Re-evaluating the role of biomass and dead organic matter in the optimal forest harvest decision with carbon sequestration

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INTRODUCTION

- July 8, 2009: G8 leaders set target to reduce global GHG emissions by 50% from 1990 levels by 2050; rich countries to reduce aggregate emissions by 80%. EU target – reduce emissions 20% by 2020; UK Climate Change Act (2008) – cut them by 34% by 2022, 80% by 2050.
- Carbon offsets have become important, especially forest ecosystem offsets. BUT questions linger regarding forest activities, esp. those to Reduce Emissions from Deforestation and forest Degradation (REDD) and the expansion of REDD to include activities aimed at sustainable forest management and biological conservation (REDD+), thus combining UNFCCC with the UN Convention on Biological Conservation [1].
- When a dead organic matter (soil) carbon pool plays a large role in a forest ecosystem, optimal forest rotation age criteria may change [2].

GOALS/OBJECTIVES

1. Examine issues related to the use of forest ecosystem carbon sinks.
2. Consider the effect on optimal forest harvest times as initial levels of carbon in the dead organic matter (DOM) pool and carbon prices change. Identify the impact of a carbon tax and initial DOM level on the projected trajectory of carbon in the DOM pool and overall.

THEORY

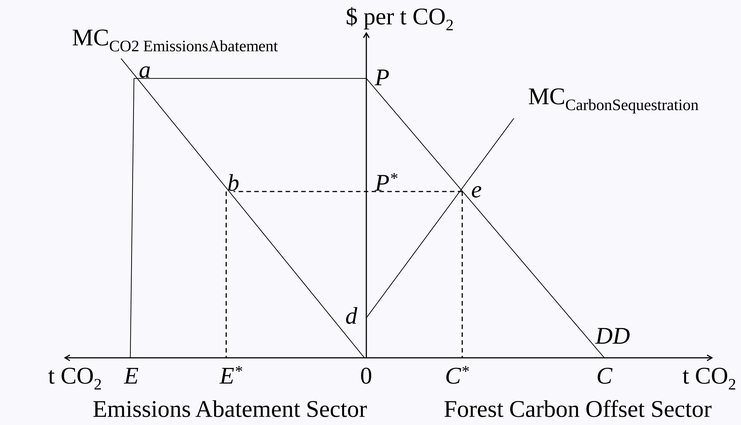


FIGURE: Emission cap *0E* met by carbon offsets from forestry equal to $0C^*=0E^*$, saving $EE^*ba - 0deC^* = deP > 0$ [3].

METHODS: DETERMINING HARVEST AGES

- Building on [2] and [4], we develop a single-stand forest harvest model that takes into account CO_2 emissions from harvesting and carbon stored in products, as well as that stored in the forest ecosystem (including dead organic matter). At a given year, landowner chooses to clearcut stand or defer decision to the following year. Original equations in discrete form:

(1) $$PV_{timber\&carbon} = \frac{(P_{logs} - C_{harvest})\, v(t) - C_{regeneration}}{(1+r)^t - 1} + \frac{\alpha\,(1+r)^t P_{CO2}\left[\beta\, v(t) + r\sum_{a=1}^{t} v(a)(1+r)^{-a}\right]}{(1+r)^t - 1}$$

where v_t timber volume at t, β converts volume into above ground biomass measured in CO_2, r discount rate, α pickle factor

- Let k=0 no harvest, k=1 harvest), f rate of litter fall, δ is the decay rate of dead organic matter (D), μ is proportion of biomass left on site after harvest. Then

(2) $$\Delta C_{t+1}^{k=0} = \beta[v_{t+1} - (1-f)\, v_t] - \delta\, D_t \qquad \Delta C_{t+1}^{k=1} = \beta\,(v_1 - \mu\, v_t) - \delta\, D_t$$

where addition of (2) modifies fixed rotation age derived in (1) so that the rotation age might vary from one harvest to next

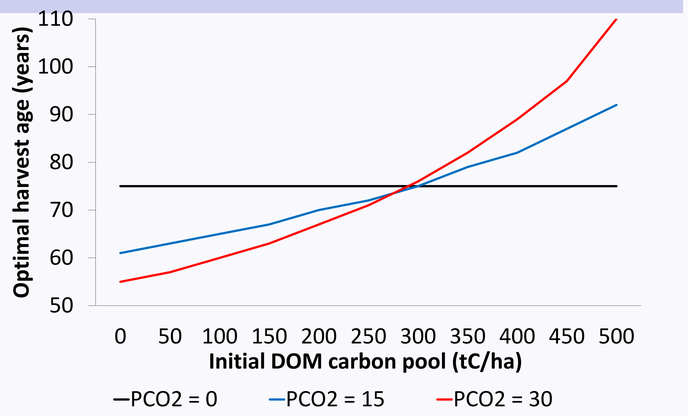
RESEARCH FINDINGS

Results

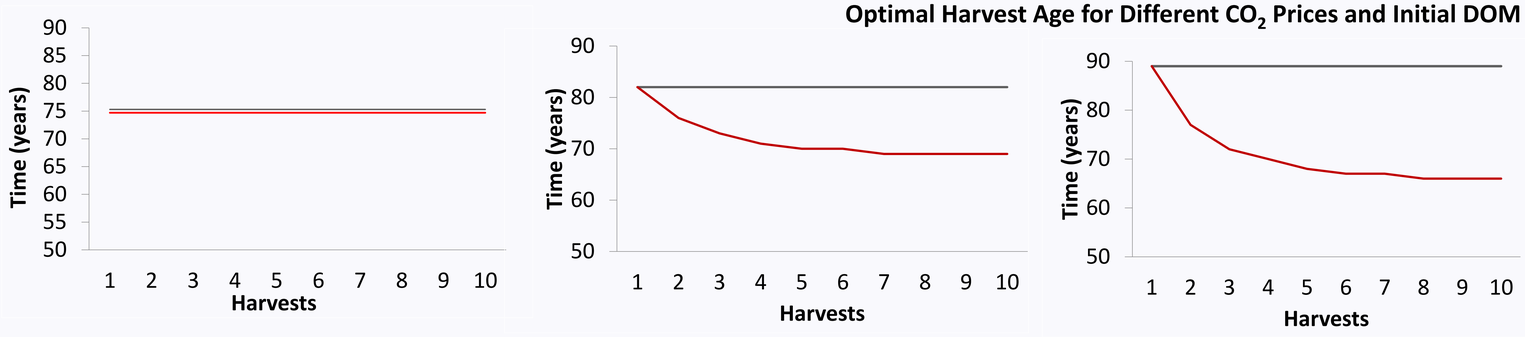
- A CO_2 tax (P_{co2} in eq.1) affects the optimal harvest age as does the initial amount of carbon stored in the DOM pool (eq.2)
- Accompanying figures indicate what happens.

Further Areas of Research

- Need to model explicitly tradeoffs between conservation (e.g., DOM) and climate mitigation costs through logging/forest product efforts. In essence, what are the tradeoffs between REDD+ and CO_2, and costs.



Optimal Harvest Age for Different CO_2 Prices and Initial DOM



Optimal rotation pattern for 10 consecutive harvests for fixed rotation (black line) and the variable rotation (red line), starting dead organic matter of 400 tC per ha and carbon taxes of $0, $15 and $30 per tCO_2 (left to right).

REFERENCES: [1] van Kooten, GC & FP de Vries, 2012. Carbon offsets. Chap 165 in *Encyclopedia of Energy, Natural Resource and Environmental Economics* edited by J Shogren. Oxford, UK: Elsevier. **[2]** Asante, P, G Armstrong & W Adamowicz, 2011. Carbon sequestration and the optimal harvest decision: A dynamic programming approach considering biomass and dead organic matter. *J of Forest Economics* 17(1): 3-17. **[3]** Murray, BC & WA Jenkins, 2010. *Designing cap and trade to account for "imperfect" offsets*. WP EE10-03. Nicholas Institute for Environmental Policy Solutions, Duke University, Durham. **[4]** van Kooten, GC, CS Binkley & G Delcourt, 1995. Effect of carbon taxes and subsidies on optimal forest rotation age and supply of carbon services, *American J of Agricultural Economics* 77: 365-374.

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