temperature targets are demanding, and require a very rapid reduction of GHG emissions globally. Rapid reduction of emissions is not enough, though. Carbon sinks and other means of carbon removal are needed to complement emission reduction efforts. In fact, by 2070 developed countries should be carbon negative.

World forests can efficiently mitigate climate change by sequestering carbon from the atmosphere. Forests capture atmospheric CO2 through photosynthesis and store it as carbon in biomass and soil. The carbon may stay in the forest biomass and soil or in wood products for some time, but the stock is temporal, since all carbon fixed by the photosynthesis is eventually released back to atmosphere when dead trees, litter, cutting residues and wood products decompose (Liski et al., 2001). Therefore, the balancing the size of carbon stock against the rate of carbon uptake is an important issue for forest management. Both afforestation and climate-smart forest management provide large mitigation potential. No wonder that majority of the countries included forests in their Intended Nationally Determined Contributions under the Paris Climate Agreement in 2015 (http://unfccc.int/focus/indc_portal/items/8766.php). As the first country in the world, New Zealand included forestry in country's emissions trading scheme. Forest landowners are allowed to earn carbon credits by sequestering carbon in their forests, but should they harvest or deforest their forests, a payback of credit is required (Adams and Turner, 2012). The EU has decided to include land use, land use change and forestry (the so-called LULUCF sector) in the EU climate policy by 2020, giving a higher role for forestry in climate policy (Nabuurs et al., 2015). However, forest owners are not compensated for forest carbon sequestration.

Currently, the absence of climate incentives for forestry represents an important missed opportunity that could have remarkable contribution to mitigation of climate change (Nabuurs et al., 2015; Moen et al., 2014). Proposed Pigouvian policies favor subsidizing carbon sequestration and taxing carbon release (van Kooten et al., 1995). As an additional source of revenue, a subsidy or a related compensation scheme presumably changes forest management in a way that results in a higher rate of tree growth or longer rotations.

* Corresponding author at: Natural Resources Institute Finland, P.O. Box 413, University of Oulu, FI-90014, Finland.
E-mail addresses: artti.juutinen@luke.fi (A. Juutinen), anssi.ahtikoski@luke.fi (A. Ahtikoski), mika.lehtonen@luke.fi (M. Lehtonen), raisa.makipaa@luke.fi (R. Mäkipää), markku.ollikainen@helsinki.fi (M. Ollikainen).

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Several studies have analyzed the effects of the inclusion of carbon sequestration subsidies on forest management. Most studies have focused mainly on the rotation length but also thinnings has been considered (van Kooten et al., 1995; Hoen and Solberg, 1997; Pohjola and Valsta, 2007; Pukkala, 2011; Asente and Armstrong, 2012). Recently, the role of initial density was incorporated in the analysis (Goetz et al., 2010; Niinimäki et al., 2013; Pihlainen et al., 2014). All papers have postulated a subsidy/tax mechanism, which represents a long-term purchase approach, originally suggested by van Kooten et al. (1995).

In this commonly applied long-term scheme landowners receive a subsidy for carbon uptake, and pay a tax when carbon is released via harvesting. But is it actually the best alternative for forest management? For rapidly growing trees with short rotation ages perhaps, but not necessarily for the slowly growing boreal forests, which have increasingly important role for forest products. Socio-economic studies suggest that landowners in boreal areas may not be willing to make long-term commitments for providing ecosystem services in their forests (Horne, 2006; Markowski-Lindsay et al., 2011).

In this paper we introduce a short-term subsidy scheme and examine how well it suits to boreal forests involving long rotation periods. Previously the short-term subsidy scheme has been applied to afforestation and carbon sequestration within REDD+ mechanism (Galinato and Uchida, 2010, 2011; Olschewski and Benitez, 2010; Galinato et al., 2013; Cacho et al., 2013). It is important to investigate, however, how the short-term carbon policy developed merely for plantation forests in tropical countries performs when applied to management of existing semi-natural forests that are gaining an increased importance in the EU climate policy (Nabuurs et al., 2015). In the short-term rental subsidy scheme landowners are allowed to sell temporal carbon credits based on the stored carbon for one to ten years, for example and reissue them after expiration. Thus landowners have a possibility to opt out of the carbon payment mechanism and change the management schedule after the expiry period without any penalty. To our knowledge, the impacts of short-term incentive mechanism on the management of commercial boreal forests have not been previously studied. Lintunen et al. (2016) compared analytically the equivalency of rental and purchase carbon policies, but they did not examined how the short-term policy impacts on optimal forest management and what is the potential of short-term rental policy in boreal forest.

We impose the short-term rental compensation scheme and ask how the landowners will manage their forests when they receive harvest revenue and income from carbon sequestration. We contribute to the literature several ways. First, instead of postulating a steady-state forestry, we allow for alternative initial states of stands when climate incentives are introduced. To create a comprehensive description of forest management, landowners are assumed to optimize over a wide range of management variables including rotation length and the number, timing, type, and intensity of thinning as well as precommercial thinning. Previous optimization studies have focused on forest stands representing different fertility classes, but have not considered variation between stands characteristics within the fertility classes (e.g., Niinimäki et al., 2013; Pihlainen et al., 2014).

Second, we also examine the role of additionality. In many practical implementations of forest-carbon policies (UNFCCC, 2011; CEPA, 2014), the payments are restricted to actions or services that are indeed additional in the sense that they have not already been carried out, or would have been carried out in the absence of the contract. Regarding afforestation projects the additionality is an obvious outcome, but that is not the case when management of existing forests is considered. In our approach the carbon credits are calculated as a difference in stored carbon between the baseline timber management and the joint management similarly as in Latta et al. (2011) and Man et al. (2015).

Third, we also focus on the role of transaction costs of the short-term payment mechanism. High transaction costs may be an obstacle to the system, in which case the prevailing market carbon prices may not provide enough incentive for adoption (Cacho et al., 2013). Given that the short-term rental mechanism is not yet applied in the EU climate policy, the transaction costs are unknown. Therefore, we assess the feasibility of the mechanism by estimating the maximum transaction cost level at which forest owner's net benefit of participation to the carbon trade is not negative.

2. Materials and methods

2.1. Carbon policy

Consider now the following voluntary climate policy targeting forest management. The landowners are allowed to produce short-term carbon credits with a year as the commitment period and sell them in the carbon market. The credited and certified carbon stock is defined as a difference in annual carbon stocks between the joint timber and carbon management and the baseline timber management, and measured in tonnes of carbon dioxide. The credit is temporary and expires at the end of the commitment period following the year during which it was issued. Then, new credits can be issued annually in any subsequent year during the rotation period as long as the stand is not clear-cut.[1] When the stand is clear-cut, the carbon stock is zero and there are no credits to sell.

The short-term credits mechanism differs fundamentally from the conventional long-term payment mechanism in which landowners sell permanent credits. A permanent carbon credit scheme is based on a change of carbon storage between two sequential periods. It will not expire but the landowner has to pay a penalty (tax) when carbon storage is reduced, because harvesting makes carbon sequestration negative. In contrast, the short-term mechanism gives landowners a possibility to opt out of the carbon payment mechanism and change the management regime after one year expiry period without any penalty. Naturally, the difference shows up in the prices of carbon, too. Under the short-term mechanism, prices for temporal credits, derived from those of permanent credits, are much smaller than under permanent payment mechanism.

We next formalize the short-term payment mechanism and the benchmark. The absence of carbon policies defines the baseline management, where the landowner maximizes only the net present value (NPV) of harvest revenue by deciding number, timing, intensity, and type of thinnings as well as rotation length. The management actions impact forest growth and biomass yield, and therefore, they also determine harvest volumes and net harvest revenues. Under the carbon payment policy, they are used to control the carbon storage in the stand and the carbon payments the landowner receives along with the net harvest revenues. Naturally, forest growth depends also on many stand characteristic, such as soil fertility and initial state of the stand.

At a general level, the landowner's optimization problem can be presented as a discrete-time system of state and control variables (cf., Cao et al., 2006; Tahvonen et al., 2013). Let Z_{t_i} describe stand state before the i th potential harvest at stand age t_i, $i =$, 0, …, T. We use t_0 to denote the initial stand age and the final harvest (clear-cutting) occurs at stand age t_T. The initial stand state Z_{t_0} is given. In the empirical modeling the stand state includes multiple variables, but here it simply denotes biomass volume of standing trees (m^3). Let k ($k = 1, …, K$) denote different timber assortments of the trees in the given stand including, for example, pulpwood and saw logs. Stumpage price (€/m^3) for a timber assortment k is denoted by p_k. Let the real interest rate be r. The harvest volumes (m^3) for each timber assortment k and harvest i are denoted by h_{ki}. The volume of precommercial thinning is denoted by $\widehat{h}_i$ and the associated unit cost by s. Obviously the precommercial thinning

[1] Choosing a year as the contract period is naturally not the only option for short-term incentives, for instance, a five year long period would be equally feasible choice (see Galinato et al., 2013). The one-year period was chosen in this paper for simplicity to facilitate the numeric optimizations, because the focus was on contract design question rather than in the specific details of a policy.