Building soil carbon in semi-arid drylands for landscape resilience

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An Action on the Ground project near Lake Boga in Northern Victoria has recently finalised. Initiated in mid-2012, project AOTGR1-167 aimed to demonstrate positive soil carbon benefits in a land use shift from long time flood irrigation to low-impact grazing and protected biodiversity. The project is reflective of a broader shift from historic flood irrigation in the southern Murray-Darling Basin (MDB) to a more balanced agricultural landscape, one where renewed drylands complement modern and efficient irrigation.

A key assumption of the project was that a return to more permanent groundcover associated with less cultivation should result in more perennial biomass, and consequently a gradual increase in soil organic carbon at a landscape scale. The project was managed by Kilter Rural, with key partners Sunraysia Environmental (sampling and analysis), Bright Futures (landscape grazier) and the North Central CMA.

Land use change in the southern Murray-Darling Basin

According to 2006 ABS statistics[1] the MDB provides around 39% of Australia's total value of agricultural production from 20% of the nation's agricultural land. In the 5 years to 2006 irrigated land in the Basin decreased by 9% to 1.7 million ha, largely due to a reduction in broad scale summer crops summer crops such as cotton and rice. This change has happened through commercial realities in the agricultural industry (narrowing of the margin between commodity prices and input costs) but accentuated by the impact of climate shocks such as the millenium drought. Structural change related to balancing the use of an increasingly stressed water resource base has resulted in irrigation modernisation and water licence buyback initiatives that is significantly changing the spatial footprint of irrigation, and therefore drylands in the landscape.

The setting of Project AOTGR1-167 in northern Victoria is not immune to this landscape scale change. It was anticipated that water savings as part of the Victorian contribution to the MDB Plan (emanating from the 2007 National Plan for Water Security) would result in around 45% of irrigators leaving the industry within the Goulburn Murray Irrigation District (GMID) that includes the area of the project. Though this figure has not been realised[2] (though the research on this is scant) general observation from across the district shows there has been a significant move away from permanent irrigated summer pastures to rainfall reliant annual pastures indicating the progressive 'drying' of the landscape.

Future Farming Landscapes as a model for change

Located between Kerang and Swan Hill Vic Super's Future Farming Landscapes (FFL) investment managed by Kilter is in the midst of this landscape transformation. Nine thousand hectares of farmland of largely historic flood irrigation legacy is being reconfigured into a mosaic of high efficiency irrigation (~3500 ha) set within a now broader dryland context. The dryland country is a mix of low intensity rotational grazing, forestry and protected biodiversity on largely reclaimed irrigation lands. This diversity of land-use, with an emphasis on retained and re-established native vegetation, creates and builds resilience in the landscape for long term sustainable production from it.

Kilter acknowledges the functional value of soils in building landscape resilience, both on its dry and irrigated lands (the latter being assisted with the mechanical incorporation of dry matter and composts). It believes central to soil health is the activation of soil biology as well as management practices that generate and retain soil carbon. The key assumption in management of its dryland areas is that the return of permanent dryland native groundcover to the landscape should result in more vegetation more of the time (perenniality), and, together with less cultivation, lead to a gradual increase in soil organic carbon. This is compared to the assumed losses in carbon in soils denuded through the practices associated with historical flood irrigation. A particular vulnerability of soils to degradation in the project area exists in relation to soil salinisation.

Sheep being cell grazed in FFL in country removed from irrigation and managed to maintain perennial groundcover

Protected biodiversity in FFL, an opportunity to build landscape resilience in part through building carbon in soils

A further imperative of the FFL investment and agriculture generally is to maximise the profitability off all corners of the farm including those areas of more marginal production. This is of contemporary relevance given tightening of gross margins for many agricultural commodities. Revenue streams from eco-service markets such as biodiversity, low impact grazing and carbon potentially make important contributions to overall farm income. As more (and often marginal) dryland country becomes reclaimed through irrigation modernisation programs there is a need to generate new returns off this land, but at the very least to manage it for its own resilience if not contribute to the resilience and value of the broader farm.

AOTGR1-167: Demonstrating the proposition of increasing soil carbon in reclaimed drylands

Management practices that maximise plant growth and minimise losses of organic carbon from soil result in greatest organic carbon storage in soils[3]. The biological degradation of above and below ground vegetation generates organic carbon compounds that become incorporated into and improve the soil structure. This creates a more productive and resilient soil that promotes further addition and retention of carbon in the soil.

The return of carbon to soil is typically a slow process and requires particular management intervention for it to be accrued and then retained - carbon restoration rates of 0.02 to 0.2%/yr have been typically observed in Victorian soils[4]. In Victoria the challenge to build carbon is no greater than in the semi-arid north where the production of vegetation is strongly constrained by moisture availability.

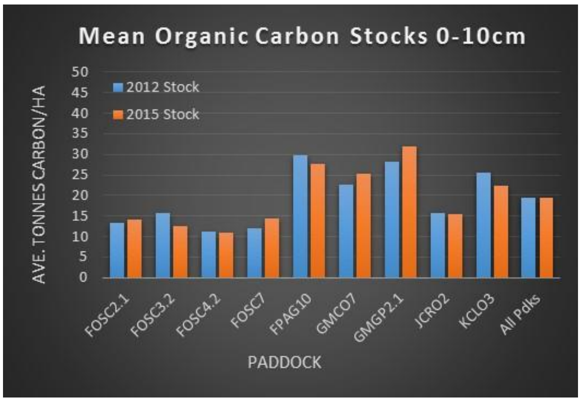
From this project and earlier investigations Organic Carbon levels across the FFL landscape typically averages 1.5% or less (by mass) in the topsoil (top 10cm). However the cracking floodplain clays (vertosols) of the region have been cited as offering good potential for soil carbon storage, in part because of the slower rates of carbon depletion generally through clays, as well as enhanced opportunity for more rapid downwards migration of carbon to more protected deeper parts of the soil profile through their shrink-swell behaviour[4]. Over the length of this project it was hoped that a conservative soil carbon increase of 0.1% (equating to around 1.4 tC/ha in the top 10cm) would be able to be detected and statistically verified. Longer term (over a decade or more) it is hoped that soil carbon levels can increase by a full 1%.

Did we increase soil carbon?

In the timeframe of this project, and especially in a circumstance of low long term accumulation rates in an inherently low soil carbon environment, it was not possible to demonstrate a statistically significant increase in soil carbon levels under the tested land use change scenarios between 2012 and 2015. This conclusion held for both individual paddocks and paddocks that could be reasonably grouped with like land-use.

In 2015 Organic Carbon over the nine paddocks averaged 19.4 tC/ha for the 0-10cm interval. This was a change of only +0.07 tC/ha in the 3 years of the project – a negligible and statistically insignificant change. When the data was analysed over the full 0-30cm interval and also with respect to Total Carbon (that also includes Inorganic Carbon) the results were similarly statistically insignificant. There were some unlikely larger changes evident in the 10-30cm interval data that were challenging to interpret, these are speculated to be the result of laboratory error. The bulk of the changes observed in soil carbon stocks were generally within the range of seasonal fluctuation evidenced in other similar soil carbon studies in the Australian dryland context[5].

Baseline soil carbon surveying in October 2012



Statistically insignificant changes in Organic Carbon in the topsoil were reported in the project

Key learnings from the project

This project has demonstrated that a long term, multi-decadal approach is likely required to build statistically measurable soil carbon stocks in the dry (but climatically variable) inlands of Australia. A decade or more may be necessary to resolve a statistically significant outcome where there is low sequestration rates associated with environments of limited vegetation growth rates.

Despite this there is a need to profitably manage reclaimed dryland areas to support farm incomes. At a minimum these areas need to be managed to control vermin and weeds. More imaginatively they can be managed to build biological, physical and therefore financial resilience across the greater farm. Building carbon in dryland soils is a key to this resilience, and also lead to opportunities for greater economic production off these areas.

To build carbon in semi-arid soils will require a strong enduring discipline to appropriate paddock management and monitoring to validate change. Though there is some direct financial incentive for this by developing products for the carbon market, there is currently a challenge in generating sufficient revenue to cover the substantial transaction costs of carbon measurement (and other) in limiting physical environments.

A full description of the project and all published outputs is available here:
http://www.nccma.vic.gov.au/Land/Dryland/BoostingSoilCarbonKilter/index.aspx

Key References

[1] ABS, 2008. Water and the Murray-Darling Basin – A Statistical Profile 200-01 to 2005-06. Report, Australian Bureau of Statistics

[2] G-MW 2015. 2014/15 Annual Report. Annual Report, Goulburn Murray Water

[3] Carson J., 2014. How much carbon can soil store? Fact Sheet for soilquality.org.au. Healthy Soils for Sustainable Farms programme, of the Australian Government's Natural Heritage Trust.

[4] ENRC, 2010. Inquiry into Soil Carbon Sequestration in Victoria. Parliament of Victoria. Paper No. 362, Session 2006-10.

[5] Baldock J., 2015. Soil organic carbon: approaches to measuring stocks. Presentation at the National Carbon Farming Expo, Albury, July 2015.