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A Perspective on Carbon Sequestration as a Strategy for Mitigating Climate Change

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The 1997 Kyoto Protocol includes, as a strategy for mitigating climate change, the option of removing CO2 from the atmosphere through biological carbon sequestration. This includes activities such as tree planting and land disturbance reduction that are commonly grouped under the abbreviation LULUCF (Land Use, Land Use Change and Forestry). Perhaps surprisingly, in the decade since 1997, such schemes have not been widely or appropriately utilized. However, LULUCF activities should only be included in a climate mitigation strategy under very restrictive circumstances. The objective in this paper is to bring perspective to the role in mitigating climate change of carbon sequestration through land use and forestry projects.

While there is no doubt that growing plants and trees remove CO2 from the atmosphere and store it in biomass or soils, this does not translate into unmitigated support for LULUCF as a source of carbon credits. There are many problems with LULUCF-generated offset credits, including:

- Measurement, monitoring and verification are difficult and costly;
- Carbon is not stored indefinitely (terrestrial carbon sinks are ephemeral);
- The time path of carbon uptake and future release is not easy to estimate or evaluate;
- Many projects cannot be considered 'additional' and would likely be implemented in the absence of climate concerns; and
- Indirect carbon and other greenhouse gas effects (leakages) are generally ignored.

As a result, it is extremely difficult to demonstrate that terrestrial projects truly generate the carbon credits that are claimed.

Suspect Sequestration Claims

The claims made by many LULUCF projects are suspect. Yet, many schemes claim to generate biologically-based carbon offset credits, including:

- In Australia for $40, Greenfleet will plant trees that "... will absorb the greenhouse gases that your car produces".
- In Scotland, Trees for Life uses the idea of a carbon footprint to solicit donations for tree planting: it offers "... you the chance to make a real difference and become Carbon Conscious."
- The Haida-Gwaii First Nation in British Columbia, Canada, intends to remove alder "growing in an unnatural manner" and replace it with the original mixed conifer species of the climax rainforest, partly funding the project from the sale of carbon credits.
- The Little Red River Cree Nation located in Northern Alberta, Canada, wished to create carbon permits by delaying harvests of forests, but was turned down by the Canadian government.
- A community group in Powell River, British Columbia, hopes to obtain carbon credits to fund activities to prevent the harvest of coastal rainforest.

There is nothing objectionable about the forgoing projects, except that, when it comes to claims that climate-mitigating offset credits are being created, these and many other projects are suspect. In some cases, the carbon credit angle is largely a marketing technique to solicit funds for a project that would proceed in any event.

Even Clean Development Mechanism (CDM) forestry activities are suspect. The first approved CDM tree-planting project establishes 2,000 ha of multiple-use forests on degraded lands in China. The CDM report indicates the project would sequester 773,842 tCO2 over the 30-year project life, but there is no information about the timing of CO2 uptake and its possible eventual release. Unless one knows how long CO2 stays out of the atmosphere, it is impossible to determine how many carbon credits are produced. Yet Spain and Italy will each claim a share of the project's 'credits'.

Some Terrestrial Carbon Sequestration Costs

Over the past decade, I investigated data on carbon uptake and costs from several hundred biological sequestration projects or proposals. Activities included soil conservation (e.g., conservation and zero tillage, reduced summer fallow), switches from annual crops to perennial ones (e.g., forages), tree planting schemes (plantations on denuded forestland and agricultural land), deforestation prevention, and forest management (enhanced silviculture). The vast majority of studies and project documents fail to identify how long carbon is sequestered, whether the activity would have taken place in the absence of concerns about global warming, and the leakages that the project induces. For example, sequestered carbon in soils as a result of tillage change, reduced fallow or land use conversion would be released very quickly once the prior practice is reinstated. Nor is the time path of carbon accumulation specified. And many studies ignore the increased emissions of CO2 or equivalent gases related to the increased use of chemicals brought about by practices to enhance soil organic carbon – leakages are ignored.

It is very difficult to appropriately credit terrestrial carbon activities. For the vast majority of biological sequestration projects the future path of carbon uptake and release is generally unknown and unknowable. There is always a risk that carbon will be released due to unforeseen hazards, such as fire and erosion; and the ability to measure/monitor actual rates of sequestration and associated leakages is inadequate. As a result, the transaction costs associated with the creation of credits via terrestrial sequestration activities are high, militating against the use of sequestration in carbon trading.

Consider conservation tillage. A study by West and Marland (2002) found that reduced tillage did not lower atmospheric CO2, because the carbon stored in soil organic matter is offset by the CO2 and other greenhouse gasses released by increased production, transportation and application of chemicals. Given the risk that carbon stored in soils is released when land use or management conditions change, reduced tillage may actually increase overall CO2 emissions.

Conversion to zero tillage is a more promising enterprise. Nonetheless, it is not uniformly true that zero tillage sequesters more carbon than conventional tillage, since less residue is available for conversion to soil organic carbon in arid regions (Manley et al. 2005), which affects the costs of creating carbon credits. Some cost estimates are provided in Table 1, and these omit the possible increased emissions related to greater chemical use and the transaction costs associated with measurement and monitoring. Even so, given that utility companies are banking on carbon credits costing no more than $20 per metric ton of CO2 as reported in The Economist (2007), the cost of generating carbon credits by changing agronomic practices is not very competitive, except perhaps in the U.S. South.

Furthermore such practices may not be additional – farmers have increasingly adopted conservation tillage practices, including no-till cropping, without requiring side payments for carbon uptake.

Table 1. Cost of Creating Carbon Credits via Zero Tillage Agriculture, $ per metric ton of CO2

Region	Wheat	Other Crops
U.S. South	$3 to $4	$½ to $1
Prairies	$105 to >$500	$41 to $57
U.S. Corn Belt	$39 to $51	$23 to $24

Source: Adapted from Manley et al. (2005)

Given that agricultural carbon uptake activities are particularly ephemeral, what about forest activities? Again, forest carbon sinks are not the answer. If anything, they are a distraction and even a means of unloading climate mitigation onto a future generation. First off, as I have shown elsewhere (van Kooten 2008), it is nearly impossible to determine how many carbon credits are actually created due to issues regarding the timing of CO2 uptake and release, measurement, leakage, etc. Second, measurement, monitoring and verification are difficult and increase transaction costs, although these are typically ignored partly because they are difficult to determine.

An indication of the potential marginal costs of forestry based carbon credits is provided in Table 2, which is based on 68 studies with costs again ignoring transaction costs. For the most part, forest activities are more costly than $20 per t CO2, except for tree planting in many tropical regions, some boreal activities and some U.S. projects. The opportunity cost of land is generally too high. This holds even when account is taken of carbon stored in wood products. The only exception occurs when trees are harvested and burned in place of fossil fuels to generate electricity, and even then not in all locations.

Future Commitments

Finally, while a country can use carbon sequestration credits to achieve some proportion of its current Kyoto emissions-reduction target, this may create problems for the future if the country remains committed to long-term climate mitigation. Suppose a country is committed, in a future commitment period (a second period is currently being negotiated), to reduce emissions beyond what it committed to for 2008-2012. It must then meet the new target plus any shortfall from the first commitment period; in particular, it still needs to reduce emissions by the amount covered in 2008-2012 by biological sink activities. But there is more: the country is also technically liable for carbon stored in the nonpermanent terrestrial sink.

Table 2. Marginal Costs of Creating Carbon Offset Credits through Forestry Activities, Various Forestry Activities and Regions, $ per metric ton of CO_2

Global	$25-29	Tropics (CDM Projects)	$0-4
Planting	$0-1	Planting & opportunity cost of land	$0-7
Planting & opportunity cost of land	$22-33	Planting, opportunity cost of land & fuel substitution	$0-23
Planting, opportunity cost of land & fuel substitution	$0-49	Forest management & opportunity cost of land	$34-63
Forest management	$1-89	Forest management, opportunity cost of land & fuel substitution	$0-50
Forest management & opportunity cost of land	$60-118	Conservation	$0-103
Forest management, opportunity cost of land & fuel substitution	$48-77	Conservation & opportunity cost of land	$26-136
Forest conservation	$2-158		
Forest conservation & opportunity cost of land	$47-195		
Europe	**$140-184**	**Boreal Region**	**$9-110**
Planting & opportunity cost of land	$158-185	Planting & opportunity cost of land	$5-128
Planting, opportunity cost of land & fuel substitution	$115-187	Planting, opportunity cost of land & fuel substitution	$1-90
Forest management & opportunity cost of land	$198-274	Forest management & opportunity cost of land	$46-210
Forest management, opportunity cost of land & fuel substitution	$203-219	Forest management, opportunity cost of land & fuel substitution	$44-108

Source: Adapted from van Kooten and Sohngen (2007)

Consider the example of a country that agreed to reduce emissions in the first (2008-2012) period by 6% and then commits to reduce them by a further 6% in a second period, for an overall reduction of 12% from the 1990 baseline emissions. Suppose that, in the first period, it reduced emissions by 4%, while relying on forest sinks to cover the remainder. For the second period, therefore, it must reduce emissions by 8% rather than 6% in order to meet the 12% target. Furthermore, if and inevitably when the terrestrial sink releases its carbon to the atmosphere, the country must also cover that loss (which amounts to 2%), implying that it must really reduce emissions by 10%. This temporal shifting in the emissions-reduction burden caused by reliance on carbon sinks is therefore likely to result in an onerous obligation for future generations.

Concluding Observations

All things considered, I concur with Julianna Priskin who states that those who intend to be "carbon neutral travelers need to be well-informed about carbon credits that finance tree plantations. ... The singular action of tree planting will not solve climate change problems ... notably because it does not lead to a reduction of fossil fuel reliance." The same applies to other biological sequestration, particularly agricultural activities.

Are we then left with no role whatsoever for terrestrial carbon sequestration? On the contrary, plants remove CO_2 from the atmosphere, while providing a host of other benefits. Thus it makes sense to implement certain environmentally sound sequestration activities. However, I see no role for biological sequestration in a carbon trading scheme given the impermanence, volatility and onerous transaction costs related to duration, measurement and monitoring.

One possible solution, however, is to provide a predetermined schedule of carbon storage for sequestration alternatives and base subsidies and penalties on this schedule. A subsidy is provided while the sequestration activity continues and a penalty assessed when land use reverts to the prior practice. Actual carbon flux need not be monitored or verified as carbon flux would be determined by the pre-determined schedule, with the value of carbon determined in the emissions trading market. The only relevant transaction costs relate to the establishment of a contract on the property that covers future landowner liability for carbon stored. However, I believe that few would undertake such an agreement since the benefit to landowners will likely be too small, and the risk that carbon prices and resultant liabilities will increase over time too large.

For More Information

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