CRITERION 5—

Chapter 10. Soil Carbon

Charles H. Perry and

Michael C. Amacher

Why Is Soil Carbon Important?

The sequestration of carbon by forest and agricultural soils has the potential to significantly reduce greenhouse gas concentrations (Pacala and Socolow 2004). Many countries are implementing field inventories of soil carbon, often combined with data from other sources, to estimate soil carbon sequestration rates and amounts (Kurz and Apps 2003; McKenzie and others 2000; Scott and others 2002). Models are currently used to predict the contribution of soil carbon to the total forest carbon sequestration in the United States (Heath and others 2002, Smith and Heath 2002). Current estimates suggest that > 50 percent of the total stored forest carbon is held in the soil with an additional fraction in the forest floor (Birdsey and Heath 1997, Heath and Birdsey 1997, Smith and others 2004). Our relatively new effort to inventory soil carbon should enrich these efforts to model soil carbon and document forest sequestration of atmospheric carbon dioxide.

The soil quality indicator was initially developed in part to assess the contribution of forest soils to the global carbon cycle, and the data can be used to construct soil carbon budgets. Once this information is linked to Forest Inventory and Analysis (FIA) phase 2 data, whole-forest carbon budgets can be constructed from the forest inventory.

Soil carbon is also important because it is the principal element of soil organic matter, and organic matter is a key component of soils. Stevenson (1986) outlines several different roles and functions of soil organic matter. It increases water holding capacity and aeration and improves soil permeability. It provides nutrients to plants and energy to microbes and other soil fauna. It contributes significantly to ECEC (see chapter 9). It can also detoxify soil pollutants by binding metals and organic compounds. Its influence on soil properties and processes is so large that without it, soils would largely be incapable of sustaining microbial populations and plant communities.

Methods

Soil samples are collected for analysis as part of the FIA soil quality indicator inventory. Between 2001 and 2003, samples were collected in most of the continental United States (see chapter 9, fig. 9.1). The sample size will increase as work in these States is completed and additional States are inventoried. The changing sample size and refinement of the database management and estimation algorithms together suggest that the results presented here should be considered preliminary.

Soil carbon content (in percent) is measured in three sampling units: (1) the forest floor, (2) 0 to 10 cm depth, and (3) 10 to 20 cm depth. Three forest floor samples and one mineral soil sample are usually collected on each plot; the forest floor samples were averaged at the plot level. The mass of the forest floor samples, the known sampling area, and the sample carbon content are used to calculate carbon on a mass per unit area basis in megagrams per hectare (Mg/ha). For the mineral soil, soil carbon content is combined with measured bulk density and corrected for the coarse fragment content to calculate soil carbon in Mg/ha. Additional details on field measurements, laboratory processing, and estimation procedures are available[1] (O'Neill and others 2005).

Spatially explicit, comma-delimited files were exported from the database and imported into ArcMap (Harlow and others 2004). For mapping purposes, soil carbon values were assigned to hexagons developed by the Environmental Monitoring and Assessment Program (EMAP) of the U.S. Environmental Protection Agency (White and others 1992). Approximately 90 percent of the hexagons had only one measurement in them; the remaining 10 percent had two observations, which were averaged. Each hexagon has an area of approximately 648 km^2, and their center points are roughly 27 km apart. Numeric data were imported into R (Venables and others 2005) for statistical analysis and plotting.

[1] The current version of the Forest Inventory and Analysis National Core Field Guide is available online at: http://fia.fs.fed.us/library/field-guides-methods-proc/.

What Do the Data Show?

Forest floor carbon accumulation is a function of annual litterfall minus decomposition. Annual litterfall is remarkably consistent among tree species growing in similar soils and climates (Pritchett and Fisher 1987). While annual litter production is inversely related to latitude, carbon accumulation is generally greater in higher latitudes because of the slower decay rates (Pritchett and Fisher 1987). Most of the carbon is stored in the top 10 cm of soil (table 10.1, fig. 10.1). The bottom mineral soil unit also stores more carbon than the forest floor (table 10.1, fig. 10.1). As a region, the Southeastern United States, with its highly weathered ultisols, has some of the lowest soil carbon values; the Interior West also has little soil carbon (fig. 10.2). Total soil carbon content is generally highest in the Northern United States where decay rates are very low (fig. 10.2).

Table 10.1—Representative carbon values for different soil layers (2001–03)

Descriptive statistics	Forest floor	0 – 10 cm	10 – 20 cm	All layers
	- - - - - - carbon content (Mg/ha) - - - - - -			
Minimum	0.01	1.37	0.14	5.03
25th percentile	2.87	16.54	7.85	32.40
Median	5.23	23.38	12.78	44.52
Mean	7.11	27.41	17.02	51.55
75th percentile	9.39	33.58	20.25	62.37
Maximum	56.84	302.32	217.58	444.26

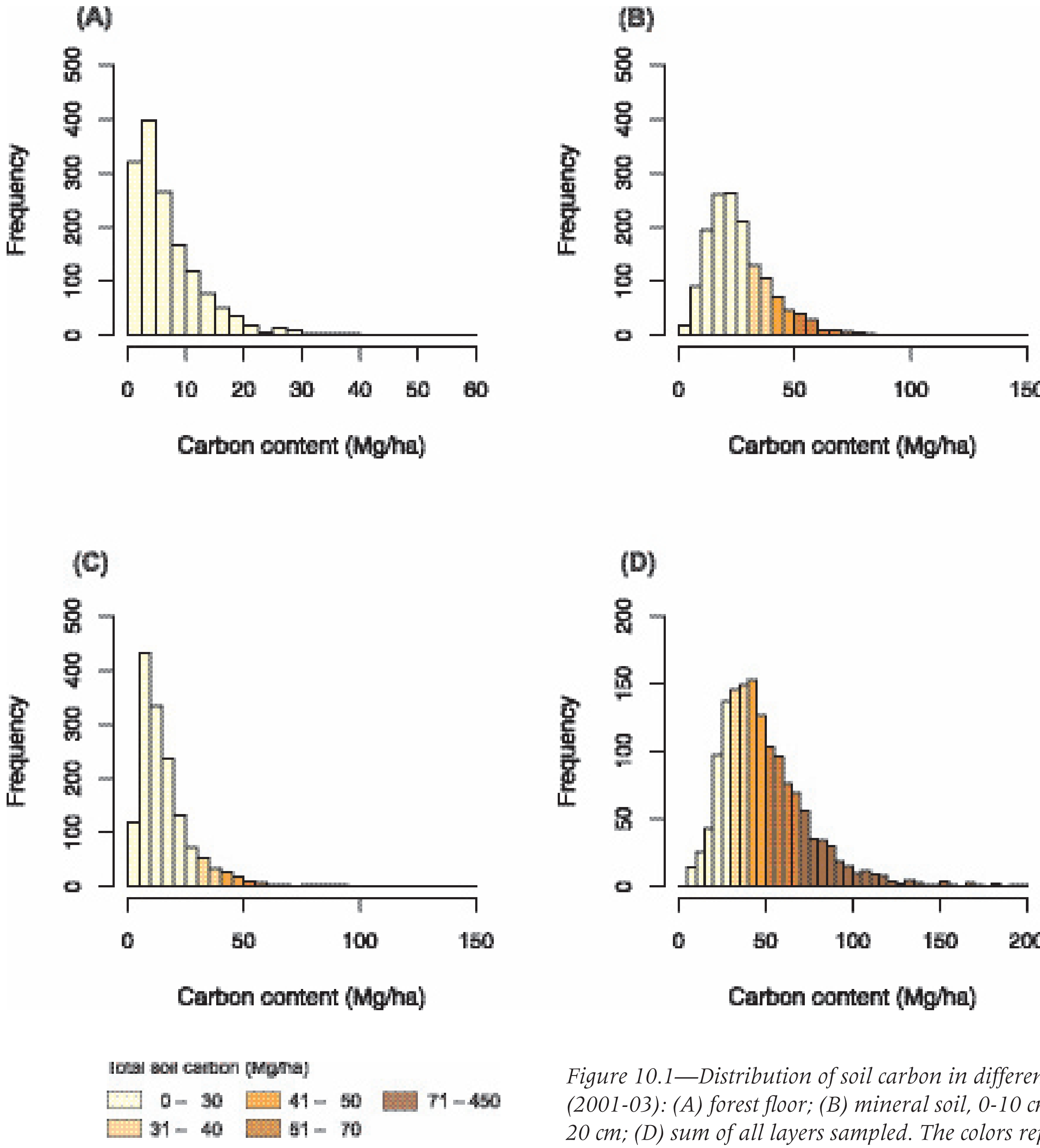

Figure 10.1—Distribution of soil carbon in different sampling units (2001-03): (A) forest floor; (B) mineral soil, 0-10 cm; (C) mineral soil, 10-20 cm; (D) sum of all layers sampled. The colors represent the same soil carbon levels they represent in figure 10.2. (Data source: U.S. Department of Agriculture Forest Service, Forest Inventory and Analysis program.)

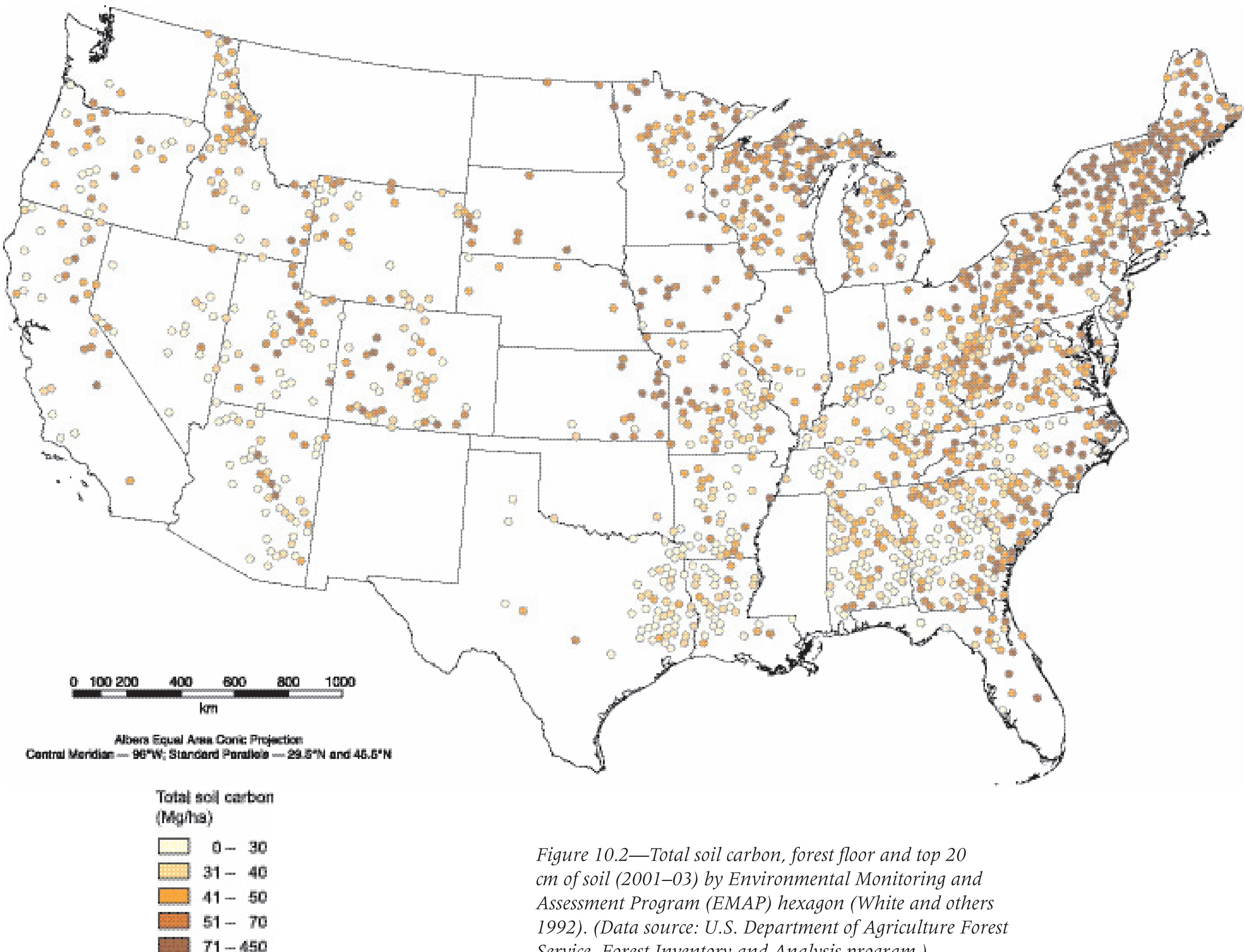

Figure 10.2—Total soil carbon, forest floor and top 20 cm of soil (2001–03) by Environmental Monitoring and Assessment Program (EMAP) hexagon (White and others 1992). (Data source: U.S. Department of Agriculture Forest Service, Forest Inventory and Analysis program.)

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