By Robert N. Stavins



# What Role For U.S. $CO_2$ Sequestration?

In previous columns, I have written about the necessity of establishing a post-Kyoto international agreement on global climate change based on sound science, rational economics, and pragmatic politics — one the United States can ratify ("A Better Climate Change Agreement," January/February 2005) — and about domestic carbon dioxide emissions reduction policies that could be cost-effective ("A Utility Safety Valve for Cutting $CO_2$," March/April 2006). Here I turn to a parallel topic: how the United States can cost-effectively reduce a significant share of its contributions to increased atmospheric $CO_2$ concentrations through forest-based carbon sequestration.

When and if the United States prepares to adopt mandatory policies to address global climate change, it will be necessary to decide whether carbon sequestration should be part of the domestic portfolio of compliance activities. The potential costs of carbon sequestration policies should be a major criterion, and so it is helpful to assess the cost of supplying forest-based carbon sequestration. Last year, Kenneth Richards of Indiana University and I wrote a report, published by the Pew Center on Global Climate Change ("The Cost of U.S. Forest-Based Carbon Sequestration") in which we surveyed and synthesized the best cost estimates.

Human activities — particularly the extraction and burning of fossil fuels and the depletion of forests — are causing the level of $CO_2$ in the atmosphere to rise. It may be possible to increase the rate at which ecosystems remove $CO_2$ from the atmosphere and store the carbon in plant material, decomposing detritus, and organic soil. In essence, forests and other highly productive ecosystems can become biological scrubbers by removing (sequestering) $CO_2$ from the atmosphere. Much of the current interest in carbon sequestration has been prompted by suggestions that sufficient lands are available to use sequestration for mitigating significant shares of annual $CO_2$ emissions, and related claims that this approach provides a relatively inexpensive means of addressing climate change. In other words, the fact that policymakers are giving serious attention to carbon sequestration can partly be explained by (implicit) assertions about its marginal cost, or (in economists' parlance) its supply function, relative to other mitigation options.

Among the key factors that affect estimates of the cost of forest carbon sequestration are: the tree species involved, forestry practices utilized, and related rates of carbon uptake over time; the opportunity cost of the land — that is, the value of the affected land for alternative uses; the disposition of biomass through burning, harvesting, and forest-product sinks; anticipated changes in forest and agricultural product prices; the analytical methods used to account for carbon flows over time; the discount rate employed in the analysis; and the policy instruments used to achieve a given carbon sequestration target.

Given the diverse set of factors that affect the cost and quantity of potential forest carbon sequestration in the United States, it should not be surprising that cost studies have produced a broad range of estimates. Richards and I identified 11 previous analyses that were good candidates for comparison and synthesis, and we made their results mutually consistent by adjusting them for constant-year dollars, use of equivalent annual costs as outcome measures, identical discount rates, and identical geographic scope. We also employed econometric methods to estimate the central tendency (or "best-fit") of the normalized marginal cost functions from the 11 studies as a rough guide for policymakers of the projected availability of carbon sequestration at various costs.

Three major conclusions emerged from our survey and synthesis. First, there is a broad range of possible forest-based carbon sequestration opportunities available at various magnitudes and associated costs. The range depends upon underlying biological and economic assumptions, as well as analytical cost-estimation methods employed.

Second, a systematic comparison of sequestration supply estimates from national studies produces a range of \$25 to \$75 per ton for a program size of 300 million tons of annual carbon sequestration. The range increases somewhat — to \$30-\$90 per ton — for programs sequestering 500 million tons annually.

Third, when a transparent and accessible econometric technique was employed to estimate the "best-fit" of costs estimated in the studies, the resulting supply function for forest-based carbon sequestration in the United States is approximately linear up to 500 million tons of carbon per year, at which point marginal costs reach approximately \$70 per ton.

A 500 million ton per year sequestration program would be very significant, offsetting approximately one-third of annual U.S. carbon emissions. At this level, the estimated costs of carbon sequestration are comparable to typical estimates of the costs of emissions abatement through fuel switching and energy efficiency improvements. This result indicates that sequestration opportunities ought to be included in the economic modeling of climate policies. And it further suggests that if it is possible to design and implement a domestic carbon sequestration program, then such a program ought to be included in a cost-effective portfolio of compliance strategies when and if the United States enacts a mandatory domestic greenhouse gas reduction program. Large-scale forest-based carbon sequestration can be a cost-effective tool that should be considered seriously by policymakers.

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