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Greenhouse Gas Emissions and Mitigation Options on Deer Farms
Case Study 2 Hawkes Bay Hill Country

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 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 or offset
Present farm system – GHG emissions only	2043	552		2595	
Present farm system – GHG emissions and carbon sequestration by trees established post 1989	2043	552	1207	2595 - 1207 = 1388	46.5% offset
Present farm system – GHG emissions and carbon sequestration by all trees	2043	552	1602	2595 - 1602 = 1224	61.7% offset
1. Increase sheep ratio from 40% to 60%	2009	556		2565	1.2% reduction
2. Change in cattle policy – finish steers earlier	2042	551		2593	0.1% reduction
3. 20 ha retired and planted with indigenous, poplar and pine trees	2043	552	520	2595 - 520 = 2075	20% offset

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 2 is located in Hawkes Bay.

3.0 FARM DESCRIPTION

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. 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.

3.1 Livestock Policy

Deer, cattle and sheep are run on the farm. 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	1489	2.49	28.5%
Cattle	1640	2.74	31.4%
Sheep	2088	3.49	40.0%
Total	5217	8.71	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

160 mixed age hinds and 30 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, 65 are sold to the works as 2 year olds and 30 join the mixed age stags. There are 150 mixed age velveting stags and 8 sire stags.

3.1.2 Cattle

230 friesian male calves come on to the farm 1 August. 150 are sold in September and then 30 are bought in December to bring weaner numbers to 55 steers and 55 bulls. 50 are sold as 1 year olds in October leaving 40 steers and 20 bulls. The 20 bulls are sent to the works in December after their second winter. The steers are sent to the works as 3 year olds with 20 sent in March and the reminder in June. 5-10 heifers are run on the farm and sold in June as R2s. 30 beef cows are bought at the end of March and typically sold in spring.

3.1.3 Sheep

1150 mixed age ewes and 350 2tooths are lambed in August and weaned in November with a typical weaning rate of 123%. 1275 lambs are sold in December and the remainder are sold in May. There are 350 replacement ewe lambs that first lamb as 2tooths.

3.2 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 in summer.

3.3 Crops

6.5 hectares of rape is sown in October and grazed in January and February by lambs and a small number of 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.

3.4 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 1 kg/ha of nitrogen, 8 kg/ha of phosphorus and 10 kg/ha of sulphur.

3.5 Trees

A river gorge runs through the middle of the farm. The gorge has been retired from grazing and has areas of indigenous trees, pines and regenerating indigenous vegetation. There are also other riparian areas and pockets of trees on the farm. The current area of trees and associated carbon stock is summarised in Table 3. An estimation has been made that 30 hectares of the gorge area, that isn't established native trees or planted trees, can be classified as regenerating indigenous forest with an age of 2 years. With time it is likely that the remaining non tree areas in the gorge will also regenerate to indigenous forest.

Table 3: Existing Tree Areas

Description	Area (ha)	Age	Carbon sequestered*	Carbon stock*	Annualised carbon stock
Pre 1990 Indigenous	25.1	39	303 tCO_2/ha	7605.3 tCO_2	195 tCO_2
Pre 1990 Pines	1	34	956 tCO_2/ha	956 tCO_2	28.1 tCO_2
Pre 1990 Gums	3	30	693 tCO_2/ha	2079 tCO_2	69.3 tCO_2
				Total pre 1990	***292.4 tCO_2***
Indigenous trees planted 1999	27.2	20	158.7 tCO_2/ha	4316.6 tCO_2	215.8 tCO_2
Poplars planted 2000	1.3	19	505 tCO_2/ha	656.5 tCO_2	34.6 tCO_2
Pines planted 2000	4.3	19	510 tCO_2/ha	2193 tCO_2	115.4 tCO_2
Poplars planted 2001	1.1	18	483 tCO_2/ha	531.3 tCO_2	29.5 tCO_2
Pines planted 2005	7.1	14	325 tCO_2/ha	2307.5 tCO_2	164.8 tCO_2
Poplars planted 2006 (non ETS)	5	13	351 tCO_2/ha	1755 tCO_2	135 tCO_2
Indigenous regeneration (stock have access)	10.8	12	40.2 tCO_2/ha	434.2 tCO_2	36.2 tCO_2
Pines planted 2012	6.5	7	155 tCO_2/ha	1007.5 tCO_2	143.9 tCO_2
Gorge indigenous regeneration	30	2	1.2 tCO_2/ha	36 tCO_2	18 tCO_2
				Total post 1989	***893.2 tCO_2***

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

There is not an ability to directly offset farm GHG emissions with carbon sequestered by trees under current regulations however, the carbon sequestered by trees on the property has been quantified to demonstrate the potential offset. 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. Based on their current age, the annualised carbon sequestered by trees established pre 1990 is 292.4 tCO_2/yr or 395 $kgCO_2$/ha/yr. Based on their current age, the annualised carbon sequestered by trees established post 1989 is 893.2 tCO_2/yr or 1207 $kgCO_2$/ha/yr. The GHG emission offset this provides is outlined in Table 7.

There is an intention to retire additional lower production areas on the farm to plant trees or allow for native regeneration which will further offset GHG emissions.

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 4 and Table 5. Overseer provides methane and nitrous oxide emissions as CO_2 equivalents (CO_2-e) calculated using 100 year global warming potentials (GWP100).

Table 4: Current Biological GHG Emissions

GHG	Source	CO_2-e kg/ha/yr
Methane	Enteric	2021
	Dung	22
	Total methane	**2043**
Nitrous oxide	Excreta Paddock	442
	N fertiliser	3
	Crops	0
	Indirect	107
	Total Nitrous oxide	**552**
Total Biological GHG emissions		**2595**

Table 5: Current Emissions per Animal Enterprise

Enterprise	Total kg CO_2-e per year	kg CO_2-e per SU
Deer	582,679	391
Beef	629,660	384
Sheep	769,525	368

Methane accounts for 79% of the total current biological GHG emissions. When looking at emissions on a per stock unit basis, deer have the highest emissions of 391 kg CO_2-e per stock unit. Deer are followed by beef with 384 kg CO_2-e per stock unit while sheep have the lowest per stock unit emissions of 368 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 29:31:40.

Sheep are the lowest emitting enterprise on a per stock unit basis, therefore increasing the sheep numbers and proportionally decreasing deer and cattle numbers would result in a reduction in GHG emissions. A scenario has been modelled with the same total stock numbers as currently but a change in the deer, cattle, sheep ratio to 20:20:60. This resulted in a 1.2% reduction in GHG emissions (Table 7, scenario 1).

There is an opportunity to improve feed conversion efficiency by finishing steers faster. Currently steers are sold to the works as 3-4 year olds. If steers are instead sold at 2-3 years old this allows for an additional 15 steers to be finished annually and results in a 0.1% reduction in GHG emissions (Table 7, scenario 2).

5.2 Crops

Approximately 1% of the farm is cropped annually. Changes to the crop area and crop type have been modelled however, a reduction in GHG emissions was not able to be achieved.

5.3 Nitrogen Fertiliser

Nitrogen is applied to crops at a relatively conservative application rate that does not exceed crop demand. A reduction in the current application rate would likely impact on crop yields. Nitrogen fertiliser is not typically applied to pasture, therefore there are no mitigation options available relating to nitrogen fertiliser use on this farm.

5.4 Imported feed

Only a small amount of supplements are imported which means changes to the type of imported feed have not resulted in a reduction in GHG emissions.

5.5 Retiring areas from grazing

Areas can be retired from grazing and where appropriate planted with indigenous or exotic tree species. Carbon sequestered by areas of trees can not currently be used to offset GHG emissions from the farm. 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.

In addition to the areas that are already retired from grazing, the intention is to retire 10.6 hectares within the next year and there is another 9.4 hectares that has been identified as a potential retirement. These proposed retirement areas and associated carbon sequestration are outlined in Table 6.

Table 6: New Tree Areas

Description	Area (ha)	Proposed Vegetation	Carbon stock* at 28 years	Annualised carbon stock
Cliffs area near stream	7.2	Indigenous	242.2 tCO_2/ha 1743.8 tCO_2	62.3 tCO_2
Runoff steep gully	3.4	Indigenous and poplars	451.6 tCO_2/ha 1535.4 tCO_2	54.8 tCO_2
McLean's steep hills	9.4	Pinus radiata	797 tCO_2/ha 7491.8 tCO_2	267.6 tCO_2
Total	**20**	-	**10771 tCO_2**	**384.7 tCO_2**

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

The proposed retirement areas have relatively low pasture production with estimated carrying capacity being 2 stock units per hectare or 40 stock units in total. An assumption has been made that overall farm stocking rates would not need to be reduced as it is thought improved pasture management will account for the retirement of these areas. The carbon sequestered by the trees has been determined using the 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 annualised carbon stock from the proposed tree areas is 384.7tCO_2 or 520 kg CO_2-e/ha/yr which offsets 20% of annual biological GHG emissions. Note carbon sequestration by trees decreases over time, therefore this may be an overestimation of carbon sequestration over the long term.

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 7: 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 – GHG emissions only *160 MA hinds, 30 R2 hinds, 93 R1 hinds* *150 MA stags, 95 R2 stags, 95 R1 stags* *110 weaner calves, 20 bulls finished, 40 steers finished* *30 cows*	2043	552		2595	

1150 ewes, 350 2tooths, 350 hoggets, 1835 lambs					
Present farm system – GHG emissions and carbon sequestration by trees established post 1989	2043	552	1207	2595 - 1207 = 1388	46.5% offset
Present farm system – GHG emissions and carbon sequestration by all trees	2043	552	1602	2595 - 1602 = 1224	61.7% offset
1. Increasing sheep ratio from 40% to 60% *112 MA hinds, 21 R2 hinds, 65 R1 hinds* *105 MA stags, 66 R2 stags, 67 R1 stags* *70 weaner calves, 13 bulls finished, 25 steers finished 19 cows* *1725 ewes, 525 2tooths, 525 hoggets, 2752 lambs*	2009	556		2565	1.2% reduction
2. Change in cattle policy – finish steers at 2-3 years instead of 3-4 years *150 weaner calves, 20 bulls finished, 65 steers finished 30 cows*	2042	551		2593	0.1% reduction
3. 20 ha retired and planted with indigenous, poplar and pine trees	2043	552	520	2595 - 520 = 2075	20% offset

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. 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, 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 and finishing beef animals faster. With currently available mitigation options, stock numbers would need to be reduced to achieve a substantial reduction in emissions. There are significant areas of trees on this property. If carbon sequestered by all trees is considered, this offsets emissions from the farm by over 60%.

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