17 WG2 Summary: Forests and the global carbon cycle: past, present, and future role

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INTRODUCTION

Research efforts over the last decade or so on the interaction of human and natural disturbances on the carbon (C) dynamics of forests have increased our state of understanding about the role of forests in the global C cycle. However, at the same time new areas of uncertainty and new data gaps have emerged. In this chapter, we present areas of improved understanding, identify areas of uncertainty that require further research, identify new data needs, discuss the future role of forests in the global C cycle, and conclude with a discussion on the need for a system for tracking the C flux from changes in the cover, use, and management of forest lands. Material for this overview chapter is based for the most part on the chapters included in this Part of the book.

NEW AREAS OF UNDERSTANDING

State and change in cover, use, and management of forest land

In discussing the role of forests in the global C cycle, it is necessary to distinguish between land cover, land use, and land management. Lack of recognition of the differences in these terms has often led to confusion about the role of forests in the C cycle (Dixon et al. 1994). Land cover (LC) refers to the physical and biological appearance of the land surface (e.g., closed forests, open forests, grasslands, etc.) and change in LC converts land of one type of cover to another regardless of its use. Change in LC can be brought about by human (e.g., clearing of forests for agriculture) and natural disturbances (e.g., wildfires or tropical storms can convert mature forests to non-forests or successional forests). Land use (LU) refers to the purpose for which land is used by humans, e.g., nature preserves, forestry, plantations, agriculture. Change in LU may or may not cause a change in LC (e.g., conversion of logged forests to forest preserves causes little to no change in LC), but a human-induced change in LC is usually associated with a change in LU. Land management (LM), a relatively new term in this field, refers to how a given LU is managed by humans, e.g., selective versus clearcut harvesting, conventional versus whole tree removal, irrigated versus rain-fed agriculture. Each of these terms has different implications for monitoring change in area and impact on C storage and flux.

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The status and rate of change in LC/LU/LM of the world's forests are among the major sources of uncertainty contributing to our inability to balance the terrestrial C budget. Major changes in forest to non-forest and *vice versa* can for the most part be monitored by both low and high resolution remote sensing platforms. However today's sensors, even high resolution ones, cannot always distinguish between cover changes caused by anthropogenic or natural factors. Furthermore, distinctions between changes in LU or LM (e.g., selectively harvested forests to protected forests, closed forests to degraded forests) cannot readily be detected by remote sensing techniques. In these situations, national inventories based on finer resolution data are required.

A more precise identification of the major processes causing change in the status of forest lands has significant implications for choice of appropriate monitoring methodologies. Major processes responsible for change in LC/LU/LM and subsequent changes in C budgets and fluxes have varied over time and by latitudinal region (Table 17.1). In general, changes in LC in the boreal zone have for the most part been and are likely to be in the future of little significance. The exception to this trend is the clearing of forests for activities associated with expansion of urban/industrial and mining/dam construction areas in the FSU (Former Soviet Union) and SCA (Scandinavian countries and European part of Russia's boreal forests). Natural disturbances have been and are projected to be the major causes of change in LC and subsequent C budgets of forests in the boreal zone (Table 17.1; see also Chapters 8, 12, and 14). Remote sensing techniques provide useful information for assessing the C budgets for boreal forests, particularly with respect to the area of forest cover, fire detection, and large insect outbreaks in these relatively remote areas (Cahoon et al. 1994; Kasischke and French 1995; Kasischke et al. 1995; and Chapters 7 and 8). More recently, changes in LU and LM are affecting forest C budgets in this zone. In this situation, national forest inventories coupled with statistical data on harvested forests are the appropriate monitoring methodology.

For temperate forests, changes in LU and LM associated with forest harvesting and changes in LC associated with conversion to and abandonment of agriculture and forestation appear to be the most significant processes affecting C budgets and flux (Table 17.1). In the future, changes in LU and LM are expected to become more important and changes in LC less important. As the major processes affecting forest C budgets are changes in LC/LU/LM, the judicious merging of the spatial and temporal capabilities of remote sensors with those from regular national forest inventories would be the method of choice.

The major processes affecting C budgets and flux in the tropics are mostly related to changes in forest cover and to a lesser degree to changes in use and management of forests (Table 17.1). For the very significant changes in LC since the 1970s, a combination of high resolution remote sensing imagery coupled with forest inventories would be the most appropriate methodology.

Initial conditions of terrestrial ecosystems

Most analyses of terrestrial C budgets have assumed that forests not directly converted to other uses since the pre-industrial era are in steady state with regard to net C exchange with the atmosphere (e.g., Houghton et al. 1983). This assumption was deemed appropriate in regions where the effects of anthropogenic disturbances are large relative to those of natural disturbances, and where data are lacking to support a more detailed analysis. The consequence of this assumption is partly responsible for the present inability to balance the terrestrial C budget.

The direct human influence on the C cycle of boreal forests of Russia and North America is small compared to the influences of natural disturbance regimes such as fire and insects (Table 17.1). Any deviation from the assumed steady state condition of forests not affected by