Plan Vivo Guidance Notes - Measuring carbon uptake in land use systems

Carbon pools

Carbon is stored in forestry and agricultural systems in a number of different pools:

On site biomass	above ground biomass	bole and crown of tree crop
		non-woody vegetation
	below ground biomass	roots of tree crop
	necromass	deadwood (standing and fallen)
		leave litter
	soil carbon	soil organic matter
Off site biomass	harvest and thinning products	

The decision over which pools to measure should be based on a) the probability of carbon flux in any given pool and b) the cost of measurement in comparison to the market value of carbon. The flux in any pool will depend on the land use system in question: tree biomass will be the most important pool in afforestation, but non-woody vegetation could be important in natural forest management. Soil carbon can also be significantly effected - both positively and negatively - by land use change. It is important that the flux in any pool that may be expected to decrease is estimated.

In the Scolel Té project it is assumed that soil carbon will remain constant. This is a conservative assumption as soil organic matter is usually greater under forests than in agriculture or pasture. However due to the difficulties of monitoring soil carbon any increases in soil carbon are not included in the carbon offset calculations.

Measuring carbon fluxes

The calculation of carbon sequestration will require estimation of how these carbon pools change over time. Carbon is accumulated through growth of living biomass and by the accumulation of litter, woody debris and soil organic matter; carbon is lost through the decomposition of dead organic matter and tree products in thinning and harvesting. The following information will be required to estimate carbon fluxes:

Above ground biomass	Growth and yield data Biomass coefficients Density of wood carbon content of biomass
Below ground biomass	Estimated root:shoot ratio
Necromass	Dead wood and litter production rate decomposition rate
Soil carbon	Humification rate Rate of oxidation of soil organic matter
Forest products	life span of products

Above ground biomass

Biomass coefficients which relate tree diameter, height or timber volume to above ground biomass are available for many species and forest types. Forestry yield tables may be available for certain species and will provide data on timber production, while field surveys can provide diameter and height data. If biomass coefficients do not exist for the species in question they may be calculated through destructive sampling of the vegetation and regression analysis.

The carbon content of dry weight biomass is approximately 50%. However, the basic density (oven dried weight of a stated volume of material) will vary among species and site conditions. There are data published on basic densities of many common species, if this is not available basic density will have to be calculated as part of biomass surveys.

Below ground biomass

The measurement of root biomass can be costly. However roots can make up a significant part of tree biomass, often around 33%. It may be possible to use published data on stem:root biomass ratios otherwise equations. However, if data are not available for the species in question conservative estimates should be used. Actual below ground biomass for species in question may be estimated using destructive sampling techniques.

Dead wood and litter

These carbon pools may be estimated by modelling the rate of production of dead wood and litter and the rate of their decomposition. These data may be obtained from the literature but caution should be used when using data gathered from different ecosystems.

Soil carbon

Although soil carbon can make up a significant proportion of forest carbon stock it is difficult and expensive to measure. Unless activities specifically aim to increase soil organic matter the cost of estimating and monitoring soil carbon may outweigh the value of resulting carbon credits.

In many cases forestry activities will tend to increase soil organic matter and it will be safe to assume that soil carbon will remain constant and therefore does not require quantification. However, in some cases, land use activities can reduce soil carbon, especially tree planting on waterlogged peaty soils, and would represent a significant source of leakage if not measured.

Forest Products

The rate at which carbon stored in wood products is released to the atmosphere as carbon dioxide depends on the fate of these products. Carbon in fuelwood will have a very short residency time while carbon in timber used for furniture will have a much longer average residency time. The proportion of timber being used for different purposes will have to be estimated along with the *average* life span of the products.

Biomass surveys

It may be possible to estimate some of these fluxes from published literature. However, even when data are available in the literature it is strongly recommended to carry out field measurements in the target area, especially for tree growth which is highly dependant on environmental conditions. This will increase the evidence-base for offset calculations and improve purchaser confidence in a projects carbon accounting.

A number of publications are available which give advise of the design of biomass surveys (see links in the Plan Vivo web site). Some key considerations are highlighted below:

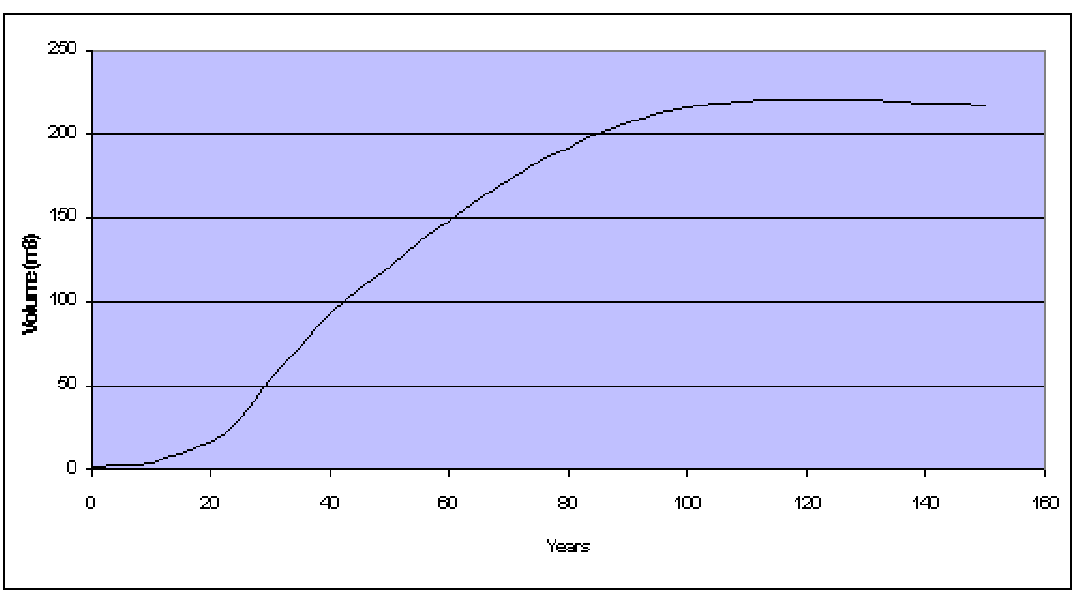
Sampling design

The estimation of biomass accumulation by planted trees and other vegetation require growth and yield data. *Data on standing biomass alone in not sufficient to calculate carbon sequestration*. Growth data may be collected by the establishment of permanent sample plots where individual trees are measured over a number of years. However, to begin with growth data may be estimated through chronosequence sampling, i.e. sampling in vegetation of different ages to estimate tree growth. To carry out chronosequence sampling plots of different ages will have to be identified. If growth is seasonally dependent, growth rings may be used to determine stand age, otherwise age must be estimated by local reports. Chronosequence sampling assumes that differences observed are due to the difference in age among plots and not due to differences in the environment. Sampling should therefore try to minimise environmental effects by stratifying sample plots into a number of environmental classes. Such stratification should be based on the variation in environment (altitude, climate, soil type etc.) found in the project area.

Sampling period

It is recommended that for initial prediction of biomass accumulation data is obtained for at least 5 points over the proposed rotation. The annual increment of a stand will vary over the rotation often following an 'S-shaped' curve, i.e. after an initial slow rate, growth will become more rapid before slowing down again as the crop ages (see figure below). It is therefore important to select the most appropriate stand ages to maximise the efficiency of sampling effort.

This is illustrated by the following graph showing the growth of oak yield class 4 over 150 years. There is little difference in biomass after year 100 and measurements after this point are less likely to detect changes than measurements in the period from 20 to 80 years. Likewise prior to year 20 biomass accumulation is slow and repeated measurements in the period will not justify sampling effort.



Sampling intensity

Initial biomass surveys do not have to be very detailed to allow preliminary carbon estimations. However carbon estimates should be evidence based, i.e. the level of survey intensity should be stated, and estimates should be refined as more data becomes available.

The number of sample plots used depends on the required level of precision for carbon estimates and the level of variation that exists in the vegetation in question. Biomass survey manuals should be consulted for more details of how to calculate appropriate sample size.

> In the Scolel Te project permanent sample plots have been established in each of the three project ecoregions. Circular sample plots are used with a 18m radius (approx 1000m2) for trees >30cm dbh, and 5.6m (approx 100m2) trees 10-30cm dbh. Dbh and height are measured every 3 years.

Survey Teams

Community technicians from farmers' groups could be asked to assist with biomass surveys with technical assistance and supervision from the technical team. The involvement of local people in the collection of field data not only enhances the transparency of the carbon quantification procedures but also helps to develop local skills and reduce the dependency on external technical assistance.