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Assessing national impacts of international environmental regimes for biodiversity protection and climate mitigatio in boreal forestry – Experiences from using a quantitative approach

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ABSTRACT

Several international regimes provide numerous recommendations for sustainable forest management and there is a growing interest in knowing more about the potential and actual effects of such regimes and improving their effectiveness. National implementation of such regimes go through different stages of development, from changes 'on paper' in regulations and guidelines (labelled *output*), to behavioural changes among target groups (labelled *outcome*) before responses are seen on the natural environment (labelled *impacts*). The main purpose of this paper is to apply a quantitative bio-economic model for analysing the potential *impacts* on Norwegian forestry of two international regimes (the Convention of Biological Diversity (CBD) and an extended version of the Kyoto Protocol), and to discuss the weak and strong points in using this kind of method in policy analysis. Our findings imply that: (i) The CBD regime has rather limited impacts on the forest structure and harvest as long as it is practised with an intensity corresponding to the forest certification schemes used at present in Norway, or with lower intensity. (ii) Practiced with maximum consideration to biodiversity the potential impact of the CBD regime on the forest structure and harvest is strong, and it can reduce the income from timber production by 30% or more compared to present forestry practices. This reduction is highest when forest climate mitigation is given low consideration. (iii) There is a significant mutual relationship between the two regimes analysed, in the meaning that the weaker one of them is implemented, the stronger marginal impact has the other. (iv) Using quantitative bio-economic modelling in policy impact analyses like this contributes to the methodological literature on regime effectiveness, and has several advantages. But due considerations should be given to underlying basic assumptions related to agent behaviour and the ecosystem detail level required.

1. Introduction

During the last decades, several international regimes[1] have provided numerous recommendations for sustainable forest management (Humphreys, 1996; Humphreys, 2006). This has created increased interest for research regarding the effects of such regimes on national forest management and the environment.

Studies of effects of international agreements are found in the literature of international regimes, like Underdal (1998, 2002a,b), Victor et al. (1998) and Young (1989, 2001, 2004, 2011). According to Underdal (2002a,b) national level implementations take time and go through different stages of development, from changes 'on paper' in regulations and guidelines (labelled *output*) to behavioural changes among target groups (labelled *outcome*) before responses are seen in the natural environment (labelled *impacts*). The literature emphasizes that a casual link from the international regimes to the national adaptations are required for a change to be considered an effect of the regime, and that separating other sources of influences is more complicated for outcome and impacts than for output (Kütting, 2000; Miles, 2002; Underdal, 2002a, 2002b; Young, 2004; Ringquist and Kostadinova, 2005).

According to Underdal and Young (2004), one should distinguish between *direct effects* attributed to the agreements and *broader consequences*, which in addition include indirect effects and interactions with other influences. While including broader consequences can give a more complete picture of influences from agreement(s), evaluating

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[1] "Regime" often refers to more than written commitments in international agreements, cf. for example the influential definition by Krasner (1983): "Regimes are implicit or explicit principles, norms, rules and decision-making procedures around which actors expectations converge in a given issue-area". In this paper, *agreements*, *processes* and *regimes* are used interchangeably as generic references to cooperative arrangements.

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them in a reliable way are no less demanding. The units in effectiveness studies can be one regime, as a stand alone arrangement, or two or more arrangements giving rise to interactions and dynamic relations between the arrangements. Studying interaction, often referred to as interplay, between regimes on similar or related issue areas is an emerging field (see e.g., Gehring, 2004; Gehring and Oberthür, 2004; Young, 2004; Oberthur and Gehring, 2006).

In Scandinavian forestry, impacts of two international environmental agreements are of particular interest: The Convention of Biological Diversity (CBD) and the Kyoto Protocol under the United Nations Framework Convention on Climate Change. The first deals with biodiversity protection and the second with reduction of the emission of greenhouse gases to the atmosphere, a challenge where carbon sequestration in forestry may play an important role. Different aspects of national impacts of these agreements on forests have been investigated, very often focusing on either biodiversity or carbon sequestration. An increasing body of literature focus on biodiversity (and other environmental and social) concerns are related to REDD (Reducing Emissions from Deforestation and forest Degradation) in tropical countries (e.g. Sahide et al., 2015). The challenges of determining effects of international agreements on national forest polices, i.e. 'output', are explored by Lindstad and Solberg (2010, 2012). Four causal pathways of influence from international to national level are described by Bernstein and Cashore (2012), while Lindstad (2015) contrast the 'four pathways approach' to the regime literature.

Neither the CBD nor the FCCC/Kyoto Protocol provides concrete 'on the ground' restrictions on national forest management. We therefore use three scenarios for biodiversity concerns reflecting alternative strengths in interpretation of the recommendations from the CBD, and different carbon prices to reflect alternative weights assigned to carbon mitigation in the Kyoto Protocol. The chosen carbon prices range from 0 to 1000 NOK per ton CO_2 to reflect respectively zero and very strong climate mitigation considerations, and are chosen based on estimates reported of the marginal costs to reduce the anthropogenic emission of green house gases (see e.g. Kolstad et al., 2014).

Quantitative modelling of regimes effectiveness is of interest in particular because it may give a better understanding of the relative and total importance of various factors involved. To analyse the relative and total potential quantitative impacts of the above mentioned two regimes, we need a quantitative model that incorporates both important biodiversity aspects and carbon sequestration related to forest management. In Norway, the bio-economic model GAYA-J has been developed and used for analysing biodiversity protection (Hoen et al., 1998; Bergseng et al., 2008) and an extended version of this model, GAYA-J/C, has been used for analysing forest management impacts of carbon sequestration (Hoen and Solberg, 1994; Raymer, 2005; Raymer et al., 2005). However, no analyses have previously used the model to simultaneously consider biodiversity and carbon sequestration.

Based on this, the main purpose of the paper is to apply the model GAYA-J/C for analysing (i) the potential impacts on Norwegian forestry of the two international regimes mentioned above (CBD and an extended version of the Kyoto Protocol), and (ii) the weak and strong points in using such kind of quantitative modelling for studying national impacts of international environmental agreements. To our knowledge this has not been done before in forestry, and neither have we come across similar studies for other sectors.

The article focuses on *impacts* in the meaning cited above from Underdal (2002a, 2002b), i.e. as responses on the forest studied. Thus, implicitly, it is assumed that the necessary policy measures are in place and that practitioners respond as anticipated. Another delimitation is that we consider only the *direct* effects, i.e. *broader consequences* as defined above are disregarded.

The next chapter describes the methodology and data used, modelling results are presented in Section 3, the methodology and main results are discussed in Section 4, and finally main conclusions are drawn in Section 5.

2. Methodology and data

2.1. Assumed agent behaviour and model structure

The modelling behaviour assumed in this study can be classified as constrained utility maximization. We assume a rational forest owner in the sense that she maximizes utility (being it net present value of income from timber production or carbon sequestration, or both) from her forest under constraints fulfilling pre-specified requirements regarding biodiversity protection.

The model used is a dynamic, aged-structured forest optimisation model for an actual forest which consists of a set of initial forest stands of different species (and species mixes), different ages and different harvesting costs. The model solutions give the optimal forest management of each forest stand solved endogenously based on the above mentioned utility assumptions. The model consists of a simulation tool (GAYA) and an optimisation (J) tool, which are both controlled from a geographical information system, GIS (Hoen and Eid, 1990; Hoen and Gobakken, 1997; Lappi, 2003). First, GAYA simulates treatment schedules for each management unit and then the management problem is solved at forest level by LP using the J algorithm (Lappi, 1992; Lappi, 2003). Connecting GAYA, J and GIS makes each treatment unit an identifiable polygon with respect to stand and vegetation characteristics. GAYA acts as a matrix generator for J defining for each forest stand a possibility set of alternative treatment schedules, and J finds the optimal forest management according to the chosen objective function and specified constraints by searching through all combinations defined by all possibility sets combined. The formal model is specified in the Appendix A.

Forest development is simulated for 100 years. A set of pre-defined forest treatment options is applied according to feasibility criteria that are based on stand characteristics linked to each treatment option (see Hoen et al., 1998). This allows GAYA to simulate a wide range of feasible treatment schedules, including "no treatment". The treatment schedules contain the most relevant biological end economical characteristics. In the reference scenario, GAYA simulated on average 255 different treatment schedules for each of the 3080 forest management units.

The optimal solution is that which maximizes net present value, NPV, and meets restrictions and requirements in the LP-problem. NPV at forest level, including land expectation value of the ending inventory, is found as the sum of NPV of all treatment schedules included in the optimal results.

In the reference scenario, net present value is maximised without constraints for biodiversity protection but including the full carbon model (described later). In the two alternative scenarios, biodiversity protection is included in the form of different restrictions on forest management. Net carbon sequestration is taken into account in the optimisations by adding the value according to the assumed carbon price and including it in the NPV of the stand.

The value of the ending inventory is not optimised in the same manner as in the analysis period itself, but is calculated by projecting forest growth for each treatment schedule in the ending inventory according to preset forest treatment rules for each tree species and site index, and then calculating the net present value of the projected growth. The preset forest treatment rules are based on a series of GAYA forest stand simulations and J optimisations to be near optimal. This may create unrealistic harvests the last 10–20 years of the optimisation period, the so-called terminal problem, and to avoid unnecessary problems in interpreting the results, we optimize over hundred years, but show the results for only the first eighty years.

2.2. Main biodiversity protection assumptions

Three biodiversity protection scenarios are analysed, reflecting three levels of strength regarding interpretation of the