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Applying *equine*RSU and seasonal livestock correction to wider equine stud farm types

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ABSTRACT

To adjust for potential overestimations in the nitrogen excretion by horses within Overseer®, a revised stock unit system has been proposed (*equine*RSU). These *equine*RSU were generated and validated using a medium-sized equine farm as a model farm. The aim of this study was to test the application of the *equine*RSU and seasonal stock number adjustment on a more complex farming model. Livestock numbers and management data were captured prospectively for the base property (128.8 ha) of a large multi-property commercial breeding stud (3 support properties, 556 ha total area) between June 2022 and May 2023. The monthly on-farm metabolisable energy (ME) requirement and pasture demand were deterministically modelled with both a customised feed budget using livestock class and weight or using the *equine*RSU and monthly adjusted stock numbers. There were multiple complex movements of horses on and off the property in the different stock classes across the year, with stock management reflecting seasonal periods of high stocking density. There was good agreement (6% variance) between actual ME demand (complex feed budget) and estimated feed demand (simplistic equineRSU model) of 4,387,187 MJ vs 4,102,770 MJ. This suggests that the *equine*RSU could be used on complex equine farm systems within Overseer®.

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Introduction

Under the Plan Change (PC1), the proposed plan to manage freshwater quality within the Waipa and Waikato River catchment, the commercial equine properties located within the district would be required to quantify and comply with regulatory restrictions on nutrient loss (Waikato Regional Council 2024). This regulatory change primarily affects the New Zealand Thoroughbred breeding industry due to the commercial scale

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of the breeding operations, and the majority of breeding farms being concentrated within the Waikato basin (Gee et al. 2017).

For quantification of nutrient cycling and leaching, Overseer® will be used as the primary regulatory tool. The revised stock unit (RSU) system is currently used to represent annual energy requirement of animals under this classification. The RSU is the same as the traditional stock unit (SU) which represents the annual feed demand of a 54 kg ewe producing a single lamb to weaning (Wheeler 2018a). Within the Overseer® model, the RSU is used to estimate feed and nutrients consumed (Wheeler 2018b). Feed and nutrient consumed contributes to the estimation of nitrogen (N) excreted by animals, which is one of the key inputs for estimating the N leaching on a farm (Wheeler 2018c).

Within the software program, horses are currently classified as an 'other' enterprise and considered an upscaled ruminant (Chin, Back et al. 2023). It has been demonstrated that the default RSU values within Overseer® for horses lead to overestimation in the energy requirement and subsequently, N intake and excretion (Chin, Back et al. 2023). This overestimation was primarily driven by directly upscaling RSU values based on bodyweight in relation to a 54 kg ewe without accounting for metabolic scaling and ignoring the differences in physiology between ruminants and horses (Chin, Back et al. 2023). As N excreted is the key input for N leaching estimation in Overseer® (Wheeler 2018c), an overestimation of feed and nutrient intake can potentially cause significant inflation of whole farm N leaching estimation. Subsequently, this can cause biased restriction on stock numbers and have severe consequences on the ability of the industry to operate commercially.

To prevent a potential overestimation, the *equine*RSU was developed using equine-specific models for energy requirement estimation at animal level (Chin, Back et al. 2023). Published data were used as the basis of the model to represent the current consensus of estimates for equine energy requirements. The estimations created using *equine*RSU were compared with published values, which demonstrated that they are reflective of horse biology and industry norms, and that they addressed the metabolic scaling issue and should minimise the overestimation in energy requirement and therefore feed intake (Chin, Back et al. 2023).

Although overestimations at animal level are minimised using *equine*RSU. One issue remains when conducting whole farm estimations. From a regulatory standpoint, assessment is based on the farm level output. The farm level energy demand would be affected by the annual stock number and their seasonal fluctuations. For equine enterprises, only one stock number value can be inputted into Overseer® for each stock class for the year when performing whole farm analysis. Therefore, the system cannot account for the seasonal fluctuation of farm metabolisable energy (ME) demand with variation in stock numbers, as typically occurs on equine breeding properties. Therefore, equineRSU was applied alongside a weighted seasonal stock adjustment approach to account for seasonal change in stock class numbers. This approach has been demonstrated to provide a simple and effective solution for modelling whole farm energy demand within Overseer for medium-sized single property equine breeding farms (Chin, Gray et al. 2023) with predictions of 6% variation from actual annual farm demand.

This modelling approach was tested first on the single property farming model as this farming model represents a large number of the Thoroughbred stud farms in New

Zealand. However, there are a number of larger Thoroughbred enterprises that utilise a different farming model where a base farm and supporting properties would be used to enable management of a larger number of horses without placing a strain on pasture quality and feed supply. Therefore, the livestock management and fluctuation can be different and more complex within these operations. While numerically small these multiple property operations are responsible for the management of a large proportion of the national Thoroughbred broodmare population. The livestock management pattern and stock number fluctuation on multi-property farm type have not been reported previously. The *equine*RSU and the seasonal weighted stock adjustment approach have not been applied to this farm type. Therefore, there needs to be a greater understanding of the differences between the two farming models, and the suitability of the weighted stock adjustment approach with *equine*RSU on multi-property Thoroughbred farming model needs to be investigated.

The aim of this study was to describe and model the livestock movement and management of horses on a large multi-property Thoroughbred stud farm and test the application of *equine*RSU and weighted stock adjustment approach in estimating annual farm ME demand.

Methods

Stock numbers and grazing management

Livestock numbers and management data were captured prospectively on a large commercial Thoroughbred breeding farm (556 ha) located in the Waikato region between June 2022 and May 2023. The base farm monitored operated as a stallion station, with mares and youngstock rotating in to be bred with the resident stallions and then transported to one of the satellite farms once the mares were mated and verified in-foal (pregnant).

The effective farm area and the size and location of paddocks were obtained using the measuring function in Google earth in conjunction with the farm map. For each paddock, the livestock class, number of stock, dates of the animals entering and exiting from the paddock, and the supplement (type, brand and quantities offered per day) were obtained from data recorded on the feed room farm map and data extracted from the farm's integrated financial and livestock management system (Ardex technology, Australia, https://www.ardex.com.au). The stock number and paddock sizes were then used to derive stocking density (horse/ha) for each paddock. The dates entering and exiting from a paddock were used to calculate rotation length (number of days).

Pasture mass

Pasture mass (kg DM/ha) measurements were obtained using a manual rising plate meter (Jenquip, New Zealand, https://www.jenquip.nz) on four occasions, early (19th Sep 2022) and late (22nd Nov 2022) breeding season, mid-summer and autumn (20th Feb 2023, 24th May 2023). At each sampling date, three to eight representative paddocks were sampled for each of the equine livestock classes. Pasture mass data was not obtained for all livestock classes on all four occasions due to some classes of equine livestock not being present on the main farm during sampling period (i.e. mares during mid-summer). The pasture plate meter was calibrated following instructions provided in manufacturer's instruction manual (Jenquip 2017).

Dry matter intake from supplements

The supplement offered was recorded on an *as-fed* basis (wet weight). Therefore, the feed offered was converted to dry matter weight (kg DM) based on manufacturers details (for equine feeds) and published data for hay and baleage (NRC 2007).

Estimated total metabolisable energy requirement

To estimate the farm level annual feed supply and demand, the farm level metabolisable energy (ME) requirements were modelled using a customised feed budget based on monthly pasture growth and stock numbers (Rogers et al. 2017). The feed budget spreadsheet estimated feed supply and demand using the pasture mass estimates (rising plate meter measures), quantities of supplements offered each category of livestock class (as recorded), number of animals in each livestock class, their ME requirements based on bodyweight estimates and predicted growth rate obtained from the published literature. The models and assumptions for daily ME requirements have been previously described in Chin, Back et al. (2023).

Estimated farm metabolisable energy requirement using equine*RSU*

The ME requirements were modelled using the *equine*RSU (Table 1) and the weighted average monthly stock number within each equine livestock category. The weighted average monthly stock number was calculated using the monthly stock numbers obtained from the farm's livestock management software (Ardex Technology, Australia, https://

Table 1. The *equine*RSU (horse-specific revised stock unit) for Thoroughbred (TB) broodmares and young horses adapted from Chin, Back et al. (2023).

Stock class	Liveweight ± SD (kg)	equineRSU
TB dry mares	576 ± 33[A]	5.64
TB Broodmare and foal	576 ± 33[A]	9.21
Working horses		
Recreational horses light work	547 ± 67	6.29
Racing TB	454 ± 35	8.46
Sport horse	533 ± 63	7.34
Stallions[B]	590	7.34
Growing TB 6–12 months	248 ± 54 (6 months) 365 ± 54 (12 months)	6.12

Note: One revised stock unit represents 6000 MJ ME required annually.
[A]Liveweight of mares is the weighted average and pooled standard deviation derived from values reported for dry mares, mares in late pregnancy (5th month) and lactating mares.
[B]Stallion energy requirement modelled using NRC 2007 recommendations for stallion (590 kg) covering 70–90 mares per day during breeding season.

www.ardex.com.au). The estimates from the *equine*RSU model were then compared to the estimates from the prospective feed budget model.

Results

Farm area

The farming operation had a total area of 556 hectares (inclusive of 3 support properties). The effective area of the stallion station (farm studied) was 128.82 ha. The median (min–max) paddock sizes were 1.22 (0.27–2.21) ha.

Stock class and movements

The farm had six resident stallions that were each individually set-stocked in a paddock year-round and two shuttle stallions (stallions from northern hemispheres) that are brought onto the farm over the breeding season. Prior to the breeding season, the farm was lightly stocked (Figure 1). In July and August pregnant mare numbers increased with the arrival of mares to foal and be mated during the breeding season (1 September to mid-December). Associated with this, was an 8–10-fold increase in livestock numbers over the breeding season starting from (June). Once mated and confirmed pregnant,

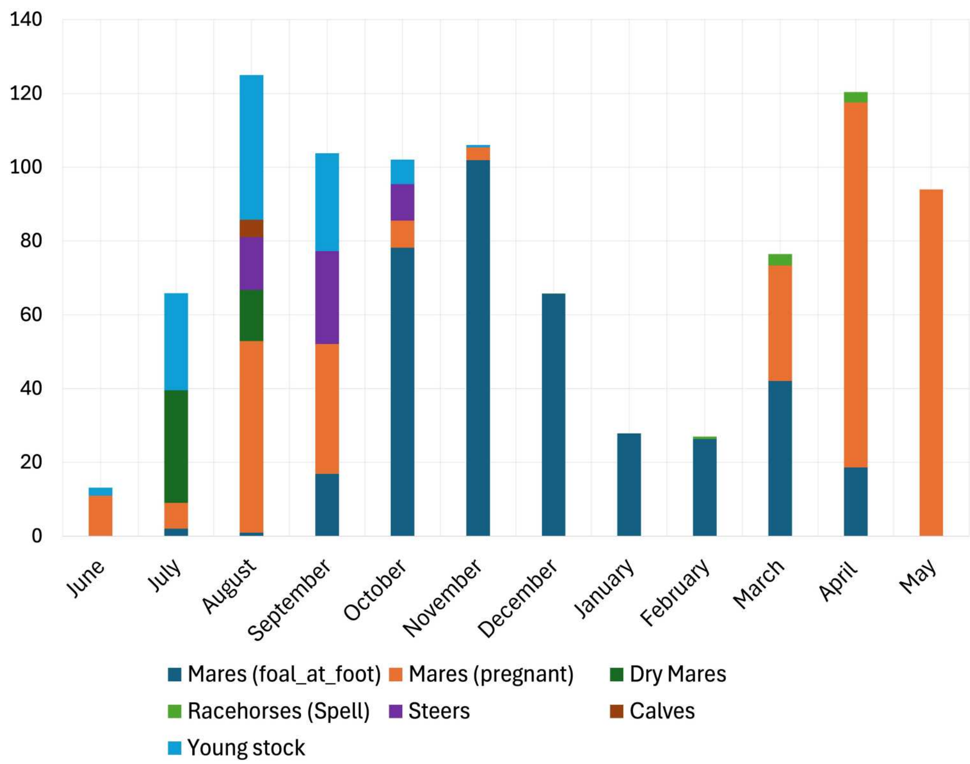

Figure 1. Seasonal stock number fluctuation between June 2022 and May 2023 on a commercial equine stud farm in Cambridge, New Zealand.

mares and foals were moved to the support farms. During the busy yearling sales season (January–February) there were a small number of horses on the farm (mares with foals at foot). From March onward, foals were weaned and sent to one of the support farms, and a small number of pregnant mares remained on the farm. There was a 4-fold increase in stock number during autumn (March–May) compared to summer (February), which was associated with mares returning to farm for weaning. Other non-breeding stock on the farm included a limited number of spelling racehorses (racehorses taking break from racing), mixed aged steers (14–25 depending on month) and weaner calves ($n = 5$).

Grazing and feeding management

The pasture mass at the time of sampling across the different livestock classes (mares and youngstock) was between 1700 and 2000kg DM/ha. Non-pregnant and non-lactating mares (empty or dry mares) were kept in the largest mobs (10 ± 0.5 horses) and at the highest stocking density (6.9 ± 1.4 horses/ha) compared to all other equine stock classes. Mares with a foal at foot were kept at the lowest stocking density (2.9 ± 1.2 mares/ha). All other stock classes were kept in mobs of 4–5 horses at a stocking density of 3–4 horses per ha. Horses were either set-stocked or strip grazed in the same paddock for 1.5- 2 months regardless of the stocking density and paddock sizes. Concentrate feed and supplements were provided across all livestock classes and seasons. These accounted for 30% for mares and up to 75% for spelling racehorses of the horse's daily energy requirements, with the remaining feed demand provided by pasture (Table 2).

Metabolisable energy model

The annual ME demand for each stock class estimated using the feed budget and *equineRSU* are presented in Table 3. Within the feed budget model, the majority (79.8%) of the whole farm ME demand was due to pregnant or lactating broodmares. There were few empty broodmares carried on the property and they only contributed 3% to the total farm ME demand. Youngstock (weanlings and yearlings) contributed only 9.9% of total farm feed demand, reflecting the low numbers of these two stock classes managed on the farm. The annual ME demand estimated using the *equine*RSU for the non-pregnant broodmares and stallions was in close agreement with the feed budget values. The *equine*RSU values underestimated feed demand by 5% for the pregnant broodmares and underestimated feed demand by 23% the youngstock class (n = 9). Consequently, the annual whole farm ME demand predicted from the *equine*RSU (4,102,770 MJ) calculation was 6% lower than the ME demand that was estimated within the feed budget (4,387,187MJ).

Discussion

The stock movement pattern on this multi-property farm system was different and more complex than the previously modelled single property farm systems. On single property breeding farms, the farm-owned mares and young stock typically account for over 40% of the equine livestock, and reside on the farm year-round (Rogers et al. 2007; Chin, Gray

Table 2. The pasture, grazing and feeding management data collected between June 2022 and May 2023 on a large multi-property commercial stud farm in Cambridge, New Zealand.

	Rotation length (days)	Paddock size (ha)	Stocking density (n/ha)	*N* horses/ paddock	Concentrate offered (kg DM/horse/day)	Roughage offered (kg DM/horse/day)	% Energy requirement from concentrates and supplement feed	Average pasture cover (kg DM/ha)
Mares with foals	44 ± 25	1.2 ± 0.4	2.9 ± 1.2	3 ± 1	3.2	0.7	32%	1756 ± 377
Pregnant mares	36 ± 16	1.5 ± 0.4	3.5 ± 2.9	5 ± 4	3.2	0.7	34%	1656 ± 377
Dry mares	36 ± 17	1.6 ± 0.26	6.9 ± 1.4	10 ± 0.5	–	–		1662 ± 201
Weanlings	52 ± 31	0.9 ± 0.2	4.5 ± 1.1	4 ± 1	2.4	0.7	31%	1685 ± 137
Yearlings	16 ± 6	1.2 ± 0.14	3.4 ± 0.61	4 ± 1	2.4	2.6	44%	1719 ± 450
Racehorses (spelling)	49 ± 10	0.3 ± 0.01	3.8 ± 0.7	1 ± 0.5	4.8	–	75%	1745
Ruminants	10 ± 3	1.31 ± 0.4	4.1 ± 1.8	5 ± 3	–	–		–

Table 3. The metabolisable energy (MJ ME) demand of different equine stock classes present on a large multi-property commercial stud farm in Cambridge, New Zealand estimated using feed budget and *equine*RSU model.

Stock class	MJ ME (Feed budget)	MJ ME (*equine*RSU)[a]	% Difference	% of total farm ME (Feed Budget)
Broodmares (non-pregnant)	129,599	128,592 (3.8)	−0.78%	3%
Broodmares (pregnant/lactating)	3503,945	3321,126 (60.1)	−5%	79.8%
Youngstock[b]	436,239	335,340 (9)	−23%	9.9%
Stallions	296,752	295,068 (6.7)	−0.57%	6.8%
Racehorses	20,652	22,644 (0.6)	9%	0.5%
Total	4387,187	4102,770	−6%	

[a]Values in bracket represent the monthly average equine stock units for calculation of ME using *equine*RSU.
[b]Youngstock includes weanlings and yearlings.

et al. 2023). In the current study, mares only resided on the farm for the short period of time associated with foaling and being mated. Once confirmed in-foal (pregnant) the mares were transported to the supporting farms. Mares and their foals returned to the farm in autumn for weaning and shortly after weaning, the weanlings were moved to one of the support properties and continued to be kept at pasture until they entered yearling preparation, and mares were sent to another support property. The farm was effectively rested in June with only 13 horses present on the farm. As a result, the seasonal fluctuation of livestock numbers in this study was more complex and greater compared to a single property farm system. Livestock numbers increased 10-fold in the current study compared to the typical 2-fold increase observed from autumn/winter to spring (breeding season) on single property breeding farms (Rogers et al. 2017; Chin et al. 2019).

The class of equine livestock and the seasons, when stocking rate was highest, were reflected in the provision of supplementary feed to the horses. Mares were provided with ~30% of their energy requirement in supplementary feed, which reflects the industry norm of providing supplements to mares in late gestation, and the provision of supplements to mares with foals at foot prior to the start of weaning (Rogers et al. 2007; Chin, Gray et al. 2023). During mid-summer (at the time of yearling sales) and winter, mares are typically provided a ration consisting predominantly of pasture. The multi-property base farm followed in this study was effectively destocked during these periods with the mares being grazed on the support properties.

The *equine*RSU was developed to provide an accurate estimation of annual ME demand for different equine livestock classes within Overseer®, under the assumption of a simple property commercial management system (Chin, Back et al. 2023). A pragmatic approach to deal with an increased complexity within the management system and movement of horses on and off the property within Overseer® is the use of monthly weighted average estimates of the number of animals in the different equine livestock classes. This approach has been validated for single property medium-sized farms (Chin, Gray et al. 2023). In this study, it was demonstrated that this approach also provides good agreement between actual farm ME demand and estimations using *equine*RSU when applied on a large multi-property stud farm despite a greater complexity in stock movement.

While there was good agreement between the approaches, the *equine*RSU calculation resulted in a 6% under estimation of ME demand when compared with the farm feed budget. This may reflect some of the inherent loss in sensitivity when a monthly weighted annual stock number for each livestock class is used instead of daily values in the feed budget. The complexity of the seasonal stock movements may also have introduced some bias into the ME demand estimates for stock class with large changes in feed demand across the season (such as lactation or growth). This was observed in the youngstock and broodmares (pregnant/lactating) which had a different seasonal stocking rate compared to the typical single property farm system assumed within the *equine*RSU model.

In the typical system, youngstock are present on the farm from weaning (5-6 months old) to 12–14 months of age (yearlings). Therefore, the *equine*RSU accounts for energy demand from 6–12 months, a period of rapid growth and increasing feed demand. During autumn (March to May) on this multi-property system, mares with foals at foot (categorised within the *equine*RSU as pregnant/lactating mares) were brought onto the farm for the weaning process. At the completion of the weaning process mares and weanlings were then sent to different properties. Hence, the young stock carried on the farm consisted of individuals that were essentially yearlings (on farm during July, August and September) and thus would have had a much greater feed demand than would be predicted from an annualised *equine*RSU which describes the annualised energy demand of a weanling with growth through to a yearling. In the pregnant/lactating broodmare category, the peak energy demand occurs immediately post-foaling and during the first month of lactation which coincided with the period of peak number of mare present on the farm. The *equine*RSU annualises the energy demand, thus effectively underestimated the actual demand as the majority of broodmares were on the property for mating and left once confirmed pregnant.

Most Thoroughbred stud farms will occasionally have spelling racehorses (racehorses having a break between training preparations) on the farm as these are future replacement breeding stock (typically fillies). The *equine*RSU models the energy demand for racehorses in full work while spelling racehorses (such as those on this farm) would have had reduced energy requirements. Thus, the overestimate of 9% was not unexpected. This stock class constituted only 1-2% of total stock numbers within a given month and only 0.5% of the whole farm ME demand, which is typical of the expectation within the Thoroughbred breeding industry.

Conclusion

The findings in the current study demonstrate the robustness of the *equine*RSU and seasonal adjustment in estimating whole farm ME demand for various equine farm system types and complexity. This approach provides a pragmatic integration within the current Overseer modelling framework. Many equine breeding farms do not routinely use feed budgets to monitor pasture feed supply and demand and thus have limited estimates of annual farm ME demand. However, most commercial properties use equine farm management systems for the billing of clients and reproduction records. Data on horse numbers in the different stock classes can be easily extracted and used with the *equine*RSU within Overseer® to assist with nutrient management.

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Data availability statement

Data are available on request from the authors.

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