

Harnessing Farms and Forests in the Low-Carbon Economy: How to Create, Measure, and Verify Greenhouse Gas Offsets. Z. Willey and B. Chameides, eds. 2007. Duke University Press, Durham, NC. 229 pp. \$60 paperback.

doi:10.1017/S1466046608080162

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This guide provides a vital reference for estimating changes in greenhouse gas (GHG) and carbon (C) offsets associated with land use change. The authors have done a wonderful job of compiling information on basic measurements of C [and carbon dioxide (CO₂)] equivalents in forested and farmland ecosystems. This manual should hold an absolutely essential place on the bookshelf of anyone serious about considering, measuring, or purchasing GHG offsets.

The guide provides the foundational steps necessary to document changes in C, methane (CH₄), and nitrous oxide (N₂O) fluxes and to express them in CO₂ equivalents. The graphics, tables, graphs, and appendices related to the direct measurement of C in forested ecosystems are particularly well conceived. The appendices, especially, give more detailed “how-to” methods for estimating changes in CO₂ equivalents. Methods associated with measuring above-ground forest C are particularly thorough. The manual also includes sections on measuring C in soils, estimating CH₄ emissions, and estimating both CH₄ and N₂O emissions from soil.

The manual focuses mainly on C, and it is unusual to address C balance changes associated with management of both farms and forests in a single volume. While some C storage changes may occur when farmers adopt no-till practices, the associated changes in C storage are inherently limited. Farms, ultimately, just don’t accumulate as much biomass C over time as forests do. This makes farms and forests fundamentally different in terms of C balance. By taking a GHG offsets perspective, however, landowners can dramatically improve over current practices. The authors clearly acknowledge that adoption of C conservative approaches in forests and farms is at some level more of a society-wide sustainability issue than an issue of GHG offsets.

A particular strength of this volume is the discussion of the economics of GHG offsets and the quantitative approaches

to calculating additionality in offsets (i.e., how much an offset actually changes emission of CO₂ equivalents relative to the status quo). In fact, the authors highlight a major problem with GHG offsets approaches. Because GHG offsets are nearly always calculated relative to “neighbors,” the GHG offset potential of any single forest or farm are necessarily reduced as a region lowers greenhouse gas emissions from forests and farms. Additionally, increasing offsets in one location is of little help if it increases “leakage” by increasing emissions elsewhere. For example, the preservation of old growth forests in the Northwest US in the 1990s did little to increase C storage, because reduced timber harvesting in the US resulted in higher harvests elsewhere in the world (i.e., demand did not change much). The authors do, however, give a detailed description of the approaches and verification steps necessary for any single landowner to incorporate leakage and additionality in calculations of GHG offsets.

A weakness and strength of any manual such as this relates to the inherent problems of error estimation in GHG flux. Current estimates of C flux are not at all precise for most forests or farms. When estimates are extrapolated, determining error can be extremely difficult. For example, when sampling a local area, one can calculate a mean value for C flux and an estimate of certainty around that mean. When values are extrapolated beyond the bounds of an original study, it is much more difficult to have any estimate of precision or error. While politically, and socially, society may be turning a corner in thinking about CO₂ and other GHGs, we are far behind in precise empirical estimates of GHG flux in most ecosystems. The authors suggest a first step in a project may be to go to the published literature and select estimates from areas that are similar to an area of interest. This could lead to gross inaccuracies, however. For example, C uptake in forests or farms can change with nutrients, genetics, biodiversity, soils, temperature, precipitation, and numerous other factors. For most ecosystems, a nuanced understanding of how to detect precise changes in C is still a major frontier in ecological research. This is especially true for belowground C, which receives very little coverage in this book.

The strength of this book is that it transfers information about how to develop site-specific estimates of above-ground C flux (and GHG flux) to a broader population. Thus, while it may be precarious to simply estimate GHG flux from published values, the authors devote multiple chapters—and appendices—to developing site-specific estimates. This is an exciting contribution.

Overall, this is an important, well-conceived, and well-written manual. It provides the opportunity to adopt re-

sponsible measurements and modifications of GHG flux. Now let's get out there and do it!