Regenerative Farming

A WORKSHOP FOR GO-AHEAD FARM
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Report by Debbie Pearson
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Introduction

Farming 2030 harnesses the vision and knowledge of the community, working with farm owners Wayne and Tyler Langford, to develop practical sustainable farming practices. In the process it fosters a community that is better informed and unified.

> ***Farming 2030:***
> ***Working together as a community to develop farming models that work for the farm, the environment, the farming family and the community.***

One of the sustainable practices the project is investigating further is Regenerative farming. Jules Matthews, a regenerative farming coach with Integrity Soil, provided expert advice for applying regenerative farming principles to Go-Ahead Farm, the Farming 2030 pilot farm owned by Wayne and Tyler Langford.

Jules ran a 2 day workshop that covered the following areas:

- Changing mindset
- The crucial role of your underground livestock
- Understanding your soil tests
- The tools in the regenerative tool box
- How to choose what actions to take
- Grazing management with your new mindset
- Financial implications

These notes capture the discussions over the 2 days of the workshop. By the end of the 2 days all of the participants came away with a whole new way of looking at the farm. Jules had firmly imparted the value of observation, and given us some powerful insights into how to interpret the analytical data. She taught us how to interpret the lab results, coupled with the information we gathered from doing visual soil assessments and observing the pasture composition and growth, to determine which of the tools in the tool box would work best to get the farm really humming. By the end of the 2 days we were all excited by the potential of what we had learnt. We hope you are similarly excited when you read this account!

Setting the Scene

Farmers carry a lot of weight on their shoulders – not only is there the financial burden of high debt, but they operate in an increasingly complex regulatory environment. And of course there are all the practical skills required to run the farm. Dairy farming is firmly in the public eye,

with increasing pressure from communities to ensure that practices are environmentally conscious. Some farming practices that have become "conventional" over time, such as the application of chemical fertilisers and sprays, have created a number of environmental issues and unintended consequences. These are not the fault of farmers, but those of us in the game are now responsible for putting things right.

Regenerative farming looks at aligning farming practices more closely with nature's cycles and inherent regenerative mechanisms. It comes from a place of wonderment and curiosity rather than a place of knowing. How we can best empower ourselves as farmers to have a more robust understanding of the system we are managing? What are our limiting factors? Air, water, minerals, microbes and our mindset are all critical for good production and a profitable enterprise.

Over time the nutrition levels in our food has plummeted. Simply put, we no longer get the same health boost from our food as we used to. The good news is that food produced using regenerative practices has been shown to be more nutritionally dense than food produced using "conventional" farming practices. Regenerative practices focus on establishing a healthy ecosystem, with a particular focus on the soil microbes and effective photosynthesis. Getting your underground livestock thriving is key to ensuring your soil is thriving. Healthy soil = healthy plants = healthy animals and a healthy environment. Working cooperatively with nature sets up a virtuous cycle.

Latest scientific research has established how crucially important our gut microbiome is for our overall health. It is the same for your land. Think of the soil as the land's "gut" - the microbes in the soil are critically important to the health of the whole ecosystem as they supply nutrients, water and protection.

The Issues for Go-Ahead farm

- Weeds: the biggest problem is Giant Buttercup, which is sprayed with Preside, a chemical spray, to keep it under control. Other weeds are gorse and barberry.
- Disappointing growth rates of pasture. In some paddocks the grass growth is patchy, including bare ground. Currently growing 7.5-8 tonnes of dry matter per hectare and aiming for 11 to 12 tonnes of production annually.
- Paddocks are quite compacted. A high stocking rate of 360 cows 5 years ago is now down to 230 cows. This gives the paddocks more chance to recover as longer rotations are achieved.
- Use of sacrifice paddocks, though a better solution would be preferred. Using the cow yard is not an option as it is used for effluent diversion.

- No longer grow winter crops as there was too much topsoil loss and risk to animal health from fodder beet through acidosis. Prefer not to have the cows in mud, particularly after high (100mm) rain fall events.
- 100 bigger framed cows are sent off farm for winter grazing.
- Some balage and hay are bought in, the rest is cut off the platform, as a variety of Lucerne and hay.
- Young heifers are sent to Collingwood from April until April the following year.
- Animal health is pretty good. Empty rate is between 8-9%. Aiming for less the 5%.
- Cows going into the spring are sometimes too light. Replacement rate is 18-20%. Don't cull on age.
- Production last year was 70,000 kg milk solids. This was a poor production year. Average is 85,000 kg milk solids/annum.

Environmental Concerns/Notes

- The river is changing course and taking out one paddock.
- Currently extending riparian planting to non-regulatory waterways to help alleviate nutrient run off
- The top half of the river is dry for 99% of the year
- Effluent system uses a weeping wall. This gets emptied every 2-3 years and goes back on the paddock.
- Changing climatic conditions
- Increasing regulatory pressure on farmers

Finances/Assets

- 95% debt loading
  Work with a low level of machinery. Contractors are brought in to apply fertilizer, drill seed, and do digger work.

Wayne's roles

CEO of "Meet the Need" a charity to provide donated meat to families that need it. (25-30 hours/wk)

Dairy Chair NZ Federated Farmers

Board member – Rural Service Centre

Regional President - Fed Farmers Golden Bay

YOLO farmer (you only live once)

Time is a constraint for Wayne!

Family Philosophy

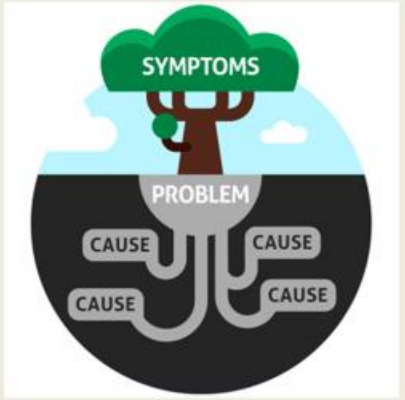
For Wayne it always used to be farm first, but now it is Family – Fun – Farm…in that order!

Wayne and Tyler are passionate about being proud of the product that goes out of the gate.

Wayne and Tyler would go organic tomorrow if it was not for the problem with Giant buttercup. They believe there are a number of Golden Bay farmers in the same situation. Cracking the Giant Buttercup problem would be a game changer.

Changing mindset

The way we view a situation determines the thinking and the ensuing actions we take. Rather than looking for switching out current products for those that are more biologically and environmentally friendly we look to change the way we view the world, seeking collaboration rather than competition. This begins with curiosity and looking to understand what nature is trying to do. A good example of this is our weeds. Shifting from something to kill and eliminate to something that is an indicator of the physical, biological and mineral conditions has us seeking to understand the complexity of nature rather than dominate and control her.



Are we treating symptoms or solving problems?

Will we be back here next year doing the same thing?

Why are these symptoms appearing

Need to look at all the pieces in the puzzle the bigger picture or "system" to help find a solution to fix the problem

Grass utilization is another good example of changing mindset to make better use of the natural cycles. There are 3 components of grass utilization:

- Cows' needs
- Plants' needs
- Soil biology's needs

Farmers generally focus most of their attention on growing the pasture required to feed their herd to satisfy the cows' needs. While these two factors are vital components of a successful farm what is often missed is the third component, the soil biology. The function of soil biology is crucial to a healthy system. Each of these areas need to be understood and given equal consideration for a natural balance to be achieved.

Focusing as much of your attention and efforts on your growing your underground livestock (your soil microbes) as you do on growing your cows and plants takes a significant mindset shift.

Good soil biology provides the plants with plant-available nutrients and, in turn, the plant feeds the biology with sugars in the form of root exudates. The plant foliage feeds the cow and the manure and gut bacteria from the cow feeds the soil biology. When we use synthetic fertilizer or chemical sprays we damage this cycle. The plant uptakes the soluble form of fertilizer and no longer needs to send root exudates to the soil biology. As the plant becomes lazy the biology ceases to thrive. Chemical sprays kill or damage the soil organisms further damaging this natural cycle. Over time this compromises soil structure and soil health.

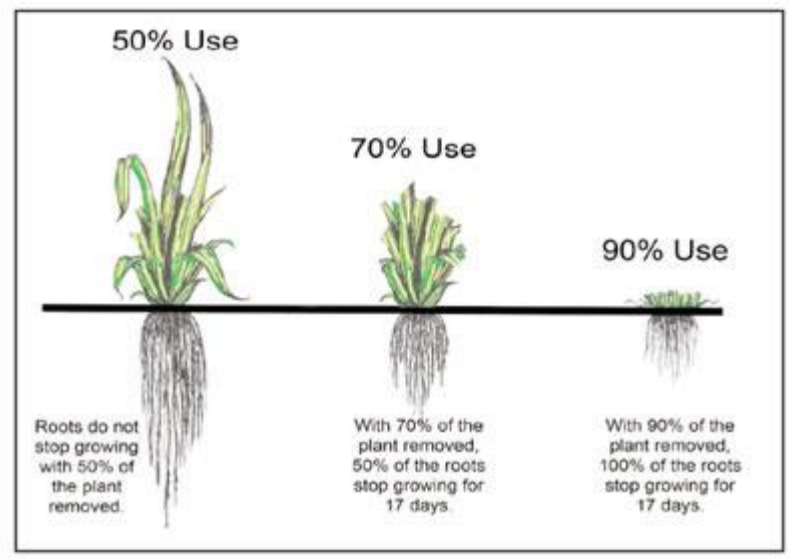
Efficient photosynthesis and good working biology in your soil builds humus. Humus is 60% Carbon, 6-8% Nitrogen, 1-2 %Phosphorus, 0.8-1.5% Sulphur. Growing humus levels improves the water holding capacity of your soil as well as nutrient cycling and resilience. A 1% increase in soil organic matter effectively increases water holding capacity by 144,000 litre/ha which during the course of a season can easily add up to a half a million litres/ha.

Pasture Management

The major source of stable soil carbon is through plant sugars and mycorrhizae. The best way to lift carbon is through practices which increase photosynthesis in the plant (Measured by Brix) and through increasing rooting depth and organic matter. The most cost effective place to start is with planned grazing.

Whole system thinking requires multiple factors to be considered both short and long term. Understanding what specifically is needed at any given point for plants, animals, soil health and farm production creates a dynamic and challenging situation.

Photosynthesis fuels life, how we manage that has a direct impact on farm performance. Adopting new strategies in grazing management requires a greater understanding of this process and how it supplies the soil biology in exchange for nutrients and water. Pasture length becomes an important factor as we move toward maximising photosynthesis. The greater the leaf surface area the greater the photosynthetic capacity. The percentage of the plant grazed at any-one time becomes a critical factor as it directly impacts root growth.



Taking 30-50% at any one time is a strategy to aim for as you work toward greater nutrient cycling and photosynthetic rate and capacity. Increasing plant rooting depth through this grazing strategy builds resilience against the drought, increases nutrient cycling and improves the cycling and storage of carbon. With low brix pastures, loss of performance can be an issue. Supplementation with minerals, loose salt and humates is a prudent approach to ensure forage conversion, animal health and performance while bringing your biological system on line. Ultimately developing diverse pasture swards with a minimum of 12 species will begin to create a high functioning system that will provide for your stocks nutrition and performance needs.

Taller grazing can increase the energy/protein ratio and fibre content of an animal's diet. In spring we have an excess of protein and deficiency in energy in our lush pastures. Livestock then burn energy that could produce milk, meat and fibre to expel the excess protein. Taking the top 30% on a quick rotation once pasture growth rates increase, allows the animals to consume the part of the plant with the most energy. Err on the side of trampling more, and leaving more material behind when making the decision to shift stock. This will help to fast track your soil objectives.

Consider building a buffer into your summer grazing plan with an area of deferred grazing. Locking up 10% or more of the farm to allow pasture to grow until the end of summer not only gives you a drought feed buffer but it has the added benefits of allowing tiller recovery, moisture retention, increases root mass, feeds soil biology and keeps soil temperatures down. This is a strategy to increase pasture density, persistence and resilience.

Root function is critical. Of course the roots feed the plant, but the way they do so most effectively is by setting up a cooperative relationship with the soil microbes. The plant provides the microbes with food in the form of root exudates (sugars) and in return the microbes provide the plant with plant-available nutrients and water. The better this relationship is working the healthier your plants and the faster your grass grows.

Deep roots have other benefits. The deeper the roots the greater the resilience of the plant to environmental changes. Deep roots also help break up compacted soil, enabling more air, and better water infiltration. The better your water infiltration the better the "capture" of water by the soil. This results in less run off during high rain events, and more available water from the soil during drought events creating a resilient system.

What's more, in summer longer grass keeps the soil cooler, enabling more moisture retention.

Long grass also has a flow-on benefit for animal health. Parasites live at the base of the grass near the soil, so when the animals are only eating the top 50% they are not re-infected with parasites. Similarly studies by Katherine Tozer have shown that facial eczema went down when paddocks were -deferred. Earthworms eat facial eczema spores, so encouraging good biology in the soil results in less facial eczema spores in the grass, and therefore lower infection rates in your stock.

Grazing Management – getting started

Aim to lift covers (i.e. increase the volume of grass by lifting grass height) to effectively increase photosynthesis, nutrient cycling, forage quality and quantity. Set up a couple of paddocks for deferred grazing, by locking them up once good spring growth allows. If it is another long dry summer you can use these paddocks as standing hay. If the season allows defer grazing these paddocks until late summer.

By this time the grass will have started to seed and you will have a mix of browns and greens (brown=carbon and green=nitrogen) in the paddock.

***Question from the floor**: Isn't that a waste of grass mass? The cows won't eat the brown section of the plant so it seems a wasteful approach?*

This is where your changed mindset comes in. Consider you are feeding your cows and your microbes. Both are important. When you open this paddock of mixed browns and greens up for feeding it is crucial that you mob up the stock to create stock high density and break feed. Timing of the shifts is crucial here. You want them to eat a percentage and trample the rest into the ground. "Browns" feed your fungi. "Greens" feed your bacteria. The left over browns and greens that are trampled into the ground are feeding your underground livestock and helping to improve the health of your soil. Your mobbed up cows are pooping and peeing, and these excreta contain gut microbes that stimulates the biology in the ground. Trampled in material, coupled with the action of your soil microbes, adds to the Organic Matter (OM) in your soil. For every 1% increase in OM your soil can retain 144,000 litres more water. So more OM makes a huge positive difference to the water holding ability of your soils as well as nutrient cycling. .

New seedlings will come through the trampled grass. The improved biology in your soil provides plant available nutrients, which feed those new seedlings and help them grow faster and more resilient. The virtuous cycle has begun.

Question from the floor: *Time is a constraint for us. Moving cattle up to 4 times a day doesn't fit with our lifestyle choices.*

There may be some technological solutions around the corner. The cow "halter" will allow the cows to be in a strip with no fences. This is about 5 years away from being commercial. Some farmers use "tumble wheels" This makes changing fences faster. It is a series of wheels fixed to fencing - when you pick it up it moves with you.

Batt latches are available, these work on a timer to open gates so animals can be moved automatically.

More about your soil microbes

Fungi help form soil aggregates, by producing glomalin, which is the sticky substance that gives soil its good structure. They are fed by liquid carbon from the plant in the form of root exudates and also require dead plant material, humates, wood chip, (the browns) or fish hydrolysates.

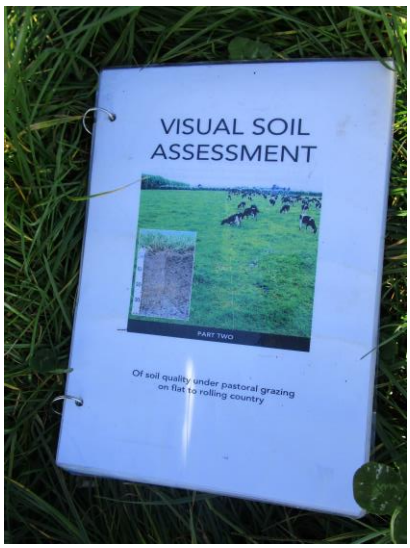
Bacteria make the fine crumb in soil. Bacterially dominated soils lose structure, this collapse means there is less air movement and water infiltration. Creating soils that are more compacted and more anaerobic. Anaerobic soils harbor pests that you don't want e.g. mealy bug, grass grub, porina, clover root weevil and root-eating nematodes. Bacteria are fed by the "greens" such as living plant material, manure, fish emulsion, sugars, and seaweed.

Bacteria have a crucial role to play in soil health as nutrient accumulators. As they multiple they take up nutrients and convert them into a more bioavailable form. These bioavailable nutrients are then released when the bacteria are eaten by protozoa and nematodes. Without a healthy population of soil microbes to cycle the nutrients they become locked up in bacterial soils.

So a healthy soil has a balance of fungi and bacteria and a healthy level of protozoa and "good" nematodes.

Observation and Analysis

This is where the workshop got practical and we all headed for the paddocks, armed with a myriad of measuring tools including a refractometer, penetrometer, pH meter, electro-conductivity meter, a plate meter, a spade and our Visual Soil Assessment guidelines.



Refractometer

The refractometer measures Brix, an indication of the sugar levels and dissolved solids in the plant. This gives a measure of how well the plant is photosynthesizing.

Brix levels for the same plant change over the day, reflecting the changing levels of photosynthesis as the sun intensity changes. They also change within the plant. Near the base of the plant the Brix levels are generally lower compared to the top of the plant.

Different ways of collecting the sample give you different information:

Collection technique	What the results indicate
Just pick your grass leaves and squeeze in the garlic crusher	Indicates how well the plant is photosynthesizing
Pick, roll, then squeeze and measure	This measures the available nutrition for the animal. It is normally higher than the pick and squeeze technique.

A fuzzy line (when you look through the refractometer) indicates that nutrients are cycling well.

A sharp line with a brix below 3 indicates that nitrates are high.

A sharp line with a Brix of 3 or above indicates that Ca is not cycling well.

Test the weeds in the paddock vs the grass in the paddock. If the brix for the weeds is higher than the brix for the grass then your paddock has the ideal conditions for the weeds rather than the grass. Think about how you can shift the paddock conditions to favour the grass or other pasture species you are growing.

Penetrometer

A penetrometer measures the compaction of the soil. Take measurements along a transect. 20 samples going one way recording the depth at 300psi. 20 samples back the other way recording the depth at 600psi.

If you don't have a penetrometer you can get an indication of the level of compaction by digging a hole in the ground and then pulling a pocket knife up the edge of the hole, noting the resistance at different levels.

Plate Meter

Estimates the dry matter in the paddock. A measure of how much grass you have.

Electrical Conductivity Meter

Electrical Conductivity (EC) is a measure of total soluble and dissolved salts in solution. Essentially a measure of the presence, availability or oversupply of nutrients. It can be used as a direct guideline for ideal fertilizer timing. As a rule of thumb, a plants sap conductivity should ideally be between 2 and 12 mS/cm.

Looking at your plants

How wide is the grass leaf and how shiny is it? A wide leaf is able to photosynthesis at a greater rate than a narrow one. When grass has a "glossy" sheen this shows that it is producing fats and lipids. Coupled with a high brix this is an indicator that your plant has good resistance to insect attack.

What weeds are present? The weeds tell a story about the soil condition. Why does nature want to grow this particular weed? Take buttercup. It is an indicator of pugged, poorly aerated soils. It is telling you that air is likely to be a limiting factor in that paddock. Rushes – these have a hollow stem and are well adapted to anaerobic environments. So they indicate the soil conditions are anaerobic. Dock – has a deep tap root that draws nutrients from deeper in the soil and helps aerate the soil. The book "When Weeds Talk" is a good resource for better understanding how to interpret what the weeds are telling you.

What's eating your leaves? An even bite out of the side of clover indicates clover root weevil. Observation of the type of leaf damage will inform you whether it is slugs, clover root weevil, clover flea or other insects feasting on the pasture.

Dig up a plant and look at the roots. Are they growing straight down or are the roots heading off to the side? Sidewise roots often indicate compaction, the presence of a hard pan, or possible water logging. What colour are the roots? Actively growing roots are often fleshy and white, while roots that are suffering from poor drainage or compaction may be thin and darker. Are rhizosheaths forming around the roots? These indicate a good symbiotic relationship between the plant and the soil microbes.

Rhizosheaths indicating a healthy symbiosis between plant and soil microbiome.

Dig up a clover and check out the root nodules. How many are there? When you cut them open what colour are they? Red indicates the nodules are nitrogen fixing, white indicates that they are not working, and green indicates that they were fixing nitrogen but they are not doing so now (this could be caused by temperature or if a soluble nitrogen application has just occurred).

Directly under the Lucerne there was a lot of worms – a lot more than we had found during our sample dig. The roots were sprawly rather than a strong deep tap root. A sprawling root on lucerne can be indicative of a poor fungal relationship, though it could be due to the roots hitting stones (there were lots of stones in the paddock!). Jules reminded us that it's good to take more than one sample – especially when things look a bit unusual. A double check by digging another lucerne plant up came up with a strong single tap root.

Visual Soil Assessment

Landcare provide an excellent visual soil assessment guide online free of charge.

Under Jules direction the workshop participants ran through the visual soil assessment guidelines. What is the soil structure like? How friable is it? What is the soil colour? Are there any mottles? What insects can you see? How many worms are there? The results from this assessment for the home paddock are shown below, alongside the lab mineral testing, plant tissue testing and soil food web tests.

It was abundantly clear that there was a huge amount of information you could glean by digging a hole and being super observant. With practice this felt like a goldmine of information at your fingertips.

Soil tests and plant tissue tests

We had the following lab tests on hand to assist with our analytics:

Albrecht "Professional Soil Report" - 24 June 2020

Soil Foodweb "Soil Biology Report" – 24 June 2020

Eurofins Comprehensive Soil preliminary report – 5 Aug 2020

Eurofins Plant Tissue test – 5 Aug 2020

A copy of these soil tests for the home paddock and the lucerne regen paddock are in the appendix.

Testing Explained

Each test is an opportunity to compare the results with what you have seen in the field after doing your VSA and gathering other relevant field data. The history of a paddock should be considered as it can have a marked bearing on the results. Particularly any anomalies which don't seem to make sense. For example high potassium (K) was explained once it was known the paddock had a history of being a holding paddock. High K is associated with compaction.

Remember good diagnostics are key here. More than knowing the answer or jumping to conclusions be ready to ask the next question and get curious about why things are the way they are.

Soil Food Web Biology Report

This is a good snap shot of your levels of bacteria, fungi and protozoa and how well they are functioning. Your biology is key in making minerals and water available to plants so knowing where things are at will guide you in how to improve the functioning of this underground workforce.

Bacteria like simple foods such as sugars, green manures, seaweed and animal manures. Fungi are carbon feeders so require fish hydrolysate, wood chip and other brown carbon materials. Think "greens (bacteria) and browns (fungi)" Use this report to guide you on what and in what ratio these foods should be applied. Aeration is key to microbial function, be sure to address any compaction as just feeding biology without addressing this issue will not create the best results. Your protozoa (amoeba, flagellates and ciliates) will increase in activity and number with an increase in their food source which are your bacteria and fungi. Protozoa are a critical workforce in nutrient cycling. Note that high ciliates is not desirable as it indicates anaerobic conditions.

Nematodes: This testing is not yet available in NZ. It is estimated over 1 billion is lost annually through pest nematodes. Encouraging healthy soil conditions to favour beneficial nematodes is key.

80% of plant health and nutrition is driven by biological functions outside the plant. Think of the soil and its life forms as the stomach of the plant.

Soil Test

pH- range of 5.8-6 was developed by MAF to get maximum DM production in pastoral farming, in setting this range pasture quality and P availability were not factored. Lifting pH to 6.3 gives you the greatest availability of P in the soil.

Biology can buffer pH by up to 2 points either way. pH is NOT a measure of calcium. Look at your cations and base saturation to see the levels of calcium, magnesium, potassium and sodium (the positively charged ions). It maybe, for example, you need magnesium and adding that will also raise your pH.

Anion Storage Capacity: (ASC)- the soils ability to hold anions which are the negatively charged ions phosphorus, nitrogen and sulphur. The soil has mostly negatively charged ions and two negatives don't attract. Anions are nutrients that are not held well in the soil. This tells you how well your soil can hold these nutrients. With a low anion storage capacity, you would

only put on small amounts of nutrients at any one time with a negative charge as they are very leachable. Volcanic soils have a very high ASC. Doing a total phosphorus test will often reveal an abundance of this nutrient in the soil. Biological activity is key in releasing locked up anions.

Cation Exchange Capacity (CEC): This is your soils ability to hold cations, the positively charged minerals calcium, magnesium, potassium and sodium. Think of CEC as the size of your bank account. A sandy soil will have a low CEC (5-7) and cannot hold vast quantities, where as a clay soil will have a higher CEC 25+ and can hold a vast amount of cations.

Some labs measure CEC at a pH of 7. This shows lower levels of cations in the base saturation. Particularly Ca and Mg and can lead to over application of these nutrients. Find a lab that will measure CEC at the actual soil pH, which gives a more accurate result.

Exchangeable Hydrogen saturation is the % of hydrogen. The hydrogen % plus the total base saturation % will add up to 100%.

Total Nitrogen & total Carbon: Totals will lift with an increase in organic matter

Some labs use NIR (near infer red) this is an estimate method. They also use this method for measuring P and S.

The combustion method as it is more accurate way to measure total N & C.

Hot water C & N:

HWC – measures microbial C in soil

HWN - measures the labile pool (what is active) It measures the mineralizable N that can be converted from OM during a season.

Organic Matter: calculated from the total carbon. Total C X1.74= OM or C = 58% of OM

C:N ratio: Tells you how well OM is cycling 10-12:1 C:N is ideal. Low 7:1 means OM is cycling too fast, so you need more carbon. High 15:1 is too slow, you need biological foods to increase activity.

Ammoniacal N and Nitrate N test – only a snap shot in time. Not particularly useful except for crops. Consider doing a total N test instead.

Olsen P– is a 30 min bicarb extraction, measuring the intensity of the P rather than plant availability. It does not measure RPR that has been applied.

Olsen P is measured as a % based on the soils anion storage capacity

- 1.4% of Total P for high ASC soil
- 2.2% of Total P for medium ASC soil
- 3.0% of Total P for low ASC soil
- 6.0% of Total P for organic soil

Colwell: Same method as Olsen but longer, 16 hrs. Will measure some RPR. Not much calibration, useful as a comparison from previous tests.

Resin P: Water extraction at soil pH. Better measure of plant available P.

Bray 2: More aggressive acidic extraction for 1 minute. Not calibrated for NZ yet. In high ASC soils it is not so accurate as soil will hold the P and not release it. Result is it undermeasures at low pH. Does measure RPR and super

Total Recoverable Phosphorus: Gives you your bank account, what is stored in the soil. P release is dependent on mycorrhizal fungi.

Total Recoverable Sulfur: Again, this is your bank account. The total pool in the soil

Sulfate sulfur: Tends to be unreliable as easily contaminated. Will be about 2% of the total S

Cations: These are positively charge ions, they are attracted to the soil particles which carry a negative charge. There are 3 different tests, they all measure what is actually there in the soil. MAFQT (MAF quick test was designed to give whole numbers with ranges (reference scale) and make it easy for farmers) cmol+/kg and PPM are other ways to measure the amount of each cation. I like to work with PPM (parts per million) this can be calculated by dividing the cmol by the CEC and then multiplying by 100 to get PPM

Mg/kg is the scientific term for PPM (parts per million)

c/mol = add all the nutrients up (plus % of other bases) to = CEC

The range for Magnesium on the MAFQT is 8-10 that is for soil. For animal health, especially dairy we require it to be 20 or above.

Ca/Mg ratio: A 7:1 ratio is often used as ideal. Remember it is a guide, don't go broke chasing numbers. Calcium opens up or flocculates your soil, with a good ratio and good biological activity you will not have compaction issues. When the magnesium ratio increases it will tighten up the soil making other nutrients less available.

Soluble salts: Not a necessary test unless you have high sodic soils.

Base Saturation: If CEC is the size of the bank account, base saturation is how full the bank account is of the 4 major cations, calcium, magnesium, potassium and sodium. Each cation has an ideal % to give optimal growing conditions. Calcium 65-75% , magnesium 10-14%, potassium 2-5% and sodium 1-2%. Remember an excess can be as much of an issue as a deficiency. For example, excess potassium will make sodium and other nutrients less available.

Total Base Saturation: Is the total of is all the four bases, calcium, magnesium, potassium and sodium, added together.

Other Bases: Positively charged cations Al, Cu, Zn, Mn

Trace Elements: Mehlich 3 test: Is a 5-minute, acid extraction at a pH of 2.6. Not calibrated. Due to the acid nature of this test it will pull a lot of aluminium out. Much of that aluminium is not plant available.

Trace elements: EDTA Test: Is calibrated and uses a pH of 5.6. It is an overnight extraction that uses a chelating agent. Is a good measure of plant available trace minerals.

Morgan: Mild extraction process. It shows the daily limit on your bank card, of P, Ca, Mg and K. When viewed with plant tissue tests it shows functionality of nutrients.

Plant Tissue and Animal Dietary Tests:

Ideally a lab will wash samples before testing. It is a good practice to take samples wearing a latex glove and not sample too low to avoid contamination.

Titanium is included as an indicator of sample contamination. Over 40ppm indicates some soil contamination in the sample.

These tests are pretty straight forward and give you a good idea of what is present in an animal's diet.

Crude ash – is the mineral material left after the organic material is burnt off.

Potassium – high, affects pasture palatability and causes metabolic issues

Sodium: Also affects palatability and is made less available by high potassium.

Ad lib loose salt is always highly recommended as animals cannot store or produce sodium.

High Manganese requires calcium and zinc to balance. Feed such as palm kernel have excess manganese. This creates stress, effects milk quality and ties up other nutrients. If you are feeding minerals check to see if there is manganese as many NZ pastures have an excess.

Feed Quality:

Crude protein is often higher than an animal's requirements. This takes significant energy for an animal to process. This use of energy to digest unwanted protein in turn effectively lowers the ME value of the pasture. To calculate this, multiply the excess protein. For example with excess protein of 14.2 X 0.18 = 2.5. Subtract the 2.5 from your ME to get a true picture of the energy the animal is getting minus the energy it takes to digest the unwanted protein. If ME was 10.1 – 2.5 = an ME of 7.6.

Be sure to feed adequate carbon such as straw to balance the excess protein.

Free choice humates can also be a good addition to manage excesses.

Soil Foodweb Results - Home paddock (24/6/2020)

Note that in a pastoral scenario we are looking to have a fungal:bacterial ratio of 1:1.

Active fungi was low, although the total fungi was in a good range. Fungi diversity appears reasonable with adequate levels of hyphae formation. Bacterial activity was within normal levels and total bacteria biomass was good.

This paddock had a balanced fungal and bacterial biomass for pasture at 1.12 to 1. A good result. The fungal biomass helps build soil aggregates and structure, reduces disease and cycles nutrients especially calcium. The bacterial biomass builds the fine crumb in the soil structure plus provides food for the predators ie worms, beneficial nematodes and protozoa.

Protozoa levels were barely within range. The nutrient cycling by the actions of these bacteria eating predators was low, providing 56-84 kg/ha of N per 3 month period. Protozoa and nematodes are essential for the efficient cycling of nutrients in a healthy soil. Stimulating the bacterial and fungal population is essential to increase nutrient cycling from protozoa and nematodes.

Mycorrhizal Fungi: normal colonization however low fungal activity suggest mycorrhiza is not functioning at optimum levels.

Summary: Home paddock has fungal dominated soil becoming more bacteria with time. Low fungal activity probably indicative of low fungal food resources.

Although the home block had a good ratio of 1.12: 1, the remaining tests over the farm showed highly bacterial soils of 0.5:1.

Visual Soil Assessment – Home paddock

Test	Result	Comments
Temp	9.3°C	
Moisture	55%	
Soil type	Silty Loam	
Soil structure	Good crumb	
Soil colour	Dark	Compared against sample dug from under the fence. Under fence slightly darker indicating higher organic matter and more moisture.
Soil Mottles	None	
Earthworms	9 Worm castings visible on surface	Are worms shiny and slick and clean? Worms with a lot of soil stuck to them means Ca availability is low
Clover Root Weevil	6	
Mealy bug	6	
Surface relief	1	Growth patchy
Water infiltration	Poor	7min for first inch. 2nd test over 12 mins.
Penetrometer (300psi)	Average: 83.5mm Range: 60 – 115mm	Compacted soil, roots are limited in their ability to easily penetrate the soil profile
GRASS		
Brix	5 sharp line	Low brix. Sharp line indicates poor nutrient cycling. Ideal is a brix of 12 or above.
EC	3.66	Adequate
pH	5.4	Low, all plants have an ideal sap pH of 6.4
CLOVER		
Brix	6 fuzzy	Ideal brix in clover is 14 and above
pH	5.5	
Nodules	Very few and almost all white	Nitrogen fixing not working well.

Interpretation – Home Paddock

(refer to Appendix, Soil Tests)

Fungi are there in good numbers but **not active.** Foods are required e.g. fish hydrolosates, humates or wood chip. You want your ratio of total fungi to total bacteria to be around 1:1.

Bacteria predator numbers are low indicating poor nutrient cycling. Earthworm numbers are low.

Sulphur is low in the soil mineral test but more than adequate in the plant tissue.

Ca is low in the soil mineral test but more than adequate in the plant tissue.

Na is low in the soil mineral test and low in the plant tissue test. This ties in with the low electrical conductivity for the paddock. Na is an electrolyte and an important contributor to EC.

Potassium is low in the soil mineral test but adequate in the plant tissue.

Boron is low in the soil mineral test and low in the plant tissue test. Note that if you have high milk urea (a measure of excess nitrate) then an addition of boron will help to reduce this excess and drop the milk urea levels.

Copper is low in the soil mineral test but adequate in the plant tissue test. When copper is low it can be seen as red in a black animal's coat.

Cobalt is low in the plant tissue test and in the soil. Cobalt is needed to make B12.

Soil is compacted with poor water infiltration.

Brix is low indicating inefficient photosynthesis.

Actions to increase microbial activity. Aerate, liquid application to stimulate and feed biology using fish hydrolysate, effective microbes EM's, molasses and humates.

The Tools

There are different options to address imbalances. The following gives you a summary of the tools in the tool kit. These can be combined in creative ways to achieve exponentially more than any one approach can on its own.

Soil Amendments	These stimulate the soil biology. Feed bacteria with "greens", living plant tissue, manure, fish emulsion, sugars, milk and seaweed. Feed fungi with "browns", dead plant tissue, wood chip, humates, fish hydrolysates. You can also inoculate the soil with a brew of living microbes. Dairy farmers have an amazing resource for making great inoculums with the effluent from the cow shed or the manure from the weeping wall. These can be applied as a foliar spray. Commercial inoculum can be purchased eg from Biosea in Nelson or EMNZ in Christchurch.

	Inoculum can be applied as a liquid foliar spray or as a solid in conjunction with your fertilizer. *Nurturing your soil biology revitalizes nutrient cycling (making soil nutrients more plant available and fixing N from the atmosphere), improves your soil structure, increases OM and water retention ability.*
Natural fertilizers	Add these to address mineral imbalances. There are wide range of natural fertilizers available. Use your soil tests to look at the best products for your unique issues. For instance Dolomite is a great fertilizer to use if both Mg and Ca are low, but if Ca is high and Mg is low then look to a Mg specific fertilizer such as Magnesium carbonate. If sodium is low, use agricultural salt or sea water is a cheap, effective way to supply sodium. Milk can be added to a liquid brew to address high nitrates in pastures. *A balanced soil mineral profile allows for optimal growth across your whole farm - your microbes, your plants, your animals…and you!*
Mineral Licks	These "free-choice" licks directly provide your animals with the minerals they need. Animals intuitively know what their bodies need and know the best sequence for consuming those minerals. Consider providing trace elements that are low on the soil tests as mineral licks. *Free choice mineral licks have a rapid positive effect on animal health and find their way to the pasture eventually from the back end of the cow!*
Mixed Sward	Adding a diversity of plants builds resilience, stimulates the soil biology, helps aerate the soil, and encourages insect diversity. Consider different swards for spring vs autumn planting and to address your individual situation. Different mixes of plants provide different remedies. There are a number of commercial seed providers in NZ who specialize in providing seed mixes for regenerative grazing and can help determine the right seed mix for you depending on what limiting factors you are needing to address.
Physical Aeration	If your soil is compacted or pugged getting air back into the soil is crucial for healthy growth or your plants and microbes. Soil can be mechanically aerated using an Aerator, a series of knife blades that are towed behind the tractor and make a single cut in the soil. The idea is to allow air to permeate while minimize the disruption to your microbes that comes with conventional tilling. Be wary of mechanically aerating when conditions are too wet or too dry. Best to aerate prior to winter. Dripping inoculant down the blades to stimulate biology can be a useful strategy. In addition, your selection of plants in your mixed sward can help to aerate the soil. Deep rooted plants like chicory, dandelion, radish and dock all help to aerate the soil.

	Once you are passed "remedial action" the best way to retain a healthy level of air in your soil is through good grazing management as well as biological and fungal activity, as they build good soil aggregates.
Grazing management	Putting the same focus on feeding your underground livestock as you do on feeding your animal herd takes a big shift in mindset. The place this shift manifests most starkly is in your grazing management. Stock density, the time animals spend in a given area coupled with plant residues left to feed the underground livestock are critical factors. Building covers, deferring some paddocks to go to seed and then mobbing up the cattle to ensure residual feed is trampled into the ground to feed your microbes. More frequent movement, denser mobbing. Where possible cattle should take no more than 50% of the grass tops before they are moved on. These techniques (explained more fully in the chapter on Grazing Management) result in healthy soil biology, better nutrient cycling, faster grass growth, higher production and healthier animals.
Mitigating chemical use	Adding humates to synthetic fertilisers at a rate of 3-10% such as urea allows you apply 30% less fertilizer while maintaining productivity vs applying straight synthetic fertilizer. Fulvic acids are used to buffer chemical sprays and in foliar feeding. **Always check product compatibility by doing a jar test when mixing liquid products.** https://www.rd2.co.nz/product/mobilizer/
Seed treatments	Consider a seed "treatment" to promote better germination or as a route to treat know soil issues. Both dry and wet products are available. Biosea http://www.biosea.co.nz/products.html or Agrimm https://agrimm.co.nz/ Alternatively use dry vermicast or a vermiliquid.

Making Inoculum

Vermifuge (worm poo) is a great inoculum. The minerals it contains are available to the plant and it contains microbes from the worm's gut that help boost the biology in the soil. Dairy effluent provides an incredible resource to build a viable worm farm.

Compost is also a great inoculum. The manure from the weeping wall, combined with some brown material such as wood chip, calf shavings or old hay, is perfect for making your own compost.

You can even put white wood chip (poplar, willow, whitewood) directly on the paddock to activate your fungi.

At Tui community they have a microbe generator that is stirred and aerated for producing their own inoculum. When setting up your own microbe generator remember to feed both your fungi

and your bacteria – if, for instance, you only add molasses you will get a bacterial dominated inoculum. It's important to feed the generator with a mix of fungal foods (wood chip, humates, fish hydrolysate) and bacteria food (seaweed, green plant, sugars, etc).

At home you can put vermifuge in a bucket, add water and then aerate with a small fish tank aerator to create a vermiliquid.

Investigate using special microbes (slurry bugs) to improve the digestion of your effluent holding ponds. The resultant liquid is then more biologically friendly for application on your paddocks. Pond treatments are available from Biosea, BioAg and EMNZ. Wayne noted that the system he uses has very little holding capacity and other farmers with the same system have had problems with sludge in the holding tanks when they added slurry bugs.

Applying Inoculum

Can apply as a solid (with the fertilizer) or as a liquid.

When you are spraying a biological product that has life in it you need to use a low pressure system. Chaos Springs or Tow & Fert are good systems for spreading your applications. These sprayers broadcast a liquid mix, keeping things whirling in suspension. You can add solids, urea, vermicast, even seed for broadcasting. It works well for all soil amendments. Chaos Springs make a relatively affordable model ($15,000) that works well.

Start small….testing your ideas

With many different options available to choose from it is sometimes hard to know which one to use. So test out your ideas on a small area. For example, you notice that your grass isn't growing as fast as you would like and when you test the brix it is low. A good solution could be a foliar spray. You chose the ingredients based on your best diagnostics and from your observations and soil tests. Now try it – just on a couple of square metres. Spray it on and test the brix in a few hours or the next day. If the brix has lifted appreciably you know you can profitably add the foliar spray across the whole paddock.

Recommendations for Go Ahead Farm

Grazing Management

Keeping it small and simple option: Lock up 2 paddocks now for deferred grazing. Follow the recommendations in the section headed Grazing Management - getting started. This is a great way to trial the techniques and assure yourself of the results before you jump in more fully.

Emboldened option: Do the above, but also lift pre-grazing covers to around 4000 kg/DM rather than the 3000 kg/DM recommended by DairyNZ. Put the cows in for one bite and then move on. This could mean using 4 breaks a day. When the cows take that first bite the plant is stimulated to pump a shot of liquid carbon down through the roots to the soil biology. Grazing the top of the grass encourages the grass to "tiller" i.e. to form many more new grass shoots from the base of the plant. Monitor the growth rates 3-4 days after the cows have been through, if the grass is not responding as fast as expected, adjust the grazing rotation to suit the rate of regrowth.

Mixed Sward

Continue to monitor the 5 paddocks of mixed sward (22 species) that were planted in March 2020. Graze these as above. To introduce new species to an existing sward several options are available. 1: Use severe grazing to arrest growth in the existing pasture and then direct drill. 2: Use a low level of herbicide buffered by fulvic acid, ideally adding in a fish hydrolysate and effective microbes to stimulate and feed the soil biology. Herbicide spray and tillage both have a negative and detrimental impact on the soil biology by destroying habitat and food availability.

Mineral and Innoculum Supplementation for the HOME PADDOCK

The Issues	Proposed actions
Fungi are not active. **Bacteria predator** numbers are low indicating poor nutrient cycling. **Earthworm** numbers are low.	Biosea fish hydrolysate – 10 litres/hectare Humates – 10-20kghectare Effective microbes (EM) 10 litres/hectare (optional) Molasses 500ml to 1 litre per hectare combined with • salt 20-40kg/ha • boron 2kg/ha • cobalt 250g/hectare All of the above can be applied in liquid form using the Chaos Springs sprayer.
Sulphur is low in the soil mineral test but more than adequate in the plant tissue. **Calcium** is low in the soil mineral test but more than adequate in the plant tissue.	Given that these minerals are showing adequate in the plant tissue test Jules recommended that adding more mineral to the soil was not essential at this time. Keep

Sodium is low in the soil mineral test and low in the plant tissue test. This ties in with the low electrical conductivity for the paddock. **Potassium** is low in the soil mineral test but adequate in the plant tissue. **Boron** is low in the soil mineral test and low in the plant tissue test. **Copper** is low in the soil mineral test but adequate in the plant tissue test.	monitoring the plant tissue levels several times a year to make sure your plants and animals are getting adequate nutrition. Set up direct mineral licks for the cows as follows: Free choice loose salt and humates. Pat Colby mineral mix (dolomite, sulphur, copper, yeast, kelp & cobalt)
Cobalt is low in the plant tissue test	Injectable B12. Also supplemented through direct licks as above.
Selenium low	Use injectable selenium before mating.
Compacted Soil. Poor water infiltration. **Inefficient photosynthesis** indicated by low Brix	Aerate and introduce diversity Seed: set up a seed treatment that adds biology to the seed to address clover root weevil.
Buttercup	Put a paddock into the full biological programme. Test plant tissue samples of the buttercup and grass in the same paddock and note what it is telling you. Do your visual soil assessment and refer to soil mineral tests if you have them. Apply tools as appropriate based on your analysis. Make a weed ooze. Pick the weed, put into a drum with a tap on the bottom. Put a heavy weight on the weed. Over time the "weed ooze" will ooze out of the bottom. Dilute with water at a ratio of 10 to 1 and spray the buttercup with it. This weed ooze will have the minerals that will help feed the soil.

Summary

Regenerative agriculture is outcome based and wholistic. It intertwines the relationships between landscape, above and below ground livestock, people and profit. The primary principle of regenerative agriculture is to optimize photosynthesis, build soil structure and function, increase

organic nutrient cycling and farm profitability. Maximizing photosynthesis combined with the use of liquid biological applications to support the plant to get to an improved level, will enable longer rotations, and grazing to be targeted to when the plant has recovered adequately. Increasing pasture diversity, feeding the soil biology and taking on some adaptive grazing techniques will serve to maximize brix levels, increase root growth, decrease weeds and improve pasture quality to enable increasing profitability and farmer satisfaction.

Appendix

Soil Tests

PROFESSIONAL SOIL REPORT

Account of SOLLYS CONTRACTING **Address** TAKAKA, NZ,

Service Representative "Kinsey Ag Service" **Date** 06/24/2020

5736833880

Farm		ROSS_WRIGHT	W_LANGFORD	W_LANGFORD	W_LANGFORD	W_LANGFORD	
Field			EFFLUENT	LUCERNE	HOME	BURNELLS	
Sample			REGEN	REGEN			
Lab No.			C0004	C0005	C0006	C0007	
Total Exchange Capacity (M. E.)			8.87	8.02	14.64	13.64	
pH of Soil Sample			5.90	5.96	5.81	5.53	
Organic Matter, Percent			4.00	3.30	5.80	6.10	
ANIONS	NITROGEN:	lbs / acre	90	83	104	106	
	SULFATE - S:	p.p.m.	9	19	14	10	
	P1 or (Olsen) PHOSPHATES: as (P2 O5) lbs / acre	Desired Value	237	237	243	242	
		Value Found	316	351	468	472	
		Deficit					
EXCHANGEABLE CATIONS	CALCIUM: lbs / acre	Desired Value	2413	2182	3981	3710	
		Value Found	2141	2135	3404	3148	
		Deficit	-271	-47	-577	-562	
	MAGNESIUM: lbs / acre	Desired Value	255	231	421	392	
		Value Found	275	162	450	170	
		Deficit		-69		-222	
	POTASSIUM: lbs / acre	Desired Value	315	312	437	415	
		Value Found	160	150	238	142	
		Deficit	-154	-161	-199	-273	
	SODIUM:	lbs / acre	31	36	31	21	
BASE SATURATION PERCENT							
Calcium (60 to 70%) } 80%			60.34	66.52	58.14	57.69	
Magnesium (10 to 20%)			12.96	8.42	12.82	5.19	
Potassium (2 to 5%)			2.33	2.40	2.09	1.34	
Sodium (.5 to 3%)			0.77	0.99	0.48	0.34	
Other Bases (Variable)			5.60	5.48	5.78	6.34	
EXCHANGEABLE HYDROGEN (10 to 15%)			18.00	16.20	20.70	28.10	
Cobalt (p.p.m.)							
Salinity 1:2 EC (dS/M)							
Chlorides (p.p.m.)							
Boron (p.p.m.)			1.15	1.25	1.04	1.19	
Iron (p.p.m.)			1570.03	1680.51	678.33	674.00	
Manganese (p.p.m.)			57.87	61.52	20.02	10.92	
Copper (p.p.m.)			2.76	2.31	0.98	9.35	
Zinc (p.p.m.)			11.91	10.33	12.73	4.84	
Molybdenum (p.p.m.)							

Control 45570

Soil Foodweb

SOIL BIOLOGY REPORT

Report prepared for:
Tasman Environmental Trust
Debbie Pearson
Kathryn Brownlie
Takaka, 7142

For interpretation of this report please contact your local Soil Steward or the lab.

Report Sent: 30 Jun 2020
Sample #: 05-7426
Unique ID: Home Block
Plant: Pasture
Season: winter
Invoice Number: 6318
Sample Recieved: 19 Jun 2020

Soil Foodweb New Zealand
12 Smith Street
Waihi, 3610 New Zealand
07 863 8556
info@soilfoodweb.co.nz
http://www.soilfoodweb.co.nz

Assay Name	Result	Units	Desired Level	Commentary
Organism Biomass Data				
Dry Weight	0.67	N/A	0.45 to 0.85	Within normal moisture levels indicating organic matter at reasonable levels, however organic matter must come in contact with active microbes to be converted into valuable, stable humus.
Active Fungi	8.01	µg/g	> 30.00	Fungal activity low. Soil's fungal food resources probably too low. Additions of fungal foods with other inputs should help to lift levels ie good quality humates, fish hydrolysate etc. -
Total Fungi	349.77	µg/g	> 300.00	Total fungal biomass in good range - Fungal diversity appears at reasonable levels with adequate hyphal formation. A few damaged and no longer viable groups also evident.
Active Bacteria	30.31	µg/g	> 30.00	Bacterial activity within normal levels.
Total Bacteria	313.57	µg/g	> 300.00	Good total bacterial biomass. -
Actinobacteria	0.00	µg/g	< 20.00	
Organism Biomass Ratios				
TF:TB	1.12		0.80 to 1.45	Correctly balanced fungal and bacterial biomass for pasture. A good result. The fungal biomass helps build soil structure, reduces disease and cycles nutrients especially calcium and the bacterial biomass helps with soil structure plus provides foods for the predators ie worms, beneficial nematodes and protozoa, thus cycling nutrients.
AF:TF	0.02		> 0.10	The overall percentage of active fungal biomass is too low.
AB:TB	0.10		> 0.10	The overall percentage of active bacteria is in good range.
AF:AB	0.26		1.00 to 2.00	Fungal dominated soil, becoming more bacterial with time.
Protozoa (Protists)				
Flagellates	6,843.00	number/g	> 5,000.00	Protozoa barely in range. Nutrient cycling by the actions of these bacterial-eating predators is low. ie 56-84 kg/ha of N per 3 month period.
Amoebae	6,843.00	number/g	> 5,000.00	
Ciliates	68.34	number/g	< 137.00	
Nitrogen Cycling Potential	56-84	kg/ha		Nitrogen levels dependent on plant needs. Estimated availability over a 3 month period
Nematodes				
Nematodes	Not Ordered	number/g	> 10.00	
Bacterial	Not Ordered	number/g	> 4.00	
Fungal	Not Ordered	number/g	> 4.00	
Fungal/Root	Not Ordered	number/g	< 1.00	
Predatory	Not Ordered	number/g	> 2.00	
Root	Not Ordered	number/g	< 1.00	
Mycorrhizal Fungi				
ENDO	69.00	%	> 10	Normal colonization. However low fungal activity may suggest mycorrhiza is not functioning at optimum levels. -
ECTO		%	> 10	not used
Ericoid		%	> 10	not used
Miscellaneous Testing				
E.coli	Not Ordered	CFU/g	< 800.00	For most areas, the maximum E.coli CFU/g is 800 - 1000. Please check your local regulations for more information. -
pH	Not Ordered			
Organic Matter	Not Ordered			
Electrical Conductivity	Not Ordered	µS/cm	< 1000.00	

Eurofins Soil Tests

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ANALYTICAL REPORT

REPORT CODE	AR-20-NU-062863-01	REPORT DATE	14/08/2020
Go Ahead Farms Wayne/Tyler Langford 562 Long Plain Road RD 1 Takaka 7183		Integrity Soils Ltd Jules Matthews 88 Kimihia Road Huntly 3700 NEW ZEALAND +64 6 7627 823 jules@integritysoils.co.nz	
Contact for your orders:	Sarah Jones	**Order code:**	EUNZAU-00291865

Sample Name	Home Paddock		
Sample Code:	816-2020-00197670	**Soil Type**	Sedimentary
Sampling Date:	05/08/2020	**Land Use**	Pastoral
Reception Date:	07/08/2020	**Depth (mm)**	100
Analysis Ending Date:	14/08/2020		

SOIL TEST RESULTS		Units	Results	◆Soil Range	◆Soil Fertility Desired
NU015	pH	pH units	6.1	5.8~6	
NU028	Anion Storage Capacity	%	21	40~80	
◆NUD09	Effective Cation Exchange Capacity	cmol+/kg	18	12~25	
◆NUD17	Exchangeable Hydrogen Saturation	%	13	10~15	
NU362	Total Nitrogen	%	0.50	0.5~0.9	
◆NU355	Total Carbon	%	6.1	4~10	
◆NU259	Organic Matter	%	10.5	7~17	
◆NU065	Carbon to Nitrogen Ratio	Number	12	10~15	
■NU05D	Hot Water Organic Carbon	mg/kg	2440	1800~3000	
■NU04X	Hot Water Nitrogen	mg/kg	270	100~200	
◆NU388	Volume Weight	g/ml	0.71		
ANIONS					
NU252	Olsen Phosphorus	mg/l	37	20~30	
◆NU287	Resin Phosphorus	mg/kg	93	50~100	
◆NU363	Total Recoverable Phosphorus	mg/kg	953	800~900	
NU369	Total Recoverable Sulfur	mg/kg	623	600~1000	
CATIONS					
NU057	Calcium MAF QT	MAF QT	11	4~10	
◆NUD04	Exchangeable Calcium	cmol+/kg	12.3		
NU189	Magnesium MAF QT	MAF QT	36	8~10	
◆NUD05	Exchangeable Magnesium	cmol+/kg	2.19		
NU280	Potassium MAF QT	MAF QT	6	5~8	
◆NUD06	Exchangeable Potassium	cmol+/kg	0.41		
NU326	Sodium MAF QT	MAF QT	4	5~20	
◆NUD07	Exchangeable Sodium	cmol+/kg	0.10		
◆NUE72	Ca/Mg Ratio		5.6		
◆NU04B	Calcium	mg/kg	2460		
◆NU04C	Magnesium	mg/kg	266		
◆NU04D	Potassium	mg/kg	161		
◆NU04E	Sodium	mg/kg	22		
BASE SATURATION					
◆NUD10	Total Base Saturation	%	87		
◆NU051	Calcium Base Saturation	%	67	60~75	
◆NU217	Magnesium Base Saturation	%	12	6~15	
◆NU171	Potassium Base Saturation	%	2.2	2~5	
◆NU234	Sodium Base Saturation	%	0.5	1~2	
◆NUE79	Other Bases	%	5.3		
TRACE ELEMENTS					
◆NU018	Aluminium	mg/kg	0.5	0~3	
◆NU047	Hot Water Boron	mg/kg	0.9	1~2	
◆NU098	EDTA Cobalt	mg/kg	0.2	0.5~4	
◆NU109	EDTA Copper	mg/kg	2.9	4~8	
◆NU169	EDTA Iron	mg/kg	1520	100~3000	
◆NU197	EDTA Manganese	mg/kg	35	5~100	
◆NU396	EDTA Zinc	mg/kg	10.0	3~20	

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TRACE ELEMENTS

MORGAN 1 EXTRACTION

◆NU05E	Morgan 1 Phosphorus	mg/kg	13
◆NU0AG	Morgan 1 Calcium	mg/kg	1870
◆NU0AF	Morgan 1 Magnesium	mg/kg	252
◆NU0AE	Morgan 1 Potassium	mg/kg	99

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Anion Storage Capacity is an inherent property of the soil, a plot is only provided to indicate if the soil is classified as low, medium, or high; rather than indicating an actual desired value. Typical values for different soil types: Volcanic soils >80%, pumice 50-70%, sedimentary 30-50%, most peats, podzols and fine textured soils are usually less than 20%. To reduce possible leaching losses of P and S fertilisers, it is advisable to apply slow release P and S fertilisers when the soil ASC < 40% on mineral soils and for peat soils when ASC < 60%.

MAF Mg levels of 8-10 are adequate for pasture growth. MAF Mg levels of less than 25 may limit animal Mg supply and cause metabolic disorders during calving/lambing. For animal nutrition MAF Mg levels of 25-30 will generally provide plant Mg concentrations of 0.22% or higher.

LIST OF METHODS

NU015	**pH:** Internal Method, Electrometry	NU018	**Aluminium:** Calcium Chloride Extraction: ICP_OES determination
NU028	**Anion Storage Capacity:** Potassium diHydrogen Phosphate Buffer	NU047	**Hot Water Boron:** 0.01% Calcium Chloride extraction: ICP_OES determination
NU04B	**Calcium:** NH4OAC pH7 Extraction: ICP_OES determination.	NU04C	**Magnesium:** NH4OAC pH7 Extraction: ICP_OES determination
NU04D	**Potassium:** NH4OAC pH7 Extraction: ICP_OES determination	NU04E	**Sodium:** NH4OAC pH7 Extraction: ICP_OES determination
NU04X	**Hot Water Nitrogen:** Hot Water Extraction	NU051	**Calcium Base Saturation:** Calculated Value
NU057	**Calcium MAF QT:** NH4OAC pH7 Extraction: ICP_OES determination	NU05D	**Hot Water Organic Carbon:** Hot Water Extraction
NU05E	**Morgan 1 Phosphorus:** Morgan 1 extraction, ICP-OES determination	NU065	**Carbon to Nitrogen Ratio:** Calculation: TC/TN
NU098	**EDTA Cobalt:** 0.02 m EDTA Extraction: ICP_OES determination	NU0AE	**Morgan 1 Potassium:** Morgan 1 extraction, ICP-OES determination
NU0AF	**Morgan 1 Magnesium:** Morgan 1 extraction, ICP-OES determination	NU0AG	**Morgan 1 Calcium:** Morgan 1 extraction, ICP-OES determination
NU109	**EDTA Copper:** 0.02 m EDTA Extraction: ICP_OES determination	NU169	**EDTA Iron:** 0.02 m EDTA Extraction: ICP_OES determination
NU171	**Potassium Base Saturation:** Calculated Value	NU189	**Magnesium MAF QT:** NH4OAC pH7 Extraction: ICP_OES determination
NU197	**EDTA Manganese:** 0.02 m EDTA Extraction: ICP_OES determination	NU217	**Magnesium Base Saturation:** Calculated Value
NU234	**Sodium Base Saturation:** Calculated Value	NU252	**Olsen Phosphorus:** Olsen Extraction: Colorimetry
NU259	**Organic Matter:** Calculation: TC x 1.724 (Van Bemmelen factor)	NU280	**Potassium MAF QT:** NH4OAC pH7 Extraction: ICP_OES determination
NU287	**Resin Phosphorus:** Cation/Anion exchange resin: Water extraction; Colorimetry	NU326	**Sodium MAF QT:** NH4OAC pH7 Extraction: ICP_OES determination
NU355	**Total Carbon:** Combustion elemental analyser: Thermal conductivity detection.	NU362	**Total Nitrogen:** Combustion elemental analyser: Thermal conductivity detection.
NU363	**Total Recoverable Phosphorus:** EPA 200.2 digestion, ICP_OES determination	NU369	**Total Recoverable Sulfur:** EPA 200.2 digestion, ICP_OES determination
NU388	**Volume Weight:** Volume weight of air-dried & sieved soil	NU396	**EDTA Zinc:** 0.02 m EDTA Extraction: ICP_OES determination
NUD04	**Exchangeable Calcium:** NH4OAC pH7 Extraction: ICP_OES determination	NUD05	**Exchangeable Magnesium:** NH4OAC pH7 Extraction: ICP_OES determination
NUD06	**Exchangeable Potassium:** NH4OAC pH7 Extraction: ICP_OES determination	NUD07	**Exchangeable Sodium:** NH4OAC pH7 Extraction: ICP_OES determination
NUD09	**Effective Cation Exchange Capacity:** Calculated by summation (ECEC field pH)	NUD10	**Total Base Saturation:** Calculated Value
NUD17	**Exchangeable Hydrogen Saturation:** Calculated Value	NUE72	**Ca/Mg Ratio:** Calculated Value: Ca/Mg
NUE79	**Other Bases:** Other Bases by Calculation		

Signature

Brent Miller

Brent Miller Technical Manager

EXPLANATORY NOTE **N/A** means Not applicable

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○ test is subcontracted within Eurofins group and is accredited
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Not Detected means not detected at or above the Limit of Quantification (LOQ)

Accreditation does not apply to comments or graphical representations.
Eurofins General Terms and Conditions apply.

Results have been obtained and reported in accordance with our general sales conditions available on request.
The tests are identified by a five-digit code, their description is available on request.

Unless otherwise stated, all tests in this analytical report (except for subcontracted tests) are performed at 35 O'Rorke Road, Penrose, Auckland, NEW ZEALAND.
References for desired levels can be supplied on request.

END OF REPORT

Eurofins Plant Tissue Test

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PRELIMINARY REPORT

REPORT CODE	PR-20-NU-001225-01	REPORT DATE	13/08/2020
Go Ahead Farms Wayne/Tyler Langford 562 Long Plain Road RD 1 Takaka 7183		Integrity Soils Ltd Jules Matthews 88 Kimihia Road Huntly 3700 NEW ZEALAND +64 6 7627 823 jules@integritysoils.co.nz	

Contact for your orders: Sarah Jones **Order code:** EUNZAU-00291760

Comments: Preliminary report. Feed quality pending.

Sample Name **Home Paddock**

Sample Code:	816-2020-00197326	**Property Name**	Go Ahead Farms
Sampling Date:	05/08/2020	**Plant Type**	Pasture winter
Reception Date:	07/08/2020		
Analysis Ending Date:	13/08/2020	**Main Animal Species**	Dairy Cows

FEED QUALITY		Units	Results	◆Plant Range	◆Plant Nutrition Desired	◆Dairy Cows	◆Animal Nutrition Desired
◆NU123	Dry Matter (DM)	g/kg	211	140~220			
◆NUD90	Crude Ash	g/kg dm	84	70~110			
◆NUE56	Organic Matter (OM)	g/kg dm	916	880~920			
DIGESTIBILITY / ENERGY							
◆NUE50	Metabolisable Energy (ME)	MJ/kg dm	12.5	9.5~11			
◆NUD76	Digestibility (DOMD, gOM/kg DM)	g/kg dm	783	609~705			
MACRO ELEMENTS							
◆NUD46	Nitrogen	%	3.9	4.5~5.5			
NU268	Phosphorus	%	0.41	0.35~0.4		0.24~0.4	
NU279	Potassium	%	2.9	2.5~3		0.6~1.2	
NU341	Sulfur	%	0.44	0.28~0.4		0.18~0.4	
NU056	Calcium	%	0.66	0.25~0.5		0.4~0.8	
NU187	Magnesium	%	0.22	0.16~0.22		0.19~0.25	
NU324	Sodium	%	0.06			0.12~0.3	
◆NUD75	Chloride	%	0.9				
◆NU117	Dietary Cation-Anion Difference (DCAD)	meq/kg dm	330				
TRACE ELEMENTS							
NU196	Manganese	mg/kg	33	25~30		25~40	
NU108	Copper	mg/kg	6.4	6~7		7~20	
NU046	Boron	mg/kg	4.8	6~15			
NU394	Zinc	mg/kg	22	20~50		20~40	
NU168	Iron	mg/kg	69	50~60		10~200	
◆NU097	Cobalt	mg/kg	0.02			0.04~0.2	
◆NU232	Molybdenum	mg/kg	1.8			0.05~1	
◆NU294	Selenium	mg/kg	0.03			0.03~0.3	
◆NU350	Titanium	mg/kg	<10				

CALCULATIONS

◆NU332	Sulfur to Phosphorus Ratio	Number	0.67

REPORT INFORMATION

For high production dairy pasture the normal range for potassium should be modified to 3.00 ~ 3.50%.

Typically starch is at very low levels in pasture and pasture silage; below the 1% detection limit of a starch enzymatic test.

SAMPLE COMMENTS

816-2020-00197326 **Home Paddock**

Low Sodium : Levels <0.1% could affect animal health and milk production levels.

Soil contamination : Titanium levels of < 10 ppm indicate little to no soil contamination.

816-2020-00197327 **Regen Paddock**

Soil contamination : Titanium result between 10 - 40 ppm would indicate slight soil contamination of the sample analysed. Soil contamination can lead to elevated levels of Cobalt, Iron and Molybdenum and can mask deficiencies of these elements

LIST OF METHODS

NU046	**Boron:** Microwave digestion, ICP_OES determination	NU056	**Calcium:** Microwave digestion, ICP_OES determination
NU097	**Cobalt:** Microwave digestion, ICP_MS determination	NU108	**Copper:** Microwave digestion, ICP_OES determination
NU117	**Dietary Cation-Anion Difference (DCAD):** Calculated Value	NU123	**Dry Matter (DM):** Oven dried at 65°C, result adjusted for residual moisture by NIRS.
NU168	**Iron:** Microwave digestion, ICP_OES determination	NU187	**Magnesium:** Microwave digestion, ICP_OES determination
NU196	**Manganese:** Microwave digestion, ICP_OES determination	NU232	**Molybdenum:** Microwave digestion, ICP_MS determination
NU251	**Nitrogen:** Combustion elemental analyser: Thermal conductivity detection.	NU268	**Phosphorus:** Microwave digestion, ICP_OES determination
NU279	**Potassium:** Microwave digestion, ICP_OES determination	NU294	**Selenium:** Microwave digestion, ICP_MS determination
NU324	**Sodium:** Microwave digestion, ICP_OES determination	NU332	**Sulfur to Phosphorus Ratio:** Calculated Result
NU341	**Sulfur:** Microwave digestion, ICP_OES determination	NU350	**Titanium:** Microwave digestion, ICP_OES determination
NU394	**Zinc:** Microwave digestion, ICP_OES determination	NUD46	**Nitrogen:** NIRS Predicted (Calibration based on EN-ISO 5983-2)
NUD75	**Chloride:** NIRS Predicted (Calibration based on L54 2009/152)	NUD76	**Digestibility (DOMD, gOM/kg DM):** NIRS Predicted (Calibration based on J.Brit. Gr. Soc. 18:104-111)
NUD90	**Crude Ash:** NIRS Predicted (Calibration based on EN-ISO 6498)	NUE50	**Metabolisable Energy (ME):** Calculated from DOMD using Lincoln University standard equation
NUE56	**Organic Matter (OM):** Calculated value from Crude Ash		

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Signature

Brent Miller

Brent Miller Technical Manager

Keshi Zhang Laboratory Technician

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