Independent
Agriculture
& Horticulture
Consultant
Network

Case Studies Revisited

Prepared for Deer Industry New Zealand

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1.0 EXECUTIVE SUMMARY

In 2019 AgFirst assessed biological greenhouse gas (GHG) emissions and possible mitigations on four case study farms for Deer Industry New Zealand. This report updates these assessments.

It looks at the possible financial implications of three GHG pricing models – the two proposed by He Waka Eke Noa (HWEN) in late 2021 and the so-called 'backstop', the NZ Emissions Trading Scheme (NZETS). It also compares the results generated by four different greenhouse gas measurement tools/calculators.

The financial impact is measured in relation to the Economic Farm Surplus (EFS) a standardised protocol for calculating earnings before interest and tax. A reduction in the EFS limits the ability of a farming enterprise to make principal and interest repayments on any mortgage or debt they hold, or to invest in productive and environmental improvements to their property.

Each of the four farms are high performing enterprises. This means the potential for increasing per animal performance (thereby reducing the GHG emissions for each kilogram of meat produced) is limited.

Potential technical mitigations for ruminant GHG emissions have been widely publicised, but none have been developed that could be applied on any of the farms. Also, the technologies that may be commercialised in the short-term (feed additives and pasture sprays) are not suited to the farms in this study.

Each of the farms has made considerable progress with excluding grazing animals from waterways, erosion-prone slopes, wetlands and areas of native biodiversity. This limits their ability to further reduce emissions through stock exclusion, short of converting significant areas of pasture to forestry.

The conversion of productive food-producing farmland to carbon forestry is publicly controversial and is outside the scope of this paper. Carbon income from the NZETS has not been factored into our calculations. However, the steady increase in the price of carbon in the NZETS may make carbon forestry a viable option on three of the four farms. On the fourth property – and by extension many other similar farms -- plantation forestry is not an option because of climate or soil type, or because it is prohibited under local or regional plans.

On those farms where plantation carbon forestry is an option, it is only a temporary solution. Annual carbon income under the NZETS is limited to 16 years for Pinus radiata and 26 years for Douglas-fir, but the land must remain as a plantation in perpetuity (unless the carbon income is repaid).

Measuring tools/calculators

The measuring tools/calculators assessed in the study generated significantly different results. Each calculator has its advantages and disadvantages from a user's perspective, but all can model to a greater or lesser extent changes in emissions resulting from changes in farm management systems.

Summary of findings

The study assessed the outcomes of following potential mitigation options that could be applied to the case study farms:

- Change stocking ratio
- Reduce nitrogen fertiliser use
- Change land use and reduce stock numbers
- Decrease stock numbers and plant trees.

It was found that on-farm emissions could be reduced by 0.07% to 0.42% through changing stocking policies or 3.73 to 8.51% by changing land use and decreasing stock numbers.

Horticulture was not an option on three of the farms because of their land class, soil type and/or climate. On one of the farms a land use change to horticulture or viticulture may be possible, although this would require considerable capital investment and specialist expertise. These possibilities were not modelled.

The financial impacts of the potential mitigation options varied between farms, depending mainly upon whether a farm could gain income from the sequestration of carbon in growing trees.

- The HWEN on-farm levy impacted profitability from +13% to -14% (where one farm received income from sequestration).
- The HWEN processor hybrid levy impacted profitability from +15% to -15% (where one farm received a benefit back to them for sequestration).
- The NZETS processor-level levy impacted profitability from -0.4% to -17% based on 2025 carbon pricing and a 95% free allocation of farm emission credits. This makes the NZETS the least costly option for three of the four case study farms in year 1.
- From year 2 onward, the HWEN levies will be less costly than the NZETS. Under current policy settings and forecast carbon prices, NZETS levies on farm production will increase by 65% a year until 2030. Also the HWEN options provide an opportunity for some of the farms to be rewarded for sequestration that is not eligible under NZETS rules.
- For one farm, carbon pricing had little impact on profitability because the majority of its income is derived from sales of velvet antler which under current policy will not be levied for GHG emissions. In contrast, the impact was severe on the farm that derived the majority of its income from venison, which will be levied.

The GHG calculators assessed in the study varied significantly in their complexity and in their calculations of GHG emissions and sequestration. Some calculators are considerably more complex to use than others and require more time and data input.

- All the calculators could assess the outcomes of the mitigation scenarios, apart from two which could not calculate a change in stock weights or supplements.
- Some of the calculators are considerably more complex than others and require more time and data input.
- The emissions calculated ranged from 8.6% difference between tools for one case study, to 27% difference for another. There was also a large range in their calculations of sequestration. This highlights the importance of farmers sticking to one tool to compare drivers of emissions between years.

2.0 INTRODUCTION

AgFirst have been commissioned by Deer Industry New Zealand to revisit the four case studies from 2019 which looked at biological greenhouse gas (GHG) emission and offsets. The purpose of this report is to re-visit the case study farms and look at three core components:

1. Assess each of the four farms using four different tools/emission calculators which are used to model on-farm greenhouse gas emissions and to compare and contrast the tools ease of use and results. The tools include Overseer version 6.4.2, FARMAX Pro, Ministry for the Environment (MfE) Agricultural Emissions Calculator and the Beef + Lamb New Zealand (B+LNZ) GHG Calculator.
2. Using FARMAX Pro, identify mitigation options that are practically available to each of the case study farms and assess the likely impact of these.
3. Consider two potential policy scenarios and assess the financial implications of these to the case study farms; these being, agriculture being included in the Emissions Trading Scheme (ETS) and the proposed He Waka eke Noa Farm-Level He Waka Eke Noa Processor-Hybrid. This work is in line with the modelling from the He Waka Eke Noa Discussion Document from November 2021.

3.0 BACKGROUND

New Zealand signed the Paris Agreement on climate change in 2016 which is an international agreement that aims to hold the global average temperature increase to below 2 °C of the pre-industrial levels and aims to limit the temperature increase above 1.5 °C pre-industrial levels. To reach this, New Zealand must reduce greenhouse gas emissions to 30% below 2005 levels by 2030.

The Zero Carbon Act in 2019 set three domestic goals to reduce emissions:

1. Reduce emissions of long-lived gasses to net zero by 2050
2. Reduce emissions of biogenic methane to 10% below 2017 levels by 2030
3. Reduce emissions of biogenic methane by 24-47% below 2017 levels by 2050

The focus on biogenic methane is primarily from ruminant animals and is likely to have the main effect on New Zealand's pastoral agricultural sector.

He Waka Eke Noa was set up as an industry, government, and iwi partnership to help farmers to measure, manage and reduce agricultural emissions: biogenic methane (CH_4) which is a short-term gas, nitrous oxide (N_2O), and carbon dioxide (CO_2) which are both long term gases. This includes an approach to recognising on-farm sequestration and other potential mitigations, and an effective system for pricing agricultural emissions from 2025 as an alternative to the Emissions Trading Scheme (ETS), which would tax farmers per kilogram of product at the processor level.

He Waka Eke Noa aims to have all New Zealand farms emissions measured by December the 31st 2022 and to have a plan written to measure and manage emissions by the 1st of January

2025. In the following report, four of the He Waka Eke Noa verified tools have been used to model greenhouse gas emissions to help highlight the advantages and disadvantages of each tool in a deer industry context. Furthermore, the ETS processor level levy and alternative He Waka Eke Noa levy have been modelled to illustrate the impacts to the case study farms used in this report.

4.0 METHODOLOGY AND APPROACH

Each of the farms was visited and then based on data provided, a base file was established using Farmax. Farmax was chosen because it enables the farm system to be modelled as well as farm financials and greenhouse gases. It can then be used to assess mitigation scenarios that retain the viability of the farm system, at least from a feed perspective (i.e. a scenario can't be considered viable if feed demand exceeds supply).

Farmax modelling was carried out in long-term mode, meaning that the farm system was modelled in steady state with balanced stock reconciliations, stock weights, and feed. These numbers were then used in across the four tools to ensure consistency of data across the tools. Mitigation options were identified based on current actions which have been recognised by the New Zealand Agricultural Greenhouse Gas Centre (NZAGRC), and which were practically able to be applied into each farm system as assessed by an expert consultant.

The assessment of tools followed user guidance on which data to use for each tool. Differences across tools was then considered and discussed. Limitations and the practical implications of using each tool was also identified. Sequestration was only included in Beef + Lamb New Zealand Greenhouse Gas Calculator and MfE Agricultural Emissions Tool. Farmax and Overseer both include ETS eligible sequestration which was included in Appendix 3.

Microsoft Excel was used to assess the policy options based on Farmax outputs. The modelling assumptions used were consistent with modelling carried out by He Waka Eke Noa[1]. Sequestration has been presented separately, and an assessment made of ETS eligible sequestration, and proposed He Waka Eke Noa sequestration.

[1] www.hewakekenoa.nz

5.0 CASE STUDY SUMMARY

Each of the four case studies are summarised below. More detail on each of the case studies can be found in Appendix 1.

The 2019 case studies were all assessed in OverseerFM version 6.4.2. A table that compares 2019 emissions to 2021 emissions is included in Appendix 2. To enable the comparison, the numbers presented use the most recent version of OverseerFM.

5.1 Case Study 1 – Hawkes Bay Velvet Farm

5.1.1 Farm Overview

The property is a total of 332.1 hectares (ha) with 320 effective. The farm is predominantly medium hill country with free draining soils. Winters are typically long and cold with minimal pasture growth. Fences have been installed to exclude livestock from some sections of waterways with a plan in place to exclude livestock from all waterways within the next 10 years. Retired areas on the farm have been planted with native or exotic vegetation.

The owners have a focus on producing quality, high value products. There is a continual emphasis on improving production and per animal performance and efficiency.

The farm is predominantly a deer breeding and velveting operation with some cattle and a small number of sheep, with 3,700 stock units at a sheep: beef: deer ratio of 5:13:82. The farm predominantly focuses on velvet and the cattle and sheep are used for pasture management.

The farm purchases around 100t of feed and has roughly 11ha of fodder crops. The farm has a total fertiliser input of 56 kg/ha of nitrogen, 21 kg/ha of phosphorus and 43 kg/ha of sulphur.

5.1.2 Greenhouse Gas Emissions per tool

Table 1 below shows the modelled greenhouse gas emissions from each tool/calculator. Note that the total figures are expressed in kilograms of carbon dioxide equivalents per hectare (kg CO_2e/ha). Note that the total is gross emissions of methane and nitrous oxide exclusive of carbon dioxide.

Table 1: Case study 1 on farm emissions by tool

GHG	Farmax (kg/ha)	Overseer (kg/ha)	MfE (kg/ha)	B+LNZ (kg/ha)
CO_2 (CO_2 e)		553	104	25
CH_4 (kg CH_4)	139	137	117	98
CH_4 (CO_2 e)	3,467	3,423	2,916	2,447
N_2O (CO_2 e)	941	1,087	609	844
Total	4,408	4,510	3,525	3,291

From the table, the emissions range from 3,291 to 4,510, a 27% difference. The farm currently does not have any ETS eligible vegetation. Based on the tools, sequestration estimates were 8.6t CO_2e/yr for the B+LNZ tool and MfE was 9t CO_2e/yr total. Note, these do not necessarily align with current or pending policy. The variation between tools is discussed in section 7 below.

5.1.3 Mitigation options

From the Farmax Gross Margin analysis, the primary source of return is from the deer at 35.7c/KgDM, followed by sheep at 15.3c/KgDM and beef at 12.6c/KgDM. Given the topography of the farm, alternative land uses such as arable cropping are not practical. Given the high deer numbers, it is difficult to decrease the cattle and sheep numbers without having an impact on pasture quality while decreasing deer numbers will have a considerable impact on profitability. Given the management, it would also be relatively hard to increase per animal performance as the farm is very well sub-divided and has optimal fertility. Furthermore, most of the land which would be marginal to farm has already been retired into natives or riparian meaning that a considerable plantation would impact production.

Production forestry would be a viable option with infrastructure nearby, including a road. Ideally a plantation would be located near the road to reduce transport and tracking costs.
The following options have been considered:

- Increase sheep to cattle ratio. This included increasing the sheep numbers by 17% and decreasing cattle numbers by 5%, while deer numbers remained stable.
- Increase beef to deer ratio. This included increasing beef numbers by 21% and decreasing the breeding deer herd by 5%.
- Plant 10ha of pines or natives and reduce stock numbers – reduce stock numbers by 4%
- Plant 20ha of pines or natives and reduce stock numbers – reduce stock numbers by 8%

Other scenarios were assessed including decreasing nitrogen fertiliser with some stock reductions, decreasing deer numbers, and increasing sheep and beef numbers, and changing the cattle policy to a buying in and finishing steers. All options only managed to slightly reduce emissions but had a reasonable impact on profitability, which would not make them viable options. These are illustrated below in table 2.

Table 2: Case study 1 emission reduction scenarios

Scenario	Profit impact prior to levy (% change EFS)	Emissions impact	Emissions (kg CO_2e/ha)	Sequestration (t CO_2e/year)
Increase sheep to cattle ratio	+0.89%	+0.07%	4,409	-
Increase beef to deer ratio	-8.87%	-0.37%	4,390	-
Plant 10ha of pines	-9.27%	-3.44%	4,255	129
Plant 20ha of pines	-21.09%	-6.44%	4,122	258
Plant 10ha of natives	-13.98%	-3.44%	4,255	65
Plant 20ha of natives	-30.52%	-6.44%	4,122	130

Notes:

- *Included in the profit impact is net forestry income assumed to be $275/ha and the cost to plant natives has been annualised at $500/ha.*
- *Profit impact is based on application of mitigation scenarios only, it does not include any levy/tax from policy/regulations.*
- *Sequestration rates are based on the ETS look up tables which can be found in Appendix 3.*
- *The carbon income has not been included in the profit impact. However, if the forestry was entered into the ETS, based on a carbon price of $85/t in 2025 this income would be greater than the cost faced by any of the policy options discussed in section 8 (i.e. the benefit received would outweigh the cost impact), but would still decrease overall profitability.*

5.2 Case Study 2 – Hawkes Bay Hill Country

5.2.1 Farm Overview

The property is a total of 740 hectares with contour ranging from flats to steep hill and is typically summer dry. The owners have a strong focus on environmental management and sustainability. Ongoing consideration is given to the most appropriate use and management of all areas on the farm.

The farm runs 4,685 stock units with a sheep: beef: deer ratio of 42:23:35. The farm is primarily a breeding operation with some bulls bought in and fattened as well as replacement hoggets. The farm tries to finish what it can but farms but is dependent on the summer and autumn conditions.

The farm imports 30t of maize grain and has 6.5ha of crops with roughly 80 bales of baleage made. Across the whole farm this equates to annual average nutrients applied from fertiliser being 2 kg/ha of nitrogen, 8 kg/ha of phosphorus and 10 kg/ha of sulphur.

5.2.2 Greenhouse Gas Emissions per tool

Table 3 below are the greenhouse gas emissions from the differing tools. Note that the total figures are expressed in kilograms of carbon dioxide equivalents per hectare (kg CO_2e/ha). Note that the total is gross emissions exclusive of carbon dioxide.

Table 3: Case study 2 on farm emissions by tool.

GHG	Farmax (kg/ha)	Overseer (kg/ha)	MfE (kg/ha)	B+LNZ (kg/ha)
CO_2 (CO_2 e)	3	76	0	3
CH_4 (kg CH_4)	71	74	62	76
CH_4 (CO_2 e)	1,780	1,857	1,551	1,896
N_2O (CO_2 e)	407	440	200	414
Total (CO_2e)	2,187	2,298	1,751	2,311

From the table, the emissions range from 1,551 to 1,896, or 18% difference. The farm has a considerable amount of sequestration. B+LNZ calculates 1,239t CO_2e/yr and MfE calculates 1,100t CO_2e/yr. Note, these do not necessarily align with current or pending policy. The variation between tools is discussed in section 7 below.

5.2.3 Mitigation Options

From the Farmax Gross Margin analysis, the primary source of return is from the deer at 29.6c/KgDM, followed by beef at 21.1c/KgDM and sheep at 13.1c/KgDM. The farm typically gets summer dry so the farm is managed in accordance to this, including selling stock if necessary. There is some easier country at the front and middle of the farm which is currently being used for forage cropping. This land could be used to for arable cropping as it has reasonable topography and fertility. There is also opportunity to manipulate the stocking ratios and to plant trees over the steeper parts of the farm, although a large amount has already been done.

The following options have been considered:

- Increase sheep to cattle ratio. This included increasing the sheep numbers by 5% and decreasing beef and steer numbers by 10%, while bull and deer numbers remained the same.
- Reduce the number of bulls carried through from 95 to 84 and sell at higher weights (20kg higher carcass weight). This would require additional grazing management but would allow for the bulls to be sold if need be.
- Cultivate 10 ha of barley and decrease the cattle numbers by 7% (keeping bulls). This is likely to put stress on the winter grazing system as well as require additional management for the crop. Although it will diversify income, there will be additional risk involved in the system.
- Plant 20ha of forestry on the eastern part of the farm and reduce sheep and cattle numbers, keeping the same number of bulls.
- plant 20ha of forest and decrease all animal numbers to 98%.

From the modelling, there is evidently a point where the increase in sheep numbers will eventually lead to becoming less profitable, which happened when cattle numbers got below 80%.

Furthermore, the reduction of cattle in the system may require a change in grazing management or get to a point where keeping low cattle numbers is no longer viable. Other options which were not modelled could include a land use change to horticulture or viticulture given the location, although this would require considerable capital investment. The results from the modelling are highlighted below in table 4.

Table 4: Case study 2 emission reduction scenarios.

Scenario	Profit impact prior to levy (% change EFS)	Emissions impact	Emissions (kg CO_2e/ha)	Sequestration (t CO_2e/year)
Increase sheep to cattle ratio	+0.38%	-0.09%	2,185	
Buy in fewer cattle and sell at higher weight	+0.16%	-0.81%	2,170	
10ha of Barley with reduced beef numbers	+1.94%	-0.75%	2,169	
20ha pines with reduced sheep and cattle numbers	+5.68%	-2.58%	2,131	258
20 ha pines with reduced sheep, cattle and deer numbers	+2.63%	-8.51%	2,001	258

Notes:

- *Included in the profit impact is net forestry income assumed to be $275/ha.*
- *Profit impact is based on application of mitigation scenarios only, it does not include any levy/tax from policy/regulations.*

- *Sequestration rates are based on the ETS look up tables which can be found in Appendix 3.*
- *The carbon income has not been included in the profit impact. However, if the forestry was entered into the ETS, based on a carbon price of $85/t in 2025 this income would be greater than the cost faced by any of the policy options discussed in section 8 (i.e. the benefit received would outweigh the cost impact), and would further increase overall profitability.*

5.3 Case Study 3 – South Island High Country

The property is located in the South Canterbury high country and is 4,374 hectares. The farm is extensive in nature, with almost half in native pasture, and considerably limited by the winter climate and altitude.

The farm has roughly 13,240 stock units and a sheep: beef: deer ratio of 51: 25: 24. The farm is predominantly breeding with no stock bought on.

The farm makes 2,000t of silage with 100 bales of hay and silage and crops 85ha of crops each year as well as buying in an additional 35t of bought in feed. 28kg/ha of urea is applied to part of the farm. Across the whole farm this equates to annual average nutrients applied from fertiliser being 3 kg/ha of nitrogen, 2 kg/ha of phosphorus and 6 kg/ha of sulphur.

5.3.1 Greenhouse Gas Emissions per tool

Table 5 below are the greenhouse gas emissions from the differing tools. Note that the total figures are expressed in kilograms of carbon dioxide equivalents per hectare (kg CO_2e/ha). Note that the total is gross emissions exclusive of carbon dioxide.

Table 5: Case study 3 on farm emissions by tool

GHG	Farmax (kg/ha)	Overseer (kg/ha)	MfE (kg/ha)	B+LNZ (kg/ha)
CO_2 (CO_2 e)		64	4	4
CH_4 (kg CH_4)	31	36	35	33
CH_4 (CO_2 e)	785	897	862	836
N_2O (CO_2 e)	192	253	118	183
Total	977	1,150	980	1,019

The tools range from 977kg CO_2e/ha to 1,150kg CO_2e/ha, or 15% variation. Based off the tools, no sequestration would be recognised by MfE or B+LNZ tools for exotics while there is potential for the B+LNZ tool to recognise some of the native "shrubland" which is less than 30 years old at 1.723t/ha. It is difficult to differentiate what is older or younger than 30 years. Alternatively, MfE requires the shrubland to be able to regenerate into a natural forest, which may be unlikely as it is still grazed. These do not necessarily align with current or pending policy. The variation between tools is discussed in section 7 below.

5.3.2 Mitigation Options

From the Farmax Gross Margin analysis, the primary source of return is from the sheep at 19.4c/KgDM, followed by deer at 11.3c/KgDM and beef at 10.6c/KgDM. Although there is a considerable amount of easy rolling country on the farm, the climate prevents arable cropping at an acceptable risk level (i.e. climatic conditions make it very high risk). The climate also creates an interesting pasture curve which requires high quality feed, such as grain, to be bought in to maintain animal performance. There are restrictions in place for planting forestry trees such as Pinus radiata meaning that natives would be the best option although their survival and growth rates, and therefore sequestration, are likely to be significantly constrained by the climate. Thus, the best option would be to retire existing native bush.

Given the constraints of the farm, the main options to reduce emissions would be to change the stocking rate or ratio, adjust cropping policies or to reduce nitrogen fertiliser.

Due to this, the following scenarios were modelled:

- Increasing sheep numbers by 105% decreasing beef numbers by 90%, while maintaining deer numbers
- Decrease fodder crop by 20ha and cattle numbers by 5%
- Reduce N fertiliser by 3.3tN and lower cattle stocking rate by 2%
- Plant and/or retire 200ha of natives and reduce stocking rate by 5%.

The results are illustrated below in table 6.

Table 6: Case study 3 emission reduction scenarios

Scenario	Profit impact prior to levy (% change EFS)	Emissions impact	Emissions (kg CO_2e/ha)	Sequestration (t CO_2e/year)
Increase sheep to cattle ratio	12.6%	-0.11%	1,003	
Decrease cropping and cattle	5.4%	-1.42	990	
Reduce N fertiliser use	6.3%	-0.98%	994	
200ha of natives	-19.2%	-3.73%	967	366 (8.3% of emissions)

Notes:

- *the 200ha of natives was assumed to be pre 2008 regenerating natives and fenced off to exclude stock under He Waka Eke Noa sequestration (assuming that the policy is implemented as proposed). Fencing was annualised to align with He Waka Eke Noa modelling. Some consideration was given to planting natives but given the cost and risk involved to establish the forest it was not likely to be a viable option. The total amount of sequestration would offset another 8.3% of total farm emissions, bringing the total reduction to 12%.*
- *Profit impact is based on application of mitigation scenarios only, it does not include any levy/tax from policy/regulations.*

5.4 Case Study 4 – South Island Venison

The property is a total of 796.7 hectares with contour ranging from flats to moderate hills with almost 190ha of irrigation and very warm summers. The owners have a strong focus on profitability, resulting in a very intensive, high input system.

The farm is a breeding and finishing operation with 11,555 stock units. The sheep: beef: deer ratio is 3:23:74. There are no breeding ewes on the farm with lambs being bought in and finished, as well as yearling stags and calves.

The farm imports 100t of grain and makes 100t of silage, 1,000 bales of baleage and 270 bales of oats. The farm has 80ha in winter crops (fodder beet and kale) and some nitrogen fertiliser applied to 200ha of non-irrigated pasture. Fertiliser is applied at an average annual rate of 55 kg/ha of nitrogen, 11 kg/ha of phosphorus and 16 kg/ha of sulphur.

5.4.1 Greenhouse Gas Emissions per tool

Table 7 below are the greenhouse gas emissions from the differing tools. Note that the total figures are expressed in kilograms of carbon dioxide equivalents per hectare (kg CO_2e/ha). Note that the total is gross emissions exclusive of carbon dioxide.

Table 7: Case study 4 on farm emissions by tool

GHG	Farmax (kg/ha)	Overseer (kg/ha)	MfE (kg/ha)	B+LNZ (kg/ha)
CO_2 (CO_2 e)	41	476	67	65
CH_4 (kg CH_4)	174	172	197	166
CH_4 (CO_2 e)	4,307	4,307	4,922	4,143
N_2O (CO_2 e)	1,039	1,147	910	1,187
Total	5,387	5,454	5,832	5,330

From the table, the emissions range from 5,330kg CO_2e/ha to 5,832kg CO_2e/ha, or 8.6% difference. The farm has a reasonable amount of sequestration, B+LNZ calculates 408t CO_2e/yr and MfE 375t CO_2e/yr. These do not necessarily align with current or pending policy. The variation between tools is discussed in section 7 below.

5.4.2 Mitigation Options

From the Farmax Gross Margin analysis, the primary source of return is from the deer at 19.4c/KgDM, followed by sheep at 17c/KgDM and beef at 12.4c/KgDM. There is a considerable amount of flat land both irrigated and non-irrigated and a mixture of rolling and medium hills on the rest.

This farm is versatile in terms of being able to transition between stock classes or cropping with few limitations apart from winter climate. The irrigation on the farm allows for high production and reduces climate risk over summer, while the large amount of trade animals gives the farm the ability to change policies easily without compromising breeding or genetics. The farm is very fertile with most of the paddocks having been developed at some point in time.
The following options have been considered:

- Increase sheep to cattle ratio. This included increasing the sheep numbers by 145% (finishing 4,350 lambs) and decreasing beef numbers by 7.

- Decrease cattle numbers to 90% and remove 5ha of fodder beet and oats.
- Additional 10ha of barley on the non-irrigated flats with a reduction in beef numbers by 4%.
- 20ha of pine trees with a reduction in sheep numbers by 80%.

From the modelling, there is evidently a point where the increase in sheep numbers will eventually leading to becoming less profitable overall, which happened when cattle numbers got below 80%. Furthermore, the reduction of cattle in the system may require a change in grazing management or get to a point where keeping low cattle numbers is no longer viable. Other options which were not modelled could include a land use change to horticulture or viticulture given the location, although this would require considerable capital investment. The results are illustrated below in table 8.

Table 8: Case study 4 emission reduction scenarios

Scenario	Profit impact prior to levy (% change EFS)	Emissions impact	Emissions (kg CO_2e/ha)	Sequestration (t CO_2e/year)
Increase sheep to cattle ratio	-0.95%	-0.42%	5,366	
Decrease cattle numbers and supplements	-2.54%	-2.15%	5,272	
10ha of barley and reduced beef	1.7%	-0.5%	5,362	
20ha of pines with reduced sheep	-1.72%	-2.2%	5,270	570

Notes:

- *Included in the profit impact is net forestry income assumed to be $228/ha/year.*
- *Profit impact is based on application of mitigation scenarios only, it does not include any levy/tax from policy/regulations.*
- *Sequestration rates are based on the ETS look up tables which can be found in Appendix 3.*
- *The carbon income has not been included in the profit impact. However, if the forestry was entered into the ETS, based on a carbon price of $85/t in 2025 this income would be greater than the cost faced by any of the policy options discussed in section 8 (i.e. the benefit received would outweigh the cost impact), and would still decrease overall profitability.*

Although there are many options for the farm, few of them will reduce emissions without impacting significantly on profitability. The most viable option would be to diversify into arable cropping, although this would increase risk due to a higher reliance on favorable climatic conditions, and/or consider retiring steeper areas into trees.

6.0 MODELLING DISCUSSION ACROSS ALL CASE STUDIES

From all the options, there is usually an opportunity to change stocking ratios to reduce emissions without impacting profitability too greatly. However, the reduction in GHG emissions are generally minimal with stock policy changes, ranging from 0.07% to 0.42%, and greater emissions reductions coming from land use change and decreasing stock numbers, ranging from 3.73 to 8.51%. The impacts on farm profitability varied considerably across scenarios. Another option modelled was to decrease animal numbers and increase per animal performance. Although this can often reduce emissions it also requires improved grazing management and possibly better animal genetics to realise the benefits. The case studies are all high performing farmers with good outputs so increasing per animal performance is unlikely to be achievable at significant levels. The results for this indicated a reduction of around 1%.

It should be noted that these changes are theoretical and modelled. There may be practical implications that prevent these scenarios from being implemented. Often, these changes can increase risk to climate variability which is why, while in theory they may increase profitability, in practice they are not implemented.

The most effective way to reduce emissions without impacting on profitability considerably would be to retire the most marginal land and plant it in trees and reduce the stock numbers accordingly. On the more highly intensive farms this is a challenge as most of the land is being utilised which means that the plantings would impact the system proportionately so the decrease in profitability would be substantial.

As the main drivers of greenhouse gas emissions are feed intake, protein content of feed and nitrogen fertiliser applications (more relevant to dairy farms), retiring land into trees would reduce the dry matter going into the system as well as offering sequestration, which is why it is the most effective strategy at reducing emissions.

In accordance with the ETS lookup tables, Pinus radiata has a considerably greater amount of carbon sequestration as well as timber income. Thus, they are often the easiest choice to plant as they can be profitable (depending on management, cost of infrastructure, harvesting and transport) and can also provide an offset if stock are displaced. Natives can provide a good aesthetic and enhance biodiversity and could provide a return if used for manuka honey production or forestry, although returns can take a lot longer to realise. However, they are considerably more expensive to plant and have lower sequestration rates. This is illustrated in table 22 in appendix 3. Table 22 also illustrates that the average age for a pine tree (with intention to harvest) would be 16 years, under likely policy settings, this means a reward would only be received until this point so is therefore a short-term solution.

Other technologies to reduce emissions may become available in the future, including methane inhibitors or vaccines. There is currently a methane inhibitor on the market but is required to be administered continually so is not suitable for any of these farms or most New Zealand pastoral farms. The vaccine may become available in the next few years. There are also studies looking into specific forages to reduce emissions. Other forms of sequestration may also be accounted for outside of the ETS, including He Waka Eke Noa’s proposals.

7.0 ASSESSMENT OF EMISSIONS IN DIFFERENT TOOLS

The main drivers of greenhouse gas emissions on farm are drymatter intake, nitrogen fertiliser application and the protein content in the feed. Thus, the more detailed tools are able to better capture all of these variables.

The four tools which were used to calculate on farm emissions were:

- FARMAX Pro – a web-based farm system and economic simulation model, which indicates the biological feasibility of a livestock system and allows users to evaluate the economics of alternative livestock policies. The tool requires a monthly or quarterly subscription.
- OverseerFM - a nutrient budgeting model, available online. It calculates nutrient inputs and outputs from a farm system (including soil types), as well as greenhouse gas emissions. The tool requires an annual subscription fee.
- Ministry for the Environment (MfE) Agricultural Emissions Calculator – online tool which requires basic stock and fertiliser data. It is free to anyone.
- Beef + Lamb New Zealand tool "B+LNZ GHG Calculator" is also an online tool which requires slightly more detailed data compared to the MfE tool but is similar. It is free to any sheep and beef farmer who fund the tool via their levy.

The results from the tools are illustrated below in table 9:

Table 9: On-farm emissions by tool

		Farmax	Overseer	MfE	B+LNZ
Case Study 1 Hawkes Bay Velvet	CO_2 kg CO_2e/ha		553	104	25
	CH_4 kg CO_2e/ha	3,467	3,423	2,916	2,447
	N_2O kg CO_2e/ha	941	1,087	609	844
	Total kg CO_2e/ha	4,408	4,510	3,525	3,291
	Sequestration (t CO_2e/year)			**8.6**	**9**
Case Study 2 Hawkes Bay Hill Country	CO_2 kg CO_2e/ha	3	76	0	3
	CH_4 kg CO_2e/ha	1,780	1,857	1,551	1,896
	N_2O kg CO_2e/ha	407	440	200	414
	Total kg CO_2e/ha	2,187	2,298	1,751	2,311
	Sequestration (t CO_2e/year)			**1,100**	**1,239**
Case Study 3 South Island High Country	CO_2 kg CO_2e/ha		64	4	4
	CH_4 kg CO_2e/ha	785	897	862	836
	N_2O kg CO_2e/ha	192	253	118	183
	Total kg CO_2e/ha	977	1,150	980	1,019
	Sequestration (t CO_2e/year)				
Case Study 4 South Island Venison	CO_2 kg CO_2e/ha	41	476	67	65
	CH_4 kg CO_2e/ha	4,307	4,307	4,922	4,143
	N_2O kg CO_2e/ha	1,039	1,147	910	1,187
	Total kg CO_2e/ha	5,387	5,454	5,832	5,330
	Sequestration (t CO_2e/year)			**375**	**408**

Each tool uses the New Zealand Inventory to measure emissions and the framework from the Fourth Assessment Report (AR4) of the Intergovernmental Panel on Climate Change (IPCC), which is known as the 100 year Global Warming Potential (GWP100). All greenhouse gasses are converted into carbon dioxide equivalents (CO_2e) whereby carbon dioxide (CO_2) is one, methane (CH_4) is 25 CO_2e and nitrous oxide (N_2O) is 298 CO_2e.

Each of the tools use stock numbers and fertiliser (non-urea, urea, and urea with urease inhibitor, apart from Farmax which has urea or other) to calculate on farm emissions. Some of the tools or calculators are considered simple or advanced depending on complexity.

Both Farmax and OverseerFM are considered detailed tools, with daily stock numbers, weights, animal losses, feed supplements (both on farm and purchased) and detailed fertiliser inputs. Due to the high level of data input required, a considerable amount of time and detailed data is required to set up the models.

Alternatively, the B+LNZ GHG Calculator requires only fertiliser inputs and a stock reconciliation which includes purchases, sales and deaths, while the MfE tool requires fertiliser inputs and just annual stock numbers (ie one number for each animal type). Support to use these tools is quite limited, although the B+LNZ GHG calculator does not let the model run if obsolete data is entered into the tool which helps to reduce input error. The B+LNZ tool has multiple different stock classes which are reflected by a stock unit. Neither of the tools consider supplementary feed (cropping or imported supplements), so the protein content of feed is not considered in as much detail. Table 10 below illustrates the relative complexity of information assessed within each tool. More detail can be found in the He Waka Eke Noa reports around GHG tools[2].

[2] Review of Models Calculating Farm Level GHG Emissions reports: https://hewakaekenoa.nz/tools-and-calculators/

Table 10: Tool comparison

Scenario	MfE	B+LNZ	Overseer	Farmax
Animal Numbers	Yearly by species	Yearly by class	Daily by class	Daily by class
Animal weights	-	-	Yearly	Daily
Sales and purchases	-	Yearly	Daily with weight	Daily with weight and price
Nitrogen fertiliser – urea, urea with inhibitor and non-urea	Yearly	Yearly	Daily	Daily – only urea and other.
Cropping	-	-	Monthly – includes cultivation method, soil type and fertiliser application.	Daily – does not include cultivation type or deal well with N fertiliser.
Supplementary feed	-	-	Monthly – able to specify what class of animals is fed to	Monthly
Supplements made on farm	-	-	Monthly	Daily
Financial implications	-	-	-	Yes
Systems feasibility	-	-	No. Need to know how to use the model before being able to do it.	Yes
Sequestration	Yes – refer to discussion	Yes – refer to discussion	Yes – aligns with ETS	Yes – Aligns with ETS

All models are based off the New Zealand emission factors from the New Zealand Greenhouse Gas Inventory. There has been no work done which compares and contrasts the underlying equations of the greenhouse gas emissions, which could also be a reason for disparities between results.

Thus, all tools can calculate the change in emissions from changes in animal numbers, N fertiliser use and areas of eligible woody vegetation. However, only Farmax and Overseer can measure the emission change by changing animal liveweights and supplementary feed such as cropping, silage, bought in supplements etc. Farmax is the only tool that will illustrate impact on pasture quantity as well as the financial implications to the system. It is also good at illustrating the impacts on the system and is the only tool which will highlight the limitations. Overseer is based on a back calculation from animal intakes so a decrease or increase in animal numbers will result in different pasture growth rates, so supplements or animal performance must be manipulated to account for this. Therefore, the user must understand the limitations to this. Farmax is better at illustrating these impacts as it has the pasture growth model can illustrate when the system will become infeasible due to feed shortages as well as quality from grazing management.

From the scenarios modelled, all tools would be able to assess emissions changes from a change in stock ratio and a decrease in stock numbers as well as a reduction in nitrogen fertiliser. However, the MfE and B+LNZ tools would not be able to reflect changes in emissions from a change in supplementary feed such as removal of crop or bought in feed or an increase or decrease in animal weights.

All tools require the user to enter data on sequestration. Farmax and Overseer use the MPI lookup tables which differentiates indigenous and exotics, including Douglas fir, exotic softwoods, exotic hardwoods, and Pinus radiata. Pinus radiata is differentiated by region. The B+LNZ GHG Calculator differentiates trees into exotic forest, indigenous forest (less than 100 years), established natural forest and shrubland (more or less than 30 years old). The tool illustrates a brief statement around what the definition of a forest is and mentions that you cannot claim carbon if the credits have already been sold. Shrubland is included and is noted that it is anything which is not likely to meet five meters height at maturity, as well as allowing areas less than a hectare to be accounted for. The MfE tool differentiates woody vegetation by planted forests (defined as plantation of forest species), tall natural forests (which is mature natural forest including self-sown exotic trees, such as wildling pines) and regenerating natural forests. There is no exclusion of pre-90 forest from the tool. The sequestration rates from the MfE and B+LNZ tools do not align with each other or the look up tables.

In November, He Waka Eke Noa released a draft discussion document which proposed a range of sequestration categories to reward under that system. He Waka Eke Noa also proposed that all ETS eligible exotic forests would need to go into the ETS, while ETS eligible indigenous forests could be entered into either system. He Waka Eke Noa will be making final recommendations in April following farmer consultation in February.

8.0 EMISSIONS PRICING SCENARIOS

Three policy pricing scenarios have been analysed for each of the case study farms using a consistent approach to the modelling work completed by He Waka Eke Noa.

The three policy scenarios are:

- Agriculture in the ETS at processor level
- He Waka Eke Noa farm level split-gas
- He Waka Eke Noa processor hybrid (split-gas)

For deer farmers, the ETS would include being taxed when buying nitrogen fertiliser and when stock are sold to the meat processor. This would not include any sequestration on farm, although farmers could register ETS eligible forests and sell the NZUs generated. He Waka Eke Noa are currently proposing two pricing scenarios including a farm-level levy and a processor level hybrid.

The farm level levy would estimate methane and nitrous oxide emissions via a central calculator and use the on farm emissions to determine pricing as opposed to national averages, which would better recognise efficiencies and mitigations made on-farm. A split-gas approach to pricing would be applied with differing levy rates for methane and nitrous oxide. There is a range of sequestration proposed to be recognized under He Waka Eke Noa (as outlined in Appendix 3).

The processor level hybrid would mean farmers face a price when animals are sold to the meat processor or when buying nitrogen fertiliser. Different to the ETS, there would be a different price for methane and nitrous oxide. Farmers could receive a payment for emissions reduction if they were to voluntarily enter an Emissions Management Contract (EMC), which could be done individually or as a collective. Once signed, the contract would be binding. Farmers could also receive payment for sequestration which is eligible under He Waka Eke Noa via a Sequestration Management Contract (SMC).

In considering the policy implications, the current and proposed policy design (apart from farm-level He Waka Eke Noa) is based on facing a price for meat production. This effectively loads velvet emissions onto venison producers.

For the ETS scenario, a discount of 95% was applied to 2025 as per current legislation of $85/t CO_2e. For the He Waka Eke Noa scenarios, the same prices were applied but with a split-gas approach to enable a direct comparison. Therefore, a methane price of $0.11/kg methane in 2025, a nitrous oxide price of $4.25/t CO_2e in 2025, and a sequestration value of $85/t CO_2e in 2025. It is important to note that this is based on policy settings for 2025 and is consistent with the assumptions in the He Waka Eke Noa modelling. The policy settings will change over time, the ETS allocation of 95% will reduce by 1% per annum from 2025. Based on this and the forecast carbon price of $138/t in 2030, the ETS price per kilogram of product will be 325% of the 2025 price in 2030, or rather the 2025 price will increase 65% per year. The values used under He Waka Eke Noa are yet to be determined but are likely to be updated annually and set by the partnership.

Table 11 below shows the likely price impact of the different policy options on each of the case study farms in 2025. The assessment is based on the assumptions above. These assumptions are likely to change but provide a consistent data-set to compare against the proposed He Waka Eke Noa approach.

Table 11: Impacts of different policy options in 2025 based on modelled assumptions.

		Case Study 1 – Hawkes Bay Velvet	Case Study 2 – Hawkes Bay Hill Country	Case Study 3 – South Island High Country	Case Study 4 – South Island Venison
ETS (processor level) – no sequestration	Annual levy to pay	$615	$4,077	$6,816	$24,649
	Impact on profitability	-0.4%	-3.3%	-5%	-17%
He Waka Eke Noa Farm-level	Annual levy to pay (emissions)	$5,993	$6,730	$18,660	$17,772
	Sequestration	17.9t CO_2e	265.9 t CO_2e	0	32.1 t CO_2e
	Annual levy to pay less sequestration	$4,469	-$15,874*	$18,660	$15,044
	Impact on profit	-2.9%	+13%	-14%	-10%
He Waka Eke Noa processor hybrid	Annual levy to pay (emissions)	$615	$4,077	$6,816	$24,649
	Sequestration	17.9t CO_2e	265.9 t CO_2e	0	32.1 t CO_2e
	Annual levy to pay less sequestration	-$1,206*	-$18,525*	$6,816	$21,921
	Impact on profit	+0.8%	+15%	-5%	-15%

Notes:

- *Sequestration values have been used consistent with the He Waka Eke Noa modelling. These numbers are highly likely to change as more detailed policy is developed. The processor hybrid analysis assumes that sequestration will be rewarded via a Sequestration Management Contract.*
- **A negative figure reflects that the farm's sequestration value is greater than the cost of the levy, resulting in a benefit to the farm.*
- *The low levy to pay for case study 1 under ETS and He Waka Eke Noa processor hybrid is due to the significant proportion of velvet stags rather than venison processed where the levy is collected.*

8.1 Discussion

The financial data from the case studies was based on actuals, with expenses and income taken from the last two years for each farm. Sources of income from enterprises not associated with the farming operation were excluded from the analysis.

There is considerable variation of the impact of emissions pricing on the farms, depending on the system they are running and the policy approach taken. More store dominant farming systems will face less of a cost with the ETS or processor hybrid if the supply chain does not pass these costs back through, whereas more finishing will face a greater cost.

When assessing the results, the fact that the processor options are based on venison rather than velvet should be considered in relation to the farm systems in the case studies. There are a number of ways that the emissions associated with velvet could be allocated including based on population (i.e. velvet stags as a percentage of total deer population), based on production (i.e. velvet production and meat production are treated equally), or based on carbon distribution (likely to require science research to determine). These allocation approaches would then allow an emissions factor per kilogram of venison to be calculated. As many velvet stags are sent for processing into meat at the end of their lives, the methodology would need to consider this also to avoid farmers paying for emissions twice.

Policy decisions are still being made for He Waka Eke Noa. This analysis suggests, at least initially, the financial impacts across the deer farms are substantially greater than the ETS alternative. He Waka Eke Noa does provide an opportunity for some of the farms to be rewarded for sequestration which they would not be via the ETS. However, it presents data based on expectations in 2025. The ETS costs are likely to increase substantially (65% per year based on modelling). The processes for establishing values under He Waka Eke Noa are yet to be determined but are likely to be done by the partnership. Until mitigation options are available to deer farmers, there are limited options to respond to policy costs. The scenario modelling done in section 5 would only be recognized under the farm level policy setting, unless picked up via a Sequestration Management Contract in the processor hybrid. They would not be recognized in the ETS.

9.0 CONCLUSION

Since revisiting the farms there have been several new tools/calculators introduced to assess on-farm greenhouse gas emissions including Overseer which was used to model the last case studies. There is considerable variation between the tools, as well as some disparities in what data the tools require and sequestration rates and definitions. Some tools are able to model more complex systems changes but require a higher level of data input while others are more simple.

The scenario modelling illustrated that GHG emissions could be reduced by 0.1 to 8.5%, with the greatest gains being achieved by reducing marginal land into forestry, although the financial implications varied widely, with most negatively impacting profitability. Most scenarios could be modelled through all tools, apart from changes to supplementary feed.

The policy pricing scenarios also illustrated the impact on farming systems. Overall, with the assumptions used, the processor hybrid levy would be most favourable, affecting on-farm profitability by -15% to 15%, in comparison to the farm-level levy which impacted profitability from -13% to 14%. Both were more favourable than the ETS processor level which impacted profitability from 0.4 to 17%.

10.0 APPENDIX 1 – CASE STUDY DATA

10.1 Case Study 1 – Hawkes Bay Velvet Farm

The property is a total of 332.1 hectares with an effective pastoral grazing area of 320 hectares. The land is predominantly medium hill country with free draining soils and a Land Use Capability classification of Class 6. The farm does not typically get as summer dry as the average Hawkes Bay farm but is reliant on more regular rainfall. Winters are typically long and cold with minimal pasture growth.

A number of ephemeral waterways and gullies run through the property. Fences have been installed to exclude livestock from some sections of waterways with a plan in place to exclude livestock from all waterways within the next 10 years. Retired areas on the farm have been planted with native or exotic vegetation.

The owners have a focus on producing quality, high value products. There is a continual emphasis on improving production and per animal performance and efficiency.

10.1.1 Livestock Policy

The farm is predominantly a deer breeding and velveting operation with some cattle and a small number of sheep. The current stock units for each enterprise are outlined in the table below.

Table 12: Case study 1 stock numbers

Stock type	Total RSU*	RSU/ha	Percentage of total
Deer	3,000	9.04	82%
Cattle	510	1.54	13%
Sheep	190	0.57	5%
Total	3,700	11.15	100%

**RSU refers to Revised Stock Unit as determined in Overseer. A RSU is defined as an animal with an intake of 6000 MJ ME (Metabolizable energy) intake per year. This is similar to a standard stock unit.*

10.1.1.1 Deer

A red deer breeding and velveting operation is run on the farm. Approximately 480 hinds are fawned with all progeny kept at weaning. 100 yearling hinds are sold in December while the remainder are mated. Of the mated yearling hinds, 20 are sold in June leaving 58 rising 2-year-old hinds along with the 400 older hinds.

All male progeny are retained until after the harvesting of spiker velvet at around 12 months of age. Following this, the best 190 for velveting potential are selected and the remainder are sold. After the harvesting of velvet as two-year-olds, 120 are sold. 30 3-year-olds are sold and the remainder join the mixed age velvet stags. 30 trophy stags are sold annually.

10.1.1.2 Cattle

A flexible cattle system is run which can include both breeding and trade stock. The intent is to run a profitable cattle operation that complements, and can be integrated with the deer operation. Cattle perform an important function of helping maintain pasture quality and also spread the business risk by offering an alternative income to deer.

In the past, the cattle policy has included trading and finishing bulls and steers. The current cattle policy is to run 55 beef breeding cows. All bull calves are sold at weaning and approximately 10 heifer calves are kept as replacements with surplus heifer calves finished or sold store.

10.1.1.3 Sheep

A small number of sheep are run on the farm for weed control. Currently 150 ewes are run on the farm with 45 kept as replacements. The rest are sold store, primarily for genetics.

10.1.2 Imported Supplement

Supplements make up approximately 11% of total feed supplied to animals. Annually, 110 bales of baleage is imported or made to be fed to all stock classes as required. 20 tonnes of maize grain is imported to be fed to weaner fawns and stags. 80 tonnes of palm kernel expeller (PKE) is imported and fed to deer on crops.

10.1.3 Crops

6 hectares of a mixed kale and swede crop is sown in November and grazed by deer during June, July and August. This crop is followed by pasja which is sown in October, grazed by deer from mid-December until the end of February, then grass is sown in March. A 5 hectare raphno crop is sown in November. The crop is grazed by deer during January, February and March before being shut up and then grazed from mid-June until the end of July. New grass is sown in this crop area in October.

10.1.4 Fertiliser

All pasture receives a fertiliser application in March that provides 17 kg/ha of nitrogen, 19 kg/ha of phosphate and 10 kg/ha of sulphur. The 145ha stag block also receives 32kg/ha of nitrogen in August. 150kg/ha of DAP is applied to new grass in spring. Crops receive 250kg/ha of Cropzeal boron boost at sowing with the kale/swedes and raphno also receiving a side dressing of 150kg/ha of SustaiN.

Across the whole farm this equates to annual average nutrients applied from fertiliser being 56 kg/ha of nitrogen, 21 kg/ha of phosphorus and 43 kg/ha of sulphur.

10.1.5 Sequestration

10.1.5.1 ETS eligible

There are no ETS eligible forests on the property.

10.1.5.2 He Waka Eke Noa eligible

Table 13: Case Study 1 He Waka Eke Noa Eligible

Vegetation category	Area (ha)	Sequestration (tonnes CO_2e/ha/year)
Post-2007 indigenous	2.3	15
Riparian	3.4	12
Woodlots	0.1	2
Scattered trees	-	-
Total	5.8	29

* These figures are approximations only.

10.2 Case Study 2 – Hawkes Bay Hill Country

The property is a total of 740 hectares with contour ranging from flats to steep hill. The farm receives 1000-1200mm of rain annually and typically gets summer dry.

A river gorge runs through the middle of the farm. The area has been retired from grazing and is vegetated with indigenous trees, pines and regenerating indigenous areas. There are also other riparian areas and pockets of trees on the farm, including poplars for erosion. There is a plan to retire additional lower production areas to plant trees or allow for indigenous regeneration.

The owners have a strong focus on environmental management and sustainability. Ongoing consideration is given to the most appropriate use and management of all areas on the farm.

10.2.1 Livestock Policy

Deer, cattle and sheep are run on the farm. The current stock units for each enterprise are outlined in table 4 below.

Table 14: Case study 2 stock numbers

Stock type	Total RSU*	RSU/grazed ha	Percentage of total
Deer	1,540	2.57	35%
Cattle	1,255	2.10	23%
Sheep	1,890	3.16	42%
Total	4,685	7.83	100%

**RSU refers to Revised Stock Unit as determined in Overseer. A RSU is defined as an animal with an intake of 6000 MJ ME (metabolisable energy) intake per year. This is similar to a standard stock unit.*

10.2.2 Deer

165 mixed age hinds and 35 R2 hinds are fawned. The mean fawning date is 1 December and fawns are weaned at the start of March. All 90-95 hinds are kept at weaning, the 60-65 non-replacements are sold to the works in May as 18 month olds. All 90-95 weaner stags are kept and get velveted until 2-years old and then all but 30 are sold to the works in January with the remaining joining the mixed age stags. There are 160 mixed age velveting stags and 10 sire stags.

10.2.3 Cattle

240 Friesian male calves come on to the farm 1 August and are raised. 140 are sold in September and remaining 95 are carried through and sold as either 1-year store (70) or 2-year prime bulls (20) in December.
There are also around 40 MA breeding cows on the farm. Five replacements are brought (wet-drys) in November and all cows go to a terminal bull. Steers and heifers are carried through to two years, but these are sold if it becomes dry.

10.2.4 Sheep

1,100 mixed age ewes and 350 2tooths are lambed in August and weaned in November. 1,200 lambs are sold from October until December and the remaining 450 are sold the following

August or September. 350 replacement ewe hoggets are brought in December and are not mated.

10.2.5 Imported Supplement

Imported supplements make up less than 1% of total feed supplied to animals. 30 tonnes of maize grain is imported to be fed to deer from January until April.

10.2.6 Crops

6.5 hectares of rape is sown in October and grazed in January and February by lambs and weaner bulls. The crop is followed by oats or new grass. 3 hectares of oats is sown in March following the rape crop. The oats are grazed by lambs and weaners and then followed by another rape crop sown in October. Roughly 80 bales of baleage is also made and fed to the hinds at the same time as the maize grain.

10.2.7 Fertiliser

Superphosphate is applied to the easier more developed country at a rate of 250 kg/ha in March. No fertiliser is applied to the steeper hills and urea is not typically applied to pasture. Fertiliser is applied to crops at sowing.

Across the whole farm this equates to annual average nutrients applied from fertiliser being 2 kg/ha of nitrogen, 8 kg/ha of phosphorus and 10 kg/ha of sulphur.

10.2.8 Sequestration

10.2.8.1 ETS Eligible

Table 15: Case study 2 ETS Eligible

Tree Species	Area (ha)	Sequestration (t CO_2e/ha/year)
Pinus radiata	26.9	347
Douglas fir		
Exotic softwoods		
Exotic hardwoods	2.4	33
Indigenous	27.2	177
Total	56.5	557

* These figures are approximations only.

10.2.8.2 Stock Excluded Areas and Trees

Table 16: Case study 2 He Waka Eke Noa Eligible

Vegetation category	Area (ha)	Sequestration (tonnes CO_2-e/ha/year)
Pre-2007 indigenous	55.1	101
Post-2007 indigenous	21.1	137
Riparian	1.3	5
Woodlots		
Scattered trees	11.7	23
Total	89.2	266

* These figures are approximations only

10.3 Case Study 3 – South Island High Country

The property is located in the South Canterbury high country and is 4,374 hectares. The farm is predominantly rolling country with silts on the more productive areas and lighter soils on the extensively managed areas. Approximately 670 hectares is developed land that fodder crops rotate through, 1,530 hectares is over-sown and top-dressed rolling hills and 2,130 hectares is native pasture. Due to the high altitude the climate can be challenging, particularly over winter.

10.3.1 Livestock Policy

Deer, cattle and sheep are run on the farm. The current stock units for each enterprise are outlined in the table below.

Table 17: Case study 3 stock numbers

Stock type	Total RSU*	RSU/ha	Percentage of total
Deer	3,240	0.75	24%
Cattle	3,440	0.79	25%
Sheep	6,560	1.51	51%
Total	13,240	3.05	100%

**RSU refers to Revised Stock Unit as determined in Overseer. A RSU is defined as an animal with an intake of 6000 MJ ME (metabolisable energy) intake per year. This is similar to a standard stock unit.*

10.3.2 Deer

A red deer breeding operation is run on the farm, with numbers being retained over the past few years. 730 hinds are fawned in November/December with weaning occurring in May. Typical weaning rate is 90%. All weaner hinds are kept at weaning, approximately 150 are sold as R2s and the remainder join the mixed age breeding hinds. The majority of males are sold at weaning with 20 kept. Half of these are sold as R2s and the remainder join the velveting stag mob of 80. There are 20 breeding stags.

10.3.3 Cattle

250 mixed age and 60 R3 angus breeding cows are run on the farm. Calving occurs during September and October and calves are weaned in mid-April. Typical weaning rate is 92%. Approximately 30 heifer calves are sold at weaning or fattened and 60 are kept as replacements and 30 are fattened to be sold to the works as R2s. All males are sold at weaning. There are 15 breeding bulls.

10.3.4 Sheep

3400 Perendale ewes and 1300 two tooths are run on the farm. Lambing is from mid-October until late-November. Lambs are weaned at the end of January with a typical weaning rate of 115-118%. All of the approximately 2500 female lambs are kept at weaning, 500 are sold in May and another 700 are sold as hoggets in December to reduce numbers to the 1300 replacements. All of the 2,500 male lambs are progressively sold from February to May. There are 55 breeding rams.

10.3.5 Supplements

Supplements include 30 tonnes of oats or barley grain bought in to be fed to sheep or deer and 12 tonnes of palm kernel expeller (PKE) which is fed to deer.

Annually 150 ha is cut for grass silage in December, 100 bales of baleage are made and 150 bales of hay.

10.3.6 Crops

Crops include 60 ha kale and 25 ha raphno, with 80 ha of plantain and clover. The kale is sown in November, grazed by hoggets and calves from June to August and then followed by a crop or permanent pasture which is sown in November. Raphno is sown in October, grazed by lambs from February to May and then followed by crop or permanent pasture. The plantain and clover are sown in October, grazed by sheep and deer, and has an intended rotation length of three to five years.

10.3.7 Fertiliser

Developed pasture areas where fodder crops do not rotate through receive 200 kg/ha of Sulphur gain 30S annually in spring. The over-sown and top-dressed country receives 125kg/ha of Sulphur gain 30S every third year. The silage area receives 75kg/ha of urea in October and 60kg/ha of potash post cut. The kale and Raphno receive 150kg/ha of Cropzeal boron boost at sowing and 100kg/ha of urea in January. The plantain and clover receives 200 kg/ha of Cropzeal 20N at sowing. The developed rolling hills receives 28kg/ha of urea in early spring.

Across the whole farm this equates to annual average nutrients applied from fertiliser being 3 kg/ha of nitrogen, 2 kg/ha of phosphorus and 6 kg/ha of sulphur.

10.3.8 Sequestration

Although there is a reasonable amount of vegetation on the farm, none of it currently meets the ETS or He Waka Eke Noa eligibility requirements. All of the ETS eligible trees were established prior to 1990. One woodlot was established in 1991 but is too small for the ETS and outside of the post-2007 threshold for He Waka Eke Noa. There is a considerable amount of scattered native bush on the farm, but as stock are not excluded so would not be eligible for He Waka Eke Noa pre08 indigenous bush. It is unknown how much would be post 2008, or post 1990.

10.4 Case Study 4 – South Island Venison

The property is a total of 796.7 hectares with contour ranging from flats to moderate hill. The farm receives approximately 740mm of rain annually and typically gets summer dry. Approximately 186 hectares is irrigated. Steeper areas and gullies have been retired from grazing and planted with trees.

The owners have a strong focus on profitability, resulting in a very intensive, high input system. Ongoing consideration is given to the most appropriate farm system and management of the property.

10.4.1 Livestock Policy

Deer, cattle and sheep are run on the farm. The current stock units for each enterprise are outlined in the table below.

Table 18: Case study 4 stock numbers

Stock type	Total RSU*	RSU/grazed ha	Percentage of total
Deer	8,950	14.14	74%
Cattle	2,290	3.62	23%
Sheep	315	0.49	3%
Total	11,555	18.26	100%

**RSU refers to Revised Stock Unit as determined in Overseer. A RSU is defined as an animal with an intake of 6000 MJ ME (metabolisable energy) intake per year. This is similar to a standard stock unit.*

10.4.2 Deer

Approximately 1,200 mixed age hinds and 650 R2 hinds are mated. Out of the 1,850 mated hinds, 300 dries are sent to the works and 500 are sold in calf at the start of July. Fawning occurs during November and December. Fawns are weaned at the start of March. There are 450 replacement female hinds from weaning with additional R1 hinds purchased in January to increase R1 hind numbers to 900. All males are retained at weaning with additional 1,200 weaner stags purchased from April to June to increase R1 stag numbers to 3160 by the start of July. These stags are progressively sent to the works from September through to the end of March. There are 50 mixed age stags, with 6 being bought.

10.4.3 Cattle

200 breeding cows are run on the farm and are mated. All replacements are kept and carried through and calved as 2-year olds. Calves are weaned in February with a typical weaning rate of 95%. 100 additional calves come on to the farm at weaning and are wintered. All non-replacement calves leave the farm in November. All male calves are kept and sold the following spring store.

10.4.4 Sheep

3,000 lambs are bought in January at around 32kg liveweight and sold until mid-March at 18.5kg carcass. The farm has no breeding ewes.

10.4.5 Imported Supplement

100t of wheat or barley grain is imported and fed to deer from the end of December through to the end of April. In addition to imported feed, 100t of barley silage is made on farm and fed from March to August to all stock as required and 1000 bales of baleage and 270 bales of greenfeed oats is made on farm and fed to deer and cattle on crops over winter.

10.4.6 Crops

35 hectares of fodder beet is sown in November with a typical yield of 18tDM/ha. 45 hectares of kale is sown in December, typical yield is 12tDM/ha. These crops are grazed by deer and cattle from May through to the start of August. 20 hectares of oats are sown in the crop paddocks that are grazed first. Oats are grazed in November with a typical yield of 8-10tDM/ha. In September, 15 hectares of barley is sown in the winter crop area with 100t of barley silage harvested in January. In September, clover or a fescue mix is sown in the winter crop areas that have not been sown in another crop.

10.4.7 Fertiliser

DAP is applied to the whole farm in late August or early September. Application rate varies across the farm depending on soil tests and productivity. 2 applications of urea at 65kg/ha occur on the irrigated area during the irrigation season. Urea is applied to 200 hectares of non-irrigated pasture in spring and autumn at a rate of 65kg/ha.

Fertiliser is applied to crops at sowing and via side dressings as required. Typical applications for crop areas are 100-150kg of DAP at sowing and then 1-2 side dressings of Ammo or urea. Across the whole farm this equates to annual average nutrients applied from fertiliser being 55 kg/ha of nitrogen, 11 kg/ha of phosphorus and 16 kg/ha of sulphur.

10.4.8 Sequestration

10.4.8.1 ETS Eligible

Given the topography of the farm, a considerable amount of land was planted pre90 in Pinus radiata or Douglas Fir, with a lot of the younger trees being second rotation. Similarly, there are several poplars and shelter belts which were established prior to 2008, discrediting them from the He Waka Eke Noa scheme. There have been no major plantings since the last case study.

Table 19: Case study 4 ETS eligible

Tree Species	Area (ha)	Sequestration (t CO_2e/ha/year)
Pinus radiata	4	32
Douglas fir	6.3	51
Exotic softwoods	-	-
Exotic hardwoods	-	-
Indigenous	-	-
Total	10.3	83

* These figures are approximations only.

10.4.8.2 Stock Excluded Areas and Trees

Table 20: Case study 4 He Waka Eke Noa eligible

Vegetation category	Area (ha)	Sequestration (tonnes CO_2e/ha/year)
Pre-2008 indigenous	11.8	22
Post-2007 indigenous	-	-
Riparian	3	11
Woodlots	-	-
Scattered trees	-	-
Total	14.8	33

* These figures are approximations only.

11.0 APPENDIX 2 – OVERSEER COMPARISON

The 2019 report was done using Overseer version 6.3.2 while the update case studies use 6.4.2. The 2019 case studies have been re-run through the 6.4.2 to compare with the current results, as illustrated below in table 21. Note that any disparities between the 2019 case study results will be due to changes in the calculations within the model.

Table 21:Case study emissions comparison between Overseer

Farms	Emissions	2019 Results (Kg CO_2e/ha/year)	2021 Results (Kg CO_2e/ha/year)	% Change
Case Study 1 – Hawkes Bay Velvet	Methane	3,191	3,423	6.8%
	Nitrous Oxide	1,017	1,087	6.4%
	Total	4,208	4,510	6.7%
Case Study 2 – Hawkes Bay Hill Country	Methane	2,046	1,857	-10.2%
	Nitrous Oxide	471	440	-7.0%
	Total	2,517	2,298	-9.5%
Case Study 3 – South Island High Country	Methane	867	897	3.3%
	Nitrous Oxide	249	253	1.6%
	Total	1,116	1,150	3.0%
Case Study 4 – South Island Venison	Methane	4,280	4,307	0.6%
	Nitrous Oxide	1,107	1,147	3.5%
	Total	5,387	5,454	1.2%

Although there have been some changes to stocking or fertiliser policies on the farms, the main reason for differences in emissions is that the 2021 files have been modelled so that the opening and closing stock numbers are the same, while in the 2019 files they are different.

12.0 APPENDIX 3 – SEQUESTRATION DEFINITIONS

For Emission Trading Scheme (ETS) eligibility, the definition of a forest must be met – that is, that it is at least 1ha, will reach at least 5m in height at maturity, will have a crown cover of at least 30% at maturity and is at least 30m wide. It also must have been planted or established after 31 December 1989. The ETS sequestration rates can be found using the Ministry for Primary Industries (MPI) look-up tables.

The proposed sequestration in He Waka Eke Noa are:

- Permanent vegetation categories
    - Indigenous vegetation established before 1 January 2008: At least 0.25ha of land wholly or predominantly in indigenous woody vegetation[3] either planted, regenerated, or a combination. Stock must be excluded from the area. For regenerating, a seed source needs to exist within 100m radius from centre of vegetation area.
    - Indigenous vegetation established on or after 1 January 2008 and was also not forested at or prior to 1 January 1990: At least 0.25ha of land wholly or predominantly in indigenous woody vegetation either planted, regenerated, or a combination, that was in pasture prior to 1 January 2008. For regenerating, a seed source needs to exist within 100m radius from centre of vegetation area. A declaration will be required stating that the land was not in vegetation prior to 1 January 1990.
- Riparian vegetation established on or after 1 January 2008: Plantings suited to margins and banks of waterways including wetlands, minimum of 1m wide from the edge of the bank of the waterway/wetland. Predominantly woody vegetation including indigenous and/or a mix of non-indigenous plants used for environmental benefit. Non-woody vegetation such as flaxes and toetoe are included but must not be the predominant species.Cyclical vegetation – all planted on or after 1st of January 2008
    - Perennial Cropland: An orchard and/or vineyard greater than 0.25 ha in size that is established on or after 1 January 2008.
    - Scattered forest: Minimum of 0.25 ha for any area counted with minimum stocking rate of 15 stems per hectare. Scattered forest is not eligible if it is >1ha, and >30% canopy cover at maturity, and >30m wide (i.e., once it meets the NZ ETS criteria).
    - Shelterbelts: A linear vegetation feature consisting of one or more rows of trees and/or shrubs planted on or after 1 January 2008 with a minimum linear canopy cover of 90%. The shelterbelt is not eligible if it is >1ha, and >30% canopy cover at maturity, and >30m wide (i.e., once it meets the ETS criteria).

[3] *Indigenous woody vegetation: includes gorse/broom (as a nursery crop for indigenous species if seed is present), manuka and/or kanuka, matagouri, mixed broadleaf/scrub such as swamp maire, five finger, coprosma, wineberry, lemonwood, cabbage trees, totara/kahikatea, old growth cut-over, and beech.*

- Woodlots/tree-lots: Up to 1 ha and at least 0.25ha of tree species that have greater than 30% canopy cover.

Table 22 below illustrates the carbon sequestration rates based on the 2017 ETS lookup tables[4]. All tree species apart from exotics have been annualised based on the averaging scheme, while indigenous has been annualised based on the permanent forest sink initiative. It is worth noting that forests under 100ha can use the lookup tables, but over must use the field measurement approach. Furthermore, Pinus radiata sequestration rates are categorised regionally while all other tree species have a single national sequestration rate. Lookup table figures have been used in the case studies regardless of the area proposed.

Table 22: ETS sequestration rates

Tree Species	Annualised rate (t CO_2e/ha/yr)
Pinus radiata	12.9t/ha/yr for case studies 1 and 2 and 8t/ha/yr for case studies 3 and 4 for 16 years
Douglas fir	8.1t/ha/yr for 26 years
Exotic softwoods	6.4t/ha/yr for 22 years
Exotic hardwoods	13.8t/ha/yr for 12 years
Indigenous	6.5 t/ha/yr for 50 years – assumed that no indigenous forest would go into averaging.

[4]https://www.mpi.govt.nz/dmsdocument/4762-A-guide-to-Look-up-Tables-for-Forestry-in-the-Emissions-Trading-Scheme

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