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Analysis

The Challenge of Mitigating Climate Change through Forestry Activities: What Are the Rules of the Game?

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ABSTRACT

In this study, the price of carbon is used to incentivize a reduction in the release of CO_2 emissions and an increase in sequestration of CO_2 through forestry activities. Forest managers essentially have two options for increasing carbon sequestration (i.e., creating carbon offset credits): (1) avoid or delay harvest of mature timber; or (2) harvest timber and allow natural or artificial regeneration (with 'regular' or 'seed-selected' growing stock). A forest management model representative of the southern interior of British Columbia is described and used to examine forest conservation that prevents emissions of CO_2, and even-flow and commercial harvesting where timber is processed into long-lived wood products that store carbon and residuals for energy. The objective of the model is to maximize net discounted returns to commercial timber operations plus the benefits of managing carbon fluxes. The model tracks carbon in living trees, organic matter, and post-harvest carbon pools. It also includes various parameters related to the weighting of future carbon flows, anticipated price of carbon, whether and to what extent use of biomass reduces fossil fuel emissions from generating electricity or production of non-wood construction materials, et cetera. The results demonstrate that the decision about which forestry activities generate carbon offset credits and how many is essentially a political and not a scientific one.

1. Introduction

Economic incentives are the best way to encourage public and private forestland owners, managers, loggers and wood processors to consider the climate impacts of forest management decisions. With appropriate incentives, forests could be managed more or less intensively for their commercial plus carbon benefits or left unmanaged. With carbon markets, economic agents can be required to purchase carbon offsets for emissions to the atmosphere and receive carbon credits for CO_2 sequestered in ecosystem sinks, growing vegetation or product pools. For example, carbon credits can be issued for carbon entering wood product pools and then used to offset emissions from fossil fuels during harvesting and processing. Lumber and engineered wood products are the most important product pools, because technological advances in engineered products have led to the construction of state-of-the-art multipurpose and multi-story wood buildings that are now less vulnerable to fire and pests, and require less energy to heat or cool thereby further reducing CO_2 emissions (Green and Karsh, 2012).

To overcome issues related to measurement and monitoring, carbon offset credits/debits can be based on a forest management (growth and yield) model specified in advance plus observed changes in land use (van Kooten, 2009). The forest management model would specify the annual carbon uptake in the various components of the forest ecosystem from the time trees are planted until they are harvested, if at all. Each year, the landowner would receive a credit for the carbon removed from the atmosphere. At the time of harvest, the owner would purchase offsets based on the CO_2 released from decaying residues left on the site, decaying residues resulting from processing and manufacturing, and decaying short- and long-lived products. It will, however, be necessary to determine how much roundwood and other biomass is harvested and how this wood is utilized to establish how much carbon enters post-harvest pools. Decay rates for each carbon pool can be established a priori and the carbon fluxes resulting over infinite time discounted to the present to determine the credits to be purchased to cover emissions at the time of harvest.

This procedure seems reasonably straightforward, but it is fraught with pitfalls, the most obvious of which is the rate used to discount future carbon fluxes – the inevitable future releases of CO_2 from decaying wood products. As demonstrated in this paper, this is a political decision. But there are many more political decisions that establish the rules for awarding carbon offset credits. For example, it is possible to provide credits for the CO_2 emissions avoided when biomass is burned in lieu of fossil fuels, or credits for the emissions avoided from producing non-wood materials when wood substitutes for steel or concrete in construction, or even credits for the emissions avoided when heating wood buildings as opposed to non-wood ones.

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These are more controversial aspects of a forest carbon uptake scheme because it could result in double counting. When biomass substitutes for fossil fuels in the generation of electricity, the utility is no longer charged for the emissions associated with the burning of fossil fuels, which is a benefit counted outside forestry. The same is true of the emissions saved from not producing steel and cement when wood substitutes for non-wood materials in construction. If such benefits are counted elsewhere and not attributable to forestry activities, the only carbon savings that can be credited occur because carbon is stored in products.

On the other hand, if CO_2 emissions avoided are credited when bioenergy is burned instead of fossil fuels, then it is just as appropriate to credit the fossil fuel emissions avoided when wood substitutes for non-wood in construction (and fossil fuel emissions avoided when less energy is required to heat or cool wood buildings as opposed to concrete and steel ones). Importantly, inclusion of these avoided emissions is a political not scientific decision, but it influences the choice of forest strategy to mitigate climate change. Thus, economic agents must know the rules of the carbon game before making forestry decisions, and these rules are ultimately established by the political authority.

The current paper abstracts from the rules established by the IPCC (2000) for calculating carbon sequestration, because the rules do not take into account the carbon life-cycle as it applies, for example, to recent pressure on forest ecosystems to deliver biomass for generating electricity, and because the role of economic incentives is neglected. It contributes to the debate about how forestry activities might best be deployed to mitigate climate change. We compare carbon uptake, storage and release under various forest management strategies, including the possibility of 'leaving the forest unmanaged.' Importantly, we take into account the life-cycle of carbon through the vertical chain of processing wood. By valuing carbon, forest managers are incentivized to choose strategies that promote carbon sequestration and storage, but they would need to take the wood product substitution rate as given. By pricing carbon and specifying the 'rules of the game', forest managers are able to balance the trade-offs between leaving forests to grow and harvesting them for wood products, including bioenergy.

We proceed as follows. In the next section, we provide an economics perspective on the life-cycle of carbon in forestry. The model used in the study is then described in Section 3, followed by the results of various scenarios in Section 4. We conclude with a discussion of policy implications regarding the management of forests.

2. Economics of Carbon Fluxes

An important consideration when managing forests for climate mitigation relates to the timing of carbon fluxes. How do forest management activities and post-harvest uses of fiber affect the stream of CO_2 release to and removals from the atmosphere? While the mitigation objective might be interpreted to mean 'sequester the greatest amount of carbon in forest ecosystems and wood product pools,' this objective is not as straightforward as it might seem. There are two reasons: One relates to the life-cycle of carbon while the other relates to the emissions avoided when wood fiber is used in construction or as a fuel, and both relate to the urgency to address global warming (Johnston and van Kooten, 2015).

Scientists clearly favor the use of radiative forcing because "it provides a kind of *physically based discounting factor* by which the biomass emissions with deviating timing can be transformed into a permanent fossil carbon emission whose cumulative warming impact within a given time horizon is the same" (Helin et al., 2013, p.481, emphasis added). The concept of radiative forcing is not commonly used by policy analysts, as they would argue that "assessments of mitigation must go beyond just considering the C [carbon] pools in forest ecosystems: it is important to also consider C use and storage in HWPs [harvested wood products] and landfills, substitution of wood for more emissions-intensive products and fossil fuels, and land-use change involving forests. Such activities are highly interconnected, [and] … need to be based on an integrated assessment of the various mitigation possibilities" (Lemprière et al., 2013, pp.298, 301).

Canadian Forest Service (CFS) scientists (Kurz et al., 2013; Lemprière et al., 2013; Smyth et al., 2014) take a systems approach that measures the carbon fluxes associated with the interaction between human activities (planting, fertilizing, thinning, harvesting) and the forest ecosystem dynamics, including wildfire, pests, et cetera. A systems approach considers carbon stored in long-lived product pools, and CO_2 emissions avoided when wood replaces steel and cement in construction and/or wood biomass replaces fossil fuels in energy production.[1] The CFS scientists find that commercial harvesting of trees to produce wood products is generally preferred to storing carbon in unmanaged forests (Smyth et al., 2014 provide some exceptions), and that production of wood products leads to a greater carbon dividend than the use of wood biomass for energy. Indeed, Lemprière et al. (2017) find that intensive forest management could account for 9.8% to 14.7% of Canada's annual CO_2-emissions reduction target of 112 Mt CO_2 between 2014 and 2020, and at a cost of less than \$50/tCO_2. At the provincial level, BC could rely on forestry activities to achieve 35% of its targeted emissions reduction by 2050 at a cost of less than \$100/tCO_2 (Xu et al., 2017). Missing from these large-landscape scale studies are the economic incentives that landowners, logging companies and wood processors require to implement the needed activities. Importantly, the incentives must also include the carbon accounting rules – particularly substitution rates for emissions avoided and how carbon fluxes are to be weighted over time.

Economic agents need to know the carbon benefit or cost associated with the decisions they make regarding harvest utilization and logging methods (size of trees, residuals), transportation (roadside waste), processing (products to produce), and regeneration, among others. Subject to technical and institutional constraints, price signals determine how much timber is harvested and how much lumber, plywood, wood chips, et cetera, are produced. Whether through the issuance of carbon offset credits for sale in carbon markets or through a tax/subsidy scheme, the introduction of carbon prices signals agents to alter their harvesting practices, choice of product mix, and overall use of wood fiber. Agents need to know whether and how many carbon offsets they will earn when wood substitutes for fossil fuels in electricity generation, or when wood substitutes for concrete and cement in construction. They need to know how much carbon is credited to their account in each period if trees are left unharvested, or if they plant faster-growing trees. That is, economic agents need to know the rules of the game, and that may require the use of models to establish the carbon fluxes related to various forestry activities.

The length of time that incremental carbon is stored in forest ecosystems, product pools or in the atmosphere may be on the order of decades. Since the release of CO_2 to the atmosphere contributes to climate forcing, while removals do the opposite, there may be some urgency to remove CO_2 from the atmosphere to avoid climate forcing. Thus, the timing of emissions and removals of carbon are important, with current emissions and removals from the atmosphere more important than later ones (Helin et al., 2013, p.476). This is a policy decision and implies that carbon fluxes need to be weighted as to when they occur, with future fluxes discounted relative to current ones (Richards, 1997; Schlamadinger and Marland, 1999).

The weights used to discount future carbon fluxes can be thought of as discount rates that can be used to put into practice the urgency of policy to address climate change (Johnston and van Kooten, 2015). If global warming is not considered a problem, the economist might use a zero discount rate, in which case it really does not matter if biomass

[1] Concrete requires five times and steel 24 times more energy to produce than an equivalent amount of sawn softwood; wood is also five times more insulating than concrete and 350 times more than steel (Risen, 2014).