



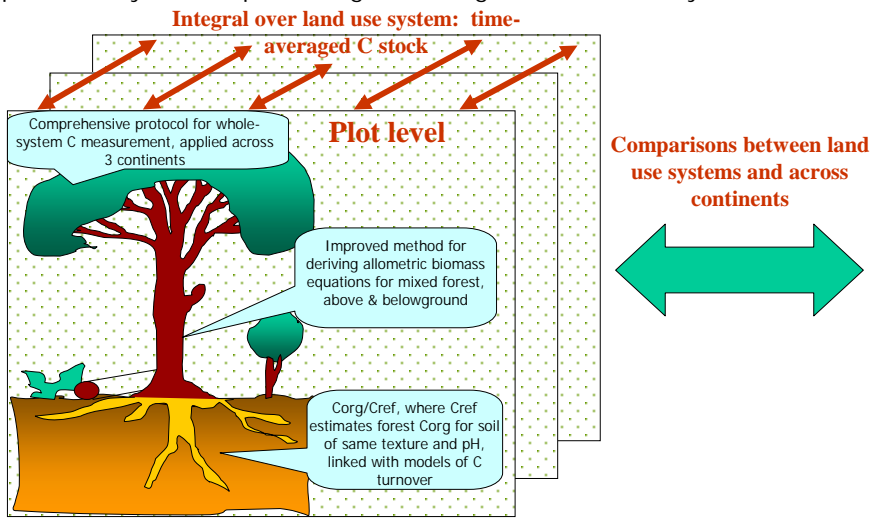
Land Use Options at the Humid Forest Margins: The Potential for Carbon Sequestration



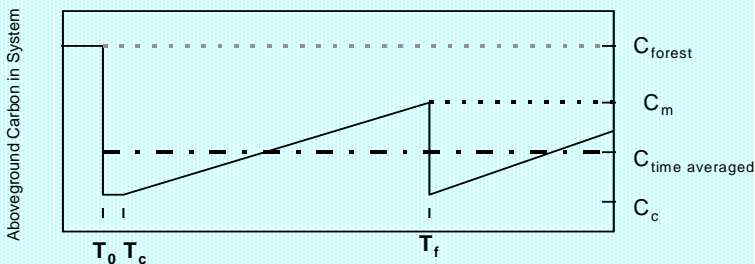
Introduction: Land-use change in the humid tropics leads to a net release of 1.1 to 2.1 Pg C y⁻¹. The uncertainty in the CO₂ flux is from inadequate estimates of land use change, the biomass of the vegetation that is cleared, and the biomass and regrowth rates of the subsequent land use systems.

ASB was initiated in 1991 to address the agronomic, environmental, social and political implications of slash and burn agriculture. A major activity was the characterization of patterns of land clearing and subsequent land use and to quantify the changes in carbon stocks.

Methods: Carbon stocks were measured in the vegetation, litter, and soils in 94 sites in Brazil, Cameroon, and Indonesia. The sites sampled in each country included undisturbed or selectively logged forests as the reference point and systems representing increasing land-use intensity.



The carbon sequestration potential of the different land-use systems was compared by use of the average C stored in the system over the rotation time of that system, the time-averaged carbon stock (Figure 2).

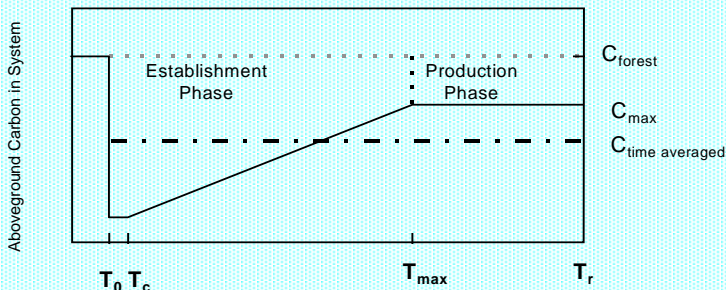


$$C \text{ accumulation rate} = I_c = (C_m - C_c) / (T_f - T_0), \text{ or if } T_c \text{ and } C_c \text{ are small then, } I_c = C_m / T_f$$

$$\text{Time averaged C} = (I_c * T_f) / 2, \text{ assuming } T_c \text{ and } C_c \text{ are small.}$$

C_m = carbon in fallow at time of clearing
 C_c = carbon in crop, assumed to be negligible
 C_{ta} = Time averaged carbon
 T_f = Time (years) in fallow phase
 T_c = Time in crop phase, assumed short compared to T_f

Figure 2a. Schematic of aboveground C losses and reaccumulation following forest clearing and cropping and fallow re-establishment.



$$\text{Maximum C in system} = C_{max} = I_c * T_{max}$$

$$\text{Time averaged C in system} = LUSC_{ia} = \text{Weighted mean } (C_{ia} \text{ Establishment and Production Phases})$$

$$C_{ia} \text{ Establishment Phase} = C_{estab} = (I_c * T_{max}) / 2$$
$$C_{ia} \text{ Production Phase} = C_{prod} = C_{max}$$
$$= [(C_{estab} * T_{max}) + (C_{prod} * (T_r - T_{max}))] / T_r$$

Figure 2b. Schematic of aboveground C losses and reaccumulation forest clearing and establishment of a tree plantation.

Results:

1. Aboveground time-averaged C (t C ha⁻¹)

Table 1. Aboveground time averaged C (t C ha⁻¹) for the various ASB land use systems.

Land use system	Aboveground time-averaged C (t C ha ⁻¹)
Primary and logged forests	300 and 100 –200
Shifting cultivation, 25 y rotation	90
Complex agroforests permanent forms 25 –30 y rotations	60 - 100 40 – 60
Tree plantations	11 - 61
Crop-short fallow (<5 yrs)	5
Pastures and grasslands	3

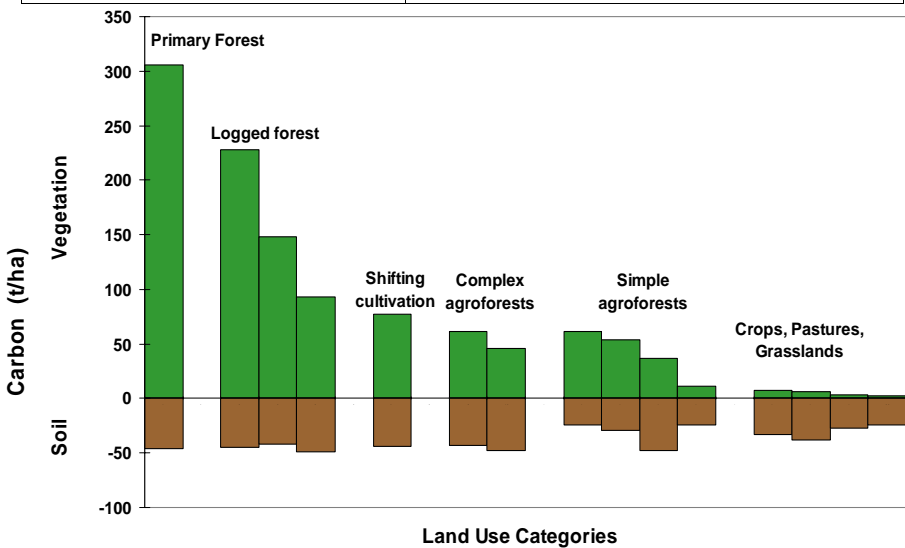
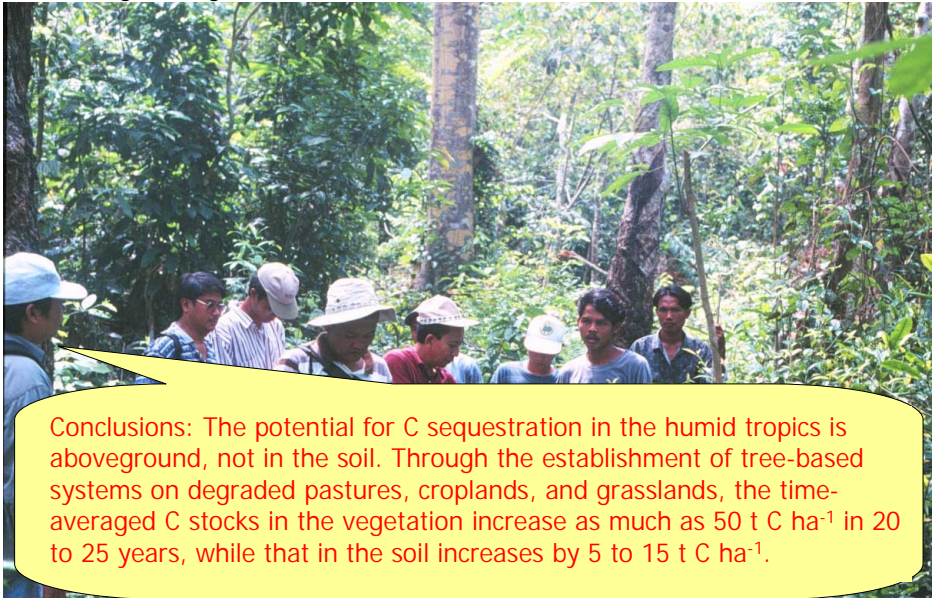


Figure 3. Aboveground time-averaged and total soil carbon (0-20 cm) for all benchmark sites

2. Aboveground C accumulation rates:
 - Natural fallows - 3.9 to 8.5 t C ha⁻¹ y⁻¹
 - Complex cacao and rubber agroforests - 3.0 to 3.6 t C ha⁻¹ y⁻¹
 - Simple agroforestry and tree plantations - 6.0 to 9.3 t C ha⁻¹ y⁻¹
3. Topsoil C (0 – 20 cm) ranged from 50 t C ha⁻¹ in forest systems to 23 t C ha⁻¹ in degraded cropping/grassland systems.

Relative soil carbon values (0-20cm) for land use systems compared to undisturbed forests.

- Long term crop/fallow – 90-100%
- Agroforestry systems 80 –100%
- Pastures – 80%
- Short term crop/fallow – 65%
- Degraded grasslands – 50% or less.



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