Biomass Carbon Neutrality

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April 15, 2010

Summary: The term "carbon neutrality" has come to mean many different things. In the context of biomass-derived fuels, it is best understood as an attribute of biomass carbon that reflects the fact that this carbon was only recently removed from the atmosphere and is part of a natural cycle. When this cycle is in balance, it has a net zero impact on atmospheric carbon; i.e. it is "neutral." This is an important distinction between biomass carbon and the carbon in fossil fuels.

The balance of the biomass carbon cycle can be assessed at different scales. Assessing the biomass carbon cycle at the individual plot level, however, yields a misleading picture. The single-plot approach to assessing the biomass carbon cycle ignores the removal of carbon from the atmosphere by trees growing on other plots that will be harvested in future years. If wood-producing land is being regrown to pre-harvest carbon stocks before it is harvested again, then year-after-year, the atmosphere sees a net zero carbon "emission" across the wood-producing region because the "emissions" from plots harvested this year are offset by the uptake occurring in new growth on other plots that will be harvested in the future.

The biomass carbon cycle is never exactly in balance. At the global level, loss of forests, primarily in the tropics, is a significant contributor to emissions of CO_2 to the atmosphere. In many other places on earth, however, there are large net removals of CO_2 from the atmosphere by forests. In the U.S., the data indicate that forested land area is stable or increasing and forest carbon stocks are growing. This means that U.S. forests in total are removing carbon from the atmosphere faster than they are losing carbon as a result of harvesting and other phenomena, such as decay and wildfires. The data also indicate that those forests supplying wood to the industry have stable or increasing carbon stocks.

The benefits of biomass-derived fuels depend not only on their impacts on the biomass carbon cycle; they also depend on how efficiently they displace fossil fuel on a life cycle basis. Research indicates that life cycle emissions of greenhouse gases are significantly lower for biomass fuels derived from sustainably managed forests than for the fossil fuels they displace. The precise benefits vary depending on processing and utilization efficiencies, and impacts, if any, on long-term average forest carbon stocks.

Introduction:

The term "carbon neutrality" has come to mean many things. It is sometimes used to describe activities, such as a conference or rock and roll tour, whose greenhouse gas emissions have been offset by carbon credits. In the context of forest carbon, however, the meaning is different. In this white paper, the concepts behind the carbon neutrality of forest biomass are explained and explored.

The biomass carbon cycle:

Photosynthesis is a process of converting radiant energy from the sun and CO_2 from the air into the chemical energy of plant tissue (Hall, 1999). Through photosynthesis, carbon in atmospheric CO_2 becomes carbon in plant tissue, also called biomass. When biomass is burned, decays or is otherwise oxidized, the chemical energy is released and the CO_2 is placed back into the atmosphere, completing a natural carbon cycle. As long as this cycle is in balance, it has a net zero impact on the carbon in the atmosphere, which is why biomass carbon is often called "carbon neutral."

The biomass carbon cycle and carbon neutrality differentiate the carbon in biomass from the carbon in fossil fuels. Fossil fuels contain carbon that has been out of the atmosphere for millions of years. When fossil fuels are burned, therefore, they put carbon in the atmosphere that is in addition to what has been cycling between the atmosphere and the earth, causing the amounts of CO_2 in the atmosphere to increase. Indeed, the primary source of increased CO_2 in the atmosphere since pre-industrial times is fossil fuel combustion (Denman, 2007).

Standard accounting protocols measure emissions from fossil fuel at the point of combustion while biogenic carbon emissions and sequestration are accounted for in the context of their impact on the biomass carbon cycle (e.g. IPCC, 2006).

The impacts of biomass carbon on atmospheric CO_2:

As long as the biomass carbon cycle is in balance, it neither adds carbon to, nor subtracts carbon from, the atmosphere. The cycle, however, is never in exact balance. If plants are removing carbon from the atmosphere faster than it is being returned to the atmosphere, the cycle is accomplishing net removals of carbon from the atmosphere, and stocks of stored carbon (primarily in forests) are increasing. On the other hand, if biomass carbon is being returned to the atmosphere faster than it is being removed by plants, the cycle is adding carbon to the atmosphere and stocks of stored carbon are decreasing.

The balance of the biomass carbon cycle can be assessed at different scales. Assessing the biomass carbon cycle at the individual plot level, however, yields a misleading picture. Plot-level assessment shows a large "pulse of emissions" occurring at the time of harvest with slow removal of these "emissions" from the atmosphere over time. This single-plot approach to assessing the biomass carbon cycle ignores the removal of carbon from the atmosphere by trees growing on other plots that will be harvested in future years. If wood-producing land is being regrown to pre-harvest carbon stocks before it is harvested again, then year-after-year the atmosphere sees a net carbon "emission" of zero across the wood-producing region because the "emissions" from plots harvested this year are offset by the uptake occurring in new growth on other plots that will be harvested in the future. The wood supply area represents the facility's or industry's supply chain and the gains or losses in carbon over a period of time should be assessed over the entire area, not just a single plot.

At the global level, the status of the biomass carbon cycle is uncertain. It is well established that because of deforestation, largely in the tropics, there have been large transfers of biomass carbon to the atmosphere, amounting to an estimated 0.5 to 2.7 billion tonnes per year in 1990s. During this period, land use change, largely due to deforestation, was responsible for between 7% and 31% of all human-caused CO_2 emissions (derived from data in Denman, 2007).

At the same time, however, attempts to develop global carbon budgets have found a large unexplained removal of carbon from the atmosphere that is attributed to processes occurring on land. This "residual land sink" is not well understood but a number of explanations have been proposed including a continuing accumulation of carbon in undisturbed tropical forests and forest regrowth on other areas such as abandoned agricultural lands and managed forests. The residual land sink was estimated to be removing 0.9 to 4.3 billion tonnes of carbon from the atmosphere per year in the 1990s (Denman, 2007). Therefore, although it is well established that deforestation in the tropics is a significant contributor to man-made CO_2 emissions, the balance in the overall biomass carbon cycle at the global level is uncertain.

In the United States, as in most of the developed world, the situation is better understood. In the U.S., forest carbon stocks continue to grow (USEPA, 2009) indicating that the biomass carbon cycle in the U.S. is continuing to accomplish net removals of CO_2 from the atmosphere. In the U.S., forested area is stable or slowly growing (USEPA, 2009). Even on industry-owned timberland, carbon stocks are stable, reflecting the effects of regeneration and regrowth that occurs under sustainable forest management practices (Heath, 2010). The data clearly indicate, therefore, that in the United States, the biomass carbon cycle is accomplishing net removals of carbon from the atmosphere. In other words, the U.S. forest biomass carbon cycle is in surplus and roughly in balance on industry–owned timberlands.

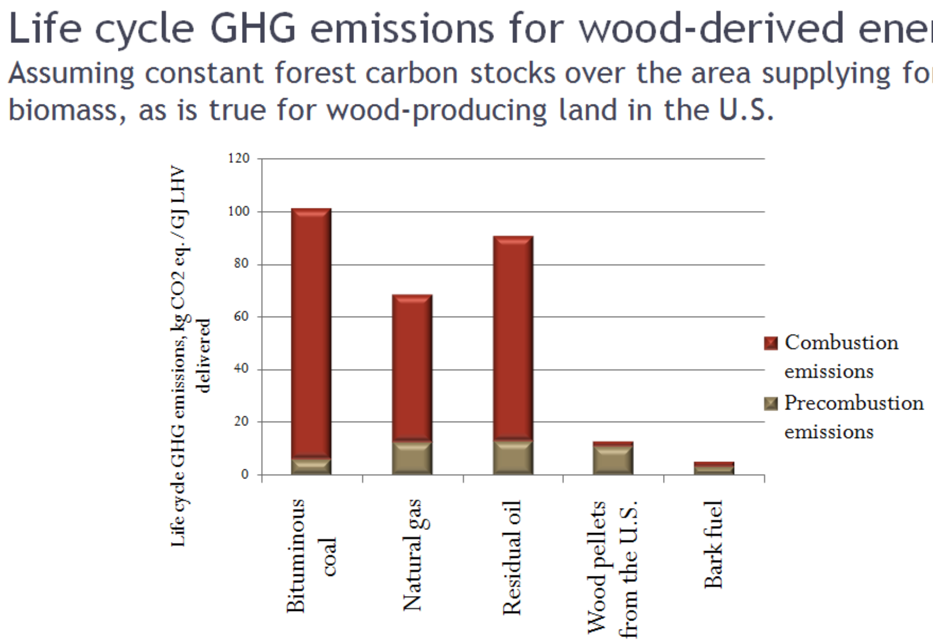
<u>The carbon benefits of biomass fuels:</u>

By inserting an energy recovery step into the biomass carbon cycle, we can produce energy without adding combustion-related fossil fuel carbon to the atmosphere. The amount of benefit we get from this, however, depends primarily on two things. First, it depends on whether the biomass carbon cycle is being thrown out-of-balance by our use of biomass. Second, it depends on how much lower the greenhouse gas emissions are for our biomass-derived fuel compared to the fossil fuel we would have otherwise burned.

Regarding the biomass carbon cycle: it was noted above that the biomass carbon cycle in the US is currently in surplus. Whether this continues will depend on whether the markets and policies that affect land use continue to value forests and the fuels and other products they produce so that the supply of forest-derived biomass will remain adequate to meet the increasing demand.

Regarding the relative greenhouse gas emissions of different fuels: When comparing greenhouse gases emissions for different fuels, one must look beyond combustion-related emissions to also include emissions that occur in raw material extraction and production, fuel processing, and transport. Looking at all of the emissions together, on a "life cycle" or "cradle-to-grave" basis, provides the most accurate picture of the relative benefits of using one fuel compared to another.

When the biomass cycle is in balance (i.e. forest carbon transfers to the atmosphere are matched by carbon uptake via new growth, so forest carbon stocks are stable), fuels derived from forest biomass have very low life cycle greenhouse gas emissions compared to fossil fuels. This is illustrated in the following figure. If the use of wood-derived energy was causing the biomass carbon cycle to be out of balance, the wood-based fuel values in the figure would include additional emissions. If the use of wood was causing carbon stocks on wood-producing land to decline (over the area supplying the industry or facility), these "emissions" would be greater than zero, but if the stocks of carbon on wood-producing land were increasing, the "emissions" would be less than zero (i.e. net sequestration).



Data sources: IPCC, USDOE USLCI Database, other public life cycle databases

<u>Accounting for carbon in forest biomass:</u>

Many countries already have biomass carbon accounting systems in place that account for changes in forest carbon stocks. In the United States, for example, the U.S. Forest Service develops an annual estimate of the changes in forested area and forest carbon stocks. The estimate is based on an extensive forest monitoring network and modeling. The results of the analysis are used in the report submitted annually by the United States in fulfillment of its obligations under the United Nations Framework Convention on Climate Change (e.g. USEPA, 2009). As noted above, the Forest Service assessments show that forest carbon stocks continue to grow (USEPA, 2009) indicating that the biomass carbon cycle in the U.S. is continuing to accomplish net removals of CO_2 from the atmosphere.

Of course, there is no guarantee that this will continue indefinitely. Fortunately, an "early warning" system is already in place to detect worrisome changes in the trends. The Forest and Rangeland Renewable Resources Planning Act (RPA) requires the Secretary of Agriculture to prepare a renewable resource assessment every 10 years (although these reports are usually updated more frequently). The last full RPA Assessment Report was released in 2000 and was updated in 2007. The 2010 report is currently being prepared (U.S. Forest Service, 2008). In addition, the U.S. Forest Service prepares RPA Assessment reports focused specifically on current and projected timber supply, the most recent of which was released in 2007 (Haynes, 2007). In these RPA

Assessment reports, the Forest Service examines trends in forest carbon stocks and, especially in the timber assessments, considers scenarios that could alter current trends.

The general accounting and analytical framework used by the Forest Service provides an excellent starting point for examining the potential impacts of using forest biomass on U.S. forest carbon stocks. Whether it is used as is, or is adapted to work over different scales of area or time, such a conceptual framework can be used to ensure that all forest carbon is accounted for.

Carbon neutrality in national greenhouse gas accounting:

The United States and many other countries include estimates of forest carbon stocks in their national inventories of greenhouse gas emissions and sinks. Changes in forest carbon stocks are treated as equivalent to CO_2 emissions or removals. CO_2 emissions associated with combustion of forest biomass are included in estimates of changes in forest carbon stocks. To avoid double counting, a CO_2 emission factor of zero is assigned to biomass fuels at the point of combustion. This convention is often equated with biomass carbon neutrality in context of national GHG accounting.

Use of a zero emission factor for biomass combustion in national GHG accounting does not mean that carbon emissions from biomass are being ignored or that biomass energy is assumed to be "neutral" in terms of its effects on the biomass carbon cycle. The zero emission factor merely reflects the fact that the impacts on the biomass carbon cycle are being tracked by following changes in forest carbon stocks rather than emissions of biomass-derived CO_2.

An alternative approach to tracking biomass carbon has been suggested that would require emissions of biomass-derived CO_2 to be considered equivalent to CO_2 from fossil fuels (see, for instance, Searchinger, 2009). While such an approach would be easy to implement, it suffers from several drawbacks. First, it tells you little about forest carbon stocks because the carbon in biomass fuels represents only a fraction of the biomass that is lost from forests due to all natural and anthropogenic causes (Gower, 2003) (Natural Resources Canada, 2007). Second, it could cause many current users of biomass fuels to switch to fossil fuels, causing permanent transfers of fossil fuel carbon to the atmosphere. This switching would take place because forest biomass-derived fuels often burn less efficiently than fossil fuels due to their water content, resulting in less usable energy per unit of carbon emissions (Bergman, 2008). Third, because it would (unnecessarily) increase the carbon liability for burning biomass fuels, it would devalue forest-derived biomass and the forested lands where it is produced. This would result in less biomass being produced (at a time when more is needed) and could cause forest owners to convert forested land to other more profitable uses. Devaluing forest biomass could also reduce the economic incentives for maintaining forest health, potentially leading to increased risks of catastrophic carbon loss due to fire (Oneil, 2007).

Ultimately, the concerns about overreliance on forest biomass are concerns about depleting forest carbon stocks and encouraging conversion of forested lands to non-forest uses. It makes sense, therefore, to rely on an accounting framework that is based on monitoring forests and associated carbon stocks, especially when such a program is (a) already largely in place and (b) avoids the many pitfalls of frameworks that focus on emissions of biomass-derived CO_2. A framework based on monitoring forest carbon stocks at the national or regional scale may not be suitable for all purposes, but, in the U.S., it is well suited to a variety of programs aimed at monitoring and potentially regulating greenhouse emissions to the atmosphere.

The challenge of accounting for forest carbon impacts in other countries:

Perhaps the most difficult question facing those attempting to develop comprehensive biomass carbon accounting methods is how to do the accounting on biomass that is imported from other countries. Fortunately, most developed countries are in the same position as the United States in that they have data on forest carbon stocks and the data show that carbon stocks are stable or increasing, especially when averaged over multi-year periods (MCPFE, 2007) (USCCSP, 2007). On the other hand, in the developing world, the data are much less reliable and large losses of forest carbon due to deforestation are still common.

The amount of forest biomass imported by the United States is relatively small. In 2008, for instance, imports of lumber and paper/paperboard were 6 and 15% of U.S. production, respectively while the imports wood chips and particles (including wood pellets) were 0.04% of US industrial roundwood production (FAO, 2010). Of the amounts for forest-derived materials imported, very little comes from developing countries. Instead, most comes from Canada and Europe. In 2005, for instance, 85% of lumber and log imports to the U.S. were from Canada (Howard, 2007) and in 2006, 84% of the imports of pulp, paper and paperboard were from Canada and Europe (AF&PA, 2007). Given these statistics, imports of forest-derived material by the U.S. are not expected to have significant connections to concerns about deforestation in developing countries.

The concerns about impacts on forests in the developing world, however, are not primarily related to the demand for forest-derived biomass. Instead, the primary concern is that forests in the developing countries will be cleared to create land for producing agriculture-based biofuels. The question of how to account for the impacts of forest clearing when characterizing the benefits of agriculture-based fuels from other countries is an important one, but it need not dictate the forest carbon accounting rules used in the U.S. or be applied to domestic forests

Concluding observations

Ultimately, the concerns about the over use of forest biomass are related to potential loss of forest area and forest carbon. It makes sense, therefore, to use an accounting framework that focuses on impacts in the forest. In the U.S. and elsewhere where the data are reliable, the impacts of using biomass fuels can be characterized within an accounting framework that (a) relies on large-scale forest carbon accounting to account for biogenic CO_2 emissions in the context of the forest carbon cycle and (b) separately accounts for other lifecycle greenhouse gas emissions. For fuels from countries without adequate data, or where forest carbon stocks are declining, it may be necessary to use other accounting frameworks, but this need not be required of all biomass-derived fuels. In the case of biomass-derived fuels produced in the US, the impacts on national carbon stocks are already being monitored and the monitoring shows that the use of biomass for all purposes, including biomass-derived fuels, is not causing forest carbon stocks to decline.

References:

AF&PA. (2007). *Statistics of Paper, Paperboard and Wood Pulp: 2007.* Washington, DC: American Forest and Paper Association.

Bergman, R. a. (2008, January). Primer on wood biomass for energy. USDA Forest Service, Forest Products Laboratory, Madison, WI.

Bowyer, J. D.-G. (2006). *Life cycle environmental performance of renewab le materials in teh context of residential building construction: Phase 1 research report.* Seattle: CORRIM, University of Washington.

Denman, K. G. (2007). *Couplings Between Changes in the Climate System and Biogeochemistry. In: Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change.* Cambridge, United Kingdom and New York, NY, USA: Cambridge University Press.

FAO. (2010). *FAOStat*. Retrieved February 10, 2010, from http://faostat.fao.org

Gower, S. (2003). Patterns and Mechanisms of the Forest Carbon Cycle. *Annu. Rev. Environ. Resour. Vol. 28* , 169-204.

Hall, D. a. (1999). *Photosynthesis, Sixth Ed.* Cambridge University PRess.

Haynes, R. W. (2007). *The 2005 RPA timber assessment update; Gen. Tech. Rep. PNW-GTR-699.* USDA Forest Service, Pacific Northwest Research Station.

Heath, L. S. (2010). Greenhouse Gas and Carbon Profile of the U.S. Forest Products Industry Value Chain. *Environmental Science and Technology* .

Howard, J. (2007). *U.S. timber production, trade, consumption, and price statistics 1965 to 2005; Research Paper FPL-RP-637.* Madison, WI: U.S. Department of Agriculture, Forest Service, Forest Products Laboratory.

IPCC. (2006). *2006 IPCC Guidelines for National Greenhouse Gas Inventories.* Hayama, Kanagawa, Japan: IPCC, c/o Institute for Global Environmental Strategies.

MCPFE. (2007). *State of Europe's forests 2007.* Warsaw: Ministerial Conference on the Protection of Forests in Europe.

Natural Resources Canada. (2007, October). Is Canada's forest a carbon sink or source? *Canadian Forest Service Science - Policy Notes* .

Oneil, E. B. (2007). Discussion Paper DP8: Eastside Climate Change, Forest Health, Fire and Carbon Accounting. In *Future of Washington's Forest and Forest Industries Study.* College of Forest Resources, University of Washington.

Searchinger, T. e. (2009, October 23). Fixing a critical climate accounting error. *Science Vol 326* , pp. 527-528.

Skog, K. e. (2008). *The greenhouse gas and carbon profile of the U.S. forest products sector; NCASI Special Report 08-05.* Durham, NC: National Council for Air and Stream Improvement.

U.S. Forest Service. (2008, August 12). *The RPA Assessment and Supporting Publications*. Retrieved February 3, 2010, from US Forest Service: http://www.fs.fed.us/research/rpa/assessment-pub.shtml

USCCSP. (2007). *The first state of the carbon cycle report: the North American Carbon Budget and Implications for the Global Carbon Cycle.* Washington, DC: U.S. Climate Change Science Program.

USEPA. (2009). *Inventory of greenhouse gas emissions and sinks: 1990-2007.* Washington, DC: United States Environmental Protection Agency.