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Greenhouse Gas Emissions and Mitigation Options on Deer Farms
Case Study 3 South Island High Country

Deer Industry New Zealand

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1.0 SUMMARY OF FINDINGS

Options to reduce biological GHG emissions from a deer farm in the South Island High Country 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 of Offset
Present farm system	885	266		1151	-
Present farm system – GHG emissions and carbon sequestration by shelter belts and tree lots			82.3	1151 - 82.3 = 1068.7	7.2% offset
1. Reducing beef to 15% and increasing sheep	878	267		1145	0.5%
2. Improving sheep performance and lower sheep stocking rate	834	251		1085	5.7%
3. Reducing kale area by 25% and replacing with imported feed	887	265		1152	+0.1%
4a. Importing maize grain instead of PKE	885	266		1151	0%
4b. No PKE imported	886	266		1152	+0.1%
5. Reduced urea use	886	265		1151	0%
6a. Retire 200ha and plant native trees – GHG emissions only	885	266		1151	0%
6b. Retire 200ha and plant native trees – GHG emissions and carbon sequestration by trees	885	266	-396	1151 - 396 = 755	34.4% offset
6c. Retire 200ha and plant pine trees – GHG emissions and carbon sequestration by trees	885	266	-841	1151 - 841 = 310	73.1% 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 version 6.3.2. 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.

3.0 FARM DESCRIPTION

The property is located in the South Canterbury high country and totals 4374 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, 1530 hectares is oversown and topdressed rolling hills and 2130 hectares is native pasture. Due to the high altitude the climate can be challenging, particularly over winter.

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/ha	Percentage of total
Deer	2,839	0.65	21.5%
Cattle	3,347	0.77	25.4%
Sheep	7,015	1.61	53.1%
Total	13,200	3.04	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 operation is run on the farm. 610 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 30 kept. Half of these are sold as R2s and the remainder join the velveting stag mob of 80. There are 20 breeding stags.

3.1.2 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 65 heifer calves are sold at weaning, 60 are kept as replacements and 15 are fattened to be sold to the works as R2s. 123 males are sold at weaning and the remaining 17 calves are sold to the works as R2 steers. There are 15 breeding bulls.

3.1.3 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 2500 male lambs are progressively sold from February to May. There are 55 breeding rams. 700 of another farms replacement ewe lambs are grazed from February to mid-May.

3.2 Supplements

Imported supplements make up less than 1% of total feed supplied to animals. 15 tonnes of oats or barley grain is imported to be fed to sheep and 12 tonnes of palm kernel expeller (PKE) is imported and fed to deer.

Annually 200 ha is cut for grass silage in December, 140 bales of baleage are made and 150 bales of hay are made.

3.3 Crops

Crops include 60 ha kale, 17.5 ha rape, 11 ha raphno, 10 ha rye corn and 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. The rape is sown in November, grazed by lambs from February to April, left fallow over winter and then kale is sown in November. Raphno is sown in October, grazed by lambs from February to May and then followed by crop or permanent pasture. Rye corn is sown in January, grazed autumn to winter and then followed by a crop. The plantain and clover is sown in October, grazed by sheep and deer, and has an intended rotation length of three to five years.

3.4 Fertiliser

Developed pasture areas where fodder crops do not rotate through receive 200 kg/ha of Sulphur gain 30S annually in spring. The oversown and topdressed 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, rape and raphno receive 150kg/ha of Cropzeal boron boost at sowing and 100kg/ha of urea in January. The rye corn receives 150kg/ha of Cropzeal 20N at sowing. The plantain and clover receives 200 kg/ha of Cropzeal 20N at sowing.

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.

3.5 Stock Excluded Areas and Trees

There are numerous shelter belts and a small number of tree lots on the farm. To demonstrate the influence of accounting for shelter belts and smaller tree lots when calculating GHG emissions for a farm, the carbon stock for these trees has been estimated. It is worth noting the majority of these trees were planted prior to 1990 which means regardless of area, they are not eligible to receive carbon credits. However, to demonstrate the impact of smaller tree areas the carbon stock of pre 1990 trees has also been determined. The tree areas and the likely carbon stock are summarised in Table 3. The carbon stock has been estimated using the Carbon Look-up Tables.

Table 3: Stock Excluded Riparian and Tree Areas

Description	Area	Vegetation	Age	Carbon sequestered*	Carbon stock*	Annualised carbon stock
Retired dams	7.8 ha	Grasses and Sedges	-		-	-
Shelter belts	6443m long	Various pine species planted	34 years	674 t CO_2/ha	7077t CO_2	208.2t CO_2

	10.5 ha	from 1980-89 (1985 used)				
Pines by dam	1.5 ha	Pines	34 years	674 t CO_2/ha	1011t CO_2	29.7t CO_2
Douglas Fir	7.3 ha	Small tree lots planted 1991	28 years	468 t CO_2/ha	3416t CO_2	122t CO_2
Total					11,504tCO_2	359.9tCO_2

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

If the 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 359.9t CO_2/yr or 82.3kg CO_2/ha/yr.

4.0 CURRENT GREENHOUSE GAS EMISSIONS

Current biological GHG emissions for the farm have been determined through modelling the farm in Overseer. Emission source and emissions from each animal enterprise are summarised in Table 5 and Table 6. Overseer provides methane and nitrous oxide emissions as CO_2 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	873
	Dung	12
	Total methane	**885**
Nitrous oxide	Excreta Paddock	202
	N fertiliser	10
	Crops	0
	Indirect	54
	Total Nitrous oxide	**266**
Total Biological GHG Emissions		**1151**

Table 6: Current Emissions per Animal Enterprise

Enterprise	Total kg CO_2-e	kg CO_2-e per SU
Deer	1,165,414	404
Cattle	1,502,025	422
Sheep	2,798,189	390

Methane accounts for 77% of the total current biological GHG emissions. When looking at emissions on a per stock unit basis, cattle have the highest emissions of 422 kg CO_2-e per stock unit, followed by deer with 404 kg CO_2-e/ha per stock unit while sheep have the lowest emission per stock unit of 390 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 22:25:53.

Sheep are the lowest emitting enterprise on a stock unit basis and beef are the highest. Therefore, increasing sheep numbers and proportionally decreasing cattle numbers, while keeping the same policies, will result in a reduction in GHG emissions. A reduction in beef numbers to 15% of total farm stock units has been modelled and resulted in a 0.5% reduction in GHG emissions (Table 7, scenario 1). Beef are an important component of the farm system as they help maintain pasture quality. It is thought reducing numbers to 15% will be achievable without compromising pasture quality however this may not be the case. A larger reduction in beef numbers has not been modelled as this would likely impact on pasture quality on this farm.

A scenario has been modelled improving sheep weaning percentage from 115% to 130%. Ewe numbers were reduced with the same numbers of lambs being weaned as currently. This allows for a small increase in the number of lamb sales as the number of replacements required is reduced. Due to the reduced stocking rate and feed demand, crop areas have been reduced by approximately 15%. This scenario reduced emissions by 5.7% (Table 7, scenario 2).

5.2 Crops

The farm includes easier country that has the potential to grow arable crops. In the past, cash cropping has been undertaken on the farm with mixed results. Climatic factors, particularly wind, impact on the success of cash cropping and mean that cash cropping is seen as too high risk on this farm.

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. Crops can result in increased nitrous oxide emissions particularly when intensively grazed in wet conditions. A reduction in winter kale crop area by 15 hectares (25% reduction in total kale area) has been modelled. This crop typically yields 7tDM/ha. An assumption has been made that an additional 3.5tDM/ha of pasture will be grown where the crop no longer occurs which means 52.5tDM of imported feed is required to compensate for the reduction in crop area. This scenario resulted in a decrease in nitrous oxide emissions by 1kg/ha however methane increased by 2kg/ha, therefore the overall result was an increase in emissions (Table 7, scenario 3).

5.3 Imported Feed

The type and amount of imported feed can have an impact on GHG emissions due to the differing feed properties such as nitrogen content. This farm imports oats or barley grain and PKE which supplies approximately 0.25% of animal intake. Scenarios to remove or change the type of imported feed have been modelled. However, due to imported feed supplying a minimal amount of the total diet, no reduction in GHG emissions was achieved (Table 7, scenario 4a and 4b).

5.4 Nitrogen fertiliser

Reducing nitrogen fertiliser inputs generally reduces nitrous oxide emissions. Reducing nitrogen applications on crops is not seen as a feasible mitigation option on this farm as it will likely impact on yields. Nitrogen is only applied to established pasture areas prior to harvesting for silage. Reducing or removing this application will likely impact on the amount of silage harvested however a small reduction has been considered to demonstrate the impact on GHG emissions. A scenario has been modelled reducing the spring nitrogen application from 200 hectares to 150 hectares. The reduced pasture production was replaced with 25.9tDM of imported feed. This resulted in the same overall biological emissions (Table 7, scenario 5).

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.

The native pasture is the least productive block on this farm. A scenario has been modelled retiring 200 hectares of the native pasture block and planting with trees. 200 hectares is 9.4% of the native block. As this block is only grazed 4 months of the year, an assumption has been made that a reduction in total stock numbers is not required as it is expected that the remainder of the block will offer sufficient feed, or the number of days the block is grazed can be reduced by 9% (11 days).

Due to the location of the farm, there are challenges with growing trees. The district plan has rules prohibiting the planting of certain exotic forestry species and it is debatable whether other species would successfully grow in the area. The harsh climate means establishing a large area of native trees would be challenging and it would likely take longer than typical to achieve 5m canopy height. Notwithstanding these challenges, both pine and native species have been modelled to show the hypothetical impact of these trees. The carbon sequestered by the trees has been determined using the ETS Carbon Look-up Tables. The Canterbury/Westcoast 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 (due to carbon removed at harevesting). It is also important to note that due to the site-specific challenges, the carbon sequestration over a 28 year period will likely be less than the figures in the ETS Carbon Look-up Tables.

The 200 hectares of pine forestry offsets 73.1% of the farms biological GHG emissions. The 200 hectares of native trees resulted in a 34.4% offset.

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 *610 hinds* *80 velveting stags* *310 breeding cows* *3400 MA Ewes* *1300 two tooths* *17tDM imported feed* *Crops – 71ha kale, 17.5ha rape, 10ha rye corn* *Fertiliser – 200kg/ha sulphur gain 30S on developed pasture in spring. 75kg/ha urea on silage area*	885	266		1151	-
Present farm system – GHG emissions and carbon sequestration by shelter belts and tree lots			-82.3	1151 - 82.3 = 1068.7	7.2% offset
1. Reducing beef to 15% and increasing sheep *177 breeding cows* *4119 MA Ewes* *1575 two tooths*	878	267		1145	0.5%
2. Improving sheep performance and lower sheep stocking rate *2788 MA Ewes (130% lambing)* *1066 two tooths*	834	251		1085	5.7%

Sheep stock units reduced by 767 or 10.9% *Crops – 60.5ha kale, 15ha rape, 8.5ha rye corn*					
3. Reducing kale area by 25% and replacing with imported feed *56ha kale* *79.5tDM imported feed*	887	265		1152	+0.1%
4a. Importing maize grain instead of PKE	885	266		1151	0%
4b. No PKE imported	886	266		1152	+0.1%
5. Reduced urea use *3.8t less urea*	886	265		1151	0%
6a. Retire 200ha and plant native trees – GHG emissions only	885	266		1151	0%
6b. Retire 200ha and plant native trees – GHG emissions and carbon sequestration by trees	885	266	-396	1151 - 396 = 755	34.4% offset
6c. Retire 200ha and plant pine trees for carbon – GHG emissions and carbon sequestration by trees	885	266	-841	1151 - 841 = 310	73.1% 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. 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

A reduction in emissions was achieved through improving sheep performance. Modelled mitigation options relating to crops, nitrogen fertiliser and imported feed did not result in a reduction in emissions on this farm. The successful establishment of trees will be challenging on this farm due to local rules and the harsh climate.

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