Carbon Cycling and Storage in a Grazing Landscape on the South-West Slopes of NSW

WHY CARBON?

Carbon is the building block of life. It forms millions of known organic substances: more than all other elements combined.

All plant and animal life (including humans) are composed of complex organic compounds containing carbon and some essential nutrients.

Plants take carbon from the atmosphere and take water and nutrients from the soil to create living biomass through photosynthesis (primary productivity).

All other living creatures on land, including humans, directly or indirectly, depend on plants to sustain their lives.

When plants and animals die, their tissues are broken down (decomposed) by microbial activity. The carbon is then released into the atmosphere (respired) and essential nutrients returned to the soil.

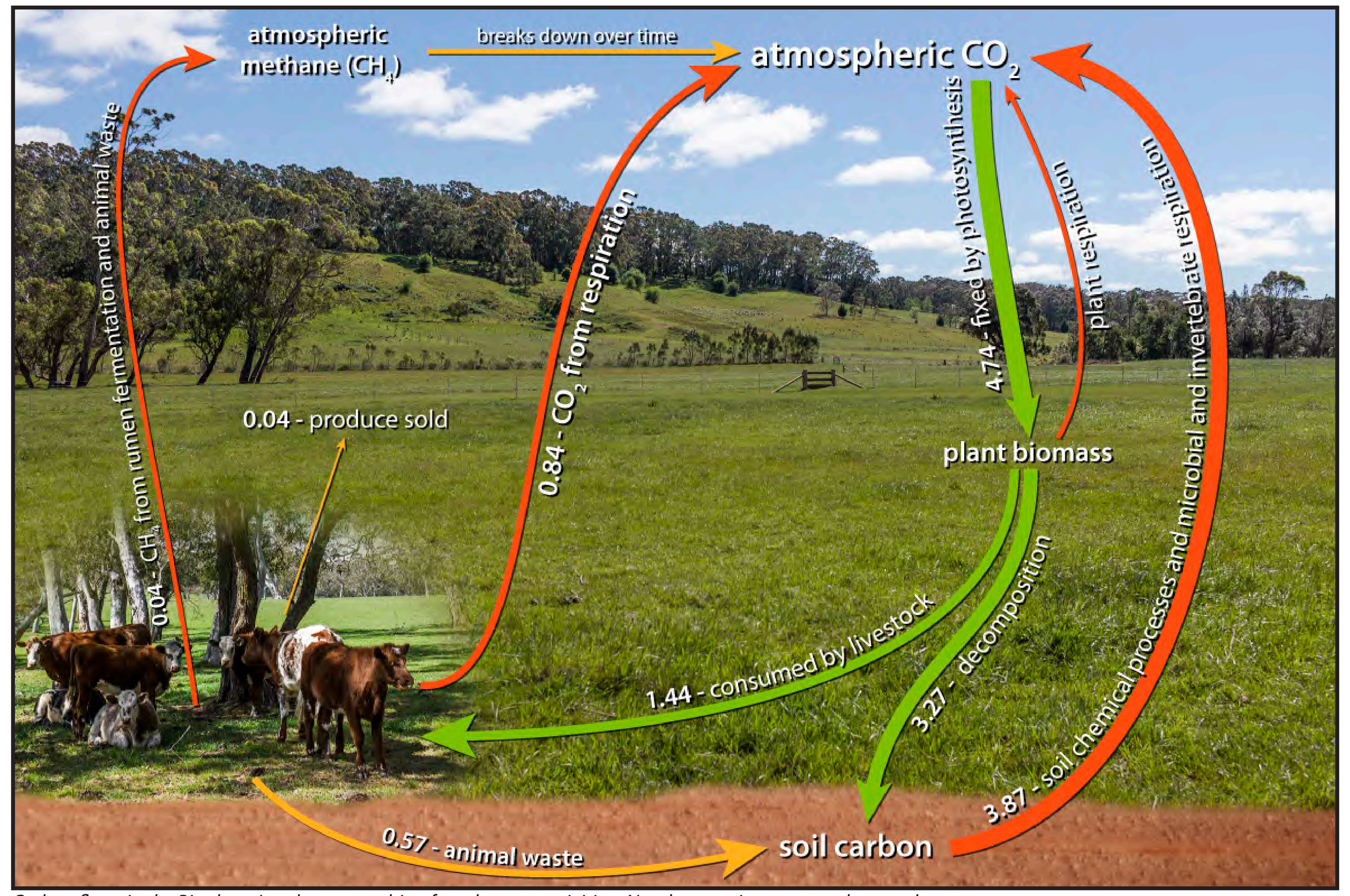
THE CARBON CYCLE

Before the Industrial Revolution, the carbon released into the atmosphere through decomposition of dead organisms and respiration was in balance with the amount taken out of the atmosphere through photosynthesis.

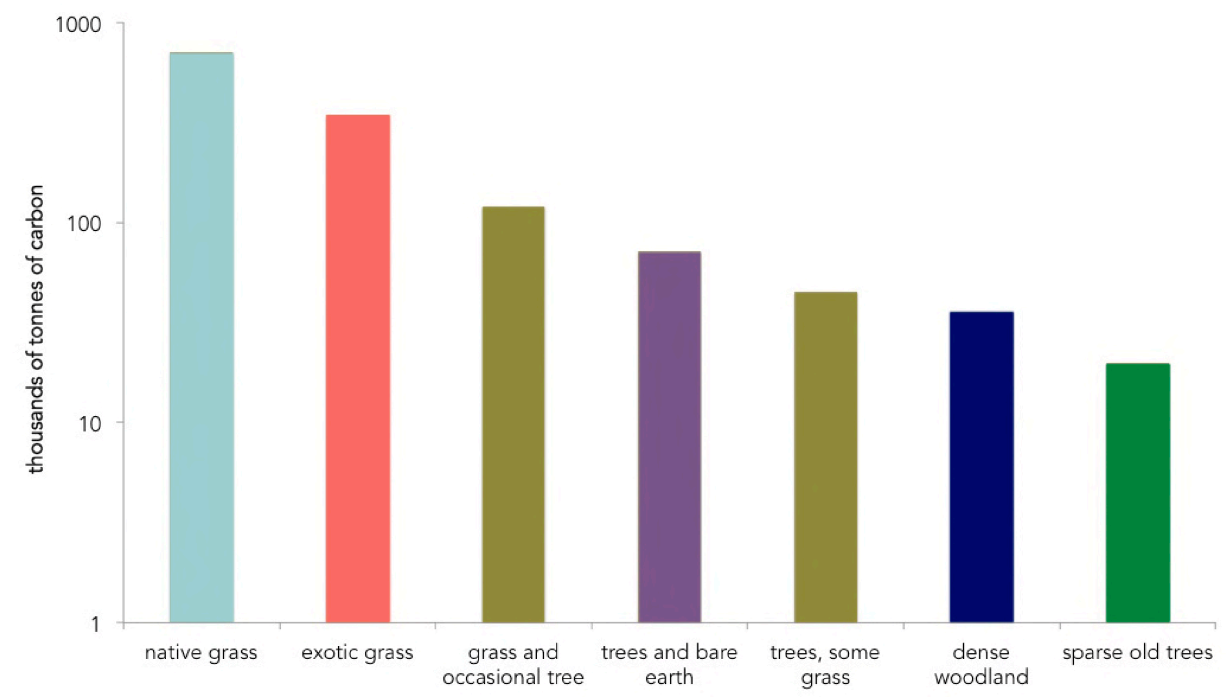
Scientists estimate that about 100 billion tonne of carbon was released each year and the same amount was taken out through photosynthesis. In other words, the amount of carbon in the atmosphere was roughly stable: what went into the atmosphere was balanced with what was taken out.

The exploitation of fossil carbon (coal, oil and natural gas) following the Industrial Revolution disturbed this balance by releasing more carbon than the plants could take out. At present some 10 billion tonne of extra carbon is being released into the atmosphere each year mainly through burning fossil fuels (80%) and intensive agriculture (20%).

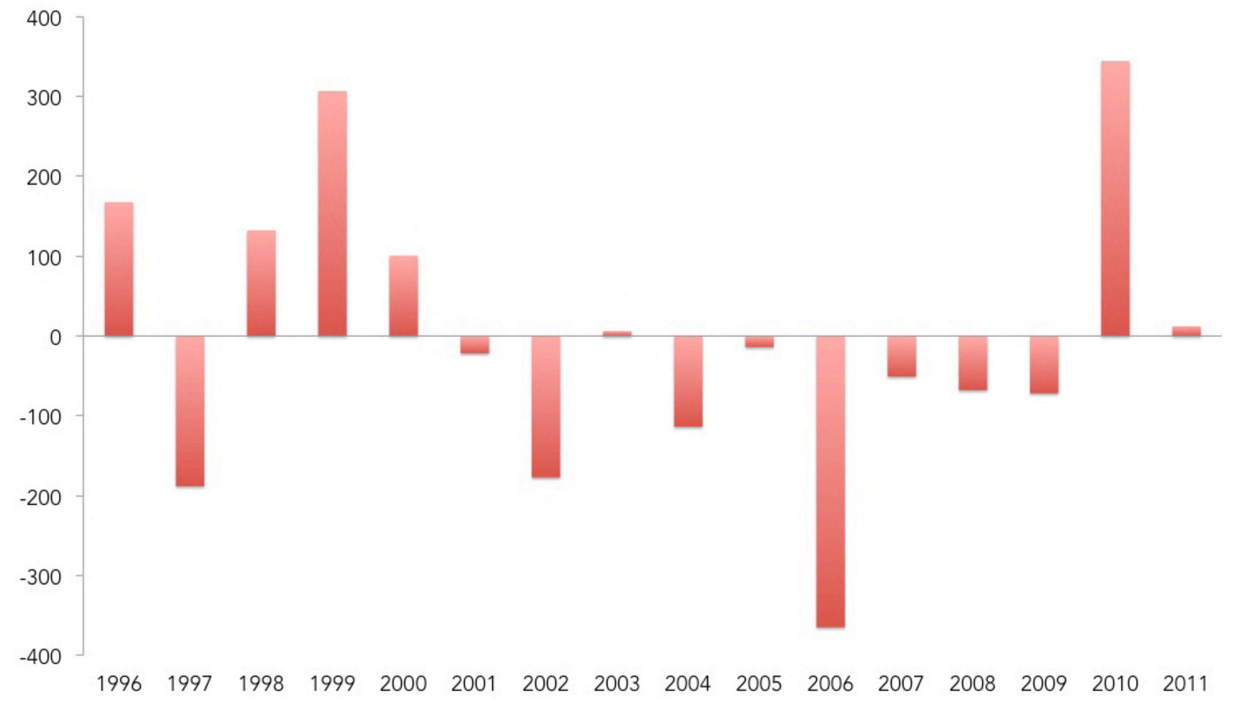
About half the extra carbon is absorbed by the oceans and by additional photosynthesising organisms (mainly phytoplankton and algae). The remaining half is accumulating in the atmosphere where it is de-stabilising the global climate.



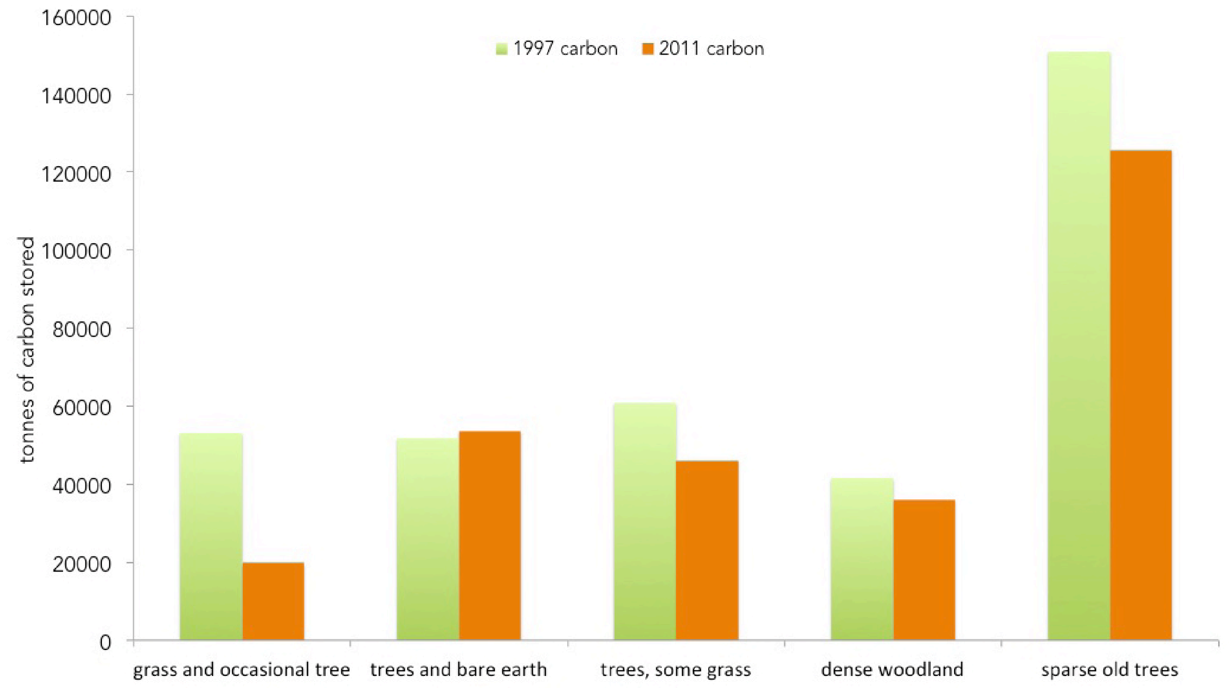
Carbon flows in the Binalong Landscape resulting from human activities. Numbers are in tonnes carbon per hectare per year



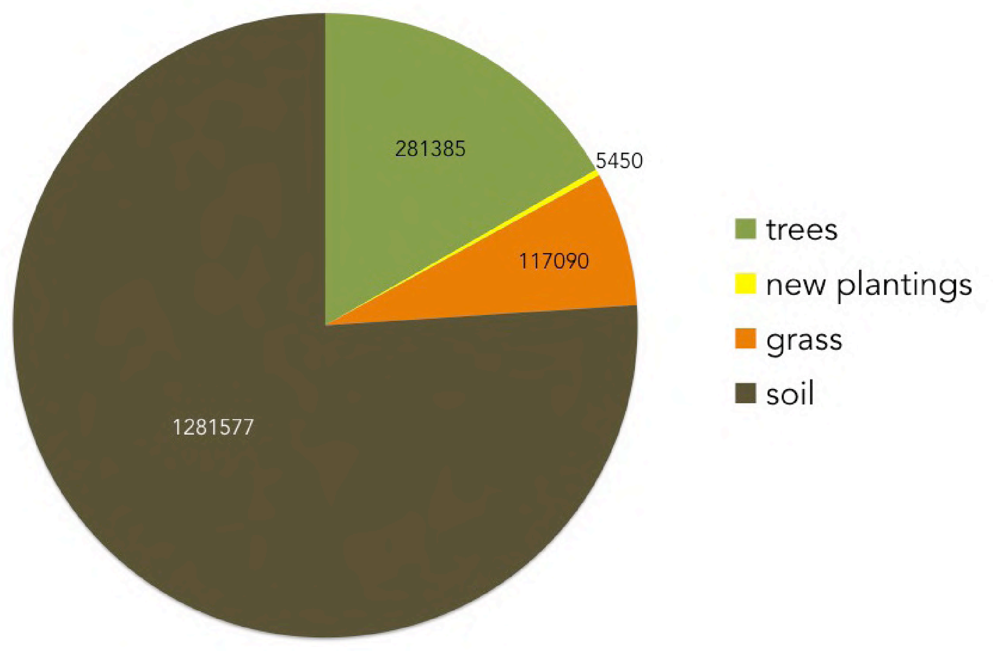
Tonnes of carbon stored in soil in 2011, broken down by vegetation type



Rainfall deviation from mean (648mm) over the study period (mm per year)



Changes in carbon stored in trees between 1997 and 2011 (tonnes of carbon)



Tonnes of carbon stored in soil and vegetation in 2011

THIS PROJECT

Members of the Binalong Landcare farming community were interested to know how much carbon they were taking out of the atmosphere and how much they were releasing through their activities. Were we net emitters or sequesters?

In 1997, Binalong Landcare undertook a comprehensive survey of the productive capacity of their area, and began a significant program of tree planting to address salinity and erosion issues.

In addition to the impact on the local carbon balance, the project also sought to see what changes occurred over the period between 1997 and 2011.

RESULTS

In 2011 approximately 1.68 million tonne carbon was stored in the Binalong landscape (an area of over 41 thousand hectares). Of this, about 76% was in the form of soil carbon, 16.7% in trees, 6.9% in grassland and 0.3% in newly planted trees (see pie chart). Rainfall over the fourteen year period varied markedly (top histogram) including 9 years of below average rainfall (from 2001-2009).

As a result of this prolonged dry period, many trees died and new plantings failed. The amount of carbon stored in trees fell significantly (middle histogram) directly as a result of drought. However, in 2011 (a year with around average rainfall) total sequestration of atmospheric carbon per hectare for the region was approximately 9.45 tonne carbon while total emissions were 5.32 tonne carbon per hectare, giving a net sequestration rate of 4.13 tonne per hectare.

It is important to note that Binalong is predominantly a mixed grazing area (sheep and cattle) on open pastures. There is a small amount of cropping for local animal feed and virtually no intensive (high methane point source) agriculture. Last figure sets out the amount of carbon stored in each vegetation type with illustrative photos for each type belowt.

TAKE HOME MESSAGES

Rainfall variability is a major factor influencing:

1. PRODUCTIVITY
2. RESILIENCE
3. CARBON SEQUESTRATION POTENTIAL

PRODUCTIVITY

Between 1997 and 2011 local farmers have successfully maintained production levels notwithstanding the prolonged dry period.

This is a significant achievement, but one that will become more difficult in future if climate variability continues to increase (as predicted). The best strategy to maintain and potentially increase production levels is to focus on building resilience.

GLOBAL IMPLICATIONS

Human activities are currently releasing an additional 10 billion tonne carbon per year of which approximately half is absorbed by the oceans and biosphere and the remaining half is added to the atmosphere every year causing global warming.

Nobody knows how much carbon is stored in the form of fossil fuels. Reported reserves of coal (681 billion tonne), oil (210.5 billion cubic metres) and natural gas (187.3 trillion cubic metres) contain around 18,900 tonne carbon. This has been accumulated over hundreds of millions of years.

Currently the atmosphere contains around 700 billion tonne of carbon and all life on earth (including all humans) contains around 650 billion tonne carbon. Thus it is certain that humans cannot burn most of the known reserves.

However, we can restore the pre-industrial carbon balance by managing terrestrial vegetation to offset emission by winding back fossil fuel use and increasing vegetation. At current rate of emissions, vegetation would need to increase by around 2% per year and fossil fuel burning reduce by 3% per year to restore the balance within the next 20 years.

RESILIENCE

Resilience in a farming landscape is the capacity of the landscape to minimise impact and recover from disturbances such as drought, fire, flood and importantly, disease outbreaks.

Factors that underpin resilience:

1. Soil water holding capacity and resistance to desiccation
2. Diversity in livestock and vegetation types.

The capacity of soil to hold water depends on its structure. The more sponge-like, the more water the soil can contain.

Soil structure is built up by the roots of plants and maintained by difficult to break-down forms of carbon. Soil disturbance through tillage and vegetation clearing destroys soil structure, lowers resilience and water holding capacity, increasing desiccation and loss of soil carbon.

Low or no-till and precision agricultural techniques maintain water holding capacity. Choice of pasture variety (eg deep rooted perennials over shallow rooted annuals) build soil carbon and hence water holding capacity.

Desiccation (especially from hot wind) is a major factor in reducing soil moisture. It is addressed by maintaining vegetation cover at all times and planting strategic shelterbelts to reduce ground level wind flow.

Disease risk decreases with diversity. Large scale intensive monocultures are highly susceptible to infective agents.

A bio-diverse landscape is more resilient as natural predation is more likely to control disease causing organisms. Chemicals kill beneficial disease controlling organisms and rapidly become obsolescent as pest species build chemical resistance.

CAPACITY TO SEQUESTER CARBON

Managing vegetation sustainably creates and maintains a productive and resilient landscape. Vegetation can be thought of as a re-generating pump that pumps atmospheric carbon into the soil.

By minimising soil disturbance, the soil carbon accumulates.

High levels of soil carbon increase water holding capacity and nutrient cycling, offset carbon emissions, and most importantly, increase productivity.

Native Pasture (Soil C 1.17% in top 0-10cm; 0.55% in10-30cm)

Exotic (Introduced) Grasses (Soil C 1.58% in top 0-10cm; 0.43% in 10-30cm)

Grass & Occasional Tree (Soil C 1.37% in top 0-10cm; 0.495% in 10-30cm)

Trees & Bare Earth (Soil C 4.72% in top 0-10cm; 1.72% in 10-30cm)

Trees & Some Grass (Soil C 2.17% in top 0-10cm; 0.74% in 10-30cm)

Dense Woodland (Soil C 3.82% in top 0-10cm; 1.07% in 10-30cm)

Sparse Old Trees (Soil C 1.21% in top 0-10cm; 0.44% in 10-30cm)

HMLG

NSW GOVERNMENT

Local Land Services Riverina

Binalong Landcare

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