Invited Feature

Changing Metabolism of Terrestrial Ecosystems under Global Change[1]

An unprecedented research effort has taken place over the last decade to acquire the fundamental knowledge to understand and predict the effects of global change on the terrestrial biosphere. Although many uncertainties still remain, this research, along with ongoing efforts, has improved our understanding of the functioning of terrestrial ecosystems and how they are likely to change as global environmental change proceeds.

As this research effort has matured it has necessarily become an integrative science in order to deal effectively with the multiple drivers of global change, which include changes in climate, atmospheric composition, and land use. When dealing with single drivers of global change (e.g., effects of elevated CO_2), research has emphasized whole ecosystem responses by integrating ecosystem physiology, structure, and community dynamics in ways that were unknown or just beginning a decade ago. Finally, terrestrial ecology has become more relevant in global analyses as we learn more about terrestrial feedbacks to the functioning of the atmosphere and oceans and, hence, to the global metabolism and associated climate.

The focus on ecosystem-level responses and the study of terrestrial feedbacks to global processes have been central to the activities undertaken over the last nine years by the Global Change and Terrestrial Ecosystems (GCTE), a Core Project of the International Geosphere-Biosphere Program (IGBP). In 1998 GCTE convened the Second Open Science Conference in Barcelona, in partnership with the Land Use/Cover Change (LUCC) project, where the idea of this Invited Feature was first formulated. The purpose of this feature is to highlight some of the most recent developments in our understanding of the effects of global change on ecosystems and the Earth system, and particularly, on relevant components of the contemporary and future carbon cycle. The four papers in this feature were selected either for their integrative approach or for the novel results and methodologies presented. The selection of papers also addresses one of the major challenges scientists face in response to the recent demands of the United Nations Framework Convention on Climate Change (FCCC), through the recently agreed Kyoto Protocol: to measure the magnitude and spatial distribution of the Earth's carbon sources and sinks and their future trajectories.

In this Invited Feature, Prentice et al. present the state-of-the-art of our understanding of the terrestrial carbon cycle with discussions on the recent past carbon fluxes in and out of the terrestrial biosphere, and on the mechanisms that are likely to have an impact on future trajectories. The synthesis is based upon multiple independent measurements with an emphasis on the need for top-down and bottom-up approaches as a critical way to constrain the carbon cycle. Ciais et al. take a closer look at the magnitude of the biospheric carbon sources and sinks over the last decade (1985–1995); in addition, they critically analyze recent developments on the coupling of inverse modeling of atmospheric transport to the long-term distribution and trends of atmospheric (CO_2) measurements. Looking at future concentrations of atmospheric CO_2, Körner summarizes the changes on ecosystem functioning that are likely to occur in a CO_2-richer world, based upon the empirical data available to date; emphasis is placed on processes and mechanisms underlying the various responses.

Future functioning of the terrestrial biosphere involves physiological and biogeochemical changes and, ultimately, changes in ecosystem structure including biome reorganization and spatial shifts. These responses will be affected by a changing environment (e.g., climate) while in turn these changes will affect the environment itself. In the final paper of this feature, Foley

[1] Reprints of this 82-page Invited Feature are available for $12.50 each. Prepayment is required. Order reprints from the Ecological Society of America, Attention: Reprint Department, 1707 H Street, N.W., Suite 400, Washington DC 20006.

et al. describe recent developments in the coupling of Dynamic Global Vegetation Models (DGVMs) to General Circulation Models (GCMs), an approach that is still under development but is likely to become a successful tool to study the two-way interactions of the terrestrial-climate system at the global scale.

The GCTE-LUCC Open Science Conference, where the papers in this Invited Feature were first presented, received the support of many organizations including the Barcelona City Council, European Community Division Generale-XII, U.S. Department of Energy, U.S. National Aeronautics and Space Administration, U.S. Forest Service, Electric Power Research Institute, Generalitat de Catalunya, Institut Cartografic de Catalunya, Centre de Recerca Ecologica i Aplicacions Forestals, the Australian Greenhouse Office, and the Global Change System for Analysis, Research and Training program.

—JOSEP CANADELL
Guest Editor
GCTE, Executive Officer
CSIRO Wildlife and Ecology
—IAN NOBLE
Guest Editor
GCTE, Chair
Australian National University

Key words: biome shifts; carbon cycle; carbon sources and sinks; climate change; elevated CO_2; GCTE; global change; inverse modeling; terrestrial ecosystems.