Pasture production under pressure despite improvements in sheep and beef livestock performance

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Abstract

Pastoral hill country landscapes are the cornerstone of New Zealand's sheep and beef sector. A growing body of evidence indicates that pasture productivity gains in New Zealand have stagnated or, in some cases, declined over recent decades. The use of methods to back-calculate animal intake from livestock energy requirements and energy concentration of pasture on offer, has proven effective in the assessment of home-grown feed for dairy, and to a limited extent, for sheep and beef. This paper explores the complexities of extracting similar information to that of Gobilik et al. (2021) to extend regional data (Class 4 lower North Island Hill Country) beyond 2011 to current times using data from the B+LNZ Sheep and Beef Farm Survey. Our analysis suggests that estimated feed demand has remained flat despite continued gains in livestock reproductive performance indicators, consistent with heightened pressure on pasture supply. This divergence is critical for livestock managers where home-grown feed is so prominent in terms of forage supply. The present analysis relied on stock-unit based feed-demand proxies rather than a comprehensive set of animal production characteristics, and further work is needed to integrate detailed farm-level measurements and improved estimates of livestock liveweight and liveweight changes, to improve the assessment of pasture productivity trends.

Keywords: grazing, herbage, livestock efficiencies, livestock requirements, pasture productivity

Introduction

Pastoral hill country landscapes in lowland (<1000 m above sea level) comprise about 4 million ha of New Zealand's land mass, about 15% of the total area of the country. These landscapes, comprised of flat (11%), rolling (32%) and (40%) steep slopes, are the cornerstone of New Zealand's sheep and beef sector and are home to >4,500 sheep and beef farms (B+LNZ 2020). The sector is overwhelmingly reliant on fresh forage supply consumed *in situ* (Morris and Hickson 2016; Rys et al. 2021). The livestock carrying capacity of these farms is considered low compared with intensive lowland livestock systems. Averaged across the country, hill country farms carry about 7.5 livestock stock units (SU; 1 SU = 550 to 600 kg DM consumed (Nicol and Brookes 2007; Gobilik et al. 2021) consuming about 4,100 to 4,500 kg DM per grazed ha (B+LNZ 2020). Averages, however, disguise the large variability in pasture production per unit of land area (herein pasture productivity) that exists both within and between farms across the hill country (Vibart et al. 2021).

A growing body of evidence indicates that pasture productivity gains in New Zealand have stagnated or, in some cases, declined over the past three to four decades (Gobilik et al. 2021; Mackay et al. 2022; Mackay et al. 2023; Chapman et al. 2024). Analysis of dairy performance data (i.e., DairyBase) has provided further insights into the cost of the decline in pasture (plus fodder crops) consumed over the last three decades. Neal et al. (2019) reported that each additional tonne of herbage grown and consumed (t DM/ha) was associated with an increase of about $300 in net operating profit per hectare. However, an equivalent estimate for the sheep and beef sector remains to be determined, limiting our ability to fully assess the impact of changes in pasture productivity.

The stagnation and declining pasture growth trends are occurring despite expectations of pasture yield enhancement under certain conditions such as increased CO_2 levels in the atmosphere and warmer temperatures (Butler et al. 1990; Korte et al. 1990; Lieffering et al. 2016; Keller et al. 2021). The pasture productivity trend is supported by data from a limited number of long-term grazing trials where pasture growth has been directly measured (e.g., Mills et al. 2021; Mackay et al. 2022) and/or by analyses of sector-wide animal production datasets. On the latter, using a theoretical metabolic energy budgeting framework, Gobilik et al. (2021) suggested an estimated 11% and 14% decline in pasture productivity and pasture consumed, respectively, in southern North Island Hill Country between 1980-1981 and 2010-2011. The decline in net herbage accumulation (NHA) was largely attributed to warmer and drier summer conditions, which constrained

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herbage accumulation and utilisation. Despite this decline, there have been considerable improvements in the productive and reproductive efficiencies of livestock such as improved feed conversion efficiencies and lambing percentages (Mackay et al. 2019; Mazzetto et al. 2023). The complexities of extracting similar information to that of Gobilik et al. (2021) for the lower North Island Hill Country in Taranaki-Manawatu using up-to-date data from the B+LNZ Sheep and Beef Farm Survey will be explored to determine if the decline in pasture production has continued beyond the 1980-2011 period.

Materials and Methods

Shortcomings and data sources

The use of methods to back-calculate animal pasture intake from livestock energy requirements and energy concentration of pasture on offer, such as metabolic energy budgeting, has proven effective in the assessment of pasture grown and consumed by dairy (Matthew et al. 2010; Neal et al. 2019; Neal and Roche 2020; Mills and Neal 2021; Chapman et al. 2024; Marmont et al. 2024) and to a limited extent by sheep and beef (Duranton and Matthew 2018; Gobilik et al. 2021). Compared with dairy systems, sheep and beef hill country farms often have lower annual herbage production per hectare, with a lower use of N fertiliser and a higher reliance on grazed pasture as the dominant feed source, with relatively limited use of crops and imported supplement. Sheep and beef systems also tend to be more complex having to manage multiple herds and flocks simultaneously (and animal physiological attributes within each), selling and trading dates, movement and grazing of livestock on more complex landscapes, and the uncertainty of liveweights (LW) and LW gains compared with more specialised dairy production systems.

Metabolic energy budgets can deliver accurate estimates of feed consumed (± 5%) based on estimates of livestock feed demand (Duranton and Matthew 2018). To better align assumptions with reality, a comprehensive set of animal data i.e., animal numbers, LW and LW gains, and physiological and efficiency data (e.g., pregnancy status, weaning percentage) is needed. For example, using a theoretical metabolic energy budgeting framework, Gobilik et al. (2021) explored the system performance changes of the average lower North Island Beef + Lamb New Zealand (B+LNZ) Class 4 farm from the 1980-1981 to the 2010-2011 season, largely with survey data collated by B+LNZ. Calculations for the average regional system were cross-examined with data from three case studies, specific production systems located within the region. A ratio between herbage consumed (calculated from animal metabolic demand) and herbage grown [an input to the Farmax model used in one of the farms and an output of the pasture growth model GROW (Butler et al. 1990)/drawingml/2006/wordprocessingDrawing] provided an estimate of herbage utilisation for these production systems (Gobilik et al. 2021). The Farmax model was used to test if the metabolic energy budget was working as expected whereas the GROW model was used to test whether changes in calculated herbage consumed over time could be explained by changes in weather patterns during the same period.

To enable the time extension of previously published estimates of animal energy demand for a given productivity, the analysis undertaken here focused on trends occurring in the lower North Island Hill Country [B+LNZ Farm Classes 3, 4, and 5; North Island Hard Hill (n = 21 farms), North Island Hill (n = 28 farms) and North Island Finishing (n = 21 farms), respectively]. However, access to such a comprehensive dataset to bring the work by Gobilik et al. (2021) to the current time was not available. Alternatively, sector-level livestock production data were obtained from the B+LNZ Sheep and Beef Farm Survey spanning the seasons 2013-2014 to 2023-2024 for the lower North Island Farm Classes 3, 4 and 5. The B+LNZ Sheep and Beef Farm Survey is performed using a random sample of >500 farms every year, with data collected, organised and stored in a database. Each farm is characterised with >2000 variables, comprising crop-livestock-forestry and other land uses, livestock policies and reconciliations, and animal production and reproduction performance. The dataset includes estimates of livestock numbers and SU (sheep and beef cattle by farm class), and productive (e.g., meat and wool produced per ha) and reproductive performance (e.g., lambing percentage). No data are available on LW, sheep offspring characterisation (proportion of single, twin and triplet lambs), lamb weaning LW, and the use of supplemental feed. Nitrogen fertiliser use is low at <15 kg N/ha on sheep and beef hill country operations (Beef + Lamb New Zealand 2020).

Estimates of livestock energy demand were used as a proxy for feed consumed, but rather than the comprehensive set of animal characteristics in Gobilik et al. (2021), livestock stock units (SU) at opening (1 July) were used as a measure of feed demand. Characterised by B+LNZ, a SU is a feed-intake based unit for farm management calculations, where one SU is equal to the amount of feed required to maintain a 55-kg breeding ewe that is mothering a lamb (1 SU = 550 kg of DM intake). It needs to be noted that the concept of ewe-equivalent standard, reported initially by Coop (1965) and with several modifications since, is in need of revision, as the concept was last revised in 1992, and the genetics and nutrition of the modern ruminant have changed since then.

In hill country systems, maintenance requirements are likely to account for the dominant share of estimated feed demand at the opening inventory date of 1 July. No energy adjustments were made for increased lambing and offspring composition (e.g., expected single-to-twin lamb ratios of 67:33 and 60:40 with lambing percentages of 130% and 140%, respectively) (Amer et al. 1999). In the absence of consistent long-term data on supplemental feeding in hill country systems, supplement inputs were assumed to be minimal relative to total feed demand, consistent with previous assessments of supplemental feed used by these systems (e.g., it was estimated that on average only 0.06 (1990-91 season) to 0.07 (2014-15 season) of the whole diet was provided by supplemental feed in NZ sheep and beef systems) (Sise et al. 2017). Other limitations to the use of farm-level data (such as that provided by the B+LNZ Sheep and Beef Farm Survey) include the lack of independent assessment of the managerial ability of the farm decision makers and the productive potential of the land (Neal and Roche 2020).

Results and Discussion

Estimates of herbage demand from pasture and fodder crops (i.e., demand per hectare based on the number of stock units per ha) in B+LNZ's lower North Island Hill Country (Taranaki-Manawatu Class 3, 4 and 5 farms) have remained relatively flat throughout the last 11 seasons (Figure 1A). A slight decline was seen in Class 4 farms whereas a slight increase was seen in Class 3 and Class 5 farms (Figure 1A). Comparatively, Gobilik et al. (2021) reported a reduction in total annual feed demand from 7,430 kg DM/ha (1980-1981) to 5,760 kg DM/ha (2010-2011) in Class 4 farms located in the lower North Island, a 22% reduction over the three-decade period (1980-1981 to 2010-2011). Corresponding estimates of annual herbage supply (9,640 and 8,700 kg DM/ha) and annual herbage utilisation (77 and 66%) were also reported for that period (Gobilik et al. 2021).

Assuming a fixed amount of energy equivalent to the concept of a revised stock unit (RSU; 1 RSU = 6000 MJ ME; Nicol and Brookes 2007) and a common, mean energy concentration of pasture on offer (10.2 MJ ME/kg DM; Pickering et al. 2025), mean (range) annual feed demand estimates were 4,720 (4,470 – 4,880), 5,420 (5,180 – 5,650) and 6,300 kg DM/ha (6,060 – 6,710) for Class 3, 4 and 5 farms, respectively. The overall mean annual feed demand estimate for Class 4 farms (5,420 kg DM/ha) is similar to that reported by Gobilik et al. (2021) for the 2010-2011 season (5,760 kg DM/ha).

Although a direct comparison between the results reported by Gobilik et al. (2021) and the estimates calculated here is not possible, the present analysis is consistent with continued pressure on pasture supply and/or pasture consumed persisting into the subsequent decade (post 2010). The present analysis is consistent with continued pressure on pasture supply and/or pasture consumed, along with varying sheep-to-cattle ratios over time (Figure 1B), but it cannot, by itself, separate the effects of varying pasture growth and/or pasture utilisation, supplement use, livestock class mix, or livestock performance. The decline in estimated pasture supply since 1980 has occurred over a period when mean temperatures have increased by 0.5° C and carbon dioxide concentrations in the atmosphere have increased by nearly 90 ppm, both effects previously considered as beneficial for NHA in the region (Butler et al. 1990; Keller et al. 2021).

Estimated feed demand may have stagnated or even declined over the last decade, but this has occurred in synchrony with improvements in animal production efficiency. For example, lambing percentage from ewes has increased from 118%, 131% and 129% (Class 3, 4 and 5 farms in 2013-2014) to 133%, 140% and 142% (corresponding farm classes in 2023-2024) (B+LNZ Economic Service). Similarly, lamb and bull beef prime carcass weights have increased by about 63 g/head and 1.0 kg/head per annum during the same period, respectively (B+LNZ Economic Service). These trends indicate improvements in reproductive performance and individual carcass weights, and have resulted in an increase in saleable meat production per hectare for Class 3 and 5 farms, but not for Class 4 farms (B+LNZ Economic Service). Consistent with a declining amount of herbage grown by Class 4 farms, the percentage of lambs and beef cattle sold as prime has declined over the same period (Figure 2). The declining prime-sale trends may reflect reduced finishing capacity, altered livestock policies, market conditions, or changes in the role of hill country farms within the wider supply chains, and cannot be solely attributed to the declining NHA trend. While consistent with constrained pasture supply, this indicator should be interpreted as a system-response signal rather than direct evidence of pasture growth stagnation or decline.

Consistent with these findings, an earlier analysis of 23 sheep and beef farms located throughout New Zealand and across all farm classes for both the 1993-1994 and 2015-2016 seasons using Farmax, showed a decline in pasture consumed (Rennie et al. 2019). Despite greater efficiency shown in recent times i.e., improved feed conversion efficiency (29.7 vs 34.0 kg DM intake per kg saleable animal product) with farms carrying fewer, heavier ewes (63.1 vs 55.8 kg LW/ewe) with a higher lamb weaning percentage (124.5 vs 106.9%), estimates of mean annual feed consumed per hectare were slightly reduced (about 4,090 kg DM/ha in 2015-2016 vs 4,250 in 1993-1994) (Rennie et al. 2019).

Measurements from long-term field experiments

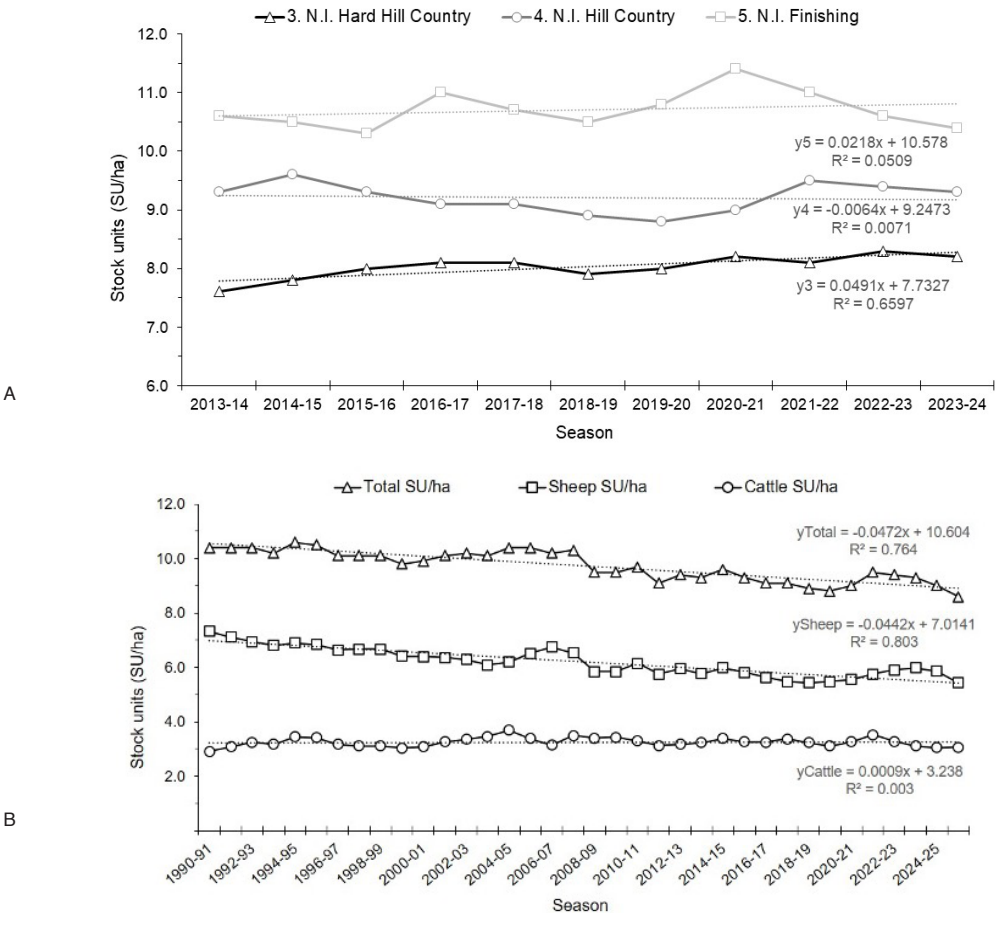


Figure 1 A: Opening livestock stock units (SU/ha) carried on lower North Island sheep and beef hill country farms [B+LNZ's Taranaki-Manawatu Hard Hill (Class 3 farms, n = 21 farms), Hill (Class 4 farms, n = 28 farms) and Finishing (Class 5 farms, n = 21 farms)] over 11 seasons. B: Opening SU/ha carried on lower North Island Class 4 Hill Country farms (B+LNZ's Taranaki-Manawatu farms) over 36 seasons.

located in the lower North Island suggest a similar decline in NHA and livestock carrying capacity. Mackay et al. (2022) reported that the NHA on the medium slope of the high fertiliser farmlet, one of three farmlets that make up the long-term phosphorus (P) fertiliser and sheep grazing experiment, in 2020-21 was only 87% of that measured on the same farmlet between 1982 and 1988, even though soil P fertility was non-limiting. The measured decline in NHA aligned with a reduction in the on-site nominal sheep stocking rate since the late 1990s. There had been some earlier expectation of enhanced NHA in this region under warmer temperatures and elevated CO_2 in the atmosphere (e.g., Butler et al. 1990), but these have not materialised. On the other hand, the decline in NHA in the Central Hawkes Bay over the last 20 years reported by Mills et al. (2021) aligns with the predictions for the East Coast of the North Island under predicted future climates (Lieffering et al. 2016). Declining trends in herbage consumed by livestock from pasture and crops have also been reported for other regions in the North Island. In the Northland and Waikato regions, for example, herbage consumed by dairy cattle from these sources has declined at an annual rate of 98 and 56 kg DM/ha, respectively, over the 2005-2006 to 2018-2019 annual production seasons (Mills and Neal 2021). This trend has been attributed to climate change, specifically a combination of warmer temperatures, changing rainfall patterns, and more intense dry spells.

Practical implications

Our analysis suggests that estimated feed consumed per hectare on lower North Island sheep and beef farms has remained flat or has declined over the past decade, despite continued gains in reproductive and productive efficiency. When considered along with earlier metabolic energy budget analyses and long-term pasture studies, these findings are consistent with

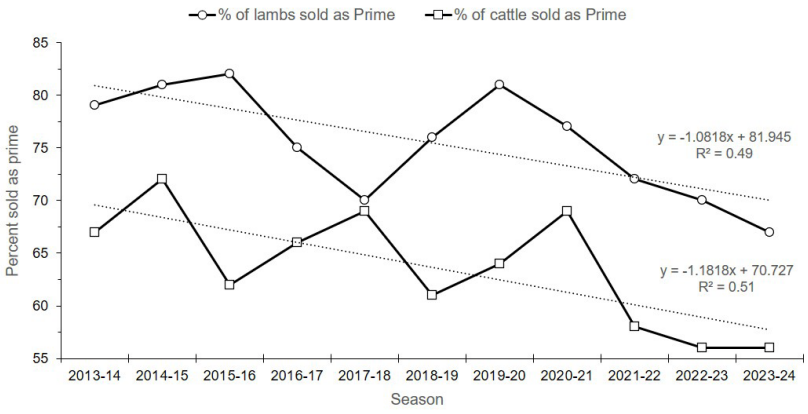


Figure 2 Percentage of lambs and cattle sold as prime over 11 seasons by lower North Island Hill Country Class 4 farms (n = 28 farms).

estimated trends of declining pasture supply and pasture consumed in these lower North Island Hill Country systems. However, because the present analysis relies on stock-unit based feed-demand proxies rather than direct pasture growth measurements, further work is needed to separate the effects of pasture growth and quality, pasture utilisation, livestock policy, liveweight change and to a lesser extent, supplemental feeding.

When considered alongside earlier studies, the persistence of these indicators suggests that pressures constraining herbage accumulation may remain active. However, despite declining pasture supply, animal production efficiency has improved. This divergence reflects gains in reproductive performance, genetics, and feed conversion efficiency, potentially masking the underlying pasture supply issue for livestock managers. However, the capacity for continued improvement in animal performance is constrained where maintenance energy requirements dominate total feed demand.

The energy budget method relies on assumptions regarding pasture energy content and livestock energy requirements. These assumptions introduce uncertainty, although consistency with previous studies supports the robustness of the observed trends. Further work should integrate detailed farm-level measurements and improved estimates of livestock LW, along with a clear understanding of the impact and degree of supplemental feeding. Modelling approaches that incorporate climate, soil, and management interactions would improve our understanding of the drivers of pasture productivity trends.

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