Resource and Energy Economics 36 (2014) 83–98

Contents lists available at ScienceDirect

Resource and Energy Economics

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

Mitigating climate change through afforestation: New cost estimates for the United States

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ARTICLE INFO

Article history:
Received 16 January 2013
Available online 25 November 2013

JEL classification:
Q15
Q54
Q58

Keywords:
Carbon sequestration
Afforestation
Cost estimates

ABSTRACT

We provide new cost estimates for carbon sequestration through afforestation in the U.S. We extend existing studies of carbon sequestration costs in several important ways, while ensuring the transparency of our approach. Our costs estimates have five distinguishing features: (1) we estimate costs for each county in the contiguous U.S., (2) we include afforestation of rangeland, in addition to cropland and pasture, (3) our opportunity cost estimates account for capitalized returns to future development (including associated option values) in addition to returns to agricultural production, (4) we develop a new set of forest establishment costs for each county, and (5) we incorporate data on Holdridge life zones to limit afforestation in locations where temperature and moisture availability prohibit forest growth. We find that at a carbon price of $50/ton, approximately 200 million tons of carbon would be sequestered annually through afforestation. At a price of $100/ton, an additional 100 million tons of carbon would be sequestered each year. Our estimates closely match those in earlier econometric studies for relatively low carbon prices, but diverge at higher carbon prices. Our results indicate a smaller, but still important, role for forest-based carbon sequestration in offsetting U.S. greenhouse gas emissions.

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http://dx.doi.org/10.1016/j.reseneeco.2013.11.001

1. Introduction

Concern about climate change has focused attention on the role of forests in the global carbon cycle. Trees and other forest plants convert carbon dioxide (CO_2) to carbon through photosynthesis, thereby reducing concentrations of CO_2 in the atmosphere. Because forests typically store more carbon than land in other uses (e.g., agriculture), expansion of forests onto non-forest lands (i.e., afforestation) has the potential to reduce CO_2 concentrations and mitigate effects of climate change. For the past several decades, economists have estimated the costs of carbon sequestration in forests to determine its competitiveness with other carbon mitigation and abatement strategies.

The first carbon sequestration cost studies appeared in the late 1980s (Marland, 1988; Sedjo, 1989; Dudek and LeBlanc, 1990), and provided point estimates of the average cost of forest carbon sequestration. The first detailed and comprehensive marginal cost estimates for the U.S. were provided by Moulton and Richards (1990) (hereafter, MR). Marginal costs are useful because they can be combined with cost estimates for other carbon mitigation and abatement approaches in order to identify the efficient portfolio of strategies. To estimate marginal costs, MR first estimated average costs of carbon sequestration for 10 U.S. regions and seven treatment types (afforestation on wet and dry cropland, afforestation on wet and dry pasture, and three forest management treatments). These estimates accounted for opportunity costs of the land, upfront treatment costs, and the total amount of carbon sequestered. MR constructed a marginal cost curve by ordering these costs from lowest to highest and then plotting them against cumulative carbon sequestration.

Following MR, economists have provided a number of refinements to the methodology for estimating marginal costs (Dempsey et al., 2010). Adams et al. (1993) recognized that a national afforestation policy would raise the marginal costs of carbon sequestration by restricting the supply of agricultural commodities, thus increasing their prices and the opportunity cost of conversion to forest. Similarly, more land in forest would increase the supply of wood products, diminishing these prices and the willingness of landowners to afforest. By combining models of the timber and agricultural sectors, these authors demonstrated that price feedbacks raise the marginal costs of carbon sequestration, particularly as the total amount of carbon sequestered increases.[1] Other studies that account for endogenous price feedbacks from forest carbon sequestration policies include Richards et al. (1993), Alig et al. (1997), Adams et al. (1999) and Lubowski et al. (2006).

A second refinement is to measure opportunity costs of land using econometric analysis, rather than bottom-up engineering methods, as in MR, or sectoral optimization models, as in the FASOM studies. The econometric approach involves analyzing historical data on the actual decisions by landowners facing returns to alternative uses. Once the relationship between land-use choices and net returns is identified, a policy simulation is conducted to estimate the response by landowners to incentives for afforestation and/or avoided deforestation. The econometric approach has the potential to account for factors that affect land-use decisions in practice but that are difficult to measure explicitly. These include option value related to holding land in its current use, as well as private non-market benefits (e.g., recreation) that landowners may derive from land in particular uses. Typically, marginal cost estimates from econometric analyses are higher than those produced with bottom-up engineering or optimization methods (Plantinga et al., 1999; Stavins, 1999; Lubowski et al., 2006). There have also been a few studies that estimate opportunity costs using a stated preference approach (e.g., van Kooten et al., 2002)

Three other innovations in the literature since MR deserve mention. The first relates to carbon accounting. MR compute the average annual increment in carbon over a 40-year project horizon. As Stavins (1999) points out, this ignores the time profile of carbon flows into and out of the forest. He proposed, as an alternative, discounting carbon flows and then annualizing the present value expression, an approach that has become standard practice in carbon sequestration studies. The second innovation has been to expand the scope of studies to other countries besides the U.S. Although the greatest number of estimates has been produced for the U.S., the review by Richards and Stokes (2004)

[1] The model in Adams et al. (1993) evolved into the Forest and Agricultural Sector Optimization Model (FASOM), which integrates the forest and agricultural sectors through competition for land (Adams et al., 1996).