Data Supermarket

Land Use Opportunities for Aotearoa

GUIDANCE DOCUMENT

AGRESEARCH

Tables of mitigation effectiveness for reducing Nitrogen, Phosphorus and Greenhouse Gas emissions for contrasting dairy types

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HOW TO USE THIS INFORMATION

A dairy typology classification system was used to develop 24 dairy types based on wetness, topography and soil properties (see table below, and also Smith et al. accepted).

Estimates of nitrogen (N) and phosphorus (P) losses were modelled for each dairy type, with N loss ranging from 17 to 141 kg N/ha while P loss ranged from 17 to 141 kg N/ha while estimates of P loss ranged from 0.5 to 6.4 kg P/ha (see "Dairy types and N, P and GHG losses" in the Data Supermarket). One of the dairy types ('Irrigated + Easy + Poorly drained': type number 20) had no data on existing dairy farms available in DairyBase, therefore it was not possible to model estimates of losses, nor assess mitigation effectiveness (see below), for this type.

The tables of mitigation effectiveness contain information on the effectiveness of a range of mitigation measures aimed at reducing N and P losses to water for the range of dairy types.

Mitigation effectiveness is presented as the estimated minimum and maximum percentage change in N and P losses compared to a farm where mitigations were not imposed, where a negative value corresponds to an increase in loss.

The tables also include data on the impact of these mitigations on greenhouse gas (GHG) emissions. Greenhouse gas emissions are split into:

- the short-lived gas methane (CH_4) and
- long-lived GHGs nitrous oxide (N_2O) and carbon dioxide (CO_2).

Methane emissions are reported as kg CH_4/ha/year, whereas the long-lived gases are reported as CO_2 equivalents (kg CO_2e /ha/year), where N_2O is converted to equivalent CO_2 emissions using the 100-year time horizon global warming potential of 298 kg CO_2-equivalent per kg N_2O (Forster et al. 2007).

Sources of CH_4 include enteric fermentation and manure management, N_2O is emitted from manure management and N fertiliser use, and includes indirect emissions, while CO_2 emissions relate to losses following urea application to land.

Modelled estimates of CH_4 emissions ranged from 198 to 495 kg CH_4/ ha, N_2O emissions ranged from 1333 to 3498 kg CO_2e/ha and CO_2 emissions from urea fertiliser dissolution following application ranged from 177 to 770 kg CO_2e/ha (see "see "Dairy types and N, P and GHG losses" in the Data Supermarket).

As for N and P, the impact of mitigations on GHG emissions is presented as estimated minimum and maximum percentage change (again, where a negative value corresponds to an increase in loss). When considering the percentage change, it is important to note the relative contributions of CO_2 and N_2O to the total long-lived gas emissions. Carbon dioxide emissions represent approximately 10-25% of the long-lived gas emissions.

Users can select the relevant dairy types table that represents the area of interest (based on the wetness, topography and soil properties – see table below) for estimating minimum and maximum percentage change in N, P, CH_4, N_2O and CO_2 losses.

Primary attribute	Class within attribute	Description
Wetness	Dry	farms where mean annual rainfall was less than 1100 mm
	Irrigated	farms where >50% of the farm area is irrigated
	Moist	farms where mean annual rainfall was between 1100 and 1700 mm
	Wet	farms where mean annual rainfall exceeded 1700 mm
Topography	Flat	flat or undulating (0-7°)
	Easy	rolling (7-15°)
Soil	Light	soils, defined as having plant available water holding capacity to 60 cm (PAW60cm) of less than 85 mm
	Poorly-drained	soils, classified as having ‘imperfect’, ‘poor’ or ‘very poor’ soil drainage classes
	Well-drained	soils, classified as ‘well’ or ‘moderately well’ drained.

Below is a table of the mitigation measures applied to representative dairy farms across all or some dairy types. These measures were aimed at reducing losses of N and P to water and were also assessed for any potential co-benefits and/or trade-offs, CH_4, N_2O and CO_2 emissions.

The data on percentage change in N, P and GHG losses provides pastoral farmers and rural professionals with information to guide initial conversations on options to reduce losses to water and air.

For catchment-scale or farm-scale analysis of mitigation measures, alternative and more detailed sources of information are recommended (e.g. catchment-scale modelling, farm-scale decision support tools).

Management strategy	Mitigation measure	Details	Alignment to typology structure
Nitrogen management	**Low risk months**: Judicious scheduling of N fertiliser to avoid risk months	No N fertiliser applied May, June of July	All
	20% less: Reducing excessive inputs of N in fertiliser and feed*	Fertiliser N reduced by 20%. High N supplements (By-products like PKE, 2.72% N) changed to lower N supplements (Maize grain/silage, 1.3%N/1.14%N, Barley grain 2.0%N or wholecrop silage 1.6%N).	All
	0 N: No N fertiliser applied to pastures*. Forage and grain crops still receive N.	Animal numbers and production adjusted accordingly	All
Off-paddock management	**Standoff pad**: Use of a standoff pad (sawdust, bark and woodchip base) for May, June, July and August	50% of animals on pad for 18 hours/day May and August 100% of animals on pad for 18 hours/day June and July	All
	Wintering pad: Uncovered wintering pad (sawdust, bark and woodchip base)	100 % of animals on June and July, 50% in August	All
	Wintering barn: Covered wintering barn (concrete base, regularly scraped)	100 % of animals on June and July, 50% in August	All
Effluent management	**Optimum area**: Effluent area increased so that total K inputs (fertiliser + effluent + supplements) are less than 75 kg K/ha.	Effluent area increased from average of 28% of farm to between 60% and 90% of farm.	All
	No N on effluent areas: Targeting N fertiliser applications to non-effluent areas*	No N fertiliser applied to effluent areas	All
	Deferred: Effluent stored and only applied between August and April	No effluent applied in May, June, or July	All
	Low-rate: effluent application	Effluent applied via low-rate application and actively managed to avoid overland flow or ponding	All

Management strategy	Mitigation measure	Details	Alignment to typology structure
Edge of field attenuation	**Wetlands:** Install an artificial wetland into farms in typologies that contain rolling contour or poorly-drained soils.	The wetland covered 2% of the catchment area which was set to 80% of the milking platform	Poorly drained soils and farms on rolling slopes
Irrigation management 1	**Irrigation poor → good**: Reduced overwatering by adjusting application depth via sensors to meet deficit target. Irrigation was previously applied at a fixed depth and fixed timing	Irrigation management was by means of soil moisture sensors with irrigation scheduled at 50% to 70% of PAW depending on soil type. Irrigation applied to achieve a soil moisture target of 95% PAW.	Irrigated farms where irrigation is applied at a fixed depth and fixed timing.
Irrigation management 2	**Irrigation average → good**: Reduced overwatering by adjusting application depth via sensors to meet deficit target. Irrigation scheduling was previously performed via a water balance model	Irrigation management was by means of soil moisture sensors with irrigation scheduled at 50% to 70% of PAW depending on soil type. Irrigation applied to achieve a soil moisture target of 95% PAW.	Irrigated farms where irrigation scheduling is done via a water balance model.

* Pasture production was reduced due to mitigation measure.

REFERENCES

Forster P, Ramaswamy V, Artaxo P, Berntsen T, Betts R, Fahey DW, Haywood J, Lean J, Lowe DC, Myhre G, et al. 2007. Changes in atmospheric constituents and in radiative forcing. In Climate Change 2007: The Physical Science Basis; Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change; Cambridge University Press: Cambridge, UK; New York, NY, USA, 2007; p. 996.

Smith C, van der Weerden T, Selbie D. 2023. Quantifying co-benefits and trade-offs of mitigation measures to reduce dairy farm N and P losses to water on greenhouse gas emissions from New Zealand dairy systems. J. New Zeal. Grasslands, (accepted).