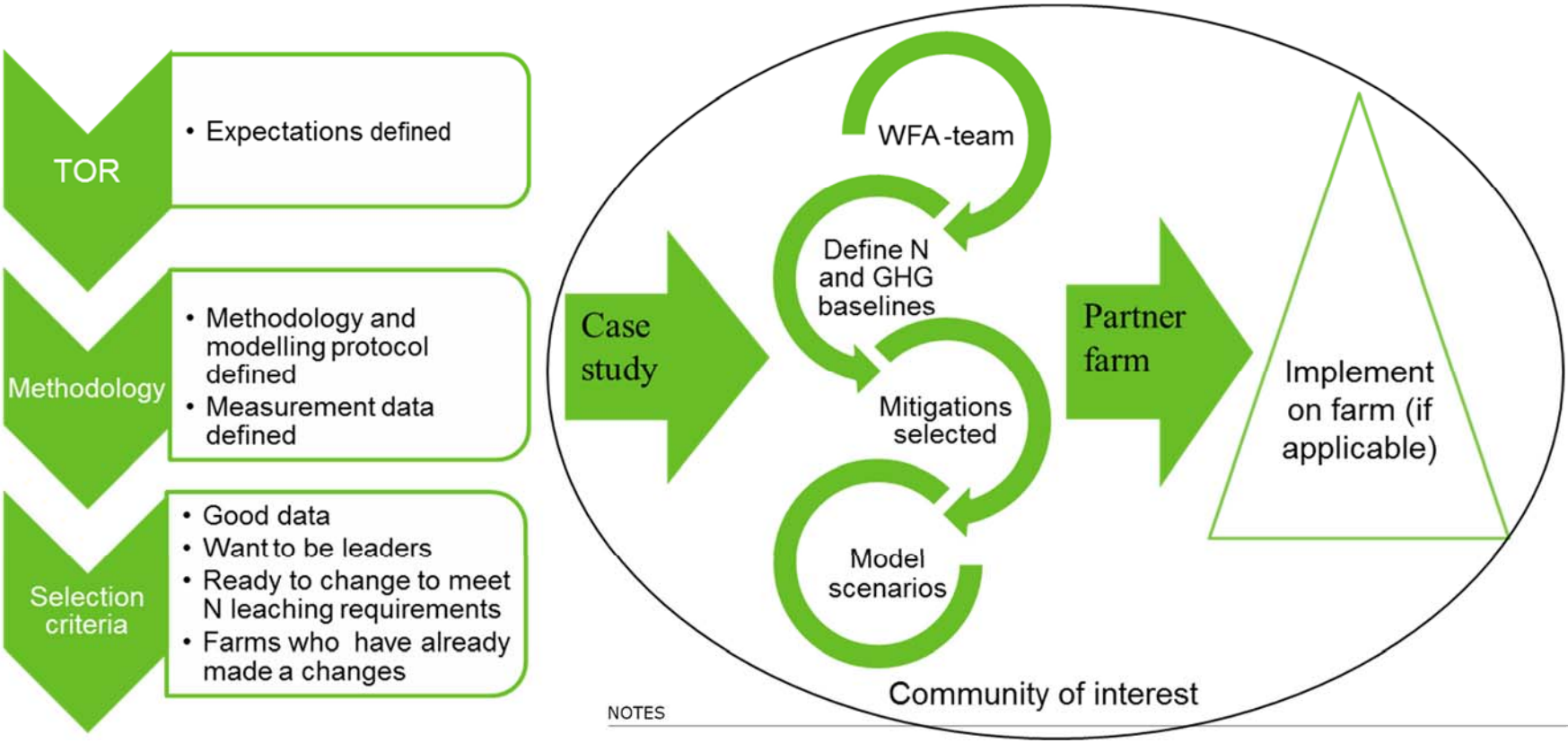
GREENHOUSE GAS PARTNERSHIP FARM OBJECTIVES

'This project will partner with farmers, scientists, rural professionals, and government to demonstrate the feasibility and practicality of implementing mitigation strategies to address greenhouse gas emissions and nitrate leaching from farm systems.'

- Set up ten GHG partnership farms across the country on a range of different farm systems
- To demonstrate the potential biological emissions reduction on dairy farms through farm system changes and to quantify the effect on production and productivity
- To ground-truth the farm system changes with dairy farmers
- To educate dairy farmers, rural professionals, and the wider sector of farm systems changes which may be possible and the implications of these changes.



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OWL FARM GREENHOUSE GAS CASE STUDY - EXECUTIVE SUMMARY,

The overall objective of this project is to partner with farmers, industry, scientists, rural professionals, and government to demonstrate the feasibility and practicality of reducing GHG emissions and N-loss to water from real dairy farms, while maintaining the farm profitability and meeting other environmental obligations.

Owl Farm is committed to taking a position of leadership on Sustainable dairying. This means that the opportunity to work with the Partner Farm Project as part of the Dairy Action for Climate Change was a great place to start.

As a Demonstration farm, Owl Farm has significant levels of detail regarding its farming operations over the last 4 years. The data and trend of performance has been measured and large gains have been made in improving profit and reducing nutrient loss to waterways. Owl Farm has been future-focussed from the outset and has evaluated a large number of potential farm systems for the long-term operation of the farm. From 11 valid options at the outset, only two systems fit with Owl Farm's overall objectives and reach targets through the range of important KPIs that the farm intends to deliver on. The availability of this information made inspection and assessment of GHG emissions from the farm a straightforward process.

In the last 4 years the farm has had a 3% reduction in total Greenhouse gas emissions, alongside a 50% lift in Farm EFS/ha, and 24% and 31% reduction in nitrogen and phosphorous loss to waterways respectively. The two viable farm pathways that remained for the farm moving forward saw further improvements in all of these areas should either of the two systems be implemented

Future options for the farm show that additional reductions in greenhouse gas can be achieved on the farm, out of the two systems modelled. In addition other options for the farm were considered, including bringing all young stock home adjusting stocking rates within the current system and a whole-farm OAD strategy which also yielded GHG benefits, but had undesirable impacts on farm profitability to varying degrees.

The farm would either invest in infrastructure to ensure high utilisation of current homegrown silage, imported concentrates and future homegrown Maize silage, along with stand-off infrastructure for soil and pasture protection. This system lifted both productivity and, profitability while further reducing nutrient loss to waterways, it also offered some mechanisms for better animal shelter. However the system required significant capital investment to be successful.

Alternatively a further de-intensification of the system with no imported feed saw profitability increase even with a total production decrease. It also reduced nutrient loss to waterways and without the capital investment required. It did have a large reduction in farm operating expenditure to protect on-farm profits, which is no longer making it into the local economy.

FARM OVERVIEW,

Owl Farm is 147 effective hectares, milking between 405-415 cows at peak. Annual rainfall of 1200mm and summer dry, they are spring calving on July 3rd. Now System 2, with 11% imported feed of PKE (250T) and silage from local farmland (80T). Homegrown feed is predominantly grass (rye/clover/cocksfoot/plantain), and summer turnips

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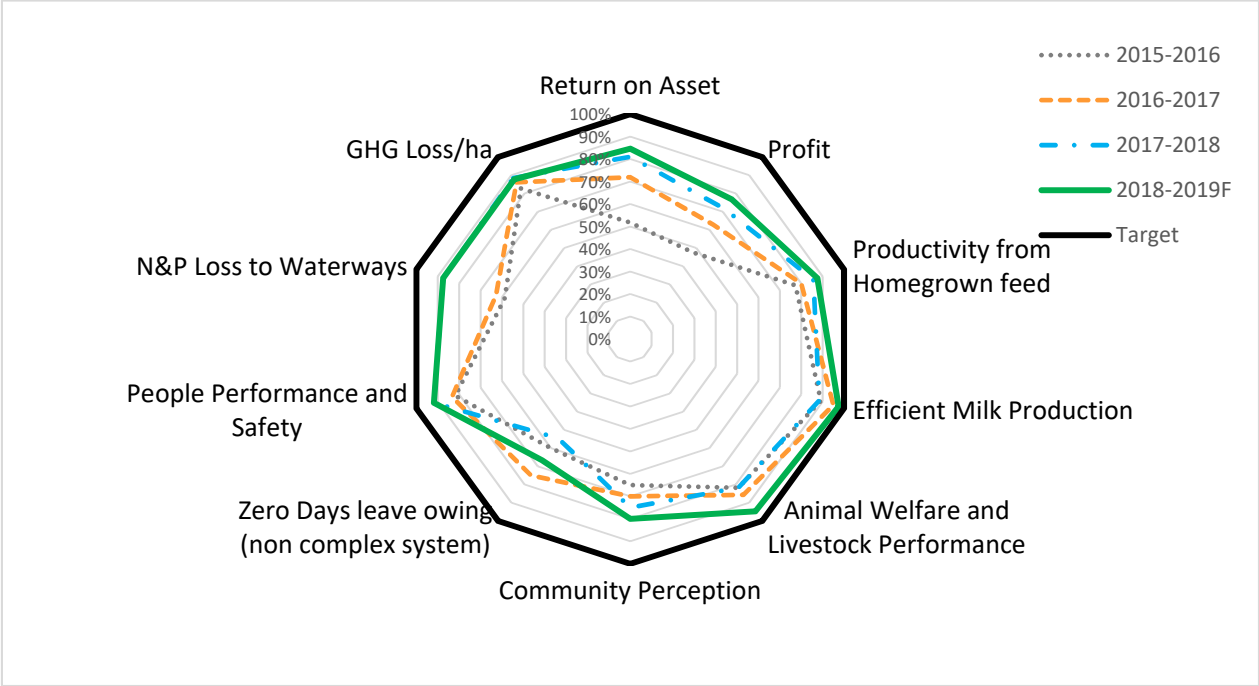
Owl Farm has developed a simple Matrix that they use to evaluate how well the farm is delivering on farm goals. The targets are summarised into performance areas and each turned into a "spoke" on a radar graph. With target on the outside and the degree to which the target is achieved as a percentage score. This graph resembles a wagon wheel, and Owl Farm say they are trying to have a round wagon wheel as a round wheel makes a smooth journey.



KPI'S,

The change between the first and most recently completed season of the Demonstration farm represent a good example of the change in farm system that has already occurred and the benefits this has yielded. There is between 3 and 7ha of run-off land that is used as a forage source of bought in feed and costed into the profit figures, varying between years as more or less of a neighbouring property is able to be used.

Key Performance Indicators	**2014/15**	**2015/16**	**2016/17**	**2017/18**
Size of Milking platform (eff ha)	164	157	148	148
Size of Support blocks (eff ha)	3	3	7	5
Cows and stocking rate (total and cows/ha)	470 (2.76)	445 (2.83)	423 (2.9)	418 (2.82)
Homegrown feed harvested (tDM/cow)	4.3	4.4	4.4	4.9
Supplement imported (tDM/cow)	1.5	1.5	1.2	0.8
Production (kgMS/ha / kgMS/cow)	1,229 / 445	1,122 / 396	1,221 / 421	1,136 / 402
Operating expense ($/kgMS)	$5.21	$4.98	$4.81	$4.53
Operating profit ($/ha at $6 payout)	$1,456	$1,189	$1,807	$2,102
N-loss (kgN/ha)	41	40	41	35
GHG (tCO2e/ha)	14.3	12.7	13.6	12.5
Efficiency (CO2e/kgMS)	11.0	11.7	12.2	11.8

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DETAIL PHYSICAL PERFORMANCE,

Driving towards lifting homegrown feed and rationalising and removing the purchased in maize silage that was fed in paddock has led to similar production/ha from less bought in feed (from 21% imported to 11% imported).

Key Performance Indicators	**2014/15**		**2015/16**		**2016/17**		**2017/18**	
	Per ha	Per cow	Per ha	Per cow	Per ha	Per cow	Per ha	Per cow
Cows and stocking rate	2.76		2.83		2.9		2.82	
Production (kgMS)	1229	445	1122	396	1221	421	1136	402
Pasture and Crop harvested (tDM)	12	4.3	12.4	4.4	12.8	4.4	13.7	4.9
Supplement imported (tDM)	4.2	1.5	4.3	1.5	3.6	1.2	2.3	0.8
Crops grown	Chicory 12.5% of farm						Turnips 8% of farm	
Total feed eaten and imported (tDM)	16.6		16.7		16.4		16.0	
Feed conversion efficiency (kg DM/kg MS)	13.2		14.8		13.4		14.0	
Average herd BW (industry at time)	150 (106)		162 (110)		107 (64)		112 (72)	
Average herd PW (industry at time)	179 (119)		189 (122)		128 (73)		135 (92)	
6-week in-calf rate	74%		73%		72%		67%	
Empty rate	13%		13%		15%		17%	
Nitrogen fertiliser applied	154		149		163		150	
Effluent applied to block	40ha		44ha		51ha		51ha	

DETAILED FINANCIAL PERFORMANCE,

The total operating profit of the farm over this time, when all years are compared at a standard $6 payout, is an increase of 115,000 or 51% lift. This is in large part due to the decrease in money spent on imported feed ($75,000 less on feed costs), the balance of profit change comes from reducing R&M costs, more efficient labour and better livestock revenue.

KPI's	**2014/15**		**2015/16**		2016/17		**2017/18**	
	Per ha	Per kgMS	Per ha	Per kgMS	Per ha	Per kgMS	Per ha	Per kgMS
Total Income ($)	6,170	5.02	4,892	4.36	7,790	6.38	8,134	7.16
Operating expense ($)	6,403	5.21	6,048	5.39	5,873	4.81	5,044	4.44
Operating profit ($)	-233.51	-0.19	-1155.66	-1.03	1,929	1.58	3,090	2.72
Operating Profit at standard $6 milk price ($)	1,456	1.18	1,189	1.06	1,807	1.48	2,102	1.85

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ENVIRONMENTAL PERFORMANCE,

A reduction in N loss overtime along with reducing Phosphate loss/ha, has been an intentional outcome of the farm systems changes that have also brought about an improved farm operating profit. Owl Farm is looking at Greenhouse gas changes and seeing small changes in per/ha and per/kgMS changes as a continued focus. Though it's critical note that the farm reduced in size in these years. So total greenhouse gas emissions reduced along with emissions per ha reducing, however both the total operating profit and per hectare profit saw greater than a 50% lift in this time.

KPI's	2014/15	2015/16	2016/17	2017/18	2018/19 Forecast
N fertiliser	+134	+149	+163	+150	+145
N in Supplements	+83	+67	+45	+39	+40
N Surplus (kg N/ha)	204	187	193	189	185
N leached per hectare (kg N/ha/yr)	41	40	41	35	33
Total N Leached (kgN/yr)	7,531	7,414	7,434	6,314	5,911
N Conversion efficiency	28%	26%	27%	25%	28%
Total GHG (tCO2e)	2,216	2,061	2,175	1,984	1,965
GHG (tCO2e/ha)	14.3	12.7	13.6	12.5	12.2
Efficiency (CO2e/kgMS)	11.0	11.7	12.2	11.8	11.7

WHAT DRIVES N-LOSS/GHG EMISSIONS FROM THE FARM,

A relatively large effluent area on the farm means a small more widespread loading around the farm from effluent. All cows winter on the milking platform and all feed is fed out in paddock throughout the year. Avoiding pugging on heavy soils is supported by careful planning to ensure there is feed staggered around the farm on differing soil types.

Variation between years N Loss has come from several key areas:

1. The reduction in imported feed by 50% from the 2014-2017 years versus the 2017-2018 year has been the biggest driver in reducing total N Loss to waterways.
2. Changing timing and types of fertiliser, with no applications in May and June, always using companion nutrients such as sulphate when necessary to ensure maximum nitrogen utilisation, and only using urease-inhibitor-coated nitrogen e.g. Sustain products.
   Ensuring satisfactory soil phosphate levels (Olsen P) or soil moisture to ensure high efficiency of applied Nitrogen, and the plant is able to grow when the N is available reduces wastage of Nitrogen.

Variation between years GHG emissions has come from several key areas:

1. Reduction in total feed eaten has reduced methane emissions over the last 4 years.
2. Reduced N Surplus on farm from reasons mentioned above, has also reduced Nitrous oxide losses and losses of Nitrate to waterways.
3. Reduced imported feed has reduced the total actual CO_2 of the farm by reducing emissions liability for imported feed that has significant transportation and other costs.

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MITIGATION STRATEGIES,

De-intensification

The first Mitigation option included looking at the de-intensification option. With a reduction of 330TDM in total feed imported onto the farm, further reductions in methane were achieved. The reduced Nitrogen imported in supplements and resulting lower stocking rates also saw a further reduction in the N surplus and N loss to waterways and as nitrous oxide emissions. Farm profit was improved by reducing expenditure in line with lowering production – however there is a decided reduction in revenue and investment in the rural sector by the farm

Add infrastructure

Option B or adding infrastructure (feed pad plus stand-off facilities) allowed for efficient utilisation of all supplements currently in the system meaning more fed eaten from the same feed offered. IN addition, growing maize silage on-farm also lifted the total feed eaten, thus increasing total methane production on the farm. However the large lift in production meant the efficiency of GHG emissions/kgMS actually became fewer GHGs/kgMS. The infrastructure, nutrient capture and dispersal via the farm effluent system all acted to reduce N loss to waterways in similar amounts to the de-intensification option.

Mitigation 3

Use of Once-A-Day milking for the whole dairy season was also considered and offered small decreases in greenhouse gas emissions, along with some changes in production and profit. However the limited nature of our industry tools to accurately model OAD milking scenarios means that the results weren't pursued further at this stage. The farm already routinely uses OAD milking throughout lactation to manage BCS, with whole herd OAD in the last months of lactation anyway.

Mitigation 4

Changes to the current system which modelled more/less cows for the same feed supply or the same number of cows with less feed supply could all affect profit in small ways. However they sought to drive more pasture harvest at home which was achieved, and ultimately lead to much smaller net changes in GHG emissions, as the total amount of feed eaten remained relatively constant, but less N in bought in supps reduced N loss to water and Nitrous Oxide emissions.

IMPACT ON PROFITABILITY AND PRODUCTION,

Profitability	*Current*	*De-intensification*	*Add Infrastructure*	*Mitigation 4*
Operating profit ($/ha)	2144	2595	3022	2,200-2,400
Operating profit/kgN leached ($)	61	87	92	64-66
Operating profit/T CO2e ($)	172	239	237	188-201
N leaching (%)		-14%	-7%	9%
GHG losses (%)		-13%	2%	3-4%
Profitability (%)		21%	41%	4-6%

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LINKS TO SCIENCE, LESSONS FROM OWL FARM'S PROFITABLE REDUCTION IN GHG EMISSIONS

In the last 2 years (from June 2016 to June 2018) Owl farm has:

- reduced total Greenhouse gas emissions by 8% (-1.1 tonnes GHG CO_2/ha, from 13.6 to 12.5 t GHG CO_2 eq/ha)
- lifted Operating profit /ha by 14%,
- reduced nitrogen loss to waterways by 14%.

Opportunities are currently available on many farms to improve both profit and reduce emissions through good management practices.
Two principles used to achieve this result at Owl farm are applicable across many farms:

1) **Reduce whole farm N surplus. N surplus = N input (fert N & imported feed N) minus N output (milk N)**
2) **Reduce total feed eaten/ha.**

Reduce Whole farm N surplus:

Owl farm's N surplus has decreased since 2016 by 20 kg N/ha from 190 to 170 kg N/ha

- Fertiliser N use has decreased (-13 kg N/ha),
- N in imported supplement has reduced by 8 kg N/ha.
- N in milk has been similar.
- In addition the N surplus captured in the effluent system is now better spread over the farm effluent area.

Dairy NZ data, using Overseer from 400 Waikato farms, shows that a reduction of N surplus by 100 kg N/ha is expected to decrease total GHG emissions by 4.26 t/ha.
The DairyNZ data predicts that reducing N surplus by 20 kg on Owl farm would be expected to reduce GHG emissions by **0.85 t GHG CO_2 eq/ha.** (20% of 4.26).
Reasons for this are less N used and less imported feed, N output in product has been retained, with increased efficiency of use of N.

Reduction in total feed eaten / ha, (with home grown feed increasing / ha).

Owl farm has reduced total feed use per ha by 0.4 t DM/ha, from 16.4 to 16 t DM/ha

- **Imported feed has reduced from 3.6 t DM/ha to 2.3 t DM/ha**
- **Home grown feed use has increased from 12.8 t DM/ha to 13.7 t DM/ha. This cancels out some of the gain from reducing imported feed.**

DairyNZ data from 400 farms shows that a 1 tonne reduction in total feed eaten/ha is expected to reduce GHG emissions by 0.73 Tonnes GHG CO_2 equivalent.
This suggests that Owl farms feed use change has reduced its GHG emissions by **0.292 t CO_2 eq/ha** (0.4 t DM/ha x 0.73).

Key Learnings:

- **Efficiency gains from good management practices in feed use and N use can be profitable and will also reduce emissions**
- **Do the numbers for your farm.**
- **Keep good records of feed use and N use**
- **As the farm becomes more efficient it becomes more difficult to reduce emissions profitably.**

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