DETERMINING THE GREENHOUSE GAS REDUCTION POTENTIAL OF REGENERATIVE AGRICULTURE

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Key processes contributing to greenhouse gas balance in agricultural systems with livestock

1

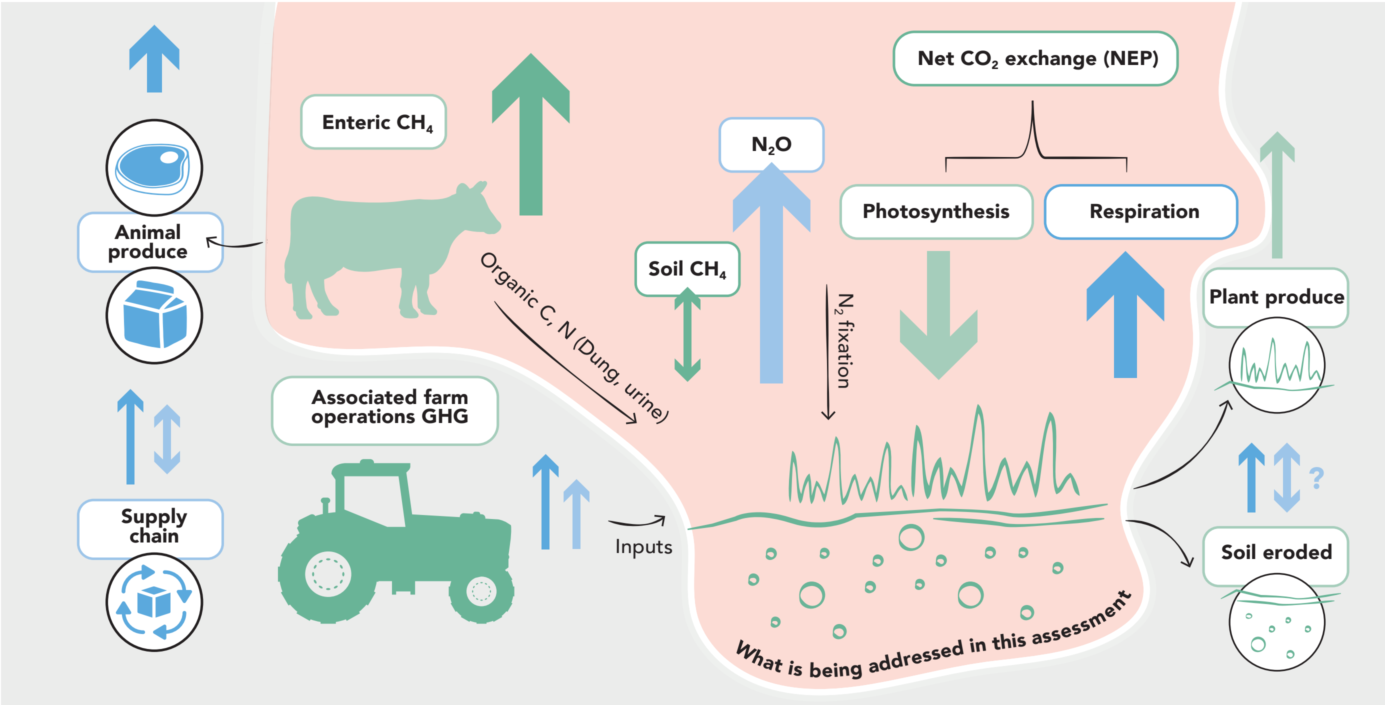

FIGURE 1. Schematic of the processes contributing to the greenhouse gas balance of an agricultural system with animals.

Solid arrows indicate GHG flows. Black arrows indicate transfers of matter in other forms that provide source material for GHG emissions. Processes shown inside the pink area occur on the agricultural land and are considered in this chapter, except for emissions from machinery. Processes outside would be accounted for in life-cycle assessments but are not considered here. For crop production, the animal-related processes shown in the top left do not occur, but the other parts of the schematic remain the same.

Proposed effects of RA and related knowledge gaps

2

1

RA increases the amount of carbon stored in soils

Possible pathways for GHG reduction:
• RA might promote C gain via greater soil retention, increased ground cover, increased plant biodiversity, plant C input at greater depth, trampling and more photosynthetically active forage.

Evidence:
Some evidence from overseas pastoral systems.
None for NZ.

2

RA reduces nitrous oxide emission from soils

Possible pathways for GHG reduction:
• Via decreased fertilizer N inputs and decreased animal excreta N
• Via increased aeration / decreased water saturation
• Via increases in plant diversity leading to more biological nitrification-inhibition

Evidence:
Some evidence about individual mechanisms.
No study so no evidence for NZ RA systems.

3

Ruminants in RA emit less methane

Possible pathways for GHG reduction:
• Via lower feed intake, less CH_4 emissions per feed intake due to forage quality, less CH_4 emissions per produce output, less CH_4 emissions per feed intake due to seaweed inputs in the system (dietary supplement/in pasture)

Evidence:
Conflicted – based on overseas and NZ studies of specific proposed mechanisms.

4

RA increases the capacity of soils to consume methane

Possible pathways for GHG reduction:
• Via lower N input from fertilizers and animal urine, as nitrogen and methane cycles interact) • Via increased soil aeration and more standing biomass • Via increased fungal-to-bacterial ratio

Evidence:
None in NZ. At standard stocking rate, enteric emissions exceed soil methane exchange max capacity by one to three orders of magnitude.

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Key consideration for effective research

- **Study whole management not practices:** RA practices are combined serially or simultaneously to achieve desired outcomes – so research must quantify the effect of management as whole, not just effect of individual practices.
- **Two possible research pathways:** changes through time or comparison between RA and mainstream
- **Set up experiments on commercial farms:** to allow best realisation of real-world conditions, measurements at relevant scales (e.g. paddock), spatial representativeness. Needs lots of replicate to account for farm-to-farm variability
- **Large number of replicates and multiple years (15+ sites or paired sites)**
- **Combine multiple technologies** (sensing, direct, micrometeorological, tracer, chamber, and include technologies in development wherever possible to advance capacity to quantify GHG at meaningful scale and lower cost)

Recommendations

Recommendation 1: Direct quantification of soil carbon stocks

1: Paired site study on existing RA vs adjacent 'mainstream systems across New Zealand.

match paired sites carefully

Include 20 or more commercial farms (20 or more).

Sample Full-profile soil C stocks (>60cm depth) at carefully

⟶ will deliver cheap and rapid (e.g. within ~1 year) answer the potential of RA to sequester additional C.

⟶ Other soil and plant parameters measured to link GHG to production outcomes and ecosystem health.

2: Replicated, farmer led/managed, paddock-to-farm scale, intentional experiments across New Zealand.

Apply RA management to one part of the farm (e.g. a paddock) – keep an adjacent area as control

Include 20 or more paired paddocks / farms.

Quantify soil carbon stocks (and other properties) before or at beginning of the transition to RA, and monitor evolution of stocks through time (more than 3 years).

⟶ allows more control of environmental variability – but takes longer

3. Incorporate RA sites into the existing National Soil Carbon Monitoring System for Agricultural Land as a separate land use class (Mudge, 2019).

Recommendation 2: Comparative soil chamber experiments for N_2O and CH_4 exchange

Compare in-situ N_2O emissions from RA and non-RA soils, with and without application of animal urine.

If desired, also quantify soil CH_4 exchange.

Include measures of plant and soil properties to gain a understanding of ecological mechanisms involved.

⟶ provide rapid indication of RA potential to alter net GHG emissions from soils

Recommendation 3: Paired paddock-scale studies for ecosystem CO_2, N_2O and CH_4 exchange

Use Eddy-covariance for carbon balance approach

Test emerging low-cost flux-gradient method for N_2O and soil CH_4.

⟶ 2-3 years required, best replicated to account for regional variability

Recommendation 4: On-farm experiments for CH_4 from animals

Undertake on-farm experiments to compare CH_4 emissions from animals on diverse RA diet and ryegrass-clover diet, combined with accurate estimations of animal feed intake, using the atmospheric dispersion model or the GreenFeed instrumentation.

Recommendation for supporting studies: Detailed small plot experiments based on results from above approaches to disentangle specific individual mechanisms

Ultimate "gold standard": combine all above approaches in randomised and replicated trials with full farm systems (Beukes et al. 2017) – combine GHG measures with measures of farm production and profit over multiple years. Technically possible, but expensive and requires large transdisciplinary research consortium. We recommend in the first instance to invest research funds in Recommendations 1 to 4.

Source:

Laubach J, Mudge P, McNally S, Roudier P, Grelet GA 2021. Determining the Greenhouse gas reduction potential of regenerative agricultural practices. Manaaki Whenua – Landcare Research Contract Report LC3954-12 for Our Land and Water National Science Challenge & The NEXT Foundation.