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Carbon Sequestration in trees and shrubs on Wool Producing Farms

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26 August 2016

Background: Wool production and carbon sequestration

Wool producers are stewards of large areas of land around the world. Establishing trees and shrubs for shelter, browse or agroforestry in sheep grazing lands can help productivity and ecosystem function and also store carbon in the landscape.

Plants take up carbon dioxide from the atmosphere in photosynthesis and convert it to organic matter. Much of this carbon is returned to the atmosphere again relatively rapidly primarily through plant respiration, but some is retained for long periods, sometimes many decades, in branches, roots and soil. Carbon dioxide is a greenhouse gas and removing it from the atmosphere and storing the carbon in organic matter make an important contribution to mitigating global warming. This is referred to as carbon sequestration. However, in wool life cycle assessment (LCA) studies, the role of trees and shrubs on sheep farms has often been overlooked and, as a result, the significance of carbon sequestration in vegetation and pasture soils is largely unknown.

As part of a larger study on the environmental impacts of wool production, carbon sequestration in areas of trees or shrubs established on sheep farms in three major regions of Australia was modelled and reported in a recent paper in *The Rangeland Journal*[1]. More information on the full life cycle assessment study and other components of the greenhouse gas budget can be found at http://www.iwto.org/news/86/, and the full paper[2] is available online by clicking here. This project was one of a series of Australian Wool Innovation funded studies seeking to ensure accurate and scientifically defensible data are used in wool LCA studies.

Key Points

- Wool growers are stewards of large areas of land, with active vegetation management commonly including planting trees and re-establishing shrubs for production and environmental benefits.
- Wool's carbon footprint should reflect stewardship practices which revegetate landscapes.
- Carbon sequestration in trees on farms in NSW and WA was estimated to reduce the climate change impact of greasy wool at the farm-gate by 7% and 2%, respectively, in the long term.
- In the semi-arid pastoral lands, carbon sequestration in re-established shrubs reduced net greenhouse gas emissions per kg greasy wool produced by 11%.
- Tree establishment and soil management on some south-east Australian farms has achieved 'carbon neutral' wool.

Introduction to the study

Recent government surveys[3] revealed that about 30% of sheep producers in Australia report that they actively managed and/or planted native vegetation. Native species were reported to cover, on average, 11% to 14% of the total area of properties. In addition, agro-forestry planting native and exotic species for timber harvesting can provide an additional income stream. Management of areas of shrubs and trees by sheep producers provides both environmental and production benefits. Improvements to productivity and animal welfare occur through provision of shelter, salinity control and reduced erosion while, beyond the farm-gate, public benefits arise through enhanced ecological and biodiversity values and climate change mitigation.

This study focused on the climate change benefit of trees. In wool LCA or carbon footprint studies, greenhouse gas emissions from livestock, growing feed, energy and fuel use are counted but carbon sequestration in vegetation and soils on sheep farms is often overlooked, in part because it is difficult to estimate accurately.

A novel method combining geospatial mapping, local climate data and yield models was developed to estimate growth and carbon biomass of trees and shrubs on case study farms representative of three major wool producing regions of Australia:

- High-rainfall zone represented by New South Wales (NSW) Northern Tablelands
- Sheep-wheat zone represented by Western Australia (WA) Central-South
- Pastoral zone represented by South Australia (SA) south-east region.

What was done

Information from site visits and farmer interviews for ten farms representative of the three major wool producing regions was combined with regional production statistics from government surveys for 2008-2012[4] to compile datasets for LCA. Data included area, age and configuration of tree plantings, application of fertiliser to pasture, and local climate parameters that determine plant growth and decomposition. This enabled carbon stocks in vegetation and soils per hectare of farm land to be modelled. An increase in carbon stocks in growing trees and shrubs translates to net uptake of greenhouse gas. Vegetation and soil carbon sequestration per hectare were modelled and expressed for each year assuming retention of the carbon for a 20 year or 100-year period.

All case study farms in NSW and WA (representative annual average rainfall of 789 and 534 mm, respectively) had established native tree species over the previous two decades and on some NSW properties exotic pines (*Pinus radiata*) were also planted. The trees were integrated into productive agro-ecosystems, e.g. as shelter belts and along contour lines on slopes, and sheep grazed among them. Wool growers reported benefits, such as improved lamb survival[5], animal shelter, pasture quality and reduced risk of run-off and erosion. Tree plantings are important for controlling salinity, particularly in Western Australia.

Shelter belts of native and exotic species in the Northern

In the more arid pastoral region of SA (annual average rainfall about 240mm) there are naturally few trees, and revegetation has occurred through regeneration of chenopod shrublands. This was achieved by managing sheep grazing in degraded areas to promote shrub recruitment and survival. Estimation of biomass in revegetated areas used calibrated species-specific expert assessment.

Soil carbon sequestration modelling used relationships applicable to soil type, climate and management regime developed through review of a large volume of Government-funded research in Australia over the past decade. Estimates of sequestration in soils have a higher uncertainty than those for vegetation but the research indicates that the long-term potential for carbon sequestration in Australian soils is low.

Carbon sequestration in vegetation and soils was expressed per unit of greasy wool leaving the farm-gate based on a cradle to farm-gate LCA[2]. This enabled calculation of the net greenhouse gas emissions per unit of wool giving a more accurate estimate of climate change impact than gross emissions alone.

Findings

Using the best available growth models for each region and climate, carbon sequestration in trees and shrubs was estimated to be -17.4 and -13.8 tones carbon dioxide equivalents per hectare per year (t CO_2-e/ha/yr) for plantings of native species and exotic pines in the NSW region, annualised for a 20 year period. Note that the negative sign indicates removal of greenhouse gas from the atmosphere. The corresponding assessments for study regions in WA and SA were -7.7 and -0.3 t CO_2-e/ha/yr. Sequestration expressed as annual uptake over 100 years are -4.4, -5.0, -2.0 and -0.07 t CO_2-e/ha/yr for NSW native, NSW pine, WA native and SA shrub vegetation, respectively.

Although sequestration per hectare in the semi-arid SA recovered chenopod shrub land was less, reflecting lower biomass of the vegetation and arid conditions (average annual rainfall <300mm), the large area (3,800 ha or 20% of total grazing land for the case study farm) translates to a significant value per kg wool produced.

In the NSW region where research indicates that it may be possible to sequester carbon under fertilised pastures of -0.09 t CO_2-e/ha/yr over 100 years, the authors recommend a conservative assumption of zero change.

Carbon sequestration in wool LCA

The significance of the estimated rates of carbon sequestration in vegetation in wool LCA depends on the area of revegetation, wool production per hectare and the rate of greenhouse gas emissions from other sources. Wool growers who invest time and resources in revegetating landscapes should receive credit for the reduction in their wool's carbon footprint.

Carbon sequestration in trees planted on wool producing case study farms in NSW and WA was estimated to reduce the climate change impact of greasy wool at the farm-gate by 7% and 2%, respectively, using the more conservative rate over 100 years.

In the semi-arid pastoral lands, carbon sequestration in chenopod shrubs re-established through active revegetation on the SA case study farm reduced net greenhouse gas emissions per kg greasy wool produced by 11%.

Next steps

This was the first study of which the authors are aware that quantified the contribution of carbon sequestration to wool's climate change impact. The results indicate the importance of developing practical methods to enable carbon sequestration to be included in wool LCA for balanced accounting. Modelling of selected farms in south-east Australia have indicated that tree establishment and soil management have achieved 'carbon neutral' wool[6,7].

Recognition of benefits of trees on farms such as salinity reduction and biodiversity enhancement as well as greenhouse gas mitigation is also important but planting trees is not suitable for all wool producing farms. Trees compete with pasture grasses for water, light and nutrients and research Is needed to provide practical understanding for wool growers on how to strategically locate trees in grazed landscapes to maximise co-benefits and minimise trade-offs for wool production.

Further information

[1] Henry B.K., Butler D., Wiedemann S.G. (2016). Quantifying carbon sequestration on land managed for sheep grazing in Australia in life cycle assessment studies. *The Rangeland Journal* **37:** 379-388. http://dx.doi.org/10.1071/RJ14109

[2] Wiedemann S.G., Yan M-J., Henry B.K. Murphy C.M. (2016) Resource use and greenhouse gas emissions from three wool production regions in Australia. *Journal of Cleaner Production* **122**: 121-132.

[3] Harris-Adams K., Townsend P. and Lawson K. (2012). *Native vegetation management on agricultural land,* ABARES research report 12.10. Australian Bureau of Agricultural and Resource Economics and Sciences, Canberra.

[4] ABARES (2013). 'Specialist Sheep Farms: NSW Tablelands, WA Central and South Wheat Belt, SA North Pastoral.' Australian Bureau of Agricultural and Resource Economics and Sciences: Canberra, ACT.

[5] http://www.rdani.org.au/files/pages/projects/farm-forestry-northern-inland-forestry-investment-group/EW_Brochure.pdf

[6] Doran-Browne, N., Ive, J., Graham, P., & Eckard, R. (2015). Carbon neutral wool farming in south eastern Australia. *Animal Production Science* 56: 417-422.

[7] http://www.jigsawfarms.com.au/

About IWTO

With a membership comprised of 60% of total wool production world-wide, encompassing the wool pipeline "from sheep to shop", the International Wool Textile Organisation (IWTO) represents the interests of the wool textile trade at the global level. By facilitating industry strategy and ensuring standards in manufacturing and sustainability, IWTO fosters connection between members and all stakeholders through mutual support of opportunities for wool. To learn more about IWTO and its activities, visit www.iwto.org.

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