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Contents

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Sheep industry turn-off update

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Western Australia turned off 1.51 million sheep and lambs in the first quarter of 2025 — down 20% from 2024 but still above 2022–23 levels. Lamb slaughter made up the largest share (47%), followed by sheep slaughter (41%).

Sheep slaughter surged 22% to its highest Q1 level since 2008, while lamb slaughter dropped 15%, likely due to lower lambing rates. Live exports plunged 37% to a 30-year low, especially to Kuwait, Jordan, and Saudi Arabia. Interstate transfers also fell sharply (−85%) after a record 2024.

WA's sheep flock has likely dropped from 12.4 million (2022) to around 9.5 million in 2024, with a further decline to 8–8.5 million projected by mid-2025.

Read the full report of the sheep industry update.

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Economic analysis of benefits from grazing unharvested standing lupin crops in a mixed farm enterprise in south-west Western Australia

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Introduction

In south-west Western Australia, weaned lambs often graze dry annual pastures and stubbles during late spring and summer (Oct to Mar), which are typically low in energy and protein. Without supplementation, many lambs fail to reach target growth rates, increasing the risk of ill-thrift, mortality, and reduced market or breeding performance.

Improved forage options, such as lucerne, biserrula, serradella, and standing cereals, can help bridge this nutritional gap. However, these systems often require specific management or are economically marginal under high grain prices.

Standing lupin (*Lupinus angustifolius*) crops present a promising alternative. Though lower yielding than cereals, they offer rotational benefits like nitrogen fixation and weed suppression, and their higher crude protein (27 to 32%) better meets lamb nutritional needs. Warner *et al.* (1998) found grazing lupins over summer near Northam outperformed harvest in gross margin terms.

To assess system-wide impacts, we used the Australian Farm Optimisation (AFO) model on a representative mixed enterprise. Results suggest incorporating standing lupins can increase whole-farm profit, particularly by improving weaner survival, ewe lamb reproduction, and stocking rate efficiency.

This analysis supports lupins as a valuable dual-purpose crop in southern WA, offering nutritional, agronomic, and economic advantages for mixed farming systems.

Key findings

Higher profitability from grazing

Grazing standing lupins increased whole-farm profit by nearly $30,000, or $200 per hectare (ha) of lupins, compared to harvesting and grazing stubble alone. Harvesting lupins decreased profit by $2,000 on average.

Optimal lupin area

The most profitable scenario involved grazing 150 ha of lupins (7% of farm area), resulting in:

- +1.2 dry sheep equivalent per ha (DSE/ha) stocking rate
- +260 lambs sold
- +$7 per lamb sale price increase
- +$105,200 in sheep sale revenue
- +70 tonnes supplementary feed use.

Grazing strategy and liveweight outcomes

Wethers and crossbred lambs grazed lupins at ~30 weaners/ha from November to January/February.

Ewes grazed remaining biomass through March. Merino ewe lambs did not graze lupins, limiting their liveweight gain (max ~30 kg).

Nitrogen fixation effects

Base farm assumed 32 kg N/ha fixation.

Profit increased by $3,000 with 50 kg N/ha fixation. Profit decreased by $7,500 with 0 kg N/ha. The overall profitability of growing lupins on the farm was influenced by the assumed level of nitrogen fixation of the crop but this did not impact the $30,000 profit increase from grazing rather than harvesting it.

Sensitivity to prices and yield

Canola price: Growing lupins on farm is impacted by canola price, but this has no impact on the margin between grazing and harvesting which remains at $30,000.

Lupin price: 25% increase slightly reduced the margin between grazing lupins and harvesting them by $5/ha.

Lupin yield: Higher yields increased total profit but did not shift the grazing vs harvesting trade-off significantly due to the small lupin area (7% of farm).

No change in weaner survival

Weaner mortality remained low (1%) across all scenarios due to adequate base nutrition and supplement use. Liveweights remained >25 kg and stable post-weaning.

Mating ewe lambs not profitable

Mating 50% of Merino ewe lambs reduced profit by ~$2,000, regardless of lupin grazing. Ewe lambs did not access lupin feed, limiting liveweight gains.

Later lamb sales boost profit

When stocking rate was fixed (13.6 DSE/ha), grazing lupins increased profit by $12,500 or $83/ha.

Supplement not a profit driver

Increased supplementary feeding (up to 100 tonnes) had minimal effect on profit, indicating that feed quantity alone was not a key profit lever.

Materials and methods

The study used the AFO model, an advanced linear programming tool derived from the MIDAS model, to simulate whole-farm systems integrating biological and economic factors. The model optimizes land use, livestock management, labour, and machinery to maximise farm profit under average seasonal conditions. This analysis applied the Great Southern Regional version of AFO, updated with new values for grazing stubble and standing crops.

The base farm was a medium mixed enterprise near Darkan, Western Australia, with an annual rainfall of 675 mm and a Merino sheep flock. The farm did not originally grow lupins.

Feed quality and quantity for stubble and standing crops were updated using data from 8 grazing trials in south-west WA, including barley, wheat, canola stubble, and standing lupin crops grazed by ewes and weaners at measured stocking rates. Liveweight changes of grazing animals were recorded and modelled using quadratic equations to estimate daily feed intake and quality. This information was incorporated into AFO to simulate animal performance and feed utilisation.

The standing crop biomass was categorised by nutritive value and linked to crop yield to calculate maximum liveweight gain per hectare. This gain could be realised through different stocking densities.

The AFO model then evaluated whole-farm profit impacts of introducing standing lupin crops, varying lupin area while maintaining cropping proportions. The model included lupin nitrogen fixation assumptions (0, 35, 50 kg N/ha) based on best fit literature.

Sensitivity analyses tested effects of ±25% changes in lupin yield, lupin price, and canola price, as well as management changes such as stocking rate constraints and supplementary feeding levels. Supplementary feeding was constrained between 36 to 42 kg per dry sheep equivalent (DSE).

Results

Impact of grazing standing lupin crops on whole-farm profitability

Grazing standing lupins increased whole-farm profit by nearly $30,000 (about $200/ha) compared to harvesting all crops (Figure 1). Harvesting lupins reduced profit by around $2,000 ($20/ha) over 50 to 150 ha. The optimal lupin area to graze was 150 ha (7% of farm). Profit gains came from a higher stocking rate (1.2 DSE/ha), 70 tonnes more supplementary feed, and $105,200 extra sheep sales revenue, including 260 more lambs and $7 higher lamb sale price.

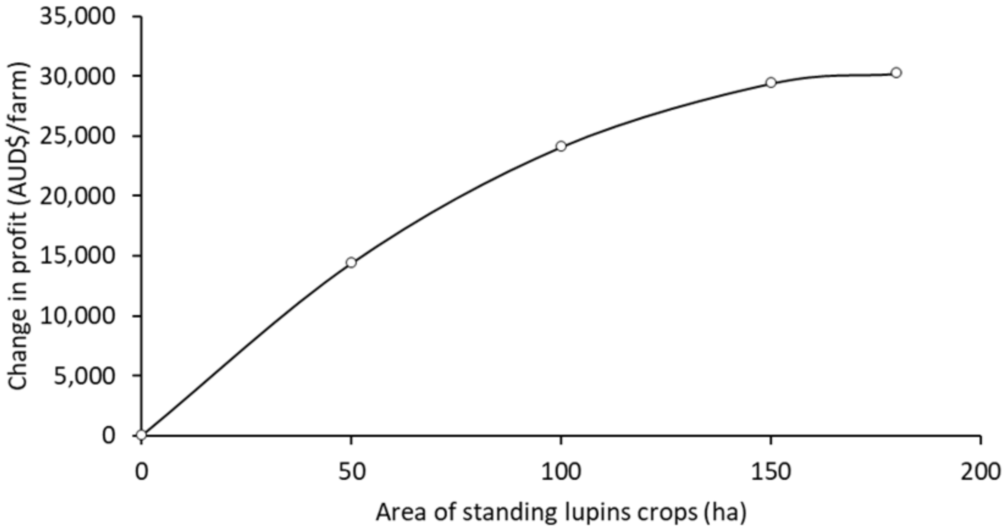

Figure 1: Change in whole farm profit (AUD$/farm) for a mixed farm in south-west Western Australia compared to the base farm with no standing crop when different areas (ha) of standing lupin crop were grazed

Optimum weaner liveweight and time of turn off when grazing standing lupin crops

About 30 crossbred wether weaners/ha grazed high-quality lupin stubble and standing crop from November to late January/early February, followed by ewe lambs grazing lower-quality crop until March. Merino ewe lambs did not graze lupins and reached a max liveweight of 30 kg (Figure 2).

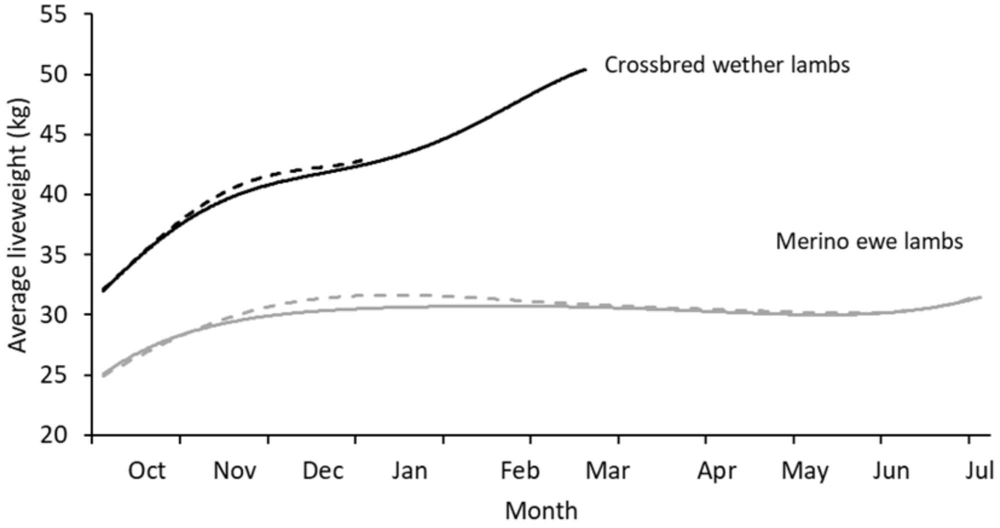

Figure 2: Optimum liveweight profile (kg) of crossbred wether lambs when able to graze standing lupin crop (black, solid line) and in the base farm with no lupins (black, dotted line), and the liveweight profile (kg) of Merino ewe lambs with the standing lupin crop (grey, solid line) and in the base farm with no lupins (grey, dotted line)

Impact of nitrogen fixation on whole-farm profitability

With 50 kg of nitrogen fixation per hectare, profit rose by $3,000; zero fixation reduced profit by $7,500. Grazing was consistently $30,000 more profitable than harvesting regardless of fixation level.

Sensitivity analysis for canola and lupin price and lupin yield on whole-farm profitability

A 25% increase in canola price cut the profit margin between no lupins and grazing lupins by $13/ha, but grazing remained more profitable (Figure 3). Lupin price changes had minimal effect; lower lupin prices increased profit due to reduced feed costs (Figure 4). Lupin yield affected profit slightly, with higher yields raising overall profit (Figure 5).

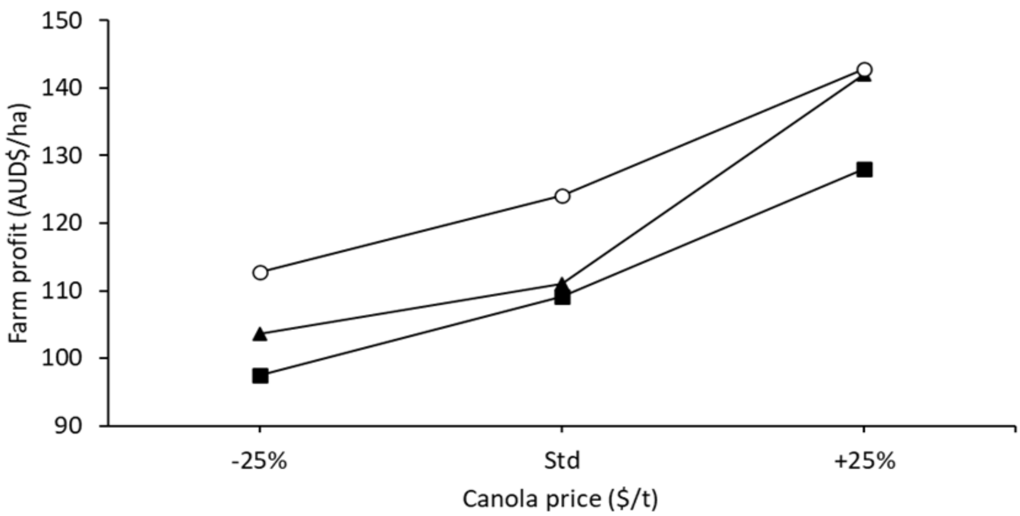

Figure 3: Whole farm profit (AUD$/ha) when canola price ($/t) was decreased by 25% below or increased by 25% above the baseline canola price of $566/t for the base farm with no lupins (p) and when 150 ha of lupins was grazed () or harvested (n) for a mixed farm in south-west Western Australia

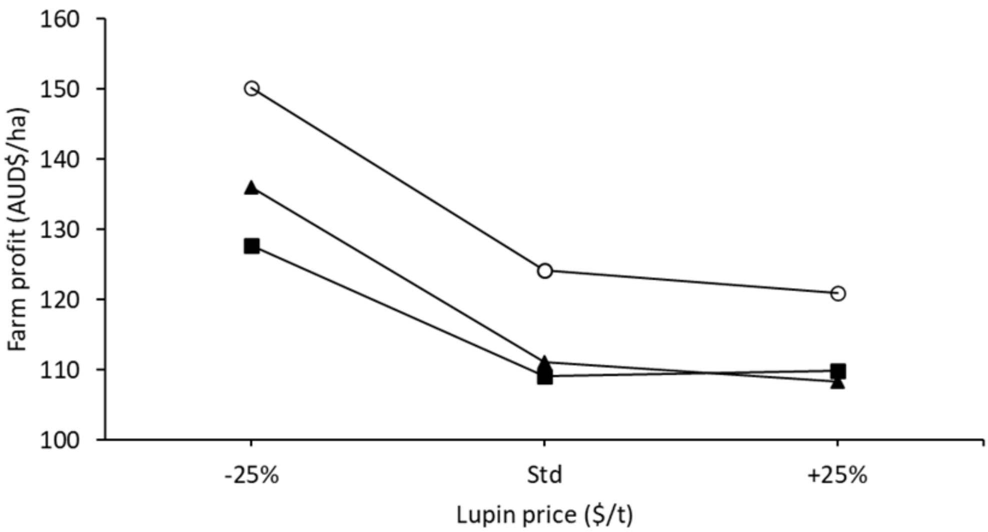

Figure 4: Whole farm profit (AUD$/ha) when lupin price ($/t) was decreased by 25% below or increased by 25% above the baseline lupin price of $330/t for the base farm with no lupins (p) and when 150 ha of lupins was grazed () or harvested (n) for a mixed farm in south-west Western Australia

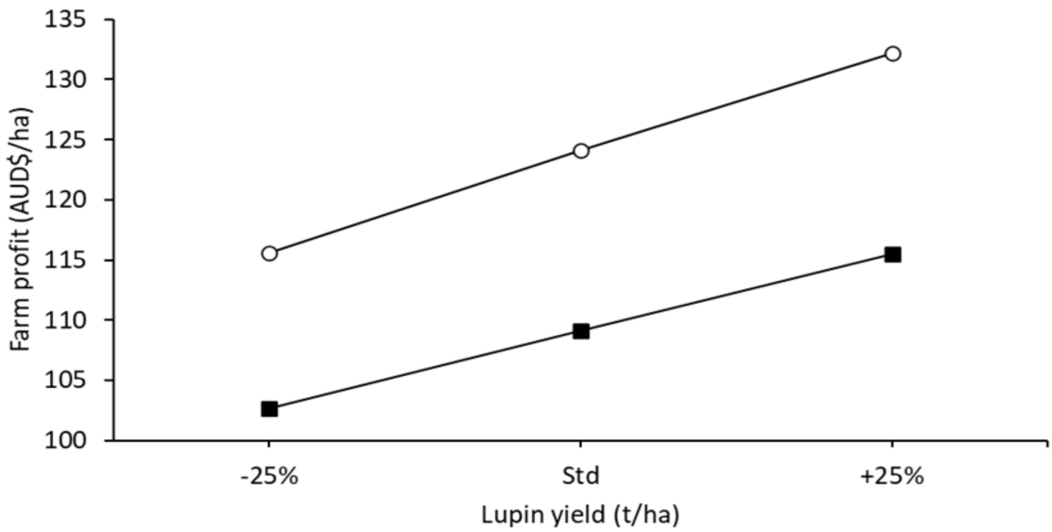

Figure 5: Whole farm profit (AUD$/ha) when lupin yield (t/ha) was decreased by 25% below or increased by 25% above the baseline lupin yield of 1.8t/ha when 150 ha of lupins was grazed () or harvested (n) for a mixed farm in south-west Western Australia

Impact of grazing standing lupin crops on weaner survival and whole-farm profitability

Weaner survival was stable at 1% mortality in both base and grazing scenarios, with liveweights maintained above 25 kg 5 months post-weaning due to high-quality grazing and supplements.

Impact of grazing standing lupin crops on mating ewe lambs and whole-farm profitability

Mating 7 to 9-month ewe lambs was not profitable, reducing farm profit by about $2,000 when forced. Merino ewe lambs did not graze lupins and had similar liveweights in both scenarios.

Impact on profitability when lambs are sold later when grazing standing lupin crops

With stocking rate capped at 13.6 DSE/ha, grazing lupins boosted profit by $12,500 ($83/ha) as lambs sold 39 days later, 2.9 kg heavier, earning $13 more each. Wool revenue also increased. Supplement feed rose by 40 tonnes but had little impact on profit.

Discussion

Incorporating standing lupin crops for grazing into mixed farming systems in south-west Western Australia increased profitability by nearly $200/ha compared to harvesting lupins, which reduced profit by $26/ha. The optimal lupin area was 150 ha (7% of the farm). Grazing lupins consistently outperformed harvesting across various lupin yields, prices, and nitrogen fixation levels, although profitability was sensitive to canola prices.

Profit gains from grazing were mainly driven by a 1.2 DSE/ha increase in stocking rate, improving feed availability in late spring and summer and reducing feed costs during shortages. This aligns with other regional studies showing improved feed sources increase stocking rates and whole-farm profit. When stocking rates were held constant, profit gains decreased but remained positive due to longer lamb growth periods and higher sale prices. Grazing standing lupins provided a more cost-effective feed source than grain supplementation.

Weaner survival and mating ewe lambs earlier were not profitable factors. Merino ewe lambs did not benefit from lupin grazing for mating weight targets. Increased lamb sale values, rather than improved ewe reproduction, drove profit increases. Lower survival rates in the model may limit gains from improved conception, suggesting results could vary in other systems. The model assumes ideal management, producing slightly higher stocking rates than practical estimates but aligns well with regional carrying capacity data. Further research is needed on liveweight data for stubble grazing, ground cover loss, and lupinosis risks. Despite limitations, this study advances understanding of the profitability of grazing standing lupins.

Conclusion

Based on the analysis, integrating grazing of standing lupin crops into a mixed farm system in south-west Western Australia offers clear economic benefits over harvesting lupins. Grazing lupins improves whole-farm profitability primarily by increasing stocking rates, lamb growth and sale prices, and supplementary feed efficiency.

The optimal lupin grazing area is around 7% of farm size, with gains sustained across varying nitrogen fixation levels, lupin and canola prices, and crop yields.

Weaner survival and ewe lamb management are largely unaffected, indicating the practice fits well within existing livestock systems without added risk.

Overall, grazing standing lupins represents a profitable, flexible strategy that enhances farm income while maintaining animal performance and resource use efficiency.

Full paper

CSIRO Publishing | Animal Production Science

Acknowledgements

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Forage brassicas can enhance the feed base and mitigate feed gaps across diverse environments

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Introduction

Forage brassicas have long been used as spring-sown crops in temperate higher-rainfall environments to fill gaps in livestock feed supply during summer–autumn and winter (Lindsay *et al.* 2007; Nie *et al.* 2020). They are highly beneficial because of their ability to produce biomass of high nutritive value over longer periods than many grass-based pastures (Barry, 2013).

Although they will continue to play an integral role in these intensive forage-based livestock systems, it is increasingly evident that forage brassicas can play a wider role as alternative forage-crop options in drier environments such as those within Australia's crop–livestock farming zone (Bell *et al.* 2020; Watt *et al.* 2021).

We modelled the production potential of autumn-sown forage brassicas grown in diverse environments and tested their ability to alter the frequency and magnitude of feed gaps.

Key findings

Across locations, median yields of forage brassicas ranged from 7 to 19 tonnes dry matter per hectare (t DM/ha), and their annual metabolisable energy (ME) yield was higher than that of forage wheat at most sites and nearly always exceeded dual-purpose canola.

Forage brassicas performed better than forage wheat in later-sowing events (late April to early May) and maintained growth and quality later into spring.

At 5 of the 7 regions, adding 15% of farm forage area to forage brassicas reduced the frequency and magnitude of feed deficits by 35 to 50% and 20 to 40%, respectively. However, they were less beneficial where winter–spring feed gaps are uncommon.

Materials and methods

Long-term production potential was simulated in APSIM for 4 forage brassica genotypes (Winfred, Goliath, and HT-R24 forage rapes, and Pallaton raphanobrassica), compared with forage wheat and dual-purpose canola across 22 diverse agro-climatic locations (Figure 1). For 7 regions, the change in frequency and magnitude of forage deficits from adding forage brassicas to representative forage–livestock systems was predicted.

Full description of APSIM inputs and configurations are available in the full paper.

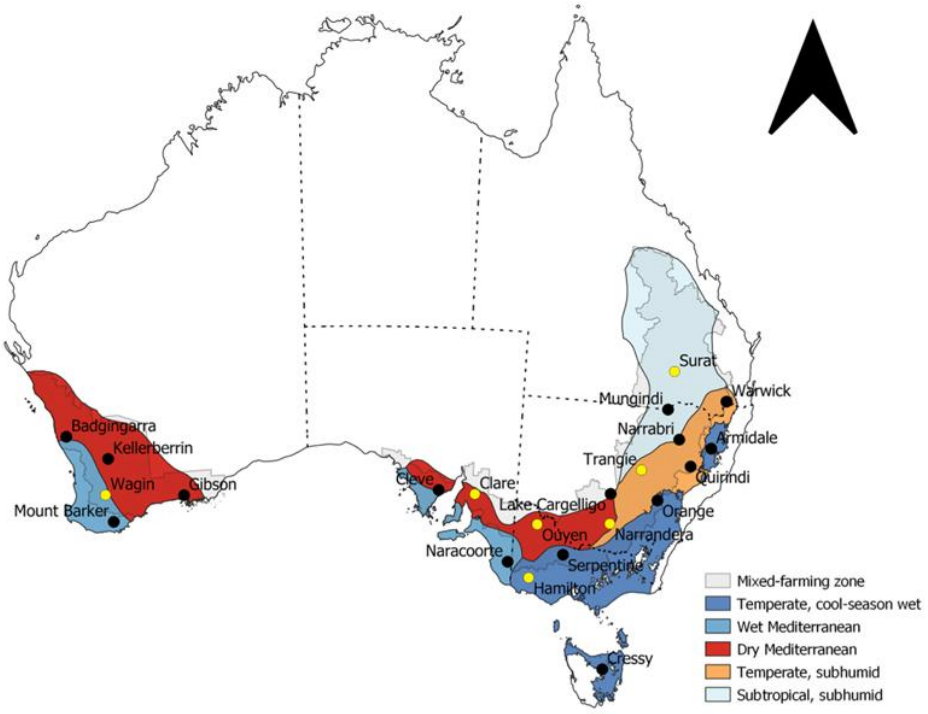

Figure 1: Distribution of the 22 simulated locations across different agro-climatic regions of Australia's crop-livestock farming zone. Black points indicate location of sites with only APSIM predictions of forage biomass production and ME yield, and yellow points indicate the seven locations included in the additional whole-farm feed base analysis

Discussion

Simulated productivity potential of forage brassicas varied considerably (range of 7 to 19 t DM/ha) across 22 locations within diverse agroclimatic environments spanning Australia's crop-livestock farming zone, with productivity being highest in environments with a long growing season associated with winter-dominant rainfall patterns, higher annual rainfall (>600 mm) and lower aridity. Despite these large differences in productivity potential, feed base analysis for 7 diverse livestock production systems showed that integrating forage brassicas into the farm feed base may consistently reduce feed gaps over late autumn to late spring, especially in environments that experience frequent feed deficits at that time of the year. This could help mitigate farm risk and improve total farm productivity via reduced supplementary feed cost and stable stocking density in poorer seasons.

Drivers of forage brassica productivity

In-crop rainfall and seasonal aridity that influence water availability and the length of growing season were critical drivers of forage brassica production potential. Autumn-sown forage brassicas were predicted to be most productive and reliable in environments with a longer growing season and lower aridity, such as wet Mediterranean, and temperate, cool season wet environments, where they could be sown early (March to early April) under optimal available soil water and rainfall conditions and encountered a mild spring that allowed them to grow into early summer. These conditions are typically where forage brassicas are already commonly used, but where they are most often sown in spring to provide forage of high nutritive value in late summer and autumn (Lindsay *et al.* 2007; Nie *et al.* 2020).

Drier environments, such as those with a dry Mediterranean, temperate subhumid, and subtropical subhumid climate, represent new potential areas for forage brassicas and, as such, there is limited comparative data. We showed in this simulation study that forage brassicas grown in dry Mediterranean environments with a lower annual rainfall (<400 mm) and higher aridity were often sown under lower available soil water and rainfall conditions that resulted in a forced sowing event at the end of May. The later sowing along with water limitations from the lower growing-season rainfall (<300 mm) contributed to the lower and much more variable predictions of total production potential (Figure 2) than in the wetter temperate environments.

Data of forage rapes and raphano brassica grown in field experiments under Decile 1 and 2 conditions (Watt *et al.* 2021) closely matched the lower end of our total production predictions for dry Mediterranean (~3.0–4.5 t DM/ha; comparable to Kellerberrin, WA) and subtropical, subhumid environments (~3.6–9.2 t DM/ha; comparable to Warwick, Qld). Our simulations showed that in more favourable seasons, greater total production is possible in these drier environments than what has been demonstrated in field experiments.

Although we showed that predictions of total production potential were generally greatest at locations where earlier sowing opportunities occurred, total production potential of the forage brassicas for each location did not tend to vary with sowing date, as was the case for the forage wheat. Thus, time of sowing was not considered a critical driver of total productivity potential among environments. This contrasts to dual-purpose canola where the grazing period is limited by the onset of reproductive development (Lilley *et al.* 2015). For forage brassicas that offer a longer grazing window, climatic conditions that influenced water availability at sowing and during the growing season into spring (including both rainfall and evaporative demand) were considered more critical drivers of overall production.

Filling feed gaps to support livestock systems

We showed from our predictions and whole-farm feed base analysis that forage brassicas have considerable potential to fill critical feed gaps and serve as an alternative to other forages (such as forage cereals) across a broad range of environments. A significant driver is the much wider and more stable sowing window of forage brassicas than of forage wheat, with the ability to produce higher or similar yields of ME at later sowing dates (late April to early May). Forage brassicas can also maintain nutritive value for longer than forage cereals, because they are slower to reach maturity (Barry, 2013; Watt *et al.* 2021). They are especially advantageous when compared with shorter-season forage cereal cultivars that are faster to mature, and, hence, have a shorter grazing window (Dove and Kirkegaard, 2014; Lilley *et al.* 2015).

In seasons or environments where later sowing and use of shorter-season forage cereal cultivars is more likely (such as Clare, Badgingarra, Cleve, Kellerberrin, or Ouyen), forage brassicas may offer an advantage to better fill feed gaps. We showed from our whole-farm feed base analysis that in these dry Mediterranean environments (such as the Victorian Mallee region), forage brassicas may alter the distribution of feed, filling feed gaps over the winter–spring period, through to summer and early autumn, and allow other on-farm forage sources to be spelled and used in later seasons when pasture supply would normally be limited. (Note: the farm feed base calculator does account for decline in nutritive value and loss of biomass that would occur if forages were deferred and used later). In contrast, integration of a short-season forage cereal crop in these drier environments may help fill the winter feed gap, but the lower total biomass potential and shorter grazing window provide little to no benefit to the farm feed base in summer and early autumn.

Complementary systems with forage brassicas and cereals are less likely to provide benefits in dry Mediterranean environments that receive <350 mm of annual rainfall and where short-season forage cereals are typically sown (such as the Mallee region). Hot, dry summers, which are typical for this environment, also increase the risk of a ‘crop-penalty’ that is more likely to occur when short-season forage cereals are used.

In environments where the sowing of multiple autumn-sown forage crops presents this risk, sowing fewer paddocks with a mixture of forage brassica and forage cereals with different growth patterns may help mitigate feed gaps, without reducing pasture area for grazing over the late-summer and early autumn months.

Conclusion

We demonstrated that autumn-sown forage brassicas can be reliable and productive contributors to the feed base in drier environments and are a suitable alternative to forage cereals.

Forage brassicas can help reduce feed gaps and improve livestock production in a range of production systems spanning Australia’s crop–livestock zone.

Full Paper

MLA Managing forage brassicas in Australian mixed farming regions booklet

Acknowledgements

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Katanning Research Station: Carbon neutral requires trees

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DPIRD is working towards carbon neutrality by 2030 at the Katanning Research Station. Strategies to reduce emissions include:

- measuring the impact of feed type on sheep methane
- reducing sheep numbers
- improving sheep and crop efficiencies
- increasing legume content in pastures to reduce fertiliser requirements
- evaluating the impact of compost granules on soil carbon and nutrient use efficiency
- adopting variable-rate technology to reduce inputs.
- investigating growing biofuels (agave trials on saline land).

By 2030, modelling suggests that these methods will reduce emissions by 12%. Hence, achieving carbon neutrality by 2030 requires sequestration to offset the remaining emissions. We will achieve the required sequestration through revegetation of non-arable or moderately arable areas.

Tree plantings: Planning, implementation and benefits

In 2022, station staff initiated a farm revegetation planning exercise, engaging various stakeholders to meet multiple objectives. This collaborative approach maximised shade and shelter benefits for livestock while delivering co-benefits, including salinity management and biodiversity habitat corridors.

To achieve the carbon-neutral target, 175 hectares (ha) of revegetation were required. Between 2022 and 2024, 50 ha were established (Image 1). An additional 50 ha are currently being planted in 2025 (Image 2), with up to 75 ha planned for 2026.

Image 1: Revegetation using direct seeding in the saline area, planted in 2023

Image 2: Preparations for the 2025 plantings. to provide sequestration, shade and shelter

As part of the 2025 plantings, shade and shelter trees will surround the newly completed 940 m² Sheep Feed Intake Shed (Image 3). These include tall native shade trees around the perimeter of holding pens and yards, habitat plantings in unused spaces, and aesthetically pleasing exotic tree species within the holding areas.

Image 3: 2025 shade and amenity plantings adjacent to the Sheep Feed Intake Shed

Image 4: Agave plantings, 2 hectares of salt affected soils on the research station

Figure 1 below illustrates the projected emission reduction and sequestration from the 175 ha of plantings. Establishment methods include machine planting, hand planting, and direct seeding.

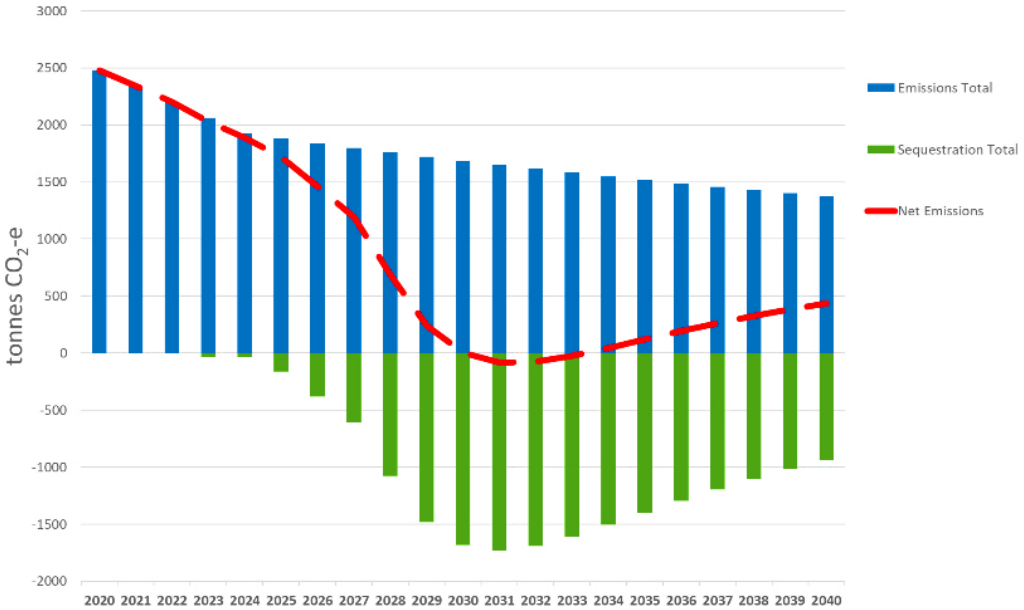

Figure 1: Graph illustrating the importance of the sequestration activities to meet net zero goal at Katanning Research Station

The revegetation efforts are already yielding co-benefits. Stabilised water tables have improved saline areas, reducing salinity expansion. Native vegetation now covers previously bare areas, significantly enhancing the farm's visual amenity, particularly along Nyabing Road. Additional improvements include simplified paddock layouts and enhanced aesthetics. In 4 to 5 years, the shade and shelter around holding paddocks will benefit livestock year-round, mitigating winter chill and providing summer shade.

The revegetation plan also emphasises corridor plantings to enhance habitat value and native biodiversity. Baseline monitoring, has been conducted, including bird counts and plant species diversity. Future opportunities to quantify these benefits will align with Natural Capital Accounting principles.

While primarily designed for carbon sequestration and livestock shade, these plantings ensure long term benefits by creating a more pleasant and visually appealing working environment for researchers, station staff, and visitors.

Assessing genetic variability in flystrike resistance across expression levels in Australian merino sheep

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Introduction

The Australian sheep industry continues to face major challenges from flystrike, a painful and costly condition affecting animal welfare and profitability. However, with proven heritability of flystrike resistance, genetic selection offers a sustainable solution. The Flystrike Genomics Reference Flock project—funded by Australian Wool Innovation—seeks to support this by collecting genetic and phenotypic data from diverse Merino flocks. The study focuses on understanding the genetic basis of flystrike resistance and identifying the level of disease expression needed to guide breeders in developing a robust reference population for flystrike-related Australian Sheep Breeding Values (ASBVs).

Materials and methods

Data: The dataset comprised 39,998 breech strike records (BRS, 1/0) from up to yearling age, including 20,806 ewes and 19,192 wethers and rams, alongside 26,136 genotypes with 61,998 markers on these animals. This dataset was collected from 21 research and industry seedstock flocks. The pedigree consisted of 79,484 animals from 6,805 sires and 36,597 dams.

Data filtering was applied across a range of expression thresholds ranging from 1% to 10% per flock, year of birth and sex (Table 1). A minimum of 20 animals per contemporary group (defined as flock, year of birth and sex) were included. At each expression threshold, the data was partitioned into 2 subsets: The **excluded** subset, consisting of records below the threshold level due to low incidence rates within each of the flock-year of birth-sex groups, and the **included** subset, containing records where the incidence rate was equal to or greater than the threshold levels.

Statistical analyses: Analyses were conducted using single-step REML in BLUPF90 software (Misztal *et al.* 2014). Initial bivariate analyses of subsets (excluded and included) revealed non-significant genetic correlations, particularly at lower thresholds (data not shown). Consequently, separate univariate analyses were conducted for each of the excluded and included subsets at each threshold level of expression.

BRS records (1/0) were standardised (mean=0, SD=1) for strike incidence rate within the flock, year of birth, and sex to account for heterogeneous variance (Dehnavi *et al.* 2024b). Linear mixed models included contemporary groups (flock, year of birth, and sex) and the birth-rear type interaction as fixed effects, with the animal's direct genetic effect fitted as a random effect. Variance components estimated from single-step REML analysis were used to compute breeding values.

Genotype data were incorporated using the H matrix in single-step genomic best linear unbiased prediction (Misztal *et al.* 2014). Heritability estimates were obtained for each subset across the different threshold levels. Because of the non-significant genetic correlation between excluded and included subsets (data not shown), Pearson correlations were calculated to compare research breeding values (RBVs) of common sires and their progeny between the two subsets, contrasting RBVs derived from the excluded data with those obtained from the included subset (Figure 1).

Table 1: Summary of the number of sires (Nsire) and their progeny count (Nprog) categorised by expression threshold excluded (exc), included (inc). The proportion of sires in common across subsets and their respective progeny counts (Link%) are provided in parentheses.

Count threshold	1%	2%	2.5%	3%	4%	5%	8%	10%
Nsire exc (Link%)	348 (32%)	523 (43%)	597 (46%)	653 (43%)	718 (34%)	756 (28%)	825 (27%)	880 (27%)
Nsire inc (Link%)	760 (15%)	698 (32%)	676 (41%)	625 (45%)	520 (46%)	454 (47%)	392 (56%)	351 (67%)
Nprog exc (Link%)	4,358 (39%)	4,898 (35%)	6,064 (39%)	4,256 (23%)	4,615 (21%)	4,333 (18%)	5,009 (18%)	5,084 (16%)
Nprog inc (Link%)	4,093 (15%)	6,925 (28%)	7,949 (34%)	6,342 (31%)	6,345 (38%)	5,270 (37%)	5,503 (53%)	4,725 (60%)

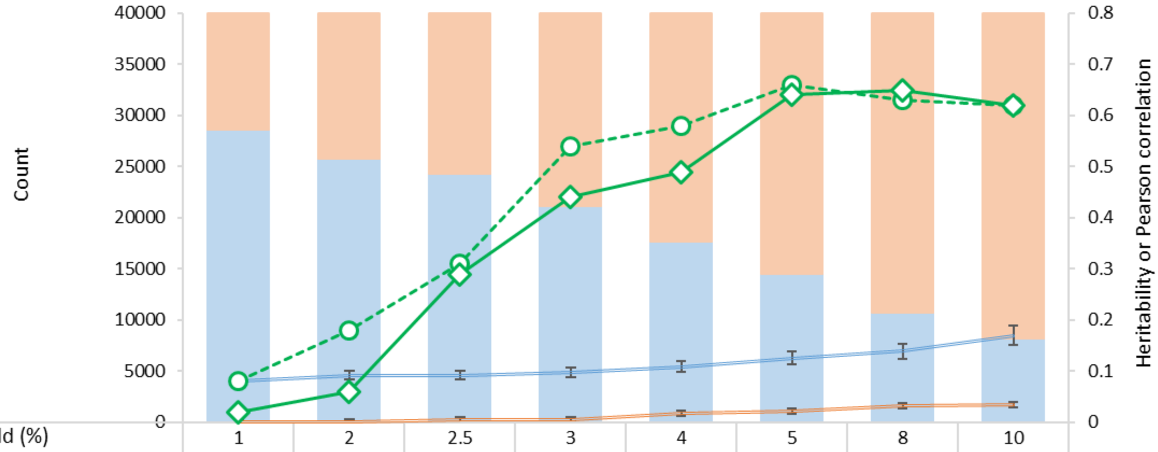
Results and discussion

As the threshold increased from 1% to 10%, a significant reduction in the number of records available for the included subset was observed. The number of sires in the excluded subset (Nsire exc) rises steadily, peaking at 880 sires at the 10% threshold. Conversely, the number of sires in the included subset (Nsire inc) decreases with increasing threshold levels, while their linkage percentage exhibits an inverse pattern, rising from 15% linkage at the 1% threshold to 67% linkage at the 10% threshold. These patterns highlight the trade-off between data quantity and the genetic linkage captured between the 2 subsets (Table 1).

Figure 1 illustrates the number of records in the excluded (exc) and included (inc) subsets across various expression thresholds, along with relevant heritability estimates (h^2). The heritability for the entire unfiltered dataset was low at 0.05 ± 0.01. However, as the thresholds increased, heritability estimates for the high-incidence subset (included; inc) improved significantly, reaching a maximum of 0.17 ± 0.02 at the 10% threshold. This suggests that applying higher expression thresholds enhances heritability but reduces the number of animals in the analysis.

These heritability estimates are lower than those reported in previous studies. These differences may stem from variations in trait definition, modelling approaches, scaling and environmental and management factors influencing trait expression. Notably, none of the earlier studies applied thresholds on expression levels.

Higher incidence rates are often associated with increased heritability on the liability scale when running a threshold model. This aligns with the observed trend in this study, where applying higher expression thresholds led to greater heritability estimates. This occurs because a greater proportion of individuals exceeding the expression threshold leads to higher observable genetic variance. However, this relationship is complex, as heritability estimates are influenced by both the proportion of individuals exceeding the threshold and the underlying genetic variance, which may not increase linearly with incidence.



Threshold (%)	1	2	2.5	3	4	5	8	10
N (Exc)	11,403	14,184	15,681	18,837	22,350	25,519	29,263	31,845
N (Inc)	28,595	25,814	24,317	21,161	17,648	14,479	10,735	8,153
h2 (Exc)	0.00	0.00	0.00	0.01	0.02	0.02	0.03	0.03
h2 (Inc)	0.08	0.09	0.09	0.10	0.11	0.13	0.14	0.17
RBVs' cor common prog	0.08	0.18	0.31	0.54	0.58	0.66	0.63	0.62
RBVs' cor common sire	0.02	0.06	0.29	0.44	0.49	0.64	0.65	0.62

Figure 1: Number of records (orange and blue bars) and heritability (double orange and blue lines) in excluded (exc) and included (inc) subsets. The subsets represent different levels of expression thresholds (1%, 2%, 2.5%, 3%, 4%, 5%, 8%, and 10%). The Pearson correlation was assessed between the RBVs of common sires and their progeny (RBVs' corr common prog or sire) derived from excluded data with those derived from included data (solid and dotted green lines)

Figure 1 also highlights the comparison of breeding values of common sires and their progeny between the 2 subsets (solid and dotted green lines). A comparison was conducted between the RBVs of common sires and their respective progeny across the 2 (excluded and included) subsets. At lower thresholds, the weaker pedigree linkage between the subsets, and the low heritability resulted in more diverse RBV predictions, as indicated by the lower Pearson correlation (solid and dotted green lines in Figure 1). Increasing the threshold levels strengthened the pedigree linkage, improving the Pearson correlation of RBVs for common individuals between the 2 subsets.

Although heritability estimates remain adequate within the included subset (inc; 0.08 to 0.09), the low linkage and reduced correlation between RBVs of common sires at these thresholds (1% to 2%) highlight the importance of incorporating high-incidence records. While a threshold of 5% appears reasonable, lowering the threshold to 2.5% is a viable compromise to enable a great level of participation. Below this level, heritability and genetic variance are minimal (with phenotypic variance approaching 1), indicating that excluding the low-incidence subset (excluded) would preserve genetic information and allow for accurate selection decisions based on genetic merit. This adjustment balances the number of excluded records, prediction accuracy, and genetic variation while encouraging breeders to actively use breeding values for selection for flystrike resistance.

Conclusion

Identifying the most appropriate threshold for flystrike expression remains an important consideration to ensure the most accurate breeding values are provided to breeders and enable future genomic selection.

The selected threshold impacts both heritability estimates and the correlations of predicted breeding values significantly. Higher thresholds improve both heritability estimates and the accuracy of breeding value predictions in sheep selection programs. However, to encourage breeders to participate effectively in direct selection for flystrike, a threshold of

2.5% appears optimal, as it excludes records with minimal genetic variation while maintaining selection efficiency for more breeders.

To ensure broader applicability, this approach will be evaluated further for body strike in young sheep and records of both breech and body flystrike across later ages.

Full paper

https://acrobat.adobe.com/id/urn:aaid:sc:AP:8cc92342-57eb-4f4b-9233-cc6ac7f2bfa0

Pages 411 to 414

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