THE HEINZ CENTER

Meeting Summary
Workshop on Carbon Storage Reporting
February 28, 2006
Washington, DC

On February 28th, 2006, the Heinz Center convened a Carbon Storage workshop to inform the development of a new core national indicator for the *State of the Nation's Ecosystems* project. Eight participants were present, and the meeting was chaired by Tony Janetos, Vice President of the Heinz Center (see full roster at end).

The workshop agenda focused on three major topics: identifying priority carbon pools that should be highlighted in the report[1], defining appropriate reporting strategies, and evaluating potential data sources. A key theme that emerged from group discussions included the need to design in sensitivity to major changes in carbon stocks, especially in carbon-dense subsystems and lands converting to new cover types or climate/disturbance patterns. The importance of accurately portraying heterogeneity within ecosystems was also emphasized.

Priority Carbon Stocks

This discussion focused on identifying carbon stocks that, now or in the future, account for the majority of net carbon loss or accumulation in U.S. ecosystems. While it is difficult to predict with accuracy how major carbon stocks will change over time, the group identified the major factors that should be considered in designing an indicator that is sensitive to important shifts in carbon storage.

Carbon in Different Ecosystem Types

Participants emphasized that, in seeking to understand large-scale carbon patterns, it is important to recognize that different ecosystems and subsystems have very different carbon storage characteristics. Within a given ecosystem type, some carbon storage characteristics are generally shared. For example, forests, unlike grasslands, commonly have a lot of aboveground carbon. However, there is also considerable heterogeneity in carbon levels *within* ecosystem types. For example, soil carbon in farmlands will vary dramatically based on climate, native soil type and management activities. Total carbon levels attributed to ecosystem types are directly related to:

Ecosystem extent. As the land *area* within a given ecosystem type changes due to land conversion, the total quantity of carbon attributed to that ecosystem type should change accordingly. It was noted that while total area undergoing land use conversion may be relatively small, the carbon effects could potentially be large.

- Land conversion to new cover types can result from forest regrowth or removal, wetland and riparian loss or restoration, clearing new agricultural lands, urbanization, or system-altering disturbance.

[1] Note that the indicator is not intended to provide a full carbon budget, but rather to address the question of whether U.S. ecosystems are net sources or sinks for atmospheric carbon.

- Development of new residential and commercial structures and communities is occurring rapidly, however the implications for carbon levels are not well-documented.

Carbon intensity. As the amount of carbon storage *per unit area* changes, total ecosystem carbon will also change. Carbon intensity is closely tied to several site properties:

- Biological community structure and total productivity strongly influence the amount of atmospheric carbon stored.
- Moisture and temperature conditions are important controls for rates of plant growth, biotic activity and decomposition.
- Management activities such as cultivation, grazing, harvest and mining influence carbon levels both directly (e.g., removal of organic material) and indirectly (disturbance-enhanced decomposition).
- Relative distribution of carbon across different pools (e.g., soil, litter, plants) affects the potential for carbon loss or gain (i.e., aboveground pools are generally more dynamic).
- Disturbances such as fire, invasive species, and erosion and deposition can produce short- or long-term changes in carbon on affected sites[2].
- Soil properties such as depth and texture also strongly influence carbon intensity, but are relatively permanent characteristics (with exceptions where disturbance alters soil depth).

Participants emphasized the importance of distinguishing between changes in carbon stocks due to altered carbon intensity from those that occur due to changes in ecosystem extent.[3]

<u>Disturbance: Meta-Equilibrium or Trend?</u>

Participants discussed the need to distinguish large-scale net change in carbon stocks from dynamic carbon processes in meta-equilibrium. An example of meta-equilibrium would be a regime of seasonal wildfires that produce consistent carbon levels across relevant geographic and time scales. Large-scale net change could result from shifts in management (e.g., fire suppression) or climate (e.g., drying conditions) that interrupt a preexisting meta-equilibrium. Wildfires, erosion, invasive species, climate shift, woody encroachment, harvest, change in land management, land use conversions, fragmentation, and mining waste disposal were all cited as examples of potentially system-altering disturbances.[4]

<u>Carbon Pools</u>

The group discussed the dramatic variation in the size and type of carbon pools (e.g., soils, litter, plants) across ecosystem types. For example, aboveground biomass in forests is a very large pool relative to counterparts in grasslands or croplands. There are, however, a number of reasons to report on a consistent suite of carbon pools across ecosystem types. First, it is of ecological interest to show the large range in carbon distributions across ecosystem types. Second, different carbon pools have different residence times so the relative proportion of carbon across pools can inform about the potential for change. Third, the potential for rapid change or vulnerability to

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[2] It was noted that disturbances generally produce rapid change in carbon levels, while recovery from disturbance produces slow carbon accretion.

[3] Suggestions for addressing this issue included reporting change in carbon per unit area, providing a carbon abundance map and linking to existing ecosystem extent indicators.

[4] A number of existing indicators in the *State of the Nation's Ecosystems* provide information on disturbance patterns, such as fire frequency, forest disturbance and soil erosion.

system-altering disturbance is different for above and belowground carbon pools. For example, total soil carbon levels commonly change very slowly, while aboveground biomass can increase or decrease relatively rapidly.[5] Conversely, carbon in peatland soils was highlighted as a pool that is particularly vulnerable to rapid change and to loss of organic material to substantial depths.

Reporting strategies

This discussion focused on approaches to aggregating carbon data that will highlight major trends. The new Carbon Storage indicator should prioritize reporting on carbon stocks that are experiencing net change over time, however large stocks that are in relative equilibrium should not be expressly excluded. There was broad agreement that double-counting is an issue that requires attention, but that omitting or obscuring important carbon stocks would be a greater problem. Individuals also recommended looking for convergence with existing carbon reporting programs.

<u>Ecosystem Types</u>

Definition. A central theme in the discussion of reporting strategies was the need to define ecosystem types in such a way that important patterns of change in carbon stocks are not obscured within large, aggregated reporting units (e.g., major ecosystem types, national averages). Several individuals suggested that carbon-dense and climate-sensitive ecosystems (e.g., wetlands, peatlands, boreal forests, riparian areas) merit distinct reporting (i.e., not subsumed into a larger ecosystem type) because they have high potential for accumulating or releasing large quantities of carbon.

Extent. Participants expressed concern about under- and over-counting of carbon stocks due to inaccuracy in tracking changes in *areal extent* of ecosystems. Ideally, land conversions are well-documented and result in carbon being reported within a new ecosystem category. However, participants cautioned that this is not always the case and therefore relying solely on carbon reporting by ecosystem type could result in misrepresentation. It was noted that guidelines for the U.S. Greenhouse Gas Inventory are changing so that the entire land base must be accounted for.

<u>Regions</u>

Climate regimes. Of equal concern to participants was appropriate aggregation in any regional representation of carbon stocks. Participants pointed out that, because carbon levels are highly sensitive to climate, carbon stocks should be represented within units that correspond to different climate regimes. In general, the group supported reporting on carbon stocks in 6-7 major geographic regions[6] – with Alaska shown as a separate region – to capture large-scale climate variability, highlight regional data gaps, and maximize policy-relevance (e.g., regional carbon sequestration planning).

Disaggregated extent reporting. Staff explained that there is a current effort to revise reporting on ecosystem extent that will maintain data in as disaggregated a form as possible. This strategy may also be appropriate for carbon reporting, enabling carbon storage data to be 'rolled up'

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[5] Different systems have different 'natural' distributions of above and below ground carbon.

[6] For example, see the regional definitions developed by the Intergovernmental Panel on Climate Change (IPCC).

within any given ecosystem type and presented in a variety of ways (e.g., to report the area of types with increasing or decreasing carbon levels).

Carbon pools.
In general, the group supported reporting on carbon pools (e.g., soils, plants) in the ecosystem-level indicators rather than in the core national indicator[7]. It was suggested that the suite of carbon pools should be consistent across the ecosystem-scale indicators, perhaps by reporting consistently on above and belowground carbon pools. In addition, there was interest in adding a figure for carbon stocks in the farmlands indicator to supplement the figure for organic matter levels to provide a more consistent presentation across the ecosystem chapters. The group articulated challenges in defining a common soil depth for reporting across ecosystems.

The group discussed whether carbon stored in wood products (e.g., wood in furniture, structures, paper) should be included in the report. There was general support for this, especially if it aligns with the overall purpose of the indicator. Further consideration is needed as to whether wood products should be incorporated within the forest[8] or urban/suburban ecosystem types.

Sensitivity to trends.
Scale. For all indicators, the group recommended identifying geographic and time scales (e.g., 5-year increments) that are sensitive to major changes in carbon stocks, but do not imply trends where there are natural oscillations or large-scale equilibrium. Additional issues raised include presenting information on past, current and future patterns and capturing information about duration within land use types. Individuals advocated for presenting historic trends that show the effects of long-term land use on carbon levels in forests, agricultural lands, wetlands, and other systems.

Total stocks vs. net change. Discussion about how to parameterize carbon levels focused on the relative merits of total carbon vs. net change in carbon. Several individuals advocated for reporting on net change in carbon stocks as a more meaningful and policy-relevant measure[9]. Others pointed out that reporting on total carbon stocks may be equally valuable, especially for aboveground pools which are more subject to rapid change. It was noted that there may be some carbon pools for which total measurement is not feasible in the near term. For example, total soil carbon is highly spatially heterogeneous due to variation in soil depth and carbon composition and residence time. In addition, measurement of total soil carbon is constrained by serious technical limitations. Total aboveground carbon stocks are more easily measured, although residence time of aboveground material is also highly variable. For some pools, it may be appropriate to focus measurements on the component of the pool where change in carbon is anticipated.

[7] The group agreed that presenting carbon pools for major regions without separating out by ecosystem would *not* provide useful information.
[8] It was suggested that wood products can make the difference between concluding that a forested system is a net source or sink.
[9] Reporting on net change in carbon will require defining the time frame for calculating net change.

Data sources

The objective for this discussion was to understand existing and future carbon monitoring programs and the suitability of the associated datasets for inclusion in the 2007 report. Based on this discussion, there are two datasets under consideration for partially populating this indicator.

Individuals commented that there has not been substantial improvement in data availability since publication of the 2002 report. While there was discussion of carbon stocks associated with erosion and deposition of organic matter, there was general agreement that it will be several years before research, data-gathering and modeling in this area will be mature enough to produce robust data. Participants also raised the issue of providing estimates of uncertainty that are associated with datasets used to populate indicators.

<u>Organic Carbon in Agricultural Soils</u>

Stephen Ogle described the work of his group at the Natural Resources Ecology Laboratory at Colorado State University to produce estimates of soil organic carbon (SOC) in agricultural soils (these estimates are reported in the U.S. Greenhouse Gas Inventory). For ~90% of U.S. agricultural lands, the process-based Century model is used to integrate spatially-explicit soil characteristics (e.g., bulk density, texture), activity data (tillage practices, fertilizer and manure additions), and precipitation and temperature information to quantify carbon accumulation and loss. For roughly 10% of U.S. agricultural lands (e.g., used for rice production, perennial crops), the Century model has not been fully tested and the Tier 2 IPCC[10] method is used to estimate SOC. Data from 50 long-term, controlled experiments are used to evaluate these composite, model-based results. A pilot program is planned with the USDA Natural Resources Inventory to conduct a limited number of field measurements for model validation.[11]

Dr. Ogle explained that their SOC estimates do not represent a measurement-based inventory, however he emphasized that the uncertainty analysis for their soil carbon estimates is rigorous and reflects that their model is robust. While it is possible to estimate total carbon stocks in the top 20 cm of soil using their method, there is less uncertainty associated with estimates of *change* in carbon given that input variables emphasize activity and weather data.

<u>Forest Carbon</u>

Linda Heath described the work of the USFS Forest Inventory and Analysis (FIA) program that produces field-based, inventory data for a number of forest carbon pools. These data contribute to the U.S. Greenhouse Gas Inventory as well as a number of other reporting venues. The FIA program is a state-based monitoring program with a national protocol that shifted to an annualized design in the 1990s. Over time, the number of forest types surveyed and the temporal resolution of measurements have improved, and efforts have been made to harmonize data across the full time series.

Measured carbon pools include live and dead trees, understory, down woody debris, litter, and belowground plant material. In addition, data for carbon in mineral forest soils are gathered in

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[10] Intergovernmental Panel on Climate Change. For details on methods of analysis, see http://yosemite.epa.gov/oar/globalwarming.nsf/UniqueKeyLookup/RAMR6MBLP7/$File/06LULUCF.pdf .

[11] Dr. Ogle indicated that national-scale soil carbon data produced through a field sampling program would not be available for ten years or more even if funding were allocated to such an endeavor.

most of the state inventory programs, however there is not yet national coverage; it is not clear how well spatial variability will be represented since one sample will be gathered for every 19,000 hectares. Dr. Heath noted that there are discrepancies in areal extent information and inconsistencies in the definitions of land use and biomass equations that are used. In addition, individual sampling points represent different acreages. Uncertainty associated with carbon data is estimated by randomly generating simulation data using a Monte Carlo analysis.

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