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Greenhouse Gas Emissions and Mitigation Options on Deer Farms
Case Study 4 South Island Venison

Deer Industry New Zealand

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1.0 SUMMARY OF FINDINGS

Options to reduce biological GHG emissions from the farm 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	4303	1104		5407	
Present farm system – GHG emissions and carbon sequestration by trees	4303	1104	-1107	-1107 =4300	20.5% offset
1. Halve beef breeding cows and replace with sheep	4274	1105		-28 5379	0.5%
2. Removal of beef breeding cows and replacement with steers and dairy cows	4303	1099		-5 5402	0.1%
3. Removal of dairy cows and feed supply decreased proportionally	4167	1082		-158 5249	2.9%
4. Reduced kale	4302	1103		-5 5402	0.1%
5a. Reduced urea use and importing feed	4288	1057		-62 5345	1.2%
5b. Reduced urea use and reduced stocking rate	4251	1056		-100 5307	1.9%
6. Change type of imported feed	4303	1102		-2 5405	0%
7a. 10ha indigenous trees			-109	-109 5298	2% offset
7b. 10ha exotic hardwood trees			-296	-296 5111	5.5% 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 4 is located in South Canterbury and has a focus on venison production.

3.0 FARM DESCRIPTION

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. Ongoing consideration is given to the most appropriate farm system and management of the property.

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	9258	14.63	78.1%
Cattle	2192	3.47	18.5%
Sheep	397	0.63	3.4%
Total	11847	18.72	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

Approximately 1200 mixed age hinds and 900 R2 hinds are mated. Out of the 2100 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 540 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 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.

3.1.2 Cattle

150 mixed age breeding cows are run on the farm. 40 replacement heifers are calved as 2-year olds. Calves are weaned in February with a typical weaning rate of 95%. 40 additional calves come on to the farm at weaning. All non-replacement calves leave the farm in November. 90 empty dairy cows are purchased in June, 10 dries are culled in January and the remaining 80 are sold as in calf cows in May.

3.1.3 Sheep

400 mixed age ewes are purchased mid-February. They lamb from mid-August through to the end of September with a typical lambing percentage of 135%. Lambs are weaned in early December and ewes are sent to the works mid-December. 50-60% of lambs are sold to the works at weaning with the remainder sold to the works by February.

3.2 Imported Supplement

Imported supplements make up approximately 2.2% of total feed supplied to animals. 400 bales of straw is imported and fed to cows over winter and 75t of wheat or barley grain is imported and fed to deer and sheep from the end of December through to the end of April. In addition to imported feed, 150t of barley silage is made on farm and fed from March to August to all stock as required and 1000 bales of baleage is made on farm and fed to deer and cattle on crops over winter.

3.3 Crops

72 hectares of fodder beet is sown in November with a typical yield of 18tDM/ha. 9 hectares of kale is sown in December, typical yield is 10tDM/ha. 4 hectares of swedes are sown in November, typical yield is 10tDM/ha. These crops are grazed by deer and cattle from May through to the end 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 150t 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.

3.4 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. 3 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, 10 kg/ha of phosphorus, 3 kg/ha of potassium and 14 kg/ha of sulphur.

3.5 Trees

The current area of trees and associated carbon stock is summarised in Table 3. There are areas that were established prior to 1990 and have since been harvested and replanted. Other areas are still the original trees.

Table 3: Existing Tree Areas

Description	Area (ha)	Age	Carbon sequestered*	Carbon stock*	Annualised carbon stock
Tree lots					
Macrocarpa and Douglas Fir	3.3	39	623 tCO_2/ha	2055.9 tCO_2	52.7 tCO_2
Cedar and Douglas Fir	1.1	39	623 tCO_2/ha	685.3 tCO_2	17.6 tCO_2
Macrocarpa	13	29	387 tCO_2/ha	5031 tCO_2	173.5 tCO_2
Douglas Fir by House	1.5	27	445 tCO_2/ha	667.5 tCO_2	24.7 tCO_2
Douglas Fir	4	24	382 tCO_2/ha	1528 tCO_2	63.7 tCO_2
Poplar and Douglas Fir	2.3	19	250 tCO_2/ha	575 tCO_2	30.3 tCO_2

Pinus radiata	4	14	170 tCO_2/ha	680 tCO_2	48.6 tCO_2
Replanted Pinus radiata	25.7	9	101 tCO_2/ha	2595.7 tCO_2	288.4 tCO_2
Replanted Pinus radiata	10.3	9	101 tCO_2/ha	1040.3 tCO_2	115.6 tCO_2
Replanted Pinus radiata	8.5	5	15 tCO_2/ha	127.5 tCO_2	25.5 tCO_2
Replanted Pinus radiata	14.1	0	-	-	-
Replanted Pinus radiata	22.4	0	-	-	-
					840.5 tCO_2
Shelter belts					
Poplar and Douglas Fir	2.3	19	250 tCO_2/ha	575 tCO_2	30.3 tCO_2
Pinus radiata	4	14	170 tCO_2/ha	680 tCO_2	48.6 tCO_2
Replanted Pinus radiata	25.7	9	101 tCO_2/ha	2595.7 tCO_2	288.4 tCO_2
Replanted Pinus radiata	10.3	9	101 tCO_2/ha	1040.3 tCO_2	115.6 tCO_2
Replanted Pinus radiata	8.5	5	15 tCO_2/ha	127.5 tCO_2	25.5 tCO_2
Replanted Pinus radiata	14.1	0	-	-	-
Replanted Pinus radiata	22.4	0	-	-	-
					41.2 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 as rules regarding offsetting may change in the future. 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 is 881.7 tCO_2/yr or 1107 $kgCO_2$/ha/yr. This offsets emissions from the farm by 20.5%.

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	4258
	Dung	45
	Total methane	**4303**
Nitrous oxide	Excreta Paddock	772
	N fertiliser	169
	Crops	7
	Indirect	156
	Total Nitrous oxide	**1104**
Total Biological GHG emissions		**5407**

Table 5: Current Emissions per Animal Enterprise

Enterprise	kg CO_2-e per SU per year
Deer	399
Beef	412
Sheep	391

Methane accounts for 80% of the total current biological GHG emissions. When looking at emissions on a per stock unit basis, beef have the highest emissions of 412 kg CO_2-e per stock unit. Beef are followed by deer with 399 kg CO_2-e per stock unit while sheep have the lowest per stock unit emissions of 391 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. Any significant reductions through changes to the livestock policy can only be achieved with a reduction in stocking rate.

The current livestock policy has a deer, cattle, sheep ratio of 78:19:3.

Sheep are the lowest emitting enterprise on a per stock unit basis, therefore increasing the sheep numbers and proportionally decreasing deer or cattle numbers would result in a reduction in GHG emissions. A scenario has been modelled reducing beef breeding cow numbers while maintaining overall stocking rate by increasing sheep. This resulted in a 0.5% reduction in GHG emissions (Table 7, scenario 1).

A scenario has been modelled reducing beef breeding cow numbers and replacing with an increase in other cattle classes. This resulted in a 0.1% reduction in GHG emissions (Table 7, scenario 2).

A scenario has been modelled removing the carryover dairy cows. Crop area and imported feed have been reduced to account for the reduction in feed demand. This resulted in a 2.9% reduction in GHG emissions (Table 7, scenario 3).

5.2 Crops

Crops provide the majority of feed intake by deer and cattle over winter, which means that overall, crops make up a significant portion of feed intake on the farm. Majority of the crop area is in fodder beet. Research to date indicates that fodder beet is a lower emission feed than alternatives. A scenario has been modelled reducing the kale area from 9 hectares to 4.5 hectares and increasing the area of fodder beet to maintain the same overall feed supply. This resulted in a 0.1% reduction (Table 7, scenario 4). If the current fodder beet area made up a smaller proportion of total cropped area, then fodder beet could be further increased while alternative crops were reduced. This would likely result in a more significant reduction in GHG emissions.

5.3 Nitrogen Fertiliser

Nitrogen application rates and timing on crops is based on soil test results and crop demand. Due to this, a reduction in nitrogen applied to crop areas is not recommended as it would likely impact on crop yield.

Nitrogen is applied to irrigated areas three times during the irrigation season to ensure intended pasture production from irrigation is achieved. Nitrogen is applied to 200 hectares of non-irrigated pasture in spring and in autumn. Removing the spring nitrogen application has been modelled. It is estimated the removal of this application will reduce pasture growth by 72tDM (12:1 response). The reduced pasture growth needs to be offset by either reducing feed demand or replacing the feed with an alternative. Replacing feed with imported maize grain (90 tDM) has been modelled and resulted in a reduction in emissions of 1.2% (Table 7, scenario 5a). Reducing feed demand has been considered by reducing ewe numbers from 400 to 250. This resulted in a reduction in GHG emissions of 1.9% (Table 7, scenario 5b).

5.4 Imported feed

The type of imported feed can have an impact on GHG emissions due to differing feed properties such as nitrogen content. A scenario was modelled replacing wheat grain with maize grain which resulted in a 2 kg CO_2-e which is less than a 0.1% reduction (Table 7, scenario 6).

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.

The majority of steeper and less productive areas on the farm have already been retired from grazing and planted with trees. One area that may be suitable to retire and plant trees is the riparian area in paddock 67. It is estimated that 10 hectares of this paddock could be retired while the remaining 3.3 hectares remains in grazed pasture. As a stream runs through the middle of this area it may not be appropriate to plant trees for harvest. This area is suitable for planting indigenous tree species. Several exotic species may be suitable however, depending on the exotic species, maintenance may be required over time. The carbon sequestration from varying trees is outlined in Table 6. The carbon sequestered by the trees has been determined using the Carbon Look-up Tables. The annualised carbon stock from the proposed tree area varies depending on the tree species from 86.5 tCO_2 to 236.1 tCO_2. This is equivalent to 109 kg CO_2-e/ha/yr to 296 kg CO_2-e/ha/yr which offsets annual biological GHG emissions by 2% to 5.5%. Carbon sequestration by trees decreases over time, therefore this may be an overestimation of carbon sequestration over the long term.

Table 6: New Tree Area

Description	Area (ha)	Proposed Vegetation	Carbon stock at 28 years	Annualised carbon stock
Riparian area in paddock 67	10	Indigenous	242.2 tCO_2/ha 2422 tCO_2	86.5 tCO_2
Riparian area in paddock 67	10	Exotic softwood	373 tCO_2/ha 3730 tCO_2	133.2 tCO_2
Riparian area in paddock 67	10	Exotic hardwood	661 tCO_2/ha 6610 tCO_2	236.1 tCO_2

The proposed 10 hectare tree area includes a stream and adjacent pasture areas that are not currently grazed, as well as areas of grazed pasture. The grazed areas are less productive than other pasture areas on the farm. Therefore, it is assumed that this area can be retired without reducing stocking rate or increasing imported feed.

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

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 *1300 hinds (MA and R2) calved on farm, 500 hinds sold in calf, 930 R1 hinds, 3160 R1 stags/hybrid females finished by 16 months, 50 MA stags* *150 MA beef cows and 40R2 heifers calved, 137 weaners/R1s sold November, 90 carryover dairy cows* *400 MA ewes and lambs* *Crops – 72ha fodder beet, 9ha kale, 4ha swedes, 20ha oats, 15ha barley*	4303	1104		5407	

Imported supplement – straw and grain totalling 215tDM *Fertiliser – DAP mix applied to all pasture in spring, irrigated pasture 3xurea applications, non irrigated pasture 2x200ha urea applications*					
Present farm system – GHG emissions and carbon sequestration by trees	4303	1104	-1107	-1107 =4300	20.5% offset
1. Halve beef breeding cows and replace with sheep *75 MA beef cows, 20 R2 heifers, 89 weaners/R1s sold November* *1245 MA ewes*	4274	1105		-28 5379	0.5%
2. Removal of beef breeding cows and replacement with steers and dairy cows *200 steers (80 sold before second winter), 180 carryover dairy cows*	4303	1099		-5 5402	0.1%
3. Removal of dairy cows and feed supply decreased proportionally *63ha fodder beet (9ha less), 165tDM imported feed (50tDM less)*	4167	1082		-158 5249	2.9%
4. Reduced kale *4.5ha kale, 74ha fodder beet*	4302	1103		-5 5402	0.1%
5a. Reduced urea use and importing feed *200hax65kg/ha urea removed, 90tDM maize grain imported*	4288	1057		-62 5345	1.2%
5b. Reduced urea use and reduced stocking rate *200hax65kg/ha urea removed, 250 MA ewes*	4251	1056		-100 5307	1.9%
6. Change type of imported feed *75t wheat grain changed to maize grain*	4303	1102		-2 5405	0%

7a. 10ha indigenous trees			-109	-109 5298	2% offset
7b. 10ha exotic hardwood trees			-296	-296 5111	5.5% 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, reducing stocking rate and reducing nitrogen fertiliser use. With currently available mitigation options, stock numbers would need to be reduced to achieve a substantial reduction in emissions. If carbon sequestered by all trees is considered, this offsets current biological GHG emissions from the farm by approximately 20%.

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