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Carbon Footprint Evaluation of Regenerative Grazing at Packhorse

Introduction

Grass-fed beef, where regenerative practices increase biosequestration in trees and soil, can change the environmental narrative of beef production. Traditional life-cycle analyses of beef production do not account for biosequestration and therefore do not tell the full carbon story of regenerative grazing. This paper will present evidence to show that grass-fed beef in regenerative grazing systems has the potential for net-zero emissions.

What is Regenerative Grazing?

Regenerative agriculture "focusses on enhancing and restoring holistic, regenerative, resilient systems supported by functional ecosystem processes and healthy, organic soils capable of producing a full suite of ecosystem services, among them soil carbon sequestration and improved soil water retention" (Gosnell et al., 2019). Regenerative farming uses a range of holistic methods, such as multi-species pastures, incorporation of deep-rooted legumes, and high-density cattle rotations accompanied by long rest periods to improve soil health and farm profitability (Colley et al., 2020). Studies have demonstrated that regenerative grazing can increase stable soil organic carbon stocks, increase aboveground productivity, improve water use efficiency, increase forage production and improve general ecological health, resilience, and durability of the farm (Apfelbaum et al., 2022; Mosier et al., 2019).

The Scope of this Work

The scope of this work is focussed on quantifying the net carbon footprint of Packhorse operations and comparing it to conventional beef production (without carbon sequestration) and other non-meat protein sources. A life cycle analysis was used to examine emissions from 'cradle to farm gate' on typical grass-fed beef production areas with and without the inclusion of carbon sequestration. The emissions from slaughter-ready animals are considered, which includes the production stages of breeding, backgrounding on pasture, and finishing on pasture or forage. The analysis does not account for downstream emissions, e.g. abattoir, shipment, packaging. However, Wiedemann et al., (2015) suggested that analysis cradle to farm-gate accounts for 90-95% of total emissions.

Packhorse Carbon Footprint

The carbon footprint of Packhorse operations (baseline and 2028, Figure 2) was calculated on a per property basis using the University of Melbourne's SB-GAF Greenhouse Gas Accounting Framework for Beef. The baseline emissions profile demonstrated that the largest source of emissions was from enteric methane (75%), followed by manure on pasture (22%).

The projected carbon footprint for 2028 (net-zero emissions) was determined using the Primary Industries Climate Challenge Centre (PICCC) and the University of Melbourne's Greenhouse Gas Accounting Framework. Soil carbon storage was determined using the SOCRATES model (Queensland University of Technology) and the storage of carbon in trees using the FullCAM model (CSIRO). The 2028 carbon footprint accounts for the expected increase in carrying capacity (livestock numbers) and the corresponding increase in emissions from enteric methane and manure.

Pathway to Net Zero Emissions by 2028

Emissions will be reduced by decreasing the reliance on fossil fuels, which includes a transition to all solar bore pumps and all homesteads off-grid by 2028 (Figure 1). Fertiliser use will be significantly reduced through the incorporation of legumes (nitrogen-fixing) into the pasture mix. Enteric methane emissions will increase from baseline to 2028 due to an increase in carrying capacity. However, on a per animal basis, enteric methane emissions will be 10% lower due to the introduction of legumes into the cattle diet (Boddey et al., 2020). This is conservative given that other technologies to reduce methane (e.g. 3-NOP, vaccine) will likely become available in the next 5 years. Emissions from manure left on pastures will also increase with greater animal numbers, but the proliferation of dung beetles on properties will reduce emissions from manure, on a per animal basis, by around 10% (Slade et al., 2016).

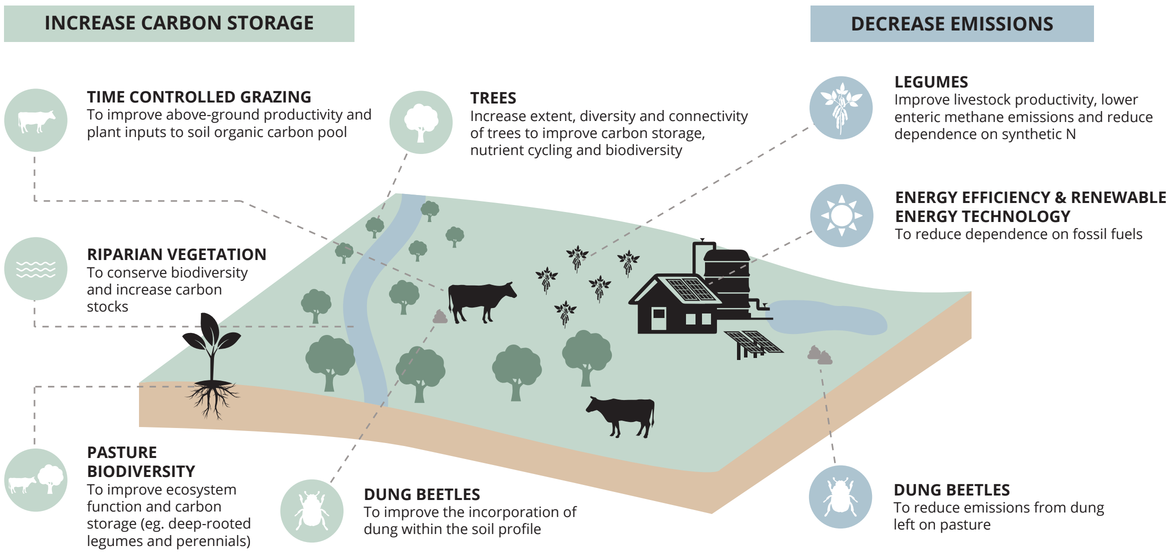

Figure 1: *Methods to increase carbon storage and reduce emissions on farm to meet net-zero by 2028. Adapted from MLA Carbon Neutral Roadmap.*

An increase in the storage of carbon in soils and vegetation will occur primarily through improved pastures and the implementation of high-density short-duration rotations of cattle to ensure long periods of pasture rest and recovery. We expect an annual increase of 0.5 tC/ha, which is based on a review of the available scientific literature (see Packhorse white paper on soil carbon). Riparian zones will be fenced off with infrequent grazing to ensure grasses do not present a fire risk. We aim to increase tree cover on properties to 20-30% (depending on the region), with a focus on preserving high-value habitat and increasing the connectivity of trees to promote the migration of flora and fauna. See Natural Capital targets and indicators in Appendix for more information on promoting landscape ecological resilience. A comparison of baseline and 2028 emissions (and model assumptions) is shown in Figure 2.

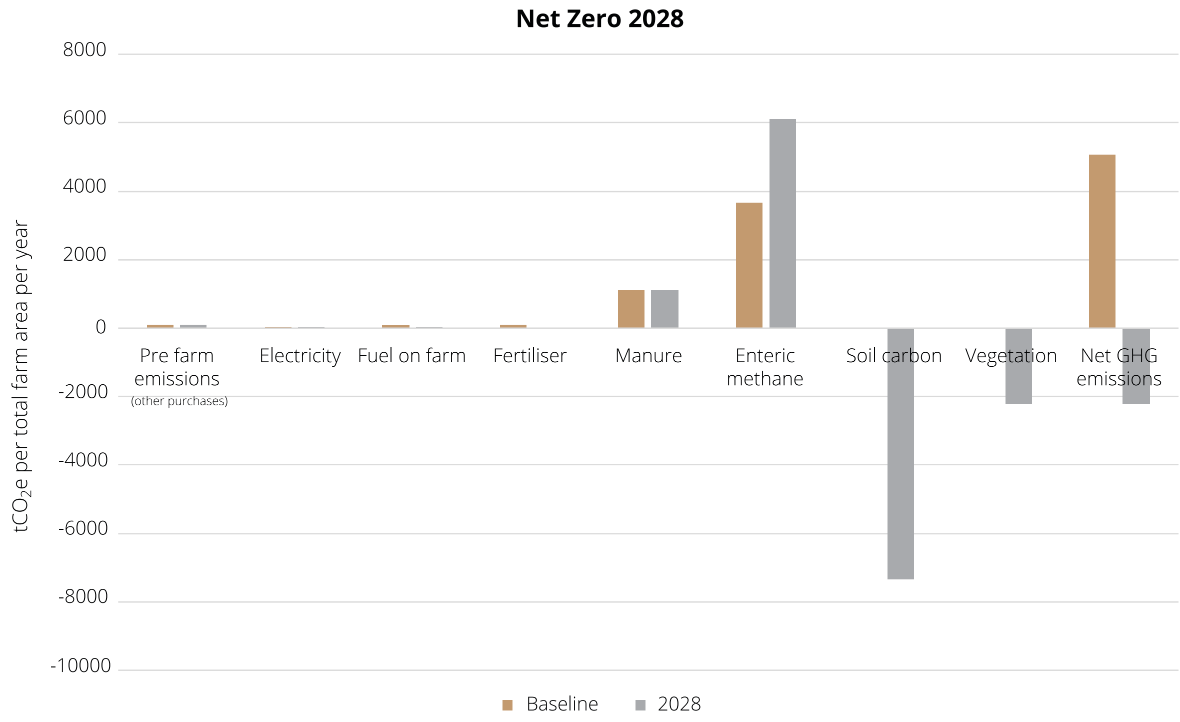

Figure 2: *Carbon Footprint for Packhorse (single property modelled) for baseline and 2028*

Model assumptions:

- Carrying capacity Y1 (baseline) = 3000 head, carrying capacity 2028 = 5000 head.
- 10% reduction in enteric methane due to the introduction of legumes (Boddey et al., 2020).
- 0.5tC/ha/yr rate of soil carbon sequestration on 50% of the property (4000 hectares of land).
- 600 hectares of riparian re-growth and re-vegetation
- Fertiliser use significantly higher in baseline year (Y1) in comparison to 2028 due to soil nutrient correction during pasture establishment phase.
- Diesel use significantly higher in baseline year in comparison to 2028 due to high diesel consumption during pasture establishment
- 30,000 L Diesel/yr in baseline year, 10,000 L Diesel/yr in 2028
- Carbon storage in vegetation calculated using the FullCAM model.
- Average Live Weight Gain 263 kg/year (Wiedemann, McGahan, et al., 2015).

Emission Intensity of Packhorse Beef

Emission intensity refers to the amount of CO_2e produced per kg of live weight. Values were compared to the benchmark analysis of Wiedemann, McGahan, et al., (2015) on the resource use and environmental impact of beef production in Queensland, Australia. Values for non-meat protein were obtained from Eady et al., (2011) and Mejia et al., (2018) (Figure 3).

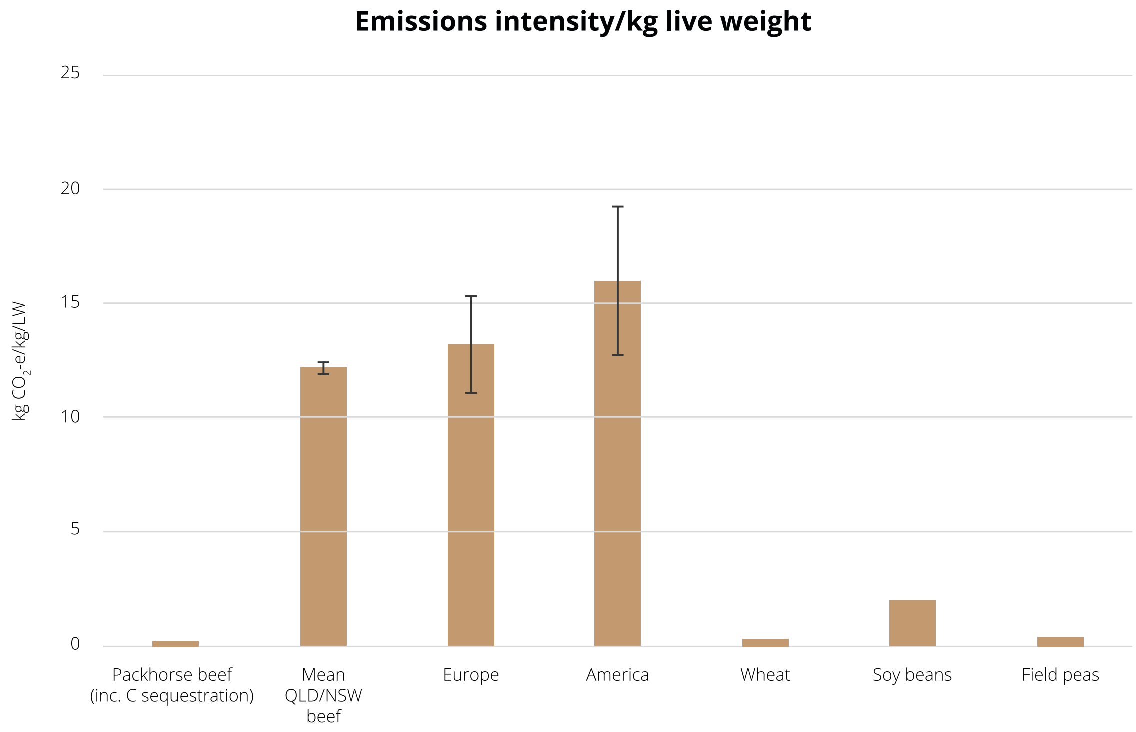

Figure 3: *Emissions Intensity of Packhorse beef when carbon sequestration is included in life cycle analysis*

Results Highlights

Packhorse beef will have a significantly lower emissions intensity than the mean value for QLD/NSW if bio sequestration is considered in the life cycle analysis. The average emissions intensity of grass-fed production (including breeding, backgrounding on pasture and finishing on pasture or forage – i.e. cradle to farm-gate) is 12.15 kg CO_2e/kg live weight at the farm gate, whereas if bio sequestration is included the emissions intensity is only 0.15 kg CO_2e/kg live weight. An emissions intensity of 0.15 kg CO_2e/kg LW puts beef on a par with other non-meat protein sources e.g., field peas emission intensity is 0.4 kg CO_2e/kg product.

It is important to note that this analysis only considers the carbon emission story. Many additional environmental benefits will ensue due to regenerative grazing practices, including increased natural habitat, increased biodiversity, reduced erosion and sediment loads due to greater ground cover, and reduced need for fertilisers.

Risks/uncertainties

- There is a risk of the non-permanence of soil carbon sequestration, where carbon sequestered is re-emitted – for example, during dry periods. However, best land management practices, e.g. maintenance of ground cover, can increase the resilience of regenerative systems to these environmental shocks.
- The rate of soil carbon sequestration slows as the soil becomes "carbon saturated". In other words, it is a finite accumulating stock and cannot accumulate indefinitely. However, given the low carbon baseline (1.2% organic carbon) and the relatively high clay content, it is unlikely that the soil carbon levels will become saturated in the next 25 years (lifetime of soil carbon project).
- There are several assumptions used in this assessment that need to be confirmed, e.g. rate of soil C sequestration. However, an extensive scientific review shows that a 0.5 t C/ha/yr sequestration rate is conservative [see Packhorse Soil Carbon White Paper, 2021].

Conclusion

- Packhorse beef is potentially on par with other non-beef protein sources concerning its carbon footprint
- There is the potential that Packhorse beef is climate positive (i.e. carbon storage is greater than emissions)
- Regeneratively grazed beef can escape the stigma of high carbon emissions attached to conventional beef.
- Packhorse is investing technology to improve the measurement of the benefits (soil carbon and other co-benefits e.g. biodiversity) of regenerative agriculture. Packhorse is also investing in research to quantify the emission reduction benefit of incorporating legumes within the cattle diet (in collaboration with Queensland University of Technology and Agrimix).

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Appendix 1: Packhorse's Natural Capital Targets and Indicators

NATURAL CAPITAL					
Focus Area	Air (GHG reduction)	Soil	Biodiversity	Water	Vegetation
Aim	• Reduce GHG emissions (net zero) • Reduce emissions from the use of fossil fuels • Increase carbon sequestration in soil and trees	• Healthy functioning soils that provide food, biomass, and ecosystem services	• Manage land to promote above and below ground biodiversity	• Improve water use efficiency and water quality	• Maximise living plant production, plant leaf density, and ground cover • Increase the extent, diversity and connectivity of trees • Preserve high-value habitat and ecosystems e.g., riparian zones, remnant vegetation, and zones of ecological significance
Targets/ Outcomes	• Net zero emissions 2028 • Carbon sequestration of 0.5tC/ha/year • All bore pumps to solar within 2 years • Homesteads off the grid with solar by 2028	• Positive trend in soil health indicators • Reduction in % area covered with salt intrusion/ erosion. • Soil health and functionality are preserved and improved • Land degradation is mitigated	• Positive trend in acoustic complexity (sound of birds, bees, insects, frogs, etc.,) • Positive trend in habitat size and condition, connectivity, and permeability • Increase plant diversity by 50% by 2028	• Positive trend in water use efficiency. • Positive trend in water infiltration and water retention in soil. • Water resources are used responsibly and equitably • Increase ground cover and manage riparian areas to reduce sediment run-off	• Increase ground cover to 85% within 3 years (stage 1 properties in 600 mm rainfall zone) • Increase tree cover to 20% • Biodiverse ecological communities are protected and enhanced
Indicators	• Diesel consumption reduced • Solar pumps installed • Soil carbon storage measured • Tree carbon and cover measured • Net ecosystem exchange	• Soil indicators: Water retention, pH levels, carbon, nutrients, microbial diversity, soil aggregate (structural) stability • Mapping soil erosion and salinification areas (remote sensing and on the ground surveys)	• Acoustic sensors and species diversity index change over time • Below ground (soil) biodiversity measured by microbial DNA • Plant diversity surveys (on the ground survey) • Remote sensing imagery to detect trends in vegetation size, condition, connectivity, etc. • Species diversity count and threatened species count • Pollinator action plan in place	• Water infiltration (ml/s) • Water use efficiency (conversion of rainfall to above-ground plant biomass)	• Remote sensing (satellite imagery) • On the ground surveys

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