Journal of Forest Economics 27 (2017) 50–59

Contents lists available at ScienceDirect

Journal of Forest Economics

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

Accounting for harvested wood products in a forest offset program: Lessons from California

Laurel Bates [a], Benjamin Jones [a], Eric Marland [a,b,*], Gregg Marland [b], Tatyana Ruseva [c], Tamara Kowalczyk [d], Jason Hoyle [e]

[a] Mathematical Sciences, Appalachian State University, Boone, NC 28608, USA
[b] Research Institute for Environment, Energy, and Economics, Appalachian State University, Boone, NC 28608, USA
[c] Government and Justice Studies, Appalachian State University, Boone, NC 28608, USA
[d] Accounting, Appalachian State University, Boone, NC 28608, USA
[e] Appalachian Energy Center, Appalachian State University, Boone, NC 28607, USA

ARTICLE INFO

Article history:
Received 6 July 2016
Accepted 9 February 2017
Available online 25 March 2017

JEL classification:
C18
Q23
Q54

Keywords:
Carbon accounting
Forest offset protocol
Decay distribution
Sensitivity

ABSTRACT

Carbon offset programs, such as that overseen by the California Air Resources Board (CA ARB), have emerged as a strategy for climate change mitigation. Offset projects sequestering carbon earn credits that can be traded on the Cap-and-Trade market to compensate for carbon emissions. The carbon stock embodied in harvested wood products can make up a substantial portion of the sequestered carbon in forest offset projects. In this paper we investigate the sensitivity of the calculations for the number of credits allocated to a forest offset project in the California system. We also examine how alternative models for the decay of harvested wood products might better reflect the dynamics of both the lifetime and cascade chain progression of the products and how this might change the amount of credits earned. The results suggest improved data collection and refinement in methodology would help to improve accuracy and reduce uncertainty in a large and important carbon stock. We conclude with offering suggestions on how an understanding of the dependence of harvested wood product stocks on life cycle parameters might affect the economics of offset programs and assist targeted mitigation efforts.

1. Introduction

In this paper we consider a variety of ways in which harvested wood products might be treated in accounting for the total number of offset credits for a forest carbon offset project. We consider management changes that might alter the amount of carbon storage in wood products, and accounting strategies that would improve the accuracy of the carbon accounting to reflect the true release of carbon to the atmosphere. We include the use of alternate decay functions to describe the loss of carbon from wood products over time.

Although establishing the most carbon-effective forest management strategies ultimately requires consideration of both: (1) the carbon stored in forests and forest products and (2) the effect of substituting forest products for other materials (see, for example, Gustavsson et al., 2017); this paper focuses only on the inventory approaches for dealing with the carbon physically stored in forests and forest products. Carbon offset projects are not generally a search for the most effective forest management strategy but they are rather an inventory to show that carbon discharged elsewhere has been offset by carbon storage in forests and forest products. The California Air Resources Board (CA ARB) accounting protocol currently deals only with the physically stored carbon in forests and forest products and avoids the potential issues of double counting when inventories include issues of product substitution. With more data and understanding of leakage issues, product substitution might eventually play a more important role (Brunet-Navarro et al., 2016).

Our focal point is the California cap-and-trade system and its forest offset protocol CA ARB (2015). The introduction of this paper provides the context and motivation for this research. In the next

* Corresponding author at: Mathematical Sciences, Appalachian State University, Boone, NC 28608, USA.
E-mail addresses: laurelb@protonmail.com (L. Bates), jonesb@appstate.edu (B. Jones), marlandes@appstate.edu (E. Marland), marlandg@appstate.edu (G. Marland), rusevatb@appstate.edu (T. Ruseva), kowalczykt@appstate.edu (T. Kowalczyk), hoylejw@appstate.edu (J. Hoyle).

http://dx.doi.org/10.1016/j.jfe.2017.02.004
1104-6899/

sections we outline the current methods for accounting for carbon sequestration in wood products. The remainder of the paper explains the results from comparing the differences in product mix on sequestration models and the impact of landfill storage, as well as the results from using different models to represent wood product decay. We conclude with some ideas on how the sensitivity of carbon stocks to various parameters might be managed more effectively and used to advantage in mitigation strategies.

In efforts to improve accounting of carbon releases to the atmosphere and to promote mitigation strategies for climate change, keeping track of the flow of carbon stocks from harvested wood products has received increasing notice in recent years in the U.S. (Bower et al., 2010). Cap-and-trade programs and other voluntary offset programs, such as those overseen by the Climate Action Reserve (CAR) (CAR, 2016), California Air Resources Board (CA ARB) (CA ARB, 2016) and the Regional Greenhouse Gas Initiative (RGGI) (RGGI, 2016) allow the use of forestry projects to offset emissions from fossil fuel activities. These offset projects must keep track of on-site carbon contained in the forest itself and the carbon stored in wood products as a consequence of harvests. In all of these programs forest carbon stocks can be increased or conserved through three types of forest projects: Reforestation, Improved Forest Management, and Avoided Conversion (RGGI, 2013; CA ARB, 2014a; CAR, 2015).

Reforestation projects involve replanting and restoring tree cover on land that is classified as having had less than 10% tree canopy cover the ten years prior to project initiation. (RGGI, 2013; CA ARB, 2014a). Improved Forest Management projects maintain or increase forest carbon stocks through a variety of ways, including (but not limited to) increasing forest productivity and increasing the age of the forest. Avoided Conversion projects aim to protect forest land at risk of conversion to non-forest cover. In Avoided Conversion and Improved Forest Management projects, harvests may take place yearly or less frequently depending on the management strategy set in place on the project site, but in Reforestation projects the California ARB system does not permit harvesting for 30 years.

1.1. *The importance of harvested wood products (HWP)*

In programs that include accounting for forest harvests, a focus is often placed on increasing the onsite carbon stock through regrowth. However, the harvests produced by forests also have a vital role in maintaining the carbon stock (EPA, 2016). By using some broad assumptions and simple calculations, we can gain a picture of the importance of the harvested wood products (HWP) stock.

For this quick calculation, we assume a normal managed forest. If we assume that the change of the stock of carbon in harvested wood products can be represented with the equation

$$\frac{dS}{dt} = J(t) - \int_0^\infty J(t-\tau)D(\tau)d\tau \tag{1}$$

where S is the stock of carbon in wood products, $J(t)$ is the rate of production of the stocks in year t, and $D(\tau)$ is a distribution function that describes the removal of stock back into the atmosphere. The integral over τ adds up the contribution of previous years' production. If $D(\tau)$ is assumed to be an exponential distribution (the current assumed rate of decay in the Intergovernmental Panel on Climate Change (IPCC) (IPCC, 2016) and CA ARB protocols), Eq. (1) reduces to

$$\frac{dS}{dt} = J - kS \tag{2}$$

Table 1
100 year storage factors (Table C.2. CA ARB, 2014a).

Product class	Softwood lumber	Hardwood lumber	Softwood plywood
100 year storage	0.463	0.250	0.484

Oriented strandboard	Non structural panels	Misc.	Paper
0.582	0.380	0.176	0.058

where k is the rate at which this stock is decaying. If J is representing the sustainable annual HWP production, then we could also think of J as

$$J = m \cdot T_{forest} \frac{2}{n} \tag{3}$$

where T_{forest} represents the total carbon contained in the live forest and m a harvesting and processing efficiency factor, representing the fraction of total forest carbon harvested and of the harvested carbon that ends up in products, ($m < 1$). The value n is the number of years in the forest's rotation cycle and the fraction $2/n$ represents the fraction of the total above ground stock that would be contained in a harvest of $1/n$ of the forest with a linear growth rate (the average tree would be half the size of the harvested trees).

If a forest has a rotation cycle of n years, we can assume that the average portion of the forest that is cut down for the production of wood products each year is $2(T_{forest}/n)$ (from Eq. (3)). Of this portion of the forest that is harvested, not all of the mass will be present in the harvested wood products. This variable will depend on the type and size of tree, the desired product mix, and the processing efficiency. Having assumed that the stock of carbon in the wood products has a first order decay/removal rate, we find that the steady state stock (S) of HWP in Eq. (2) is

$$S = \frac{J}{k}. \tag{4}$$

where $k = (\ln(2)/H)$ and H is the product half-life. Therefore, the total carbon in the forest and the total carbon in the stock of harvested products from Eqs. (3 and 4) can be compared with the equations:

$$S = \frac{J \cdot H}{\ln(2)} \quad \text{and} \quad T_{forest} = \frac{J \cdot n}{2m}$$

A conservative estimate for the half life of all products that are produced from a forest might be 12 years (see Table 1). If we assume that a forest has a rotation cycle of about 40 years, and assume a mill efficiency value of 0.584 (the average mill efficiency value for the southeastern states CA ARB, 2014a) we end up with the following results.

$$S = \frac{J \cdot 12}{\ln(2)} \quad \text{and} \quad T_{forest} = \frac{J \cdot 40}{1.168}$$

$$S \approx J \cdot 17.31 \quad \text{and} \quad T_{forest} \approx J \cdot 25.68$$

This is a very simplistic model, but it suggests that the carbon stored in these products can be of the same order of magnitude as the carbon within the forest (aboveground biomass, at least). In this case HWP are 50.54% of the aboveground carbon. This would be the case for a single managed forest.

To get an idea how the comparison of HWP to aboveground biomass applies more broadly, the currently reported values from Table 6.12 in the 2016 US GHG inventory suggests that the total carbon in harvested wood is 18.74% of the total carbon in aboveground biomass (EPA, 2016). This figure comes from both managed and unmanaged forest land and is presumably more accurate than the simple model above.