# MODELLING EWES GRAZING DUAL-PURPOSE WHEAT.

S. R. McGrath *et al.*

## Modelling the effect on stocking rate and lamb production of allowing ewes to graze a dual-purpose wheat crop in southern New South Wales

**S. R. McGrath[A,B,C,E], J. M. Virgona[B,D] and M. A. Friend[A,B,C]**

[A]School of Animal and Veterinary Sciences, Charles Sturt University, PO Box 588, Wagga Wagga, NSW 2678, Australia.

[B]Graham Centre for Agricultural Innovation, Locked Bag 588, Wagga Wagga, NSW 2678, Australia.

[C]Future Farm Industries CRC, University of Western Australia, Crawley, WA 6009, Australia.

[D]Present address: Graminus Consulting Pty Ltd, 1 Heron Place, Wagga Wagga, NSW 2650, Australia.

[E]Corresponding author. Email: shmcgrath@csu.edu.au

Slow pasture growth rates during winter limit the potential gross margins from autumn and early winter lambing in southern New South Wales (NSW) by limiting stocking rates and/or increasing supplementary feed requirements. Dual-purpose crops can fill the winter feed gap in mixed-farming systems by increasing the available feed in winter. The simulation software AusFarm was used to model a mixed-farming system at Wagga Wagga with Merino ewes joined to terminal sires and grazing lucerne-subterranean clover pasture over a 41-year period. A paddock of dual-purpose wheat was then added to the system, and ewes were allowed to graze the wheat crop when feed on offer reached 850 kg DM/ha and before GS31. Weaned lambs were sold after late August if lamb growth rates fell below 20 g/head.day, mean lamb weight reached 45 kg or production feeding of lambs was required. Lambing in June resulted in the highest median gross margin whether or not ewes were able to graze the wheat crop during winter. Grazing of a dual-purpose wheat crop resulted in greater proportional increases in gross margins as the stocking rate was increased, increased lamb production and reduced supplementary feed-ing costs, and reduced interannual variability in gross margin returns.

### TOC ABSTRACT

Grazing dual-purpose wheat provides high quality feed for livestock at a time of year when pasture growth rates in southern Australia may be slow, and farmers may therefore consider changing their time of lambing to exploit this. Simulation modelling of a Merino ewes flock producing first-cross lambs and grazing lucernebased pastures and producing first cross lambs identified that

the optimal time of lambing, in terms of highest median gross margin over the long-term, was not changed by inclusion of crop grazing in winter. Allowing ewes to graze a wheat crop in winter increased producer returns and reduced supplementary feeding requirements and the variability of returns.

## Introduction

A range of lambing times are used across Australia and at a local level (Croker et al. 2009; McGrath et al. 2013). Lambing in spring in southern Australia generally allows the period of maximum demand of the ewe-lamb unit to be met by pasture, whereas lambing in autumn requires additional supplementary feeding to meet demands during winter when pasture growth rates are slow (Shallow 1996). Importantly, lambing in spring may allow higher stocking rates than autumn lambing (Trengove 1990) and the stocking rate is a key driver of profitability (Warn et al. 2006). Despite this recommendation many producers continue to lamb in autumn (Croker et al. 2009). One reason for this, particularly in a meat-production system, is the opportunity for lambs to grow out to meet market requirements (Reeve and Sharkey 1980; Freer et al. 1994; Sackett and Francis 2006). Carrying capacity is affected by growing season length (Saul and Kearney 2002) and the optimal lambing time, in terms of gross margins, will depend on factors such as the length of the growing season and the sale policy used (Warn et al. 2006; Robertson et al. 2014, this issue).

Dual-purpose crops such as wheat (Triticum aestivum) are now an important part of the feedbase in mixed farming systems in southern New South Wales (NSW; McMullen and Virgona 2009; McGrath et al. 2013) and can increase livestock production during the winter compared with lucerne (Virgona et al. 2008). Rather than replacing an area of sown pasture in mixed farming systems, dual-purpose crops can increase the feed quantity available if a portion of the spring wheat is replaced by a dual-purpose wheat that is sown earlier and grazed during the winter (McMullen and Virgona 2009). The opportunity cost is therefore any reduction in grain yield from grazing the dual-purpose crop compared with the ungrazed spring wheat.

This modelling study sought to identify whether the time of lambing resulting in highest median gross margin was altered in southern NSW when ewes were able to graze a dual-purpose wheat crop sown in April. In this model, grazing of crops was considered opportunistic given that, if a spring wheat had been sown instead of a dual-purpose wheat, this area would not be available to graze; the ewe stocking rate was therefore calculated based on the area of pasture and excluding the cropped area. A lucerne-based pasture is modelled, being a widely used pasture in mixed-farming systems in the area, and with advantages for both nitrogen fixation and livestock production (Humphries 2012). A flexible selling system with no production feeding, where lambs could be grown out to heavier weights if seasonal conditions allowed, was modelled.

## MATERIALS AND METHODS

Simulation modelling was conducted using AusFarm® version 1.4.7 (www.grazplan.csiro.au/), which allows the GRAZPLAN and APSIM models to simulate grazing and cropping systems, and included crop grazing (Moore et al. 2007; Moore 2009). The model was run using weather data for Wagga Wagga, NSW (GRAZPLAN weather database; 35°10¢S, 147°27¢E) from 1 January 1965 to 31 December 2011, with analysis of lamb birth and weaning data for calendar years 1970–2010, and gross margin, supplement feeding and lamb sales data for financial years ending July 1971–2011.Variables used were date of commencement of lambing in monthly increments from April to August and stocking rates of 6, 8 and 10 ewes/ha of per-manent pasture. Separate simulations were run for whether or not sheep were allowed to graze the wheat crop.

## FARM

A self-contained portion of a mixed-farming enterprise was modelled for a site at Wagga Wagga. The system included 400 ha of semi-winter dormant lucerne (Medicago sativa) and subterranean clover (Trifolium subterraneum cv. Seaton Park) pasture divided into four equal paddocks; cropping and livestock activities occurring on other parts of the farm were not modelled, and for simplicity no rotation of lucerne and crop paddocks was applied. The soil type for all paddocks was a brown chromosol (APSOIL #179).

An additional 350-ha paddock was added to the system in which a dual-purpose wheat crop was sown annually. The size of the wheat paddock provided a stocking rate when grazing crop similar to the average in producer surveys in the district and in local field experiments (McGrath et al. 2013; McGrath et al. 2014). Dual-purpose wheat (cultivar EGA Wedgetail) was sown each year during April following a cumulative rainfall total of 25 mm over a 5-day period, or on 30 April if these conditions had not occurred. Wheat was sown at row spacing 17.5 cm and depth 25 mm with plant establishment density of 120 plants/m$^2$.

## SHEEP FLOCK

The livestock enterprise was a medium Merino ewe flock (breed standard reference weight 50 kg; breed reference fleece weight 4.5 kg) joined to Dorset rams (breed reference weight 55 kg) using a ram ratio of 0.01 and a 44-day joining period. Ewes were culled annually after shearing (before joining) at 6 years of age. Replacement ewes (age 19 months) were purchased annually on the day after cast cast-for for-age ewes were sold to maintain flock size at the target stocking rate.

Lambs were weaned at median age 12 weeks. Ewes and weaned lambs grazed crop concurrently if the conditions for crop grazing were met; otherwise ewes and weaned lambs grazed separate pasture paddocks until lambs were sold.

## GRAZING AND SUPPLEMENTARY FEEDING RULES

Pasture was checked every 14 days and sheep were moved to the pasture paddock with the highest feed on offer (FOO; kg DM/ha, with ewes given priority over lambs), or the crop paddock if conditions for grazing crop were met(see below. If available biomass in the 'best available paddock' fell below 500 kg DM/ha, then ewes were confinement-fed wheat grain (ME 13.8 MJ/kg DM, CP 14% DM) in a feedlot un-til such time as the available biomass in a paddock increased above this threshold. Maintenance feeding of ewes occurred in the paddock when the lowest ewe body condition score fell below 2.0. To prevent early sale or excessive mortality rates of April- or May-born weaned lambs during winter, maintenance feeding of lambs was introduced up until 24 August if lamb growth rates fell below 0.05 kg/head.day, unless pasture availability was below 500 kg DM/ha, in which case the lambs were sold. No production feeding of lambs was used.

In the simulation that included grazing of the wheat crop, crop grazing commenced When the simulation was set for crop grazing this occurred when the crop had accumulated 850 kg/ha of green feed and developmental stage was before Growth Stage 31 (Zadoks et al. 1974). When these conditions were met, all sheep grazed the crop pad-dock to rest pastures (Virgona et al. 2008), even if higher FOO was available in other paddocks. Sheep were removed from the crop paddock if the crop reached Growth Stage 31, above ground biomass of the wheat crop was reduced below 500 kg DM/ha or the date reached 23 August (as few producers in the region would choose to graze beyond this date).

## COMMODITY AND INPUT PRICES

A skin price of AU$5/head was applied to all lambs sold, regardless of size, and the same dressing percentage (0.41) applied to lambs and cull ewes. Lamb and wool prices were applied as per Robertson et al. (2014, this issue) of 361 c/kg for 18–22 kg carcass weight, 343 c/kg for 16–18 kg and 312 c/kg for carcass weights <16 kg; wool price for 21–22 micron wool of 852 c/kg clean, and wheat price for maintenance feeding of AU$250/MT. A sensitivity analysis was included to consider the effect on mean gross margins of increasing or decreasing the gross value of lamb or wool sold or cost of supplement by 20%.A sensitivity analysis of Sale of cull ewes was set at AU$1.77/kg carcass weight and replacements purchased at AU$60/head. A pasture maintenance cost of AU$50/ha.year was included; however, no labour cost was included, and income and costs for the cropping operation were excluded.

## SELLING RULES

A flexible selling policy was applied for the sale of lambs. Lambs were sold after weaning when the mean weight of lambs reached 45 kg, the mean growth rate of weaned lambs fell below 0.02 kg/head.day or ewes were put in the feedlot, indicating that pasture biomass had declined below the nominated thresh-old.

Analysis

Outputs from the model were analysed using Microsoft Office Excel 2007, with box plots produced in GENSTAT 16th edition (VSN International Ltd, Hemel Hempstead, UK).

## RESULTS

Pasture growth rates of lucerne and subterranean clover pastures were compared with those reported by Hall et al. (1985) at Wagga Wagga for the period 1975–77 and considered acceptable. Pasture growth rates tended to peak in the spring, the lucerne component was able to respond to rainfall and soil moisture in the summer and autumn, and winter was typified by low pasture growth rates. Mean daily growth rates for wheat in the crop grazing model (July lambing flock at 8 ewes/ha) were 16, 22 and 15 kg DM/ha.day for June, July and August, respectively, which is lower than some other suggested growth rates (Anonymous 2008). The growth rate of ungrazed wheat in 2004 was 75 kg DM/ha.day in the model, compared with 71 kg DM/ha.day reported by Virgona et al. (2006) for a site north of Holbrook during the same period and with the same cultivar. The mean day that grazing of crops commenced was 30 June (median 9 July) in years when crop grazing occurred, and no crop grazing occurred in 1983 and 2007. The mean number of days grazing crop ranged 49–50 days, except for April and May lambing at a stocking rate of 10 ewes/ha where crop grazing days averaged 44 days.

The number of lambs weaned : ewes joined ranged 0.82–0.89 across lambing months, stocking rates and whether or not crops were grazed, and tended to be highest for May and June lambing. Lamb mortality rates to weaning were highest when lambing commenced in July and August (both 21%) and lowest when lambing commenced in April (7%) and May (12%), and were not substantially affected by stocking rate or whether ewes had wheat crop available to graze. Mean weaning weight across years was in-creased when crop grazing was available, with the effect greater for May and June lambing dates; however, mean weaning weights remained higher when lambing commenced later (data not presented).

The amount of grain fed increased at higher stocking rates and was reduced with later lambing months and when ewes were able to graze the wheat crop; the proportion of years when more than 50 kg was fed per ewe followed a similar trend (Table 1).

The mean number of lambs sold annually increased and the mean sale weight of lambs across years was reduced as the stocking rate increased. The increase in amount of lamb produced when crop grazing was permitted was proportionally greater for autumn lambing compared with later lambing at stocking rates of 8 or 10 ewes/ha (Table 1). The proportion of years when mean sale weight of lambs exceeded 39 kg liveweight increased at lower stocking rates and generally increased when crop grazing was permit-ted, with the effect being greatest for autumn lambing at the higher stocking rates (Table 1). In general, the mean sale date was not changed substantially by the inclusion of crop grazing for a given lambing month/ and stocking rate combination, although the sale date was slightly earlier for June lambing and slightly later for April and May lambing at higher stocking rates when crop grazing occurred compared with when it did not (Table 1).

The median gross margin was highest when lambing took place in June at a stocking rate of 8 ewes/ha regardless of whether crop was grazed or not (Fig. 1). Optimal stocking rate (in terms of median gross margin) was 6 ewes/ha for April and May lambing when no crop grazing was permitted, and the median gross margin was similar for 6 or 8 ewes/ha for July and August lambing (Fig. 1a). The optimal stocking rate increased to 8 ewes/ha for April and May lambing and 10 ewes/ha for August lambing when grazing crops were included, but did not change for June and July lambing (both 8 ewes/ha; Fig. 1b). The vari-ability in the gross margins increased with the stocking rate; however, this effect was reduced by the in-clusion of crop grazing (Fig. 1).

Varying the sale price of wool or lamb or the cost of supplement by 20% from the standard values af-fected mean gross margins, but did not have a major impact on the month with the highest mean gross margin (Table 2). The stocking rate at which the highest mean gross margin occurred for a given lambing month was affected by changes in commodity prices for some lambing months.

## DISCUSSION

The median gross margin for the first cross lamb enterprise on a lucerne-based pasture was increased by inclusion of dual-purpose wheat in the feedbase and the highest median gross margin was achieved with a June lambing date at 8 ewes/ha for the sale policy used. Inclusion of crop grazing increased lamb pro-duction, reduced supplementary feeding and increased gross margins across lambing times and stocking rates (Table 1, Fig. 1).

The stocking rate is a key driver of profitability and the key benefit of optimising lambing time is by allowing stocking rates to be increased without an increase in the risk of needing to supplementary feed (Warn et al. 2006). Wool is a key component of the income but was not affected substantially by the lambing date in this model at an equivalent stocking rate, but contributed to the higher gross margins when the stocking rate was increased to levels that maximised the long-term gross margin (data not shown). Increasing the stocking rate can increase income from lambs and wool, but may also result in higher sup-plementary feeding costs and greater year-to-year variation in gross margins (Table 1, Fig. 1), indicating greater risk (Warn et al. 2006). Dual-purpose winter crops such as wheat provide additional feed for live-stock during the period when pasture growth rates can constrain production, and this model demonstrat-ed that inclusion of dual-purpose wheat in the feedbase reduced risk by reducing supplementary feeding costs and interannual variability in income at a given stocking rate, allowing stocking rates to be in-creased for some lambing months. Inclusion of crop grazing affected lamb production as the stocking rate increased; for April and May lambing, increasing the stocking rate had a large impact on lamb production when crop grazing occurred compared with when it did not (Table 1). In comparison, crop grazing had little impact on the proportional change in lamb production with stocking rate for later lambing, although lamb production increased with the stocking rate. Although the stocking rate at which the highest medi-an gross margin occurred did not change with inclusion of crop grazing when lambing in June, allowing sheep access to the dual-purpose crop increased the gross margin and reduced inter-annual variability in income

Given the lower price for lambs <18 kg carcass weight, there may be an advantage for lambing in months that allow turn-off of heavier lambs providing this does not reduce the number of ewes that can be run or greatly increase the cost of supplementary feeding. In the current model, lambing in June had lower supplementary feeding costs than April and May lambing, and a higher proportion of years where lambs achieved at least 39 kg liveweight at sale compared with July or August lambing (Table 1). This resulted in the highest median gross margin with inclusion of grazing crops occurring with June lambing. Increasing or decreasing the commodity prices did affect mean gross margins and the stocking rate at which the highest mean gross margin occurred, with the highest mean gross margins occurring with May or June lambing across the different scenarios (Table 2). The sale policy used had the advantage of allow-ing lambs to be retained until they reached a target weight if pasture quality and availability allowed; however, the lambing month that optimised gross margins may change with sale policy (Robertson et al. 2014, this issue). Lucerne is noted for its complementarity with other species by providing feed at different times of the year (Humphries 2012). Low pasture growth rates and, on occasion, digestibility of lucerne during the winter, resulted in high supplementary feeding costs during the winter in some years in the current mod-el. A lucerne feedbase may therefore be a good fit with dual-purpose cropping; conversely, the current model may overestimate the advantage of grazing the dual-purpose crop that would be achieved if other species with superior winter growth and quality are available for grazing by sheep. Further modelling with other pastures in combination or as an alternative to lucerne may be informative for producers considering the use of dual-purpose crops.

No gross margin for the cropping enterprise was included in the analysis. This enabled a more simplistic model to be used without requiring crop rotations and enabled us to demonstrate the benefits of allow-ing a crop to be grazed. Grazing of crops can negatively impact grain yields, although the effect can be minimised by good management, in particular the removal of livestock before Growth Stage 31, and in some circumstances grazing can increase grain yields compared with ungrazed crops (Virgona et al. 2006; Harrison et al. 2011). Modelling across regions in southern Australia suggested lower grain yields from dual-purpose wheat relative to spring wheat in the order of 3–17% (Moore 2009). Given only relatively small increases (<20%) in median gross margins were achieved at stocking rates of 6 ewes/ha in our mod-el when crop grazing was permitted (Table 1), it may be considered riskier to graze crops if stocking rates are not increased. In contrast, the large increase in gross margins at higher stocking rates when utilising the crop for grazing would likely improve overall gross margins even if a small reduction in grain yield was incurred. For example, if June-lambing ewes stocked at 8 ewes/ha are allowed to graze crop, the me-dian gross margin increases by AU$112/ha for the sheep enterprise, or an additional AU$44 800. Assum-ing a net grain price of AU$250/MT and base yield of 3 MT/ha, any yield reduction less than 17% due to grazing would result in a profitable outcome. Further modelling considering grain yields of spring wheat cultivars compared with grazed dual-purpose cultivars at different sites will assist to determine the relative benefits over the long term. Additional inputs such as nitrogen applications to assist crop recovery post-grazing would also need to be considered when analysing the financial impact for the farm overall.

## CONCLUSIONS

Allowing ewes access to some of the dual-purpose wheat sown on a mixed farm can increase gross margins from the sheep operation by increasing stocking rates and the amount of lamb and wool produced and reducing supplementary feeding requirements. Whether allowing ewes to graze a dual-purpose crop improves the farm economic performance depends on the effect on grain yield, along with the lambing time and stocking rate used.


## ACKNOWLEDGEMENTS

The authors gratefully acknowledge the assistance of Neville Herrmann, Eric Zurcher and Andrew Moore (CSIRO) and Susan Robertson (CSU) for advice with setting up the model, and the financial contributions of Meat and Livestock Australia, Australian Wool Education Trust, NSW Rural Assistance Authority and Future Farm Industries CRC.


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Manuscript received 12 March 2014, accepted 16 June 2014

Fig. 1. Effect of lambing month on variation in gross margin (1971–2011) at stocking rates of 6, 8 and 10 ewes/ha for lambing months commencing April to August when (a) no grazing of dual-purpose wheat occurred, and (b) when ewes were able to graze the dual-purpose wheat crop. The box represents inter-quartile range with the median marked by the central line; whiskers show range of data, with outliers marked if exceeding 1.5 times the interquartile range beyond the quartiles (×).