

Estimation of Reference Forest Carbon Stocks

Dr. Mark Lung

Methods

Study area

Four study areas (between 450-800 ha each) were delineated within mature forest adjacent to project sites (Figure 1) and data collected in May-October 2008. Three study areas (A1-3) were located in proposed protected cores areas (KIFCON 1994, Wass 1995) and one study areas (B3) in proposed subsistence regions. This was done to compare forest carbon in regions of different use. Each study area projects into forest from a forest edge. In protected core areas this edge is associated with natural glades, regenerating forest of different ages or plantations. In the subsistence area the edge is associated with settlement and subsistence agriculture. Recent studies suggest that the protected core study area around Isecheno has remained relatively undisturbed in last 20 years and maturing to climax (Fashing et al. 2004). Glenday (2006) found that these areas have significantly higher amounts of carbon due primarily to lack of human disturbance (e.g. cut trees).

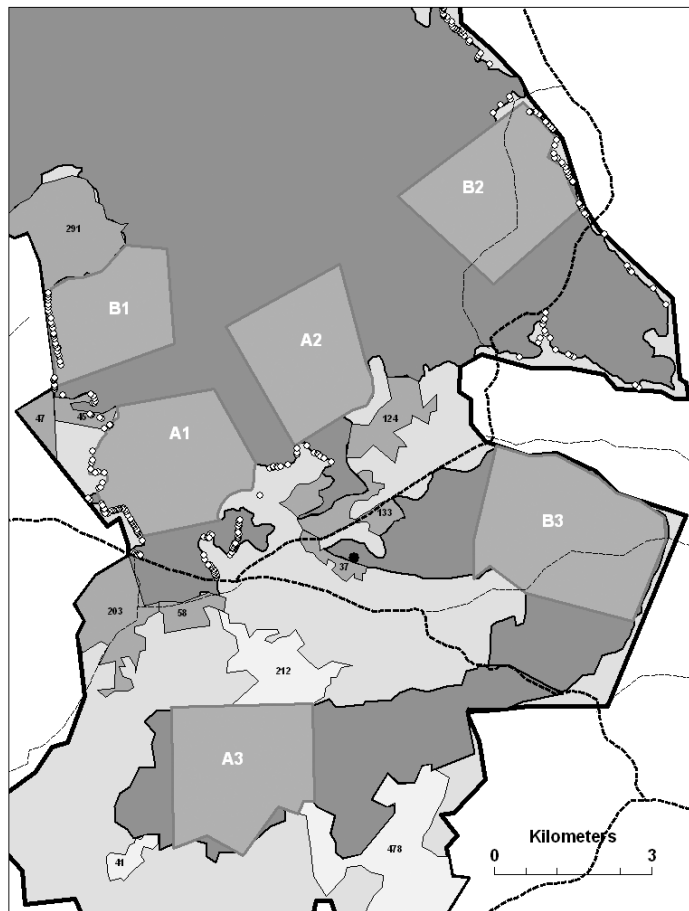


Figure 1: Map of central forest area showing study areas. A1-3 are study areas within proposed protected core region and B3 within subsistence use region. Light grey with solid black is gazetted forest region; dark grey regions are indigenous forest. Also show are proposed project sites associated with approximated area (ha).

Study Design

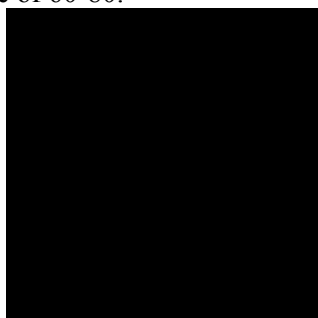
Within each of the four study areas sample plots were systematically located at randomly determined perpendicular distances from existing trails at 0.5 km intervals into forest from forest edge (Pearson et al. 2007,

IPCC 2006). Most existing trails entering mature forest from edges have already been mapped and trails used for initiating sampling protocol were be randomly chosen. Each study area had 5 trail transects spaced 0.5 km apart with four-five sample plots along each. Total sample size was 95.

Sample size estimation. Using CDM protocol for appropriate sample sizes ($n=[t*SD/E]^2$), we estimated that a sample size of 60-80 sample plots would be necessary to estimate the mean biomass within 10% at 95% confidence interval. Based on Glenday (2006), who calculated an average above ground and below ground tree carbon biomass of 249 tons per hectare (95% CI = ± 45 ; standard deviation = ± 150), our desired precision of 10% at the 95% confidence interval would require a sample size of 142. However, our sampling design is developed to reduce the standard deviation in the following ways (based on recommendations from Glenday (2006)):

1. Larger sample plots (approx 3x Glenday 2006)
2. Using ladders to measure DBH above buttresses

Based on an analysis of various standard deviations this results in the following sample sizes needed to ensure 10% precision at 95% CI. It is anticipated that the standard deviation can be reduced to 100-110 through these measures and thus a sample size of 60-80.



Each sample plot was a nested circular plot with radii of 20 m, 14 m, and 5 m (Figure 2). Within each sample plot, we estimated above and below ground live tree biomass and deadwood. The biomass of trees within sample plots was estimated by measuring the diameter at breast height (DBH) of live trees ≥ 5 cm DBH. All trees > 50 cm were measured in 20 m plot; all trees 20-50 cm were measured in 14 m plot; all trees 5-20 cm were measured in 5 m plot. Diameter was measured at 1.3 m above ground unless the tree contained a buttress. If tree had a buttress or growth, then diameter was measured at top of buttress, above growth, or 3 m whichever came first. Diameter was then used in a general allometric equation (Brown 1997) for moist tropical forests to estimate above ground biomass (AGB):

$$AGB = \exp[-2.134 + 2.530 * \ln(DBH)]$$

Below ground biomass (BGB) was calculated using AGB based on shoot:root ratio developed by Cairns et al. (1997). The biomass of all downed trees and branches (deadwood) was estimated by measuring the diameter and decomposition status of each piece ≥ 10 cm along two perpendicular 20 m transects (see above) from center of sample plot (based on Glenday 2006). **Total biomass** in each nested plot was summed (AGB + BGB + Deadwood) and then expanded to hectares using the following expansion factors (20 m plot – 8; 14 m plot – 16.2; 5 m plot – 127.4). Total biomass per hectare is the sum of expanded nested plots. It was assumed that carbon was 50% of biomass (IPCC 2006, MacDicken 1997).

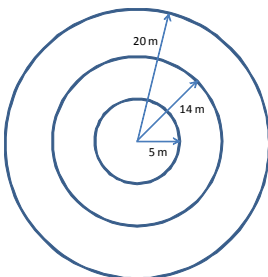


Figure 2. Nested sample plot.

Results

We calculated an average ($\pm$ 95% CI) of 191.03 ($\pm$ 16.5) tons of above ground carbon biomass. This is similar to findings by Glenday (2006) in the same region. Below ground carbon biomass was 45.85 ($\pm$ 3.96) and deadwood was 11.84 ($\pm$ 1.02). Total carbon biomass (sum of above) was calculated as 248.72 ($\pm$ 21.49). We detected no differences in carbon biomass between regions.

Carbon Pool	Carbon Stock (mean tonnes C/ha $\pm$ 95% CI)
Above Ground Biomass	191.0 $\pm$ 16.5
Below Ground Biomass	45.8 $\pm$ 4.0
Deadwood	11.8 $\pm$ 1.0
Total	248.7 $\pm$ 21.5

References

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