Appendix F: Carbon Assessment Technical Guidance

Existing standards, processes, and programs that apply

The Forest Service and USDA have several relevant programs that can help guide the baseline assessment and some aspects of a strategic carbon management assessment.

- Forest Inventory and Analysis (FIA) provides the core monitoring data and analysis for U.S. forests, and compiles the annual carbon inventory for U.S. forests and wood products (http://www.fia.fs.fed.us/Forest%20Carbon/default.asp)
- The FS Global Change Research Program (FSGCRP) conducts research that is relevant to management of forest carbon, and provides technical support for monitoring, reporting, and analysis methods (http://www.fs.fed.us/research/climate/)
- The National Resources Inventory (NRI) conducts inventories and assessments of non-Federal lands – the methods and data may be relevant to carbon management assessment especially for grasslands (http://www.nrcs.usda.gov/technical/NRI/)
- Carbon tools and accounting rules and guidelines established under previous Congressional and Executive office direction, e.g., the voluntary greenhouse reporting program (http://nrs.fs.fed.us/carbon/tools/)

For some areas of the U.S. there may be state or regional guidelines for monitoring, estimating, and reporting project-level greenhouse gas reductions. These may be relevant if the reporting Unit is involved in existing regional or local management strategies.

The Intergovernmental Panel on Climate Change (IPCC) has established guidance for countries to use in monitoring, estimating, and reporting inventories of greenhouse gases at the country level and for some kinds of activities.

Recommendations in this document are consistent but less detailed than may be contained in the guidelines mentioned above. In developing assessments, reporting entities may need to consult the more detailed guidelines or an expert in their application.

Approaches to baseline assessment

For the baseline assessment, the reporting entity should estimate current (within last 5 years) carbon stocks and recent changes (within last 15 years) in carbon stocks for all lands. It is highly desirable to develop separate estimates for forest and grasslands, and for meaningful subdivisions of these land classes, such as forest type or an equivalent classification for grasslands or other cover types. It is also useful to compile estimates for each of the main ecosystem carbon pools (live biomass, dead wood, litter, and soils), and if timber harvesting takes place, the amount of carbon sequestered in harvested wood products. Finally, it is useful to identify the main causes of changes in carbon stocks, which may include growth, mortality (and mortality agents), timber removals, and grazing.
Estimates for Forests
The different recommended approaches are arranged by tiers following the IPCC approach, with higher tiers providing more accurate estimates but also being more complex and demanding of forest-specific data. Regardless of the tier selected, it is recommended that the calculations use the “stock-change” method to calculate rates of change: estimate carbon stocks at time 1 (past date) and time 2 (current date), and divide the difference by the number of years to estimate average annual change in carbon stocks. If possible, it is desirable to have estimates of carbon stocks for three successive times, to calculate the changes over two time periods for trend analysis. The size of the Unit or area within a Unit may influence the choice of tier or method especially with respect to use of FIA data. Larger Units will typically have more FIA sample plots to use, which will generally reduce uncertainty, unless there has been intensified sampling compared with the standard.

☑ Tier 1 – Use Unit-specific area data and “default” or regional carbon density estimates. Multiply the area of the Unit times the average carbon density (quantity of carbon per Unit area) for the specified vegetation condition. This approach will not provide sufficient accuracy unless the area of appropriate vegetation conditions can be specified, such as age class, time since disturbance, or volume class. Carbon density estimates are available from the suggested references (especially Smith et al., 2006), or there may be local or regional estimates available in the literature. The Carbon On Line Estimator (COLE) may also be used to estimate local/regional carbon density for various user-defined vegetation classes (see carbon tools website for information about COLE and related guides).

☑ Tier 2 – Use forest-specific FIA data from repeated surveys as a basis for estimating carbon stocks for two or more time periods. For most Eastern National Forests, two or more FIA surveys are available, though access to the older data may require consultation with the appropriate FIA Unit. For many Western National Forests, only the most current inventory data may be available, though older inventory data not collected by FIA may be available. In all cases, care must be taken in implementing the tier 2 approach to be sure that methods and data are sufficiently consistent to provide a logical basis for estimating changes. There are several ways to access the FIA data – it is recommended to refer to the “carbon tools” web site for information about COLE and the Carbon Calculation Tool (CCT), which may provide ready access to pre-compiled FIA data that may be used for carbon assessment, though individual National Forests may not be separated in all cases. COLE provides only data for the most recent inventory. CCT can provide trend analysis of carbon stocks, but only at the State level (though ownership class may allow for identification of forest-specific trends). Direct access to FIA data is provided through FIA data retrieval tools such as FIDO and EVALIDATOR, though this approach requires a higher level of familiarity with FIA data collection and analysis methods than either COLE or CCT. In the future, FIA may develop a version of the CCT that is specific to National Forests, which could greatly simplify the data retrieval and analysis process for carbon assessment.

☑ Tier 3 – Use an existing vegetation monitoring/analysis system specific to the forest, or establish a new one. Some forests may have their own land monitoring systems or be collaborating with other organizations to estimate carbon stocks and changes in carbon stocks. There are many different approaches to use, involving unique combinations of remote sensing, modeling, and inventory data.
It is important to keep in mind that the standards and definitions used with this approach should be consistent with FIA and other standards referenced here, and that guidelines for using models should be followed (see reference by Prisley et al.).

**Hybrid approaches** – combinations of approaches described in the different tiers may be the most efficient and provide reasonable estimates. For example, the reporting entity may use FIA data following the tier 2 approach for the current inventory, and use a simple model of carbon density change as described under tier 1.

**Harvested wood products**
Estimates of changes in carbon stored in harvested wood products should be included in the inventory if there is a significant amount of timber harvest from the reporting entity. Estimates of carbon remaining sequestered from harvested wood products in use and landfills over time are contained in Smith et al. (2006) although there are currently no direct spreadsheet or other tools to make calculations. Tables from Smith et al. have been used to make local estimates of carbon stored in HWP (Healey et al. 2009).

A simpler but less accurate approach is to consult estimates of annual changes in harvested wood products at a larger analysis scale such as a state (see USDA 2008) and scale down to the smaller area of interest for reporting purposes.

**Estimates for Grasslands**
Compared with information about forests, there is little information available about carbon stocks on Federal grasslands, though this may be important in some regions. Methods of evaluating carbon stocks are different between forests and non-forest lands. Non-forest lands are uniquely challenging as much of the sequestered carbon in these systems is found below ground. Methods currently used for estimating carbon stocks on non-forest lands include ecosystem simulation models (e.g. Century and derivatives and Biome-BGC, Hibbard et al. 2003), remote sensing (ground-based, Reeves 2009; airborne, and satellite, Hunt et al. 2004), flux towers (Svejcar et al. 2008) and chamber measurements (Jawson et al. 2005) or combinations of these techniques. Generally speaking, all these techniques will be limited by a lack of supporting field data on critical facets of shrub-and grasslands such as species composition and stand structure on federal lands. Since the process of estimating carbon stocks on non-forest lands under federal jurisdiction has not been undertaken, appropriate data collection on non-forest lands must be considered. Units are encouraged to consult regional climate change coordinators and science partners for guidance on how to address Grassland carbon estimates.

**Approaches to strategic carbon management analysis**

**Overview of approaches**
The objectives of the strategic carbon management assessment are to identify activities that may be undertaken to reduce emissions or increase sequestration, to quantify the expected emissions reductions, to prioritize future actions, and to analyze how carbon benefits might interact with other goods and services produced by the Unit. A good strategic carbon management assessment will also put management in the context of other factors that can affect carbon storage, such as disturbances by pests or fire, changes in vegetation composition, or changes in climate.
The strategic assessment should logically follow the baseline carbon assessment, from which a historical baseline can be derived. If models are available and robust enough to produce credible projections of future carbon stocks (taking factors such as climate change into account), then a future (or dynamic) baseline may be established. As a general principle, the analysis should compare each proposed management strategy (or a scenario of actions) with the baseline management scenario to estimate “additionality,” which is the additional carbon reduction expected from implementing a given strategy.

The strategic carbon management assessment should start with a common accounting framework for the carbon storage and emission types that will be considered by the assessment. But which elements of the framework are estimated and the estimation methods used will depend in part on local circumstances.

The accounting framework should include all categories of carbon sinks or emissions that could change as a result of the treatments being evaluated. Life cycle analysis methods help determine the categories for a common accounting framework (see below). Evaluation would determine which categories may have a change that is significant enough to make estimates. The estimation methods used would consider whether there is an existing mitigation analysis and/or climate change action plan that includes the reporting entity, what models or analysis techniques have been developed for the area or region, and what are the skills and time availability of the analysts. Models are often involved in strategic analysis – appropriate use of models should take account of the guidelines provided in Prisley and Mortimer (2004).

The Forest Vegetation Simulator (FVS) is often used in strategic analysis of vegetation management. FVS includes a carbon calculator embedded in the fire and fuels extension, which facilitates analysis of the impacts of alternative stand management practices on forest and harvested wood product carbon stocks. Stand-level projections need to be scaled up to the whole forest area to support the strategic assessment of carbon management. There are many other models available for projecting growth and yield of vegetation, some of which may include carbon variables such as biomass. Such models are not reviewed here, though they may be entirely appropriate to use for individual Units depending on local circumstances.

**Life cycle analysis**

If harvested wood products are an important activity on the forest, or there is interest in evaluating additional use of harvested wood products (e.g. for biofuel), it is recommended to use a life cycle analysis approach. Comparing the carbon consequences (impact) of changing from baseline management to alternate management is termed a “consequential” life cycle assessment (Brander et al. 2008). If wood harvest changes from the baseline to alternate management cases, carbon storage emissions could be altered over time and should be considered (and possibly estimated) (Perez-Garcia et al. 2005; Sathre and O’Connor 2008). These could potentially include changes not only in carbon storage in wood products or fossil energy emissions, but market induced changes – e.g. changes in emissions to make steel and concrete if wood replaces them or differences in land use change if higher revenue for wood/biomass keeps more land in forests.
Life cycle analysis has been used to specifically evaluate increasing wood use for energy and past studies indicate that carbon offset benefits vary over time and by wood source (among other factors) (Marland and Schlamadinger 1997, Marland et al. 1997, Zanchi et al. 2010). Life cycle analysis provides the most complete accounting of the effects of management alternatives, but can be complex to implement and may be more suitable on a larger scale than the Unit level. In the future, life-cycle analysis tools will become more available to facilitate widespread use of this approach.

**Greenhouse gas management activities**

Strategic management options for reducing greenhouse gases fall into several general categories, which should be considered for including in the management assessment.

- **Changes in land management** -- Land management has long-term effects on carbon stocks and therefore may be modified to reduce emissions or increase storage in forest ecosystems and harvested wood products. Forests recover in a predictable pattern after management or natural disturbance that varies with site, forest type, and other factors. Alteration in management that changes harvest of wood for products has a significant effect on the overall C balance of a forest. Long-lived wood products produce the most positive C balance (compared to short-lived products) and, in addition to storing carbon, they have the potential to offset emissions from fossil fuel to the degree that they substitute for steel and concrete that emits more GHGs in manufacturing and transport. Managing at the landscape scale facilitates application of appropriate treatments to diverse individual stand conditions.

- **Afforestation (and other land use changes)** – Some areas of the U.S. have significant non-forest land that could be afforested or agricultural lands that could be converted to forests or perennial grasslands. Areas of marginal grassland that could be converted to forest, areas needing restoration, and old agricultural fields that could be converted to forest or grassland may be available on specific Units. Afforestation and conversion from agricultural lands to perennial grassland usually results in significant increases in carbon stock in biomass, and occasionally may increase soil carbon.

- **Avoiding loss of forest land** -- Forest loss causes significant loss of carbon stocks, so reducing the rate of forest loss would avoid emissions of stored carbon. This option is often associated with private land, but there may be some opportunities to reduce conversion on National Forests that occurs from various activities.

- **Bioenergy** -- Biomass in the forest or grassland or at a facility could be used for energy, and some carbon credit gained from substitution for fossil fuel. The amount of carbon “offset” depends on many factors such as sources and energy needed for transportation. The actual amount of biomass that is available for fuel is likely less than the total inventory of biomass available because of other owner objectives or the economics of transporting and converting the biomass to fuel.

**Uncertainty analysis**

It is recommended that both the assessment of carbon stocks and the carbon management analysis include some quantitative assessment of the uncertainty, and a discussion of the main causes of uncertainty. Estimates must be sufficiently accurate to assess differences among management actions with some confidence. Additional guidance will be provided on how to conduct uncertainty analysis and what standards may be useful.
References


http://www.usda.gov/oce/climate_change/gg_inventory.htm

http://www.epa.gov/climatechange/emissions/usinventoryreport.html