Milestone report NZ Equine Trust - - Nutrient Management

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The primary objective of this project was to provide a pragmatic pathway or if possible solution for the inclusion of horses within the regional councils' nutrient regulation process. The primary focus was the New Zealand Thoroughbred breeding industry as accurate animal and farm data is required for the implementation of Overseer quantification of equine farm nutrient loss by 2029.

We are fortunate to have made significant progress towards this goal with the current project. A summary of what has been completed and where we as an industry need to go with research for industry participants and stakeholders is included in Appendix 1. The brief information page distributed via the New Zealand Thoroughbred Breeders Association on Facebook is included as Appendix 2.

Papers and conference presentations are included in the reference list.

List of tasks / milestones within application

Objective Number	Objective	Tasks
1	Systematic literature review and collection of NZ production data	Compilation of known equine production data for New Zealand from the literature and collection of data via field trials where required

2	Tabulation / collection of production data and generation of weighted average estimates	Generation of weighted average estimated
3	Testing data within Overseer	Testing data within overseer
4	Compilation of production systems literature	Compilation of known equine system data for New Zealand and collection of data via field trials where required
5	Development of farm classification model	Generation of preliminary farm classifications
6	Model equine classification systems	Refinement of classification to most robust options
7	Identification of limitations in horse and farm level data	Development of research objectives to backfill gap and ranking in order or priority

Objective 1 Systematic literature review and collection of NZ production data

Systematic literature reviews have been conducted. Pasture utilisation and management data has been obtained from some selected trials. The material is being collated into an industry friendly reference –"New Zealand Equine Farm guide" [1-3]

Objective 2 Tabulation / collection of production data and generation of weighted average estimates

Production data has been collated and industry weighted averages estimated for most parameters. Input data and weighted averages are being collated into an industry friendly reference –"New Zealand Equine Farm guide".

Objective 3 Testing data within Overseer

Early production data values were entered into Overseer and preliminary tests for biological plausibility were conducted. It became obvious that the input pasture consumption values suggested for horses in Overseer required revision. Using data obtained in the earlier literature review we reverse engineered the suggested pasture consumption values in Overseer to generate Equine relative stock units (EquineRSU) for the major classes of equine livestock. These values and the process to develop these are included in a manuscript currently under review [4](Chin et al, Animal Production Science) and have been presented at the Farmed Landscape conference [5].

Objective 4 Compilation of production systems literature

During this phase we identified the limitation in the data on nutrient loss and the validation of our early deterministic quantification of the per horse nitrogen loss. To validate this data and generate real world data we have collected pasture growth and feed demand data from a cohort of

horses managed on a small block of land at the Massey University Large Animal Teaching Unit. On the "model farm" we have prospectively collected water runoff, taken soil samples and used in- field suction cups to measure nitrogen in the ground water. The preliminary results of this study were presented at the 2022 Farmed landscapes conference [6], and demonstrated support for our deterministic modelling of per animal nitrogen loss. To ensure robust data to reflect the fluctuations throughout the full season we will continue to collect data until March 2023.

Using stock reconciliation data and feed budgets previously collected on local commercial Thoroughbred stud farms we have been able to model and test how best to address the issue of seasonal changes in stock numbers and the feeding of supplements to youngstock. The preliminary findings from this work have been presented at the 2023 Farmed Landscapes conference [7]

Objective 5 Development of farm classification model and Objective 6 Model equine classification systems

The initial plan was to develop farm classification models for the main equine industries. To a large extent the development of the Equine relative stock units (EquineRSU) and the seasonal adjustments developed and described in objective 4 have negated the need for this. The most pragmatic (and accurate) approach to use with Overseer has been to develop the seasonal adjustments for the equine RSU's for each stock class which are modified at the point of entering data into Overseer rather than attempting to develop complex models within Overseer. The preliminary findings from this work have been presented at the 2023 Farmed landscapes conference [5], and will be presented in a manuscript for submission.

Objective 7 Identification of limitations in horse and farm level data

At this stage we appear to have generated accurate animal level estimates for nitrogen turnover and loss for horses managed under New Zealand pasture-based conditions. The farm level data is a more complex issue. The modelling based on our historical farm data indicates that for these farms we have been able to retrospective obtain biologically plausible outputs. Preliminary work has identified that the farm level correction factors may change with increasing farm scale. This still requires testing and validation to ensure these can be applied in a regulatory process to generate sensible and biological plausible data.

Summary:

The findings from this project have provided a robust platform describing nutrient loss and nitrogen turnover at a horse and farm level. As a result of the data presented at the recent farmed landscape conference we are now working with the development team at Overseer^{TM} so they can upload our preliminary data and workings into the revised Overseer^{TM} model. This represents a major step forward for the equine industry. This collaboration will ensure fair and equitable consideration of horses within the regulatory process.

References

1. Chin, Y.Y.; Rogers, C.W.; Gee, E.K.; Stafford, K.J.; Cameron, E.Z. The pattern of breeding and management within the New Zealand Thoroughbred breeding industry 2005–2015. 1. The stallion population. *Animal Production Science* **2022**, -, doi:https://doi.org/10.1071/AN21388.
2. Chin, Y.Y.; Rogers, C.W.; Gee, E.K.; Stafford, K.J.; Cameron, E.Z. The pattern of breeding and management within the New Zealand Thoroughbred breeding industry 2005–2015. (II) The mare population. *Animal Production Science* **2022**, -, doi:https://doi.org/10.1071/AN21534.
3. Adams, B.R.; Gee, E.K.; Back, P.J.; Rogers, C.W. Defecation behaviour reduces horse's utilisation of pasture. *New Zealand Journal of Animal Science and Production* **2021**, *81*, 74-80.
4. Chin, Y.Y.; Back, P.J.; Gee, E.K.; Horne, D.J.; Rogers, C.W. The quantification of Relative Stock Units for horses within a pasture-based production system *Animal Production Science* **2023** - *under review*.
5. Chin, Y.Y.; Back, P.J.; Gee, E.K.; Horne, D.J.; Rogers, C.W. The quantification of Relative Stock Units for horses within a pasture-based production system. In *Diverse solutions for efficient land, water and nutrient use*, Christensen, C.L., Horne, D.J., Singh, R., Eds.; Farmed Landscapes Research Centre, Massey University, : Palmerston North, New Zealand, 2023; Volume Occasional Report No. 35.
6. Martin, N.P.; Adams, B.R.; Horne, D.L.; Linton, S.; Back, P.J.; Rogers, C.W. Horses, grazing and nitrogen in soils. In Proceedings of the Adaptive Strategies for Future Farming. , Palmerston North, 2022.
7. Chin, Y.Y.; Linton, S.; Sclater, J.; Back, P.J.; Gee, E.K.; Horne, D.J.; Rogers, C.W. Seasonal fluctuation of livestock numbers on equine stud farms and the impact on modelling of farm level nitrogen leaching. In *Diverse solutions for efficient land, water and nutrient use*, Christensen, C.L., Horne, D.J., Singh, R., Eds.; Farmed Landscapes Research Centre, Massey University, : Palmerston North, New Zealand, 2023; Volume Occasional Report No. 35.

Appendix A **Equine farm nutrient management research to date and future direction (overview document to key stakeholders – December 2022**

Appendix B **Facebook article for industry on nutrient loss in the horse compared to a cow**

Appendix A: Equine farm nutrient management research to date and future direction

Chris Rogers [1,2], Penny Back [1], Erica Gee[2], David Horne[1], Yin Chin[2], Natalia Martin[1], Hannah Airey[3], Sally Linton[4]

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Background

The Waikato Regional Council's Healthy Rivers Plan Change 1 (PC1) required large-scale farming operations located within the catchment area of Waikato regional council to calculate a nitrogen loss baseline and comply to the regional council's nutrient management plan. This will be required for equine properties by 2029, when the regulations are implemented.

Overseer® is currently used as the primary tool to estimate farm level nutrient cycles and management for regulatory purposes.

Challenges relevant to the equine industry

- The variables within the Overseer® software that estimate animal (horse) feed intake, nutrient excretion, nitrogen distribution and leaching are based on ruminant physiology, and the dairy and beef farming systems (Watkins & Selbie 2015), not monogastrics like horses.
- At present Overseer does not consider the selective grazing and latrine behaviour in horses, or the livestock management characteristics on equine farms (seasonal fluctuation on horse numbers, class and stocking density).
- The basis of estimated nitrogen excretion and therefore leaching is the feed intake. Feed intake is currently estimated using revised stock unit (RSU) which is a modification of stock unit (annual feed requirement for a 54 kg ewe to rear a single lamb to weaning). The RSU is currently upscaled for horses based on the bodyweight difference in relation to a "standard ewe". This method fails to account for:
    - Metabolic scaling: Metabolism does not increase linearly as weight increases, but at the rate of the power of 0.75 (less than 1), meaning the modified horse RSU overestimates feed intake.

- Equine specific requirements: Differences in energy requirements for various physiological processes (growth, exercise, lactation, pregnancy).

Knowledge gaps

- There was a lack of published data on nitrogen utilisation and excretion by horses.
- Nitrogen deposition pattern and nitrogen loss in drainage have not been investigated or quantified for horse paddocks.
- Current Overseer® model assumptions for ruminants could lead to overestimations and the modelled *vs* on-farm values have not been investigated.

Research and findings

Research project: Deterministic modelling of nitrogen utilization and excretion in horses.

Findings: Nitrogen excretion in ruminants, particularly sheep (0.62 g/ kg BWT), is higher than horses (0.18 in racehorse, 0.48 g N/kg BWT in Thoroughbred mares) at a per kg liveweight basis.

Research project: Quantification of nitrogen intake for equine stock classes using equine specific models, and comparison to values obtained using current RSU within the Overseer®.

Findings: The estimated N intake by Overseer® is 52%-108% higher than that of those estimated using equine specific model indicating overestimation of nitrogen intake for horses by the model. This over-estimation translates to over-inflation of nitrogen excretion and subsequent nitrogen leaching estimations.

Research project: Seasonal fluctuation of livestock numbers on equine stud farms and the impact on modelling of farm level nitrogen leaching.

Findings: The true feed consumption was modelled for a real commercial stud farm using an in-house equine feed budget model that accounted for seasonal variation in the different equine stock classes. This "true feed demand" was then compared with estimations obtained within Overseer®. We identified Overseer had an estimated feed demand 47% greater than the modelled true feed consumption.

Research project: Soil nitrogen, drainage quantities and drainage nitrogen concentration were collected from the "Massey mini equine farm" and compared to Overseer estimated using original and the modified input variables (from earlier projects).

Findings: The soil nitrogen concentration in the "latrine" area was higher than in the lawn reflecting higher N loading rate in the rough/ latrine area. The nitrogen leaching per ha was 19 kg N/ha vs 34 kg N/ha estimated using original baseline variables in Overseer (~ 50% over estimation by the model compared to empirical data). Using the modified input variables from the earlier equine projects in Overseer resulted in agreement between Overseer and actual N leaching.

Summary:

The findings to date demonstrate that the original input assumptions within Overseer® ignores the differences in physiology and biology between ruminant and horses. This results in overestimation of nitrogen intake and excretion by approximately 50%. Ignoring the seasonal fluctuation in stock numbers on equine farms compounded this error and overestimated feed demand. Combined, these overestimations inflate equine farm level nitrogen leaching.

The use of modified input variables (modified RSUs, and seasonal adjustment for stock levels) resulted in agreement of Overseer estimates and real data collected from the Massey University "mini equine farm".

What's next:

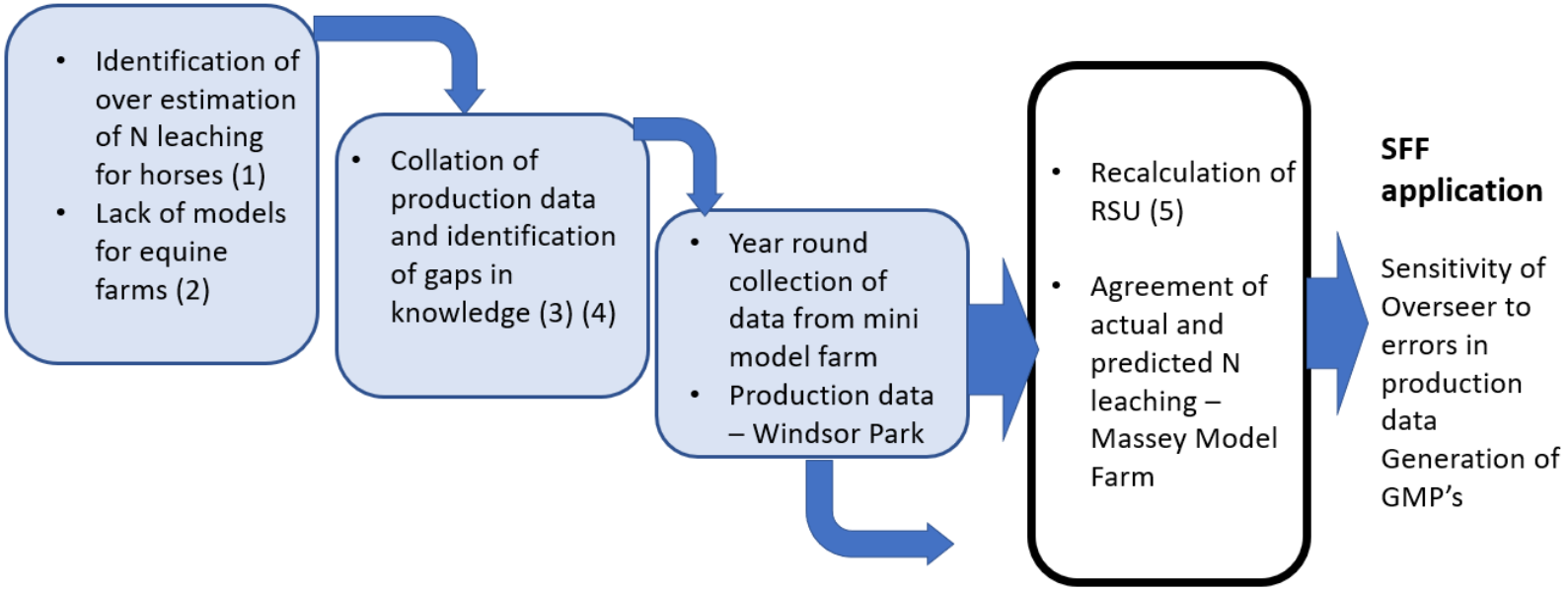
We have made great progress in the last year in solving some of the major problems for modeling nitrogen leaching and horses. However, validation of the modified input variables has only been testing on a very limited small scale "Massey mini equine farm". We now need to test if the modified input variables work in a real-world setting - commercial equine farm(s).

The focus on the commercial farms will be to obtain real world data on pasture utilization (via pasture plating and feed budgets) and identification of the best model to describe the changes in stock numbers associated with increases during the breeding season and subsequent destocking (such as does this pattern differ between farms and with farm size).

Key information to be collected and analyzed in 2023/24.

- Soil samples for nitrogen loading profile
- Pasture mass / pasture on offer and feed demand (including supplementary feed offered)
- Stocking density
- Seasonal stock numbers with stock class break down (dry mare, pregnant mare, resident/non-resident mares, stallions, weanlings (weaning age), yearlings)
- Fertilizer application (what applied, when and quantity)

Timeline and progress to date



2019 WRC hearings & Submissions → 2020 & 2021 → 2022 NZ Equine Trust funding obtained → 2022 – 2023 SFF application

References

Manuscripts:

- (1) Chin, Y. Y., Back, P. J., Gee, E. K., & Rogers, C. W. (2019). Deterministic modelling of nitrogen utilisation by horses managed under pasture-based, intensive and semi-intensive systems with different levels of pasture intake. *New Zealand Journal of Animal Science and Production, 79*, 1-7.
- (2) Chin, Y. Y., Back, P. J., Gee, E. K., & Rogers, C. W. (2019). Livestock and pasture management on commercial Thoroughbred breeding farms: implications for estimating nitrogen loss. *New Zealand Journal of Animal Science and Production, 79*, 65-70.
- (3) Chin, Y. Y., Rogers, C. W., Gee, E. K., Stafford, K. J., & Cameron, E. Z. (2022). The pattern of breeding and management within the New Zealand Thoroughbred breeding industry 2005–2015. 1. The stallion population. *Animal Production Science*, -. https://doi.org/10.1071/AN21388
- (4) Chin, Y. Y., Rogers, C. W., Gee, E. K., Stafford, K. J., & Cameron, E. Z. (2022). The pattern of breeding and management within the New Zealand Thoroughbred breeding industry 2005–2015. (II) The mare population. *Animal Production Science*, -. https://doi.org/10.1071/AN21534
- (5) Chin, Y. Y., Back, P. J., Gee, E. K., Horne, D.J & Rogers, C. W. (2023) The quantification of relative Stock Units for horses within a pasture-based production system (under review – Animal Production Science).

Conference presentations:

- Rogers, C. W., Back, P. J., Gee, E. K., Chin, Y. Y., Linton, S., & Wark, A. (2020). *Predicting nutrient loss - what to do with equine properties?* Paper presented at the Proceedings of the Farmed Landscapes Research Centre Annual Workshop.
- Martin, N. P., Adams, B. R., Horne, D. L., Linton, S., Back, P. J., & Rogers, C. W. (2022). *Horses, grazing and nitrogen in soils.* Paper presented at the Adaptive Strategies for Future Farming. , Palmerston North.

Appendix B: facebook post and short guide for New Zealand Thoroughbred Breeders Association. Distributed via the NZTBA facebook page and reshared via a number of equine pages.

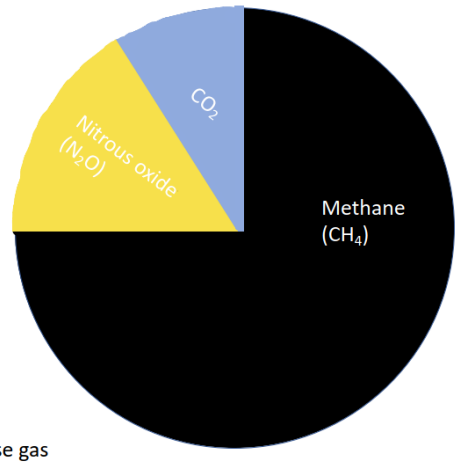
Agricultural greenhouse gas emissions

Agriculture contributes 48% to New Zealand's green house gas emissions.

Dairy, beef and sheep make up 97% of all agricultural greenhouse gas emissions in New Zealand.

Horses and other non-ruminants contribute ~3% of all agricultural greenhouse gas emissions in New Zealand.

Methane is the main greenhouse gas produced by the agricultural industry making up a total of 29.4% of New Zealand's total greenhouse gas emissions.



Excess phosphorus leached from animal urine promotes the growth of algae in the water ways causing harm to the sea life and water quality.

Nitrous Oxide is the most potent of the gases and makes up approximately 7% of New Zealand's total greenhouse gas emissions.

N_2O emissions contribute approximately 17% of agricultural emissions.

92.5% of gross nitrous oxide comes from agricultural soil mainly due to urine and dung.

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500kg Dairy cow (ruminant)

Cattle are the number one source of agricultural greenhouse gas emissions in New Zealand with a single cow emitting approximately 100kg of methane a year.

As a cow ruminates (regurgitates food and re chews it) it releases CH_4 (methane gas) into the atmosphere.

Image modified from Wikihow

CH4 is released through the cattle's bowel movements.

52% of the Nitrogen consumed by a cow is excreted via urine and 28% in the dung.

Cow manure is a source of direct Nitrous Oxide (N_2O) emissions.

Fresh cow urine can have phosphorus concentration levels of 305mg/L and total ammonia nitrogen concentrations of 105mg/L.

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Cow's rumination process leads to the release of CH_4, a contributor to New Zealand's greenhouse gas emissions. Cows also excrete more nitrogen than horses.

450kg Broodmare (monogastric)

Horses are monogastric hindgut fermenters and are not able to burp or regurgitate and therefore do not release CH_4.

30-40% of Nitrogen consumed by a horse is excreted via urine and 25% in dung.

0.14kg of N and 0.033kg P are found in a day's worth of manure (14kg) from a 450kg horse

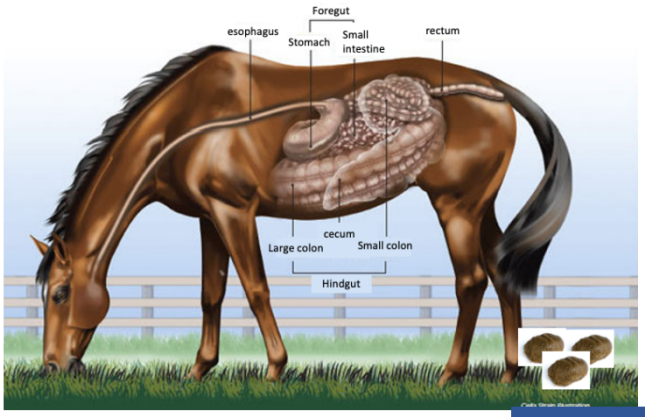
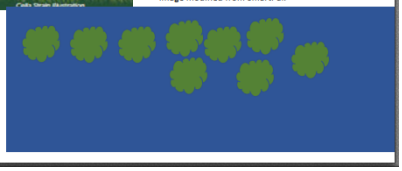


Image modified from SmartPak

If horse manure is not managed appropriately when composting N_2O (nitrous oxide) can form. Dry aerobic conditions provide an environment more conductive for N_2O production.

There is currently no data on N_2O levels produced from a single horse manure.



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Horses excrete less nitrogen than cows and do not release methane gas as they are not ruminants. Horses release very little toxic gas into the environment.