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Greenhouse Gas Emissions and Mitigation Options on Deer Farms
Case Study 1 – Velvet Farm

Deer Industry New Zealand

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TABLE OF CONTENTS

1.0 SUMMARY OF FINDINGS

Options to reduce biological GHG emissions from a deer farm in Hawkes Bay have been considered. The main findings are summarised in Table 1.

Table 1: Mitigation Options to Reduce or Offset Biological GHG Emissions

Scenario	Methane CO_2-e (kg/ha/yr)	Nitrous Oxide CO_2-e (kg/ha/yr)	Carbon sequestration (CO_2 kg/ha/yr)	Combined CO_2-e (kg/ha/yr)	Percentage Reduction of Offset
Present farm system	3090	1021		4111	
Present farm system – GHG emissions and carbon sequestration by shelter belts and tree lots			288	4111 – 288 = 3823	7.0% offset
1 Change in cattle policy – trade steers only	3092	1016		4108	0.1%
2 Change of imported feed type	3084	1018		4102	0.2%
3 Removing spring nitrogen fertiliser and replacing with imported feed	3084	978		4062	1.2%
4a Retiring 5% of land and planting with pine trees – GHG emissions only	2939	970		3909	4.9%
4b Retiring 5% of land and planting with pines – GHG emissions and carbon sequestration			1317	3909 – 1371 = 2538	38.3%
4c Retiring 5% of land and planting native trees – GHG emissions and carbon sequestration			417	3909 – 417 = 3492	15.1%
5a Retiring 20% of land and planting with pines – GHG emissions	2468	819		3287	20.0%
5b Retiring 20% of land and planting with pines – GHG emissions and carbon sequestration			5485	3287 – 5485 = -2198	153.5%

5c Retiring 20% of land and planting with native trees – GHG emissions and carbon sequestration			1667	3287 – 1667 = 1620	60.6%
6a New riparian retirement – GHG emissions only	3003	991		3994	2.9%
6b New riparian retirement – GHG emissions and carbon sequestration			240	3994 – 240 = 3754	8.7%
7 Use of nitrification inhibitor	3090	907		3997	2.8%

2.0 BACKGROUND

AgFirst have been commissioned by Deer Industry New Zealand to complete biological greenhouse gas (GHG) emission case studies on four deer farms. The purpose is to determine current emission levels and identify potential options to reduce or offset emissions. GHG emissions are determined through modelling in Overseer. Carbon sequestration has been determined using the Carbon Look-up Tables for Forestry in the Emissions Trading Scheme.

Differing farm systems and locations have been selected to demonstrate variation in potential opportunities and limitations. Case Study 1 is located in Hawkes Bay and has a predominant focus on velvet production.

3.0 FARM DESCRIPTION

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, however regular rainfall is required. 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.

3.1 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 Table 2.

Table 2: Livestock Enterprises

Stock type	Total RSU*	RSU/grazed ha	Percentage of total
Deer	2,737	8.6	78.7%
Cattle	556	1.7	16.0%
Sheep	182	0.6	5.2%
Total	3,476	10.9	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.*

3.1.1 Deer

A red deer breeding and velveting operation is run on the farm. Approximately 476 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, 40 are sold in June leaving 92 rising 2-year-old hinds along with the 384 older hinds.

All male progeny are retained until after the harvesting of spiker velvet at around 12 months of age. Following this, the best 180 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.

3.1.2 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 60-65 beef breeding cows and 20 trade steers or heifers. Bull calves are sold at weaning, approximately 20 heifer calves are kept as replacements with surplus heifer calves finished or sold store.

3.1.3 Sheep

A small number of sheep are run on the farm for weed control. Typically, ewes are purchased in spring and then sold in summer or later in the season depending on the feed situation.

3.2 Imported Supplement

Supplements make up approximately 2.5% of total feed supplied to animals. Annually, 120 bales of baleage is imported to be fed to all stock classes as required. 20 tonnes of maize grain is imported to be fed to weaner fawns and stags. 30 tonnes of palm kernel expeller (PKE) is imported and fed to deer on crops.

3.3 Crops

9 hectares of a mixed kale and swedes 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 7 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.

3.4 Fertiliser

All pasture receives a fertiliser application in March that provides 34 kg/ha of nitrogen, 20 kg/ha of phosphate and 29 kg/ha of sulphur. The 145 hectare stag block also receives 23kg/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 49 kg/ha of nitrogen, 23 kg/ha of phosphorus and 31 kg/ha of sulphur.

3.5 Stock Excluded Areas and Trees

There are numerous smaller areas that stock are excluded from on the property. These areas are largely along waterways and have been planted over time with a variety of exotic or indigenous species. There are also shelter belts on the property of exotic and indigenous species. In total 8.9 hectares has been defined as stock excluded riparian areas and an additional 3 hectares as trees. These areas and the likely carbon stock are summarised in Table 3 and Table 4. Where areas include dams or waterways and trees, an assumption of 50% tree area has been made. The carbon stock has been estimated using the ETS Carbon Look-up Tables. Where areas include multiple classifications of trees, the carbon stock figures have been averaged.

Table 3: Stock Excluded Riparian and Tree Areas

Description	Area hectares	Vegetation	Age	Carbon sequestered/ha	Carbon stock*	Annualised carbon stock
Dam	0.4 (0.2 trees)	Gums and macrocarpas planted 1989	30	Gums 693tCO2 Macs 403tCO2 Average 548tCO2/ha	109.6t CO2	3.7tCO2
Dam with surrounding area planted	2.5 (1.25 trees)	Pines and oaks planted 1987	32	Pines 907tCO2 Oaks 716tCO2 Average 812tCO2/ha	1014.4t CO2	31.7tCO2
Gully with ephemeral waterway	3.6 (1.08 trees)	Poplars, flax and grass planted 2005 (30% poplars)	14	Poplars 381tCO2/ha	411.5t CO2	29.4tCO2
Wetland	1.7	Grasses and sedges	-	-	-	-
Gully	1.3 (0.65 trees)	Indigenous planted 2018	1	0.6tCO2	0.4t CO2	0.4t CO2

Dams and gully	2.3	Pasture – indigenous to be planted 2019	-	-	-	-
Total					*1535.9tCO2*	*65.2tCO2/yr*

These figures are approximations only; more precise measurements would need to be taken to determine accurate carbon stock.

Table 4: Shelter Belts

Vegetation type	Year planted	Age	Area of shelter belt	Carbon sequestered/ha	Carbon stock*	Annualised carbon stock
Pines	1980	39	140m long x 12m wide = 0.17 ha	1075tCO2	182.8t CO2	4.7tCO2
Gums and macrocarpas	1985	34	1180m long x 12m wide = 1.42 ha	Gums 735tCO2 Macs 454tCO2 Average 595 tCO2/ha	844.9t CO2	24.9tCO2
Poplars and flax	2012	7	270m long x 5m wide = 0.14 ha (30% poplars)	137tCO2/ha	5.8t CO2	0.8tCO2
Native shrubs and flax	2018	1	400m long x 3m wide = 0.12 ha	0.6tCO2/ha	<0.1t CO2	-
Total					*1034tCO2*	*30.4tCO2/yr*

These figures are approximations only; more precise measurements would need to be taken to determine accurate carbon stock.

If carbon sequestered by trees was taken into consideration, the carbon stock would need to be annualised to allow for comparison with annual emissions from the farm. The annualised carbon sequestered by these trees is 95.6tCO2/yr or 288kgCO2/ha/yr.

4.0 CURRENT GREENHOUSE GAS EMISSIONS

Current biological GHG emissions have been determined through modelling the farm in Overseer version 6.3.2. Emission source and emissions from each animal enterprise are summarised in Table 5 and Table 6. Overseer provides methane and nitrous oxide emissions as CO2 equivalents (CO_2-e) calculated using 100 year global warming potentials (GWP100).

Table 5: Current Biological GHG Emissions

GHG	Source	CO_2-e kg/ha/yr
Methane	Enteric	3047
	Dung	42
	Total methane	**3090**
Nitrous oxide	Excreta Paddock	666

	N fertiliser	175
	Crops	2
	Indirect	178
	Total Nitrous oxide	**1021**
Total biological GHG emissions		**4111**

Table 6: Current Emissions per Animal Enterprise

Enterprise	Total kg CO_2-e	kg CO_2-e per SU
Deer	1,203,218	440
Beef	240,256	432
Sheep	73,205	401

Methane accounts for 75% of the total current biological GHG emissions. When looking at emissions on a per stock unit basis, deer have the highest emissions of 440 kg CO_2-e per stock unit. Deer are followed by beef with 432 kg CO_2-e/ha per stock unit while sheep have the lowest emissions per stock unit of 401 kg CO_2-e.

5.0 OPTIONS TO REDUCE EMISSIONS

5.1 Livestock policy

GHG emissions can be reduced through:

- changes in livestock enterprises run on a property;
- changes to stock classes within each enterprise; and
- improvements in animal efficiencies through measures such as reducing stocking rate and improving per animal performance.

Achieved reductions are largely related to improvements in feed conversion efficiency and how much total dry matter eaten is going into production rather than animal maintenance.

The current livestock policy has a deer, cattle, sheep ratio of 79:16:5. There are a number of major income sources from deer on this farm including velvet, meat and the sale of stock to other farms. The main income source for both cattle and sheep is the sale of animals for meat. Income received from each enterprise is dependent on demand and markets, and is therefore variable from year to year. As a generalisation, on a per stock unit basis, deer are the most profitable followed by beef, with sheep being the least profitable.

Sheep are the lowest emitting enterprise on a stock unit basis, therefore increasing the sheep numbers and proportionally decreasing deer and cattle numbers would result in a reduction in GHG emissions. However, there is minimal desire to increase sheep numbers as this would add complexity to the farming operation. In addition to this, increasing sheep numbers would impact on profitability as sheep are the least profitable stock class on this farm.

There is an opportunity to improve feed conversion efficiency by replacing the beef breeding cows with beef trade stock. This results in a 0.1% reduction in GHG emissions (Table 8, scenario 1). This change in policy may not be considered worthwhile due to the minimal reduction achieved.

On this farm, the per animal performance of deer has been steadily increasing over time through investment in genetics and selective culling. The current per animal performance is above industry average, therefore it is questionable whether meaningful production gains could be made through reducing total stock numbers and aiming to further improve per animal performance.

5.2 Crops

The farm is moderate hill country which means growing arable crops is not an option.

Currently winter and summer forage crops are grown. Forage crops are an important part of the farm system as they supply reliable high-quality feed at times of the year when pasture growth is slowed due to climatic conditions. All crops are brassicas; research to date indicates that brassicas show promise for reducing enteric methane emissions, however further research is required.

Crops can result in increased nitrous oxide emissions, particularly when intensively grazed in wet conditions. Potential GHG reduction through good management of crops is currently hard to quantify. On this farm direct drilling is used to sow seed rather than cultivating. There is no use of break feeding on crops as all crops are grazed by deer which allows for unrestricted grazing. For the last month of winter crop grazing, deer are given access to an adjacent paddock of pasture and are fed grain.

5.3 Imported Feed

The type of imported feed can have an impact on GHG emissions due to the differing feed properties such as nitrogen content. This farm imports baleage, maize grain and PKE. A scenario was tested replacing the imported PKE with maize grain which resulted in a 0.2% reduction in emissions (Table 8, scenario 2).

5.4 Nitrogen fertiliser

Reducing nitrogen fertiliser inputs generally reduces nitrous oxide emissions. A scenario has been modelled replacing the spring nitrogen application with imported feed. This resulted in 1.2% reduction in emissions (Table 8, scenario 3).

5.5 Retiring areas from grazing

Areas can be retired from grazing and where appropriate planted with native or exotic tree species. Retired areas will qualify to earn carbon credits if they meet the following criteria:

- The area was non forest (i.e. was pasture) prior to 1990;
- There is at least 1 hectare of trees in an individual area;
- Tree species are capable of reaching 5 metres in height;
- Tree density will provide a minimum of 30% crown cover;
- The average width of the area is at least 30 metres.

When retiring land from grazing, it is important to identify the most appropriate land to retire. This is typically land that has lower pasture production potential than other areas on the property or areas that are higher risk from an environmental management point of view. Common areas to retire include steeper hills or riparian areas. If the intention is to convert the area to plantation forestry, access to the forestry block and location of the property are important considerations.

There is minimal variation in contour or productive potential across the farm as all land is classified as LUC Class 6. There are no obvious areas to convert to forestry as all land is considered suitable for pastoral farming. In order to test the influence of incorporating forestry into the farm system, scenarios have been modelled where 5% and 20% of pastoral land is planted with trees. Both pine and indigenous trees have been modelled. To account for the reduction in grazeable land, stock numbers have been reduced by the same percentages. No other changes have been made to the farm system. The carbon sequestration by trees has been determined using the ETS Carbon Look-up Tables. The Hawkes Bay value at 28 years has been used and then divided to provide an annualised figure. It is important to note that the pine scenario outlines carbon sequestered for the first rotation of trees, once second rotation occurs, additional land will need to be converted to forestry to achieve the same amount of net carbon sequestration. The carbon sequestration associated with each of the scenarios is outlined in Table 7.

Table 7: Potential New Tree Areas

Description	Area (ha)	Carbon stock* at 28 years	Annualised carbon stock	Total farm annualised $kgCO_2/ha/yr$
5% of pastoral land retired and planted with indigenous trees	16	242.2 tCO_2/ha 3875.2 tCO_2	138.4 tCO_2	417 $kgCO_2/ha/yr$
5% of pastoral land retired and planted with pine trees	16	797 tCO_2/ha 12752 tCO_2	455.4 tCO_2	1371 $kgCO_2/ha/yr$
20% of pastoral land retired and planted with indigenous trees	64	242.2 tCO_2/ha 15500.8 tCO_2	553.6 tCO_2	1667 $kgCO_2/ha/yr$
20% of pastoral land retired and planted with pine trees	64	797 tCO_2/ha 51008 tCO_2	1821.7 tCO_2	5485 $kgCO_2/ha/yr$
Retirement of 13.9ha of riparian areas and 9.2ha planted with indigenous trees	9.2	242.2 tCO_2/ha 2228.2 tCO_2	79.6 tCO_2	240 $kgCO_2/ha/yr$

**These figures are approximations only; more precise measurements would need to be taken to determine accurate carbon stock.*

There are a number of gully systems and ephemeral waterways that run through the property. These areas have been identified as suitable to retire from grazing. The preference is to plant indigenous species in these areas to enhance biodiversity on the property. In addition to this, it is considered that forestry would not be suitable in the majority of these areas as there is an elevated risk of environmental impacts at harvesting due to proximity to waterways.

In addition to the riparian areas that have already been fenced off, another 13.9 hectares has been identified as suitable to retire. Of this area, 4.7 hectares is best suited to be left in its current state or planted with sedges, the remaining 9.2 hectares can be planted with a mixture of indigenous species. It is expected that the 9.2 hectares will be able to meet the criteria to claim carbon credits. Carbon sequestration for this area has been determined using the ETS Carbon Look-up Tables for indigenous forest. The value at 28 years has been used and divided to give an annualised figure (Table 7). Note carbon sequestration by trees decreases over time therefore this may be an overestimation of carbon sequestration over the long term.

The 13.9 hectares includes highly productive flat areas and less productive steeper banks and gullies. An assumption has been made that this area will currently be carrying 7 RSU/ha (compared to the average across grazed areas on the farm of 10.9 RSU/ha). Without having to make any other changes to the farm system, the retirement of this area will result in the reduction in stock numbers by 96 RSU.

5.6 Nitrification inhibitors

The effectiveness of nitrification inhibitors at reducing nitrous oxide emissions has been proven however nitrification inhibitors are not currently available for use on New Zealand farms. There is potential for nitrification inhibitors to be commercially available again in the future.

The effectiveness of nitrogen inhibitors is impacted by factors such as temperature, rainfall, soil type and timing, therefore well considered use is required to optimise the benefits. A scenario has been modelled using the nitrification inhibitor DCD with one application occurring in autumn and one in early spring. This resulted in a 2.8% reduction in biological GHG emissions (Table 8, scenario 7).

6.0 SUMMARY OF MITIGATION OPTIONS

The potential mitigation options outlined above have been modelled in Overseer. The resulting emissions on a per hectare basis are summarised in Table 7.

Table 8: Mitigation Options to Reduce or Offset Biological GHG emissions

Description	Methane CO_2-e (kg/ha/yr)	Nitrous Oxide CO_2-e (kg/ha/yr)	Carbon sequestration CO_2 (kg/ha/yr)	Combined CO_2-e (kg/ha/yr)	Percentage Reduction or Offset
Present farm system *476 Hinds (incl. 92 R2s) 247 MA velveting stags* *64 beef cows* *20 heifers/steers* *150 ewes* *Imported supplements - 72t baleage, 20t maize grain, 30t PKE* *Crops – 7ha kale, 9ha rape, 9ha kale/swedes* *Fertiliser – all pasture receives N:P:S 34:20:29 in autumn, stag block 23 kgN/ha in August*	3090	1021		4111	
Present farm system – GHG emissions and carbon sequestration by shelter belts and tree lots			288	4111 – 288 = 3823	7.0% offset
1. Change in cattle policy – trade steers only *120 steers, half finished before second winter, rest*	3092	1016		4108	0.1%

sold before following summer					
2. Change of imported feed type *30t PKE replaced with 23t maize grain*	3084	1018		4102	0.2%
3. Removing spring nitrogen fertiliser and replacing with imported feed *Removing 3418.5kg N (10:1 pasture response) and replacing with 45.6tDM of imported feed*	3084	978		4062	1.2%
4a. Retiring 5% of land and planting with pine trees, stock numbers reduced in line with reduced feed supply – GHG emissions *453 hinds (incl. 88 R2s)* *235 MA velveting stags* *61 beef cows* *143 ewes*	2939	970		3909	4.9%
4b. Retiring 5% of land and planting with pine trees – GHG emissions and carbon sequestration			1317	3909 – 1371 = 2538	38.3%
4c. Retiring 5% of land and planting with indigenous trees – GHG emissions and carbon sequestration			417	3909 – 417 = 3492	15.1%
5a. Retiring 20% of land and planting with pine trees, stock numbers reduced in line with reduced feed supply – GHG emissions *381 hinds (incl. 74 R2s)* *198 MA velveting stags* *51 beef cows* *120 ewes*	2468	819		3287	20.0%
5b. Retiring 20% of land and planting with pine trees – GHG emissions and carbon sequestration			5485	3287 – 5485 = -2198	153.5%
5c. Retiring 20% of land and planting with indigenous trees – GHG emissions and carbon sequestration			1667	3287 – 1667 = 1620	60.6%

6a. New 13.9ha riparian retirement – GHG emissions *463 hinds (incl. 90 R2s)* *235 MA velveting stags* *62 beef cows* *146 ewes*	3003	991		3994	2.9%
6b. New 13.9ha riparian retirement – GHG emissions and carbon sequestration			240	3994 – 240 = 3754	8.7%
7. Use of nitrification inhibitor – *DCD applied in August and March*	3090	907		3997	2.8%

7.0 POTENTIAL FUTURE MITIGATION OPTIONS

There is potential for a number of mitigation options to become available in the future. However, there is uncertainty around the timeframe for these options to become commercially available in New Zealand and uncertainty around the effectiveness for reducing emissions. With this farm system, a methane vaccine could be utilised if the effectiveness for all stock enterprises on the farm is demonstrated. Methane inhibitors such as 3-NOP may be an option, however, with this farm system stock are not handled regularly and are predominantly fed pasture, therefore the challenge will be supplying methane inhibitors to stock in a way that will be effective.

8.0 CONCLUSION

Small reductions in emissions were achieved through changes in stock class, nitrogen fertiliser use and imported feed. This farm is already achieving above average per animal performance, therefore options to decrease stocking rate and maintain overall productive performance of the farm are limited. To achieve significant reductions in emissions, land had to be retired from grazing.

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