# Carbon Credits of Wooded Ecosystems

Recent media discussion about the efficacy of carbon accreditation in forest and woodland plant communities warrants our consideration as to the legitimacy of carbon offsets.

A carbon offset for $CO_2$ equivalents emitted from an enterprise is claimed where a corresponding nett assimilation of $CO_2$ is achieved by photosynthesis for the accrual of carbon in standing biomass and in soil. This is a challenging task of evaluation as there is a need to quantify the shift in the annual carbon balance of perennial plant communities dominated by woody species.

Detailed measurement of carbon and water fluxes in both woodland and forest systems has failed to reconcile carbon gain from the atmosphere with ecosystem carbon accrual specified in terms of increased carbon in soil and biomass. This means that the Clean Energy Regulator must estimate annual rates of nett assimilation of $CO_2$ using determinations of annual growth rate with satellite information as the most readily available source of pertinent data. It is then possible to convert such estimates by applying an inverse relationship between $CO_2$ assimilation and increase in standing biomass. The plausibility of a solution for the annual flux of $CO_2$ assimilation can then be judged based on weather data to indicate if there is adequate solar radiation and rainfall to support the solution.

Media discussion on this topic focuses on criticism by Professor Andrew MacIntosh who claims the Clean Energy Regulator has been delinquent in management of the $4.5 Billion Emissions Fund through the purchase of carbon credits in wooded communities irrespective of their capacity for carbon accrual. This criticism has support of the Australian Conservation Foundation, the Australia Institute, and a CSIRO Report. The Regulator has been robust in defence pointing to an independent rigorous review justifying taxpayer expenditure to achieve due carbon conservation across an array of projects.

As an approach to resolving this issue in an objective manner, a simple description of ecosystem gain, loss and transfer of carbon is offered with an emphasis on capacity for carbon accrual by woody systems.

Ecosystem carbon gain occurs through the process of photosynthesis during sunlight by a green canopy maintained with a reasonable level of tugour. $CO_2$ is assimilated from the atmosphere via apertures (stomata) in the illuminated leaf surfaces to be fixed in the mitochondria to start the metabolic processes for biomass formation. There is an energy requirement for fixation as the interception of approximately 300 MJ solar radiation for 1kg $CO_2$ fixed. Six fixed molecules are then combined with six molecules of water to form one molecule of sucrose attended by the evolution of six molecules of oxygen.

$$6CO_2 + 6O_2 = C_6H_{12}O_6 + 6O_2\nearrow$$

Sucrose becomes the substrate for tissue development through further metabolism and translocation of carbohydrate material. At this stage, we can note that half the mass of recently acquired $CO_2$ represents the pool for biomass formation with conservation of this assimilated carbon. Metabolic energy for biochemical transformation is derived from a carbohydrate pool comprising a component of earlier assimilated $CO_2$. The outcome of energy consumption for biochemical transformation is respiratory loss as $CO_2$ evolution. The level of carbon conservation becomes affected by the biochemical composition of the biomass material both above and below ground. Carbon loss is lowest for carbohydrate compounds, intermediate for protein and greatest for lipids.

Further respiratory losses are incurred for both growth and maintenance of functional plant material. These losses are detectable at night, but field measurement has proved elusive, contributing to uncertainty in determining the quantity of carbon gain. There are also respiratory losses during daylight, and these have a partial effect of blocking carbon gain from the atmosphere. Respiratory losses both day and night in being difficult to measure pose challenges to definition of the carbon balance with further implications for evaluating dynamic shifts in the balance.

Downward transfer of carbon from the initial canopy store becomes complex in the case of allocating carbon pools between standing biomass and the subterranean stores, organic, comprising root biomass and microflora material as well as a mineral store within the soil matrix such as calcium carbonate. Carbon allocation to roots incurs addition of nitrogen for protein rich biomass necessary for structural strength enabling extension to depth. Respiratory costs for root function are clearly high and are compounded by root mass turnover which contribute in part to the soil carbon store. The challenge for carbon accounting of the dynamic root environment is to determine a residence time of that carbon fraction allocated from the initial assimilation pool.

Woody ecosystems are typically longstanding and are supported by extended root systems that are required for perennial function. The attraction of forest carbon conservation is based on the proposition that carbon accrual can be equivalent between stores above and below ground. Investment of resources, water and carbon to achieve maximal storage is conservative by comparison with fertilized agriculture. This means that claims for superior offsets by forests is needs to be judged with caution.

Frank Dunin

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