The Soils Gap

Interactions between Science, Commerce and Culture

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1. Executive Summary

Soils lay the foundation of all farming productivity. Whether the farm is managed conventionally or holistically; it all starts with soil.

How farmers manage their soil is influenced by multiple factors. Overarching all of them is our scientific space which affects farmers' perceptions both culturally and technically.

Linear, cause and effect, output focused, studies suit fertiliser research and fit well with our commercialised scientific frameworks. This product based mentality has extended into our shift towards environmental research with productive environmental science providing solutions through this lense. Meanwhile studies on soil function have been limited, and studies on soil function relating to productivity are non-existent. With baseline biological data missing, soil biology studies related to fertiliser usage have used inconsistent rudimentary measures that have not been built on over time.

The major players within our commercialised scientific frameworks have been driven by market incentives in a way that flies by soil biology and function without stopping to investigate. Public funding is limited, private funding won't receive a product from it and our scientists have entire careers within this framework that encourages short term thinking. So the long game of soil, unwinding its complexity and variation, falls by the wayside in spite of the possibilities it can bring.

Farmers, in an effort to do the best they can, take advice based on these scientific outputs. The science technically supports fertiliser and culturally supports linear thinking. There is no scientific basis for holistic management, because the studies have not been conducted.

Combined with political and media portrayals, an unnecessary cultural gap is created between conventional and holistic farmers. A gap that limits what conventional farmers see as viable options and leaves holistic farmers to do their own experimentation.

This paper does not make arguments for or against either strategy, but rather highlights how different farmers consider soils within their systems and the challenges they experience in managing them. Combined with the views of advisors and scientists, it tries to explain the drivers behind these challenges and perceptions.

2. Acknowledgments

Thank you to the team at Kellogg Rural Leaders and all their partners who make this course happen. It has been an eye opening and challenging experience that I long thought I wouldn't engage with.

I could not have done so without my solid team of staff on farm, particularly Charly my Assistant Manager who has stepped up on multiple occasions while I was away.

I would also like to thank Findal for giving me a push to engage with the programme and to my parents for their support.

I appreciate the time given to me by all interviewees involved. I had some fascinating conversations, not all of which made it into this report.

3. Introduction

Soils hold an odd space within our agricultural sector. Their variety of base material defines many management practices and production capacities, with variation not just by region but also within individual holdings. While their importance is acknowledged across all farming styles and strategies, many do not focus on soils specifically as a driver of their system.

As a broad statement, traditional (conventional) farming in New Zealand happens above the ground. We assess pasture growth as a defining feature of soil health. When considering who regards soil as core to their systems, looking past base material to other features like structure and biology, the path leads towards those in the holistic farming space.

Many view these two strategies as separate from each other, focusing on different elements for different outcomes. However, at their foundation they share more similarities than differences. Both systems seek to draw a profitable business from perennial pastures grown from soil and grazed by stock. As many have noted, from an international view, all New Zealand pastoral farming would be considered holistic; and yet collaboration between the two strategies is minimal.

Considering approaches to soils as a defining feature between conventional and holistic farming, this report shows the influence of perspective, driven by technical support, resulting from the impacts of incentivisation.

4. Purpose

This report seeks to identify elements that affect how farmers consider soils within their systems. Through interview and analysis, it will touch on technical and cultural elements that intertwine to define farmer perspectives regarding soils.

Intentionally broad, the purpose is to link together elements expressed from different stakeholders regarding soils and the optimisation of soils through different management strategies.

Answering the question: What barriers affect uptake of a soils focussed approach on South Island dairy farms?

5. Literature Review

5.1 Winchmore Research Station

Set up in 1949, with the Phosphate (P) study beginning in 1952. The Winchmore research station (Winchmore) has been integral for P fertilisation on light silt loam soils. With data now spanning more than 70 years, it is the world's longest continuously running Superphosphate trial.

Of 434 published works from Winchmore, just 7 considered soil biology in relation to fertilisation, and a further 4 regarded soil biology in relation to other effects for a total of 12 soil biology studies between 1952-2012 (Rickard, D., & Moss, R. 2012) (Cousins, KA. & McDowell, RW. 2012) (Schon, et al 2025).

Primarily these studies focused on a narrow range of broad biological indicators—such as earthworm abundance, microbial biomass, and enzyme activity—without assessing the diversity or function of soils; treating microbial communities as a "black box". (Schon et al. 2025)

5.2 Fertiliser and Biology

The inefficiency of P applications have been noted as 70-95% of P applied as Single Super Phosphate (SSP) is bound up in soil, locked in place and unavailable to plants. With some sites, after 50 years of SSP applications, containing bound P as high as 1000 mg/kg of soil - a reserve high enough for multiple generations of production capacity if made available. Routes to unbind it to soil solution were assessed. Overseas literature reviewed in the study looked at the role of Mycorrhizal Fungi (MF), soil properties and cations as vessels for release (Trolove. S.N, et al. 2003)

Specifically looking at P-Solubilising Bacteria (PSB), another study assessed the relationship between SSP applications and PSB's. It found SSP application decreased PSB populations, and noted the relationship between bound P and PSB populations is worth studying further. PSB's undoubtedly release bound P, with some coming into soil solution for plant uptake but it is currently unclear for what purpose this happens, be it an overflow of what can be used individually or a side effect of another process. The study also assessed previous studies completed and highlighted the minimal work done at Winchmore on soil biology as well as the inability to build upon that work due to the metrics used. (Mander, C. et al, 2011)

5.3 Urea and Clover

Urea applications depress clover emergence, when clover is in competition with ryegrass. Rates above 100 kgN/ha/yr showed at these rates stolon length and growing point density were affected. At rates of 225 KgN/Ha/Yr white clover growth was suppressed by 45%. This was consistent across the 12 cultivars assessed. (Caradus, J,R. Et al. 1993)

5.4 New-generative Approach

Rowarth et al (2020) wrote a paper to consider New Zealand agriculture in the context of international perspectives on holistic farming. The article outlines aspects of regenerative agriculture as soils focused and reimagines the meaning of mixed sward grazing. The piece is very concerned with methane outputs per production unit. It highlights multiple areas of lacking research within New Zealand, but does not call for them to be focused on. It concludes with the following definition for a new-generative approach to pastoral farming - "Mixed pastures maintained at optimal quality allowing maintenance of high soil organic matter content and the soil ecosystem 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 natural environment" (Rowarth, J. Et al. 2020)

5.5 Commercial Scientific Models

In 1985, a government directive was given to our publicly funded scientific frameworks, essentially capping funding and encouraging a commercialisation of our science, raising capital by selling products to the public and industry. This "user pays" directive flowed similarly into university science through other government agency funding.

It is a fundamental characteristic of science that it is a highly networked activity. Progress occurs over time because scientists publish, and hence share their findings. Competition among and between science groups is the antithesis of the spirit of science. The funding pool created from the government directive change, distributed through contract applications requiring commercial applicability encourages competition.

Predictable outcomes of this change include conflicts of interest within science driven by an incentive change from national good towards profit, accountability within a public/private good dynamic, performance measures driven by financial KPIs over other measurable outcomes as well as the loyalty of scientists to science itself or to the company who pays. (Edmeades, D. 2004)

5.6 The Fertiliser Industry

Balance and Ravendown collectively hold a market share over 90% of the fertiliser industry in New Zealand. For the majority of this product supplied, they have also conducted the soils tests and provided the advice (Woodford, K. 2014).

This constitutes a functional duopoly that benefits farmers due to their co-operative models, which aim to provide their shareholders with the cheapest possible fertiliser through economies of scale.

6. Method

6.1 Hypothesis

The outline of the study began very broadly, and remained so until analysis of the interviews began to develop. A hypothesis was intentionally not set as this could narrow the scope of findings.

6.2 Literature Review

The published literature review in this report contains publications cited in the discussion. (See Limitations of the Study)

6.3 Interview Questions

A broad list of 10 main questions, plus supplementary questions were written out, primarily focussed on the farmer interviewees and how they approach soils. (See Appendix)

6.4 Interviewees

Farmers, Researchers and Advisors were identified as 3 groups to interview from.

Farmers were primarily sourced locally through known contacts, or references from those contacts. Difficulty was had in getting conventional farmers to be interviewed. The only candidates who declined to be involved were farmers identified to be within the conventional grouping. In addition to this, farmers referred for the study who the author expected to fall within the conventional group ultimately fell into the transitional group upon analysis.

Holistic farmers primarily came through known contacts, but also from chance encounters. Their geographic placement was wider than the more conventional groupings.

Researchers were identified during literature review and emailed accordingly.

The Advisors grouping came from a combination of known contacts and chance encounters.

In total this came to 8 Farmer, 3 Researcher and 3 Advisor interviewees for 14 conducted interviews

6.5 Interviewing

Semi-structured interviews were conducted over a 6 week period between March and April 2025. The base time outlined for them was 1 hour, however most ran longer. General discussion was allowed to happen and in some cases specific topics were identified for certain interviewees.

Interviews were recorded using a microphone or AI assistant. They were then uploaded into Otter AI for transcription

Consent forms were distributed to and signed by interviewees.

6.6 Analysis

Interviews were then thematically analysed. While AI themes were assessed, this was primarily done through listening, and re-listening, to the interviews as well as reading of the transcriptions.

Relevant sections were highlighted in the Otter app and re-assessed during the writing process.

6.7 Narrative

As the interview and literature review process took place, with some overlap into analysis. Themes were identified and a narrative was allowed to take shape based on the evidence found. In some cases, interviewees were contacted for clarification on some comments and to maintain accurate representations.

6.8 Abbreviations and Definitions

• AK - Albrecht - Kinsey	• N - Nitrogen fertiliser
• Cations - Calcium, Magnesium, Sodium, Potassium	• P - Phosphorus fertiliser
• CF - Conventional Farmer	• PSB - Phosphate Solubilising Bacteria
• Conventional - Mainstream style of farming in New Zealand	• SoM - Soil Organic Matter
• The Duopoly - Balance and Ravensdown	• SSP - Single Super Phosphate
• FA - Farm Advisor	• TC - Transitional Conventional Farmer
• HF - Holistic Farmer	• TH - Transitional Holistic Farmer
• Holistic - Synonymous with Regenerative Agriculture	• Traces - Trace elements such as Boron, Copper, Iron, Manganese, Molybdenum and Zinc

• HSA - Holistic Soils Advisor	• VAMs - Vesicular Arbuscular Mycorrhizal Fungi
• MF - Mycorrhizal Fungi	

6.9 Conventional - Holistic Spectrum

The farmers are placed on a spectrum of Conventional to Holistic Management. This was done by setting metrics in place and running their interviews through ChatGPT.

Metrics were identified in analysis as the key differences between the most conventional and most holistic interviewees. They were:

- Plant focused - Soil focused
- Soluble fertiliser use - Eliminated soluble fertiliser use
- Soil biology not considered - Soil biology a core area of focus
- Production focused - Soil function focused

The metrics ran on a 1-5 scale, with 1 being very conventional and 5 very holistic, resulting in a score out of 20. See Table 1.

	Interviewees							
Theme	**CF1**	**CF2**	**TC1**	**TC2**	**CH1**	**TH1**	**TH2**	**HF1**
1. Plant - Soil	2	2	3	4	4	5	5	5
2. Soluble Fertiliser	2	2	3	4	4	4	3	5
3. Soil Biology	1	2	3	4	5	3	5	5
4. Production vs Function Focus	2	2	3	4	3	4	5	5
Total Score (max 20)	**7**	**8**	**12**	**16**	**16**	**16**	**18**	**20**

Figure 1 - Table data taken from farmer interviewees. A value of 1 highlights conventional approaches, 5 represents holistic approaches

Conventional	5-9
Transitional	10-18
Holistic	19-20

Table 2 - Categorisation Values based on total scores

Conventional Farmers	CF1, CF2
Transitional Conventional Farmers	TC1, TC2
Conventional Holistic Farmer	CH1
Transitional Holistic Farmers	TH1, TH2
Holistic Farmer	HF1

Table 3 - Naming scheme based on spectrum values

7. Analysis

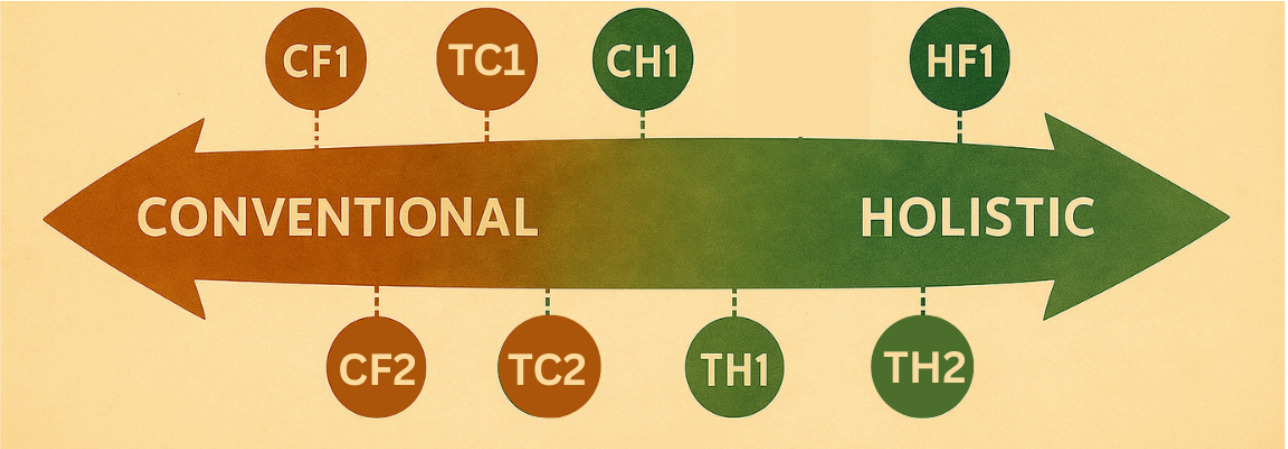

Figure 1 - Farmers placed on a spectrum

7.1 The Farmers

7.1.1 The Duopoly

Across the board, every farmer interviewee looked at the fertiliser industry with a degree of cynicism. All but two of the farmers currently engage with the duopoly in some fashion. Both conventional farmers took advice from and sourced their product from the duopoly, whilst the rest received independent advice and brought all or most of their product from the 2 main companies. HF1 and CH1 sit completely outside of mainstream fertilisation using bespoke products and independent advice. If not currently, all participants had taken full recommendations and product sourcing from the duopoly in the past.

A consistent theme among the group was that the advice they received from the duopoly was basic and cookie cutter. Multiple expressed issues with inconsistent knowledge from nutrient advisors, and frequent changes of personnel. One conventional farmer stated that they are not taking outside advice for fear of the pricing schedule being used against them - whether founded or not, this reflects the view that farmers have of how the duopoly operates competitively.

TC1 spoke quite deeply of the co-operative duopoly, acknowledging that most have lost their way at one point or another (including the co-operatives outside the fertiliser space) as that's the nature of culture and leadership changes. They went on to say that having two

large co-op's competing in a single space should be beneficial to farmers. However, they continued that given their collective market share in giving advice, and selling products, creates a conflict of interest which is possibly compounded by protectionism of their processing infrastructure that requires a volume of product to remain viable.

7.1.2 Complexity

HF1 reflected on the trial and error process they're going through in navigating the holistic space. 7 years in, they believe good progress has been made but still haven't got the system quite right. For them, experimental navigation is part of the excitement of being on the frontier, but for others the unknown is too high in risk. This excitement of feeling your way through a new space is reflected in the transitional farmers as well, they all share an interest like this but are bound by other pressures that alter their risk appetite. For the conventional farmers the complexity is too large to sift through. The black box of soils remains unopened

7.1.3 Financial pressures and risk

This factor was primarily seen in the transitional group, though it was expressed as one of many reasons for the conventional group not to shift towards holistic approaches. One of the main drivers for CH1 thus far had been production efficiency as they have scrutinised their fertiliser usage by mapping their property to 20m2 accuracy on soil type to be utilised in application decisions. Combined with the use of RPR's and other products that are "softer on the land" they have cut $180k from their yearly fertiliser bill. For them, a greater shift towards holistic management would mean assessing aspects of their wider system, like stocking rates and seed mixes, requiring a step into a more unknown space that possibly sacrifices production for other gains. They indicated that it is something they would like to shift to in the future once their property is in a more comfortable debt position.

Similarly TC2 and TH2 felt it is less risky to enact holistic approaches on their run-off first rather than the dairy platform. TH2 is slowly implementing reduced fertiliser usage on the dairy platform and some diversity in their pasture sward - though a board member for the property has expressed that they would need to step down if the holistic approach from their runoff was applied to the dairy platform due to concerns held about regenerative agriculture. The run-off however is in a full multi-species mix with fertiliser focused on cations and traces. TC2 uses a little and often approach to fertiliser on the dairy platform, with the run-off planted in a diverse pasture sward mix that only receives effluent and bio-stimulant as nutrient applications

TH1 is held to their current system as they share a run-off with family. In order to make the land financially viable, their herd must be grazed off for winter. In turn, this requires a higher stocking rate on the dairy platform. In addition to this, a portion of the farm is earmarked as a possible sale option. This area is managed conventionally since they believe farming it holistically could lower its market value since "some people just don't get it". Without these constraints a lower stocking rate and a self contained holistic system would be applied.

TC1 stated their risk profile is higher than most. They have drastically reduced their N inputs and wintered on grass, something most conventional farmers wouldn't consider. For most farmers dropping the production and controllability of N inputs would be unthinkable and pasture wintering is seen as requiring too much land. Though on pasture wintering TC1 had concluded that the land requirement is the same as a kale wintering system when crop transition is taken into consideration.

TC1 mitigates risk by reading scientific papers to educate their choices. TC1 sits in a doldrums area, unable to find definitive scientific papers that relate to holistic management practices and thereby reducing how far they step into the space.

7.1.4 Science

Both CF's expressed they'd consider changes to their system if solid scientific basis for holistic approaches was presented to them; HF1 would like to see more work done in New Zealand, but takes their advice from within the small holistic space here and looks to work done overseas.

The transitional group felt the least represented by the current availability of research. Conceptually this makes sense, they have shifted away from the mainstream due to finding holes, issues and misrepresentations in conventional farming but do not have the belief in the alternative system to dive in head first. Within this group it is unlikely they would return to a fully conventional system, taking the full suite of advice and product from the duopoly, as their systems are working; but progress is slowed to the effects of changes they can see from their own experimentation.

TC1 is heavily influenced by this effect. In addition to technical analysis of how holistic systems work in the soil, they would also need to see region relevant case studies with financial analysis. Willing to go through the pain of transition - having already done so in reducing N inputs to increase the clover content of their pasture sward - if evidence shows it will pay off on the other side. North island, dryland, volcanic soil case studies are interesting but not seen as relevant. The properties of volcanic soils are diametrically different to light stony Canterbury soils and the lack of irrigation can be seen to encourage practices less relevant when consistent water can be applied.

7.1.5 Disclarity on what holistic is

Something that permeated during the interviews through the conventional group, and into the transitional group, was the uncertainty on what regenerative agriculture meant. There was a feeling that it required a hardline full change of systems and approach. Both conventional farmers found it synonymous with the use of sunflowers, annual grasses, organics and zero fertilisation. This is somewhat a reflection of the lack of scientific research into the space, as the media grabbing aspects are what gets distributed. In some fashion

TC1, TC2, TH1, TH2 and HF1 have all engaged with the stereotypical regenerative sunflower, annual, perennial transition crop. Attitudes towards it are mixed with the consensus of the more holistic farmers being that it is a tool to be used in specific situations and TC 1 and 2 stating it "looked cool" but isn't necessary.

The aspect of transition was lost to the conventional farmers, with both questioning if they could continue to use antibiotics and any form of fertiliser. All farmers on the holistic side of the spectrum currently use both. CH1 and HF1 have eliminated chemical fertiliser and HF1 is eliminating drench and antibiotics. TH1 utilizes alternative mastitis treatment products, but is not eliminating the use of antibiotics for mastitis treatment.

HF1 is transitioning to organic production as it makes sense to their current context. This will happen regardless of Fonterra bringing organic milk supply to the South Island. Returning to the concept of transition, this view has happened over 7 years of change and is not something implemented quickly. HF1 noted that this season was the first year that no calves were drenched with anthelmintics, though was prepared to do so if required. A key practice to this change, in their view, has been allowing the young stock to graze under no grazing pressure.

7.1.6 Mindset

Conventional farmers defined holistic systems by their practices, or restriction of practices, however the holistic farmers defined it more by mindset than practice *per se*.

Circular mindsets are key to holistic approaches, they acknowledge trade-offs in the interconnectivity of systems. Nothing happens in isolation. By contrast conventional systems follow a lineality, having gone to great lengths to isolate components of production in order to find simplicity.

Both mindsets come with advantages and disadvantages, the reduction of less impactful elements in linear mindsets allow for large gains towards specific goals. But this reduction loses nuance and the accumulation of small advantages resulting in less resilience.

7.2 The Advisors

The farm advisors (FA1 and FA2) and holistic soils advisor (HSA)

7.2.1 Soils

As a part of their Bachelor of Agriculture Science degree at Lincoln University, FA1 said soils was a module in their first year, and they were in the minority of students who took the elected module in their final year.

"It wasn't a popular course, there was only four or five of us"

Had they known about soil science sooner, it likely would have been their primary study subject.

"... nobody told me about soil science. Then suddenly in year one, here it is. It's a whole branch of science and it's not really something we do as a country."

"I'm a generalist not a technician"

FA2 keeps themselves informed on recent soil studies but has changed their approach over the years.

"I'm familiar with soil science, but I no longer do soil advice. I peer review other people's work and look at the costs."

7.2.2 Biology

"You don't see cow pats on your farm sitting for 2-3 years… the worm activity, the insect activity, it's just amazing. That tells me the system is working"

The importance of biology was understood by both advisors, but so was the lack of research available

"In terms of (research on) microbes and soil biology, we're still floundering a bit, which is frustrating for us"

7.2.3 Alternative Fertilisers

FA2 consumes a lot of what they describe as "marginal science", with multiple clients who engage with biological and alternative fertiliser products. They're quick not to dismiss new possibilities and acknowledge the cost of basic studies is a barrier for fledgling companies. But their role as an advisor means they must be science driven.

"I don't want to see a paddock with (product) and one without it. I don't want an anecdote from a farmer, I'd like some science please."

They went on to say good advice and strategies are out there.

"Some of the alternative soil and fertility advisors I do really trust. They're just getting sulfur and nitrogen.. potash and just keeping it really efficient. Maybe some seaweed or a bit of magnesium, especially magnesium. Just things you might not see on a (fertiliser duopoly) recommendation."

7.2.4 Unfunded Science

Holistic Soils Advisor (HSA) expanded on the frustration that FA1 and FA2 have about the lack of available science, having spent time trying to engage the New Zealand agriscience community

"25 years ago we were talking to researchers about coming to see what (some of my clients) were doing. This could be a game changer, but they were totally disinterested, they shut the door on us"

This has on flowing effects where the rejection has meant some of our most established holistic farmers are content to stay within their own farmgate.

7.2.5 Transitional Difficulties

FA2's clients have had mixed results in transitioning to holistic strategies. How each farmer has approached it is different too, with some going it alone.

"A little bit of knowledge might be really dangerous… you might have an unbalanced system now, but spend a lot of money to create another unbalanced system"

They went on to say how one client is coming out the other side.

"They had a couple years where they just didn't do the production, but we've fixed that now. Some budget constraints helped"

The importance of advice in transition was highlighted by HSA

"I fundamentally disagree that we lose production in transition. It's a myth that needs to be dispelled. That happens because people are guessing and trying stuff, they're doing it without good support."

7.2.6 Skills Shortage

While FA2 spoke of good advice existing in New Zealand, and the importance of farmers accessing it within their specified contexts. HSA noted a shortage that exists.

"I shouldn't be doing basic soil health workshops, there are others here but far less than there should be"

7.2.7 External Forces

HSA talked about outside forces affecting culture which sculpt the way farmers look at soils and holistic strategies.

"There's this polarity that exists in New Zealand. It's so carrot and stick and it's been politicized. It actually makes sense that people are resistant to it (regenerative agriculture), because they feel like they're being forced. But none of my clients are like that, it's coming from elsewhere."

7.3 The Researchers

The mainstream researchers responded in similar yet distinct ways, reflective of their individual careers. Both hold degrees in soil science and have worked in the public and private sectors.

7.3.1.1 The Research Space

Both researchers directly quoted the ethos of agricultural science in New Zealand was to "grow 2 blades of grass where one grew before". This ethos permeated through the scientific community in the 1970's and 1980's. In the late 1990's it developed into "...grow 2 blades of grass where 1 grew before; and improve our environmental outcomes". They noted the importance of this shift, and equally acknowledged a split in what studies are funded. The change in directive ethos meant our restricted public money goes almost entirely to environmental studies, with the production side being driven by the private sector. These productive studies primarily focus on proving product efficacy rather than management practices.

7.3.1.2 Clover

One researcher viewed the funding change to be reflected in our farmers' shift away from strong clover based pastures. With farmers unsupported in how to maintain clover quantities within the sward, they have been left to the merchants of products who have filled the lack of legume-fixed N with urea, creating unbalanced fertilisation.

At the other end of the spectrum they said the loss of legume based pastures has pushed farmers into the holistic space as they have never seen or experienced a strong clover sward and the researcher believed simply focussing on clovers offers what they are looking for.

"Clover is the most important component of our pastoral system"

No explanation was offered for the rise in urea use nationally, other than its push by the product's sales people. However the other researcher spoke of being instructed, early in their public sector career, to find a use for urea within pastoral farming due to the creation of the Kapuni Plant during Prime Minister Robert Muldoon's 'Think Big' initiative. At the time, imported urea was almost exclusively used by arable farmers.

"I don't think people have properly made the connection. You hear now and again, where a farmer will say, I've started putting nitrogen on. And now I'm trapped, I have to keep putting it on"

Urea use skyrocketed in the 1990's. Dairy conversions being done on low fertility soils needed a boost to get production going and established farms used it to increase growth when clovers are dormant. As urea suppresses clover, the clover never establishes on the freshly converted properties and stops flourishing on the traditional dairy platforms. But pasture production is consistent, urea applications become a regular habit and as we shift into the 2000's it is unthinkable to farm without it. By this time no functional studies into clover management within modern dairying exist. The research space has funded multiple studies on ureas efficiency and environmental impact. Now 30 years on, the skill set of retaining a strong clover sward is lost with few examples available to farmers and so those looking for solutions to an imbalance system are offered either fertiliser input solutions or step outside the conventional space completely.

7.3.1.3 Farmers and soil biology

"I don't think they think about it much"

Getting farmers to engage with soil health in any depth has been a struggle and neither researcher believes conventional farmers think about their soil outside of fertiliser and wet weather management. Partially this has been the fault of scientists in not communicating their findings well, but also of nutrient advisors from the duopoly who, in most cases, are a farmers main touchstone to advice regarding soils. Nutrient advisors are frequently encouraged to talk to farmers about the wider aspects of their soil outside of their fertiliser programmes. However the nature of the nutrient advisor role means they are not incentivised to do so, and it falls more into soft skills of service providing as well as knowledge earnt over time. It was also noted that the turnover rate in these roles plays a part here as skills within a team are reset with new hires.

"I keep telling (nutrient advisors) that they don't talk to farmers about soils enough. They talk a lot about fertiliser and nutrients but not about soils or biology"

7.3.1.4 Soil Biology

The work of Norman Taylor was highlighted, adding we have known that soil is a living entity for more than 100 years. The vastly complex make up of the soil microbiome is integral in plant acquisition of nutrients, defence against disease and resilience to stressors like drought or frost.

"Our soils are teeming with all sorts of bacteria and mycorrhizal fungi"

Science has been hampered by its ability to measure the soil biome. This has changed over the last 20 years, where we can now extract the DNA of specific organisms within a sample (Mander, 2012). Previously we were resided to bulk measures like microbial respiration, biomass and earthworm counts (Fraser. Et al. 1994. As cited by Schon et al. 2025).

In native grasslands there is a hugely diverse microbiome but each organism exists in low quantities. These organisms lay mostly dormant as they wait for optimal conditions that suit themselves. Driven by low fertility status there is little nutrient cycling happening and as such the microbiome is not very active.

"Comparing native grassland to farmland isn't a fair comparison. It's apples with oranges"

7.3.1.5 Biological Farming

Both researchers made statements that there is an alignment between them and the holistic space on the importance of the soil biome, with one complimenting a prominent holistic soils advocate on their ability to portray the function of the soil biome in layman terms.

However on implementing biological systems, they both strongly held that systems which consider soil structure through management, with ryegrass/clover swards and appropriately fertilise with P K and S will outperform no fertiliser, or non-chemical fertiliser, based systems.

Their view is backed by research evidence that shows chemical fertiliser does not impede biological function within soils, and in fact benefits biological activity (Schon, et al 2025). The reduction of biological diversity in soils under conventional fertilisation is the result of fertility status in the soil, which creates optimal conditions for a less broad range of organisms. However those organisms, adapted to high fertility status soils, remain at a higher activity state as shown in the quicker nutrient cycling and pasture production of those soils.

Holistic approaches, in their view, were less economical and significantly more difficult to achieve. It is simply easier to manage soil fertility by PKS fertilisation and to turn a profit from a higher productive state. While possible, the science is not available to make conclusive

recommendations on how to optimize the soil biome for pastoral farming through management practices.

Discussions of optimising soil biology inevitably sat around adding exogenous biological products, like soil probiotics or mycorrhiza, which have a short term benefit - if they work at all - rather than increasing stable populations.

7.3.1.6 Superphosphate

The use of SSP in NZ was recognised as a driving force of production over the last 60 years. The depth of knowledge we have of its function and recommendation rates developed from sites such as Winchmore are unparalleled internationally.

The functional dynamics of soluble P applications were discussed. SSP is solubilised from the granule into soil solution within a matter of hours, and then quickly covalently bonds to clay colloids within the soils. This speed is environmentally friendly as leaching occurs from nutrients in soil solution. Bonded P particles operate like a bank account, released into soil solution through dynamic equilibrium as plant roots draw P up from it. Plants can only access P from soil solution and are unable to remove it from the soil itself. Microbial activity does take an initial hit as P in soil solution spikes, but it returns to normalised levels as equilibrium is reached.

The researchers spoke of the positive impact SSP has on soil biology, citing Winchmore studies that showed bulk measures like earth worm counts, microbial respiration and microbial biomass all increased with its use. When asked of the impact SSP use has on specified microbes like P-Solubilising bacteria (PSB) they stated that there would be a suppressive effect based on PSB's favouring low fertility conditions. PSB's expend energy in P-solubilisation not for the plants benefit but for themselves, some excess may be made available for other plants or organisms but the function isn't intentionally symbiotic. When soluble P is available, bacteria do not display this trait as the energy expense is unnecessary.

They went on to note that a similar occurrence happens with symbiotic relationships like mycorrhizal fungi (MF). In low fertility situations the effect of root extension from MF mycelia is necessary for both MF and the plant. But soils of optimised fertility status for pastures do not suit MF and so they disappear. The effect is high production plant growth but a lower diversity soil biome.

7.3.2.1 Holistic Researcher

Holistic Researcher (HR) is conducting a multi functional study covering a systems approach to farm management and diversity. While the study is in its early days, it is unique in many ways.

To cover a systems approach it has needed to redefine the classic control vs hypothesis study structure. Aiming instead to separate management aspects from diversity itself and

look at changes over time. It is the first study in New Zealand to look at regenerative agriculture in the way its proponents wish to see it studied.

"There were people who were saying we know it doesn't work, it's not backed by science. And others saying I like the idea but we want to know if it works before we adopt it. So I quite glibly said to both groups, this has something for everyone. If you're wanting research, it's being done. If you're saying it's unscientific, the research is being done"

7.3.2.2 Baseline Data

One hurdle the study has quickly run into is the lack of locally specific baseline data for some key aspects of soil biology. One example given was Vesicular Mycorrhizal Fungi (VAMs). While they can identify that they exist, there is no register in New Zealand with which to reference. This means time, and money, that would otherwise be spent on analysing the effects of management and diversity are being redirected to collecting primary source material.

"The libraries we've got come from Japan, The USA and Europe. There's nothing in the southern hemisphere. We know it belongs to a family of fungi, but we don't know exactly which one it is."

This extends into other aspects of the soil microbiome, where the baseline knowledge simply hasn't been acquired as it hasn't been studied to that depth.

7.3.2.3 Funding Soil Research

"The funding hasn't been there"

Functional soil science has fallen into blue sky research. The complexity of soils means an understanding of no single element brings large gains in comprehension. This is not conducive with our short term, goal oriented funding structures in the public sector; and it does not produce a product for funding from industry.

"The funding models have been, generally, short term and output driven rather than outcome driven"

HR noted that broadening the scope of studies is where you find the value in soils. They made correlations with parallel work done on the human microbiome and highlighted that most human medicines from the last few decades have come from soil organisms. Something which doesn't happen if general studies aren't conducted to be built on later.

Short term, goal oriented studies have meant scientists live in a funding cycle following research subjects determined by available money.

7.3.2.4 Length and Breadth

HRs study sits outside this cycle, having secured funding for 7 years largely through public money but also in collaboration with industry. They have 31 postgraduate students involved, the study length means their skills can be retained and knowledge built on.

"We have students who have finished (their PhD) and are now coming back, working with partner organisations within the project"

7.3.2.4 Intellectual Property

The study works collaboratively across the sector too, with industry funding covering most aspects of agriculture. Unusually for privately funded work, this means they have direct competitors working together. Industry money, understandably, comes with expectations for a return on investment. But HR has stipulated the study will not produce any IP.

"The project is partly privately funded, but majority public money. I specified that no public money will be used to produce IP. They can bring their products, and test their own things within our playground. But we're not spending public money to validate your product."

7.3.2.5 Skeptical Cynicism

"As Scientists we should be agnostic"

HR's background is not within the holistic space and admits to being skeptical of what some holistic proponents expect them to find. However they contrasted this by saying there is a difference between healthy skepticism and cynicism.

"..cynics consider the door closed. Skepticism means we hold onto our ideas somewhat loosely."

Within the scientific community, HR has run into attitudes that say the study is an ineffective use of funding as it looks at dynamics which we already know the answer to. Diverse pastures being one that was studied as far back as the 1930's. But the scope of HR's study is significantly broader than the previous work done.

"Diverse pastures were studied by Everetts back in the 1930's. But they only looked at growth. They didn't look at environmental outcomes, they didn't look at soil interactions, they didn't look at greenhouse gas production, they didn't look at animal intake or animal product quality."

The content of the pastures are different too, with cultivar development progressing over the last 30 to 40 years.

"30-40 years ago plantain and chicory were both flat weeds and hadn't been selected to stand upright in pastures. Red clover and lucerne were one hit wonders as grazing them would damage the crown"

7.3.2.6 Scientific Protectionism

Whether driven by competitive funding models or human nature, there exists a habit of discriminating against new ideas that challenge our current understanding.

"I've felt as a scientist of being dismissed or ignored because someone knew different. When they didn't even know what I was talking about. They didn't care, because (they believed) they had the answers."

7.3.2.7 Reactive Views

HR noted some quite visceral reactions towards the topic of holistic agriculture by farmers and researchers alike. Driven by media perceptions and scientific protectionism, they expected a more hostile environment when first entering a holistic discussion group. But found it welcoming and no different to the conventional space.

"It was just farmers being farmers"

"Why are we in such a tizz about regenerative?"

While they found the holistic space conciliatory, there is a feeling among some of being outcasted from the wider farming community. HR hopes their study will aid in bridging that gap.

7.4 Consistencies

Across all interviewees, one question drew the same answer. Throughout the course of your career, what study on soil or fertiliser has been the most impactful?

Every farmer and advisor, multiple of whom read published works on a regular basis, responded with uncertainty. Not a single study was noted.

"Most of our fertiliser work was done it the '70's"

"On soil or fert? It's been a bit thin hasn't it"

This response was often followed by a reference to the work done on Urease inhibitors, but swiftly followed by a dismissal of it.

"...the research into (urease) inhibitors, in hindsight it was just a multi-million dollar distraction"

"Urease inhibitors. No farm has been asking for that. I could not name a single person that has heralded it up as a solution"

8. Discussion

8.1 Barriers

The complexity of soils and the associated risk in changing fertility management strategies are two key barriers stopping farmers focussing on soils more acutely. In addition mainstream views on holistic approaches, including uncertainty on what regenerative agriculture is, and the mindset that it brings, compound on preconceived notions of its applicability. Media portrayals and politicisation, affected by a tense environmental space make farmers feel as though they are being pushed towards systems that are less productive and based on ethos over evidence.

8.2 Complexity

Soils are complicated, their function hinges on no singular dynamic but rather a multitude of individual functions relating to each other in varying degrees of symbiosis, competition and benign coexistence. Oft-considered a black box of mysteries, what goes on below ground has long been separated from productive agricultural science.

8.3 Risk

Managing risk is essential to any business and risk appetites will vary amongst people. Risk is mitigated by understanding a problem, making the chances taken more calculated.

"I just enjoy understanding more about (soils), and hence can lower my risk because I feel like I understand it better to make educated decisions."

If a farmer has a low understanding of a concept, then it appears more complex. As learning happens, understanding increases. Which allows for educated decisions to be made. Mitigating risk and reducing complexity.

8.4 A feeling of being pushed

Dairy farming has had a spotlight put on it in recent decades. In the contextual hangover of the dirty dairying campaign, the attempted 3 waters legislation, multiple regulation changes, milk company compliance increases and a perceived urban rural divide, farmers feel like they are being told what to do. Sensitive to outside voices that affect their profitability, farmers switch off to calls that they should engage with a production system that they don't understand.

Some sections of the political and media sphere have purported regenerative agriculture as a necessity in New Zealand. In the perception of the conventional farmer, it has become a loud minority. Highlighting low or no fertiliser applications, decreased stocking rates and a focus on non-monetary capital, the portrayals make the system seem foreign to the mainstream.

Within the media and political context of the last decades, farmers feel coerced towards a lower quality of life for the same effort and cost.

"There had been a lot of stuff in the media (about regenerative agriculture) and I was going to my first regenerative discussion group. I was expecting some push back (having come from the conventional space), so I came prepared having read up on some points. It wasn't needed, it was so welcoming, not at all what I expected"

8.5 Views on what holistic agriculture is

Defining holistic approaches can be tricky, the strength and weakness of regenerative agriculture is in its breadth of definition. Not constrained by a set of rules to follow, its practitioners are open to experimentation and can engage with conventional strategies as they see fit. But this open book of discovery makes it difficult to describe to those who don't understand the ethos or for anyone looking for a prescription to follow.

8.6 Ethos and Evidence

With few studies existing that look at its holistic practices and equally light research on soil biology, practitioners are seen to be engaging with regenerative agriculture from a basis of principle and belief. They bridge the evidence gap by believing in the function of natural cycles, based on the principle that managed diversity can enhance those cycles.

This is a strong barrier to the conventional farmer, who base their systems on decades of science disseminated to them through various channels. But the reality is that most farmers do not have a deep understanding of fertiliser dynamics or a scientific understanding of plant growth. They bridge this gap of understanding with trust.

8.7 Trust and Belief

Trust and belief are intertwined as concepts with doxastic (belief based) trust requiring first a belief (trust-belief) that the trusted party will do what is stated. Evidence is central to the rationality of doxastic trust, if trust is non-doxastic (separated from belief) then evidence has no bearing as the trust is irrational. Belief, both alone and as a component of doxastic trust, cannot be created voluntarily. This implies evidential aspects exist within the concept of belief (A Keren, 2020).

Within these concepts, any individual could strongly hold a non-evidential irrational opinion of either system. Conversely, evidence in rationalising trust-belief can be applied to both conventional and holistic practitioners.

A conventional farmer, who hasn't read the literature, first places a trust-belief in advice given to them by nutrient advisors on the applicability of fertiliser. This trust-belief deepens as they see the effects of fertiliser applied and from seeing the majority of farmers around them following the same advice. They are told the science is conclusive that this is the most effective way of providing the necessary nutrients for them to remain profitable. P fertiliser has a positive relationship with soil biology. Unless they see an issue on their property, which isn't solved through this advice network, they have no reason to question their trust in the framework. The trust is doxastic, as applying the trust is evidential from their own results and from their peers results in receiving the same advice, but at some depth there is a component of non-doxastic trust applied to the strength of the science their advice is based on.

When a conventional farmer finds an issue within their system, not solved by the advice of further fertiliser applications, trust in the system is broken. This leads them to seek alternative options. Through this process they find the weakness in our scientific soil knowledge which further breaks trust in our mainstream systems. This is the making of a holistic farmer. Unsupported in conventional frameworks, they place belief in what they see. In the natural nutrient cycles that govern all growth. How this belief operates, and whether it remains as a non-consciously evidential belief or develops to a doxastic trust-belief depends on how they engage with gathering knowledge, advice and information.

Robust soil science, related to production, would diametrically change this dynamic. Holistic farmers operate on belief and principle through the necessity of broken trust, not by an inherent faith required to engage with natural systems. By contrast, trust in our current systems by conventional farmers is based on a belief that science is unbiased and the results conclusive.

8.8 Science

Underpinning the barriers above is a lack of science, not just on holistic management as a system but of soil biology and its function in general. Holistic practices are often described as unscientific, this is disingenuously used as a definitive statement that implies the studies have occurred. The evidence does not exist in favour of or opposed to regenerative agriculture as it has not been studied in depth. Compounding this, the research on soil biology that would support practical regenerative studies have not been conducted either. The implications of this are seen in our agricultural focus on fertiliser inputs as that is what the research supports.

"...Norman Taylor, who was called the father of soil science in New Zealand. In the 40s and 50s he identified that soil biology was an inherently important part of soil function. Before that it was kind of separated from agriculture."

This separation has extended to the present day. In 60 years of research at Winchmore, just 7 of 434 conducted studies considered soil biology (Rickard D, & Moss R, 2012). None of those 7 studies followed any consistent measurements that were built on between them, and the measurements used were broad (Schon, 2025).

This lack of foundational work is affecting the progress of current studies, as noted by Holistic Researcher who found no genealogical register of VAMs in New Zealand.

A lack of technology to properly identify specific microorganisms within the soil has, understandably, been a barrier to progress. But standardising measures to draw consistent trends within the technologies available has not occurred either.

The mainstream researchers spoke of the importance soil biology has to our agricultural systems, noting the importance of multiple macro and micro organisms within the soil. But would then go on to speak of soil biology's non-essential status in high fertility situations where soluble fertiliser circumvents biological cycling.

This ignorance seems out of line with our targeting of agricultural efficiency, as the vast majority of applied P is bound up in the soil and not plant available (Trolove S.N., et al. 2003) while possible microbial P-solubilizers are suppressed by SSP applications (Mander. 2012). This same suppressive function of fertilisation is seen in the relationship between urea use and clover (Caradus, J.R. et al 1993).

8.10 Funding

The consequences of our publicly funded science being required to act commercially are showing. Conflicts of interest and competitive elements within the scientific space impede gains and a loss of science for science sake narrows the scope of studies and reduces the path that they can build upon each other. (Edmeades, 2004)

Within this commercially focussed dynamic, soils do not fit. Understanding biology, while important for our farmers, does not provide any intellectual property for the public or private sector to exploit.

8.11 Studies out of step with farmers

A recent example of our commercialised study framework is shown in the work done on urease inhibitors. This work was the most often cited piece when interviewees, across every category, were asked of an impactful study done in the last 30 years on soils or fertiliser.

Almost uniformly, with the exception of one, the response was contemptuous. This work is out of step with farmers and emblematic of a system operating in self service.

8.12 Competition and patch protection

Further reinforcing a disconnect between the conventional and holistic farmers are papers like Rowarth's (2020) article "A New-Generative Approach". The piece aimed to reimagine dynamics of regenerative agriculture in the context of New Zealand's current systems through which it concludes with a "new-generative" definition so broad that every farming interviewee across the conventional - holistic spectrum would fall within it.

The piece acknowledges multiple times that research is lacking on regenerative agriculture and soil biology, but expands to citing reductionist studies making statements that appear conclusive. It asks no questions, nor does it call for new areas of focus to expand New Zealand's agricultural research.

The tone of the article appears to seek to protect the status quo, gently alluding to gaps missed by our funded studies but then removes the context from soil focused or holistic practices to cite research of narrow scope that dismisses the gap and entrenches the current.

This interpretation of tone was confirmed by a researcher interviewee who was familiar with the article and, when prompted, admitted that it was written in response to funding being given to studies on holistic agriculture. It is unclear whether the motives were driven by competitive human nature and/or are reflective of tight funding budgets creating competition.

Regardless of motive, the piece lacks curiosity to areas we do not understand scientifically and entrenches a separation between holistic and conventional farming that is not constructive to either system.

8.13 Incentivisation

Whether incentivised to protect their corner of study for future funding or to fund more research on sellable products, the outcomes of these incentive realities has far reaching effects on farming systems. The duopoly, researchers and public funding institutions have not actively suppressed soil biology studies related to production, but they are not incentivised to promote them either. Studies on soil biology don't create a commercialisable output, they fall very close to blue sky research.

This creates de facto suppression. One mainstream researcher made comments, within a few minutes of each statement that - soil biology is monumentally important - we don't know enough about it to advise on biological farming - our available tools for assessing biology in

the past were rudimentary - we know SSP is good for soil biology and that SSP circumvents biological systems through its solubility.

This researcher has had an entire career looking at soils in relation to fertiliser inputs, so it is understandable their perspective is seen through this lense. The studies they referenced were looked at by Schon (2025) and noted for their simplistic measurements, convenient for showing a positive relationship between SSP and soil biology. The incentive the researcher has is to cite the outcomes of these studies that strengthen their, or their companies, work. But neglects weaknesses in the research. It is counter intuitive to say we haven't had the tools to assess soil biology to the depth required for a full understanding, but those same primitive tools are enough to conclusively say we know the effects of SSP on soil biology.

Further still, if SSP does not require soil biology to transfer P into soil solution for plant uptake then truly what incentive does anyone involved with its research, production, sale, advisory or application have to care about SSPs effects of the soil microbiome. This now totally separates our practices from soil function.

Returning then to our researchers statements made on the importance of soil biology. In large part, this biology is the difference between soil and dirt. Have we left soil behind to farm on dirt with supplementary fertility? Do we operate with endemic nutrient cycles or are we hydroponic farming?

9. Conclusion

No matter the style of farming, soils lay the base. Unfortunately the incentive structures in place do not encourage the major players to focus on them in relation to productive farming. Continuing a decades-long trend, soils remain in a black box of mysteries.

Conventional farmers feel unsupported. No tangible progress on fertiliser has been made for 40 years, does this mean we have reached the peak of its performance? If so, would it not be prudent to look to other areas for advancement? The incentive crux here is that farmers would be the key beneficiaries from that type of research, not commercial entities.

Holistic farmers feel unsupported. The baseline data that they look towards to build a system on has not been done. The system focused research that clarifies the interconnectivity that they see has not been done. They are left to experiment on their own and are therefore judged by the inconsistency of their results.

Farmers look to the scientific space for confirmation and guidance, and what they have received is far from the whole picture. Both of what has been studied and in portrayals of what has not. New Zealand's productive agricultural science does not understand soils, not to any functional depth. The disingenuous nature of comments that conclusively say we know the effect of any practice on soil biology is holding our sector back. When considering the validity of these statements, consider the incentive.

The cultural gap between conventional and holistic is entrenched by scientific incentive, and expanded by politics and media. Conducting studies relating soil biology and function to productive farming would benefit both camps and minimise the gap. Creating better collaboration opportunities, diminishing separatism and offering a wider range of options for farmers to engage with in their specific contexts.

10. Recommendations

1) Fund studies on Soil biology

Obtain the baseline data such as what populations exist within New Zealand. Use this to build upon our understanding of managing this biology. Relate these findings to opportunities for production within farming. This process can fit within our current frameworks and farming ethos'.

2) Fund studies on holistic agriculture

Consider regenerative agriculture within its own context. Diminishing aspects of diversity when viewed through a lens of a single metric (such as the issues of managing diverse pastures based on different heading dates) is irrelevant to the point of diverse pastures. Within these studies it is essential to take a wholly systems approach, considering the challenges and benefits across multiple factors

3) Assess the performance of our publicly funded research frameworks

Commercialisation was instituted as a response to financial pressures of the 1980's. Financial performance was instituted to provide the most 'bang for buck' spend from limited resources. 40 years on, we can see the effects from it on an entire generation of farms and scientists. Has it worked as planned? How can we bring a nuance to aspects of accountability, public good and limited capital?

4) Bring together the agricultural space

Perceptions, separatism and cultural division are doing a disservice to conventional and regenerative agriculture alike. These terms need not exist. In the same way that high and low input dairy farming exists in the same context. Regenerative and conventional farming should as well. The two spaces share more similarities than differences and support of soil biology science would greatly benefit both. As many have pointed out, we are all regenerative within the context of international agriculture. New Zealand is famed for "natural" farming and efficiency. Leaning into this will not harm our sector, but leaning against it will certainly cut down our options to progress and our ability to stay on top.

11. Limitations of the Study

11.1 Overview of limitations

This is a very large subject and any singular barrier could have entailed a complete paper on its own. Ironically, the shortcomings of this paper are representative of the difficulty that can come with taking on a systems approach as the breadth of it can be overwhelming. Specifically, a deeper dive into research papers produced over the years would aid a more specified look at agriscience within New Zealand, as would a deeper understanding of soils by the author.

Restricted by time and length, the discussion section in this report was kept as brief as possible. There are multiple areas the author would have liked to expand on, hopefully readers find it coherent and succinct enough to portray the narrative found through interview.

Nitrogen, PH, soil organic matter, soil structure and water holding capacity are all elements not focussed on. As was the effect and drivers of political and media portrayals or the specific political leaning of participants in their perspectives.

The history of fertiliser and soil research and mapping of historic fertiliser use is another important context.

11.2 Omitted sections

Below are some sections omitted from the final report due to edited length, time to include in literature review and clarity on the reports main narrative.

11.2.1 Albrecht - Kinsey

Both researchers were critical of a ratio strategy for nutrients as an ideal ratio can still fall short of optimised quantity. They also highlighted a soils cation exchange capacity (CEC) is defined by its source material - typically its clay content. New Zealand soils are of more variable charge than most due to our less weathered and younger geological status, but CEC is still largely fixed. They would also say of the expense required in raising base cations (Ca, Mg, K, Na) to a sufficient saturation.

FR talked about the Backtrack Dairies comparison study (Bryant. 2019) as being a prime example of this as after 5 years the Albrecht-Kinsey (AK) managed side had not yet recouped its increased fertiliser cost compared to the conventional.

An advisor interviewee was familiar with the Backtrack study and said the initial applications were excessive as the practitioners of the study didn't account for how soluble Dolomite is. A

discount of the initial input cost was applied to the report findings, but it was not acknowledged in the report.

The report itself is light, considering the comparison study is the first of its kind on large scale properties. The tone of the piece reflects the protectionism outlined elsewhere in this report. The cost of fertiliser was highlighted, though per cow production, in calf rate performance, metabolic issue reduction and pasture production improvements on the AK side were all minimised as statistical anomalies.

FR went on to speak of AK fertilisation in the context of American agriculture, who shifted to MAP/DAP fertilisers as opposed to SSP. MAP/DAP contains no Ca within it, unlike SSP which is 20% Ca in the form of Gypsum. Combined with a lack of liming practices as standard in the USA, FR theorised that William Albrecht had simply found the benefits of liming. He would go on to say that Albrecht didn't believe in the effects of soil PH on plants.

The unacknowledged affect soil PH has on plants within AK was backed up by HSA, who stated it as an issue in following the strategy. However they also note the importance of base saturation when considering soil fertility with a focus on CEC being paramount. For many, these elements are synonymous with AK,

11.2.2 Urea

While urea usage makes a showing in some analysis sections, it does not show in the discussion. Interviewees were asked about it, but a choice was made to focus on P fertiliser. Noted by many interviewees was that prior to the 90's farms did not have an abundance of clover in their sward's. While clover fixed nitrogen had been a focus, managing 30% emergence was a consistent challenge. The reality of clover is that it is seasonally active, requiring longer round lengths than is optimal for ryegrass.

While it may seem like urea and clover are intertwined, a more fair analysis of the dramatic urea uptake throughout the 1990's and 2000's is in the controllability of N applications and clear profitability of its use. In irrigated systems, not as limited by volatilisation, N use skyrocketed.

Multiple interviewees spoke of yearly applications above 300 units N/ha with disdain, highlighting a necessity for this undoubtedly showed issues of unbalanced fertility. The advisors also spoke that their clients within this zone did not have the expected production shortfall after reducing to 190 units N/ha. For a 40% of N inputs to have no tangible production effects highlights the amount of unnecessary product used, driven by a "more is better" mindset, outlined by the incentivisation surrounding advice on urea usage. Further highlighting the lack of support around reducing N use are the irrigated farms applying below their 190 unit cap, but importing additional feed. This was discussed with one

farm advisor and it was concluded the practice is merely done for optics but also shows a mentality of production somewhat separated from profitability.

Of note in the analysis section is the statement made by one researcher who was "...tasked with the job…" of finding a use for urea in pastoral farming due to the creation of Kapuni Urea Plant. The statement was not expanded on, so speculation has not been made within this report. But prior to this our imported urea was used primarily in the arable sector.

11.2.3 Mindset

Initially expected to be a key focus of this report, but through analysis the heart of the narrative became incentivisation and frameworks. A point seen was how these elements affect mindsets on farm. The narrow, linear and short term components of agriscience are reflected in conventional farmers. Below is an exemplification and expansion of how these mindsets show.

A practice previously used by HF1, and one gaining traction in the wider holistic dairy sector, is "Bale Grazing". This involves a high density of hay bales simply unwrapped on pasture and fed adlib. No bale feeders or mechanical spreading of the bales are employed, with the cows given free access to 3 days of feed. Utilisation is reinterpreted with a high (1700-2000KgDm/Ha) grass residual left behind and around 1/3rd of the bale left as litter. Conventional thinking says this is wastage, under utilisation of feed offered. A circular mindset sees nothing wasted to the system, what is not eaten by the cows remains on the land to be broken down to the soil as organic matter, with viable seeds from the hay operating as patches of regrassing. In a self-contained system, the paddocks grazed in June and July bounce back quicker due to the high residual and can be grazed again in September, lengthening the first round and dropping a requirement to have paddocks out for regrassing. Aspects of cow comfort are noted too, with the bale litter offering dry bedding in wet conditions.

In contrast the mindset of conventional farming is to maximise a set of outcomes for production. Typically these are utilisation, pasture quality and growth. High utilisation, consistent flat residual pastures, with fertiliser applied to maintain rapid growth ensures ME quality and sufficient quantity of pasture to stock. It's simple, it works and it has a clear start and end. The only time this closed loop is interrupted, with an acknowledged trade off, is in wet conditions when farmers are mindful of pugging. In this case a consistent residual is sacrificed for reduced soil damage. Lineality is further exemplified in attitudes to fertilisation, where all conventional respondents, including both researchers and the advisors, stated fertiliser is used to feed the plant not the soil. This may seem like a minor detail, but it shows a practice focused on outcome without thought to the process of mineral transfer through the soil biome and into the plant - which happens regardless of method.

This difference in mindset shows clearly along the conventional - holistic management spectrum, to the point that it could be recharacterized as a linear - circular mindset spectrum. How mindset impacts practices is quite different at each end. Holistic farmers hold a circular mindset central to their decision making, it directly influences the practices they engage with and has been a challenge for them in understanding it. Conversely, linear mindsets on the conventional side are not overt but rather an outcome of simplifying problems with product solutions. In the conventional space, you could explain a circular mindset as adding complication to a solved problem.

Examples of circular mindsets do show in conventional farming, typically this is in solving more complex problems. Take the example of in-calf rates. A linear mindset leads to the solution of Cidrs and intervention in order to solve non-cycling issues or to bring calving dates forward. However, ask any farmer who has improved a herds fertility. They will tell you it is a multi year process. No single change that they made is the reason for improvement. They likely did a combination of improved body condition throughout the season and carried through to the next, considered mineralisation in a different way, focussed on achieving a rising plane of nutrition post calving, improved feeding rates to R1-R2's, focussed on maintaining consistent pasture quality throughout the seasons, utilised OAD as appropriate. This list could go on, but the main thing they did was not consider any one season in isolation. They acknowledged that what happens now will affect how they perform later and they understood that the details add up to larger improvements.

While circular mindsets are undoubtedly a barrier for conventional farmers entering holistic practices, they have certainly experienced them within their current contexts.

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13. Appendices

13.1 - Appendix 2 - Interview Questions

Primary	Secondary/follow-up
• Please describe your role and experience?	• Farm size, stocking rate, imported feed • How would you describe your farm system /business strategy?
• What place do soils hold within your system?	• What practices do you implement which focus on soil health?
• How do you approach fertiliser use on your property?	• What places of advice do you use? • Do applications vary by year? ○ What impacts this variance?
• How do you perceive the use of fertilisers in relation to soils?	• Is this the same for NPKS, Urea, Lime and trace elements? • What role do fertilizers have in maintaining healthy soils? • What does soil health mean to you?
• Over the course of your career, how has fertiliser use changed?	• Over this time, what breakthrough in research has made the biggest impact on your system?
• What opinions do you hold about the fertiliser duopoly?	• Do you believe they have an additional responsibility to farmers due to their Cooperative structure? ○ In what ways have they fulfilled or fallen short of this responsibility?
• How effective is information transfer from researchers down to farmers?	• What changes could be made to improve the information chain? • In what area would you like to see more research done that would assist your business? • What opinion do you hold of the CRI funding system?
• How do you perceive your farming system operating with natural environments?	• Do we… ○ Work with natural systems? (Water cycle, nitrogen cycle, photosynthesis etc)

	○ Are we improving them? (supplementing for higher production i.e. fertiliser inputs) ○ Battling against them? (weeds, native grasses, floods/drought) ● In what way does this view frame your choice of farming system?
● How do you feel about the term "Regenerative agriculture"?	● How would you describe regenerative agriculture? ● Do you consider your system regenerative? ○ Why/Why not? ● What changes would need to be made to be/be more regenerative? ○ What barriers do you foresee in doing this?