"Achieving Outcomes by Building Capability"

The AgriBusiness Group

Godley Peaks the path to net zero emissions.

Prepared for Godley Peaks Station

Prepared by The AgriBusiness Group

July 2024

Contents

Please Read

Executive Summary

Warren Lewis purchased Godley Peaks in 2023 he has stated two goals for the property:

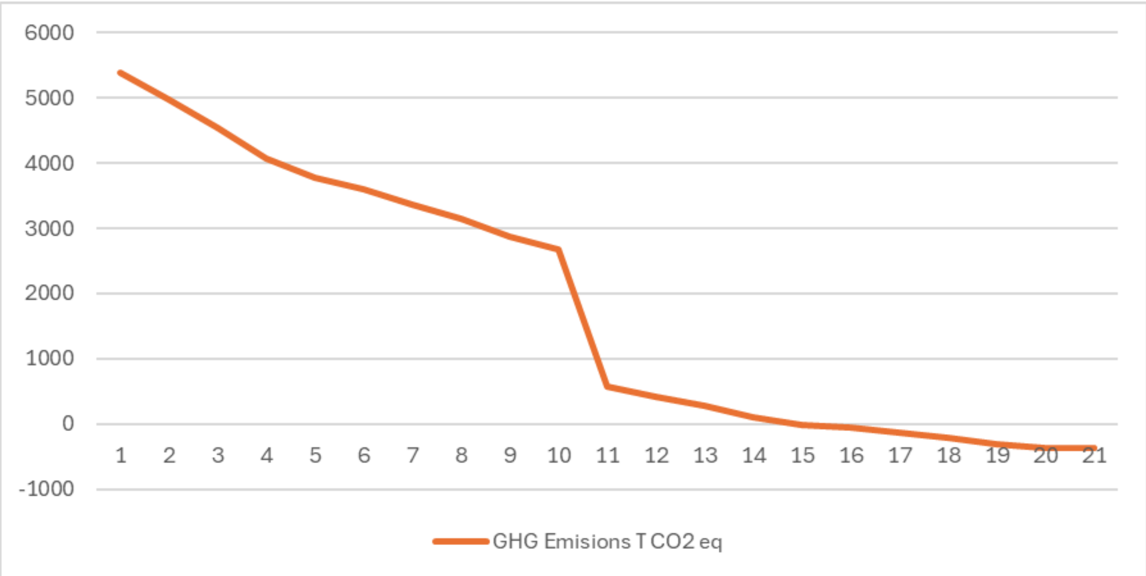
That Godley Peaks will be able to run as a stand alone financial venture after a five year development period.

And that:

Godley Peaks can operate as, at least, a net carbon zero operation.

This report is the result of taking Godley Peaks through two stages the first stage was the completion of an emissions budget for the station in its steady state and then a list of all the possible mitigations that could be used to diminish the stations carbon emissions. At the end of this stage Godley Peaks chose the options which they wished to explore on more detail. Stage two was testing the options be modelling in Overseer and the financial performance through the financial budget of the property. This was discussed with Godley Peaks and they chose their preferred pathway.

The total impact of adopting this combination of sequestration/ mitigation options is shown in ES Figure 1. What we can see from ES Figure 1 is that there is a steady reduction in GHG emissions on the station for the first 10 years ending up with a reduction of approximately 60 % at that point. There is then a rapid reduction with the advent of the vaccine / inhibitor which reduces the emissions by a further 30%. This means that the station meets carbon zero at year 2044. Because the advent of the vaccine / inhibitor is still very uncertain we would recommend that Godley Peaks look at increasing the amount of exotic forestry that it adopts to ensure that it is able to meet the target of being carbon zero.



ES Figure 1: Total emissions from Godley peaks over time.

Adoption of this path will involve the following actions which The AgriBusiness Group would be happy to assist Godley Peaks to achieve them.

Conversion to Hydro

This should be carried out as soon as it is practically feasible.

Native Forestry

There is approximately 80 ha of fencing off and establishment of native areas detailed in Godley Peaks Stations Biodiversity Plan[1], we are of the opinion that it will be relatively easy for the Station to either expand the areas suggest by E3 Scientific or find some other suitable areas to make the area up to at least 100 ha. We understand that this is to occur over the next two years.

Exotic Forestry

We have modelled the station as planting 25 ha every five years in order to achieve a harvestable forest rotation. If you wished to advance this planting regime that will speed up the time that it will take to achieve net zero.

Efficiency Gains

It has been suggested that it may be difficult to achieve much in terms of efficiency gains while you are increasing and changing your stocking mix but we would like to suggest that some of the station system efficiency gains are possible to integrate into your system at the same time as you are increasing sticking rate so we would urge you to not lose track of the possible efficiency gains.

Animal Genetics

This should be adopted as soon as you are able to source the type of sheep and cattle that you require which can also offer you emissions reductions at the same time.

Vaccine / Inhibitor

These up both unknowns at this point. We would recommend that we should have an update of your carbon status every two years where we can update you on the progress that is being made in developing them and perhaps devising an alternative option if their development is delayed or still uncertain.

The aim is to have Godley Peaks at carbon zero by the year 2050 if at all possible.

[1] E3 Scientific. (2024) : Godley Peaks Station Farm Biodiversity Plan.

1 Background

Warren Lewis purchased Godley Peaks in 2023 and has moved his household from Auckland to Godley Peaks. Although he doesn't have much knowledge of the process of farming his attraction to Godley Peaks revolves around his deep personal knowledge of the station itself, the Mackenzie country, and the wider South Canterbury area. He is effectively coming home.

He has stated two goals for the property:

That Godley Peaks will be able to run as a stand alone financial venture after a five year development period.

And that:

Godley Peaks can operate as, at least, a net carbon zero operation.

The AgriBusiness Group (TAG) has been chosen as an organisation which has the relevant expertise that can assist the Godly Peaks team towards achieving the carbon zero goal.

1.1 Godley Peaks

The following is a brief description of the current and future state of Godley Peaks which concentrates on the aspects which are relevant to the planning necessary to achieve net carbon zero.

The property is 13,467 ha which will be reduced to 3,600 ha once tenure review is finalised, it is expected that some grazing rights will be retained across the DOC estate once tenure review is completed. Post tenure review the property is predominantly made up lower altitude country on the Western side of Lake Tekapo, which consists of moderate to easy rolling country with approximately 530 ha which are possible to irrigate with a maximum of 447 ha which is able to be irrigated annually.

The long cold winter is the limiting factor in terms of productivity. Irrigation capability on the property allows for a relatively high stocking rate through spring to autumn and then maintains that stocking rate through the winter by the provision of supplementary feed in the form of silage and feed crops. There is approximately 100 tonnes of Barley imported into the system allowing the station to hold the higher stocking rates over the winter - spring period.

The irrigation water is supplied to four large pivots with the remainder of the area irrigated by guns. Currently all of the irrigation is driven by diesel powered generators. The irrigation areas have had their soil fertility run down over the last few years. There is an agreed program to reinstate the fertility of areas which is expected to lift the stocking rate of the property by approximately 1,000 ewes. At the same time, it is the aim to lift the per head performance of the ewes in particular but over all of the livestock.

Stocking of the property currently is 240 Breeding Cows with all progeny taken through the first winter and sold as prime before their second winter. Sheep are made up of 5,000 breeding ewes and 1,250 Hoggets which are predominantly merinos producing fine wool with some half-breds. All sheep progeny are finished on the property.

It is our opinion that the relatively high stocking rate, driven by the high proportion of irrigation means that Godley Peaks is atypical of other High Country stations. This means that achieving net carbon zero status on the property will be a different proposition from achieving it on the more traditionally run stations.

The net consumption of energy is currently dominated by the use of diesel. The plans that are currently in place to replace the reliance on fossil fuels with the creation of renewable energy sources will contribute greatly to the goal of achieving net zero carbon emissions.

1.2 The Process

This report is stage one of a three stage process which is designed to create an emissions budget which has been calculated by modelling a future steady state of the farming operation in Overseer and then displaying it in an easy to understand format which provides the owners the ability to determine exactly where their emissions are coming from. This analysis has been broken down into subcategories under the three main emission types of:

- Methane
- Nitrous Oxide
- Carbon Dioxide

These have been displayed as emissions per stock unit for each of the major stock types that are on the farm. At the same time the contribution of each of the emissions has been displayed as their contribution to Gross and Net revenue. This has been carried out in order to offer the owners the opportunity to understand which of their stock types are contributing the most in terms of emissions and financial performance.

Godley Peaks has both a development plan and financial budgets for the future steady state that has been used to create this data.

The full range of mitigations has been included in this stage with a brief explanation of the manner in which the mitigation works and an estimated cost of each mitigation. The cost information has been used to create a mitigation cost curve which is able to demonstrate the relativity of each mitigation.

The information gathered has been provided in a draft report and then TAG will lead a discussion on the next stage where the owners will choose the options which they want to explore in more detail.

1.3 This Report

This report is presented in three sections:

- The emissions from Godley Peaks.
- The range of possible mitigations and an order of costs.
- A brief profile of the range of services offered by the certifier Toitu.

2 Godley Peaks Emissions

In this section we quantify the amount of emissions generated by Godley Peaks (as calculated as interim) and then discuss the possible range of mitigations and the cost of carrying out those mitigations.

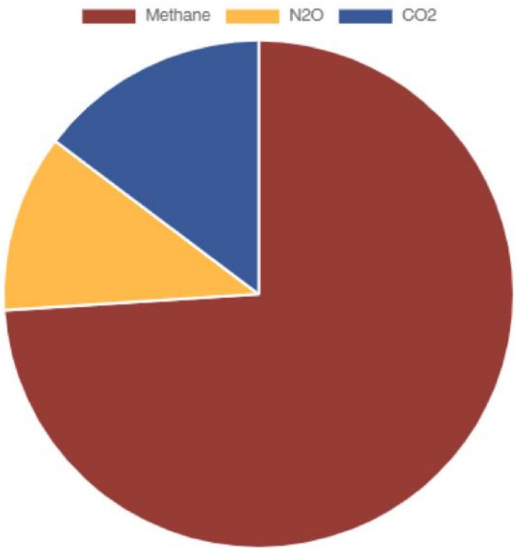
The baseline for the Net Zero Emission stage 1 has been modelled on OverseerFM – scenarios – Status Quo.

Assumptions have been made based on the information provided by Peter Young ‘Godley Peaks Station Ltd Development Report”, January 2024 along with in-depth conversations with Grant Murray to fact check the information and make this as accurate as possible. The modeling depicts the state of total emissions that will occur at the end of the development phase.

At the end of the development phase there are 10,626 stock units in sheep which are made up of 5,220 ewes and 2,200 ewe Hoggets with all progeny finished on the farm from a 99% birth rate. Beef cattle make up 6,005 stock units which are made up of 300 Mixed Age Cows and 100 R2 Heifers and all progeny are finished on the property from a 93% birth rate.

Assumptions made:

- Areas have been blocked based on soil types, crops or pastures, topography, irrigation and fertiliser treatments.
- Crop rotation and stock numbers have been supplied by Peter Young and Grant Murray.
- Crops have been grouped under the same pivot where possible due to water restrictions being a possibility and allowing targeted watering.
- Crop rotations have been modelled April 1st – March 31st to match financial years.
- Supplements have been made from a combination of areas from the rotorainer and pivot areas which total over 200ha, producing roughly 4t Dry Matter (DM) /ha.
- Supplements are fed from March – Sept (50% cattle, 50% sheep)
- Fertiliser applications have been supplied by Peter Young and timings by Grant Murray .
- Soils have been grouped based on S-Map modelling from the 2023 YE budget.
- 3 tree blocks have been modelled at the age of 50years between 70 – 100% of area.
- Pivot has been modelled to run Nov – Mar using a soil moisture sensor – Trigger Point – Fixed applied depth (overseer defaults).
- Rotorainer has been modelled with a fixed depth return period of 30mm and 6 day return period.
- GHG information has been kept as defaults at this stage.
- Animals have been removed from model for “grazed outside budget area” during the projected summer grazing of the DOC hill block.
- Shane Harold has supplied fertiliser element break downs.
- Maintenance fertiliser has been applied in November as in the 2023 model.
- Grazing of the right block has been included in model



With the current assumptions emissions are as shown in **Figure 1** and **Table** 1

Please note that the non-animal production information is using the defaults that are in Overseer currently.

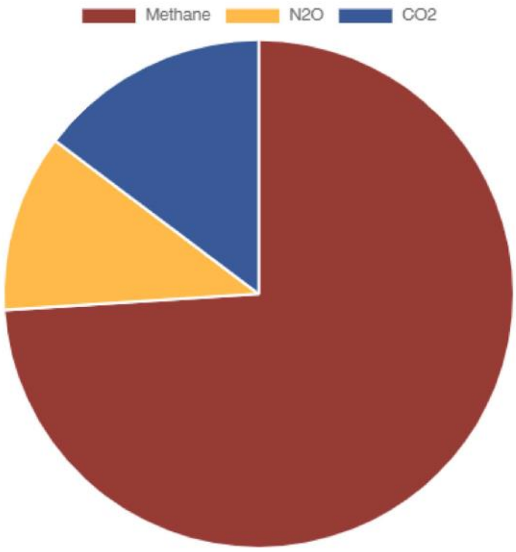


Figure 1: GHG emissions by category.

Table 1: GHG emissions by category and percentage.

Category	CO2 e (tonnes)	Percentage (%)
Methane	4,806	73%
N^2O	749	11%
CO^2	1,022	16%
Total	6,577	100%

Methane is the biggest emitter on Godley Peaks with approximately 73 % of the total emissions produced, 37% of it is from the cattle, 62% of it is from the sheep and 1% of it is from dung. Of the N2O which contributes 11%, 55% of it comes from excreta in the paddock. Of the C02 which contributes 16%, 65% of it comes from the fertiliser and the rest is evenly distributed amongst smaller contributors.

The four biggest emitters (Beef, Sheep, Excreta and Fertiliser) make up 90% of the emissions on Godley Peaks with beef contributing 25%, sheep 43% excreta 13% and fertiliser 8%. While it will be possible to reduce some of the emissions significantly, unless they are addressing the animal emissions they will not contribute much in terms of reductions to the total for the Station.

3 The range of possible mitigations and an order of costs.

The following section outlines the range of possible mitigations that are available to reduce the amount of greenhouse gas emissions produced on Godly Peaks. The reported mitigation options come from various channels of research which were carried out in the completion of the *Report on Agricultural Greenhouse Gas Mitigation Technologies* for the Climate Change Commission. This includes a literature review and discussions with key stakeholders in the research, government and commercial sectors.

3.1 Forestry

Trees and vegetation can reduce the amount of carbon in the atmosphere by sequestering carbon throughout its growth phase. As trees and vegetation grow, they store more carbon holding it in accumulated tissue. The amount of carbon sequestered annually is dependent on the size and health of the trees. Trees and vegetation can be used as an offset for emissions produced on farms. Forestry can be incorporated into sections of the farm that are currently unproductive or have a low productivity to offset emissions produced on the farm through other practices or systems. Forestry acts as an effective way to make large offsetting differences through its incorporation into farm systems.

In order to qualify as being a valid offset the amount of carbon that is able to be sequestered must be able to be quantified through an established and trusted method.

While there are a myriad of international options to follow in terms of registering/ recording the quantum of offsetting achieved. The land owner would need to follow the protocol of whichever market system they employ which in most cases will be complex; e.g. International Organization for Standardization (ISO)[2], WRI GHG Protocol for Project Accounting[3], SocialCarbon[4], and Climate, Community & Biodiversity Standards[5], to name a few.

It is our opinion that the method adopted by Toitu is the only relatively simple and valid form to calculate the quantum of offsets that Godley Peaks can gain on the Station. There is a brief summary of the Toitu method of calculating the amount of offsets that are available in Section 4. An important element of the methodology adopted by Toitu is the use of the MPI look up tables to estimate the amount of carbon sequestered in any individual year. The MPI lookup tables are for native and exotic species.

The annual carbon sequestration of native species per Hectare (ha) that is allowed for in the MPI carbon lookup tables is shown in **Figure 2**.

2 https://www.iso.org/standard/66454.html
3 https://ghgprotocol.org/standards/project-protocol
4 https://www.offsetguide.org/understanding-carbon-offsets/carbon-offset-programs/add-on-standards/socialcarbon-standard/
5 https://www.offsetguide.org/understanding-carbon-offsets/carbon-offset-programs/add-on-standards/climate-community-biodiversity-standards/

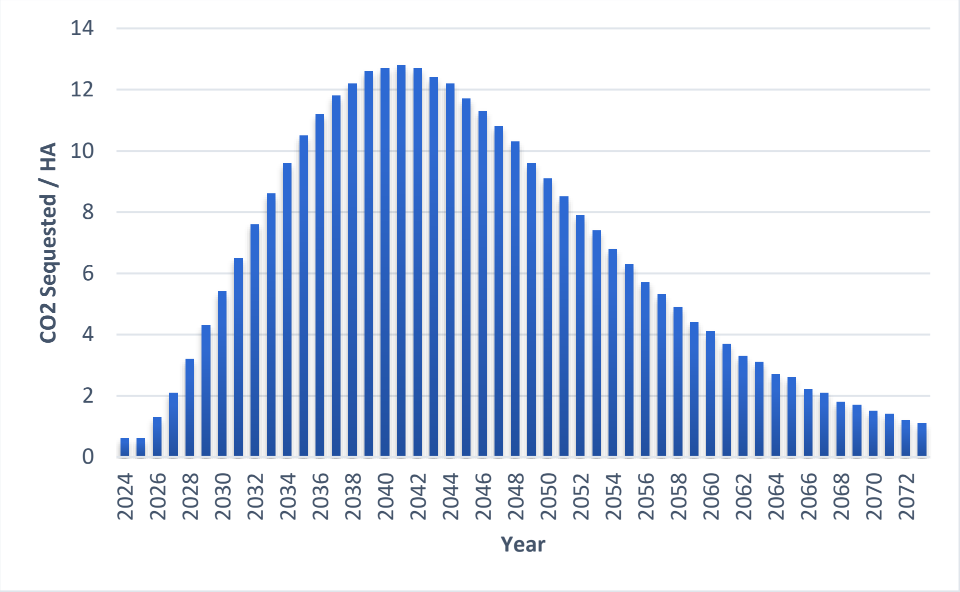


Figure 2: Annual carbon sequestration of native species per ha (CO^2e)

What we can see from **Figure 2** is that the annual amount of carbon sequestered rises steadily until it reaches a peak of 12.8 tonnes of CO^2e per ha per annum at about year 17 and then drops off gradually until year 50 after which there is no recognition of sequestration after that time. In total there are 323 tonnes of CO^2e sequestration possible per ha for exotic forests over the 50 year lifetime of sequestration.

Figure 3 shows the annual amount of carbon sequestered annually by a Pinus Radiata forest under the MPI look up table method.

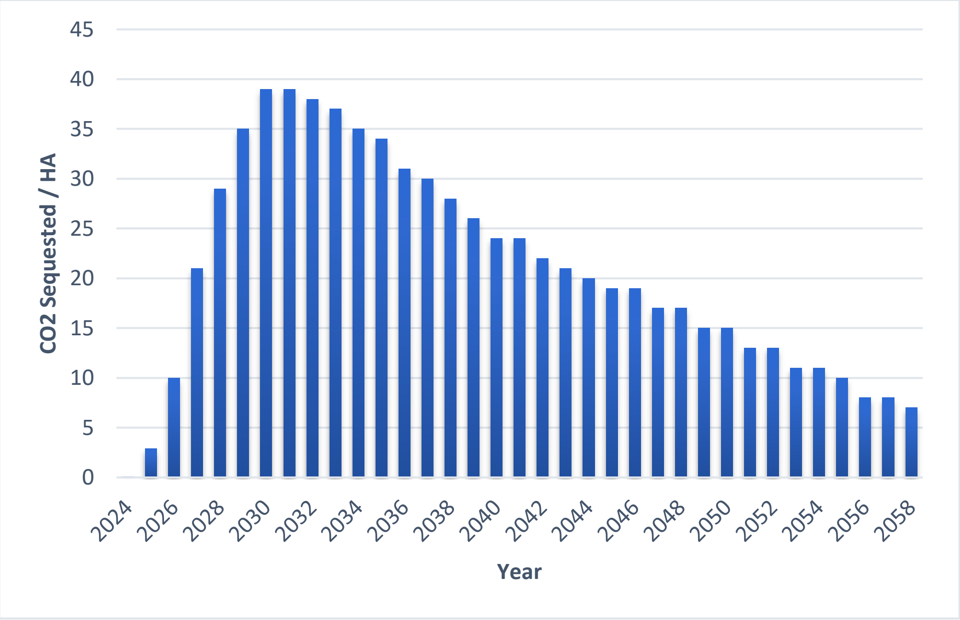


Figure 3: Annual carbon sequestration of exotic hardwood species per ha (CO^2e)

What we can see in **Figure 3** is that the amount of sequestration rapidly rises to 39 tonnes of CO^2e per ha per annum in years 8 and 9 and then gradually declines until they reach zero after 35 years. Over this period, they sequestered 729 tonnes of CO^2e.

It is theoretically possible to extend the period of sequestration in the native forest model beyond 50 years by carrying out selective harvesting providing a 30% canopy cover is maintained. MPI have indicated that they will allow units to be earned for an additional 20 years but the rate of sequestration has yet to be determined.

Under the Toitu method of calculation there is an allowance for harvesting and replanting so it is possible to gain both credit from the forest for sequestration and provide for an income stream.

The costs of planting the two alternatives are much different with exotics costing approximately $1,500 per ha while natives will cost $10,000 plus per ha.

3.2 Sheep Genetics

Extensive research on sheep genetics has focused on the possibility of breeding sheep that produce lower emissions has been underway in New Zealand since 2007. This work established that some sheep naturally emit less methane per kilogram of food eaten than others. The research found that this variation is statistically significant. Subsequent NZAGRC funding has enabled low-emitting animals to be genotyped for markers that identify the low-emission trait.

Subsequent studies have demonstrated that selective breeding can result in a variation of up to 12% between high-emitting and low-emitting sheep[6]. It is worth noting that a report published in 2018 by NZAGRC predicted a maximum feasible divergence of 30% between high-emitting and low-emitting sheep[7] . In 2020, traits associated with low greenhouse gas emissions were included in the Sheep Improvement Database, and by 2019, Beef and Lamb Genetics had incorporated breeding values for methane emissions. The use of relatively low-cost portable accumulation chambers allows breeders to measure methane emissions from their own flocks[8]. Researchers have found that breeding for low-emission sheep can achieve a cumulative annual emission reduction of 1% without negatively impacting sheep productivity[9].

This development has resulted in reducing methane emissions in New Zealand's national sheep flock through genetic selection – The Cool Sheep® Programme. This ground-breaking and world first project aims to give every sheep farmer in New Zealand the opportunity to use genetic selection to reduce greenhouse gas emissions from the national flock.

Any project to achieve genetic gain is a slow process because of the relatively low turnover of animals and heritability of the traits. Nevertheless once started a breeding program which is designed to improve the traits of the animals can make significant gains over time so it is best started sooner rather than later.

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6 [NZAGRC]. Breir, D. (2021, August 27). *NZ Agricultural Climate Change Conference 2021* [Video]. Youtube. https://www.youtube.com/watch?v=RL8IGDGoW04&t=11617s

7 Reisinger, A., Clark, H., Abercrombie, R., Aspin, M., Ettema, P., Harris, M., Hoggard, A., Newman, M., & Sneath, G. (2018, April 8). *Future options to reduce biological GHG emissions on-farm: Critical assumptions and national-scale impact*. Ministry of Primary Industries.

8 Beef and Lamb (2020, October 15). *Low methane-emitting sheep a reality in New Zealand*. Beef and Lamb NZ., from https://beeflambnz.com/news-views/low-methane- emitting-sheep-reality-nz

9 NZAGRC]. Breir, D. (2021, August 27). *NZ Agricultural Climate Change Conference 2021* [Video]. Youtube. https://www.youtube.com/watch?v=RL8IGDGoW04&t=11617s

3.3 Station system efficiency gains

3.3.1 Reducing Stocking Rates

Reducing stocking rate has a direct impact on greenhouse gas emissions. The effectiveness of this strategy depends on the starting position of the farm (stocking rate/ per animal production) and grazing management. If Godley Peaks was operating beyond its optimal level (point B on FX) reducing stocking rate would both increase profitability and reduce emissions.

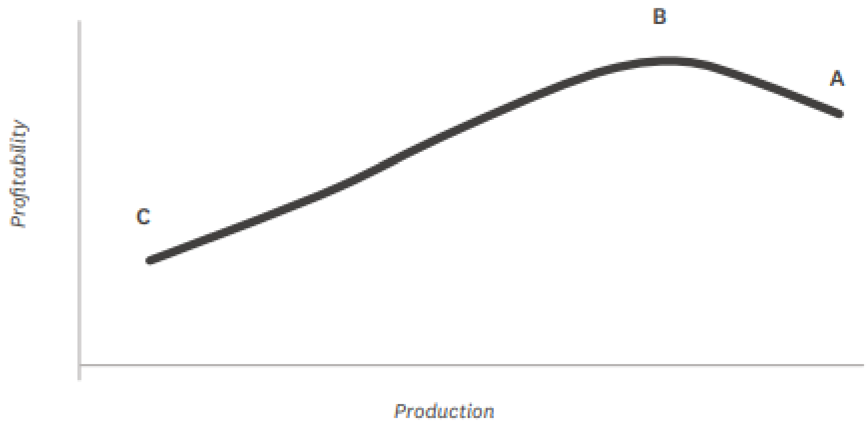

Figure 4: Productivity Curve[10]

While reducing the stocking rate can lead to an increase in productivity and therefore profitability as seen by point B on the above graph, without productivity gains reducing stocking rates would have a positive impact on emissions however a negative impact on profit. Modelling[11] has shown that a 10% reduction in stocking rate with no corresponding improvement in productivity leads to a 12% reduction in emissions (CH4 + N20) at the same time as a 10-40% reduction in farm Earnings Before Interest and Tax (EBIT).

3.3.2 Reducing Replacement Rates

Reducing the replacement rates can have a positive impact on greenhouse gas emissions. For example, a reduction in replacement rates from 23% to 15% has been modelled to show a 2-3% reduction in emissions and a 3% gain in EBIT. The GHG emission reduction is achieved because there are less animals consuming DM, and the improvement in EBIT is due to the saving in operating costs (e.g. less animal health, less supplementary feed).

There is a very important precondition in achieving a reduction. Death rates must be low, and in-calf/in-lamb rates must be high. If either of these conditions aren't met, then genetic gain on the farm will be severely reduced.

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[10] NZIPIM Greenhouse Gas Seminar

[11] Takahuri-Whenua-approaches-to-systems-and-land-use-change-to-reduce-ghg-emissions. https://www.nzagrc.org.nz/publications/takahuri-whenua-approaches-to-systems-and-land-use-change-to-reduce-ghg-emissions/

3.3.3 Shorter Finishing Times

Finishing stock to similar slaughter weights, but in a shorter time period achieves a more efficient use of feed by reducing the amount of time that maintenance feed is consumed. If steers reach a 300kg carcass weight by 20 months instead of 24, greenhouse gas emissions could drop by 2-3%, while farm profitability could also increase by a similar margin. The decrease in emissions primarily stems from reduced maintenance in dry matter consumption during the shorter finishing period.

3.3.4 Change in stock types

This approach involves substituting less productive or profitable livestock types with more productive alternatives. An example is replacing breeding animals with those that are being finished, where the maintenance cost in dry matter is lower. Another example is exchanging breeding cows for finishing bull beef, steers, or heifers, which are generally more profitable. When modelled across several sheep and beef farms, this shift resulted in a fluctuation in greenhouse gas emissions ranging from a 6% increase to a 15% decrease, averaging a 2% reduction. Correspondingly, farm earnings before EBIT ranged from a 22% decrease to a 53% increase, averaging a 30% increase.

Since sheep emit slightly less N20 compared to cattle, adjusting the sheep to cattle ratios by increasing sheep and reducing cattle while maintaining the original stocking rate can lead to similar methane emissions but slightly lower N_2O emissions, typically down by 1-2%.

3.3.5 Fertigation

Fertigation refers to the application of fertilizers through an irrigation system. This method offers significant advantages over traditional broadcast methods by improving the timing, quantity, and accuracy of fertilizer application. However, managing an irrigation system with fertigation requires a different approach compared to conventional irrigation.

A recent example from a Canterbury dairy farm, as reported by S. Breneger from BP Consulting, demonstrated the benefits of installing a fertigation system. The farm improved nitrogen use efficiency from 60-70% with conventional solid nitrogen fertilizer application to 85% with fertigation. This allowed the farmer to reduce nitrogen fertilizer input by 21%, from 190 kg N/ha to 150 kg N/ha, while maintaining similar dry matter responses.

Overseer analysis indicated a 4.6% reduction in N_2O emissions, a 9.3% reduction in embedded CO_2 emissions, and a 1.9% reduction in total GHG emissions. Additionally, nitrogen leaching decreased by 3%. Although this hasn’t been modelled on a sheep and beef property the same principles would apply.

3.4 Different forage types

Certain forages have been identified for their potential to decrease methane (CH_4) or nitrous oxide (N_2O) emissions when consumed. Some feeds ferment differently in the rumen, thus lowering methane production, while others have lower protein levels, leading to reduced nitrogen excretion and subsequent N_2O emissions.

Forage rape and fodder beet are recognized for their ability to diminish CH_4 emissions per unit of feed consumed. Forage rape consistently reduces methane emissions by approximately 30% when provided as the sole feed. Fodder beet proves effective in methane reduction only at very high feeding rates, exceeding 75%.

Fodder beet also has a lower protein concentration compared to standard grass/clover diets. Incorporating higher proportions of these feeds into the diet reduces the overall dietary nitrogen concentration, resulting in decreased nitrogen excretion and subsequent reductions in N2O emissions.

Ongoing research on plantain suggests it has potential to mitigate N2O emissions and nitrate leaching. Current findings suggest a near-linear effect on N2O reduction, ranging from 0% to 60% of plantain in the diet. Research indicates that including 30% plantain in the diet could achieve approximately a 4% reduction in N2O emissions.

3.5 Pasture Quality

Maintaining or improving pasture quality can reduce the amount of DM required to achieve the same level of animal production and have a positive impact on reducing greenhouse gas emissions. A trial carried out by Beef+Lamb investigating feed requirements relative to energy levels in growing Friesian bulls from 300 to 600kg liveweight.

Table 2: B+LNZ results of trial investigating the impact of feed quality on growth rate of Friesian bulls.

Feed quality (MJME/kg DM)	Bull LWG (kg/day)	Weeks to finish	Feed Efficiency (kg DM/kg LWG)	Feed Required (kg DM)	kg CH4
9	0.4	113	20.4	6,123	129
10	0.98	44	10.7	3,209	67
11	1.47	29	8.0	2,423	51

As shown in **Table 2** bulls consuming pasture with 11 MJME/kg DM took only 25% of the time to reach the desired weight, consumed 40% of the pasture, and generated 40% of the methane, in contrast to animals fed pasture with 9 MJME/kg DM.

3.6 Reduced Supplementary Feed

Modelling the complete removal of external supplementary feed across various dairy farms revealed GHG reductions ranging from -5% to -11% (with an average of -7%), and an impact on farm EBITDA ranging from +5% to -22% (with an average of -5%). Removing external supplementary feed effectively decreases the dry matter within the system, leading to reduced GHG emissions. Additionally, adjusting supplementary feed allows for the modification of protein levels in the diet, which can affect the amount of N2O emissions produced. Although this hasn’t been modelled on a sheep and beef property the same principles would apply.

3.7 Future Potential Mitigations

There is a very large amount of research[12] being carried out in New Zeeland and internationally to identify an appropriate means of reducing the amount of methane that is emitted from livestock. It

[12] https://www.nzagrc.org.nz/

is expected that once a method has proven to be successful and economic to be used across New Zealand's livestock industries that te country will be able to greatly reduce the amount of emissions that we produce. Currently there is no good indication of when this will occur.

3.7.1 Methane Vaccine

A methane vaccine operates by introducing antibodies from saliva into the rumen, where they interact with antigens to disrupt the growth and survival of methanogens, leading to the reduction in methane emission[13]. In New Zealand there has been intensive research into the potential for methane vaccines due to their suitability to the New Zealand farming system. New Zealand researchers and scientists have been aiming to create a vaccine that reduces methane emissions by 30%. Commercial availability of a vaccine is estimated to take 7-10 years after demonstration of a prototype and this prototype has yet to be identified as the concept is still in the research to identify a suitable vaccine. Our modelling work has outlined that vaccines will likely not be available for adoption until 2044[14].

3.7.2 Methane Inhibitor

A methane inhibitor is a chemical compound that blocks critical enzymatic pathways in rumen-dwelling methanogens, therefore restricting their ability to produce methane. Extensive research is being conducted within New Zealand to identify a suitable compound that can be used in New Zealand's predominantly grass fed farming system. Several organizations, including AgResearch, DairyNZ, Victoria University, and the University of Auckland, are actively involved in projects aimed at addressing this issue. These initiatives primarily revolve around the development, application, and feasibility of methane inhibitors on farms[15]. AgResearch is specifically focusing on formulating slow-release capsules for animals raised on pasture. The objective is to create a capsule that can effectively inhibit 30% of methane emissions and remain functional within the animal's system for up to 320 days[16]. Assuming an antigen is found by 2028 and that the product would take approximately 11 years to be trialed and go through regulatory approval then it is likely that an inhibitor would be available by 2039.

3.7.3 Nitrous Oxide Inhibitor

Nitrification inhibitors are chemical substances that can be added to fertilizers or to the soil to reduce the emission of nitrous oxide by suppressing soil microbes responsible for converting nitrogen to nitrate, which leads to nitrous oxide production. Up until 2011 the nitrification inhibitor dicyandiamide (DCD) was available in New Zealand and was used on some farms[17]. However, traces of DCD were detected in milk, resulting in its removal from the market in New Zealand. This severely limited New Zealand options around reducing nitrous oxide emissions. NZAGRC funded research has been conducted by AgResearch and Pastoral Robotics and has resulted in the

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[13] [NZAGRC]. Janssen, P. (2023, March 13). *NZACCC 2023: Day 2: Panel: State of Science – Methane (2): Peter Janssen* [Video]. YouTube. https://www.youtube.com/watch?v=XqpUqUviT2A

[14] AgriBusiness Group (2023) *Report on Agricultural Greenhouse Gas Mitigation Technologies*

[15] NZAGRC (n.d.). *Methane Inhibitors*. NZARGC. Retrieved June 28, 2023, from https://www.nzagrc.org.nz/domestic/methane-research-programme/methane-inhibitors/

[16] [NZAGRC]. (2023, March 11). *NZACCC 2023: Day 2: Panel: State of Science – Methane (1): Ron Ronimus* [Video]. YouTube. https://www.youtube.com/watch?v=A4l8lQzCieE

[17] NZAGRC (n.d.). *Nitrification Inhibitors*. Retrieved June 30, 2023, from https://www.nzagrc.org.nz/domestic/nitrous-oxide-research-programme/nitrification-inhibitors/

identification of a potential inhibitor that has been trialed in both field and laboratory experiments with similar efficacy to DCD without the risks. There are predictions that this product should be available in the next 3-5 years and have an efficacy rating of up to 50%[18].

3.7.4 GM Ryegrass

AgResearch has been conducting research on the development of a genetically modified ryegrass called highly metabolizable energy ryegrass (HME)[19] offshore. Initial experiments were conducted in 2018 and yielded encouraging outcomes. The initial findings demonstrated that HME ryegrass exhibits accelerated growth, up to 50% faster than traditional ryegrass, has enhanced energy storage capabilities, increased resistance to drought, and reduced methane emissions from livestock by up to 23%[20]. After attempting to gain registration of HME in Australia AgResearch have changed the direction of their research and are looking to gain the same results which they have had with HME with a ryegrass that is sourced from another plant family. Under the assumption that a suitable ryegrass is created by 2025 it would be likely to be available by 2035.

3.7.5 Mootral

Mootral is a feed additive that was developed in the UK. Mootral works via targeting archaea which are a group of microbes that are responsible for production of methane inside the rumen[21].

In the United Kingdom, in vitro tests were conducted to assess the impact of Mootral Ruminant[22]. The trial administered Mootral in pellet form, on two breeds of cattle: Friesian and Jersey. Over a period of 12 weeks, the cattle were fed the pellets, and the outcomes revealed promising effects on methane production. The results from this trial showed an average reduction of methane of 30% with the addition of 3-5% increases in milk yield[23].They did not identify any negative impacts on cow health or milk quality. The product has shown a high level of consistency however isn't approved for use in New Zealand and hasn't been trialed within our pastoral systems or within the sheep and beef sector.

3.8 Cost of Available Mitigations

Table 3 expresses the cost of the mitigations per tonne of CO2e mitigated for the range of options currently available.

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18 NZAGRC (n.d.). *Nitrification Inhibitors*. Retrieved June 30, 2023, from https://www.nzagrc.org.nz/domestic/nitrous-oxide-research-programme/nitrification-inhibitors/

19 AgResearch (2019, August 28). *HME ryegrass making steady progress.* Retrieved June 30, 2023, from https://www.agresearch.co.nz/news/hme-ryegrass-making-steady-progress/

20 International Service for the Aquisition of Agri-biotech (2018, August 1). *AgResearch tests GM highly metabolizable energy ryegrass*. ISAAA. Retrieved June 30, 2023, from https://www.isaaa.org/kc/cropbiotechupdate/article/default.asp?ID=16655

21 (n.d.). *The Science*. Mootral. Retrieved July 7, 2023, from https://mootral.com/science/

22 Roque B, Van Lingen H, Vrancken H, Kebreab E (2019) Effect of Mootral—a garlic- and citrus- extract-based feed additive—on enteric methane emissions in feedlot cattle. *Translational Animal Science.* Volume 3, Issue 4, July 2019, Pages 1383–1388, https://doi.org/10.1093/tas/txz133

23 Eger M, Graz M, Riede S and Breves G (2018) Application of Mootral™ Reduces Methane Production by Altering the Archaea Community in the Rumen Simulation Technique. *Front. Microbiol*. 9:2094. doi: 10.3389/fmicb.2018.02094

Table 3: Cost of Mitigations[24]

Mitigation	Cost ($/t CO2e)
Sheep Genetics	34
Lower Stocking Rate	91
Lower Stocking Rate/ Improved Productivity	-348
Reduced Replacement Rates	-494
Change in stock types	-90
Pasture Quality	n/a
Different Forage Types	n/a
Shorter Finishing Times	n/a
Reduced Supplement Feed	91
Fertigation	n/a
Reduced N	145
Forestry Native	1,577
Forestry Exotics	0

3.9 Estimated Costs of Future Potential Mitigations

Table 4: Cost of Future Potential Mitigations[25]

Mitigation	Cost ($/t CO2e)
Methane Vaccine	44
Methane Inhibitor	69
Nitrous Oxide Inhibitor	1,703
GM Ryegrass	16

We note that on current information the costs of future mitigations are highly competitive with those mitigations which are currently available. Hence a lot of farmers have not moved on adopting emissions reductions strategies, preferring to wait till these more cost effective methods have arrived.

[24] AgriBusiness Group (2023) *Report on Agricultural Greenhouse Gas Mitigation Technologies*
[25] AgriBusiness Group (2023) *Report on Agricultural Greenhouse Gas Mitigation Technologies*

3.10 Cost Mitigation Curve

Figure 5 represents the emissions mitigation curve for the currently possible mitigations on Godley Peaks. We can see that the cheapest emissions reductions start with efficiency gains within the farming system, in fact they improve profitability rather than cost, then forestry then sheep genetics.

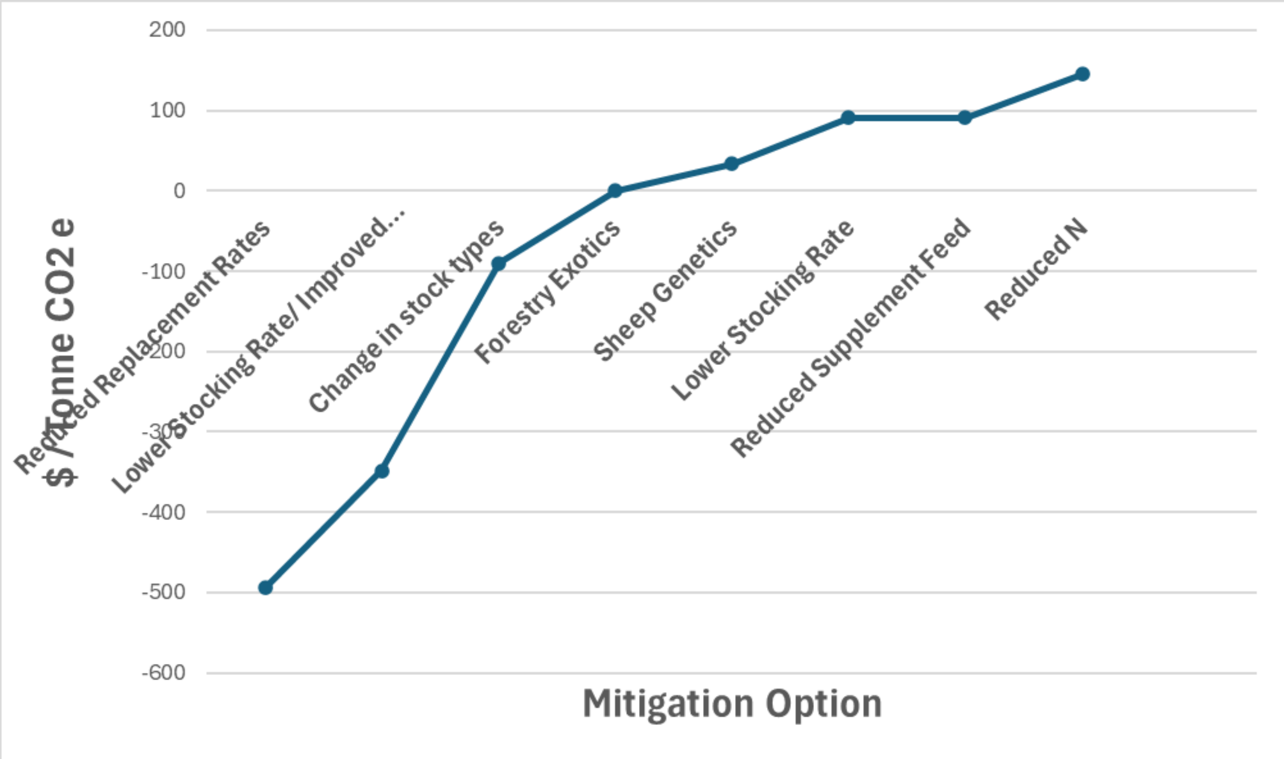

Figure 5: Cost mitigation curve for those mitigations that are currently available.

4 Toitu Certification Program

This section is a brief synopsis of Toitu which is the prime certifier of GHG emissions in New Zealand. The Toitu program is ISO14064 accredited. For farming clients, they use AsureQuality as their auditors.

Toitu offer three forms of carbon certificates:

- Carbon Reduce: which is recognition that the farm has measured, managed and reduced the carbon footprint as much as is possible.
- Net Carbon Zero: which certifies that a farm has been able to measure, manage, reduce and offset their carbon emissions to the point where they are net carbon zero.
- Climate Positive: which certifies that the farm has achieved a net position of offsetting 125% of their carbon emissions.

The Toitu process for farms is to first model your farm in Overseer and then to import the data from Overseer into Toitu's emanage software which has some additional questions which are designed to provide further detail which is not covered by Overseer. The results of this exercise are displayed on a dashboard. Once you are happy with your total emissions you then go through a verification process and eventually gain certification. In order to maintain certification you will require to be audited every three years.

The treatment of forestry in the Toitu certification scheme is different from that which is used in the MPI Emissions Trading Scheme. Basically it relates to the permanent nature of forestry land and so allows harvesting as long as it is followed by replanting.

Key elements of the treatment of forestry within Toitu certification are:

- Using MPI look-up table values.
- Forest blocks cannot be in the ETS or involved in carbon credit trading.
- No minimum size requirement of 1ha.
- No 30m minimum width restriction.
- 80% of removals counted.
- No riparian strips or soil sequestration.

After a discussion with Toitu about their certification programs we have found that the Carbon reduce option is more about the fact that the station has a reduction plan which it is following than about the fact that the station has reduced the carbon footprint as much as is possible. Toitu indicated that Godley Peaks could gain Reduce certification now and go through a period of increases in carbon emissions as long as the plan was to reduce it in the long term.

This plan is in place for five years and the station would retain its certification status during those five years as long as the annual audit showed that they were following the plan. A new plan would be required at the end of the five years for the station to continue to maintain its certification status. The cost of this was estimated by Toitu as $12,000 per annum.

It is our opinion that there would be little point in Godley Peal entering the Reduce certification process while it was still increasing in its carbon emissions unless there was some financial advantage in doing so that would at least cover the cost of the annual fee. One the station was on a reduction path that decision could be revisited and weighed up against the cost of the annual subscription against the advantages which the station can get by the certification whether they be financial or in some other form.

5 Stage Two Testing the options.

After a discussion around the material provided in the Stage 1 report the following scenarios are the ones that have been selected for further testing.

- Scenario 1: Native Forestry

All areas that are considered to be non-productive in an agricultural sense on the station will be fenced off and allowed to revert into native forestry.

- Scenario 2: Exotic Forestry

All areas that are of lower productivity will be put into an appropriate exotic forest species.

- Scenario 3: Efficiency Gains

We will calculate the most efficient farming system based on Dry Matter produced. This will be calculated using the Excel optimisation function which will report the optimum number and reproductive and growth performance for the station. This will be entered into Overseer to determine the amount of emissions that can be reduced by achieving the optimum efficiency.

- Scenario 4: Lower Stocking Rate

The station will be modelled in Overseer to determine the amount of emissions that are reduced by a 10, 20 and 30% reduction in its stocking rate.

- Scenario 5: The combined optimum reduction.

This will be presented as the combination of all of the previous mitigations that best represent the best combination of emissions reductions and at the same time maintaining the stations profitability at least in a positive situation.

The modeling that has been carried out in Stage 2 has been carried out assuming that Godley Peaks will enter the Toitu verification system and therefore uses the Toitu interpretation of a range of the techniques available to sequester carbon on farm.

5.1 Sequestration / Mitigation

5.1.1 Conversion to Hydro

It is proposed that Godley Peaks will be able to convert from its current major energy source, diesel, to a renewable energy source hydro which is able to be generated on the station. We have been able to model this transition in Overseer and it shows that this will be able to reduce the total emissions of the station by 108 t CO2 eq annually or 2%of the initial emissions.

5.1.2 Native Forestry

The assumption used for native forestry is that the station is able to fence off 100 ha along stream margins and in areas of little or very low productivity and exclude stock from grazing that area. The amount of sequestration is taken from the MPI Sequestration Look Up tables for indigenous vegetation. The impact of establishing 100 ha of native forestry in this way can be seen in **Figure 6** where the amount of sequestration peaks at 1,280 t CO2 eq at year 13 (2043) and then slowly declines to 1,030 t CO2 eq at year 20 (2050). The percentage impact on the total stations initial emissions is 19% at the peak and 13% in 2050.

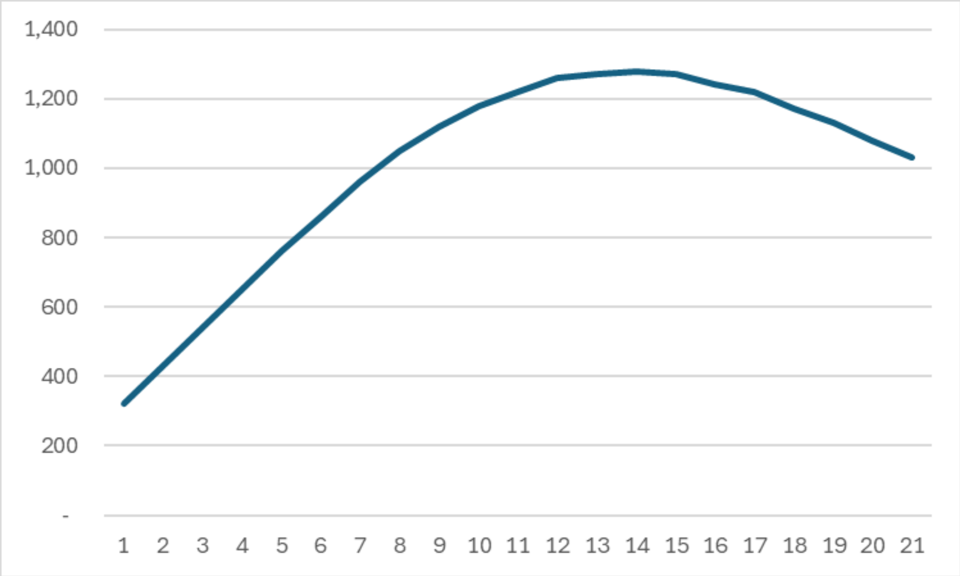

Figure 6: Trajectory of sequestration from 100 ha of native forest over 20 years.

We have assumed that this area will not have an impact on the financial performance of the station apart from the $164,000 of capital spent in the fencing off of the land.

5.1.3 Exotic Forestry

It is our understanding that Toitu accepts 80% of the amount of sequestration that is shown in the MPI Sequestration Look Up tables for exotic vegetation for forests that are harvested and then replanted. That is land which is permanently in forest which is in harvest regime. We have used the look up table values for Canterbury in this exercise.

In order to achieve a high continuous amount of sequestration we have planted 20% of 100 ha every five years. This is assuming that the trees are harvested every 35 years in the Mackenzie Basin. The trajectory of this planting regime in terms of the volume of sequestration can be seen in **Figure 7**. We can see from **Figure 7** that the amount of sequestration slowly increases until it levels off at about 2,100 t CO2 eq at year 2050, which is 32% of the stations initial volume of emissions.

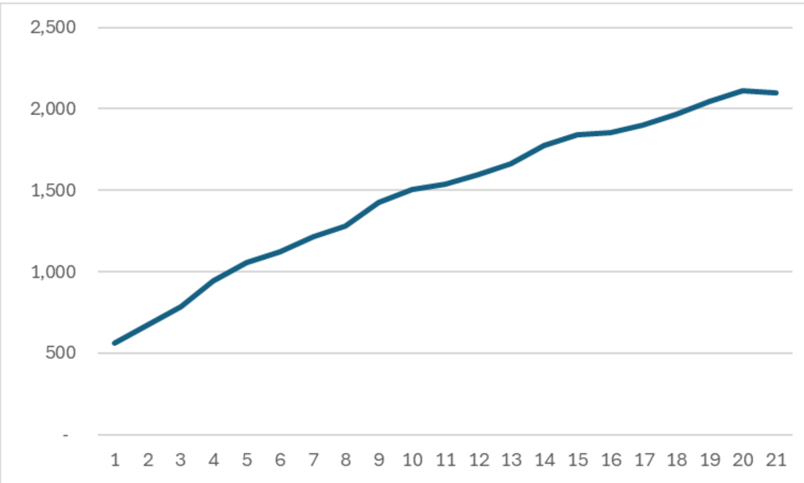

Figure 7: Trajectory of sequestration from 100 ha of exotic forest over 20 years.

5.1.4 Efficiency Gains

We have modelled a much more efficient farming system than that suggested in the stations development program. It has been designed to produce the same amount of output. It incorporates elements of:

- Reduction of the stations stocking rate.
- Reducing replacement rates of breeding animals.
- Shorter finishing times.
- Different forage types.
- Improved pasture quality.
- Reduced imported supplementary feed.

The biggest change was increasing the lambing % from 100 to 120%. This led to a reduction in breeding ewes by 17% along with achieving the same volume of finishing stock achieving the same weights but achieving that much quicker than that which was modelled. The cattle were changed to reduce the number of animals that were retained by replacement and achieving the finishing weights of the R2 cattle four months sooner.

This system was modelled in Overseer and accounted for an 808 t CO_2 eq reduction in emissions which is a 13% reduction overall.

5.1.5 Reducing Stocking Rate

We have modelled reductions in stocking rate in Overseer by 10, 20 and 30% from the stocking rate determined by the efficiency gains scenario. The results of this exercise are shown in **Table 5**.

Table 5: Reductions in emissions achieved by a reduction in stocking rate.

Reduction in Stocking Rate	Reduction on Emissions (t CO_2 eq)	Reduction from initial. (%)
10%	454	7%
20%	932	14%
30%	1,688	26%

5.1.6 Animal Genetics

The adoption of animal genetics has been modelled at the known rate of 1% mitigation per year, which is compounding from year 20 (2040). At year 20 (2050) it is achieving a reduction of 856 t CO_2 eq per annum which is 13% of the initial emissions.

5.1.7 Vaccine / inhibitor.

Although this hasn't as yet been proven in New Zealand we have modelled it as the rate of efficacy (30%) and at the time when we estimated that it would be available for commercial use (2040).

5.2 Total Reductions

The range of sequestration/ mitigations that we have incorporated into the model all have quite different impacts. Some, such as native forestry have a diminishing impact over time, some such as exotic forest have a slow increase and then reach a peak at which they can be maintained and some such as energy conversion to hydro and efficiency gains have a steady rate of impact on reductions. These can be seen in **Figure 8**.

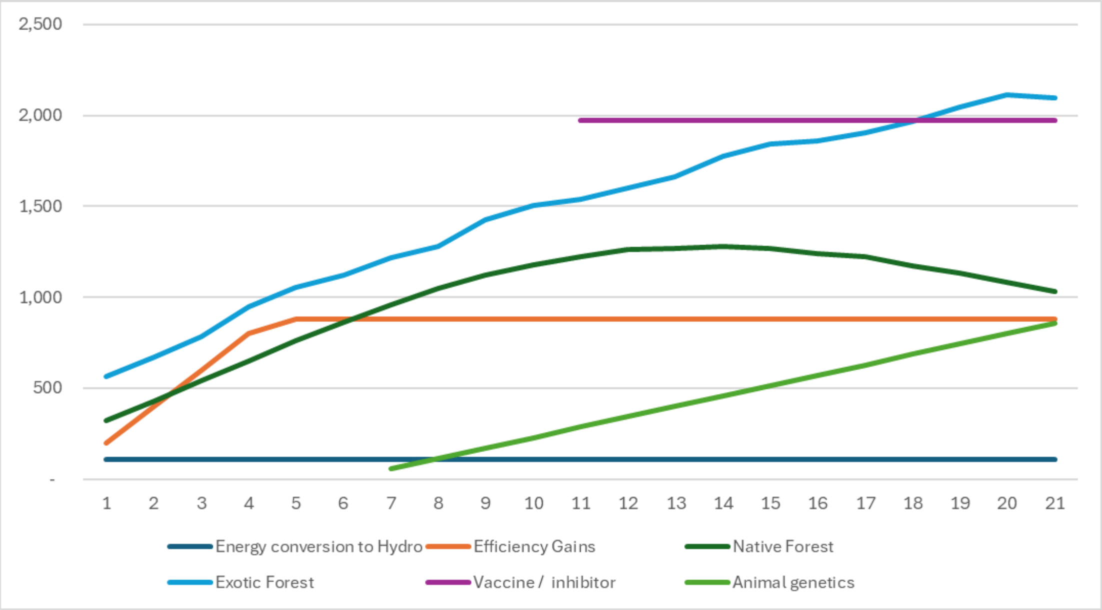

Figure 8: Figure showing the range of impacts that are achieved by the range of sequestration / mitigation options.

The total impact of adopting this combination of sequestration/ mitigation options is shown in **Figure 9**. What we can see from **Figure 9** is that there is a steady reduction in GHG emissions on the station for the first 10 years ending up with a reduction of approximately 60 % at that point. There is then a rapid reduction with the advent of the vaccine / inhibitor which reduces the emissions by a further 30%. This means that the station meets carbon zero at year 2044. Because the advent of the vaccine / inhibitor is still very uncertain we would recommend that Godley Peaks look at increasing the amount of exotic forestry that it adopts to ensure that it is able to meet the target of being carbon zero.

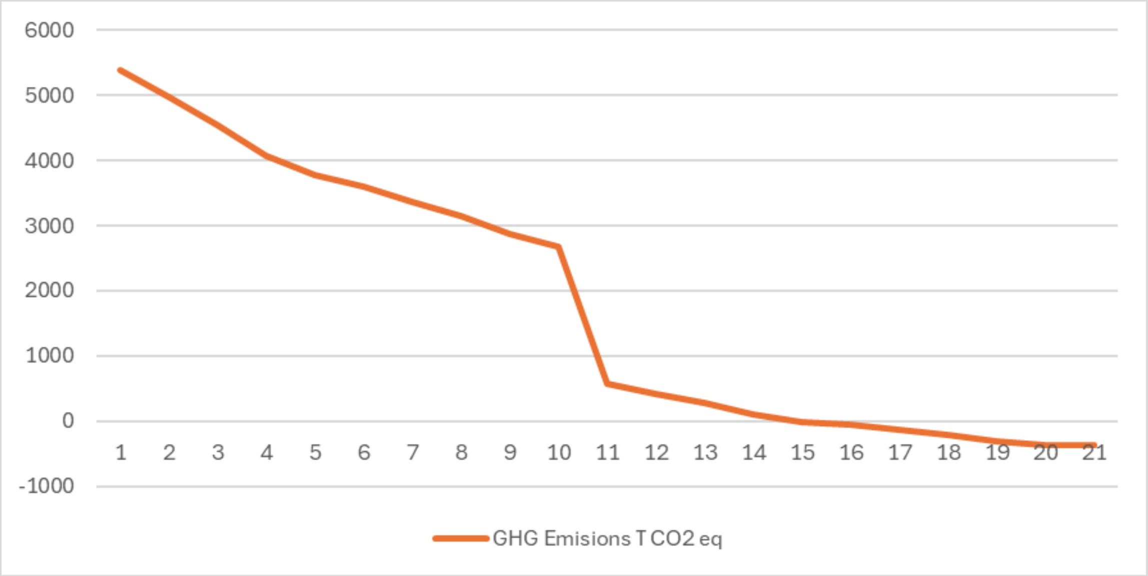

Figure 9: Total emissions from Godley peaks over time.

5.3 Financial

The financial impacts of the range of reductions/ mitigations modelled are shown in **Table 6**. What we can see from **Table 6** is that:

- the native forestry achieves the same EBIT as the status quo but consumes an additional $165,000 capital.
- The exotic forestry improves the EBIT considerably while consuming $165,000 capital.
- The efficiency gains improve EBIT marginally but return $164,000 capital.
- Each of the lowering of stocking rate scenario reduced EBIT quite considerably until it is negative for the 20 and 30 % scenarios while returning significant sums in capital.
- The optimum scenario improves EBIT marginally while consuming $165,000 in capital.

Table 6: Financial performance of the range of reduction / mitigations modeled.

	Status Quo	Native Forestry	Exotic Forestry	Efficiency Gains	LSR 10%	LSR 20%	LSR 30%	Optimum
Farm Income net of purchases	1,850,946	1,850,946	2,040,646	1,850,946	1,665,851	1,480,757	1,295,662	2,040,646
Farm Working Expenses	1,267,263	1,267,263	1,372,663	1,252,973	1,244,768	1,237,384	1,230,737	1,443,537
Vehicle Expenses	85,000	85,000	85,000	85,000	85,000	85,000	85,000	85,000
Repairs & Maintenance	102,000	102,000	102,000	102,000	102,000	102,000	102,000	102,000
Administration	60,100	60,100	60,100	60,100	60,100	60,100	60,100	60,100
Standing Charges	60,000	60,000	60,000	60,000	60,000	60,000	60,000	60,000
Earnings Before Interest and Tax	**276,583**	**276,583**	**360,883**	**290,873**	**113,983**	**-63,727**	**-242,175**	**290,009**
Capex	-	164,604	164,604	-164,109	-127,452	-242,159	-345,395	165,099

6 The Pathway

After discussion about the range of options Godley peaks agreed to adopt the optimum option that was suggested. This will involve the following actions.

6.1 Conversion to Hydro

This should be carried out as soon as it is practically feasible.

6.2 Native Forestry

There is approximately 80 ha of fencing off and establishment of native areas detailed in Godley Peaks Stations Biodiversity Plan[26], we are of the opinion that it will be relatively easy for the Station to either expand the areas suggest by E3 Scientific or find some other suitable areas to make the area up to at least 100 ha. We understand that this is to occur over the next two years.

6.3 Exotic Forestry

We have modelled the station as planting 25 ha every five years in order to achieve a harvestable forest rotation. If you wished to advance this planting regime that will speed up the time that it will take to achieve net zero.

6.4 Efficiency Gains

It has been suggested that it may be difficult to achieve much in terms of efficiency gains while you are increasing and changing your stocking mix but we would like to suggest that some of the station system efficiency gains are possible to integrate into your system at the same time as you are increasing sticking rate so we would urge you to not lose track of the possible efficiency gains.

6.5 Animal Genetics

This should be adopted as soon as you are able to source the type of sheep and cattle that you require which c an also offer you emissions reductions at the same time.

6.6 Vaccine / Inhibitor

These up both unknowns at this point. We would recommend that we should have an update of your carbon status every two years where we can update you on the progress that is being made in developing them and perhaps devising an alternative option if their development is delayed or still uncertain.

The aim is to have Godley Peaks at carbon zero by the year 2050 if at all possible.

[26] E3 Scientific. (2024) : Godley Peaks Station Farm Biodiversity Plan.