Monitoring Greenhouse Gas Emissions On Māori Farms

An NZAGRC Project

End of Year Report for 2015

Tanira Kingi, AgResearch
Graham West, Scion
Phil Journeaux, AgFirst

Table of Contents

Summary of Project and Progress over the Year

The project is designed to assist Māori farmers in New Zealand to improve their collective capacity to increase resource efficiency and farm productivity while lowering greenhouse gas (GHG) emissions.

This involves three objectives:

1. Define the characteristics of the Māori agribusiness sector drawing on a network of 30 Māori farm entities that are representative of the main farm typologies (predominant pastoral farming systems) on Māori land;

2. Identify the key factors that underpin farm productivity, resource and emission efficiency and sustainable profitability; and

3. Identify, test and communicate a range of mitigation strategies to other Māori farms and the wider industry.

Progress over the first year includes:

- Development of a typology of Māori farming
- The collection of farm and GHG emission profiles on 29 Māori farms from around the country, with 2 more to come. This includes 18 sheep & beef farms, and 11 dairy farms
- The selection of 4 Focus farms; 2 dairy (Bay of Plenty, Taranaki), and 2 S&B (Northland, East Coast)
- The development of Farmax files for each focus farm to allow for farm system modelling, and Overseer files to (a) establish the base GHG emission profile and (b) model the impact of change scenarios
- Data collated to allow for national benchmarking of the emission profiles
- Meetings held with the Trustees of the 4 focus farms and agreement gained re (a) participation in the project and (b) discussion on scenarios for modelling
- Development of priority scenarios for modelling of change in farm systems and subsequent impacts on GHG emissions.
- Development of farm maps to assist with the modelling
- A paper has been produced on the project to date and submitted to an international journal.

Summary of Maori Typologies

The selection of the 29 farm entities as a group that was representative of the Maori pastoral sector was established using a typology methodology, which in this context is a classification system for grouping items according to their similarities.

Approaches to Farm Typologies in NZ

In the context of this report, a *typology* is a system for putting things into groups according to their similarities. A typology of Māori farms is simply a classification scheme for grouping Māori farms, with each group labelled a 'type'. At a very broad level, Māori farms are a *type* of farm within a *typology* of New Zealand farms classified according to their ownership. A typology can be hierarchical, allowing types to be amalgamated or disaggregated, but the individual types are non-overlapping.

Such a broad classification is of limited use, although further division is possible based on data collected, such as farm size and production. The main purpose of the Māori farm typology developed by this project is to describe the structure and diversity of the Māori farm resource and to ensure that this diversity is represented by a representative sample farms selected for further analysis.

There are a number of approaches to classifying NZ farms including MPI pastoral farm monitoring reports based on regional dairy, deer and sheep-beef model farms. The ARGOS study on the sustainability of farm management practices classifies sheep-beef farms into one of three production systems: conventional, integrated and organic and two production systems for dairy farms: conventional and organic along with attitudinal categories based on off-farm income and the impact of exogenous factors on their farm business. Beef and Lamb NZ classes capture regional variability of farm systems across the country while the Dairy NZ classes capture it indirectly through implications for stock feed.

Maori Land and Maori Ownership Typologies

Defining Māori farmers is often done using one of two approaches (or a combination of both): (1) the ethnicity of the owner of the farm; and/or (2) the tenure status of the land. A definition of Māori farming and Māori farmers is often made in reference to Māori farming that occurs on Māori land. Māori land refers to land that comes under its own legislation – Te Ture Whenua Māori (Māori Land Act) 1993, and under this piece of legislation there are a number of organisational structures[1]. Given the range of ownership structures within the Māori sector a "working definition" of Māori farming and Māori farmers include entities that fall into one of the following ownership structure categories under the TTWMA[2]:

1. Ahuwhenua Trust - designed to manage blocks of multiple owned Maori land and are the most common structure used by Maori landowners.

[1] As of September 2014, the TTWMA 1993 has been under review. The TTWMA 2015 Bill is planned to be presented to the Māori Development Select Committee in October 2015.
[2] Te Ture Whenua Māori Act, 1993

2. Māori Incorporation - a body corporate with perpetual succession and with powers which, in form and basic structure, are similar to the joint stock company.
3. Whenua Topu Trusts – these trusts are similar to the Ahu Whenua trust in that its structure is designed to manage the entirety or major proportion of a tribal estate. It differs in one aspect however, in that the individual's land owning interests are not maintained.
4. Whanau Trusts – trusts used by whanau to halt the fragmentation of share interests. The Whanau Trust holds the interests in the land and additional members are added to the list of owners without receiving individual interests.

Ahu whenua trusts and Maori incorporations are the most common structures used to facilitate decision making over Maori land. While they are considered the most commercially orientated of the structures under Te Ture Whenua Maori Act, they nevertheless have a number of inherent weaknesses when compared to non-Maori structures. In 2008 there were 129 Māori incorporations and 5,201 Ahuwhenua trusts which together administered around two-thirds of Māori land. Another common structure under the legislation is the Whanau Trust.

Post-Settlement Governance Entities (PSGEs)

The Post-Settlement Governance Entity (or PSGE) has emerged in recent years through the on-going Treaty Settlement process. These new iwi-hapu entities have a wider mandate from their tribal constituents and many are now involved in managing farms (including Landcorp farms).

Categorising Māori famers according to scale, diversity and ownership

Māori farming activity within each of these ownership categories vary significantly. The following framework proposes 4 categories based on farming activity, scale and organisational complexity.

Category 1	Multiple farms, multiple enterprise, multiple structures (TTWMA plus limited liability company/companies
Category 2	Multiple farms, multiple enterprise, single governance structure
Category 3	Single farm, multiple enterprise, single governance structure
Category 4	Single farm, single enterprise

A more simplified and effective categorisation of Māori farming that is often used is based on a combination of the ethnicity of the owners in combination with the legal status of the land. For the purposes of developing a network of Māori farmers these criteria provide a useful guideline that acknowledges the diversity of tenure and governance structures. Māori farmers include:

A. Entities that own or manage pastoral land that is defined as Maori land under Te Ture Whenua Māori Act 1993 (e.g. Māori Incorporations and Trusts)
B. Organisations that administer land defined as General Land where these organisations are owned by Māori (e.g. PSGEs)
C. Individual Māori that own or manage pastoral land

Maori Farming Typology Framework

Applying an amalgam comprising of Whatmore's 3 approaches along national farming systems and farm classifications and the Maori land tenure and institutional structures framework that has historically been used to classify Maori land and Maori land utilisation (outlined above) a Maori farm typology framework was developed. This is outlined below.

The Maori farms selected need to fall into the following categories and sub categories:

1. **Regional spread** – the Maori Land Court regions are commonly used as the reference for the distribution of entities: Taitokerau (Auckland/Northland), Waikato (Waikato region), Waiariki (Bay of Plenty, Rotorua and Taupo), Tairawhiti (East Coast, Gisborne), Aotea Whanganui (Taranaki, Whanganui), Takitimu (Hastings, Wairarapa), Te Wai Pounamu (South Island). Each of these regions needed to be represented in the selection.

2. **Farm Type** – the two main farm systems are dairy and sheep & beef. Enterprise diversity was also important with farms that have forestry and indigenous forestry also selected.

3. **Scale** – entities need to be representative across a range of farm sizes

4. **Structure** – there were 3 main structures that needed to be represented: ahuwhenua trusts, incorporations and whanau trusts. Others that were sought included post settlement entities.

5. **Organisational complexity** – given the diversity of Maori entities that own farms it is important that small simple structures be represented along with entities that have multiple farms and enterprises.

TYPOLOGY MATRIX

There 3 categories of organisational entities that Māori farmers fall into:

Ownership Structure

a. **Te Ture Whenua Māori Act (TTWMA) 1993 entities**
    i. Ahuwhenua Trust
    ii. Māori Incorporation
    iii. Whenua Topu Trusts
    iv. Whanau Trusts

b. **Post Settlement Governance Entities (PSGEs)**

c. **Individual Māori**

Scale and Enterprise Diversity

Category 1 Multiple farms, multiple enterprise, multiple structures (TTWMA plus limited liability company/companies
Category 2 Multiple farms, multiple enterprise, single governance structure
Category 3 Single farm, multiple enterprise, single governance structure
Category 4 Single farm, single enterprise

There are no Whenua Topu trusts in the network given the low number of these structures in existence nationally. However, 2 structures that don't come under the TTWMA but are the partnership and company. These are listed in the matrix below.

Table 1: Typology Matrix

CATEGORY		TE TURE WHENUA MĀORI ACT (TTWMA) 1993 & OTHER STRUCTURES			
	Ahu Whenua Trust	Incorporation	Whanau	Other	TOTAL
1 Multiple farms, multiple enterprises, multiple structures	4	2		1	7
2 Multiple farms, multiple enterprises, single structure	2	5			7
3 Single farm, multiple enterprise, single structure	8	2			10
4 Single farm, single enterprise	2		2	1	5
TOTAL	16	9	2	2	29

Summary of the Profile Farms

The network currently consists of:

Farm Types:

Sheep and beef farms	18
Dairy	11

Discussions have been held two further dairy farms (South Island and Taranaki) who have agreed to provide farm and GHG emission profiles.

Scale:
The largest farms are sheep and beef ranging from 7,200ha for Aohanga Inc down to 531ha for Pouto Topu. Dairy farms ranged in size from 300ha down to 77ha. The average size of the S&B farms was 2,337ha and dairy 202ha.

Structures:
There are 2 main structure used in the Maori pastoral sector – Trusts and Incorporations. The network has 17 trusts, 9 incorporations, 2 whanau trusts and 1 partnership (made up of Ahuwhenua Trusts).

Regional coverage:
Selecting a network of organisations that were representative of all of the main regions was a challenge. There are 2 additional organisations that are in discussions to join the network including a dairy farm from the South Island and a dairy farm from Taranaki. These two entities are large multi farm organisations – one an incorporation, the other a post settlement entity.

Hawkes' Bay	1
Manawatu	1
Tairawhiti	6
Taitokerau	8
Taranaki	1
Waiariki	3
Takitimu/Wairarapa	1
Waikato	4

A summary of the entities is given below

Table 2: Profile Farms by Governance Structure

ENTITY	FARM	STRUCTURE	REGION	TYPE	EFFECTIVE	TOTAL
Aohanga Inc	Owahanga	Incorporation	Wairarapa	S&B	2200	7211
Te Whakaari Inc	Paparatu	Incorporation	Tairawhiti	S&B	3709	5570
Marotiri Partnership	Marotiri	Partnership	Tairawhiti	S&B	1941	3999
Parengarenga Inc	Paua Farm	Incorporation	Taitokerau	S&B	2430	2754
Otakanini Topu Trust	Otakanini	Trust	Taitokerau	S&B	1530	2750
Parengarenga Inc	Te Rangi	Incorporation	Taitokerau	S&B	2100	2513
Nuhiti Inc	Nuhiti Station	Incorporation	Tairawhiti	S&B	900	1299
Te Uranga B2	Upoko	Incorporation	Waikato	S&B	1153	2129
Onuku Maori Lands Trust	Onuku S&B	Trust	Waiariki	S&B	908	1686
Hauiti Trust	Iwinui Station	Trust	Tairawhiti	S&B	1137	1254
Kapenga M Trust	Kapenga Station	Incorporation	Waiariki	S&B	905	1271
Maraetaha Inc	Patemaru	Incorporation	Tairawhiti	S&B	947	1158
Taheke 8C	Taheke	Trust	Waiariki	S&B		952
Rangihamama Trust	Omapere	Trust	Taitokerau	S&B	773	1079
Oparau Trust	Oparau Station	Trust	Waikato	S&B	515	830
Pouto Topu A Trust	Pouto Topu A	Trust	Taitokerau	S&B		531
Hereheretau	Hereheretau	Trust	Wairoa	S&B	1740	2143
Oromohoe Trust	Oromohoe	Trust	Taitokerau	S&B	1079	765
Te Rua O Te Moko	Te Rua O Te Moko	Trust	Taranaki	Dairy	170	
Parekarangi Trust	Parekarangi Dairy	Trust	Waiariki	Dairy	352	427
Pouto Topu A Trust	Pouto Topu D3	Trust	Taitokerau	Dairy	250	301
Rangihamama Trust	Rangihamama Farm	Trust	Taitokerau	Dairy	170	280
Pouto Topu A Trust	Pouto Topu D1	Trust	Taitokerau	Dairy	247	272
Haerepo Trust	Haerpo	Trust	Waikato	Dairy		293
Te Aute Trust	Ngawapurua	Trust	Hawke's Bay	Dairy	223	228
Pukehina M3 Trust	Pukehina	Trust	Waiariki	Dairy		152
Te Uranga B2	Paatara	Incorporation	Waikato	Dairy	120	133
Ngatitu Whanau Trust	Ngatitu	WTrust	Taranaki	Dairy	80	83
Te Hore Farm Trust	Te Hore	WTrust	Manawatu	Dairy	72	77

GHG and Leaching Profiles for the Profile Farms

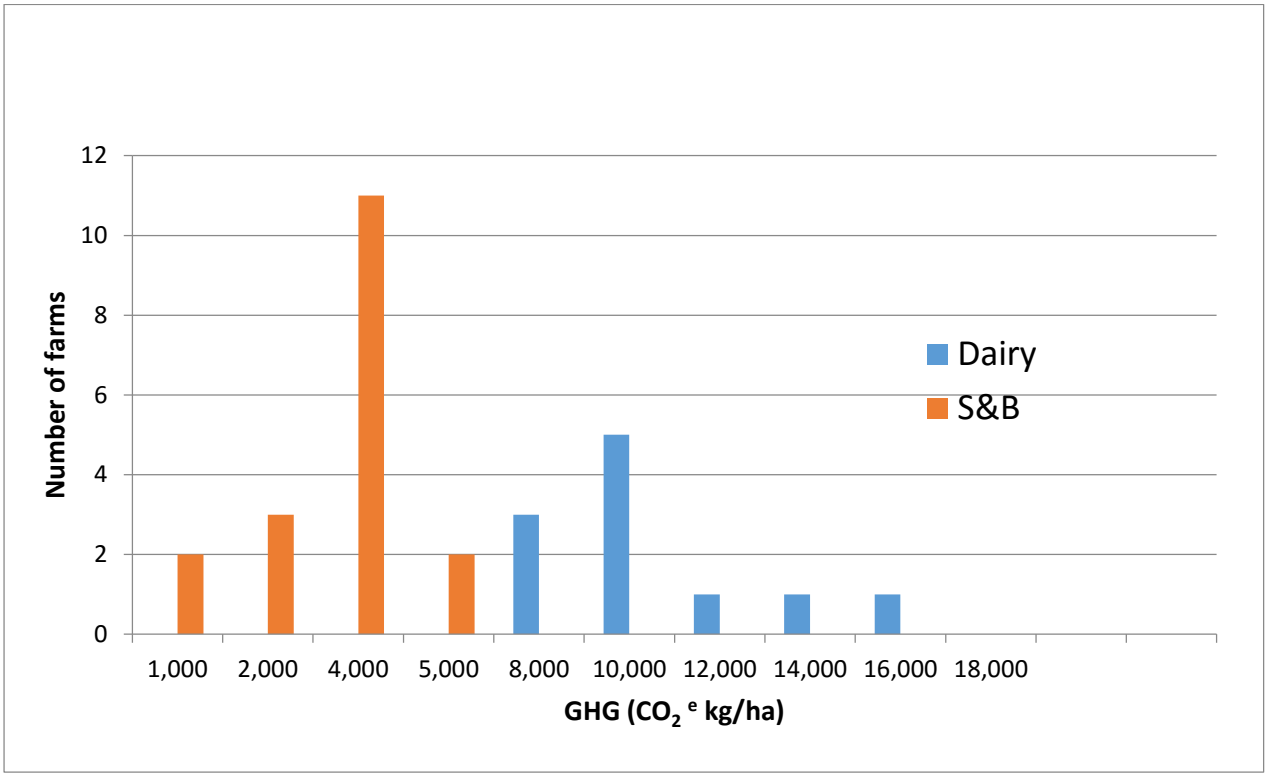
The results of the Overseer (Version 6.2) modelling of GHG and N and P emissions for the 11 dairy farms and 18 drystock farms (S&B) are shown in the Table below. These results are for the whole property and show considerable variability. They must be compared in the context of the land uses for the whole property and will be influenced by the area of bush or plantations that make up the farm total. The 29 properties provide a sample of farms to form a benchmark of emissions and gives context to the four focus farms highlighted in green.

Table 3: GHG and N &P emissions for whole property modelling with Overseer v6.2

Farm Type	Region	Farm Name	Methane kg/ha CO_2 e	N_2O kg/ha CO_2 e	CO_2 kg/ha CO_2 e	Total kg/ha CO_2 e	N kg/ha	P kg/ha
Dairy	BOP	Pukehina M3 Trust	7,787	6,270	910	15,057	29	3.4
Dairy	BOP	Parekarangi Dairy	5,461	2,838	1,548	9,846	50	2.4
Dairy	Northland	Pouto Topu A Trust - D1	5,341	1,844	952	8,137	27	2.9
Dairy	Northland	Pouto Topu Trust - D3	5,486	1,675	794	7,955	23	4.0
Dairy	Northland	Rangihamama	7,025	2,295	1,678	10,998	32	0.6
Dairy	Sth HB	Te Hore Farm Trust	6,101	1,738	673	8,512	22	0.5
Dairy	Taranaki	Ngatitu WT2008	9,240	5,613	1,772	16,625	65	2.0
Dairy	Taranaki	Te Rua O Te Moko	6,583	2,462	1,744	11,060	26	0.5
Dairy	Waikato	Haerepo Trust	7,123	2,001	1,325	10,449	46	1.2
Dairy	Waikato	NB Paatara	6,818	2,903	1,338	11,059	54	1.2
Dairy	Wairarapa	Aute Te Case	5,888	5,451	1,575	12,914	37	0.6
		Average	**6,637**	**3,187**	**1,300**	**11,124**	**37**	**1.8**
		Std Deviation	**1,209**	**1,636**	**413**	**2,842**	**15.1**	**1.3**
S&B	BOP	Kapenga Drystock	2,705	767	286	3,758	19	1.8
S&B	BOP	Onuku Sheep/Beef	3,627	992	172	4,791	17	1.6
S&B	BOP	Taheke 8C	729	142	42	913	5	0.9
S&B	East Cape	Iwinui Station	2,650	806	89	3,545	18	1.4
S&B	East Cape	Marotiri Farm Partnership	1,269	707	25	2,001	7	0.8
S&B	East Cape	Paparatu Station	1,475	847	47	2,369	8	0.8
S&B	East Cape	Patemaru Station	2,392	1,037	80	3,509	11	2.2
S&B	East Cape	Nuhiti Station	1,499	778	19	2,296	7	0.6
S&B	East Cape	Hereheretau	2,420	2,554	76	5,050	15	1.7
S&B	Northland	Otakanini	3,080	819	241	4,140	12	1.5
S&B	Northland	Paua Station	2,553	625	149	3,327	6	6.1
S&B	Northland	Pouto Topu A Trust - S&B	3,430	714	39	4,183	19	0.5
S&B	Northland	Te Rangi	3,061	732	87	3,880	4	2.3
S&B	Northland	Omapere	2,731	866	376	3,973	7	5.0
S&B	Northland	Oromahoe Trust	1,768	484	149	2,401	7	1.5
S&B	Waikato	Oparau Station	2,813	1,053	69	3,935	9	0.4
S&B	Waikato	TB2 Upoko	2,697	850	127	3,674	14	1.4
S&B	Wairarapa	Owahanga Station	843	337	17	1,197	5	0.5
		Average	**2,345**	**847**	**116**	**3,308**	**11**	**1.7**
		Std Deviation	**845**	**481**	**99**	**1197**	**5.2**	**1.5**

Figure 1 gives the distribution and range of GHG emissions and compares dairy with S&B. As reported from other research, dairy emissions are higher than S&B and are related to the number of cows, use of N fertilisers, use of supplementary feed, effluent management, and soil type.

Figure 1: GHG emissions by farm type



Discussion

As can be seen from Table 3, the average total CO_2 equivalent emissions from the dairy farms was 11.1 Tonnes/ha, with a standard deviation of 2.8 T/ha. The range varied from 8 T/ha through to 16 T/ha. The 16 T/ha farm is based in Taranaki, and is run relatively intensely; 3.5 cows/ha, 1,315 kg MS/ha, total nitrogen input (via fertiliser, clover, and supplements) of 359 kg/ha, and total supplements imported onto the farm of 0.62 Tonnes DM/cow.

For the sheep & beef farms, average total CO_2 equivalents is 3.3 Tonnes/ha, with a standard deviation of 1.2 T/ha. The range was 0.9T/ha through to 5.0 T/ha. This latter figure was due to significant cattle numbers being run on the property.

The correlation between CO_2 equivalents emitted and nitrogen leach was also calculated, as shown in Table 4:

Table 4: Relationship between CO_2 emitted and N leached

	Total CO_2 vs N leached		N_2O vs N leached	
	Correlation	R^2	Correlation	R^2
Total Sample	87%	0.81	74%	0.62
Dairy farms	55%	0.44	37%	0.30
S&B farms	62%	0.38	38%	0.14

These figures are lower than those indicated by Smeaton et al (2011), who showed R^2 values of 0.90 for total CO_2 vs N leached. It is important to note though that;

(i) The Smeaton et al data was from modelled scenarios within a single farm, and

(ii) The sample (as per Table 2) is relatively small.

Emission Intensity

The intensity of CO_2 equivalent emissions was also calculated. For the dairy farms this was across milksolids production, whereas for the sheep & beef farms the calculation was somewhat cruder, in that the only information available was total stock units, and "kg liveweight sold/ha grazed" from Overseer. How this latter factor is calculated within Overseer is unknown, and its reliability is suspect – the figures calculated bear no relationship to actual intensities (ref Table 10).

The results are shown in Tables 5 and 6.

Table 5: Intensity of emission from the dairy farms

Farm	Farm Type	Hectares	Total kg/ha CO_2 e	Production (kg MS)	Intensity: kg CO_2/kg MS
Pukehina M3 Trust	Dairy	153	15,057	135,052	17.0
Parekarangi Dairy	Dairy	427	9,846	282,354	14.9
Pouto Topu A Trust - D1	Dairy	180	8,137	102,605	14.3
Pouto Topu Trust - D3	Dairy	250	7,955	146,169	13.6
Rangihamama	Dairy	171	10,998	180,000	10.4
Te Hore Farm Trust	Dairy	72	8,512	68,690	8.9
Ngatitu WT2008	Dairy	74	16,625	103,293	11.9
Te Rua O Te Moko	Dairy	186	11,060	185,871	11.0
Haerepo Trust	Dairy	290	10,449	350,000	8.7
NB Paatara	Dairy	133	11,059	112,022	13.1
Aute Te Case	Dairy	209	12,914	160,883	16.7
Average			11,124	166,085	12.8
Std Deviation			2,842	79,599	2.7

It is interesting to note that the farm with the highest absolute emissions (Ngatitu) has a relatively modest level of intensity of emission, which is below the average.

Table 6: Intensity of emission from the S&B farms

Farm	Effective Hectares	Total kg/ha CO_2 e	Total SU	Kg liveweight sold/ha	Intensity: kg CO_2/SU	Intensity: kg CO_2/kg LW sold
Kapenga Drystock	1,232	3,758	11,467	315	404	11.9
Onuku Sheep/Beef	855	4,791	11,347	702	361	6.8
Taheke 8C	952	913	2,386	244	364	3.7
Iwinui Station	1,254	3,545	11,361	214	391	16.6
Marotiri Farm Partnership	1,941	2,001	17,245	263	225	7.6
Paparatu Station	5,570	2,369	28,462	98	464	24.2
Patemaru Station	1,158	3,509	9,565	129	425	27.2
Nuhiti Station	1,770	2,296	9,057	244	449	9.4
Hereheretau	2,586	5,050	21,167	134	617	37.7
Otakanini	1,530	4,140	16,473	310	385	13.4
Paua Station	2,600	3,327	21,514	147	402	22.6
Pouto Topu A Trust - S&B	521	4,183	5,727	256	381	16.3
Te Rangi	2,100	3,880	21,000	149	388	26.0
Omapere	773	3,973	7,113	295	432	13.5
Oromahoe Trust	1,042	2,401	6,551	533	382	5.7
Oparau Station	515	3,935	5,801	530	349	7.4
TB2 Upoko	1,575	3,674	15,553	533	372	6.9
Owahanga Station	7,211	1,197	20,688	265	417	4.5
Average		3,309	13,471	298	406	14.5
Std Deviation		1,142	6,923	164	74	9.3

Emission by Governance Structure (Typology)

The total average CO_2 equivalent emissions by governance structure is shown in Table 7:

Table 7: CO2 Emission by Governance Structure

		Sample	Av Total CO_2 equiv Emission (kg/eff ha)
Dairy	Trust	8	10,771
	Incorporation	1	11,059
	Whanau Trust	2	12,569
S&B	Trust	9	3,727
	Incorporation	8	3,001
	Partnership	1	1,997

Note: These results are derived via OVERSEER, and hence do not include carbon sequestration via trees.

It is difficult to be too definitive on the differences between the total CO_2 equivalent emissions between the different entities due to the small sample size for several of the entities. For sheep & beef farms, with a similar sample size for both Trusts and

Incorporations, the total emissions from Incorporations is approximately 20% less than those from the Trusts. The main reason behind this is that a number of the Incorporation farms are being run less intensely relative to the Trust farms.

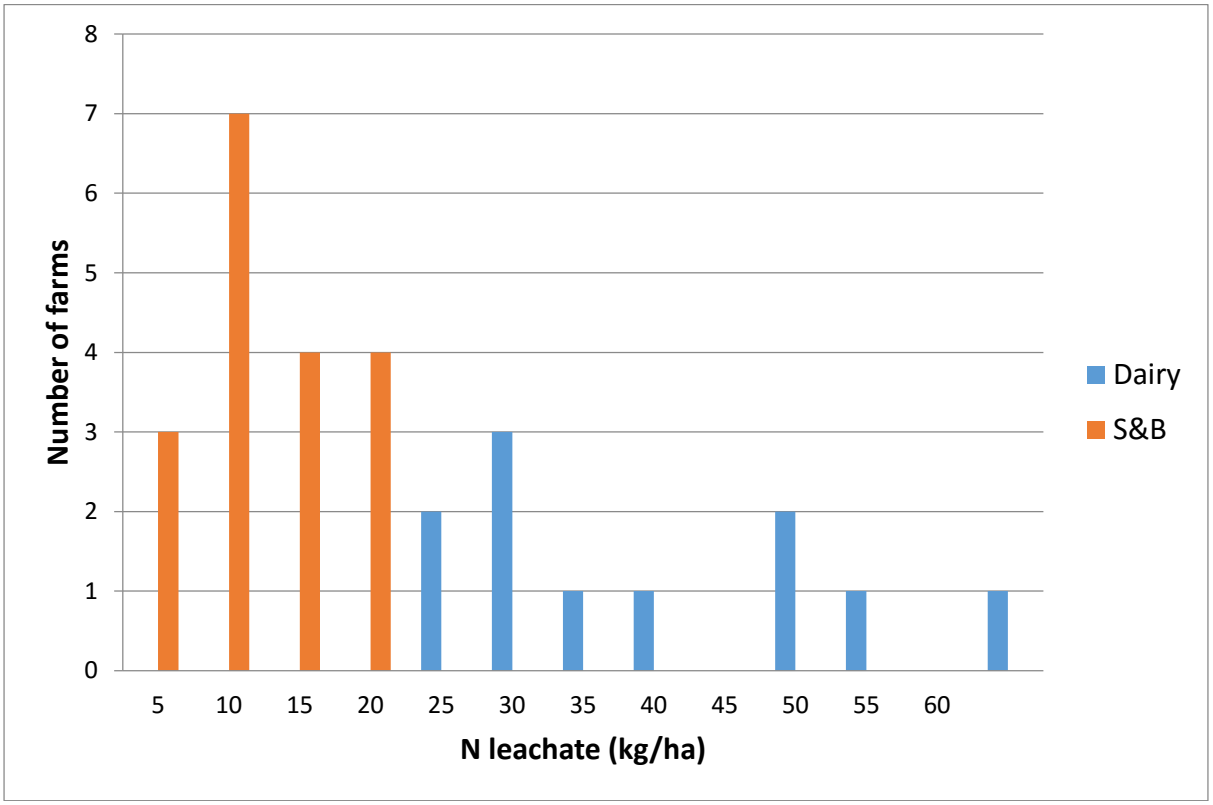
Those Iwi groups with multiple enterprises (e.g. several farms) are likely to have governance with a higher level of skills, and use consultants. In addition, most dairy farms would (a) use consultants, and (b) be much more likely to be pushing the farming system harder compared with sheep & beef farms.

Nutrient Discharge

As the Overseer modelling system also gives nitrate (N) and phosphate (P) emissions (to ground water) these results have also been reported to give a complete assessment of environmental impact.

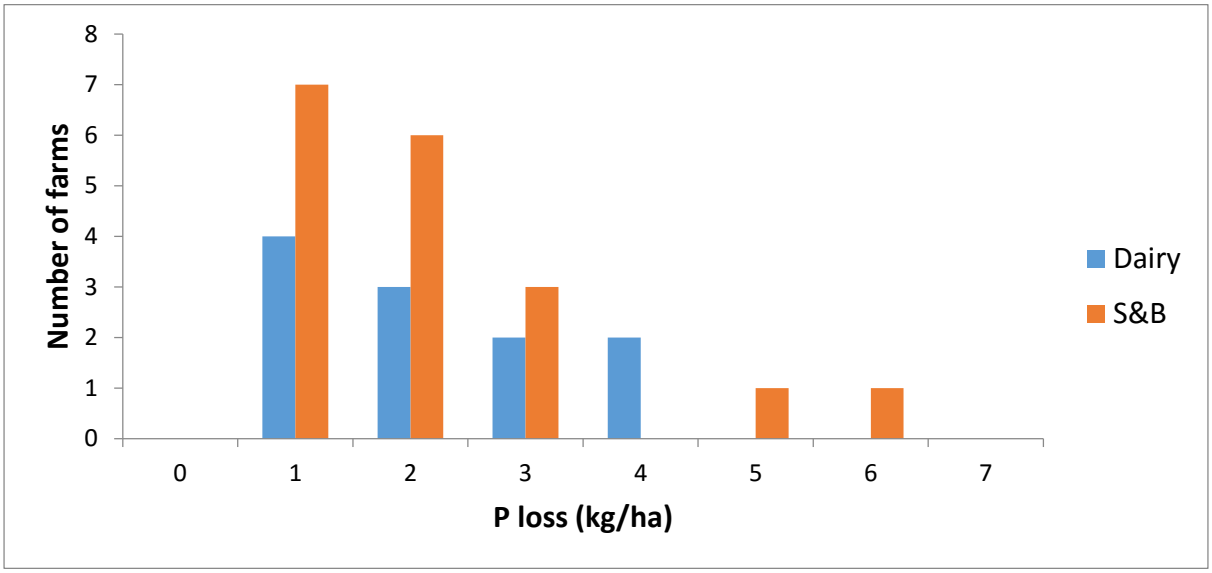
Figure 3 gives the distribution and range of N emissions and compares dairy with S&B. Dairy are significant higher than S&B and are related to similar factors that affect GHG (i.e. the number of cows, use of N fertilisers, supplementary feed, effluent management, and soil type).

Figure 2: N leachate by farm type



Although phosphate loss is not a major problem in most regions it can influence water quality in lakes and streams. Phosphate loss is given by farm type in figure 3.

Figure 3: Phosphate loss by farm type



To give context to these emissions a national benchmark was sought. The best available is the National Monitor farms assembled in 2011/12 run through Overseer and averaged for each region.

The National Monitor farms were originally run in Overseer 5.11. Thirty six dairy monitor farms from the Waikato/BOP region were rerun in Overseer 6.2. The average difference between versions was found to be +3.1% in total GHG. This was used to adjust all the averages for the regions in the National Monitor farm data to make them comparable to the Maori farms run in Overseer 6.2, as shown below.

Figure 4: Comparison of regional averages for Dairy farm GHG emissions

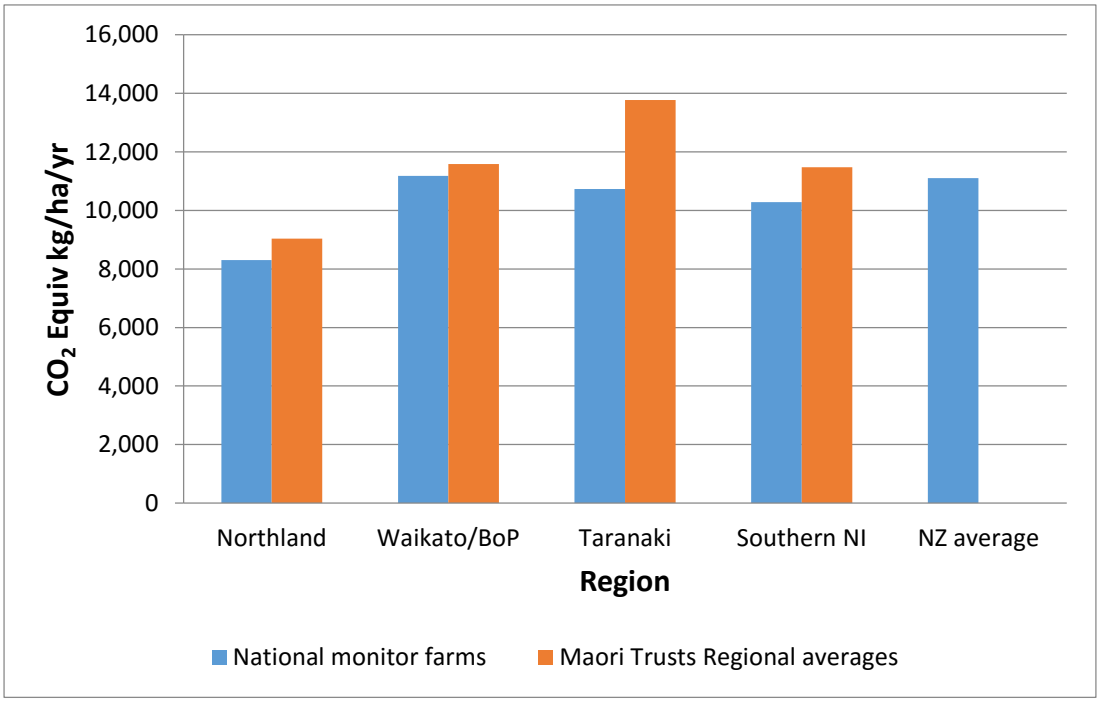
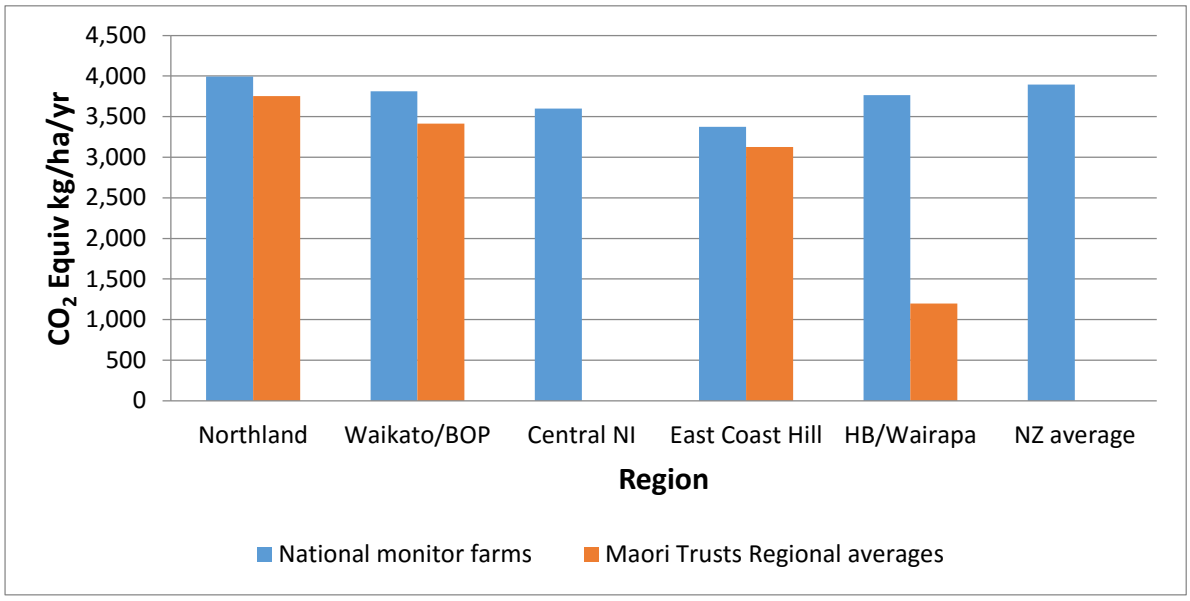


Figure 5 gives results that compare the Maori S&B farms in this project with the regional estimates from the National Monitor farms.

Figure 5: Comparison of Maori S&B farms GHG with National Monitor farms



From this it appears that the Maori dairy farms are reasonably on a par with the benchmark, albeit slightly higher, and with the Taranaki comparison clouded by the fact there is only 2 farms one of which is run quite intensively.

For the S&B farms, the Maori profile farms are below the benchmark, mostly because they are run less intensively. The Hawke's Bay/Wairarapa comparison is not valid as there is only one Maori profile farm involved.

Criteria for Selection of the Focus Farms

The criteria used to select the focus farms were:

(i) A geographic spread; the intent was to ensure a reasonable spread of farms around the country, and on differing soil types. With the bulk of the farms located in the North Island, the focus farms were distributed as widely as possible within the North Island (refer map below).

(ii) A mix of dairy and sheep and beef. Given there were 4 focus farms, the intent was that 2 would be dairying, and 2 sheep & beef.

(iii) Size; ideally there would be a range of farm size, albeit restricted given 2 farms of each type.

(iv) Intensity of farming. Again ideally a range of farming intensity to be represented by the focus farms.

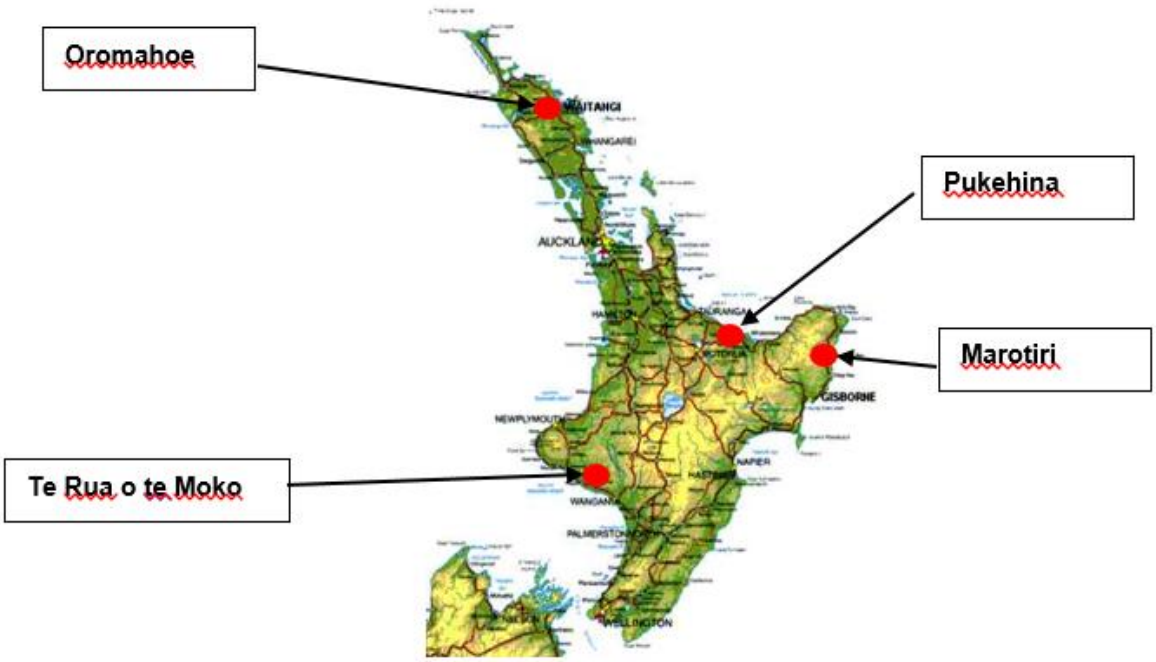
(v) Climate. This is linked to the geographic spread, but the intent was to look for farms in differing climate zones.

(vi) Able to benchmark current GHG emissions

(vii) Farm governance and management are agreeable to be a focus farm and to allow scrutiny via the discussion groups and the wider public.

(viii) The farm needed to have a consultant working with it, who was capable of using Farmax and Overseer.

Figure 6: Location of Focus Farms



Summary Description of the 4 Focus Farms

1. Te Rua o Te Moko Ltd

Ownership: Four blocks of land that were owned by 4 Ahuwhenua trusts and have formed a farming company. It also encompasses a treaty settlement. Awarded the Ahuwhenua Maori Farmer of the Year in 2014.

Location: Austin Road, Normanby, 10 km from Hawera.

Size: 209 ha (170 effective milking platform).

General description:	Spring calving system 2 to 3 dairy farm with sharemilker or contract milker.
Stock breeds:	Cross bred.
Replacement policy:	22%. R1 heifers grazed off until 20 months old.
Calving dates:	15 July.
Stocking rate:	2.94 cows/ha
Winter stock numbers (2014):	400 cows, 108 R2 in calf heifers. Peak milks 490 cows.
Calving %:	Not specified. 6 week in calf rate of 82-85%.
Milk production:	866-1,121 kg MS/ha. 301-385 kg MS/cow, 190,000 total MS.
Supplements:	Produces 70 t DM grass silage, 180 t DM maize silage. Buys in 200 t DM PKE. Also grows 15 ha turnips.
Grazing management:	Rotational grazing. An estimated 11 t DM/ha/yr grown. With low winter/early spring growth and very high late spring/early summer growth.
Topography:	71% flat, 23% rolling, 6% non-mowable.
Soil type:	Ash soils.
Fertiliser used (average last 3 years):	103-147 kg N/ha. Rest not specified. Soil test regularly and make fertiliser plans annually with Ballance.
Forestry:	Nil.
EBIT (or EFS) last 3 years:	$1,513-$1,696/ha.
Distance to:	
Nearest servicing town:	10 km (Hawera).
Nearest town >5,000 people:	
Nearest port:	New Plymouth (70 km)

2. Pukehina M3 Trust

Ownership:	Multiple Maori owners, administered by Te Pumu Paeroa
Location:	1993 State Highway 2, RD6, Te Puke
Size:	Total 160ha, effective 153ha
General Description:	Seasonal supply dairy, twice a day milking
Stock breed:	Friesian x Jersey cross
Replacement policy:	20% replacement rate. Grazed off from May to May.

Calving date:	Starts 7th July
Stocking rate:	2.78 cows/ha (effective).
Winter stock numbers:	450 wintered, 425 milked at peak
Production:	2011/12: 127,088 (830 MS/ha) 2012/13: 113,373 (741 MS/ha, drought) 2013/14: 149,491 (977 MS/ha)
Supplements:	
Grown:	6ha maize, 13 ha summer turnips
Purchased:	150tDM maize silage, 45t PKE.
Topography:	90ha flat, 70ha slightly undulating
Soil type:	Peat on flats, free draining sandy loam otherwise.
Fertiliser used:	2011/12 (kg/ha): 186N, 28P, 64K, 41S, 10Mg, 121Ca 2012/13 (kg/ha):142N, 5P, 13K, 32S, 6Mg, 57Ca
Forestry:	Nil
EbiT (or EFS) last 3 years:	2011/12: $344,047 = $2,250/ha (effective) 2012/13: $257,512 = $1,683/ha (drought)
Distance to:	
Nearest servicing town:	20km to Te Puke
Nearest town:	36 km to Tauranga
Nearest port:	36 km to Tauranga

3. Marotiri Farm Partnership

Ownership:	The farm is made up of 3 main blocks; the proprietors of Mangahauini 7 and other adjoining blocks, the proprietors of Tokomaru K5B, Pararaki Trust
Location:	Spread between Hikuwai and Te Puia, averaging 92 km from Gisborne.
Size:	4,400 ha, 2,350 ha effective, 250 ha pine forestry.
General description:	Sheep and beef breeding and finishing.
Stock breeds:	Cattle Angus, with some mixed breed cows, Romney sheep.
Replacement policy:	Romney sire with facial eczema resistance. Rate not specified.
Calving/lambing:	Mid points: MA cows 16 October, R2 heifers 16 September, old ewes 23 August, MA ewes and 2 tooths 2 September.
Stocking rate:	8.7 SU/ha; 45% sheep, 55 % cattle.

Lambing/calving %: 83 to 123% lambing, beef cows 83-87%.

Supplements: Corn waste purchased when required.

Grazing management: Ewes and cows are rotated on hills, during the year but set stocked for calving and lambing. After the ewes are weaned in November/December they go back on rotation. Bulls are in cell systems on flats and easy hill and rotated regularly. Lambs are finished on the flats and are set stocked until they require shifting or have reached target weights.

Winter stock numbers:

Cattle:	
MA cows	614
R1 heifers	214
R2 heifers	217
R3 heifers	164
Mixed sex calves	50
R2 bulls	496
R1 bulls	449
Breeding bulls	15
Total cattle:	**2,219**
Sheep:	
Mixed aged ewes	3,539
2th ewes	2,089
Terminal ewes	1,017
Ewe hoggets	1,967
Wether hoggets	759
Breeding rams	23
Total sheep:	**9,394**

Topography: 8% flat, 55% easy to medium hill, 37% steep hill.

Soil type: Mostly Mokau sandy loam and Whangamomona silt loam, but also Mohoenui silt loam, Wainstead clay loam, Matakaoa sandy loam, Patoka fine sandy loam.

Fertiliser used: Majority of fertiliser is superphosphate, but nitrogen or DAP 13S is used strategically if required. Average of 109 tonnes.

Forestry: 250 ha pines.

EbiT (or EFS) last 3 years: $108 to $192/ha.

Distance to:

Nearest servicing town: Tokomaru Bay, Tolaga Bay
Nearest town >5,000 people: Gisborne (92 km)
Nearest port: Gisborne 91 km.

4. Oromahoe Trust

Location:	470 State Highway 10, Oromahoe
Total Area:	1079 ha
Effective Grazing Area:	745 ha
Plantation Forest:	38 ha
Wetlands, waterways	136 ha
Buildings, races, yards	20 ha
Native Forest and Trees	140 ha
Farm Type:	Sheep and Beef, breeding ewe flock and beef finishing.
Stock Breeds:	Sheep: composite breeding ewes and replacements Terminal sires over hoggets. Cattle: predominantly Friesian bulls, traditional beef bulls preferred, some steers.
Replacement Policy:	Sheep: 20-25% replacements bred with composite rams Cattle: all cattle are bought in, age and weight range depending on price and availability
Lambing dates:	Ewes: September 7th - 12th Hoggets: September 20th
Calving dates:	No breeding cows
Stocking rate:	Standard stock units 5 year average 8.79 Weight based stock units 5 year average 10.47

Winter Stock Numbers		30/06/2014
Sheep	Breeding ewes	1,159
	Ewe Hoggets	360
	Mixed sex lambs	564
	Rams	18
	Total Sheep	**2,101**
Cattle	1 yr steers	59
	2 yr steers	39
	1 yr bulls	668
	2 year bulls	33
	Total cattle	**799**

Lambing %	Ewes 2014 lambing. (Average ~140%) 175%
Hoggets:	2014 lambing 84%
Wool Production:	3 year average 12,658 kgs, 17 kgs/ha

Beef Production:	Net beef production 291,474kgs; 391kgs/ha Lwt (2013/14)
Sheep Production:	Net sheep production 42,541 kgs; 57kgs/ha Lwt (2013/14)
Total Production:	346,673kgs; 465 kgs/ha Lwt
Supplements:	Variable - made on farm, 120 round baleage on average, none made in 2013/14
Cropping:	30 hectares. Plantain, Chicory
Topography:	Soil types - see soil and land classification provided

General Farm Management
Beef finishing predominantly bulls aiming at 300 plus carcass weight, some steers. Heavier bulls preferred if available (360+kg).

Sheep, breeding flock of composite ewes, hoggets are put to the ram, all lambs finished or transferred to second farm.

Grazing Management
Rotational grazing of all stock except for a very short period for ewes at lambing as they are shed.

The shedded ewes with lambs at foot are mobbed after a few days and rotationally grazed as soon as possible. Cattle are cell grazed through winter depending on weather and pasture damage.

Forestry:	Native Forest and Trees 140 ha mature forest and scattered trees Plantation Forest 38 ha Pinus Radiata with some plantation Totara 2 ha Pinus radiata planted 1994 - harvest 2028 309 ha Pinus radiata planted 1997/98 - harvest 2028 3.8 ha Totara from local seed. Planted 1997/98

EBIT	2011/12	2012/13	2013/14
	$187,981	$3,713	$69,893

Distance to:

Nearest servicing town:	Waipapa - farm supplies	15 km
	Moerewa - Stock processing	11.8 km
	Kaikohe - saleyards	22.8 km
Town greater than 5000	Kerikeri, 5,800 population	
Nearest port	Marsden Point	116 km

GHG and Leaching Profiles for the Focus Farms

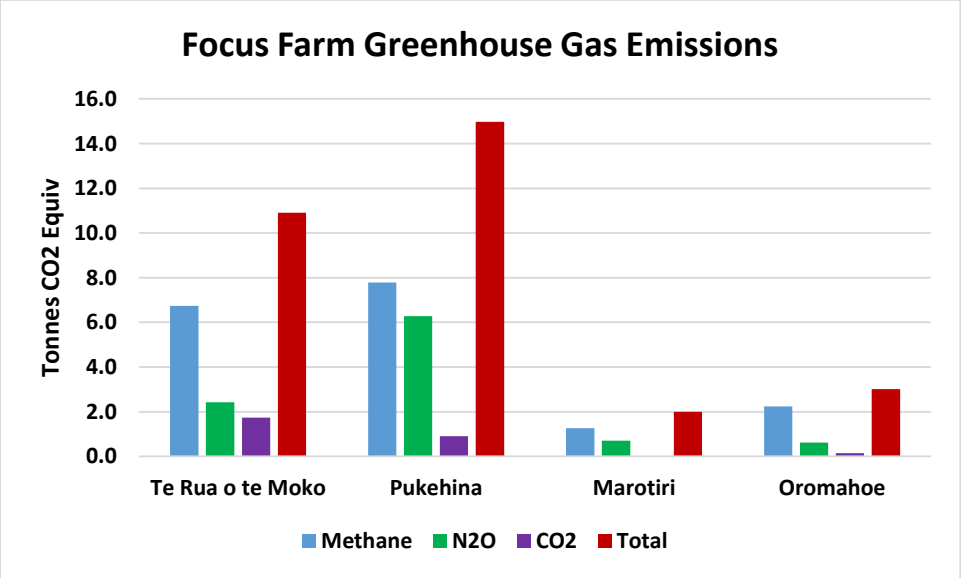
The following Tables and Figures show the base GHG emissions and nutrient losses for the four focus farms.

Table 8: Focus Farm GHG emissions (Tonnes CO_2 equiv) and Nutrient Losses (kg/ha)

	Methane	N_2O	CO_2	Total	Nitrogen	Phosphorous
Te Rua o te Moko	6.8	2.4	1.7	11.0	26	0.5
Pukehina	7.8	6.3	0.9	15.0	29	3.4
Marotiri	1.5	0.8	0.0	2.2	7	0.8
Oromahoe	2.4	3.0	0.1	5.5	7	1.5

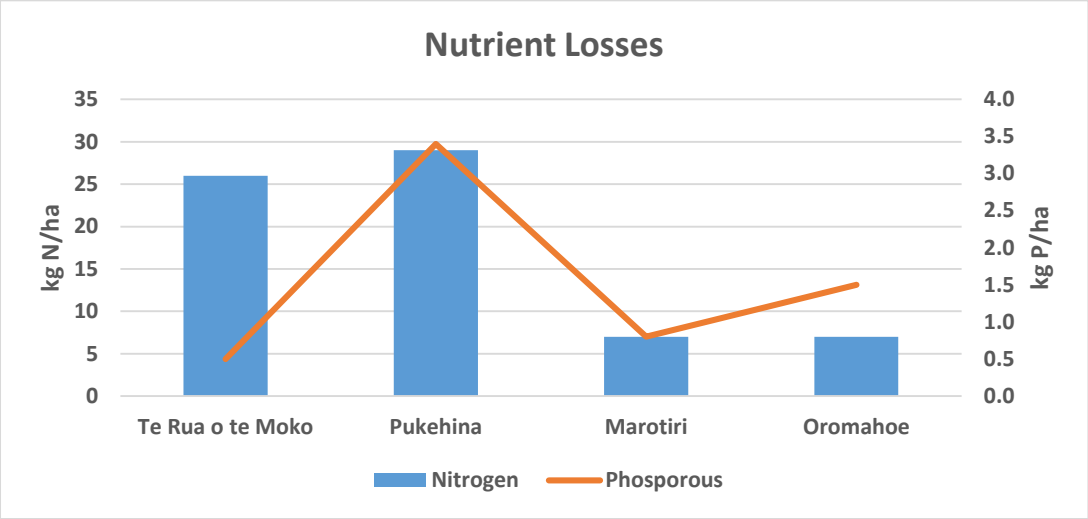
This is shown in graphical form, below.

Figure 7: GHG Emissions (Tonnes CO_2 equivalent/ha)



Note: Te Rua o te Moko, Pukehina = dairy farms, Oromahoe, Marotiri = sheep & beef farms

Figure 8: Nutrient losses (kg/ha)



Governance Structure

The governance structure of the Focus Farms is shown in table 9

Table 9: Governance Structure of Focus Farms

Farm	Type	Governance Structure
Pukehina M3	Dairy	Trust
Te Rua O Te Moko	Dairy	Trust
Marotiri Farm	S&B	Partnership
Oromohoe	S&B	Trust

While it was desirable to get a mix of governance structure amongst the focus farms, in the event other selection criteria took precedence.

Comment

(i) The figures show that Pukehina has a relatively high level of emissions, with a total emission of 15.0T CO_2 e/ha (cf profile group average of 11.1T/ha). This is mainly due to relatively high N_2O emissions as a result of the peat soil-type.

(ii) The emissions from the other 3 focus farm are within expectation, being around, or below, the group average.

(iii) Nutrient losses are well within expectation, with the exception of the phosphorous loss from Pukehina, which is slightly high. This loss is consistent over the whole farm, from both soil types; peat, and pumice.

(iv) The above factors are directly related to the initial modelling scenarios (discussed below), where each farm is looking at factors that would help mitigate losses relative to the issues they face.

(v) While the farmers are interested in GHG emission levels, they are not regarded as significant issues at this point in time. Currently, nutrient discharge levels are of far more interest to the dairy farms given the expectation of nutrient discharge limits.

(vi) There are a number of Maori cultural and economic factors which create tensions around GHG mitigations. These include:

- Matauranga Maori framework. From a Maori perspective, the management of land (and water) is a blend of cultural norms and modern practices. This includes balancing the productive aspect of land management with an environmental stewardship ethic.
- Maori land is owned by multiple owners, with often many shareholders per title. This ownership, usually based on a genealogical connection to the land, means that Maori land cannot, or won't ever, be sold. While this can present a variety of challenges, it does mean that Maori often take a very long term view of issues, which can assist with GHG emissions around forestry development.
- The politics of Maori land in New Zealand, coupled with recent Treaty settlements, has often resulted in a combination of an under-utilisation of that land, and/or a strong desire to improve the productivity/profitability from that land.

Overall therefore, there are some inherent tensions around potential GHG mitigations, and the intense pressure governance bodies are under to improve financial returns. Within the focus farms, the latter is certainly a dominant factor.

The intensity of emissions (based on actual production levels) are:

Table 10: Focus farm emission intensity

Farm	Hectares	Total kg/ha CO_2 e	Production (kg MS)	Intensity: kg CO_2/kg MS
Pukehina M3 Trust	153	14,970	135,052	17.0
Te Rua O Te Moko	186	10,901	185,871	10.9

Farm	Hectares	Total kg/ha CO_2 e	Production (kg meat & wool sold/ha)	Intensity: kg CO_2/kg production
Oramohoe Trust	1,042	2,401	156.2	15.4
Marotiri Farm Partnership	3,973	1,997	135.1	14.8

Mitigation Modelling Scenarios

The initial modelling scenarios for the focus farms (to be carried out in Year 2) were determined via discussions with the farm Trustees, farm managers, and their consultants. These scenarios are:

Pukehina

- Remove summer and autumn crops and replace with supplements
- Partial wintering facilities (on/off)
- In-shed feeding system
- Retire marginal land and increase forest plantings (3ha on Dry area, currently 50% relative productivity)

Te Rua o te Moko

- Replace maize with fodder beet
- Replace N fertiliser with low N feed (maize silage)
- Eliminate N fertiliser
- Remove summer and autumn crops and replace with supplements (maize silage/PKE)
- Retire marginal land and increase forest plantings (2 ha on Farm block – 60% relative productivity)

Oromohoe

- Impact of 100 ha Techno system for bull beef
- Retire 30 ha marginal land for forest plantings. Pinus or Totara.
- Replace 500 stock unit equivalents of finishing cattle with store lambs for finishing for winter/spring slaughter.
- Improve lambing percentage from 135% to 160%

Marotiri

- Eliminate N fertiliser
- Increase sheep to beef ratio; currently 44% sheep, 56% cattle – change to:
  (i) 50/50
  (ii) 60/40
- Retire marginal land and increase forest plantings. 50ha on Mangahaini block, currently 40% productivity cf rest of block.

Programme Summary for Year 1

This programme has an ambitious aim to assist Māori farmers in New Zealand to improve their collective capacity to increase resource efficiency and farm productivity while lowering greenhouse gas (GHG) emissions and an equally ambitious key objective of establishing a national network of Maori farming entities from which modelling of mitigation options on 4 case study farms will be used to communicate to the wider industry.

The team has met all milestones and while there remains 1 farm still to be entered into the profile network they do have a number of issues that are being worked through but we are confident that they will come on board. The size of this entity and their profile within the Maori agribusiness sector has meant that they are cautious about their involvement.

This is the first national network of Maori farms established for a research project and it has received interest from a number of research organisations wanting to leverage the network for related research projects.

Engagement and collaboration in this project by the Maori farming community has been excellent. 29 of the planned 30 sample farms have been recorded in detail and run through Overseer with the help of numerous agricultural consultants and farm managers. 11 dairy farms and 18 drystock have participated and these are scattered over almost every region in the North Island.

Results in terms of GHG emissions indicate there is significant variation in GHG emission between farms, with dairy generally averaging 11,100 kg CO_2 e/ha/yr and drystock averaging 3,300 kg CO_2 e/ha/yr. When compared to a national benchmark from farm monitoring farms the dairy result was found to be slightly higher (perhaps indicating greater intensification) and the drystock farm less than the benchmark. Four focus farms have been identified and in consultation with stakeholders, practical mitigation options have been identified and will be tested in the next year.

Other results;

- Within the dairy farms there was a wide range of intensities (CO_2/kg MS) calculated, with a variety of reasons behind this, from intensity of farming system through to soil type.
- The relationship between governance structure and GHG emissions was difficult to differentiate due to the small sample.
- The relationship between total CO_2 equivalent emissions and nitrogen leaching was relatively poor.

It is important to note that while the CO_2 emissions have been modelled via Overseer, the model does not incorporate carbon sequestration in forestry blocks. This aspect will be included in the scenario modelling scheduled in Year 2, to give a more accurate picture of the net CO_2 emissions from the focus farms.

We are in discussions with a number of related projects including: (1) NZAGRC funded *Integrated Farm Systems* (led by Robyn Dynes, AgResearch); (2) SLMACC funded

Co-benefits (led by Mark Shepherd, AgResearch); (3) DairyNZ PGP funded *Managing GHG emissions* (led by Cecile de Klein, AgResearch); (4) MPI SFF funded *Maori benchmarking and monitoring framework* (led by FoMA) and (5) MBIE funded *Forages for reduced nitrate leaching* (led by Ina Pinxterhuis, DairyNZ).

The synergies with these projects strengthen the programmes relevance to the wider industry and the foundation for the projects sustainability beyond the term of the NZAGRC funding.

The following paper has been submitted; Kingi, T.T., Wakelin, S., Journeaux, P., & West, G. *Collective land tenure systems and greenhouse gas mitigation among Māori farmers in New Zealand*. In Pan Pacific Indigenous Resource Management. Ed. D'Arcy, P. (in press). Canberra: Australian National University Press.

References

Smeaton, D.C., Cox, T., Kerr, S., Dynes, R. 2011. *Relationship between farm productivity, profitability, N leaching and GHG emissions: a modelling approach*. Proc NZ Grasslands Association, 73 57-62.