Scobie, D.R.; Dynes, R.; Faris, J.; Taylor, A.; Wright, B.; Wright, S., 2020. Sheep, beef and forestry to balance carbon emissions. In: *Nutrient Management in Farmed Landscapes*. (Eds. C.L. Christensen, D.J. Horne and R. Singh). http://flrc.massey.ac.nz/publications.html. Occasional Report No. 33. Farmed Landscapes Research Centre, Massey University, Palmerston North, New Zealand. 6 pages.

SHEEP, BEEF AND FORESTRY TO BALANCE CARBON EMISSIONS

David R Scobie[1], Robyn A Dynes[1], Jessica B Faris[1], Anna L Taylor[1], Bill K Wright[2] and Shirley G Wright[2].

[1]AgResearch Lincoln, Private Bag 4749, Christchurch, 8140, New Zealand

[2]816 Cannington Road, RD14, Cave, 7984, New Zealand Email: Scobie@agresearch.co.nz

Abstract

A unique farm in South Canterbury was modelled to determine total CO_2 emissions. The farm has 360 effective hectares of pasture and carries around 4500 stock units in an average year. Overseer® (version 6.2.0) modelling estimated 1574640 kg of CO_2 equivalents came from this farm in the 2016-2017 season. The Lincoln University online Farm Carbon Footprint Calculator predicted 56.2 ha of the farm would need to be planted in *Pinus radiata* to balance CO_2 equivalent emissions from ruminant livestock with CO_2 sequestration in trees. Hypothetical scenarios with plantation forestry in areas of low pasture production were modelled. Although 56.2 ha is 15.6% of the effective area, these challenging sites generally produce poor-quality pasture that is less palatable, at times of year when the rest of the farm has surplus forage. One scenario planting trees on the least productive land, reduced annual pasture dry matter production by 9.4 % and livestock by 499 stock units. An alternative scenario considered planting native species on riparian areas and forestry on erosion prone slopes, both of which will improve environmental outcomes. This required 63.2 ha and reduced stock units by 613. Thus, there is potential to balance carbon emissions, provide shade, shelter and drought forage reserves while reducing the risk of erosion of slopes and riparian areas. On this farm, the owners already have forest and accept that they are sheep, beef and forestry producers set to capture more value from the 'story' of 'balanced' food production.

Introduction

Sheep and beef farming will need to change to meet greenhouse gas emission targets. A unique farm in South Canterbury (-44.357, 170.939) was modelled to determine total CO_2 emissions. The farm has 360 effective hectares of pasture with another 19 hectares of trees and scrub. The farm carries around 4500 stock units in an average year. The farm is separated into two blocks, the original farm is called "Highlands" and has a riverbed dissecting a small portion from the rest of the farm. A second block of land located a short distance away was purchased later and is called "Coles block". Neither block has irrigation.

An image of Highlands farm is shown in Figure 1. Some existing forestry is evident adjacent to the river and on steep land. What it would take to balance release of CO equivalents (CO_2-e) released from the ruminant farming enterprise by accumulating carbon in further tree planting was investigated here.

FIGURE 1. Highlands farm from an imported aerial map from ArcGIS Pro and a Ravensdown Smart Map of the farm, the paddock boundaries for Highlands were digitised (outlined in red): ArcGIS Pro® software by Esri, Copyright © Esri

Methods

Farm details including livestock numbers, areas of forage crop and supplements were entered into Farmax (version 6.4.5.23) (White et al. 2010), to develop a working model of the farm with a feasible outcome for grazed livestock. Outputs from Farmax and further information such as soil type were entered into Overseer® (version 6.2.0) (Wheeler et al. 2003). Methane and nitrous oxide emissions were calculated in Overseer as 3,579 kg/ha and 795 kg/ha respectively, for a total CO_2-e of 4,374 kg/ha. The farm is comprised of 360 effective hectares making the total CO_2-e emissions 1,574,640 kgs (1574.6 tonnes) per year.

The greenhouse gas production predicted from Overseer was entered into the "Lincoln University online Farm Carbon Footprint Calculator" (Lincoln University, 2019). For ease of use this will be abbreviated to the "Carbon Footprint Calculator". Limited further details can be used by this application, including livestock numbers, production details, fuel use, fertiliser and farm area. However, using GHG emissions from Overseer, the application will give an estimate of the area of trees required to accumulate sufficient carbon to offset the carbon equivalents released by the farming operation. Estimates of the area required to balance emissions if planted in *Pinus radiata* or in native forest are outputs, with the latter covering much larger areas given the slower growth of native forest. Hypothetical scenarios for plantation forestry on areas of low annual pasture production were proposed and the effect of removing them from the farming system were modelled.

Results

Sown with either fodder beet or maize, some cultivatable paddocks on the farm have been measured to produce more than 20000 kg DM/ha/yr. Other areas that are either not cultivatable or have relatively poor soil have been found to produce less than 4600 kg DM/ha/yr.

Modelling with Overseer estimated 1,574,640 kg of CO_2 equivalents came from this farm in the 2016-2017 season. Other seasons were available, where livestock numbers were affected by drought (2015-2016) or during periods of good rainfall in subsequent years (Table 1). The 2016-2017 season was chosen as an example for CO_2-e, but since this is largely a finishing farm with no irrigation, livestock numbers vary dramatically from year to year and season to season within years, and forage can be carried between years such that average livestock numbers could be misleading. Note this may not be the case with irrigated finishing farms for example, or breeding farms that have more stable numbers, but this particular enterprise is very actively managed according to available herbage.

Table 1. Carbon dioxide equivalent emissions from Highlands (1991) and Highlands plus Coles (from 2016). (*Note figures for 2018 and 2019 were estimated using Overseer Science Version 6.3.2)

Year (to 30 June)	1991	2016	2017	2018*	2019*
CO2-e (kg/ha/yr)	4386	2746	4374	5036	4333

The Carbon Footprint Calculator predicted 56.2 ha of the farm would need to be planted in *Pinus radiata* for CO_2 sequestration in trees to balance CO_2 and N_2O emissions from ruminant livestock. Although 56.2 ha is 15.6% of the effective area, this scenario reduced annual pasture dry matter production by 9.4% and livestock by 499 stock units. Figure 2 shows the map of Highlands from Figure 1 with imagery of the area of forest required. This may not be the most appropriate configuration of the farm for future livestock management, but existing paddock areas and fencing infrastructure were utilised to visualise the concept.

FIGURE 2. What Highlands would look like with 56.2 hectares of the least productive pastures planted in *P. radiata*.

An alternative scenario considered planting native species on riparian areas and forestry on erosion-prone slopes, both of which will improve environmental outcomes. This required 63.2

ha and reduced stock units by 613. Some of the soils bordering the streams are very stony and were estimated to produce as little as 2500 kg DM/ha/yr. Figure 3 shows an image of Coles block with 23 ha of the riparian areas planted, while the remainder would be planted on Highlands (not shown). This model created in ArcGIS Pro® displays 50m riparian planting zones surrounding Mathias Creek, Middle Creek and End of Lane/Backline Rd Creek.

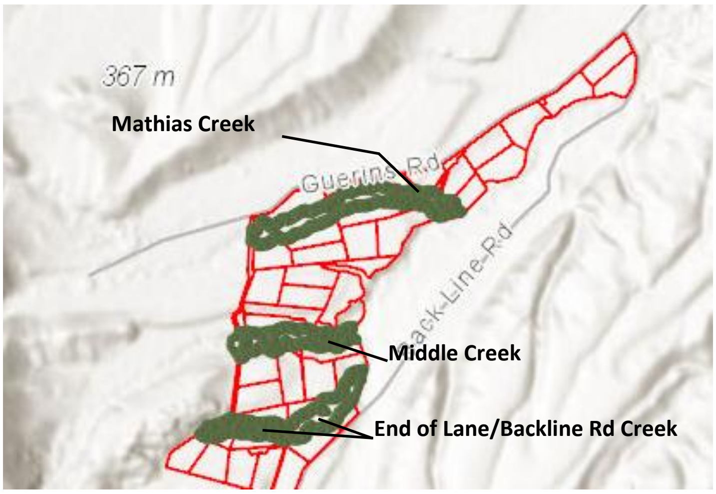

FIGURE 3. Coles Block with 23 ha of riparian planting**.**

Indigenous forest covering 246 ha was reported by the Carbon Footprint Calculator but was rejected by the current authors. This would leave little area for livestock, diminished economies of scale and would render many improvements obsolete. Other sectors of the community may hold alternative opinions about this scenario.

Discussion

On this farm, the owners already have forest, however new drivers provide opportunities to expand forestry and capture the benefits of an integrated system with diverse products. Challenging sites generally produce poor-quality pasture that is less palatable, at times of the year when the rest of the farm has surplus forage. Granted, poor soils may also produce poor forestry outcomes and carbon accumulation may be impaired on poorer soils, but rainfed paddocks that grow very heavy forage crops were considered sacrosanct to the authors. Likewise, the simplicity of removing a portion of the farm in minutes with a computer keyboard deserves further iteration, and practical consideration to determine how the farm would function without these paddocks, how the farm would transition to this format and the opportunities and unintended consequences from this transition. The increased acceptance of such a farming landscape, where the expectation of societal outcomes are changing both locally and globally also merits further consideration.

The Carbon Footprint Calculator suggests 56.2 ha should be planted, which seems a very prescriptive area, but this is the requirement to balance carbon emissions and accumulation in a steady state relative to the 2016-2017 production year. Choosing other years would require different areas and clearly some long term average will be needed to more accurately estimate the balance point. Trees accumulate very little carbon when they are young and again when they are mature and the forest senesces, while they accumulate most during a vigorous growing phase in between. For *P. radiata* one might want to split plantings into smaller manageable areas of 2 ha per year for example, have slightly more area and fell 2 ha at 30 years old to retain around 60 ha in forest, with a portion vigorously accumulating carbon each year. Some other combination of planting and harvest times may suit better, provided the forest is accumulating and turned over. Unlike agricultural crops, within some limits the harvest of trees can be brought forward or pushed out to improve financial returns as circumstances prevail. Furthermore, the climate and soil types present on this farm lend themselves to other species such as eucalypts, for which current end-products suit a shorter lifespan but have quite a different carbon accumulation pattern and were not considered by the Carbon Footprint Calculator used here.

Readers should also note that only 30% canopy cover at 5 metres high is required by the relevant legislation (Ministry for Primary Industries, 2019), such that some grazing would be available after the trees become established. New Zealand research has supported the opportunity for diversification into forestry, and understorey pasture production (Hawke and Maclaren, 1990). Reduced pasture production and therefore carrying capacity (Cossens and Hawke 2000) and reduced lamb growth rates in the presence of trees would certainly discourage many from planting trees, but Cossens and Hawke (2000) suggested the approach examined here, to plant less productive areas in trees. Thorrold *et al.* (1997) found that strategies planting pines, eucalypts or wattles were all more profitable than sheep and beef farming alone on hill country and yet recent decades has seen a marked reduction in the area of forests. Current pressures on environmental protection may force farmers to reconsider of riparian planting even on cultivatable flat land.

The farm owners were aware of the benefits of forestry to diversify production and planted areas of Highlands soon after purchasing the farm. There are many other advantages such as shade, shelter and drought forage reserves or reducing erosion of slopes and riparian areas. Thus, there is potential to balance carbon emissions, improve animal welfare and reduce environmental impact. Current financial incentives to plant trees will help defray some costs of fencing and establishment (Te Uru Rākau Forestry New Zealand, 2018). Other sheep and beef farmers should consider whether to add carbon and potentially lumber to their farming business, with a focus on the right enterprise in the right place.. The industry might then capture more value from the 'story' of 'balanced' food production. Finally, it would be very useful if an integrated forestry and agricultural model could be developed to model the net effects of the enterprise on the environment.

References

Cossens GG Hawke MF (2000) Agroforestry in Eastern Otago: results from two long-term experiments. *Proceedings of the New Zealand Grasslands Association* **52:** 93-98

Hawke MF Maclaren JP (1990) Agroforestry – an opportunity overlooked? *Proceedings of the New Zealand Grasslands Association* **51:** 55-58

Lincoln University (2019). https://dotnetrest.lincoln.ac.nz/O365flowClient/cache/sites/www-content/Lincoln%20WWW/research/research/rc/aeru/carbon-calculator/CarbonCalculator.html

Ministry for Primary Industries (2019) *About the one billion trees programme.* https://www.teururakau.govt.nz/funding-and-programmes/forestry/planting-one-billion-trees/

Te Uru Rākau Forestry New Zealand (2018) *The one billion trees program: our future, our billion trees.* https://www.teururakau.govt.nz/dmsdocument/31860-guide-to-the-one-billion-trees-programme-2018

Thorrold BS Knowles RL Nicholas ID Power IL Carter JL (1997) Evaluation of agroforestry options for three tree species. *Proceedings of the New Zealand Grasslands Association* **59:** 187-190.

Wheeler DM Ledgard SF DeKlein CAM Monaghan RM Carey PL McDowell RW Johns KL (2003) OVERSEER® Nutrient Budgets – Moving towards on-Farm Resource Accounting. *Proceedings of the New Zealand Grassland Association* **65**:191–194.

White TA Snow VO King W (2010) Intensification of New Zealand Beef Farming Systems. *Agricultural Systems* **103**: 21–34