Forest Policy and Economics 47 (2014) 14–24

Contents lists available at ScienceDirect

Forest Policy and Economics

journal homepage: www.elsevier.com/locate/forpol

Optimal contract length for biodiversity conservation under conservation budget constraint☆

Artti Juutinen [a,b,c,*], Markku Ollikainen [d], Mikko Mönkkönen [e], Pasi Reunanen [e], Olli-Pekka Tikkanen [f], Jari Kouki [f]

[a] Finnish Forest Research Institute, P.O. Box 413, 90014 University of Oulu, Finland
[b] Thule Institute, University of Oulu, Finland
[c] Department of Economics, University of Oulu, Finland
[d] Department of Economics and Management, P.O. Box 27, FI-00014 University of Helsinki, Finland
[e] Department of Biological and Environmental Science, P.O. Box 35, 40014 University of Jyväskylä, Finland
[f] School of Forest Sciences, University of Eastern Finland, P.O. Box 111, 80101 Joensuu, Finland

ARTICLE INFO

Article history:
Received 30 November 2012
Received in revised form 25 November 2013
Accepted 28 November 2013
Available online 19 December 2013

Keywords:
Biodiversity
Conservation contracting
Payments for ecosystem services
Transaction costs

ABSTRACT

We examine the optimal length of a contract period in a conservation program with payments for ecosystem services aiming at protecting biodiversity on privately owned forests. The government chooses the number of stands and the length of contracts so as to maximize biodiversity benefits under a binding conservation budget. We examine the implication of two alternative budgets: a separate budget for each period (periodic budget) or one budget that to be used in all periods (intertemporal budget). The impact of the budget type shows up in the fact that with intertemporal budget choice set is larger and more high quality stands are available for contracting. Based on theoretical characterization we conduct a numerical landscape-level analysis. We find that both short and long conservation contracts are used to protect privately owned forest land. Transactions costs tend to reduce the number of short contracts. A budget increase results in a use of longer contracts.

1. Introduction

Conservation contracting programs with payments for ecosystem services (PES) are increasingly used as means to protect biodiversity in privately owned lands. In this voluntary, market-based policy, landowners receive payments in exchange for adopting land management practices that contribute to the supply of biodiversity benefits. Biodiversity is a public good, and therefore, PES programs targeted to biodiversity conservation are typically government-financed (Engel et al., 2008). Conservation contracts are traditionally applied in agri-environmental policy schemes but recently also as a part of forest conservation policies (Wunder et al., 2008). In Finland, the government initiated conservation contracting in 2003 to protect biodiversity in private commercial forests in Southern Finland (Juutinen et al., 2008).

Wendland et al. (2010) present several arguments supporting the use of the PES approach for meeting biodiversity goals over other conservation interventions. In particular, PES uses direct incentives to reach biodiversity targets, which is considered more cost-effective than traditional indirect conservation policy tools, such as establishing strictly protected areas. There are, however, many issues concerning conservation policy design that influence performance of a PES program (Ferraro, 2008; Hanley et al., 2012). One of the key issues in maintaining biodiversity in boreal commercial forests is to choose the proper length of contracts, because conservation benefits gained from an area may quickly change, for example, due to forest succession. Thus, the following question arises: should one use short or long contracts in temporal conservation given that biodiversity evolves in time and the government has only limited annual funds available for conservation? To answer this question, one needs to know which contract length provides the highest benefits over the cost of the contract.

In this paper we examine the optimal length of a contract period aimed at protecting biodiversity on privately owned forest. We assume that the government chooses the number of stands and the length of contracts so as to maximize biodiversity benefits when the government has a binding conservation budget. We examine the biodiversity benefits of two alternative types of conservation budgets: a separate budget for each period (periodic budget in what follows) and one budget that can be allocated to all subsequent periods (intertemporal budget). While the periodic budget leads to choices within one period only, one budget for all periods creates a temporal dependence between choices of contracts, as money used today cannot be used tomorrow when possibly better stands become available.

Our analysis contains two further aspects that have largely been neglected in earlier research. First, we take into account transaction

☆ This article belongs to the Special Issue: *Forest and Ecosystem Services: Outlines for New Policy Options*.

* Corresponding author at: Finnish Forest Research Institute, P.O. Box 413, 90014 University of Oulu, Finland. Tel.: +358 408015341.
E-mail address: artti.juutinen@metla.fi (A. Juutinen).

1389-9341/$ – see front matter © 2013 Elsevier B.V. All rights reserved.
http://dx.doi.org/10.1016/j.forpol.2013.11.008

costs (e.g. costs of evaluation of a stand quality and negotiation a contract) related to the contracting, which de facto decrease conservation budget. Short contracts cause larger transaction costs than long contracts because a higher number of contracts are needed to achieve a certain biodiversity level targeted in a conservation program by using short contracts than using long contracts. The performance of short and long contracts may critically hinge on the type of budget (periodic vs. intertemporal) and budget size; the more government has money available the longer contracts are possible. Therefore, we secondly examine how the size of budget affects optimal contract length. As our focus is on the length of the contracts, we simplify the rest of the analysis by assuming that contracting between the government and forest landowners is efficient in other respects.

We conduct a landscape-level analysis and focus on spruce-dominated forests that cover most of the forest land in our study area In Finland. We utilize a species-specific habitat suitability index to assess the biodiversity value of a forest stand, focusing on rare and red-listed species that are conservation-dependent. Besides harvesting, our approach includes also a no-harvest option. Drawing on a stand-based analysis, we characterize the economic logic of conservation contracts under the two alternative budgets. Using a simulation model, we examine the effects that contract periods and contract types have on landscapes and species.

Our work relates to previous literature as follows. Gulati and Vercammen (2005) examine optimal contracts for carbon sequestration on agricultural land. They show that farmers' marginal benefit of remaining in the contract is declining over time, whereas marginal opportunity cost is rising, so that the optimal length of the contract is finite. Furthermore Gulati and Vercammen (2006) investigate benefits of time-varying payment schedules to overcome time-inconsistency inherent in the conservation contracts. Ando and Chen (2011) examine the optimal contract length for voluntary ecosystem service provision in grassland and forest environments. They find that the optimal contracts are longer for forest (environmental benefits mature slowly) than for grassland. Lennox and Armsworth (2011) elaborate how uncertainty regarding a landowner's willingness to re-enroll on contract completion and future ecological benefits impacts the optimal choice of contract duration. They find among other things that long contracts are preferred when future site availability becomes more unlikely. These theoretical studies use numerical simulations merely as illustrative examples. In forestry context, a recent numerical study by Juutinen et al. (2012) assess how stand characteristics and species habitat requirements influence on the optimal choice of contract length. The results suggest that a cost-effective conservation policy for protecting privately owned forest land involves both short- and long-term contracts between landowners and environmental agencies. Juutinen et al. (2012) also show that species dependent on late decay phase of dead wood require longer contracts than species requiring fresh dead wood. Our work adds significant new elements to previous studies: first, following Juutinen et al. (2012) we make explicit use of actual stand information in our landscape; second, we use conservation budget to create temporal dependency between contract choices; and third, we account for transaction costs of contracting, as well.

The rest of the paper is organized as follows. Section 2 develops the framework and outlines the choice of conservation contracts under two alternative budget constraints. Section 3 presents the data and the numerical model. Section 4 presents our finding and a concluding Section 5 ends the paper.

2. Theoretical framework: biodiversity conservation under a binding conservation budget

Consider a government launching a voluntary program with associated payments to promote biodiversity conservation in a given area. The government wants to choose ecologically valuable stands to the conservation program that is financed by a fixed conservation budget. For landowners willing to participate in the program, the government offers differing contract lengths depending on the ecological status and the conservation costs of their stands. The terms of the contract are its length, the payment to the landowner and the ban of harvesting during the contract period. As we are interested in examining the contract length, we assume that the government and landowners reach contracts that compensate precisely the landowner's conservation costs. We assume in the theoretical part that the government can assess the contribution of each stand to biodiversity in the area. To determine the length of the contract and assess the payments, the government must have information on the privately optimal rotation age of each stand but details of forest management are actually private information.

We rely on the traditional Hartman model (1976) and describe the biodiversity values provided by a stand under the conservation program by

$$\hat{E}_i = \int_{T_i^*}^{T_i^*+\delta_i} B_i(s)e^{-r(s-T_i^*)}ds + e^{-r\delta_i}E_i^*, \tag{1}$$

where, δ_i denotes the length of the contract and E_i^* describes the biodiversity values from all future rotations under optimal rotation age. We assume in Eq. (1) that the conservation contract is made at the privately optimal rotation age, T_i^* and biodiversity benefits increase with the length of the contract (the first term of Eq. (1)). Furthermore, contract also postpones the future biodiversity evolvement, E_i^*, and this impact is captured by the discount factor in second term in Eq. (1). The government objective is to maximize the sum of biodiversity benefits from stands enrolled in the conservation program, $\sum_{i=1}^{I}\hat{E}_i$, where $i = 1, \ldots I$ refers to the number of stands in the program. As old-growth forests are the most threatened forest types in boreal forest, it is natural to assume that the longer the contract period, the higher the biodiversity values. This is, however, contrasted with the fact that the longer the contract period, the larger the payment to the landowners, because revenue from timber production reduces due the longer rotation period, as we shall shortly see.

To determine the payments for the stands, the government must assess the costs of conservation. To assess the conservation costs for any participating landowner, the government must determine the difference in forest rent under the private optimum and rents when landowners participate in the program. The landowners maximize the net present value of harvest revenues from their stands (Faustmann, 1849). In the absence of the conservation program, a stand i will be clear cut at the optimal rotation age T_i^*. Under this harvesting plan and at the privately optimal rotation age T_i^*, the land value can be expressed as,

$$\pi_i(T_i^*) = pf(T_i^*) + V_i^*(T_i^*), \tag{2}$$

where p denotes the stumpage price of timber, r the real interest rate, $f(T_i)$ the forest growth function, and $V_i^*(T_i^*) = \left(pf(T_i^*)e^{-rT_i^*} - c\right)\left(1 - e^{-rT_i^*}\right)^{-1}$ is the maximum net present value of profit from all future rotations where c is regeneration cost.

If the landowner participates in the voluntary conservation program, the harvest plan is changed, as the contract bans harvesting during the contract period. The contract is made at the rotation age of the stand, T_i^*. Therefore, for the participating landowner the land value can be expressed as

$$\pi_i(T_i^* + \delta_i) = pf(T_i^* + \delta_i) + V_i(T_i^*). \tag{3}$$

A comparison of Eqs. (3) to (2) suggests that the new harvesting plan leads to a lower land value, because the currently growing stand will be over-mature when harvested after the contract has expired. The size of the conservation costs, C, is defined by the difference: $C_i(\delta_i) = \pi_i(T_i^*) - \pi_i(T_i^* + \delta_i)e^{-r\delta}$. We assume that the payment for