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Date: August 23, 2012

Re: Comments on SAB panel's draft report reviewing EPA's accounting framework for biogenic carbon dioxide emissions from stationary sources

The attached document provides comments on the SAB panel's draft report of July 26, 2012. As suggested in the *Federal Register* (Vol. 77, No. 152 / Tuesday, August 7, 2012 / Notices, pp. 47067-47068), these comments "provide specific scientific or technical information or analysis for the SAB panel to consider" and also "relates to the clarity or accuracy of the technical information" in the SAB draft report.

The primary organizing framework for these comments is provided by the EPA's "charge questions" posed to the SAB panel, and the panel's responses. Most of the direct responses to the charge questions do not provide a readily discernible yes or no reply. The SAB panel's report would be improved with shorter and more direct replies to the charge questions. In addition, the comments herein identify some key things about the implications of the EPA's proposed accounting framework and the carbon cycle that the SAB panel did not include in its draft report.

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Review and Comments on the EPA's Science Advisory Board (SAB) Draft Report (7/26/12) for Quality Review Regarding the EPA's Proposed Accounting Framework for Supporting Potential Regulation of Biogenic Greenhouse Gas Emissions from Stationary Sources Producing Bioenergy

by
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Table of Contents

Abstract 2

1. Introduction 3

2. Key findings of this review 4

3. SAB panel responses to EPA "charge questions" plus reviewer's comments 6

4. Conclusions 18

References cited..... 19

Box 1. Key SAB panel responses to EPA's "charge questions" 4

Box 2. Balancing rapid early carbon uptake with carbon accumulation over time 8

Figure 1. Cumulative timber growing stock and carbon stock for newly planted Douglas-fir forests on average sites in four western regions, compared with loblolly pine in the Southeast Region 20

Figure 2. Carbon sequestration (uptake) rates for newly planted Douglas-fir forests on average sites in four western regions, compared with loblolly pine in the Southeast Region.. 21

Figure 3. Carbon stock production function (total, average, and marginal product) for newly planted Douglas-fir on average sites, Pacific Northwest Eastside Region, with time as the single variable input factor 22

Figure 4. Carbon stock production function (total, average, and marginal product) for newly planted loblolly pine on average sites, Southeastern Region, with time as single variable input factor 23

Figure 5. Long-term total carbon uptake for four rotation ages of newly planted Douglas-fir on average sites, Pacific Northwest Eastside Region 24

ABSTRACT

The SAB panel's draft report finds the EPA's proposed accounting framework for biogenic emissions is neither scientifically defensible, especially in the wood bioenergy sector, nor easily implementable. The SAB panel's draft report calls upon the EPA to explain its quest for an accounting framework to undergird a policy to regulate biogenic emissions. Missing from the SAB panel's report are some contextual facts indicating that biogenic emissions from wood bioenergy are not a problem. Wood combustion provides 2 percent of the energy consumed in the U.S. and produces 57 tons of carbon that end up in the atmosphere (190 million metric tonnes of CO_2 or 3.2 percent of all U.S. CO_2 emissions). However, each year the manufacture of durable wood products adds a net 57 million tons of carbon to carbon storage pools, equaling the carbon emissions from wood bioenergy. In addition net annual forest growth captures and stores 256 million tons of carbon from the atmosphere. Summing up, the net annual growth of forest and wood products carbon pools together offset biogenic emissions from wood bioenergy by a factor of 4.5 to 1. How then can greenhouse gas emissions from wood bionergy production pose a problem for society? The EPA's efforts to regulate greenhouse gas emissions from wood bioenergy should be abandoned to relieve current regulatory uncertainty and free the manufacturing sector of our economy to make more wood bioenergy. Together with manufactured wood products derived from sustainably managed forests that substitute for building products requiring large quantities of fossil fuel energy, wood bionergy can help improve national energy security. Unaddressed in these comments are concerns about land-use change that can be triggered by demands for liquid transportation fuels produced from annual crops.

1. Introduction

As noted by the U.S. Department of Energy's Energy Information Administration, but absent from the SAB panel's draft report, is that renewable energy provides about 8 percent of all the energy consumed in the U.S., and energy from biomass feedstocks provides more than half of that (EIA 2011, Figure 10.1, Table 10.1). A small percentage of bioenergy feedstocks comes from municipal landfills. About half of the bioenergy we use is from converting grain to ethanol for extending gasoline supplies. The other half is combustion of wood for heat and power, with about three-fourths of that in the industrial and commercial sectors and the remainder in the residential sector. These review comments pertain primarily to woody biomass.

This set of comments is in four sections. In section **2** key findings of these review comments are summarized. Although I am acquainted with about half of the SAB panel members, by way of background I agree with the panel's statement that "Assessing the greenhouse gas implications of using biomass to produce energy is a daunting task" (SAB draft letter, p.1, l.25). I know this better than most, because earlier I provided two sets of comments in response to separate calls for information by the EPA (see O'Laughlin 2010, 2011). Based on those comments, I was nominated to serve on the SAB panel but was not chosen.

Although many of my earlier comments to the EPA are pertinent, with a few exceptions I will refrain from repeating them because they are a matter of record and accessible to the SAB panel. Those exceptions are primarily matters of context. The EPA's decision whether and how to regulate biogenic emissions from stationary sources will affect forest management and the role forests can play in sequestering atmospheric CO_2. As Birdsey et al. (2006) put it, within the next century U.S. forests will shift from functioning as a net carbon sink to a net source of carbon under current forest management strategies and policies. If society decides it is important to reduce atmospheric CO_2, forests will have a new role to play and these policies can be changed. I also feel it is necessary to reinforce a point made by the SAB panel that the EPA's proposed accounting framework is more of a policy decision than a technical scientific consideration.

Instead of repeating earlier comments, section **3** offers suggestions to the SAB panel that could make its report clearer to audiences who lack in-depth knowledge about biogenic greenhouse gas emissions. This is done by commenting on the SAB panel's responses to the EPA's "charge questions." Some responses are straightforward, some could be clearer. My comments follow excerpts of the panel's responses and form the bulk of this document. These comments include a brief digression into forest carbon sequestration rates as a function of time. The temporal dimension chosen for the EPA's accounting framework is crucially important, and not addressed by the SAB panel except in the statement that "there is no scientifically correct answer when choosing a time horizon" (SAB panel draft report, p.17, l.20).

Conclusions are drawn in section **4**. The main one is that the sooner the EPA decides that emissions from wood bioenergy are exempt from regulation, the better.

2. Key Findings of This Review

The key findings are in **Box 1**, which consists of responses to the EPA's charge questions by the SAB panel. Taken together these responses indicate that the EPA's proposed accounting framework is neither scientifically defensible, especially in the wood bioenergy sector, nor easily implementable. Because the SAB panel did not always provide yes or no replies, they are inserted and underlined based on this reviewer's interpretations, then followed by a quotation from the SAB panel's draft report.

Box 1. Key SAB panel responses to EPA's "charge questions"

Question 3.1. Does the SAB support EPA's assessment and characterization of the underlying science and the implications for biogenic CO2 accounting?

No. "There is no scientifically correct answer when choosing a time horizon, …"

Question 4(b). Is the [accounting] framework scientifically rigorous?

No. "The SAB did not find the *Framework* to be scientifically rigorous. Specifically, the SAB identified a number of deficiencies that need to be addressed." These issues include time scale, spatial scale, additionality, assessing uncertainty, leakage, and some other issues and inconsistencies, some of which are identified in reply to ***Question 4(g)***.

Question 4(g). Are there additional limitations of the accounting framework itself that should be considered?

Yes. "A number of important limitations of the *Framework* are discussed below: framework ambiguity, feedstock groups, potential for unintended consequences, and assessment of monitoring and estimation approaches."

Question 4(e). Is [the accounting framework] simple to implement and understand?

No. "It is neither."

Question 6(a). Does the report—in total—contribute usefully to advancement of understanding of accounting for biogenic CO_2 emissions from stationary sources?

"Yes, the *Framework* … addresses many issues that arise in such an accounting system. … However, the solutions offered in many cases, particularly those related to the use of harvested wood for bioenergy, lack transparency or a scientific justification."

As indicated above (**Box 1**), the SAB panel's draft report states clearly that science cannot help the EPA select a time frame for the proposed accounting framework. In addition, the spatial scale of individual stationary sources is inadequate for beginning to effectively and efficiently account for U.S. contributions to a global phenomenon. Although the panel suggested improvements to the accounting framework, it would likely be prohibitively expensive to implement them.

The EPA seems to be concerned that the creation of energy from woody biomass may create greenhouse gas emissions that would exceed such emissions in the absence of efforts to convert the solar energy stored in woody biomass into forms of energy humans can use. The key issue, as the EPA and the SAB

panel both clearly recognize, is the time frame or temporal dimension for the analysis that would support a regulatory scheme to control biogenic emissions at the source of energy production.

Over the long term, all biomass will die and the energy, carbon, and other chemical elements stored in the biomass will be released. Implicit in the EPA's concern, then, is that the time frame for analysis should be short term. However, "There is no scientifically correct answer when choosing a time horizon" (SAB panel draft report, p.17, l.20).

The SAB panel recognizes that it would be appropriate to treat the different biomass feedstocks differently. I agree, especially because of the potential for land-use change that can be triggered by bioenergy demand for liquid transportation biofuels. The SAB panel "Note[s] that EPA can only regulate end-of-stack emissions and thus has to design a system that fits within its regulatory authority ... [furthermore,] computing global emissions changes from individual facilities has its own daunting challenges" (SAB panel draft report, p.12, l.17-18 & l.8-9). Together these statements imply that land-use regulation cannot be part of the EPA's regulatory framework for greenhouse gas emissions, and that the geographic scale chosen by the EPA is problematic.

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3. SAB Panel Responses to EPA "Charge Questions" plus Reviewer's Comments

This reviewer looked for yes or no responses to the EPA's questions, and in most cases did not find such and instead inferred yes or no from the SAB panel's equivocal or conditional responses. These underlined inferences immediately follow each question, and then are followed by the quotation from which the inference was drawn. It would be preferable if the SAB panel itself provided direct yes or no replies to the questions. In one instance, the EPA's question was vague enough that unknown is an appropriate response. Note that quotation marks distinguish SAB panel comments from those made by this reviewer.

3.1. The Science of Biogenic CO_2 Emissions

Charge Question 1: In reviewing the scientific literature on biogenic CO_2 emissions, EPA assessed the underlying science of the carbon cycle, characterized fossil and biogenic carbon reservoirs, and discussed the implications for biogenic CO_2 accounting.

Does the SAB support EPA's assessment and characterization of the underlying science and the implications for biogenic CO_2 accounting?

Comment. This charge question and the SAB panel's response to it are crucial. The response is not clear, but could be interpreted for both parts of the questions to be no. Explanation and discussion follow.

No, on ***assessment and characterization***. "In the following [3-page long] section, the SAB describes a series of deficiencies with the EPA characterization of the science behind biogenic CO_2 accounting and suggests some areas where the science could be strengthened." Those areas are *time scale*, *disturbance* (harvesting, fire), and *non-CO_2 greenhouse gases*. The SAB panel's conclusions on each point are excerpted as follows, and then comment by this reviewer is included.

- *Time scale* – After 2.5 pages of discussion the SAB panel concludes that "There is no scientifically correct answer when choosing a time horizon, although the *Framework* should be clear about what time horizon it uses, and what that choice means in terms of valuing long term versus shorter term climate impacts" (SAB panel draft report, p.17, l.20).

  Comment. The choice of a time scale for CO_2 accounting has implications for forestry that were not acknowledged by the SAB panel. In testimony before the U.S. Congress in 2007, Professor John Helms championed the use of wood products and woody biomass energy as a carbon management strategy. Pertinent to the time scale of forest carbon accounting, he addressed the relative contributions of young and old forests and concluded, "This much is certain: rapidly growing trees sequester carbon more quickly and efficiently than old ones. That fact should stay front and center in policy discussions. If we want to maximize carbon sequestration and storage, we need forest management that results in healthy forests of all ages on the landscape. That means sustainable forestry and plenty of young forests." [1]

[1] Dr. Helms was testifying on April 27, 2007, before the U.S. House of Representatives Select Committee on Energy Independence and Global Warming. At the time he was President of the Society of American Foresters, and was formerly Professor and Head of the Department of Forestry and Resource Management at the University of California – Berkeley. His testimony is available online at http://globalwarming.house.gov/toolon April s/assets/files/0296.pdf

Shortly after Dr. Helms' testimony, Professor William Schlesinger testified before a different congressional committee: "It is tempting to suggest that we should cut down such old, mature forests that no longer provide carbon sequestration and replace them with young forests that do so. This would be a mistake. When an old forest is cut, much of the carbon that it contains is released back to the atmosphere as CO_2."[2]

Is Dr. Schlesinger right and Dr. Helms wrong, or vice-versa? Actually, statements by both professors are correct, but as policy advice they have different implications. The advice one chooses to follow is based on the temporal and spatial dimensions of each argument. Dr. Helms is considering the fate of carbon after it has left the forest as a timber product and either stored in wood products or burned for energy use, and Dr. Schlesinger is not. The former viewpoint replaces fossil fuels that are used to create concrete or steel indirectly with wood building products (see Lippke et al. 2011, Malmsheimer et al. 2011), or directly by burning wood instead of coal or natural gas to produce heat and/or electricity; the latter does not consider those off-site effects.

Dr. Helms takes into account the way trees grow, attempting to find a balance between young and old, as forestry has always done. Dr. Schlesinger asserts that in addition to stored carbon the other goods and services provided by old trees and forests have value, but fails to mention that even the largest and oldest trees eventually succumb and return the carbon they have stored to the atmosphere. Whatever time scale is chosen, including tree mortality argues for a temporal dimension for carbon emissions accounting no shorter than the average life span that trees could reach on a given site. Others may argue that regardless of time scale, while some trees are dying others are growing and an old forest ecosystem is therefore in balance, a point Dr. Schlesinger made.

The previous point brings in spatial considerations, and the large forest area needed to support a wood bioenergy facility, where for each unit of wood harvested for energy this year an additional area of forest is needed in future years and on all those additional areas trees will be growing and uptaking more carbon. Even on short pulpwood rotations of 15 years that means fifteen time more forest is growing than is harvested.

Absent from the SAB panel discussion is the way trees grow, something that Dr. Helms says needs to be front and center in every discussion of forest carbon management policy. That should include discussion as severely limited in its spatial dimension as this one that only considers the biogenic CO_2 emissions from an individual stationary source. As Dr. Helms noted, young trees are much more efficient at the business of carbon uptake than are old trees, but as Dr. Schlesinger noted, old trees store more carbon.

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[2] Dr. Schlesinger was testifying on May 1, 2007, before the U.S. House of Representatives, Committee on Natural Resources, Subcommittee on Energy and Mineral Resources. At the time he was the Dean of the Nicholas School of the Environment and Earth Sciences at Duke University. He was elected a member of The National Academy of Sciences in 2003, and was President of the Ecological Society of America for 2003-2004. His testimony is available online at http://www.gpo.gov/fdsys/pkg/CHRG-110hhrg35059/pdf/CHRG-110hhrg35059.pdf

Consider the following statement on active forest management in an Intergovernmental Panel on Climate Change report:

> "In the long term, a sustainable forest management strategy aimed at maintaining or increasing forest carbon stocks, while producing an annual sustained yield of timber, fibre or energy from the forest, will generate the largest sustained mitigation benefit" (Nabuurs et al. 2007, p. 543).

This statement by the IPCC implies that the choice of an accounting framework for regulating GHG emissions has implications for forest management that are overlooked in the SAB panel's draft report. To fill this analytical gap in forest carbon cycle literature, I used a production function approach (see Gregory 1987, Figure 14.3, p. 315) to develop graphic illustrations that identify the balance point between forest growth rate and carbon accumulation. These are included as attachments at the end of this document, with the main points summarized in **Box 2**.

Box 2. Balancing rapid early carbon uptake with carbon accumulation over time

Figure 1 illustrates how carbon accumulates over time for newly-planted Douglas-fir forests in four regions of the West, and loblolly pine in the Southeastern Region. These two species comprise the largest shares of the forest growing stock inventories in the western and southern United States, respectively. As trees age forest growing stock increases (**Figure 1(a)**) and more carbon is stored (**Figure 1 (b)**). **Figure 2** is derived from the data in **Figure 1(a)** and illustrates the growth rate of carbon accumulation. Young trees clearly uptake considerably more carbon than old trees. From a carbon management point-of-view the optimum balance between uptake, where young trees have the advantage, and storage, where old trees have the advantage, is the culmination of the mean annual increment (Gregory 1987, p. 315). This is found at a relatively young age: about 35 years for Douglas-fir in Pacific Northwest Eastside Region forests (**Figure 3**) and 25 years for loblolly pine (**Figure 4**). **Figure 5** draws on results from **Figure 3**, and compares the long-term carbon storage implications of short and long rotation ages. Over the long term short rotations capture and store more carbon onsite than do longer rotations (**Figure 5**). In addition to that one could add the fossil fuel substitution effect from wood products and wood bioenergy (see Lippke et al. 2011, Malmsheimer et al. 2011) and the carbon management advantage of the shorter rotation ages would be more pronounced.

- *Disturbance* – The SAB panel concludes that "the state of knowledge about disturbance and impacts on carbon stocks and turnover should be reviewed within the context of relevant time scales and spatial extents."

  Comment. One wonders why the SAB panel did not review that state of knowledge within temporal and spatial contexts, except to include the statement that "there is no scientifically correct answer when choosing a time horizon," as previously mentioned. The SAB panel should make a similar statement about spatial context.

  In addition, a large portion of the SAB panel's draft report focuses on soil carbon. Although the importance of soil as a forest carbon pool is undeniable, it is a relatively minor factor in forest carbon flux or net change. Woodbury et al. (2007) estimated that forest soils represent almost half

(48%) of all forest carbon pools, but forest soils represent only 2% of the flux or net change in forest carbon pools. Given that, the emphasis of the SAB panel's report on the need to include soil carbon flux in the accounting framework does not seem to be particularly relevant for the forest and wood bioenergy sector.

- *Non-CO_2 greenhouse gases* – The SAB panel concluded that "For biogenic feedstocks, the 34 most important source of non-CO_2 emissions is likely to be N_2O produced by the application of fertilizer (Crutzen, et al. 2007)."

  Comment. Biogenic emissions also include other Clean Air Act criteria air pollutants, and the SAB panel should at least recognize that fact.

No, on ***implications*** (see ***Question 3.1*** above). Although the SAB panel did not speak to ***implications*** in the direct response to ***Question 3.1***, as was their charge, the negative response to the first part of ***Question 3.1*** implies that this response would also be negative.

Conclusions. The SAB panel's response to the two parts of ***Question 3.1*** is crucial. In its call for information the EPA laid out three principles for assessing different approaches to carbon accounting: "This reconciliation [of differing viewpoints] will require careful attention to issues of spatial and temporal scale, to ensure that the principles of practicality, predictability, and scientific soundness are met." The SAB panel was given the charge to ascertain what is known about the carbon cycle as it pertains to the development of an accounting framework for regulating biogenic emissions.

As the responses above concluded, the SAB panel certainly recognizes the importance of time and space scales in a regulatory scheme. The SAB panel stated that there is no rationale for selecting a time frame and did not recommend one or even a way to arrive at one. The SAB panel also did not address what science has to say about the appropriate spatial scale. The inference is that because the carbon cycle is a global phenomenon, there can be no scientific rationale for selecting individual stationary sources as the focus of an accounting framework. Instead, the SAB panel states that the EPA had no choice because anything else would be outside the agency's authority.

The SAB could have concluded its work at this point, and perhaps should have, but because the EPA asked other charge questions the SAB panel dutifully provided responses. Each response to these other questions should be viewed in the light that there is no scientific rationale for selecting particular temporal and spatial scales and that these are policy choices rather than technical matters.

3.2. Biogenic CO_2 Accounting Approaches

Charge Question 2: In this report, EPA considered existing accounting approaches in terms of their ability to reflect the underlying science of the carbon cycle and also evaluated these approaches on whether or not they could be readily and rigorously applied in a stationary source context in which onsite emissions are the primary focus. On the basis of these considerations, EPA concluded that a new accounting framework is needed for stationary sources.

2(a). Does the SAB agree with EPA's concerns about applying the IPCC national approach to biogenic CO_2 emissions at individual stationary sources?

"Yes. The IPCC national approach is an inventory of global greenhouse emissions (i.e., all emissions are counted). It is comprehensive in quantifying all emissions sources and sinks, but does not describe linkages among supply chains. In other words, it is essentially a 'production-based inventory' or 'geographic inventory' rather than a 'consumption-based inventory' (Stanton et al. 2011). Moreover, it offers a static snapshot of emissions at any given time, but it does not expressly show changes in emissions over time. As such, the IPCC national approach does not explicitly link biogenic CO_2 emission sources and sinks to stationary sources, nor does it provide a mechanism for measuring changes in emissions as a result of changes in the building and operation of stationary sources using biomass."

Comment. A key issue here, unaddressed by the SAB panel, is the scientific rationale for the EPA to limit spatial scale for accounting to individual stationary sources. As noted above, there is no such rationale, other than the EPA lacks the authority to do anything else, as noted by the SAB panel.

2(b). Does the SAB support the conclusion that the categorical approaches (inclusion and exclusion) are inappropriate for this purpose, based on the characteristics of the carbon cycle?

Yes. The SAB panel's response equivocates by digressing about "carbon neutrality" which it defines based on "the fact that the carbon released as CO_2 upon combustion was previously removed from the atmosphere as CO_2 during plant growth."

Comment. This fact is unequivocal, but the SAB panel does not say so, and defined "carbon neutrality" too narrowly. This reviewer's interpretation is that the SAB panel wants to say yes to this question (i.e., it does not support categorical exclusion of biogenic emissions), when the correct scientific answer based on the carbon cycle is that unless there is land-use change, there is no net gain of atmospheric greenhouse gas from biogenic emissions because they will be recaptured by future plant growth. This is also the reason why the categorical inclusion of biogenic emissions as equivalent to fossil fuel-burning emissions is inappropriate. The SAB panel should address this issue directly and succinctly.

2(c). Does the SAB support EPA's conclusion that a new framework is needed for situations in which only onsite emissions are considered for non-biologically-based (i.e., fossil) feedstocks?

"Through discussions with the Panel at the public meeting, the EPA agreed that this question is redundant with other charge questions and therefore does not require a separate response."

2(d). Are there additional accounting approaches that could be applied in the context of biogenic CO_2 emissions from stationary sources that should have been evaluated but were not?

Yes. "Several other agencies are developing methods for assessing greenhouse gas emissions by facilities that could inform the approach developed by the EPA. These include the DOE 1605(b) voluntary greenhouse gas registry targeted to entities, which has many similar characteristics to the approach proposed by EPA for stationary sources. There is also the Climate Action Registry developed in California that uses a regional approach to calculate baselines based on inventory data and may inform the delineation of geographic regions and choice of baselines in the EPA approach. USDA also is developing in parallel an accounting approach for forestry and agricultural landowners. It would be beneficial if the

EPA and USDA approaches could be harmonized to avoid conflicts and take advantage of opportunities for synergy."

Comment. The SAB panel should also acknowledge that the DOE has been reporting GHG emissions from biomass, and identify the magnitude of those emissions in comparison to the magnitude of carbon uptake by terrestrial ecosystems. For example, reported data for 2010 show that producing energy by combusting biomass emitted 190 million metric tons of CO_2; this was approximately 3.2 percent of the total emissions of almost 6 billion metric tons of CO_2 produced in the U.S. (EIA 2012, Table A19). By comparison, U.S. forests in 2003 captured and stored 256 million tons of carbon from the atmosphere, and another 57 million tons of carbon were added to the durable manufactured wood products carbon storage pool (Pacala et al. 2007, Table 3.1; uncertainty factor is 95% confidence that estimates are within 25%). Applying appropriate conversion factors and assuming that 2003 and 2010 were roughly comparable, 57 tons of carbon were emitted from burning biomass to produce 2 percent of the nation's energy consumption, while U.S. forests provided a net carbon sink for 199 million tons of carbon. This does not include the 57 million tons of carbon added to the durable wood products carbon pool that same year. These wood products are a direct result of timber harvesting, with the wood bioenergy for the most part a byproduct of wood products manufacturing. To shed some light on the issues and implications under consideration here, as a matter of context the SAB panel should include data such as these that reflect the magnitude of the forest carbon sink in comparison with wood bioenergy emissions.

To sum up the preceding data, wood combustion provides 2 percent of the energy consumed in the U.S. and produces 3.2 percent of all CO_2 emissions (190 million metric tonnes of CO_2, or 57 tons of carbon). However, each year the manufacturing of durable wood products adds a net 57 million tons of carbon to the wood products storage pool, thus offsetting biogenic emissions from wood bioenergy. In addition forest growth captures and stores 256 million tons of carbon from the atmosphere. By a factor of 4.5 to 1, the annual net growth of forest and wood products carbon pools offsets biogenic emissions from wood bioenergy. Why then are biogenic greenhouse gas emissions from wood bionergy production a problem? Unless the EPA can explain why this poses a problem for our society, the proposed regulation of greenhouse gas emissions should be abandoned in order to relieve current regulatory uncertainty so that the manufacturing sector of our economy can make more wood products and wood bioenergy, both of which substitute for fossil fuel energy and thereby improve national energy security.

3.3. Methodological Issues

Charge Question 3: EPA identified and evaluated a series of factors in addition to direct biogenic CO_2 emissions from a stationary source that may influence the changes in carbon stocks that occur offsite, beyond the stationary source (e.g., changes in carbon stocks, emissions due to land-use and land management change, temporal and spatial scales, feedstock categorization) that are related to the carbon cycle and should be considered when developing a framework to adjust total onsite emissions from a stationary source.

3(a). Does SAB support EPA's conclusions on how these factors should be included in accounting for biogenic CO_2 emissions, taking into consideration recent advances and studies relevant to biogenic CO_2 accounting?

No. "The SAB's response to this question differs by feedstock. On balance, the *Framework* includes many important factors but some factors suffer from significant estimation and implementation problems." The SAB panel included 6 pages of explanation.

3(b). Does SAB support EPA's distinction between policy and technical considerations concerning the treatment of specific factors in an accounting approach?

No. "A clear line cannot be drawn between policy and technical considerations in an accounting approach. In fact, the lack of information on EPA's policy context and the menu of options made it more difficult to fully evaluate the *Framework*. Because the reasonableness of any accounting system depends on the regulatory context to which it is applied, the *Framework* should describe the Clean Air Act motivation for this proposed accounting system, including how the Agency regulates point sources for greenhouse gases and other pollutants."

Comment: In my earlier comments submitted to EPA (see O'Laughlin 2010), I included a quotation from a widely cited *Science* article on carbon emissions accounting:

> "Bioenergy can provide much energy and help meet greenhouse caps, but correct accounting must provide the right incentives" (Searchinger et al. 2009, p. 528).

Now I would add that the wisdom in the first clause is muddied by the mixing in of policy tools (i.e., incentives) in the second. In its 2010 call for information the EPA asked for policy analysis. So in response to the seminal Searchinger et al. (2009) article and the above quotation I wrote:

> Accounting is a bookkeeping exercise; incentives are a policy tool. Proper accounting helps inform policy makers. An effective forest carbon accounting system at the national level would identify the greenhouse gas (GHG) emissions from burning biomass to produce energy. Both the U.S. Department of Energy (DOE) and the Environmental Protection Agency (EPA) currently do this. Keeping forest lands in forests provides opportunities for society to obtain the multiple forest benefits people desire. Some analysts warn that renewable energy incentives could encourage forest clearing and land conversion to biofuel crops (Fargione et al. 2008, Searchinger et al. 2008). Such incentives arise not from a GHG emissions accounting system but from policies that promote some types of renewable energy and discourage others. It is preferable that accounting methods facilitate the monitoring of policy outcomes irrespective of policy goals and means of attaining them (O'Laughlin 2010).

I feel the same way today. Furthermore, the SAB panel's draft report supports my earlier position. The SAB panel recognizes that the choice of an accounting framework is a policy issue rather than a technical consideration, and that the two things cannot be separated.

I disagree. A credible accounting method needs to be developed separate from the policy, otherwise the accounting method will appear to have been developed to promote a particular policy rather than being policy neutral. Apparently the SAB panel feels that a policy neutral

accounting framework cannot be developed. If that is so, then the accounting framework will fail to meet the EPA's principle of "scientific soundness."

3(c). Are there additional factors that EPA should include in its assessment? If so, please specify those factors.

Yes. Extracted from the SAB panel's one-paragraph response are the following factors:

- Agricultural biomass
  - Leakage
  - Soil carbon
  - Residue disposition
  - Land management changes
- Forest biomass
  - Time path of carbon accumulation (after energy emissions from harvested roundwood)
  - Forest investment and multi-stand decisions
  - Weigh benefits …
- Other considerations
  - Methane (CH_4) and other gaseous emissions from landfills
  - Nitrous oxide (N_2O) emissions from fertilizer use
  - Consistent accounting for non-CO_2 greenhouse gases between biogenic and fossil fuel accounting
  - Transportation emissions from delivery of natural gas

3(d). Should any factors be modified or eliminated?

Yes. According to the SAB panel, three specific factors should be modified because of time scale issues. Another needs to be modified to be scale-insensitive and address additionality. Two factors may not be relevant for crop and forest residues.

3.4. Accounting Framework

Charge Question 4: EPA's Accounting Framework is intended to be broadly applicable to situations in which there is a need to represent the changes in carbon stocks that occur offsite, beyond the stationary source, or in other words, to develop a "biogenic accounting factor" (BAF) for biogenic CO_2 emissions from stationary sources.

Question 4(a). Does the Framework accurately represent the changes in carbon stocks that occur offsite, beyond the stationary source (i.e., the BAF)?

Yes and no. Yes, for agricultural biomass; no, for roundwood and logging residues, as explained in charge ***Question 4(b)***. In addition, the SAB panel expressed concern that methane (CH_4) is not treated appropriately in the *Framework*.

Question 4(b). Is the Framework scientifically rigorous?

No. "The SAB did not find the *Framework* to be scientifically rigorous. Specifically, the SAB identified a number of deficiencies that need to be addressed." Those are time scale, spatial scale, additionality, assessing uncertainty, leakage, and some other issues and inconsistencies.
Comment. These are all quite important, and to this reviewer provided a strong argument to abandon the attempt to create an accounting framework and subsequent regulatory scheme for biogenic emissions.

Question 4(c). Does the Framework utilize existing data sources?

Unknown. "First, and most importantly, the *Framework* does not provide implementation specifics. Therefore, it is difficult to assess data availability and use.

"A more meaningful question is 'Are the proposed data sets adequate to account for the effects of biogenic carbon cycling on CO_2 emissions from a facility?' The *Framework* does use existing data, but the data are not adequate to attribute emissions to a facility. For example, the *Framework* mentions the use of the USDA Forest Service's Forest Inventory and Analysis (FIA) data at some unspecified scale. However, carbon stock change data are likely not very accurate at the scale of the agricultural or forest feedstock source area for a facility."

Comment. Although many forest resource analysts, including this reviewer, would welcome improved forest inventory data, the costs of obtaining such data so that it could be used to evaluate biomass feedstocks for individual bioenergy facilities likely would be a prohibitively expensive burden upon society.

Question 4(d). Is it easily updated as new data become available?

No. "In principal it would be feasible to update the calculations as new data become available. Some kinds of data, such as those from FIA, are updated periodically, could be used to update the analysis. However, as discussed for other sub-questions, it is not clear exactly what data and resolution are required and whether all the required data are readily available.

"The Framework uses an annual or five-year interval for updating calculations. For some kinds of data, such as soil and forest carbon stocks, this interval is too short to detect significant changes based on current or feasible data collection methodologies. This implies that statistical or process models would be used to estimate short-term changes for reporting purposes.

Question 4(e). Is it simple to implement and understand?

No. "It is neither."

Question 4(f). Can the SAB recommend improvements to the framework to address the issue of attribution of changes in land-based carbon stocks?

Yes. "The Framework uses a reference year baseline approach to determining BAF in combination with a regional spatial scale. As mentioned in response to charge question 4(b), this approach is not adequate in cases where feedstocks accumulate over long time periods because it does not allow for the estimation of

the incremental effect on greenhouse gas emissions over time of feedstock use. To gauge the incremental effect on forest carbon stocks due to the use of forest-derived woody biomass (specifically, the value of the LAR), an anticipated baseline approach is needed. This involves estimating a 'business as usual' [BAU] trajectory of emissions and forest stocks and comparing it with alternate trajectories that incorporate increased demand for forest biomass over time."

The SAB panel then devotes 2.5 pages to discussion of the difficulty of their recommended improvement based on BAU modeling to the *Framework*.

Question 4(g). Are there additional limitations of the accounting framework itself that should be considered?

Yes. "A number of important limitations of the *Framework* are discussed below: framework ambiguity, feedstock groups, potential for unintended consequences, and assessment of mentoring and estimation approaches."

3.5. Case Studies

Charge Question 5: EPA presents a series of case studies in the Appendix of the report to demonstrate how the accounting framework addresses a diverse set of circumstances in which stationary sources emit biogenic CO2 emissions. Three charge questions are proposed by EPA.

Question 5(a). Does the SAB consider these case studies to be appropriate and realistic?

No. "The case studies did not incorporate 'real-world' scenarios which would have served as models for other situations that may involve biogenic carbon emissions."

Question 5(b). Does the EPA provide sufficient information to support how EPA has applied the accounting framework in each case?

No. "There remained considerable uncertainty in many of the inputs. In addition, some sensitivity/uncertainty analysis would be useful."

Question 5(c). Are there alternative approaches or case studies that EPA should consider to illustrate more effectively how the framework is applied to stationary sources?

Yes. "Additional case studies should be designed based on actual or proposed biomass to energy projects to capture realistic situations of biomass development, production, and utilization."

3.6. Overall Evaluation

Charge Question 6: Overall, this report is the outcome of EPA's analysis of the science and technical issues associated with accounting for biogenic CO_2 emissions from stationary sources.

Question 6(a). Does the report—in total—contribute usefully to advancement of understanding of accounting for biogenic CO_2 emissions from stationary sources?

"Yes, the *Framework* contributes to advancing the understanding of accounting for biogenic emissions and addresses many issues that arise in such an accounting system. It is thoughtful and far reaching in the questions it tackles. Its main contribution is to force important questions and offer some ways to deal with these. It covers many of the complicated issues associated with the accounting of biogenic CO_2 emissions from stationary sources and acknowledges that its choices will have implications for the estimates of CO_2 emissions obtained. These include those raised by SAB and discussed above, related to the choice of baseline, region selection and the averaging of emissions/stocks over space and time. However, the solutions offered in many cases, particularly those related to the use of harvested wood for bioenergy, lack transparency or a scientific justification."

Comment. Despite the lack of transparency or scientific justification for developing an accounting framework for regulating wood bioenergy emissions, the SAB panel nevertheless applauds the EPA's proposed approach. Had I been appointed to the SAB panel I would not have been so generous with praise.

Question 6(b). Does it provide a mechanism for stationary sources to adjust their total onsite emissions on the basis of the carbon cycle?

No. "Clearly the *Framework* offers a mechanism to adjust total on-site emissions. For short accumulation feedstocks (i.e., agricultural residues, perennial herbaceous crops, mill wood wastes, other wastes), the *Framework* could, with some modifications and careful consideration of data and implementation, accurately represent the direct carbon changes offsite. Leakage, however, both positive and negative, remains a troublesome matter if left unresolved. Moreover, the *Framework* offers no scientifically sound way to define a region. The definition of the regional scale can make a large difference to the estimate of emissions from a facility using wood as a biomass. …

"Overall, the EPA's regulatory boundaries, and hence the *Framework*, are in conflict with a more comprehensive carbon accounting that considers the entire carbon cycle and the possibility of gains from trade between sources, among sources or between sources and sinks to offset fossil fuel combustion emissions. Scientifically, a comprehensive greenhouse gas accounting would extend downstream – to emissions from by-products, co-products or products such as ethanol combustion or ethanol by-products such as distillers dried grains that are sold as livestock feed that ultimately becomes CO_2 (or CH_4)."

Comment. The above responses point out several problems that arise from limiting the accounting scale to individual stationary sources. As noted earlier, the SAB panel needs to address the spatial scale issue directly, rather than defaulting to what the EPA is and is not authorized to do. The issue here is an effective and efficient emissions accounting framework.

Question 6(c). Does the SAB have any advice regarding potential revisions that might enhance the final document?

Yes. "Overall, the *Framework* would be enhanced by including a description of its regulatory context and specifying the boundaries for regulating upstream and downstream emissions while implementing the regulation. …

Comment. I agree, especially in the wood bionergy sector. The SAB panel seems to be asking the EPA to pay careful attention to problem definition.

"If EPA decides to revise the *Framework*, the following recommendations for specific improvements are summarized below.

- "Develop a separate BAF equation for each feedstock category as broadly categorized by type, region, prior land use and current management practices. Feedstocks could be categorized into short rotation dedicated energy crops, crop residues, forest residues, perennial crops, municipal solid waste, long rotation trees and waste materials including wood mill residue and pulping liquor.
  - "For long-accumulation feedstocks like woody biomass, use an anticipated baseline and landscape approach to compare emissions from increased biomass harvesting against a baseline without increased biomass demand. For long rotation woody biomass, sophisticated modeling is needed to capture the complex interaction between electricity generating facilities and forest markets, in particular, market driven shifts in planting, management and harvests, induced displacement of existing uses of biomass, land use changes, including interactions between agriculture and forests and the relative contribution of different feedstock source categories (logging residuals, pulpwood or roundwood harvest).
  - "For residues, consider incorporating information about decay after an appropriate analysis in 32 which storage of ecosystem carbon is calculated based on decay functions. 33
  - "For materials diverted from the waste stream, consider their alternate fate, whether they might decompose over a long period of time, whether they would be deposited in anaerobic landfills, whether they are diverted from recycling and reuse, etc. Implementation complexity, cost and scientific accuracy should be considered. For feedstocks that are found to have relatively minor impacts, the EPA may need to weigh ease of implementation against scientific accuracy. After calculating decay rates and considering alternate fates, EPA may wish to declare certain categories of feedstocks with relatively low impacts as having a very low BAF or setting it to 0.
- "Incorporate various time scales and consider the tradeoffs in choosing between different time scales.
- "For all feedstocks, consider information about carbon leakage to determine its directionality as well as leakage into other media."

Comment. The issues of accounting for each feedstock type with a separate BAF, developing a baseline for woody biomass, time scales, and leakage are complicated. Without a clearly defined problem there can be no rationale for doing such work to support an accounting framework and regulatory scheme. Using scarce agency resources to do the work suggested by the SAB panel to improve the proposed accounting framework will be inefficient compared to other actions that could be taken to address the accumulation of CO_2 in the atmosphere.

4. Conclusions

The EPA's deferral of the "tailoring rule" to regulate biogenic greenhouse gas emissions from stationary in order to study of the science related to biogenic emissions was a good idea, but it has created an environment of regulatory uncertainty. The sooner this effort is concluded the better it will be for developing additional sources of wood bioenergy to replace fossil fuel energy. Although the EPA's proposed *Framework* "… addresses many issues that arise in such an accounting system. … the solutions offered in many cases, particularly those related to the use of harvested wood for bioenergy, lack transparency or a scientific justification" (SAB panel draft report, p.42, l.31-32).

Although the EPA may have no intention or authority to regulate land-use activities, nevertheless land-use change is the issue behind the concerns expressed in the three *Science* articles (Searchinger et al. 2008, 2009: Fargione et al. 2008) that are driving the ongoing carbon accounting discussion. As if in response to concerns about land-use change, the SAB panel notes:

> "... EPA can only regulate end-of-stack emissions and thus has to design a system that fits within its regulatory authority ... computing global emissions changes from individual facilities has its own daunting challenges" (SAB panel draft report, p.12, l.17-18 & l.8-9)

Furthermore, "Assessing the greenhouse gas implications of using biomass to produce energy is a daunting task" (SAB draft letter, p.1, l.25). Daunting, indeed. So daunting that one must ask why as a society we would want to add up all the emissions from individual facilities to see how they balance with sequestration from terrestrial biomass, when we already have estimates of national emissions and sequestration in the existing GHG inventory approach. Based on data presented herein, the net annual sequestration of carbon in the forest and wood products pools exceeds emissions from the production of wood bioenergy by a factor of 4.5 to 1.

Because the tasks in developing a scientific rationale for regulating biogenic emissions are daunting, I earlier recommended that the EPA defer GHG accounting to the way USDA and DOE already do it (see O'Laughlin 2010). Implicit in this recommendation was that vegetation causing biogenic emissions would be replaced and thus biogenic emissions would be exempted from regulation as long as annual additions to carbon stocks exceed emissions. Facts presented herein and my earlier position thus support the conclusion expressed by SAB panel member Roger Sedjo in the dissenting opinion in Appendix E of the SAB panel's draft report. I find nothing else in the SAB panel's draft report that would lead me to alter my earlier opinion, and sufficient support scattered throughout the report favoring abandonment of the idea of regulating greenhouse gas emissions from wood bioenergy.

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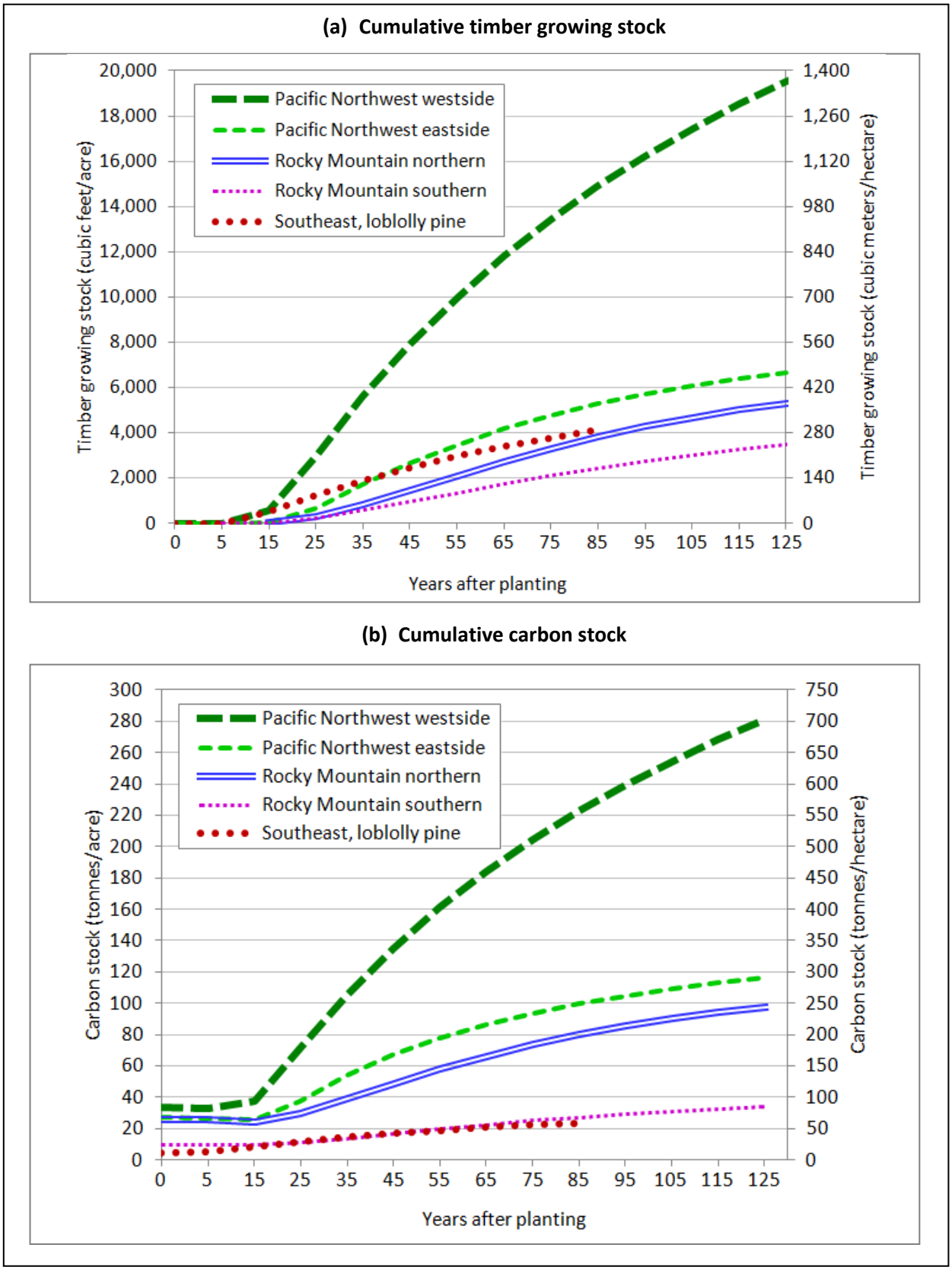

Figure 1. Cumulative (a) timber growing stock and (b) carbon stock for newly planted Douglas-fir forests on average sites in four western regions, compared with loblolly pine in the Southeast Region . **Note:** These data are the production functions for (a) timber growing stock or (b) carbon stock as the output yield, or total product, and time as the single variable input factor.
Data source: Smith et al. (2006).

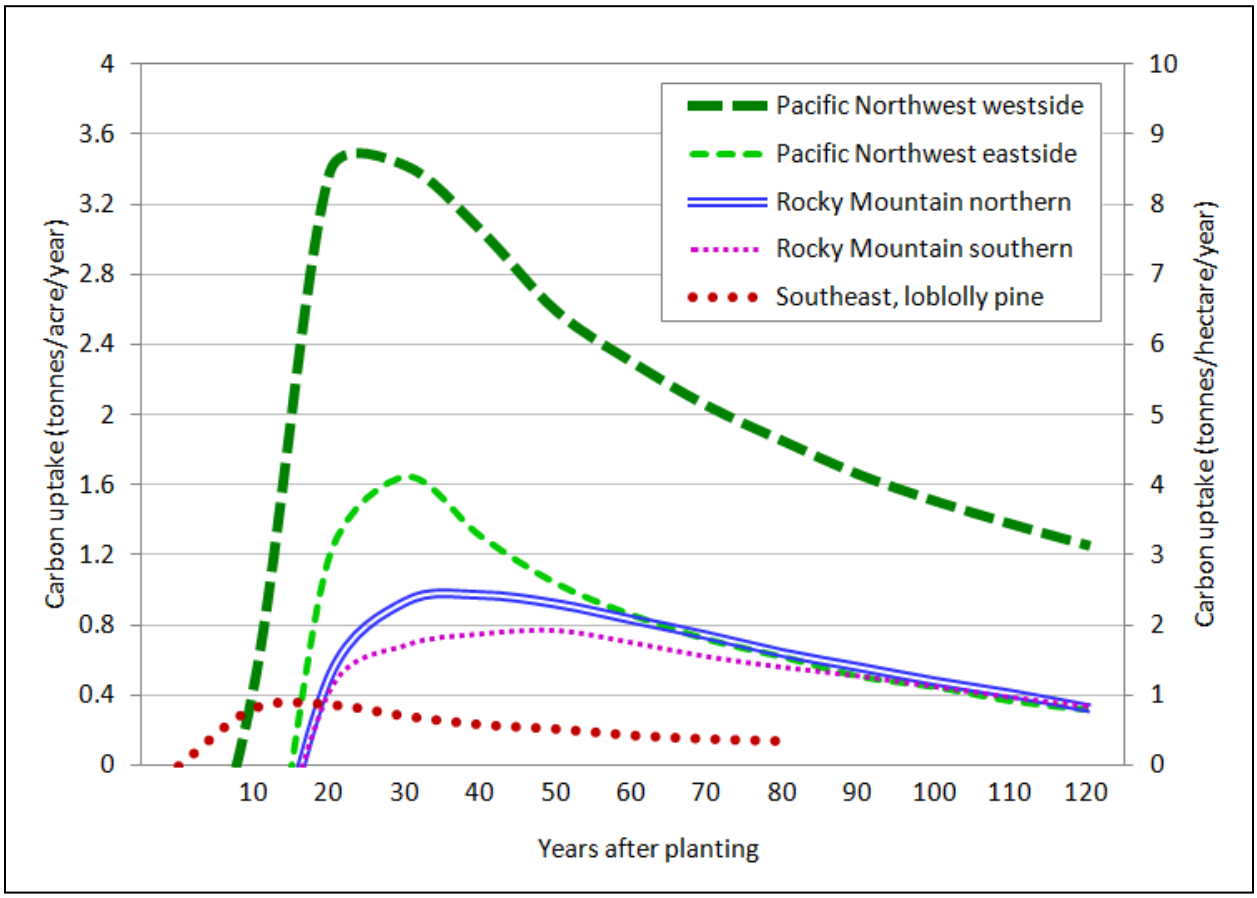

Figure 2. Carbon sequestration (uptake) rates for newly planted Douglas-fir forests on average sites in four western regions, compared with average loblolly pine site in the Southeast Region. This is the growth rate, marginal product, or current annual increment and is derived from **Figure 1(b)** as the difference between output yield at two different times divided by the time interval.

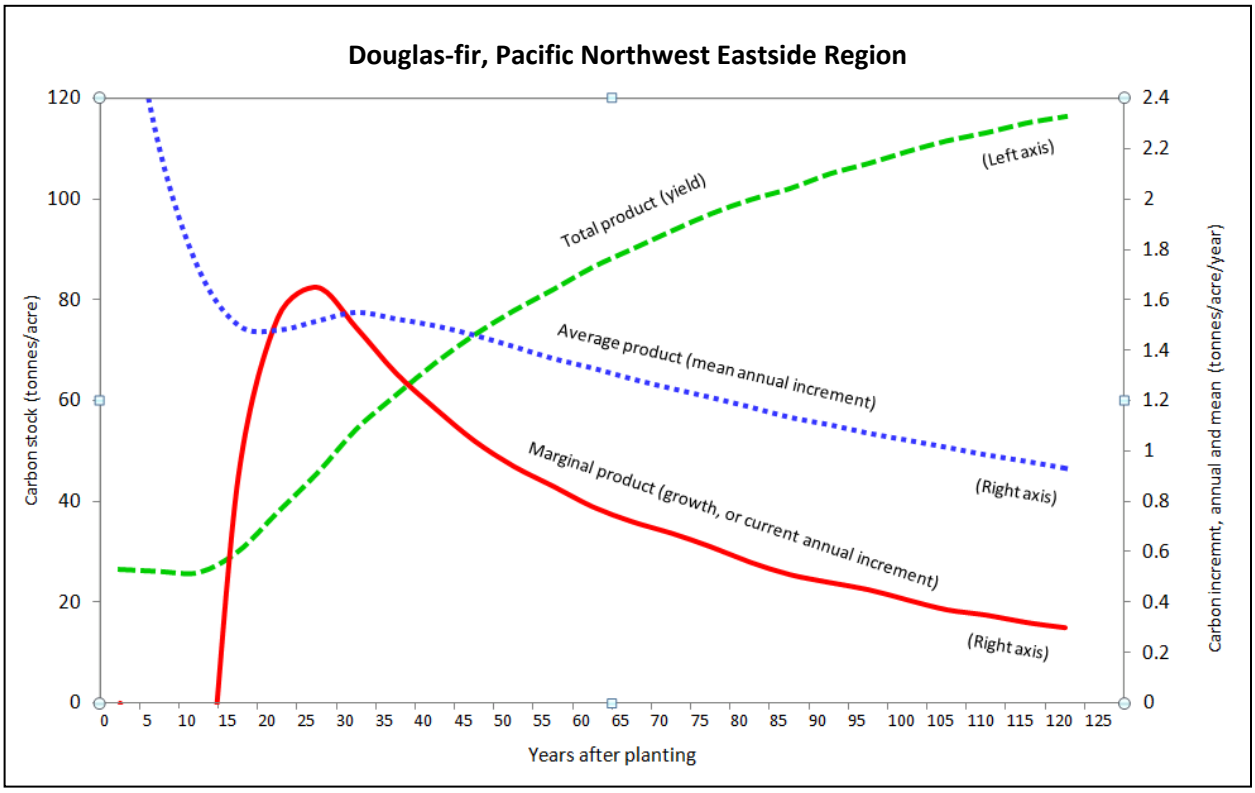

Figure 3. Carbon stock production function (total, average, and marginal product) for newly planted Douglas-fir on average sites, Pacific Northwest Eastside Region, with time as the single variable input factor (see **Figure 1(b)**). Marginal (see **Figure 2**) and average product curves are displayed on the right vertical axis (note different scales; adapted from Gregory 1987, p. 315, Figure 14.3). In forestry the average product is also called the mean annual increment and is derived by dividing the total product by the time in years after planting. The culmination of the mean annual increment is the point at which the average product and marginal product from the current rotation are equal (this takes the first equilibrium point at approximately 20 years out of consideration because the growing stock carbon residual from the previous harvest is diminishing). The optimum rotation age for maximization of forest carbon accumulation over a long-term period is approximately 35 years.

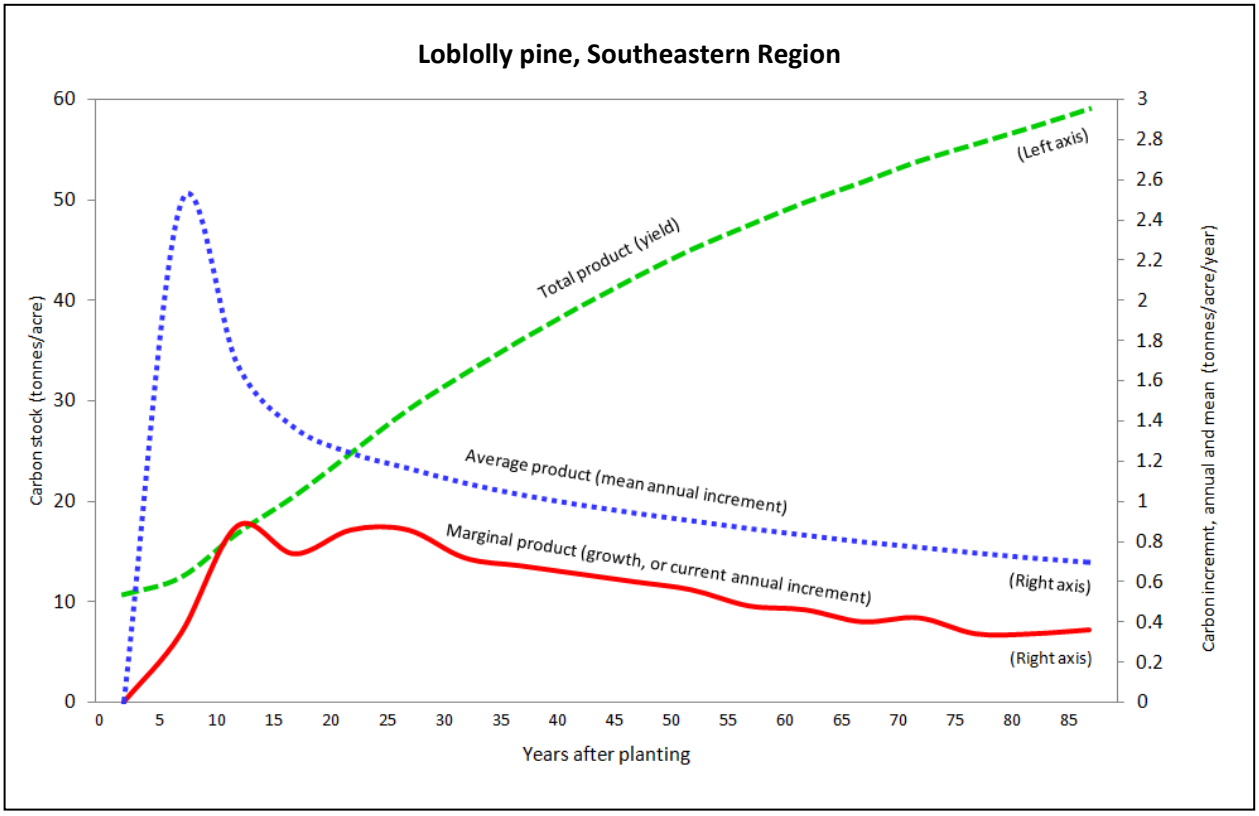

Figure 4. Carbon stock production function (total, average, and marginal product) for newly planted loblolly pine on average sites, Southeastern Region, with time as the single variable input factor (see **Figure 1(b)**). Marginal (see **Figure 2**) and average product curves are displayed on the right vertical axis (note different scales; adapted from Gregory 1987, p. 315, Figure 14.3). **Note:** The data plotted between 15 and 25 years appear to be incorrect due to the shape of the marginal product of growth curve (see Smith et al. 2006, Table A39, p. 86). In forestry the average product is also called the mean annual increment and is derived by dividing the total product by the time in years. The culmination of the mean annual increment is the point at which the average product and marginal product from the current rotation are equal. In this case, however, due to gains and losses in the various forest carbon pools, the marginal product never exceeds the average product. However, it is clear that growth is at a maximum at approximately age 25, which would be the optimum rotation age for maximization of forest carbon accumulation over a long-term period.

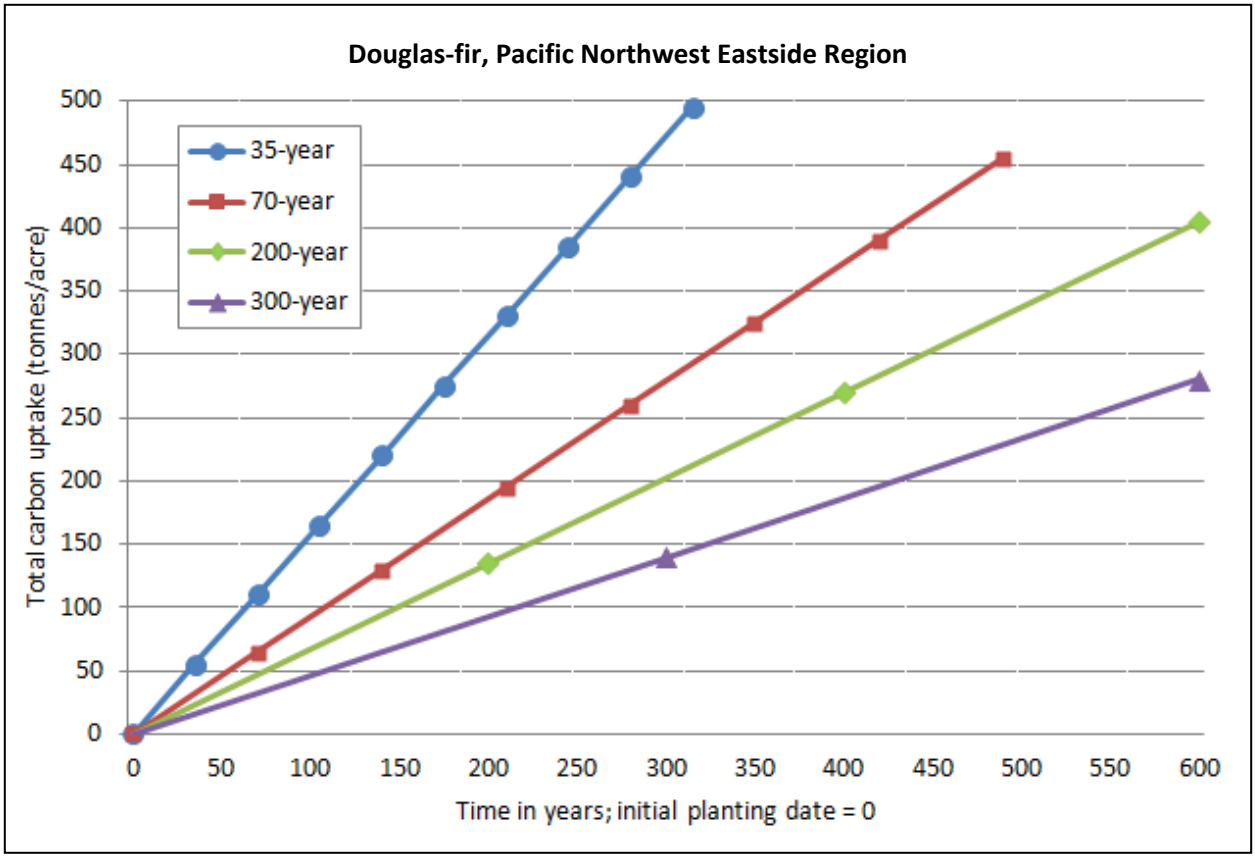

Figure 5. Long-term total carbon uptake for four rotation ages of newly planted Douglas-fir on average sites, Pacific Northwest Eastside Region. **Note:** This analysis simply adds the cumulative carbon stocks at the end of each of the rotations that can be fitted within a 600 year time frame. Although the fate of stored carbon at the end of each rotation is not accounted for, this illustrates that shorter rotations will uptake more atmospheric CO_2 than longer rotations.