Changes in New Zealand red meat production over the past 30 yr

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Implications

- Consumer attitudes globally and nationally influence pasture production systems in New Zealand.
- New Zealand red meat production has decreased its environmental footprint per unit of production over the last 30 years.
- The national ewe flock has halved but gains in animal production have maintained similar levels of meat production.
- Meat production has been improved through increased lambing percentages and lamb growth rates on fewer but larger farms.
- Greater animal production has been supported through improved pastures with an emphasis on their legume component which has increased lamb growth rates and reduced methane emissions per unit of product.

Key words: land use change, New Zealand, red meat

Introduction

The "consumer is king" is the mantra that underpins animal production systems in New Zealand. As a small, export-based economy, there is a national obsession in overseas trends and fashions in food consumption. Therefore, sustainable production is at the forefront of decisions within the industries. Over 40% of the national export income annually is from animals directly fed on pasture in the red meat ($NZ10.4bn) and dairy ($NZ17.4bn) sectors. Both export over 90% of their products and are acutely aware that the customers they must satisfy are in distant markets, with several supply chain steps between producer and consumer (Beef + Lamb New Zealand (B+LNZ) and Meat Industry Association (MIA) 2020; Heilbron, 2020a). As a consequence, the overall reputation of our collective food production systems is important to encourage consumers to purchase New Zealand products, and preferably pay a premium for doing so. Pastoral scenes are also an integral part of the visual landscape and sense of identity of New Zealanders (Heilbron, 2020b). This adds intense scrutiny from stakeholders that include central and local government, *tangata whenua* (Maori as first inhabitants) and the general public, many of whom now have little or no connection to farming practices or communities. Politically, this has meant New Zealand is unable to grow genetically engineered crops or pastures (Ministry for the Environment (MfE), 2016) and the use of antibiotics is low by global standards and strictly controlled (O'Neill, 2015).

Meat and milk production has always been pastoral based and therefore "grass fed." Promoting that fact has recently become a part of informing consumers about the New Zealand red meat story. The farm systems required to achieve this are locally adapted to account for large variations in rainfall and temperature that occur over relatively short distances, due to the high mountain ranges that run north to south along the country. Wetter western areas have more reliable summer rainfall, which allows low-cost dairy farming on flat to rolling hill country. Sheep and beef grazing is on higher and steeper regions. In the rain shadow of the mountains, eastern regions are frequently summer dry, with 2–4 months of low to no pasture growth. These farming systems require flexible management to cope with highly variable periods of no rainfall. Dairying only occurs in eastern areas with irrigation but competes for land with high value horticultural and arable crops.

This article outlines the major changes that have occurred in the red meat sector in New Zealand over the last three decades. It highlights changes in land used, stock numbers, and stock performance as indicators of on-farm performance. Underpinning these changes are adaptations to mitigate climate change, and the collective need for financially viable, environmentally sustainable, and socially acceptable farm systems.

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Changes in New Zealand Land Use and Livestock Numbers

All animal production systems in New Zealand are closely integrated. Changes in red meat production since 1990/1991 are linked to the expansion of dairy production. Traditionally, summer safe regions of New Zealand that received at least 1,000 mm of rainfall annually grew perennial ryegrass (*Lolium perenne* L.) and white clover (*Trifolium repens* L.) pastures to be grazed by dairy cows. In the 1990s, the arrival of center pivot irrigation in the summer dry (650 mm annual rainfall) Canterbury region led to rapid expansion of dairy farming (Moot, 2020). The legume component of pastures was attacked by the invasive clover root weevil (*Sitona lepidus* Gyllenhal), which reduced clover content and therefore nitrogen fixation (Eerens et al., 2005). Urea ferilizer replaced fixation as the main N source and high stocking rates (3.4 cows/ha; 2018/2019) on shallow soils led to increased ntirate leaching and a public backlash against the industry (Moot, 2020).

The dairy herd expansion also required additional land for feeding replacement stock and increased areas of forage crops on which to winter cows. From 1990/1991 to 2020/2021, the pastoral land under dairy increased from 1.4 to 2.2 M ha, and the total number of sheep and beef farms declined from 19,600 to 9,165. The red meat sector lost much of the flat and rolling hill country that had traditionally been used to "finish" or grow lambs to slaughter weight. These finishing farm numbers declined from 6,650 to 2,085.

The number of breeding ewes has decreased from 40.4 M in 1990/1991 to 16.6 M in 2020/2021 (Figure 1), and the sheep and beef cattle occupied grazing land area decreased from 12.4 to 7.7 M ha. Conversely, the area of nongrazed tussock and woody vegetation and forestry increased, from 1.3 to 1.7 M ha, with other minor land use changes to lifestyle blocks near population centers, horticulture, viticulture, and orchards. Remarkably, the productivity of the sheep industry has increased over this period. The lambing percentage has increased from 100% to 132% (Figure 1), and lamb carcass weights at slaughter have increased 32% from 14.4 to 19.0 kg/hd (Figure 2a).

Over the same period, total beef cattle numbers declined from 4.6 to 3.9 M, whereas the number of dairy cattle increased from 3.4 to 6.1 M. This has resulted in the beef supply from the dairy industry increasing from 18% to 33% of the cattle slaughtered. Sheep and beef farms also take-in dairy calves and rear these for beef production (Plate 1). In 1990/1991, dairy and dairy beef cross animals represented 38% of the cattle slaughtered from sheep and beef farms, but this increased to 52% in 2020/2021 (Figure 3). This class of stock has added flexibility to many grazing systems because they can be bought and sold relatively easily if local weather conditions change the pasture supply either positively or negatively.

Changes in New Zealand Red Meat Pastures

There have been several reasons for increased productivity in the sheep and beef sectors, with one of the main ones being a focus on the quantity and quality of feed being produced on hill country farms. On average, the grazing area on these farms occupy 17% flat (0 to 8°), 32% rolling (8 to 20°), and 37% steep (≥20°) land areas. In addition to the grazing area, 2% of the occupied "farm" land is in exotic forestry and 12% is in native bush, woody scrub vegetation, and wetlands.

A focus on these farms has been to encourage the legume component of these pastures to encourage nitrogen fixation and the provision of high-quality feed, particularly during lactation. In summer dry regions, there has been an emphasis on utilizing any flat or cultivatable areas (<15° slope) to provide lucerne (*Medicago sativa* L.) direct fed to ewes and lambs to transform on farm performance (Avery et al., 2008; Moot et al., 2019). For steeper summer dry regions,

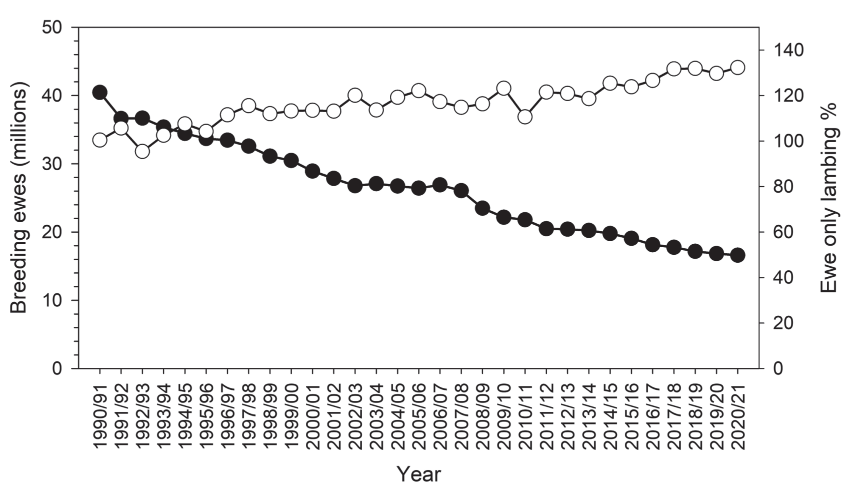

Figure 1. Change in the total number of breeding ewes (two tooth and over put to ram; ●) and ewe lambing percentage (○) in New Zealand from 1990/1991 to 2020/2021. (Note: This figure was produced from data supplied by the Beef + Lamb New Zealand (B+LNZ) Economic Service (personal communication) and includes Stats NZ's data which are licensed by Stats NZ for reuse under the Creative Commons Attribution 4.0 International licence.)

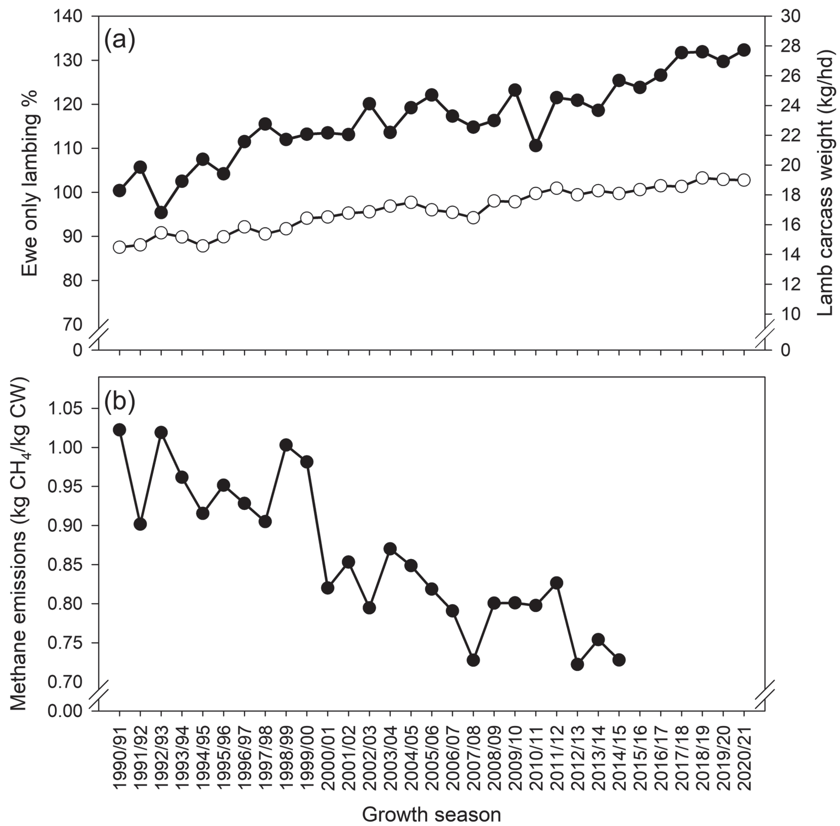

Figure 2. Changes over time in (a) (●) lambing percentage (ewe only; %) and (○) carcass weight (CW; kg/hd) based on data supplied by the B+LNZ Economic Service (personal communication) and includes Stats NZ's data, which are licensed by Stats NZ for reuse under the Creative Commons Attribution 4.0 International licence), and (b) methane (CH_4) emissions per kg CW sold from the average New Zealand sheep farm (reproduced from Ledgard, 2017).

emphasis has been on managing subterranean clover (*T. subterraneum* L.), as the earliest growing of the annual legumes, with equally dramatic on-farm results (Grigg et al., 2008; Olykan et al., 2019).

In regions where water is nonlimiting, a lack of nitrogen in the system is a major limitation to pasture production. Mills et al. (2006) found pastures with nonlimiting water grew ~9.8 t DM/ha/yr. When growth rates were standardized for annual temperature fluctuations by using thermal time (growing degree days; °Cd), it was shown that the fully irrigated pastures grew ~3.3 kg DM/ha/°Cd, but this more than doubled to 7.2 kg DM/ha/°Cd when nonlimiting water and nitrogen were applied, which produced 21.5 t DM/ha/yr. On flatter areas of these farms, specialist pastures containing red (*Trifolium pratense* L.) and white clovers with commercialized plantain (*Plantago lanceolata* L.) are providing the high-quality feed to increase animal live weight gains (Cranston et al., 2015). Novel establishment techniques, including "aerial no til" using helicopters, have been developed to allow previously uncultivatable land to be developed with high-quality pastures (Lane et al., 2016). The aim is to balance poorer quality maintenance feed, which can be used for dry stock, with high-quality pastures for rapid growth rates of production stock (Table 1). In all of these developments, there has been a need to ensure that on-farm development has balanced environmental outcomes to maintain the social licence to farm.

Environmental Outcomes for Red Meat Sector

New Zealand produces over 70% of its energy from renewable (largely hydro) sources. This means that our greenhouse gas emission profile is unique among developed countries, with 48% attributed to agricultural production. These are from methane emitted by grazing ruminants and nitrous oxide released from fertilizer application and urine patches. Thus, reductions in agricultural emissions are a politically active topic. Both the red meat and dairy industries have low emissions intensity, measured as kg of product per kilo of CO_2eq. Since 1990, land use and productivity changes in the red meat sector mean absolute emissions have declined by 30% and emissions per unit of product by 40% (Figure 2b; Ledgard, 2017). Policies to restrict nitrogen fertilizer use have validated the red meat sectors focus on legume-based pastures to grow animals quickly (Avery et al., 2008). For example, Moot et al. (2019) reported preweaning merino lamb growth rates increased from 190 to 290 g/hd/d over a 10-yr period, due to the expansion of lucerne grazing. The higher lamb growth rates shortened the lactation phase by 35 d and contributed to reduced methane emissions (Table 1). The red meat sector has also seen a 21% reduction in nitrate leaching per kilogram of saleable

Plate 1. Bull beef sourced from the dairy industry direct grazing rainfed lucerne (alfalfa; *Medicago sativa* L.) at 'Bonavaree' farm in Marlborough, New Zealand (Photo credit: Doug Avery).

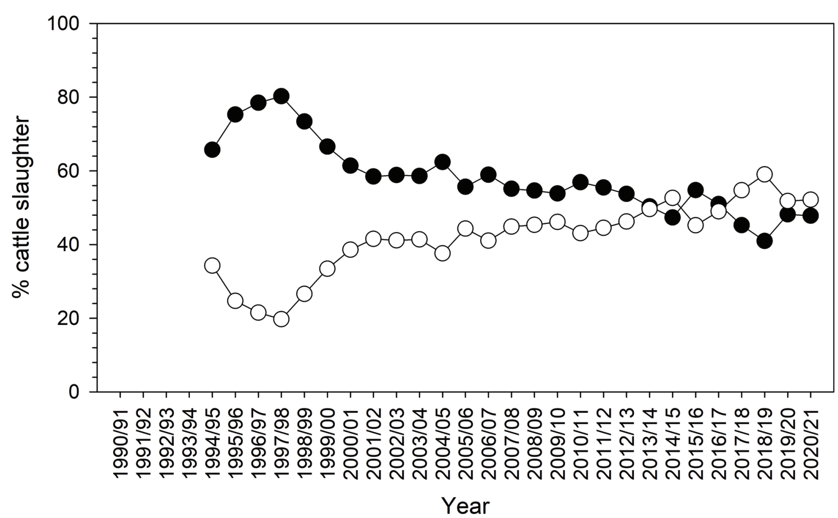

Figure 3. Change in percentage (%) of cattle slaughtered from beef cattle (●) or dairy and dairy/beef cross (○) origins finished in New Zealand sheep and beef farms systems from 1995/1996 to 2019/2020. (Note: This figure was produced from data supplied by the B+LNZ Economic Service [personal communication] and includes Stats NZ's data which are licensed by Stats NZ for reuse under the Creative Commons Attribution 4.0 International licence.)

product (Shepherd et al., 2016). The planting of land to exotic and native forestry at an individual farm level means the sector is close to or already carbon neutral (Case and Ryan, 2020). Water use per kilogram of beef (210 liters) and sheep (46 liters) are low by international standards because farms are rainfed with limited use of irrigation to "finish" stock (Zonderland-Thomassen et al., 2014). Being on hill country, red meat producers are acutely aware that soil erosion and consequent phosphorous loss may be an issue (McDowell and Condron, 2004), so on-farm mitigation is promoted as part of individual farm environment plans, supported by the industry funded levy organization Beef + Lamb New Zealand (B+LNZ).

Table 1 Metabolisable energy requirement (MJ ME/d) for lamb growth from 25 to 35 kg liveweight/hd (Brown 1990)

Lamb growth rate (g/hd/d)	Energy supply (MJ ME/hd/d)	Days on farm	Energy consumed (MJ ME/hd)	Methane[1] (g/kg gain)
100	13	100	1300	303
200	17	50	850	199
300	22	33	726	165

[1]Assumes 40-kg lamb fed pasture at 11 MJ ME/kg DM (de Klein et al. 2008).

About the Authors

Derrick Moot received his PhD from Lincoln University and then completed his postdoctoral study on climate change in the UK. He is currently the Professor of Plant Science at Lincoln University where he leads the Dryland Pastures Research Programme. His research has focused on using legumes to provide nitrogen and high-quality feed to summer dry pasture systems to maximize water use efficiency and increase animal production. His research has underpinned part of the transformational change that has occurred in the red meat sector in New Zealand over the last 30 yr. He is internationally recognized for his work on lucerne physiology, which has been adapted to improve lucerne grazing systems on-farm. **Corresponding author:** Derrick.Moot@lincoln.ac.nz

Rob Davison is the Executive Director of the Beef + Lamb New Zealand Economic Service, which for 70 yr has been providing insights into the state and financial health of New Zealand's agriculture industry, primarily through its Sheep and Beef Farm Survey. Rob is widely respected economist and has been with the organization for over 40 yr, working on a range of issues from climate policy to forecasting meat production. He was awarded an Officer of the New Zealand Order of Merit (ONZM) in the 2016 New Year's Honours List. He was also recognized with the Outstanding Contribution to New Zealand's Primary Industry Award at the 2020 Primary Industries Summit.

Conclusions

The importance of meat and milk production from pastures to the New Zealand economy is unquestioned. At the same time, all aspects of farm practice are being scrutinized by an increasingly urban population and distant international consumers. The tension between the environment and economy is palpable. Despite the retreat of the red meat sector to more difficult hill and high-country regions, there have been substantial efficiency gains, and a reduced environmental footprint. Continued refinement of best management practices has enabled farming to remain financially viable, environmentally sustainable, and socially acceptable. Without science-based solutions, it is highly likely that further regulatory restrictions will be imposed. Central to the challenge is efficient use of nitrogen, as the most limiting nutrient, to support productive pastures for animal production. Fortunately, New Zealand farmers, scientists, and the agribusiness community have consistently shown a collective willingness and ability to confront and solve problems for the New Zealand environment and economy.

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