LAMBPLAN: a sheep breeding strategy

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The mammalian or avian species involved

The species involved are sheep, initially focussing on sheep bred and managed for lamb production, but with a more recent widening of focus to include Merino sheep which are bred and run primarily for apparel wool.

The breed(s) or species involved

The following chart and table show the basic production systems for lamb/sheep production in Australia and the major breeds involved.

Major breeds used in the various categories include:

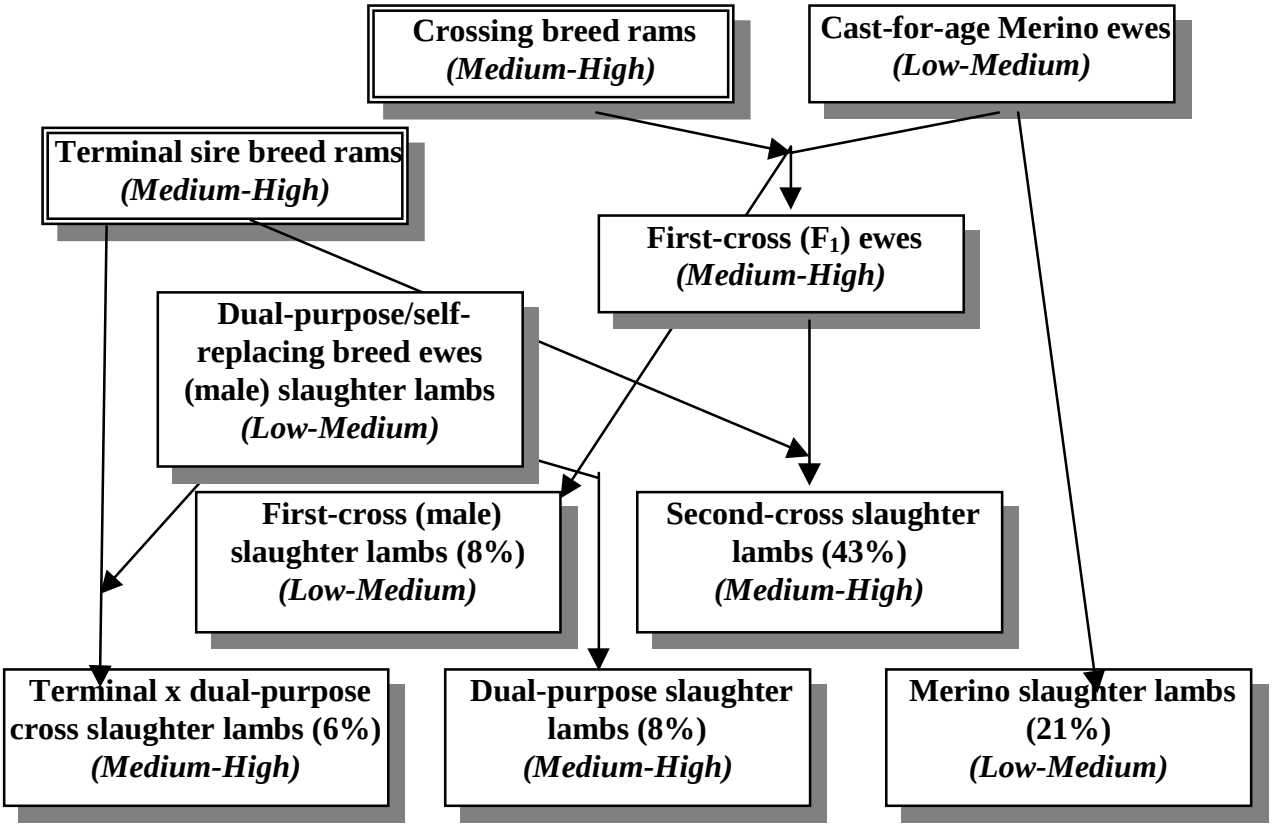
Terminal Sire	Crossing	Dual-purpose/self-replacing
Poll Dorset (0.67)	Border Leicester (1)	Corriedale (0.5)
White Suffolk (0.1)		Coopworth (0.5)
Suffolk (0.1)		
Texel (0.1)		

The core product of the lamb industry is a lamb slaughtered at approximately six months, with carcass weight of approximately 18 kg and carcass fatness of 8-14 mm at the GR site (110 mm out from the backbone at the 12^{th}/13^{th} rib).

There are in addition approximately 14 percent of slaughter lambs bred as Terminal sire x Merino.

Overall, the Australian lamb production system results in cross-bred lambs being produced primarily from higher rainfall zones within the country, and the dams of these slaughter animals being produced in poorer countries, to a large extent as an "off-shoot" of the Merino ewe population (approximately 60 million).

Figure 1. Crossing systems for lamb production in Australia.



Explanatory note for the diagram

Stud or Nucleus Population(s)

Commercial Populations

The phrases in brackets in each text box in the diagram describe the input levels typical of the locations / environments in which each type of animal is run within Australia:

Low: average feed availability and quality is low, and levels fluctuate widely. Parasite burden can be high.

Medium: feed resources may be better managed especially for growing stock, but typically there is a short growing season for pasture.

High: higher rainfall (>650 mm p.a.) supports more intensive pasture production, but may still be quite seasonal. Wetter areas typically impose internal parasite challenges.

This "stratified" system is analogous to that utilised within Britain, with Merinos in harsh dry regions being analogous to the hill breeds run on the high country in Britain. The "first-cross" in both systems "adds" better genetic merit for maternal performance, and the "second-cross" "adds" the genes of fast-growing, higher carcass merit terminal sire breeds.

The approximate input level

In FAO developing country terms, I would assume that the overall input levels are medium / high (but see above).

The approximate number of animals concerned

The total terminal sire breed ewe population (the stud or nucleus population) is approximately 150 000, and the total of crossing and dual-purpose / maternal breeds (again in the stud sector) is 75 000 breeding ewes. The total Merino breeding ewe population (stud ewes) is approximately 750 000 ewes.

Sectors of the breeds involved and dissemination

LAMBPLAN initially targeted the terminal sire sector (1989-1995), then began to increase efforts aimed at adoption within the crossing / dual-purpose / maternal sector.

Dissemination of improved genetic material has been through the sale of breeding animals within the stud sector, with more recently, a rapid growth in the use of AI.

Dissemination to the commercial sector is via sale of commercial rams and commercial ewes (where "commercial" means their progeny are grown for slaughter).

Very little attempt has been made to change the mechanics of movement and sale of genetic material, although as across-flock evaluation has been implemented and breeders' concerns about disease risk have increased, AI has become much more widely used. LAMBPLAN has actively worked with breeders and breeding groups to ensure cost-effective use of AI (and more recently ET).

The approach through which the breeding goal was established

In the initial stages, where the focus was on terminal sires, the broad goal was to enhance capacity to produce larger, leaner lambs. In the absence of either value-based trading for slaughter lambs or clear price signals for fatness / leanness, a simple "desired gains" approach was used with three standard index options (and hence objectives):

- High Growth: designed to maximise genetic improvement in weight at constant age whilst restricting genetic change in fatness to zero;
- High Lean: designed to maximise reduction in fat depth at constant weight, with a small increase in weight at constant age;

- Lean Growth: designed to give equal (in genetic standard deviation units) improvement in weight at constant age and fat depth at constant weight.

The Lean Growth Option was accepted by breeders as the ideal "default" option.

More recently, this approach has evolved considerably:

- In terminal sire breeds, index options are moving more and more towards formal $ Indexes as more traits are incorporated and trading of both seedstock and slaughter lambs become more and more value-based;
- In dual-purpose / maternal breeds, formal $ Indexes were made available almost as soon as the relevant traits were delivered (the trait was defined, genetic parameters estimated, and Estimated Breeding Values or EBVs produced), although simple "desired gains" options have also been provided. The major maternal breeds each have breed-specific $ Indexes, in some cases with more than one option to suit particular production system x target market niches.

In all cases, delivery of Index options has involved discussion with, and feedback from, breeders and some iteration through time as breeders consider more traits, the desirability of particular trait changes and the strengths and weaknesses of their particular breeds / flocks.

Note that Index options tend to be "breed oriented", although a very small number of individual breeders have used customised indexes they have developed either themselves or with some input from LAMBPLAN.

The plan designed to achieve this breeding goal

No formal plan was ever in place, but the key activities involved were:

- procedures for delivering EBVs and Index values were developed;
- these were promoted to breeders;
- the value of superior breeding stock was outlined and promoted to commercial producers.

At what stage of the development of the programme did the diversion occur?

I think the approach outlined in the former chapter has continued to be the basis of LAMBPLAN. What has changed (and this has been gradual), is the range of traits for which EBVs can be produced, the range of Index options, and more recently, the effort put into improving breeding programme design at the individual and group level.

The stimulus for this evolution has been:

a) feedback from breeders wishing to incorporate more traits into their breeding objectives; and
b) feedback again from breeders recognising the existence of some specific production pathway x target market niches, and seeking indexes appropriate to those niches.

Traits included in the breeding goal

The following tables outline the traits available in LAMBPLAN and the major Selection Index options available (excluding Merino Indexes at this point). The traits measured and / or reported in LAMBPLAN are reported in table 1.

Maternal and direct EBVs for all weight traits will be available by August 1999.

The main Selection Index options available through LAMBPLAN are outlined in the table 2.

The selection criteria followed

The previous tables outline the range of traits for which EBVs can be produced. Clearly, many of these can be used as criteria in a multi-trait evaluation system, for the traits included in the indexes outlined above.

LAMBPLAN has worked with breeders to identify the cost-effectiveness of different combinations of criteria (in terms of accuracy of the resulting Index values and hence potential for genetic gain). The decision as to which criteria will in fact be measured rests with the breeder or breeding group.

LAMBPLAN has recently introduced “Data Quality Grades”, which are recording and measurement protocols differing in their effect on individual trait and index accuracy. Gold is quite intensive recording, silver less so, and bronze lower still. These Grades are an attempt at a more practical approach to accuracy / reliability, and have been enthusiastically adopted by LAMBPLAN clients.

Table 1. Traits measured and/or reported in LAMBPLAN.

Trait code	Trait name
bwt	Birth weight
wwt	Weaning weight
wwtm	Weaning weight maternal
pwwt	Post-weaning weight
cwt	Carcass weight
ywt	Yearling weight
hwt	Hogget weight
awt	Adult weight
Trait code (cont'd)	Trait name (cont'd)
pwcf	Post-weaning fat depth
cfat	Carcass fat depth
ycf	Yearling fat depth
hcf	Hogget fat depth
yfat	Yearling GR fat depth
pemd	Post-weaning eye muscle depth
cemd	Carcass eye muscle depth
yemd	Yearling eye muscle depth
hemd	Hogget eye muscle depth
ygfw	Yearling greasy fleece weight
hgfw	Hogget greasy fleece weight
ycfw	Yearling clean fleece weight
hcfw	Hogget clean fleece weight
acfw	Adult clean fleece weight
yfd	Yearling fibre diameter
hfd	Hogget fibre diameter
afd	Adult fibre diameter
nlb	Number of lambs born
nlw	Number of lambs weaned
ysc	Yearling scrotal circumference
pfec	Post-weaning faecal egg count
yfec	Yearling faecal egg count

NB: in addition, a range of wool style/quality traits, and a range of structural soundness traits, are being introduced to LAMBPLAN during 1999. Research is now being initiated that will lead to the implementation of a range of eating quality traits during 1999/2000.

Table 2. The main Selection Index options available through LAMBPLAN.

Index	Selection Emphasis (as % of Total Genetic Change)						
	wwt	ywt	Yfat	yemd	ygfw	yfd	nlw
Wool & Reproduction	10	20	- 20	- 5	20	-	25
Dual-purpose + Muscle	20	20	- 0	20	20	-	
Corriedale Standard	20	0	20	20	20	0	20
Corriedale + Growth	23	27	0	10	20	0	20
Coopworth	18	25	- 1	5	16	-	35
Border Leicester	15	25	- 3	6	16	-	35
Terminal Sire ~ 60:20:20		60	- 20	20			
Terminal Sire ~ 80:10:10		80	- 10	10			

N.B.: absolute values across a row sum to 100; where a – sign is included this indicates direction of selection.

Dissemination of improved material

See material on chapter "Sectors of the breeds involved and dissemination".

The population breeding structure

The lamb industry has a clear division between breeding flocks (studs, or the nucleus) and commercial production flocks.

There is little formal structure within the breeding sector, although LAMBPLAN has worked with a number of groups that are now becoming the elite nuclei (dispersed) within their respective breeds (or composites).

A small number of nucleus or group breeding schemes have existed from time to time, with initial screening usually relatively unplanned and inaccurate genetically.

Since the move to across-flock evaluations, newer moves are being made to establish genetically elite nucleus operations, both within pure-bred and new composite populations. Technically these are very advanced, but it remains to be seen whether these operations will have the business skills to develop and win significant market share.

Farmer and government involvement

Financial support

The following tables outline investment levels by source into LAMBPLAN over the period 1998-1997, and 1998-2002. Note that all values are in Aus$ million.

Table 3. Return on Investment in LAMBPLAN (Aus$ million) 1988–1997.

Expenditure (-) and benefits (+) in Aus$ million over 1988-1997	Breeders	Levy payers	Gov't. Direct	Processors and retailers	Totals
Genetics R&D		-1.1	-1.1		-2.2
LAMBPLAN delivery	-1.6	-0.9	-0.9		-3.4
Breeder cost / return	+11.6	-11.6			
Producer cost / return		+13.3		-13.3	
Cost / return to others				+48.0	+48.0
Net Benefits	+10.0	-0.3	-2.00	+34.7	+42.4
% of the Aus$48 m benefit - by sector	+23.6%	-0.1%		+81.8%	=100%
Benefit to cost ratio	6.25 to 1	0.98 to 1		3.6 to 1	7.6 to 1

Table 4. Return on Investment in LAMBPLAN (Aus$ million) 1998-2002.

Expenditure (-) and benefits (+) in Aus$ (million) over 1988-1997	Breeders	Levy payers	Gov't. Direct	Processors and retailers	Totals
Genetics R&D		-1.0	-1.0		-1.9
LAMBPLAN delivery	-0.6	-0.3	-0.3		-1.1
Breeder cost / return	+37.3	-37.3			
Producer cost / return		+73.0		-73.0	
Cost / return to others				+263.4	+263.4
Net Benefits	+36.7	+34.4	-1.3	+190.4	+260.4
% of the Aus$260 m benefit - by sector	+14.1%	+13.2%		+73.1%	=100%
Benefit to cost ratio	61 to 1	1.9 to 1		3.6 to 1	8.8 to 1

R&D Levies: under industry development legislation in Australia, sheep and beef producers pay a small (up to 2 percent of gross value) ad-valorem levy to a farmer-owned corporation (Meat and Livestock Australia (MLA). This corporation invests these funds in R&D, marketing and promotion, training and so on. The R&D funds invested are matched up to specified limits by Commonwealth Government funding. The levy-payers are therefore commercial sheep and beef producers.

Note that it is expected that breeders and the combination of commercial producers and taxpayers will approximately equally share the direct LAMBPLAN costs (management, database, data processing and reporting and direct research) over the next five years. Commercial producers and taxpayers will share the costs of expected general genetics research (new traits, genotype x production system interaction and gene markers) over this period.

Clearly, overall "system performance" over the next five years should be much better than during the first ten. This is due to the joint impact of:

a) the lag time for improvement to flow into the commercial population;
b) considerable increase in rate of genetic gain after the move to across-flock evaluations.

Finally, this analysis highlights two features that are typical of the development of livestock improvement systems:

a) there is a lag period before benefits accrue, which depends on the generation length of the species, the rate of adoption of genetic selection as well as on the rate of gain; and
b) there is an uneven distribution of benefits within livestock supply chains, the majority share accrues to processors, retailers and consumers. The benefit accruing to consumers is in the form of lower real price of food and improved quality and may be considered as the "benefit" that the industry has to deliver to consumers simply to sell anything.

Also, the relative distribution of benefits will vary as the system develops. The fact that the majority share of the benefits of investment in genetic improvement accrues off-farm, means that genetic improvement effectively "buys" market share in the medium- to long-term. Lack of genetic improvement virtually guarantees loss of market share through failure to maintain or increase real price competitiveness and often also through suffering an increasing quality gap with alternative consumer products.

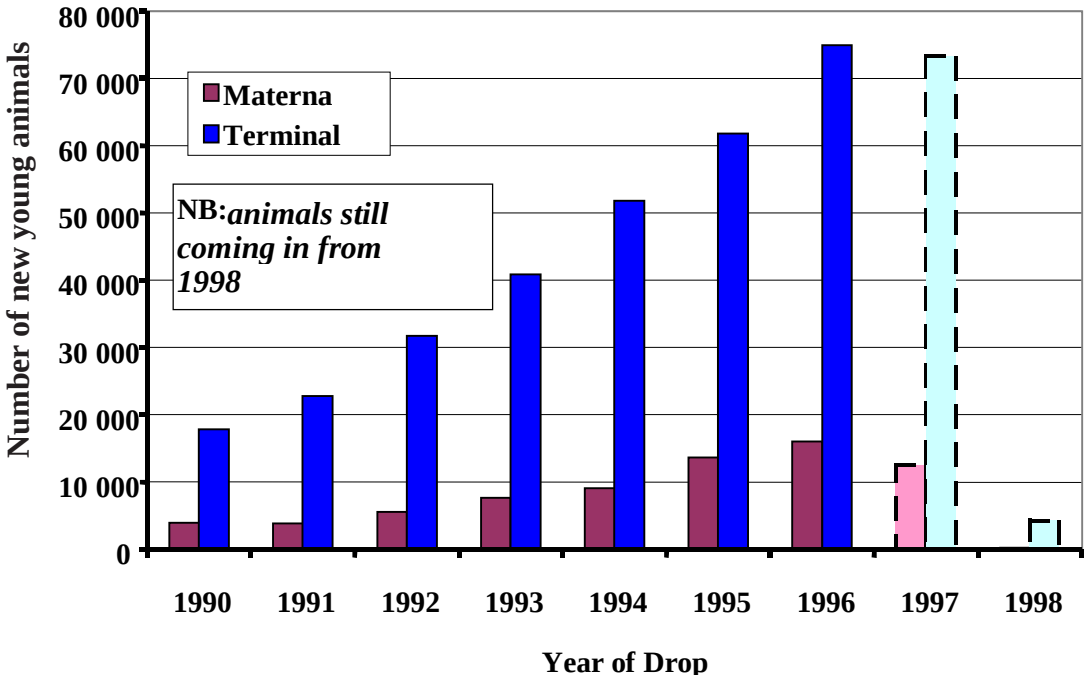
Levels of acceptance of the scheme over time

The following three charts outline growth in numbers of animals being evaluated through LAMBPLAN differentiating terminal sire and dual-purpose / maternal animals, in numbers of flocks using LAMBPLAN and average numbers per flock and total numbers by drop.

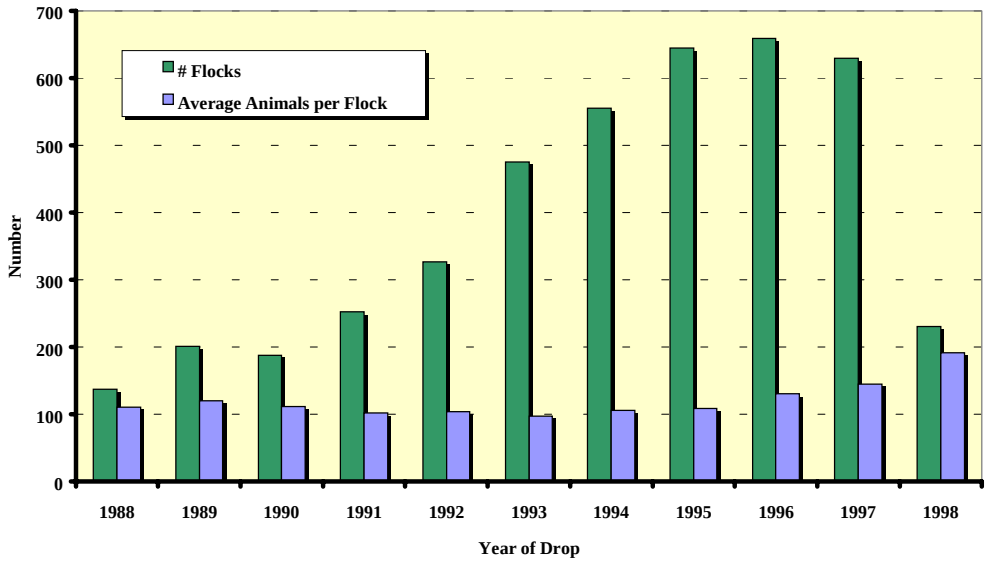
Numbers of studs using LAMBPLAN and numbers of animals being tested have grown steadily, and continue to grow, as has average number evaluated per flock.

Note that the total "market" for terminal sire breed animals is approximately 150 000 p.a. and for dual-purpose/maternal is 100 000 animals p.a. Current throughput is approaching 70 percent of all terminal sire breed animals per drop, some 11 percent of crossing breed animals and 85 percent of dual-purpose/maternal.

LAMBPLAN Throughput by Year of Drop



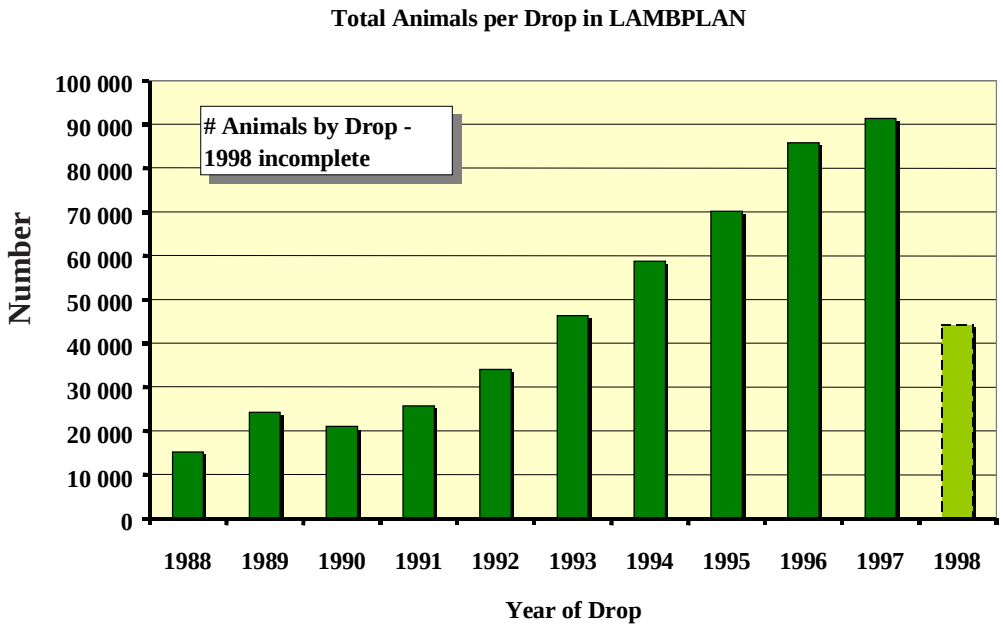
Nos. of Flocks using LAMBPLAN and Average No. Animals per Flock



NB: data from the 1998 drop will continue to come into the database for the next ten to twelve months and we expect another small amount of data from the 1997 drop.

These totals do not include Merino data.

Note that the average number of animals per flock is rising steadily, as breeders enter more female animals and a proportion of breeders are increasing their flock sizes.



NB: Data from the 1998 drop will continue to come into the database for the next ten to twelve months

Policy development

No specific policy or legislative issues have been involved in the development of LAMBPLAN, apart from the decision of the Meat Research Corporation to invest R&D levies in the programme and some supporting R&D projects during the period 1986-1999.

Type and nature of technical support

Farmer support

Most farmer support has been very simple extension aimed at highlighting the on-farm value of differences in EBV or Index via terminal sires. Typically these "trials" have involved generating between 100 and 500 lambs sired by High v Low or High v Average sires. Farmers are then involved in collecting data on the lambs, following the lambs through to slaughter and even retail, and evaluating the differences in progeny performance.

Further support has focussed on involving EBV information in sire buying, usually at auction.

More recently, a considerable effort has been made to encourage and assist the development of farmer production and marketing alliances, with some emphasis on ensuring that seedstock sources are appropriate to the production system x target market niche. This extension has involved not only awareness of genetics, but also improved feeding and management, value-based trading and coordinated marketing.

Research and development

Industry has invested in a number of R&D projects designed to enhance and support LAMBPLAN. These are briefly outlined below:

1. Meat Elite: establishment of an elite terminal sire nucleus flock incorporating CT-scanning in measurement protocols. This project achieved a number of outcomes: successfully producing crops of very high merit animals that have had enormous impact on industry, development of genetic parameters for some body composition traits, assisting industry in practical evaluation of nucleus schemes and leading to the establishment of highly successful dispersed nucleus programmes in all major meat breeds in Australia.
2. Maternal Trait Genetic Parameters: a straightforward variance component estimation project focussed on traits relevant to dual-purpose and maternal breeds.
3. Commercial Progeny Expression of Sire EBVs under varying nutrition: progeny testing sires ranging in genetic merit in a number of sex x nutritional regime treatments.
4. Terminal Sire Central Progeny Testing: wide-scale progeny testing of industry terminal sires in a small number of central locations (usually government research stations) with designed linkage between sites and years. Over 400 sires have been tested over nine sire intakes. The programme is now evolving to concentrate on young genetically elite sires with most testing efforts focussed on carcass composition and eating quality traits.
5. Maternal Central Progeny Testing: a smaller scale and more recent version of the Terminal CPT, evaluating sires from a number of breeds largely on the basis of their cross-bred daughter lifetime performance.

6. Structural Trait Genetic Evaluation: now close to completion, this project has been stimulated by the increasing use of AI (and ET), and greater concern about disease risks.

Recently, LAMBPLAN has been involved in developing a number of R&D projects which will focus on detection and utilisation of genetic markers / QTLs / major genes for carcass and meat quality traits. Not all of these will be funded, but there will be major effort in this area during the next five years.

Throughout all these projects, there has been a very strong focus on strengthening links between research and practice and on encouraging wider adoption of measurement, objective selection and cost-effective breeding programme design.

Training

Most training efforts have been limited to maintaining animal assessment and basic advisory skills in the LAMBPLAN Field Operators (accredited fat and muscle scanners), and in general extension to breeders and commercial producers.

What actions were successful?

I think it is fair to say that no activities have been unsuccessful: all have involved evaluation and demonstration of the value of genetic differences in production traits in some way, and all have aimed at promoting wider adoption of recording and use of genetic information.

To date, LAMBPLAN has had the least success in achieving adoption in the Border Leicester breed, which is used as a crossing sire and for which ram prices are essentially unrelated to daughters' lifetime performance. This breed has a very traditional "attitude", but is now facing serious competition from new dam breeds and composites and from genetically improved dual-purpose Merinos. Within the next five years, the breed seems likely to undergo serious decline in ewe numbers. A small dispersed nucleus programme has been established throughout the breed, and there is evidence of satisfactory genetic improvement within the Border Leicester flocks using LAMBPLAN.

In hindsight, I believe greater effort should have been made to introduce across-flock evaluation earlier. This would have required better R&D coordination within Australia and greater expenditure on extension, but there is clear evidence of accelerated genetic gain after the transition from within-flock to across-flock. It is important to stress, however, that the extension challenges arising would have been very much greater, because of the pressure placed on breeders by the existence of across-flock evaluations.

Reasons for introducing the scheme

LAMBPLAN was introduced as part of a relatively well-coordinated approach to turning around the fortunes of the Australian lamb industry.

By the mid- to late-1980s the industry was in serious relative decline, due to rejection of its basic product by consumers (for being too fatty and with insufficient lean meat), and to non-competitive cost-of-production.

The initial focus of LAMBPLAN was on terminal sire breeds, which (in hindsight) provided an opportunity to rapidly address the product appeal problem. As this has been tackled and gradually improved (average carcass weight is now rising by approximately 0.4 kg per year, with a steady decline in carcass fatness at constant weight), attention is shifting to include reducing costs-of-production through improved maternal efficiency.

What are the most significant activities of the scheme?

A prototype of the scheme was developed by the NSW State Department of Agriculture, with very simple, one-on-one, extension and servicing.

This was extended nationally under the aegis of the Meat Research Corporation, beginning in 1988. A small number of key breeders were involved from the start.

During this phase, the involvement and dedication of a very small number of experienced extension personnel was critical to steady adoption and to give a sense of ownership amongst breeders who used the scheme.

Since LAMBPLAN was launched as a national programme in 1989, there has been continuous involvement of a very small number of individuals, scientists, advisers and field technicians. There has been one national coordinator throughout that time. The dedication and patience of these individuals has undoubtedly been critical.

Equally important has been the steady programme of supporting R&D, always focussed on practical, commercial outcomes and wherever possible aiming at very simple messages for breeders and producers.

Increasingly, breeders have taken more and more ownership of the programme, reflected in the fact that as of 1998, LAMBPLAN has been adopted as part of the farmer-owned Meat and Livestock Australia, and breeders have accepted the challenge of meeting full cost-recovery for LAMBPLAN services.

Finally, it is important that LAMBPLAN has been part of a wider industry programme aimed at improving all factors affecting product quality and cost-of-production throughout the value chain: breeders have been continually made aware that all sectors of the industry face the challenge of continuous improvement.

What changes should be made now to the design and operation of the scheme to make it more successful and why?

Two areas of technical development are obvious:

- enhancing electronic data capture at all points and increasing web-based reporting;
- providing for some "product differentiation" between clients simply interested in basic genetic information and those pursuing extremely high rates of genetic gain, and / or closer commercial integration with customers / partners through the value chain.

In addition, LAMBPLAN faces some decisions concerning the optimal skills base of the field technicians and accredited consultants, and the exact nature of their contractual relationship(s) with LAMBPLAN and its clients.

Expanding on this point, it seems almost certain that there will be increasing emphasis on providing more and more advanced training in the skills of animal breeding.

This implies that the future success of the LAMBPLAN business depends on maintaining steady growth in, and effective integration of:

- technical "power", the capacity to understand and utilise genetic variation;
- practical and commercial competence ensuring that breeders, producers and others in the supply chain know how to exploit genetic variation and to manage the businesses that depend on this.

What are the future directions for development in design, operation and policy to expand the success of the scheme over time?

LAMBPLAN is currently considering developments in a number of areas. These will only be implemented if careful assessment and market research suggests that they will add to technical and / or commercial effectiveness and to client satisfaction.

These potential developments include:

- moving to fortnightly (or weekly) complete updates of all evaluations (currently carried out monthly);
- moving to across-breed evaluations initially for terminal sires and then for all breed groups;
- incorporation of procedures for evaluating, reporting and utilising markers, QTLs and major genes;
- delivery of tools for integration of genetic and management decision-making through the value chain;
- direct contracts for genetic information delivery and management through to retail;
- closer involvement in the adoption of advanced reproductive and genetic analysis technologies;
- evolution of the relationship between LAMBPLAN and its clients towards relationships more closely resembling business partnerships;

- direct investment in technologies utilising more intensive genetic information.

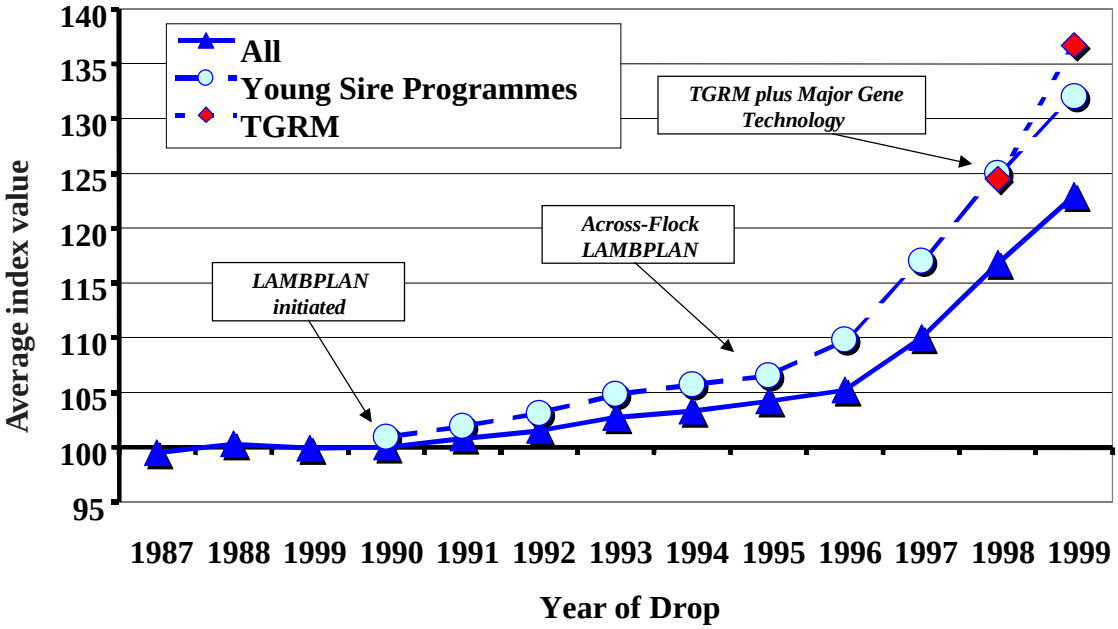
LAMBPLAN has progressed through a steady development process to this point: this process is summarised in the following table and chart (over page).

Table 4. Phases in the development of the LAMBPLAN system.

Phase	Time Period	Value-adding Processes	Average Rate of Gain (Index Standard Deviations per Year)
Pre-LAMBPLAN	Pre 1988	Very limited data, limited adjustment for fixed effects	0
Sire Model, Within-Year and Flock	1988 -1995	Steady growth in data, better adjustment for fixed effects, use of half-sib information, within-flock and within-year evaluation only	0.13
Animal Model, Across-Flock and Year	1994 -1999	a) Continuing growth in data, improved models, across-flock and across-year evaluation. b) Organized programmes using AI	a) 0.31 b) 0.70
"TGRM plus"	1998	Continuing growth in data and better models, across-breed evaluations, TGRM plus major gene technology plus reproductive technologies	Average approximately 0.50, but full application of breeding programme design tools will achieve >1.5

"TGRM plus": an informal phrase indicating that LAMBPLAN is moving to focus service around the TGRM product, and linking a range of analysis and value-adding components into the overall package of genetic information delivered to clients.

Genetic Trends in Sheep Breeding



LAMBPLAN is now entering an era where the service provided to clients is in fact management of the entire genetic resource, so that optimal breeding programme design is the core output, but which comprises a series of "information components", such as EBVs, Indexes, and so on.

Available estimates of genetic change in the population due to the scheme

These estimates are presented as genetic trends for the major indexes used in the major breeds using LAMBPLAN. Selection emphasis in these Indexes is summarised in the Table 1.

Genetic trends in component traits are available from the author: they are generally in line with predictions from index theory both in amount and relative change, or balance of response. The "balance of response" has become closer to prediction as breeders are made aware of the importance of ensuring that the appropriate data is available to support reliable genetic prediction.

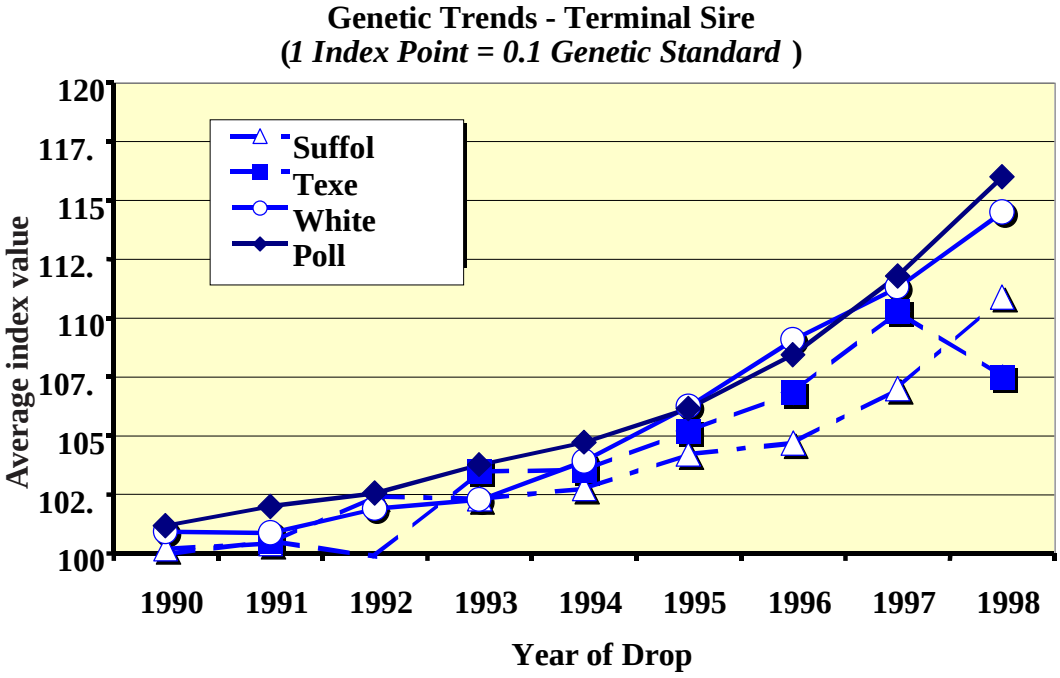
The number of traits included in the indexes seems almost certain to increase as:

a) producers, processors and retailers become more aware of the impact

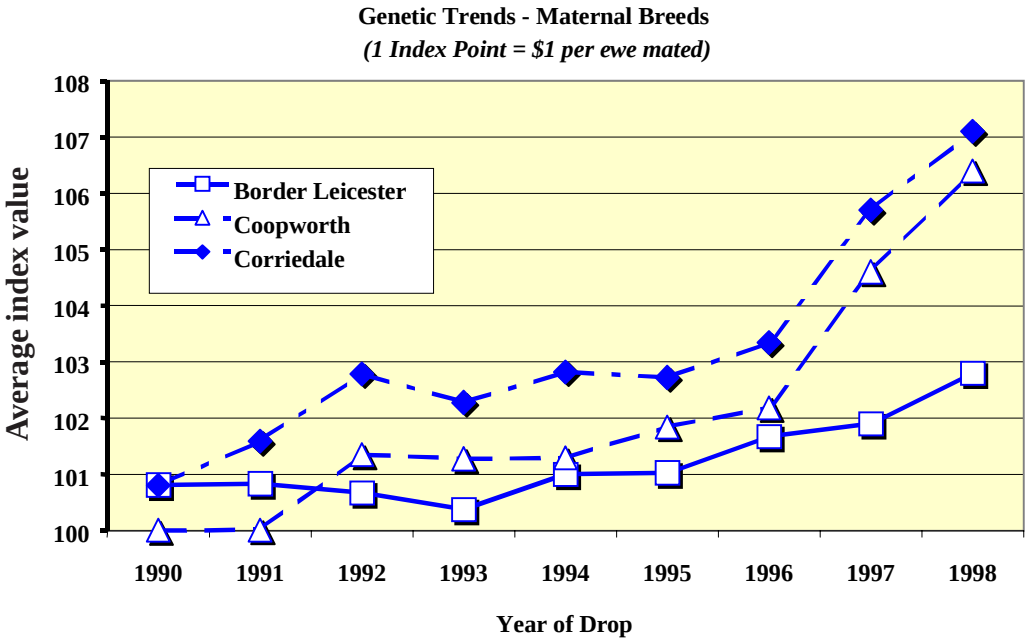
of genetic differences on profit functions at each stage in the supply chain;

b) breeders (and others) become increasingly aware of the benefits of genetic change (and of the costs of unwanted or unanticipated correlated responses).

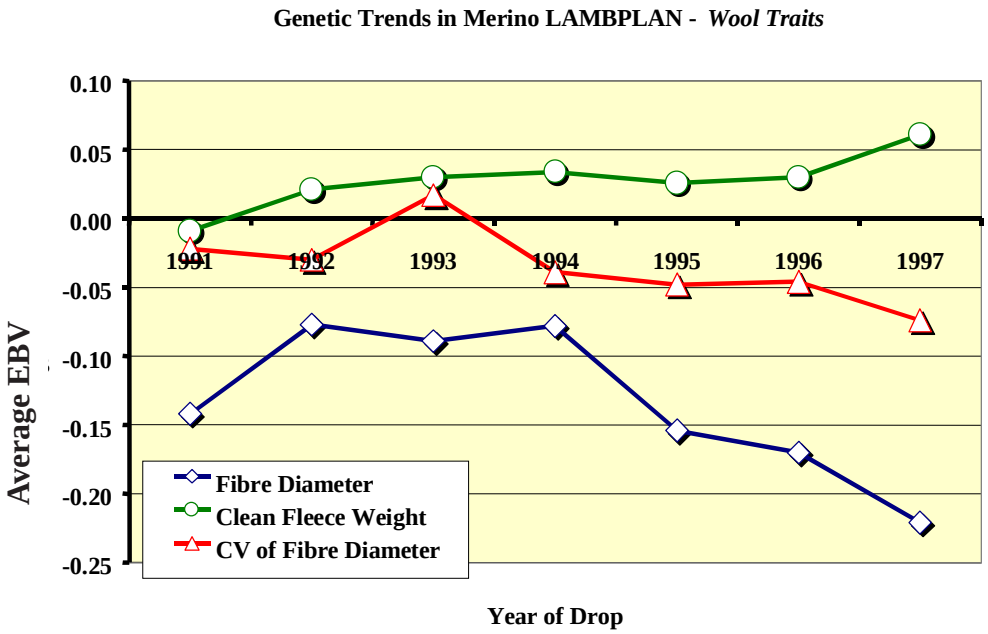
Genetic Trends in Index - Major Terminal Sire Breeds



Genetic Trends in Index - Major Dual-Purpose/Maternal Breeds



Genetic Trends in Merinos using LAMBPLAN - major wool traits



Genetic trends in Merinos using LAMBPLAN - maternal traits