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BIOGENIC CARBON ACCOUNTING: CONSIDERATIONS TO A REVISED FRAMEWORK

DISCUSSION DRAFT

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Table of Contents

Background and Summary

Presented here is a revised accounting framework to track biogenic carbon emissions, or the greenhouse gas (GHG) emissions associated with the production and use of biomass resources. It is designed to achieve three overarching principles: to be cost-effective, to be adaptive and responsive to changing conditions, and to provide incentives for continuous improvement. While the first two are most directly relevant to present efforts by the U.S. Environmental Protection Agency (EPA) to establish an accounting methodology for biogenic emissions, the latter is perhaps best seen as a separate but supporting policy objective, one that adds additional robustness to the system. The revised framework achieves the three principles through a three-tiered system. The first tier consists of the establishment of regional default biogenic accounting factors (BAFs) for classes of feedstock. The second is the targeted exemption of individual feedstocks based on evidence of minimal net emissions associated with their use. The third and final tier provides the opportunity for individual feedstock producers to become certified under the framework, and in doing so, employ a BAF other than the feedstock default. To highlight the practical considerations involved in adopting such a framework, I review each of the three tiers in the recommended approach, providing applied, quantitative examples to highlight key issues or findings. Although biogenic carbon dioxide (CO_2) accounting is complicated, and any accounting framework will surely involve economic, scientific, and political tradeoffs, I hope to show that an intuitive and defensible system is nonetheless possible to construct.

Overview of a Possible Framework

The accounting framework discussed here shares an important similarity with a September 2011 framework released by the U.S. EPA (U.S. EPA 2011): its reliance on a so-called biogenic accounting factor, or BAF. The BAF is a straightforward and reasonable concept that allows users of a biomass resource to adjust their net emissions based on the embodied carbon storage and emissions in their fuel of choice. Apart from saying that the concept of a BAF is a useful one, I do not expand upon what specifically it includes or the equation specifically used to calculate it. The September 2011 framework devotes significant time and energy to this. As the EPA's Science Advisory Board (SAB) has noted in its deliberations, multiple aspects of the BAF as described in the September 2011 framework may require significant modification or even wholesale revision. I am nonetheless confident that equations can be tweaked and variables adjusted. For the purposes of the below discussion, assume only that a BAF must somehow account for carbon removed from the landscape and the change in carbon on the landscape (adjusting if necessary for any indirect effects).

Key Principles

The overarching objective of this framework is to provide a cost-effective and defensible means to assess the carbon consequences of biomass bioenergy utilization. To achieve this, the framework attempts to abide by three central principles. The first is to minimize cost and administrative burden. Costs can themselves be viewed as consisting of two separate components: direct costs and indirect costs. Direct costs include those expenditures and losses explicitly tied to participation in a particular market or program. For the purposes of the discussion here, let us consider these to be comprised of the costs of making changes in management to produce biomass, the costs of transporting the biomass to a buyer or other end user, and the costs of complying with program requirements (e.g., measurement costs, certification audit expenses). Indirect costs are harder to quantify, but include things like general unfamiliarity with a particular program, process, or approach. When creating a new program or regulatory process, central considerations should be precedent and context, or what can be learned from existing programs or processes. In this regard, special attention should be paid to the regulatory context to which the accounting framework will be applied (box 1).

Box 1. A note on regulatory context.

An absolutely critical consideration, but one that is receiving precious little attention in the biogenic accounting debate, is the manner in which biogenic emissions will be regulated under the Clean Air Act (CAA).[1] The decision over how and where to regulate biogenic emissions could have a dramatic influence on the accounting framework necessary to inform the process. Biogenic sources could conceivably factor into at least two regulatory programs under the CAA: the Prevention of Significant Deterioration (PSD) and New Source Performance Standard (NSPS) programs.[2] Although many of the key considerations discussed here could apply to both a PSD or NSPS regulatory context, the scenarios modeled below generally assume that facilities will need to update their emission factors over time.

The PSD program requires preconstruction permits for new stationary sources that exceed certain GHG emissions thresholds and for certain modifications to existing sources.[3] Recipients of PSD permits have an ongoing responsibility to comply with permit requirements, such as emission limits that restrict increases in concentrations of controlled pollutants. Biogenic accounting may play a role in the PSD program in two ways: (1) by factoring into the determination of whether or not the PSD threshold is reached, and/or (2) by factoring into the determination that the facility is making use of best available control technology (BACT). If regulated under the PSD program, biogenic emission threshold determinations will likely be required upfront, at the time of facility construction or modification. This places greater emphasis on "getting the number right" and evaluating future conditions. An accounting system designed to achieve this might not be as concerned with the process for updating a given facility's emissions factor over time. Rather, emphasis would be placed on future conditions modeling and on the selection of conservative emissions estimates. It is also conceivable that demonstration of BACT could require continued compliance with some minimum level of reduction, necessitating more frequent updating of accounting factors.

Alternatively, NSPS requires that large steam-generating electric-utility generating units and combined-cycle combustion turbines achieve an annual emissions rate.[4] An accounting framework under NSPS (or in support of a continuously updated BACT requirement) would therefore place greater emphasis on the process by which emission factors change over time and the process by which these updated factors are adopted by regulated facilities. Thus, in the first situation (PSD), an accounting framework must be capable of generating a BAF that is valid over some multiyear time period. In the second (NSPS or continuously updated BACT), the BAF must reflect the emissions associated with use of particular feedstocks over a much shorter period of time.

The second principle is to be adaptive and responsive to changing conditions on the ground. One reason that biogenic accounting is so difficult is the inherent uncertainty that accompanies any attempt to foresee future conditions. Unless properly designed, new biomass markets could lead to undesired changes in landscape composition, intersectoral competition, and/or net increases in GHG emissions. Even if properly designed, accounting systems must be capable of detecting unexpected or undesired shifts in performance and somehow provide feedback into a process for addressing it. The challenge here is how to achieve this feedback process while at the same time providing participating entities some degree of certainty.

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[1] The SAB does note the link between regulatory context and accounting system in their deliberative draft report, but does not pursue the issue further. Feedback is welcomed on the correctness of the characterization of these CAA programs or the appropriateness of assuming a regularly updated emissions factor.

[2] For example, the EPA mentions biogenic CO_2 emissions in the proposed NSPS rule but refrains from "making particular proposals for treatment of biogenic CO_2 emissions." EPA Standards of Performance for Greenhouse Gas Emissions for New Stationary Sources: Electric Utility Generating Units, 77 Fed. Reg. 22,392, 22,400 (Apr. 13, 2012) [hereinafter Proposed NSPS].). The EPA has also deferred for three years a decision on the applicability of PSD permitting requirements to biogenic CO_2 emissions Deferral for CO_2 Emissions from Bioenergy and Other Biogenic Sources Under the Prevention of Significant Deterioration (PSD) and Title V Programs: Proposed Rule, 76 Fed. Reg. 15,249, 15,251 (Mar. 21, 2011).

[3] EPA Tailoring Rule, 75 Fed. Reg. 31,514 (June 3, 2010).

[4] Proposed NSPS, 77 Fed. Reg. at 22,392.

The third and final principle is to provide incentives for improvement. This is less an accounting issue than a policy objective, and so may be beyond the scope of current EPA accounting methodology efforts. That said, setting a low barrier to entry, at least as far as direct and indirect costs go, allows the greatest possible number of individuals to participate in the system. Accompanying this must be a process that provides the incentive to improve performance once there. The theory is that willing and able producers will undertake actions that yield increased emission benefits for the system if doing so simultaneously generates increased financial benefits in the process. A properly designed system, one that includes such incentives for performance improvement, will tend to achieve greater GHG emission benefits over time as individuals increasingly move beyond minimum compliance.

Conceptual Overview of a Revised Framework

Similar to the September 2011 framework, this revised framework retains the notion of a BAF and examines only the biogenic portion of emissions. In other words, it does not consider the full lifecycle emissions of biomass use. A key difference between this framework and the September 2011 one is the explicitly tiered structure of this framework and the scale at which it operates. The framework begins with the establishment of a default BAF that can be used by all facilities using a given biomass feedstock. This represents the first tier. The second tier of the framework allows for the exemption of specific low- or no-emission feedstocks. The third and final tier is the creation of a producer-specific self-certification process that allows individual biomass suppliers to replace the default BAF with one derived from their particular production practices.

The three-tiered system can be viewed in the context of multiple continua (Figure 1). A primary advantage of the system is that it sets a low barrier to entry. Facilities wishing to use biomass may simply adopt the default factors to account for their biogenic emissions. This likewise means that individual producers wishing to sell material to a facility have a low barrier to entry as well, so long as they choose to have their material bound by the same default factor. The second and third tiers meanwhile provide an implicit incentive for performance improvement. As producers and facilities progress to the second and third tiers, GHG accounting and chain of custody requirements become more rigorous. One would expect that only those seeing an advantage in improving their BAF will undertake the additional work needed to realize those gains.

Approach	GHG Estimation Complexity	Chain of Custody Complexity	Incentive Transmission	Scale of Operation
Tier 1: Default Factor	Least complex	Least complex	Weak	Region
Tier 2: Targeted Exemption				
Tier 3: Self-Certification	Most complex	Most complex	Strong	Individual producer/ facility

Figure 1. A revised three-tiered accounting framework across multiple continua.

Some As-Applied Examples

In the sections below, I run through the three tiers of the proposed revised framework, illustrating key challenges and considerations. For each, I present a few options and animate the potential implications of choosing one approach over another using SubRegional Timber Supply (SRTS) model output.[5] Data are derived from model runs underlying existing reports and analysis. I use data from existing work for three reasons. The first is efficiency—existing data are quicker and easier to employ than defining and running new scenarios. The second is transparency—the data from existing reports are part of analyses that are publicly available, and which as a result have received the benefit of either formal or informal peer review. A third reason is context. The examples presented below are but a small part of a variety of larger processes and phenomena, so drawing data from existing analyses inherently relates what is discussed here to landscape-level trends discussed at length elsewhere.

All analyses discussed herein in some way pertain to the potential supply-side effects of increased demand for forest biomass in the Southeastern United States. One study (Abt et al. 2010) evaluates the forest carbon effects of maximizing coal cofire capacity at regional and subregional scales. A similar analysis (Galik and Abt 2012a) builds off of this initial work to include state-level effects in a comparative analysis of the role of assessment scale. Galik and Abt (2011) meanwhile examine a broad array of renewable energy and fuel demand scenarios, and in the process investigate supply-side effects in three Southeastern states. Galik and Abt (2012b) continue work on the role of assessment scale, but limit the analysis to different geographic areas within a single Southeastern state.

As for the focus on forest biomass, there are several reasons. Forest biomass is but one possible feedstock, but it arguably faces many of the most difficult considerations from a biogenic carbon accounting perspective. As opposed to dedicated plantings such as energy crops, forests occur naturally and store a great deal of carbon on their own. As opposed to agricultural residues, a significant market already exists for finished forest products. Depending on the form of the eventual product, carbon could be released in the near term or stored for decades. Forests likewise possess a long planning horizon, and planting decisions made today will yield usable biomass only at some future point in time. The collective uncertainty introduced by all of this complicates attempts to model the forest carbon dynamics associated with the implementation of new policies or the emergence of new markets (box 2).

[5] For more information on the SRTS model, see, e.g., Abt et al. (2009) and Prestemon and Abt (2002).

Box 2. The GHG dynamics of forest biomass production and use.
The GHG dynamics associated with forest biomass production and use has been the source of tremendous debate over the last few years. While the nuances of the debate are too numerous and complex for review here, there are generally two parts of the story. The first is that the relative inefficiency of wood as compared to its fossil counterparts (e.g., coal) implies that a greater amount of wood must be harvested and combusted to generate the same amount of useable energy. On balance, this inefficiency results in more GHG emissions being released (at least in the near term) when using forest biomass than simply continuing to use a fossil fuel alternative. Even when aggregated across a state, forest ecosystem, or geopolitical region, these studies can be reduced down to stand-level changes in growth and harvest. Prominent studies illustrating this part of the story include Manomet Center for Conservation Sciences (Walker et al. 2010), Biomass Energy Resource Center et al. (2012), and Mitchell et al. (2012).

A second part of the story suggests that the emergence of a large-scale bioenergy market can affect landscape-level GHG dynamics in ways that either counteract or compound stand-level effects. The basic premise here is that increased demand for biomass leads to higher prices for a variety of forest products, which in turn increases the incentive to manage more intensively, to plant or replant more frequently or consistently, and to reduce the rate of conversion to other land uses. On balance, inclusion of these "economic" or market components may result in greater GHG benefits than would have otherwise occurred (Abt et al. 2010; Daigneault et al. 2012; Abt et al. 2012). Research has even shown that inclusion of these components shows increased GHG performance at the state level even when a stand-level analysis shows the opposite (Galik and Abt 2012b).

Tier 1: Establishment of Default Factors

The first tier of this revised framework consists of establishment and adoption of default biogenic accounting factors. By establishing a default value that can be used "off the shelf" by biomass-consuming facilities, one can lower administrative barriers to biomass use. Facilities finding it cost effective to add biomass to their fuel mix in light of established default factors will do so, while those that don't will not. The question is, of course, how does one calculate such a default factor? Among the necessary policy considerations are how improvement is gauged (i.e., what the baseline is), how often the factor is updated, the size of the area from which the factor is calculated and to which it is applied, and the manner in which feedstock is differentiated. Each consideration is reviewed further below.[6]

Consideration 1: Baselines

This is quite possibly the most philosophically charged consideration that must be made under any GHG accounting framework. It essentially reduces to "what are you trying to achieve?" This is because establishment of a baseline sets the reference point against which gains or losses are measured. If one is simply interested in the net change of carbon relative to a particular point in time, the process of setting a baseline is fairly straightforward: measure forest carbon now, measure forest carbon later, and compare the two. Critically, the number yielded in such an exercise does not tell you the net gains or losses attributable to a given activity, only the absolute change in forest carbon stock. It only tells you that, for whatever reason, you have more or less forest carbon than you once did. This approach is generally referred to as a base-year or reference-point approach.

Alternatively, one might be interested in gauging whether a particular action, policy, or market resulted in more or less carbon storage relative to what would have otherwise occurred. In this context, simply measuring the amount of carbon present now and in some future time fails to provide an appropriate answer. Rather, one needs to know (or perhaps more appropriately, estimate) the level of carbon that *would have been stored*, and compare recorded changes to this number. This approach is generally termed a business-as-usual or BAU approach. While a theoretically sound means to assess the marginal impact of

[6] The SAB is currently in the process of evaluating the use of a default BAF, along with many of these same considerations.

an action or set of actions, the errors that come with estimating hypothetical counterfactual scenarios can offset the advantages of a BAU approach.

Different variations on these two themes are of course possible. For example, one might gauge whether a trend is changing in the presence of an action, policy, or market (i.e., going from year-over-year gains in forest carbon to a loss). The September 2011 framework devotes some time to discussing the differences between a number of possible approaches for establishing baseline, but in the end devotes the most time and energy to discussing a single approach: reference point. This is important, as the choice of baseline is not a trivial matter. As seen in Figure 2 below, simply tracking the change in forest carbon over time in the presence of increasing demand for forest biomass ("Gross") suggests an increase in regional forest carbon stock. Alternatively, comparing the observed changes in forest carbon against a without-biomass, business-as-usual scenario ("Net") suggests a drop in forest carbon storage relative to what would have occurred. The "Difference" line indicates the disparity between the two scenarios, and can be quite significant in any given year. The take-home is quite clear: in situations where carbon stocks are increasing, a failure to take into account the background trend of stock change can lead to an overly optimistic output metric, at least in this particular case of forest biomass use in the Southeastern United States.

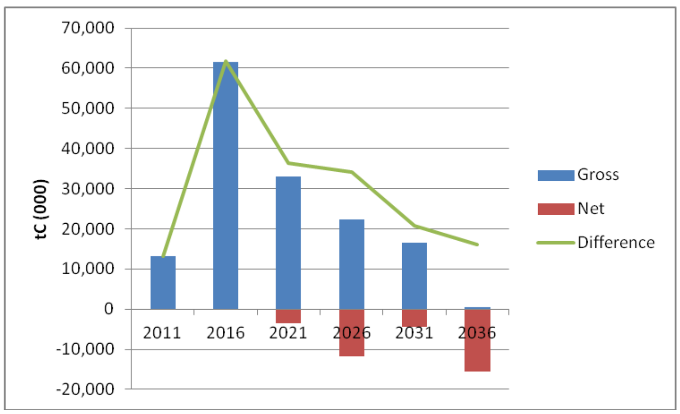

Figure 2. Gross versus net changes in forest carbon. Gross changes indicate the recorded changes in forest carbon in the mid-Atlantic region cofire scenario as defined in Abt et al. (2010). Net changes indicate the difference between changes in forest carbon in the business-as-usual scenario and the cofire scenario. Neither Gross nor Net figures reflect reduced emissions from displaced coal. Source: Data derived from Abt et al. (2010).

One situation where a reference-point baseline could work could be where the BAU carbon stocks are assumed to be unchanging. This could conceivably apply to lands managed for sustainable timber production, in which carbon lost to harvest is replaced by either contemporaneous growth elsewhere on-site (for larger sites) or subsequent regrowth (for smaller ones). Even if such lands do manage to achieve a stable carbon stock over time, the question becomes, how best to separate out such "working lands"? Some have suggested that a growth-drain ratio could be useful in this regard (Lubowski et al. 2012).

A difficulty in using a growth-drain metric is the spatial and temporal variation expected to come with it. Previous research suggests that regions with the greatest rates of pine inventory increase also have the highest rates of harvest (Galik and Abt 2012a). The comparative advantage of these areas is exploited as additional biomass harvest activity shifts to the area. This increased harvest activity serves to reduce the initial comparative advantage, and correlation of additional harvest with initial harvest declines (Figure 3). In time, new plantations come online, industrial displacement drops, and harvests recover, starting the cycle over again.

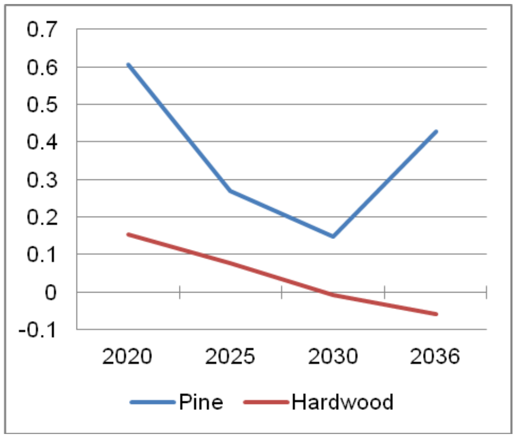

Figure 3. Spatial correlation between starting pulpwood harvest and increased pulpwood harvest in response to increased demand for woody biomass. The example presented here is for a 50% residue utilization scenario. Source: Galik and Abt (2012a).

Could something other than a BAU or reference-point approach work? At least in the case of Southeastern forests, a modified historical baseline (essentially a measure of recent trends in forest carbon change) could possibly do the job. As seen in Figure 4, the black "BAU" line represents what actually happened in the modeling exercise, taking the difference between the model output for the biomass demand scenario and the output for a counterfactual, without-biomass scenario. This represents the benchmark to judge other approaches. The gray line represents the answer returned by a reference-point baseline, while the blue line represents a situation in which the observed change in forest carbon is compared to the average observed change across the five prior years. The red line is largely the same thing, but represents a situation in which annual data may not be available, and so is updated only every five years. In the absence of perfect information, a modified historical baseline could nonetheless work, especially if the goal is simply to get a general sense of the direction and magnitude of change.

Consideration 2: Timing

Relevant to calculation of a default factor is the frequency at which it is updated. The choice of frequency is itself a function of multiple other considerations. If field data is being used to inform the development of the default factor, sufficient data must be gathered to yield a statistically significant metric. As Lubowski et al. (2012) show, increasing measurement interval allows for smaller changes in forest carbon stock to be detected using U.S. Forest Service Forest Inventory and Analysis (FIA) Program data. Another consideration is the regulatory regime within which any biogenic accounting framework is to reside (see box 1). regardless of the timing of other regulatory processes, a longer-lived factor would tend to instill a greater degree of certainty among users of a particular feedstock.

Below, we see a situation in which three hypothetical Virginia facilities begin cofiring woody biomass, sequentially, beginning in 2011 (Figure 5).[7] The first comes online in that year, the second in 2016, and the third in 2017. Together, the facilities have a collective biomass demand of approximately 1.8 million green tons of wood per year. The "SRTS Reference" line indicates the actual level of emission reduction observed in model output. The "Annual" line reflects the total emission reductions estimated under the September 2011 framework for the three facilities, with each facility's BAF updated on an annual basis. The "15-year" line reflects the same, but assumes that BAFs are updated only once every 15 years. Clearly seen is that both "Annual" and "15-year" figures tend to overestimate the level of near-term emission reductions, but that the duration of the overestimate in the "15-year" approach is much greater.

[7] Note that Figure 5 and Figure 7 also include the emission reductions associated with displaced coal. Displaced fossil emissions are not considered in the current version of the EPA accouting framework.

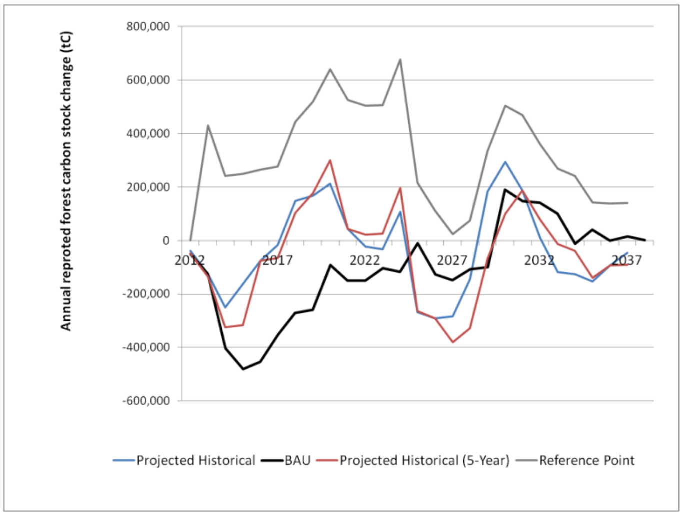

Figure 4. Observed annual forest carbon change using a BAU, reference-point, projected historical, and projected historical (5-year) baseline. BAU compares the observed carbon stock to a hypothetical "without biomass use" scenario. Reference point compares observed carbon stock to that recorded in year 1 of the scenario. Projected historical compares the observed change in carbon stock to the average observed change across the five prior years. Projected historical (5-year) is similar, but locks in the average observed value for five-year increments. Figures do not reflect reduced emissions from displaced coal. Source: Unpublished analysis using data derived from Galik and Abt (2012b).

The reason for the discrepancy between "Annual" and "15-year" estimates is simple: a locked-in BAF does not react to changes in forest or market conditions. This latter point is especially important if new entrants are expected over time. New facilities will be aware of existing facilities as they are calculating their initial BAF, but existing facilities may not have a reason or mechanism to "re-open" their BAF in response to new actors. Only when recalculating a BAF will these new entrants be recognized by existing ones. This implies that longer-lived factors, especially those with no means to capture dramatic shifts in forest or market conditions, should be set conservatively at the outset. So while longer-lived factors may help deliver greater certainty to biomass users, they would likely need to be set at less favorable levels than shorter-lived ones, possibly decreasing the appeal of biomass use in the first place.

Figure 5. Comparison of emission reductions reported from three hypothetical cofiring coal facilities operating in the Virginia coastal plain using factors updated annually and every 15 years. "SRTS Reference" indicates the actual level of emission reductions in this scenario. Reductions in emissions from displaced coal are included in each estimate. Source: Unpublished analysis using data derived from Galik and Abt (2012b).

Consideration 3: Scale
Also relevant to calculation of the default factor is the size of the area used to calculate the factor, along with the scale at which it is applied. The former is important for a number of reasons. If modeling the supply-side effects of increased biomass demand, the distribution of expected demand and available supply become critical assumptions. This is seen in Figure 6 below, in which different assumptions are made on the sourcing of woody biomass to meet a set demand—specifically, the amount of woody biomass needed to maximize biomass cofiring in existing coal facilities across the Southeast (see Galik and Abt 2012a). In the “State” scenario, we assumed that all demand for biomass within a particular state is met with resources from that particular state. In the “Subregion” scenario, we defined seven subregions across the Southeast, and required all demand for woody biomass within a subregion to be met with material produced within that same subregion. The “Region” scenario allows woody biomass produced anywhere in the Southeast to satisfy biomass demand, regardless of location. Note that in all three scenarios, aggregate demand is the same; the only differences are how demand is apportioned and supply restricted. What this shows is that assumptions about the size and reach of a particular market can influence the resulting GHG story. Assuming a narrow geographic reach of biomass markets, we see positive forest carbon implications (the “State” scenario). Assuming a more fluid market (“Region”) yields lower estimates of forest carbon.

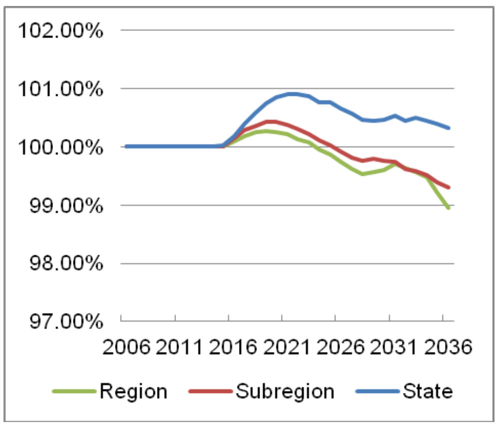

Figure 6. Percent carbon differential, cofire scenario versus baseline (assuming utilization of 50% of available residues). Values above 100% indicate an increase in forest carbon storage relative to baseline conditions. Figures do not include reduced emissions from displaced coal. Source: Galik and Abt (2012a).

Another reason that scale is important ties back to timing and the availability of sufficient data to yield a robust metric. Much as longer measurement intervals can increase levels of confidence for detecting smaller changes in forest carbon stock, so too can larger forest areas (Lubowski et al. 2012). At least so far as the FIA is concerned, a possible tradeoff therefore exists between the size of the area and the length of measurement interval; different combinations of timing and scale can be used to yield statistically significant estimates of changes in forest carbon.

Yet another consideration is the scale at which the factor is applied. The September 2011 framework envisioned a facility-level accounting system, in which each facilitiy generated and applied its own BAF. A danger in such an approach is that it can be somewhat myopic, as applied. Similar to what occurs in Figure 5 above, use of a facility-specific BAF can suggest much higher emission reductions than are actually achieved. This is apparent in Figure 7, in which the emission reductions recorded by the same three plants are compared to a SRTS benchmark. Here, “Individual Plant Sum” shows the combined total for all three facilitites over time, using an annually updated BAF calculated at the facility level. The “Procurement Area Default” line meanwhile shows the level of emission reductions recorded when each facilitiy uses a single, regionally estimated BAF (likewise updated on an annual basis). In capturing the collective influence of all three facilities on forest carbon stocks, the "Default" line does a much better job tracking actual emission reductions expressed by the "SRTS" line.

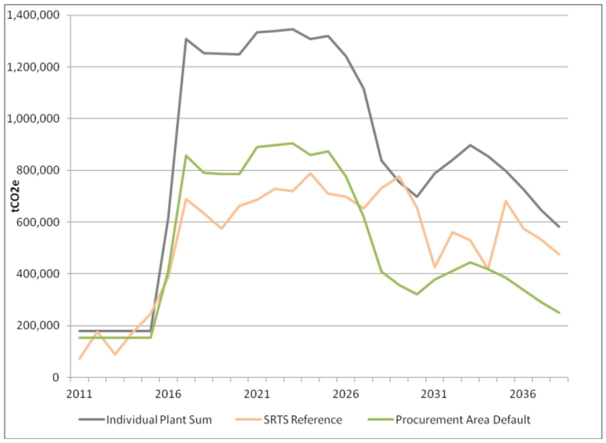

Figure 7. Comparison of reported GHG benefits as calculated using facility-specific BAFs versus a default BAF calculated at the regional level and applied to each facility. "SRTS Reference" indicates the actual level of emission reductions observed. Reductions in emissions from displaced coal are included in each estimate. Source: Unpublished analysis using data derived from Galik and Abt (2012b).

Consideration 4: Feedstock differentiation

Another important consideration is how to group or differentiate feedstocks so that any default factor best captures the underlying carbon dynamics. If a feedstock is defined too broadly, an unnecessary level of heterogeneity will be introduced into the carbon dynamics of its production and use. If defined too narrowly, calculation and use of a default factor could become unnecessarily burdensome. The key is to define feedstocks in such a way so as to group together material with similar carbon dynamics and that responds to biomass markets in a similar manner. Of course, this is easier said than done.

Even within a particular type of feedstock—forest biomass—there exists a great deal of heterogeneity that may be masked by taking too broad a perspective. This is apparent in data from the cofiring example first explored above. In the particular example shown in Figure 8, we see that total forest carbon falls over time. Disaggregating total carbon into individual management types shows a great deal of variation by forest management type, however. In particular, notice the difference between planted pine and the other management types. This suggests that "forest biomass" may be too broad a feedstock grouping in this case, and that further differentiation into "planted" and "natural" forest types might be warranted. Practically, this makes sense, as plantation management would be expected to respond to changes in demand differently than would management of natural forest types.

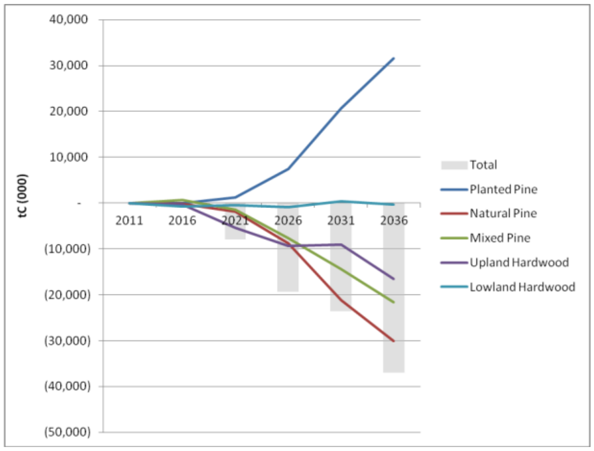

Figure 8. Comparison of net changes in live-tree carbon by forest management type in the mid-Atlantic region co-fire scenario as defined in Abt et al. (2010). Figures do not reflect reduced emissions from displaced coal. Source: Data derived from Abt et al. (2010).

Tier 2: Targeted Exemption

The second tier of this framework allows for the exemption or removal of a certain class or subset of feedstock material from accounting obligations.[8] This could occur if in the process of assessing default factors for biomass materials, the resulting figures suggest either no net contributions to atmospheric GHG concentrations or even net reductions. A central consideration is how to determine whether a feedstock contributes minimal levels of GHG emissions. As with the default factor, feedstock differentiation is a central consideration, as is the baseline to which actual emissions can be compared. In the case of forest residues, the issue often hinges on the timing of the assessment, further explored below.

Consideration 1: Short- versus long-term carbon dynamics

Over long enough of a time period, unused residues are assumed to decay, minimizing the net GHG effects of their use. In the context of a biogenic accounting system, the relevant question therefore becomes, what's the appropriate time period to use? As seen in Figure 9, the choice of accounting window can have dramatic influence on whether a given feedstock can be seen as low-emitting or not. Here, the solid lines represent forest carbon stock change relative to a BAU scenario as measured on the ground in any given year. The "25%" line represents the relative change in carbon stock in a scenario in which 25% of available forest harvest residues are removed and used for biomass. Similarly, "50%" represents a 50% removal rate. The dashed lines meanwhile represent forest carbon stock change in a situation where the carbon in on-site harvest residues is adjusted by the amount remaining 30 years post-harvest. Put another way, the dashed lines include only that portion of carbon in harvest residues that remains in the forest for more than 30 years.

[8] Although functionally similar to "categorical exclusions" as discussed by the SAB, the term exemption is used here to reinforce that it is only individual feedstocks or classes of feedstocks that may be removed from consideration, and not all biomass as a matter of course.

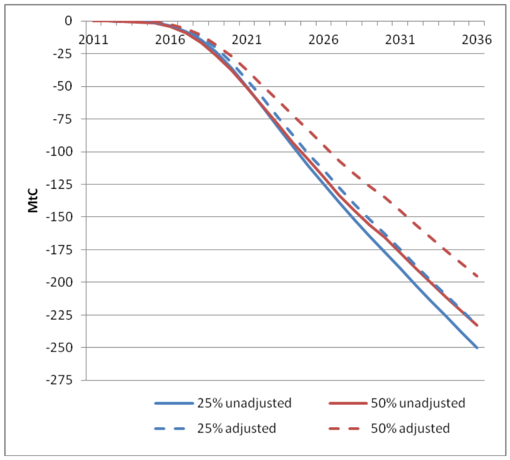

Figure 9. Comparison of net forest carbon change in the Southeast region cofire scenario as defined in Abt et al. (2010), assuming both 25% and 50% residue removal rates. Adjusted scenarios discount the change of carbon in the residue pool by the amount that would have been lost to decay within 30 years. Unadjusted scenarios report only carbon on-site in the year of observation. Figures do not reflect reduced emissions from displaced coal. Source: Unpublished analysis using data derived from Abt et al. (2010).

The difference between dashed and solid lines of the same color illustrates the importance of timing when evaluating feedstock GHG emissions. The dashed, adjusted lines show that the long-term carbon implications of using harvest residues for bioenergy may be significantly lower than suggested when simply measuring the near-term change in forest stock. Of course, other considerations are likewise important to consider, such as the effect of residue removal on forest productivity and other amenities such as wildlife habitat (e.g., Scott and Dean 2006; Forest Guild Southeast Biomass Working Group 2012). It is therefore not surprising that the difficulties associated with accurately measuring and attributing the GHG emissions associated with residue decay are a recurrent issue raised in comments to the EPA on the subject of biogenic accounting.

Tier 3: Individual certification

The third tier of the accounting framework allows for individual producers to self-certify, or to generate and apply an operation-specific BAF to the materials they produce. In doing so, they may realize gains over the default BAF that would otherwise apply to the materials they produce. I should note at the outset that the term "certification" as used in this context is different from what is commonly understood as "forest certification." The latter can be thought of as an outward sanctioning of forest management practices under a recognized set of rules. The Forest Stewardship Council, the Sustainable Forestry Initiative, and American Tree Farm System are prominent examples of this. Here, certification refers to a process by which individual producers can have the carbon implications of their production system estimated, reported, and transmitted to an end-use facility through a chain of custody. So while they are similar, they should not be thought of as the same thing; compliance with one does not necessarily imply compliance with the other.

An advantage of a self-certification mechanism is that it creates incentives to manage in ways that improve the carbon score of biomass feedstock. Being voluntary, it leaves the decision to certify completely up to the individual producer, who then determines whether the cost (in the form of increased management costs, increased administrative burden, etc.) is outweighed by the benefit (in the form of improved carbon score, greater demand for feedstock, etc.). Those who will realize gains will certify; those who do not will not.

Of course, simply allowing for self-certification does not remove all potential issues or complications. Several in fact remain. A primary one is the connection between individual actions and regional carbon dynamics. For example, how does one account for the effects that a single self-certifying landowner's reduction in output has on local, regional, and global timber markets? And how does the decision of a landowner to self-certify affect the default BAF in a given region? Another area of consideration pertains to the administrative burden expected to accompany such a program. For example, how can the program be designed so as to provide fair and reasonably accurate representations of changes in carbon stock while minimizing compliance costs? This last set of issues is indeed important, but perhaps is largely addressable through policy design. Small landowners could be aggregated into larger portfolios, audits could be combined with traditional forest certification processes, or other efficiencies or economies of scale realized. The issues relating to regional carbon dynamics and the default BAF assigned to an area are potentially thorny, however, and could benefit from additional exploration.

Consideration 1: Indirect effects

A particularly difficult issue to address in the context of individual certification involves indirect effects. Even if a particular management strategy helps to improve the carbon score on an individual's land, those same actions could indirectly lead to carbon losses elsewhere. An oft-cited example is a situation in which harvests are curtailed in one place only to be increased in another in response. Termed *leakage*, the issue is a fundamental consideration in the context of forest carbon offset markets (see, e.g., Murray et al. 2004), and is likewise relevant here.

Apart from simply ignoring the issue, there are essentially two approaches for accounting for the indirect effects of individual landowner certification. The first is to conduct an economic assessment through the use of large-scale economic models, or econometrically, using historical forest composition, production, and market data. Either approach could generate a number that could be used by certified landowners to gauge and adjust for their expected indirect effects. Alternatively, a certifying landowner could be required to show that they maintain some minimum level of output, the theory being that indirect effects will be minimized if changes in production of traditional forest product markets are likewise minimal. Such an approach is similar in many respects to the leakage management provisions outlined in a 2008 draft improved forest management offset protocol recommended to the Regional Greenhouse Gas Initiative (RGGI; Maine Forest Service et al. 2008). One way by which landowners could address leakage provisions under that draft was to verify that post-project harvest approximated the BAU production of the area.

So what would this look like in the case of self-certification efforts? Examples of both economic modeling and output-based approaches are provided to show how they might operate, as applied (Table 1). Certification could simply require that historical production be maintained. Alternatively, it could stipulate that no obligation exists to calculate or adjust for leakage so long as production numbers are maintained, but that more complex modeling would come into play should production numbers decline. The modeling exercise would itself result in some number or conversion factor that could be used to adjust the reported change in biogenic carbon.

Table 1. Hypothetical changes in embodied carbon in forest product output, the related indirect emissions or leakage, and their collective effect on changes in net carbon storage using both an economic modeling approach and output requirement approach to address indirect effects. The variable "*x*" reflects the value of some adjustment factor that accounts for relationship between change in output and indirect shifts in forest carbon elsewhere. "N/A" indicates that a given scenario could be disallowed under that particular approach.

Change in Output	Leakage Outcome: Economic Modeling	Leakage Outcome: Output Requirements
+10	0	0
0	0	0
-10	-10*x*	N/A

The answer generated by the modeling exercise doesn't necessarily have to be 100% correct if default and landowner numbers are updated constantly using observational field data. Assuming that a default BAF is "wall to wall" for a given market and captures all relevant activity, a failure to capture the indirect effects for individual landowners will nonetheless show up in the regional default factor. Over time, it may even be "overcaptured," especially if regional default factors are not adjusted in a positive direction to correspond to negative adjustments by individual landowners. Furthermore, increasingly negative default factors can drive increasing numbers of producers to certify. Once all or nearly all producers are self-certified, indirect effects are less an issue as any change must be reflected on someone's balance sheet. Of course, this again assumes that the region fully contains all relevant market activity. The global nature of timber and (ever increasingly) bioenergy markets warrants careful consideration of such an assumption and how to address it in practice.

Consideration 2: Effect of certification on default factors

As a regional default is based on the carbon dynamics of a multitude of individual landowners operating within its set boundaries, there is a strong relationship between individual landowner actions and that region's default BAF. An individual landowner's decision to self-certify likewise has implications on the default BAF. If self-certified lands are not excluded from the data on which the regional default is calculated, changes in management may be captured in the default number over time. If self-certified lands are exempt from the data on which the regional default is calculated, then the default must be recalculated to reflect the fact that these lands are no longer contributing to the regional score. The working assumption here is that self-certification removes an individual's lands from consideration when calculating a regional default. Otherwise, the entire region would benefit from the individual landowner's improved carbon score, increasing the risk of free ridership and diluting the incentive for individuals to improve management in the first place.

The question then becomes, how best to "true up" the default factor based on the certification decisions of individual landowners? Much as with the timing considerations above under the first tier, reopening the default factor too often can lead to unnecessary uncertainty among biomass users, while reopening too infrequently risks use of an out-of-date figure. There are essentially two options for addressing this issue. Option one is to allow for certification only at designated points in time. This is similar in concept to the discrete signup periods under the Biomass Crop Assistance Program (BCAP) or general signups under the Conservation Reserve Program (CRP). The idea is that there are set windows for signing up and termed commitments for those who self-certify. Windows could be coordinated with default factor estimation processes, so that factors could be calculated knowing who is self-certified and who is not.

Option two is to allow for continuous certification and adjust the default factor in real time. Adjustments could be made to the default factor using the carbon stock or percent change associated with a producer's holdings. If one is using a look-back approach, making use of historical data to project expected near-term changes in forest carbon stock on certified lands, then the recorded levels of production and standing carbon stock on the certified land can be used to adjust the default going forward. If one is using a modeled approach, then one can subtract the projected levels of production and carbon storage and apply that to the calculated default, in this case moving forward.

It is nonetheless worthwhile exploring the effect individual self-certification can have on a region's BAF. Turning to the example above in which three existing facilities hypothetically begin using biomass in sequence, we can observe the effect that simply separating accounts can have on default factors. Using the approach outlined in the September 2011 framework, let's specifically examine the change in a BAF calculated with a reference-level baseline. To calculate the BAF for the procurement area likely sourced by the three hypothetical facilities (including the certifying landowner), the procurement area (minus the certifying landowner), and the certifying landowner only, we must first estimate carbon change at each level. This is shown in Figure 10 below. Note the minimal (almost imperceptible) difference between the procurement area and the procurement area minus the individual landowner.

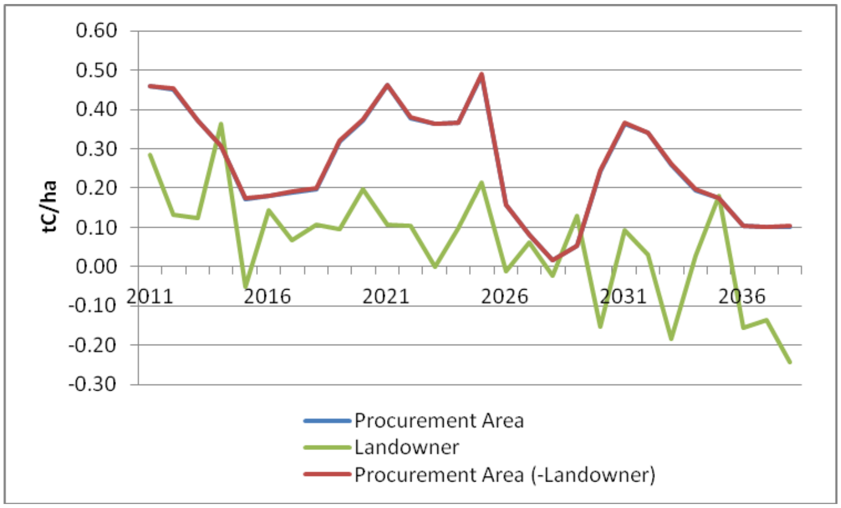

Figure 10. Change in forest carbon stock (tC/ha) in the baseline scenario for a hypothetical individual landowner and for a FIA survey-unit-sized facility biomass procurement area. Areas are the same as those defined in Galik and Abt (2012b). Source: Unpublished analysis using data derived from Galik and Abt (2012b).

From here, we calculate the BAF for each level using the average change in carbon in the first five years of the scenario and an estimate of demand based on the total facility demand for the procurement area and the observed biomass harvest at the landowner level.[9] This yields a value of 0.636 for the procurement area, a value of 0.875 for the landowner, and a value of 0.617 for the procurement area minus the landowner. In this particular example, a self-certifying landowner making no changes in management would actually see a substantial increase in BAF (0.636 to 0.875), so there would be no benefit in doing so. Note also that the regional factor drops only slightly. This is because the certifying landowner comprises only 0.7% of the total forest land in the procurement area.

Regardless of how a BAF is calculated, it makes sense that a certifying landowner would either possess a much more favorable BAF to begin with or would make management changes so as to achieve a better value once certifying. If no changes in production are expected under the former situation, then we would expect a similar result as the above example, but in reverse: a large relative benefit for the certifying landowner and a small loss for the default. Of course, the relative size of both the region and certifying landowners will strongly influence how this relationship plays out. A large landowner holding a substantial portion of the forest carbon stock in a particular area could single-handedly drive the default factor up or down depending on their actions. In a situation where the certifying landowner changes production upon certifying, the change in default factors will depend on the regional spillover effects and how the factor is calculated. For example, if a certifying landowner increases production by such an extent as to depress the prevailing price for biomass in the region, regional forest carbon storage could actually fall over time in response (see, e.g., Abt et al. 2012, for an example). A default factor accounting for this loss in carbon would become less favorable as the market responds to the actions of the now-certified landowner.

Conclusions and Recommendations

Plainly put, biogenic accounting is hard. It is complicated and fraught with scientific, economic, and political challenges. The examples and considerations reviewed above show that implementation decisions have potentially significant implications on the ground, and that decisions to pursue one approach over another should be done openly, transparently, and with thought to the ultimate objectives

[9] "Procurement area minus landowner" is calculated as would be expected: total facility demand minus that harvested at the landowner level.

of the program. Furthermore, the multiple linkages across considerations mean that any accounting system should also be viewed holistically. For example, decisions involving timing potentially influence the scale at which the default factor is calculated and the window for landowners to self-certify. Spatial-scale determinations potentially affect the timetable for default factor updates, the outcome of feedstock differentiation determinations, and process for assessing indirect emissions.

The above considerations and examples also seek to show that, while difficult, it is nonetheless possible to design a system that can track changes in carbon, transmit these changes through a supply chain, and create incentives for management improvement over the long run. This is accomplished through the use of a three-tiered framework. The use of a regional default factor sets a low bar for entry, requiring minimal analysis, monitoring, and reporting on the part of feedstock or bioenergy producers. At the same time, establishing factors for all major feedstocks in all major regions of feedstock production can help to minimize unaccounted-for domestic indirect effects (i.e., leakage). Updating the factors over time can likewise capture unexpected changes in land use or management. Meanwhile, the second tier, exemption of targeted feedstocks, can reduce the administrative burden associated with default factor calculation, while potentially addressing the uncertainty attributable to changing factors over time. The third tier, individual producer certification, further addresses uncertainty by allowing feedstock and bioenergy producers to lock in a set BAF. Although this certainty comes at the cost of increased chain of custody, measurement, and reporting requirements, it is a voluntary component of the framework—only those who see the benefit of pursuing it will do so.

So what would a three-tier accounting system look like, as applied, in the case of Southeastern forests? In light of the quantitative examples reviewed above, one could envision use of a modified historical baseline as a starting point to establish regional default factors. The factors could be set at the FIA survey unit level and updated every five years. Feedstock could be differentiated by type and management (e.g., natural vs. planted), harvest residues exempted if standard practice is to otherwise dispose on-site, and certification allowed at set intervals (1–5 years). Indirect emissions could be addressed in the near term by limiting certification to those entities maintaining some measure of historical output, but in time broadened to allow for displaced production so long as the expected impact can be reasonably quantified and otherwise account for. Of course, simply spelling out an approach on paper does not take the place of in-depth, applied case study analysis. My hope is that what is presented here nonetheless adds to the present discussion in a positive and constructive manner.

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