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LAMBPLAN - Review of adoption by the Australian meat sheep breeding industry

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Executive Summary

Throughout the past quarter century systematic selective breeding practices that are founded in competent genetics science have played a significant role in the improvement of animal performance in most first-world livestock industries. Launched in 1987, LAMBPLAN is the Australian national system for describing the genetic worth of animals in the meat sheep industry and has played a significant role in genetic improvement in that industry.

LAMBPLAN evolved from several R&D projects that were undertaken by the New South Wales Department of Primary Industries, Victorian Department of Primary Industries and Primary Industries and Resources South Australia in the early 1980s and was a significant component of an overall strategy to develop an Australian lamb industry that could meet product specifications of lucrative markets identified by consumer research undertaken in the late 1970s and early 1980s. In the early 1980s, much of the broader sheep industry research and extension activity aimed at improving carcase quality was focused on developing nutrition programs. In this sense, the R&D that led to LAMBPLAN represented a significant change in approach.

LAMBPLAN uses Best Linear Unbiased Prediction (BLUP) algorithms to predict an individual ram's ability to produce superior progeny by analyzing data relating to the ram's own performance as well as the performance of all recorded relatives in the flock, which is recorded on a national database. The trait data that is recorded on the database is collected by accredited LAMBPLAN operators and captured using various accurate trait measurement technologies such as ultrasound. The ram's performance and that of its progeny is articulated in the form of Estimated Breeding Values (EBVs) and Indexes that combine EBV's for specific meat production and reproductive traits.

Effectively EBVs allow ram buyers to select either terminal rams that when joined with either Merino Ewes or first cross ewes are likely to produce slaughter lambs that meet the producer's meat production objectives, or maternal rams that when crossed with a merino ewe, will produce a first cross ewe that meets the producer's reproduction efficiency objectives.

Traditionally, selective breeding decisions have been based on a visual assessment of an animal, a skill which was believed to be the foundation expertise of a reputable stud

breeder. LAMBPLAN has removed much of the risk from breeding stock selection decisions. While visual assessment may still be necessary to ensure basic structural integrity and health of an animal, the ability to assess the genetic merit of an animal by comparing objective data relating to the heritability of specific traits has removed much of the mystery associated with the traditional breeding industry and has facilitated evidence based decisions in seedstock selection.

The overall uptake of LAMBPLAN by the broader Australian meat sheep breeding industry was rapid in the first decade of operation of LAMBPLAN, growing from just 25 breeders in its first year of operation to over 700 breeders in 1996. Breeder registrations with LAMBPLAN have remained relatively constant since the late 1990s at about 600 registered breeders. Comparatively, the number of animals registered on the LAMBPLAN database has continued to grow at a relatively constant rate from less than 500 in 1987 to approximately 150,000 in 2004.

The uptake of LAMBPLAN has been more prolific among the terminal sire breeding sector than the maternal sire breeding sector. This is to be expected as demand for effective terminal sires has been driven by a priority for commercial producers to produce lambs that meet the stringent carcase specifications of processors and exporters servicing the more lucrative lamb markets, particularly the United States, rather that increasing the volume of lamb output. However, the adoption of LAMBPLAN by the maternal sire breeding sector has also been lower because achieving genetic change in maternal traits is a slower and more complicated process.

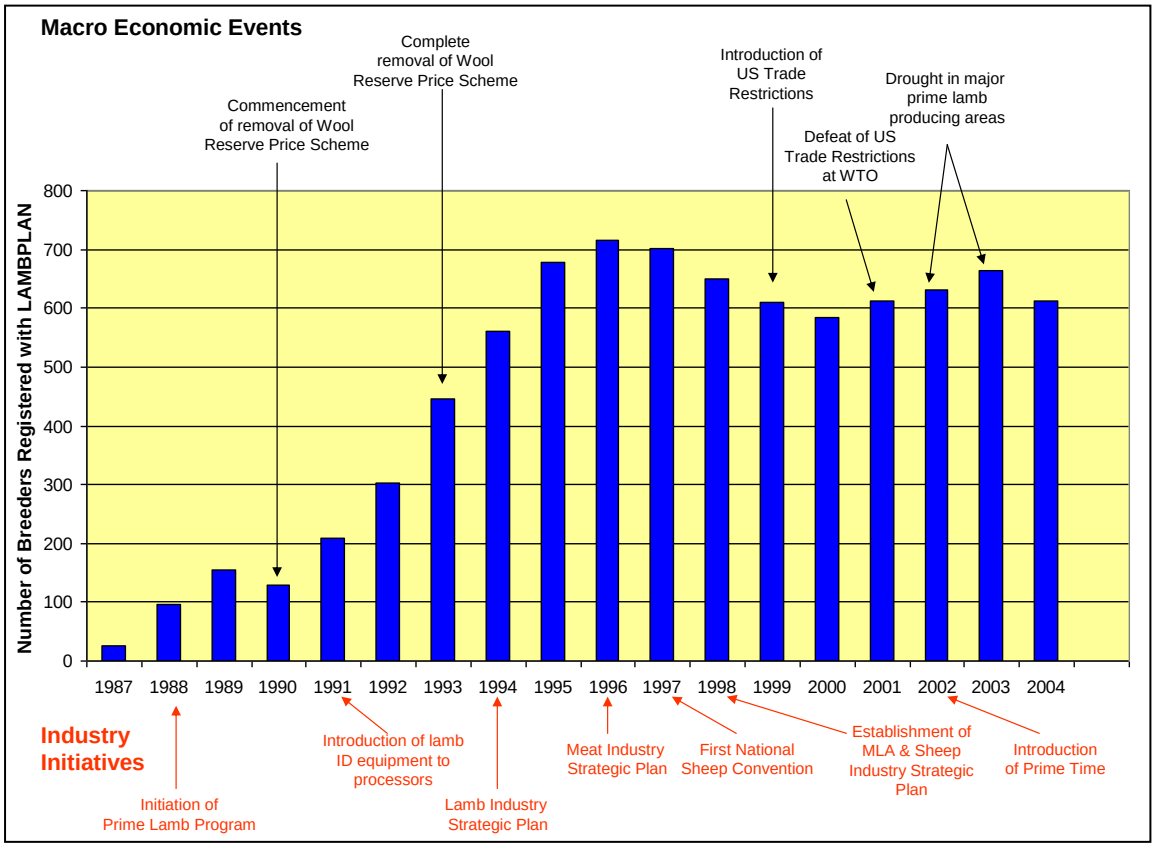
When LAMBPLAN launched, the Poll Dorset breeding sector accounted for 66 percent of breeders registered with LAMBPLAN. Today, LAMBPLAN is used by a far more diverse range of breeders, although Poll Dorset and White Suffolk breeders collectively account for 50 percent of registered breeders. The table overleaf demonstrates the rate of adoption of LAMBPLAN, by breeders in each of the main meat breed sectors.

Breed	1990 Adoption		1997 Adoption		2004 Adoption	
	Breeders	Ram Lambs	Breeders	Ram Lambs	Breeder	Ram Lambs
Poll Dorset	6.1%	25.4%	25.4%	67.0%%	20.4%	70.0%
White Suffolk	22.1%	n.a.	47.3%	n.a.	29.1%	n.a.
Texel	n.a.	n.a.	36.2%	36.0%	25.6%	58.0%*
Border Leicester			7.8%**	22.0%**	15.5%	74.0%
Suffolk			21.0%**	n.a.	24.5%	n.a.
Merino	0.7%	0.4%	3.0%	16.0%	5.7%	40.0%
Poll Merino	1.0%	5.0%	3.5%	24.0%	10.0%	68.0%

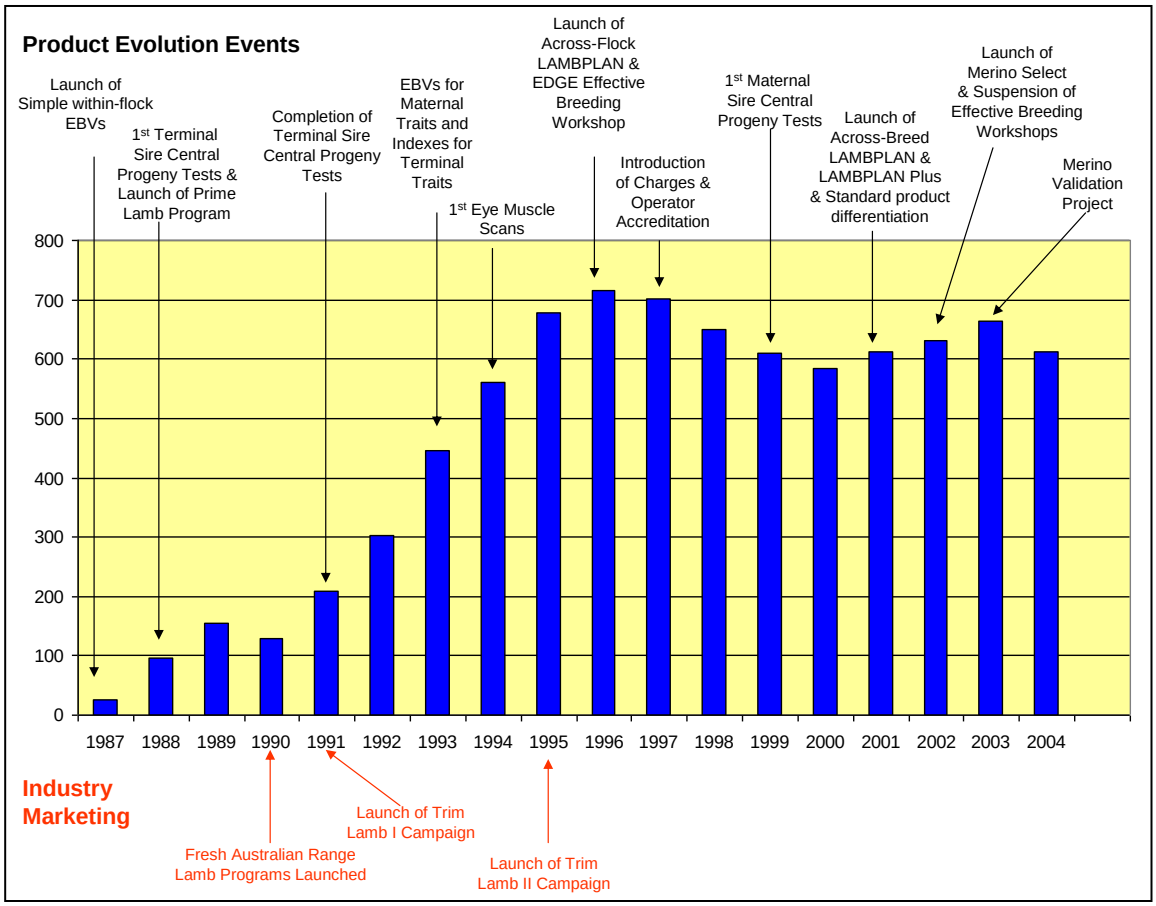
NB: these statistics and estimates are based on numbers from the LAMBPLAN database and official breed society statistics derived from the respective flock books.

LAMBPLAN has had considerable impact on the sheep production sector, with an estimated 45 percent of today's industry lambs being sired by LAMBPLAN rams and an estimated 55 percent of today's industry slaughter lambs being sired by LAMBPLAN rams. The impact of LAMBPLAN on the lamb production sector is further evidenced by the strong correlation between the growth in exports of Australian lamb, the growth in average carcase weights and the growth in adoption of LAMBPLAN.

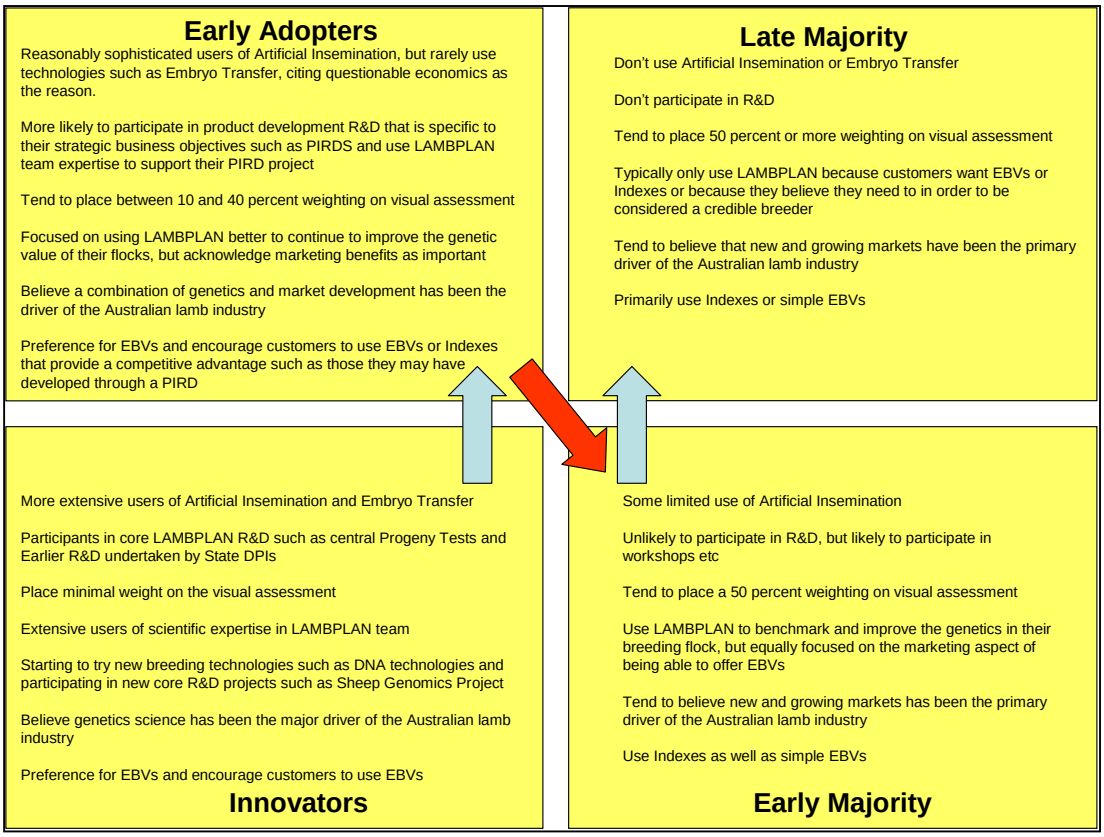
A multitude of macro-industry events, industry development initiatives, market development initiatives and product development initiatives have impacted on the adoption of LAMBPLAN. However, it is clear from the investigation the subject of this report that factors that effect the perceived relative advantage that LAMBPLAN offers and its compatability with the felt-needs of potential adopters have been the main factors that have driven adoption. Specific macro-economic and industry initiatives that have impacted on LAMBPLAN are summarized in the figure below.



Additionally, specific product development and industry marketing events that impacted on the adoption of LAMBPLAN are summarized in the figure below.



The investigation into the adoption of LAMBPLAN also provides evidence as to the pathway to adoption that LAMBPLAN followed. Key characteristics of the different adopter segments for LAMBPLAN were evidenced in the interview and are summarized in the figure overleaf.



Several key lessons emerge from this investigation into the adoption of LAMBPLAN that can be applied to future innovation adoption strategies and these are as follows:

1. When developing the technology platform for the innovation think in terms of technology convergence as it creates broader opportunities and possibilities for product development, increasing the likelihood that the product will be able to evolve to meet the different felt-needs of different adopter segments;
2. Undertake high profile, collaborative R&D that demonstrates the robustness of the science that underpins the technology platform as well as the ability of the innovation to convert that science into workable solutions for industry. This provides the basis for effective evidence based marketing.

3. Look for either growing industries that need a solution to a clear and significant problem that the innovation can solve better than the existing solution, or events in an existing industry that have the potential to change the dynamics of that industry such that the innovation would demonstrate a relative advantage.
4. Where the outcome will clearly benefit industry, use promotional horsepower in both markets and production environments to illuminate the need for a solution to the existing problem and the relative advantage demonstrated by the innovation with respect to solving that problem, or to capitalize on the event that has changed the dynamics of the industry and the relative advantage that the innovation has in the new industry dynamic.
5. Be mindful of the need to address the entire supply chain in developing and marketing the innovation.
6. Identify the different adoption behaviour segments for the specific innovation, develop a clear understanding of their adoption profiles and develop a strategy designed to drive the innovation down a broad market adoption pathway.
7. Target 'Innovator' adopters to develop the innovation from the technology platform and test customer usage of the innovation through technical, base level cooperative R&D.
8. Develop cooperative R&D projects with 'Early Adopters' to develop products that provide unique competitive advantage to those 'Early Adopters'.
9. Develop a detailed understanding of the felt-need of the different 'Early Majority' market segments and develop products that clearly match those felt-needs.

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Chapter 1: Introduction and background

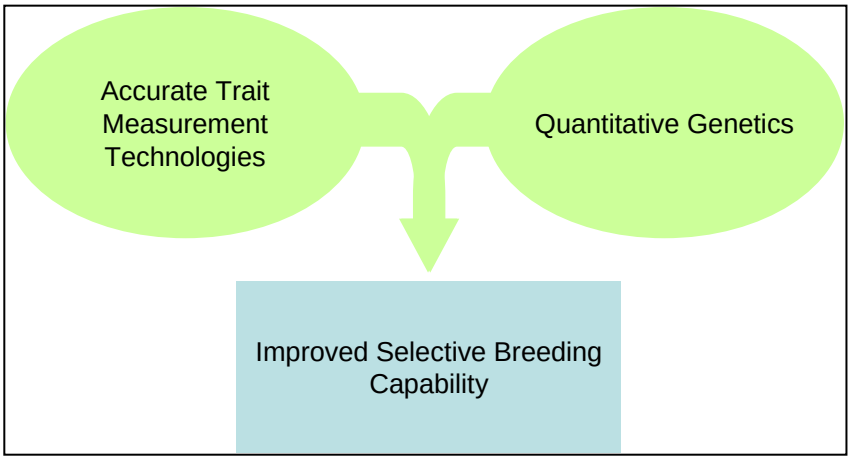
Throughout the past quarter century systematic selective breeding practices that are founded in competent genetics science have played a significant role in the improvement of animal performance in most first-world livestock industries. In the case of the Australian sheep meat industry, the positive impact that genetics science has played is acknowledged by both scientists[1] and industry practitioners[2]. As demonstrated in Table 1 below[3], genetic improvement has fuelled both productivity and profit growth in the Australian sheep and cattle industries.

[1] Banks, R. (2004), *Meat Sheep Breeding in Australia,* MLA, Armidale
[2] The majority of all breeders interviewed agreed that scientific approaches to genetic management has played a major role in animal improvement.
3 Banks, R. (2004), *Challenges in Investing in Genetic Improvement for the Australian Extensive Livestock Industries*, Internal Paper, MLA, Armidale

Category	Rate of progress - $ per breeding female per year (1999-2004)	Rate of progress - $ per DSE	Rate of progress in $ per DSE as % of average gross margin per DSE	Rate of progress in $ per DSE as % of average net profit per DSE
Beef Cattle (Weighted Herd)	1.79	0.10	0.5%	1.4%
Leading Angus Herds	5.00	0.28	1.5%	4.0%
Terminal Sire Meat Sheep Average	0.97	0.54	3.0%	11.5%
Leading Terminal Sire Flocks	1.37	0.76	4.3%	16.1%
Merino Average	0.25	0.14	0.7%	2.0%
Leading Merino Flocks	1.00	0.56	2.8%	8.0%
Dairy Cattle	5.00	0.28	1.5%	4.0%

[Is there any data on rate of progress $ for slaughtered lambs sired by LAMBPLAN rams and ewes??]

The ability to effectively manage genetics in selective breeding practices has been the result of the following developments (see adjacent Figure 2):



- Quantitative genetics methods that allow the performance of progeny to be more accurately predicted from the assessment of the performance traits of its relatives. Algorithms such as Best Linear Unbiased Prediction (BLUP) are used by the Australian beef, dairy and meat sheep industries to predict an animal's ability to produce superior progeny by drawing on data relating to the sire's own performance as well as the performance of all of its known relatives; and

- Technologies that facilitate the accurate measurement of certain performance traits as well as the measurement of performance traits that have previously not been measurable. The most important of these has been ultrasound equipment that, in the case of meat sheep, facilitates the accurate measurement of fat depth, eye-muscle depth and area and in the case of beef cattle, the accurate measurement of muscle area, depth and marbling which is an important indicator of eating quality in beef cuts.

While it is broadly acknowledged that accurate trait measurement technologies have played a significant role in improving animal performance in the sheep meat industry, there is a history of some contention among industry practitioners as to the role that quantitative genetics has played[4]. To understand the source of this contention it is important to understand the evolution of animal assessment methods in the Australian sheep industry. Traditionally, the measurement of the performance traits of a sheep has been the proprietary skill of sheep breeders who make visual assessments of a ram, making subjective judgments as to the ram's structure and other features. Some of the factors they consider include the animal's length (to determine if there is adequate portion of high value cuts which are located between the shoulders and hind legs), mouth (to ensure that it can eat), feet (to ensure that it can walk around a paddock) and, in the case of rams, scrotum size (to estimate its fertility). The judgment based on this visual assessment is then [subjectively] validated by the ram's performance in the show ring. Some breeders still rely solely on visual assessment to determine and describe an animal's merits.

[4] All breeders that were interviewed agreed that objective measurement of traits using technologies has played a major role in improving animal performance. While the vast majority of all breeders agreed that LAMBPLAN had played some role in improving the quality of Australian lambs, only those using LAMBPLAN agreed that the LAMBPLAN program had played a major role.

The emergence of accurate trait measurement technologies such as ultrasound and weight measurement at different ages has allowed breeders and buyers of seedstock to accurately and objectively assess a range of performance traits in an individual animal such as weight at birth, eye-muscle area and depth, wool staple strength measured using ATLAS testing/grab sampling or diameter measured on-farm using OFDA and faecal egg count. This has somewhat negated the need for show ring validation, although many breeders still show animals as it provides further validation, provides marketing advantage with some customers, and is still a strong customary practice in some segments of the industry. However, it would seem that most breeders who still use visual assessment also use accurate measurement technologies to further validate their visual assessment[5].

Neither visual assessment nor accurate trait measurement technologies used in isolation provide a reliable assessment of the genetic merit of an animal. However, by maintaining and analyzing a database of animal's pedigrees and accurately measured performance traits of related animals over time, the ability of sires to pass exhibited performance traits onto their progeny can be predicted. This is the basis for LAMBPLAN and breeders who use LAMBPLAN all use accurate trait measurement technologies to collect the objective performance data that is used in the database to predict the genetic merit of the animal because accurate measurement is required to preserve the integrity of the information produced from the database. All users of LAMBPLAN use visual assessment to some degree, but tend to place less weight on visual assessment in an animal selection decision.

The contention in the industry as to the role that quantitative genetics has played, has been the result of a number of factors including:

- There is a long tradition in the sheep industry whereby the skill of a sheep breeder to assess an animal visually has been revered and objective systems such as LAMBPLAN can serve to undermine that tradition;
- While accurate trait measurement using technologies in isolation tends to confirm the visual assessment of many performance traits, the assessment of an animal's ability to pass on those traits using LAMBPLAN will often not, simply because the heritability of traits is variable and the animal's ability to express a performance trait

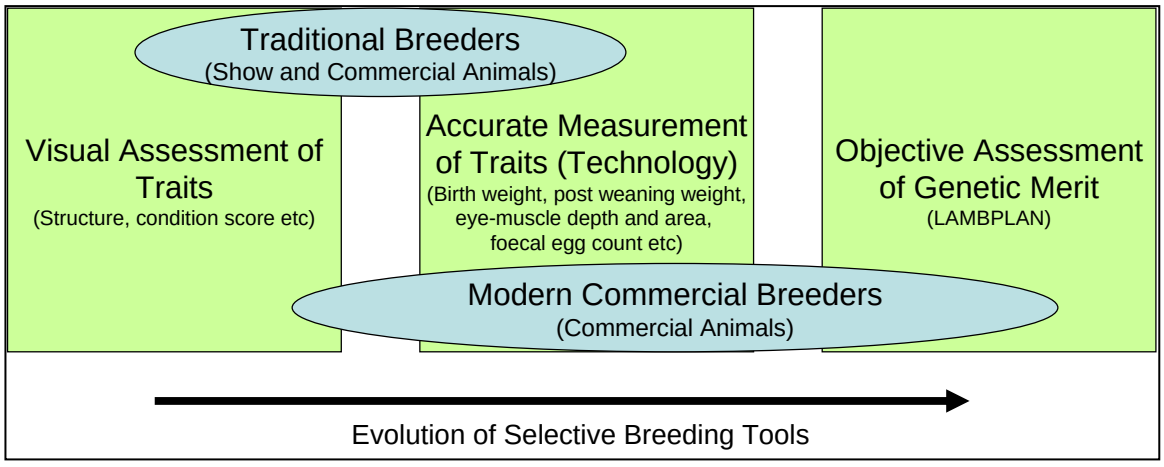
[5] Most breeders interviewed who did not use LAMBPLAN reported that they used objective measurement tools such as Stockscan to objectively assess traits.

can also be affected by nutrition and environment. In other words, an animal that performs well on certain traits in a show ring environment does not necessarily have a strong genetic basis for those traits and as such, may not have the ability to pass those traits onto its progeny. For breeders committed to the traditional approach, this somewhat discredits their assessment.

It would seem that the weight of this argument is now heavily in favour of LAMBPLAN as it is clear from the adoption data that most significant breeders of commercial seedstock in the Australian meat sheep industry use LAMBPLAN (see Chapter 3 for adoption levels among major breeding sectors). However, while it would appear that objective measurement of genetic merit will play an increasingly important role in assessing animals in the meat sheep industry[6], it is likely that visual assessment will remain as an important source of decision information for both breeders and buyers of seedstock for the following reasons:

- Visual assessment is entrenched as a traditional practice and seems to be practiced extensively among small show animal breeders;
- Livestock purchasers take into account non genetic factors in their purchasing decision such as basic structural factors; and
- Quantitative genetics provides an estimation of the genetic potential of an animal and as such, some decision makers will source additional comfort from a visual appraisal.

Figure 3 below demonstrates the evolution of practices used to assess the genetic merit of a ram in the sheep industry



[6] Almost all breeders interviewed agreed that objective measurement would play an increasingly important role in the industry.

In terms of industry adoption, LAMBPLAN has been widely acknowledged as being one of the most successful projects undertaken by a Rural Development Corporation (RDC) in Australia. This paper reports on an investigation into the historic adoption of LAMBPLAN.

Researching and accurately documenting the adoption of LAMBPLAN by the Australian meat sheep breeding industry will identify environmental and project specific factors that have both facilitated and detracted from the adoption of LAMBPLAN, providing valuable information that will:

- Improve the predictability of adoption of future MLA innovations with similar characteristics to the LAMBPLAN project; and
- Assist MLA with developing future adoption strategies.

Chapter 2: Investigation methodology

The investigation on which this publication is reporting was conducted according to the following process:

1. A desktop review of the historic performance and macro-environment in which the Australian lamb industry underwent its transformation was undertaken in order to understand market and industry signals that may have affected the adoption of LAMBPLAN as well as to provide prima facie evidence of the impact on industry performance of LAMBPLAN.
2. A desktop review of internal and published MLA reports relevant to LAMBPLAN was undertaken in order to identify issues that could potentially impact on adoption, internal and independent assessments of those issues as well as product design, promotional and education initiatives that may have impacted on adoption.
3. Analysis of data maintained by relevant sheep breeding societies was undertaken to determine the size of breed sectors as well as an analysis of LAMBPLAN data to determine usage of LAMBPLAN by relevant sheep breed sectors. These analyses were compared for each of the years 1987 through to 2004 to determine an approximation of adoption. The sheep breeding societies from which data was collected were the Australian Poll Dorset Association, Australian Texel Stud Breeders Association, Australian White Suffolk Association, Australian Association of Stud Merino Breeders, Australian Stud Sheep Breeders Association and the Australian Coopworth Association. The LAMBPLAN data used was provided by MLA and detailed the number of registered breeders in each year who have remained registered with LAMBPLAN. The reason for using this data is that as a result of considerable consolidation in the Australian meat sheep breeding industry over the life of LAMBPLAN, the use of raw registration data would misrepresent the level of discontinuance. In order to ensure that discontinuance is covered by this review a number of breeders that formerly used LAMBPLAN were interviewed.
4. Interviews with a cross section of breeders that use LAMBPLAN as well as those that do not use LAMBPLAN was undertaken determine factors that have

influenced decisions to adopt, not to adopt or to discontinue usage of LAMBPLAN.

5. Interviews were conducted with other key stakeholders in the LAMBPLAN program including individuals involved in its development and delivery over time, sheep meat processors, commercial lamb producers and current and former members of the LAMBPLAN advisory committee.
6. Analysis of the main factors positively and negatively affecting the adoption of LAMBPLAN as determined by synthesising and analysing information gathered in the above steps using contemporary best-practice frameworks for assessing industry adoption of innovations.
7. Development of a framework for planning and estimating the adoption of innovations with similar characteristics to LAMBPLAN.

Chapter 3: What is LAMBPLAN?

Product and Service Overview

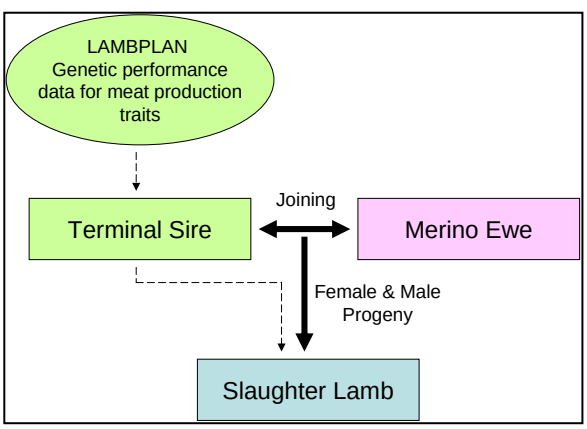
Launched in 1987, LAMBPLAN is a national system for describing the genetic worth of animals in the Australian meat sheep industry. Based on initial R&D and service development work undertaken by the New South Wales Department of Primary Industries, Victorian Department of Primary Industry and Primary Industries and Resources South Australia (see Chapter 5), LAMBPLAN was developed and continues to be operated by MLA and its predecessor organisations

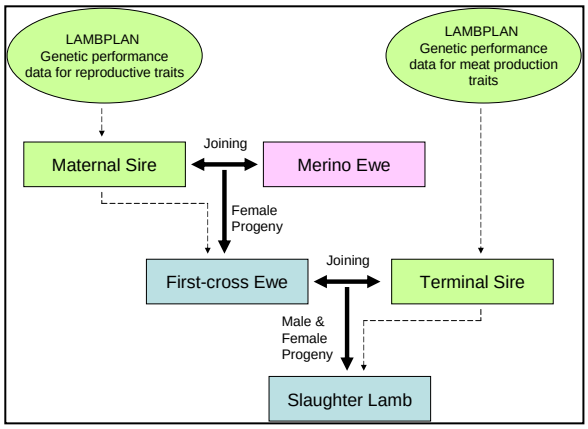
The LAMBPLAN software, OVIS, uses Best Linear Unbiased Prediction (BLUP) algorithms to predict an individual ram's ability to produce superior progeny by analysing data relating to the ram's own performance as well as the performance of all recorded relatives in the flock, as assessed by accurate trait measurement technologies. Primarily the ram and its progeny's predicted performance is articulated as Estimated Breeding Values (EBVs) for specific meat production and reproductive traits that are assigned to each animal on the LAMBPLAN database. EBVs are adjusted for any environmental factors that might affect the animal's performance such as the ram's age, whether it was a twin or single and different feeding programs.

There are two key benefits of LAMBPLAN information for the meat sheep industry:

- Ram purchasers have a greater ability to identify a ram's genetic merit accurately; and
- Breeders have a greater ability to identify rams and ewes with the best genetic merit, which allows for much higher rates of genetic improvement that would be the case without LAMBPLAN

EBVs allow ram buyers to select either terminal rams that when joined with either Merino ewes or first-cross ewes are likely to produce slaughter lambs that meet the producer's meat production objectives, or maternal rams that when crossed with a merino ewe, will produce a first cross ewe that meets the producer's reproduction efficiency objectives. The genetic flow for terminal and maternal breeding practices based on LAMBPLAN are demonstrated in Figure 4 overleaf.





The specific traits for which LAMBPLAN EBVs are currently available are described in Table 2 overleaf.

Live Weight Traits	Carcase Traits[7&8]	Reproduction Traits
Birth Weight (BWT) - Estimates the genetic difference between animals in liveweight at birth.	**Post Weaning Fat Depth (PFAT) -** Estimates the genetic difference in GR fat depth at 45 kilograms liveweight.	**Number of Lambs Born (NLB)** Estimates the genetic difference between animals for number of lambs born at each lambing opportunity.
Weaning Weight (WWT) - Estimates the genetic difference between animals in liveweight at 100 days of age.	**Yearling Fat Depth (YFAT) -** Estimates the genetic difference in GR fat depth at 60 kilograms liveweight.	**Number of Lambs Weaned (NLW)-** Estimates the genetic difference between animals for number of lambs weaned at each lambing opportunity.
Post Weaning Weight (WWT) - Estimates the genetic difference between animals in liveweight at 225 days of age.	**Hogget Fat Depth (HFAT) -** Estimates the genetic difference in GR fat depth at 70 kilograms liveweight.	**Post Weaning Scrotal Circumference (PSC) -** Estimates the genetic difference for scrotal circumference at 225 days of age.
Yearling Weight (YWT) - Estimates the genetic difference between animals in liveweight at 360 days of age.	**Post Weaning Eye Muscle Depth (PEMD) -** Estimates the genetic difference in Eye Muscle Depth at the C Site at 45 kilograms liveweight.	**Yearling Scrotal Circumference (YSC) -** Estimates the genetic difference for scrotal circumference at 360 days of age.
Hogget Weight (HWT) - Estimates the genetic difference between animals in liveweight at 450 days of age.	**Yearling Eye Muscle Depth (YEMD)-** Estimates the genetic difference in Eye Muscle Depth at the C Site at 60 kilograms liveweight.	**Hogget Scrotal Circumference (HSC) -** Estimates the genetic difference for scrotal circumference at 450 days of age.
Adult Weight (AWT) - Estimates the genetic difference between animals in liveweight at 540 days of age.	**Hogget Eye Muscle Depth (HEMD) -** Estimates the genetic difference in Eye Muscle Depth at the C Site at 70 kilograms liveweight.	
Maternal Weaning Weight (MWWT) - Estimates the ewe's potential for milk production and ability to provide a better maternal environment. MWWTs are expressed as kilograms of liveweight at 100 days of age (weaning).		

[7] GR Site is 110 mm from the centre of the animal's spine at 12/14th rib.
[8] Eye Muscle Depth (EMD) is the depth of the animal's eye muscle (longissimus dorsi) at the C Site, which is 45 mm from the centre of the spine at the 12/13th rib.

Additionally, LAMBPLAN combines the EBVs from each ram into a single index according to specific production or breeding objectives such as growth, reduced fat and increased muscling. Each ram is then ranked and placed in quality grades according to their index as demonstrated in Table 3 below.

Grade	Percentile
Blue	First
Red	Second
Green	Third
Unranked	Fourth

When LAMPLAN commenced it was only possible to compare animals within a specific flock. Following the Terminal Sire Central Progeny Test Program in the early 1990s and the accumulation of a critical mass of data, the ability to compare LAMBPLAN rams directly on index regardless of stud or breed started to become available due to the high level of genetic linkages between terminal sires and breeds. This was known as Across Flock LAMPLAN and, in 1997, LAMBPLAN became available as Across Flock data only.

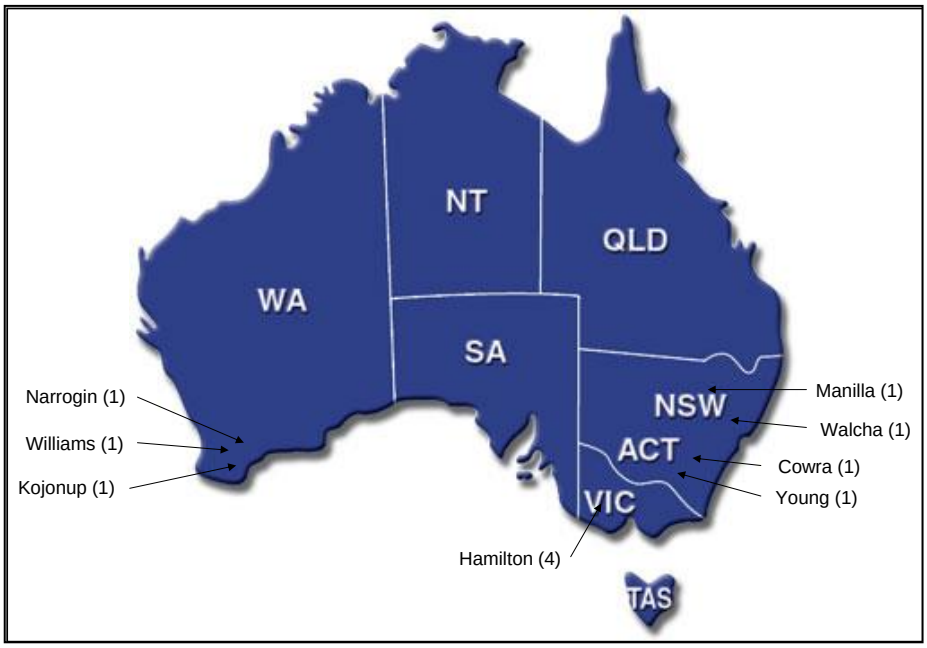
This is critical for producers because in a given production environment and nutritional program, they can feel considerably more comfortable that they will be able to produce to the carcase weight and leanness specifications of the various high value markets for Australian prime lamb. The weight and leanness requirements of the key markets are demonstrated in Table 4 below.

Market	Carcase Weight Range (Kg)	GR Tissue Depth[9] Range (mm)

[9] GR Tissue Depth is the depth of tissue of the 12/13th rib 110mm out from the backbone. A deeper GR measurement indicates a fatter carcase. GR depth is the basis of carcase fat grading in Australia.

Export (often trimmed back to 17mm equivalent)	19-31	5-20
Export Fresh Premium Lamb	20-26	7-14
Heavy Trade	20-23	7-12
Trade	16-20	7-12
Middle East Export	8-14	3-7

The objective data for individual animals from which the EBVs and Indexes are based is collected by accredited LAMBPLAN operators who scan a breeder's rams and ewes for live weight, fat depth and eye-muscle depth using ultrasound equipment. The data collected by the accredited operators is entered into the LAMBPLAN database remotely using the LAMBPLAN data entry software known as Pedigree Wizard. In November 2005, there were eleven accredited operators in Australia, distributed according to Figure 5 below.



In essence, LAMBPLAN has removed much of the risk from a breeding stock selection decision. While visual assessment may still be necessary to ensure animals have basic structural integrity, the ability to assess the genetic merit of animal by comparing

objective data relating to specific traits has removed much of the mystery associated with the traditional breeding industry and has facilitated evidence based decisions in livestock selection.

LAMBPLAN versus Other Trait Measurement Services

It is important to discuss the difference between LAMBPLAN and other trait measurement services that are available, as these other measurement services are often inaccurately compared as similar services[10]. While some breeders that do not use LAMBPLAN acknowledge that other trait measurement services that operate in the Australian sheep industry do not provide a measurement of the genetic merit of an animal, many breeders that do not use LAMBPLAN believe that these services are comparable to LAMBPLAN. This has been a significant source of contention between breeders that use LAMBPLAN and those who do not.

StockScan is a New Zealand based company that has provided sheep ultrasound scanning services to New Zealand sheep farmers since the early 1990s and Australian sheep farmers since the early 2000s, including pregnancy scanning, stud ram and ewe muscle scanning and ewe flock replacement meat yield scanning. It also provides data processing and reporting services. In other words, it provides an accurate trait measurement and data service similar to that which the accredited LAMBPLAN operators provide. It does not support a national database of this data and does not conduct analysis on the genetic merits of an animal by comparing its performance to all known relatives using quantitative genetics techniques. In this sense, StockScan and LAMBPLAN are not comparable services.

Falkirk is another New Zealand based scanning service that is similar to StockScan and there are also a few independent operators. None of these services have the technical capability to provide an accurate prediction as to the genetic merits of an animal.

Meat sheep breeders that do not use LAMBPLAN typically use StockScan or a similar service to obtain objective data on eye-muscle area, eye-muscle depth, the depth of fat between the eye-muscle and skin and the fat depth at the GR site on a specific animal.

[10] Almost all breeders interviewed who do not use LAMBPLAN use an alternative accurate measurement service and believe that it is a substitute for LAMBPLAN.

Furthermore, some livestock buyers incorrectly view this data as a substitute for LAMBPLAN EBVs or Indexes[11].

Quantitative Genetic Assessment Services in Other Livestock Industries

The use of quantitative genetics tools to record the genetic merit of livestock is not a concept that is unique to the Australian meat sheep industry. Services similar to LAMBPLAN exist in the Australian beef cattle and pig industry and there have been attempts at similar services in the wool industry.

Australian Wool Industry

Independent of the wool trait EBVs that are to be made available under Sheep Genetics Australia (see Future of LAMBPLAN below); the Australian wool industry has made two attempts to launch a system similar to LAMBPLAN. WoolPlan was developed by the Australian Wool Corporation and operated from the mid 1980s to the early 1990s. A modified version of WoolPlan continued under the guise of RamPower when the Australian Wool Corporation evolved into its successor, Australian Wool Innovations, and ran from the early 1990s to the late 1990s. Effectively RamPower was a collection of R&D projects in genetics, merino sire evaluation and producer extension programs relating to the importance of genetics in seedstock selection. RamPower was administered by various fleece testing laboratories around Australia. Australian Wool Innovations reports[12] that, during RamPower, approximately 90 percent of the 200,000 or so merino rams sold each year carried RamPower performance data. The key difference between RamPower and LAMBPLAN is that while some individual fleece testing laboratories maintained records and calculated estimated breeding values, the majority did not. As such, there was not a central national database from which meaningful breeding values could be developed.

More recently, Merino Genetic Services (MGS) has developed a system identical to LAMBPLAN for which wool production specific traits are recorded and analysed. This will be incorporated into Sheep Genetics Australia.

[11] Most breeders interviewed who do not use LAMBPLAN confirmed that their customers typically wanted some ‘figures’ on an animal and that they used other accurate measurements services to provide those figures.
[12] Interview with Ian Rogan, AWI, former national coordinator of RamPower.

Beef Cattle Industry

The LAMBPLAN equivalent in the Australian beef cattle industry is BREEDPLAN. BREEDPLAN is a national system for describing the genetic merit of animals in the Australian beef cattle industry and is based on the same quantitative genetics engine as LAMBPLAN, measuring performance traits specifically relevant to beef cattle production. While adoption of BREEDPLAN is understood to be stronger among the breeders in the Southern Agricultural Zone, than breeders of breeds more commonly found in the Northern Agricultural Zone, it has had a similar level of success to LAMBPLAN in terms of establishing itself as an important industry tool. Importantly, BREEDPLAN has allowed breeders and producers to measure traits that have not previously been measurable, such as marbling in muscle. A key difference between LAMBPLAN and BREEDPLAN is that while LAMBPLAN is still operated by an industry-wide owned body, BREEDPLAN is still owned by the same industry body, but its delivery has been outsourced.

Australian Pork Industry

PIGLUP is an on-farm trait measurement, recording and quantitative genetics analysis software package that pig breeders can use. The important difference between PIGLUP and LAMBPLAN, is that PIGLUP does not record or take into account across stud data. The reason for this is two-two fold:

- Pig breeds in the commercial industry are mostly synthetic lines; and
- The culture in the commercial pig producing industry is such that commercial producers do not consider objective genetic measurement in their purchasing decisions, relying on the breeder to advise them on suitable seedstock.

As such, some commercial pig breeders use PIGLUP to assess their stock and provide advice to their customers based on their own knowledge supported by internal PIGLUP data[13].

The Future of LAMBPLAN – Sheep Genetics Australia

While this review is focused on the adoption of LAMBPLAN, it is worthwhile noting that the future of LAMBPLAN is as part of an expanded genetic evaluation and information service for the entire sheep industry including sheep meat, wool and mixed enterprises. Known as Sheep Genetics Australia (SGA), the expanded service represents a merger

[13] Interview Ian Johnsson, Pork Australia Limited

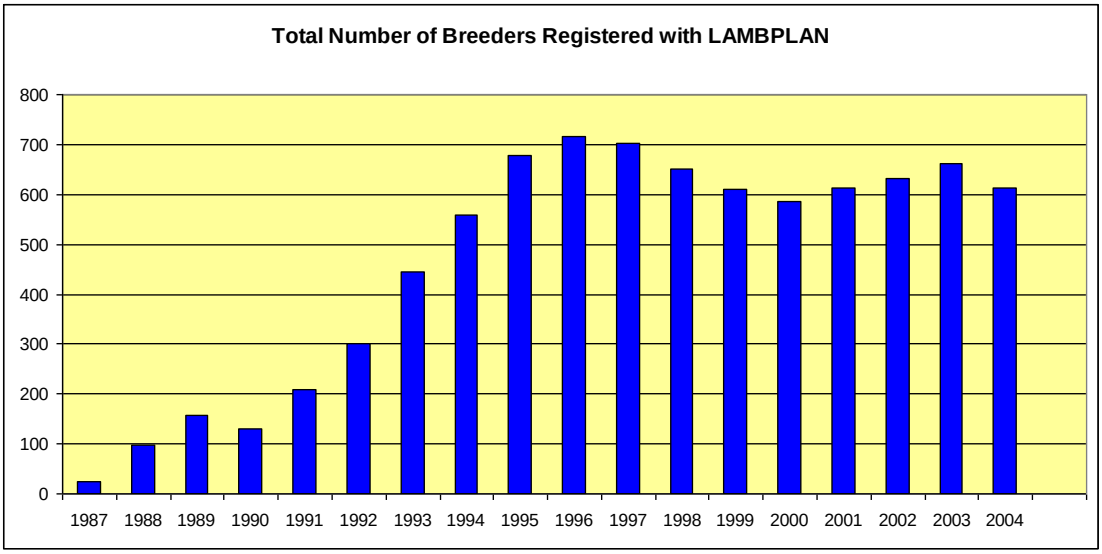
of LAMBPLAN with a similar trial service known as Merino Genetic Services (MGS). Under the SGA model, estimated breeding values for meat, wool and other important sheep industry production traits will be collectively termed Australian Sheep Breeding Values (ASBVs).

In addition to the meat traits set out in Table 1, SGA will provide breeding values for additional wool traits including fleece weight, fibre diameter, fibre diameter coefficient of variation, staple strength, staple length and curvature estimates at yearling, hogget and adult ages. It will also provide breeding values that estimate worm burden at weaning, post weaning and yearling ages.

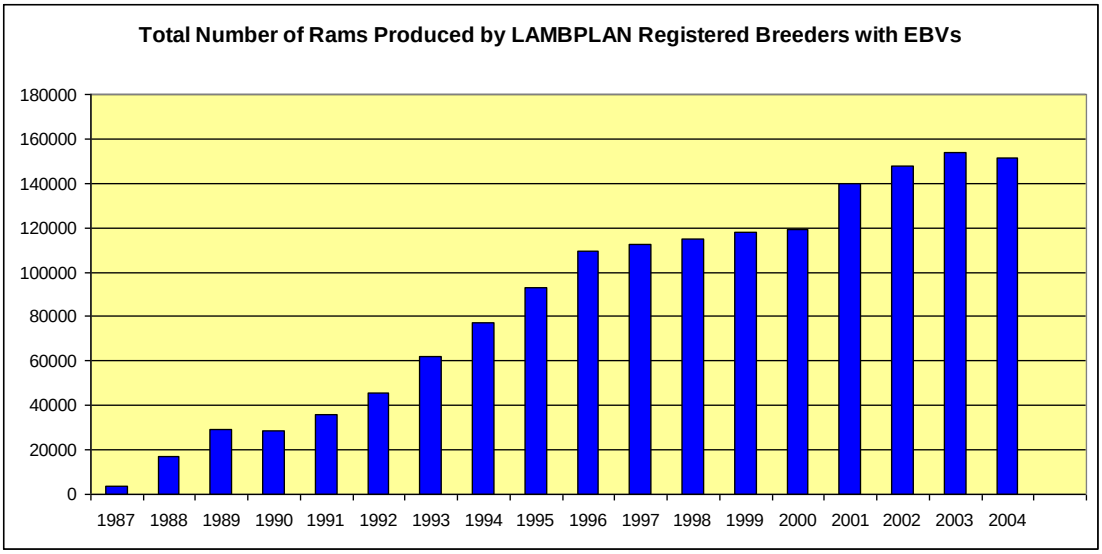
Driving adoption of SGA in the merino sector may prove more challenging than has been the case for LAMBPLAN in the meat sheep industry. This is discussed in more detail in the final chapter of this report.

Chapter 4: Meat Sheep Breeding Industry Adoption of LAMBPLAN

The overall uptake of LAMBPLAN by the broader Australian meat sheep breeding industry was rapid in the first decade of operation of LAMBPLAN, growing from just 25 breeders in its first year of operation to over 700 breeders in 1996. Breeder registrations have remained relatively constant since the mid 1990s. This is demonstrated in Figure 6 below.

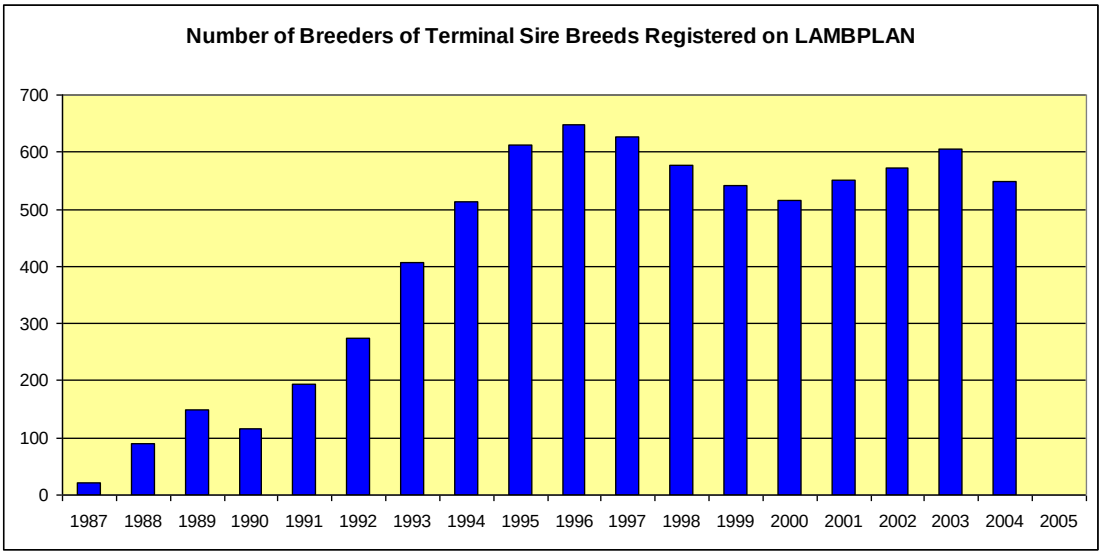


Comparatively, the number of animals registered on the LAMBPLAN database has continued to grow at a relatively consistent rate. This is demonstrated in Figure 7 overleaf.



This is indicative of the considerable industry consolidation that seems to have occurred in the Australian meat sheep breeding industry over the lifetime of LAMBPLAN.

Figure 8 below demonstrates the uptake of LAMBPLAN by the terminal sire breeding sector.

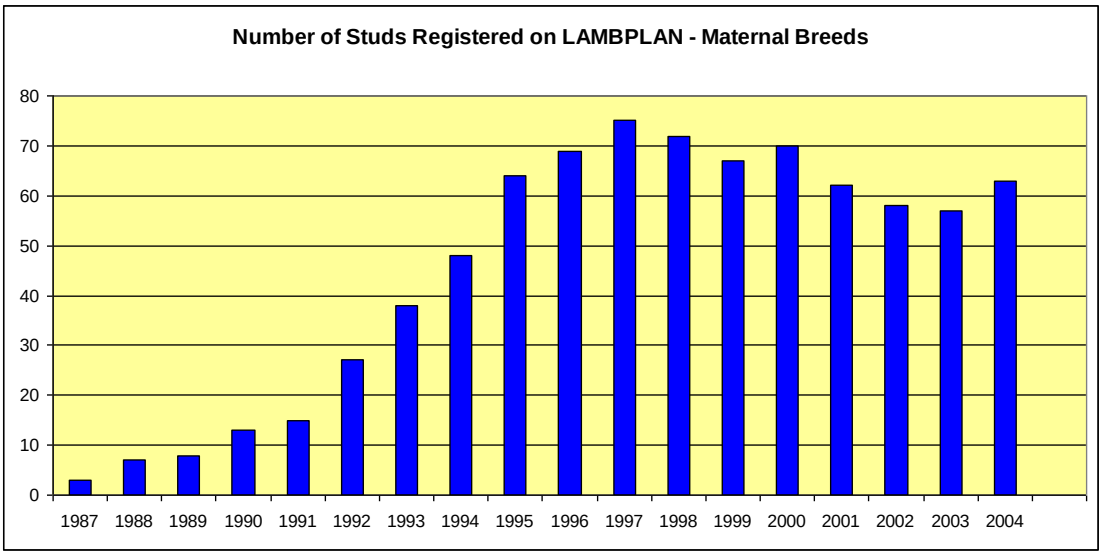


The uptake of LAMBPLAN has been more prolific among the terminal sire breeding sector than the maternal sire breeding sector. This is to be expected as demand for effective terminal sires has been driven by a priority for commercial producers to produce lambs that meet the stringent carcase specifications of processors and exporters servicing the more lucrative prime lamb markets, particularly the United States,

rather than increasing the volume of lamb output. Another possible reason for the lower levels of uptake of LAMBPLAN among the maternal sire breeding sector is that achieving genetic change in maternal traits is a slower and more complicated process by virtue of the following factors[14]:

- Low heritability of reproductive traits;
- Longer time taken for progeny to express reproductive traits; and
- The need for repeated measurements to assess reproductive traits.

While there are fewer maternal sire breeders registered with LAMBPLAN, the rate of uptake of LAMBPLAN among maternal sire breeders has been similar to that of breeders of terminal breeds. This is demonstrated in Figure 9 below.



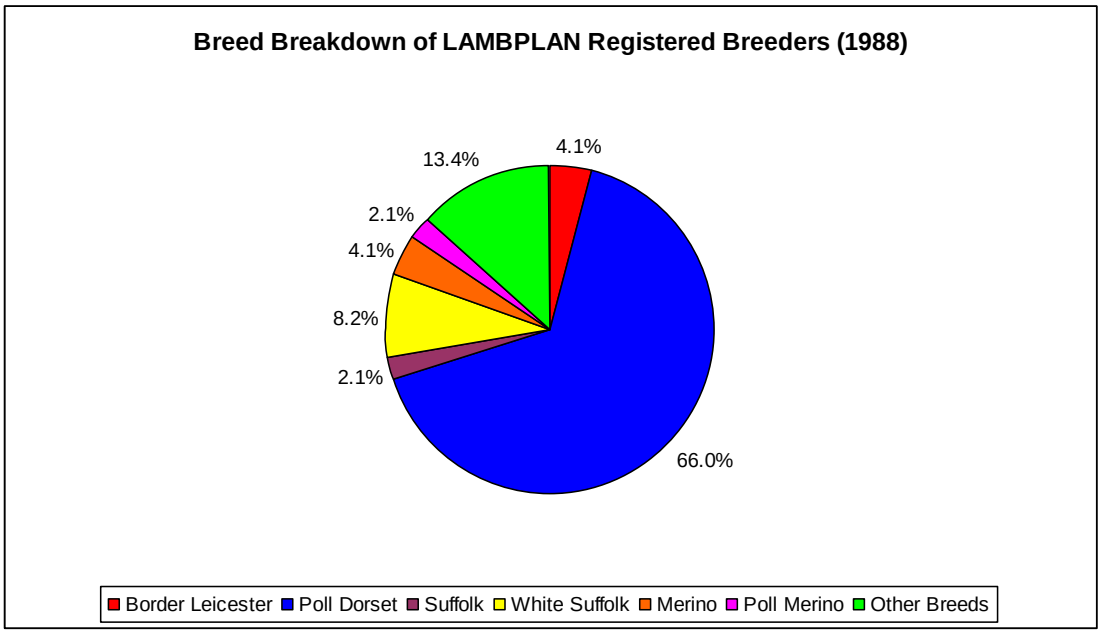
There seems to be some concern among breeders that use LAMBPLAN that because of the focus on carcase quality and the development and launch of SGA, the application of LAMBPLAN to the improvement of the maternal characteristics of ewes in production flocks is a long way from achieving its potential[15]. In particular there is concern that there needs to be more R&D focus on improving the accuracy of maternal EBVs and Indexes and that the launch of SGA will continue to draw internal LAMBPLAN resources away from the maternal sire sector to the merino sector.

[14] Brown, D., Reverter, A. and Tier, B., 'Influence of Environmental Factors and Trait Representation on the Genetic Evaluation of Reproductive Traits in Sheep', *Professional Association of Animal Breeding Genetics,* Vol. 14, pp.131-134

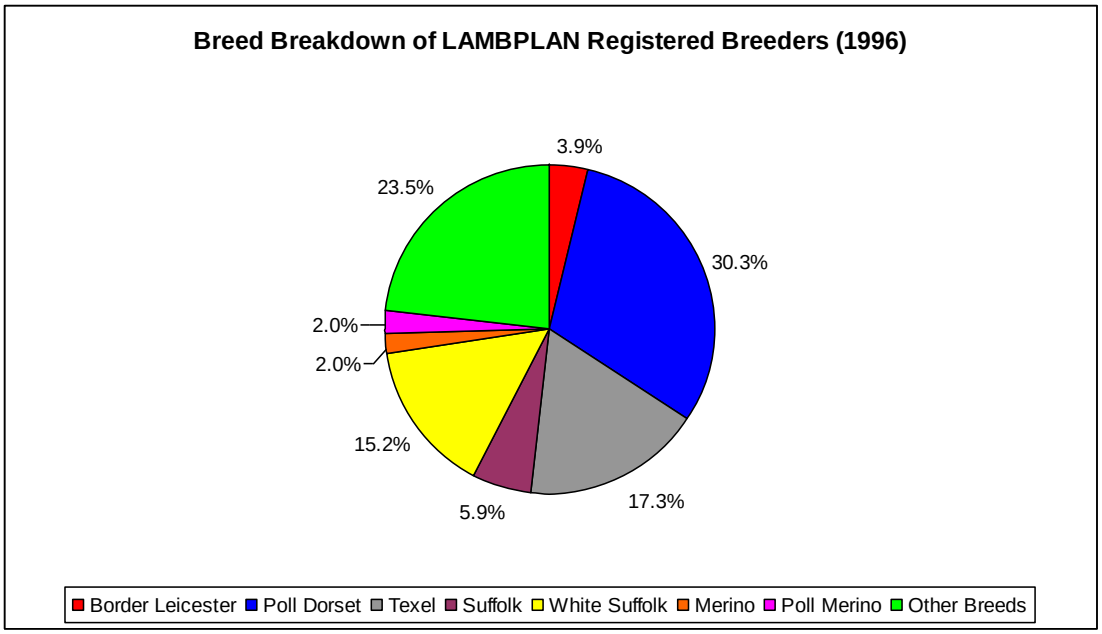
[15] A number of breeders interviewed expressed a concern that LAMBPLAN was underutilized with respect to improving the maternal trait performance of ewes in commercial flocks and that this needed to be a focus moving forward.

Distribution of LAMBPLAN Registered Breeders

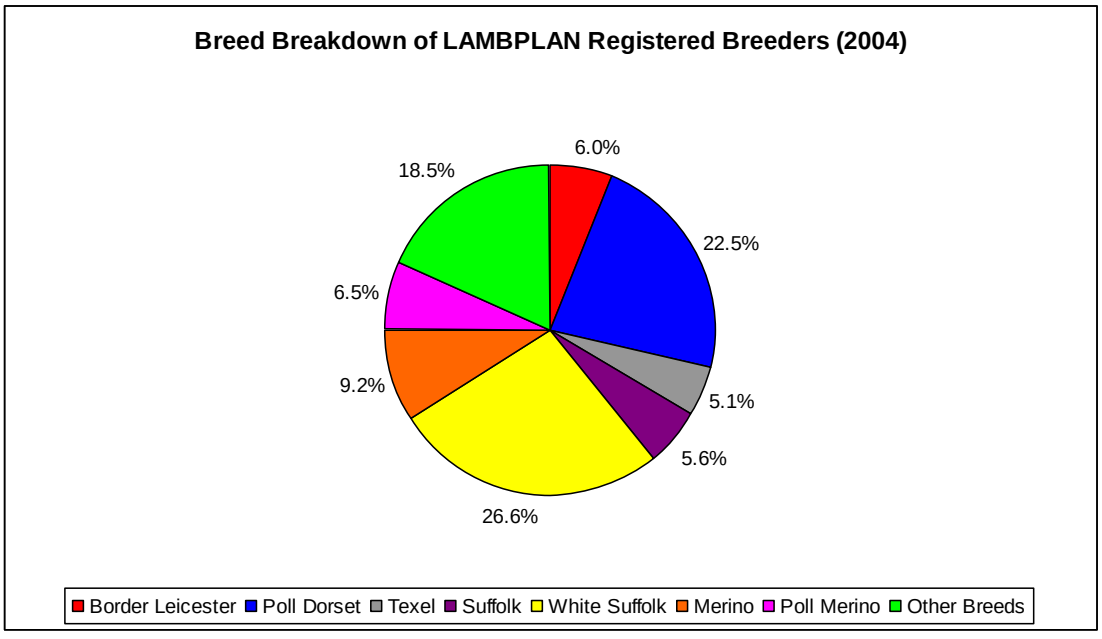
Today there are breeders for eight maternal sire breeds and forty-two terminal sire breeds registered on the LAMBPLAN database. Prior to the introduction of the Texel breed to Australia in the early 1990s, breeders of five terminal breeds and a single maternal breed (Border Leicester) accounted for over 85 percent of the breeders registered with LAMBPLAN, with Poll Dorset breeders accounting for the vast majority of registrations. This is demonstrated in Figure 10 below



By 1996, the portion of registrations accounted for by the six main breeds had decreased to just over 75 percent and breeders of Texel and White Suffolk accounted for an increasing portion of breeder registrations. This is demonstrated in Figure 11 overleaf.



Today, the seven main breeds still account for approximately 80 percent of LAMBPLAN registered breeders. However, the representation from each of those main breeds is more evenly spread. This is demonstrated in Figure 12 below.



Reach of LAMBPLAN in the Commercial Production Sector

It is difficult to estimate the reach of animals produced from LAMBPLAN registered breeders with any degree of accuracy, particularly in the case of the progeny of maternal

sires. In the case of terminal sires we can make an indicative estimate. For example, from simple deduction we can estimate that the 70,000 sires sold from flocks using LAMBPLAN in 2004 produced approximately 45 percent of all lambs produced in the Australian sheep industry and 55 percent of the total lambs produced for slaughter by the Australian sheep industry in 2004. This basic calculation is demonstrated in Table 4 below.

Variable	Value
Number of LAMBPLAN rams sold in 2004	70,000
Estimated number of joinings per ram[16]	110
Estimated Lambing Rate[17]	93%
Estimated marking rate[18]	125%
Total Number of Lambs Produced by LAMBPLAN Rams	10.1 million
Total Number of Lambs Marked in 2004[19] (not including Merino lambs retained)	22.2 million
Percentage of Total (non-Merino) Lambs Produced by LAMBPLAN Rams in 2004	**45 %**
Total number of lambs slaughtered in 2004[20] (not including Merino lambs)	15.7 million
Estimate of percentage of slaughter (non-Merino) lambs produced by LAMBPLAN rams	**55%**

Although this estimation is only indicative, it does demonstrate the order of magnitude affect that LAMBPLAN is having on the genetic base of the Australian flock. The impact is further evidenced by the results of the Terminal Sire Central Progeny Tests (see Chapters 5 and 6) and the relationship between adoption of LAMBPLAN and improved average carcase weights (see Chapter 5).

[16] Brown, S. (2002), 'LAMBPLAN for Commercial Lamb Producers', *Farmnote,* AGWA, Perth
[17] Hooper, S., Blias, A. & Ashton, D. (2003), *Australian Prime Lamb Industry,* ABARE, Canberra
[18] Brown, S. (2002), 'LAMBPLAN for Commercial Lamb Producers', *Farmnote,* AGWA, Perth
[19] ABARE (2005), *Australian Commodity Statistics,* Canberra
[20] ABARE (2005), *Australian Commodity Statistics,* Canberra

Adoption of LAMBPLAN by the Main Meat Sheep Breeds

The following subsections discuss the adoption of LAMBPLAN by breeders in the main meat sheep breeds over the life of the LAMBPLAN program. The breed sectors examined are:

- Poll Dorset
- White Suffolk
- Texel
- Border Leicester
- Suffolk
- Merino
- Poll Merino

From an interest perspective, the Coopworth sector is also examined as LAMBPLAN registration is a condition precedent to membership of the Coopworth Society of Australia.

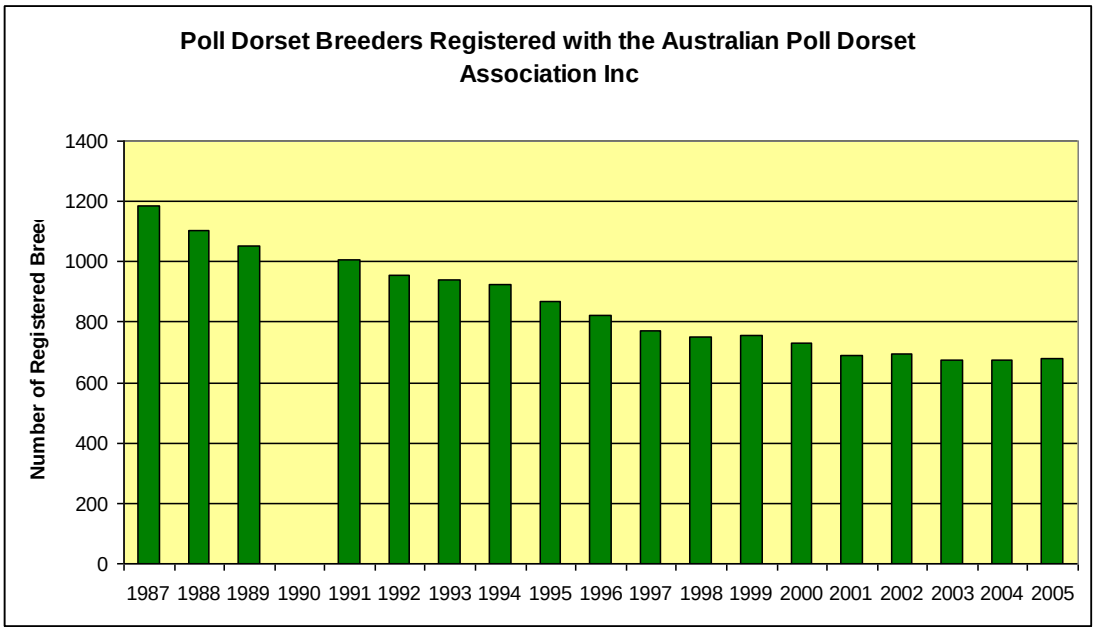
Adoption of LAMBPLAN by Poll Dorset Breeders

Traditionally, Poll Dorsets have been the most popular terminal sire for the production of Australian prime lamb, siring over 75 percent of Australian prime lambs[21]. They are typically joined with cross-bred merino and pure merino ewes to produce slaughter lambs. The breed was developed in Australia between 1934 and 1954 by introducing the poll gene to Dorset Horn flocks from two other poll breeds, resulting in an animal more suited to the meat trade.

Poll Dorset breeders have been a major user of LAMBPLAN since the program's inception, initially accounting for over 65 percent of all registered breeders. Today they

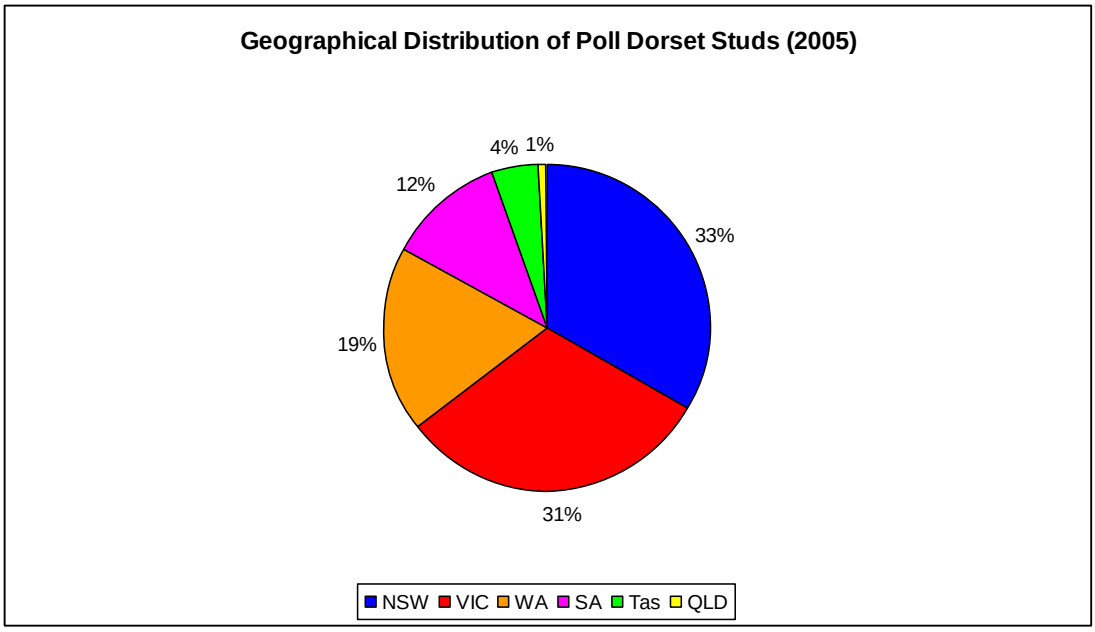
[21] Australian Poll Dorset Association

account for 22 percent of all breeders registered with LAMBPLAN. The number of Poll Dorset breeders registered with the Australian Poll Dorset Association has declined from over 1,100 in 1987 to approximately 680 today[22], as demonstrated in Figure 13 below. This is indicative of the reported consolidation in the Australian meat sheep breeding industry and the growth in popularity of other terminal sire breeds, particularly White Suffolks.

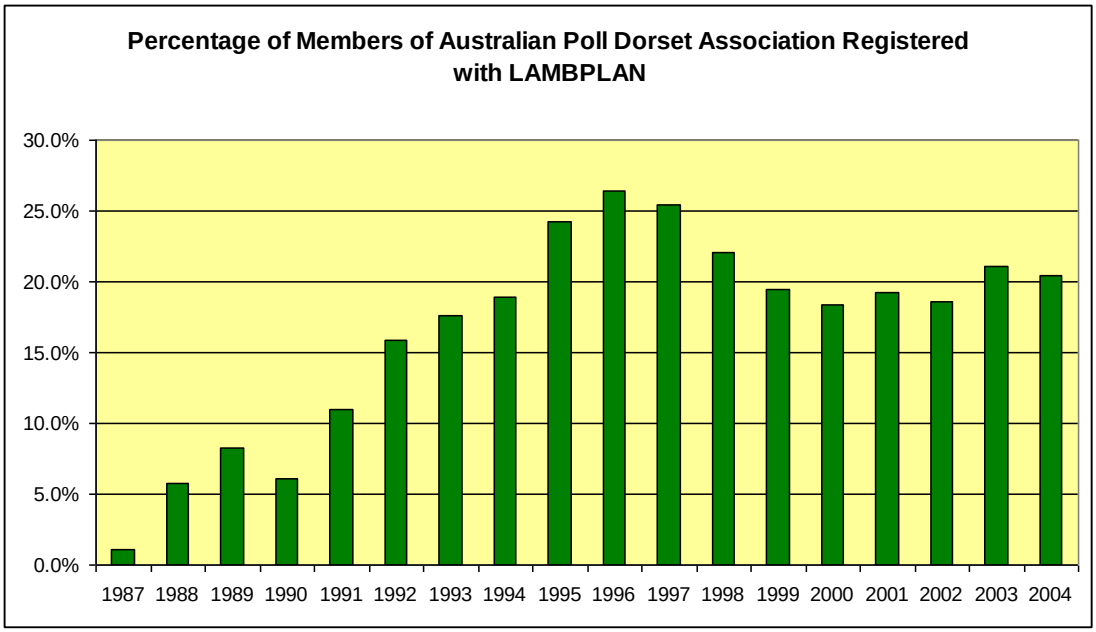


As demonstrated in Figure 14 below, the majority of Poll Dorset breeding operations are located in New South Wales and Victoria.

[22] Australian Poll Dorset Association Flock Books, 1987 to 2005.

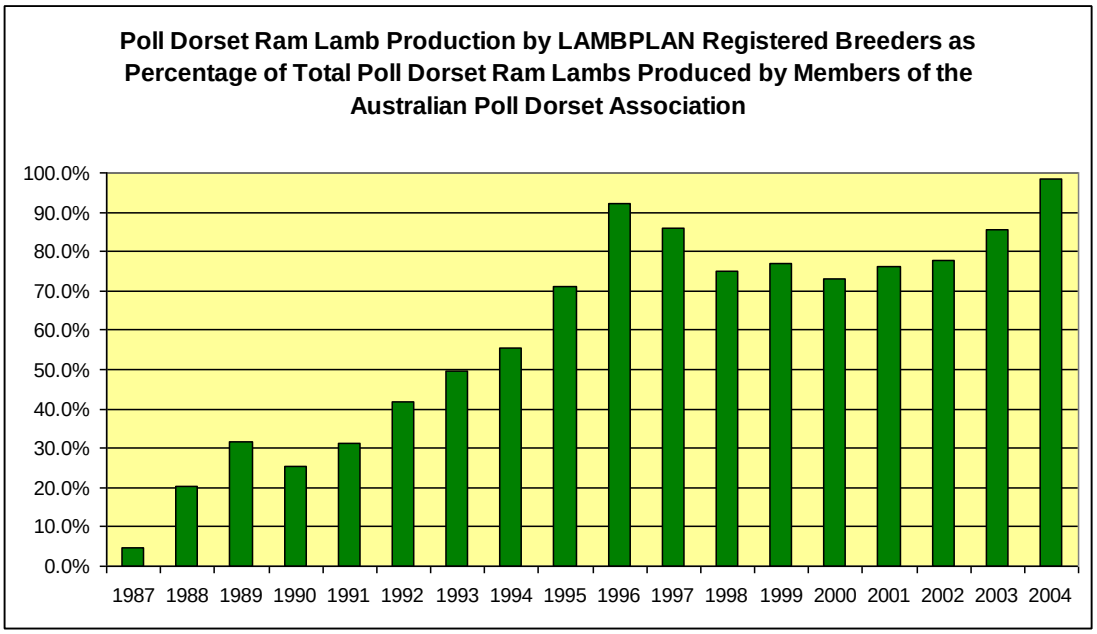


Adoption of LAMBPLAN by registered Poll Dorset breeders has grown rapidly from 1 percent of registered breeders in 1987 to a peak of 26 percent in 1996. Adoption has remained constant since 1996 at approximately 20 percent of registered breeders. This is demonstrated in Figure 15 below.

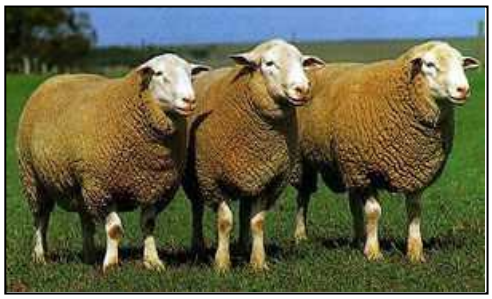


It is important to note that in the case of Poll Dorsets, the main terminal sire breed, the approximate 20 percent of registered breeders that have been registered with LAMBPLAN over the past six years have produced between 75 and 95 percent of all

ram lambs produced by the Poll Dorset breeding sector, as demonstrated in Figure 16 overleaf. This suggests that most major commercial Poll Dorset breeders are using LAMBPLAN as both a genetics management and marketing tool.



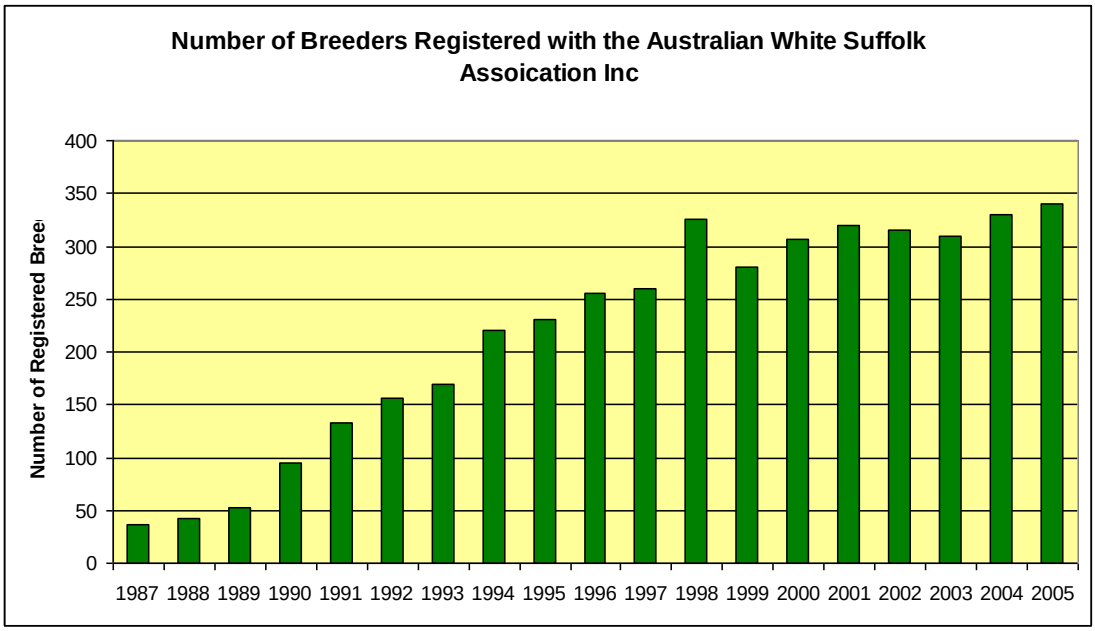
Adoption of LAMBPLAN by White Suffolk Breeders



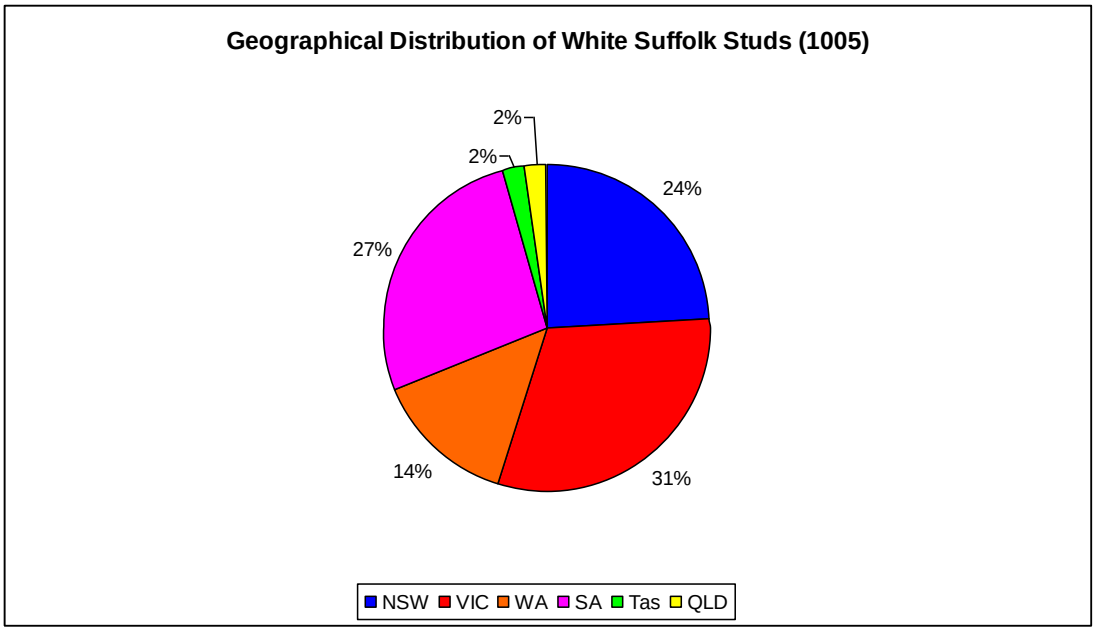
White Suffolks are the second most common breed of terminal sire used in the Australian prime lamb industry. The breed was developed to be a meat trade animal, specifically suited to the Australian environment. It was developed through breeding programs that involved crossing the Suffolk breed with white breeds, particularly Poll Dorsets[23]. White Suffolk breeders have been registered with LAMBPLAN since the program's inception and strong growth in adoption of LAMBLAN by White Suffolk breeders has seen them account for approximately 27 percent of all breeders registered with LAMBPLAN today.

[23] Australian White Suffolk Association

Unlike the Poll Dorset sector, there has been a consistent pattern of growth in the number of White Suffolk breeders registered with their respective association, the Australian White Suffolk association[24]. This is demonstrated in Figure 17 below.

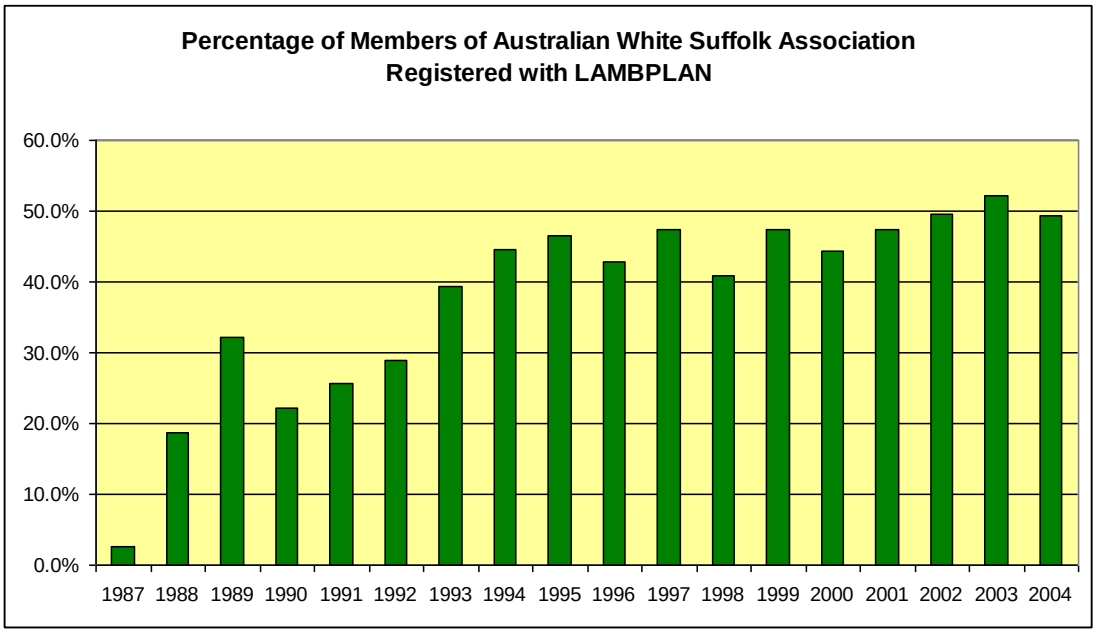


The majority of White Suffolk breeders, some 80 percent are located in New South Wales, Victoria and South Australia. This is demonstrated in Figure 18 below.



[24] Australian White Suffolk Association Flock Books (1987 to 2005)

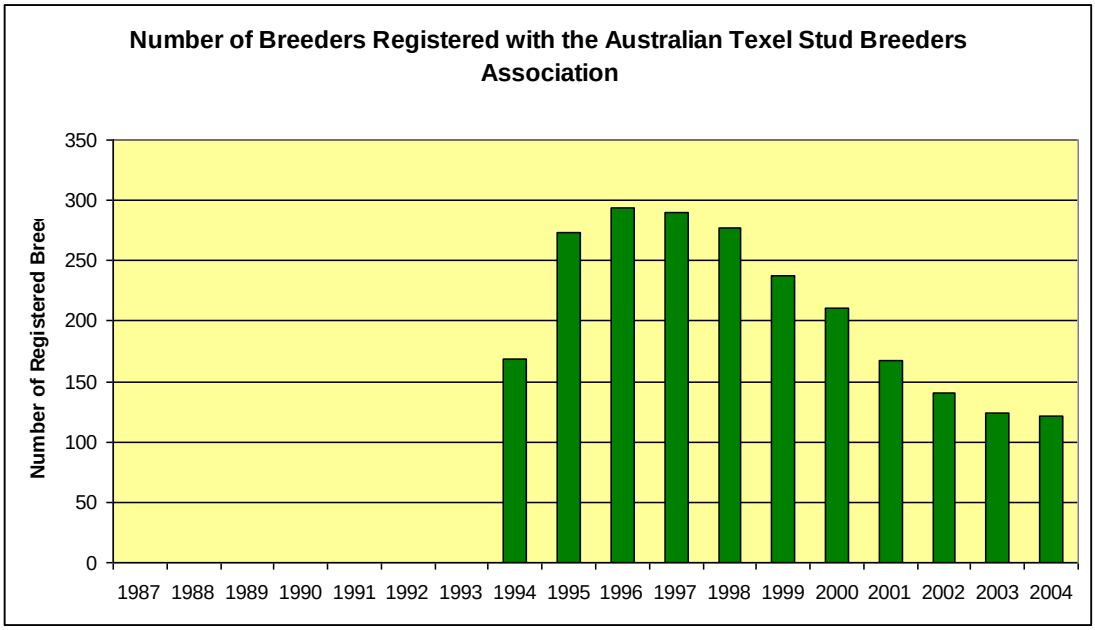
White Suffolk breeders have been among the strongest adopters of LAMBPLAN, with an adoption level of between 40 and 50 percent of all registered White Suffolk breeders having been sustained over the past ten years. This is demonstrated in Figure 19 below.



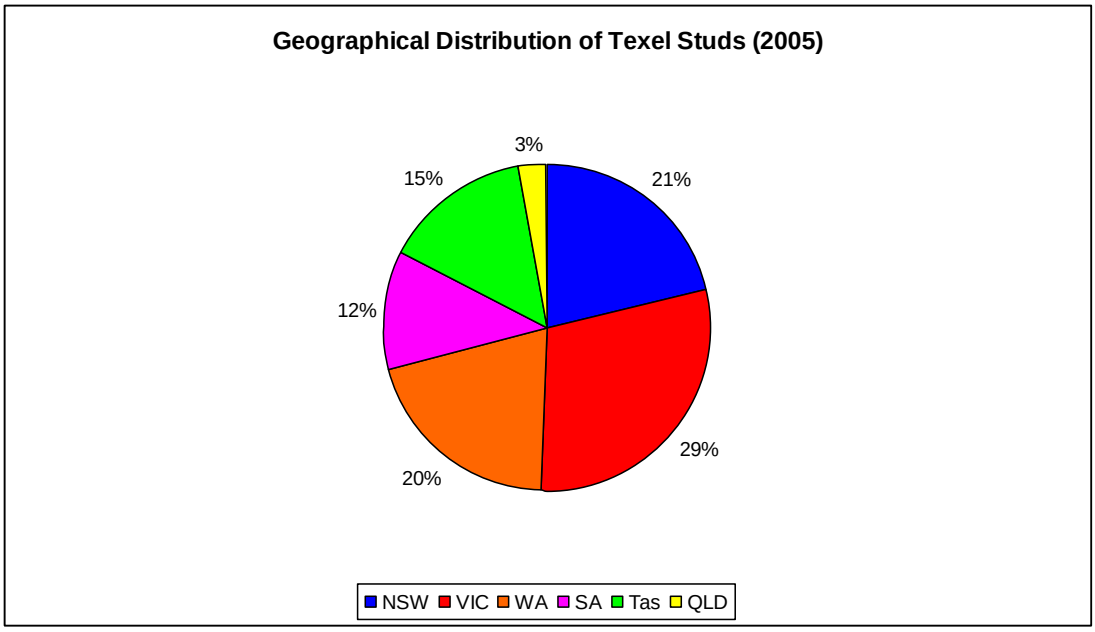
The White Suffolk breeders registered with LAMBPLAN currently produce 30,681 ram lambs per annum. The total number of ram lambs produced by members of the Australian White Suffolk Association is not maintained by the Association. However, given the number of White Suffolk ram lambs registered with LAMBPLAN in 2004 is equivalent to 80 percent of the total ram lambs produced by the entire Poll Dorset breeding sector (the largest meat sheep breeding sector), we can reasonably estimate that LAMBPLAN registered White Suffolk breeders account for the vast majority of White Suffolk rams produced each year.

Adoption of LAMBPLAN by Texel Breeders

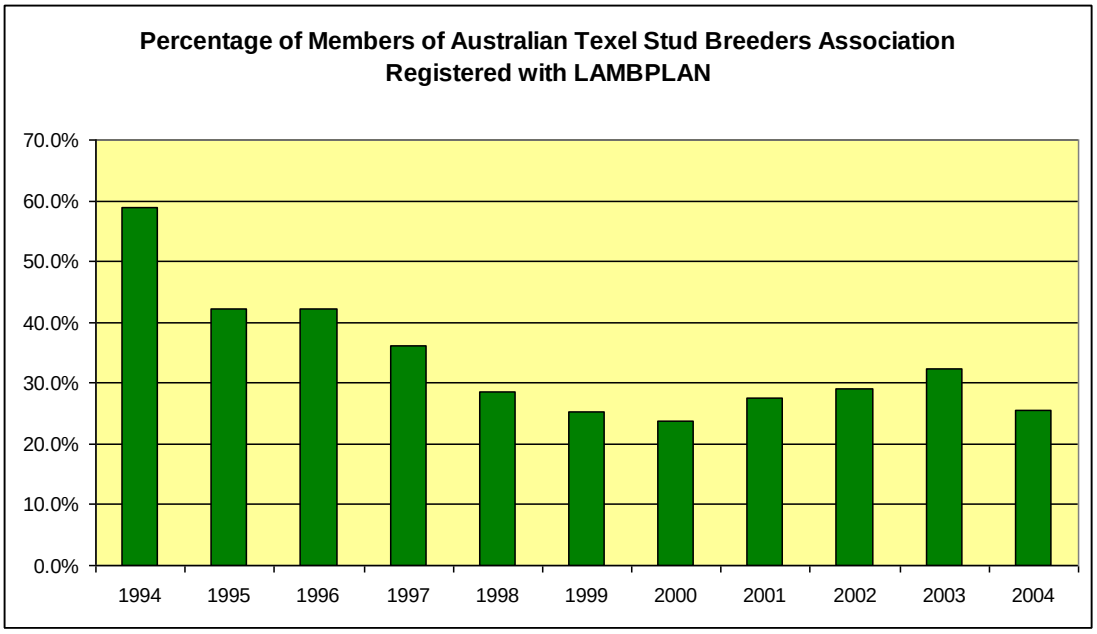
Texels are a relative new breed of terminal sire in Australasia. They were introduced from Denmark and Finland to New Zealand in 1988 and to Australia in 1993. When introduced the breed demonstrated a very immediate and strong appeal as a terminal sire in the Australian prime lamb industry, most likely founded on expectations generated from observations of its success in the British lamb industry. However, although it remains an important terminal sire breed in the Australian prime lamb industry, the number of breeders registered with the Australian Texel Stud Breeders Association has halved since the breed was introduced. This is demonstrated in Figure 20 below.



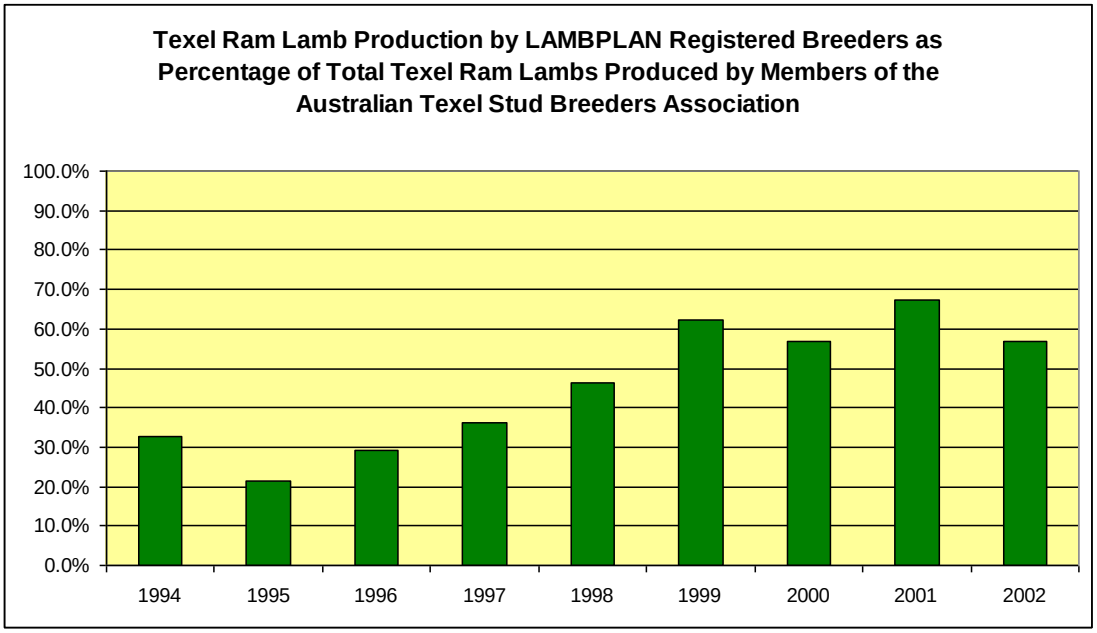
Currently Texel breeding operations are distributed relatively evenly throughout the main prime lamb producing states, as demonstrated in Figure 21 overleaf.



With rapid uptake of the Texel breed came rapid initial adoption of LAMBPLAN by Texel breeders, with 60 percent of Texel breeders registered with LAMBPLAN the year after the breed was introduced to the Australian prime lamb industry, as demonstrated in Figure 22 overleaf. This may be indicative of the emergence of a more sophisticated meat sheep breeding industry in Australia as it demonstrates a willingness to identify and use more suitable meat sheep breeds while simultaneously applying sophisticated technologies and tools that will assist in improving the genetic make-up of the industry. However, the decline in the number of Texel breeders over subsequent years coincided with a decline in the portion of those breeders registered with LAMBPLAN. This suggests that many of the early Texel breeders may have only adopted LAMBPLAN as a tool to help them sell rams to commercial producers, rather than using it to manage genetics.

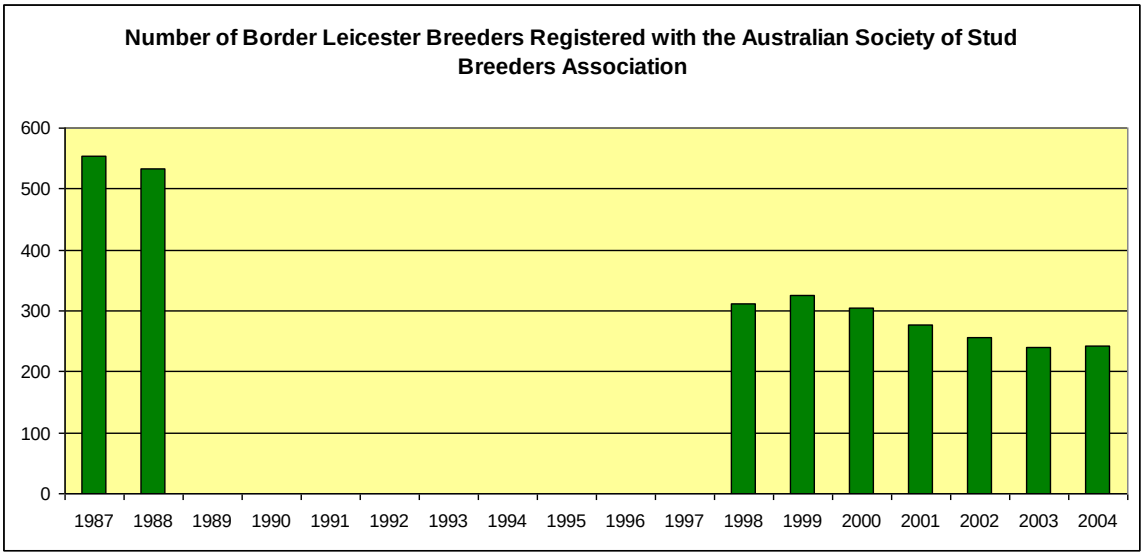


Supporting this notion is the fact that while the percentage of the Texel breeding sector using LAMBPLAN has declined, the portion of total industry ram lambs produced by LAMBPLAN registered Texel breeders has increased considerably, as demonstrated in Figure 23 below. This suggests that major commercial Texel breeders continue to use LAMBPLAN for genetic management purposes as well as marketing.



Adoption of LAMBPLAN by Border Leicester Breeders

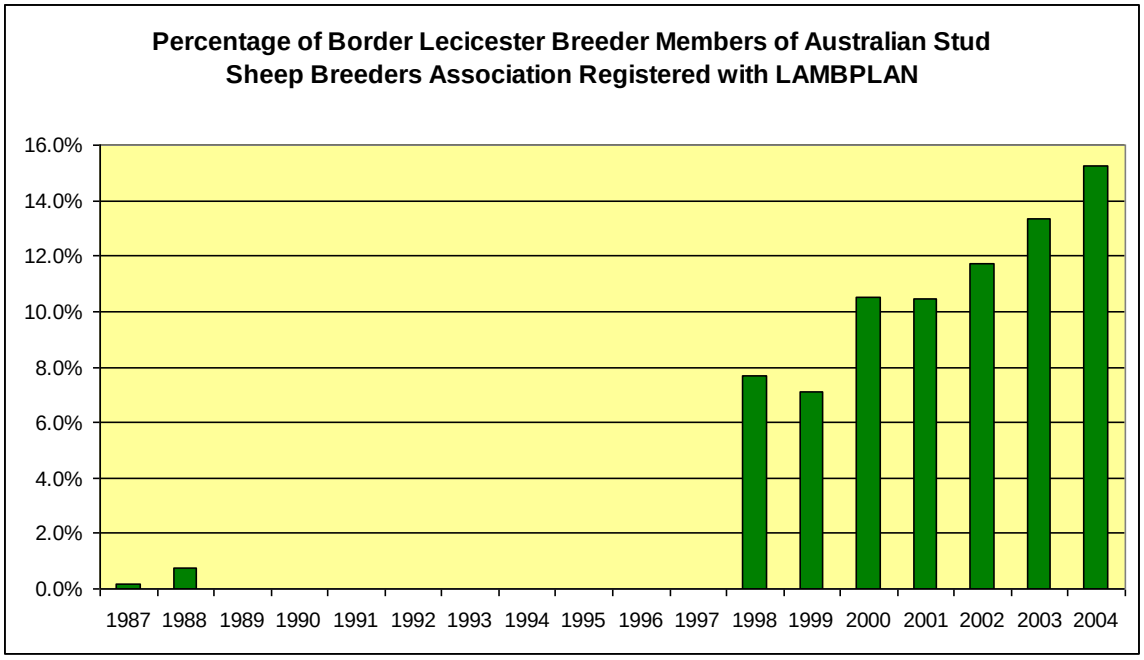
The first flock of Border Leicesters in Australia was established in Geelong in 1881. As a result of the breed's ability to pass onto its progeny the high fertility, mothering and milking traits that are characteristic of the breed, Border Leicesters are widely considered one of the most important maternal sires in the Australian prime lamb industry. They are the most prominent maternal sire breed registered with LAMBPLAN. According to the Australian Stud Sheep Breeders Association, there are currently 243 Border Leicester breeders in Australia[25], with over 60 percent of these breeders located in New South Wales[26]. The total number of Border Leicester breeding operations registered with the Australian Stud Sheep Breeders Association has halved over the life of the LAMBPLAN program. This is demonstrated in Figure 24 below.



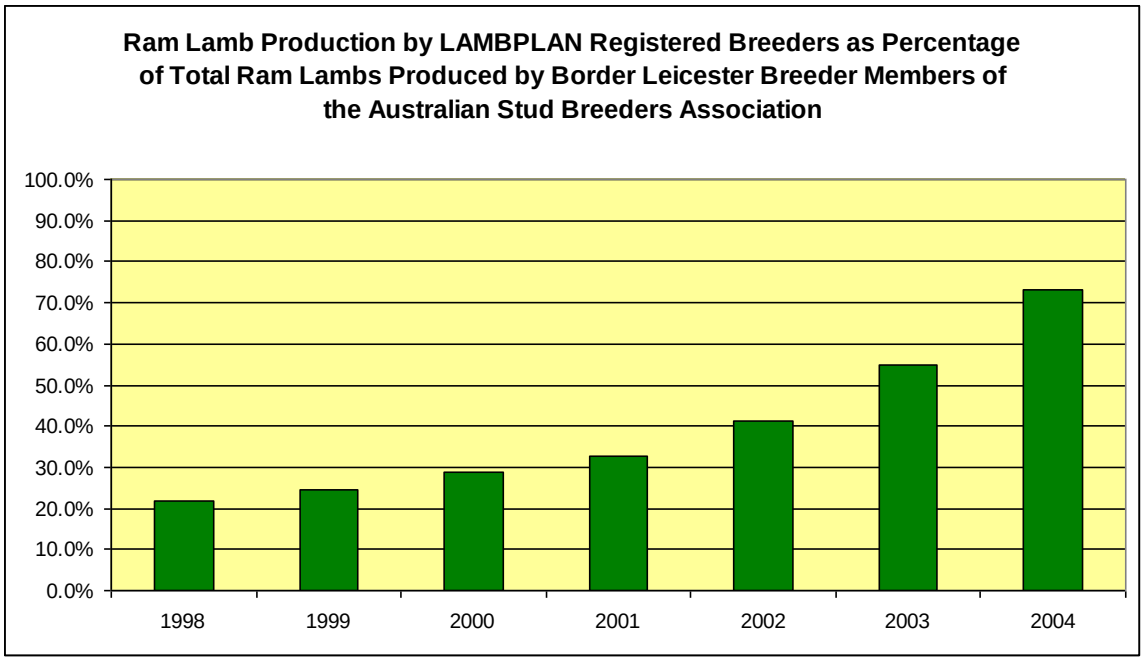
For reasons discussed in the introduction to this chapter, maternal sire breeders have been less prolific adopters of LAMBPLAN, and Border Leicester breeders are no different. The data set of all Border Leicester breeders registered with the Australian Stud Sheep Breeders Association is incomplete, but the data that is available does provide some information on the adoption of LAMBPLAN by the Border Leicester breeding sector. As can be seen from Figure 25 overleaf, adoption of LAMBPLAN by the

[25] Karen Bond, Federal Secretary, Australian Stud Sheep Breeders Association
[26] www.nswboderleicester.org

Border Leicester breeding sector has grown from a negligible level in 1987 to approximately 15 percent of the breeders in the sector today.



Despite the apparently low levels of adoption of LAMBPLAN by the Border Leicester sector compared to the main terminal sire sectors discussed previously, it would appear that LAMBPLAN registered Border Leicester breeders have accounted for an increasing portion of the ram lambs produced by the sector, as demonstrated in Figure 26 overleaf. Judging from the available data, it would appear that LAMBPLAN registered Border Leicester breeders now account for some 70 percent of the ram lambs produced by the sector.



Adoption of LAMBPLAN by Suffolk Breeders

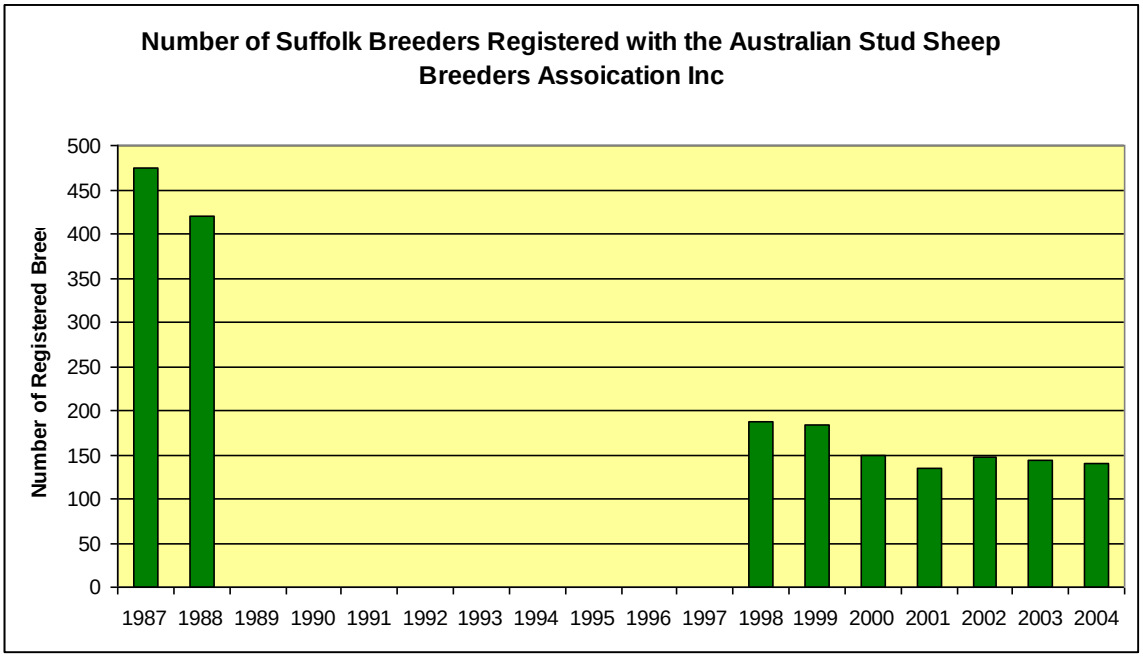
The Suffolk breed was first developed in the United Kingdom in the early nineteenth century, by crossing Southdown rams with Norfolk Horned Ewes, two breeds that were renowned for meat quality. The Suffolk breed was first introduced to Australia in 1904 and since that time has become a popular terminal sire for the Australian prime lamb industry. The breed can also be used in mixed enterprises as it produces a fleece in the 28 to 32 micron range.[27]

There are several breed societies that provide services to the Australian Suffolk breeding sector, namely:

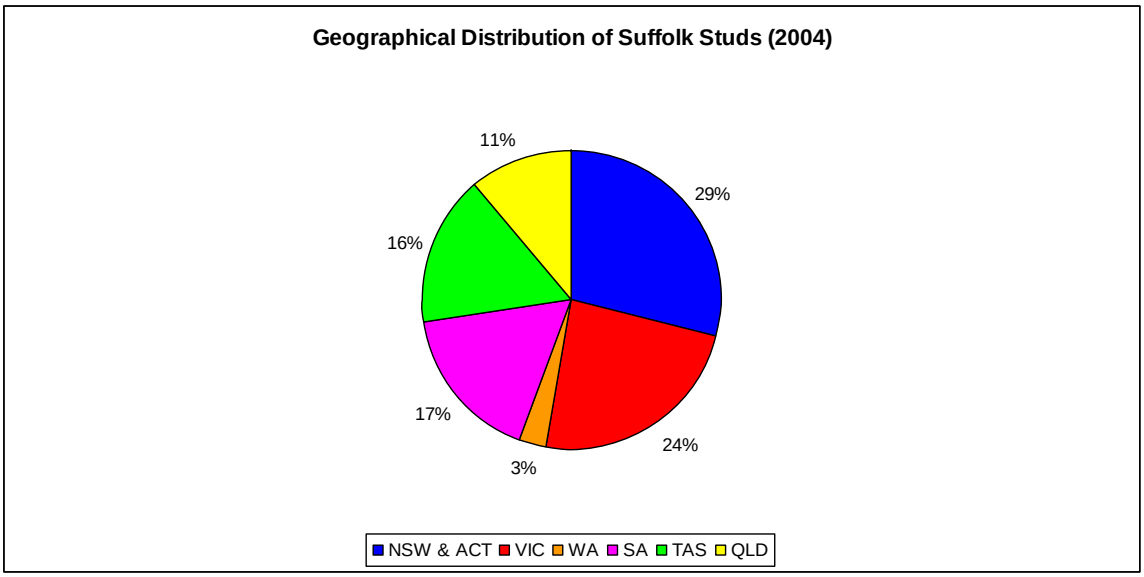
- Australian Suffolk Association
- Suffolk Sheep Society of Australia
- New South Wales Suffolk Society
- Australian Stud Sheep Breeders Association

[27] Australian Suffolk Association

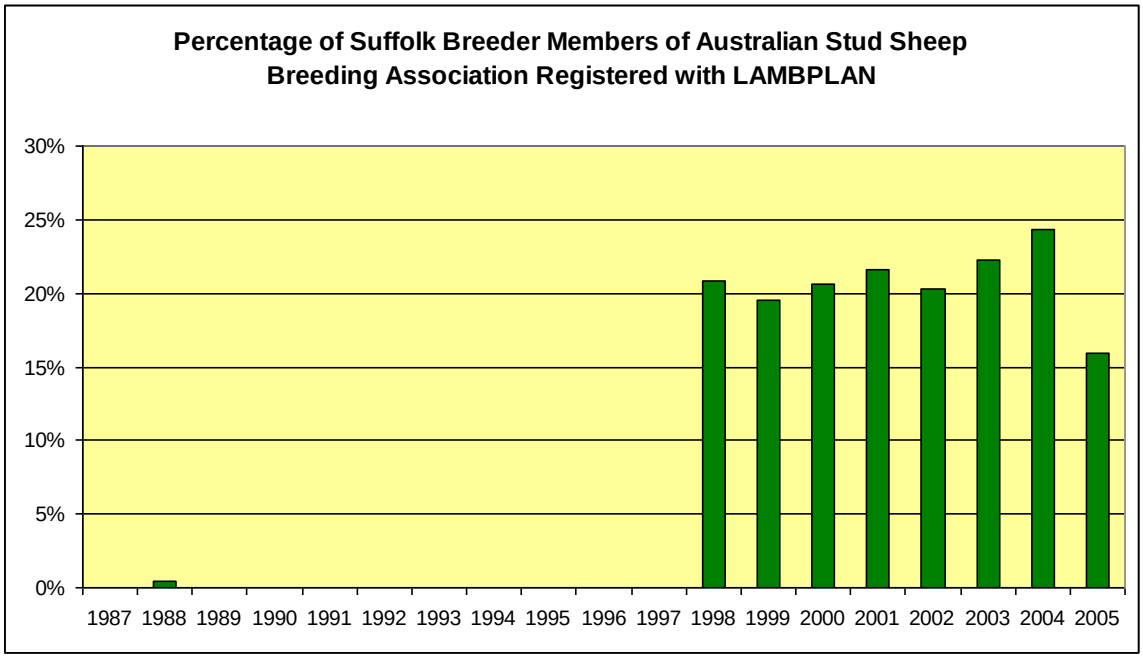
The existence of four separate relevant societies makes determining the exact size of the sector difficult. As an indicative assessment of the size of the Suffolk breeding sector this analysis will use data provided by the Australian Stud Sheep Breeders Association. According to this data, the number of breeders that comprise the Suffolk sector has declined dramatically since 1987. This is demonstrated in Figure 27 below.



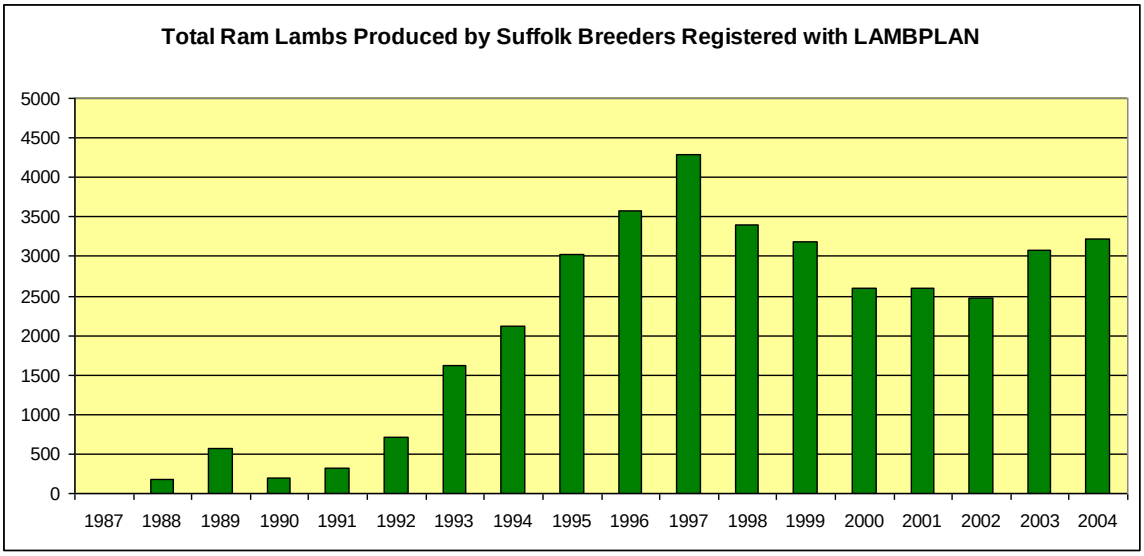
Over 85 percent of Suffolk breeders are located in the states of New South Wales, Victoria, Tasmania and South Australia. This is demonstrated in Figure 28 below.



Based on the Australian Stud Sheep Breeders Association data, adoption of LAMBPLAN by breeders in the Suffolk sector as averaged at the most 20 percent of the industry over the past seven years (this figure may actually be less if not all Suffolk breeders are registered with the Australian Stud Sheep Breeders Association). This is demonstrated in Figure 29 below.



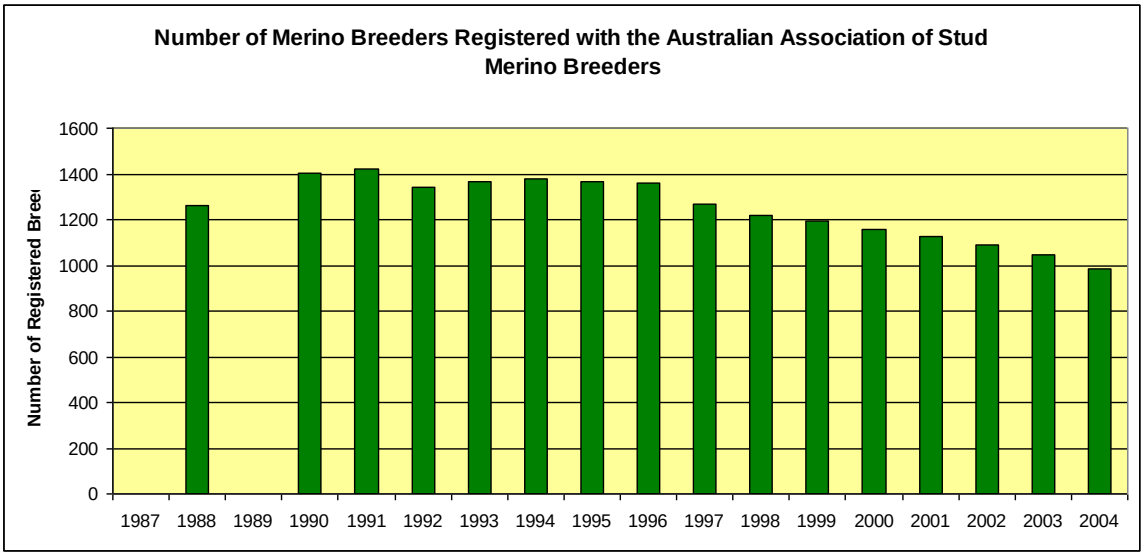
Unfortunately, it is not possible to derive a meaningful estimation of the percentage of total Suffolk ram lambs produced by LAMBPLAN registered Suffolk breeders. However, the following Figure 30 demonstrates the number of ram lambs produced by the Suffolk breeders registered with LAMBPLAN.



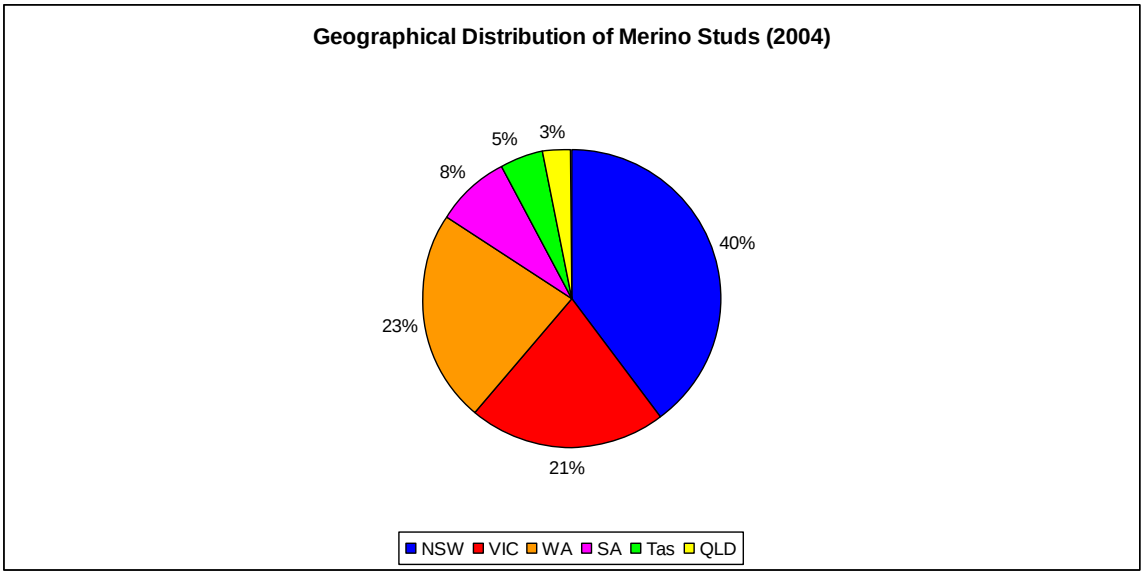
Adoption of Merino Genetic Services by Merino Breeders

Merinos are the most common sheep breed in Australia, comprising some 85 percent of the total Australian flock. Merinos are primarily bred for their wool producing ability. However, they also play a critical role in the meat sheep industry. Firstly, Merino ewes are crossed with maternal sires to produce first-cross ewes that provide the reproductive capacity for the prime lamb industry. Secondly, Merino sires that have strong meat traits are desirable for mixed enterprises seeking revenue from both wool and meat products.

Membership of the Australian Merino Stud Breeders Association has declined from around 1,400 members in the mid-1990s to less than 1,000 in 2003, reflecting a trend in de-stocking of commercial Merino flocks following the collapse of the Wool Reserve Pricing Scheme and the 2002-03 drought (see Chapter 4). This is demonstrated in Figure 31 below.



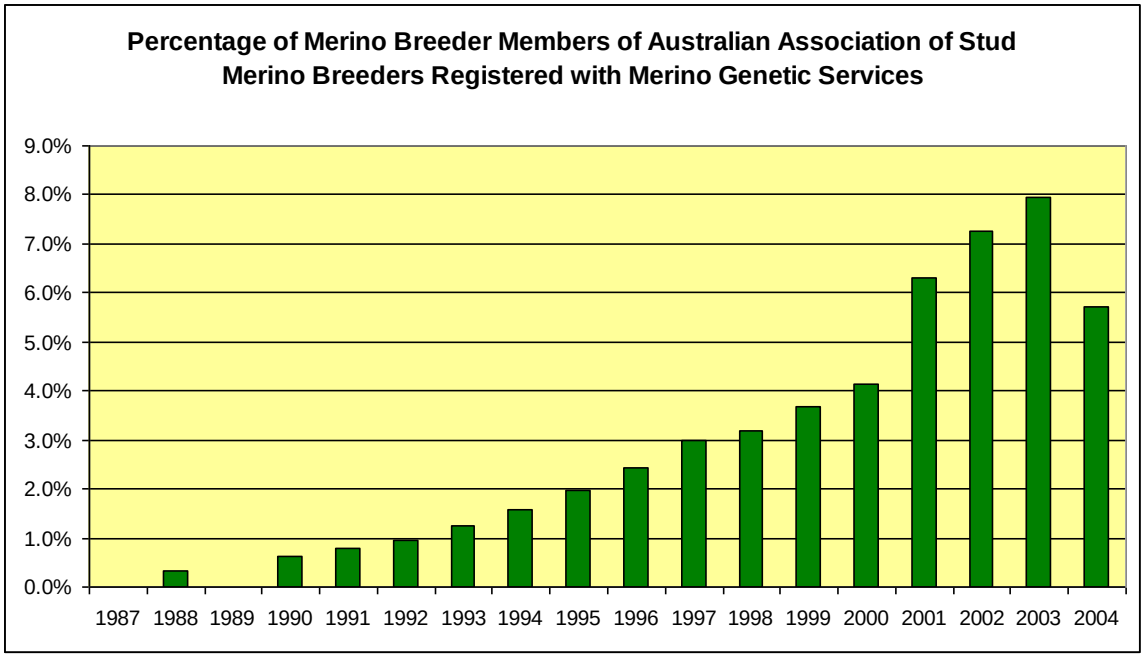
The vast majority of Merino breeding operations, some 85 percent, are located in New South Wales, Victoria and Western Australia[28]. This is demonstrated in Figure 32 below.



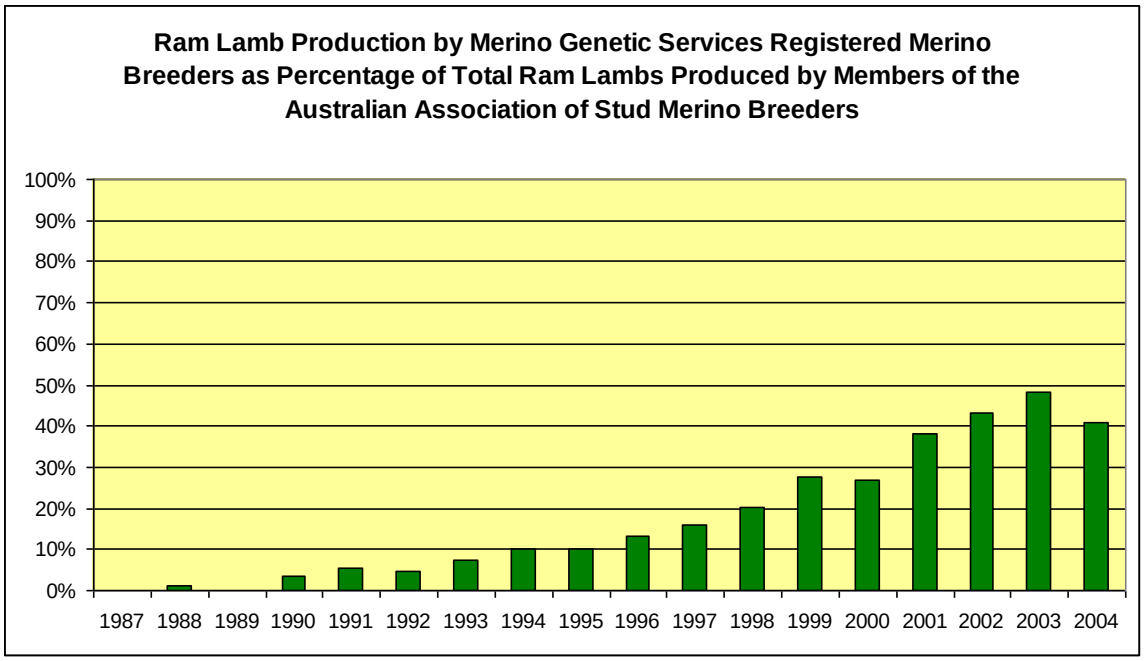
The LAMBPLAN based genetic service that is available to Merino Breeders is called Merino Genetic Services (MGS) and it provides data on both meat and wool traits. Because Merinos are primarily used as a wool producing animal and there are issues associated with the adoption of objective genetic measurement to assess wool traits (see Final Chapter), it is not surprising that adoption of MGS among Merino breeders has been less significant than the adoption of LAMBPLAN by breeders of meat sheep

[28] Australian Association of Stud Merino Breeders

breeds. Nevertheless, growth in adoption of MGS by Merino breeders, particularly since 2000, has been exceptionally strong, as demonstrated in Figure 33 below.

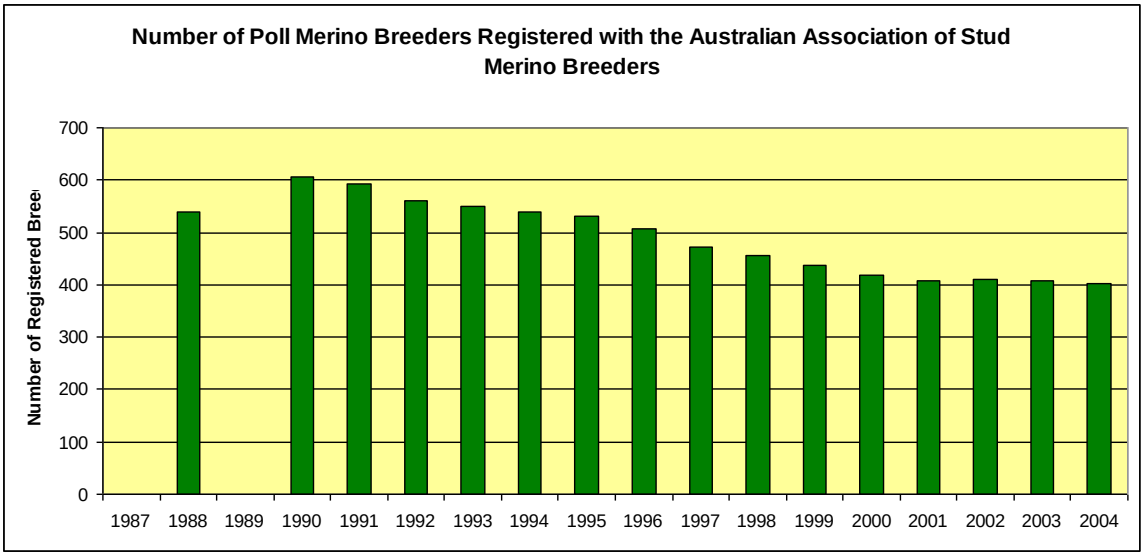


Very interestingly, the small portion of total Merino breeders registered with MGS account for a disproportionately high number of the Merino rams produced by the Merino breeding industry, as demonstrated in Figure 34 below. This may indicate that the larger commercial Merino breeders are increasingly interested in producing Merino rams that have strong meat traits as well as wool traits for their customers.

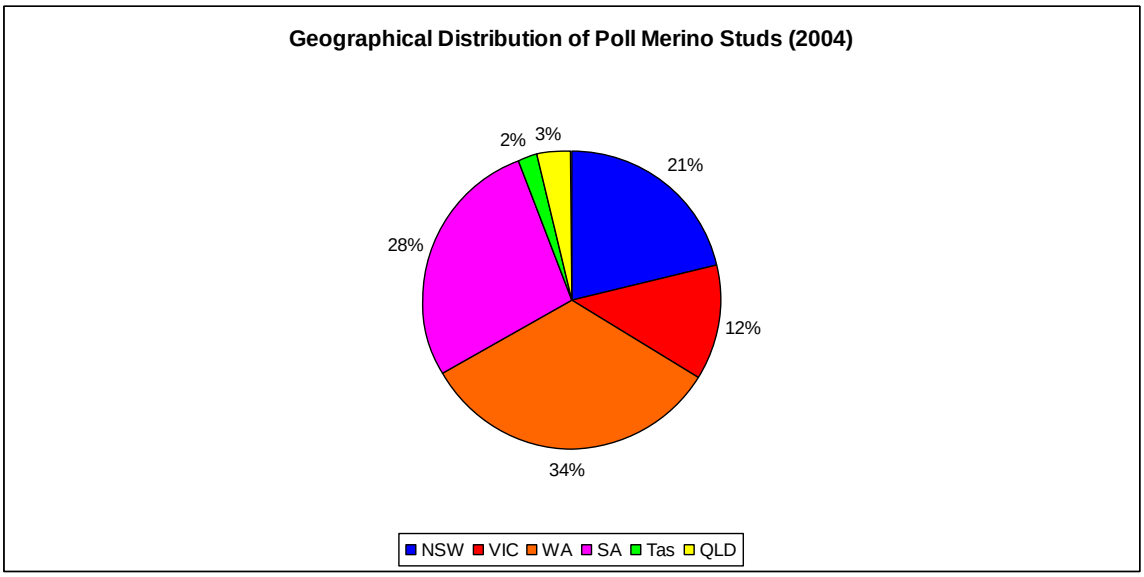


Adoption of Merino Genetic Services by Poll Merino Breeders

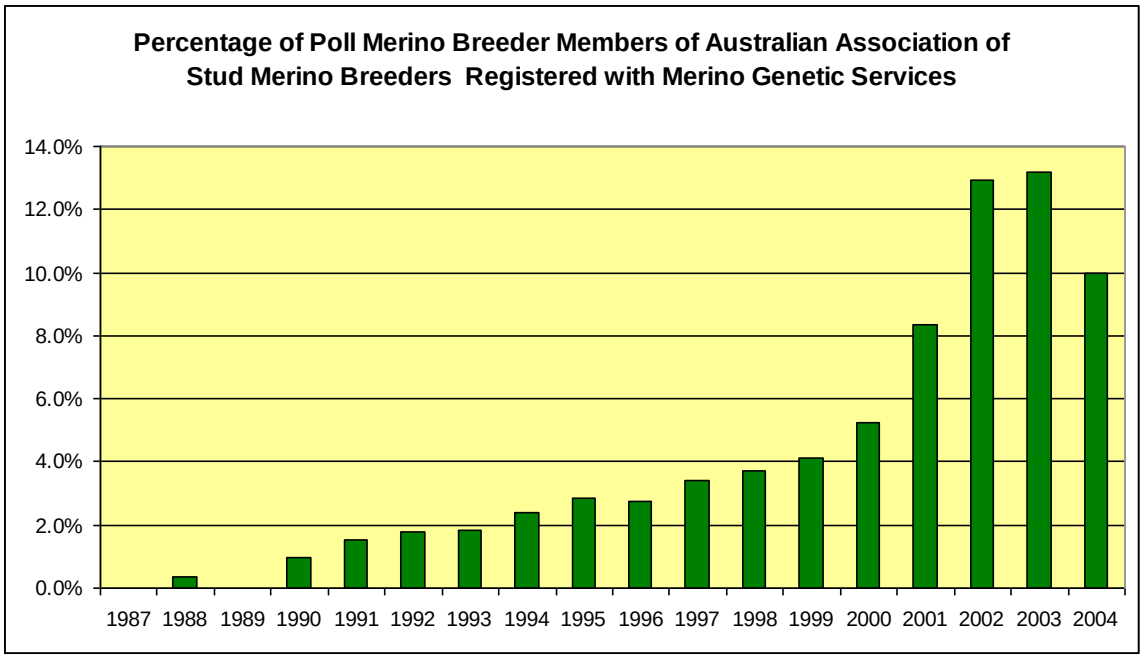
The Poll Merino breed is basically a pure merino without horns. The breed was developed by crossing Poll rams with Merino ewes, resulting in a production friendly animal that is large framed, easy to handle and which reaches maturity rapidly. As with Merinos and for the same reasons, the number of Poll Merino breeders registered with the Australian Association of Merino Stud Breeders has also been on a declining trend. However, this trend seems to have stabilized over the past four years, perhaps reflecting the stronger meat production qualities of the Poll Merino over the Merino. This is demonstrated in Figure 36 below.



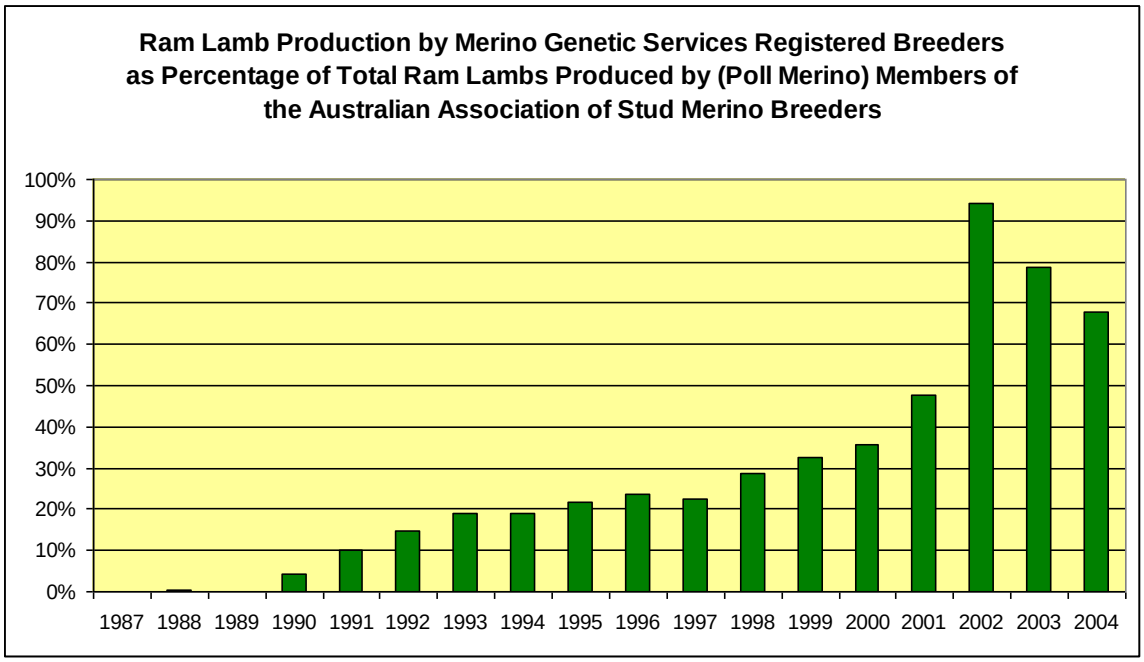
Poll Merino breeding operations have a similar geographical distribution to Merino breeding operations, as demonstrated in Figure 37 below.



As with Merino breeders, Poll Merino Breeders have adopted Merino Genetic Services (MGS) to a much lesser extent than the breeders of pure meat breeds have adopted LAMBPLAN, but there has been a considerable acceleration in the rate of adoption since 2000. This is demonstrated in Figure 38 below.

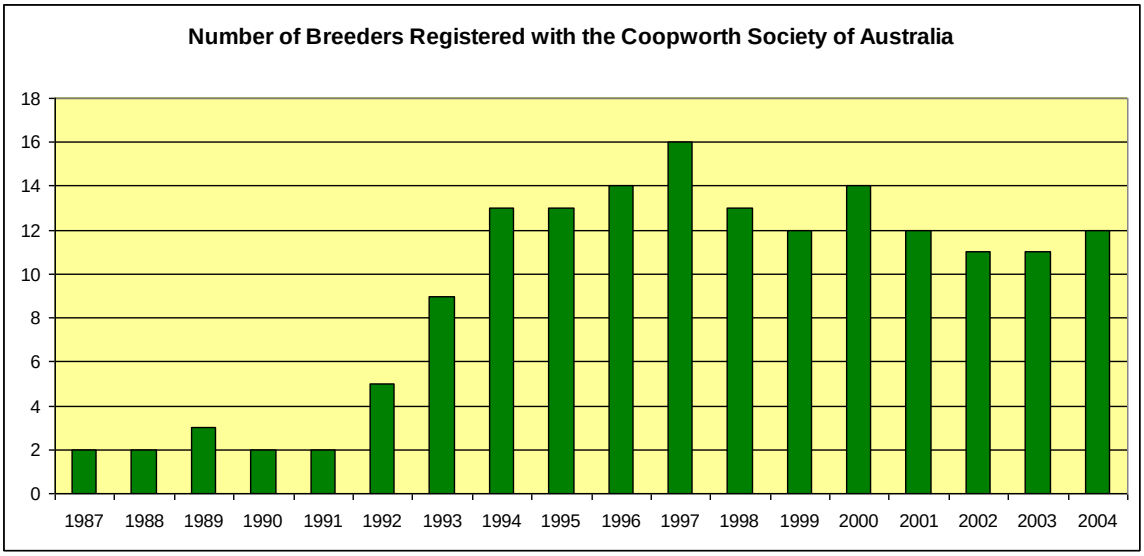


However, the MGS registered Poll Merino breeders produce a significantly larger portion of the total ram lambs produced by the Poll Merino breeding industry, perhaps reflecting the greater emphasis on meat of this breed. This is demonstrated in Figure 39 below.

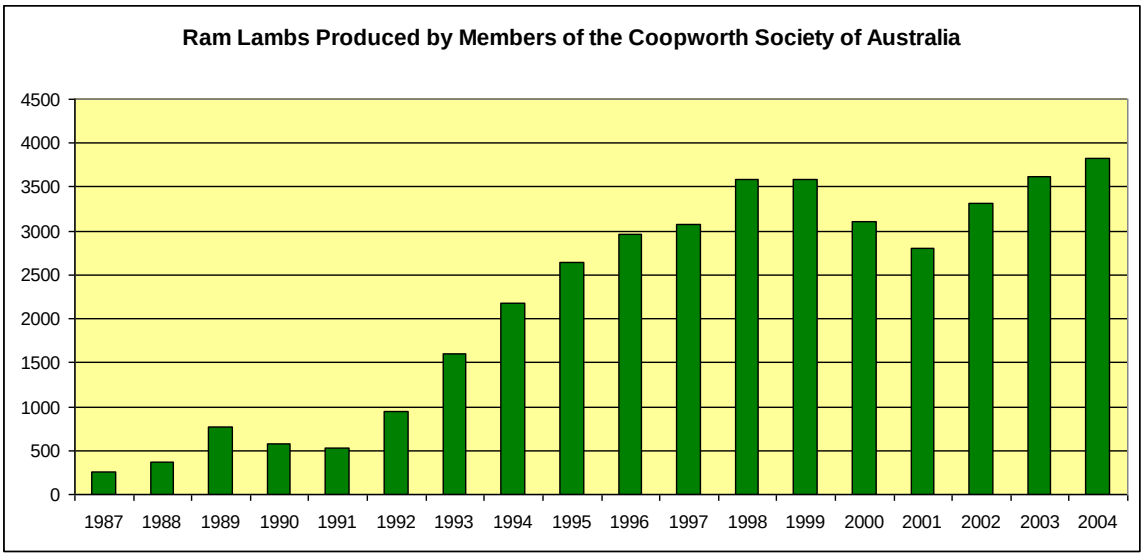


Mandated Adoption – The Case of Coopworths

It is worthwhile noting that the Coopworth Society of Australia has made LAMBPLAN registration a condition precedent to membership. Coopworths are a maternal sire breed that was developed in the 1950s and 1960s by crossing the Romney ewe with the Border Leicester ram. The Coopworth breeding sector is very small, even for the maternal sire industry, being less than 5 percent of the size of the Border Leicester sector in terms of number of breeders. This is demonstrated in Figure 40 below.



Despite its small size the number of ram Lambs produced by this breed has increased significantly as demonstrated in Figure 41 below.



Discussion on Adoption of LAMBPLAN by the Australian Meat Sheep Breeding Industry

The following Table 5 summarises the progress in levels of adoption of LAMBPLAN and MGS among the main terminal and maternal breeding sectors over the life of the program.

Breed	1990 Adoption		1997 Adoption		2004 Adoption	
	Breeders	Ram Lambs	Breeders	Ram Lambs	Breeder	Ram Lambs
Poll Dorset	6.1%	25.4%	25.4%	86.1%	20.4%	98.3%
White Suffolk	22.1%	n.a.	47.3%	n.a.	29.1%	n.a.
Texel	n.a.	n.a.	36.2%	36.0%	25.6%	58.0%*
Border Leicester			7.8%**	22.0%**	15.5%	74.0%
Suffolk			21.0%**	n.a.	24.5%	n.a.
Merino	0.7%	0.4%	3.0%	16.0%	5.7%	40.0%
Poll Merino	1.0%	5.0%	3.5%	24.0%	10.0%	68.0%

It would appear from this analysis that by the late 1990s, LAMPLAN had been adopted by most major commercial breeders in the main terminal and maternal sire breeding sectors. In the largest terminal sire breeding sector, Poll Dorsets, adoption by major commercial breeders would appear to be almost 100 percent, with over 98 percent of ram lambs in that sector carrying LAMBPLAN EBVs.

If the Border Leicester sector is an indication, it would appear that while this level of adoption has not been replicated in the maternal sire breeding sector, adoption of LAMBPLAN is still considerable, at least among the main maternal breeds.

It would also appear that the only periods of decline in LAMBPLAN adoption that are relatively consistent across the main breeds are:

- 1990, which coincides with the commencement of the removal of the Wool Reserve Pricing Scheme (see Chapter 5 and 7);
- 1996, which coincides with the launch of Across Flock LAMPLAN for the Terminal Sire Breeding Industry and the introduction of charges for using LAMBPLAN (see Chapter 6 and 7); and
- 2002, which coincides with one of the most significant recorded droughts in prime lamb producing areas in the history of Australian agriculture (see Chapter 5 and 7)

Chapter 5: The Industry Adoption Environment

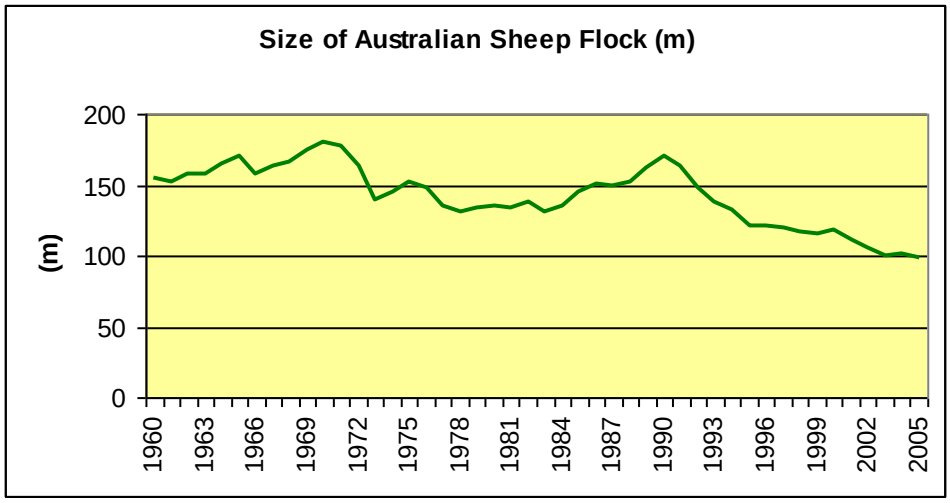
The adoption of LAMBPLAN is an interesting story from many perspectives including the fact that it was introduced at the very early stages of a period of significant transformation in the Australian lamb industry. Indeed, the Australian meat sheep industry is now widely considered one of the rising stars of the Australian agricultural industry. While there can be no doubt that this growth would not have been possible if the genetic improvement in the Australian meat sheep breeding industry that LAMBPLAN has facilitated had not occurred[29], other initiatives such as improved production management, nutritional programs, supply chain management and the development of lucrative new markets have also played an important role in this success story.

Additionally, market indicators that are typical from a growing industry have most certainly encouraged meat sheep breeders to adopt LAMBPLAN[30]. As such, an overview of the development of the Australian lamb industry environment over the life of the LAMBPLAN program is important to demonstrate both the industry impact of LAMBPLAN and market indicators that have influenced its adoption.

A Recent History of the Australian Sheep Industry

There has been a dramatic decrease in the size of the of the Australian sheep flock, particularly since the early 1990s, reducing at an annualized rate of approximately 4 percent from 170 million sheep in 1990 to 98 million today. This is demonstrated in Figure 42 below[31].

[29] The vast majority of breeders that both use and do not use LAMBPLAN that were interviewed commented that LAMBPLAN had facilitated genetic improvement that the industry could not have grown without.
[30] All breeders that used LAMBPLAN that were interviewed commented that the prospects of the Australian lamb industry was a major factor in their decision to invest in LAMBPLAN.
[31] ABARE (2005), *Australian Commodity Statistics,* ABARE, Canberra



In addition to the reduction in size, the Australian sheep flock has also undergone a considerable change in composition over a similar timeframe:

- Ewes have increased from 39.2 percent to 46 percent of the national flock[32]
- Wethers have decreased from 28.2 percent to 16.8 of the national flock[33]
- Lambs have increased from 16.7 percent to 20 percent of the national flock[34]
- Merinos have decreased from 89.4 percent to 85.1 percent of the national flock, representing a reduction of 40 million merino sheep[35]
- Crossbred sheep have increased from 8 to 10 percent of the national flock[36]

Collectively, these trends are indicative of a decline in the wool production industry and a growing meat sheep industry. During the period 1997-98 to 2004-05 Australian wool production decreased by 25 percent to 525,000 tonnes. The trend toward de-stocking of Merino flocks and the resulting reduction in wool production have been producer responses to lower wool prices and an unattractive outlook for wool in the global markets. Removal of the Wool Reserve Price Scheme, a global trend away from formal wear to casual wear, which favours cotton and synthetic fibres, decreased cost of synthetic fibres and the dismantling of the Multifibre Agreement resulting in the

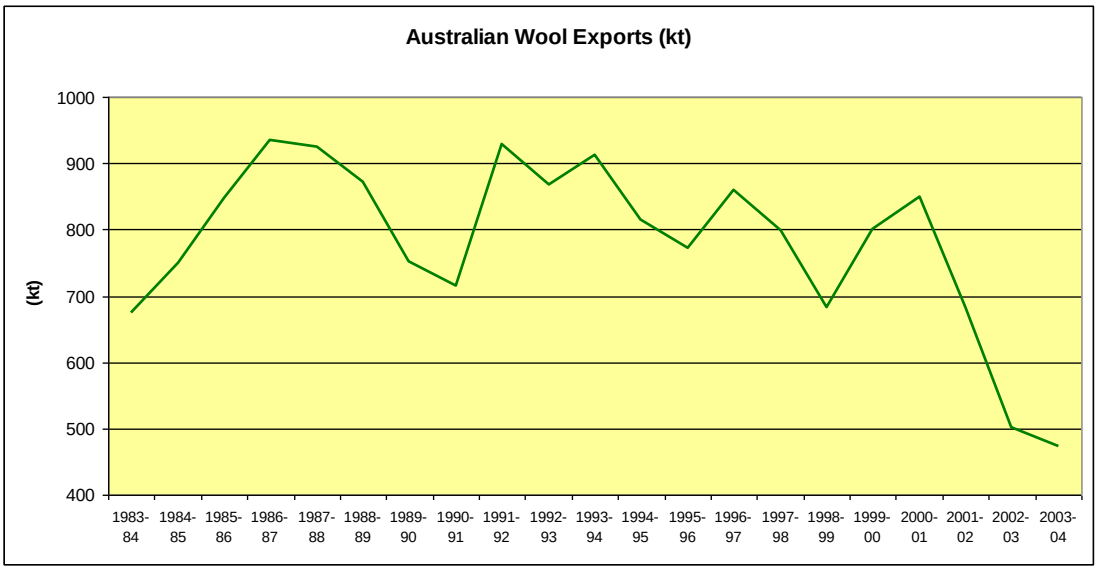
[32] ABARE (2005), *Australian Commodity Statistics,* ABARE, Canberra
[33] ABARE (2005), *Australian Commodity Statistics,* ABARE, Canberra
[34] ABARE (2005), *Australian Commodity Statistics,* ABARE, Canberra
[35] Barrett, D., Ashton, D. and Shafron, W. (2003), *Australian Wool Industry,* ABARE, Canberra
[36] ABARE (2005), *Australian Farm Surveys Report,* ABARE, Canberra

Collapse of the Wool Reserve Price Scheme

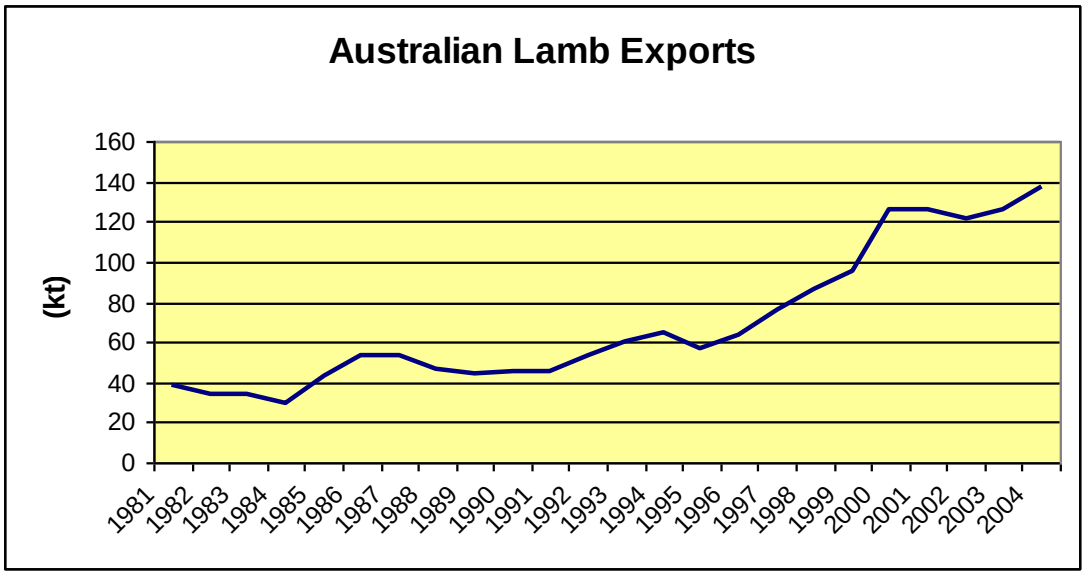
Introduced in 1974, the Wool Reserve Price Scheme was funded by a portion of the tax paid by producers on the value of shorn wool and was administered by the then Australian Wool Corporation. It was designed to provide some stability in wool prices for Australian producers by setting a minimum price at which the Australian Wool Corporation would purchase any Australian wool that did not meet the minimum reserve price at auction. A combination of decreasing global demand for wool and a high reserve price that was set in a period of high demand in the 1980s resulted in a burgeoning stockpile (ABS 2002 Yearbook).

In January 1991, the Australian Government announced the suspension and subsequently, in agreement with industry, the abandonment of the Wool Reserve Price Scheme. The immediate effect of this event was an overnight reduction in the price of wool from $7.00 per kilogram to $3.40 per kilogram. It also left Australia with a stock pile of 4.7 million bales of wool (which is approximately equivalent to one year's production) and an associated debt of A$2.8 billion. (Bardsley, P., 1994. 'The Collapse of the Australian Wool Reserve Price Scheme', *The Economic Journal,* vol.104, no.426, pp.1087-1105)

globalization of the textile industry have collectively rendered wool production a far less attractive enterprise for most Australian producers than has been the case for most of the last century. This has been reflected in a major decline in Australian wool exports, as demonstrated in Figure 44 below. Arguably, the biggest disturbance in the history of the Australian sheep industry has been the collapse of the Wool Reserve Price Scheme (see adjacent text box). During the decade subsequent to the abolition of the Wool Reserve Price Scheme, the Australian flock reduced from 170 million sheep to 115 million sheep. This had an overall destabilising effect on the entire industry, including lamb production, because while some sheep producers shifted their focus to lamb production, others left the industry entirely, which impacted on the Australian lamb industry in its early stages of transformation.

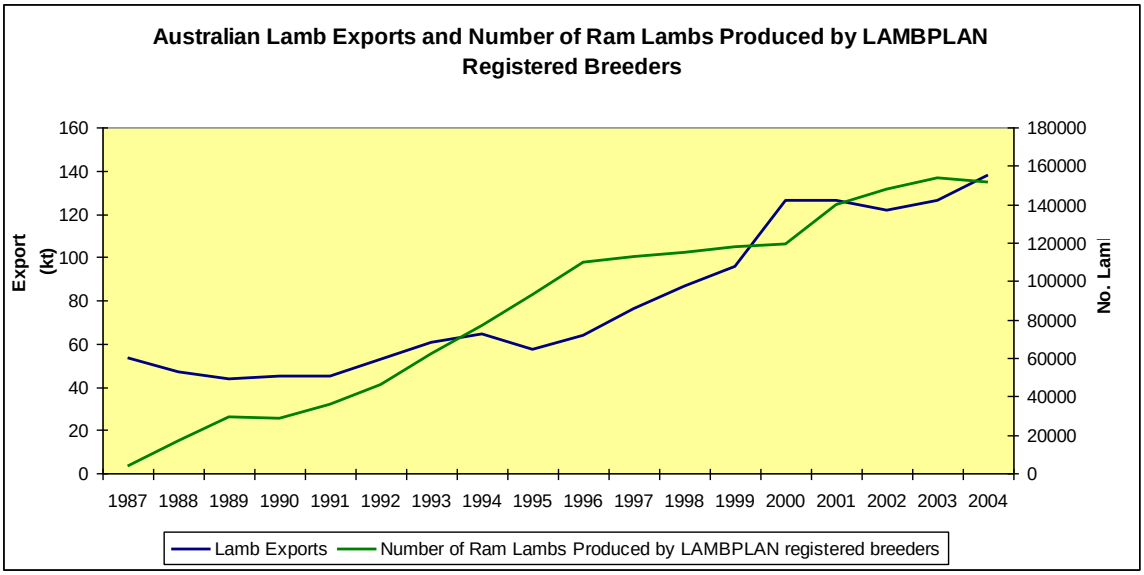


In sharp contrast to the situation in the wool industry, Australian lamb exports have increased dramatically. This is demonstrated in Figure 45 below.



This paradigm has created an environment that has been conducive to the adoption of LAMBPLAN for two reasons:

- Merino breeders and wool producers had a long tradition of visually assessing animals and constructing breeding programs based on visual assessment. Furthermore, compared to meat traits, wool traits are highly visible as they are external to the animal. This provided Merino breeders with a degree of comfort with their traditional visual assessment techniques. For most breeders and commercial producers a shift in focus to meat was unfamiliar visual assessment territory. As such, for some breeders and producers, LAMBPLAN was a valuable decision support tool in the new unfamiliar environment,
- As will be discussed in the next section, competing in the lamb industry required dramatic improvement in carcase quality. LAMBPLAN was seen by many as a 'must-have' to achieve this. Indeed, as demonstrated in Figure 46 overleaf, there is a strong correlation between the growth in Australian exports of lamb and the growth in the number of ram lambs produced by LAMBPLAN registered breeders.



Performance of the Australian Prime Lamb Industry

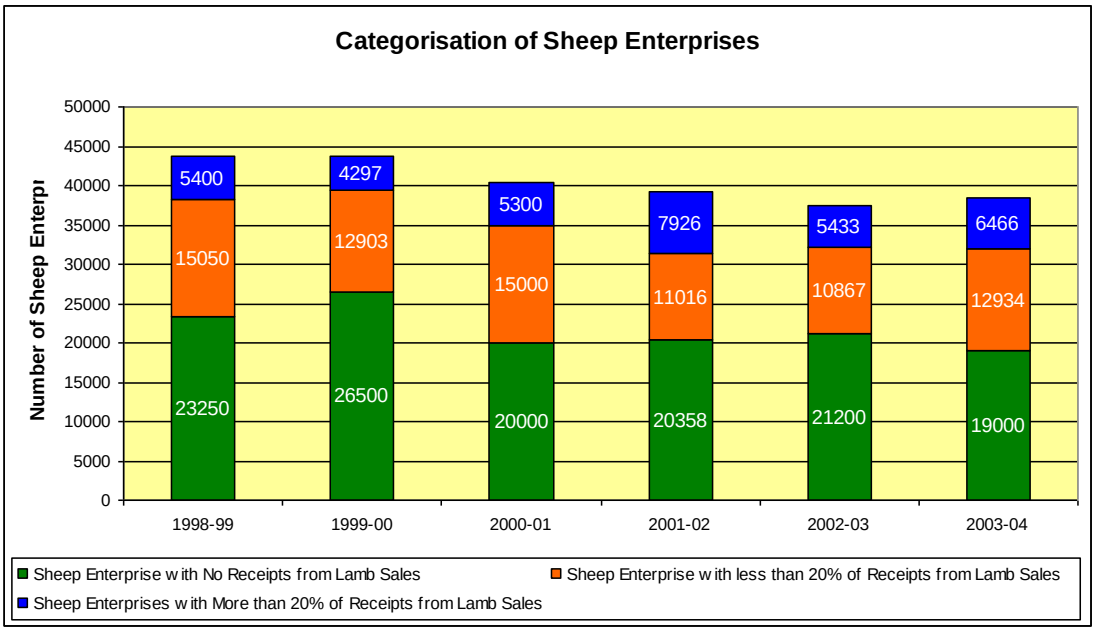
The growth and emerging sophistication of the Australian lamb industry has been a considerable success story on any agricultural industry benchmark. The most significant concentration of the industry is found in the sheep-wheat and high rainfall areas of Victoria, South Australia and New South Wales. While at least some of its success can be attributed to the favourable production climates and agronomic conditions that are generally found in these areas, it is the sophisticated approach to genetics, nutrition, farm management, supply chain management and marketing that have been the main drivers of industry performance.

Emergence of the Prime Lamb Specialist

In the late 1990s, lamb was still being produced primarily in conjunction with wool enterprises and as a complement to other broad acre enterprises, particularly cropping. However, as a result of lower wool prices and increasingly high value export markets for lamb, many producers started to report that lamb revenues were accounting for increasingly high portions of total farm revenue, and in some cases lamb was considered to be the primary enterprise[37]. The portion of sheep enterprises that are reporting significant portions of total revenues from lamb sales has continued to increase.

[37] Connell, P., Hooper, S. and Brittle, S. (2000), *Australian Prime Lamb Industry,* ABARE, Canberra

In 1998-99 approximately 34 percent of the total 43,700 sheep enterprises in Australia were earning some revenue from lamb sales. A further 12 percent of sheep enterprises were earning more than 20 percent of their farm receipts from lamb sales, which can be categorized as lamb specialists. By 2003-04, the total number of sheep enterprises had reduced by 12 percent to 38,400. The portion of enterprises receiving some receipts from lamb sales remained at around 34 percent. However, the portion of enterprises that could be considered lamb specialists (earning more than 20 percent of farm receipts from lamb sales) increased to 17 percent, demonstrating a trend toward specialization in lamb production. This is demonstrated in Figure 47 below[38] [39] [40] [41] [42] [43].



Generally speaking, the lamb specialist is a sophisticated producer, achieving higher rates of growth in labour productivity and non-land farm capital productivity than their industry compatriots. This is demonstrated in Table 6 below[44] [45].

[38] Connell, P., Hooper, S. and Brittle, S. (2000), *Australian Prime Lamb Industry,* ABARE, Canberra
[39] Connell, P., Hooper, S. and Brittle, S. (2001), *Australian Prime Lamb Industry,* ABARE, Canberra
[40] Connell, P., Hooper, S. and Helali, S. (2002), *Australian Prime Lamb Industry,* ABARE, Canberra
[41] Hooper, S., Blias, A. and Ashton, D. (2003), *Australian Prime Lamb Industry,* ABARE, Canberra
[42] ABARE, (2004), *Prime Lamb Industry Performance and Outlook,* ABARE, Canberra
[43] ABARE, (2005), *Prime Lamb Industry: Financial Perforamnce,* ABARE, Canberra
[44] ABARE, (2004), *Australian Sheep Industry Productivity,* ABARE, Canberra
[45] ABARE, (2005), *Prime Lamb Industry Financial Performance,* ABARE, Canberra

	Sheep Industry Farms	Specialist Prime Lamb Farms
Total Factor Productivity		
Outputs	1.6	3.7
Inputs	0.4	2.1
Productivity	1.2	1.6
Partial Productivity		
Labour	2.4	3.3
Capital (Including Livestock Capital)	3.0	3.5
Purchased Inputs	0.7	0.2
Land	-1.9	-0.6
Input Use		
Labour	-0.8	0.4
Capital	-1.4	0.2
Purchased Inputs	0.9	3.5
Land	3.5	4.3
Prices		
Outputs	1.2	2.3
Inputs	2.6	3.0
Terms of Trade	-1.4	-0.7

2002 Drought

National droughts (Late 1960s, 1976/77, 1982/83 and 1994) have consistently resulted in a reduction in sheep numbers throughout the history of the Australian sheep industry. The drought that occurred in Australia during 2002-03 has been cited as perhaps the worst in the history of Australian agriculture and most certainly the worst since competent financial records have been maintained (2003 ABC Interview with Saule Eslake, Chief Economist, ANZ Bank). By November 2002, approximately 62 percent of Australia had serious or severe nine month rainfall deficiencies and over the same period, the Australian average maximum temperature was the highest on record. The net result was a 30 percent reduction in agricultural output (Australian Government Bureau of Meteorology – 2003 – Impacts of Climate Change on Australia).

Despite the Commonwealth Government committing $728 million over three years in drought relief packages, the impact was significant on almost all Australian agricultural industusties (AFFA).

A major contributor to the superior productivity achieved by the lamb specialist has been progress in increasing lambing rates and reducing lamb death rates. While the 2002-03 drought (see adjacent text box) reduced lambing rates and increased lamb death rates across the entire sheep industry, lamb specialists have achieved lambing rates between 90 and 100 percent over the past 15 years compared to a range of 75 to 85 percent for non-specialist producers. Similarly, death rates for specialist lamb producers

have ranged between 8 percent and 3 percent compared to a range of 11 to 4 percent for non-specialist producers over the same period.[46] While it is true that specialist lamb producers tend to be located in areas with climate and agronomic conditions more favourable to pasture and crop growth and hence more conducive to high ewe fertility and lamb survival[47], it was the main prime lamb producing areas of southern New South Wales and Victoria that experienced some of the worst drought conditions. As such, it is clear that at least part of the prime lamb specialists superior reproductive performance is attributable to the superior genetics typically used by the lamb specialist. For example, the use of Border Leicester-Merino cross ewes has demonstrated improved lambing and weaning rates and similarly, the use of Poll Dorset (and formerly Dorset Horn) rams have allowed further gains to be achieved from the hybrid vigour derived from Border Leicester – Merino Cross ewes. The usage of such genetics by the lamb specialist is demonstrated by:

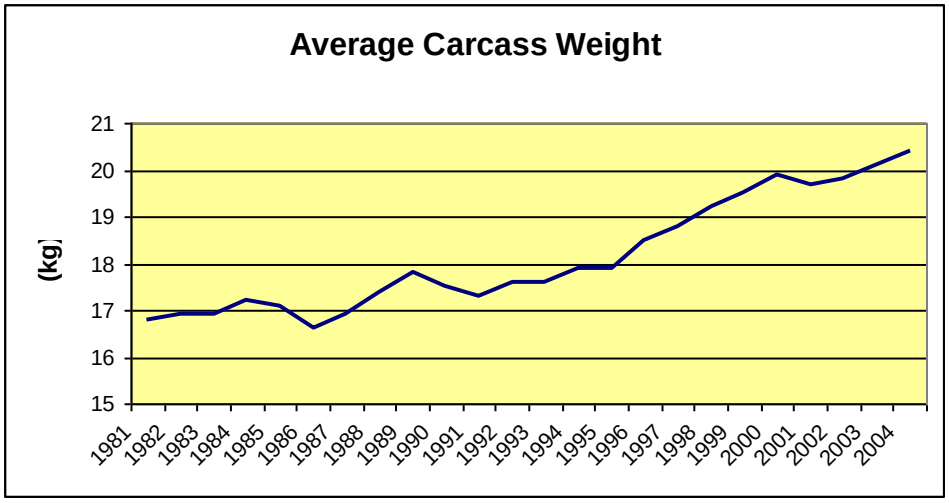
- The fact that between 1996-97 and 1999-00, the percentage of first-cross Merino ewes in flocks of prime lamb producers increased from 12 percent to 18 percent and the number of Dorset Horn and other short wool breed rams used by prime lamb producers increased from approximately 31 percent to 45 percent[48] ; and
- The fact that lamb specialists have a much higher portion of first-cross and non-merino breed ewes in which twinning is more common[49].

The fact that lamb specialists seem significantly more focused on reproduction efficiency than the rest of the industry goes some way to explaining the relative size of the terminal and maternal sire industries and the disproportionately low number of maternal sire breeders registered with LAMBPLAN. Where most enterprises breeding for meat will use terminal sires to improve meat characteristics of progeny, if it is only the lamb specialists (17 percent of the industry) breeding for reproduction efficiency, then demand for maternal genetics will be relatively low.

[46] ABARE, (2005), *Prime Lamb Industry Financial Performance,* ABARE, Canberra
[47] ABARE, (2004), *Prime Lamb Industry Performance and Outlook,* ABARE, Canberra
[48] Connell, P., Hooper, S. and Helali, S. (2002). *Australian Prime Lamb Industry,* ABARE, Canberra
[49] ABARE, (2005), *Prime Lamb Industry: Financial Performance,* ABARE, Canberra

It is probably timely to raise at this point a concern that has been expressed in relation to reproductive efficiency in the lamb industry. Currently, Merino ewes provide the reproductive foundation of the lamb industry. Lamb specialists cross Merino ewes with maternal sires to produce a first-cross ewe with superior reproductive capability and then breed slaughter lambs by joining the first cross ewe with a terminal sire breed. However, there are concerns in the industry that because of higher lamb prices, some lamb producers are slaughtering first cross ewe lambs and merino lambs, reducing the reproductive stock of the industry. This phenomenon combined with the trend in merino de-stocking has been cited as a future concern for the industry[50].

The other major achievement of the Australian prime lamb industry is the significant increase in average carcase weight from approximately 17 kilograms in the late 1980s to 20.5 kilograms in 2004[51]. This is demonstrated in Figure 48 below. Most importantly, this considerable gain in carcase weight has not been associated with a concomitant increase in carcase fatness.



While improved farm management and nutrition programs have made some contribution to this capability, improved terminal genetics have been the major contributor and LAMBPLAN has been the main vehicle through which those improved genetics have been delivered to and managed by industry[52]. Genetic improvement has fundamentally changed the growth pattern of the animals so that they grow heavier weights before they

[50] Interviews
[51] ABARE, (2005). *Australian Commodity Statistics,* ABARE, Canberra.
[52] Most breeders that both use LAMBPLAN and do not agreed that improved genetics has been the major reason carcase weights have improved and that LAMBPLAN has played a significant role in this improvement.

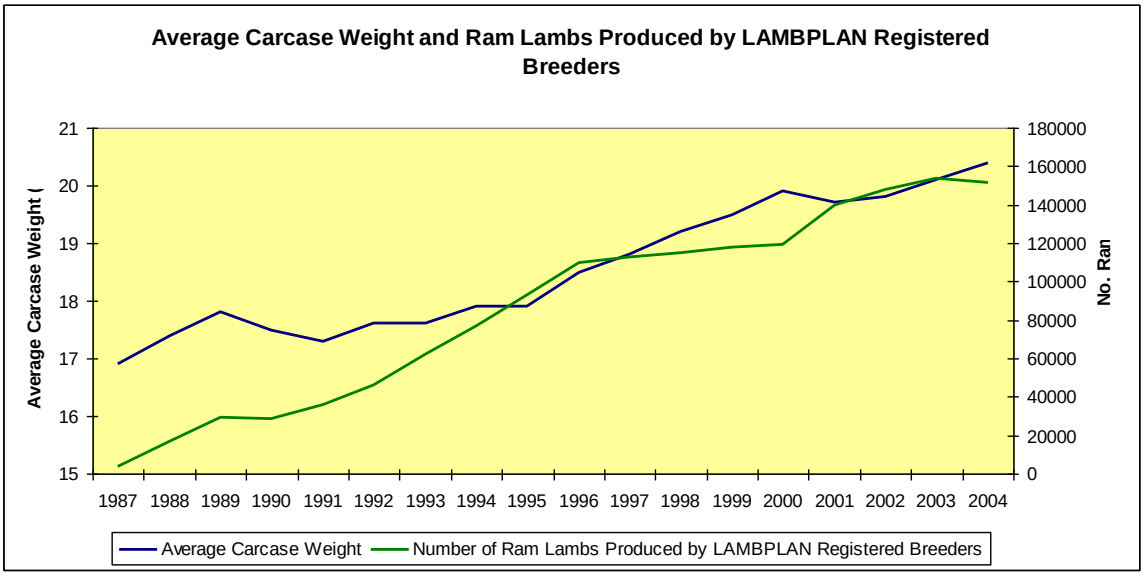
start to lay down fat. MLA data demonstrates that in each year the average Australian lamb has approximately 230 grams of additional lean tissue, 5 grams less fat and about 10 grams more bone. Indeed the results from the first Terminal Sire Central Progeny Tests in Glen Innes, New South Wales demonstrate the impact of LAMBPLAN on carcase improvement. Table 7 below shows the distribution of lambs by carcase weight and fat intervals from the first intake of animals into the Glen Innes Terminal Sire Central Progeny Test.

Cryptorchids			**Fat Score**			
Carcase Weight Range	**1**	**2**	**3**	**4**	**5**	**Total**
Under 19	1%	13%	5%	0%	0%	20%
19-21	0%	12%	9%	1%	0%	22%
21-23	0%	8%	15%	1%	0%	23%
23-25	0%	3%	18%	1%	0%	23%
25 plus	0%	1%	6%	5%	0%	12%
Grand Total	**2%**	**37%**	**53%**	**8%**	**0%**	**100%**
Ewes			**Fat Score**			
Carcase Weight Range	**1**	**2**	**3**	**4**	**5**	**Total**
Under 17	6%	45%	6%	0%	0%	57%
17-19	0%	16%	9%	0%	0%	25%
19-21	0%	4%	9%	0%	0%	13%
21-23	0%	1%	3%	1%	0%	5%
Grand Total	**7%**	**66%**	**26%**	**1%**	**0%**	**100%**

Cryptorchids are rams that have not been castrated, but who have had their testicles blocked from descending into the scrotal cavity. Because the testes remain at body temperature, they are unable to produce viable sperm but they maintain the hormonal levels of a non-castrated ram. Because cryptorchids have the same hormonal levels as uncastrated males they develop carcase characteristics more similar to uncastrated males than wethers, or castrated males. These animals were historically promoted as a potential solution to achieving the carcase characteristics required by lucrative export markets. However, using cryptorchids to produce larger leaner carcases failed to gain traction in the market, because of concerns over eating quality and difficulties in animal management. However, Table 7 above demonstrates that by using high ranking LAMBPLAN rams as opposed to average rams, ewes were able to be bred that

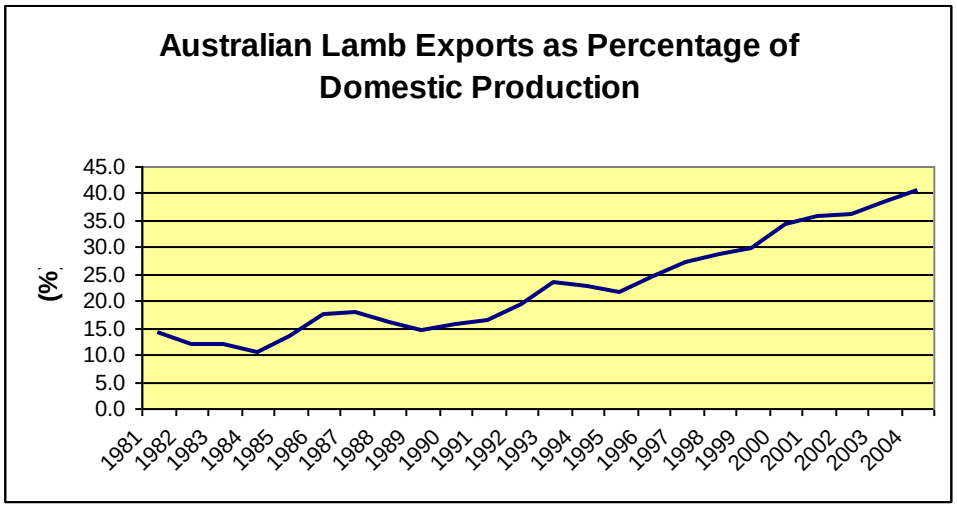
demonstrated the same carcase characteristics as wethers and wethers were able to be bred that achieved the same carcase characteristics as cryptorchids (demonstrated by the blue shading in the table), without any impact on eating quality or animal manageability. Indeed given that the national average carcase weight is now 21.5 kilograms and the average fat score is 2-3, it can be argued that LAMBPLAN has turned average lamb production into animals that are equivalent to what can be achieved in terms of carcase weight and leanness using cryptorchids.

Furthermore supporting the impact of LAMBPLAN on carcase weight is the strong correlation between the improvement in average carcase weight and the increase in the number of ram lambs produced by LAMBPLAN registered breeders, as demonstrated in Figure 49 below.



Export Markets for Australian Lamb

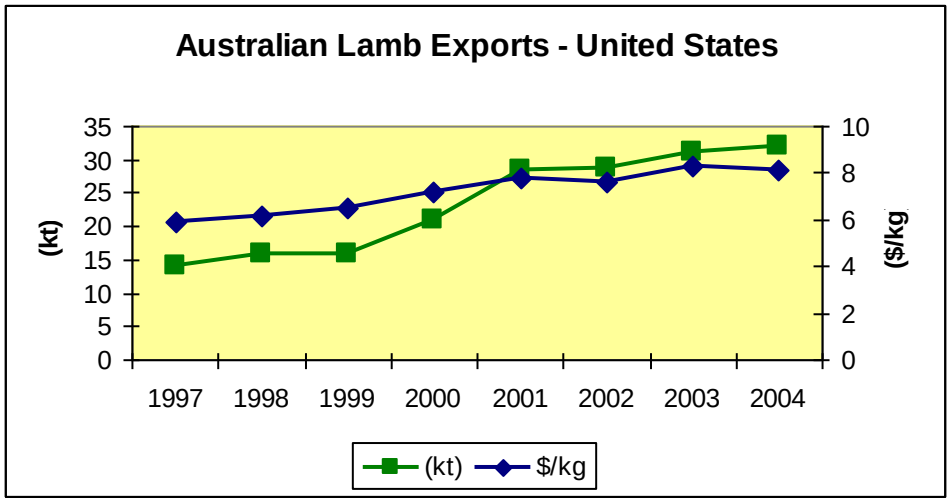
The improvements in carcase quality and size that have been a direct result primarily of improved genetics, have allowed the Australian lamb industry to grow exports considerably. In the early 1980s, lamb producers were primarily servicing the domestic market, with exports accounting for only approximately 10 percent of production. The lamb export industry grew extensively from the early 1990s to present, with lamb exports now accounting for over 40 percent of domestic production. This is demonstrated in Figure 50 overleaf.



Similarly, the on-farm value of Australian lamb exports has grown from approximately A$265 million in 1997 to approximately $650 million in 2004, which is the equivalent of approximately $20,000 in additional income to the producer per annum. The markets of the United States, European Union, Japan and United Arab Emirates account for 70 percent of Australian lamb exports. The single largest export market for Australian lamb is the United States, which has grown from $83 million in 1997 to $260 million in 2004. As demonstrated in Figure 51 overleaf, this has been the result of both increased volumes as well as increased prices, indicating an improved capability of the Australian lamb industry to meet United States lamb product standards. This capability is further demonstrated by the reputation that Australian prime lamb has in the United States:

'Fresh Australian Range Lamb is America's leading brand of fresh lamb and the lamb program of choice among top chefs throughout the country'[53]

[53] Buckhead Beef. (www.buckheadbeef.com/products/lamb/html). Accessed 13 April 2006.



The potential of Australian lamb in the United States market is further evidenced by the United States Government's response to growing imports of Australian Lamb. In 1999, the United States International Trade Commission determined that imports of lamb meat from Australia and New Zealand was a serious threat to United State's sheep farmers and the domestic lamb meat industry and as such imposed considerable tariff penalties (see adjacent text box). While these penalties were short lived, they had considerable impact on the Australian lamb industry. Obviously, the effective ceiling on export volumes placed restrictions on the ability of the Australian lamb industry to continue to grow its most promising market while the tariffs remained in place. However, there were also positive outcomes from the attempt by the United States to reduce competition in the United States market from Australian lamb:

United States Trade Restrictions

From July 1999, the United States introduced a three-year (with possible extension for a further five years) tariff rate quota on imports of lamb from Australia and New Zealand. The table below demonstrates the tariff penalties that were imposed:

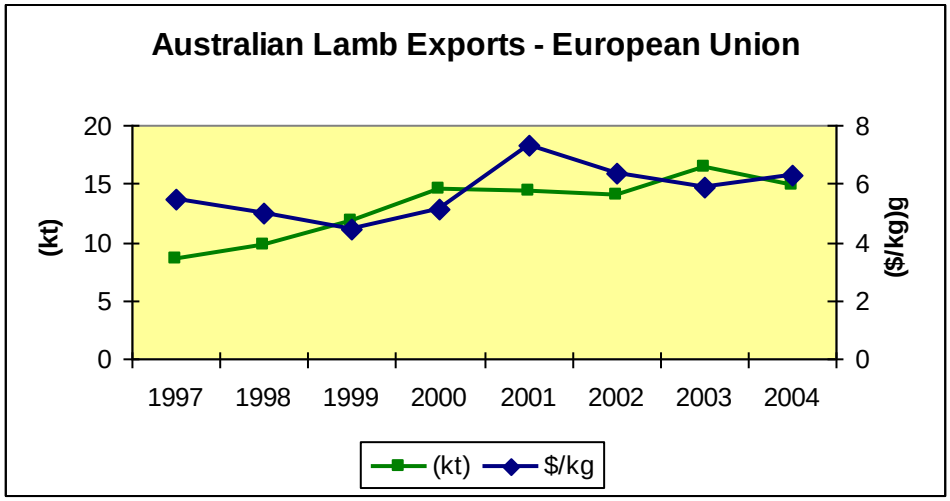
	In-quota Duty	In-quota Quantity	Over-quota Duty
Year 1	9%	31,851t	40%
Year 2	6%	32,708t	32%
Year 3	3%	33,565t	24%

Australian and New Zealand initiated a World Trade Organisation (WTO) action in October 1999, claiming the restrictions were illegal. In December 2000, the WTO Dispute Settlement Panel found in favour of Australia and New Zealand, determining that the United States' actions were inconsistent with its obligations under the WTO Safeguards Agreement and Article XIX of the General Agreement on Tariffs and Trade. In February 2001, the United States filed an appeal, which was subsequently overturned by the WTO Appellate Body in May 2001 (Australian Department of Foreign Affairs and Trade Media Release 2001)

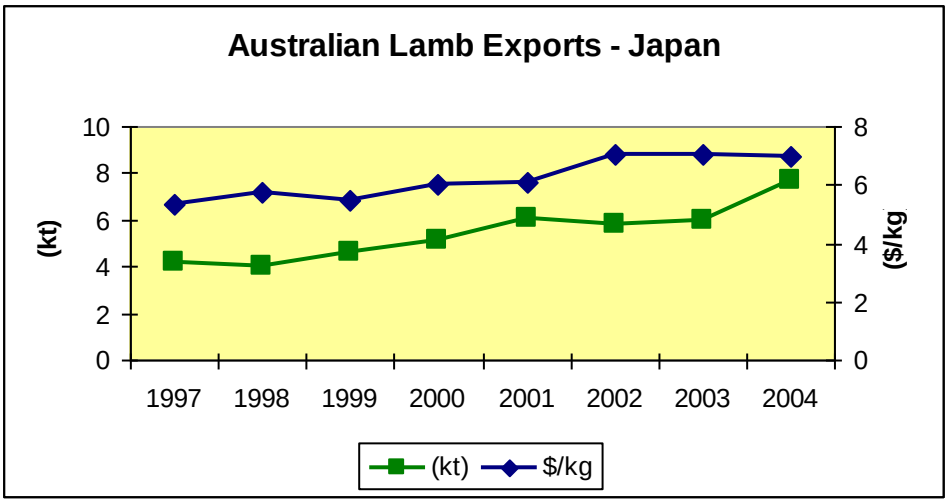
- The controversy raised the profile of Australian lamb in the United States and globally; and

- Because the tariff quota was based on weight, it encouraged Australian processors to develop innovative meat cuts that represented higher value for less weight, such as boneless cuts.

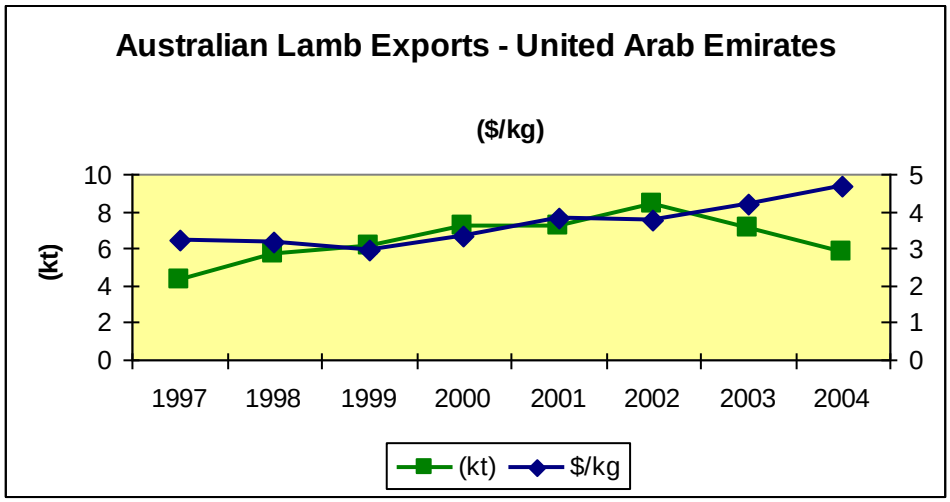
Although prices have been slightly more volatile in the European Union, it is also considered a growth market for Australian prime lamb, with exports to the European Union growing from approximately $50 million in 1997 to approximately $93 million in 2004. This is demonstrated in Figure 52 below.



While still only a relatively small market for Australian lamb, Japan has doubled in value from $22 million in 1997 to $53 million in 2004, as demonstrated in Figure 53 below. This increase in value has been the result of both increasing prices and volume, indicating an improved ability of the Australian lamb industry to meet Japanese market specifications.



Like Japan, the United Arab Emirates is a relatively small market for Australian prime lamb, but one that has doubled in value during the period 1997 to 2004, mostly as a result of increased prices. This is demonstrated in Figure 54 below.



Future of the Australian Lamb Industry

As with most Australian primary produce, export markets are critical to future growth. This is a sentiment broadly shared among all stakeholders in the Australian prime lamb industry, who collectively agree that developing existing and new overseas markets will continue to drive growth in the Australian prime lamb industry. Markets that have been typically cited as holding the greatest future potential include the United States, Europe and China. North African markets such as Egypt, Algeria and Morocco have been cited as possible future markets as well as potential premium product markets that may emerge in the Middle East as processor and importer relationships slowly become more sophisticated in those countries[54].

Traditionally, New Zealand has been Australia's major competitor in these markets. However, China is emerging as Australia's most likely future competitor. This is a considerable threat given that China's meat sheep industry has been largely influenced

[54] Interviews

by Australian genetics (Merino, Poll Dorset and Texel) and as a result the Chinese lamb product appears very similar to the Australian product[55].

There is a general view that in light of increased domestic and international production, lamb prices will decrease in the medium to long term. As such, it is imperative that the industry continues to develop new markets, adopt further technologies that reduce costs and continue to use genetics to develop leaner, larger, more productive sheep as well as better lamb products.

[55] Interviews

Chapter 6: Development History of LAMBPLAN

This section of the report details the various scientific achievements, market research and development initiatives, industry development initiatives, promotional exercises and actual product developments that contributed to LAMBPLAN throughout its lifetime. The purpose of this exercise is to identify specific events that had either a negative or positive effect on adoption.

A Brief Pre-LAMBPLAN History

It is commonly understood that LAMBPLAN emerged from an experimental sheep testing service operated by the New South Wales Department of Primary Industries (NSW-DPI) in the late 1970s and early 1980s, the New South Wales Meat and Sheep Testing Service. This work was focused on defining the genetic parameters for improved meat production and determining the best methods for practically measuring those parameters. In the early to mid 1980s the Victorian Department of Primary Industries (VIC-DPI) undertook a number of on-farm validation trials of the genetic parameters and measurement methods developed by the NSW-DPI to determine the best way of implementing a national genetic program such as LAMBPLAN. In the mid-1980s, Primary Industries South Australia (PIRSA) was also offering a Sheep Meat Testing Service.

At around the same time as these tests were being undertaken, domestic and international market research into consumer preferences for lamb was being undertaken by the NSW-DPI and VIC-DPI. This research clearly demonstrated that the existing Australian lamb product did not meet market requirements in terms of cut size and leanness, both in Australia and internationally.

In the early 1980s much of the broader sheep industry research and extension activity aimed at improving lamb carcase quality was focused on developing nutrition programs. The role that genetics could play in improving carcase quality was not widely understood by industry at this time. However, it was clear to a very small group of genetics experts in the industry that the only way Australian lamb carcases could be developed to the extent

that was needed to meet the market requirements determined by the market research was through an industry-wide, sustained genetic improvement program.

Senior members of the current LAMBPLAN team within MLA who were originally involved in the NSW-DPI program supported the then Australian Meat and Livestock Corporation (AMLRDC) and engaged with members of VIC-DPI and PIRSA with the view to developing a coordinated R&D and extension program, with genetic improvement being a major focus. This resulted in Prime Lamb Program being launched in the late 1980s with the goal of producing Australian prime lamb carcases weighing in excess of 21 kilograms with a fat score of 2-3. LAMBPLAN was closely aligned with the Prime Lamb Program, but did not formally become part of the program until the mid 1990s.

In its early years, LAMBPLAN was very reliant on strong cooperation from the various State DPIs from an R&D, extension and delivery support perspective. In addition to the initial R&D undertaken by the various state DPIs, the core LAMBPLAN team and key individuals from the State DPIs undertook far reaching extension activities and the State DPIs provided scanner operators for the program. This strong collaborative relationship between LAMBPLAN and the various State DPIs though to the mid 1990s was critical to raising awareness and setting the foundations for LAMBPLAN in industry. Furthermore, the ability of that team to engage with processors to demonstrate the commercial supply chain relevance of LAMBPLAN was essential in establishing it as an industry tool.

However, since that time, most of the responsibility for the operation of LAMBPLAN and aligned extension initiatives has increasingly resided with the LAMBPLAN team at MLA. There are a number of possible factors that could have contributed to this:

- As industries grow out of start-up phase, in most free market economies it is a natural course of events for the industry to take more control of its issues. In particular, the resulting gains in carcase weight and leanness generated increasingly more interest from processors who started locking in supply chain relationships with producers. This somewhat negated a major facilitation role that State DPIs had been performing;
- During the late 1990s LAMBPLAN became substantially more technical and complex, particularly with the emergence of Indexes. As such, breeders were seeking specific technical expertise that primarily resided with the LAMBPLAN team at MLA; and

- Senior management changes in some DPIs during this time may have resulted in a change in DPI focus and the cessation or reduction in funding for LAMBPLAN related DPI programs.

Enabling Innovations

Several key complementary innovations have facilitated the establishment of LAMBPLAN and the development of a product and service that has achieved substantial penetration in its target market. Primarily, these have allowed a usable and reliable product to be developed around the core genetics science.

Quantitative Genetics Algorithms

Although quantitative genetics methodologies have been understood for several decades, the refinement of the math into sophisticated algorithms such as BLURP, coupled with the widespread availability of high performance computing capability has enabled considerably more accurate prediction and the results to be presented in formats that are relatively simple to understand. Furthermore, the ability to effectively scale both hardware and software processing capability was important once the critical mass of data was achieved that facilitated across flock and breed LAMBPLAN.

Real-time Ultrasound

Since breeding stock are not slaughtered, carcase traits must be assessed indirectly for stud animals. Traditionally, this has been done visually, often resulting in considerable inaccuracy. The introduction of ultrasound technology facilitated objective measurement of carcase traits[56]. While ultrasound has been used to measure fat and muscling in swine and cattle since the 1950s, the earlier technologies suffered from inaccuracy and operational difficulties in a farm environment. The introduction of real-time ultrasonic equipment in 1984 was a major development for the livestock industry, as it allowed for practical farm ultrasound tools[57]. It was these later technologies that provided part of the accuracy on which the credibility of LAMBPLAN is largely based. Additionally, the provision of scanning services for LAMBPLAN by accredited operators has allowed

[56] Hiemke, C.J., Lee, L., Thomas, D., Taylor, T., Gottfredson, R. and Pinnow, S., *Ultrasound Fat and Muscle Measurements of Live Lambs as a Predictor of Carcase Fat and Muscle Measurements and Changes in Ultrasound Rib Eye Area and Fat Thickness as Lambs Grow*

[57] Stouffer, J.R. and Liu, Y. (1997). *Real Time Ultrasound Technology: Current Status and Potential,* National Swine Improvement Federation, United States

breeders to obtain accurate trait measurement data without a major disruption to farm management practices.

Web Enabled Software - Pedigree Wizard

Pedigree Wizard is a software program that allows breeders to enter their scan data through a simple user interface on their home or office computer and download that data to the LAMBPLAN database via the Internet. The absence of the Internet and such software would render data entry a time consuming activity, prone to inaccuracy.

Complementary Innovations

There are a number of other innovations that while they are not directly related to the operation of LAMBPLAN, have played some role in its adoption either because:

- They have resulted in some users having familiarity with using science and technology in breeding management practices and assisted them with obtaining a basic understanding of some of the science behind best-practice breeding techniques; or
- Using these innovations in conjunction with LAMBPLAN improves and accelerates the realization of positive results.

Artificial Insemination

Artificial Insemination (AI) is increasingly becoming standard practice in the breeding and commercial production sectors of the Australian meat sheep industry. Certainly, a significant portion of all breeders interviewed used AI in their operation[58]. Effectively, AI allows a breeder or producer to dictate when a ewe falls pregnant. This is particularly useful for:

- Producing lambs all year round;
- Obtaining maximum reproductive efficiency from high performing ewes;
- Using preferred sire genetics without buying the specific sire; and
- Fertilising ewes that haven't fallen pregnant as a result of natural servicing.

The use of hormones to exactly time ovulation together with the artificial insemination with previously frozen sperm results in pregnancy rates of up to 80 percent in highly

[58] Interviews

fertile ewes, although more typical ranges are 40 percent to 70 percent in season[59]. AI is a complementary technology for LAMBPLAN because a breeder or producer can buy or use sperm from a LAMBPLAN ram and have a high degree of confidence in the genetic make-up of the progeny. Furthermore, because AI increases the efficiency of reproduction, it shortens the time in which a user begins to see genetic improvement in the flock from using sperm from a LAMBPLAN ram.

An example of the effective use of AI is the Young Sires Producer Initiated Research and Development (PIRD) Program[60]. This allowed the superior performance genes of an industry nucleus flock (a flock that formed part of the Meat Elite Program R&D) to be dispersed among industry through AI. Under the Young Sires Program, breeders could acquire semen from the nucleus flock with known genetic merit by virtue of the LAMBPLAN data that had been generated from that nucleus flock. In this sense, LAMBPLAN also assisted the diffusion of AI, as it gave breeders the ability to identify the genetic merit of semen they were buying.

Embryo Transfer

While not used as extensively in the meat sheep breeding industry as AI, Embryo Transfer seems to be practiced by a small number of the earlier adopters of LAMBPLAN. ET is complementary to AI because while AI allows a breeder to more widely distribute high performing male genetics, ET allows the breeder to widely distribute strong female genetics.

ET greatly increases the potential number of offspring that a single high performing ewe can have in a year. Several days after joining, around five to ten embryos are removed from a high performing ewe and either frozen or immediately transferred to other surrogate ewes to carry the pregnancy[61]. Like AI, ET has the potential to accelerate the time taken for a LAMBPLAN user to see genetic improvement in the flock, particularly when used in conjunction with AI.

[59] Turner, R. (2003), 'Laparoscopy to Enhance Chance of Pregnancy in Goats and Sheep', *Bellwether: News Magazine of the University of Pennsylvania School of Veterinary Medicine,* Issue 52.
[60] Banks, R., Ball, A. and Field, S., *Young Sire Programs in Meat Sheep Breeds in Australia – A Vehicle for Rapid Genetic Improvement and Continuous Research and Development*, University of New England, Armidale
[61] Turner, R. (2003), 'Laparoscopy to Enhance Chance of Pregnancy in Goats and Sheep', *Bellwether: News Magazine of the University of Pennsylvania School of Veterinary Medicine,* Issue 52.

Juvenile In-Vitro Embryo Transfer (JIVET)

Juvenile In-Vitro Embryo Transfer (JIVET) is a relatively new reproductive technology to the Australian sheep industry and as such, its adoption has not been limited. JIVET provides the ability to collect large numbers of oocytes (a female germ cell in the maturation stage) from juvenile lambs. This means that generational intervals can be substantially reduced. For example, Chinese researchers claim to have developed a JIVET technology that enables a 45 day old ewe to produce extra ova, resulting in 200 offspring per year by the age of one[62].

In Australia, results have been slightly more conservative. Australian R&D projects revolving around JIVET have resulted in considerable improvements in the mean number of oocytes harvested per lamb. The mean number of embryos transferred per donor lamb and the mean number of lambs produced per donor lamb are currently 10 to 15 for Merino and 5 to 10 in non-Merino breeds[63].

As with AI and ET, JIVET shortens the time taken to realize gains from LAMPLAN. However, as a result of both prohibitive cost and the impracticalities associated with the need for invasive procedures, its adoption by the meat sheep industry has been minimal.

Lamb Identification and Description Technologies

In 1991, Lamb Identification and Description technology was introduced to meat processing operations. This technology has evolved over the past 15 years to sophisticated RFID tagging systems that allow individual animals to be rapidly and accurately scanned, linking their genetic information as described by EBVs and Indexes with carcase measurements. This provides processors with the ability to provide accurate and timely performance feedback to producers potentially improving supply chain relationships and efficiency.

VIAscan

VIAscan was developed by Systems Intellect Pty Ltd and VQA Australia as part of the Australian Sheep Meat Research Corporation's Objective Carcase Measurement

[62] China View, (2006), *JIVET Technology Helps Increase Sheep Reproduction',* May 16 Edition (www.chinaview.cn)
[63] South Australian Research and Development Institute, *Juvenile In Vitro Embryo Tansfer (JIVET)*, (www.sardi.sa.gov.au/pages/livestock/meat_and_wool/genetics_and_reproduction.htm). Accessed: 13 April 2006.

Program[64] . VIAscan is used by meat processors as an objective grading tool that utilizes Video Imaging Analysis (VIA) technology to rapidly and accurately assess lamb and beef carcase characteristics.

In the Australian meat sheep industry, once a carcase is scanned, VIAscan uses algorithms to predict lean meat yield based on a study of 360 lamb carcases. Based on this method, VIAscan will predict yield within plus or minus 4 percent of the actual yield, which is significantly more accurate than other forms of objective carcase measurement[65].

VIAscan information benefits producers by facilitating immediate and accurate information on their carcase quality. Furthermore, when integrated with yield based payment systems, producers can receive price premiums for high yielding carcases. This is complementary to LAMPLAN because it allows immediate and accurate feedback on progress toward breeding objectives which in turn, both crystalises results from using LAMBPLAN rams and allows the producer to tailor their breeding program and LAMBPLAN figure requirements to supply chain needs.

To date, VIAscan has mostly only been adopted by processors that are part of a very tight supply chain. This is possibly a result of current market conditions in which there is a shortage of supply of slaughter rams. In such an environment it is plausible that some processors are wary of penalizing poor performing carcases because of the risk they will lose supply of slaughter lambs to competitors.

Comment on Complementary Innovations

The above technologies that complement LAMBPLAN have played a role in the adoption of LAMBPLAN by early adopter segments (see Chapter 7) from two main perspectives:

- Breeders that had previously deployed AI and ET in their operations had a sound knowledge base and best-practice mentality which potentially made the decision to adoption LAMBPLAN easier; and
- Technologies such as Lamb Identification and Description systems and VIAscan have played a role in facilitating the integration between producers and processors

[64] Ferguson, D., Thompson, J. and Cabassi, P. (1995), 'Video Imaging Analysis', *Proceedings of Meat '95 – The CSIRO Meat Industry Research Conference.*
[65] Davidson, R. and Pethick, D. (2005). 'Benefits of VIAscan to Producers and WAMMCO', *Sheep Updates 2005,* Department of Agriculture Western Australia.

that has been necessary to optimize the economic rewards realized by producers who use LAMBPLAN.

Later adopters of LAMBPLAN have benefited from the program simply by virtue of the penetration that LAMBPLAN animals have had in the industry (see Chapter 4). Access to the larger and leaner animals that have resulted from LAMBPLAN have enabled later adopters to meet processor requirements, albeit not to the same extent and consistency as LAMBPLAN users, just by virtue of the fact that LAMBPLAN has resulted in these animals being more readily available.

It is important to note that all of these complementary technologies add not insignificantly to the cost of production. Some interviewees commented that one of the main challenges facing the Australian prime lamb industry is increasing costs of production[66]. With this in mind, it would appear that breeders and producers are only enthusiastically adopting those technologies and innovations that result in timely demonstrable improvement in productivity or revenue.

Market Research Initiatives

The first investigations into Australian consumer preferences for lamb were undertaken as early as 1978. These studies identified the need for a significant change in the Australian lamb product if the Australian lamb industry was to survive and prosper. Additionally, various market study tours to the United States were funded by NSW-DPI and VIC-DPI during 1986 and 1987 to determine if their was a market for Australian lamb in the United States. In the mid to late 1990s further market studies were conducted[67] [68] [69] in order to confirm that preferences had not shifted and that industry production targets were on track. The key discoveries of these collective studies are as follows[70]:

- Only 40 percent of consumers agreed that lamb was tender, juicy and delicious
- 33 percent of consumers had difficulty purchasing lamb of consistent and preferred quality

[66] Interviews
[67] Australian Meat and Live Stock Corporation (1997), *Lamb Usage and Attitude Study,* Australian Meat and Livestock Study, Sydney
[68] Bennett, J.M. (1997), *Eating Quality of Lamb-Meat Research Corporation Situation Paper,* MLA, Sydney
[69] Yann, M., Campbell, A., Hoare, W. and Wheeler, A. (1994) *Market Description of Beef and Lamb – Consumer Research Program – Report on Stage 2 of Project M.360 for Meat Research Corporation,* MLA, Sydney
[70] Russell, B.C., McAlister, G., Ross, I.S. and Pethick, D.W. (2005), 'Lamb and Meat Eating Quality – Industry and Scientific Issues and the Need for Integrated Research', *Australian Journal of Experimental Agriculture,* Vol.45, pp.465-467

- 75 percent of consumers indicated that they would purchase more lamb if they had access to a more tender and tasty product
- Eating quality was the most important decision factor in a consumer decision to repurchase meat (65 to 68 percent) and price was the second most important decision factor (25 to 28 percent)
- Consumer decisions at the point of sale are determined by the visual appearance of a meat product, particularly visual fat content. In the case of lamb, there is poor correlation between the visual appearance of the product and its eating quality.

This market information enabled both industry and science to set clear goals for genetic improvement, an essential input to the LAMBPLAN program.

Market Development Programs

Trim Lamb Program

The Trim Lamb Program was a promotional campaign driven by the Australian Meat and Livestock Council. It was targeted at Australian butchers and retailers, designed to get lamb product into the consumer market place that the previous consumer market research had indicated would be more saleable. The first Trim Lamb campaign was launched in 1991 to promote new boneless, fat free lamb cuts. A second Trim Lamb Program was launched in 1995. While this had the same promotional objectives as the first Trim Lamb Program, it was very much focused on major supermarkets with a view to better integrating the supply chain for the new cuts.

Fresh Australian Range Lamb Program

In 1990, the Australian Meat and Livestock Council also launched the Fresh Australian Range Lamb campaign in the United States. This was the first major promotion of specified product to the United States market and since that time, Fresh Australian Range Lamb has become one of the main premium lamb brands in the United States.

Over-the-Hooks Selling

In the late 1980s approximately 35 percent of all sheep and lambs were sold by producers in the paddock and approximately 65 percent were sold by producers at auction. Almost no lamb or sheep were sold by producers ‘over-the-hooks’. Since that time there has been a steady decline in the percentage of lamb and sheep sold in the

paddock to less than 20 percent today and a dramatic increase in 'over-the-hooks' sales to over 30 percent of all lamb and sheep sold by producers. Furthermore, while the reduction in auction sales has not been as dramatic as the reduction in paddock sales, it has also declined in popularity as a selling method.[71]

The emergence of 'over-the-hooks' selling as a standard industry practice has aided the adoption of LAMBPLAN because the price of the carcase varies in accordance with how well the animal meets specifications, providing a more direct link between genetic improvement and financial reward as well as immediate feedback on progress toward breeding targets.

Industry Development Initiatives

Because the Australian lamb industry has been in a state of development throughout most of LAMBPLAN's life, there have been a number of deliberate initiatives in both R&D and industry coordination that will have had some impact on the adoption of LAMBPLAN.

Industry, Scientist and Extension Conferences

The first national conference of industry participants, scientists and extension officers was held in 1983. This conference was in part motivated by market information from the consumer market research that was undertaken in the late 1970s and was designed to investigate the innovation that would be required for the Australian lamb industry (total supply chain) if it was to meet the consumer needs identified in the market research.

As the Australian prime lamb industry expanded, so did conference activity focused on the industry. The National Lamb Industry Convention is an initiative supported by the Meat Sheep Council of Australia, various state farmer organizations, state DPIs, the Australian Meat Council and MLA. The first National Lamb Industry Convention was held in Melbourne in 1997, with subsequent conventions in Sydney in 1999 and Adelaide in 2001. There is to be an additional Convention in Spring 2007.

Prime Lamb Program (Elite Lamb)

The Prime Lamb Program, or Elite Lamb as it became known, was a program that operated from 1988 to the early 1990s to promote the production of large lean lambs

[71] ABARE (2004), *Prime Lamb Industry: Production and Sale of Sheep and Lambs,* Meat and Livestock Australia.

(animals in excess of 21 kilograms and a fat score of 2-3). LAMBPLAN was closely aligned to Elite Lamb, but did not become part of the program until the mid 1990s.

Lamb Industry Strategic Plan

The Lamb Industry Strategic Plan (LISP) was developed in 1994 and was the first deliberate effort by industry to coordinate production, marketing and R&D at a national level to achieve set production goals based on market requirements. Its development followed a workshop intimately involving all industry stakeholders including State DPIs, Meat Research Council and Australian Meat and Livestock Corporation (later to become MLA), commercial producers and the various breed societies.

Formation of Meat and Livestock Australia

Meat and Livestock Australia was formed in 1998 as the successor of the Meat Research Corporation and has become the preeminent market development and research and development industry body for the Australian meat sheep industry. Key people involved in the development and early promotion and delivery of LAMBPLAN transferred to MLA to head-up the significant MLA LAMBPLAN program.

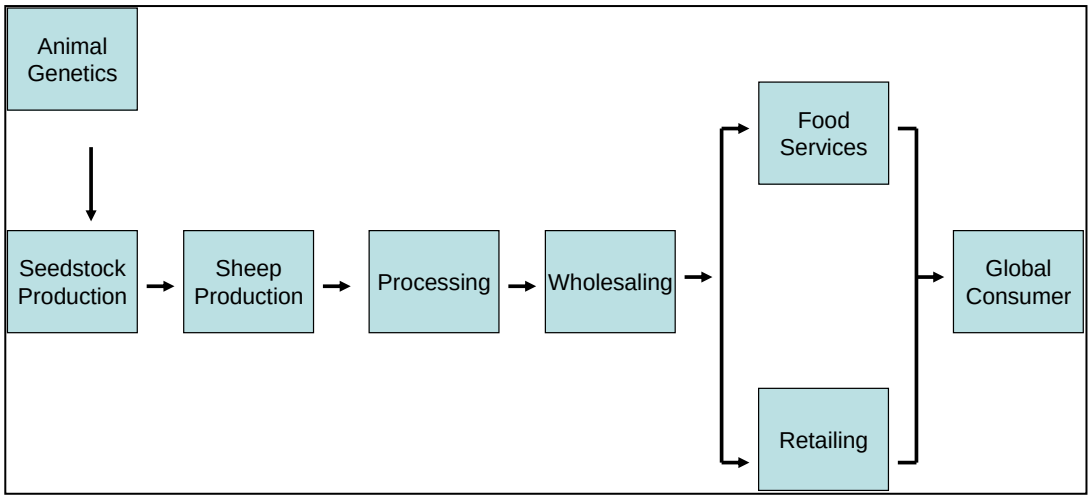
Sheep Industry Strategic Plan

The sheep industry Strategic Plan was developed and implemented in 1998 by the Sheep Meats Council following the establishment of MLA as the successor to the Australian Meat Research Council as the main sheep industry market development and research and development funding body. The objective of the Sheep Industry Strategic Plan was to coordinate activities in all major sectors of the Australian mutton and lamb industries to achieve the following goals by 2005:

- To improve market access
- To provide consumers with innovative modern food products
- To grow market share, specifically in global retailing and food service sectors
- To bring about further industry cultural change
- To continue the development of relevant industry alliances
- To enhance quality assurance and food safety management practices
- To ensure consistent product supply and product quality

- To achieve greater industry accountabilities
- To realize profitable, efficient and sustainable producer enterprise

The following Figure 55 is flow chart of impact of specific initiatives on supply chain sectors outlined in the Sheep Industry Strategic Plan, demonstrating that genetics was a major focus of the strategy.



Meat Industry Strategic Plan

What was this and where can I get info on it?

PrimeTime

Launched in 2002, PrimeTime was a broad industry promotional campaign that focused producers on improving genetics, nutrition and management practices for prime lamb production. Over 5,000 producers and breeders attended PrimeTime workshops and functions. The PrimeTime campaign was staged over three years as follows:

- The first year's activities targeted sheep and lamb producers located in the Sheep Wheat Zone with a view to shifting focus away from cropping back to sheep production;
- The second year's activities, focused on Merino producers, promoting the future opportunities for prime lamb production; and

- The third year's activities targeted prime lamb producers with a view to changing their focus from increasing the number of lambs produced, to improving yield and leanness.

PrimeTime was the main vehicle through which the sheep industry was made aware of how improved genetics, nutrition and farm management practices could be adopted to reach the market objectives identified by the consumer market research. Genetics formed a major part of PrimeTime and key LAMBPLAN executives played a major role in delivering the genetics content of the PrimeTime campaign.

LAMBPLAN R&D Programs

From an adoption perspective, the two major LAMBPLAN specific R&D projects have been the Terminal and Maternal Sire Central Progeny Tests. A number of breeders who use LAMBPLAN, cited these tests as giving them confidence in the accuracy of the system[72]. Additionally, adoption levels typically increased steadily in the terminal and maternal breeding sectors throughout the duration of the Central Progeny Tests.

Terminal Sire Central Progeny Tests

The Terminal Sire Central Progeny Tests were undertaken from 1988 to 1991 at Rutherglen in Victoria, Struan in South Australian and Glen Innes in New South Wales. A progeny test is a form of pedigree selection based on estimating the breeding value of an animal by measuring the performance phenotype of its progeny. The purpose of the Terminal Sire Central Progeny Tests were to demonstrate that there were sires available with the genetics to produce larger leaner lambs. The program generated the additional benefit of strong genetic linkages between flocks and breeds, which assisted with the development of Across Flock Terminal Sire LAMPLAN products.

Maternal Sire Central Progeny Tests

The Maternal Sire Central Progeny Tests were undertaken in 1999 at Cowra in New South Wales, Struan in South Australia and Rutherglen in Victoria. The Maternal Sire Central Progeny Tests focused on maternal genetics and was run by the New South Wales Department of Agriculture, Department of Primary Industries Victoria and the

[72] Interviews

South Australian Research and Development Institute with support from MLA and the Australian Sheep Industry CRC. Through assessing ninety high performance maternal sires, the project provided information on the potential of genetics to improve maternal traits.

At an operational level crossbred ewes by different sires can have a very large difference in performance and profitability. The Maternal Sire Central Progeny Tests demonstrated that the sire of the crossbred ewe has a marked effect on the:

- Lambing rate of the crossbred ewe
- Growth of their second cross lambs
- Carcase merit of their second cross lambs
- Proportion of second cross lambs meeting carcase specifications
- Wool returns from the crossbred ewes
- Worm resistance of the crossbred ewes[73].

Border Leicesters were among the trait leaders for weight, muscle depth and wool weight in first cross ewes and these traits seemed to carry through for second cross lambs. The resulting evidence of accuracy may have contributed to the subsequent higher levels of adoption of LAMBPLAN among the maternal sire breeding industry, as demonstrated by the high level of adoption in the Border Leicester breeding sector. Although in the case of Border Leicesters, the SuperBorder PIRD was most likely the primary driver of adoption.

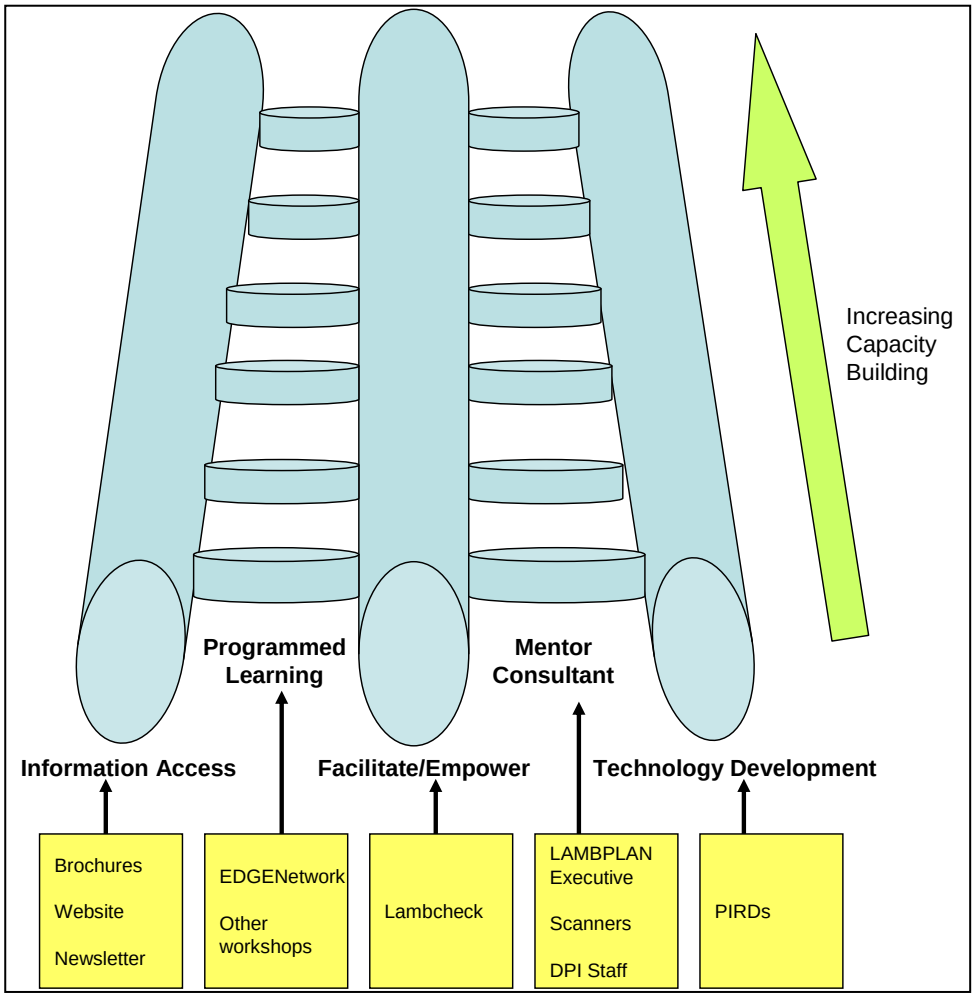
Merino Validation Project

The Merino Validation Project was undertaken during 2003 to validate the genetic links for meat, scrotal circumference and foecal egg count in Merino breeds as a preliminary activity associated with SGA.

[73] Fogarty, N. (2003), *Project Paper – Maternal Sire Central Progeny Test (MCPT) and Implications for Border Leicester Breeders,* Australian Sheep CRC

LAMBPLAN Extension and Promotion Initiatives

We can examine the primary mechanisms through which LAMBPLAN has been promoted the lamb industry and through which knowledge transfer with respect to using LAMBPLAN effectively has been transferred to breeders and producers by examining specific initiatives in the context of the Capacity Building Ladder model. This model is promoted as best-practice by the Cooperative Venture for delivering extension for innovations in Rural Industries[74]. The model proposes that effective extension is an ongoing process based on initiatives that are collectively designed to motivate the target market to use new innovations and empower them with the skills to use those innovations effectively. This is demonstrated in Figure 56 below[75].



[74] Interview with MLA Manager of Communications and Research Adoption Livestock Production Innovation
[75] Rural Industries Research and Development Corporation

Information Access Initiatives

Basic information on LAMBPLAN and the various products that comprise it has been provided through a website, several publications and newsletter.

LAMPLAN Website

The website (www.sheepgenetics.org.au/lambplan/) provides basic information on LAMBPLAN, how to use LAMBPLAN, how to use LAMBPLAN information to make breeding and production decisions, links to LAMBPLAN registered breeders, breed societies and breeding groups, breed reports and individual sire and breeder reference searching capability. It is a source of information on using LAMBPLAN as well as an operational tool, allowing producers and breeders to research an animal before making a purchase decision.

Brochures and Publications

Besides basic brochures on LAMBPLAN, a publication called the Lamb Guide, which has a detailed section on LAMBPLAN is available to members free of charge and at a small cost to non-members. Over 18,000 copies of this booklet have been distributed[76].

LAMBPLAN Newsletter

When LAMBPLAN was first launched in 1987 the LAMBPLAN newsletter was distributed approximately quarterly to all LAMBPLAN registered breeders. In 1999, it began a monthly circulation. The Newsletter provides industry stories and editorials relating to LAMBPLAN and genetics as well as updates on developments in the LAMBPLAN product.

[76] Interview, MLA Manager – Communication and Research Adoption, Livestock Production Innovation

Programmed Learning

EDGENetwork

The EDGENetwork was established by MLA and DPI-VIC in 1996. It provides as series of fifty practical workshops, farm walks, facilitated discussion group forums and individually tailored projects designed to assist participants in developing and implementing an effective livestock enterprise business plan. Participants can either undertake the entire program or select modules that they believe are most suited to their specific needs. Broadly speaking, EDGENetwork topics cover marketing, finance, human resources, natural resource management, pasture and livestock management and quality management. Over 10,000 primary producers have participated in an EDGENetwork activity since 2001[77]

The Network is established in a region-by-region basis across Australia, with workshop content tailored for local needs. The workshop programs serves as the primary channel through which knowledge and information created by MLA funded research relating to better livestock enterprise management is made available to industry.

The EDGENetwork also has a national data centre that allows participants to confidentially record, share and access information so that participants can compare their individual enterprise performance with other enterprises on the Network. Benchmarking on local, regional and national levels provides useful comparison information to producers and breeders on livestock and pasture production, marketing processes and labour management.

Broadly speaking the livestock management and quality management workshops raise awareness as to the role that LAMBPLAN can play in a livestock and quality management plan. However, specifically, the EDGENetwork workshop on Effective Breeding served to educate participants on how LAMBPLAN can be used to improve genetics for lamb production and reproduction efficiency. Over 1,200 breeders and producers attended the effective breeding workshop in the four and a half years leading up until 2001[78] when it was suspended for review and updating.

[77] Interview, MLA Manager – Communication and Research Adoption, Livestock Production Innovation
[78] Interview, MLA Manager – Communication and Research Adoption, Livestock Production Innovation

Other Workshops

Other workshops that create awareness of and provide some usage knowledge on LAMBPLAN have been run by MLA in conjunction with the various State DPIs include:

- Money Making Merinos, which has been attended by 107 producers over the last two and a half years;
- Money Making Mums, which has been attended by 148 producers over the last two and a half years; and
- Wean More Lambs, which has been attended by 486 producers over the last two years[79].

It is interesting to note the higher attendance at the Wean More Lambs workshops, indicating a general greater producer interest in producing more lambs.

Facilitation and Empowerment

LambCheck

LambCheck is a three year course run by the VIC-DPI that involves some mandatory workshops covering topics necessary for improving lamb producing enterprises followed by a facilitated 'self-help' group. LAMBPLAN is generally promoted as a tool to improve genetics in this program and is a forum where producers can discuss their experiences with LAMBPLAN.

Mentoring

There is a consistent view across all stakeholders in the industry, that the strong personalized service that characterized LAMBPLAN throughout its development as an industry tool has been critical to its successful adoption by industry.

LAMBPLAN Team

Most breeders that both use and do not use LAMBPLAN cite in particular, Dr Robert Banks and Dr Alex Ball as being effective promoters of LAMBPLAN throughout their involvement in the program. Importantly, the breeders interviewed that use LAMBPLAN all have cited that easy access to the expertise of these individuals with respect to using

[79] Interview, MLA Manager – Communication and Research Adoption, Livestock Production Innovation

LAMBPLAN in their operations has been an important factor in having the confidence to use the service.[80]

DPI Staff – Product Development Officers

Prior to LAMBPLAN being launched and during its initial years, the various DPIs provided staff (Product Development Officers) to work with participants in the lamb industry in their respective states and support their use of LAMBPLAN.

In particular, the various State-DPIs did a lot of work to develop producer – processor relationships based on:

- Specified processor carcase requirements;
- Producers using genetic management to meet those requirements;
- Tools for accurate measurement of carcase specifications (such as VIAscan); and
- Price ratchets (grids) for carcases that perform well against the processors specifications.

As a result, a number of processors around the nation have adopted technologies such as VIAscan, set a specifications grid, developed producer relationships to help them meet those specifications by providing immediate and accurate carcase feedback and offered considerable price ratchets (up to 35 percent on the sale-yard price) for high performing carcases. This has provided producers with immediate economic benefit from using LAMBPLAN rams and placed high performing LAMBPLAN rams in high demand.

Technology Development

Producer Initiated Research and Development Schemes

Producer Initiated Research and Development Schemes (PIRDS) are producer managed 'R&D' programs based on new science being introduced to the industry by MLA. They serve as a useful channel to get early adopters using and developing an innovation for commercial needs. The basic concept revolves around a group of aligned producers, supported by MLA, using and adapting a new innovation into a commercially valuable product. Notable LAMBPLAN related PIRDS include SuperWhites, YoungSires, MeatElite and the SuperBorders programs.

[80] Interviews

The SuperBorder Program emerged from a PIRD based on the LAMBPLAN program that was designed to set a benchmark for the Border-Dollars LAMBPLAN Index with a goal to remove animals that performed poorly with respect to number of lambs weaned and leanness. Under the SuperBorder Program, animals that can demonstrate a Border-Dollars Index above the set benchmark are branded and tagged as 'SuperBorders'. Currently the SuperBorder program has 24 stud members based on a $500 joining fee and $5 per animal tagged.

LAMBPLAN Product Developments

The LAMBPLAN product and service mix has undergone considerable development over the life of the program.

Early LAMBPLAN Product

When LAMBPLAN was launched in 1987-88 it was a relatively simple product. All evaluations were within flock and within year and the only pedigree information was sire pedigree information (i.e. 50 percent of the genetics of progeny). EBVs were only available for weight and fat at one age and there were three simple Indexes available allowing selection emphasis on growth rate, leanness or an equal combination of both.

In 1993, the first EBVs were made available for maternal traits and Indexes were released for each maternal breed. In 1994, the first eye-muscle scans were taken in a commercial setting, providing accurate measurement of eye-muscle depth.

From the period 1987 to 1995, LAMBPLAN was provided to members free of charge, albeit a nominal fee was required for scanning services that were then provided by the State DPIs.

Across Flock LAMBPLAN and the Introduction of Charges

In 1996, Across Flock LAMBPLAN was introduced and in 1997, LAMBPLAN moved totally to Across Flock comparisons. This has been a major objection from antagonists of the LAMBPLAN program and a product development that some breeders have cited as a major reason for their decision to cease using LAMBPLAN. The major reason for this objection is an argument that animals that are grazed in different climatic and agronomic conditions cannot be compared.

In 1997, a national pricing regime for LAMBPLAN was introduced comprised of the charges demonstrated in Table 7 below. The period 1997 to 2001, represented a period of experimentation with different pricing models.

Charge	Rate
Joining Fee	$100
Membership Fee	$225
Processing Fee	$1.20 per sheep
Scanning Fee	$3.00 - $3.50 per sheep

In 1998, the national fee regime for LAMBPLAN was modified such that there was a significant reduction in the membership fee and a charge for a genetic information package. This is demonstrated in scheduled in Table 8 below and represented a pricing package that directly linked charges to value adding services and products.

Charge	Rate
Joining Fee	$100
Membership Fee	$60
Genetic Information Package	$165
Processing Fee	$1.20 per sheep
Scanning Fee	$3.00 - $3.50 per sheep

The concept of value-linked pricing was further developed in 1999, when discounts were offered for Genetic Information Packs relating to additional breeding flocks operated by the breeder. A discount of $130 was offered on the Genetic Information Pack for the second breeding flock and a discount of $140 on the third. This was designed to be an incentive for large breeding operations to include more animals in their LAMBPLAN program.

In 2000, an evaluation of the LAMBPLAN product and charges was undertaken.[81] Subsequent to this evaluation there was a major change to the national pricing regime, although these changes were short-lived. The subscription and Genetic Information Package service were combined as a per sheep charge, with significant discounts for second and third flock sheep. This was designed to decrease the entry cost and risk, such that a new potential LAMBPLAN user could cost effectively experiment by trying LAMBPLAN on a small number of animals and to encourage large established LAMBPLAN users to register more sheep with LAMBPLAN. Nominal charges were also imposed for ancillary LAMBPLAN products and services. The post 2000 pricing schedule is demonstrated in Table 9 below.

[81] Welsman, S. (2000), *LAMBPLAN: Products and Pricing Evaluation,* Meat and Livestock Australia.

Charge	Rate
Joining Fee	$100
Subscription Fee & Genetic Information Service (1st Stud)	$18.75 per sheep
Subscription Fee & Genetic Information Service (2nd Stud)	$2.90 per sheep
Subscription Fee & Genetic Information Service (3rd Stud)	$2.10 per sheep
Processing Fee	$1.20 per sheep
Scanning Fee	$3.00 - $3.50 per sheep
Breeder Directory	$10.00
Lambing Data Entry Books	$20.00
Previous Newsletters	$5.00

Introduction of Across Breed and Differentiated Product and Service Packages

Following the development of a new business plan for LAMBPLAN in 2001, LAMBPLAN introduced across breed evaluation of Terminal Sires. Additionally, the LAMBPLAN product was split into a simple service, known as LAMBPLAN Standard, a premium service known as LAMBPLAN Plus and a Merino sector specific service known as LAMBPLAN Merino. This allowed, LAMBPLAN to target different adopter segments of the market with products and service more tailored to their specific needs. The LAMBPLAN Plus product is used mostly by the large, more sophisticated commercial breeders and commands a considerable price premium to the Standard and Merino packages. The charging schedules for the different LAMBPLAN products is detailed in Table 10 below.

Charge	Rate
LAMBPLAN STANDARD	
Subscription Fee and Genetic Information Pack (1st Stud)	$165
Subscription Fee and Genetic Information Pack (2nd Stud)	$99
Subscription Fee and Genetic Information Pack (3rd Stud)	$33
LAMBPLAN MERINO	
Subscription Fee and Genetic Information Pack (1st Stud)	$165
Subscription Fee and Genetic Information Pack (2nd Stud)	$99
Subscription Fee and Genetic Information Pack (3rd Stud)	$33
LAMBPLAN PLUS	
Subscription Fee and Genetic Information Pack (1st Stud)	$357.50
Subscription Fee and Genetic Information Pack (2nd Stud)	$214.50
Subscription Fee and Genetic Information Pack (3rd Stud)	$71.50
Standard Additional Charges for All Services	
LAMBPLAN Processing Fee	$2.20 per sheep
MERINO Processing Fee	$1.32 per sheep
(all additional charges capped at $2,750 per stud)	

Merino Genetic Services

In 2002 Merino Genetic Services was launched as a new LAMBPLAN product based on the earlier Merino LAMPLAN.

Future Product Development

As discussed in the Chapter describing LAMPLAN, the future of LAMBPLAN is as part of a genetics management program serving the entire sheep industry, Sheep Genetics Australia (SGA). Concerns have been expressed by some interviewees, particularly those breeders operating in the maternal sector, that driving adoption of SGA among the more conservative merino industry will be considerably more challenging than has been the historic case with LAMBPLAN and the meat sheep industry. LAMBPLAN has evolved with the developing prime lamb industry. Whereas the merino industry is a mature

industry that is in decline. The concern exists because there is a view that, in turn, this will detract resources away from developing additional products for the meat sheep industry, particularly, the smaller maternal sire sector[82].

[82] Interviews

Chapter 7: Analysis of the Meat Sheep Breeding Industry's Adoption of LAMBPLAN

The purpose of this section is to systhesise the information collated in the previous chapters with information acquired from the interviews using contemporary best-practice models and frameworks for analyzing the adoption of new innovations. This is to be done in order to determine the impact that specific factors may have had on the adoption of LAMBPLAN and the analysis will be approached from three perspectives:

- An analysis of the potential impact on adoption of specific macro events, industry initiatives, events in the evolution of the LAMBPLAN product and industry marketing initiatives;
- An analysis of the probable pathway to broad industry adoption; and
- An analysis of factors that are likely to have influenced the decision by breeders to adopt or reject LAMBPLAN at different stages of the adoption decision process.

From this analysis lessons can be learned for both developing strategies designed to drive adoption for future MLA innovations and predicting the level of adoption that those innovations are likely to achieve.

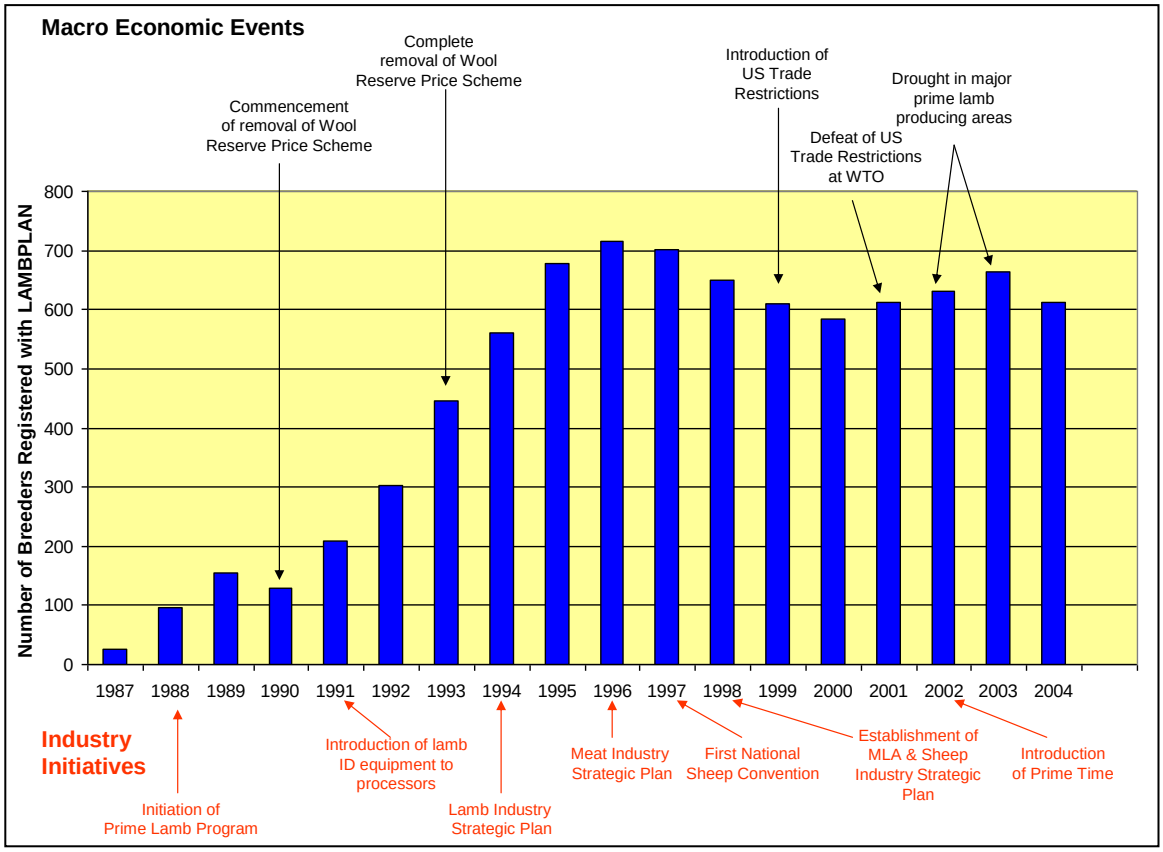
Impact on Adoption of Specific Macro Events, Industry Initiatives, Event in the Evolution of the LAMBPLAN Product and Industry Marketing Initiatives

Specific macro economic, industry initiatives, product developments and industry marketing initiatives discussed in earlier sections of this report have had, to varying degrees, an impact on the adoption of LAMBPLAN. The extent of the impact of any specific event is difficult to determine because of the large number, and the close timing a many events. However, it would seem relatively clear that only factors that affect the perceived relative advantage and compatability of the innovation (see later section on LAMBPLAN adoption decision process) have had significant and relatively sustained impact on the adoption of LAMBPLAN. This

should not detract from the importance of the role other less potent factors discussed in this section have played in supporting the adoption of LAMBPLAN.

Macro Economic Events and Industry Initiatives

Figure 57 below demonstrates the uptake of LAMBPLAN by meat sheep breeders against the timing of specific macro economic events and industry initiatives.



Macro Economic Events

As discussed in Chapter 5 of this report, the announcement by the Federal Government that the Wool Reserve Price Scheme was to be abolished caused general destabilisation in the sheep industry. While some sheep farmers changed from a wool focus to a meat sheep focus, many left the industry altogether. Furthermore, the uncertainty created by this event resulted in reluctance to invest in new technologies. This is reflected in a short term decline in adoption of LAMBPLAN in 1990. Additionally, the decline in adoption by

meat sheep breeders resulting from this event also resulted in decline in the number of ram lambs produced by breeders registered with LAMBPLAN. However, once the abolition of the Wool Reserve Price Scheme was announced, the lamb industry quickly re-stabilised and the adoption of LAMBPLAN continued to grow through the early 1990s, partially as a result of the new focus by sheep industry participants on lamb production and the fact that LAMBPLAN represented a tool that some believed would help them better assess the merits of an animal in unfamiliar assessment territory.

The introduction of US trade restriction on Australian lamb occurred toward the end of a period where there was both a decline in uptake of LAMBPLAN and a plateauing of the number of ram lambs produced by LAMBPLAN registered breeders. Interestingly, in the year the US trade restrictions were defeated a trend toward increased adoption began as did a trend toward increasing numbers of lamb rams produced by LAMBPLAN registered breeders. This supports the notion put forward by a number of interviewees that the US trade restrictions both raised the profile of Australian lamb in international and domestic markets and motivated the development of innovative meat cuts.

The final major macro economic event that has impacted the adoption of LAMBPLAN was the 2002-03 drought, resulting in both a reduction in the number of breeders registered with LAMBPLAN in 2004 and the number of ram lambs produced by LAMBPLAN registered breeders in 2004. This is not suprising, given the broad impact this drought had on most Australian agriculture. As with the abolition of the Wool Reserve Price Scheme, sheep industry participants are less likely to invest in technologies in an environment of uncertainty.

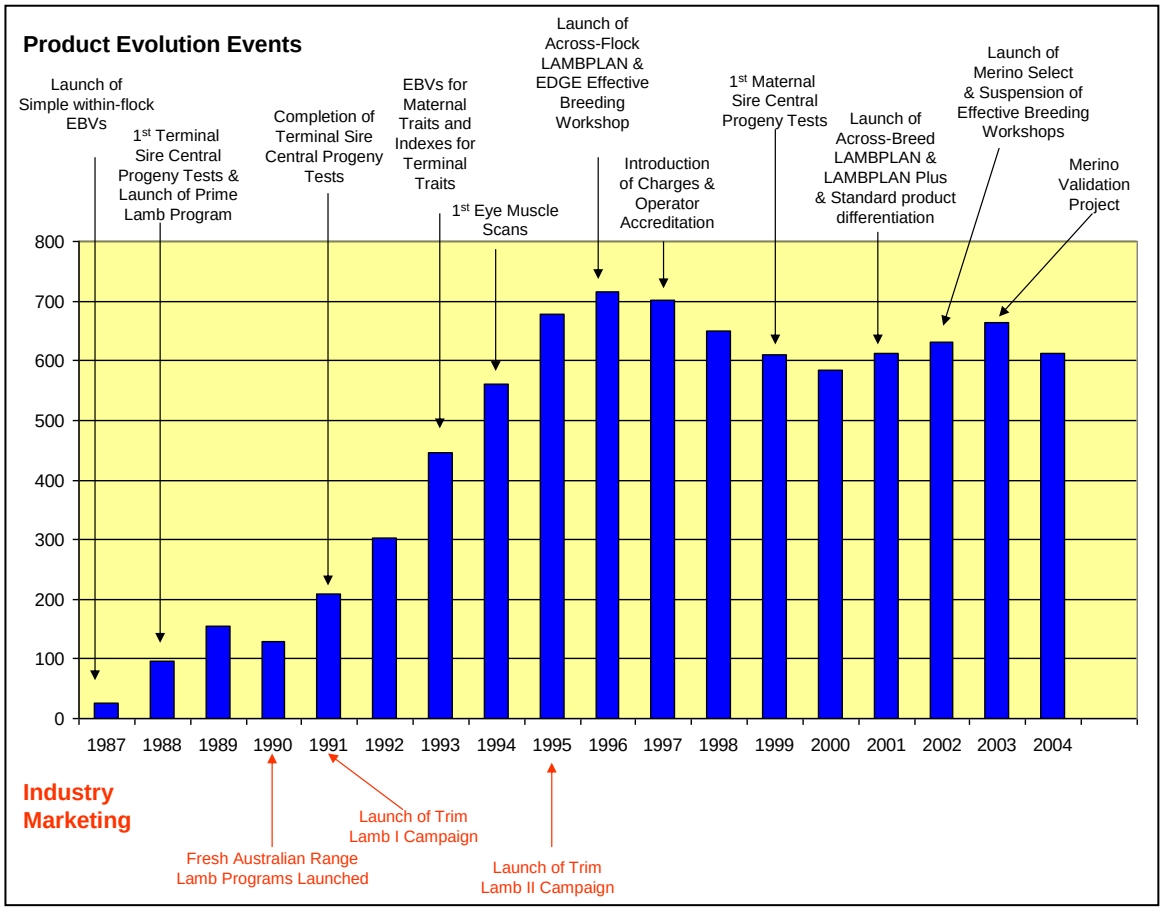
Industry Initiatives

The industry initiatives discussed in this report are unlikely to have had as significant direct impact on the adoption of LAMBPLAN as some of the other factors discussed. Most certainly the Prime Lamb Program will have raised awareness among Innovators and Early Adopters as to the important role that genetics must play in order for the industry to reach its objectives. The introduction of lamb ID equipment to processors facilitated the establishment of more effective supply chains and mechanisms for producers to receive premiums for high performing carcases, creating the necessary ‘pull through’ demand for LAMBPLAN. The Lamb Industry Strategic Plan has been cited as having been an important process in steering all industry participants and stakeholders toward relatively common goals in R&D and production and this

coordination was further promoted by the National Sheep Conventions. It is difficult to determine if Prime Time has had any direct impact due to it being a relatively recent phenomenon and the fact that it was launched in the middle of an upward trend in the adoption of LAMBPLAN.

Events in Product Evolution and Industry Marketing Initiatives

Figure 58 below demonstrates the uptake of LAMBPLAN by the meat sheep breeding sector against specific events in the evolution of the LAMBPLAN product and specific industry marketing initiatives.



Product Evolution Events

As discussed in Chapter 1, when LAMBPLAN was launched in 1987, it was a very simple within flock product offering a few basic EBVs. The initial adopters of this product were breeders who were involved in the related R&D projects that had been undertaken by the various State DPIs. While there was considerable growth in adoption over the next few years (over 100% per annum), adoption seems to have been volatile until the

completion of the Terminal Sire Central Progeny Tests in 1991, at least partially due to the upsetting influence of the abolition of the Wool Reserve Price Scheme in 1990.

The Terminal Sire Central Progeny Tests were a significant event in the adoption history of LAMBPLAN, as they provided the evidence that the correct use of LAMBPLAN can fundamentally improve the accuracy of stock selection and thus the ability of breeders and producers to meet breeding goals. Adoption of LAMBPLAN grew dramatically in the following five years as did the number of ram lambs produced by LAMBPLAN registered breeders.

The impact of Indexes for terminal traits and EBVs for maternal traits in 1993 and the introduction of commercial eye-muscle scanning 1994 are difficult to determine because there was no change in the rate of adoption following those events and most interviewees did not cite these events as being significant. However, most certainly these developments would have helped drive adoption as they tailored the product to different felt needs of different adopter segments.

The next major product development event to impact on the adoption of LAMBPLAN was the introduction of Across-Flock LAMBPLAN. This event resulted in discontinuance by some breeders and discouraged breeders that might have otherwise adopted LAMBPLAN from doing so. Some breeders who were using LAMBPLAN up to this point were of the view that animals in different climates and agronomic conditions cannot be compared using EBVs and therefore stopped using LAMBPLAN and in some cases, took-up other scanning services that do not provide information on the genetic merit of animals[83]. The introduction of Across-Flock LAMBPLAN also created the perception among some potential LAMBPLAN adopters that if they registered their animals with the program, those animals would initially have poor performing data and thus LAMBPLAN registration would be a hindrance to their marketing efforts[84]. The introduction of Across-Flock LAMBPLAN resulted in four years of declining adoption of LAMBPLAN and a substantial slowing of the rate of growth of the number of ram lambs produced by LAMBPLAN registered breeders. However, it may well be that the introduction of Across-Flock LAMBPLAN was necessary for the program to achieve the optimal outcomes for industry.

[83] Interviews
[84] Interviews

The significant impact of the introduction of Across-Flock LAMBLAN makes the impact of the EDGENetwork effective breeding workshops difficult to determine. As discussed below, such programs are limited as to the extent of impact they can have on adoption. However, by transferring some knowledge relating to the use of LAMBPLAN and its operating principles, they may have prevented further discontinuance and provided some potential adopters who were concerned about the Across-Flock product with the confidence to adopt, thus reducing the negative impact of Across-Flock LAMBPLAN to some degree.

The introduction of a charge for LAMBPLAN in 1997 is unlikely to have had a major impact on the rate of adoption of LAMBPLAN, with all interviewees citing LAMBPLAN as representing value for money and those who discontinued LAMBPLAN adopting basic scanning services at a comparable cost. Although it is possible that the introduction of charges for LAMBPLAN may have been an issue that compounded discontent with Across-Flock LAMBPLAN for some breeders who discontinued use during this period.

Due to the relative small size of the maternal sire breeding sector, the commencement of the Maternal Sire Central Progeny Tests have not had a positive impact on the adoption of LAMBPLAN overall. There was a slight increase in the total number of maternal sire breeders registered with LAMBPLAN in the year subsequent to the tests, followed by a significant decline in the total number of maternal sire breeders registered with LAMBPLAN. However, in the case of the largest maternal sire breeding sector, the Border Leicester sector, there has been a strong rate of growth in both the percentage of Border Leicester breeders registered with LAMBPLAN and the percentage of ram lambs produced by LAMBPLAN registered Border Leicester breeders in the years subsequent to the commencement of the Maternal Sire Central Progeny Tests, demonstrating a similar effect on adoption in the Border Leicester sector as the Terminal Sire Central Progeny Tests had on adoption in the Terminal Sire sector.

Interestingly, the introduction of Across-Breed LAMBPLAN has not had a detrimental effect on the adoption LAMBPLAN, as was the case with the introduction of Across-Flock LAMBPLAN. This is because, LAMBPLAN users in 2001, were used to comparison of animals from different climatic and agronomic environments, so acceptance of Across-Breed comparisons required only a relatively incremental change in mind set.

It is unclear whether the introduction of product and service differentiation in LAMBPLAN Plus or Standard had any impact on adoption. Although, as discussed later it most

certainly allows for low risk product trialling of LAMBPLAN and may meet the felt-needs of certain adopter segments.

It would seem that the launch of Merino Select in 2002 and the Merino Validation Project in 2003 did not have any significant impact in terms of the number of Merino or Poll Merino breeders registered with LAMBPLAN or the number of Merino or Poll Merino ram lambs produced by Merino breeders. Any potential positive impact of these events on these sectors would have been significantly overshadowed by the dramatic impact that the 2002-03 drought had on the already suffering wool industry.

Industry Marketing

As with industry development initiatives, industry marketing initiatives can have an indirect impact of adoption. As discussed in Chapter 6, the Australian lamb industry undertook several initiatives to promote Australian lamb in both the domestic and overseas markets during the early to mid 1990s. In particular, the Fresh Australian Range Lamb Campaign in the United States and the first phase of the Trim Lamb campaign in the domestic market, created demand for Australian lamb and raised awareness among producers and breeders of the potential for Australian lamb. As such these events will have been an indirect factor in encouraging the adoption of LAMBPLAN. The effect of the second phase of the Trim Lamb Campaign is difficult to determine because of the dramatic impact that the introduction of Across-Flock LAMPLAN had on the adoption of LAMBPLAN in the year immediately following the its launch.

Summary

In summation the major events that have had a significant and relatively sustained impact on the adoption of LAMBPLAN have been:

- Terminal Sire Central Progeny Tests provided the basis for evidence based marketing of LAMBPLAN;
- Abolition of the Wool Reserve Pricing Scheme, while initially having a destablising effect on the entire Australian sheep industry, forced some industry participants to change focus into the unfamiliar territory of lamb production, where traditional animal assessment techniques are challenged and where clear production goals needed to be reached, rendering LAMBPLAN a highly relevant tool;

- Promotion of Australian lamb in overseas and domestic markets by industry which created both confidence that there would be demand for Australian lamb and the realisation of that demand, including higher prices for lamb;
- The launch of Across-Flock LAMBPLAN which resulted in a decline in adoption of LAMBPLAN;
- US trade restrictions on Australian lamb, which resulted in increased profile for Australian lamb in domestic and global markets and which when defeated, contributed to a return to growth in adoption of LAMBPLAN; and
- The 2002-03 drought which had a negative impact on most sectors of the Australian agricultural industry.

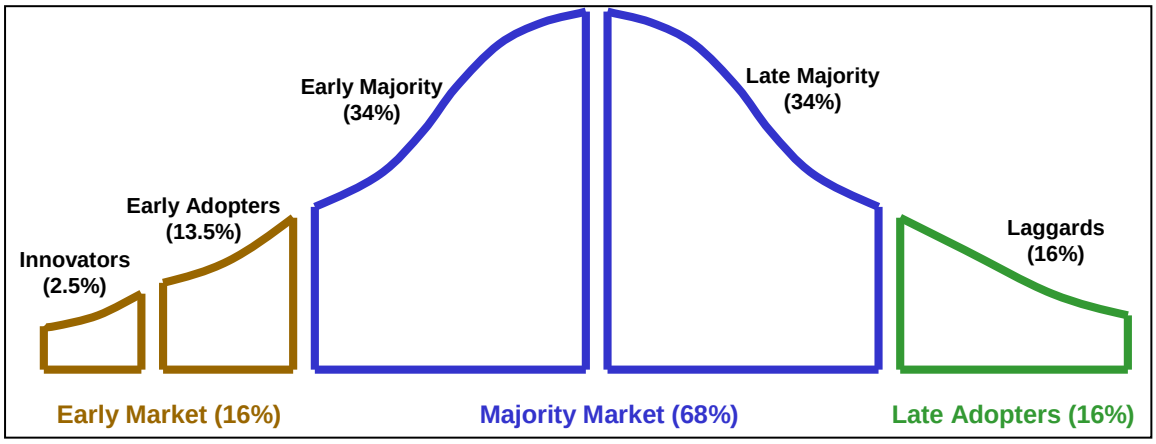
It is also worth noting that the Maternal Sire Central Progeny Tests have had a positive impact on adoption in the Border Leicester sector, although this is not reflected in the gross LAMBPLAN adoption figures.

The most important observation is that all of the above six events that have had a significant and relatively sustained impact on the adoption of LAMBPLAN are events that effect either the perceived relative advantage or the perceived compatability of LAMBPLAN in the LAMBPLAN adoption decision (see discussion on the LAMBPLAN Adoption Decision below).

Adoption Profiles and Pathway to Adoption

The potential market for any new innovation can be analysed as a population of potential users of the innovation, whose adoption behaviours and thus propensity to adopt a particular innovation are different, but regress toward an 'average' type of adoption behaviour with respect to the particular innovation and thus an average propensity to adopt that innovation. Considerable research has demonstrated that the market for any innovation is comprised of five different segments of adopter behaviour[85]. This is demonstrated in Figure 59 below. This investigation has not analysed a large enough population of LAMBPLAN users to clearly identify different adopter groups, but the interviews have provided some insight as to possible characteristics of adopter segments for LAMBPLAN.

[85] Rogers, E. (1995), *Diffusion of Innovations,* Free Press, New York

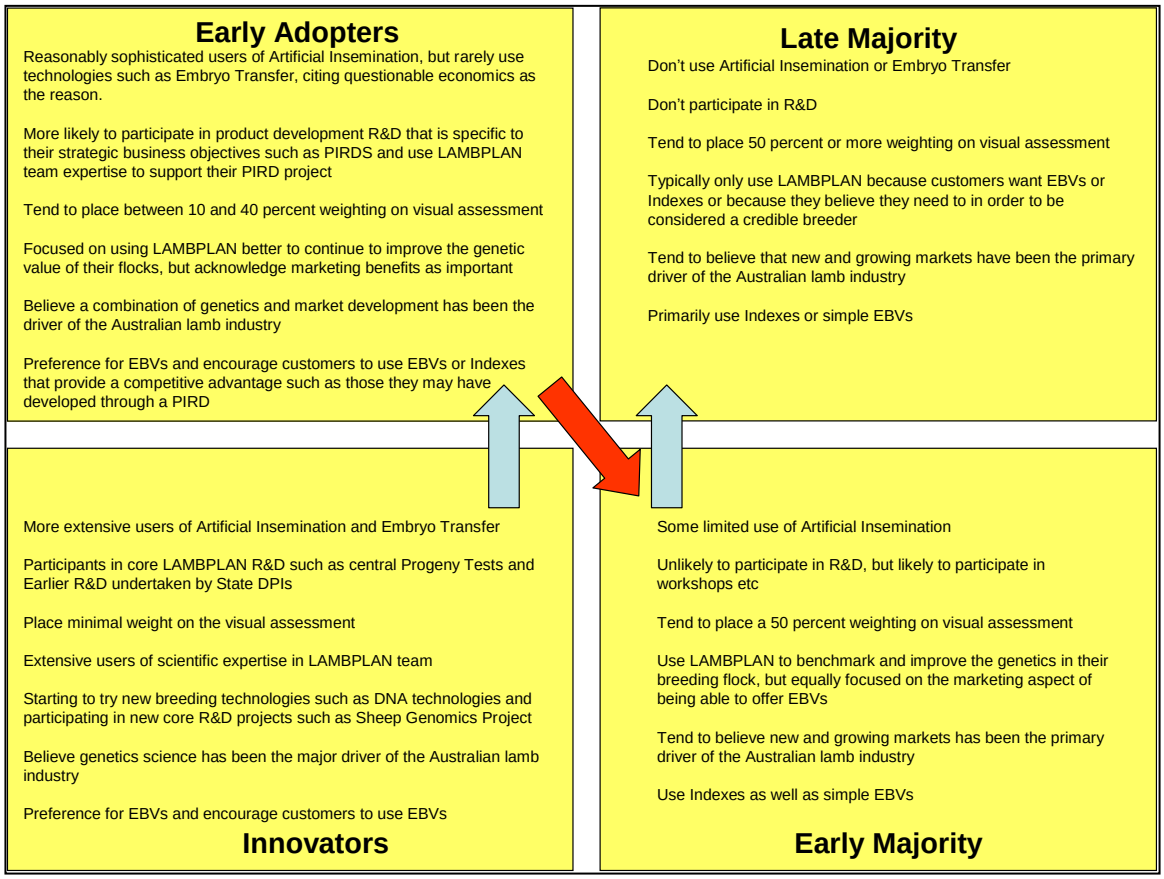


Furthermore, the progression of adoption from the Innovator, through Early Adopter, Early Majority and Late Majority market segments is neither continuous nor guaranteed for two fundamental reasons:

- While the different adopter segments might share the same broad problem for which they need a solution, the intensity to which they experience that problem and their specific felt-need for a solution to that problem is usually very different. This means that a compelling product based on the technology that will meet the felt-need of an innovator is different to that of an Early Adopter, Early Majority and Late Majority market participant. Unless the product based on the innovation is able to evolve to meet the felt-needs of these different adopter segment needs, broad market adoption is unlikely to occur.
- There is discontinuity in the adoption process because communication between the different adopter segments is not effective and later adopters don't necessarily view earlier adopters as valid reference customers in their adoption decision. This is particularly problematic between the Early Majority and Early Adopter segments. The Early Adopters at least look to the Innovators to see how they use the technology and to validate the technology in application and the Late Majority look to the Early

Majority in the sense that they want to see a product based on the technology become the 'industry standard' before they adopt. However, the Early Adopters considered themselves to be industry leaders and are trying to develop a competitive advantage based on the new innovation. As such they are unlikely to share their experiences with the majority of industry whom they believe are ineffective. Conversely, the Early Majority view Early Adopters as industry 'mavericks' and aren't really interested in their approaches to the business of the industry. This means that in most cases, Early Adopters are not valid reference customers for the Early Majority. This results in what is known as the 'Chasm', a period of decline in adoption that results from the promoter of the innovation's inability to develop an effective reference customer in the Early Majority segment by developing a product based on the innovation that meets that segment's felt-needs. In complex, multi-variable adoption environments, such as that for LAMBPLAN, the chasm can be difficult to detect.

Figure 71 below demonstrates a likely pathway to adoption and some of the adoption characteristics of the different adopter segments for LAMBPLAN as identified from the interview process.



These adopter segments are discussed further in the following subsections.

LAMBPLAN Innovators

Innovators are the first group of individuals to adopt a new innovation. They are sometimes referred to as technology enthusiasts and provided the new innovation is relevant to their business, affordable and they can afford for the innovation not to solve their problem to the degree that they expect it to, they will tend to adopt the new innovation to try it. They are a very forgiving customer as they will often tolerate a highly technical product with a lack of functionality that other adopters will not.

Most Innovator adopters of LAMBPLAN seem to have been primarily Poll Dorset breeders, although this is partly the result of the lack of competition from other terminal sire breeds in the early days of the transformation of the Australian lamb industry.

The Innovator adopters of LAMBPLAN seem to be relatively significant users of other breeding technologies. While a reasonable portion of the industry seems to use Artificial Insemination, the Innovator adopters of LAMBPLAN seem also to be relatively significant users of Embryo Transfer and to a lesser extent DNA based technologies.

This segment also seem to be more interested in LAMBPLAN R&D, with all having working knowledge of the Central Progeny Tests and some having participated in those tests as well as the earlier R&D programs conducted by DPI-NSW and DPI-VIC and the Sheep Genomics Program. They are extensive users of technical consultation with the LAMBPLAN team. LAMBPLAN Innovators are likely to also be involved in new R&D programs such as the Sheep Genomics Program.

They also seem more likely to cite genetic science as being the major driver of the past and future Australian lamb industry. Indeed, this segment seems more likely to place a weighting in excess of 80% on LAMPLAN data over visual assessment when making an animal selection decision.

The Innovators believe that EBVs are a more accurate tool and discourage the use of Indexes.

LAMBPLAN addressed the felt-need of this adoption segment by providing a technical solution to animal selection that was affordable (free of charge) together with opportunities to be involved in cutting-edge R&D programs and access to technical

speciailists. In an environment where the abolition of the Wool Reserve Price Scheme had place LAMBPLAN in a context where it offered relative advantage to industry participants switching to lamb production, this seems to have represented a compelling product proposition.

LAMBPLAN Early Adopters

Early adopters are individuals in an industry that usually run relatively innovative business models and will expose themselves to some technology risk to develop an innovative business model. They consider themselves to be industry leaders and are constantly looking to develop a competitive edge to stay at the front of the industry. They are not interested in technology per se, but are interested in technology that facilitates a new way of doing business, if that new way of business provides them with a competitive advantage. They often look to the Innovators to see technology being used and then try to work with the vendor to develop a competitive edge for themselves by using the technology.

It would seem that the Early Adopter segment for LAMBPLAN emerged in the mid to late 1990s and was comprised primarily of both White Suffolk and Texel breeders, although they may also be Poll Dorset breeders. Adopters of LAMBPLAN from these breeding sectors demonstrate a behaviour that is indicative of developing an innovative business model designed to put them at the leading-edge of industry in the sense that they have invested in new meat trade breeds at the same time as adopting an innovation that is able to help them further improve the meat performance traits of these breeds and better market the breed as a high performance lamb industry terminal sire, namely LAMBPLAN.

Another example of activities undertaken to improve competitive advantage is the strong participation of Early Adopters in PIRDs. PIRDs allow the Early Adopter to satisfy their need to under take ‘R&D’ that provides them with an exclusive competitive advantage.

Additionally the Early Adopter segments seem to be users of other sophisticated breeding technologies, but only where there is a clear business case. For example, most of the Early Adopter breeders use Artificial Insemination and Embryo Transfer as part of a strategy to create clear competitive advantage, but are yet to adopt Juvenile Embryo Transfer or DNA technologies, citing an unclear economic case as the reason. Indeed, when the Texel breed was introduced, there is some evidence that Early Adopter

breeders were identifying the best Texel rams from LAMBPLAN information and using Artificial Insemination to diffuse these genes in their already high performing flocks. This is evidence that the Early Adopters are using a range of complementary technologies in a sophisticated genetic management system designed to achieve significant genetic gains in their flock as well as market advantage, and thus competitive advantage.

They also seem more likely to cite both genetic improvement and new markets as being the major drivers of the Australian lamb industry and although they place a high importance on LAMBPLAN data in an animal selection decision, they are more likely to also require a visual assessment, albeit that they would typically not choose a strong visually performing animal if it had poor LAMBPLAN performance data. They tend to place a 60 to 90 percent weighting on LAMBPLAN data in their selection decisions.

The Early Adopters prefer to use EBVs over Indexes and often discourage their customers from using Indexes, with the exception of Indexes they may have developed through a PIRD program to provide themselves with a competitive business advantage.

LAMBPLAN was able to evolve into a product that the Early Majority could use to develop competitive advantage. The PIRDS were the main vehicle for this, allowing some Early Majority adopters to ‘reinvent’ LAMBPLAN into products and marketing tools that suited their business. Furthermore, Early Adopters were able to integrate LAMBPLAN with other breeding technologies to improve the efficiency of their breeding operations. In an environment where demand for Australian lamb was growing this ability to use LAMBPLAN to enhance existing competitive advantage and create new competitive advantage seems to have been a compelling product proposition.

LAMBPLAN Early Majority

The early majority are pragmatists and see technology risk as a way to lose money and waste time rather than develop a competitive advantage. They are not interested in technology or in developing particularly innovative business models. They see an investment in a new innovation as a way of wasting time and money. They typically only adopt a technology once it has been built into a product that is very easy to use and one which is starting to become recognized as an ‘industry-leading’ solution. They are looking to adapt their business model to stay slightly ahead of most of the industry.

The Early Majority users of LAMBPLAN seem to have emerged in the late 1990s and are much less prolific users of other technologies, particularly JIVET and DNA testing. Although some use Artificial Insemination to limited degrees.

Early Majority adopters of LAMBPLAN are unlikely to have participated in any R&D programs, including PIRDS and are most likely to have learnt about LAMBPLAN from industry promotion or attendance at workshops and seminars such as the EDGE Network or PrimeTime.

They use LAMBPLAN to benchmark and manage the genetics of their flock to some degree, but place at least an equal importance on perceived marketing benefits associated with being able to offer customers LAMBPLAN data.

Early Majority adopters of LAMBPLAN believe the growing demand for lamb has been the principle driver of the industry and tend to place a weighting of 50 percent of less on LAMBPLAN data in an animal selection decision. They are unlikely to select an animal that does not meet basic visual assessment criteria, irrespective of the animals LAMBPLAN performance data. They will use both indexes and EBVs.

The simplicity of Indexes created the perception that it would be easier to use figures to select a balanced sheep and to benchmark. This selection based on a ‘balanced’ sheep may have made the transformation from visual assessment easier, particularly if the assessment is being used in conjunction with visual assessment. Additionally, the growing demand for high performance sheep increased the marketing advantage from being able to offer LAMBPLAN data to potential buyers of rams. This seems to have been a competitive product proposition in the eyes of the Early Majority and the Indexes which facilitated assessment of a ‘balanced’ sheep may have been the product that provided a ‘beachhead’ for LAMBPLAN in the Early Majority market segment.

LAMBPLAN Late Majority

The late majority are conservative. They will typically only adopt a new innovation once it has become the ‘industry-standard’ and is incorporated in a product such that the technology is almost ‘invisible’. The Late Majority adopters of LAMBPLAN seem to have emerged in the early 2000s.

It is possible that many of the Late Majority segment of the market have adopted LAMBPLAN primarily for marketing reasons. While they probably acknowledge that

using LAMBPLAN can result in genetic gains in their flock, they are probably not using it effectively to do so. There is some evidence that as LAMBPLAN has increasingly become recognized as the industry standard for genetic measurement and as such, some breeders have started using the system simply because it allows them to better market their animals and/or because they believe that if they are to be taken seriously as a breeder they should be using LAMBPLAN. There would also seem to be a portion of Late Majority Adopters who believe they should be offering 'figures' on their animals and not necessarily LAMBPLAN EBVs. These potential Late Majority adopters are typically using services such as StockScan.

Some of the Late Majority market is perhaps being discouraged from adopting LAMBPLAN. Such breeders may be achieving reasonable show results but are of the view that if they start using LAMBPLAN now, their results will be discredited.

Late Majority adopters of LAMBPLAN seem to have only adopted LAMBPLAN once it became evident that it was becoming the industry standard and either adopted LAMBPLAN because of the marketing advantage it provides or because they believed they should be using LAMBPLAN if they are to be taken seriously as a credible breeder.

It is worth noting that many technology promoters don't commit resources to attempts to penetrate the Late Majority, either because they:

- Consider their existing penetration in the Innovator, Early Adopter and Early Majority segments adequate;
- Believe the Late Majority will either eventually follow the adoption of the Early Majority or will leave the industry; and/or
- Have other technology projects at early stages of market penetration that require their attention.

However, the Late Majority account for approximately 35 percent of the total market and therefore potentially a significant increase in sales, or in the context of MLA, considerable industry impact. In the case of LAMBPLAN, it is difficult to determine if resource should be allocated to addressing this segment of adopters more effectively because in the case of many breed sectors the current levels of adoption are accounting for disproportionately higher percentages of animals produced.

LAMBPLAN Laggards

Laggards are the last to adopt an innovation and often won't adopt the innovation at all. Often their only participation in the market for a new innovation is to try to discredit the innovation. Small show breeders are likely to represent most of the laggards in the case of LAMBPLAN. Such breeders breed sheep primarily as a 'hobby' to win show-ring categories. Because they are not operating a commercial breeding enterprise, LAMBPLAN is of little use to them and would tend to undermine the expertise on which their 'hobby' is based. Furthermore, for very small flocks, LAMBPLAN is sub-economic.

However, there are also a small number of significant breeders who are not users of LAMBPLAN. These breeders seem to have one of two views:

(a) That using LAMBPLAN data to guide a breeding strategy does not result in improved flock performance, particularly since Across Flock LAMPLAN and Indexes were introduced; or

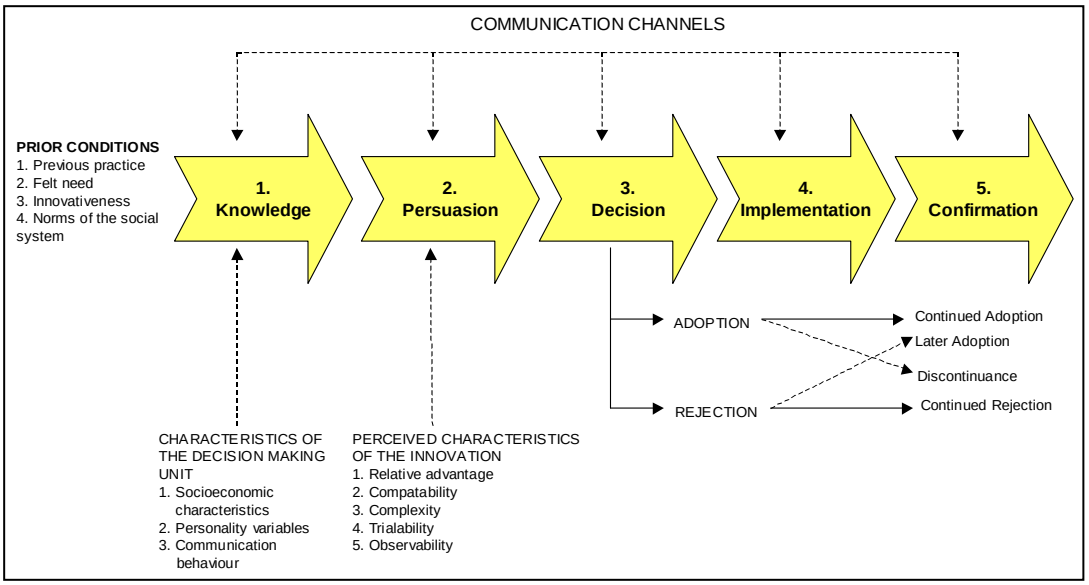
(b) That LAMBPLAN is only a useful tool for breeders who do not have well developed visual assessment skills.

Furthermore, laggards in the LAMBPLAN marketplace are motivated to discredit LAMBPLAN not only because they do not believe it is a valid tool, but because they are of the view that the industry levies that they pay to MLA should not be used to support a service that they do not believe is valid and which promotes breeders who use LAMBPLAN above those who do not.

The LAMBPLAN Adoption Decision

Despite demonstrating different adoption behaviours, each participant in a market for a new innovation goes through a similar adoption decision process. The extent to which the decision-maker is able to make positive validations against the criteria at each stage of that decision process has direct impact on both the rate and extent of adoption of the innovation.

Variations of a five stage model originally conceptualized in 1943[86] form the basis for most modern innovation adoption decision making analysis. A version of this model is demonstrated in Figure 72 below.



The basic tenets of this model will be used to develop an understanding of how the various issues and initiatives discussed in the previous chapters may have influenced the decision by breeders to either adopt or not adopt LAMBPLAN.

Stage 1: Knowledge

The innovation adoption decision process commences when an individual is exposed to an innovation's existence and gains an understanding of how the innovation functions. An individual may become aware of innovations either passively or through actions that they initiate. Individuals tend to expose themselves to ideas that are relevant to their interests, needs and existing attitudes. Individuals also consciously or unconsciously avoid messages that are in conflict with their existing predisposition. An individual may have a need and seek out an innovation that addresses that need or an innovation may assist an individual in realising that they have a need (latent need).

There are three types of knowledge relating to an innovation that need to be considered:

[86] Ryan, B. and Goss, N. (1943), 'The Diffusion of Hybrid Seed Corn in Two Iowa Communities', *Rural Sociology,* 8:15-25, RS(E)

- *Awareness Knowledge*

  Awareness knowledge is nothing more than information that the innovation exists. It may motivate an individual to seek a second and third type of knowledge, referred to as 'how-to' knowledge and 'principles' knowledge. Alternatively, the individual may ignore the information that the innovation exists if it is not relevant to the individual's interests, needs or attitudes.

  It would seem that most Innovator and Early Adopter breeders became aware of LAMBPLAN through one of three channels:

  (a) Involvement with earlier LAMBPLAN related R&D programs operated by the various State DPIs

  (b) Breed society newsletters and functions;

  (c) Attendance at a field day or similar networking event where members of the LAMBPLAN team, particularly Dr Rob Banks, delivered talks on LAMBPLAN; or

  (d) Other breeders

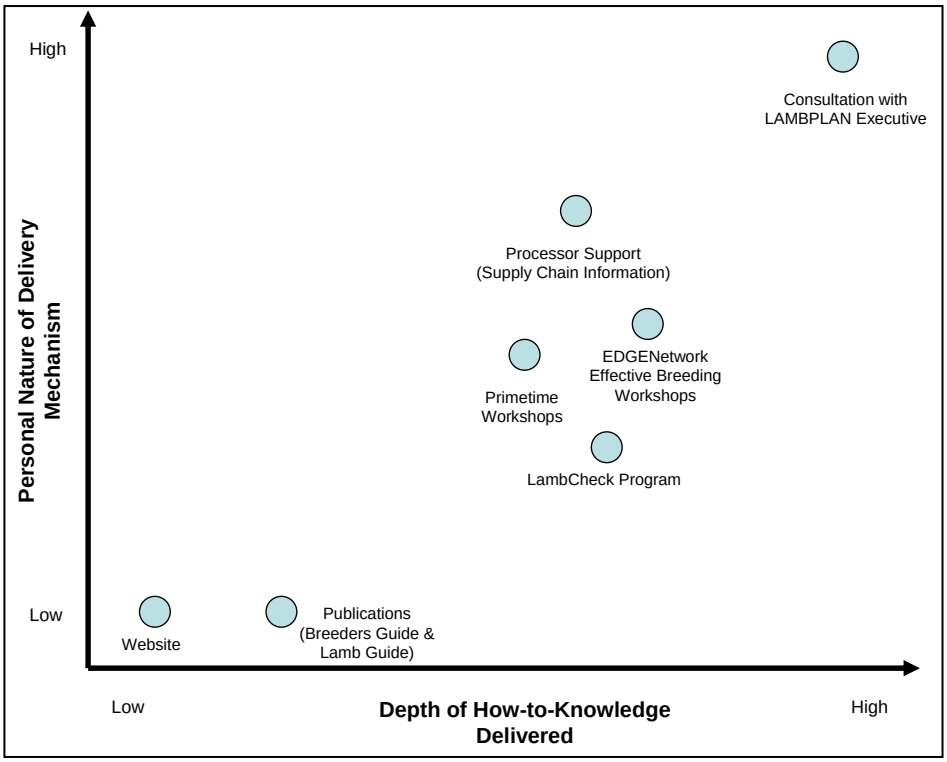
  Later adopter categories seem to have been made aware of LAMBPLAN through State DPI publications and information services, field days or from colleagues.

- *How-to Knowledge*

  How-to knowledge consists of the information set that is necessary to use an innovation effectively. In the case of a complex innovation, the amount of knowledge needed for adoption is considerably greater than in the case of a less complex innovation. Furthermore, where an inadequate level of how-to knowledge is obtained prior to trialing or adopting the innovation, the likelihood of rejection or discontinuance is significantly increased.

  The delivery of how-to knowledge with respect to LAMBPLAN has occurred to varying degrees through a number of channels that vary in both depth of how-to-knowledge as well the degree of personal interaction with a mentor. This is demonstrated in Figure 73 below. The most important delivery mechanism of how-to knowledge for Innovators and Early Adopters of LAMBPLAN seems to have been

through one-on-one consultation with the LAMBPLAN executive, particularly Dr Robert Banks and Dr Alex Ball. This has remained an important conduit for how-to knowledge, but is now supplemented by traditional extension style workshops. Furthermore, processors whom are actively engaging producers and breeders in supply chain management initiatives such as Q-Lamb are also providing how-to knowledge at least with respect to how to select LAMBPLAN animals to meet their specific carcase requirements. The website and publications such as the Lamb Guide and LAMBPLAN Breeder's Guide serve more as day-to-day sources of information and standard operating procedures.



Given that LAMBPLAN is a relatively complex product and that there has been some discontinuance, the issue whether adequate how-to knowledge has been delivered is raised. It would seem that most discontinuance has been the result of objection to the introduction of Across Flock LAMBPLAN and Indexes, which would suggest that an absence of principles knowledge is more likely the driver of discontinuance in the case of LAMBPLAN.

- Principles Knowledge

  Principles Knowledge consists of the information set dealing with the functioning principles underlying how the innovation works. In the case of LAMBPLAN this would include the fundamentals of sheep reproduction, selective breeding and quantitative genetics. Of course, it is possible to adopt an innovation without principles knowledge, however, there is the risk that the innovation will be misused or not used to its optimum effectiveness, resulting in later discontinuance.

  Breeder participation in a number of LAMBPLAN R&D programs has been a major conduit for Principles Knowledge transfer to the Innovator and to Early Adopter segments of the LAMBPLAN market. Participation in the Terminal and Maternal Central Progeny Tests has been one source Principle's knowledge that has resulted in users of LAMBPLAN that are learned in its underlying principles. These breeders then act as a source of Principles Knowledge for the colleagues. The Innovator adopter segment has been the major participant in these projects.

  Principles Knowledge has also been transferred very effectively in the case of LAMBPLAN through the Producer Initiated Research and Development (PIRD) programs. By providing technical support to PIRDs such as SuperBorders, the LAMBPLAN executive has been able to instill a strong understanding of the principles of LAMBPLAN in a group of breeders whom then become powerful promoters of Principles Knowledge in the market place, as they tailor that principles knowledge into products that provide them with competitive advantage in the marketplace. Given the greater commercial focus of PIRDs, Early Adopters are likely to have been greater participants in these projects.

Most promoters of innovations focus on awareness knowledge and to a lesser extent, how-to knowledge, with many viewing the transfer of principles knowledge as the role of formal education. The LAMBPLAN executive seem to have been very successful in extending principles knowledge by making themselves available for consultation, encouraging breeder participation in specific LAMBPLAN R&D projects and supporting PIRDs. It is not clear, however, the extent to which principles knowledge has been transferred to the Early or Late Majority market segments and indeed it is more difficult to transfer principles knowledge to these adopter segments simply by virtue of the skepticism that they hold toward new innovations. This may be a main reason for discontinuance.

Stage 2: Persuasion

Following knowledge acquisition the individual forms either a favourable or unfavourable attitude toward the innovation. A significant difference between the persuasion and knowledge acquisition stage is that where the knowledge acquisition stage mostly involves objective cognitive mental activity, the thinking at the persuasion stage is far more subjective based. It is at this stage that the individual develops a general perception as to the degree of fit that the innovation has with that individual's life and work practices.

The persuasion stage involves a far more complex and risky reasoning process as the individual must look into future scenarios to see how the innovation may improve that individual's enterprise, work practices or life. The individual assesses the hypothetical question – what if I adopt this innovation, what are its advantages and disadvantages in my personal situation?

The individual will seek to validate his or her perception of the answer to this question. While such validation information is usually available from scientific sources, it is usually sought from peers whom have similar enterprise and social characteristics to themselves. It is also at this stage where the conflict between LAMBPLAN and traditional animal assessment practices becomes apparent.

This stage is critically important to the overall adoption of an innovation because it is the individual's perceptions of certain characteristics of the innovation that will motivate him or her to decide to trial or adopt the innovation. These characteristics are critical considerations in product design and are as follows:

- Relative advantage of the innovation

  Relative Advantage refers to the degree to which a product or service based on the innovation is perceived to be superior to the solution that it supersedes. A number of attributes of the innovation may affect its Relative Advantage including the initial cost of the innovation, the degree to which it contributes to a reduction in operating costs or increased revenues, the degree to which it makes a task easier to perform or the degree to which it confers a superior status in the industry. This later attribute can

result in over-adoption, where a certain segment of the market makes a decision to adopt the innovation based on a desire to be perceived as a certain status in the industry and then later discontinues when the innovation fails to perform in the context of the operation of their enterprise. Additionally, the immediacy at which the relative advantage is realised also impacts on the rate of adoption. The relative advantage can also be 'artificially' increased by providing cash or in-kind incentives to adopters or by mandating adoption.

Some Innovators and Early Adopters perceived that LAMBPLAN would be a superior system to visual assessment before they adopted. They believed that the benefits of objective measurement and benchmarking would provide them with an unprecedented ability to measure and increase genetic gain. Other Innovators and Early Adopters were more skeptical, but soon realised resultant genetic gain in their flocks or had their skepticism resolved by the results of the Central Progeny Tests. The time to realisation of tangible economic genetic gain has been cited as being between one and eight years, with most effective users of LAMBPLAN citing between one and three years. For those who were of the view that genetic progress through traditional animal selection process was not going to enable them to achieve the necessary carcase gains quickly enough, the relative advantage of LAMBPLAN was clear.

LAMBPLAN was initially provided free of charge with a nominal fee to be paid for scanning. However, even after a fee regime was introduced in 1997 and then modified several times since then, all LAMBPLAN users believe the service represents value for money. Furthermore, very few LAMBPLAN users believe implementing and using LAMBPLAN requires significant changes in management practices or additional operational requirements.

Most importantly, all users of LAMBPLAN interviewed are reporting significant premiums for high performing LAMBPLAN rams, albeit that in most cases this has been a relatively recent phenomenon. This reinforces the relative advantage of LAMBPLAN.

Most certainly, a portion of the Late Majority are using LAMBPLAN simply because it is recognised as an 'industry standard'. Whether this leads to future discontinuance among these breeders is yet to be tested.

The mandating of LAMBPLAN has been tested in the case of Coopworths, where LAMBPLAN usage is a condition precedent to membership of the Coopworth Society of Australia. However, given the relatively small size of this maternal sire breeding sector, it is difficult to gauge the effectiveness of mandated adoption.

- Compatibility

  Compatibility refers to the degree to which an innovation is perceived as consistent with the existing values, past experiences and felt-needs of potential adopters. Obviously, the more compatible an innovation with the existing values, past experiences and felt-needs of potential adopter segments, the more likely it is to be adopted by individual adopter segments. An innovation can be compatible or incompatible with socio-cultural values and beliefs at a societal or industry level. Because previous experiences are one of the main mental tools that individuals use to evaluate an innovation, innovations that are similar to previously adopted innovations (particularly if adoption involves limited change in practices), are likely to be adopted more readily. However, this can also cause over-adoption. The most important aspect of compatibility is the degree to which the product based on the innovation is compatible with the felt-need of the potential adopter. This is a critical input to whole of product design.

  From a basic philosophical point of view, compatibility goes a long way toward explaining why adoption of LAMBPLAN has been significantly less among traditional stud breeders. The use of objective measurement and quantitative genetics is contrary to their beliefs in a traditional custom of visual assessment where the breeders expertise is revered, particularly when it contradicts that expertise.

  An interesting observation of compatibility is that some prime lamb industry participants in Southern New South Wales and Northern Victoria also run cattle enterprises. Given that the adoption of BreedPlan has been significant in the Southern Agricultural zone, it is reasonable to presume that some LAMBPLAN adopters would have compatible mental frames by virtue of their exposure to BreedPlan. Similarly Innovator and Early Adopter market segments have been relatively extensive users of other breeding technologies such as artificial insemination and to a lesser extent, embryo transfer. These would have influenced the degree to which they had compatible mental frames for adopting LAMBPLAN.

The ability of LAMBPLAN to address the felt needs of different adopter segments was a major factor in its successful adoption and this has been discussed in the previous section.

- Complexity

  Complexity refers to the degree to which an innovation is perceived as relatively difficult to understand and use. While complexity is negatively correlated to rate of adoption, it is typically not as an important factor in rate of adoption as relative advantage and compatibility, because it can most often be overcome in effective product design.

  LAMBPLAN is an example of an innovation that has been readily adopted despite its complexity. Certainly enabling technologies such as BLUP which allows complex genetic data to be expressed in simple descriptive rankings, real-time ultrasound and accredited operators and web enabling technologies have made LAMBPLAN easier to use even though its underlying principles remain fairly complex. Indeed most users of LAMBPLAN describe it as being relatively easy to use and understand.

  This issue helps explain why the adoption of LAMBPLAN has been lower among breeders of maternal sires. The low heritability, longer time taken for reproductive traits to be expressed by progeny and the need for additional measurements, render maternal sire LAMBPLAN products more difficult to understand.

- Trialability

  Trialability is the degree to which an innovation may be experimented with on a limited basis prior to a full adoption decision being made and implemented. Generally speaking, innovations that exhibit a high degree of trialability experience higher rates of adoption. Again, this is not as a critical factor in the rate of adoption, because in most cases it can be engineered into the whole product design.

  Most certainly, many LAMBPLAN users initially used LAMBPLAN on a trial basis, only measuring and recording a portion of their flock. The LAMBPLAN product facilitates trialing, but pricing is structured to encourage full adoption. Furthermore, the recent introduction of product differentiation based on service levels further facilitates trialling on a limited financial exposure to the product.

This issue goes further toward explaining the slower rate of adoption of LAMBPLAN by maternal sire sectors. The long lead-time to results means that the user needs to remain with the program for several seasons before results might be seen.

Conversely, the fact that BreedPlan had been operating with some success in the cattle industry for a number of years prior to the launch of LAMBPLAN somewhat reduced the need for trialibability in the minds of some breeders who adopted LAMBPLAN[87].

- Observability

  Observability is the degree to which the results of an innovation are visible to others. Innovations that are easily observed and communicated to others tend to exhibit higher rates of adoption.

  It would appear that the results of LAMBPLAN are highly observable:

  (a) Breeders using LAMBPLAN report realisation of genetic gain within 1 to 8 years, with most realizing in shorter periods of time;

  (b) Rams with high performing LAMBPLAN data are achieving price premiums in the marketplace; and

  (c) There is some evidence that high performing LAMBPLAN rams are emerging as the best show-ring animals.

  Some breeders who do not use LAMBPLAN will argue that this is not the case because they see highly ranked LAMBPLAN rams that have a poor visual appraisal.

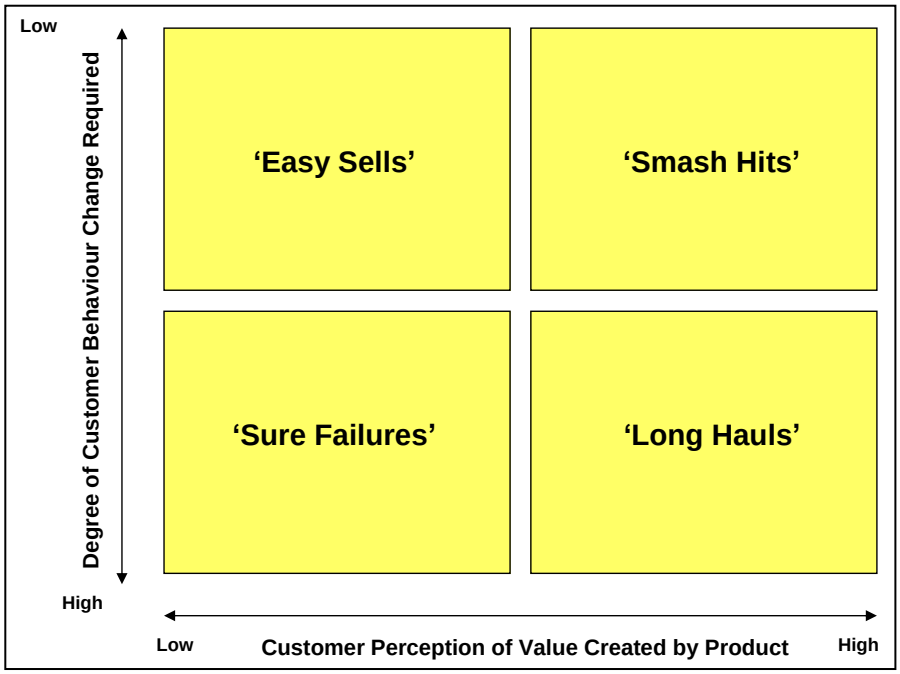
  Again, with the maternal sire breeding sector, the benefit of breeding for reproductive traits is only visible in the first cross ewe. Given the vast majority of first cross ewes are sold the improvement of reproductive performance that is achieved from the maternal sire is more difficult for the breeder to assess.

Most of the variance in the rate of adoption of innovation (49 to 87 percent) is explained by these above five attributes of the innovation.[88] Because, complexity and trialability can typically be addressed through product design, it is relative advantage and

[87] A number of the Breeders who use LAMBPLAN who were interviewed commented that they did not feel the need to trial the product because it had been working successfully in the cattle industry for a number of years.

[88] Rogers, E. (1995). *Diffusion of Innovations,* Free Press, New York.

compatability with felt-needs that primarily drive adoption. If we translate this into simple sales industry jargon, 'smash hits' in terms of sales usually come from products that offer improved value for the customer, but require limited change in the customers behaviour for the customer to use those products. This is demonstrated in the Figure below[89].



Other factors that affect the rate of adoption are:

- Communication Channels Used for Various Stages of the Adoption Decision Process

  It would seem that the communication channels used to target different stages of the adoption decision process have been effective.

- Nature of the Target Market for LAMBPLAN

  In the early years, the target market for LAMBPLAN was not so clear. While domestic and international consumer market research had identified an opportunity for Australian lamb, considerable gains in weight and leanness had to be achieved in order to capitalize on this opportunity. Furthermore, at the time of LAMBPLAN's launch the Wool Reserve Price Scheme was still in place providing a more positive

[89] Gourville, J.T. (2006), 'Eager Sellers, Stoney Buyers: Understanding the Psychology of New Product Adoption', *Harvard Business Review,* (84)6.

outlook for wool than today, albeit that there was concern at the time among some industry participants that its future was uncertain. At the time, it was not clear to the vast majority of the Australian lamb industry that genetic improvement would be a necessary component of any strategy designed to capitalize on the opportunity or indeed, that the wool industry had troubled times ahead (with the exception of some Innovators and Early Adopters). As such, LAMBPLAN was launched into a target market that was at best, skeptical as to its value.

Sentiment in the entire sheep industry, and thus the target market for LAMBPLAN, underwent a sharp decline following the collapse of the Wool Reserve Pricing Scheme. However, once the decline in industry sentiment stabilised and genetics became established as a major contributor to carcase improvement in the early 1990s, the target market for LAMBPLAN became more favourable.

Since the mid 1990s the target market for LAMBPLAN has demonstrated more favourable conditions for adoption. Rising lamb prices, new and expanding export markets and an increasingly unattractive environment for wool production collectively shifted sheep producer attention toward lamb. Additionally, initiatives such as the Lamb Industry Strategic Plan would have created a sense of industry direction and promoted the role that genetic management should play in achieving the goals set by industry. It should be noted that the development of export markets was the result of proactive promotional efforts by the industry and primarily MLA.

Particularly in more recent years, the industry has gained considerable momentum, with prime lamb specialists achieving higher rates of productivity and profitability than the rest of the Australian sheep industry. Collectively, these factors have created a generally more positive target market for LAMBPLAN since the early to mid 1990s.

As discussed previously, the two major upset in this generally positive trend in the target market for LAMBPLAN since the early 1990s were the imposition of US trade restrictions and the 2002-03 drought

Additionally, the positive market sentiment was fuelled by the adoption of accurate measurement technologies, pricing grids and supply chain management by processors and exporters. These proactive efforts by processors and exporters were, in turn, driven by retailer demand that was the direct result of the consumer and

retailer targeted campaigns, namely Trim Lamb in the domestic market and the Fresh Australian Range Lamb program in the United States.

- Promotional Efforts of LAMBPLAN Team

  Most certainly the promotional efforts by the LAMBPLAN team, particularly Dr Robert Banks and Alex Ball have played a major role in driving the rate of adoption throughout the life of LAMBPLAN, but particularly among the earlier adopter segments. Traditional extension programs have probably played a more important role among the later adopter segments.

Stage 3: Decision

The Decision Stage involves the activities that lead to an individual making the decision to adopt or reject an innovation. Such activities may include trialing the innovation before adopting the innovation or observing a peer trialing the innovation (if the nature of the innovation allows for a trial).

At this stage the individual may chose to adopt the innovation, adopt the innovation and then reject it (discontinuance), actively reject the innovation or passively reject the innovation. The individual actively rejects the innovation where they have given due consideration to the adoption of the innovation and then decided not to adopt. Passive rejection refers to the situation where the individual never really considered using the innovation.

Most rejection in the case of LAMBPLAN discontinuance has been active rejection.

Stage 4: Implementation

The Implementation Stage involves putting the innovation into practice and as such involves transferring the adoption decision process from a strictly mental exercise to a practical exercise. The typical individual will still harbour a degree of uncertainty as to how the innovation will fit with their enterprise, work practices and life until it is

implemented and as such active information seeking by the individual typically occurs at this stage, which is a major focus for product support functions.

Sometimes the successful implementation of an innovation may involve some re-invention (changing or modification) of the innovation or how it is used by the individual so it is a better fit with that individual's enterprise, work practices or life. This is particularly prevalent among the Early Adopter market segment and is a necessary input to product design when trying to drive the adoption of innovation from the Early Adopter segment to the Early Majority segment. PIRDs have been a major facilitator of re-invention in the case of LAMBPLAN.

Stage 5: Confirmation

Confirmation is the final stage in the adoption decision process and involves the individual seeking information that reinforces their decision to adopt the innovation. It can result in a decision to continue using the innovation or discontinuance. Discontinuance is a decision to reject the innovation after having previously adopted it. Replacement discontinuance results from a decision to reject an innovation where a better innovation supersedes the original innovation. Disenchantment discontinuance occurs where a decision to reject the innovation is a result of dissatisfaction with its performance. Disenchantment discontinuance can occur where the individual's expectations have not been met, where they have not implemented the innovation property or where their situation has changed, rendering the innovation less compelling.

The limited cases of discontinuance of LAMBPLAN seemed to have occurred post the confirmation stage as breeders who have stopped using LAMBPLAN typically used it for a number of years before stopping. The main reasons why former users of LAMBPLAN discontinued with the product are:

- A belief that Across Flock comparisons are invalid and the Across Flock data results in an inaccurate measurement of an animal's performance;
- A belief that Indexes misrepresent an animal's genetic merit; and/or
- A belief that the LAMBPLAN system can be 'rorted' by some breeders.

Furthermore, most of this discontinuance has been replacement discontinuance because all former users of LAMBPLAN interviewed currently us Stockscan or a similar service, believing it to be a better innovation.

Chapter 8: Lessons from LAMBPLAN

The LAMBPLAN story clearly demonstrates the need for three critical ingredients in successful innovation:

- A robust platform technology that is based on competent science from which products that meet the different felt-needs of different adopter segments can be developed;
- An industry or competitive environment that results in those products being able to demonstrate a relative advantage over the existing solution to the problem that they target;
- An understanding of the different perceptions of relative advantage and the different felt-needs of adoption segments and the ability to develop the product such that it address the different perceptions of relative advantage and felt-needs of those segments.

The LAMBPLAN story also clearly demonstrates how other factors that support adoption can be used effectively when these three key ingredients are in place.

Implications for Future R&D Projects

The LAMBPLAN adoption story provides us with insight as to how to plan adoption strategies for future innovations and how to predict the extent to which a future innovation may be adopted by industry.

Competent Science and Product Development Capability

Ingredients for Successful Broad Industry Adoption of Innovations – Demonstrable Technology Platform:

1. When developing the technology platform for the innovation think in terms of technology convergence as it creates broader opportunities and possibilities for product development, increasing the likelihood that the product will be able to evolve the meet the different felt-needs of different adopter segments.
2. Undertake high profile, collaborative R&D that demonstrates the robustness of the science that underpins the technology platform as well as the ability of the innovation to convert that science into workable solutions for industry. This provides the basis for strong evidence based marketing.

In the case of LAMBPLAN, the capability to convert proven genetics science into a workable product (innovation) arose as the result of the convergence of genetics science, low cost high speed computing power and web enabled technologies. The resulting technology platform provided extensive LAMBPLAN product development capability in terms of the development of different EBVs and Indexes that can be tailored and developed to meet the different felt-needs of the different adopter segments and Across-Flock and Across-Breed products. Furthermore, the effectiveness of these products was clearly demonstrated through the Central Progeny Tests, providing a strong foundation for evidence based marketing.

Favourable Adoption Climate

Ingredients for Successful Broad Industry Adoption of Innovations – Creating a Favourable Adoption Environment:

1. Look for either growing industries that need a solution to a clear and significant problem that the innovation can solve better than the existing solution or events in an existing industry that have the potential to change the dynamics of that industry such that the innovation would demonstrate a relative advantage.
2. Where the outcome will clearly benefit industry use promotional power in both markets and the production environment to illuminate the need for a solution to the existing problem and the relative advantage demonstrated by the innovation with respect to that problem or to capitalize on the event that has changed the dynamics of the industry and the relative advantage that the innovation has in the new industry dynamic.
3. Be mindful of the need to address the entire supply chain in developing and marketing the innovation.

There is a saying in the venture capital industry, *find a fast flowing river, jump-in and swim as hard as you can with the current.*[90] There is no doubt that innovations that are introduced to a market where the industry environment results in those innovations having a clear and significant relative advantage are likely to experience higher levels and rates of adoption. As a technology development organisation, MLA has an advantage in that it also has a

[90] Ferris, B., 2000, *Nothing Ventured Nothing Gained: Thrills and Spills in Venture Capital,* Allen and Unwin, Sydney

mandate to market and promote in the best interests of industry. There is no doubt that, while in part the collapse of the Wool Reserve Price Scheme created an opportunity to shift producer focus from wool production to lamb production, the promotion of Australian lamb product in the domestic and international markets and the promotion of lamb production to the Australian sheep industry went a long way to creating an environment that was conducive to the adoption of LAMBPLAN.

Furthermore, LAMBPLAN clearly demonstrates that because most agricultural businesses fit into a relatively long supply chain, the conducive environment needs to be created along the supply chain. As a result of consumer demand, retailers began to compete by providing quality innovative lamb cuts. Processors met this demand by sourcing quality carcases and meeting the innovative cut demand. Producers who could deliver quality carcases to processors were rewarded either through over-the-hooks sales price premiums or by participating in formal supply chain grids. Buying LAMBPLAN rams gave producers confidence that they would be able to consistently produce quality carcases and as such, there was demand for LAMBPLAN rams from producers, compelling meat sheep breeders to adopt LAMBPLAN.

A Pathway to Broad Market Adoption

Ingredients for Successful Broad Industry Adoption of Innovations – A Pathway to Broad Market Adoption:

1. Identify the different adoption behaviour segments for the specific innovation and develop a clear understanding of their adoption profiles.
2. Target 'Innovator' adopters to develop products from the technology platform and test customer usage of those products through technical, base level cooperative R&D.
3. Develop collaborative R&D projects with 'Early Adopter' adopters to develop products that provide unique competitive advantage to those 'Early Majority' adopters.
4. Develop a detailed understanding of the felt-need of the 'Early Majority' adopter's felt-need and develop a product that very clearly matches that felt-need.

Many years of research in the field of innovation diffusion clearly demonstrates that the market for any new innovation is characterized by segments that demonstrate different adoption behaviours with respect to a specific innovation and as such, different propensities to adopt the specific innovation. The prior identification of these segments and their adoption behaviours and characteristics allows the promoters of the innovation to assess whether the technology platform on which the innovation is based is capable of developing products that meet the felt-needs of these adopter segments. It also allows the promoter of the innovation to develop innovation

marketing strategies that assist each segment with achieving a positive adoption outcome as members of that segment negotiate the adoption decision process.

LAMPLAN's ability to develop a pathway to broad market adoption is discussed in detail in the previous section. It is not clear that the LAMBPLAN project set out to deliberately define and follow an adoption strategy that identified and executed on this pathway to adoption from the outset. However, it is clear that the LAMBPLAN team was able to identify different customer needs and evolve the product to meet those needs.

Given that the relative advantage, compatability with felt-needs, tialability and observability of the innovation account for between 49 and 87 percent in the variance in adoption, getting these critical ingredients correct goes a long way toward determining the adoption potential of an innovation and developing innovation strategies more likely to drive broad industry adoption. Furthermore, given that trialability and observability can typically be addressed by product design, it is relative advantage and compatability with felt-need that are the critical issues.

Implications for Sheep Genetics Australia

Because the role out of Sheep Genetics Australia (SGA) will have a significant focus on the merino sector, it is worthwhile discussing challenges that SGA may encounter in that sector. Certain characteristics of the merino sector are likely to exacerbate some of the challenges that LAMBPLAN faced in the meat sheep sectors:

- The merino breeding industry has a much deeper and more robust culture of traditional breeding and visual animal selection practices than the meat sheep industry. Furthermore, established traditional breeders have considerable voice and political influence in the industry.
- Whereas the meat sheep industry is going through a period of expansion, the wool industry is in decline, with a far less attractive outlook.
- Because they are external to the animal, wool traits are more 'visual' than meat traits, possibly making it more difficult to convince breeders to use accurate trait measurement technologies.

- Because of the poor mothering characteristics of merino ewes, identifying pedigree will be more difficult than is the case with most meat sheep breeds, making on-farm implementation more challenging.

If SGA is to achieve significant penetration in the merino sector, these issues will need to be considered as major inputs to the product development, innovation marketing and adoption strategy for SGA.

Appendix 1: Category of Interview Candidate

The table below demonstrates the number of individuals interviewed for the purpose of this investigation in each of the main interview categories.

Interview Category	Number of Interviewees
Breeders using LAMBPLAN from the Poll Dorset, White Suffolk, Suffolk, Texel, Border Leicester, Merino and Poll Merino Sectors	14
Breeders not using LAMBPLAN from the Poll Dorset, White Suffolk, Texel, Border Leicester, Merino and Poll Merino Sectors	6
Commercial lamb producers	6
Lamb processors	2
LAMBPLAN Scanner Operators	3
Executives and Scientists involved in development and delivery of LAMBPLAN	10
Total Interviews	41

Appendix 2: Reasons Given by Interviewees for Adopting LAMBPLAN

The table below demonstrates the main reasons that interviewees provided for using LAMBPLAN and the adopter category most commonly associated with that reason.

Reason for Adopting LAMBPLAN	Adopted Segment
Selection decisions based on science rather than fantasy	Innovator
Make much better, more objective decisions on selecting the sires that the breeder wants to use.	Innovator
Made very little genetic progress in the past and needed a more objective approach to benchmarking and improvement management	Early Adopter
Central Progeny Tests provided confidence in the accuracy of the system	Early Adopter
LAMBPLAN has the potential to hasten genetic progress	Early Adopter
LAMBPLAN is far more information risk that other trait measurement services	Early Adopter
LAMBPLAN figures confirm the practices of the good breeders	Early Majority
Industry was pushing the use of LAMBPLAN	Early Majority
Some numeric information is better than no information	Early Majority
Customers require LAMBPLAN figures and would lose customers if couldn't provide LAMBPLAN figures	Innovators, Early Adopters and Some Early and Late Majority
LAMBPLAN helps develop a stock of ewes that are able to meet production requirements	Early Majority
LAMBPLAN is good value for money	All Adopter Segments

Need to compete with Texel breed when it was introduced	Early Majority
Suits selecting animals for carcase competitions as opposed to show-ring competitions	Early Majority

Appendix 3: Reasons Given by Interviewees for Not Adopting LAMBPLAN

The table below demonstrates the main reasons interviewees gave for not using LAMBPLAN.

Reason for Not Adopting LAMBPLAN
Visual assessment by an experienced breeder is the most accurate way to measure the potential performance of a ram and its progeny.
Already know what a 'good' sheep looks like and prefer Stockscan because it gives eye-muscle area data that the LAMBPLAN scanners are unable to provide.
Sheep ranked highly on LAMBPLAN figures don't always perform well in the show-ring.
Sheep ranked highly on LAMBPLAN figures don't always rank highly when visually appraised.
Customer concern that high LAMBPLAN ranking sheep are visually unappealing.
LAMBPLAN promoters will not listen to advice from experienced breeders.
Across flock and across breed LAMBPLAN is inaccurate.
Indexes are not an accurate representation of a balanced animal

Appendix 4: Factors that Interviewees Believe to have Contributed to the Growth of the Australian Lamb Industry

The table below demonstrates some of the more common factors that interviewees believed have contributed to the historic growth of the Australian lamb industry.

Historical Factors that have Contributed to Growth of the Australian Lamb Industry
LAMBPLAN has allowed genetic improvement based on objective measurement. It links genetic values with profit and allows performance benchmarking.
Development of export markets which has underpinned the price for Australian lamb and generated producer interest in the industry.
Innovation in lamb products resulting in new markets, premium products and to a degree, the de-commoditisation of lamb. Particularly the improvement in carcase leanness.
MLA's promotion of lamb in the domestic and international markets and efforts to transform and grow industry.
Decline in the price of wool and the resulting demise of the woo industry has resulted in producers switching focus to meat production.
Modernisation of the carcase market through the development of over-the-hooks selling and supply chains.
Introduction of British sheep breed genetics to Australia.
2002-03 drought forced producers to rethink enterprises, with some changing from a wool to meat focused production base.

Appendix 5: Factors that Interviewees Believe to have Detracted from the Growth Potential of the Australian Lamb Industry

The table below demonstrates some of the factors the interviewees more commonly believed have historically detracted from the Australian lamb industry's ability to reach its growth potential.

Historical Factors that have Detracted from the Growth Potential of the Australian Lamb Industry
Historically lower lamb prices made getting started in the industry difficult.
Continued debate over the merit of objective measurement and breeding values has created confusion and uncertainty over best-practice breeding.
Slow change in traditional breeding culture and practices means that the industry has not been able to reach its genetic potential.
Adverse publicity associated with the live export trade has impacted on the prime lamb industry to some degree.
Lack of competition in the processing industry and still inadequate feedback of price rachets for producers supplying the better lambs from most processors.

Appendix 6: Factors that Interviewees Believe will be Future Drivers of Growth in the Australian Lamb Industry

The table below demonstrates factors that interviewees more commonly considered to be potential detractors from the future potential of the Australian lamb industry.

Factors that may be Future Drivers of the Australian Lamb Industry
The production of lamb is not viable for the long term.
Identification and use of genetics that continue to improve animal performance.
Development of additional markets for Australian lamb based on a 'clean – green' and disease free image where other emerging major producers such as China and Brazil cannot compete.
Increased sophistication in the producer – processor relationship, along the lines of the Q-LAMB program.
Continued product innovation, particularly 'healthy' lamb.

Appendix 7: Factors that Interviewees Believe may be Future Challenges for the Australian Lamb Industry

Future Challenges for the Australian Lamb Industry
Adequate supply of merino ewes if wool industry continues to decline
Slaughtering of breeding stock when lamb prices are high.
Cost-price squeeze – a 20 percent reduction in the price of lamb would place considerable pressure on the industry.
Continuation of the trend away from livestock production to cropping.
Breaking into larger markets such as China
Cost of labour in Australian means that labour intensive jobs need to be minimized.
International trade politics (subsidies and tariffs in target markets)
Competition from China, Brazil and New Zealand
Integration of the pro and anti LAMBPLAN camps in industry, although interviewees were of the view that non LAMBPLAN breeders will not be able to be competitive in the marketplace in the future.