New-Generative Agriculture: based on science, informed by research and honed by New Zealand farmers… an update for 2022

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Introduction

Science is important. It provides a foundation for improvement and has a framework for advances. It is a system of constant challenge and critique. Scepticism is healthy. It requires an open and enquiring mind to imagine what might be in the future. It requires rigour and attention to detail to ensure that facts, evidence and data are analysed dispassionately… however passionate the scientist might be about the topic. It also requires the ability to set new material in the context of what has occurred in the past to achieve insights.

The recent platform of Regenerative Agriculture (RA), into which many are urging us to commit ourselves for the good of the country, is an example of enthusiasm preceding science. We have been told that making change cannot wait for the science (Burns 2021). In fact, we already have considerable research on organic agriculture which "can inform the evaluation of regenerative agriculture" (Terra Genesis International n.d.). In addition, the similarities between organics and RA have been well described (Burgess et al. 2019), the main difference being prohibiting synthetic chemicals in organics in comparison with minimising their use in RA.

Over the past two years, Regenerative Agriculture advocates have been vocal in explaining what it aims to do and how the goals can be achieved. The publication of a 'White Paper' (Grelet et al. 2021), funded by MPI and involving 70 authors and many contributors, sought to identify future research focuses to support RA. The White Paper used this quotation at the forefront:

By 2050, our planet will need to feed close to 10 billion people. **It is vital that we transform our agricultural and food systems so they work with and not against nature***. This is the only way to ensure people everywhere have access to a healthy and nutritious diet (Inger Andersen, Executive Director, UN Environment Programme). (*bold is as presented in the document.)

Of course, these words are a truism but the implication of their use in the introduction of the White Paper is clear – conventional agricultural systems work against nature whereas regenerative agriculture works with it. In effect, the term 'conventional agriculture' has been weaponised (Sumberg & Giller 2022): RA encapsulates 'good' and virtually everything else is 'bad'. This is a dangerous generalisation. While some of the intensive food production systems in the US and Europe (e.g. large-scale feedlots) might appear to be 'working against nature', the predominantly pastoral agricultural systems in New Zealand would seem to be closer to 'working with nature'. Nevertheless, in the spirit of continuous improvement, it behoves us to look closely at Regenerative Agriculture.

"RA is much more than a system of farming: it is a mindset that questions the status quo, and instead of becoming defeatist sees opportunities for different ways of living, working and farming" (Grelet et al. 2021). People who work with New Zealand farmers know that farmers question their activities all the time and are constantly seeking better ways of doing things. Rather than being 'defeatist,' the great majority of farmers have an appetite for change and the existence of the NZGA is testament to that; the journals are full of examples.

The White Paper (Grelet et al. 2021) identified 17 research needs, 15 priorities and contained other sections where specific questions were asked. We maintain that many of these research needs already have at least some data to inform the conversation, much of which has been ignored in the white paper. Some of these data do not support the principles of RA. In this paper, we list White Paper's 15 priorities and use existing data to develop a commentary on the validity and importance of them. First though, it is important to provide some context – some sense of the canon of relevant NZ farm systems knowledge.

Grazing principles

Most articles written about regenerative agriculture in New Zealand (and see Associate Professor Jason Rowntree, Michigan State University, speaking at the World Hereford Congress 2020) advocate pastures that are both long (i.e. high biomass) and species-rich, often with species that are flowering and setting seed. This is at least partly a reaction to overcultivation and overgrazing in pastures in other countries that create low plant density and significant bare ground meaning less solar energy can be converted into edible forms (Gordon et al. 2021). The starting point of overcultivation and overgrazing is not appropriate for New Zealand where permanent pasture under rotational grazing management is the norm.

Long pasture grazing

Long pasture or 'top of the production curve' grazing is mentioned in regenerative agriculture as a way of maximising leaf area and hence photosynthesis. Regenerative grazing coaches suggest that grazing only the top one third to one-half of a taller pasture is healthier for the stock and the soil (e.g. https://www.odt.co.nz/rural-life/rural-people/grazing-coach-keen-help-others 2018) and growing taller pastures and only taking the top half results in more grass growth on farm (https://www.nzherald.co.nz/hawkes-bay-today/news/next-level-grazing-comes-to-waipukurau/MRJPZJGAMALAZJ5E5H6D4SNSXE/ 2020)

Further claims include 'resting paddocks until the main indicator grass plant (the desirable species you have the most of) in the paddock reaches the boot stage… which puts you at the end of the fastest growth stage of the plant so you can be sure you have capitalized on what Andre Voisin called ""the blaze of growth"". We found when we reached a grazing height of 50cm and a residual of 20cm our stock was the healthiest and so was the pasture' (https://www.phwealth.co.nz/knowledge/regenerative-farming-a-case-study 2019).

It is critical to note that this recommendation is at least twice the height of what has been described consistently in Beef+Lamb and DairyNZ advice as optimal for pasture quality.

Increasing rotation length to graze pasture after the 3-leaf stage reduces pasture quality as older leaves begin to die. Grazing too late and increasing rotation length beyond the 3-leaf stage results in wastage as the first leaf begins to die. This dead material reduces pasture quality. https://www.dairynz.co.nz/feed/pasture/assessing-and-allocating-pasture/leaf-stage/

https://www.dairynz.co.nz/media/880808/technical_series_august_2014.pdf; https://beeflambnz.com/knowledge-hub/PDF/achieving-good-cattle-growth-rates-while-maintaining-pasture-control.pdf

In addition, increased weed ingression is likely and the deterioration in pasture quality will increase GHG per unit of production because of decreased animal performance (Burggraaf et al. 2018 MPI Funded review). The DairyNZ/Beef+LambNZ recommendation that 'Consistent grazing residuals of 3-5cm (1500-1600 kg DM/ha) will enable sun light to reach the base of the pasture' acknowledges that this process ensures perennation of key species in the sward (e.g. https://www.dairynz.co.nz/media/880808/technical_series_august_2014.pdf; https://beeflambnz.com/knowledge-hub/PDF/achieving-good-cattle-growth-rates-while-maintaining-pasture-control.pdf).

Time to achieve dynamic equilibrium

Of considerable importance in the establishment of research trials to investigate changes such as a reduction in fertiliser inputs, is that results from the first few years are not necessarily indicative of the final dynamic equilibrium. A 'reasonable impression' of the ultimate (sustainable) outcome of a change in N input 'yield' (of milk or meat) can be obtained, but little indication on C sequestration and N emissions will be revealed (Parsons et al. 2016). Long term superphosphate trials confirm that changes continue for many years: 'Pasture measurements on farmlets where fertiliser has been withheld for 15 years show that changes in dry matter production and botanical composition are continuing to occur' (Dodd & Ledgard 1999).

Analysis of changes to complex farm systems

Farm systems are complex, relying on the interaction between physical, biophysical, social and cultural systems to deliver high-value food from solar energy. Experiments are usually focused on a single variable within the system, with all other variables controlled for (where possible). One way to gain insight into what outcomes might be expected from a systems-level change (such as RA) is to use a model. This is especially true where long-term field data is limited or absent. There are few models, however, that can be appropriately parameterised to reflect the changes required for RA and then predict systems-level outcomes. The Hurley Pasture Model (HPM) does and has been in a comprehensive examination of the impact of changes to pastoral agricultural systems on system-scale outcomes (Parsons et al. 2016). While not focused on RA, the results from this paper can be used to understand the outcomes of 'RA-like' practices on the whole farm system.

In brief, Parsons' work indicated that a change in a dairy operation from 300 kg/ha N to 150 kg/ha N per year will reduce carbon sequestration from a total of approximately 90 t/ha to approximately 70 t/ha (22%). Carbon stocks equilibrated over the following 200 years, with the bulk of the change in the first few decades. Production from the dairy farm would decrease from approximately 145 kg/ha of N in milk to approximately 105 (28% decrease), and N loss (nitrous oxides and nitrate) would decrease from 155 kg/ha N to approximately 50 kg/ha N (68% decrease). In contrast with the above, with long pasture grazing N emissions would be slightly higher at the same N (150 kg/ha) input - approximately 65 kg/ha N. Long pasture grazing would also reduce milk production (to approximately 80 kg/ha N; 45% decrease) and be balanced by an increase in soil carbon to almost 120 t/ha (33% increase).

Consideration of White Paper Priorities

It is important to note that the fifteen priorities listed by Grelet (and repeated here) are not independent – nor did Grelet intend them to be. Each one is considered separately with some overall concluding remarks below.

1. Impact of RA on freshwater outcomes

Concerns about quality of freshwater hinge around sediment, nutrients and bugs (faecal coliforms) (Parliamentary Commissioner for the Environment 2012), collectively termed contaminants. The management systems and technologies that farmers have been implementing since 1995 have resulted in a significant decrease in potential contaminant load (Monaghan et al. 2021). In brief, 45% more N and 98% more P would have entered rivers from dairy-farmed land between 1995 and 2015 if farmers hadn't changed their practices. On sheep and beef farmed land, 30% more sediment would have entered rivers between 1995 and 2015 if farmers hadn't changed their practices. The reduction was achieved through improved effluent management and irrigation, and stock exclusion from waterways.

Researchers estimated that if all known and developing mitigation actions were implemented by all dairy and sheep and beef farmers by 2035, current water quality objectives could be achieved in most catchments. The impact of changing the current system to regenerative agriculture would depend on what the new approach entailed, however the HPM work discussed above would suggest a potential increase in N emissions with possible impact on waterways.

Conclusion: It is possible that RA-style long, diverse pastures may have some negative impact.

2. Impact of RA on food quality and safety

There is no evidence that food produced in organic systems is substantively higher quality (nutrient concentration) than food produced in conventional systems; differences due to cultivar, season and soil type are apparent, whatever the production system (Rowarth et al. 2020a and references therein).

Organically produced food is often claimed to be 'safer' with no herbicide residues for example. Food safety in New Zealand is high, whatever the production system. MPI's Total Diet Survey 2016 (released in May 2018), involved the analysis of 1056 composite food samples, with eight samples taken of 132 different food types representing the most consumed foods for the majority of New Zealanders. All samples were analysed for 301 agricultural chemical analytes, six contaminant elements (aluminium, arsenic, cadmium, lead, mercury and tin) and four nutrient elements (iodine, selenium, sodium and zinc). Sub-groupings of foods were analysed for further analytes, fungicides and herbicides. None of the estimated dietary exposures to agricultural chemicals represented a risk to health, with the highest dietary exposure reflecting only 2.9% of the respective health-based guidance value. Most of the agricultural chemicals for which analysis was performed in the survey were not detected and therefore calculated to have a zero exposure.

Conclusion: it is reasonable to conclude that food from RA systems will not differ in quality. There will, however, be less of it.

3. Relationship between RA and farmer empowerment and mindset

Research by Ogilvy et al. (2018) and the subsequent financial analysis by Francis (2021), both included in Rowarth et al. (2020a), but not referenced in the White Paper (Grelet et al. 2021), remains the only readily available published material. Francis showed that the regenerative graziers had foregone approximately A$2.45 million over a ten-year period. The title of the Ogilvy et al. (2018) report: Graziers with better profitability, biodiversity and wellbeing implied otherwise, but profit had been calculated per animal rather than per hectare. Of further interest is that biodiversity was not measured – graziers with higher biodiversity as indicated by above ground plants, were assumed to be regenerative. Well-being was self-assessed and, in the small sample in the research, was higher than for conventional graziers. Regenerative graziers actually indicated higher stress than conventional graziers due to financial concerns (Ogilvy et al. 2018).

Conclusion: the few existing data are qualitative. The empowerment and mindset of farmers is subjective and highly personal. It remains unclear as to what impact research might have in this space

4. Long-term viability of whole systems and stewardship

Viability requires finances to be in the black. Data from Australian graziers showed that regenerative agriculture is not as profitable as conventional agriculture (Francis 2021). Align Farming, which is featuring in a series of articles in the Dairy Exporter, has shown that at least during the conversion process, regenerative agriculture per hectare produces lower returns than conventional agriculture.

Research has found no evidence to support the contention that organic yields 'pick up' after the initial decrease (Kirchmann et al. 2016); whether regenerative agriculture is different has yet to be shown.

A premium is required for organic production systems to be viable but, as yet there is no premium associated with regenerative agriculture. A willingness to pay study (Yang & Renwick 2019) reported that consumers would be willing to pay a premium of 25% and 22.3% for grass-fed dairy and meat products, respectively and 29% and 31% for organic dairy and red meat products, respectively. Environmental claims (nitrogen and carbon) were associated with a premium of 25% and 19%, respectively.

In an extension of the Yang and Renwick (2019) research, Lucci et al. (2019) explored the economics. A C-neutral system decreased N losses but relied on imported feed to maintain production. Off-farm feed production effects were included in the carbon footprint calculations, but not in N leaching estimates which were only from the farm.

Lucci et al. (2019) calculated that without a premium, most farms would be in negative effective farm surplus. The authors warned that although organic dairy offered the best option, delivering organic and pasture-fed attributes came with a greater risk from drought or unseasonal weather, limiting feed options and increasing costs substantially during a 'bad' year, and wouldn't be appropriate for all farmers. This conclusion supports earlier work (Shadbolt et al. 2005, 2009) and has implications for resilience.

Conclusion: RA effectively removes some management tools from the farmer's toolbox and adds constraints around livestock management i.e. grazing. This adds cost and risk, running counter to RA claims.

5. Impact of RA on animal welfare

New Zealand has a C grade on animal welfare from World Animal Protection's index (https://api.worldanimalprotection.org/ 2020). Comparison with other countries indicates that achieving a higher score would require upgrading laws around suffering, zoos (captivity), rodeo (draught and recreation), and companion animals. In farming and research New Zealand is scored at least as highly as the countries with which we trade.

The White Paper asked: How do young animals/low social order animals in mixed age/species livestock flocks/herds perform in terms of animal production?

This seems to be a question for countries other than New Zealand where young animals are typically run separately until they have similar feed and management requirements to the adults (e.g. Allison 1977).

The very fact that animals are in paddocks rather than feed lots generally reduces competition.

Mixing animal species is often done on farms but not generally within the same paddock (unless pasture management requires it in, for instance, beef and sheep operations). Keeping them separate enables management of pasture and parasites by meeting the needs of different stock classes at different times of the year.

Conclusion: RA is unlikely to directly contribute to better animal welfare outcomes in New Zealand.

6. On-farm total (all taxa) biodiversity under RA

The desire is for all parts of the faming environment to be biodiverse, for example, microbial, insects, plants, birds, genetic, and in soils (Grelet et al. 2021).

The start is hyper-diverse pastures and the 60-species Jena experiment in Germany (Weisser et al. 2017) is often cited. The biggest changes in numbers of organisms above and below ground occurred with moving from 1-10 species, although there was an ongoing positive response. In process rate (e.g. decomposition, weed suppression, pathogen resistance) the biggest change was achieved between 1 and 5 species (Weisser et al. 2017).

The Jena trial did not involve grazing animals. The standard management involved no fertiliser and 2 mowings; production was 10,000 kg/ha DM with 60 species. Adding fertiliser (including 100 kg/ha N) increased production to approximately 11,500 kg/ha DM. Average rainfall was approximately 598 mm and evapotranspiration was 573 mm. In New Zealand, research has indicated that there is little to no advantage in dry matter production beyond a 3 species mix (Black et al. 2017). More species leads to difficulties in optimising management, competition, death and weed ingress (Tozer et al. 2011) which results in decreased pasture quality.

A question was posed in the White Paper (Grelet et al. 2021) about the grazing principles in highly diverse pasture swards, i.e. how selective and competitive grazing affects pasture performance including feeding and nutritive values? However, as considerable work has been done on pasture quality and animal performance, and no differences have been reported in nutritive values between conventional and organic agriculture, it is not clear why there would be differences in regenerative agriculture.

Further, research has shown that the biggest impact on biodiversity is the expansion of agriculture (Sanchez-Bayo & Wyckhus, 2019) not the type of agriculture being undertaken, therefore reduction in production per hectare is not desirable, as that would necessitate more land under agriculture to produce the same amount of food (Schneider et al. 2022).

Conclusion: at a farm scale, RA will probably increase biodiversity, at least that of plants, but have little effect on the product.

7. Soil carbon (particularly in RA farming systems)

Decreasing carbon offtake in meat and milk allows more carbon to be trampled into the soil. The RA concept is that the increased carbon in the soil will offset climate change (mentioned in the White Paper Grelet et al. 2021). However, in the soil the trampled plant material is decomposed by soil organisms, returning carbon dioxide to the atmosphere. Recent research from Europe (Berthelin et al. 2022) states that "The requirement to add many times more carbon than what one aims to sequester makes it practically impossible to add sufficient amounts of crop residues to soils to have a lasting, non-negligible effect on climate change."

Further, increasing soil carbon requires other nutrients (a tonne of carbon is associated with 80-100 kg N, 20 kg P and 14 kg S, for instance), a fact which is generally overlooked (Rowarth et al. 2020b). The nutrients have to come from somewhere which, in a productive system, typically means fertiliser of some type (Roberts 2020).

Conclusion: any changes in soil C due to RA will likely be small and temporary.

8. Impact of RA on farm and landscape resilience to extreme weather

(How is productivity of regenerative systems influenced by adverse events in comparison to conventional systems, including resilience and persistence?)

Resistance (the degree of change after perturbation) and resilience (time until pre-perturbation state is regained) of aboveground biomass production against drought has been reported to be only partly dependent on species richness; the main driver was found to be management intensity (Weisser et al. 2017). This has implications for grazing management which is an important factor in pasture persistence (Tozer et al. 2011).

Although Ogilvy et al (2018) suggested that regenerative graziers were more resilient than conventional graziers (and that more research was required), this appeared to be associated with 'an increased degree of inter-annual stability, returning consistent financial returns with significantly reduced variability compared to conventional farms'. Francis commented that the cost of this was almost a quarter of a million Australian dollars a year (averaged over a decade) – the regenerative graziers were not able to take advantage of a good year.

Conclusion: effects due to RA seem unlikely

9. Accountability in food systems

Accountability was mentioned three times in the White Paper but no explanation of what it means was given. It is possible that it refers to the United Nations commitment to sorting out global food supplies (no hunger being one of the Millennial goals) but reducing production is unlikely to assist.

Conclusion: not possible

10. Impact of RA on NZ access to premium and niche markets

Access is a matter of trade agreements, and it may be that regenerative agriculture becomes a non-tariff barrier to trade. Large companies such as Danone, Nestle, Walmart, Unilever and Cargill have already declared their intention to become carbon neutral by planting trees and encouraging farmers, particularly those in cropping) to adopt regenerative farming.

Conclusion: Access to customers might hinge on embracing the concept of RA.

11. Role of RA in configuring farmscape for native biodiversity

A quarter of New Zealand's total indigenous vegetation cover (temperate evergreen forest, shrublands, wetlands and grasslands) is on farm. It covers 2.8 million ha (approximately 25% of New Zealand's total) within the almost 11 million ha of land used for pastoral farming in New Zealand, and most is on mixed livestock farms. Modelling a change from grazing to biodiversity enhancement was found to affect farm system design, which had a knock-on effect on livestock policy, sale and purchase dates of livestock and the grazing management plan. The result was a decrease in farm revenue and Net Present Value (Dominati et al. 2021). It is difficult to see how regenerative agriculture per se will affect farmscapes.

Conclusion: the meaning of this priority is obscure. RA does not specifically refer to native species

12. Seed contaminations (arable) from multispecies crops and pastures

Seed contamination potential arising from hyper-diverse pastures seeding in situ has been raised as a potential problem (Charlesworth et al. 2020, Harrington 2020). The valuable seed multiplication industry is perceived to be at risk (Stewart, A. CEO Foundation for Arable Research, pers. comm. 2020); concerns were articulated in the August edition of Countrywide last year.

Conclusion: RA systems are a risk and closer scrutiny needs to be made of promoted seed mixtures.

13. Relationship between farmer support and learning network

There is no question that farmer support and learning networks are important. There is also no question that they have been a major part of the agricultural industry, whether they take the form of the Deer Industry's advance parties, the DairyNZ discussion groups or the Beef+Lamb field days. Conferences, seminars and workshops also play a role here. Regenerative agriculture has been described (Merfield 2021) as being where organic agriculture was in the 1920s-40s (in that it is a loose but coalescing group of like-minded people, mostly farmers and growers, the first formal associations are starting to be formed, and the message is spreading globally). A major difference, however, is that the message is growing rapidly, due to the internet and particularly social media, neither of which were available in the 1920s-40s.Whether this is a positive advantage for RA over organic farming adoption is yet to be seen.

Conclusion: if RA stimulates conversations between farmers who would normally ignore regular industry support channels, then some good may come of it. IF the information provided is accurate.

14. Profitability of RA farming systems

This has been discussed under Priority 4.

15. Role of RA for increasing enjoyment in farming.

Enjoyment is fundamental in discussion groups and other group activities discussed under Priority 13. The regenerative agriculture discussion groups are not different and are, as Merfield (2021) suggests 'a loose but coalescing group of like-minded people'.

Further questions and topics in the White Paper

A further series of questions posed in the White Paper (Grelet et al. 2021) included:

- What are the impacts of farm management (diverse pastures/cover-crops/bio-stimulants) on product quality (meat/milk/wine) and quantity?
- Which tools require further development to estimate quantity and quality of diverse pastures?
- What is the potential for use of Brix measurements (e.g. determine the susceptibility of plants to insect pests)?

Additional topics mentioned included humates, the Albrecht Kinsey approach to soil testing, and the use of seaweed.

The research addressing these points has been covered in AgScience 57 and in the AgScience Hot Topic on Regenerative Agriculture (Rowarth 2020).

Conclusions

The research priorities and questions proposed in the White Paper are aimed at investigating farm system changes that might occur as a result of using RA practices.

If RA is focussed on continuous improvement, there will be no change for the New Zealand farmer who has been on that trajectory of improvement for decades. If it is a fundamental reset to much lower production and productivity, the consumer will be expected to pay more for the product – and consumers are fickle.

Setting aside tools and approaches advocated (especially the long pasture grazing and hyper-diverse pastures, with humates and seaweed additions, checked with Brix and Albrecht Kinsey) leaves farmers with what we are already doing, and the concept expressed in the previous paper (Rowarth et al. 2020b):

> Mixed pastures maintained at optimal quality allowing maintenance of high soil organic matter content and the soil organisms it supports by managing grazing animals in a rotation programme which recognises rapid pasture growth in good growing conditions while creating the world's most efficiently produced milk and meat from animals in a natural environment.

This year we can add – managed by innovative farmers constantly striving to improve their performance and supported by agricultural scientists focussed on the same goals.

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