(IN AND) OUT OF AFRICA: ESTIMATING THE CARBON EXCHANGE OF A CONTINENT

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ABSTRACT
Understanding the diverse elements of the global carbon cycle has been the focus of much recent research [*Prentice et al.* 2001, *Schimel et al*. 2001, *Gurney et al.* 2002, *House et al*. 2003]; research that is vital to our understanding of the missing sink, future atmospheric carbon dioxide concentrations, and future climate [Fan et al. 1998, *Houghton et al.* 1998]. Much research has concentrated on carbon dynamics of the large ocean basins [*Lee et al*. 1998, *Le Quéré et al.* 2003] and terrestrial exchange in North America and Eurasia [*Pacala et al*. 2000, *Schimel et al.* 2000]. Despite representing 20% of the global land mass, Africa has thus far been largely neglected in these studies. We will examine current understanding of carbon stocks and fluxes within Africa and discuss how uncertainty in global carbon dynamics arises in part from uncertainty in the African components. We outline areas where new measurements and research in Africa can contribute to understanding at both continental and global scales.

INTRODUCTION
The continent of Africa represents 20% of the global land mass, second only to Eurasia in terms of the surface area of the major continents. It is a diverse continent, with large areas of moist tropical forest, seasonal and semi-arid tropical forest, savanna and desert, and smaller regions of Mediterranean and montane vegetation. Africa is also the least developed continent, where human populations look to the region's natural resources for increased agricultural and industrial production and future changes in land use and management are expected. Relative to most other parts of the world the carbon dynamics of Africa has been neglected, such that we currently have little information on the carbon source-sink dynamics of the continent or the impacts of land use change, and management activities such as fire, on Africa's overall carbon budget. However, new initiatives at individual research sites across the continent, and at regional and continental scales, seek to redress this imbalance. This paper will review current understanding of the carbon cycle in Africa using available empirical, site-based studies, regional and continental-scale model analyses, and global/continental scale atmospheric inversions. We present analyses of the medium-term (20 year) inter-annual variability in African NPP to understand the patterns of variability related to biome type, climate variability, land use change and fire. We also describe a continental-scale initiative using forward and inverse techniques, optimized for Africa, to estimate carbon uptake and release at local to continental scales and thereby greatly improve our understanding of the role of Africa in the global carbon cycle.

Initial estimates of carbon stocks and the various flux pathways suggest that the continent plays a significant role in atmospheric CO_2 dynamics at time scales ranging from sub-seasonal to decadal and longer. Patterns of carbon stocks in soils and vegetation are highly correlated with annual rainfall but, despite large arid and semi-arid areas in the subtropical subduction and monsoonal areas, the fraction of global annual net primary production (NPP) that occurs in Africa is similar to the fractional terrestrial area of the continent. Carbon stocks per unit land area in vegetation and soil are centered on the equator and decline to north and south with increasing proportion of arid systems. However, because of the greater northern hemisphere land area in Africa, total C stocks and NPP peak at latitudes to the north of the equator (Fig. 1). Atmospheric inversion studies suggest that Africa as a whole is carbon neutral on an annual to long-term basis, despite considerable carbon emissions related to land use change and burning. This suggests that re-growth following land clearance and sequestration of carbon in vegetation and soils is sufficiently large across the continent to offset the loss terms.

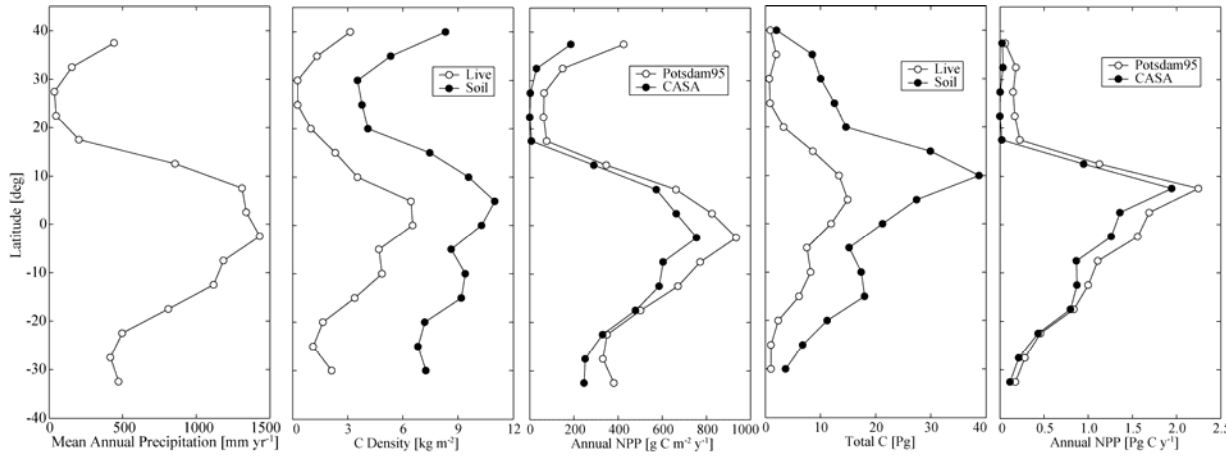

Fig. 1. Latitudinal transect through Africa of longitudinally averaged mean annual precipitation, density of carbon in live biomass and soils, annual net primary production (NPP) per unit ground area, total carbon in live biomass and soils, and total annual NPP.

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